Gemini Project

Surface Water Assessment

Magnetic South Pty Ltd

1238-01-G1, 26 September 2019

Report Title	Gemini Project
Client	Magnetic South Pty Ltd
Report Number	1238-01-G1

Revision Number	Report Date	Report Author	Reviewer
1	26 September 2019	MJB	DN

For and on behalf of WRM Water & Environment Pty Ltd
Level 9, 135 Wickham Tce, Spring Hill
PO Box 10703 Brisbane Adelaide St Qld 4000
Tel 07 3225 0200

Michael Batchelor
Senior Principal Engineer

NOTE: This report has been prepared on the assumption that all information, data and reports provided to us by our client, on behalf of our client, or by third parties (e.g. government agencies) is complete and accurate and on the basis that such other assumptions we have identified (whether or not those assumptions have been identified in this advice) are correct. You must inform us if any of the assumptions are not complete or accurate. We retain ownership of all copyright in this report. Except where you obtain our prior written consent, this report may only be used by our client for the purpose for which it has been provided by us.

Contents

1 Introduction 9
1.1 Background 9
1.2 Project Description 9
2 Regulatory framework 13
2.1 Commonwealth 13
2.1.1 EPBC Act 13
2.1.2 Independent Expert Scientific Committee 13
2.2 Queensland 13
2.2.1 EP Act 1994 13
2.2.2 Water Act 2000 15
2.2.3 Water Supply (Safety & Reliability) Act 2008 16
3 Environmental Values 17
3.1 Aquatic Ecosystem Environmental Values 19
3.1.1 Fitzroy Basin Aquatic Ecosystem Health 19
3.1.2 Aquatic ecology assessment of the Project area 19
4 Existing surface water environment 20
4.1 Local climate - rainfall and evaporation data 20
4.2 Catchment context 22
4.3 Local stream morphology 26
4.4 Streamflow 30
4.5 Flooding 30
4.6 Water quality 33
4.6.1 Baseline quality of receiving waters 33
4.6.2 Geochemical characterisation of overburden 33
5 Proposed water management strategy 34
5.1 Site water types 34
5.2 Mine development and staging 36
5.3 Water management system components 42
5.3.1 Mine affected water dams 42
5.3.2 Sediment dams 42
5.4 Catchment areas and land use 44
6 Site water balance 49
6.1 Water demands 49
6.1.1 Coal handling and preparation plant 49
6.1.2 Train loading operation (TLO) 50
6.1.3 Haul road dust suppression 50
6.1.4 Potable water demands 50

6.2 Groundwater inflows to mining pits 50
6.3 Water balance model 51
6.4 Simulation methodology 52
6.4.1 Modelled staging of mine plans 52
6.5 Catchment runoff 52
6.5.1 Catchment runoff salinity 52
6.5.2 Catchment runoff rates 52
6.6 Modelling of water demand 55
6.6.1 Haul road dust suppression 55
6.7 Summary of demands 56
6.8 Operating rules 57
6.9 Water balance model results 59
6.9.1 Mine water dam behaviour 59
6.9.2 Likelihood of pit inundation 59
6.9.3 Water supply reliability 61
6.9.4 Sediment dam releases 61
6.9.5 Overall site water balance 63
7 Flood mitigation and impacts 64
8 Final void behaviour 73
8.1 Overview 73
8.2 Final void configuration 73
8.3 Conceptual model 76
8.4 Numerical modelling approach 76
8.5 Stage-storage characteristics 77
8.6 Catchment runoff 77
8.7 Pit surface evaporation 77
8.8 Groundwater 77
8.9 Climate change impacts 78
8.10 Lake Salinity 81
8.11 Model results 82
8.12 Sensitivity analysis 86
9 Vulnerability to climate change during operations 87
10 Potential surface water impacts and mitigation measures 88
10.1 Overview 88
10.2 Flooding impacts 88
10.3 Final void lakes 89
10.4 Geomorphological impacts 89
10.5 Impacts on downstream flow regime 89
10.6 Impacts on receiving water quality 91

10.6.1 Seepage 91
10.7 Cumulative impacts 91
10.7.1 Regional water availability 91
10.7.2 Controlled releases 91
11 Water monitoring 92
11.1 Receving water monitoring 92
11.2 Mine water system monitoring 94
11.2.1 Mine affected water dam monitoring 94
11.2.2 Spoil and sediment dam monitoring 94
12 References 95
Appendix A Flood impact assessment 96

List of Figures

Figure 1.1 – Locality Plan 11
Figure 1.2 – Project layout 12
Figure 3.1 – Mackenzie River Sub-basin EVs 17
Figure 4.1 – Annual rainfall at Dingo Post Office - 1889 to 2019 (SILO) 21
Figure 4.2 – Average monthly rainfall and pan evaporation at Dingo Post Office 21
Figure 4.3 – Fitzroy River Basin 23
Figure 4.4 – Site catchments 24
Figure 4.5 – Regional receiving environment 25
Figure 4.6 – Drone photograph looking south across along Charlevue Creek across the Capricorn Highway to the Project area (source: Magnetic South Pty Ltd) 26
Figure 4.7 – Drone photograph looking southwest along Charlevue Creek at the site of the proposed haul road crossing (source: Magnetic South Pty Ltd) 26
Figure 4.8 – Photograph of Charlevue Creek channel upstream of the mine area (source: aarc) 27
Figure 4.9 – Photograph of Charlevue Creek channel upstream of the mine area (source: aarc) 27
Figure 4.10 – Drone photograph looking south along Springton Creek near the proposed location of AB Pit (source: Magnetic South Pty Ltd) 28
Figure 4.11 – Photograph of Springton Creek channel near proposed AB Pit location (source: aarc) 28
Figure 4.12 – Photograph of Springton Creek channel and floodplain near proposed AB Pit location (source: aarc) 29
Figure 4.13 – Drone photograph looking southeast to Springton Creek at confluence of unnamed tributary crossing proposed AB Pit (source: Magnetic South Pty Ltd) 29
Figure 4.14 – Drone photograph looking northeast along upper reach of the unnamed tributary of Springton Creek crossing proposed C Pit (source: Magnetic South Pty Ltd) 30
Figure 4.15 – Existing conditions 1% AEP flood depths and water level contours 31
Figure 4.16 - Existing conditions 1% AEP flood velocities 32
Figure 5.1 – Proposed water management system layout - Stage 1 (Year 1) 37
Figure 5.2 – Proposed water management system layout - Stage 2 (Year 5) 38
Figure 5.3 – Proposed water management system layout – Stage 3 (Year 11) 39
Figure 5.4 – Proposed water management system layout – Stage 4 (Year 14) 40
Figure 5.5 – Proposed water management system layout – Stage 5 (Year 16) 41
Figure 6.1 – Proposed integrated water management system schematic 54
Figure 6.2 – Mine Water Dam – stored water volume behaviour 59
Figure 6.3 – AB pit – stored volume behaviour 60
Figure 6.4 – C pit – stored volume behaviour 60
Figure 6.5 – Raw water pipeline usage 61
Figure 6.6 – Sediment dam spills to Charlevue Creek 62

Figure 6.7 – Sediment dam spills to Springton Creek 62
Figure 7.1 – Developed conditions 1% AEP flood depths and water levels 65
Figure 7.2 – Impacts of the Project on 1% AEP flood levels 66
Figure 7.3 – Upper reach of unnamed Springton Creek tributary – existing 1% AEP flood depths 67
Figure 7.4 – Upper reach of unnamed Springton Creek tributary – proposed 1% AEP flood depths 68
Figure 7.5 - Upper reach of unnamed Springton Creek tributary – proposed 1% AEP flood velocities 69
Figure 7.6 – Lower reach of unnamed Springton Creek tributary at AB Pit – existing 1% AEP flood depths 70
Figure 7.7 – Lower reach of unnamed Springton Creek tributary at AB Pit – proposed 1% AEP flood depths 71
Figure 7.8 - Lower reach of unnamed Springton Creek tributary at AB Pit – proposed 1% AEP flood velocities 72
Figure 8.1 – Final landform and final void catchments 74
Figure 8.2 – Final landform and flood levels in Probable Maximum Flood 75
Figure 8.3 – Final landform and pit lake catchment 76
Figure 8.4 – A partition of Global Climate Models for future climate using global warming sensitivity and ocean warming indices (source: DSITIA, 2015) 79
Figure 8.5 – Plot of net evaporation versus AB Pit runoff for HI, HP, WI and WP GCM groupings 81
Figure 8.6 – Results of final void modelling AB Pit 83
Figure 8.7 – Results of final void modelling C Pit 83
Figure 8.8 – Modelled void lake salinity – AB Pit 85
Figure 8.9 – Modelled void lake salinity - C Pit 85
Figure 11.1 – Proposed upstream and downstream receiving water monitoring points 93
Figure A.1 – XP-RAFTS model configuration 98
Figure A.2 – Comparison of RFFE and XP-RAFTS design discharges 102
Figure A.3 – TUFLOW model topography 105
Figure A.4 – TUFLOW model configuration 106
Figure A.5 – Manning's 'n' configuration 107

List of Tables

Table 3.1 – Water Quality Objectives for the Mackenzie River sub-basin 18
Table 4.1 – Rainfall stations in the vicinity of the Project 20
Table 4.2 – Monthly Rainfall Statistics for Dingo Post Office (mm/month) 20
Table 5.1 – Site water types 35
Table 5.2 – Gemini Project mine affected water dam details 42
Table 5.3 – Gemini Project sediment dam details 43

Table 5.4 – Catchment areas and land use breakdown summary – Stage 1 - Year 1 44
Table 5.5 – Catchment areas and land use breakdown summary – Stage 2 - Year 5 45
Table 5.6 - Catchment areas and land use breakdown summary – Stage 3 - Year 11 46
Table 5.7 - Catchment areas and land use breakdown summary – Stage 4 - Year 14 47
Table 5.8 - Catchment areas and land use breakdown summary – Stage 5 - Year 16 48
Table 6.1 - Forecast CHPP and TLO demands 49
Table 6.2 – Estimated net annual groundwater inflow to pits after losses 51
Table 6.3 – Simulated inflows and outflows to the water management system 51
Table 6.4 – Adopted AWBM parameters 53
Table 6.5 - Forecast haul road dust suppression demand 55
Table 6.6 – Summary of adopted demands and expected groundwater inflows 56
Table 6.7 – Gemini Project water management system operating rules 57
Table 6.8 – Average annual site water balance 63
Table 8.1 – Final void surface catchments (ha) 77
Table 8.2 – Percentage change in evaporation by model and sensitivity 80
Table 8.3 – Percentage change in rainfall by model and sensitivity 80
Table 8.4 – Average annual final void water balance – at equilibrium 84
Table 8.5 – Sensitivity analysis – high runoff - average annual final void water balance – at equilibrium 86
Table 10.1 – Catchment excised by site water management system at Year 18 90
Table 10.2 – Catchment excised by site water management system at mine closure 90
Table 11.1 – Receiving water monitoring points 92
Table A.1 – Median pre-burst depths (mm) and ratios 100
Table A.2 – Comparison of Rational Method and XP-RAFTS model design discharges 101
Table A.3 – Comparison of RFFE and XP-RAFTS model design discharges 101
Table A.4 – XP-RAFTS design discharges and critical durations at the outlet (SD01) of the combined Charlevue Creek & Springton Creek catchment 102
Table A.5 – Adopted hydraulic roughness Manning's 'n' values 103
Table A.6 – Culvert details 104
Table A.7 – Bridge details 104
Table A.8 – Proposed new culverts in Project area 108
Table A.9 – Adopted XP-RAFTS sub-catchment parameters 112
Table A.10 – Springton Creek estimated discharges SD15 113
Table A.11 – Springton Creek estimated discharges SD02 114
Table A.12 – Springton Creek estimated discharges SD21 115
Table A.13 – Springton Creek estimated discharges SD24 116

1 Introduction

1.1 BACKGROUND

Magnetic South Pty Ltd proposes to develop the Gemini Project (the Project), a coal mine and associated infrastructure, located within the Fitzroy Basin. The proposed mine development site is located approximately 7.6 km west from the township of Dingo and 19.4 km southeast of Bluff (Figure 1.1).

WRM was commissioned by Magnetic South Pty Ltd to undertake a surface water impact assessment for the Project. This report presents the following:

- An overview of the regulatory framework which applies to the Project;
- A description of the existing surface water environment surrounding the Project, and the associated environmental values;
- A detailed description of the proposed water management strategy in and around the Project and details of the expected performance of the proposed water management system;
- A discussion of the potential impacts of the Project.

1.2 PROJECT DESCRIPTION

The Gemini Project is a greenfield open cut mine to produce Pulverised Coal Injection (PCI) coal and Coking Coal products for export for steel production. The Project term is anticipated to be 25 years from grant of the ML, with this term including initial construction, mine operation and rehabilitation activities. The main activities associated with the Project include:

- Exploration activities continuing in order to support mine planning;
- Development of a Mine Infrastructure Area (MIA) including mine offices, bathhouse, crib rooms, warehouse/stores, workshop, fuel storage, refuelling facilities, explosives magazine and sewage, effluent and liquid waste storage;
- Construction and operation of a Coal Handling Preparation Plant (CHPP) and coal handling facilities adjacent to the MIA (including Run-of-Mine (ROM) coal, product stockpiles and reject stockpiles [coarse and fine rejects]);
- Construction and operation of a surface conveyor from the product stockpiles to a Train Load Out (TLO) facility and rail loop connecting to the Blackwater-Gladstone Branch Rail to transport product coal to coal terminals at Gladstone for export;
- Construction of access roads from the Capricorn Highway to the MIA, and to the TLO facility;
- Installation of a raw water supply pipeline to connect to the Blackwater Pipeline network;
- Construction of a 66 kV transmission line and switching/substation to connect to the existing regional network;
- Other associated minor infrastructure, plant, equipment and activities;
- Development of mine areas (open cut pits) and out-of-pit waste rock emplacements;
- Drilling and blasting of competent waste material.
- Mine operations using conventional surface mining equipment (excavators, front end loaders, rear dump trucks, dozers);

- Mining up to 1.9 Mtpa ROM Coal – average 1.8 Mtpa for an operational mine life of approximately 20 years;
- Progressive placement of waste rock in:
    - Emplacements, adjacent to and near the open cut voids;
    - Mine voids, behind the advancing open cut mining operations.
- Progressive rehabilitation of waste rock emplacement areas and mined voids;
- Progressive establishment of soil stockpiles, laydown area and borrow pits (for road base and civil works). Material will be sourced from local quarries where required;
- Disposal of CHPP rejects (coarse and fine rejects) in out-of-pit spoil dumps, and in-pit behind the mining void;
- Progressive development of internal roads and haul roads including a causeway over Charlevue Creek to enable coal haulage and pit access;
- Development of water storage dams and sediment dams, and the installation of pumps, pipelines, and other water management equipment and structures including temporary levees, diversions and drains.

Figure 1.2 shows the layout of key project features, in particular the two proposed mine pits, associated out-of-pit spoil dumps, haul roads and CHPP, MIA and TLO.

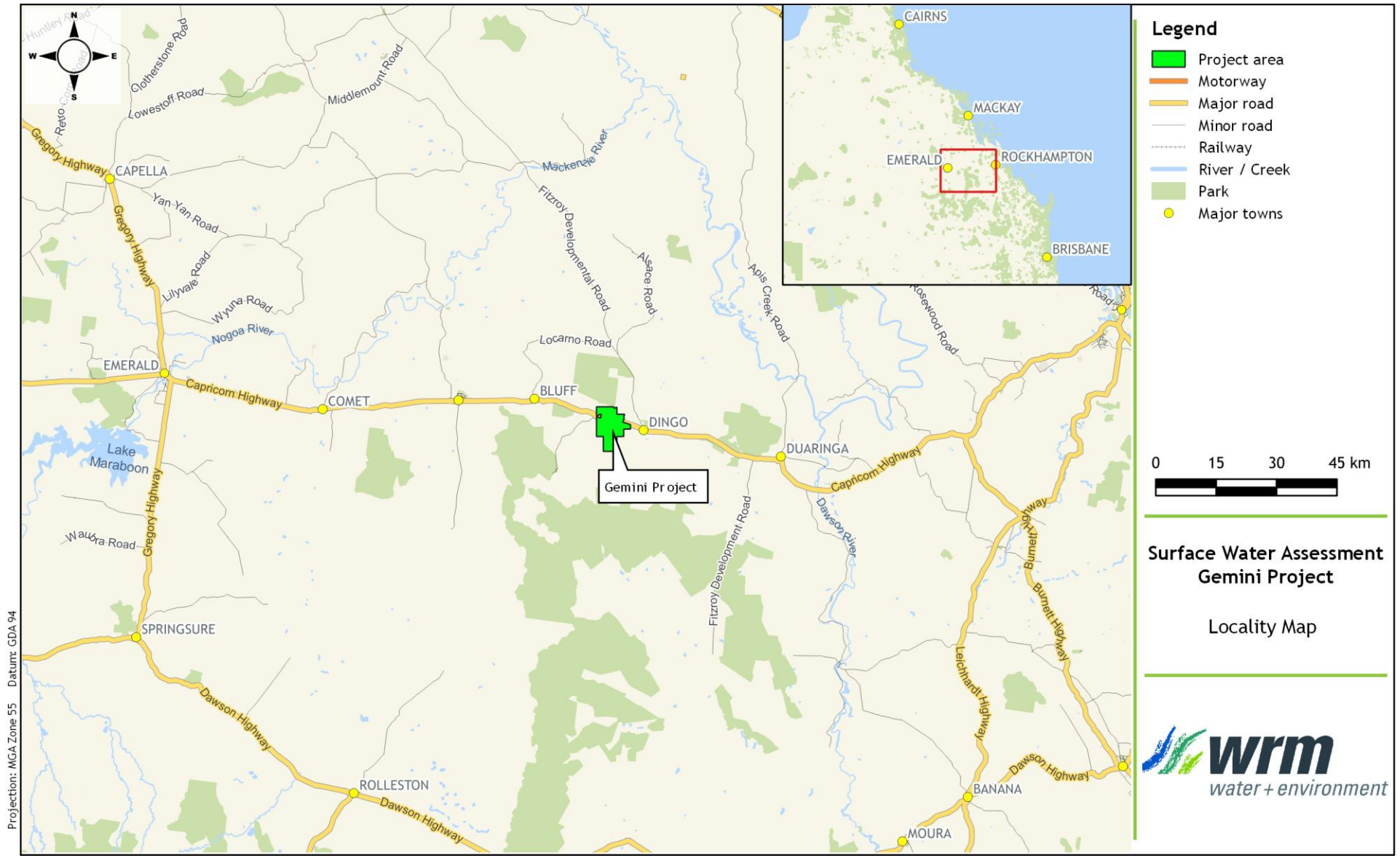


Figure 1.1 – Locality Plan

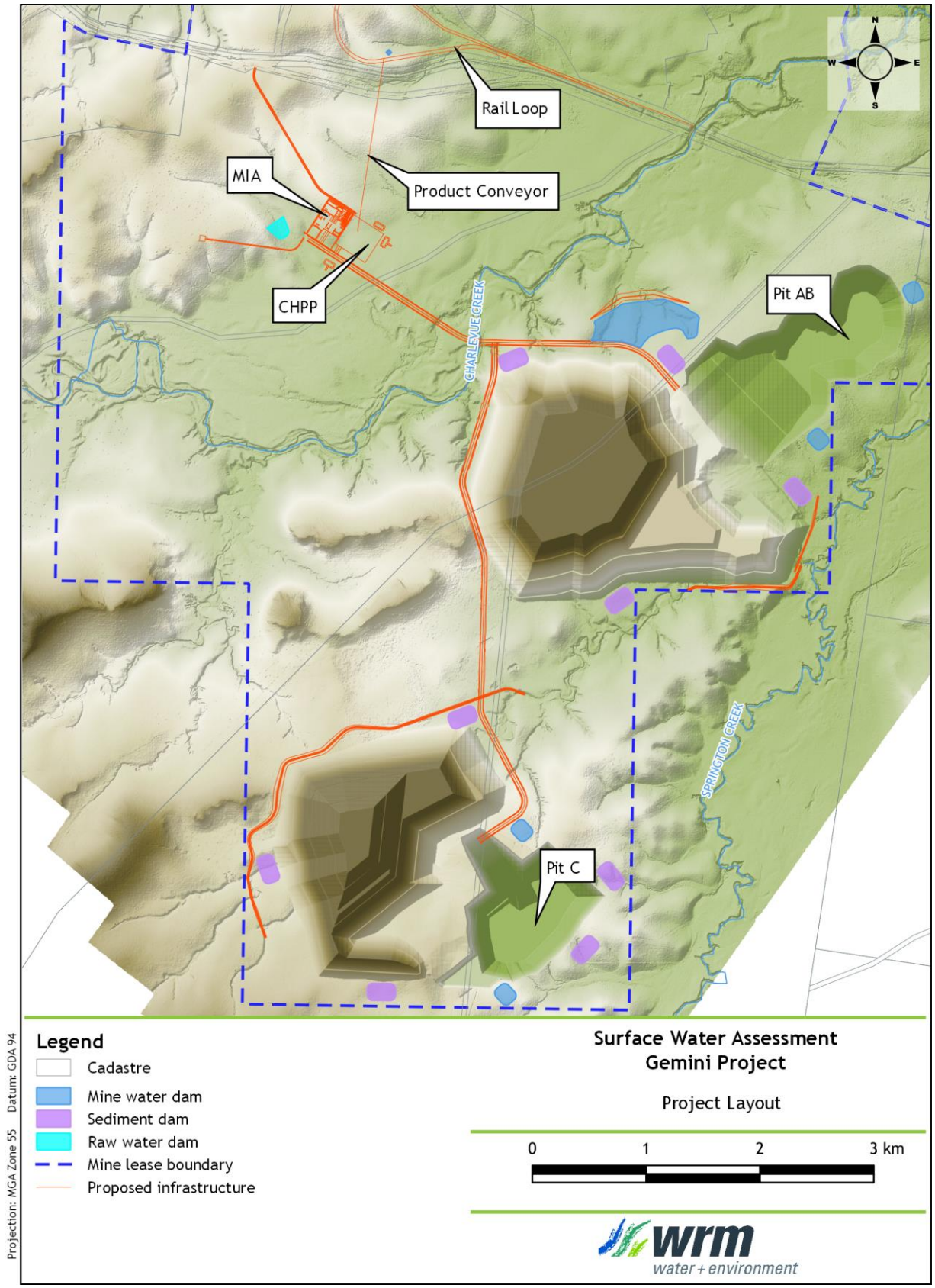


Figure 1.2 - Project layout

2 Regulatory framework

This section describes the regulatory framework (legislation, policies and standards) at Commonwealth and State level that would apply to surface water management for the Project.

2.1 COMMONWEALTH

2.1.1 EPBC Act

Under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act), an action requires approval from the Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a Matter of National Environmental Significance (MNES).

An EPBC Referral (2010/5775) for the project lodged in 2010, was declared 'Not a Controlled Action if undertaken in a Particular Manner' in July 2011.

The Particular Manner Decision (EPBC 2010/5775) required the following measures to be taken to avoid significant impacts on the Fitzroy River turtle:

- To prevent downstream impacts to the Fitzroy River Turtle (Rheodytes leukops) the person taking the action must appropriately bund or locate pits in a manner that prevents surface water from entering the pit during a 1:1,000 year flood event.
- To prevent downstream impacts to the Fitzroy River Turtle (Rheodytes leukops) the person taking the action must appropriately bund or locate dams in a manner that prevents surface water from entering or damaging the dams during a during a 1:1,000 year flood event.

The currently proposed Gemini Project is consistent with the original EPBC referral in that:

- It is unlikely to have a significant impact on a MNES; and
- The same measures will be taken for the Gemini Project to avoid significant impacts on the Fitzroy River Turtle.

2.1.2 Independent Expert Scientific Committee

The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Developments provides scientific advice to decision makers on the impact that coal seam gas and large coal mining development may have on Australia's water resources.

The IESC provides independent, expert scientific advice on coal seam gas and large coal mining proposals as requested by the federal and state government regulators. The IESC assesses the proposals against the Information Guidelines for Independent Expert Scientific Committee and provides advice (IESC, 2018) on coal seam gas and large coal mining development proposals where there is a significant impact on water resources. The core purpose of the guideline is to determine whether a coal seam gas (CSG) or large coal mining development has or is likely to have a significant impact on a water resource. The requirements of the guideline have been considered in preparation of this surface water assessment.

2.2 QUEENSLAND

2.2.1 EP Act 1994

Resource activities are defined as environmentally relevant activities (ERAs) under the Queensland Environmental Protection Act 1994 (EP Act) and as such, the development and operation of the Project is regulated by the EP Act. The objective of the EP Act is to:

Protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development).

2.2.1.1 Environmental Authority

An environmental authority (EA) is granted in accordance with the EP Act and details the prescribed conditions that govern the ERA. In the context of surface water management, the EA sets out conditions that will be relevant to the Project, including:

- Management of contained water including release;
- Water management plan requirements;
- Regulation of water structures including dams and levees;
- Saline drainage management;
- Acid rock drainage management; and
- Storm water and sediment laden runoff management.

Model Mining Conditions

New mining project EA applications should apply the model mining conditions as outlined in Model Mining Conditions (DEHP, 2017). The purpose of the model mining conditions is to provide a consistent set of conditions to meet the general environmental protection commitments given for EAs for mining activities administered under the EP Act. The model conditions may be used as a basis for proposing environmental protection commitments in application documents (such as an EIS). Model conditions can be modified to suit the specific circumstances of a mining project, subject to the assessment criteria outlined in the EP Act.

Schedule F – Water (Fitzroy model conditions) form the basis of the requirements for the Project Water Management System design.

2.2.1.2 Environmental Protection (Water) Policy 2009

The Environmental Protection (Water) Policy 2009 (EPP Water) is the primary instrument for surface water management under the EP Act. The EPP Water governs discharge to land, surface water and groundwater, aims to protect environmental values (EVs) and sets water quality guidelines and objectives.

The processes to identify Environmental Values (EVs) and to determine Water Quality Guidelines (WQGs) and Water Quality Objectives (WQOs) in Queensland waters are based on the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ guidelines).

2.2.1.3 Mackenzie River Sub-basin Environmental Values and Water Quality Objectives 2011

The relevant document, pursuant to the EPP Water, for the Project is the Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin (DEHP, 2011). The document is made pursuant to the provisions of the EPP Water. It contains Environmental Values (EVs) and Water Quality Objectives (WQOs) for waters in the Mackenzie River Sub-basin, and they are listed under Schedule 1 of EPP Water. Refer to Section 3 for further details.

2.2.1.4 Manual for Assessing Consequence Categories and Hydraulic Performance of Structures

The Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (the Manual) (DES, 2016) defines the methodology and assessment criteria to determine if a structure associated with an ERA should be regulated under the EP Act. The Manual details the hydraulic design requirements for regulated structures and has been used as a

reference in the preliminary design of the water management system and preliminary sizing of dams associated with the Project.

2.2.1.5 Guideline – Application Requirements for Activities with Impacts to Water

This guideline focuses on the types of impacts that environmentally relevant activities (ERAs) can have on water and outlines the information to be provided to the department as part of the ERA application process.

Section 4 of the guideline requires the applicant to provides details on a number of surface water-related issues, including:

- Discharges and releases;
- Unplanned and uncontrolled releases;
- Water infrastructure;
- Wetlands;
- Hydrology of receiving waters; and
- Mixing zones.

The guideline also refers to the department's technical guideline "Wastewater releases to Queensland waters", which is discussed in Section 2.2.1.6.

2.2.1.6 Technical Guideline – Wastewater Release to Queensland Waters

This guideline is provided to support a risk-based assessment approach to licensing releases of wastewater to surface water and applies the philosophy of the ANZECC & ARMCANZ (2000) Water Quality Guidelines and the intent of the Environmental Protection (Water) Policy 2009.

The information requirements identified in this guideline are as follows:

- Describe the proposed activity.
- Describe the receiving environment.
- Predict outcomes or impacts of the proposed wastewater release.
- Set circumstances, limits and monitoring conditions.

The Project's accommodation village will comprise a small sewage treatment plant. Waste sludge is expected to be removed for disposal by a regulated waste contractor. Treated effluent will be irrigated to a designated area in accordance with accepted conditions.

2.2.2 Water Act 2000

In Queensland, the Water Act 2000 (Water Act) is the primary statutory document that establishes a framework for the planning, allocation and use of non-tidal water. The Water Act is primarily administered by the Department of Natural Resources, Mines and Energy (DNRME) and the Department of Energy and Water Supply (DEWS).

The main purpose of the Water Act is to provide a framework for the following:

- The sustainable management of Queensland's water resources and quarry material by establishing a system for:
    - The planning, allocation and use of water; and
    - The allocation of quarry material and riverine protection.
- The sustainable and secure water supply for the south-east Queensland region and other designated regions;
- The management of impacts on underground water caused by the exercise of underground water rights by the resource sector; and

- The effective operation of water authorities.

A watercourse is defined by the Water Act as a river, creek or stream in which water flows permanently or intermittently and includes the bed and banks and any other element of a river, creek or stream confining or containing water.

The diversion of drainage features does not require authorisation under the Water Act.

2.2.2.1 Water Plan (Fitzroy Basin) 2011

The Water Plan (Fitzroy Basin) 2011, which replaces the Water Resource (Fitzroy Basin) Plan 2011, is subordinate legislation to the Water Act. The plan is developed and administered by DNRME. The purpose of the plan is:

- To define the availability of water in the Fitzroy Basin;
- To provide a framework for sustainably managing water and the taking of water;
- To identify priorities and mechanisms for dealing with future water requirements;
- To provide a framework for establishing water allocations;
- To provide a framework for reversing, where practicable, degradation in natural ecosystems;
- To regulate the taking of overland flow water; and
- To regulate the taking of groundwater.

The Project is located in the area managed by the Water Plan (Fitzroy Basin) 2011 that manages overland flow. Works on drainage features that capture overland flow must meet the requirements of the plan and may require authorisation under the Water Act.

2.2.2.2 Water Regulation 2016

Water Regulation 2016 is subordinate legislation to the Water Act and provides details, protocol and instruction for the following:

- Water rights and planning;
- Statutory authorisations to take or interfere with water;
- Matters relating to water licenses;
- Water allocations;
- Water supply and demand management;
- Declarations about watercourses.

2.2.3 Water Supply (Safety & Reliability) Act 2008

The Water Supply (Safety and Reliability) Act 2008 provides for the safety and reliability of water supply in Queensland. The purpose is achieved primarily by:

- Providing a regulatory framework for providing water and sewerage services in the State;
- Providing a regulatory framework for providing recycled water and drinking water quality, primarily for protecting public health;
- The regulation of referable dams; and
- Stating flood mitigation responsibilities.

3 Environmental Values

The Project is located within the Mackenzie Southern Tributaries (refer section 2.2.1.3) of the Mackenzie River sub-basin shown in Figure 3.1. The following EVs have been nominated broadly to the mapped areas for protection of zone:

- Aquatic ecosystems;
- Farm supply/use;
- Stock Water;
- Human consumption;
- Primary recreation;
- Secondary recreation;
- Visual recreation;
- Drinking water;
- Industrial use;
- Cultural and spiritual values.

The following WQOs for the above EVs are provided in Table 3.1. Where different EVs have different WQOs the lowest value has been adopted. WQOs are displayed for physio-chemical parameters only.

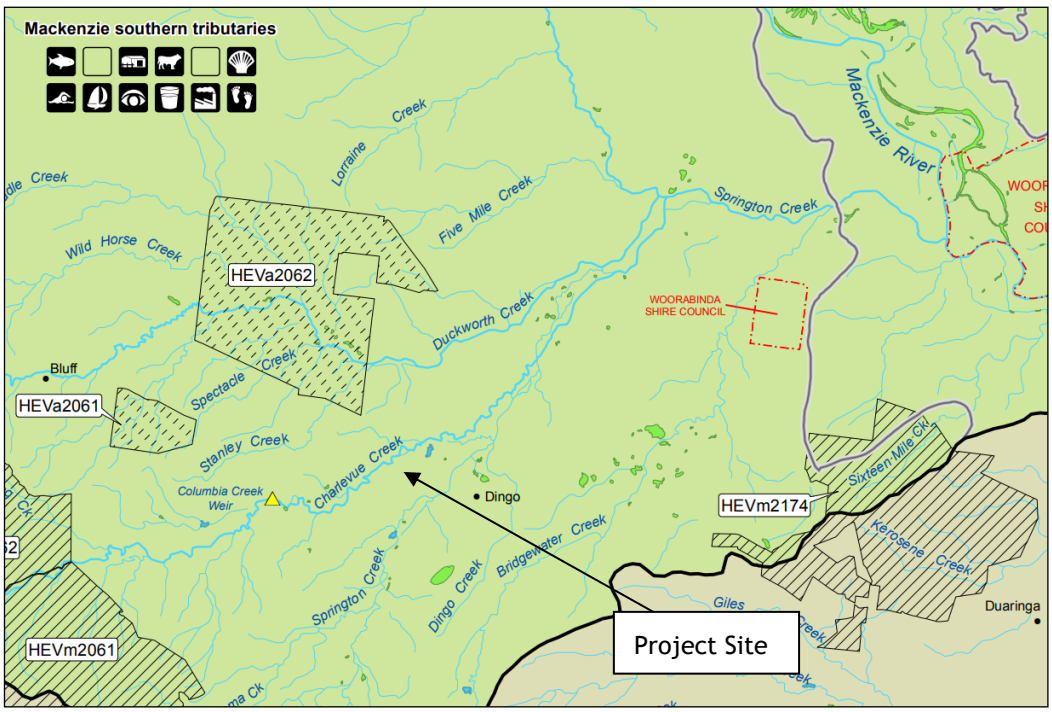


Figure 3.1 – Mackenzie River Sub-basin EVs

Table 3.1 – Water Quality Objectives for the Mackenzie River sub-basin

Parameter	WQO	Relevant EV
Ammonia N	< 20 µg/L	Aquatic ecosystem
Oxidised N	< 60 µg/L	Aquatic ecosystem
Organic N	< 420 µg/L	Aquatic ecosystem
Total nitrogen	< 500 µg/L	Aquatic ecosystem
Filterable Reactive Phosphorus (FRP)	< 20 µg/L	Aquatic ecosystem
Total Phosphorus	< 50 µg/L	Aquatic ecosystem
Chlorophyll a	< 5 µg/L	Aquatic ecosystem
Dissolved oxygen	85-110% saturation > 4 mg/L at surface	Aquatic ecosystem Drinking water
Turbidity	< 50 NTU	Aquatic ecosystem
Suspended solids	< 55 mg/L	Aquatic ecosystem
pH	pH 6.5-8.5	Aquatic ecosystem
Conductivity (EC) baseflow	720 µS/cm	Aquatic ecosystem
Conductivity (EC) high flow	250 µS/cm	Aquatic ecosystem
Sulphate	25 mg/L	Aquatic ecosystem
Total Dissolved Solids	< 2000 mg/L	Stock watering
Colour	50 Hazen Units	Drinking water
Total Hardness	150 mg/L as $CaCO_3$	Drinking water
Sodium	< 30 mg/L	Drinking water
Aluminium	< 5 mg/L < 0.055 mg/L	Stock watering Aquatic ecosystem
Arsenic	2.0 mg/L 0.5 mg/L up to 5 mg/L < 0.024 mg/L	Irrigation, Stock watering Aquatic ecosystem
Beryllium	< 0.5 mg/L	Irrigation
Boron	< 5 mg/L < 0.37 mg/L	Stock watering Aquatic ecosystem
Cadmium	< 0.01 mg/L < 0.0002 mg/L	Stock watering Aquatic ecosystem
Chromium	< 1 mg/L < 0.001 mg/L	Stock watering Aquatic ecosystem
Cobalt	< 0.1 mg/L	Irrigation
Copper	< 1 mg/L < 0.0014 mg/L	Stock watering (cattle) Aquatic ecosystem
Fluoride	< 2 mg/L	Irrigation
Fluoride	< 2 mg/L	Irrigation
Fluoride	< 2 mg/L	Irrigation
Iron	< 10 mg/L	Irrigation
Lead	< 0.1 mg/L < 0.0034 mg/L	Stock watering, Aquatic ecosystem
Lithium	< 2.5 mg/L	Irrigation
Manganese	< 10 mg/L < 1.9 mg/L	Irrigation Aquatic ecosystem
Mercury	< 0.002 mg/L < 0.00006 mg/L	Irrigation Aquatic ecosystem
Molybdenum	< 0.05 mg/L	Irrigation
Nickel	< 1 mg/L < 0.011 µg/L	Stock watering Aquatic ecosystem
Selenium	< 0.02 mg/L < 0.005 mg/L	Stock watering, Aquatic ecosystem
Uranium	< 0.1 mg/L	Irrigation
Vanadium	< 0.5 mg/L	Irrigation
Zinc	< 5 mg/L < 0.008 mg/L	Irrigation Aquatic ecosystem

3.1 AQUATIC ECOSYSTEM ENVIRONMENTAL VALUES

3.1.1 Fitzroy Basin Aquatic Ecosystem Health

The Fitzroy Partnership for River Health is a collaboration between Government, industry, research organisations and community to facilitate improved water quality monitoring, collate and assess data, and publicly report on waterway health and sustainable use.

The Partnership compiles water quality, biological and ecological health data for all waterways in the Fitzroy Basin and assigns them one of the following grades:

a. **Excellent**. All water quality and biological health indicators meet desired levels.
b. **Good**. Most water quality and biological health indicators meet desired levels.
c. **Fair**. There is a mix of good and poor levels of water quality and biological health indicators.
d. **Poor**. Some or few water quality and biological health indicators meet desired levels.
e. **Fail**. Very few or no water quality and biological health indicators meet desired levels.

In 2017-18 the Fitzroy Basin (including the Mackenzie River tributaries covering the Project area) received a C grade for aquatic ecosystem health. The Mackenzie Basin was graded C overall. It was graded B for physical/chemical and nutrients, C for toxicants and D for ecology. It was graded B for stock use and A for cropping use.

3.1.2 Aquatic ecology assessment of the Project area

Baseline aquatic ecology surveys for the Project were undertaken by AARC, and details of the results are provided in a separate report. The following extract from that report summarises the aquatic values of the Project area.

Extensive clearing for agricultural purposes has been undertaken across much of the study area including the removal of riparian vegetation. The removal of riparian vegetation and direct stock access to the waterways has resulted in bank instability, erosion and occurrence of weeds.

Stream sediments were found to contain a high proportion of sand particles with some sites containing a mixture of silt and clay. Metal concentrations in stream sediment were generally low, except for nickel levels at site DWR6.

Macroinvertebrate diversity, abundance and PET richness were generally low. SIGNAL scores were correspondingly low and consistent with the expected results for ephemeral streams in an agricultural setting. The AusRivAS predictive modelling assessed the aquatic environments at the sample sites as significantly impaired to highly degraded. While impaired habitats are common in ephemeral creeks, the extent and severity of the impairment indicates low waterway health.

The diversity and abundance of fish and crustaceans was found to be low.

4 Existing surface water environment

4.1 LOCAL CLIMATE - RAINFALL AND EVAPORATION DATA

Figure 4.3 shows locations of Bureau of Meteorology (BOM) and DNRME rainfall and evaporation recording stations with a significant period of record near the Project. Table 4.1 shows summary details of these stations.

Table 4.2 shows the variability in monthly rainfall at Dingo Post Office, which is the nearest rainfall station.

Table 4.1 – Rainfall stations in the vicinity of the Project

Station No.	Station Name	Data Obtained	Elevation (mAHD)	Distance from Project (km)	Opened	Lat	Long
035025	DINGO POST OFFICE	Rainfall	110	15	1896	-23.65	149.33
035172	MELMOTH	Rainfall	122	17	1914	-23.45	149.26
035186	BLACKDOWN TABLELAND AL	Rainfall	952	20	2010	-23.77	149.12
035132	NEW CALEDONIA	Rainfall	152	33	1968	-23.43	148.93
035134	BLACKWATER AIRPORT	Rainfall/Evap	193	40	2013	-23.60	148.81

Table 4.2 – Monthly Rainfall Statistics for Dingo Post Office (mm/month)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	111.6	110	74.8	37.1	33.4	35.4	26.8	22.5	25.3	46.2	64.5	101	**685.4**
Lowest	0	0	0	0	0	0	0	0	0	0	0	0	**237.6**
5th %ile	10.8	6.7	3.9	0	0	0	0	0	0	0	4.9	6.7	**331.6**
10th %ile	25.6	15	6.9	0	0	0	0	0	0	5.7	7.5	21.1	**395.7**
Median	90.9	84.4	53.3	19.8	16.1	26	11.5	16.4	10.1	30.6	52.8	94	**659.6**
90th %ile	222	245.4	167.1	92.4	76.3	87.3	69.2	54.4	75.6	98.5	140.9	185.2	**993.1**
95th %ile	264.1	281.5	197.9	135.4	118.2	106.8	100.3	76.4	92	130.5	165.9	226.5	**1072.9**
Highest	672.6	513.4	313.8	305.6	259.1	197.9	270	120.7	220.9	207.4	217.5	409.1	**1351.1**

Long term daily rainfall and evaporation data for the area from January 1889 to August 2019 (130 years) was obtained from the SILO (https://www.longpaddock.qld.gov.au/silo/). This data set is corrected for accumulated daily rainfall totals and missing data and is well suited to use in water balance modelling. Annual rainfall is presented in Figure 4.1. Monthly average rainfall and evaporation are shown in Figure 4.2. Average annual rainfall is 692 mm/a and average annual (pan) evaporation is 2,053 mm/a.

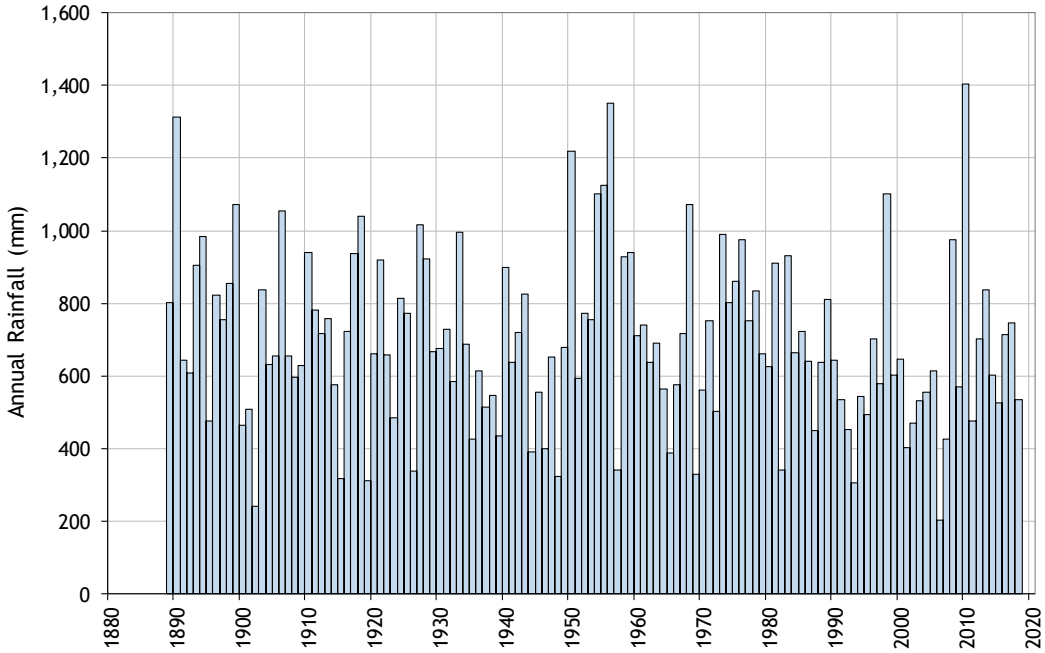


Figure 4.1 - Annual rainfall at Dingo Post Office - 1889 to 2019 (SILO)

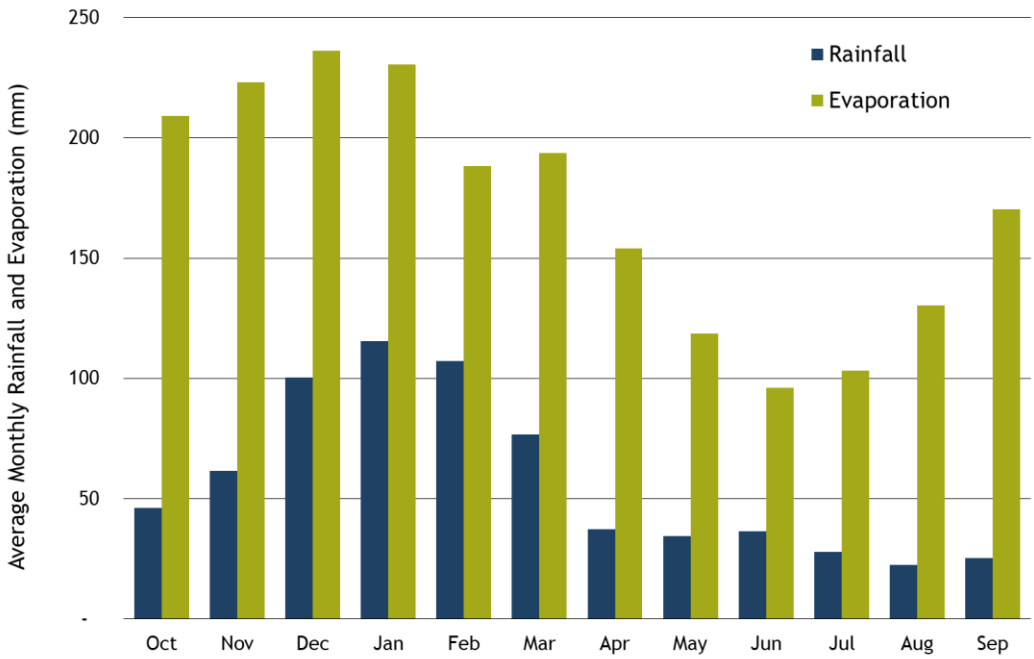


Figure 4.2 - Average monthly rainfall and pan evaporation at Dingo Post Office

4.2 CATCHMENT CONTEXT

As shown in Figure 4.3, the Project area is in the upper Mackenzie River catchment – part of the Fitzroy River Basin.

The Project area is in the catchment of Springton and Charlevue Creeks. Springton Creek joins the Mackenzie River approximately 47 km downstream of the Project. The upstream extent of the Fitzroy River is at the Dawson River/Mackenzie River. The Fitzroy River flows to the ocean east of the City of Rockhampton, approximately 400 km downstream of the Project area, and has a total catchment area of approximately 143,000 km^2. The total catchment area of the Mackenzie River sub-basin (including the catchments of the Nogoa and Comet Rivers) is 12,989 km^2.

As shown in Figure 4.4, the streams crossing the Project area (which include Charlevue Creek and Springton Creek) flow generally northeast, where Charlevue Creek joins Springton Creek approximately 3.6 km downstream of the Project, then later joins the Mackenzie River (Figure 4.4).

The Project mining lease application area is approximately 55.7 km^2. Charlevue Creek has a catchment area of approximately 343 km^2 to its confluence with the Springton Creek crossing the Project area and Springton Creek has a catchment area of 325 km^2 to the confluence with Charlevue Creek.

All waterways of the Project area are ephemeral and experience flow only after sustained or intense rainfall in the catchment. Stream flows are highly variable, with most channels drying out during winter to early spring when rainfall and runoff is historically low, although some pools hold water for extended periods. Therefore, physical attributes, water quality, and the composition of aquatic flora and fauna communities are also expected to be highly variable over time.

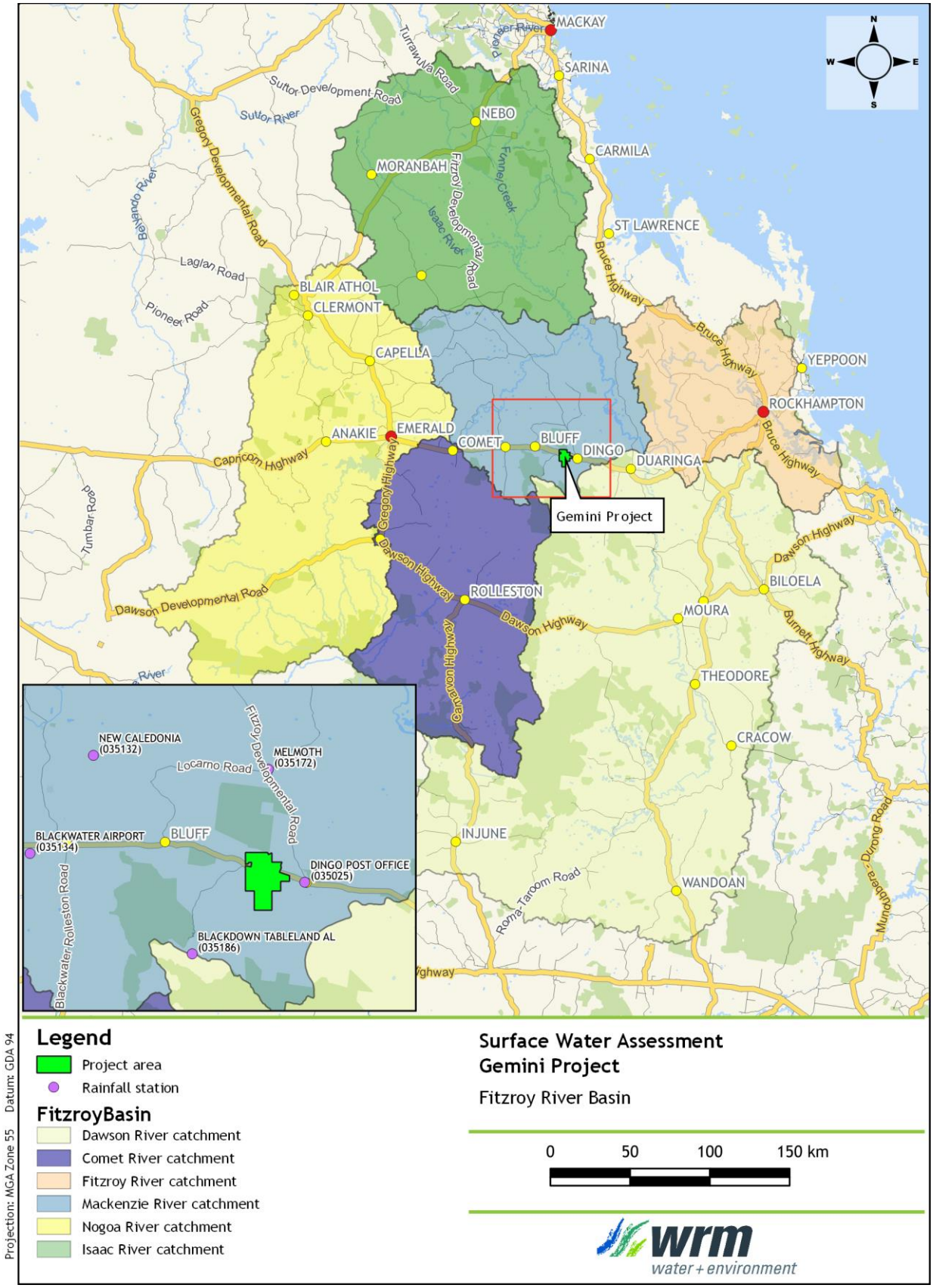


Figure 4.3 – Fitzroy River Basin

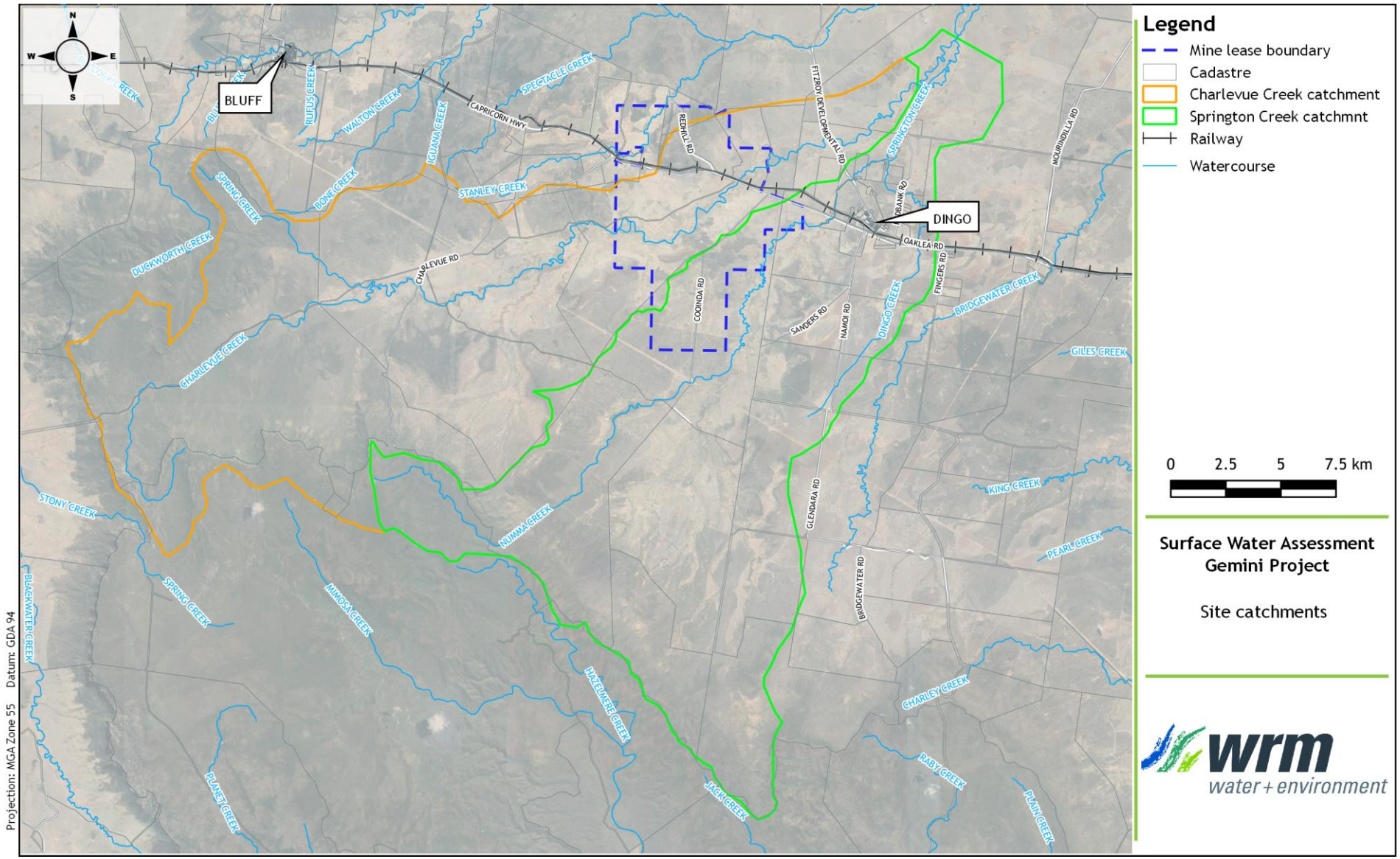


Figure 4.4 - Site catchments

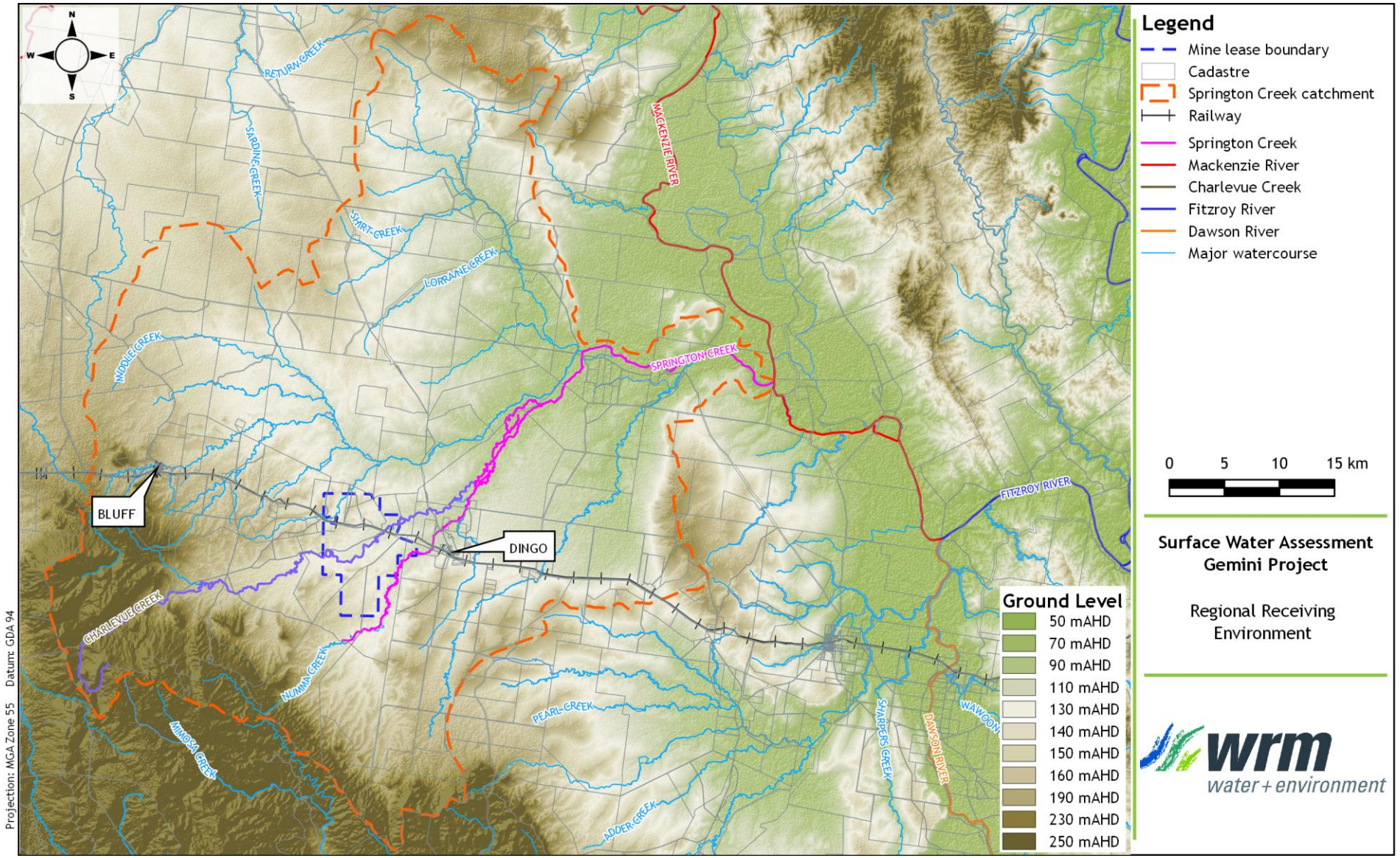


Figure 4.5 - Regional receiving environment

4.3 LOCAL STREAM MORPHOLOGY

The Project area is located within the Central Highlands region of the central Bowen Basin. The Bowen Basin is an early Permian to middle Triassic basin, extending through eastern Queensland from Collinsville in the north to Goondiwindi in the south.

The local stratigraphy typically comprises Permian coal measures overlain by Triassic and Tertiary sediments.

All nearby drainage features are ephemeral. In the Project area, Springton Creek and Charlevue Creek cross alluvial floodplains. The reaches of Springton Creek and Charlevue Creek in the proposed mining area have well-defined channels, typically with alluvial clay beds and well established in-channel vegetation.

Figure 4.6 – Drone photograph looking south across along Charlevue Creek across the Capricorn Highway to the Project area (source: Magnetic South Pty Ltd)

Figure 4.7 – Drone photograph looking southwest along Charlevue Creek at the site of the proposed haul road crossing (source: Magnetic South Pty Ltd)

Figure 4.8 - Photograph of Charlevue Creek channel upstream of the mine area (source: aarc)

Figure 4.9 - Photograph of Charlevue Creek channel upstream of the mine area (source: aarc)

Figure 4.10 – Drone photograph looking south along Springton Creek near the proposed location of AB Pit (source: Magnetic South Pty Ltd)

Figure 4.11 – Photograph of Springton Creek channel near proposed AB Pit location (source: aarc)

Figure 4.12 – Photograph of Springton Creek channel and floodplain near proposed AB Pit location (source: aarc)

Figure 4.13 – Drone photograph looking southeast to Springton Creek at confluence of unnamed tributary crossing proposed AB Pit (source: Magnetic South Pty Ltd)

Figure 4.14 – Drone photograph looking northeast along upper reach of the unnamed tributary of Springton Creek crossing proposed C Pit (source: Magnetic South Pty Ltd)

4.4 STREAMFLOW

There are no streamflow gauges located in the local catchments in the vicinity of the Project. The local streams are ephemeral, and based on the observed behaviour of other streams in the region, streamflow mostly occurs shortly after rainfall between September and April.

4.5 FLOODING

A flood study has been undertaken for this assessment. The extent, depth and velocity of flooding across the MDL in the 1% AEP flood are shown in Figure 4.15 and Figure 4.16. The full details of the flood study are provided in Appendix A.

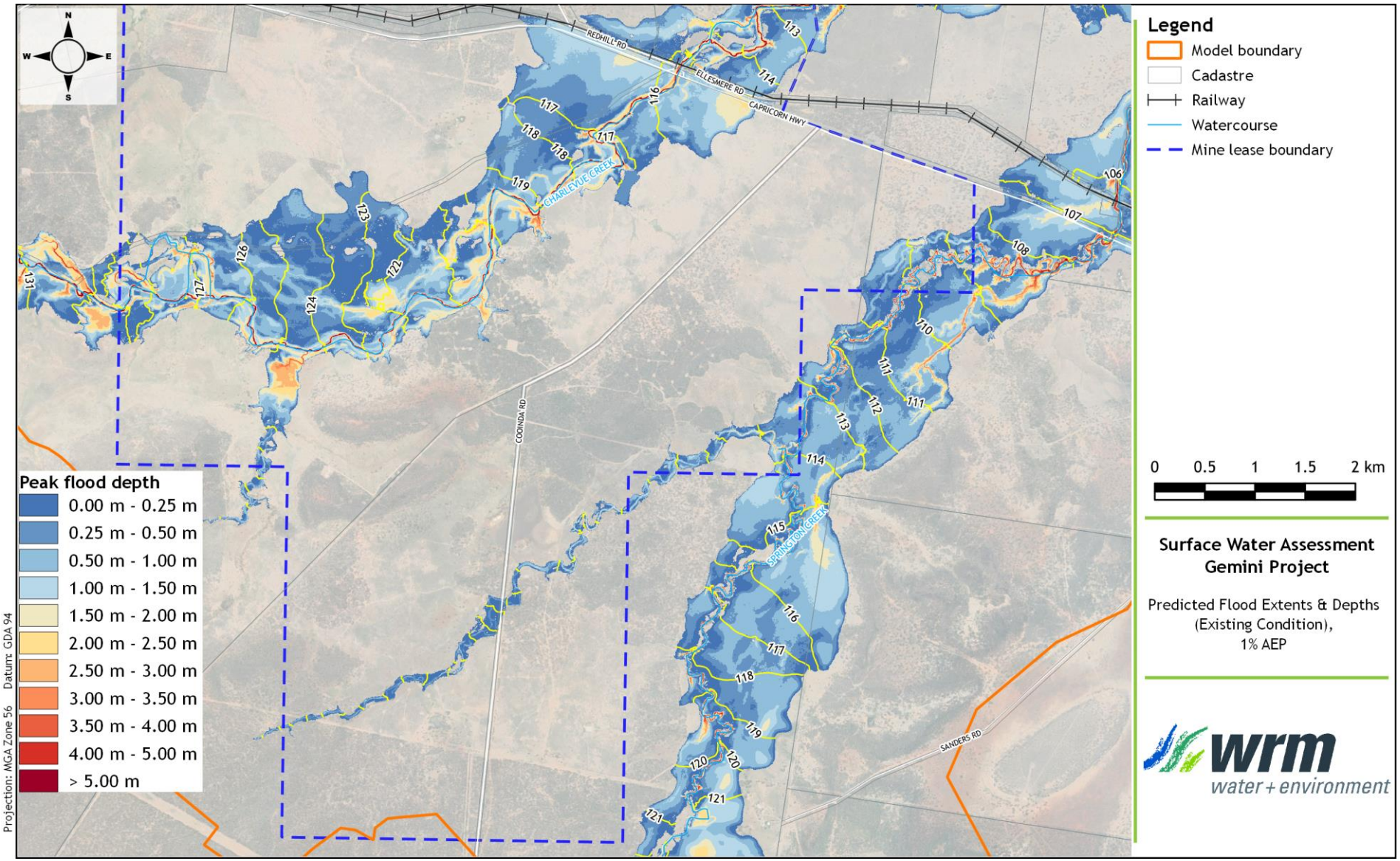


Figure 4.15 - Existing conditions 1% AEP flood depths and water level contours

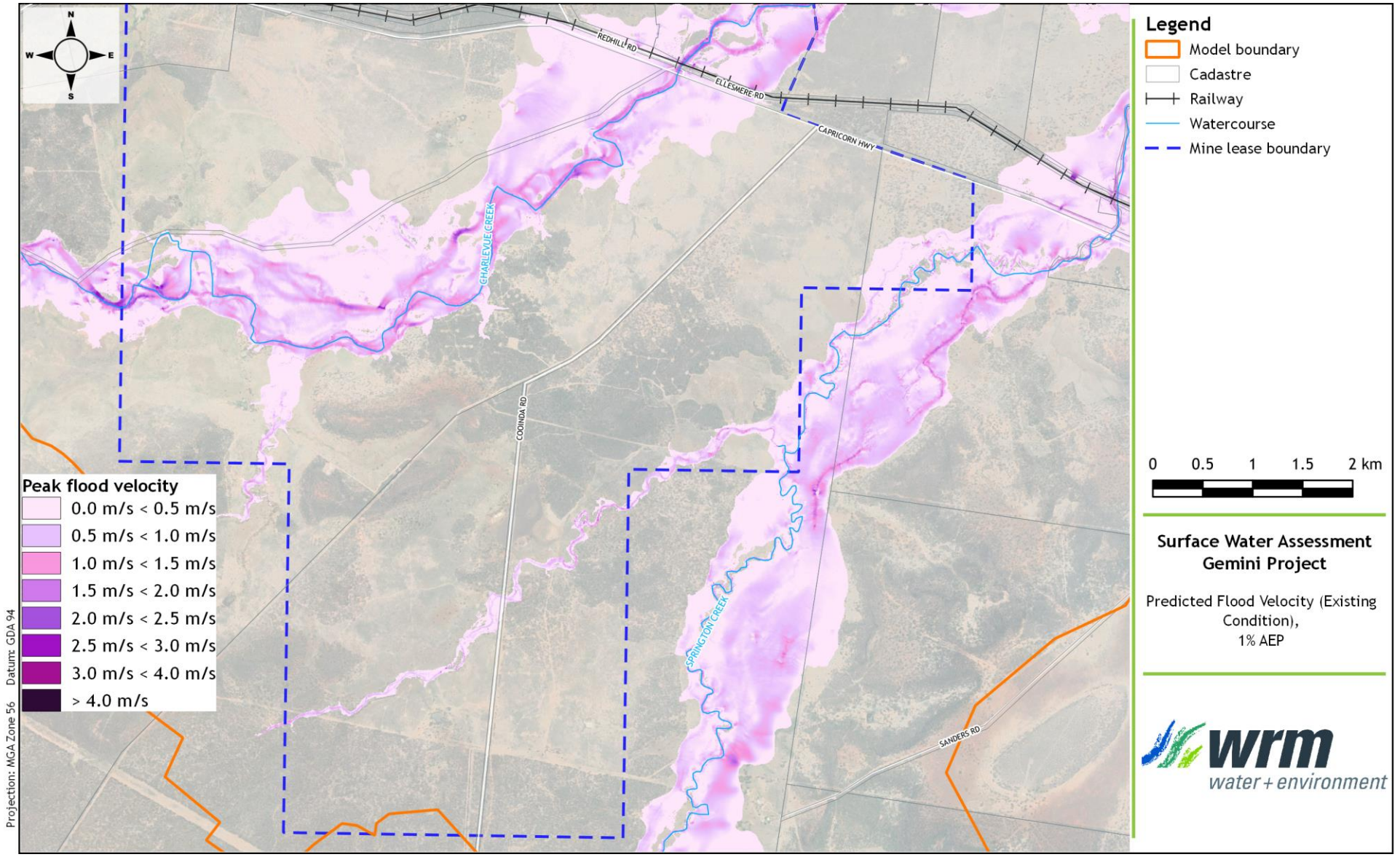


Figure 4.16 - Existing conditions 1% AEP flood velocities

4.6 WATER QUALITY

4.6.1 Baseline quality of receiving waters

Water quality of the region is variable and dependent on antecedent flow conditions and site-specific factors, such as adjacent land use and site disturbances.

A baseline water quality monitoring program has been implemented for the Project, and limited water quality data is available to characterise site water quality

AARC (2019) provided the results of laboratory testing of field samples taken in Charlevue Creek and Springton Creek in late February 2018 and mid April 2019. The results for some key physico-chemical parameters can be summarised as follows:

- electrical conductivity (EC) within the WQO (i.e. 72 – 138 µS/cm);
- turbidity and suspended solids higher than the WQO (i.e. 422 – 5,630 NTU and 58 - 6,170 mg/L respectively);
- pH generally within but occasionally lower than the WQO (i.e. 6.1 – 7.3).

Surface water quality was found to be generally poor. Exceedances of the turbidity WQO were observed across all sites. Low DO levels were also recorded in stagnant pools along ephemeral the waterways. However, at the time of sampling there was no surface flow, and as such, these exceedances are not reliable indicators of long-term system health.

Petroleum hydrocarbon concentrations in Charlevue Creek and Springton Creek exceeded WQO values at downstream locations. These results may indicate an existing local source of petroleum hydrocarbons. Possible sources include crude oil, heavy fuel oils, lubricating oils, asphalt. The Capricorn Highway is a possible point source for the petroleum hydrocarbons observed at nearby locations.

4.6.2 Geochemical characterisation of overburden

RGS undertook a geochemical assessment (RGS, 2018) of representative samples of mining waste materials for the project. The samples represented the main overburden, interburden and potential coal reject materials likely to be encountered. The main findings of the assessment are as follows:

- Initial and ongoing surface runoff and seepage from mining waste materials is expected to be moderately alkaline and have a moderate level of salinity.
- Kinetic leach column (KLC) test results indicate that mining waste materials are unlikely to generate acid conditions and are more likely to generate pH neutral to alkaline conditions.
- Metal/metalloid enrichment was limited to cobalt in a single carbonaceous siltstone sample. However, the nature of a coal deposit means some metals/metalloids are expected to be slightly elevated in some materials.
- Most metals/metalloids are sparingly soluble at the neutral to alkaline pH of leachate expected from bulk mining waste materials. Dissolved metal/metalloid concentrations in surface runoff and leachate from bulk mining waste materials are therefore expected to be low and unlikely to pose a significant risk to the quality of surface and groundwater resources at relevant storage facilities.
- Most mining materials appear susceptible to dispersion and erosion, and appropriate management processes will need to be developed based on field trials for progressive rehabilitation of these materials during operations and at mine closure.
- Mining waste materials should be amenable to revegetation as part of rehabilitation activities, although, gypsum and fertiliser addition may need to be considered for sodic materials to limit dispersion and erosion and to provide a reasonable growth medium for revegetation and rehabilitation.

5 Proposed water management strategy

5.1 SITE WATER TYPES

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas (including coal stockpiles, etc.) may have increased concentrations of salts and other pollutants when compared to natural runoff.

For the purpose of site water management, site water has been classified into the types shown in Table 5.1 on the basis of the likely water quality characteristics.

Table 5.1 – Site water types

Water Type	Definition
Mine affected water	In accordance with the DEHP Guideline Model Mining Conditions, mine affected water means the following types of water: i) pit water, tailings dam water, processing plant water; ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the Environmental Protection Regulation 2008 if it had not formed part of the mining activity; iii) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water; iv) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated; v) groundwater from the mine dewatering activities; vi) a mix of mine affected water (under any of paragraphs i to v) and other water.
Sediment water	Surface water runoff from areas that are disturbed by mining operations (including out-of-pit waste rock emplacements). This runoff does not come into contact with coal or other carbonaceous material and may contain high sediment loads but does not contain elevated level of other water quality parameters (e.g. electrical conductivity, pH, metals, metalloids, non-metals). This runoff must be managed to ensure adequate sediment removal prior to release to receiving waters.
Clean catchment water	Surface runoff from areas unaffected by mining operations. Clean catchment water includes runoff from undisturbed areas and fully rehabilitated areas.
Raw water	Untreated water, generally from an external water supply, that has not been contaminated by mining activities.
Potable water	Treated water suitable for human consumption.

The proposed strategy for the management of surface water at the Project is based on the separation of water from different sources based on anticipated water quality.

On the basis of the expected runoff and groundwater inflow quality, the site water management system separates water into two segregated management systems:

- Mine affected water system - which will manage runoff and seepage from the mine pits, CHPP, coal stockpiles, and MIA. This is a closed system designed to prevent releases of mine affected water to the environment.
- Sediment water system - runoff from overburden dumps will be managed under an erosion and sediment control plan which is to be implemented throughout the Project, such that sediment generated and transported by runoff will be settled in a sediment dam. As overburden runoff quality is expected to be relatively benign, the sediment dams will potentially discharge directly into the environment (after the settlement of suspended sediment), and as such, will not affect the mine water balance. However, the water balance assessment has also assumed sediment dams will be pumped back to the CHPP for reuse.

Clean water from undisturbed areas is generally diverted around the areas of disturbance. A raw water supply pipeline is proposed to supplement site water supplies, and will be delivered to a dedicated raw water dam, which will also intercept clean water from its local upstream catchment.

5.2 MINE DEVELOPMENT AND STAGING

Over the 18-year operating life of the Project, the operation will be staged as indicated in the following series of figures, which show the catchment areas to each mine water storage and the land use types comprising each catchment. These “snapshots” of mine operations have been adopted for the purpose of the site water balance modelling.

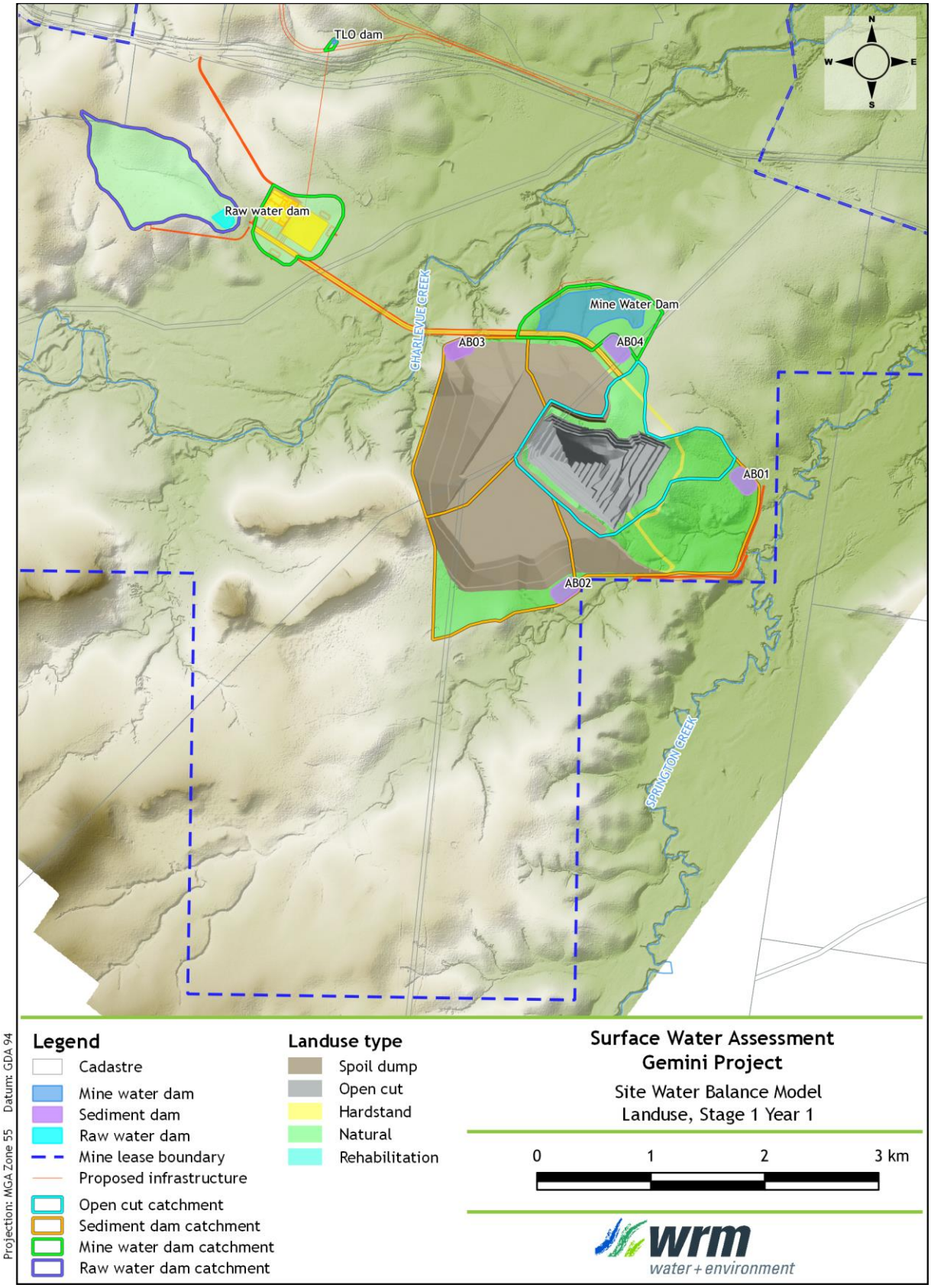


Figure 5.1 - Proposed water management system layout - Stage 1 (Year 1)

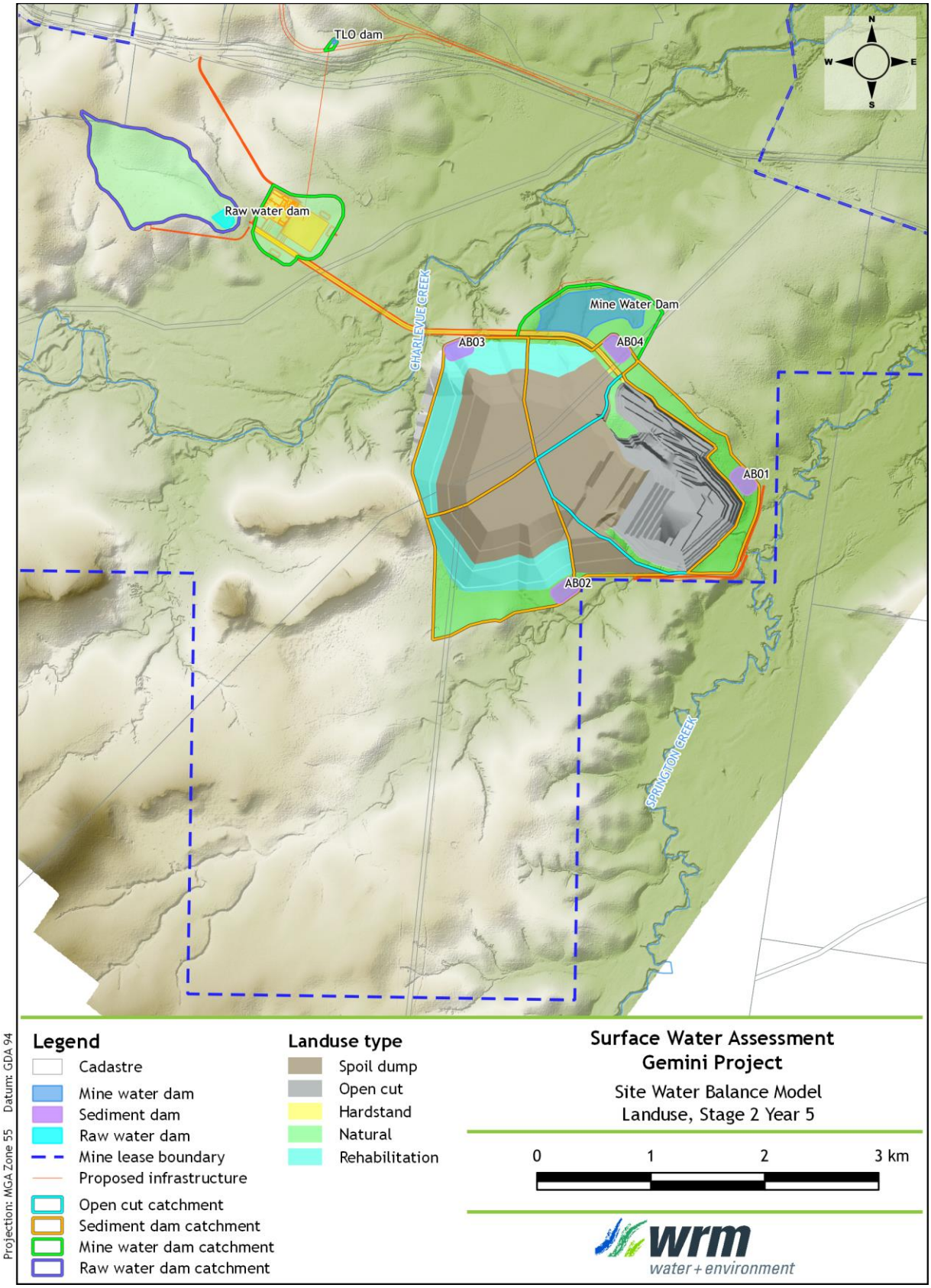


Figure 5.2 - Proposed water management system layout - Stage 2 (Year 5)

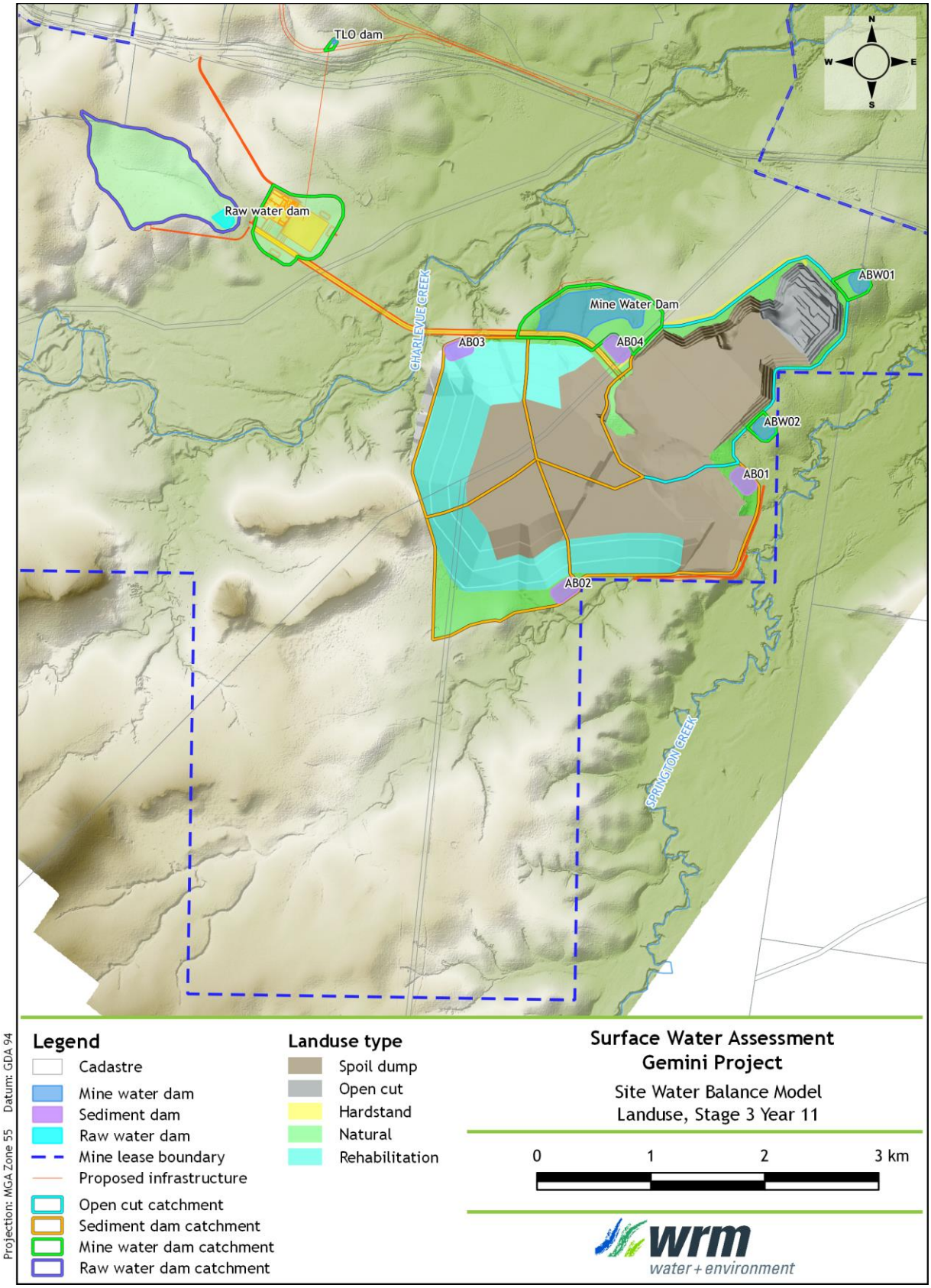


Figure 5.3 - Proposed water management system layout - Stage 3 (Year 11)

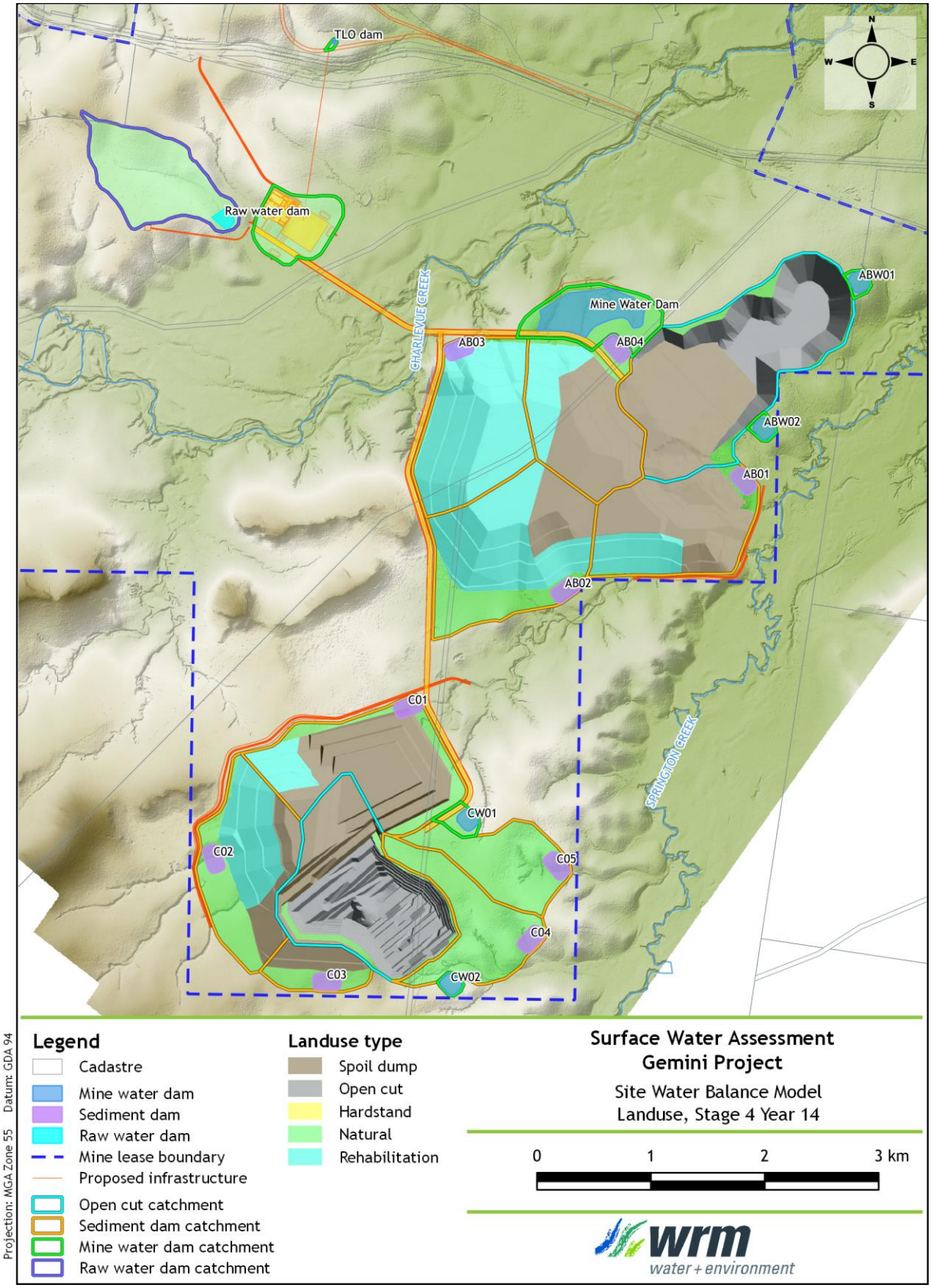


Figure 5.4 - Proposed water management system layout - Stage 4 (Year 14)

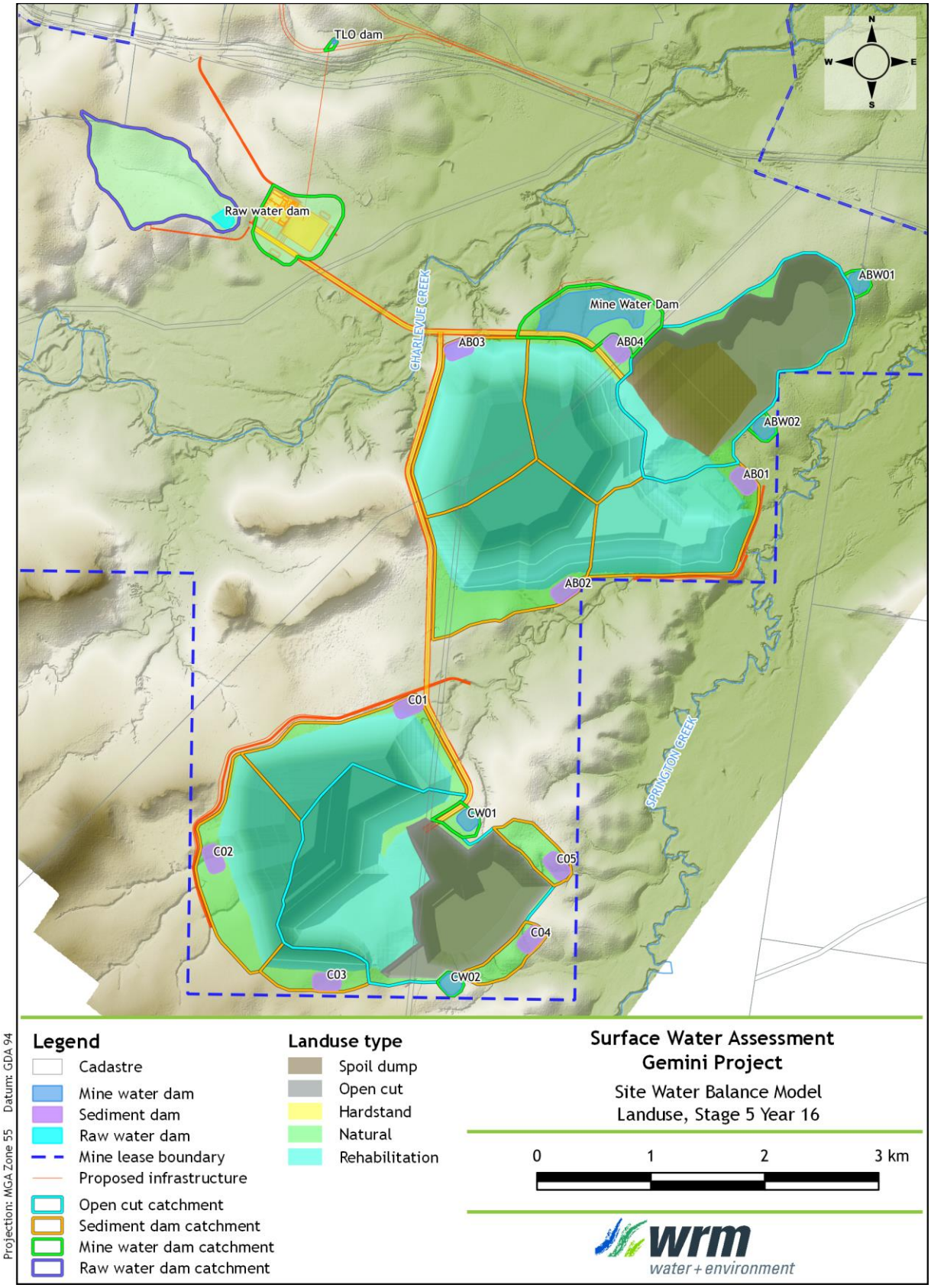


Figure 5.5 - Proposed water management system layout - Stage 5 (Year 16)

5.3 WATER MANAGEMENT SYSTEM COMPONENTS

5.3.1 Mine affected water dams

Several types of dams are proposed to hold mine affected runoff, including:

Raw Water Dam – Receives raw water imported via the offsite water supply pipeline. This dam will also capture clean surface runoff from its local undisturbed upslope catchment.

Mine Water Dam – receives pumped groundwater and surface runoff dewatered from AB Pit and C Pit. Water will be transferred from the Mine Water Dam for reuse at the CHPP and for other uses as required. Offsite discharge of mine water will be avoided by operating below a maximum operating level and directing emergency overflows from the Mine Water Dam via a spillway to the mine pit. If stored water quality allows, controlled mine water releases may be made to Charlevue Creek in accordance with the Environmental Authority (these releases have been conservatively excluded from the site water balance model to ensure water can be contained on site without release under historical climate conditions).

AB Pit – will be used as a supplementary mine water storage after commencement of mining in C Pit.

Out-of-pit mine water dams – a number of small staging dams may be used to collect water pumped from the mine pits before transferring to the Mine Water Dam. These dams are small and have not been included in the site water balance model. Offsite discharge of mine water from these dams will be avoided by directing emergency overflows via spillways to the mine pit.

MIA Dams – will capture and contain runoff from the MIA and coal stockpiles. Oil/water separators are proposed for vehicle wash and workshop areas to treat hydrocarbon contaminated runoff prior to capture. These dams will be sized and operated such that the risk of off-site release is very low.

TLO Dam – A series of sediment traps and small drainage dams will be used to capture washdown and overflow from trains and sumps before it is directed to the TLO Dam. Water collected in this small dam will pumped to the Mine Water Dam. The dams will be sized and operated such that the risk of off-site release is very low.

Table 5.2 – Gemini Project mine affected water dam details

Storage	Catchment area (ha)	Storage capacity (ML)
Mine Water Dam	50.3	1,000
MIA Dams	38.0	90
Raw Water Dam	78.1	56.6
TLO Dam	0.5	0.5

5.3.2 Sediment dams

Catchment runoff from overburden dumps at AB Pit and C Pit will be captured in sediment dams. Sediment dams will be designed and operated in accordance with the Department of Environment and Heritage Protection Guideline - *Stormwater and environmentally relevant activities (DEHP, 2017).*

This guideline states that"

"For events up to and including a 24 hour storm event with an ARI of 1 in 10 years, the following must be achieved:

i. a sediment basin must be designed, constructed and operated to retain the runoff at the site(s) approved as part of the ERA application;

ii. *the release stormwater from these sediment basins must achieve a total suspended solids (TSS) concentration of no more than 50mg/L for events up to and including those mentioned above. For events larger than those stated above, all reasonable and practical measures must be taken to minimise the release of prescribed contaminants."*

The sediment dams have therefore been sized as follows:

- Water storage capacity 1 in 10 AEP 24 hour storm event with and adopted volumetric event runoff coefficient for disturbed catchments of 0.5; and;
- total sediment basin volume = settling zone capacity + sediment storage volume. The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted;
- solids storage volume = 25% of water storage volume.

If required, water captured in sediment dams will be pumped back into the mine water system. Table 5.3 shows the required sediment dam volumes using this method.

Table 5.3 – Gemini Project sediment dam details

Storage	Catchment area (ha)	10year 24 hour water storage capacity (ML)	Solids storage volume (ML)	Total Storage capacity (ML)
AB01	146.1	105.9	26.5	132
AB02	155.5	112.7	28.2	141
AB03	121.8	88.3	22.1	110
AB04	114.9	83.3	20.8	104
C01	132.7	96.2	24.1	120
C02	106.8	77.4	19.4	97
C03	32.4	23.5	5.9	29
C04	76.0	55.1	13.8	69
C05	64.8	47.0	11.7	59

5.4 CATCHMENT AREAS AND LAND USE

A summary of adopted catchment areas and land use types for each stage are provided in Table 5.4 to Table 5.8. The proposed disturbance footprints are shown in Figure 5.1, Figure 5.2, Figure 5.3, Figure 5.4, and Figure 5.5.

Table 5.4 - Catchment areas and land use breakdown summary - Stage 1 - Year 1

Dam	Contributing catchment (ha)					
	Spoil dump	Open Cut	Road/ Hardstand	Natural	Rehabilitation	Total
AB01	21.8	-	3.4	79.1	-	104.3
AB02	98.0	-	-	37.2	-	135.2
AB03	117.6	-	-	2.5	-	120.1
AB04	34.9	-	1.3	10.5	-	46.7
C01	-	-	-	-	-	-
C02	-	-	-	-	-	-
C03	-	-	-	-	-	-
C04	-	-	-	-	-	-
C05	-	-	-	-	-	-
AB PIT	12.1	71.8	2.8	52.8	-	139.5
C PIT	-	-	-	-	-	-
ABW01	-	-	-	-	-	-
ABW02	-	-	-	-	-	-
CW01	-	-	-	-	-	-
CW02	-	-	-	-	-	-
Mine Water Dam	-	-	2.4	47.9	-	50.3
MIA Dam	-	-	17.1	21.0	-	38.1
TLO Dam	-	-	-	0.5	-	0.5
Raw Water Dam	-	-	-	78.1	-	78.1

Table 5.5 - Catchment areas and land use breakdown summary - Stage 2 - Year 5

Dam	Contributing catchment (ha)					
	Spoil dump	Open Cut	Road/ Hardstand	Natural	Rehabilitation	Total
AB01	20.8	-	-	1.7	-	22.5
AB02	58.3	-	-	37.2	38.7	134.2
AB03	73.1	-	-	2.5	46.2	121.8
AB04	42.0	-	1.3	10.3	12.6	66.2
C01	-	-	-	-	-	-
C02	-	-	-	-	-	-
C03	-	-	-	-	-	-
C04	-	-	-	-	-	-
C05	-	-	-	-	-	-
AB PIT	58.1	111.9	0.2	9.0	-	179.2
C PIT	-	-	-	-	-	-
ABW01	-	-	-	-	-	-
ABW02	-	-	-	-	-	-
CW01	-	-	-	-	-	-
CW02	-	-	-	-	-	-
Mine Water Dam	-	-	2.4	47.9	-	50.3
MIA Dam	-	-	17.1	21.0	-	38.1
TLO Dam	-	-	-	0.5	-	0.5
Raw Water Dam	-	-	-	78.1	-	78.1

Table 5.6 - Catchment areas and land use breakdown summary - Stage 3 - Year 11

Dam	Contributing catchment (ha)					
	Spoil dump	Open Cut	Road/ Hardstand	Natural	Rehabilitation	Total
AB01	102.4	-	-	10.6	33.2	146.2
AB02	44.0	-	-	37.2	51.5	132.7
AB03	32.7	-	-	2.5	86.6	121.8
AB04	59.6	-	1.4	9.7	20.6	91.3
C01	-	-	-	-	-	-
C02	-	-	-	-	-	-
C03	-	-	-	-	-	-
C04	-	-	-	-	-	-
C05	-	-	-	-	-	-
AB PIT	157.3	38.5	0.7	27.6	-	224.1
C PIT	-	-	-	-	-	-
ABW01	-	-	-	5.7	-	5.7
ABW02	-	-	-	3.9	-	3.9
CW01	-	-	-	-	-	-
CW02	-	-	-	-	-	-
Mine Water Dam	-	-	2.4	47.9	-	50.3
MIA Dam	-	-	17.1	21.0	-	38.1
TLO Dam	-	-	-	0.5	-	0.5
Raw Water Dam	-	-	-	78.1	-	78.1

Table 5.7 - Catchment areas and land use breakdown summary - Stage 4 - Year 14

Dam	Contributing catchment (ha)					
	Spoil dump	Open Cut	Road/ Hardstand	Natural	Rehabilitation	Total
AB01	79.6	-	-	9.7	27.0	116.3
AB02	29.4	-	-	37.2	88.9	155.5
AB03	-	-	-	2.5	119.3	121.8
AB04	71.9	-	1.2	10.5	31.1	114.7
C01	91.9	-	-	23.0	17.8	132.7
C02	26.3	-	-	37.8	48.6	112.7
C03	16.9	-	-	15.5	-	32.4
C04	-	-	-	76.0	-	76.0
C05	-	-	0.5	64.3	-	64.8
AB PIT	98.0	104.6	-	15.1	-	217.7
C PIT	49.2	98.6	-	11.3	-	159.1
ABW01	-	-	-	3.9	-	3.9
ABW02	-	-	-	3.9	-	3.9
CW01	-	-	0.9	6.4	-	7.3
CW02	-	-	-	3.2	-	3.2
Mine Water Dam	-	-	2.4	47.9	-	50.3
MIA Dam	-	-	17.1	21.0	-	38.1
TLO Dam	-	-	-	0.5	-	0.5
Raw Water Dam	-	-	-	78.1	-	78.1

Table 5.8 - Catchment areas and land use breakdown summary - Stage 5 - Year 16

Dam	Contributing catchment (ha)					
	Spoil dump	Open Cut	Road/ Hardstand	Natural	Rehabilitation	Total
AB01	-	-	-	9.7	106.7	116.4
AB02	-	-	-	37.2	118.3	155.4
AB03	-	-	-	2.5	119.3	121.8
AB04	-	-	1.3	10.5	103.2	115.0
C01	-	-	-	15.6	86.9	102.5
C02	-	-	-	37.8	74.9	112.7
C03	-	-	-	15.2	14.7	29.9
C04	-	-	-	15.7	-	15.7
C05	-	-	-	17.6	-	17.6
AB PIT	71.0	104.6	-	15.1	27.0	217.8
C PIT	-	115.7	0.1	15.8	165.2	296.8
ABW01	-	-	-	3.9	-	3.9
ABW02	-	-	-	3.9	-	3.9
CW01	-	-	0.9	6.4	-	7.3
CW02	-	-	-	3.2	-	3.2
Mine Water Dam	-	-	2.4	47.9	-	50.3
MIA Dam	-	-	17.1	21.0	-	38.1
TLO Dam	-	-	-	0.5	-	0.5
Raw Water Dam	-	-	-	78.1	-	78.1

6 Site water balance

6.1 WATER DEMANDS

6.1.1 Coal handling and preparation plant

The CHPP will comprise a dense medium cyclone / spirals / flotation plant. Flotation tailings, screen bowl effluent and concentrate, fines reject thickening cyclone overflow, fines reject screen undersize and belt press filter filtrate will be fed to a tailings thickener to separate solids. Solids from the tailings thickener will be processed with belt press filters to remove rejects from the flocculants.

The use of the belt press filters reduces the total water demand compared to traditional tailings disposal methods due to the low losses to waste moisture. The project description provides the following CHPP demand estimates throughout the project life, which includes allowance for coal crushing and conveyor dust suppression. Table 6.1 shows the details of forecast CHPP demands.

Table 6.1 - Forecast CHPP and TLO demands

Year	CHPP Demand (ML/a)	TLO Demand (ML/a)
1	162.0	0.72
2	162.0	0.73
3	162.0	0.73
4	162.0	0.73
5	162.0	0.73
6	162.0	0.72
7	162.0	0.72
8	162.0	0.71
9	162.0	0.72
10	162.0	0.72
11	162.0	0.70
12	162.0	0.74
13	162.0	0.74
14	162.0	0.74
15	162.0	0.74
16	162.0	0.72
17	162.0	0.74
18	143.4	0.65

6.1.2 Train loading operation (TLO)

TLO water demands for controlling dust generation for the TLO, rail loading and freight would be managed by:

- Shrouding and sprays on delivery/transfer to the loadout bin;
- During wagon loading;
- Telescopic chutes;
- Use of water sprays and surfactants;
- During freight - application of a veneer prior to departure;
- Removal of any wagon overload situations.

A 40L/wagon water demand is adopted, where a wagon contains 80 tonne of product coal. Table 6.1 shows the details of forecast CHPP demands.

6.1.3 Haul road dust suppression

The proposed mining schedule for the project includes starting mining at AB Pit and progressing to C Pit.

Mine affected water will be used as a priority for haul road dust suppression. Water for haul road dust suppression will be sourced from the Mine Water Dam which will be supplied with water from the operational pits and supplemented with sediment dam or raw water when required.

Haul Road water demand will be increasing throughout the project life where. Haul road dust suppression water demand is expected to commence at around 315 ML/a, and increases to approximately 512 ML/a at Stage 5.

6.1.4 Potable water demands

Potable water will be delivered to site by truck and stored in potable water tanks before distribution around the site using pressure pumps and small-bore poly pipes.

6.2 GROUNDWATER INFLOWS TO MINING PITS

Groundwater inflows were estimated by JBT Consulting Australia Pty Ltd (JBT, 2019). The estimates provided by JBT Consulting are net inflows to the pit after evaporation losses from the pit faces and the entrained moisture losses due to mining. The adopted net inflow rates are provided in Table 6.2.

Table 6.2 - Estimated net annual groundwater inflow to pits after losses

Year	AB Pit Net GW Inflow ML/a	C Pit Net GW Inflow ML/a
1	31.5	-
2	31.5	-
3	31.5	-
4	31.5	-
5	31.5	-
6	31.5	-
7	31.5	-
8	31.5	-
9	31.5	-
10	31.5	-
11	220.8	-
12	220.8	-
13	189.2	-
14	189.2	15.8
15	15.8	15.8
16	15.8	15.8
17	15.8	15.8
18	15.8	31.5

6.3 WATER BALANCE MODEL

A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the mine water balance under conditions of varying rainfall and catchment conditions throughout the development of the Project. The OPSIM model dynamically simulates the operation of the water management system and keeps complete account of all site water volumes and representative water quality on a daily time step.

The model has been configured to simulate the operations of all major components of the water management system. The simulated inflows and outflows included in the model are given in Table 6.3.

Table 6.3 - Simulated inflows and outflows to the water management system

Inflows	Outflows
Direct rainfall on water surface of storages	Evaporation from water surface of storages
Catchment runoff	CHPP demand
Raw water supply	Haul road dust suppression demand
Groundwater inflows	TLO water demands
	Dam overflows

6.4 SIMULATION METHODOLOGY

6.4.1 Modelled staging of mine plans

The water balance model was run on a daily time step for an 18 year period, corresponding with the proposed mine life between Year 1 and Year 18. The model assumes that operations commence in January.

Catchment land use changes were assessed through the discrete stages, described in the previous section. These stages have been selected using the mining progression information, and provide a representative disturbance footprint for each stage.

6.5 CATCHMENT RUNOFF

6.5.1 Catchment runoff salinity

The OPSIM model includes a conservative salt balance with each catchment type assigned a fixed salinity.

Water samples taken from Springton and Charlevue Creeks had a median EC of 114 µS/cm (74 mg/L). For the purpose of the site salt balance, runoff from undisturbed (natural) catchments was assumed to have a salinity (EC) of 150 µS/cm.

Kinetic leach column (KLC) testing of the local overburden material (RGS, 2019) showed that leachate from all KLC samples (apart from the carbonaceous siltstone and coal) had initial EC values less than 800 µS/cm, and at the end of six months less than 203 µs/cm. Based on these results, for the purpose of the site salt balance, runoff from spoil was assumed to have a salinity of 600 µS/cm. Runoff from highwalls was assigned an EC of 8,000 µS/cm to account for potential contact with the coal seams, which would result in increased salinity, and hardstand areas were conservatively assigned an EC of 900 µS/cm.

6.5.2 Catchment runoff rates

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton, 2003) to estimate runoff from rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff. The AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evaporation (surface stores only). Simulated surface runoff occurs when the conceptual storages fill and overflow.

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily water balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying the contributing catchment area.

The model parameters define the storage depths (C1, C2 and C3), the proportion of the catchment draining to each of the storages (A1, A2 and A3), and the rate of flux between them (Kb, Ks and BFI).

Catchments across the site water management system have been characterised into the following land use types:

- Natural/undisturbed, representing areas in their natural state;
- Roads, hardstand and mining pit floor areas;
- Spoil dump, representing uncompacted dumped overburden material;
- Open cut, representing pit area; and
- Rehabilitated, representing established rehabilitated spoil areas.

Adopted rainfall runoff parameters are summarised in Table 6.4. In the absence of site-specific parameters, parameters typical for coal mines in the Bowen Basin were adopted.

Table 6.4 – Adopted AWBM parameters

Parameter	Spoil Dump	Hardstand	Natural	Established Rehab	Open Cut
A1	0.134	0.134	0.134	0.134	0.134
A2	0.433	0.433	0.433	0.433	0.433
A3	0.433	0.433	0.433	0.433	0.433
C1	10	5	25	11	5
C2	50	20	100	60	20
C3	120	40	180	130	40
C_{avg}	74.9	26.7	124.6	83.7	26.7
BFI	0.35	0	0.2	0.35	0
K_{base}	0.6	0	0.82	0.6	0
K_{surf}	0.1	0.1	0.17	0.1	0.1
Rehab runoff/rainfall	9.8%	20.9%	5.1%	8.6%	20.9%
Runoff salinity (EC) µS/cm	600	900	150	150	8,000

Figure 5.1 to Figure 5.5 show how catchment landuse will change as the project develops.

A schematic of the integrated Gemini Project water management system configuration is shown in Figure 6.1. A summary of the proposed storages within the integrated WMS and their operating strategies are summarised in the following sections.

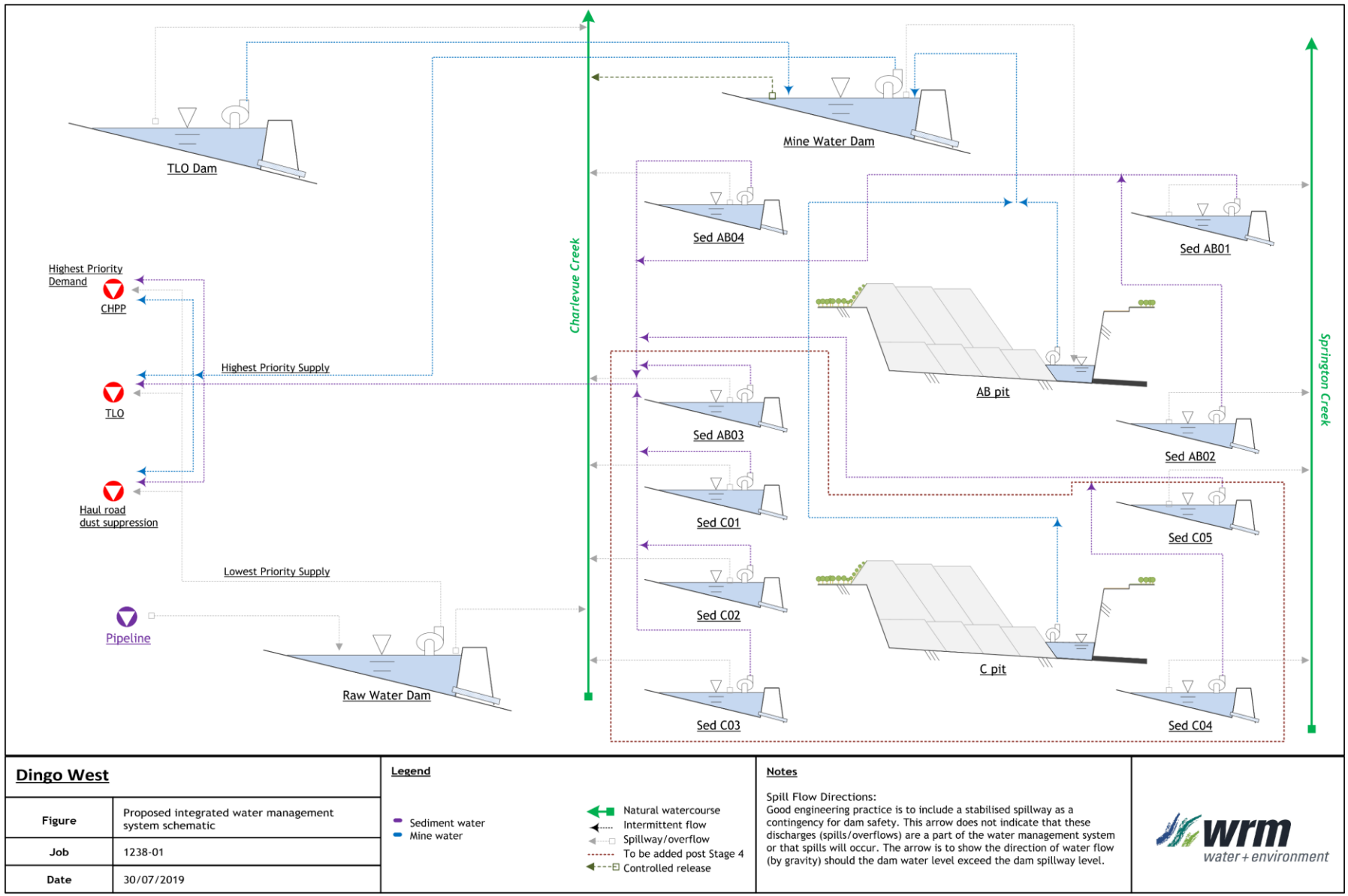


Figure 6.1 - Proposed integrated water management system schematic

6.6 MODELLING OF WATER DEMAND

6.6.1 Haul road dust suppression

Haul road dust suppression watering rates were applied to haul road areas that vary as mining progresses. The following rules were used to determine the applied dust suppression rate on any given day of the historical rainfall record:

- The assessment used daily evaporation rates sourced from the SILO evaporation dataset;
- For a dry day (zero rainfall), the haul road watering rate is equal to the daily evaporation rate;
- For a rain day when rainfall is less than the daily evaporation rate, the watering rate is reduced and is only required to make up the remaining depth to the daily evaporation rate;
- For a rain day when rainfall exceeds the daily evaporation rate, no haul road watering is required; and
- It was assumed that 29 metres of the haul road width would be watered.

The estimated consumption rates for each phase are summarised in Table 6.5 (but note that the totals will vary with climate in the model).

Table 6.5 - Forecast haul road dust suppression demand

Year	Stage	Haul road length (km)	Average daily application rate (mm/d)	Maximum daily application rate (mm/d)	Average annual demand (ML/a)	Average daily demand (ML/d)
1	1	6.7	4.4	9.7	314.6	0.86
2	1	6.7	4.4	9.7	314.6	0.86
3	1	6.7	4.4	9.7	314.6	0.86
4	1	6.7	4.4	9.7	314.6	0.86
5	2	7.1	4.4	9.7	333.4	0.91
6	2	7.1	4.4	9.7	333.4	0.91
7	2	7.1	4.4	9.7	333.4	0.91
8	2	7.1	4.4	9.7	333.4	0.91
9	2	7.1	4.4	9.7	333.4	0.91
10	2	7.1	4.4	9.7	333.4	0.91
11	3	8.7	4.4	9.7	401.5	1.10
12	3	8.7	4.4	9.7	401.5	1.10
13	3	8.7	4.4	9.7	401.5	1.10
14	4	9.9	4.4	9.7	464.9	1.27
15	4	9.9	4.4	9.7	464.9	1.27
16	5	10.9	4.4	9.7	511.8	1.40
17	5	10.9	4.4	9.7	511.8	1.40
18	5	10.9	4.4	9.7	511.8	1.40

6.7 SUMMARY OF DEMANDS

The estimated annual demands and groundwater inflows to the mine are summarised in Table 6.6 below. Potable water demands have not been modelled.

Table 6.6 – Summary of adopted demands and expected groundwater inflows

Year	Demand (ML/a)				Net GW Inflow (ML/a)
	CHPP	Haul Road	TLO	Total	
1	162.0	314.6	0.72	477.3	31.5
2	162.0	314.6	0.73	477.3	31.5
3	162.0	314.6	0.73	477.3	31.5
4	162.0	314.6	0.73	477.3	31.5
5	162.0	333.4	0.73	496.1	31.5
6	162.0	333.4	0.72	496.1	31.5
7	162.0	333.4	0.72	496.1	31.5
8	162.0	333.4	0.71	496.1	31.5
9	162.0	333.4	0.72	496.1	31.5
10	162.0	333.4	0.72	496.1	31.5
11	162.0	401.5	0.70	564.2	220.8
12	162.0	401.5	0.74	564.2	220.8
13	162.0	401.5	0.74	564.2	189.2
14	162.0	464.9	0.74	627.6	205.0
15	162.0	464.9	0.74	627.6	31.5
16	162.0	511.8	0.72	674.5	31.5
17	162.0	511.8	0.74	674.5	31.5
18	143.4	511.8	0.65	655.9	47.3

6.8 OPERATING RULES

The operating rules to be applied to the links joining the various elements in the water balance model are summarised in Table 6.7 below.

Table 6.7 – Gemini Project water management system operating rules

Item	Node Name	Operating Rules
1.0	***External Water Supply***	
1.1	Pipeline	• Supplies the Raw Water Dam – which in turn supplies the haul road dust suppression, CHPP and TLO; • Yearly allocation assumed unlimited; • Capacity limited to 200L/s.
2.0	***Supply to Demands***	
2.1	CHPP	• Demands in priority, from the Mine Water Dam, Sediment Dams and Raw Water Dam respectively.
2.2	Haul road dust suppression	• Demands from the Mine Water Dam, Sediment Dam and Raw Water Dam; • Demands vary daily according to the loss model detailed in this report.
2.3	TLO	• Demands from the Mine Water Dam, Sediment Dams and Raw Water Dam; • Demands according to the coal production rate and usage rate (L/t ROM).
3.0	***Transfer of pit water***	
3.1	Mine Pit	• Pit dewatering directed to Mine Water Dam, at a nominal rate of 200 L/s. Pumping to cease when the maximum operating level reached.
4.0	***Operation of site dams***	
4.1	Mine Water Dam	• Receives pumped transfers from the Mine Pit up to the maximum operating level; • Storage overflows to Pit; • Controlled releases in accordance with the EA conditions may be made to Charelevue Creek if required, but this has been conservatively excluded from the model.
4.4	Raw water Dam	• Receives pumped transfers from pipeline to a maximum operating level (to be determined); • Overflows to Charlevue Creek.
4.5	TLO Dam	• Pumping to Mine Water Dam; • Overflows to Charlevue Creek.
4.6	AB01	• Sediment dam, active from Year 1 onwards; • Overflows to Springton Creek.
4.7	AB02	• Sediment dam, active from Year 1 onwards; • Overflows to Springton Creek.
4.8	AB03	• Sediment dam, active from Year 1 onwards; • Overflows to Charlevue Creek.
4.9	AB04	• Sediment dam, active from Year 1 onwards; • Overflows to Charlevue Creek.

Item	Node Name	Operating Rules
4.10	C01	• Sediment dam, active from Year 14 onwards; • Overflows to Charlevue Creek.
4.11	C02	• Sediment dam, active from Year 14 onwards; • Overflows to Charlevue Creek.
4.12	C03	• Sediment dam, active from Year 14 onwards; • Overflows to Charlevue Creek.
4.13	C04	• Sediment dam, active from Year 14 onwards; • Overflows to Springton Creek.
4.14	C05	• Sediment dam, active from Year 14 onwards; • Overflows to Springton Creek.
5.0	***Receiving water***	
5.1	Springton Creek	• Receives uncontrolled overflows from the following sediment dams: ○ AB01; ○ AB02; ○ C04; ○ C05.
5.2	Charlevue Creek	• Receives uncontrolled overflows from the following sediment dams: ○ AB03; ○ AB04; ○ C01; ○ C02; ○ C03.
6.0		• All storages and pits receive local catchment runoff and lose water through evaporation

6.9 WATER BALANCE MODEL RESULTS

The results of the site water balance model are summarised in the following sections.

6.9.1 Mine water dam behaviour

The results of the water balance model presented in Figure 6.2 show that as pit catchments and groundwater inflows increase, the likelihood of needing to store large volumes of water in the mine water dam increases. By the end of Year 7, the median stored volume is at the Mine Water Dam's maximum operating volume.

The mine water dam's maximum operating level has been chosen to manage the risk of overflows. The spillway directs overflows to AB Pit, so the likelihood of uncontrolled offsite discharge from the Mine Water Dam is negligible.

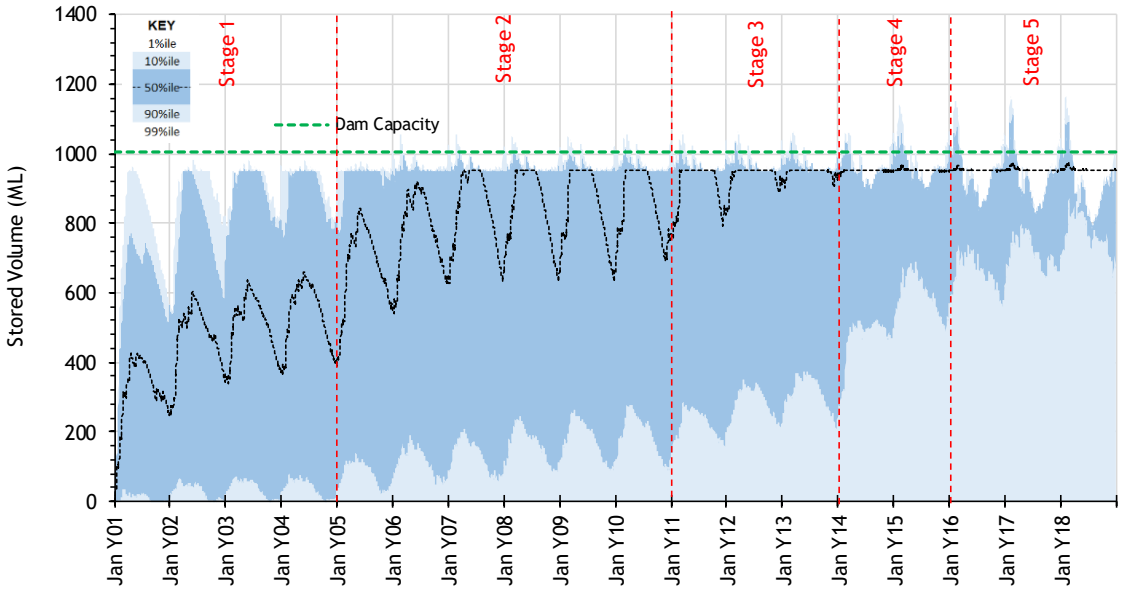


Figure 6.2 – Mine Water Dam – stored water volume behaviour

6.9.2 Likelihood of pit inundation

Figure 6.3 shows a plot of water volumes accumulating in AB pit and C pit over the project life. The plot shows the median stored volume is minimal on all days.

At AB Pit, stored water volumes can be maintained at relatively low volumes which would not interrupt mining operations. The 10th percentile In pit inventory is negligible prior to each wet season, prior to the end of AB Pit mining at the end of Year 13.

After Year 13, AB Pit can be used to stored excess water from C Pit in very wet periods. While the median stored water volume is negligible, up to 3,250ML of water could be stored in AB Pit at the 1% confidence level, which corresponds to a level just below the expected equilibrium final void lake water level.

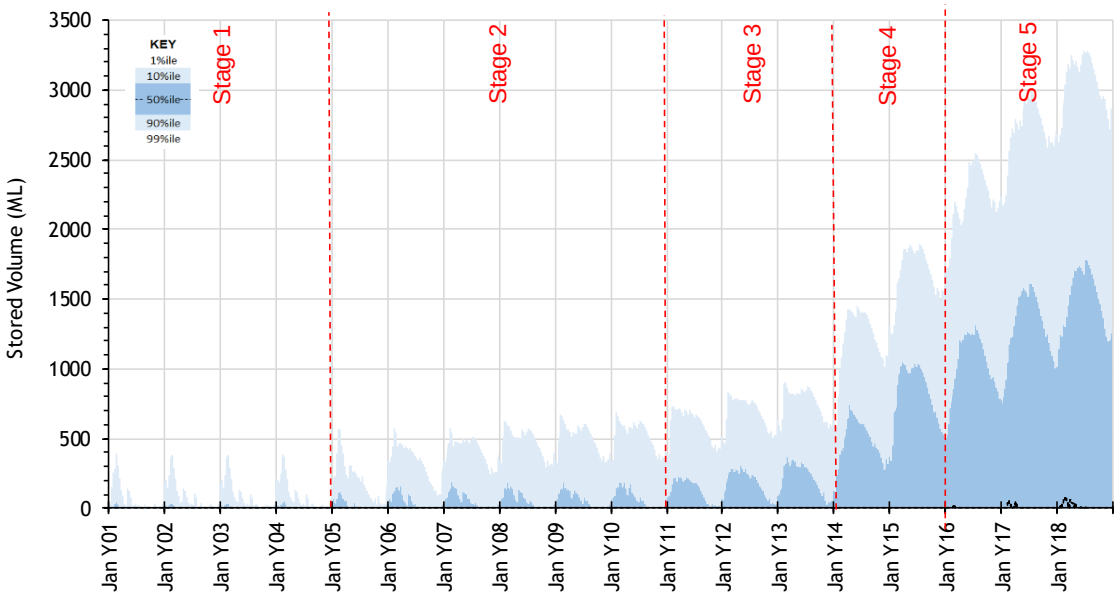


Figure 6.3 - AB pit - stored volume behaviour

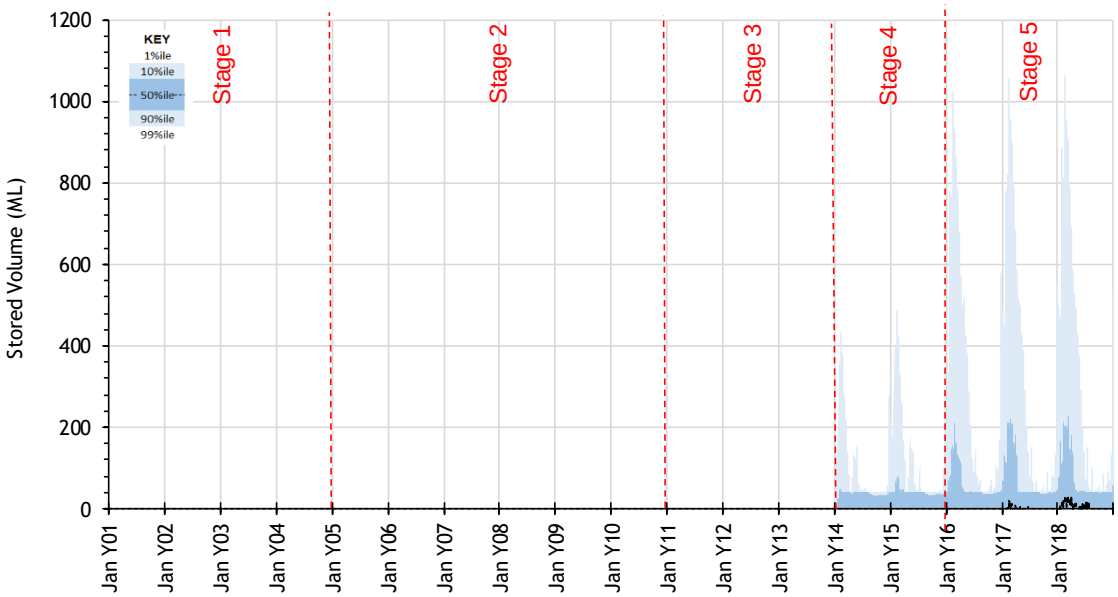


Figure 6.4 - C pit - stored volume behaviour

6.9.3 Water supply reliability

Figure 6.5 shows imported water requirements from the external pipeline are highest in the early project stages. Under very dry conditions, the demand could reach 500 ML/a, but median Year 1 demand is less than 100 ML/a. During later years, accumulated stored pit and sediment dam water is sufficient to supply demands in all but the driest years.

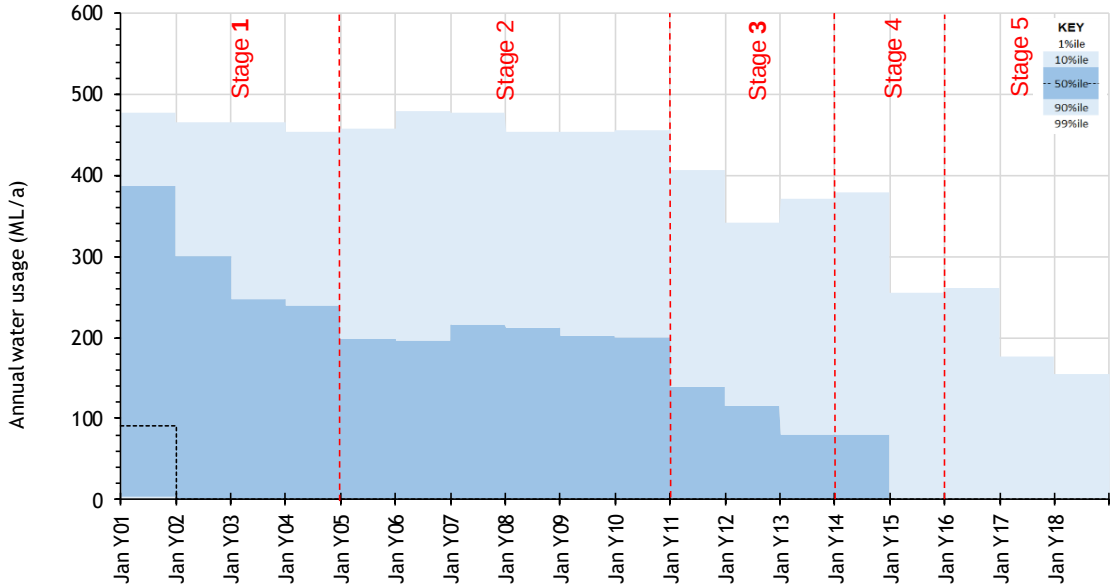


Figure 6.5 – Raw water pipeline usage

6.9.4 Sediment dam releases

Figure 6.6 and Figure 6.7 show that the likelihood of sediment dam discharges to Charlevue and Springton Creeks increases over the mine life. In the early years, the likelihood of discharge is low, as contributing catchments are relatively small, and captured water may be used to supplement site water demands. However, in later years the likelihood of discharges increases. Water captured in sediment dams is expected to have low salinity and coarse sediments will settle out, such that any impacts to downstream water quality are expected to be minor.

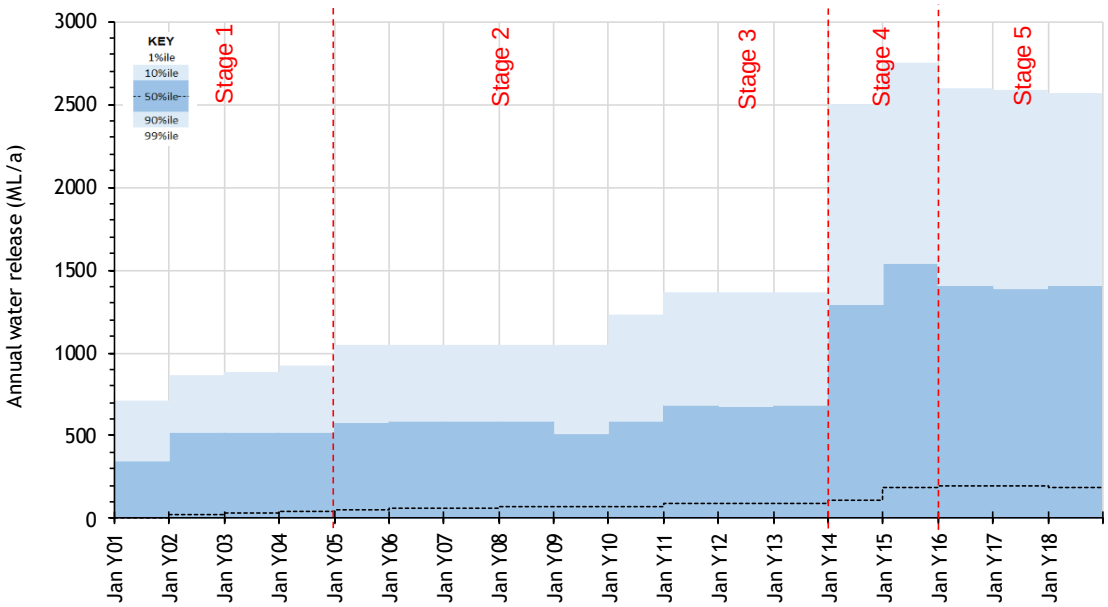


Figure 6.6 – Sediment dam spills to Charlevue Creek

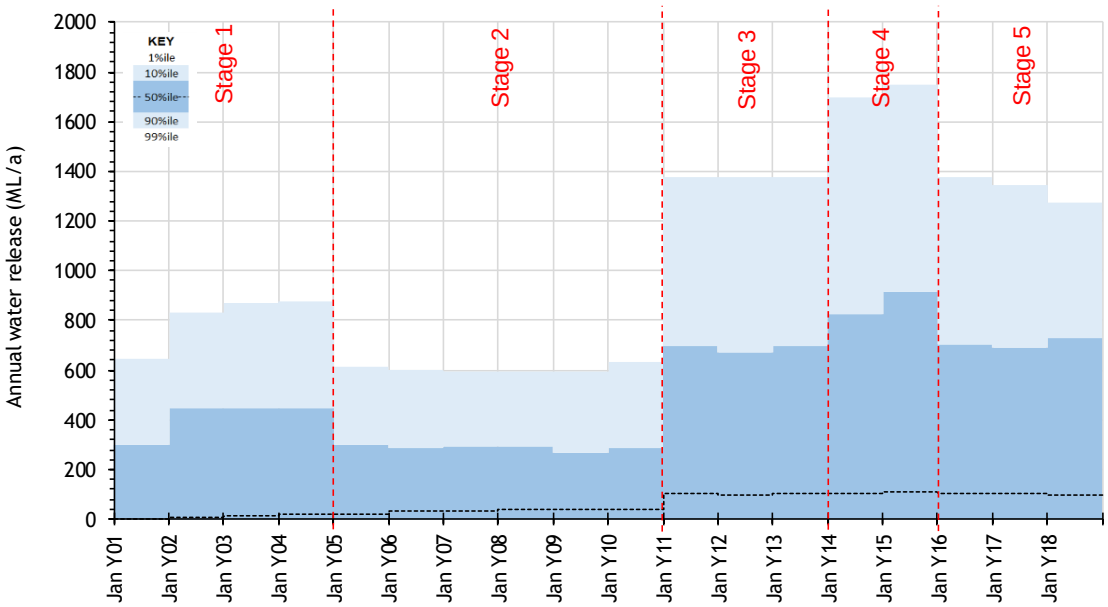


Figure 6.7 – Sediment dam spills to Springton Creek

6.9.5 Overall site water balance

The overall average annual site water balance is summarised in Table 6.8.

Table 6.8 – Average annual site water balance

Component	Process	Volume (ML/a)					
		Stage 1 Y1 - Y4 (4 years)	Stage 2 Y5 - Y10 (6 years)	Stage 3 Y11 - Y13 (3 years)	Stage 4 Y14 - Y15 (2 years)	Stage 5 Y16 - Y18 (3 years)	Total (18 years)
Inflows	Rainfall and runoff	973	1,052	1,215	2,148	2,214	7,602
	Net groundwater inflow	32	32	210	118	37	428
	External supply pipeline	89	51	29	17	11	196
	Total	1,093	1,135	1,454	2,283	2,261	8,226
Outflows	Evaporation	250	317	386	629	762	2,344
	Haul road dust suppression	315	336	405	469	515	2,040
	CHPP Usage	162	162	162	162	162	810
	Spill from Raw Water Dam	37	41	41	43	44	206
	Spill from Sediment Dams	223	245	398	669	652	2,187
	Spill from Mine Affected Water Dams	0	0	0	0	0	0
	Total	988	1,102	1,392	1,972	2,135	7,587
Change in Site Water Inventory		**102**	**29**	**59**	**308**	**122**	**619**

7 Flood mitigation and impacts

The proposed mine operations and associated infrastructure are largely located outside of the Charlevue Creek and Springton Creek flood inundation areas identified in section 4.5. However, the potential for the following project features to interact with floodwater has been investigated as part of this assessment:

- The rail loop, which is located near the northern margin of the Charlevue Creek floodplain, in close proximity to the existing Capricorn Highway and Aurizon's Blackwater rail corridor.
- The CHPP/MIA fill pad which is located to the north of the Charlevue Creek floodplain.
- The haul road between AB Pit and the CHPP, which crosses Charlevue Creek;
- The AB Pit spoil dump, which encroaches towards the Charlevue Creek floodplain
- The AB Pit levee, which is required to prevent inundation of the AB Pit mine area from flooding at the downstream end of an unnamed second order tributary of Springton Creek, which is to be diverted around the proposed mine area.
- The C Pit overburden dump which will necessitate the construction of a drain to divert clean runoff in the upper reaches of the unnamed second order tributary of Springton Creek around the workings.

The locations of the mine infrastructure horizontal alignments of the drainage channels and associated levees are shown in Figure 7.1. The flood models were used to:

- Assess the impact of the Project on peak flood levels.
- Assess peak water levels and velocities along the levees and channels proposed to protect the proposed mine areas from flooding;

Figure 7.1 shows the Project will temporarily increase Charlevue flood levels immediately upstream of the proposed haul road crossing. In the 1% AEP flood, these impacts are contained within the mine lease area.

There will be no impact on flood levels in the Charlevue Creek or Springton Creek at the existing Capricorn Highway, Blackwater Rail corridor, or downstream of the Project area.

While the unnamed tributary of Springton Creek is not a watercourse as defined under the Water Act, the diversion channel will be designed taking into consideration the principles set out in the Guideline: "Works that interfere with water in a watercourse – watercourse diversions" (DNRM, September 2014). This document sets out key design principles and requirements for the functional designs of permanent diversions. It includes guidance on watercourse diversion design and operation including maintenance, monitoring and revegetation. Preliminary designs are shown in Figure 7.3 to Figure 7.8 which also show the post development flood conditions with diversions and levees in place.

The works at AB Pit will locally increase flood levels in Springton Creek by up to 0.22 m in the 1% AEP flood. These impacts would extend off the lease area onto land owned by Magnetic South Pty Ltd, and reduce with distance downstream of the boundary.

The full details of the methodology and results of flood modelling for a range of flood events are presented in Appendix A.

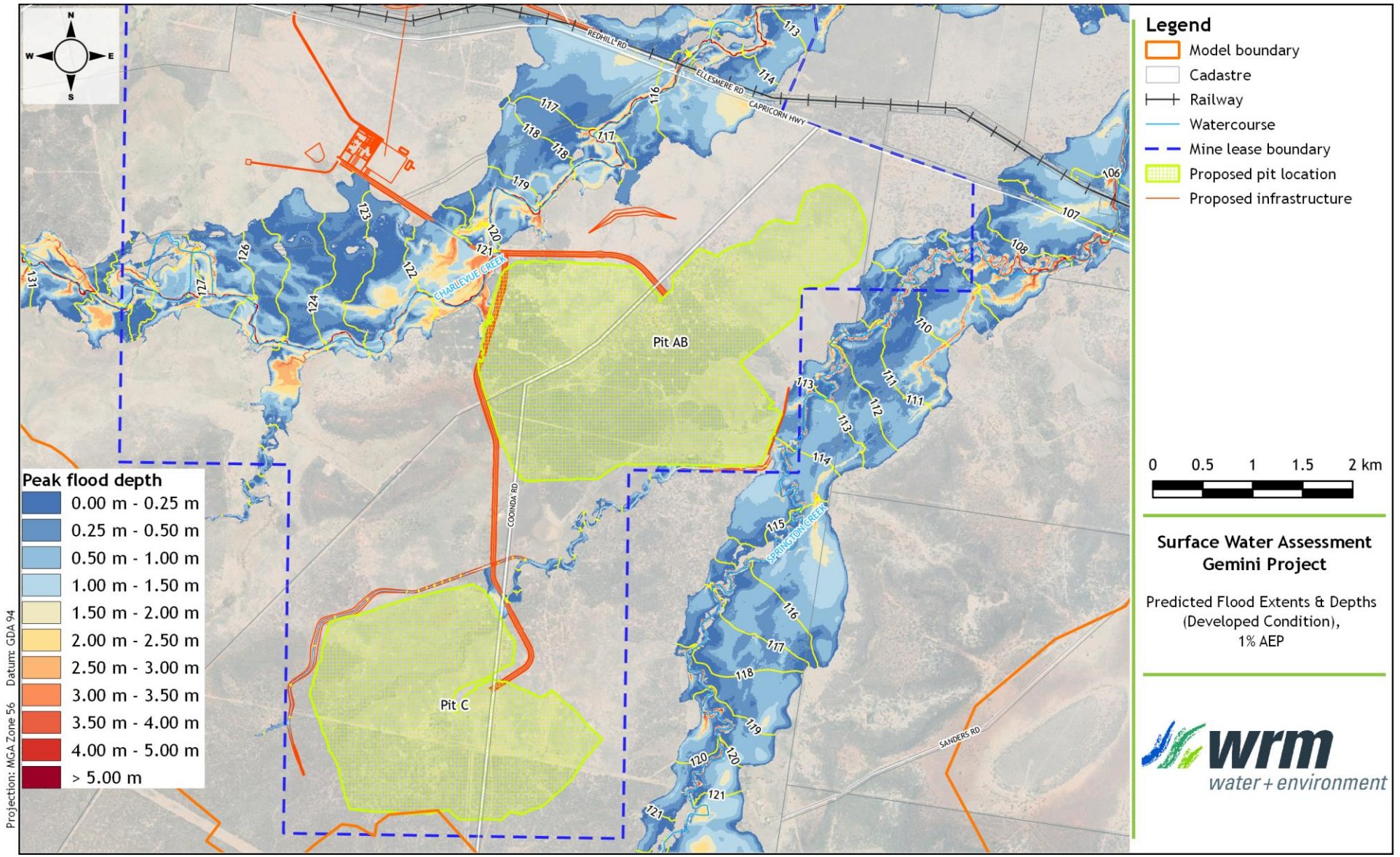


Figure 7.1 – Developed conditions 1% AEP flood depths and water levels

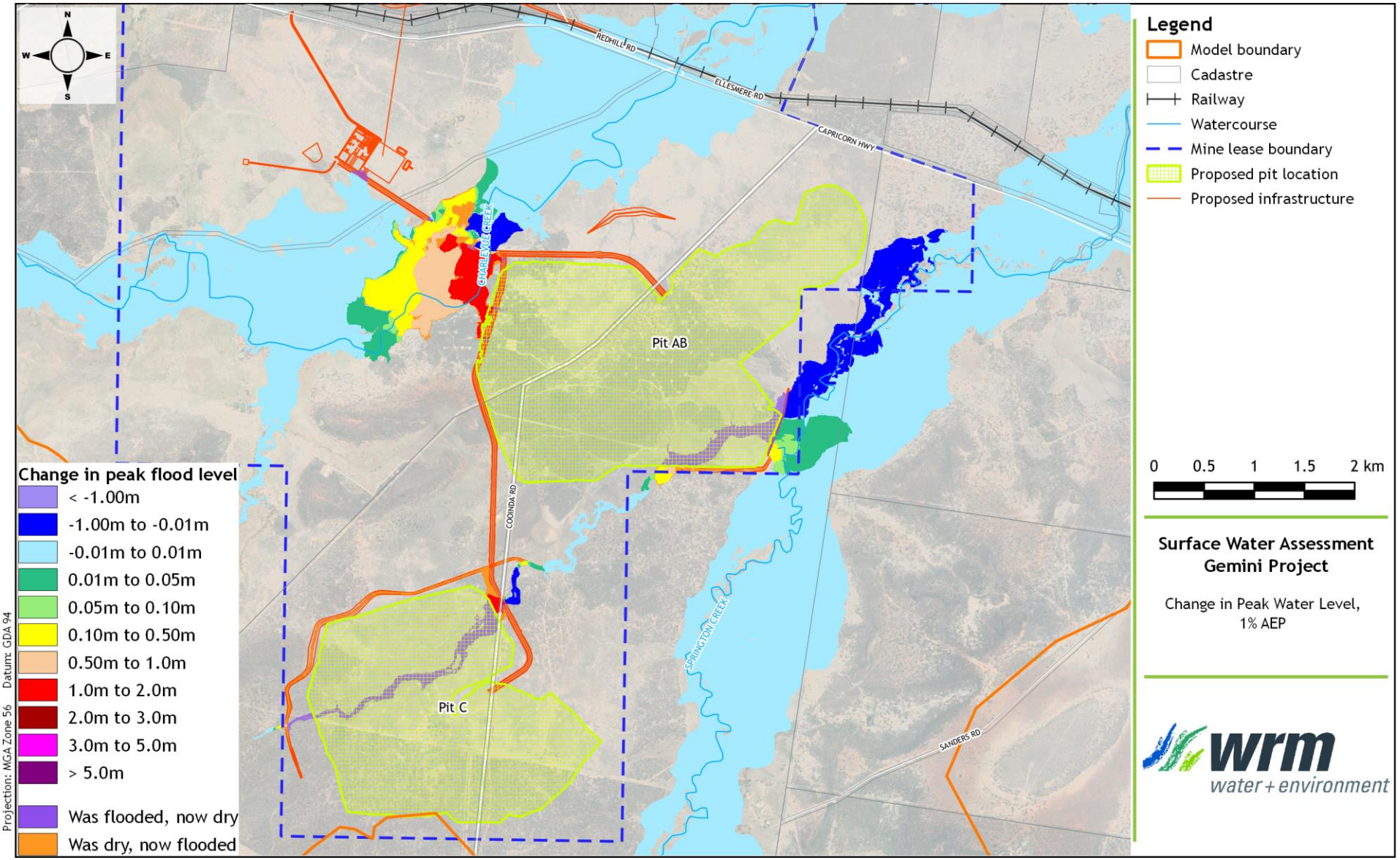


Figure 7.2 – Impacts of the Project on 1% AEP flood levels

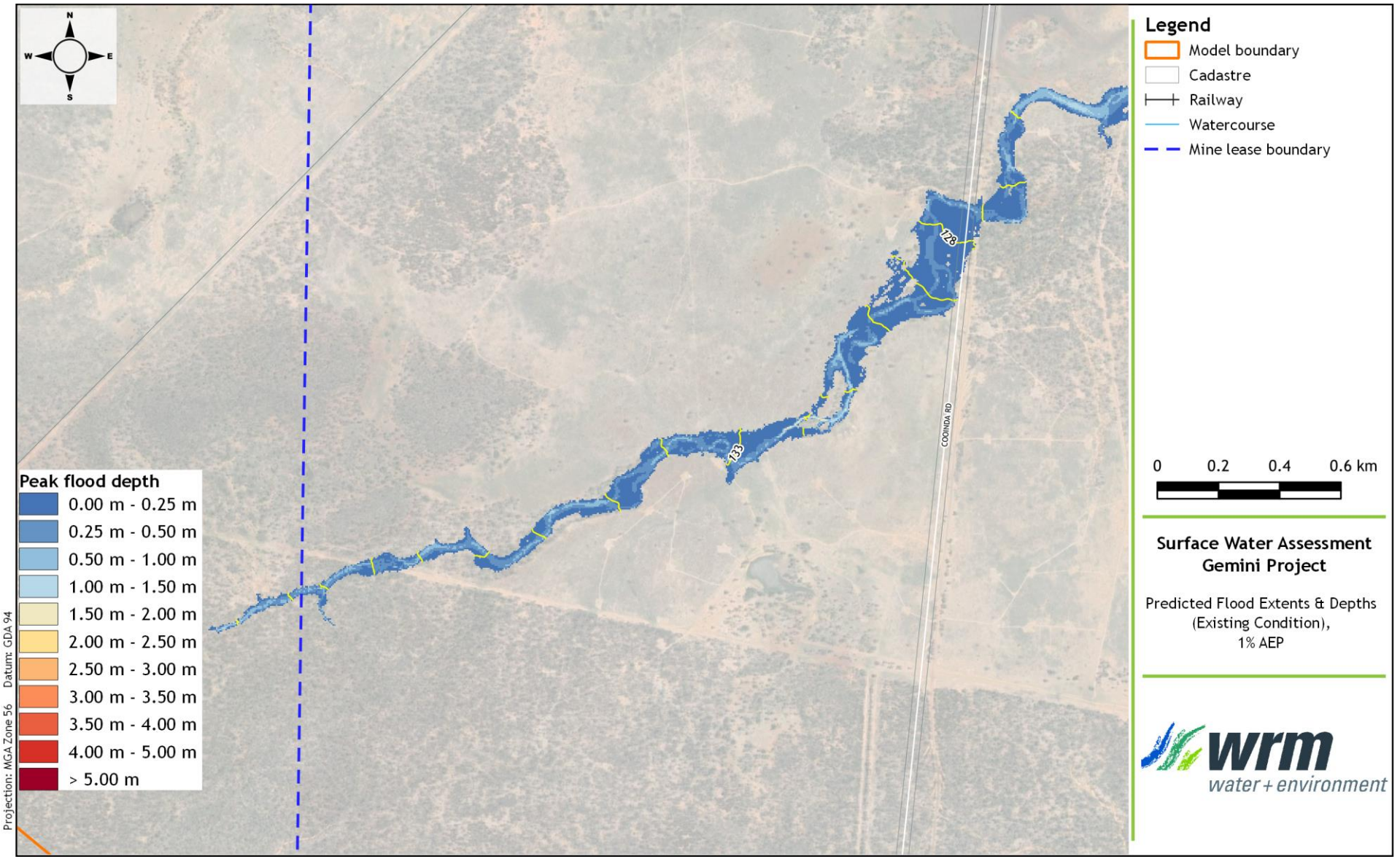


Figure 7.3 – Upper reach of unnamed Springton Creek tributary – existing 1% AEP flood depths

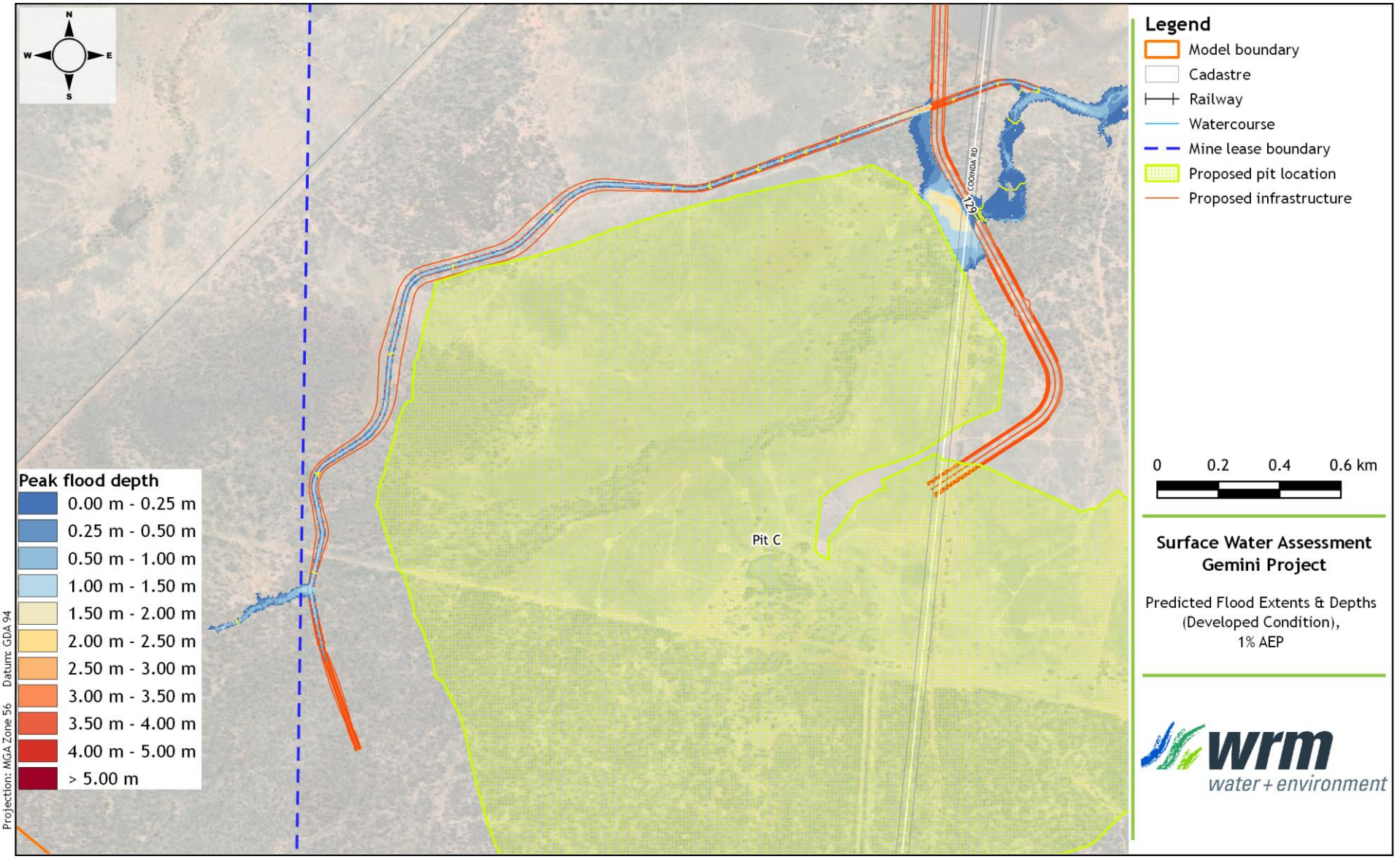


Figure 7.4 – Upper reach of unnamed Springton Creek tributary – proposed 1% AEP flood depths

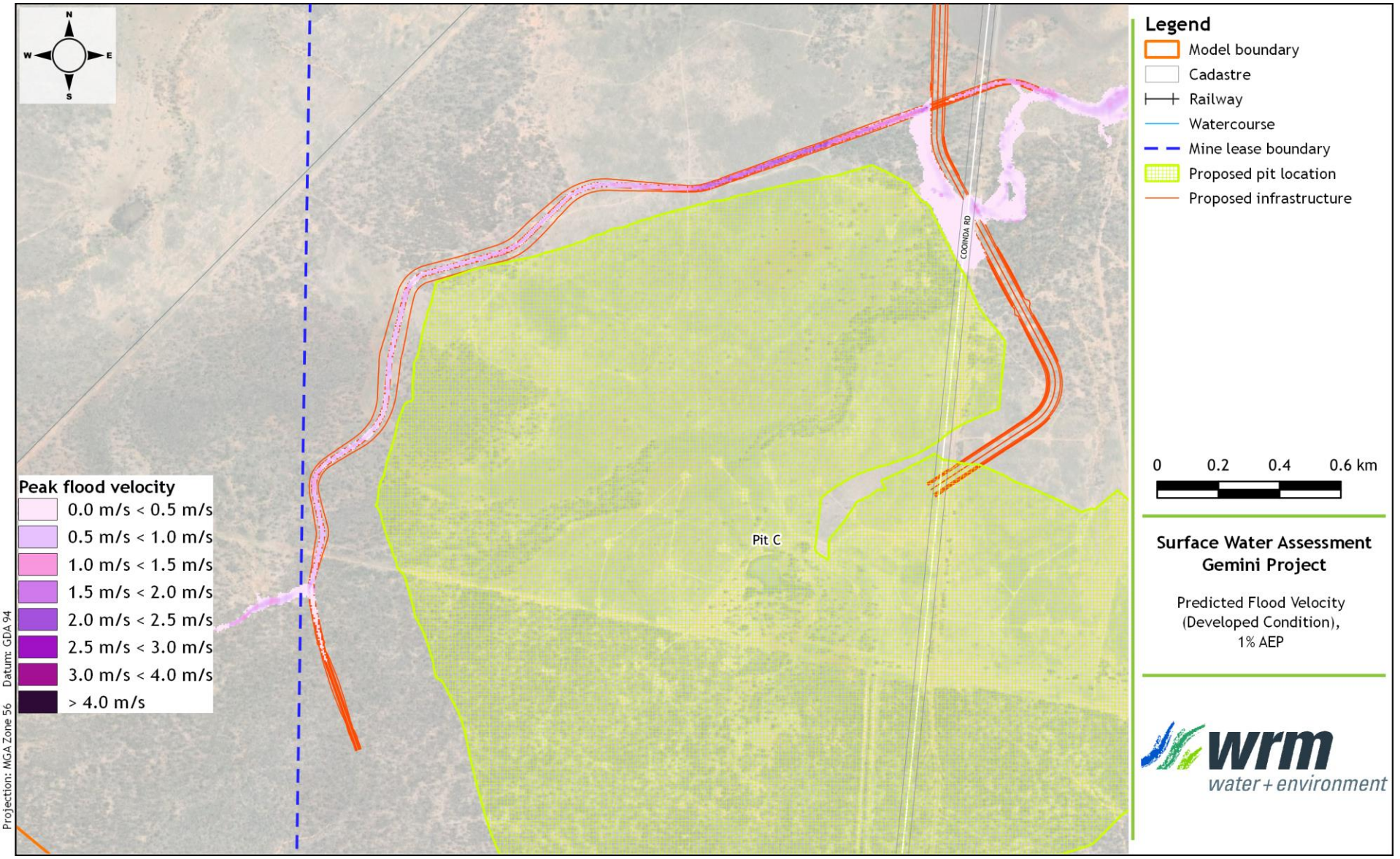


Figure 7.5 - Upper reach of unnamed Springton Creek tributary - proposed 1% AEP flood velocities

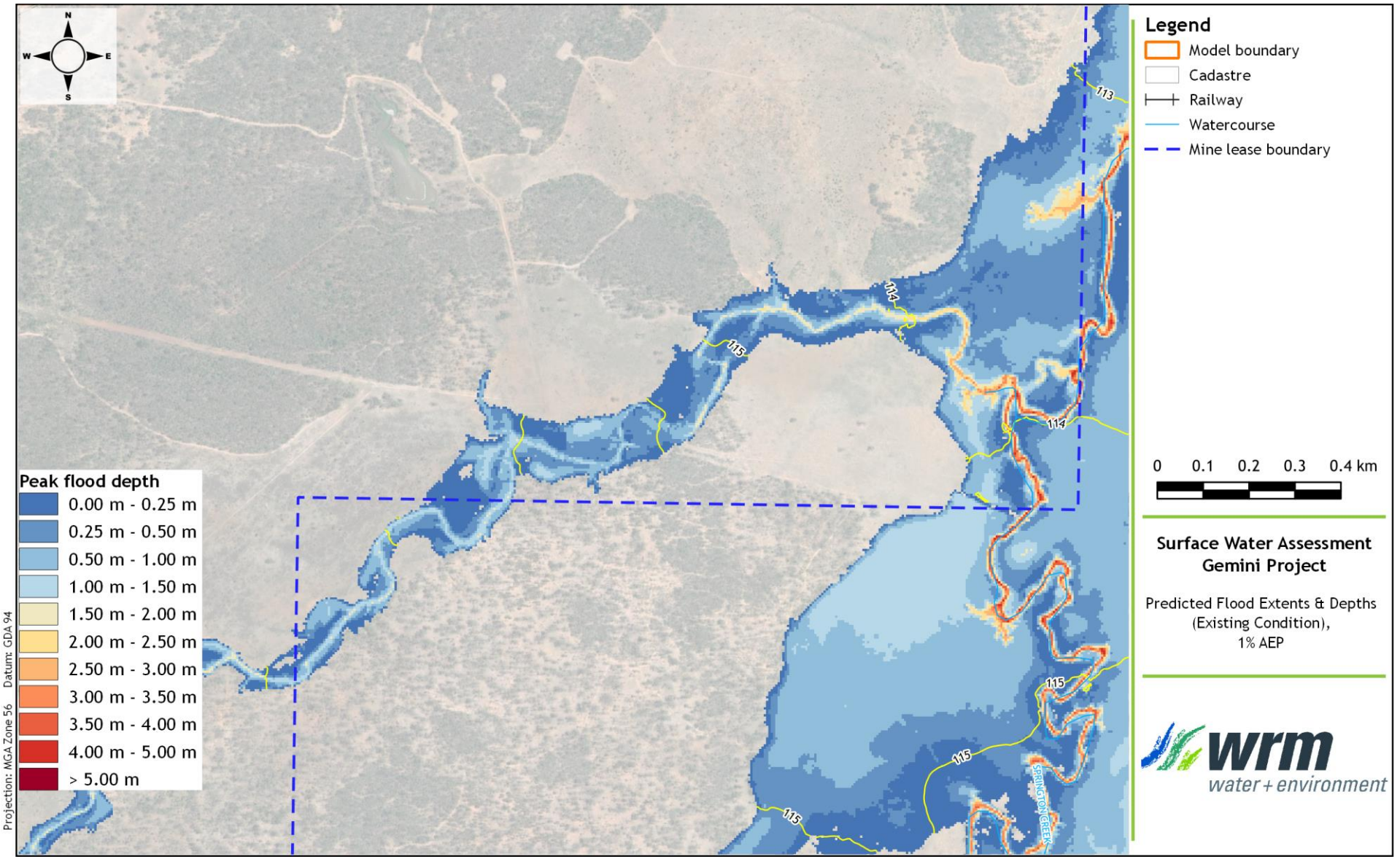


Figure 7.6 - Lower reach of unnamed Springton Creek tributary at AB Pit - existing 1% AEP flood depths

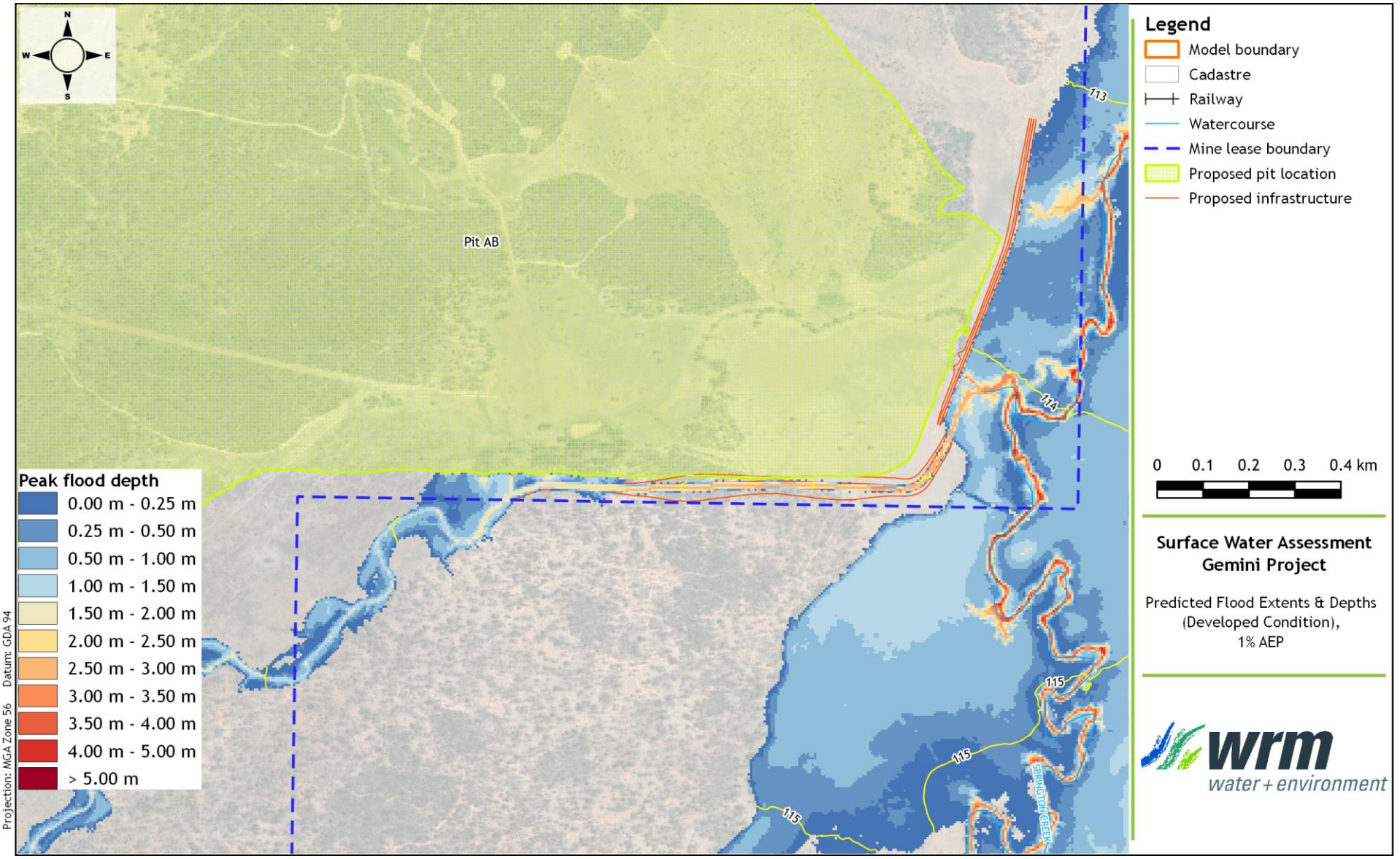


Figure 7.7 – Lower reach of unnamed Springton Creek tributary at AB Pit – proposed 1% AEP flood depths

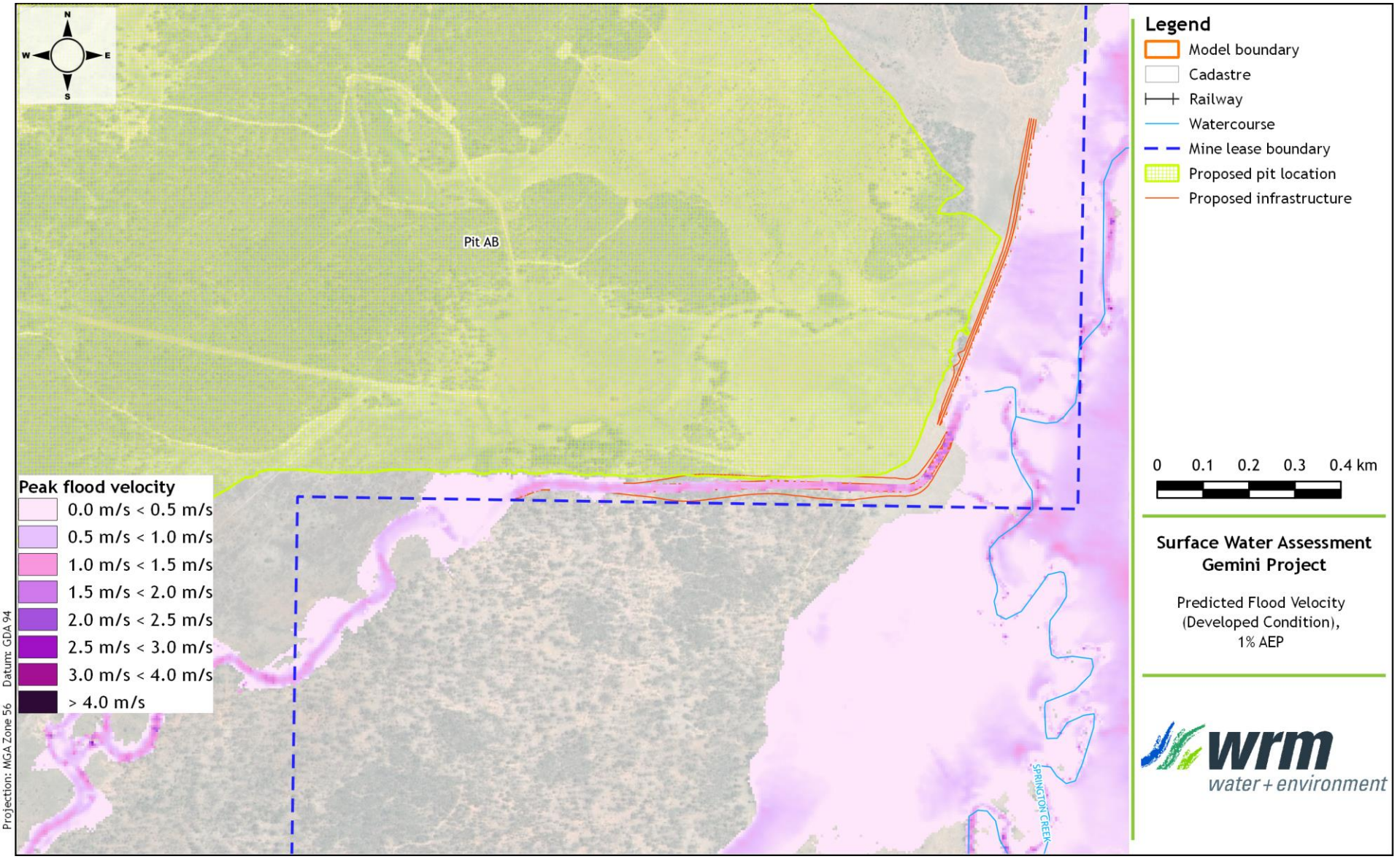


Figure 7.8 - Lower reach of unnamed Springton Creek tributary at AB Pit - proposed 1% AEP flood velocities

8 Final void behaviour

8.1 OVERVIEW

Water levels in the final voids will vary over time, depending on the prevailing climatic conditions, and the balance between evaporation losses and inflows from rainfall, surface runoff, and groundwater.

A GOLDSIM model (separate to the OPSIM model used for the operational modelling) was used to assess the likely long-term behaviour of the final void pit lakes. The historical rainfall and evaporation sequences were repeated 5 times to create a long-term climate record for use in the model.

The potential effects of climate change were assessed using climate-change adjusted SILO climate data developed as part of the Consistent Climate Scenarios (CCS) project by the Queensland Government's Department of Environment and Science (DES).

8.2 FINAL VOID CONFIGURATION

The final void configurations and contributing catchment areas are shown in Figure 8.1. The proposed final void catchments include the pits' plan areas, and immediate upslope catchments. Key details of the final voids are as follows:

- AB Pit final void will be approximately 72 m deep, with a floor level of 40 mAHD and an overflow level of approximately 112 mAHD.
- C Pit final void will be approximately 70 m deep, with a floor level of 58 mAHD and an overflow level of approximately 128 mAHD.

The final void will be located and designed such that it is not inundated by flooding in the probable maximum flood (refer Figure 8.2).

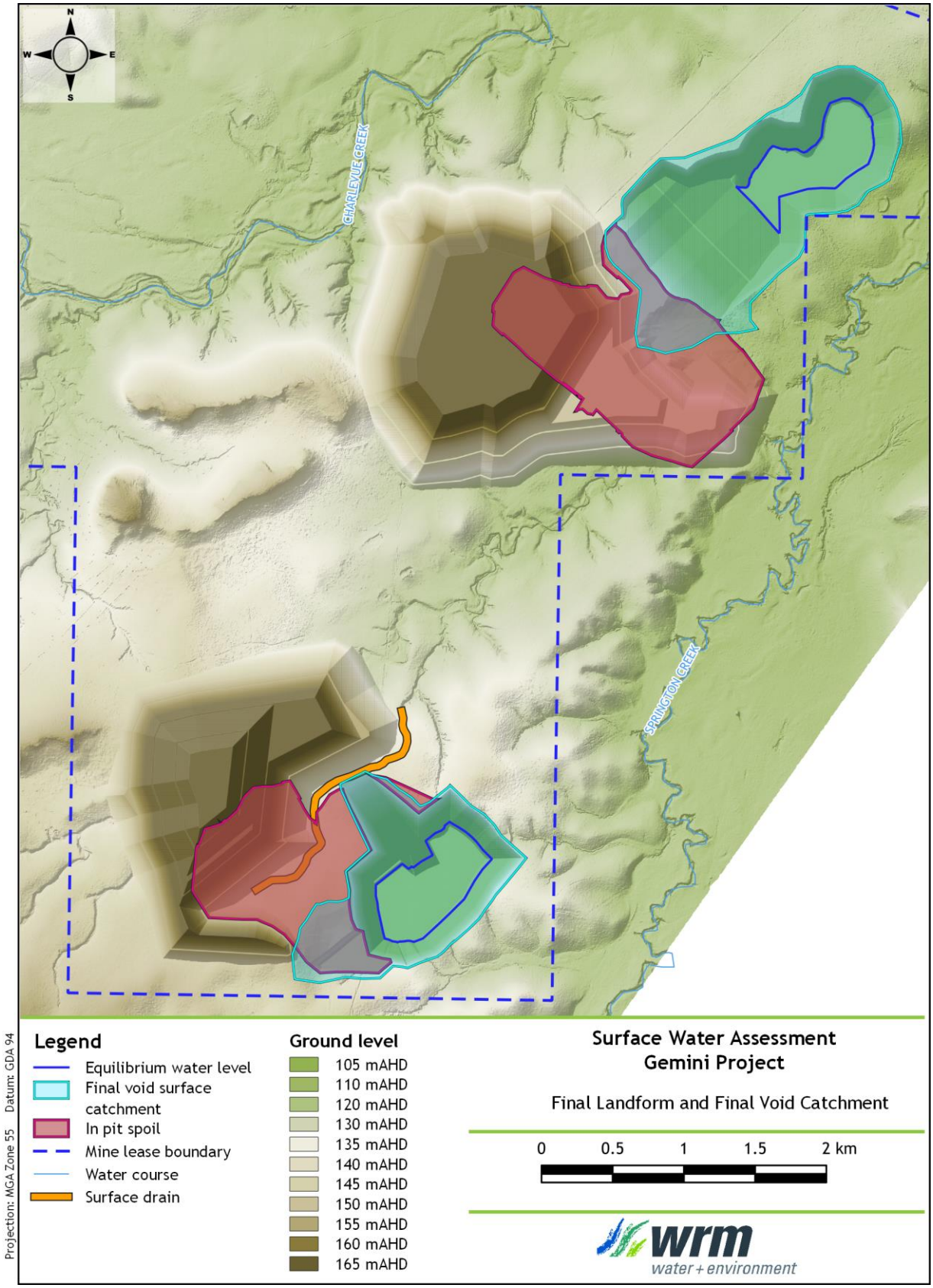


Figure 8.1 - Final landform and final void catchments

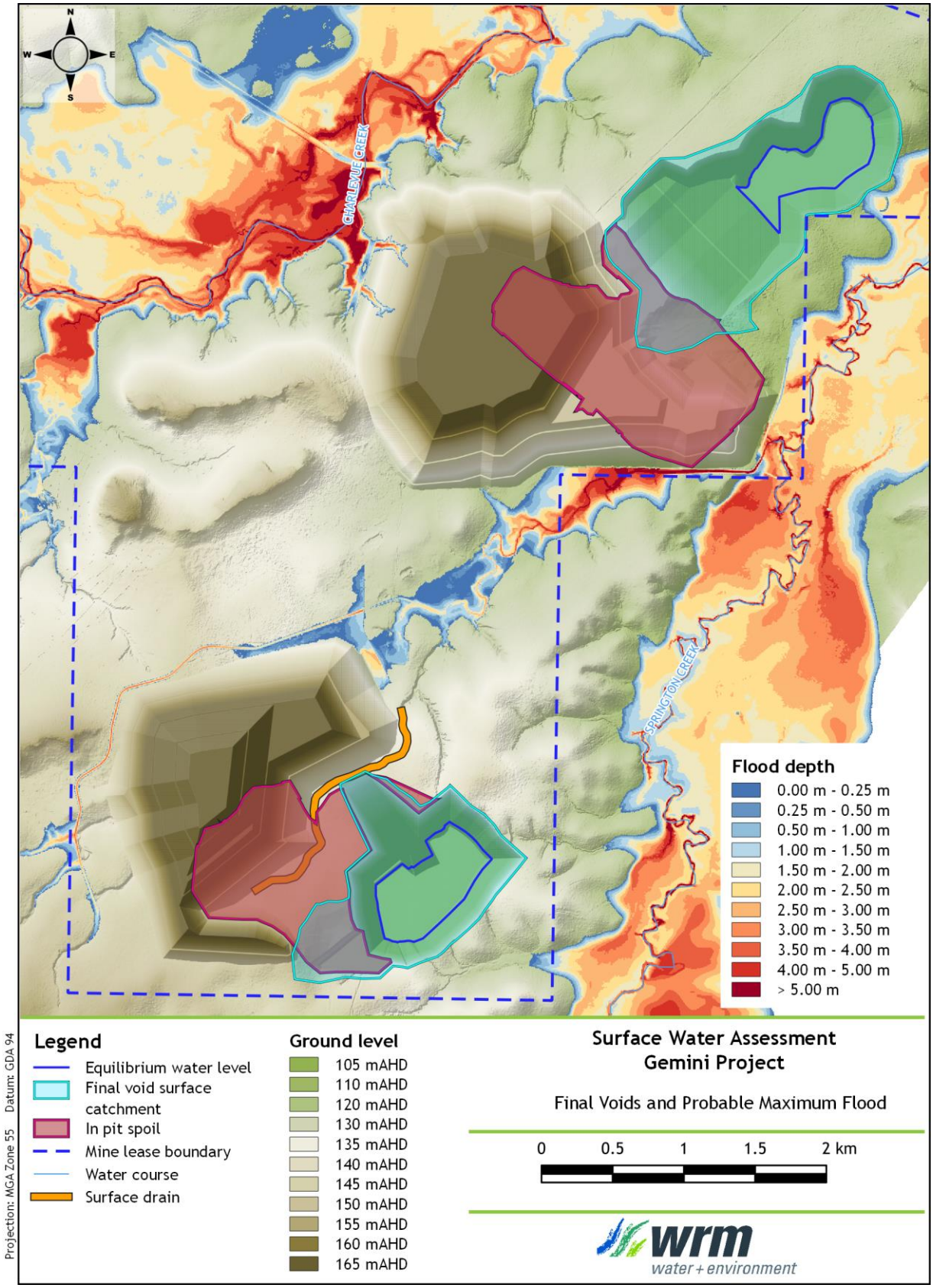


Figure 8.2 - Final landform and flood levels in Probable Maximum Flood

8.3 CONCEPTUAL MODEL

A representative schematisation of a conceptual final void water balance is presented in Figure 8.3.

The figure shows that key water inputs include rainfall on pit lake water surfaces, runoff from pit faces and rehabilitated upstream catchment areas, and groundwater interception. Depending on the configuration of the spoil dump, rainfall may also infiltrate through in-pit spoil.

Outflows are generally limited to evaporation. Under certain circumstances (i.e. if the final void water level exceeds the level of a neighbouring aquifer), outflows may also include seepage losses to surrounding aquifers. Water accumulating in the pit lake may also infiltrate into the adjacent overburden, creating additional water storage in this 'spoil aquifer'.

Sources of salt include salts dissolved in groundwater and catchment runoff. In the absence of any seepage or surface outflows to the environment, there is generally no removal of salt from the system, and thus, salts are expected to accumulate over time.

In principle, for an initially empty void, water is expected to accumulate until evaporative losses from the wetted surface area balance the combined influence of catchment runoff, rainfall and groundwater interception. Where catchment inflows are limited, over a sufficiently long time-scale, water levels are expected to reach a nominal steady state, with some variation about the steady state level during prolonged periods of wet or dry climate bias. This principle works in reverse for any voids that are filled (e.g. by pumping) above their steady state level prior to relinquishment; water levels will reduce due to evaporation until the wetted surface contracts to a point where evaporative losses balance inflows.

The Gemini Project voids are to be partially backfilled to prevent the interchange of water between the coal seams and the lakes – resulting in lower water levels and salinities than would otherwise be the case.

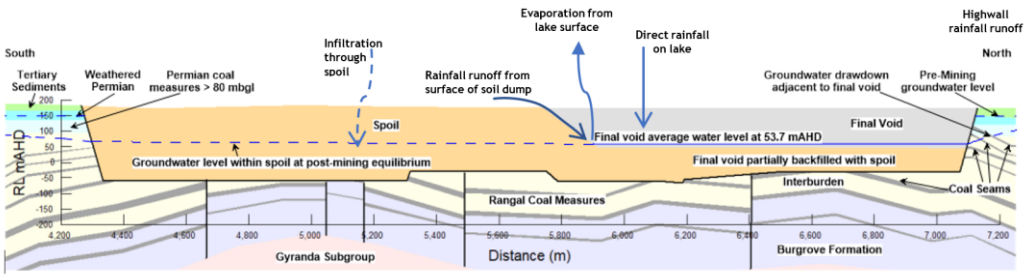


Figure 8.3 – Final landform and pit lake catchment

8.4 NUMERICAL MODELLING APPROACH

The GOLDSIM model simulates the generation, movement and loss of water on a daily time-step within each final void, over a 515-year period. The volume of water in the void is calculated at each time step as the sum of direct rainfall to the void surface, catchment runoff, and groundwater inflows, less evaporation losses.

The model tracks the quantity salt captured and stored within the system. Key components of the model are summarised in the following sub-sections, including descriptions of key model inputs, assumptions and sensitivity parameters.

8.5 STAGE-STORAGE CHARACTERISTICS

The stage-storage and stage-area curves for the voids were estimated from the final landform terrain model. The adopted relationships are shown in Figure 8.6.

8.6 CATCHMENT RUNOFF

Surface runoff catchment areas draining to the final voids were determined based on the adopted final landform. The following land use assumptions were adopted:

- All overburden dumps and cleared areas within the final void catchments will be rehabilitated and revegetated after cessation of mining;
- All rehabilitated catchment will naturally revert toward pre-disturbed conditions over time (as vegetation matures and top soil weathering and consolidation takes place). The long-term runoff properties will be somewhere between rehab and natural catchment.

The AWBM was used to model surface water runoff. The AWBM parameters adopted for rehabilitated areas in the operational water balance were also used for the final void analysis. The modelled surface catchments to each void are summarised in Table 8.1.

Table 8.1 – Final void surface catchments (ha)

Catchment type	AB Pit	C Pit
Natural	15.1	2.0
Pit	104.6	115.7
Rehab	98.0	20.3
Total	**217.7**	**138.0**

8.7 PIT SURFACE EVAPORATION

Evaporation from the void lake water surface was modelled using estimates of Morton's Lake evaporation. The reduced evaporation resulting from shading and wind shielding provided by the pit walls was modelled using an adjustment factor referred to herein as the 'pit factor'. A linearly varying depth-dependent storage evaporation factor has been applied to each void to simulate the change in evaporation as void water levels increase. The storage evaporation factors are as follows:

- Bottom of void – 0.5;
- Top of void – 0.8.

Pit factors are supported by the findings of ACARP Project No. C7007 (2001) which entailed development of a practical methodology for predicting the hydrology and water quality of final spoil-void systems. The study proposed adopting typical pit factors of 0.56 for near-empty pits and 0.78 for near-full pits based on modelling undertaken at several mines in Queensland and NSW.

8.8 GROUNDWATER

Ground water investigations by JBT Consulting indicate that due to partial backfilling of the voids, groundwater inflows to the final voids are expected to be negligible.

8.9 CLIMATE CHANGE IMPACTS

Climate-change adjusted SILO climate data are available from the Queensland Government Department of Environment and Science (DES), and were developed as part of the Consistent Climate Scenarios (CCS) project. The CCS project hosts data from 19 separate global climate models (GCMs), which explore four emissions scenarios, three timing horizons and three climate warming sensitivities. The nineteen separate models can be split into four Representative Future Climate (RFC) partitions, defined below:

- HI: a high level of global warming, where the Eastern Indian Ocean (EIO) warms faster than the Western Pacific Ocean (WPO);
- HP: a high level of global warming, where the WPO warms faster than the EIO;
- WI: a low level of global warming, where the EIO warms faster than the WPO; and
- WP: a low level of global warming, where the WPO warms faster than the EIO.

Figure 8.4 is an excerpt from the CCS project user guide (DSITIA, 2015) showing the four RFC quadrants, component models and indicative rainfall trends. The caption associated with the original version of this figure has been reproduced as a footnote[1].

Data based on the mean result of all models within each RFC quadrant is offered by the CCS for applications where considering the output of all 19 models is not feasible/practical. This approach has been followed for the purposes of assessing climate change sensitivity as part of current investigations. Table 8.2 and Table 8.3 list the percentage change in evaporation and rainfall respectively, based on mean output for the four RFC quadrants. Data is based on the most conservative carbon emission rate (RCP8.5) available in the CCS dataset, and expected climate as at 2070. Data has been listed for the low, medium and high sensitivities. Information is for the Gemini Project location.

The adjustments listed in Table 8.2 and Table 8.3 have been applied to the long-term SILO daily climate time-series, and passed through the AWBM rainfall runoff sub-model to produce daily estimates of runoff (rehabilitated land use AWBM parameter set used). Annual average runoff depths have been plotted against average annual net evaporation depths (evaporation minus rainfall) in Figure 8.5 to illustrate the potential to impact on long-term water levels in the Gemini Project pit lakes. Note the naming convention used in the figure, and henceforth in this document, is XX.Y where XX is the scenario (e.g. HI) and Y is the sensitivity (medium).

Figure 8.5 shows that all scenarios predict increases in net evaporation, and that all scenarios predict reductions in runoff. It is evident that all scenarios will result in lower final void water levels than the base case scenario. The sensitivity of final void water levels to changes in future climate change have been assessed by modelling all the above scenarios.

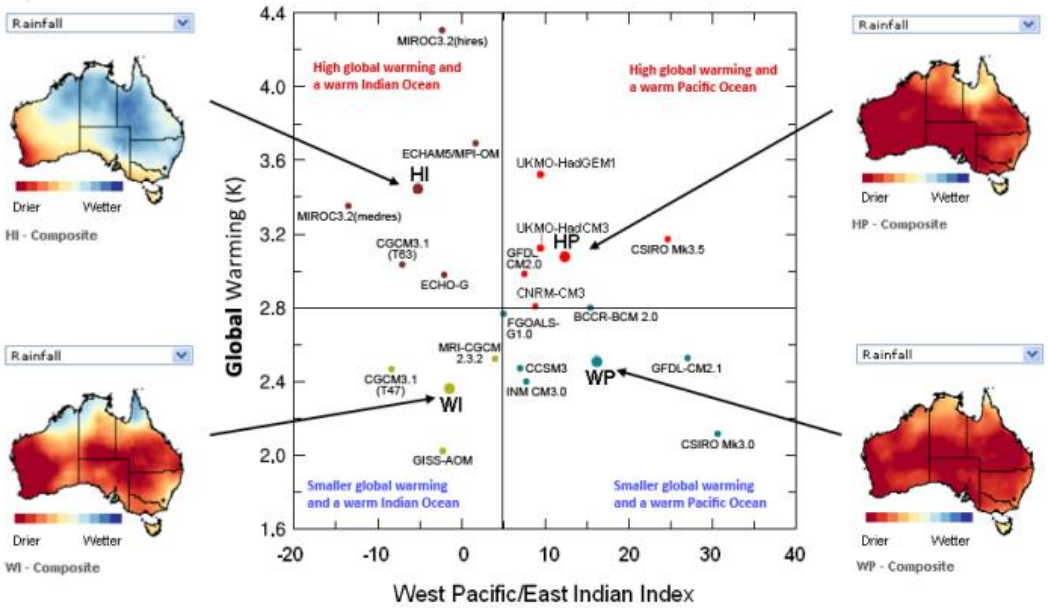


Figure 8.4 – A partition of Global Climate Models for future climate using global warming sensitivity and ocean warming indices (source: DSITIA, 2015)

[1] From DSITIA, 2015 – Figure 8.1 (verbatim): A partition of CMIP3 Global Climate Models (GCMs) for future climate using global warming sensitivity and ocean warming indices (adapted from Watterson, 2011). Values for nineteen individual GCMs (forced by the SRES A1B emissions scenario) are represented by the small dots and labelled by their GCM model code (Table 8.2). The central horizontal and vertical lines separate the four Representative Future Climate (RFC) partitions. The larger dots indicate the CCS composite means for GCMs within each of the four RFC responses: (HI) high global warming and a warmer Indian Ocean; (HP) high global warming and a warmer Pacific Ocean; (WP) lower global warming and a warmer Indian Ocean and (WP) lower global warming and a warmer Pacific Ocean. The maps show projected 21st Century changes in rainfall for the GCMs clustered in each of the four (HI, HP, WI and WP) RFC partitions.

Table 8.2 - Percentage change in evaporation by model and sensitivity

Model*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
HI (high)	16.2	18.6	21.5	15.8	12.8	10.2	8.2	9.2	14.1	14.0	20.1	11.2	13.1
HI (med)	10.0	11.5	13.3	9.8	7.8	6.0	5.0	5.6	8.8	8.8	12.6	7.0	7.5
HI (low)	5.4	6.2	7.2	5.3	4.2	3.1	2.6	2.9	4.8	4.8	6.9	3.8	3.3
HP (high)	16.9	19.2	19.3	16.6	15.8	17.2	13.8	17.1	17.2	18.1	18.4	14.9	15.3
HP (med)	10.7	12.1	12.1	10.4	9.9	10.8	8.6	10.8	10.9	11.5	11.7	9.5	9.0
HP (low)	5.9	6.6	6.6	5.7	5.4	5.9	4.7	5.9	6.0	6.3	6.5	5.3	4.2
WI (high)	15.8	18.1	14.0	10.9	8.6	11.3	12.0	10.5	13.4	9.1	11.6	11.8	10.7
WI (med)	10.0	11.3	8.7	6.7	5.2	6.9	7.4	6.4	8.4	5.6	7.2	7.4	6.0
WI (low)	5.5	6.2	4.7	3.6	2.7	3.7	4.0	3.4	4.6	3.0	4.0	4.1	2.5
WP (high)	27.7	17.9	24.4	24.0	26.2	19.2	15.6	14.1	14.5	16.7	23.4	12.7	17.8
WP (med)	17.5	11.1	15.3	15.2	16.4	11.8	9.6	8.7	9.0	10.5	14.8	7.9	10.5
WP (low)	9.6	6.0	8.4	8.4	9.0	6.3	5.2	4.7	4.9	5.8	8.1	4.3	5.0

Note: * model is RFC partition, text in brackets is the sensitivity

Table 8.3 - Percentage change in rainfall by model and sensitivity

Model*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
HI (high)	-7.3	37.8	-14.3	-55.3	66.7	-48.1	3.3	-10.7	-9.1	-9.0	-46.0	4.1	-3.6
HI (med)	-4.9	25.3	-9.6	-37.0	44.7	-32.3	2.2	-7.2	-6.1	-6.0	-30.8	2.7	-2.4
HI (low)	-2.8	14.7	-5.6	-21.5	26.0	-18.7	1.3	-4.2	-3.5	-3.5	-17.9	1.6	-1.4
HP (high)	-12.2	-6.2	4.8	-20.3	-32.2	-37.4	-14.6	-39.6	-45.5	-60.0	-46.4	-27.8	-23.9
HP (med)	-8.2	-4.1	3.2	-13.6	-21.6	-25.0	-9.8	-26.5	-30.5	-40.2	-31.1	-18.6	-16.0
HP (low)	-4.8	-2.4	1.9	-7.9	-12.5	-14.5	-5.7	-15.4	-17.7	-23.3	-18.0	-10.8	-9.3
WI (high)	-15.7	5.4	9.1	-11.5	2.7	-18.1	-3.6	-14.2	-17.2	-3.3	-21.5	-17.9	-8.4
WI (med)	-10.6	3.6	6.1	-7.7	1.8	-12.2	-2.4	-9.5	-11.6	-2.2	-14.4	-12.0	-5.6
WI (low)	-6.1	2.1	3.5	-4.5	1.0	-7.1	-1.4	-5.5	-6.7	-1.3	-8.4	-7.0	-3.3
WP (high)	-11.1	11.0	7.6	-9.3	-65.5	20.0	-6.6	21.5	-12.5	-29.5	-42.6	12.9	-6.9
WP (med)	-7.5	7.4	5.1	-6.2	-43.9	13.4	-4.4	14.4	-8.4	-19.7	-28.6	8.7	-4.6
WP (low)	-4.3	4.3	2.9	-3.6	-25.5	7.8	-2.6	8.4	-4.9	-11.5	-16.6	5.0	-2.7

Note: * model is RFC partition, text in brackets is the sensitivity

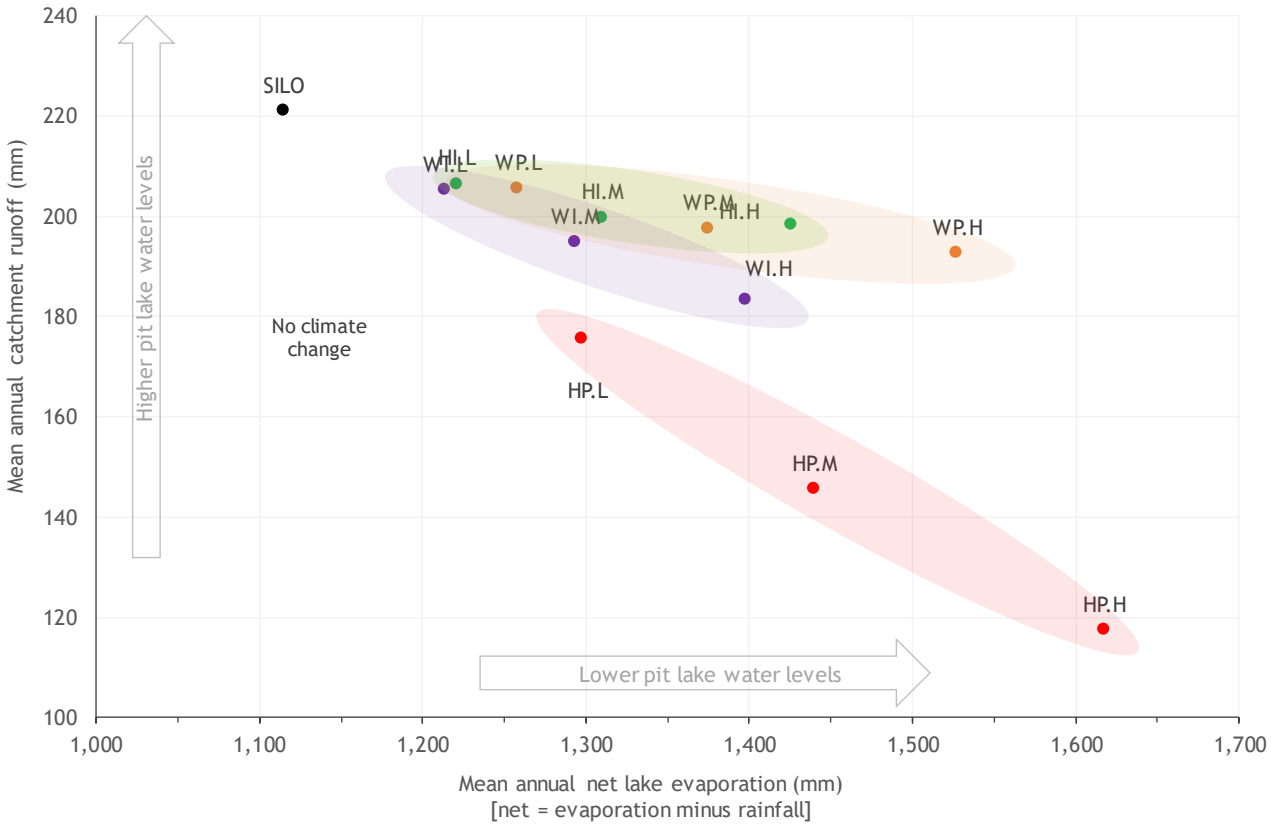


Figure 8.5 - Plot of net evaporation versus AB Pit runoff for HI, HP, WI and WP GCM groupings

8.10 LAKE SALINITY

As the void lake will not spill, and seepage into the local Permian material is expected to be minimal, salinity will rise over time as salts are transported from the local surface catchment and contained in the void. A simple conservative solute model was coupled with the lake water balance to estimate the potential lake salinity.

Water samples taken from Springton and Charlevue Creek had a median EC of 114 µS/cm, while kinetic leach column (KLC) testing of the local overburden material (RGS, 2019) showed that leachate from all KLC samples (apart from the carbonaceous siltstone and coal) had initial EC values less than 800 µS/cm, and at the end of six months less than 203 µs/cm.

While runoff salinity is therefore likely to gradually decline over time as salts are leached from the adjacent ground into runoff and seepage, for this final void assessment, runoff was conservatively assumed to have the following fixed salinities:

- Natural Runoff - 100 mg/L (equivalent to EC of approximately 150 µS/cm);
- Rehabilitation - 200 mg/L (equivalent to EC of approximately 308 µS/cm);
- Pit Runoff – 390 mg/L (equivalent to EC of approximately 600 µS/cm).

These assumptions will tend to result in the model overestimating long-term contribution of runoff to void lake salinity.

8.11 MODEL RESULTS

Figure 8.6 shows the simulated long-term water levels in the final voids. The results show the following:

For AB Pit:

- Under the existing (SILO) climate scenario - the modelled water level reaches equilibrium at around 52.9 mAHD within 50 years and generally remains at this level throughout the remainder of the simulation (fluctuating between 47.4 and 57.6 mAHD).
- The maximum modelled water level (57.6 mAHD) is around 54 m below the void overflow level of approximately 112 mAHD, and well below the potential level of groundwater seepage to the tertiary aquifer.
- Under the climate change scenarios, the equilibrium water level is lower than the existing climate scenario.

For C Pit:

- Under the existing (SILO) climate scenario - the water level reaches equilibrium at around 70.3 mAHD within 50 years and generally remains at this level throughout the remainder of the simulation (fluctuating between 66.0 and 73.5 mAHD).
- The maximum modelled water level is around 54.4 m below the void surface overflow level of approximately 128 mAHD, and well below the potential level of groundwater seepage to the tertiary aquifer.
- Under all climate change scenarios, the equilibrium water level is lower than the existing climate scenario.

Table 8.4 summarises the simulated long-term water balance for the base case scenario and the WP.M scenario, which is closest to the average of all modelled climate scenarios.

Figure 8.8 and Figure 8.9 show the results of the salt balance. Salt accumulates within both voids over time. Under the existing climate conditions scenario, the void lake salinity exceeds a TDS of 30,000 mg/L after approximately 500 years of simulation. During the first 200 years, apart from short periods when inflows are very low, and salt concentrations temporarily increase rapidly due to evaporation, lake salinities are predicted to be less than 10,000 mg/L.

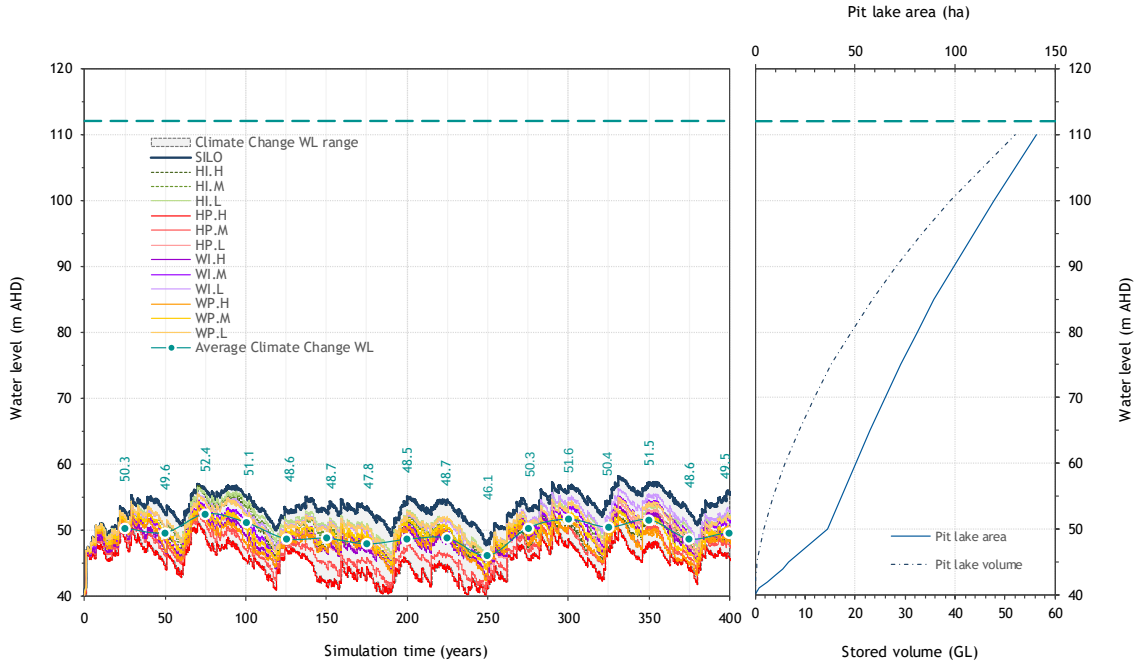


Figure 8.6 - Results of final void modelling AB Pit

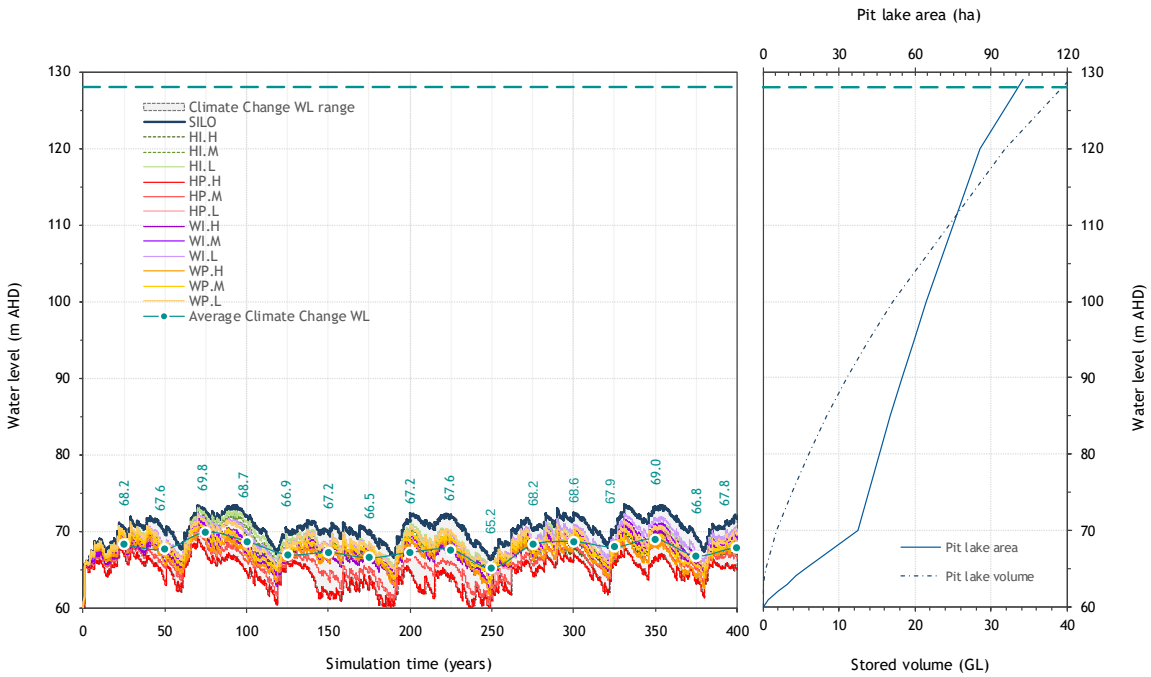


Figure 8.7 - Results of final void modelling C Pit

Table 8.4 - Average annual final void water balance - at equilibrium

		AB Pit		C Pit	
		Climate Scenario		Climate Scenario	
		EXISTING (SILO)	WP.M	EXISTING (SILO)	WP.M
Climate Averages					
Evaporation	mm/a	1,811	2,033	1,811	2,033
Rainfall	mm/a	694	656	694	656
Runoff characteristics					
Rehab runoff	mm/a	*59.9*	*52.6*	*59.9*	*52.6*
Rehab runoff/rainfall		8.6%	8.0%	8.6%	8.0%
Natural runoff	mm/a	*35.6*	*30.7*	*35.6*	*30.7*
Natural runoff/rainfall		5.1%	4.6%	5.1%	4.6%
Pit runoff	mm/a	*145.0*	*129.9*	*145.0*	*129.9*
Pit runoff/rainfall		20.9%	14.3%	20.9%	14.3%
Inflows					
Direct Rainfall	ML/a	283	202	253	176
Runoff	ML/a	156	150	127	125
GW inflow	ML/a	0	0	0	0
Outflows					
Pit evaporation	ML/a	439	352	380	301

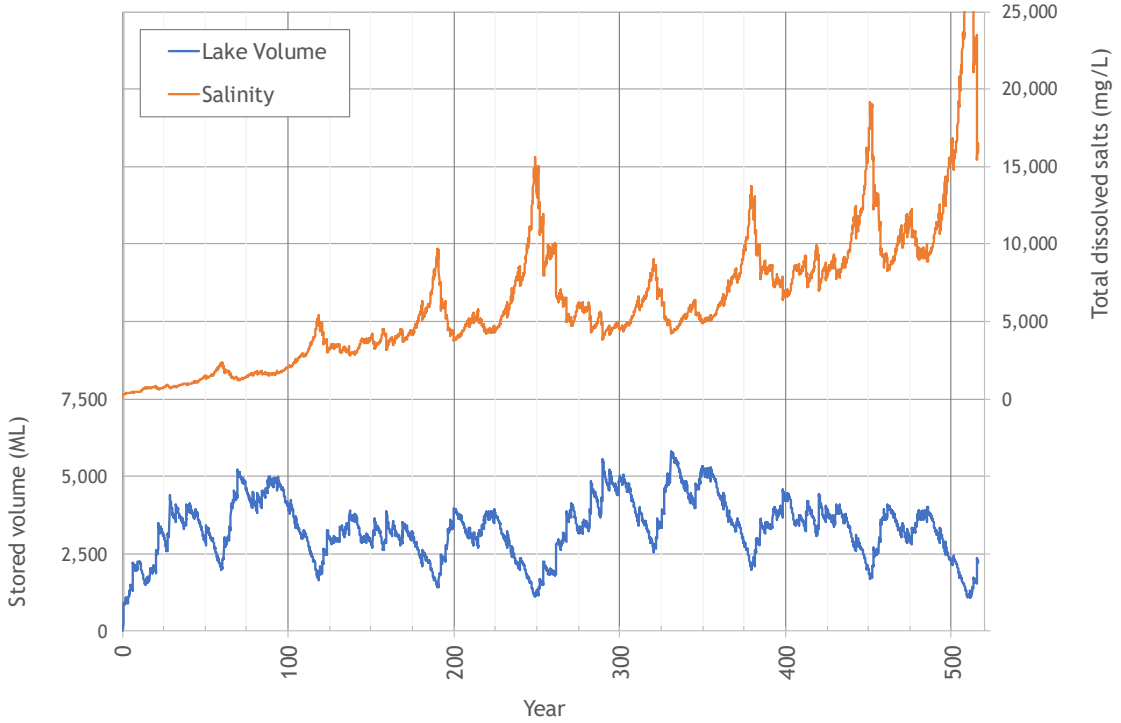


Figure 8.8 - Modelled void lake salinity - AB Pit

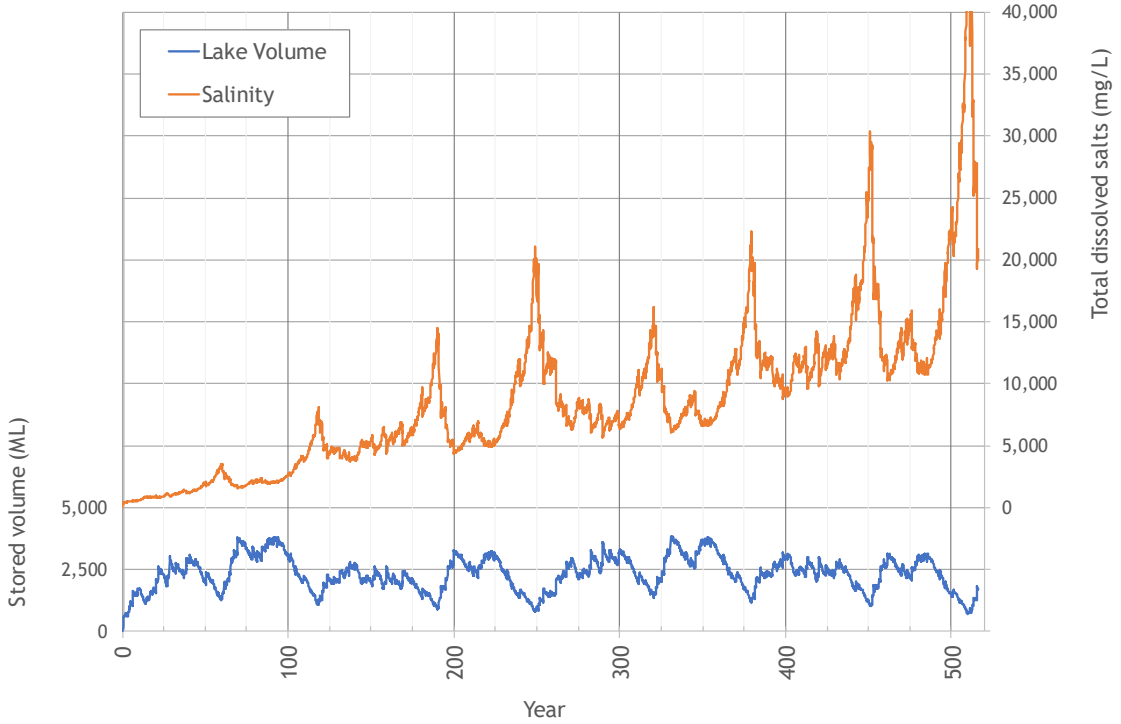


Figure 8.9 - Modelled void lake salinity - C Pit

8.12 SENSITIVITY ANALYSIS

The sensitivity of the equilibrium water level to uncertainty in the key input parameters was tested by reducing the AWBM USC values to half their original values – to increase runoff to the void.

Under these conditions, the equilibrium water level remained below:

- 63.9 mAHD at AB Pit, and
- 80.0 mAHD at C Pit.

Table 8.5 shows that under the high runoff scenario, total average inflows at equilibrium increase by approximately 26% compared to the base case, and the increase in lake water surface area results in a corresponding increase in evaporation.

Table 8.5 – Sensitivity analysis – high runoff - average annual final void water balance – at equilibrium

		C Pit	
		Sensitivity analysis	
		Base Case	High Runoff
Climate Averages			
Evaporation	mm/a	1,811	1,811
Rainfall	mm/a	694	694
Runoff characteristics			
Rehab runoff	mm/a	*59.9*	*111*
Rehab runoff/rainfall		8.6%	16.0%
Natural runoff	mm/a	*35.6*	*35.6*
Natural runoff/rainfall		5.1%	5.1%
Pit runoff	mm/a	*145.0*	*218.8*
Pit runoff/rainfall		20.9%	31.4%
Inflows			
Direct Rainfall	ML/a	253	297
Runoff	ML/a	127	183
GW inflow	ML/a	0	0
Outflows			
Pit evaporation	ML/a	380	480

9 Vulnerability to climate change during operations

The long-term effects of climate change on final void behaviour have been assessed in Section 8.

A number of potential adaptive measures have been considered to assist with resilience to climate change effects, most of which will be implemented in any case to cater for the high climatic variability experienced in the region:

- Contingency measures for directing excess inflows to the mine pit;
- Off-site water supplies of sufficient capacity to deliver the entire site water demand;
- Water efficient plant design;
- Overdesign of drainage and containment systems to cater for increased duration, frequency and intensity of rainfall due to climate change effects.

10 Potential surface water impacts and mitigation measures

10.1 OVERVIEW

The potential impacts of the Project on water resources identified in the preceding sections of the report, and proposed mitigation measures, are summarised in the following sections:

- the diversion of an unnamed tributary of Springton Creek, including changes to the channel and floodplain geometry – and resultant potential changes to stream morphology;
- impacts on the flooding regime in Charlevue Creek and Springton Creek;
- impacts on flood levels at the Capricorn Highway and the Blackwater Rail Corridor upstream of the proposed rail loop and train loadout;
- the creation of a final void lake at the completion of mining;
- short-term loss of catchment area – and subsequent reduction in streamflow in local streams due to the capture of runoff within on-site storages and the open cut pit;
- long-term reduction in streamflow in local streams due to residual loss of catchment to the final void;
- impacts on regional water availability due to the potential need to obtain water from external sources to meet construction and operational water requirements for the Project;
- adverse impacts on the quality of surface runoff draining from the disturbance areas to the various receiving waters surrounding the Project, during both construction and operation of the Project;
- adverse impacts on environmental values in the Mackenzie River catchment associated with releases from the sediment management system.

10.2 FLOODING IMPACTS

The outcomes of the flood impact assessment are as follows:

- The proposed rail loop will not impact Charlevue Creek or Springton Creek flooding.
- The Project will temporarily increase Charlevue Creek flood levels immediately upstream of the proposed haul road crossing. These impacts are contained within the mine lease area.
- There will be no impact on flood levels in the Springton Creek or Charlevue Creek at the existing Capricorn Highway, Blackwater Rail corridor, or downstream of the Project area.
- The works at AB Pit will locally increase flood levels in Springton Creek by up to 0.22 m in the 1% AEP flood. These impacts would extend off the lease area onto land owned by Magnetic South Pty Ltd, and reduce with distance downstream of the boundary.
- There will be localised off-lease impacts on flood levels in the unnamed tributary of Springton Creek immediately upstream of AB Pit and C Pit.

10.3 FINAL VOID LAKES

At mine closure, final voids will remain at each mine pit.

The floor of the AB pit will be at an elevation of approximately 40 mAHD or 72 m below the natural surface elevation (112 mAHD). The floor of the C pit will be at an elevation of approximately 60 mAHD or approximately 68 m below the natural surface elevation (128 mAHD).

Over time, the voids will fill with surface water runoff to form a lake. Based on water balance modelling:

For AB Pit:

- Under the existing (SILO) climate scenario - the modelled water level reaches equilibrium at around 52.9 mAHD within 50 years and generally remains at this level throughout the remainder of the simulation (fluctuating between 47.4 and 57.6 mAHD).
- The maximum modelled water level (57.6 mAHD) is around 54 m below the void overflow level of approximately 112 mAHD, and well below the potential level of groundwater seepage to the tertiary aquifer.
- Under the climate change scenarios, the equilibrium water level is lower than the existing climate scenario.

For C Pit:

- Under the existing (SILO) climate scenario - the water level reaches equilibrium at around 70.3 mAHD within 50 years and generally remains at this level throughout the remainder of the simulation (fluctuating between 66.0 and 73.5 mAHD).
- The maximum modelled water level is around 54.4 m below the void surface overflow level of approximately 128 mAHD, and well below the potential level of groundwater seepage to the tertiary aquifer.
- Under all climate change scenarios, the equilibrium water level is lower than the existing climate scenario.

Salt will accumulate within both voids over time. The void lake salinity is expected to exceed a TDS of 30,000 mg/L after approximately 500 years. Final void modelling suggests that during the first 200 years after closure, apart from short periods when inflows are very low, and salt concentrations temporarily increase rapidly due to evaporation, lake salinities will be less than 10,000 mg/L.

10.4 GEOMORPHOLOGICAL IMPACTS

An unnamed tributary of Springton Creek will be diverted to allow mining of the resource at both pits. This stream is not defined as a watercourse under the Water Act. Nonetheless, it is proposed that where practicable, the diversion works will be constructed to comply with the design principles set out in the Guideline: “Works that interfere with water in a watercourse – watercourse diversions”.

The proposed diversion channel would be designed to accommodate flood flows at velocities which would be non-erosive in the 1 in 100 AEP flood with appropriate channel lining.

10.5 IMPACTS ON DOWNSTREAM FLOW REGIME

During operations, the Project’s water management system will intercept runoff from disturbed areas of the mine site.

The water management system has been designed to achieve a high level of containment of mine affected water, with any overflows from the Main Water Dam directed to the mine pit. As controlled releases are not part of the proposed water management strategy for the mine affected water management system, runoff currently flowing from these parts of

the catchment to Charlevue Creek and Springton Creek will be temporarily stopped during project operations.

As overburden runoff quality is expected to be relatively benign, sediment dams will potentially discharge directly into the environment (after the settlement of suspended sediment), and as such, will not reduce downstream flows. However, sediment dams will be pumped back to the mine affected water system if water quality monitoring shows the water is unsuitable for release. As shown in Table 10.1, the maximum captured catchment areas represent:

- 1.0% of Charlevue Creek catchment upstream of the Springton Creek confluence;
- 3.6% of Springton Creek catchment upstream of the Charlevue Creek confluenc; and
- 2.3% of Springton Creek catchment downstream of the Charlevue Creek confluence.

Table 10.1 - Catchment excised by site water management system at Year 18

Description	Charlevue Creek	Springton Creek	Total
Total Intercepted in MW System (ha)	336.9	1,174.9	
To confluence (U/S) (ha)	32,243	32,497	
	1.0%	3.6%	
Downstream of confluence (ha)		2.3%	64,740

After mine closure, the water management system will be decommissioned but there will be some residual impact on streamflow due to drainage to the final voids. As shown in Table 10.2, the maximum captured catchment areas represent:

- 0.03% of Charlevue Creek catchment upstream of the Springton Creek confluence;
- 1.1% of Springton Creek catchment upstream of the Charlevue Creek confluence; and
- 0.6% of Springton Creek catchment downstream of the Charlevue Creek confluence.

Table 10.2 - Catchment excised by site water management system at mine closure

Description	Charlevue Creek	Springton Creek	Total
Total Intercepted in Final Void (ha)	10.0	345.0	
To confluence (U/S) (ha)	32,243	32,497	
	0.03%	1.1%	
Downstream of confluence (ha)		0.6%	64,740

10.6 IMPACTS ON RECEIVING WATER QUALITY

The potential impacts on receiving water quality will be managed by the site water management system.

To avoid significant downstream impacts, the system has been designed to achieve a high level of containment without the need for controlled releases, as the opportunities to release mine water are likely to be very limited. However, should water quality allow, water may be released to Charlevue Creek in accordance with Environmental Authority conditions consistent with the "*Model water conditions for coal mines in the Fitzroy basin*".

Any unplanned overflows from the Mine Water Dam, would overflow to the mine pit. The only potential mine water release points are the MIA Dam spillways. However, these dams will be operated in such a way that the risk of release is small.

Runoff from overburden dumps will be managed under an erosion and sediment control plan to reduce sediment loads to background levels before release. Water would be discharged either via sediment dam spillways or perforated riser pipes.

10.6.1 Seepage

There is some potential for seepage of water from the Mine Water Dam to Charlevue Creek. The dam will be designed with a floor and sides of material that will limit seepage to avoid environmental harm.

10.7 CUMULATIVE IMPACTS

The only known existing coal mine within the Springton Creek catchment is the recently commenced Bluff Coal Mine. The Walton Coal Project is also proposed within the catchment. These two projects are of relatively small scale and short life. The potential cumulative impacts of the two projects are discussed in the following sections.

10.7.1 Regional water availability

The water balance model shows that (due to the relatively low water requirements of the coal preparation plant) the mine site water requirements of the Gemini Project can largely be sourced from water collected within the site water management system.

Shortfalls in water supply for both the Walton Coal Mine and the Bluff Coal Mine are to be supplied with mine water from the Jellinbah Mine. As a result, the potential cumulative impacts of mine projects on water availability in the catchment of Springton Creek is limited to the effect of cumulative catchment excision by the two projects.

Based on catchment information presented in the Bluff Coal Mine EIS, the cumulative impact of the projects on flows in Springton Creek will be minimal.

10.7.2 Controlled releases

Mine affected water from the Project will be managed through a mine water management system which is designed to achieve full containment of mine water under historical conditions. The water management plans for the other project are similarly designed for the complete containment of mine water. Releases would only occur in accordance with Environmental Authority conditions consistent with the "*Model water conditions for coal mines in the Fitzroy basin*".

Releases from sediment dams are authorised under the EA if an ESCP is appropriately implemented. Water releases from both projects would only be allowed from the sediment water system if water quality meets the sediment dam release criteria to be set in the Environmental Authority.

If operated in accordance with the EA, the impact of releases from the projects on water quality in the regional catchment systems would be minimal.

11 Water monitoring

11.1 RECEVING WATER MONITORING

A Receiving Environment Monitoring Plan (REMP) will be developed for the Project in accordance with the model mining conditions. The REMP would be implemented to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity.

Water quality monitoring will be undertaken upstream and downstream of the project to detect downstream water quality impacts and to demonstrate compliance with the Environmental Authority release conditions. The proposed receiving water monitoring points are listed in Table 11.1 and shown in Figure 11.1. Locations have been chosen so that the sites are unaffected by the project operations but are accessible during wet weather.

Water quality will be monitored for the 'standard' suite water quality parameters included in the Model Water Conditions for coal mines in the Fitzroy basin - but not limited to, pH, EC, major anions (sulfate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS and a broad suite of soluble metals/ metalloids.

Water quality monitoring will be compliant with the National Water Quality Management Strategy. Samples will be collected monthly or during each flow event, where possible. Continuous water level, salinity, turbidity and pH monitoring equipment will be installed at the downstream stations.

Table 11.1 – Receiving water monitoring points

Description	Latitude (deg)	Longitude (deg)
Springton Creek US	-23.6976	149.2738
Springton Creek DS	-23.6434	149.3145
Charlevue Creek US	-23.6305	149.2715
Charlevue Creek DS	-23.6469	149.2104

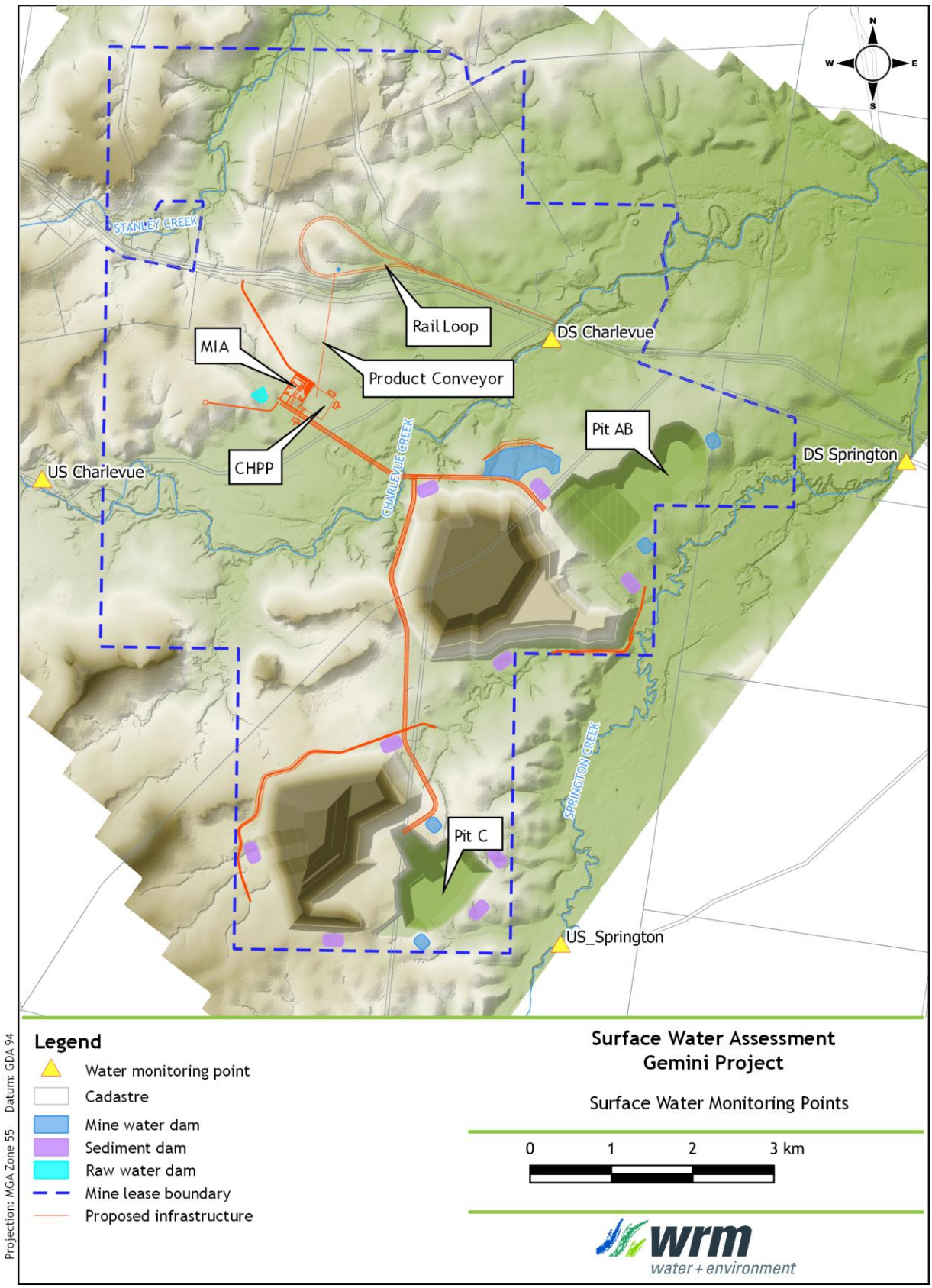


Figure 11.1 - Proposed upstream and downstream receiving water monitoring points

11.2 MINE WATER SYSTEM MONITORING

An onsite water monitoring system will also be used to validate system performance against the design assumptions in terms of water quality and water quantity, so that an adaptive management can be implemented to protect the surface water environment.

11.2.1 Mine affected water dam monitoring

Surface runoff and seepage water collected in the Mine Water Dam and Process Water Dam will be monitored for 'standard' water quality parameters including, but not limited to, pH, EC, major anions (sulphate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS and a broad suite of soluble metals/metalloids.

11.2.2 Spoil and sediment dam monitoring

Validation testwork will be undertaken on potential spoil materials as the Project develops to enable appropriate spoil management measures to be planned and implemented as required.

Some spoil materials may be sodic with potential for dispersion and erosion. Where highly sodic and/or dispersive spoil is identified, this material would not be placed in final landform surfaces and would not be used in construction activities. Regardless of the spoil type, especially where engineering or geotechnical stability is required, testing would be undertaken during construction to determine the propensity of such materials to erode.

Surface runoff and seepage from spoil piles, including any rehabilitated areas, would be monitored for 'standard' water quality parameters including, but not limited to, pH, EC, major anions (sulfate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS and a broad suite of soluble metals/ metalloids.

The sediment dam monitoring would be used to validate the anticipated quality of water runoff reporting to sediment dams and haul road runoff dams. Initially, the sediment dam monitoring would occur on a regular (e.g. monthly) basis to demonstrate the water quality of stored waters is consistent with the relevant operating parameters to allow releases from sediment dams to occur when required. Subject to demonstrating the water quality objectives can be met, the frequency of monitoring and suite of parameters for the sediment dam monitoring would be reviewed and updated accordingly (e.g. to occur only when releases occur).

12 References

AARC, 2019 — *Gemini Project Aquatic Ecology Report* prepared for Magnetic South by aarc environmental solutions, September 2019

DEHP, 2017 — *Guideline Stormwater and environmentally relevant activities Department of Environment and Heritage Protection ESR/2015/1653* • Version 1.02 • Effective: 17 FEB 2014 1.02 3-Jul-17 https://environment.des.qld.gov.au/assets/documents/regulation/pr-gl-stormwater-guideline-era.pdf

JBT, 2019 — *Gemini Project- Groundwater Assessment* - JBT Consulting Pty Ltd, September 2019

RGS, 2018 — *Dingo West Coal Project Geochemical Assessment of Mining Waste Materials* – Report prepared for Magnetic South Pty Ltd, 19 March 2018

Appendix A Flood impact assessment

A1 Introduction

A1.1 PROJECT OVERVIEW

The Gemini Project is a proposed open cut coal mine in the Fitzroy Basin. The proposed mine development site is located approximately 7.6 km west from the town of Dingo and 19.4 km southeast of Bluff. The two main regional centres are Emerald, 110 km west of the site and Rockhampton, 134 km east of the Project area.

The mine development schedules are expected to include two open cut pits, AB Pit and C Pit (Figure A.3). AB Pit will disturb an area of 694 ha within the mining lease application areas and C Pit will have a 465 ha disturbance area. Additional disturbance areas include sediment and mine water dams, a mine industrial area (MIA), a coal handling processing plant (CHPP), a conveyor, a dedicated rail loop, train load out (TLO) and mine roads interconnecting this infrastructure.

The proposed mine lease area is crossed by two main drainage paths flowing in a northeasterly direction. The northern stream is Charlevue Creek and the southern stream is Springton Creek, where Charlevue Creek joins the Springton Creek 5.2 km northeast of Dingo.

A1.2 SCOPE OF THIS STUDY

A1.2.1 Study objectives

This report presents the methodology and results of hydrologic and hydraulic modelling undertaken to assess the impacts of the Gemini Project on flood behaviour in the reaches of Charlevue Creek and Springton Creek crossing the Project area. The modelling results define the existing flood conditions, as well as conditions during operation of the Project. The key outcomes of the study are to:

- Define existing flood conditions across the Project area for a range of design flood events, in terms of peak water levels and peak velocities;
- Assess peak water levels and velocities along the levees proposed to protect the proposed mine areas from flooding;
- Determine the impacts of the proposed Project during project operations;
- Assess the long-term flood conditions in events up to the probable maximum floodi and the residual impacts of the Project following mine closure.

As the flood investigations detailed in this report have been specifically undertaken for the purpose of impact assessment, the results presented herein should not be used for any other purpose without seeking advice from WRM regarding their applicability.

A2 Estimation of design discharges

A2.1 METHODOLOGY

The XP-RAFTS runoff-routing model (XP Software, Version 2018.1.2) was used to estimate design discharges for the Charlevue Creek and Springton Creek catchments. In the absence of suitable stream gauge data, the peak discharges estimated by the XP-RAFTS model were validated against the Rational Method and Regional Flood Frequency Estimation (RFFE) estimates.

The validated XP-RAFTS model was used to estimate design discharges based on design rainfall and temporal pattern data developed using AR&R 2016 methodology (Ball et al, 2016). Design discharge hydrographs were estimated for the 50%, 10%, 2%, 1% and 0.1% annual exceedance probability (AEP) design discharges as well as the probable maximum flood (PMF) design discharge.

A2.2 XP-RAFTS MODEL CONFIGURATION

A2.2.1 Spatial configuration

Figure A.1 shows the XP-RAFTS model configuration adopted in the vicinity of the Project area. The hydrologic model includes both Charlevue Creek catchment and Springton Creek catchment to 4 km downstream of the confluence of Charlevue Creek and Springton Creek. The combined catchment has a total area of 680.5 km^2, consisting of 43 sub-catchments.

A2.2.2 Sub-catchment parameters

The XP-RAFTS model uses a single sub-catchment approach to determine runoff hydrographs, based on the overall sub-catchment parameters (fraction impervious, roughness and slope). Sub-catchment fraction impervious and roughness (Manning's 'n') parameters were weighted based on the various land use types in each sub-catchment based on available topographic data and aerial photographs.

Table A.9 presents the adopted sub-catchment parameters including catchment area, percentage impervious, catchment slope and PERN 'n' catchment roughness coefficients.

Model parameters for each sub-catchment were determined as follows:

- A percentage impervious of zero was adopted for all sub-catchments;
- Catchment slopes were determined based on the available topographic data;
- A sub-catchment storage coefficient multiplication factor 'Bx' of 1.0 was adopted for all events;
- Sub-catchment PERN 'n' values were determined based on the density of vegetation in each sub-catchment. The adopted sub-catchment PERN 'n' value was 0.05 for sub-catchments with largely bushland areas; and
- Initial (IL) and continuing (CL) losses for the validation events were determined based on the recommended AR&R 2016 data hub parameter. The selection of initial and continuing losses for design events is described in Section A2.6.

A2.2.3 Routing parameters

Channel routing in the XP-RAFTS model was configured based on specifying a 'K' and 'X' value for each routing link. An 'X' value of 0.25 was adopted for all routing links. The 'K' values represent estimated flow travel times (in hours) and were calculated based on the flow path lengths and an assumed conservative flow velocity of 1 m/s.

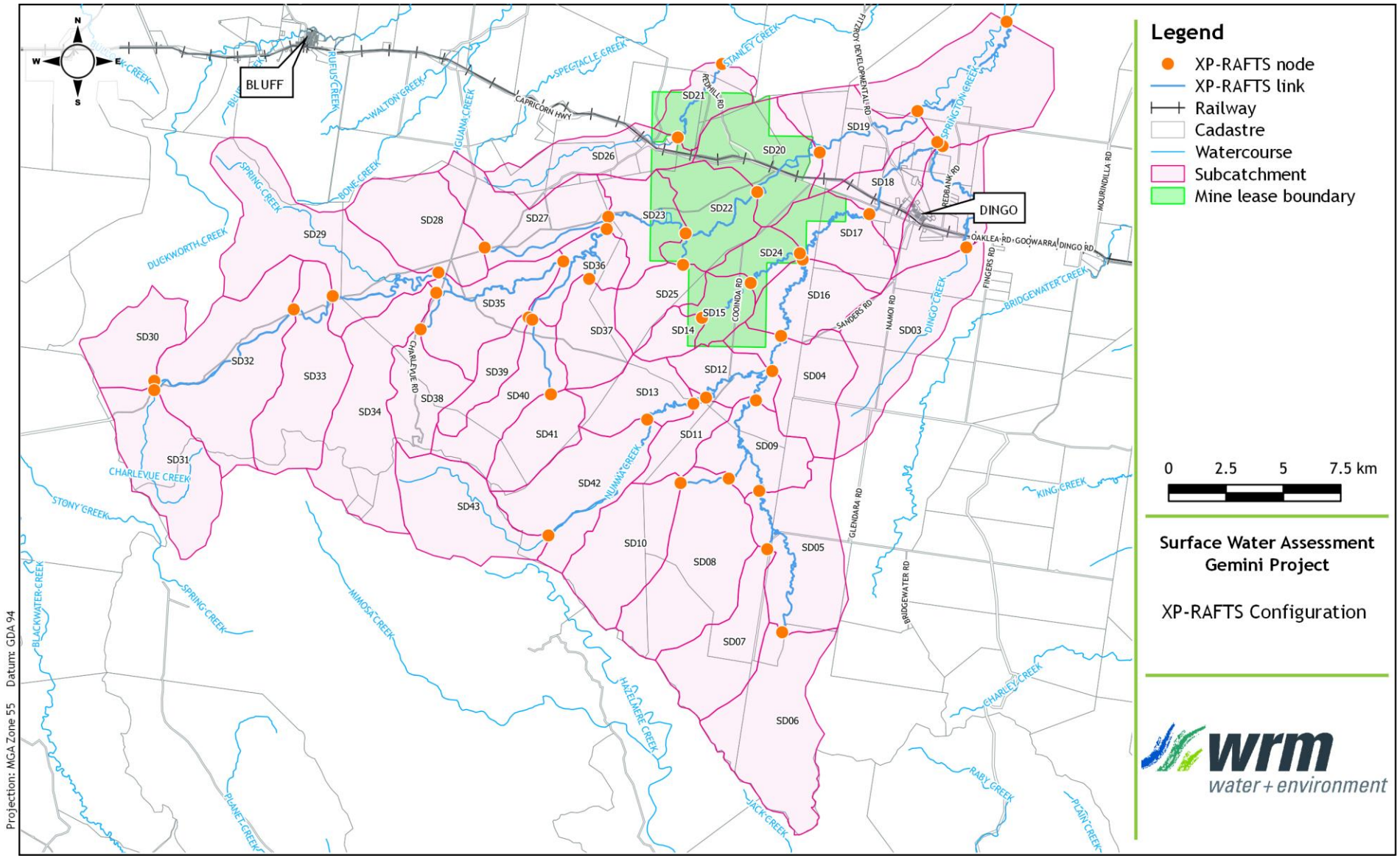


Figure A.1 – XP-RAFTS model configuration

A2.3 DESIGN RAINFALL DEPTH

A2.3.1 50% to 0.1% AEP design events

Design rainfall depths and intensities were derived using intensity-frequency duration (IFD) data obtained from the Bureau of Meteorology's (BoM's) 2016 Rainfall IFD Data System. Design rainfall IFDs were obtained based on the centroid point location at the combined Charlevue Creek and Springton Creek catchment.

A2.3.2 Probable maximum flood design event

PMP rainfall depths for durations up to 6 hours were estimated using the methodology given in *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method (GSDM)* (BoM, 2003).

PMF rainfall depths for durations longer than 6 hours were estimated using the standard methodology given in *The Estimation of Probable Maximum Precipitation: Generalised Tropical Storm Method Revised (GTSMR)* (BoM, 2006).

The followings parameters were adopted:

- For GSDM:
  - The terrain was assumed to be 100% rough, S = 0;
  - Elevation Adjustment Factor, EAF = 1;
  - Moisture Adjustment Factor, MAF = 0.85.
- For GTSMR:
  - Located in the coastal zone;
  - Annual Moisture Adjustment Factor, AMAF = 0.75;
  - Winter Moisture Adjustment Factor, WMAF = 0.78;
  - Decay Amplitude Factor, DAF = 1.0;
  - Topographical Adjustment Factor, TAF = 1.13.

Note that aerial reduction factors are already applied to the PMP rainfalls due to the catchment area being incorporated into the PMP rainfall estimation methodology.

A2.4 AREAL REDUCTION FACTORS

The areal reduction factor was obtained from the ARR data hub and has been applied based on the combined catchment size in the model for design events up to 0.1% AEP.

A2.5 TEMPORAL PATTERNS

A2.5.1 50% to 0.1% AEP design events

Temporal patterns were obtained from the AR&R 2016 data hub based on the centroid of the combined Charlevue Creek and Springton Creek catchment. The AR&R 2016 temporal pattern methodology involves the use of an 'ensemble' of 10 temporal patterns, which produces 10 design hydrographs (and peak discharges) for each duration for each AEP. For each location and AEP, the storm duration with the highest median peak design discharge of the ensemble is selected and the temporal pattern that produces the peak design discharge just above the ensemble median is adopted.

A2.5.2 Probable maximum flood design event

The temporal patterns for storm durations up to and including 12 hours were obtained from the GSDM methodology (BoM, 2003). Temporal patterns for durations longer than 12 hours were obtained for Coastal Zone storms from the GTSMR methodology (BoM, 2006).

A2.6 DESIGN RAINFALL LOSSES

For design events up to 0.1% AEP, an initial loss (IL) of 42 mm and continuing losses (CL) of 2.0 mm/hr were adopted for this assessment based on the AR&R 2016 data hub report. An IL of 0 mm and CL of 1 mm/hr were used for PMP design event.

The incorporation of pre-burst depths specified in AR&R 2016 data hub is achieved by applying median depth values (ratio multiplied by initial loss) at an initial timestep for each event duration. Table A.1 shows the adopted median pre-burst and depth ratio values used in calculating design rainfall continuing losses.

Table A.1 – Median pre-burst depths (mm) and ratios

Duration min (hours)	50% AEP	2% AEP	1% AEP
60 (1.0)	0.4 (0.012)	5.5 (0.070)	6.5 (0.074)
90 (1.5)	0.1 (0.003)	4.1 (0.046)	6.1 (0.061)
120 (2.0)	0.0 (0.001)	5.3 (0.054)	7.7 (0.069)
180 (3.0)	0.5 (0.011)	6.8 (0.062)	9.4 (0.076)
360 (6.0)	0.0 (0.000)	14.5 (0.108)	23.4 (0.153)
720 (12.0)	0.0 (0.000)	17.4 (0.104)	27.5 (0.143)
1080 (18.0)	0.0 (0.000)	17.6 (0.092)	27.8 (0.126)
1440 (24.0)	0.0 (0.000)	12.2 (0.058)	20.8 (0.085)
2160 (36.0)	0.0 (0.000)	10.6 (0.043)	18.5 (0.065)
2880 (48.0)	0.0 (0.000)	3.1 (0.011)	5.4 (0.017)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

A2.7 MODEL VALIDATION

The peak design discharges produced by the XP-RAFTS model were validated against the Rational Method and Regional Flood Frequency Estimation (RFFE) estimates.

A2.7.1 Rational method

The Rational Method was applied to a number of sub-catchments with areas less than 25 km^2.

Table A.2 compares the Rational Method results and XP-RAFTS peak discharges estimates at 4 sub-catchment outflow locations. The time of concentration was calculated using the Modified Friend's equation with no overland flow component.

The outflow locations used in the Rational Method calculation correspond to the XP-RAFTS nodes of SD02, SD15, SD21 and SD24. The Rational Method 1% AEP peak design discharges at these nodes are ranged between 13.8 m^3/s and 34.8 m^3/s. The estimated XP-RAFTS model discharges match the estimated Rational Method discharges well (within 10%) for sub-catchment SD15 and SD24, while the XP-RAFTS model gives a larger discharge compared to the RM estimates at sub-catchments SD02 and SD21.

Table A.2 – Comparison of Rational Method and XP-RAFTS model design discharges

Design event	Sub-catchment	Rational Method	XP-RAFTS	Difference
1% AEP	SD02	23.0	34.8	34%
	SD15	13.7	14.5	6%
	SD21	16.0	20.4	21%
	SD24	12.8	13.8	7 %

A2.7.2 RFFE estimates

The RFFE method was applied to the combined Charlevue Creek & Springton Creek catchment. Figure A.2 and Table A.3 show comparisons between RFFE estimates and XP-RAFTS model results. Design discharges obtained using XP-RAFTS match the RFFE estimates well (within +/-30%) for all design events.

The calibrated XP-RAFTS model was used to derive flood discharge hydrographs for use in the hydraulic model.

Table A.3 – Comparison of RFFE and XP-RAFTS model design discharges

AEP	Adopted XP-RAFTS design discharge (m^3/s)	RFFE discharge (m^3/s)			Difference
		Lower 5% confidence limit	Expected parameter quantile	Upper 95% confidence limit	
50%	180	57	149	391	17.1%
20%	-	137	345	877	
10%	604	199	544	1,480	10.0%
5%	-	262	798	2,420	
2%	1,061	345	1,240	4,410	-16.8%
1%	1,316	411	1,680	6,740	-27.6%

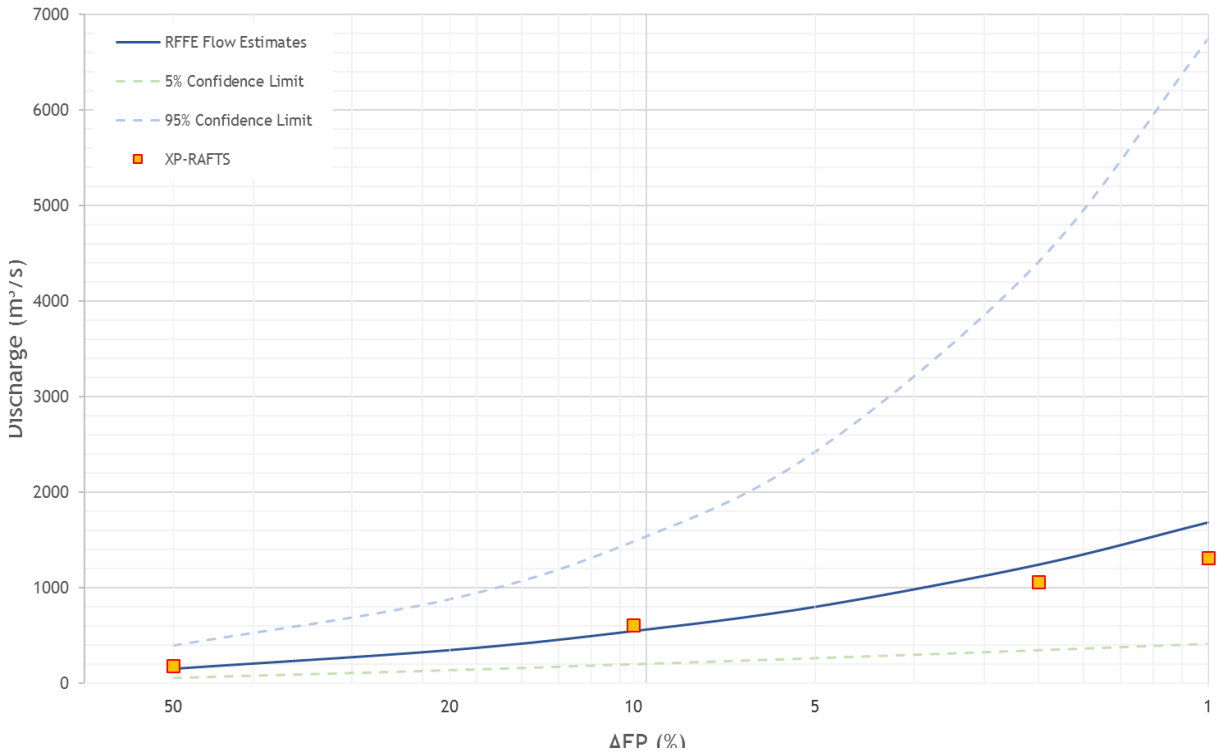


Figure A.2 - Comparison of RFFE and XP-RAFTS design discharges

A2.8 ADOPTED DESIGN DISCHARGES

Design discharges were estimated in accordance with AR&R 2016 guidelines for the 50% (1 in 2), 2% (1 in 50), 1% (1 in 100) and 0.1% (1 in 1,000) AEP events as well as the probable maximum flood (PMF) event.

Table A.4 shows XP-RAFTS predicted design peak discharges and relevant critical storm durations and temporal patterns for all modelled design events at the outlet (SD01) of the combined Charlevue Creek & Springton Creek catchment.

The design discharge hydrographs from the XP-RAFTS model were adopted as inflows to the TUFLOW hydraulic model.

Table A.4 - XP-RAFTS design discharges and critical durations at the outlet (SD01) of the combined Charlevue Creek & Springton Creek catchment

AEP	Combined Charlevue Creek & Springton Creek catchment		
	XP-RAFTS discharge (m^3/s)	Critical duration (hours)	Corresponding Temporal Pattern
50%	180	24	10
10%	604	24	10
2%	1,061	24	6
1%	1,316	24	2
0.1%	2,384	24	9
PMF	12,952	24	-

A3 Hydraulic modelling

A3.1 OVERVIEW

The TUFLOW hydrodynamic model (BMT WBM, 2016) was used to estimate flood extents and depths along the channel and floodplain of Charlevue Creek and Springton Creek and their tributaries for a range of design events. TUFLOW represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. The model automatically identifies breakout points and flow directions within the study area. All hydraulic modelling was undertaken using the TUFLOW Build 2018-03-AD HPC solver.

Figure A.3 shows the TUFLOW model boundary. The model covers an area of approximately 139.4 km^2 where the Project area is bounded by Charlevue Creek to the north and Springton Creek to the south.

The TUFLOW model was configured using a grid cell size of 5 metres. This provides a reasonable compromise between a coarse grid cell size sufficient for Charlevue Creek and Springton Creek, and a fine enough grid cell size required for the tributaries crossing the Project area.

A3.2 EXISTING CONDITIONS TUFLOW MODEL CONFIGURATION

A3.2.1 Topography

Topographic LiDAR survey data covering the majority of TUFLOW model area (purple region in Figure A.3) was provided by Magnetic South Pty Ltd.

Additional LiDAR data covering the area to the northeast near Dingo (green region in Figure A.3), was obtained from the Foundation Spatial Data Framework – Elevation and Depth portal (http://elevation.fsdf.org.au/) (referred to as ELVIS). The ELVIS LiDAR data is available on a 1 m grid and was acquired in 2012.

Hydrologically-enforced SRTM (Shuttle Radar Topography Mission) lidar data was used to cover an upstream portion of the Springton Creek floodplain (red region in Figure A.3). This data is available on a 30m grid, with a vertical accuracy of +/- 9.8 m. The SRTM was modified to better match the LiDAR at the boundary by lowering it by 1.8 m and applying a z-shape to smooth the transition between (geometry reinforcement in Figure A.4).

The combined data was converted into a digital elevation model (DEM) for use as the base TUFLOW model topography.

A3.2.2 Hydraulic roughness

Hydraulic roughness in the TUFLOW model is represented by Manning's 'n' roughness coefficients. Manning's 'n' values for the various land use types were selected based on typical published values. Land use types within the existing conditions model were identified using aerial photography.

Table A.5 shows the adopted Manning's 'n' values used in the model and Figure A.5 shows the locations of the Manning's 'n regions.

Table A.5 – Adopted hydraulic roughness Manning's 'n' values

Area	Manning's 'n'
Dense riparian vegetation	0.060
Creek / river channel	0.050
Pasture	0.035

A3.2.3 Inflow and outflow boundaries

Figure A.4 shows the locations of inflow and outflow boundaries in the TUFLOW model. The model includes a total of 16 inflow boundaries. The model inflow boundaries were applied within the 2D model domain using surface-area "SA" polygons. Using this approach, flows are initially applied to the lowest point within each SA polygon. Design discharge hydrographs for these inflow boundaries were obtained from the XP-RAFTS hydrologic model.

A3.2.4 Tailwater conditions

The downstream boundary was set to minimise its influence on predicted flood behaviour. Flood slopes between 0.1% and 0.15% were adopted for the Springton Creek outlet in northeast of the Project area. A 0.4% bed slope was applied for the model outlet at Stanley Creek north of the Project area.

A3.2.5 Hydraulic structures

Bridges and culverts within the Project area have been surveyed and modelled in the TUFLOW hydraulic model. Culverts are treated as 1D networks and bridges are modelled as 2D layered flow constrictions, with points snapped onto the lines to represent the road/rail elevation.

Under existing conditions, a total number of 4 culverts were modelled, two located on the east of Charlevue Creek and two located on the west of Charlevue Creek. Two bridges were modelled (Figure A.4). Both bridges are located on the Capricorn Highway, one across Springton Creek and one across Charlevue Creek. An 800 mm thick slab and 500 mm height guard rails were adopted for both bridges.

Table A.6 and Table A.7 provide summary information on the existing culverts and bridges located under Capricorn Highway and Blackwater railway line embankments included in the model.

Table A.6 – Culvert details

Name	Road/ Rail Crossing	Dimension	IL U\S (mAHD)	IL D\S (mAHD)
SM02_a	Capricorn Hwy	3 x 0.75h*1.2w RCBC	114.06	113.53
SM02_b	Blackwater Rly	12 x 1.65m RCPs	113.90	113.63
SM04_a	Capricorn Hwy	9 x 0.75h*1.2w RCBC	113.66	113.31
SM04_b	Blackwater Rly	10 x 1.38m RCPs	113.77	113.68

[a] – RCP = reinforced concrete pipe, RCBC = concrete box culvert

Table A.7 – Bridge details

Name	Road/Rail Crossing	U/S Invert (mAHD)	D/S invert (mAHD)
BRD01	Capricorn Hwy/ Springton Creek	106.85	106.90
BRD03	Capricorn Hwy/ Charlevue Creek	114.90	114.90

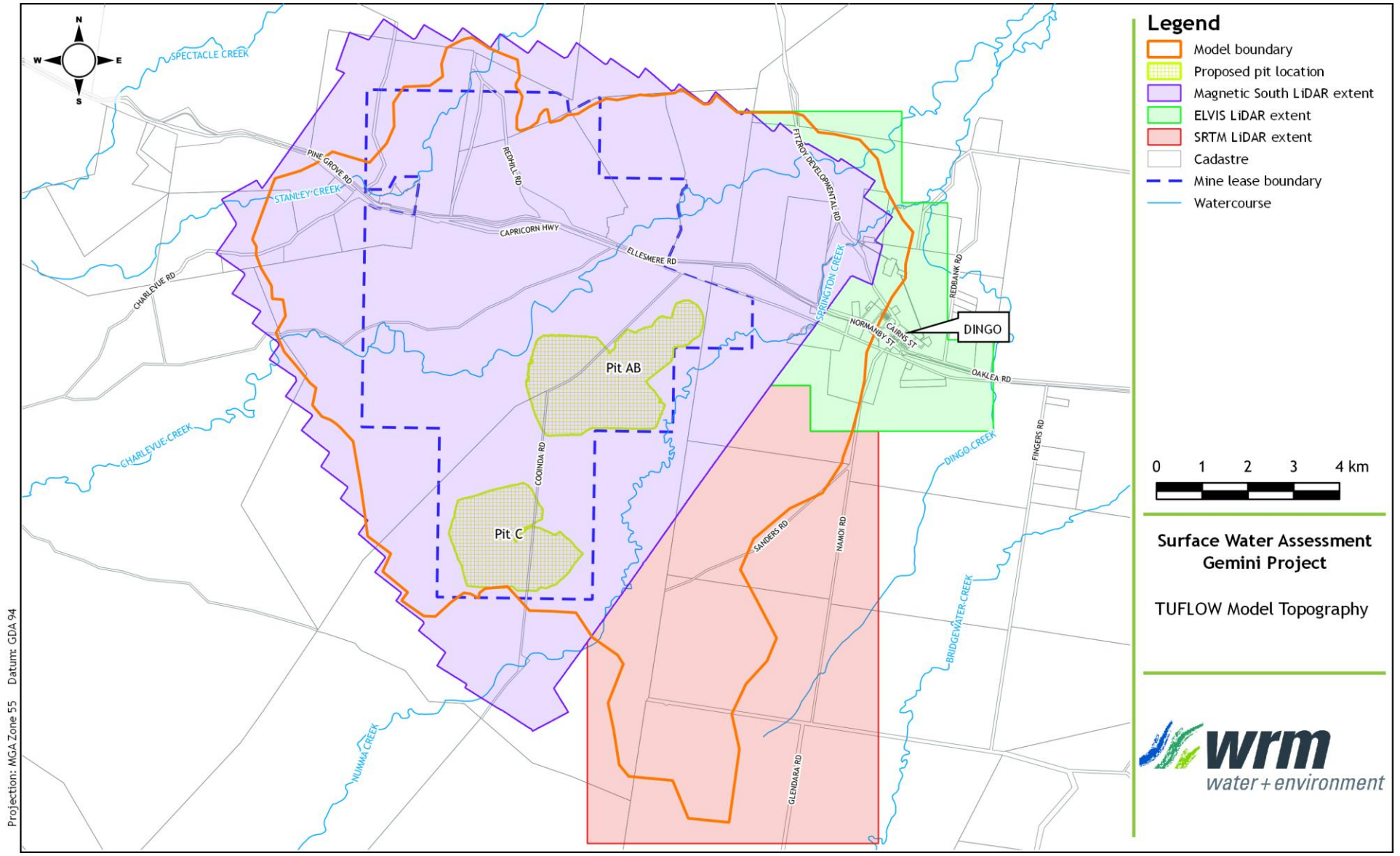


Figure A.3 – TUFLOW model topography

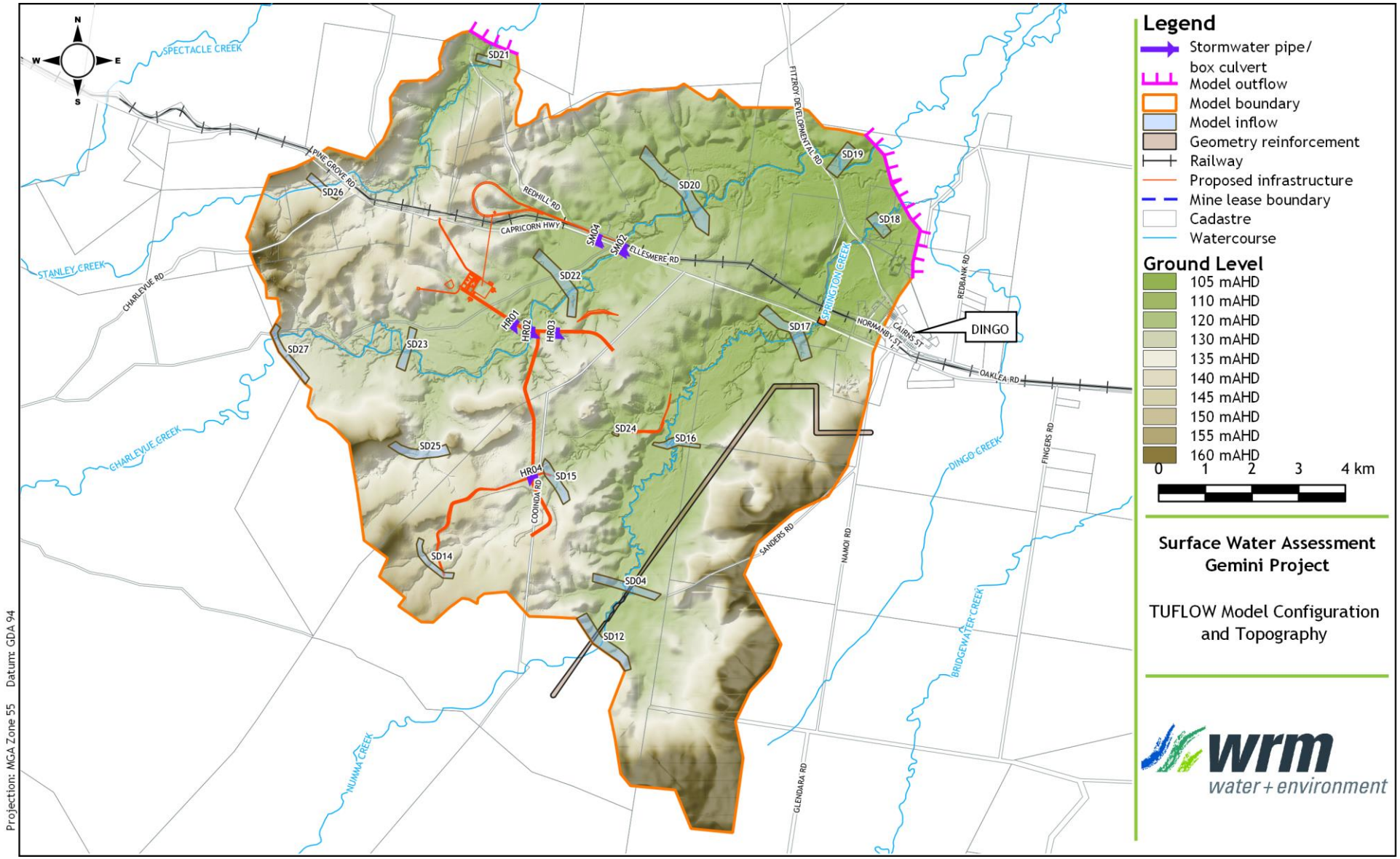


Figure A.4 – TUFLOW model configuration

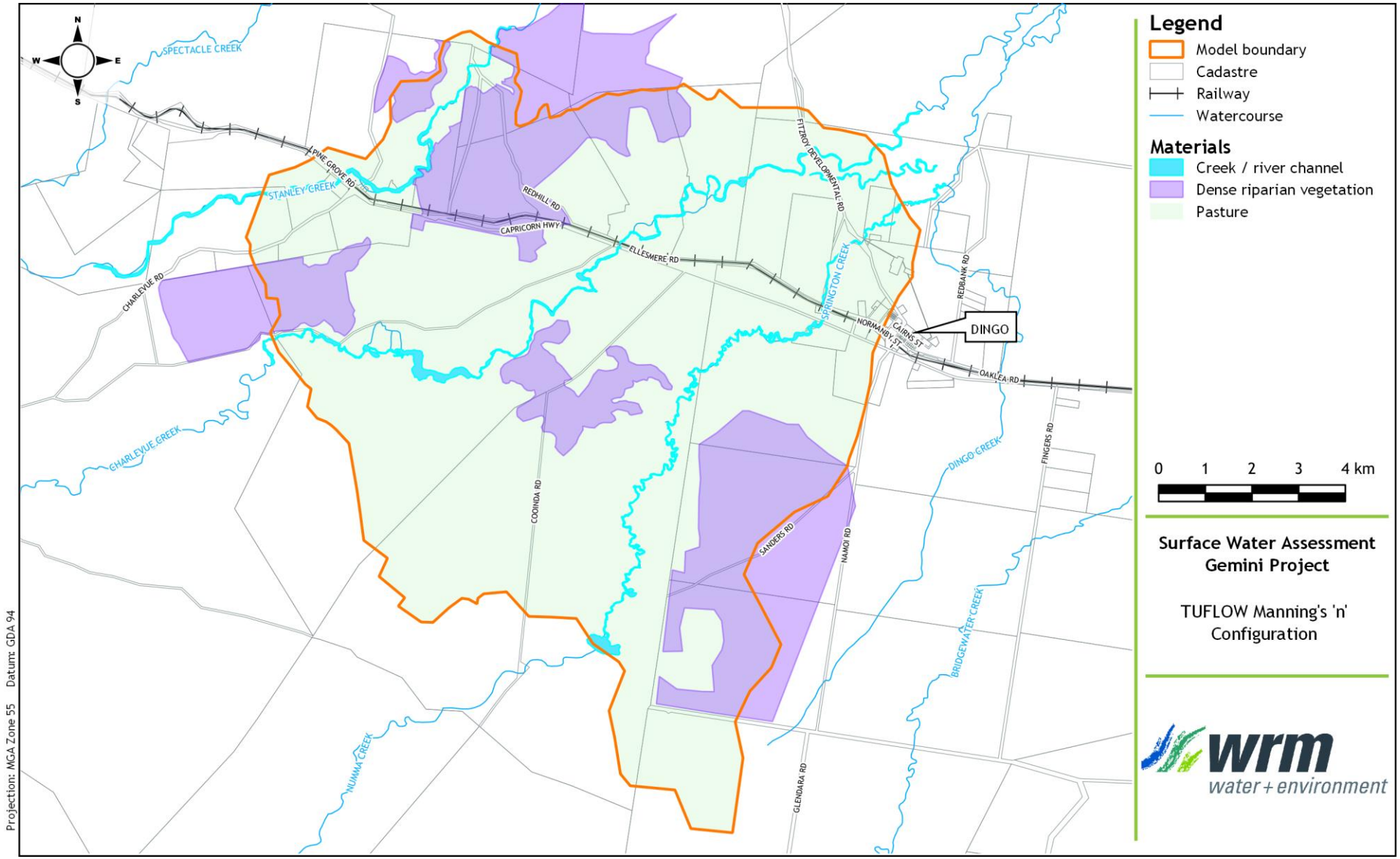


Figure A.5 – Manning's 'n' configuration

A3.3 DEVELOPED CONDITIONS TUFLOW MODEL

A3.3.1 Topography

A number of changes were made to the model DEM to reflect changes associated with:

- proposed overburden dumps and pit protection levees;
- haul roads connecting the two mining pits to the MIA and CHPP;
- diversion channels for the minor tributary of Springton Creek crossing the mine area.

The locations of these proposed structures are shown in Figure A.4.

A3.3.2 Hydraulic roughness

Land use types within the developed conditions model were identical to those defined for the existing conditions model.

A3.3.3 Inflow and outflow conditions

No changes to the existing conditions inflow and outflow locations were made.

A3.3.4 Hydraulic structures

Additional culverts under the proposed haul roads were added in the developed conditions. Details of the proposed Project culvert configurations are provided in Table A.8.

Table A.8 – Proposed new culverts in Project area

Name	Road/ Rail Crossing	Dimension	IL U\S (mAHD)	IL D\S (mAHD)
HR01	Haul Road (North)	3 x 0.9m RCPs	118.34	117.84
HR02	Haul Road (North)	3 x 2.1m RCPs	114.97	114.60
HR03	Haul Road (North)	2 x 0.9m RCPs	122.69	122.20
HR04	Haul Road (South)	3 x 0.9m RCPs	126.70	126.28

A3.3.5 Diversion channels

Earthworks models of the preliminary diversion channel designs were provided by TMM group and included in the model. The transitions between the diversion channels and the adjacent landforms were modified slightly to improve hydraulic performance.

A3.4 TUFLOW MODELLING RESULTS

Flood maps showing design peak flood depths and water level contours for the 1% AEP event under existing conditions and developed conditions are shown in Section A8.

Flood maps showing design peak flood velocities for the 1% AEP under existing and developed conditions are shown in Figure A.13 to Figure A.16 and Figure A.17 to Figure A.19 respectively.

Maps showing the water level difference between developed and existing conditions are shown in Figure A.20 to Figure A.21.

Flood mapping for a range of other design events (50% AEP,2% AEP, 0.1% AEP, and PMF) are provided in Section A8.

A4 Summary of findings

The purpose of this flood study was to:

- Define existing flood conditions across the Project area for a range of design events, in terms of peak water level, peak velocity, and water depth;
- Assess peak water levels and velocities along the levees proposed to protect the proposed works from flooding;
- Determine design flood conditions at the proposed haul road crossing, to assist in the preliminary design of cross-drainage infrastructure;
- Determine design flood conditions at the proposed railway crossing and to determine the potential for impacts on flood conditions;
- Assess the hydraulic conditions in the channels proposed to divert runoff in the unnamed Springton Creek tributary around both mining areas;
- Determine the residual impacts of the proposed Project during project operations.

An XP-RAFTS hydrologic model was developed to estimate design discharge hydrographs for the catchments of Charlevue Creek and Springton Creek which cross the Project area. In the absence of gauged streamflow data, the resulting peak discharges were validated against peak discharges estimated using the Rational Method and RFFE.

The model was used to estimate design discharges for the 50%, 10%, 2%, 1%, and 0.1% AEP events as well as the PMF design event in accordance with the AR&R 2016 approach using an ensemble of design temporal patterns.

- The 0.1% AEP design flood event was used in the design of flood levees;
- The 2% AEP and 1% AEP design events are of interest when assessing the impacts on road, rail and other off-site infrastructure;
- The PMF event was used in the risk analysis for the proposed final void location.

A TUFLOW hydraulic model was also developed to determine existing and developed conditions flood behaviour in Charlevue Creek, Springton Creek, and its unnamed tributary crossing the mine area. The adopted grid cell size was five metres, and the inflow boundaries were represented using design discharge hydrographs estimated using the XP-RAFTS runoff-routing model. The model incorporated the proposed works, including the haul roads, levees and diversion channels.

The outcomes of the study are as follows:

- The Project will temporarily increase Charlevue Creek flood levels in the immediate vicinity of the proposed haul road crossing. These impacts are contained within the mine lease area.
- There will be no impact on flood levels in Charlevue Creek or Springton Creek at the existing Capricorn Highway, Blackwater Rail corridor, or downstream of the Project area.
- While the unnamed tributary of Springton Creek is not a watercourse as defined under the Water Act, the diversion channel will be designed taking into consideration the principles set out in the Guideline: “Works that interfere with water in a watercourse – watercourse diversions” (DNRM, September 2014). This document sets out key design principles and requirements for the functional designs of permanent diversions. It includes guidance on watercourse diversion design and operation including maintenance, monitoring and revegetation. Preliminary designs are shown in Figure 7.3 to Figure 7.8 which also show the post development flood conditions with diversions and levees in place.

- The works at AB Pit will locally increase flood levels in Springton Creek by up to 0.22 m in the 1% AEP flood. These impacts would extend off the lease area onto land owned by Magnetic South Pty Ltd, and reduce with distance downstream of the boundary.
- There will be localised off-lease impacts on flood levels in the unnamed tributary of Springton Creek immediately upstream of AB Pit and C Pit.

A5 References

Ball et al, 2016	Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I (Editors), 2016, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia
BMT WBM, 2016	*'TUFLOW User Manual'*, GIS Based 2D/1D Hydrodynamic Modelling, Build 2016-10-AA, BMT WBM, 2016.
BOM, 2003	Bureau of Meteorology, *The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method (GSDM), 2003,* Commonwealth of Australia
BOM, 2006	Bureau of Meteorology, *The Estimation of Probable Maximum Precipitation: Generalised Tropical Storm Method Revised (GTSMR)*, 2006, Commonwealth of Australia
Chow, 1959	*Open-Channel Hydraulics,* McGraw-Hill Inc., Singapore, 1959
XP-Software, 2018	XP-Software, 2018, *XP-RAFTS*, Florida, USA.

A6 Model parameters

A6.1 XP-RAFTS SUB-CATCHMENT PARAMETERS

Table A.9 – Adopted XP-RAFTS sub-catchment parameters

Sub-catchment ID	Area (km²)	Percentage impervious (%)	Catchment slope (%)	Catchment PERN 'n'
SD01	0.29	0	0.11	0.05
SD02	0.15	0	0.34	0.05
SD03	0.26	0	0.29	0.05
SD04	0.17	0	0.07	0.05
SD05	0.23	0	0.23	0.05
SD06	0.28	0	1.12	0.05
SD07	0.17	0	0.98	0.05
SD08	0.28	0	0.54	0.05
SD09	0.14	0	0.18	0.05
SD10	0.19	0	0.82	0.05
SD11	0.07	0	0.40	0.05
SD12	0.09	0	0.17	0.05
SD13	0.11	0	0.37	0.05
SD14	0.04	0	0.49	0.05
SD15	0.06	0	0.32	0.05
SD16	0.13	0	0.09	0.05
SD17	0.13	0	0.01	0.05
SD18	0.10	0	0.15	0.05
SD19	0.16	0	0.14	0.05
SD20	0.17	0	0.16	0.05
SD21	0.09	0	0.31	0.05
SD22	0.14	0	0.15	0.05
SD23	0.11	0	0.18	0.05
SD24	0.06	0	0.29	0.05
SD25	0.09	0	0.31	0.05
SD26	0.15	0	0.40	0.05
SD27	0.19	0	0.33	0.05
SD28	0.19	0	0.39	0.05
SD29	0.24	0	0.82	0.05
SD30	0.12	0	2.22	0.05
SD31	0.21	0	3.91	0.05
SD32	0.32	0	0.92	0.05
SD33	0.22	0	1.93	0.05
SD34	0.27	0	2.78	0.05
SD35	0.17	0	0.30	0.05
SD36	0.08	0	0.16	0.05
SD37	0.11	0	0.47	0.05
SD38	0.11	0	3.51	0.05
SD39	0.07	0	1.01	0.05
SD40	0.13	0	1.21	0.05
SD41	0.11	0	1.21	0.05
SD42	0.21	0	0.78	0.05
SD42	0.20	0	7.33	0.05

A7 Rational Method calculations

Table A.10 - Springton Creek estimated discharges SD15

Catchment:	SD15

Catchment area and coefficient of runoff	
Catchment Area (ha)	612.63
C_{10}	0.40

Channel Characteristics	
Channel length (m)	4009
Channel slope (m/m)	0.003
Manning's 'n'	0.050
Channel bottom width (m)	10.00
Channel side slope (m/m)	0.250

Design Discharges

ARI (years)	AEP (%)	Frequency Factor F_y	C_y	t_c[a] (mins)	Rainfall Intensity (mm/h)	Peak Discharge (m^3/s)
1	63	0.80	0.32	154.0	16.4	8.93
1.44	50	0.85	0.34	153.3	16.5	9.53
4.48	20	0.95	0.38	151.9	16.6	10.7
10	10	1.00	0.40	151.2	16.6	11.3
20	5	1.05	0.42	150.6	16.7	11.9
50	2	1.15	0.46	149.5	16.8	13.1
100	1	1.20	0.48	149.0	16.8	13.7

a - Time of Concentration (t_c) is calculated using Modified Friend's equation

Table A.11 – Springton Creek estimated discharges SD02

Catchment:	SD02

Catchment area and coefficient of runoff	
Catchment Area (ha)	1513.00
C_{10}	0.40

Channel Characteristics	
Channel length (m)	7564
Channel slope (m/m)	0.003
Manning's 'n'	0.050
Channel bottom width (m)	10.00
Channel side slope (m/m)	0.250

Design Discharges

ARI (years)	AEP (%)	Frequency Factor F_y	C_y	t_c[a] (mins)	Rainfall Intensity (mm/h)	Peak Discharge (m^3/s)
1	63	0.80	0.32	255.3	11.1	15.0
1.44	50	0.85	0.34	254.0	11.2	16.0
4.48	20	0.95	0.38	251.8	11.3	18.0
10	10	1.00	0.40	250.8	11.3	19.0
20	5	1.05	0.42	249.9	11.3	20.0
50	2	1.15	0.46	248.2	11.4	22.0
100	1	1.20	0.48	247.3	11.4	23.0

a - Time of Concentration (t_c) is calculated using Modified Friend's equation

Table A.12 – Springton Creek estimated discharges SD21

Catchment:	SD21

Catchment area and coefficient of runoff	
Catchment Area (ha)	869.00
C_{10}	0.40

Channel Characteristics	
Channel length (m)	5434
Channel slope (m/m)	0.003
Manning's 'n'	0.050
Channel bottom width (m)	10.00
Channel side slope (m/m)	0.250

Design Discharges

ARI (years)	AEP (%)	Frequency Factor F_y	C_y	t_c[a] (mins)	Rainfall Intensity (mm/h)	Peak Discharge (m^3/s)
1	63	0.80	0.32	199.3	13.5	10.4
1.44	50	0.85	0.34	198.3	13.5	11.1
4.48	20	0.95	0.38	196.5	13.6	12.5
10	10	1.00	0.40	195.7	13.7	13.2
20	5	1.05	0.42	194.9	13.7	13.9
50	2	1.15	0.46	193.5	13.8	15.3
100	1	1.20	0.48	192.9	13.8	16.0

a - Time of Concentration (t_c) is calculated using Modified Friend's equation

Table A.13 – Springton Creek estimated discharges SD24

Catchment:	SD24

Catchment area and coefficient of runoff	
Catchment Area (ha)	584.76
C_{10}	0.40

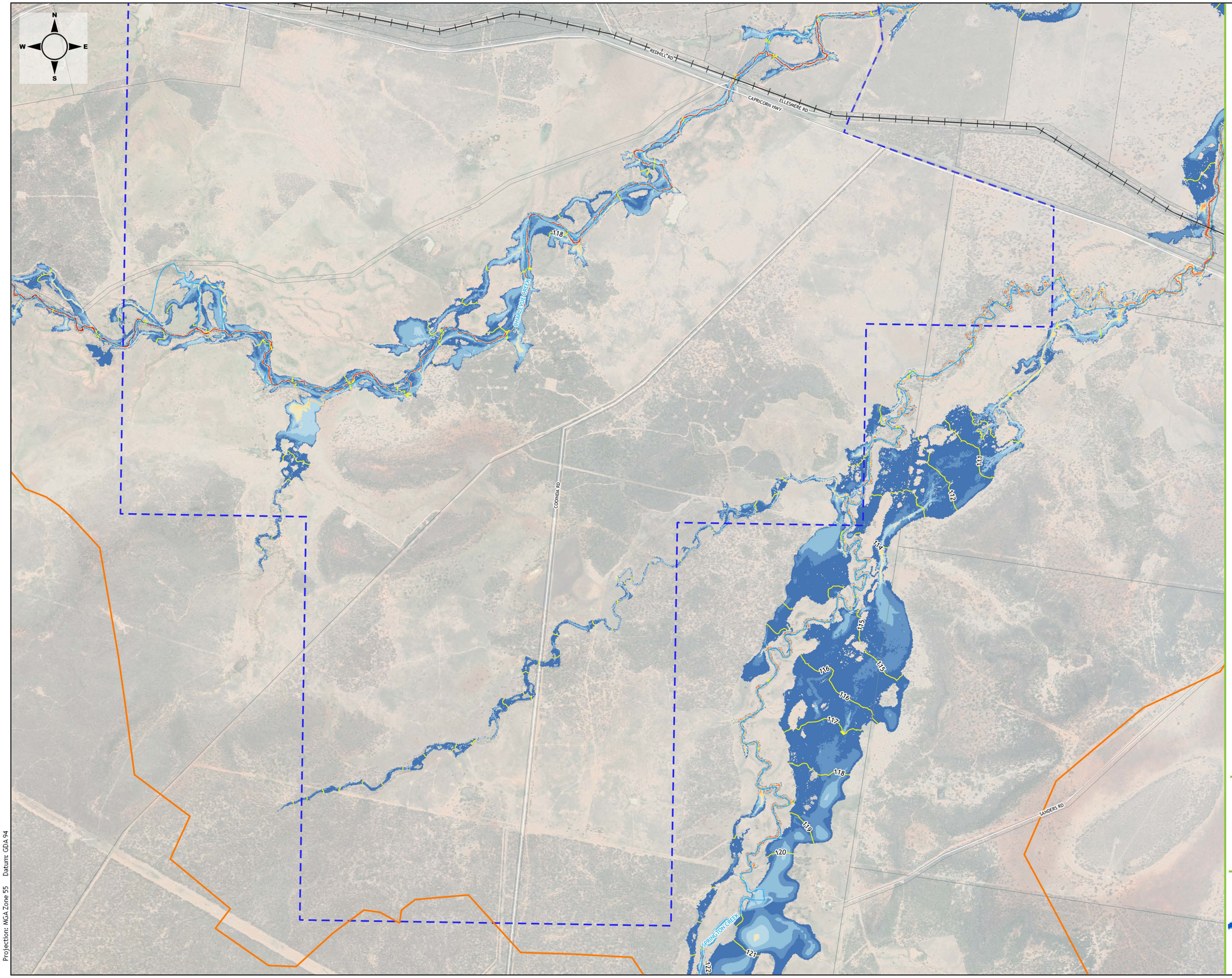
Channel Characteristics	
Channel length (m)	4092
Channel slope (m/m)	0.003
Manning's 'n'	0.050
Channel bottom width (m)	10.00
Channel side slope (m/m)	0.250

Design Discharges

ARI (years)	AEP (%)	Frequency Factor F_y	C_y	t_c[a] (mins)	Rainfall Intensity (mm/h)	Peak Discharge (m^3/s)
1	63	0.80	0.32	158.8	16.0	8.33
1.44	50	0.85	0.34	158.0	16.1	8.89
4.48	20	0.95	0.38	156.6	16.2	10.0
10	10	1.00	0.40	155.9	16.3	10.6
20	5	1.05	0.42	155.3	16.3	11.1
50	2	1.15	0.46	154.2	16.4	12.2
100	1	1.20	0.48	153.7	16.4	12.8

a - Time of Concentration (t_c) is calculated using Modified Friend's equation

A8 Flood maps



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

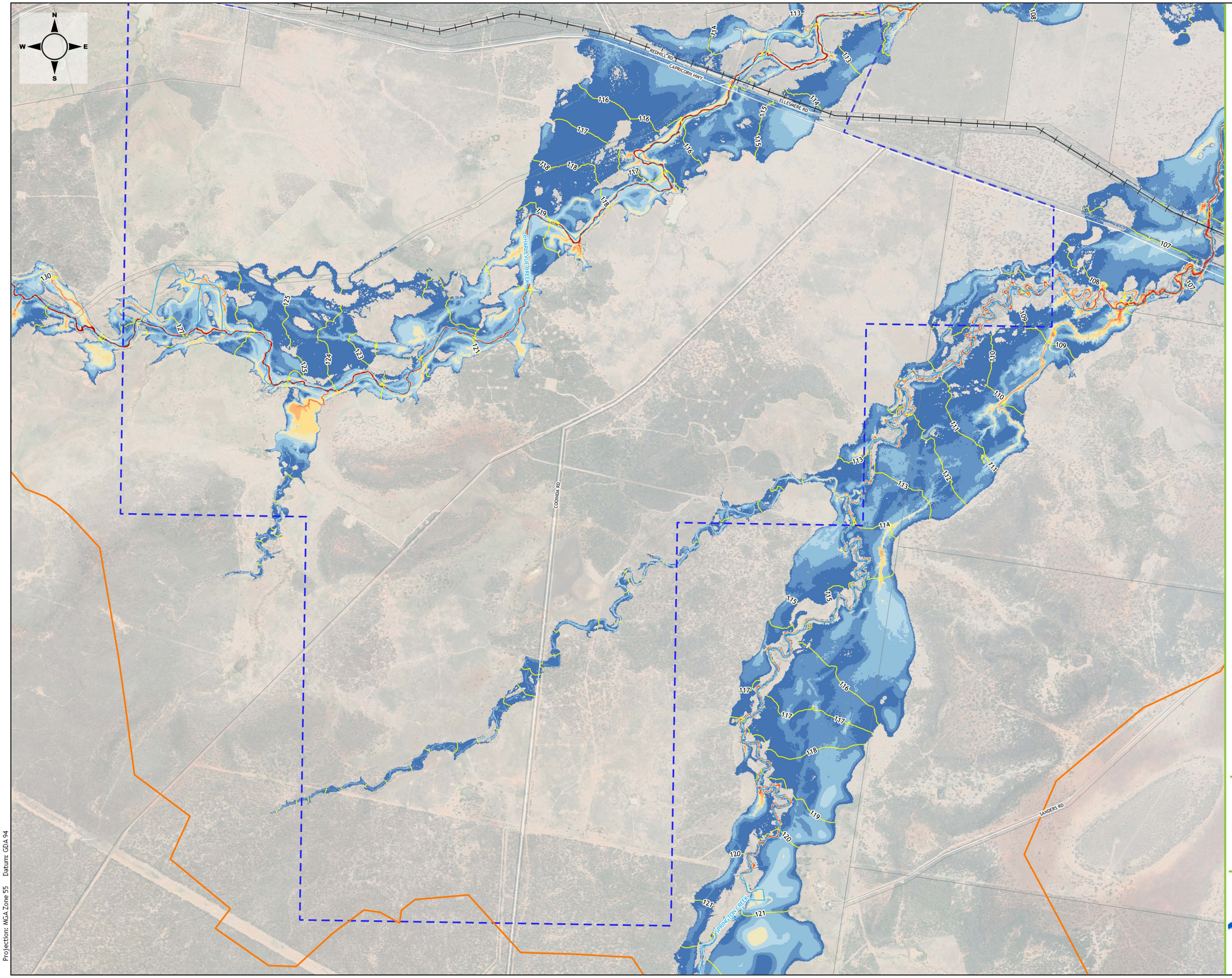
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Existing Condition),
50% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

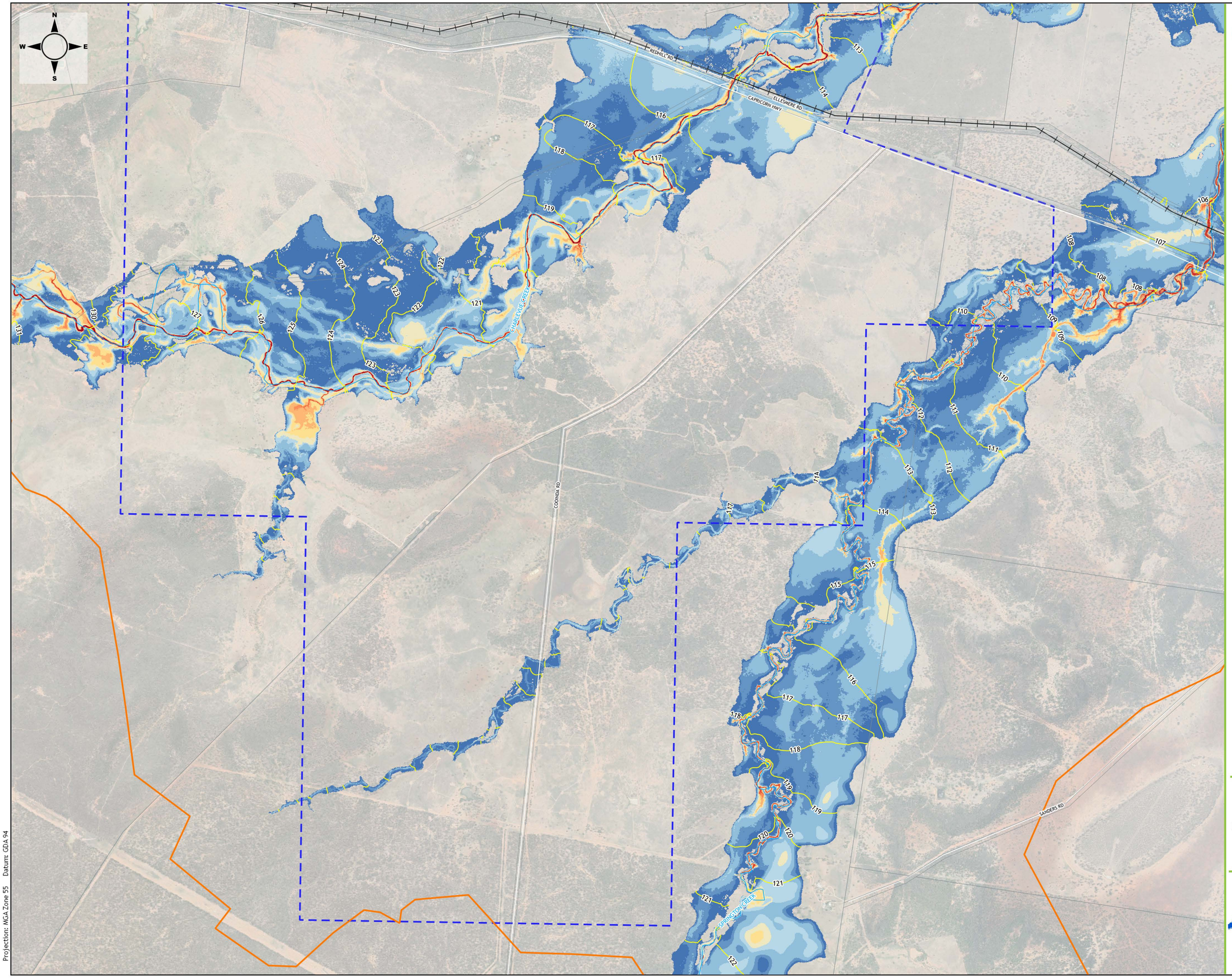
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Existing Condition),
10% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

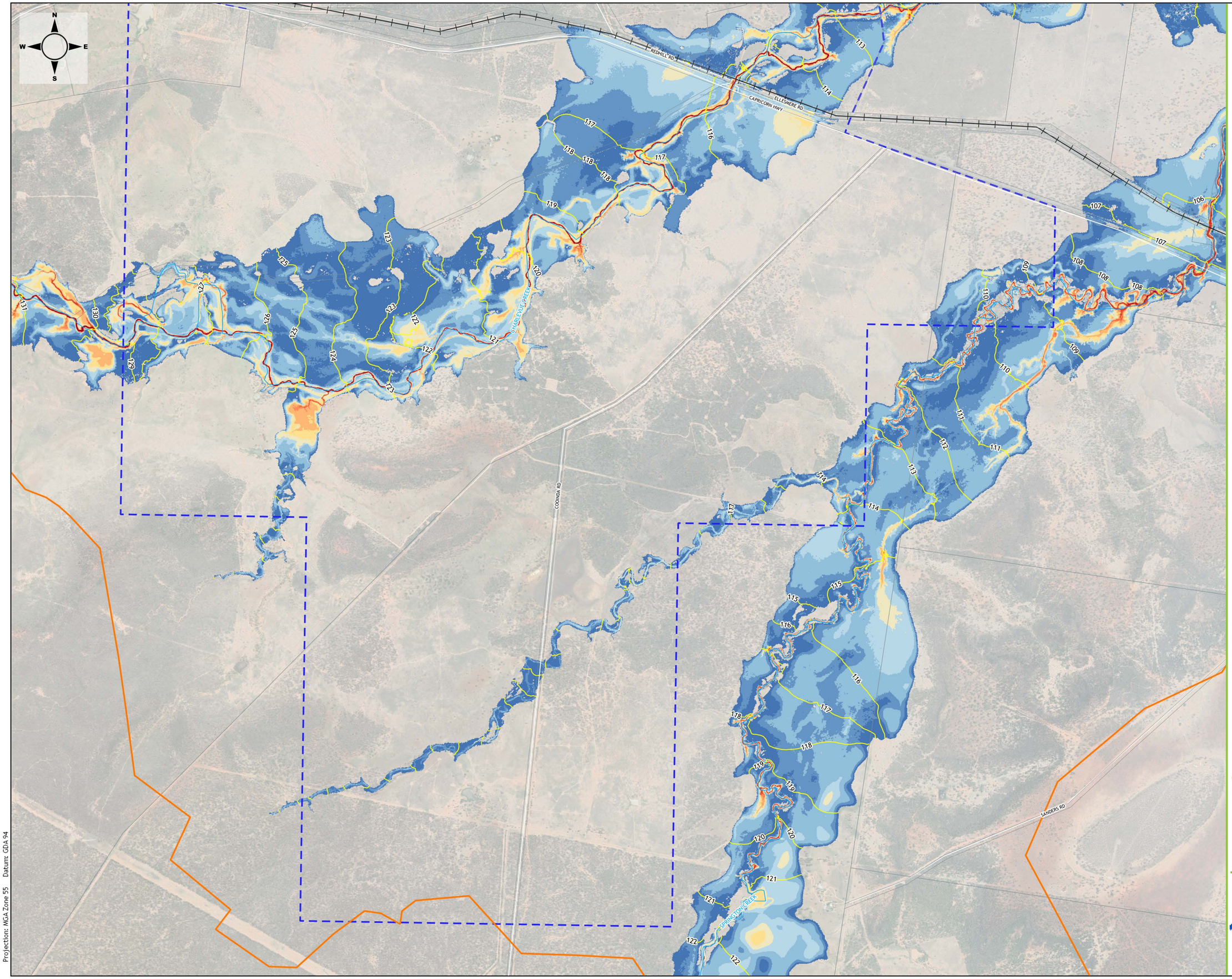
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Existing Condition),
2% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

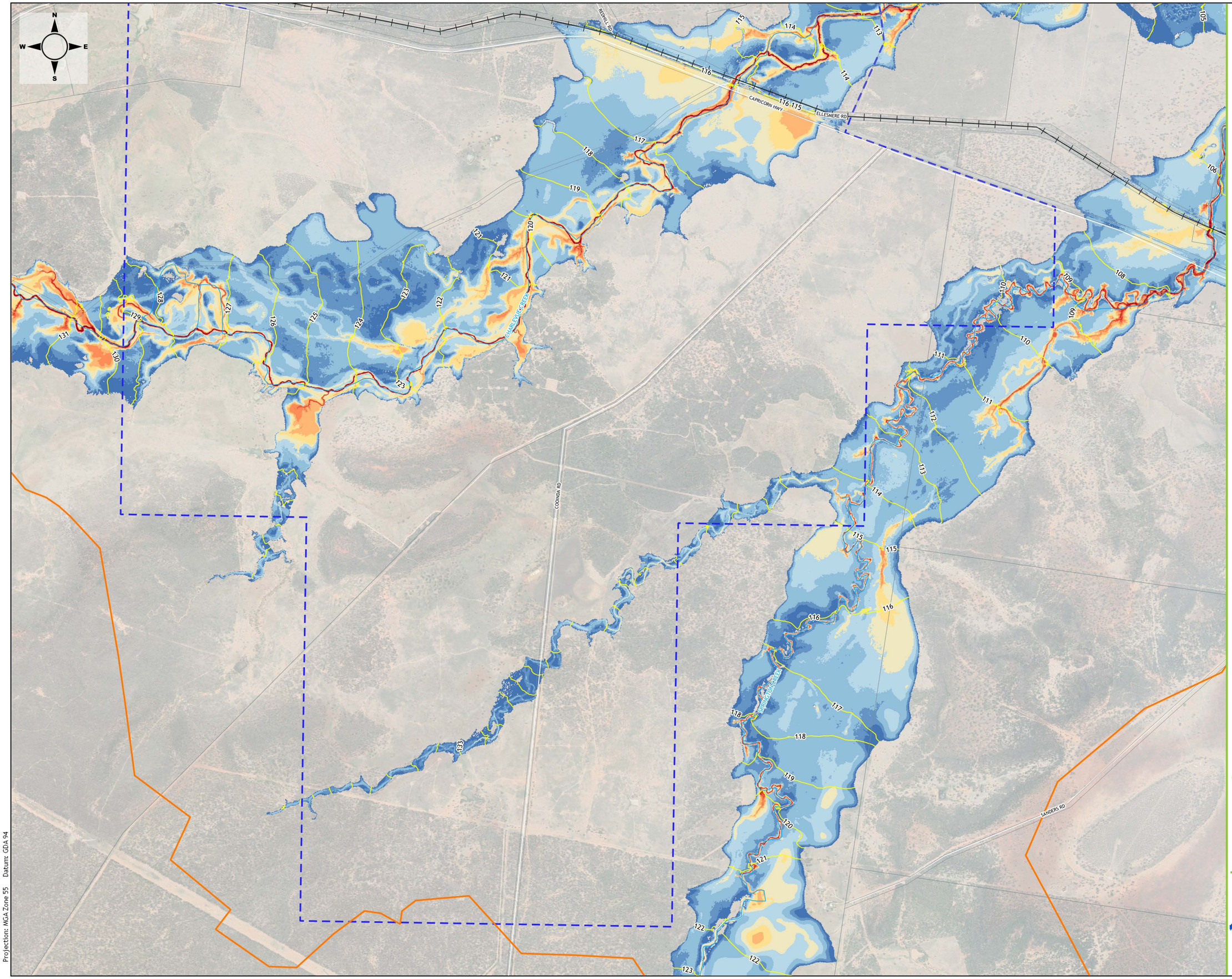
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Existing Condition),
1% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

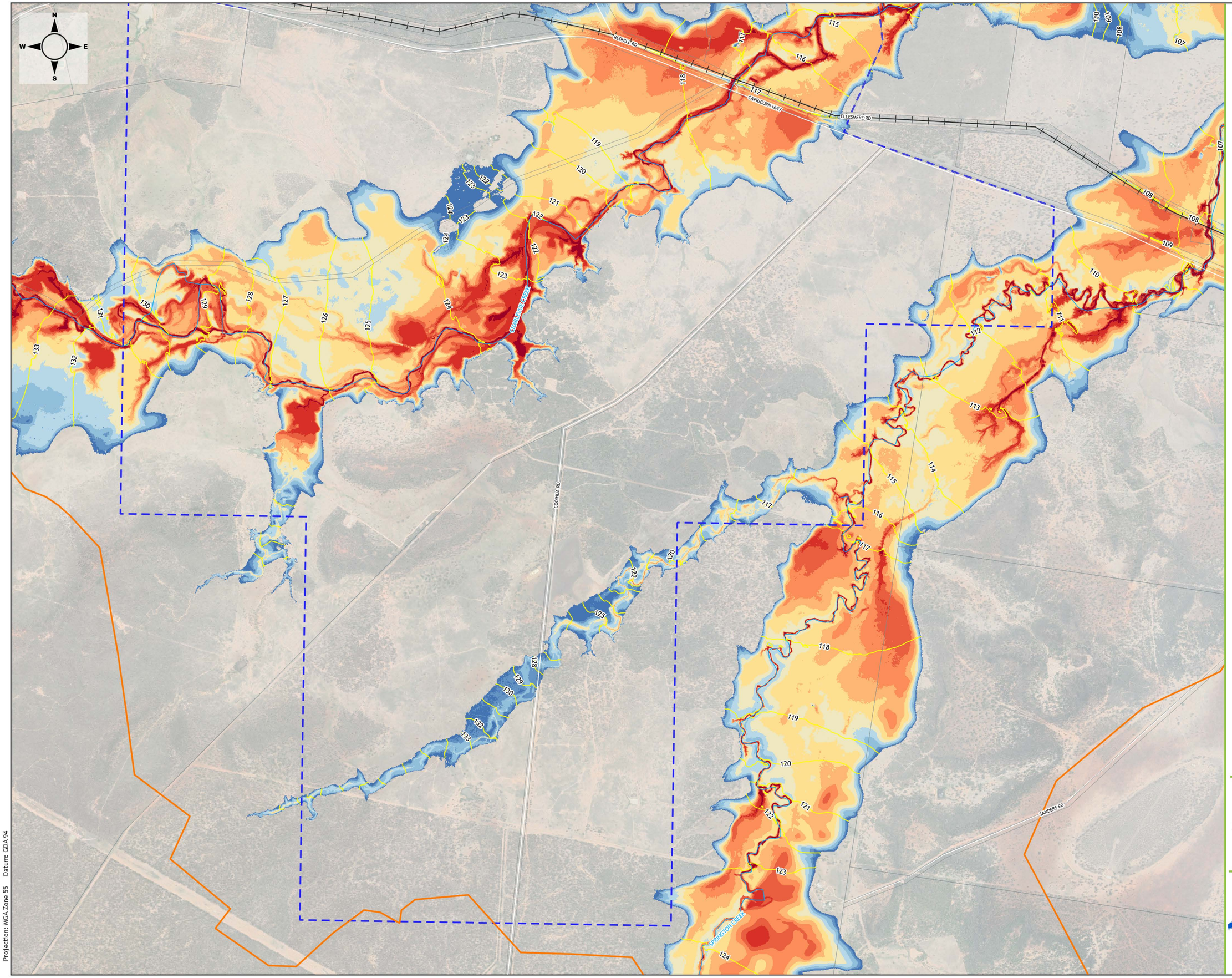
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Existing Condition),
0.1% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

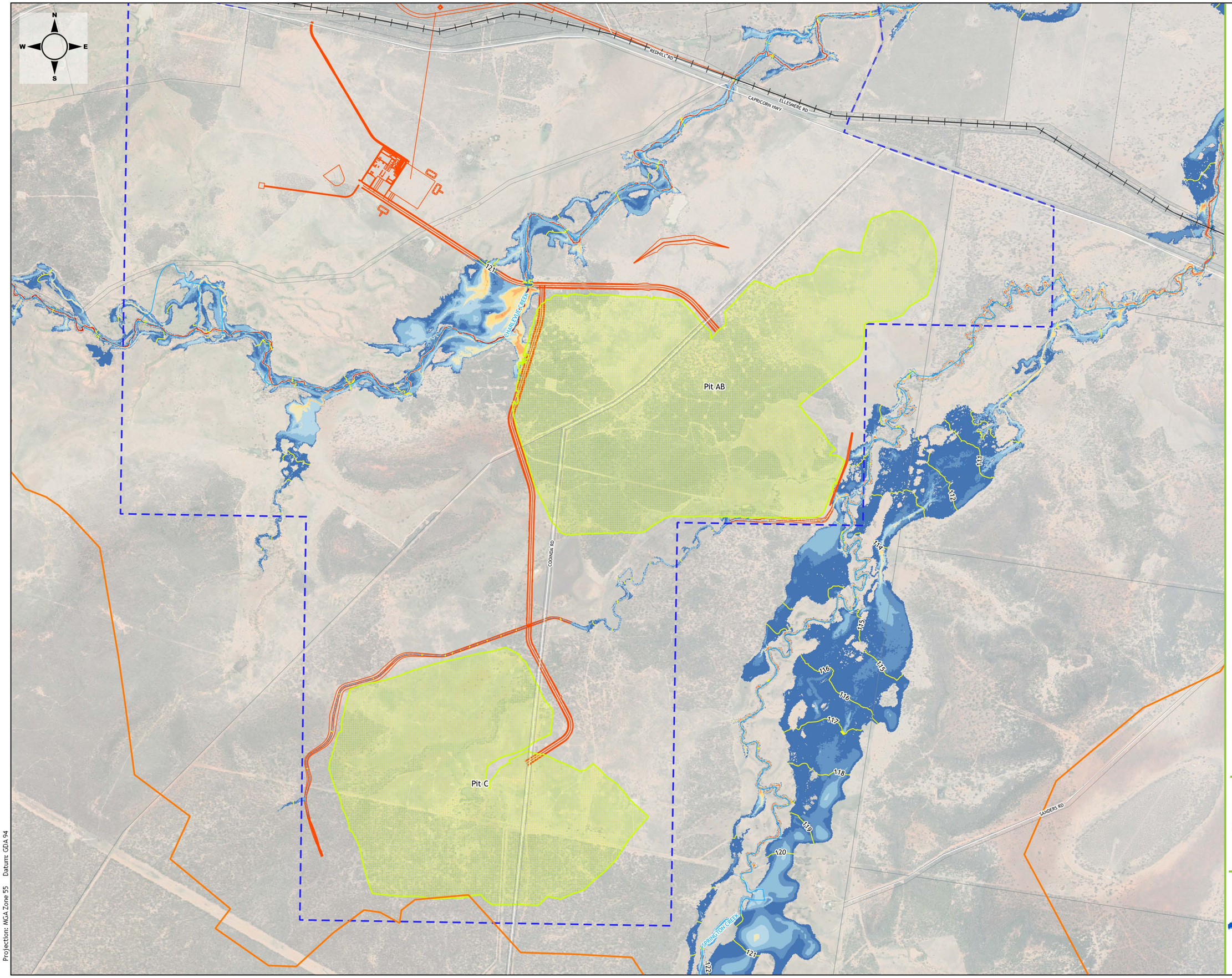
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Existing Condition),
PMF

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Projection: MGA Zone 55 Datum: GDA 94

Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood depth

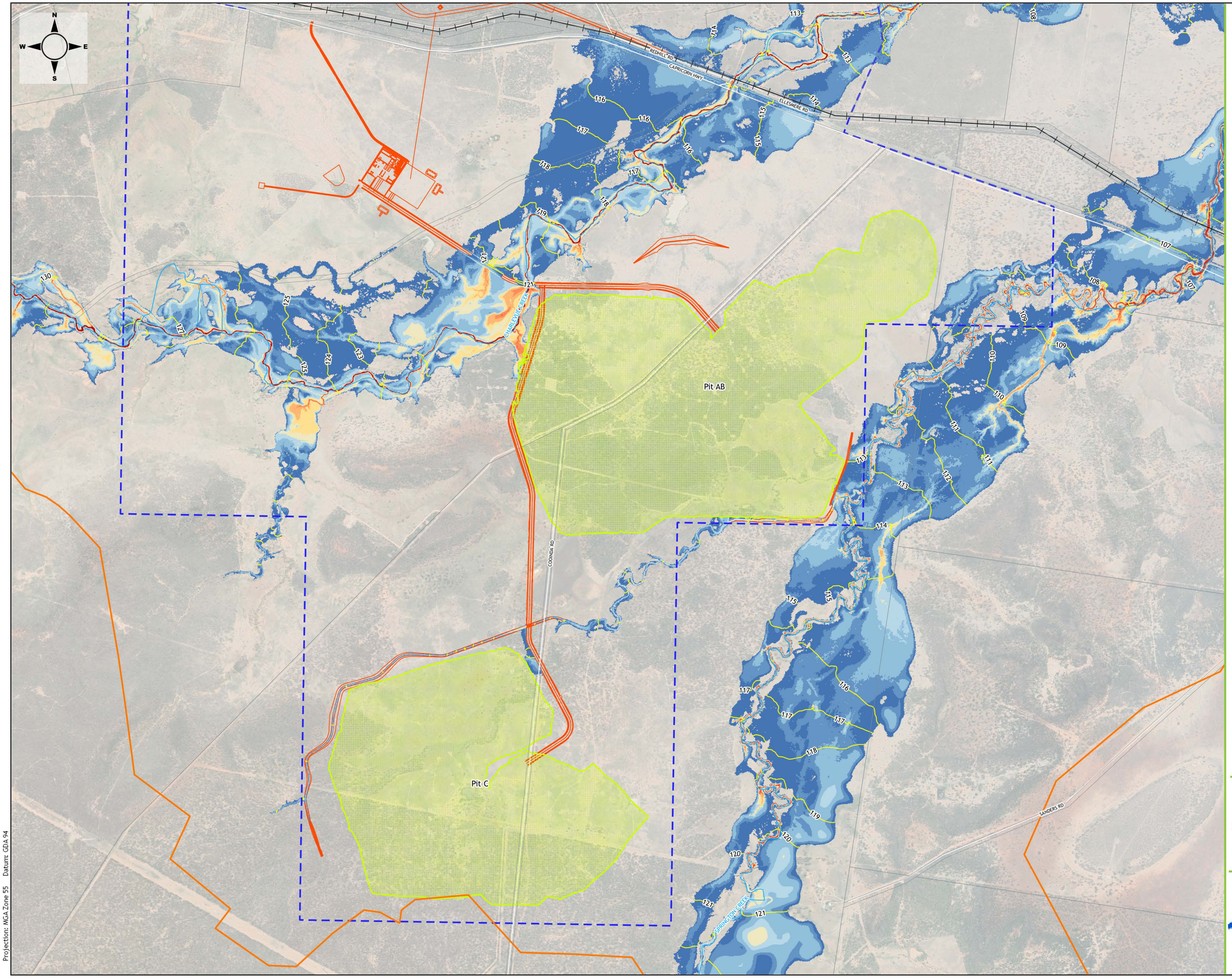
- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Developed Condition),
50% AEP

wrm water + environment



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

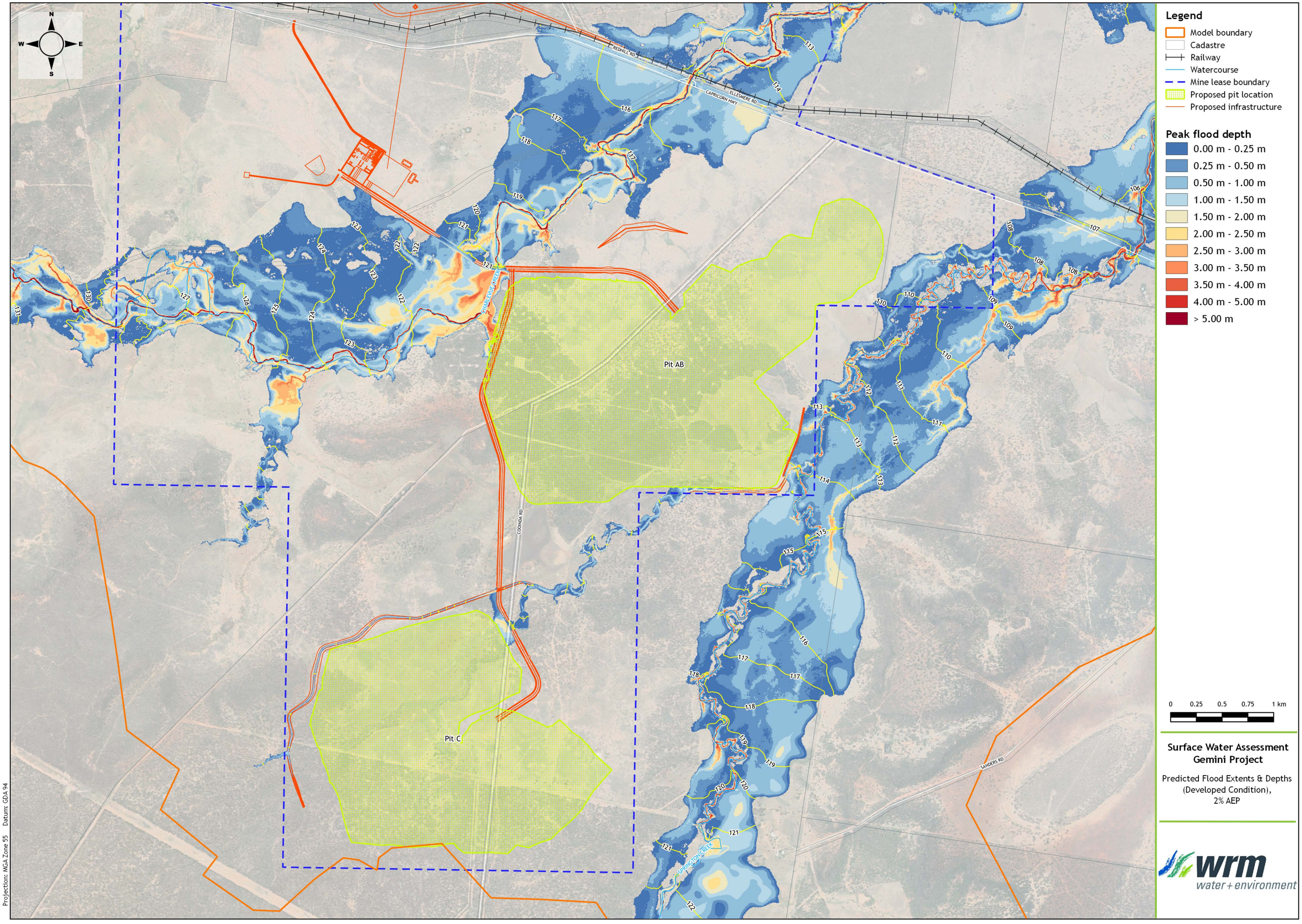
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Developed Condition),
10% AEP

wrm water + environment

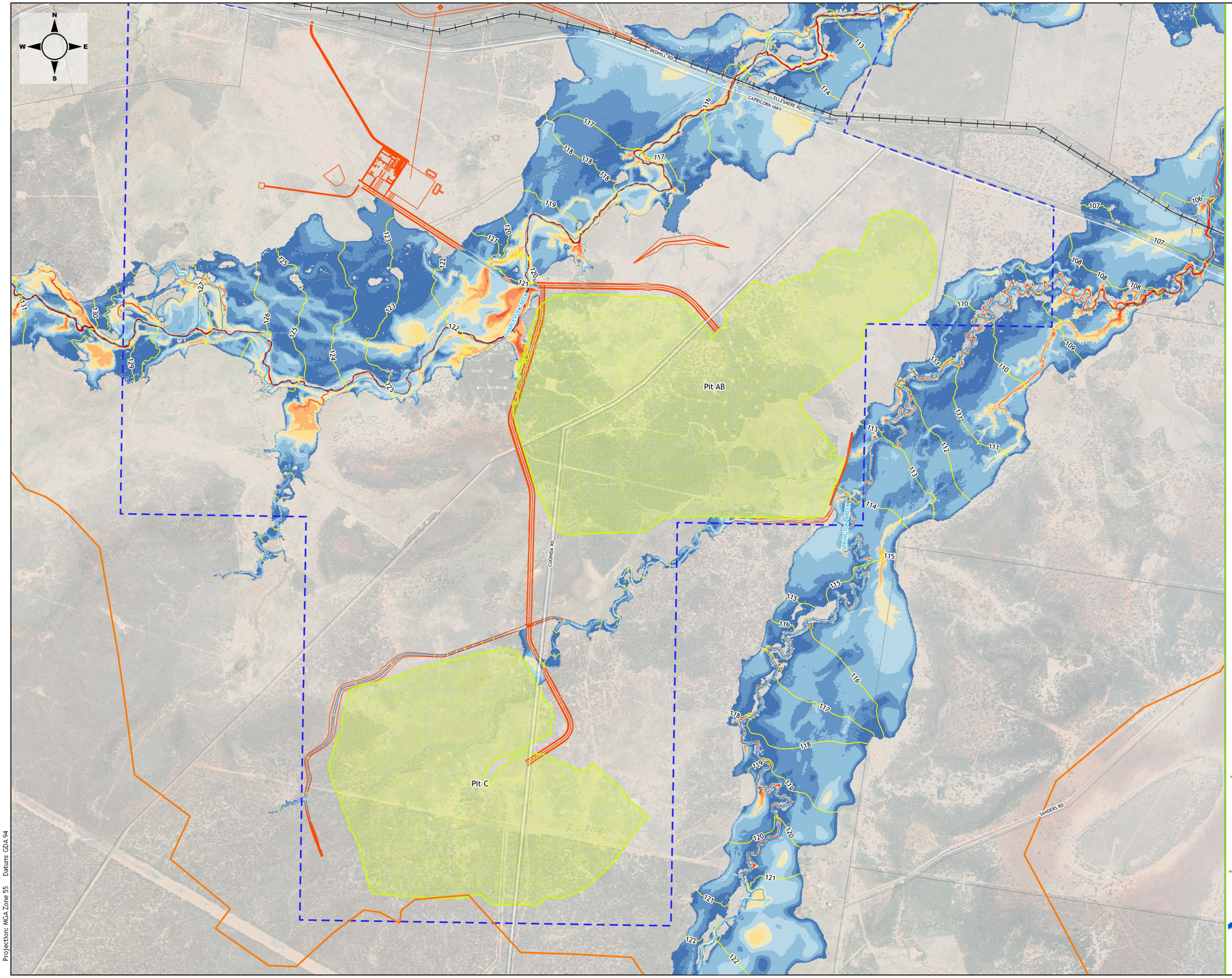
Projection: MGA Zone 55 Datum: GDA 94



Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Developed Condition),
2% AEP

wrm
water + environment



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Developed Condition),
1% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

N
W
E
S

REDHILL RD
CAPRICORN HWY
ELLESMERE RD
GRADEVALE CREEK
COONDA RD
SPRINGTON CREEK
SANDERS RD
Pit AB
Pit C

Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

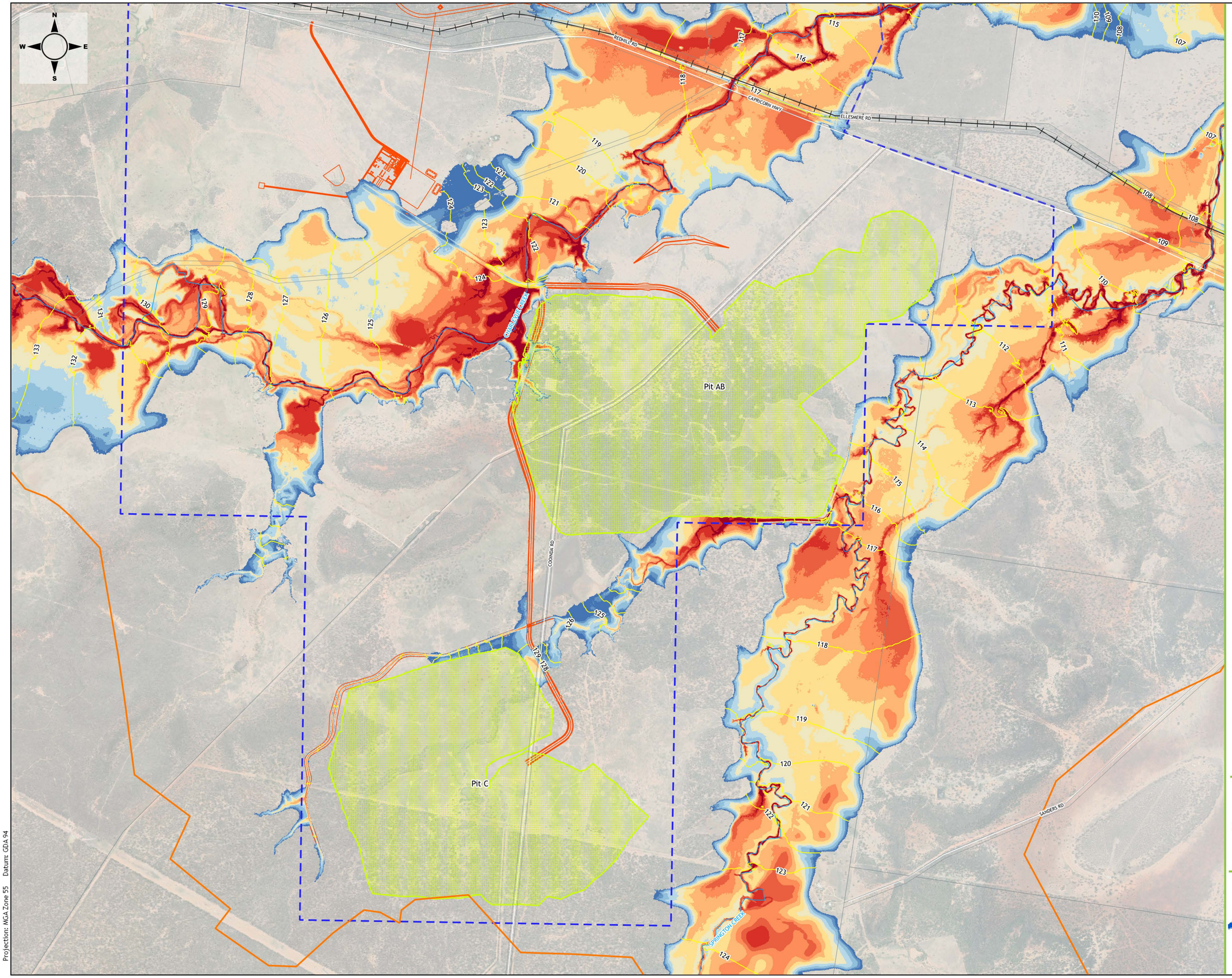
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Developed Condition),
0.1% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood depth

- 0.00 m - 0.25 m
- 0.25 m - 0.50 m
- 0.50 m - 1.00 m
- 1.00 m - 1.50 m
- 1.50 m - 2.00 m
- 2.00 m - 2.50 m
- 2.50 m - 3.00 m
- 3.00 m - 3.50 m
- 3.50 m - 4.00 m
- 4.00 m - 5.00 m
- > 5.00 m

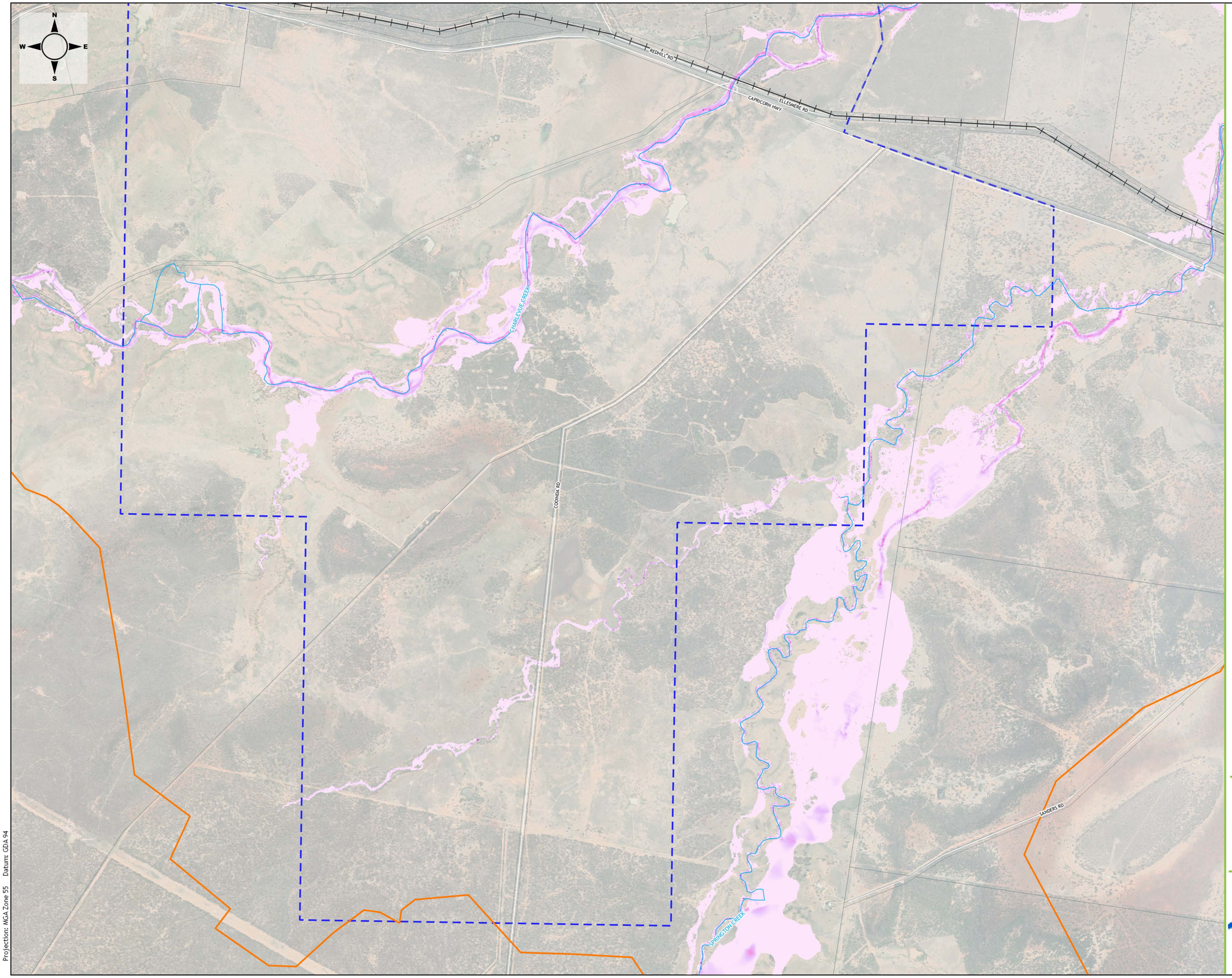
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Developed Condition),
PMF

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
50% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

N
W
E
S

REDHILL RD
CAPRICORN HWY
ELLESMERE RD
CHARLEVUE CREEK
COONDA RD
SPRINGTON CREEK
SANDERS RD

Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
10% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

N
W
E
S

REDHILL RD
CAPRICORN HWY
ELLESMERE RD
CHARLEVUE CREEK
COONOA RD
SPRINGTON CREEK
SANDERS RD

Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
2% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

N
W
E
S

REDHILL RD
CAPRICORN HWY
ELLESMERE RD
CHARLEVUE CREEK
COONDA RD
SPRINGTON CREEK
SANDERS RD

Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
1% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

N
W
E
S

REDHILL RD
CAPRICORN HWY
ELLESMERE RD
CHARLEVUE CREEK
COONDA RD
SPRINGTON CREEK
SANDERS RD

Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

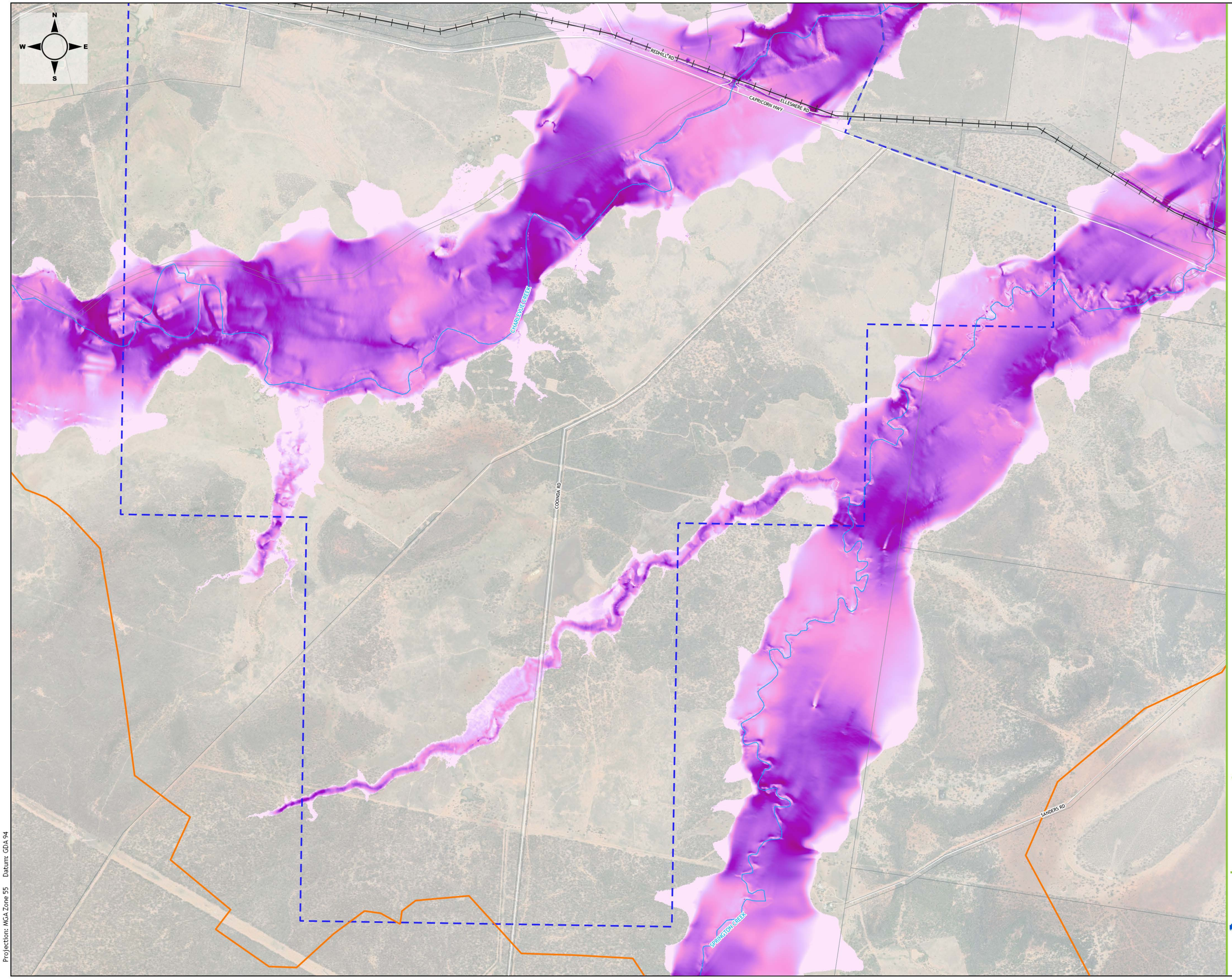
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
0.1% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

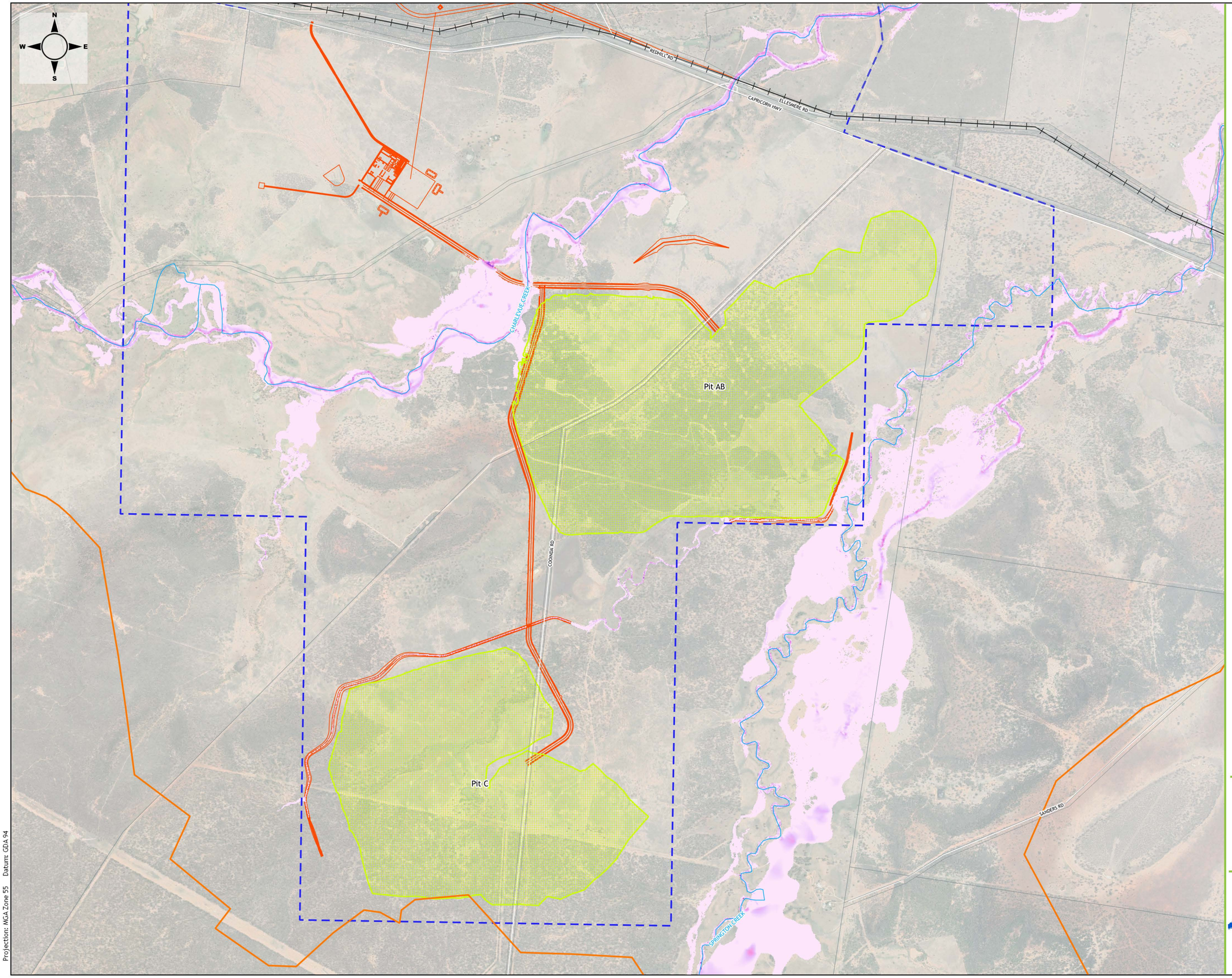
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
PMF

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
50% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

N
W
E
S

REDHILL RD
CAPRICORN HWY
ELLESMERE RD
CHARLEVUE CREEK
COONDA RD
SANDERS RD
SPRINGTON CREEK
Pit AB
Pit C

Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
10% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

N
W
E
S

REDHILL RD
CAPRICORN HWY
ELLESMERE RD
CHARLEVUE CREEK
COONDA RD
SANDERS RD
SPRINGTON CREEK
Pit AB
Pit C

Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
2% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

N
W
E
S

REDHILL RD
CAPRICORN HWY
ELLESMERE RD
CHARLEVUE CREEK
COONDA RD
SPRINGTON CREEK
SANDERS RD

Pit AB
Pit C

Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

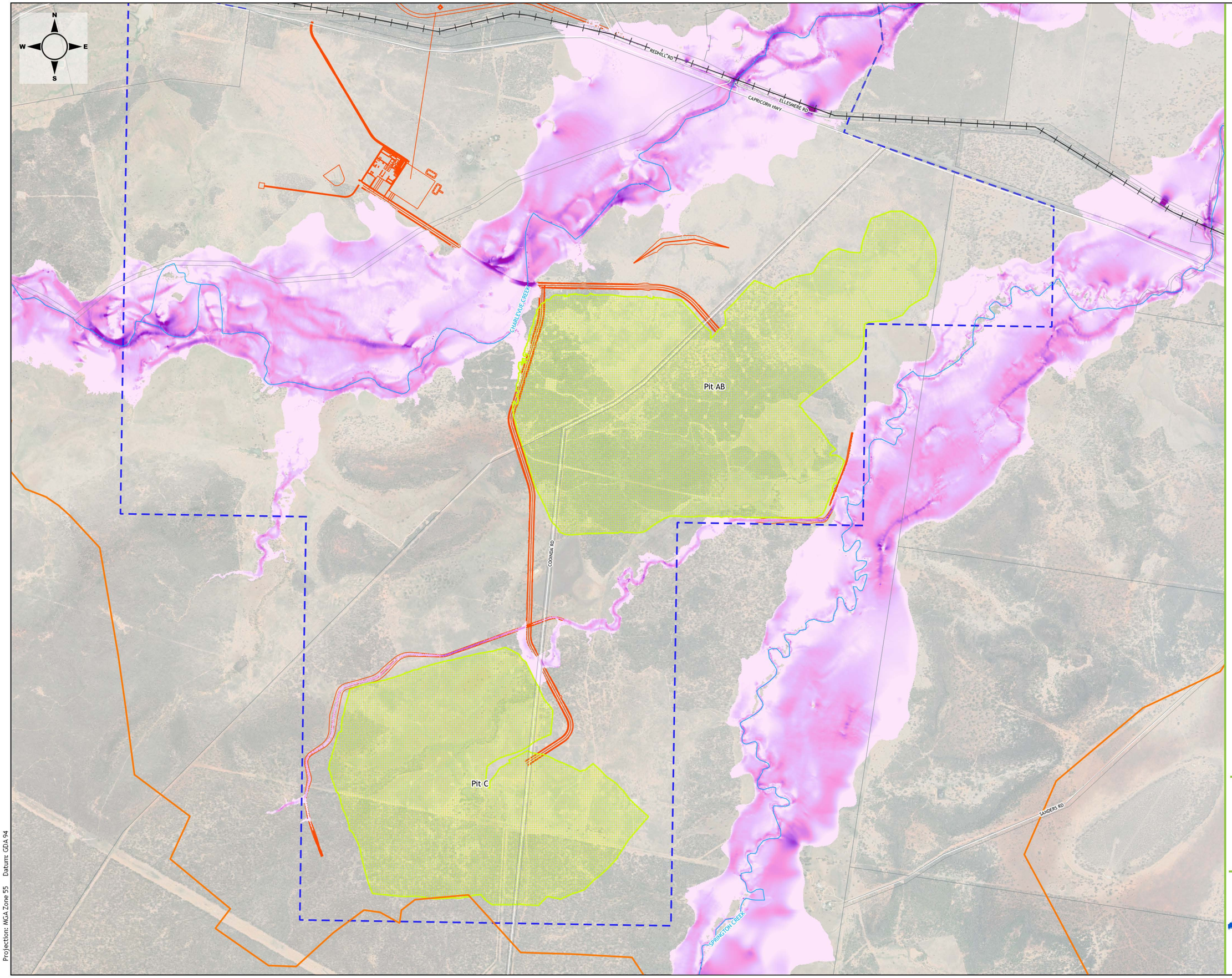
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
1% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
0.1% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94

N
W
E
S

REDHILL RD
CAPRICORN HWY
ELLESMERE RD
CHARLIEVUE CREEK
COONDA RD
SANDERS RD
SPRINGTON CREEK
Pit AB
Pit C

Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

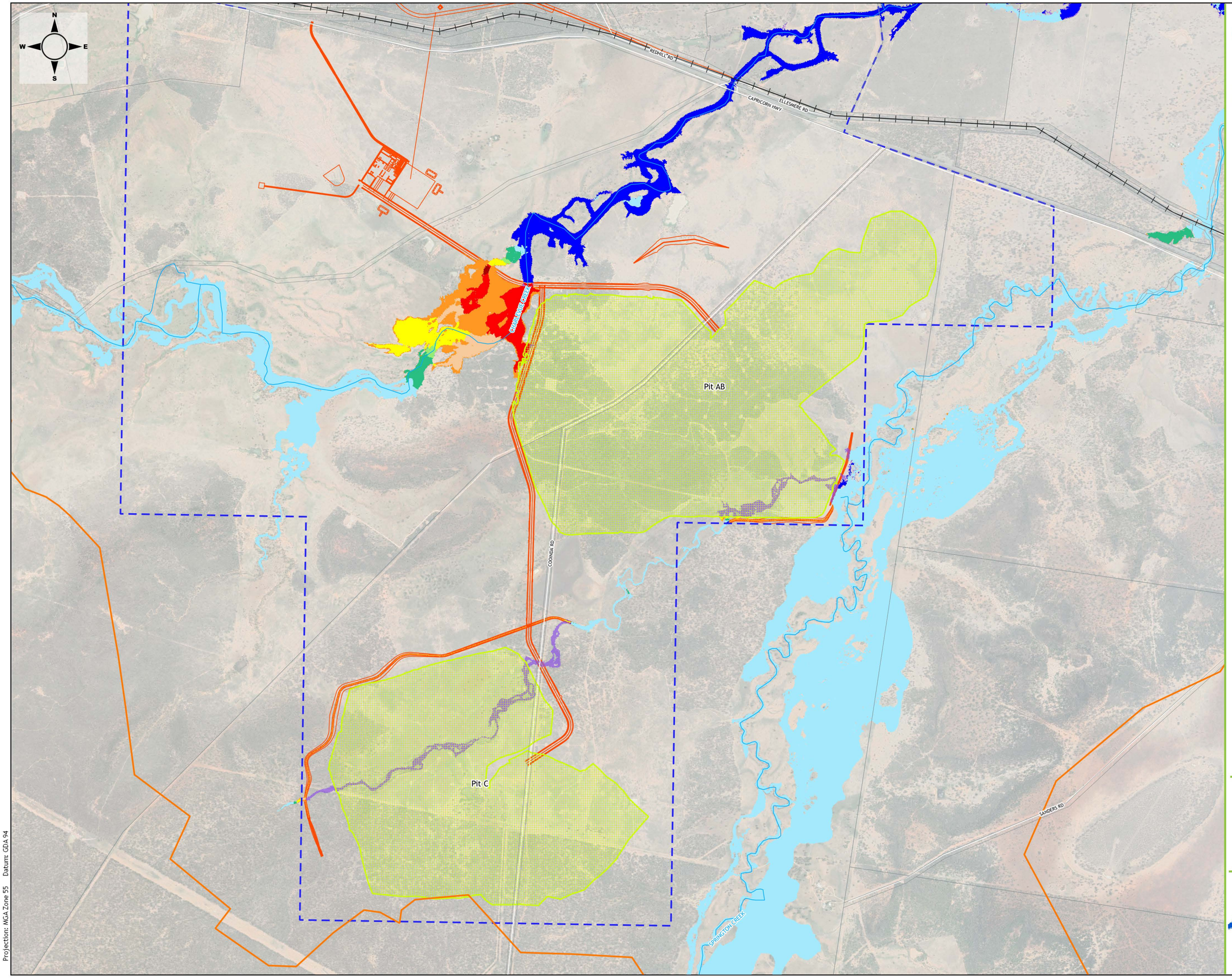
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
PMF

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Change in peak flood level

- < -1.00m
- -1.00m to -0.01m
- -0.01m to 0.01m
- 0.01m to 0.05m
- 0.05m to 0.10m
- 0.10m to 0.50m
- 0.50m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m
- > 5.0m

- Was flooded, now dry
- Was dry, now flooded

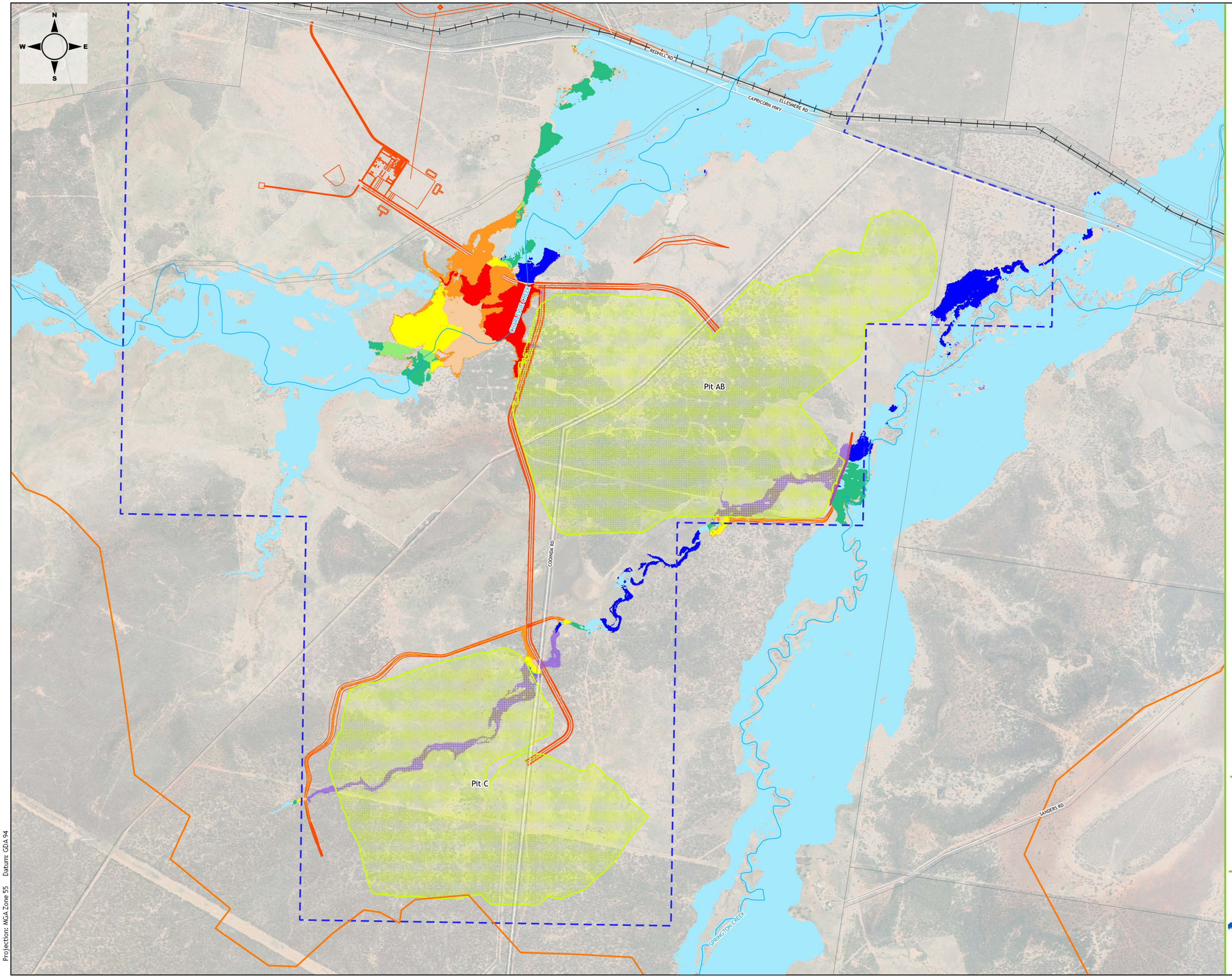
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Change in Peak Water Level, 50% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Change in peak flood level

- < -1.00m
- -1.00m to -0.01m
- -0.01m to 0.01m
- 0.01m to 0.05m
- 0.05m to 0.10m
- 0.10m to 0.50m
- 0.50m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m
- > 5.0m

- Was flooded, now dry
- Was dry, now flooded

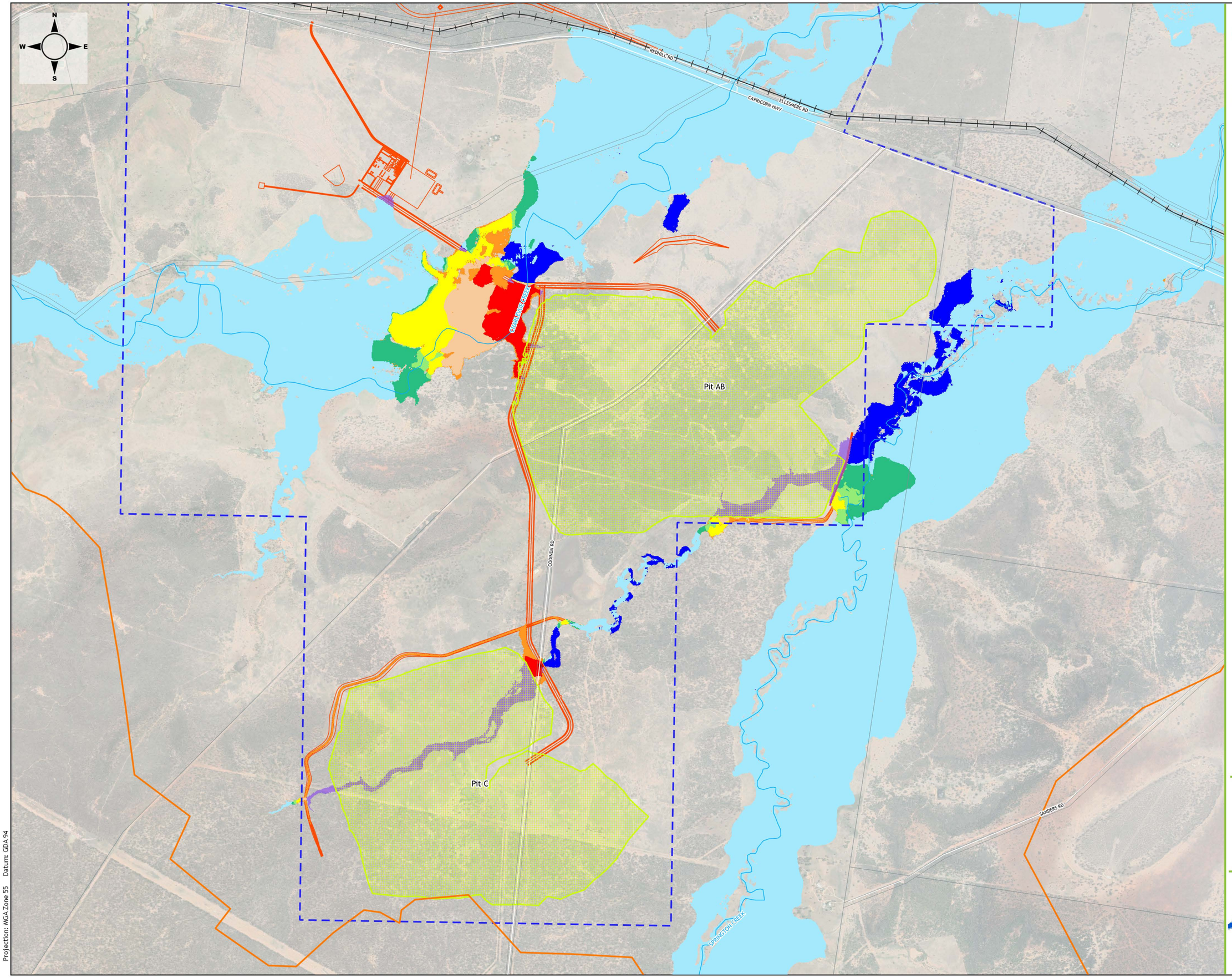
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Change in Peak Water Level, 10% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Change in peak flood level

- < -1.00m
- -1.00m to -0.01m
- -0.01m to 0.01m
- 0.01m to 0.05m
- 0.05m to 0.10m
- 0.10m to 0.50m
- 0.50m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m
- > 5.0m

- Was flooded, now dry
- Was dry, now flooded

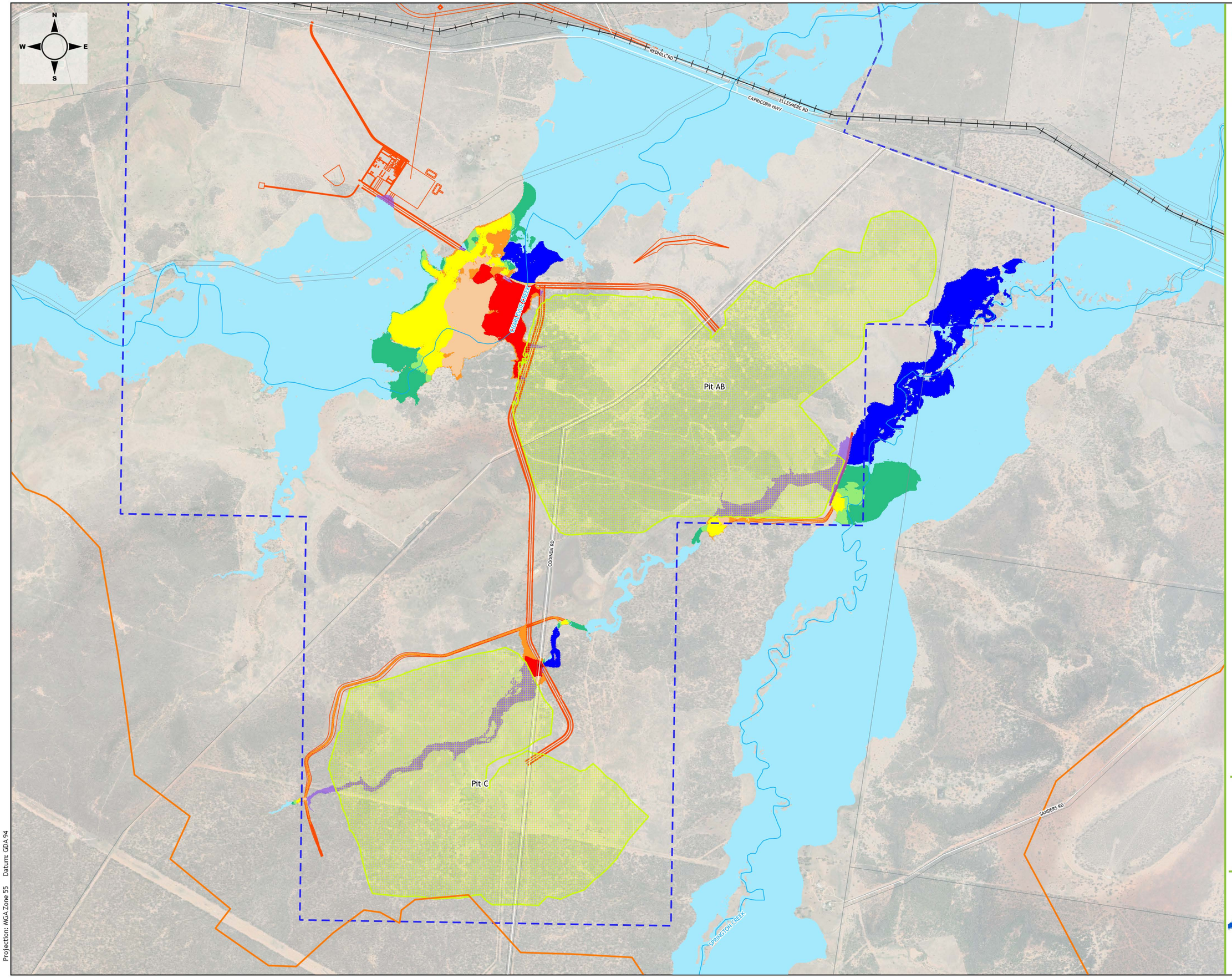
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Change in Peak Water Level,
2% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Change in peak flood level

- < -1.00m
- -1.00m to -0.01m
- -0.01m to 0.01m
- 0.01m to 0.05m
- 0.05m to 0.10m
- 0.10m to 0.50m
- 0.50m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m
- > 5.0m

- Was flooded, now dry
- Was dry, now flooded

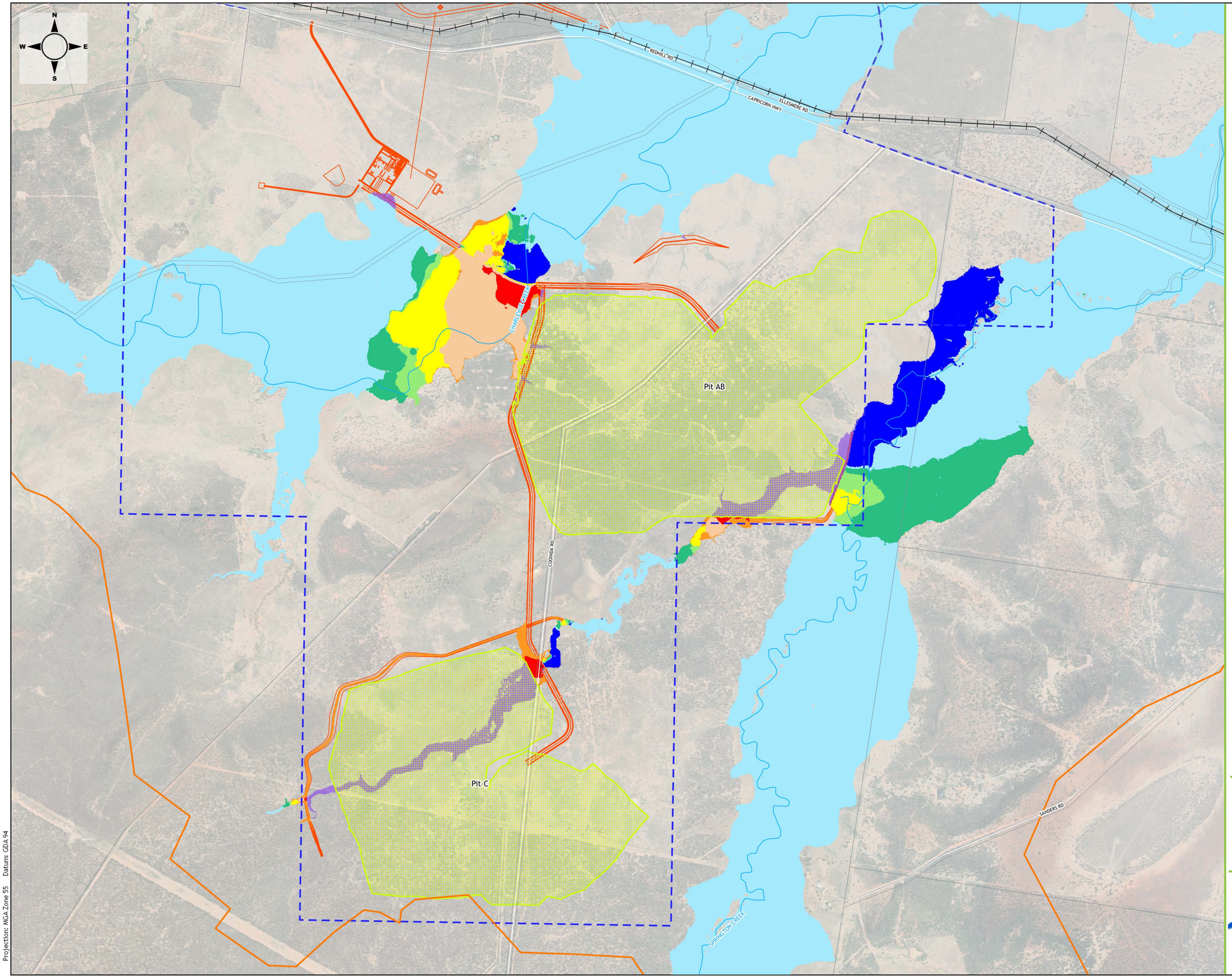
0 0.25 0.5 0.75 1 km

Surface Water Assessment
Gemini Project

Change in Peak Water Level,
1% AEP

wrm water + environment

Projection: MGA Zone 55 Datum: GDA 94



Legend

- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

Change in peak flood level

- < -1.00m
- -1.00m to -0.01m
- -0.01m to 0.01m
- 0.01m to 0.05m
- 0.05m to 0.10m
- 0.10m to 0.50m
- 0.50m to 1.0m
- 1.0m to 2.0m
- 2.0m to 3.0m
- 3.0m to 5.0m
- > 5.0m

- Was flooded, now dry
- Was dry, now flooded

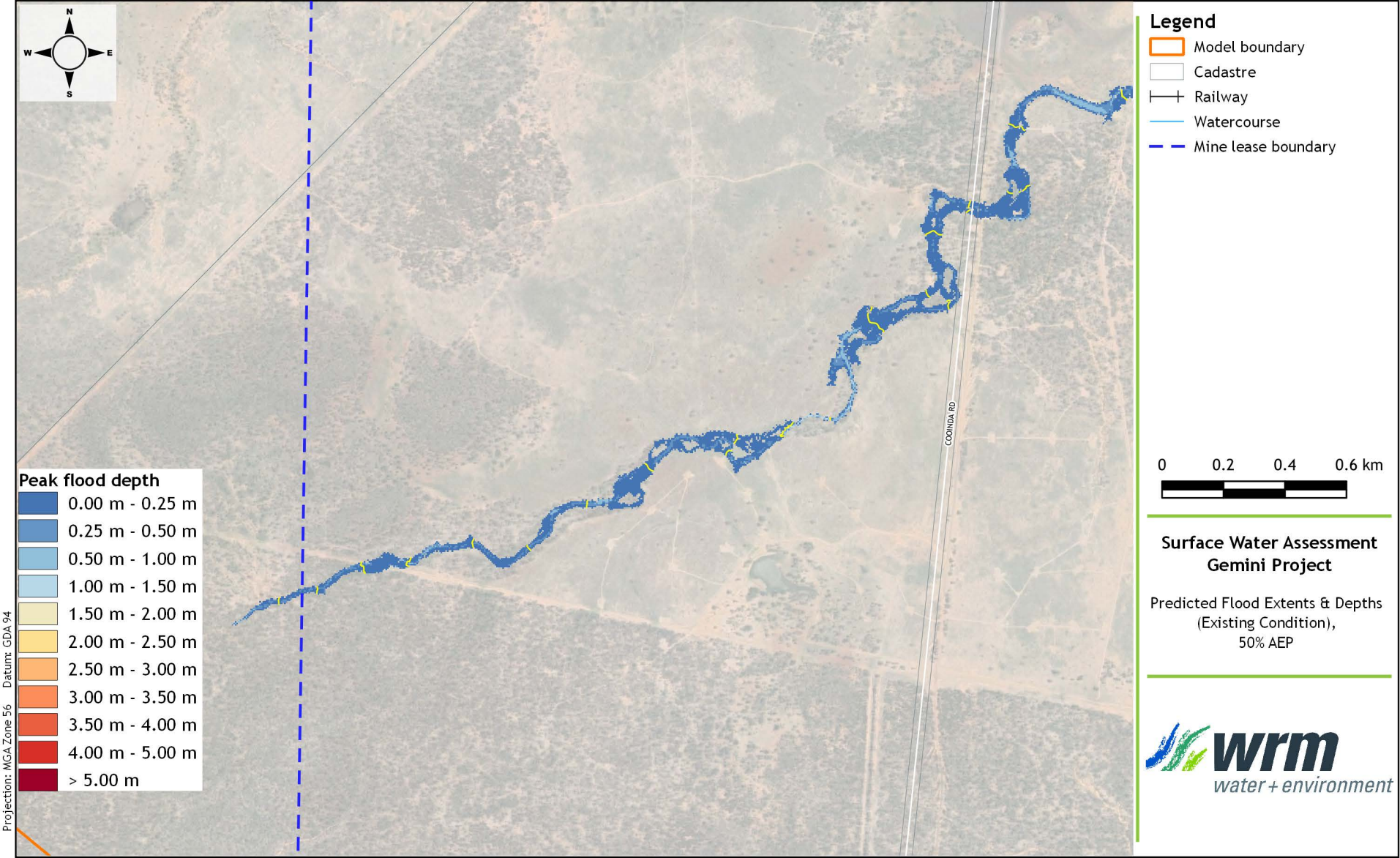
0 0.25 0.5 0.75 1 km

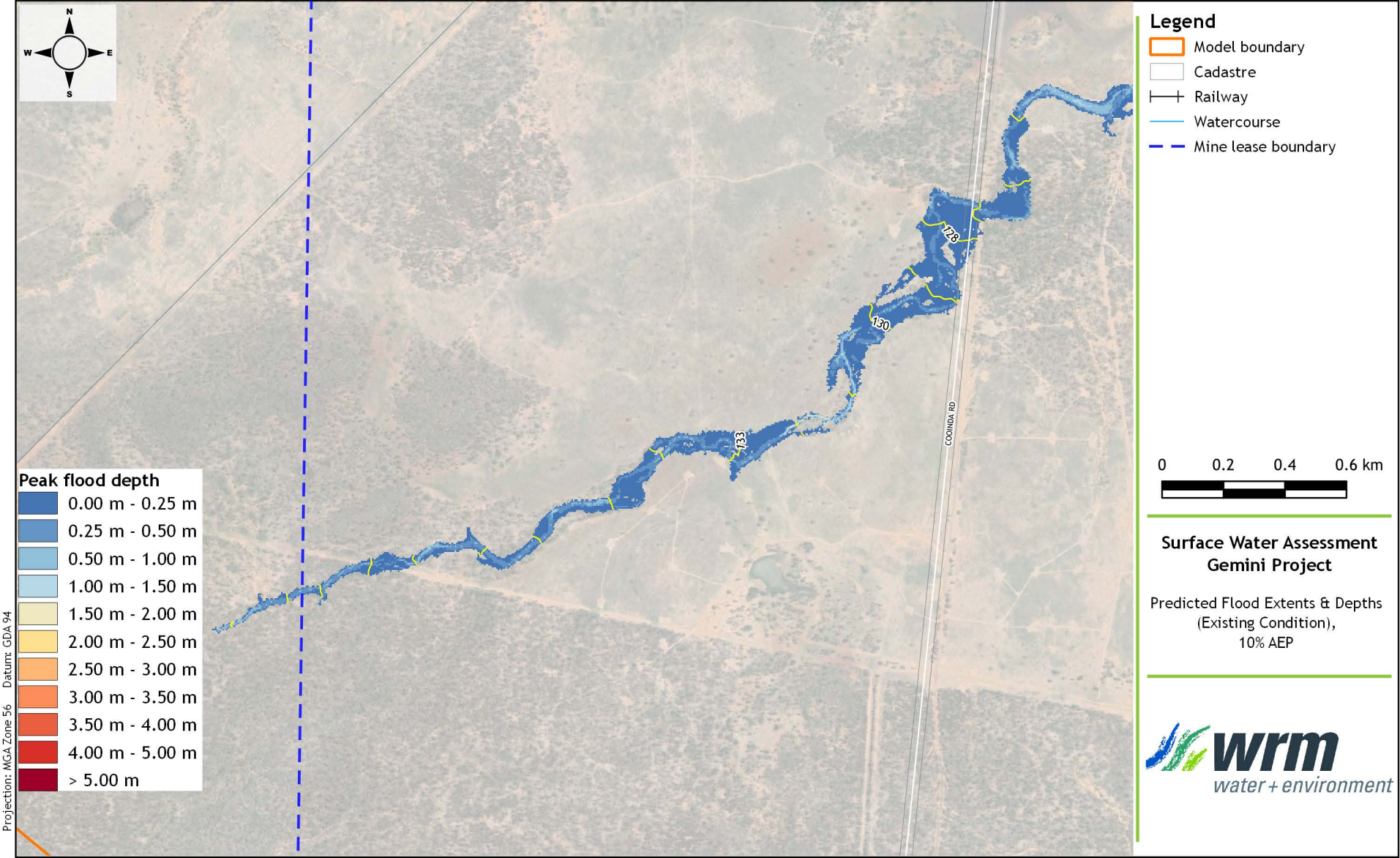
Surface Water Assessment
Gemini Project

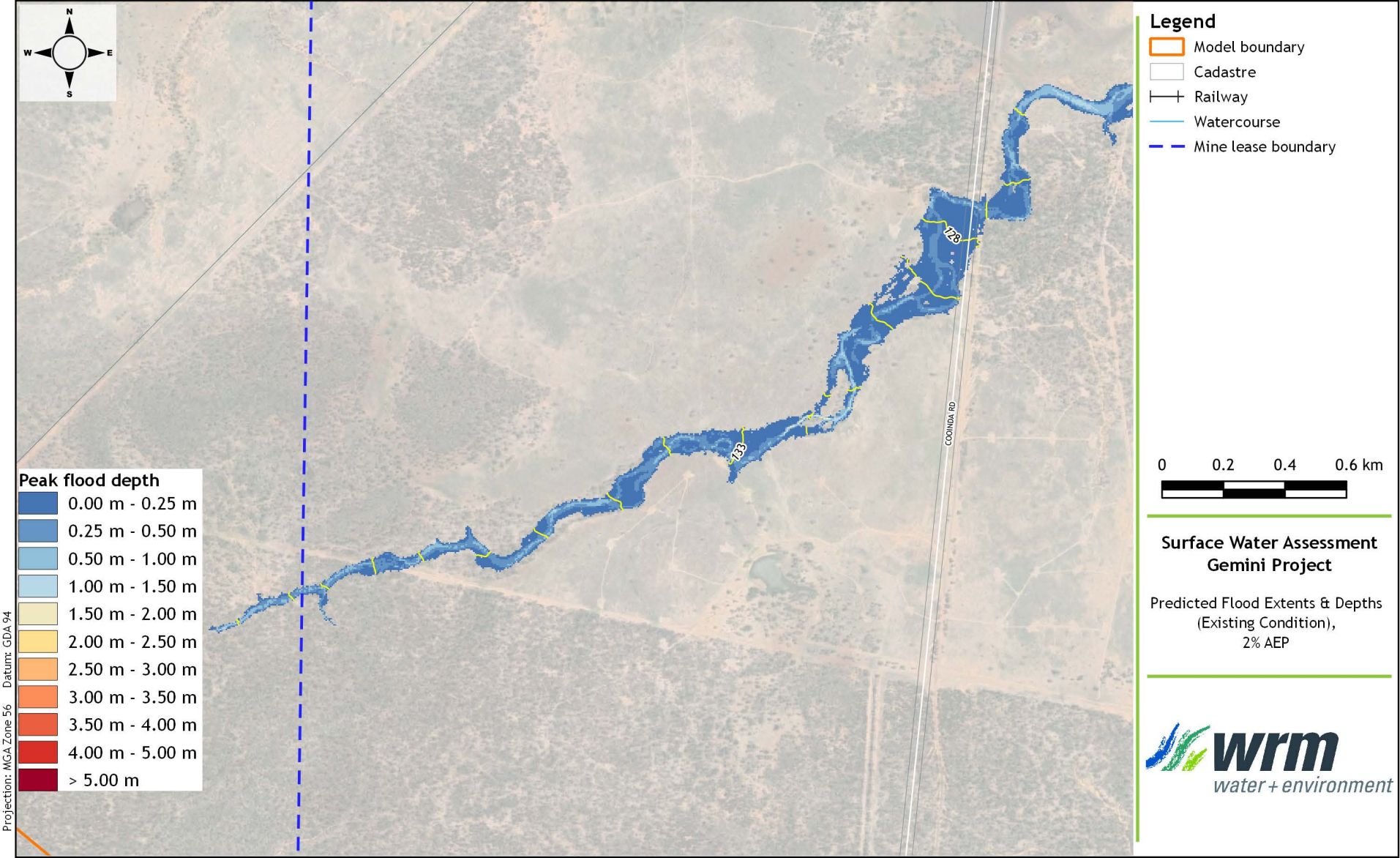
Change in Peak Water Level,
0.1% AEP

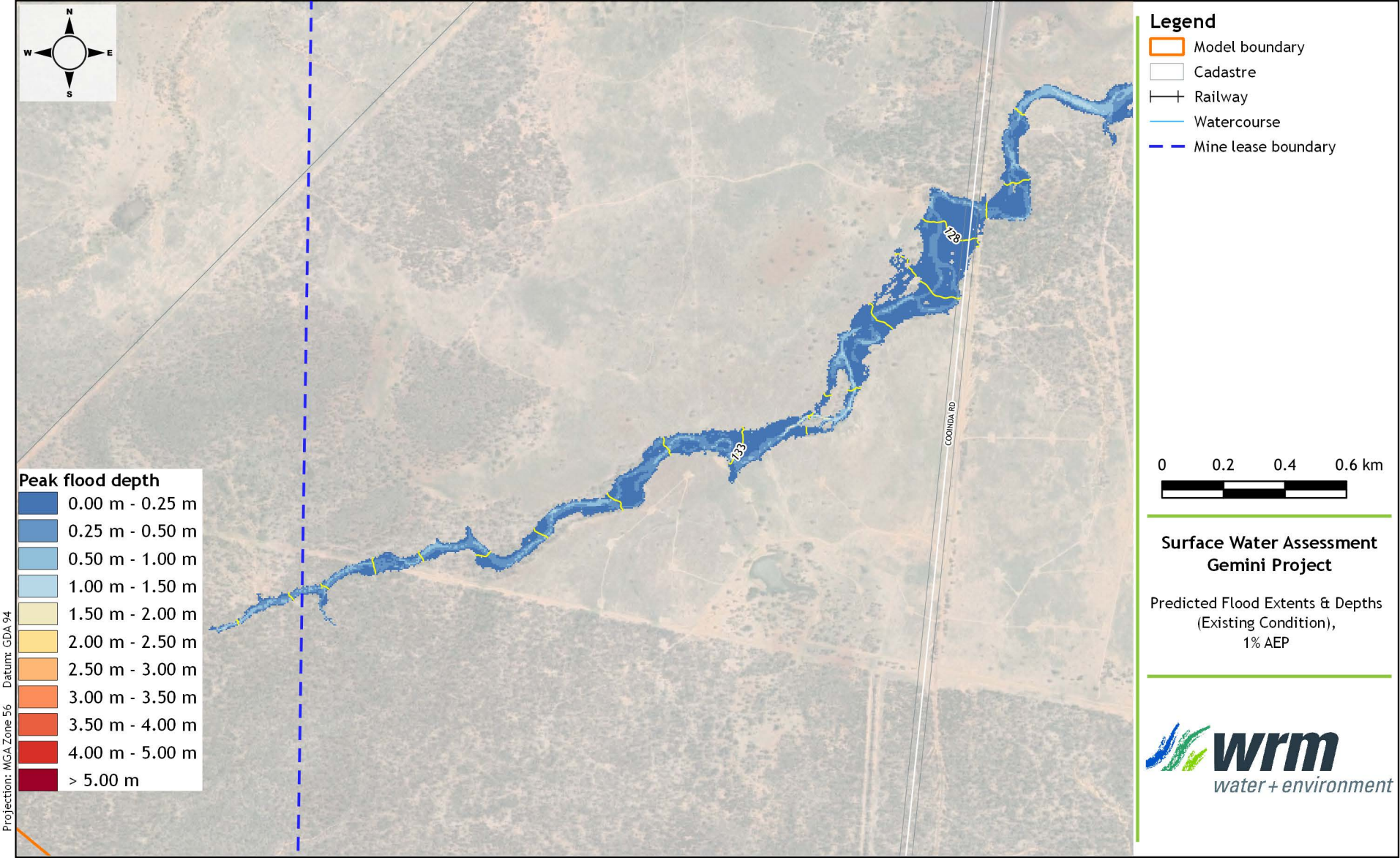
wrm water + environment

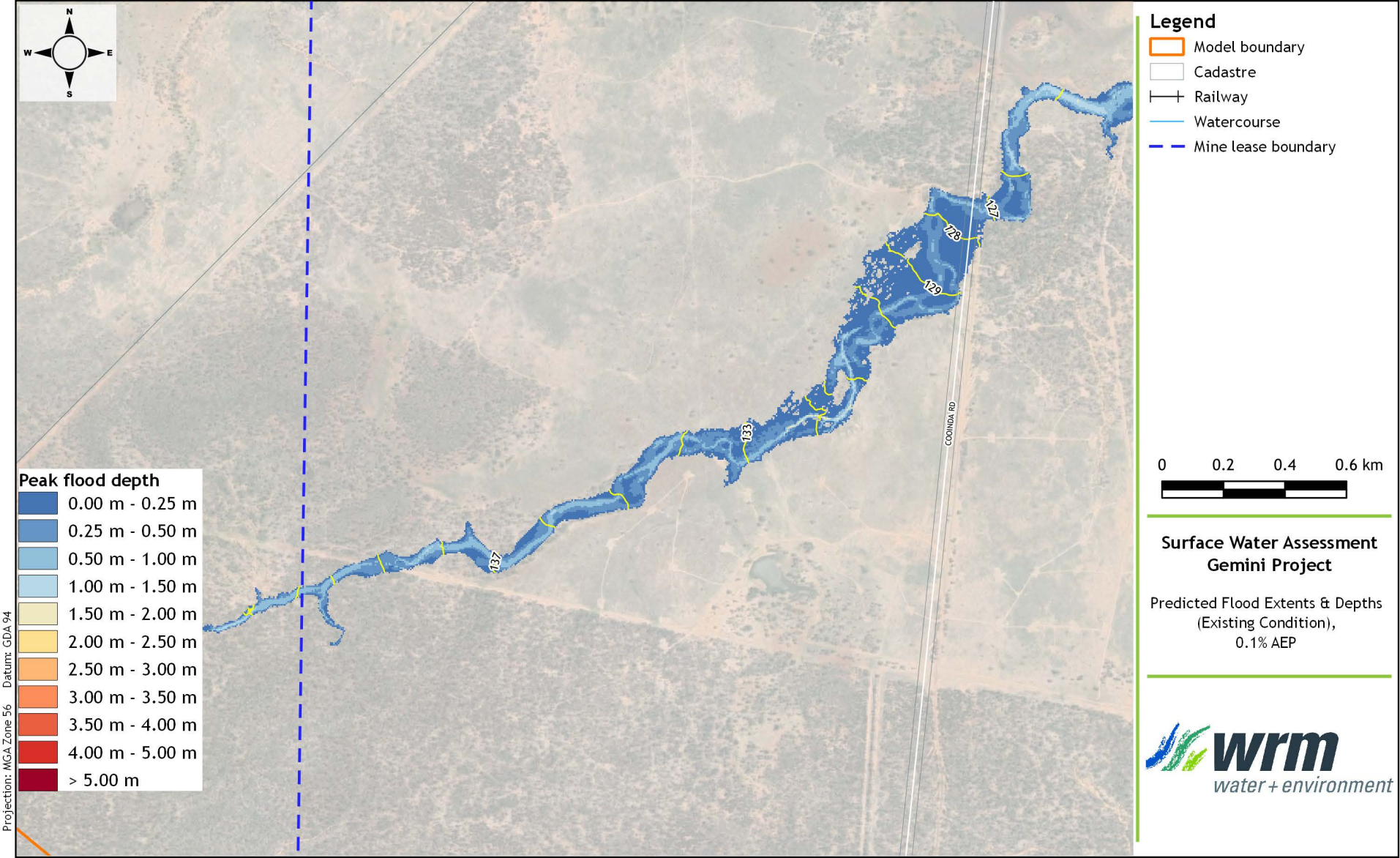
Projection: MGA Zone 55 Datum: GDA 94

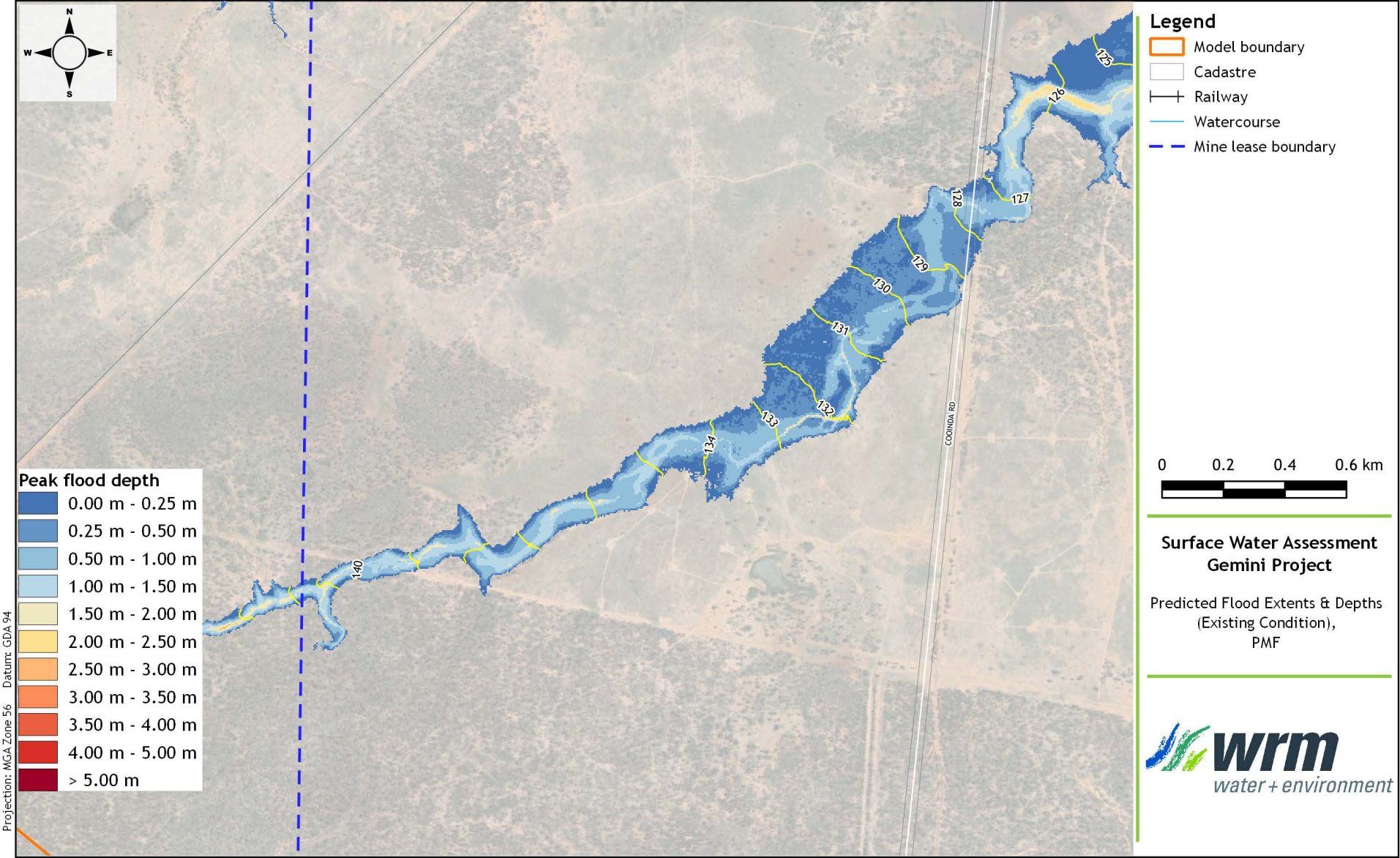

N
W
E
S
COONDA RD
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.2 0.4 0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Existing Condition),
50% AEP
wrm
water + environment

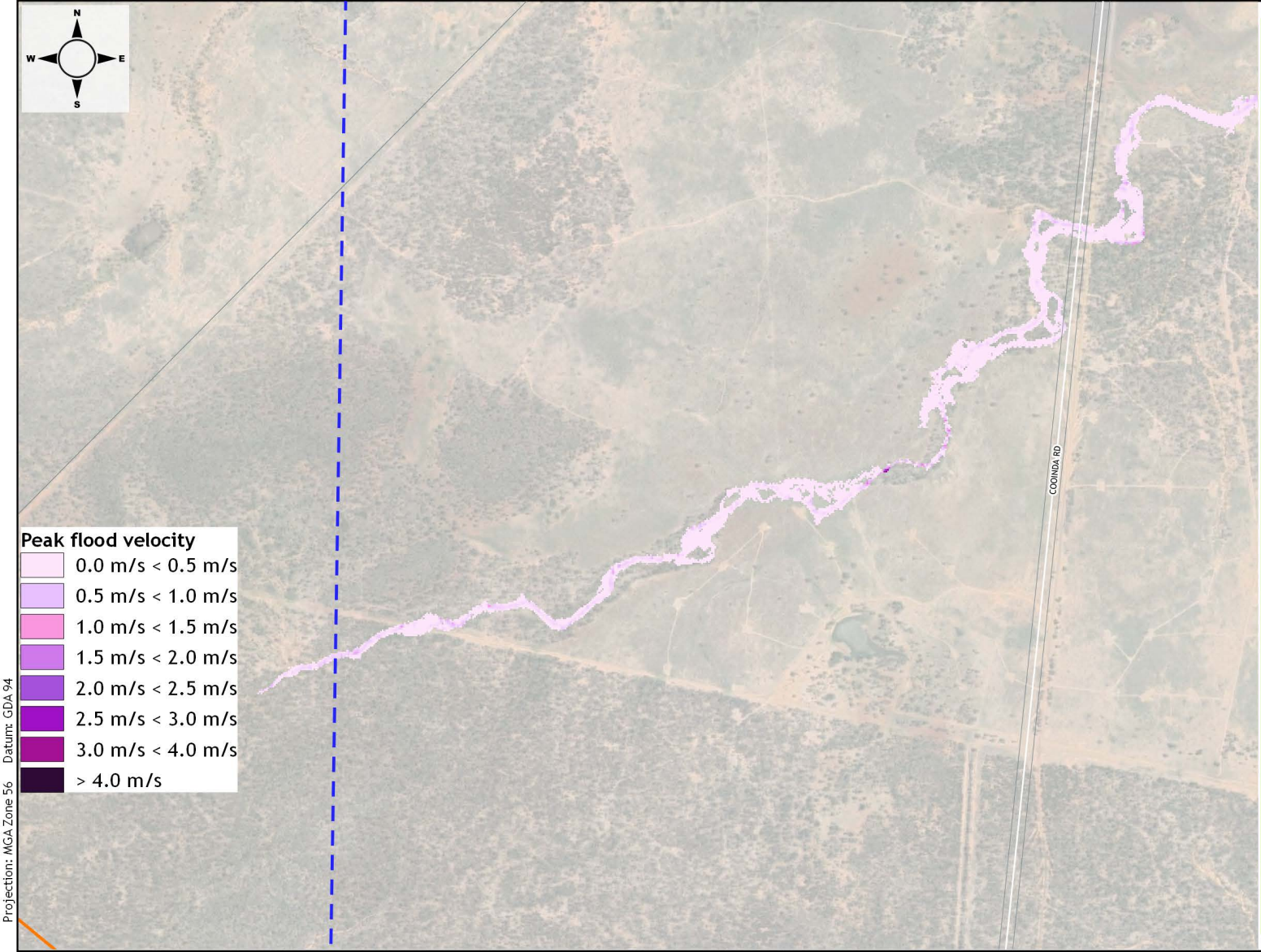

N
W
E
S
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
128
130
133
COONDA RD
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0
0.2
0.4
0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Existing Condition),
10% AEP
wrm
water + environment


N
W
E
S
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
128
133
COONDA RD
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.2 0.4 0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Existing Condition),
2% AEP
wrm
water + environment


N
W
E
S
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
COONDA RD
128
133
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.2 0.4 0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Existing Condition),
1% AEP
wrm
water + environment


N
W
E
S
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
127
128
129
133
137
COONDA RD
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0
0.2
0.4
0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Existing Condition),
0.1% AEP
wrm
water + environment


N
W
E
S
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
125
126
127
128
129
130
131
132
133
134
140
COONDA RD
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
0
0.2
0.4
0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Existing Condition),
PMF
wrm
water + environment
Projection: MGA Zone 56 Datum: GDA 94



Legend

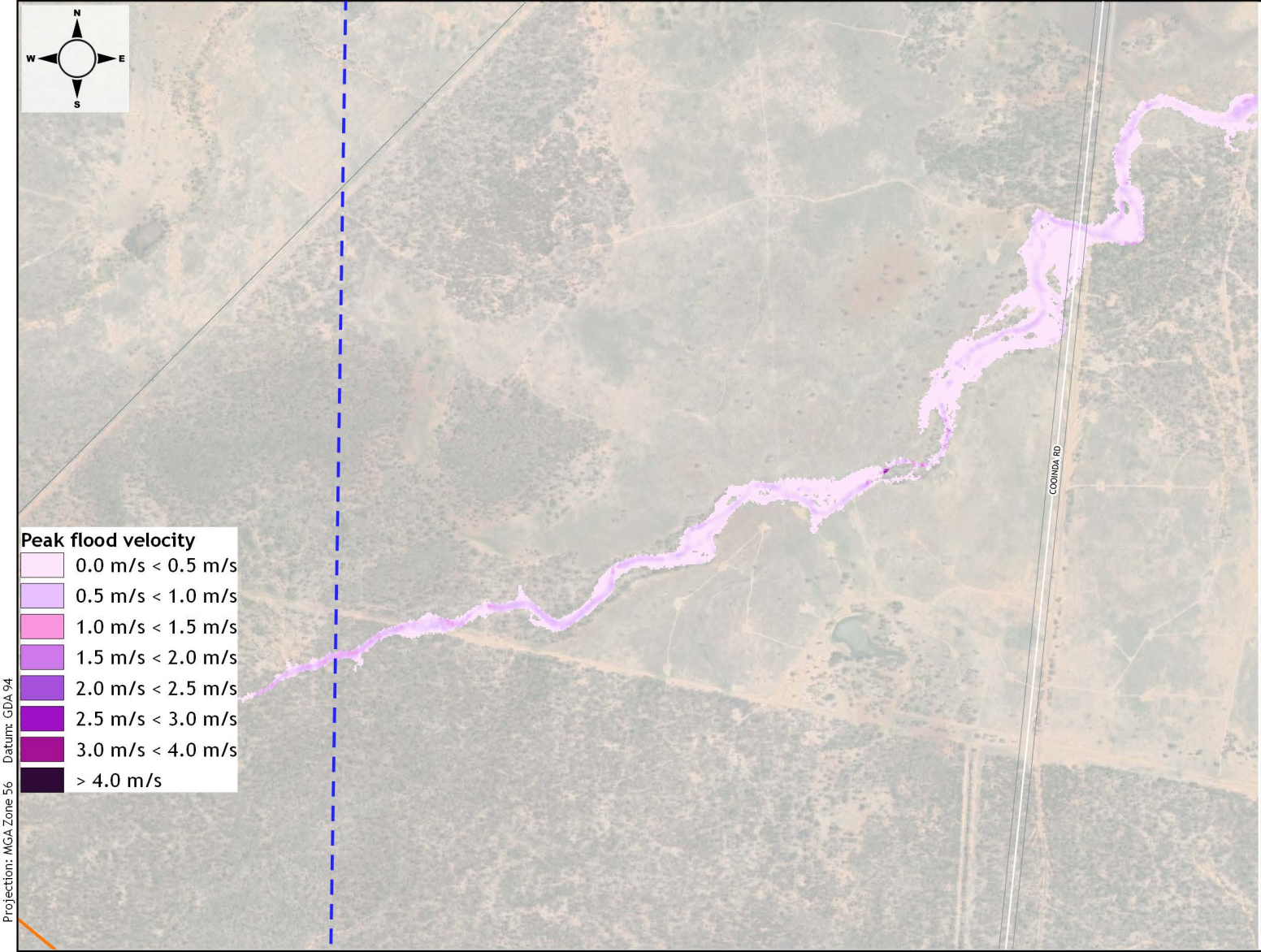
- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

0 0.2 0.4 0.6 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
50% AEP

wrm water + environment



Legend

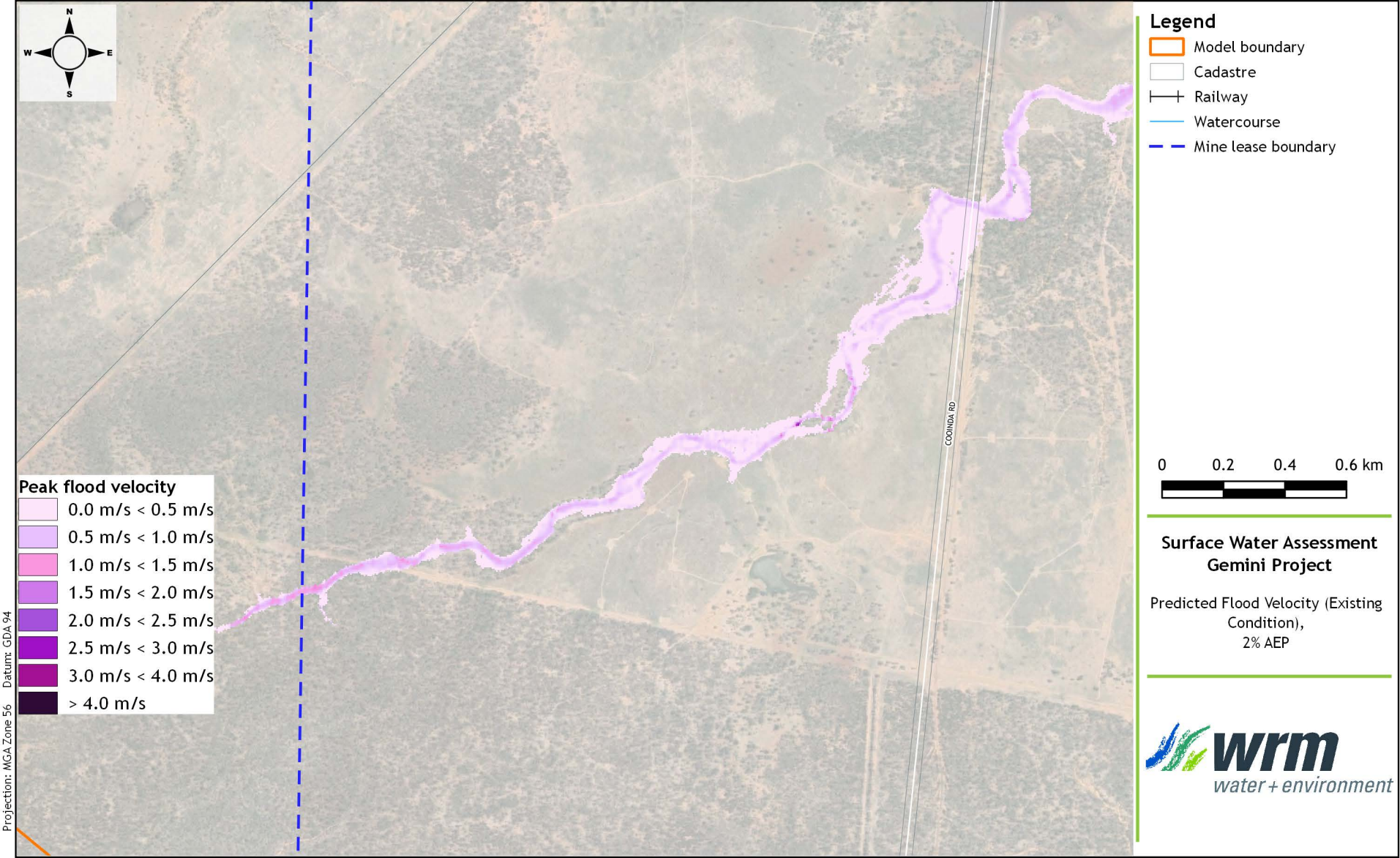
- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

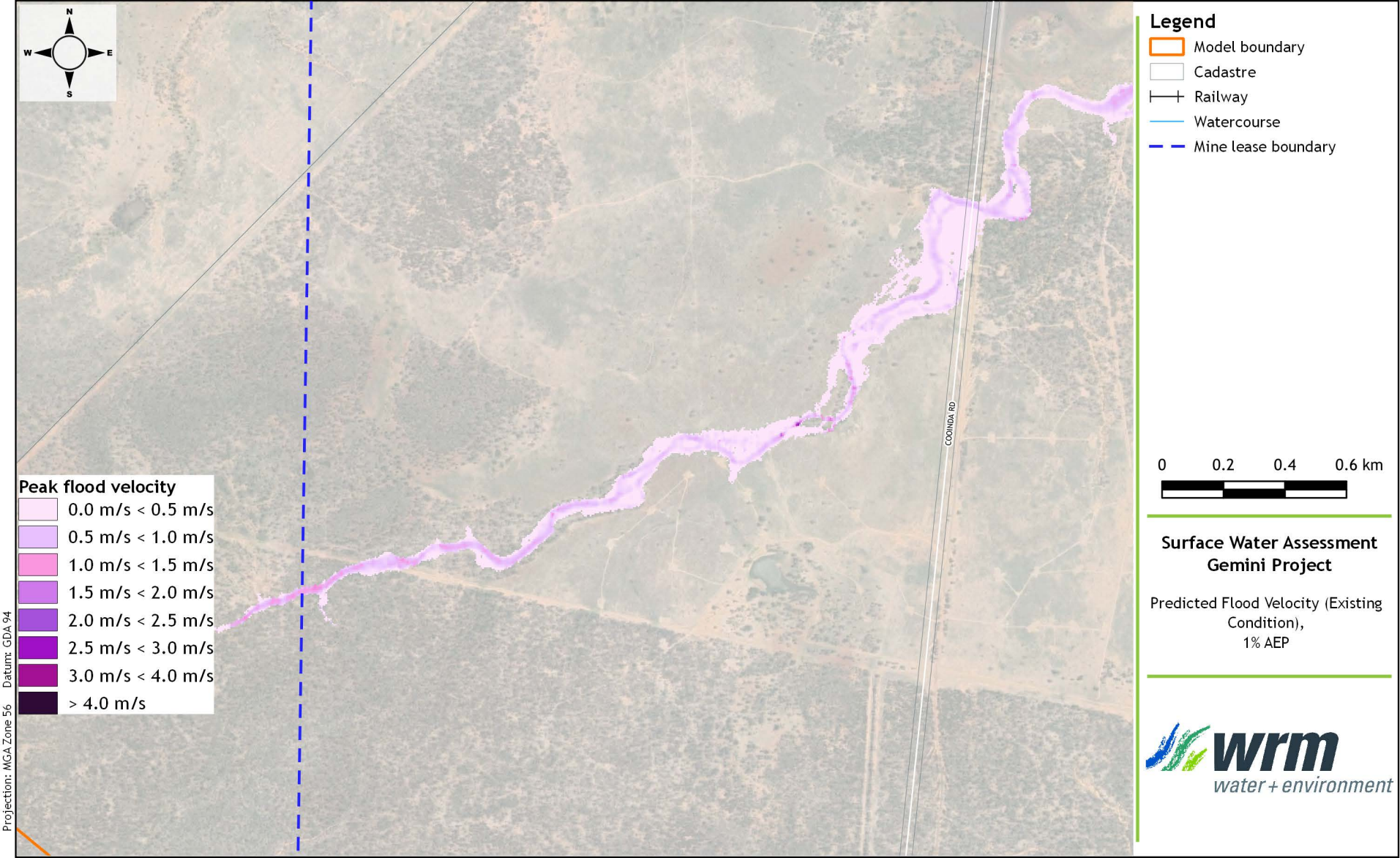
0 0.2 0.4 0.6 km

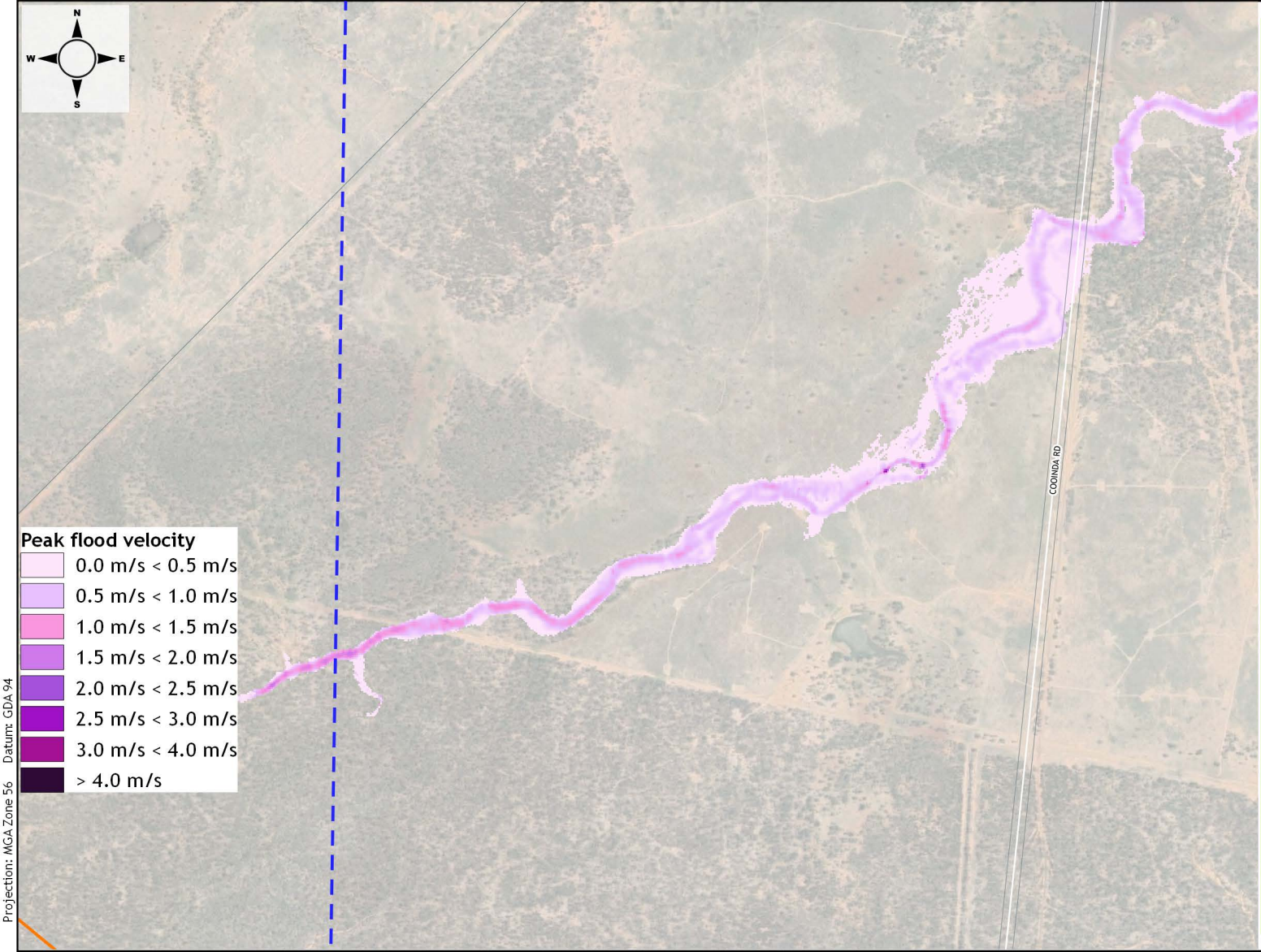
Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
10% AEP

wrm water + environment


N
W
E
S
COONDA RD
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.2 0.4 0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity (Existing Condition),
2% AEP
wrm
water + environment


N
W
E
S
COONDA RD
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.2 0.4 0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity (Existing Condition),
1% AEP
wrm
water + environment



Legend

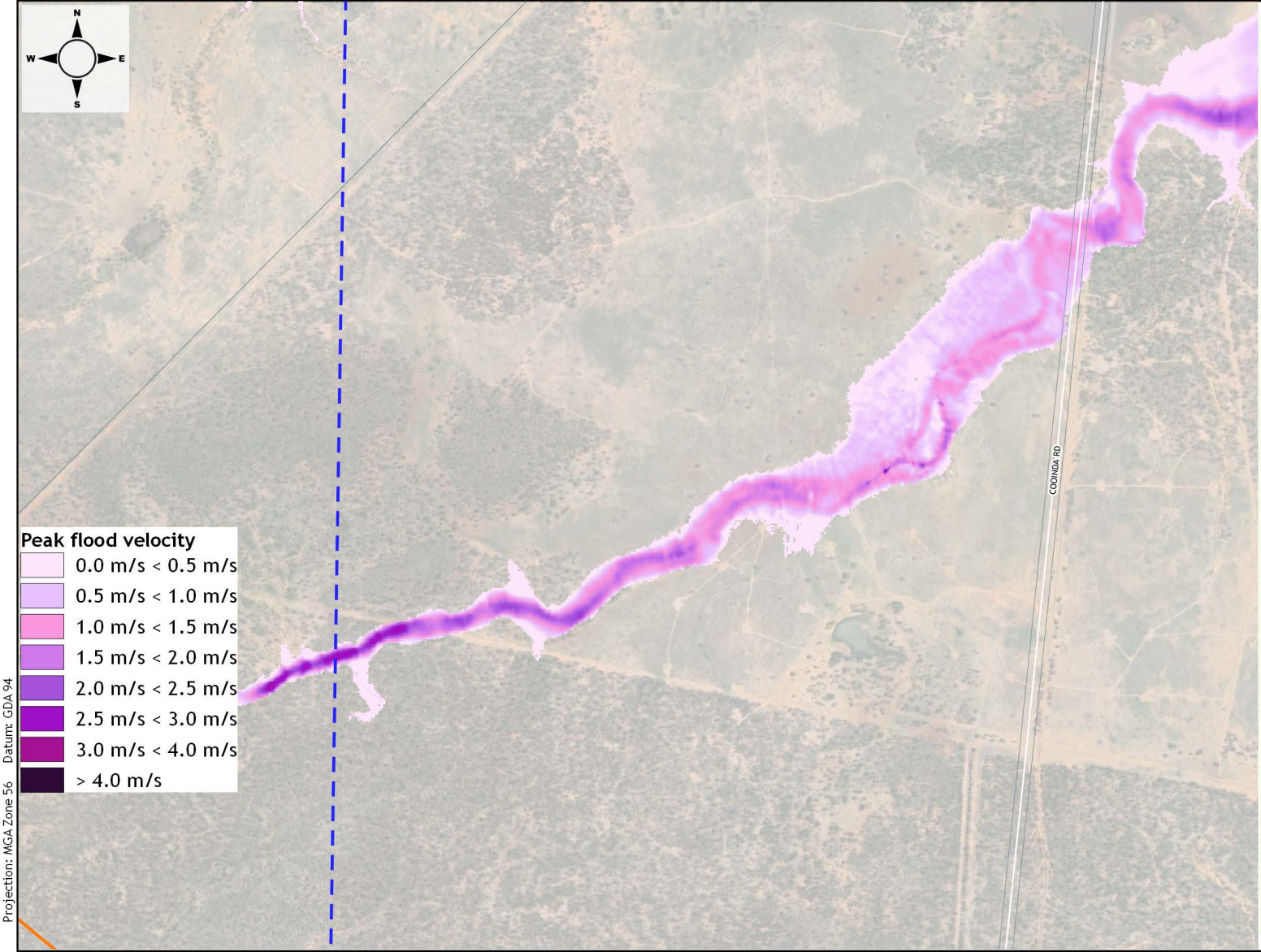
- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

0 0.2 0.4 0.6 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
0.1% AEP

wrm water + environment



Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

Projection: MGA Zone 56 Datum: GDA 94

Legend

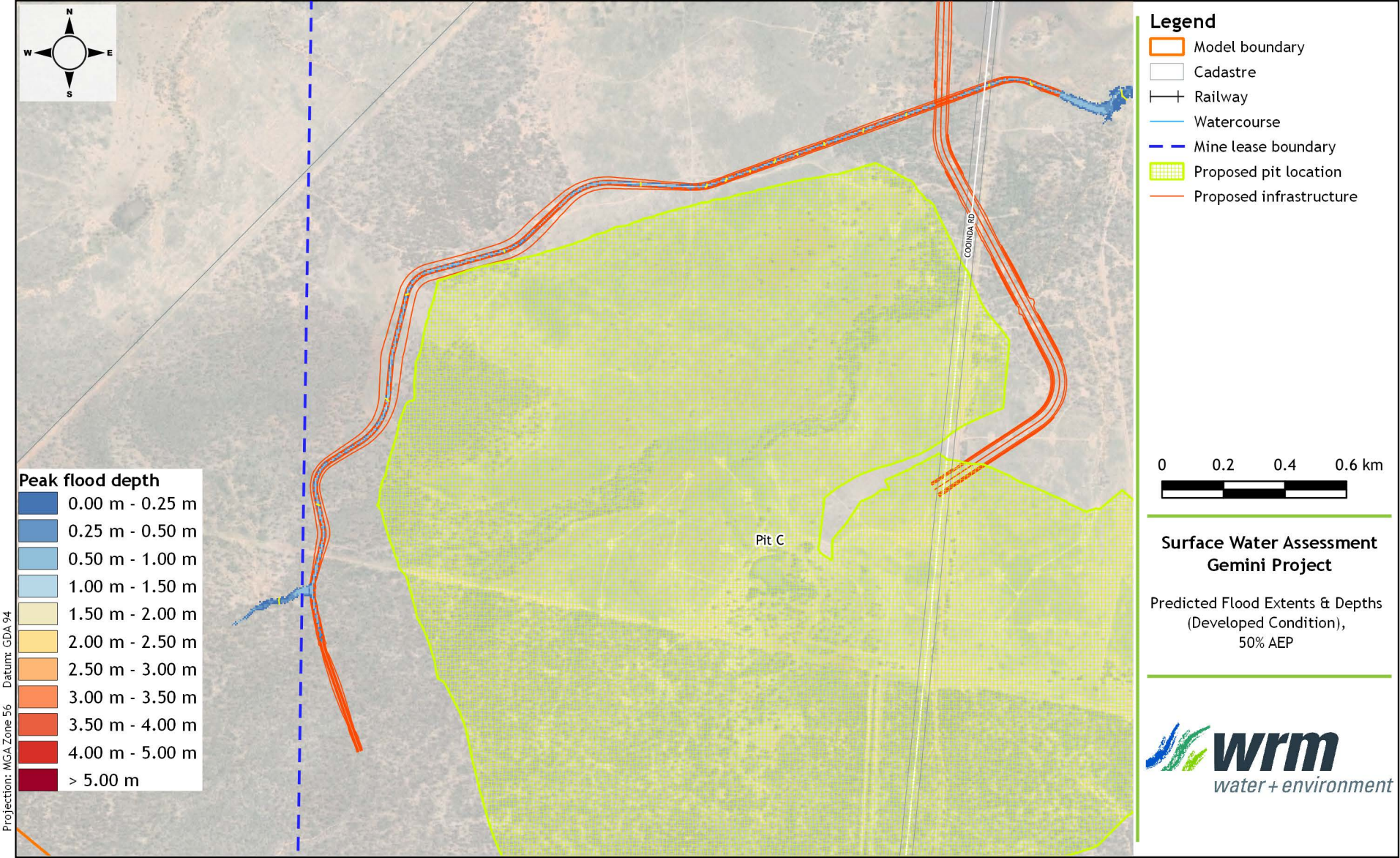
- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

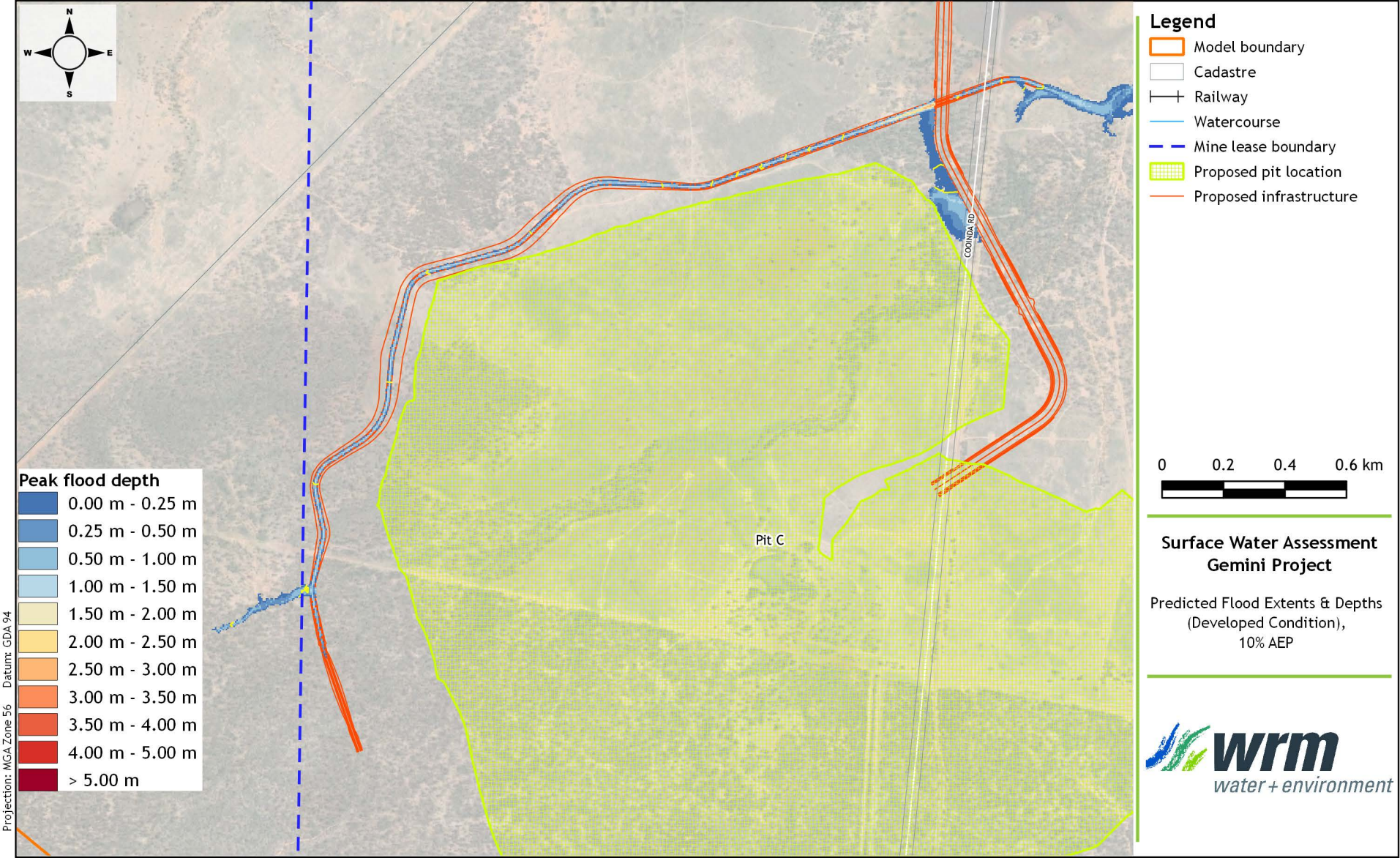
0 0.2 0.4 0.6 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
PMF

wrm water + environment

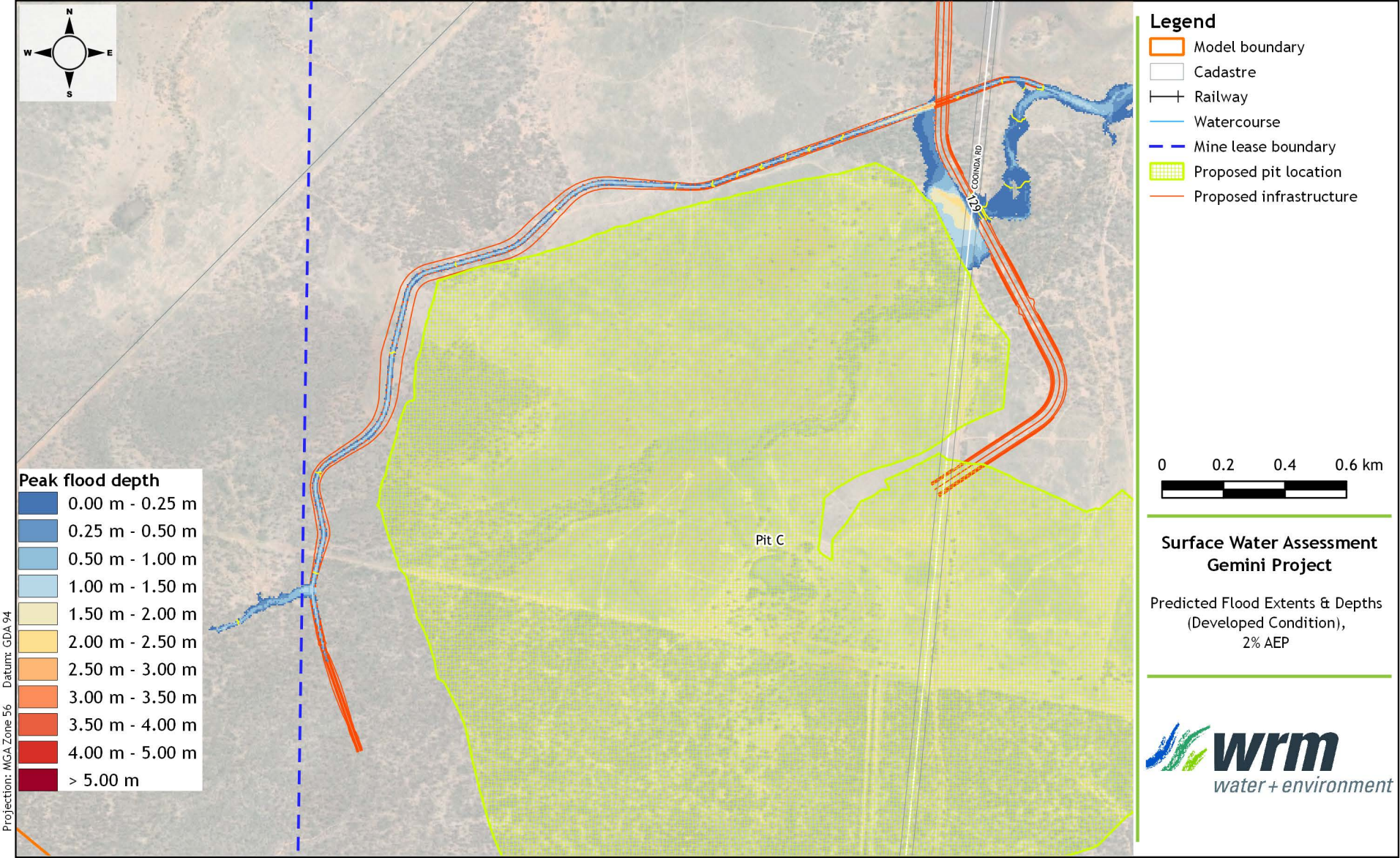

N
W
E
S
COOINDA RD
Pit C
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.2 0.4 0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Developed Condition),
50% AEP
wrm
water + environment

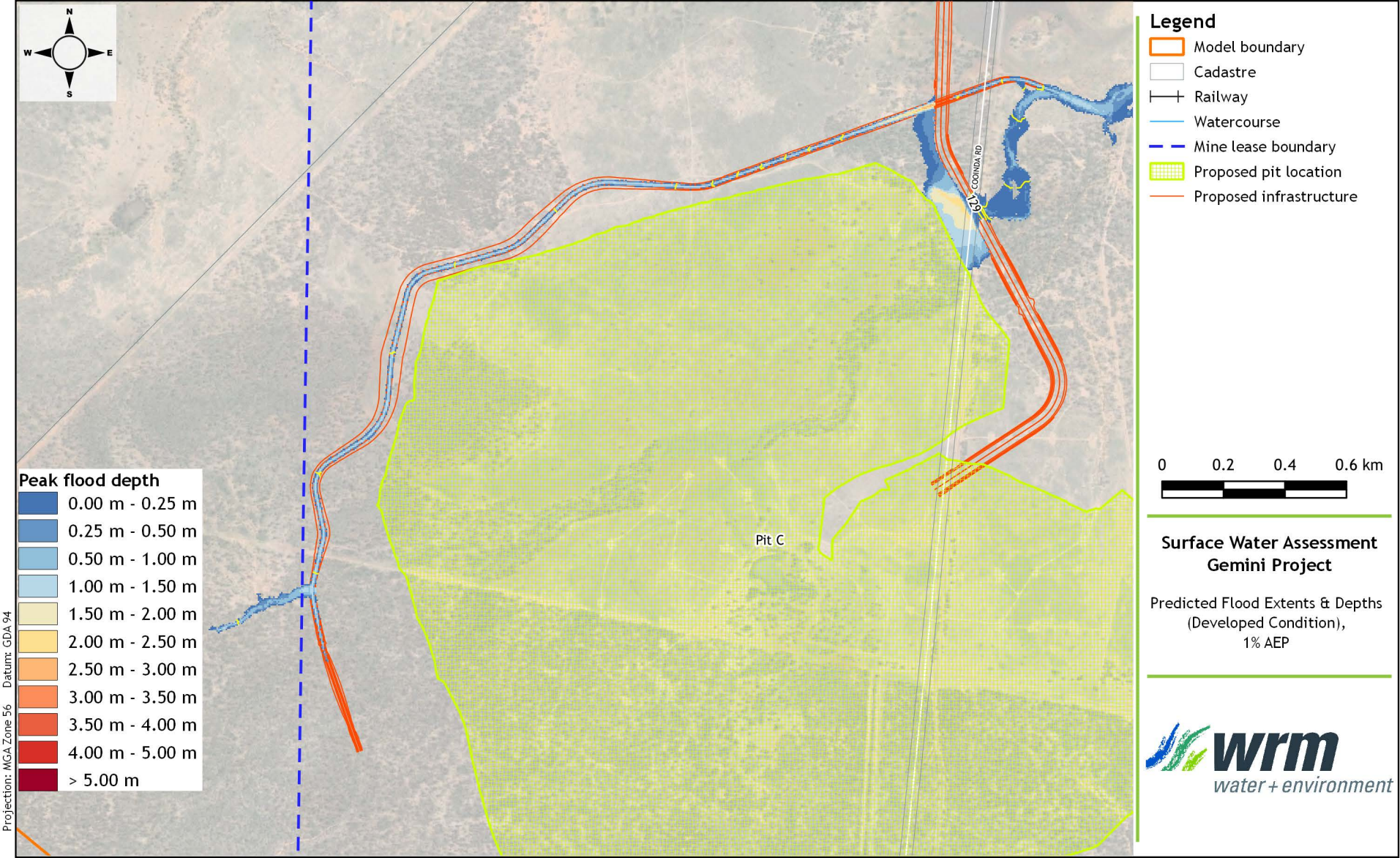


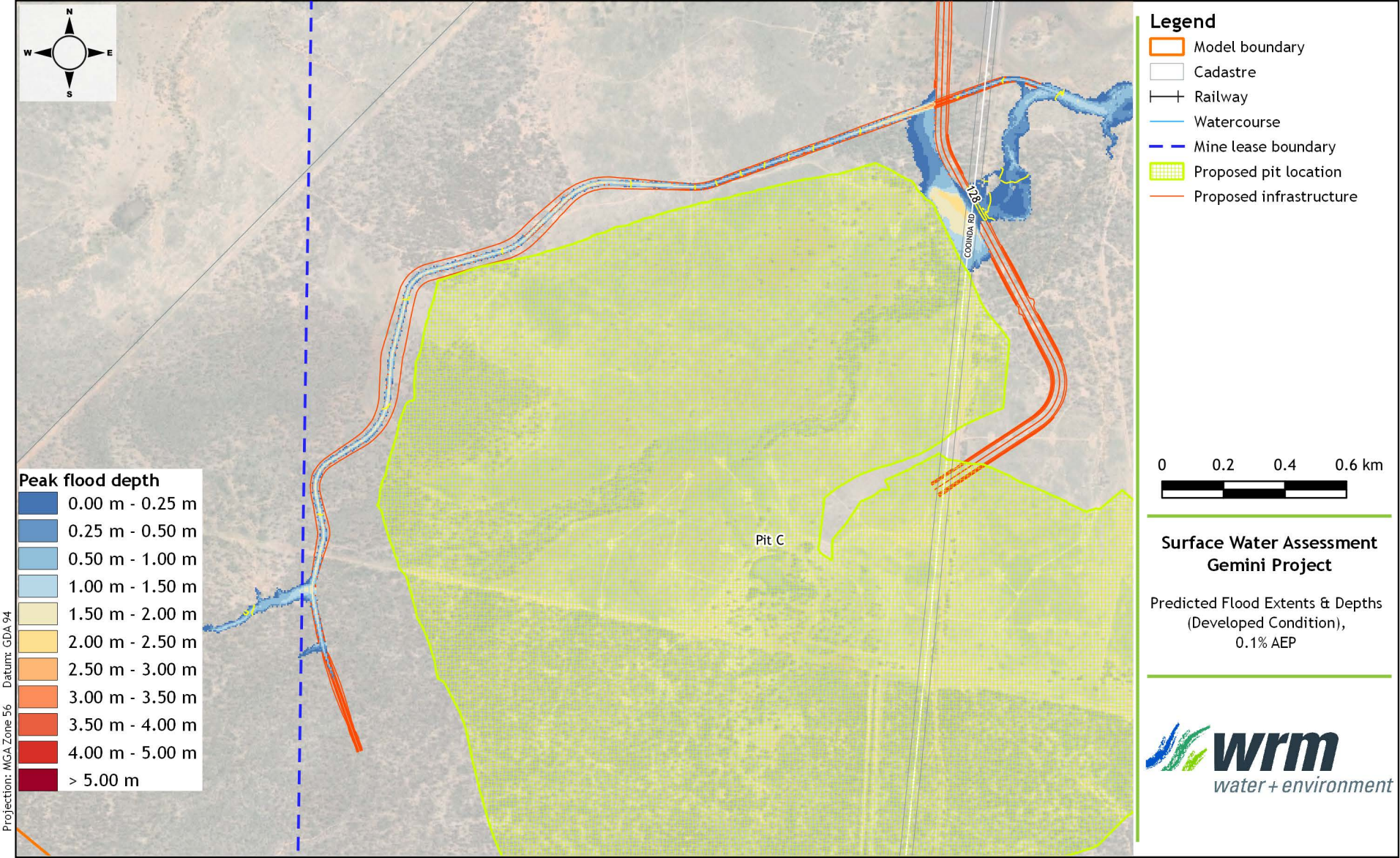
Surface Water Assessment
Gemini Project

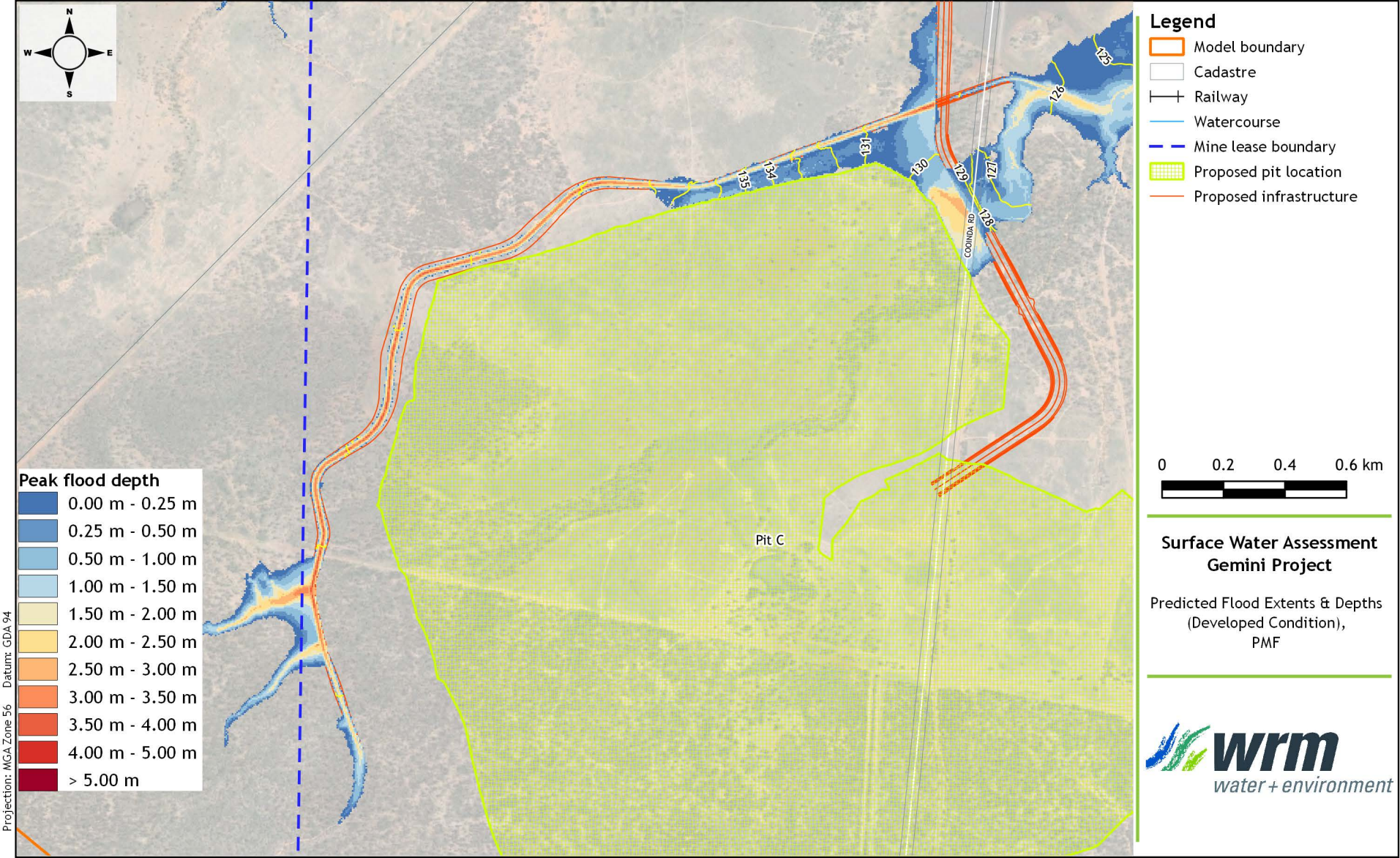
Predicted Flood Extents & Depths
(Developed Condition),
10% AEP

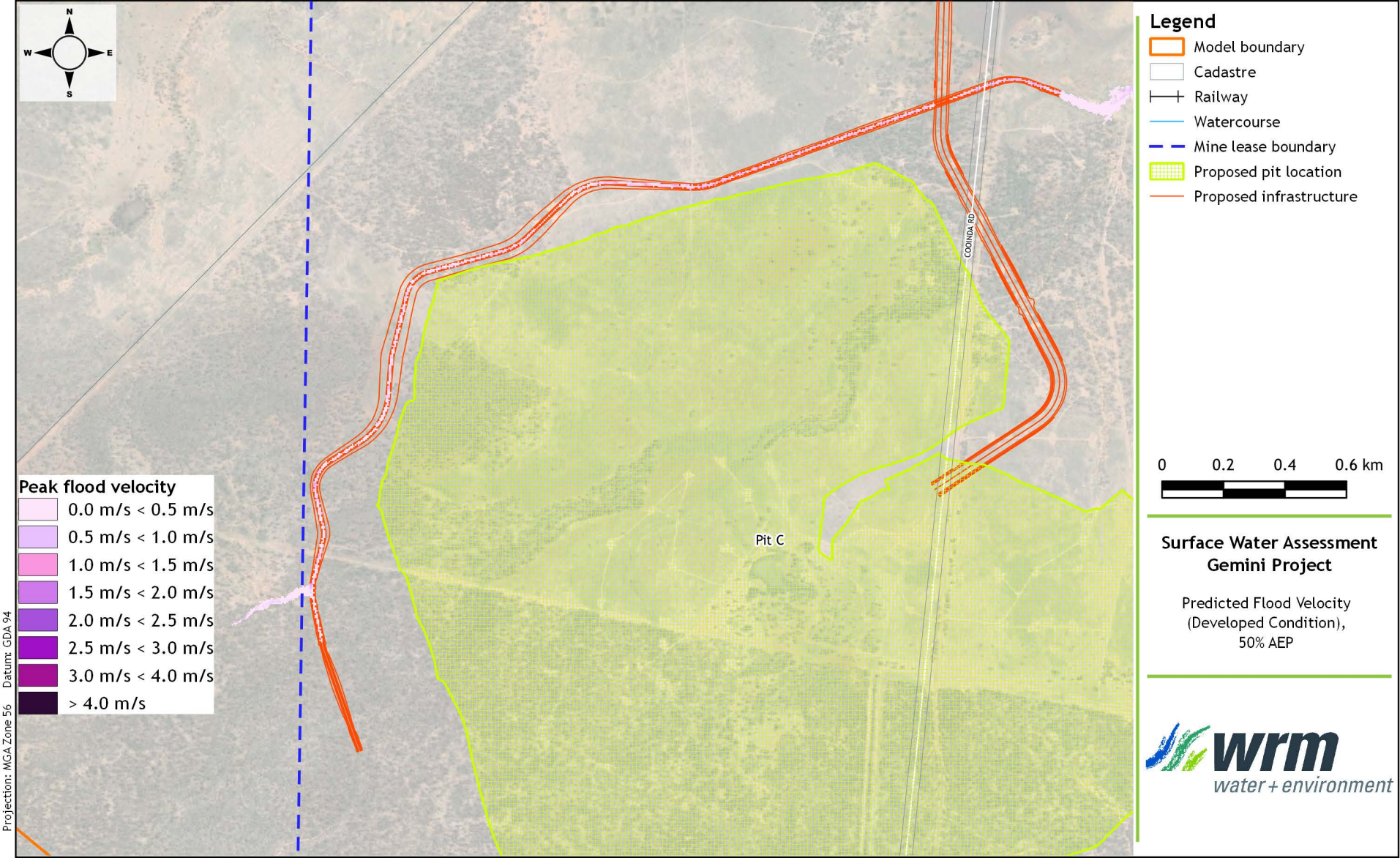
wrm water + environment


N
W
E
S
COONDA RD
Pit C
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.2 0.4 0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Developed Condition),
2% AEP
wrm
water + environment


N
W
E
S
COONDA RD
Pit C
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.2 0.4 0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Developed Condition),
1% AEP
wrm
water + environment


N
W
E
S
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Pit C
128
COOINDA RD
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0
0.2
0.4
0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Developed Condition),
0.1% AEP
wrm
water + environment

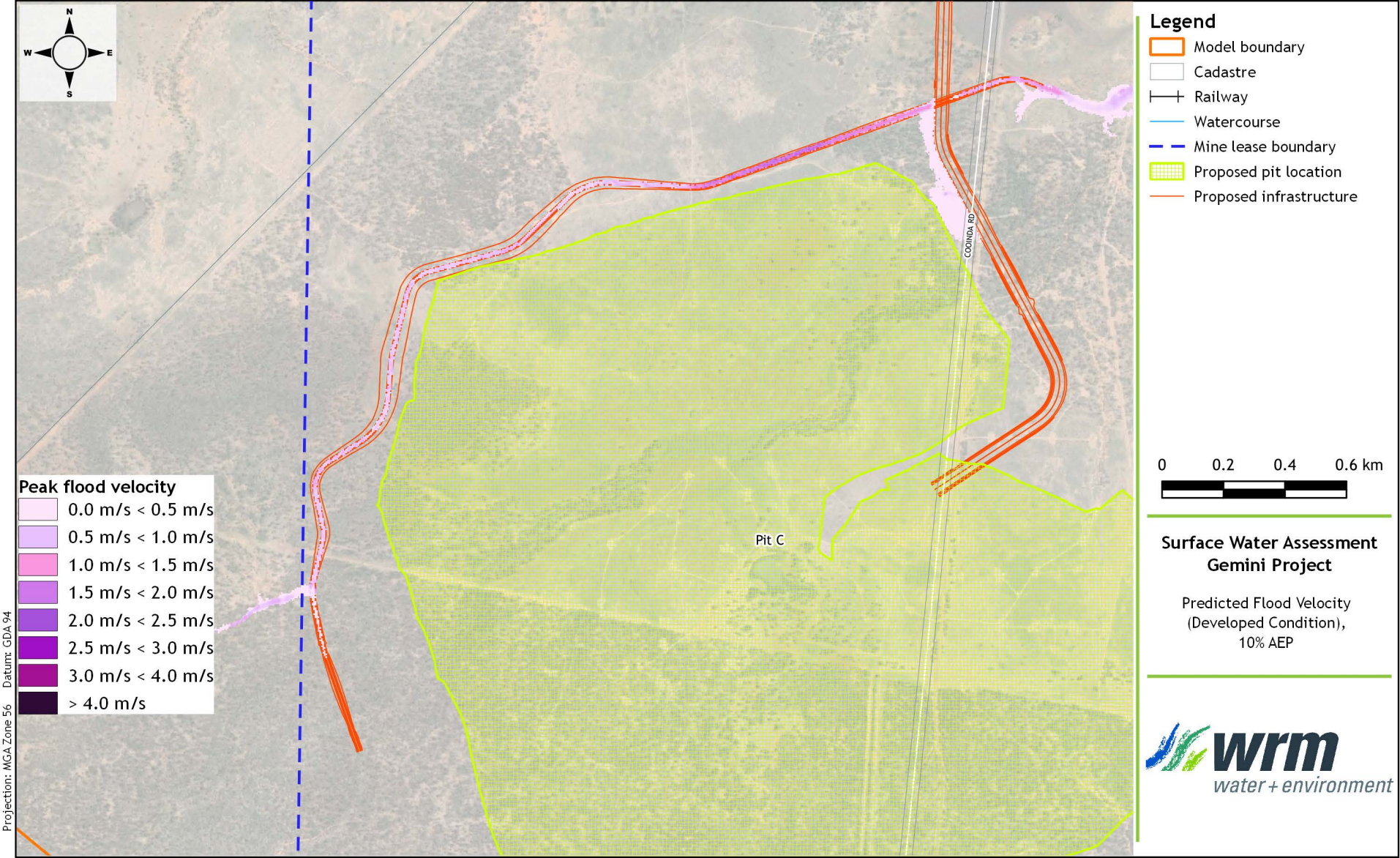

N
W
E
S
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
125
126
127
128
129
130
131
134
135
COOINDA RD
Pit C
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0
0.2
0.4
0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Developed Condition),
PMF
wrm
water + environment

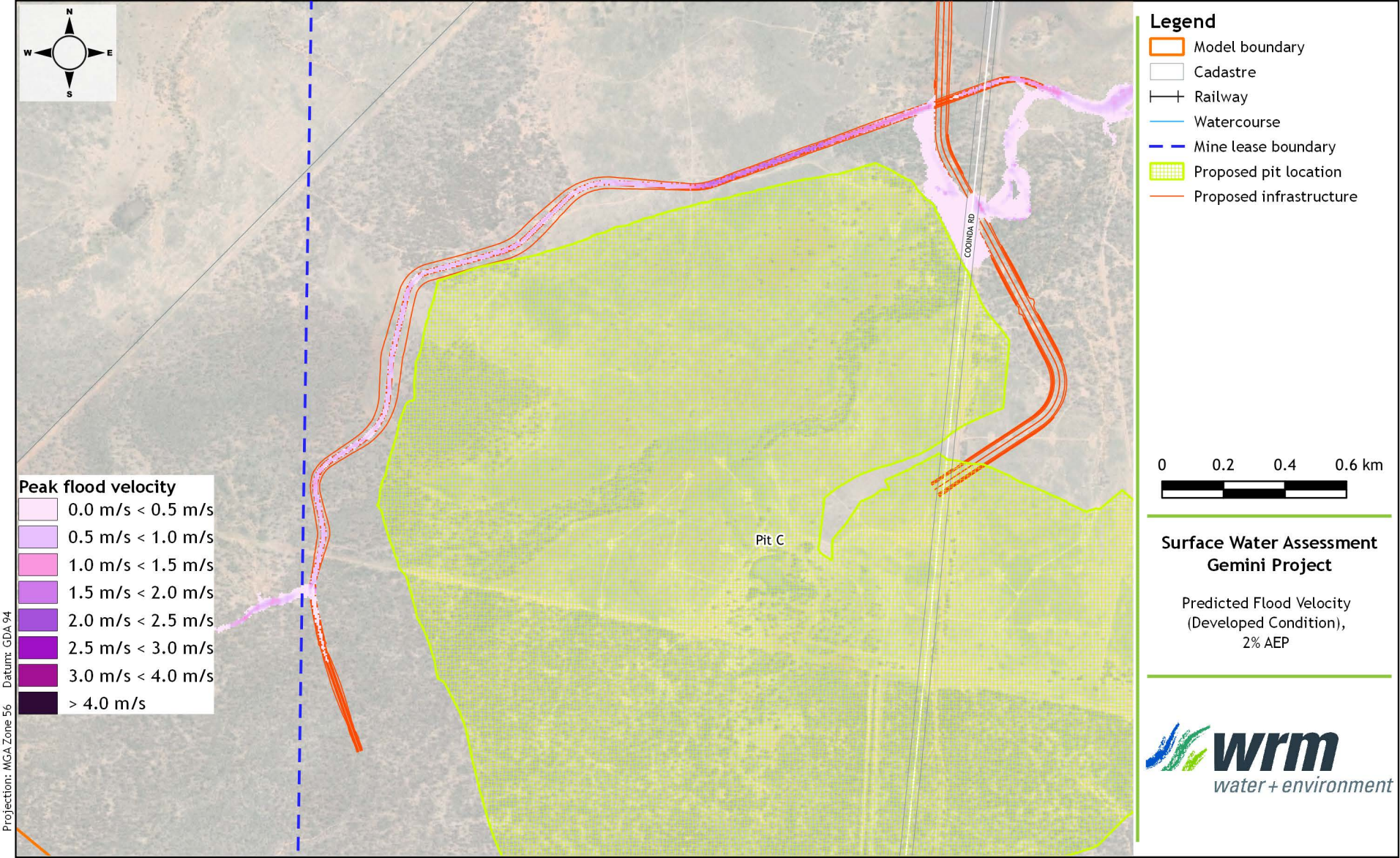


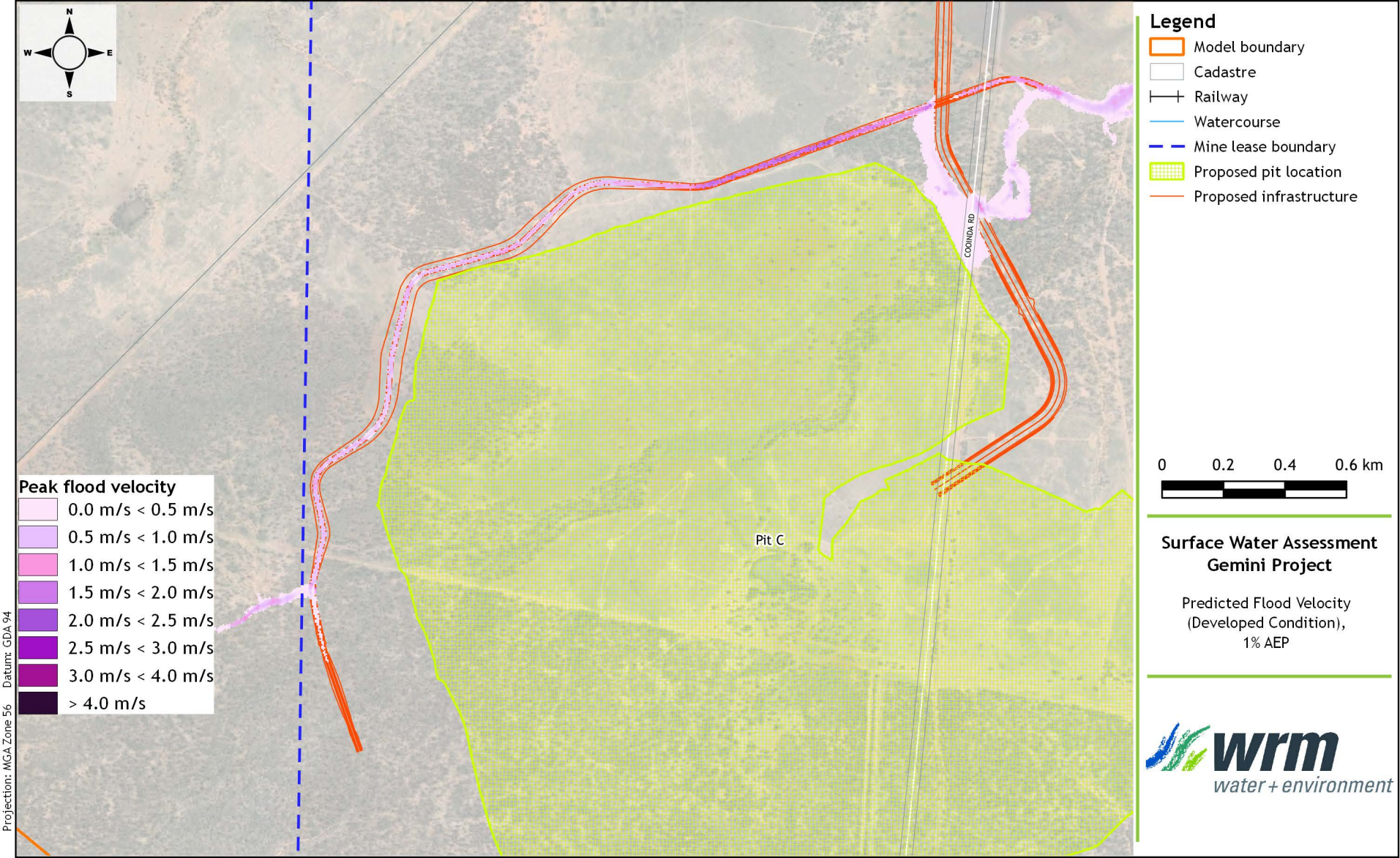
Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
50% AEP

wrm
water + environment


N
W
E
S
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
COOINDA RD
Pit C
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
0
0.2
0.4
0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity
(Developed Condition),
10% AEP
wrm
water + environment
Projection: MGA Zone 56 Datum: GDA 94

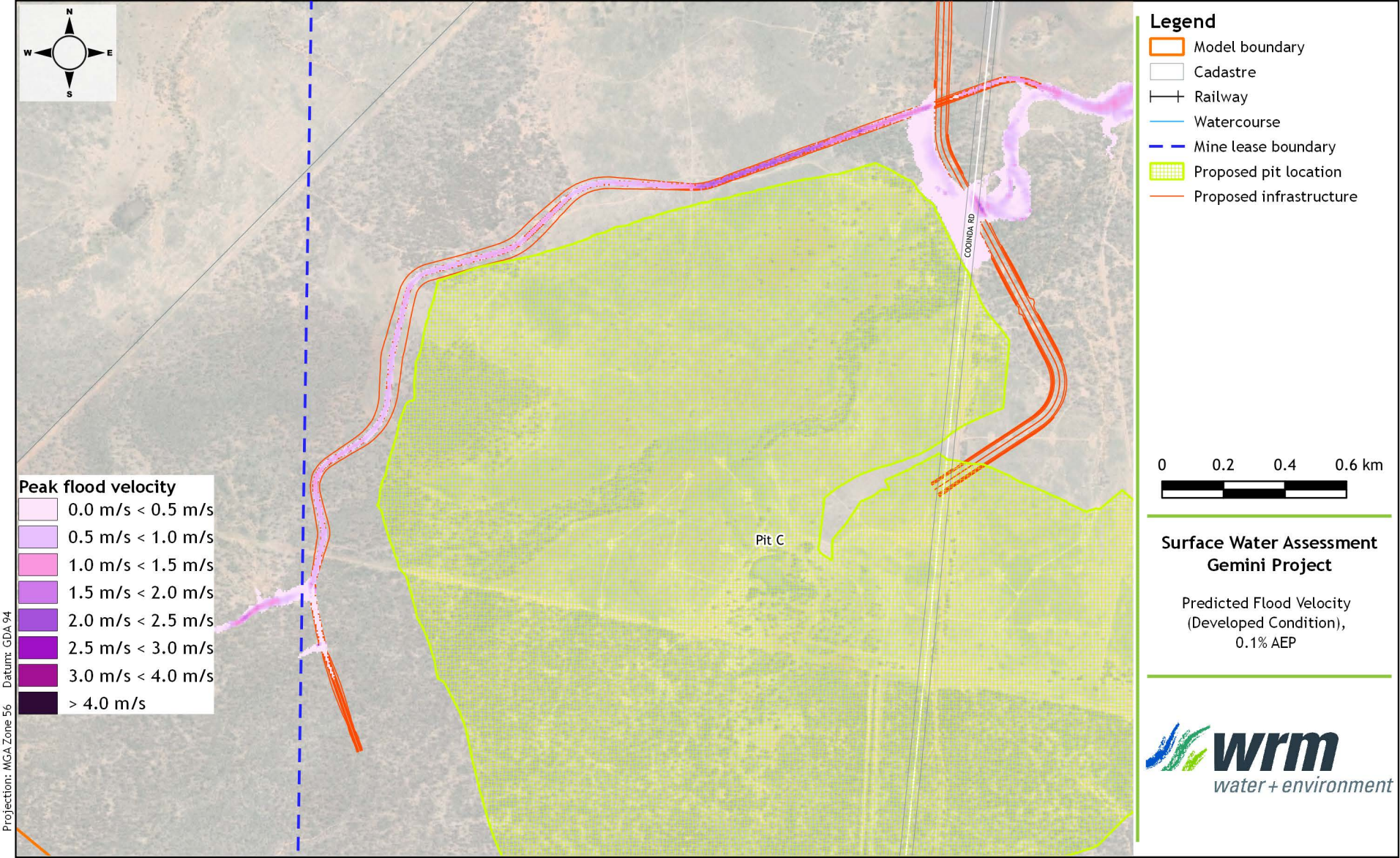

N
W
E
S
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
COOINDA RD
Pit C
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
0
0.2
0.4
0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity
(Developed Condition),
2% AEP
wrm
water + environment
Projection: MGA Zone 56 Datum: GDA 94

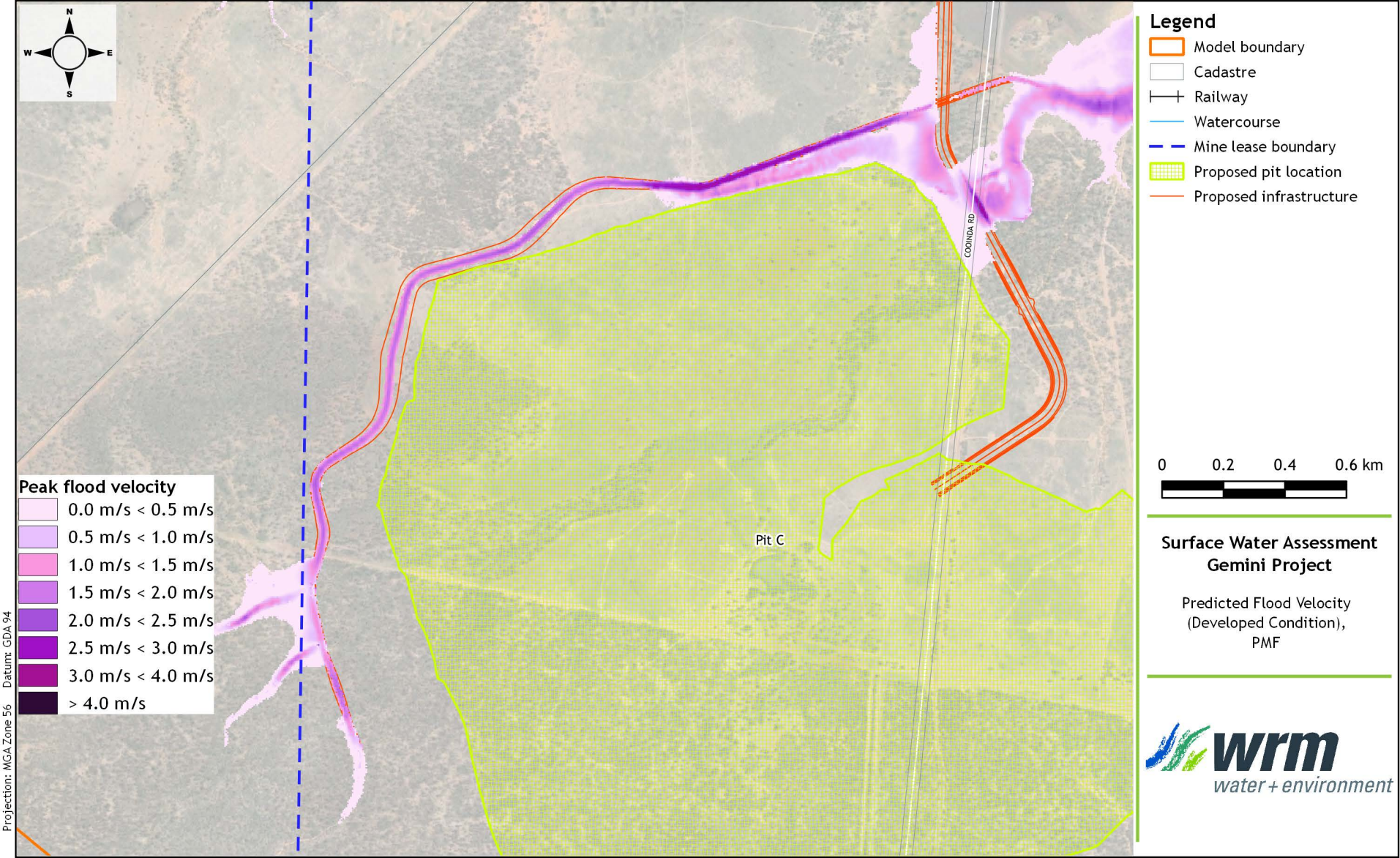


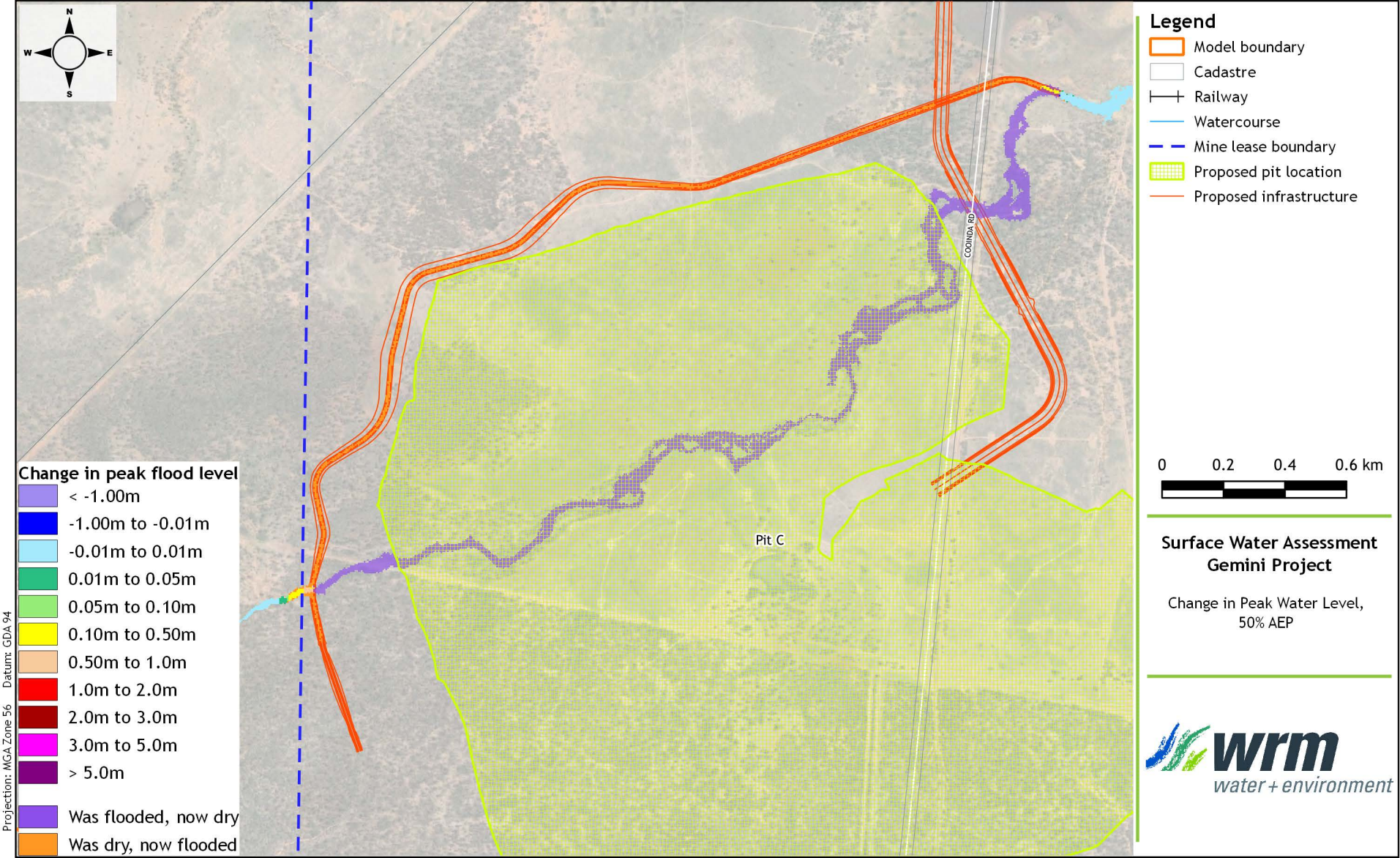
Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
1% AEP

wrm water + environment


N
W
E
S
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
COOINDA RD
Pit C
0 0.2 0.4 0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity
(Developed Condition),
0.1% AEP
wrm
water + environment

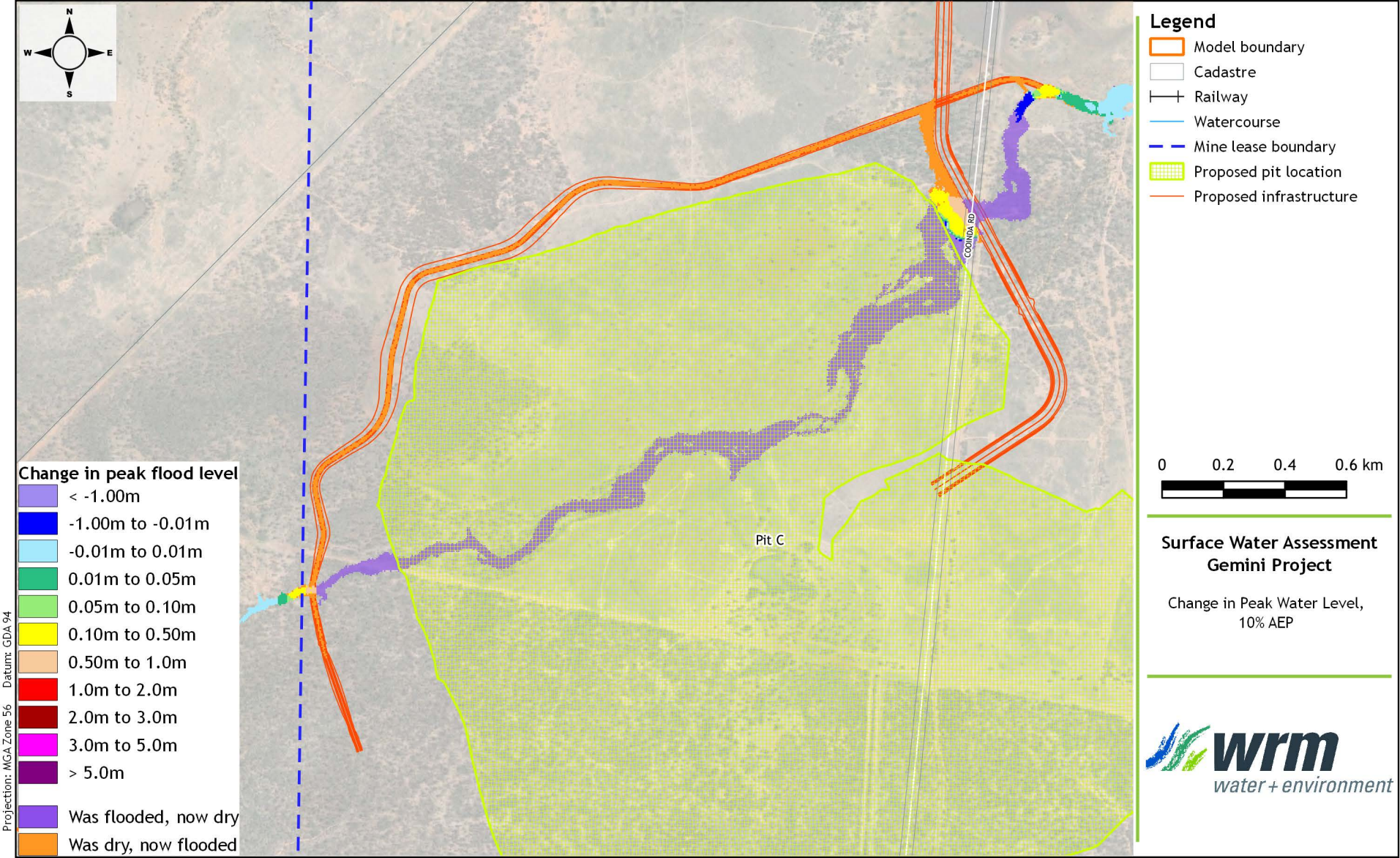

N
W
E
S
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
COOINDA RD
Pit C
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
0
0.2
0.4
0.6 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity
(Developed Condition),
PMF
wrm
water + environment
Projection: MGA Zone 56 Datum: GDA 94



Surface Water Assessment
Gemini Project

Change in Peak Water Level,
50% AEP

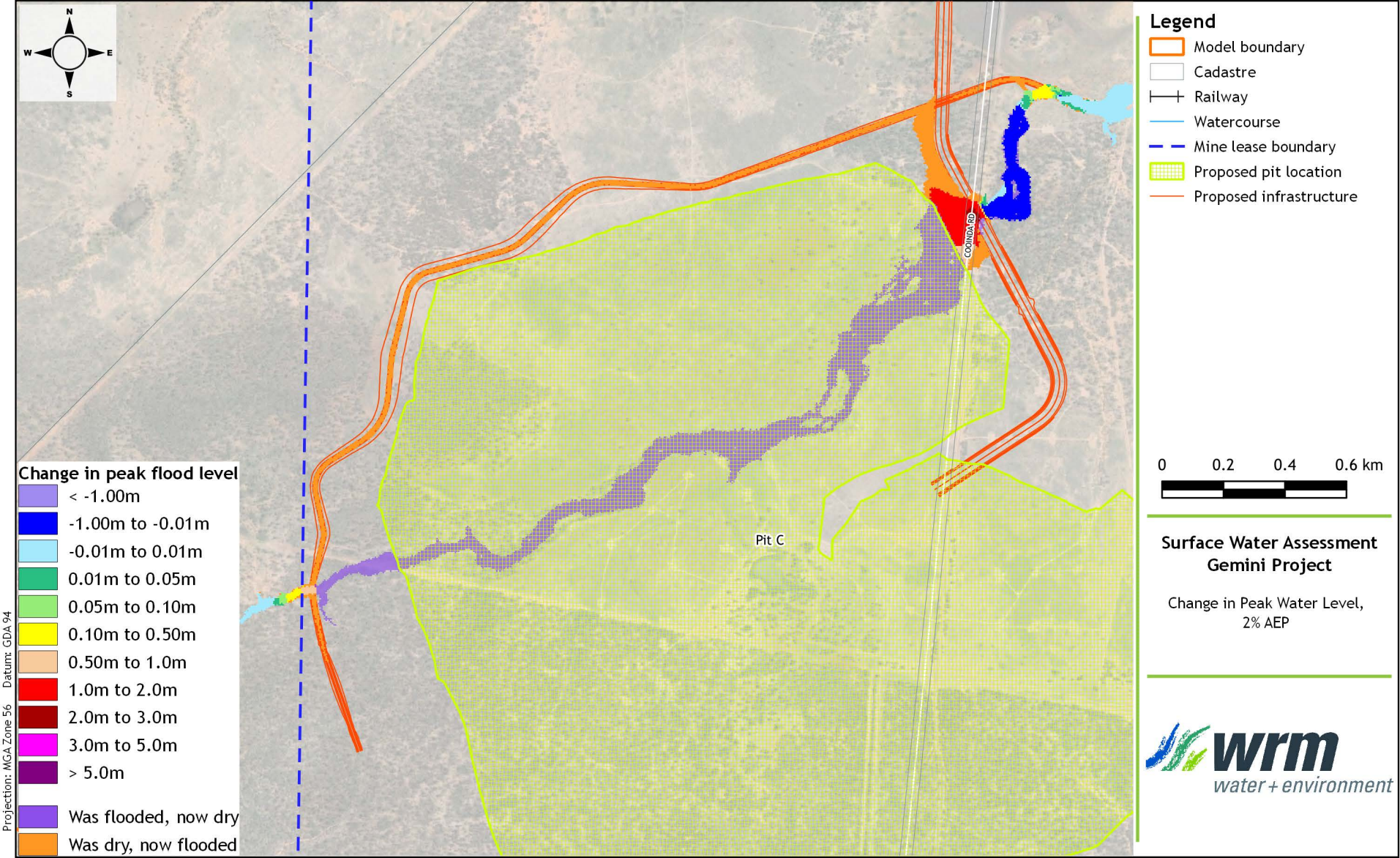
wrm
water + environment



Surface Water Assessment
Gemini Project

Change in Peak Water Level,
10% AEP

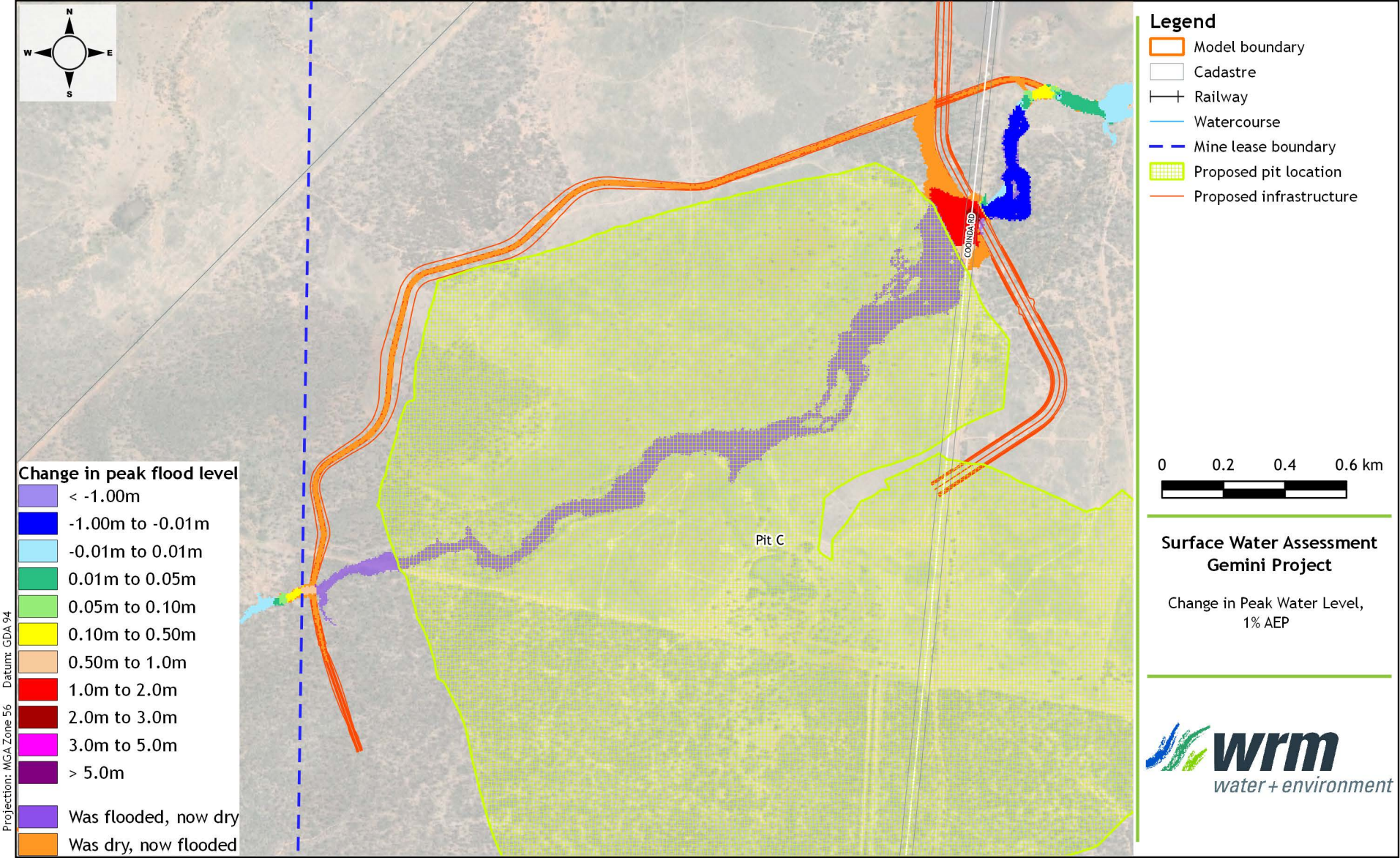
wrm
water + environment



Surface Water Assessment
Gemini Project

Change in Peak Water Level,
2% AEP

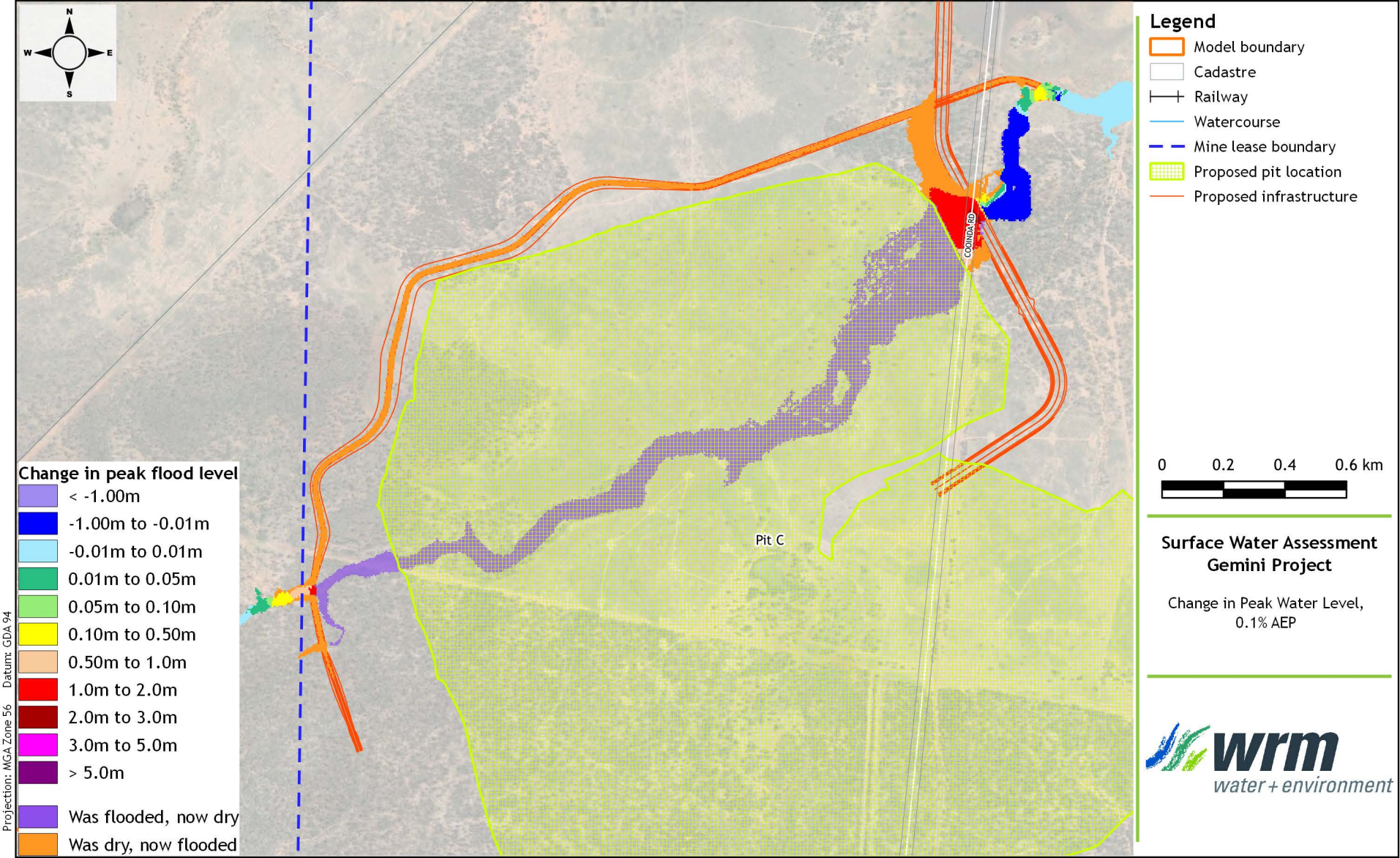
wrm water + environment



Surface Water Assessment
Gemini Project

Change in Peak Water Level,
1% AEP

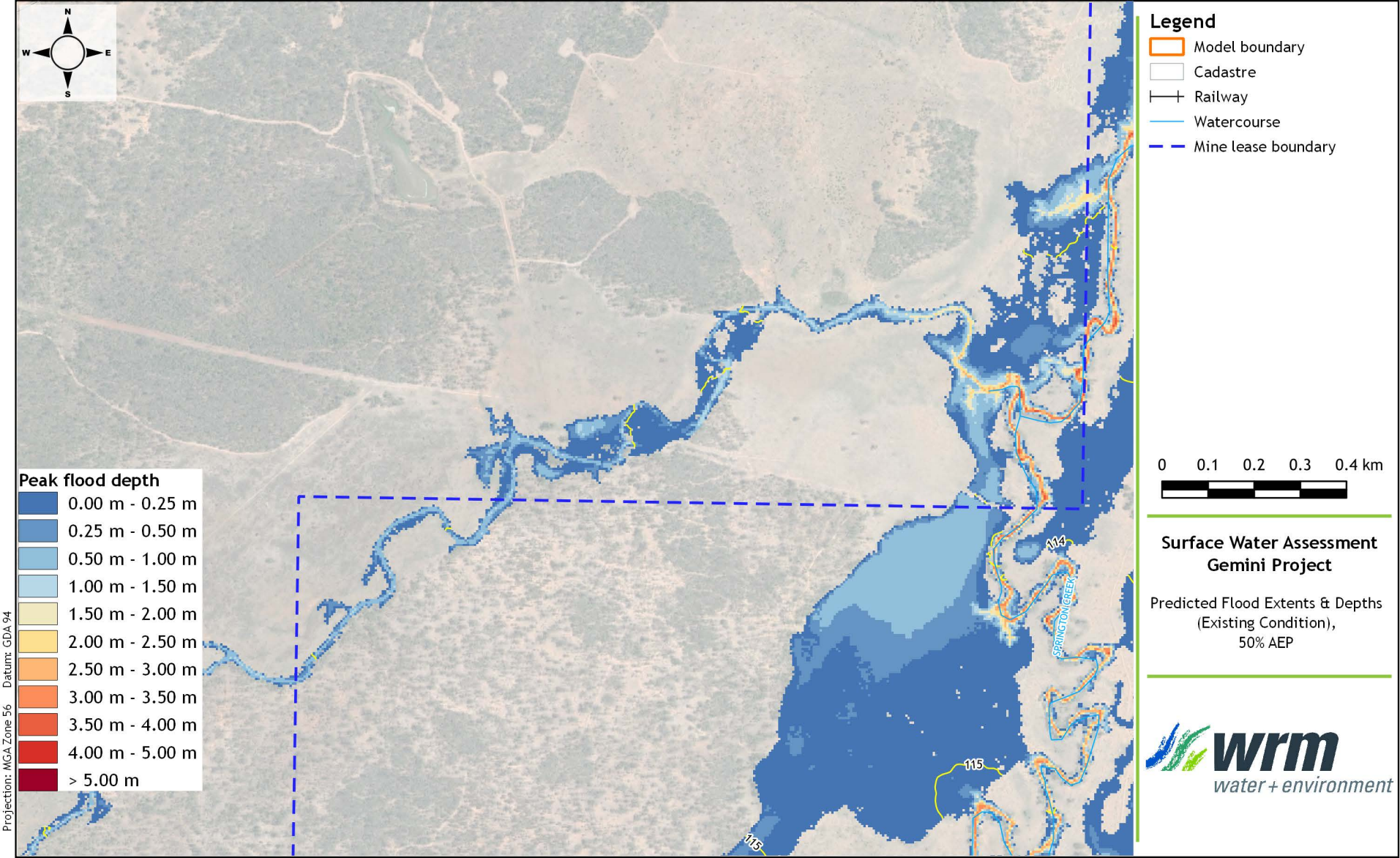
wrm water + environment

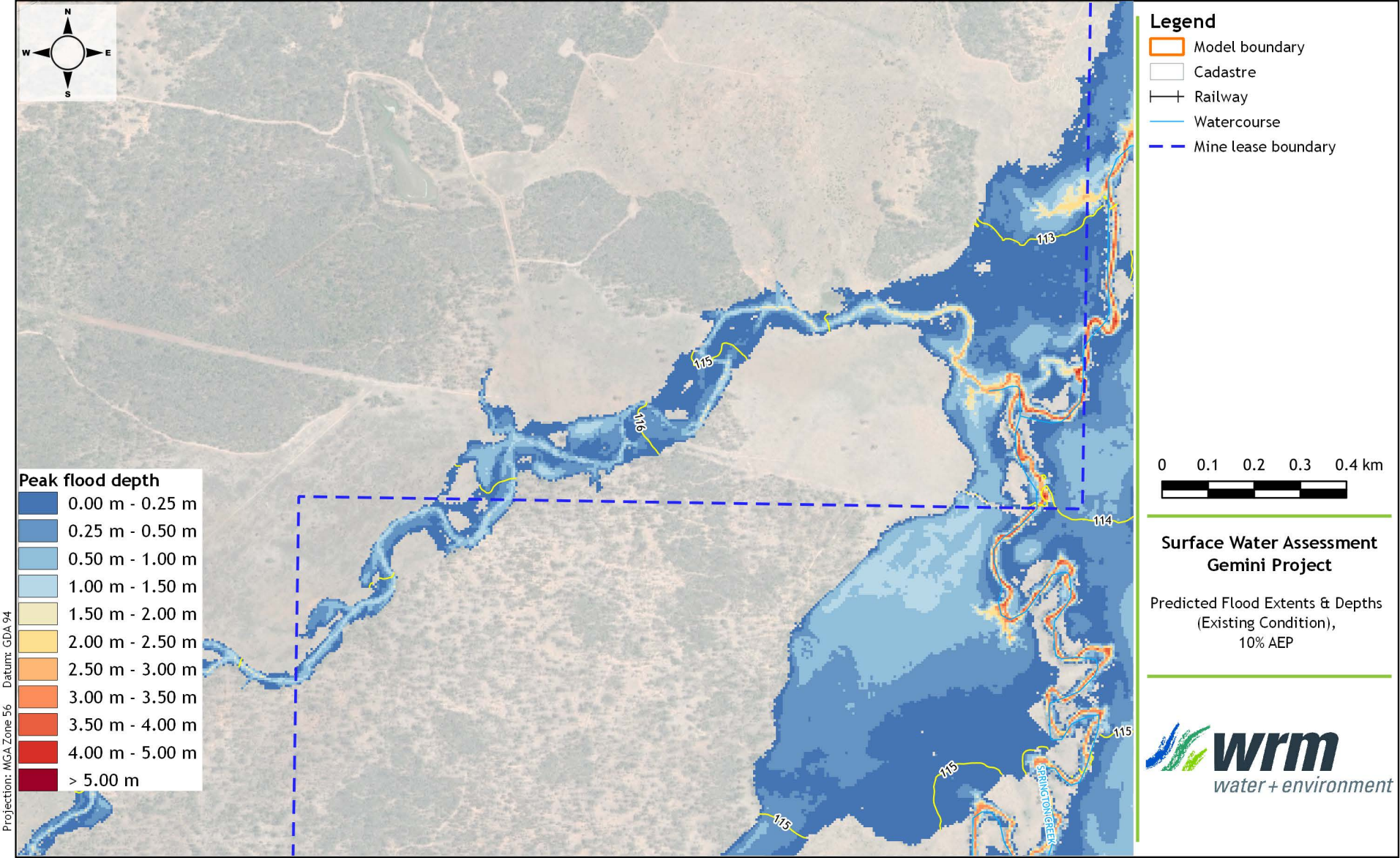


Surface Water Assessment
Gemini Project

Change in Peak Water Level,
0.1% AEP

wrm water + environment

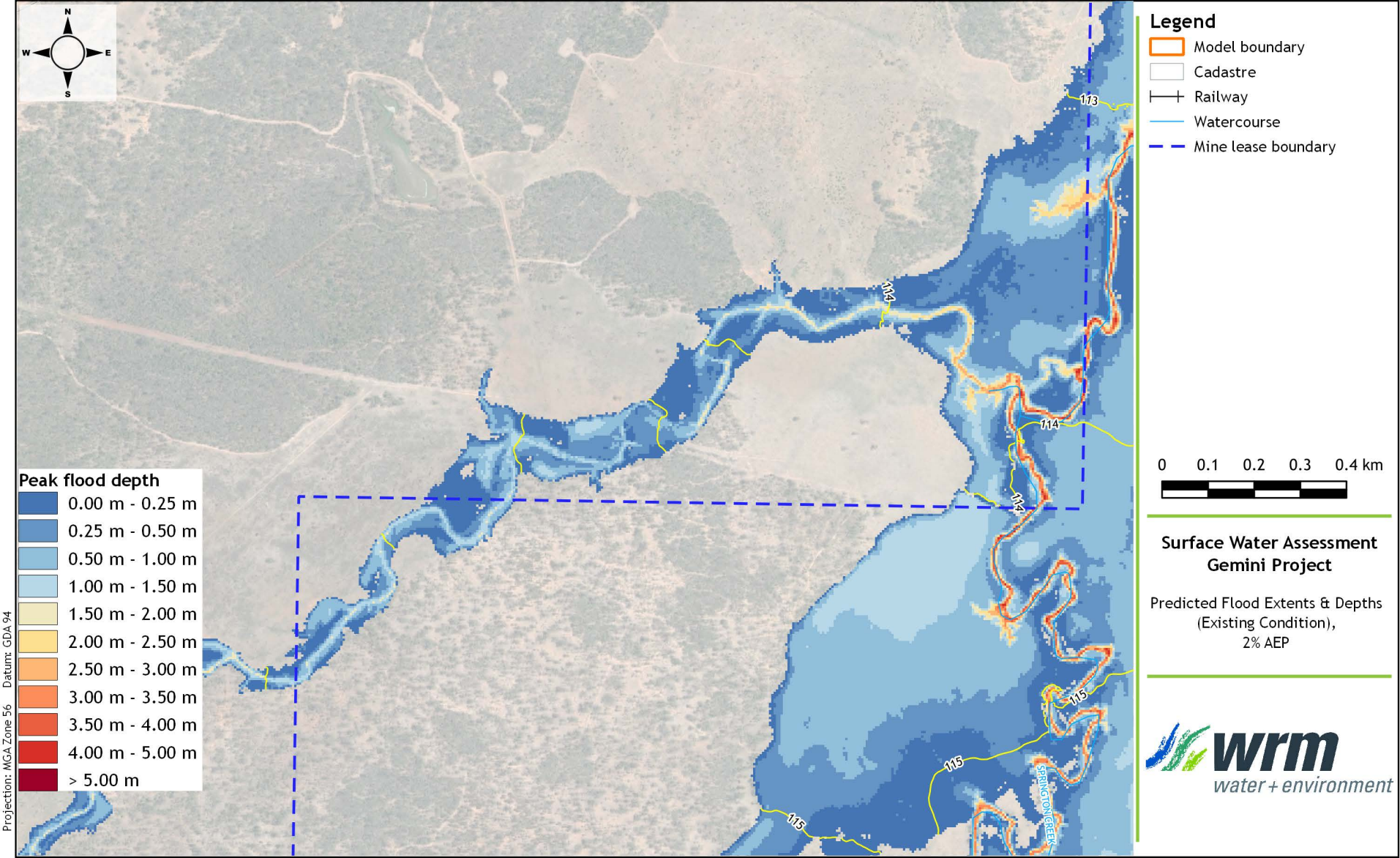

N
W
E
S
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Existing Condition),
50% AEP
wrm
water + environment
114
115
SPRINGTON CREEK



Surface Water Assessment
Gemini Project

Predicted Flood Extents & Depths
(Existing Condition),
10% AEP

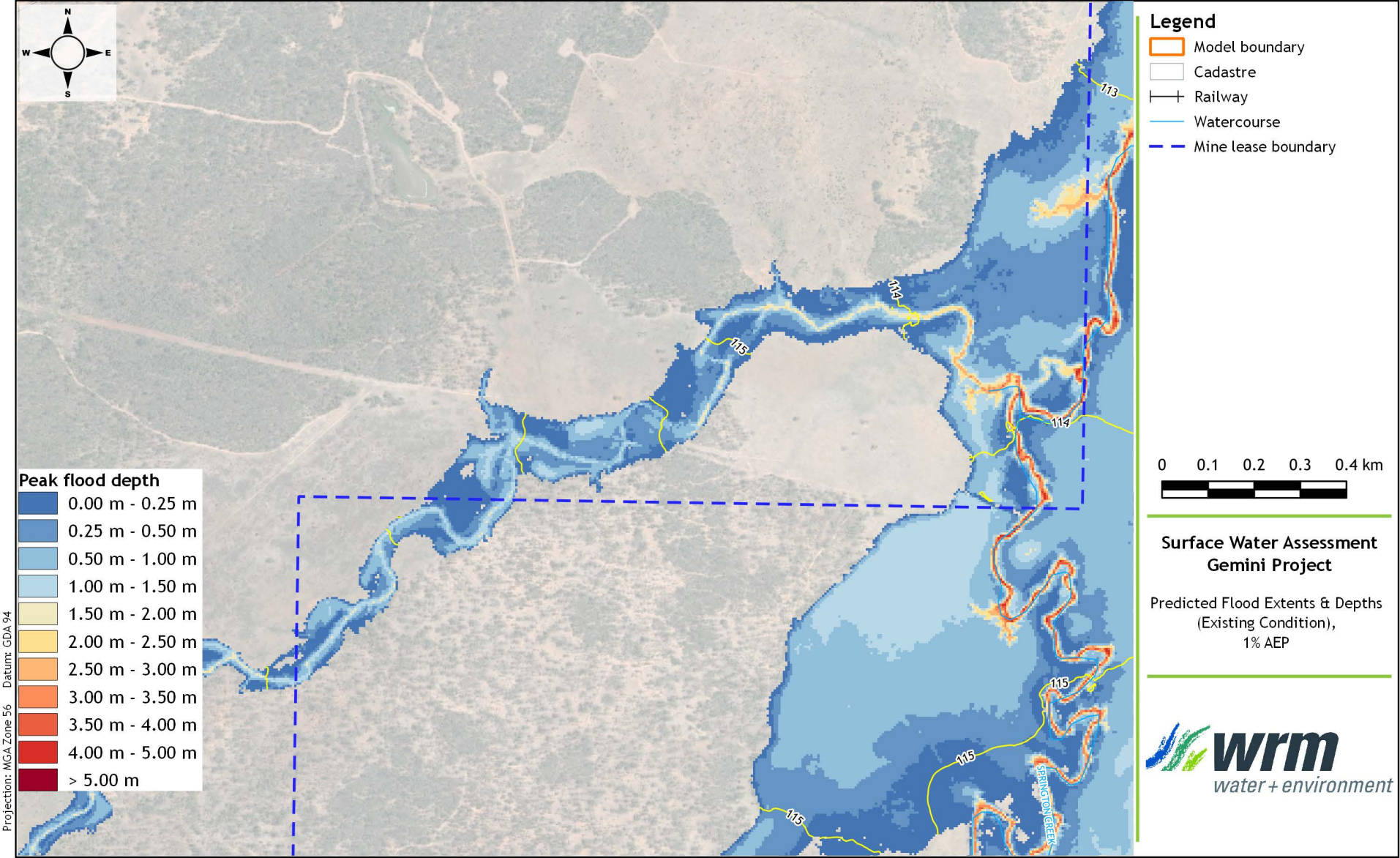
wrm water + environment

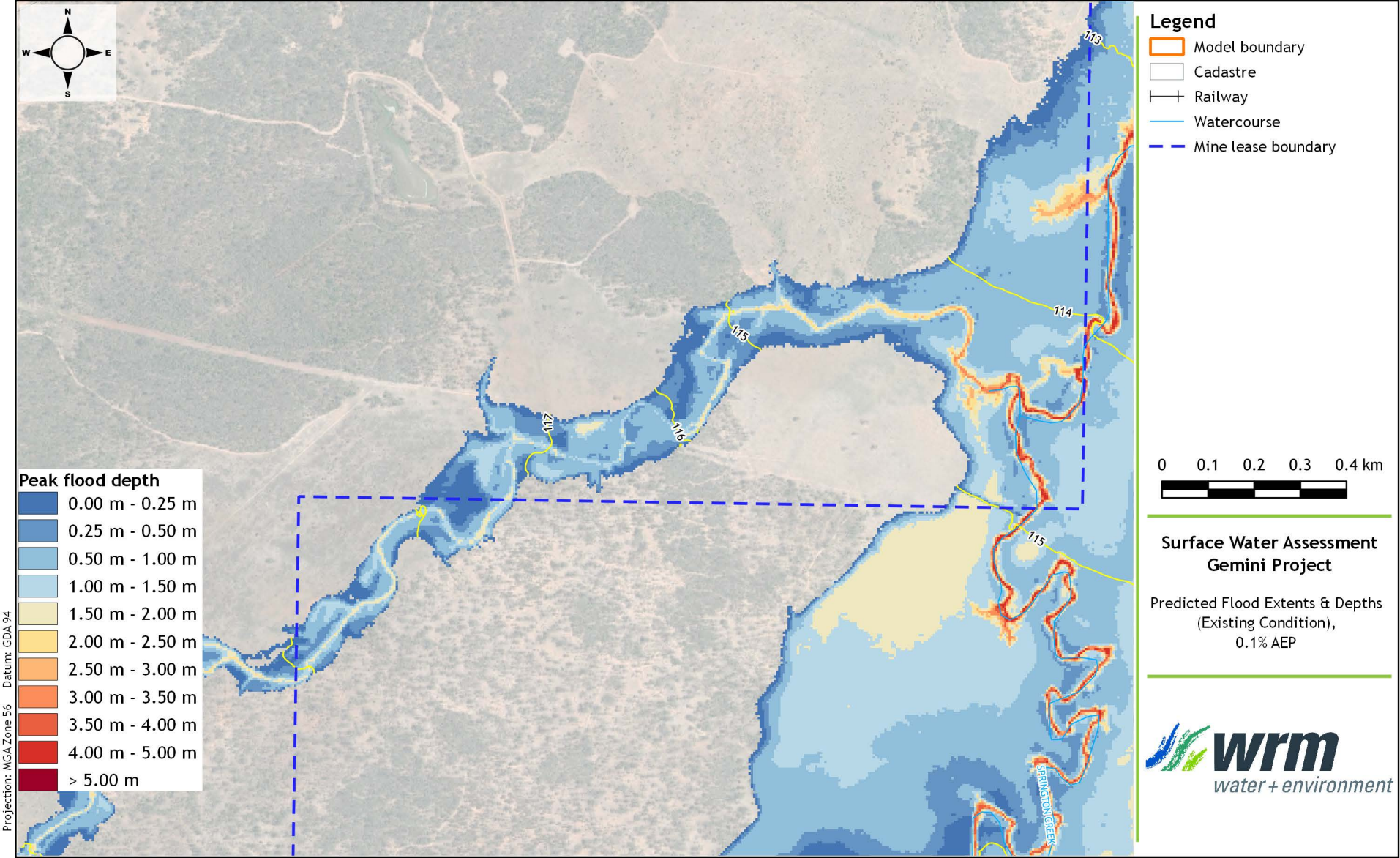


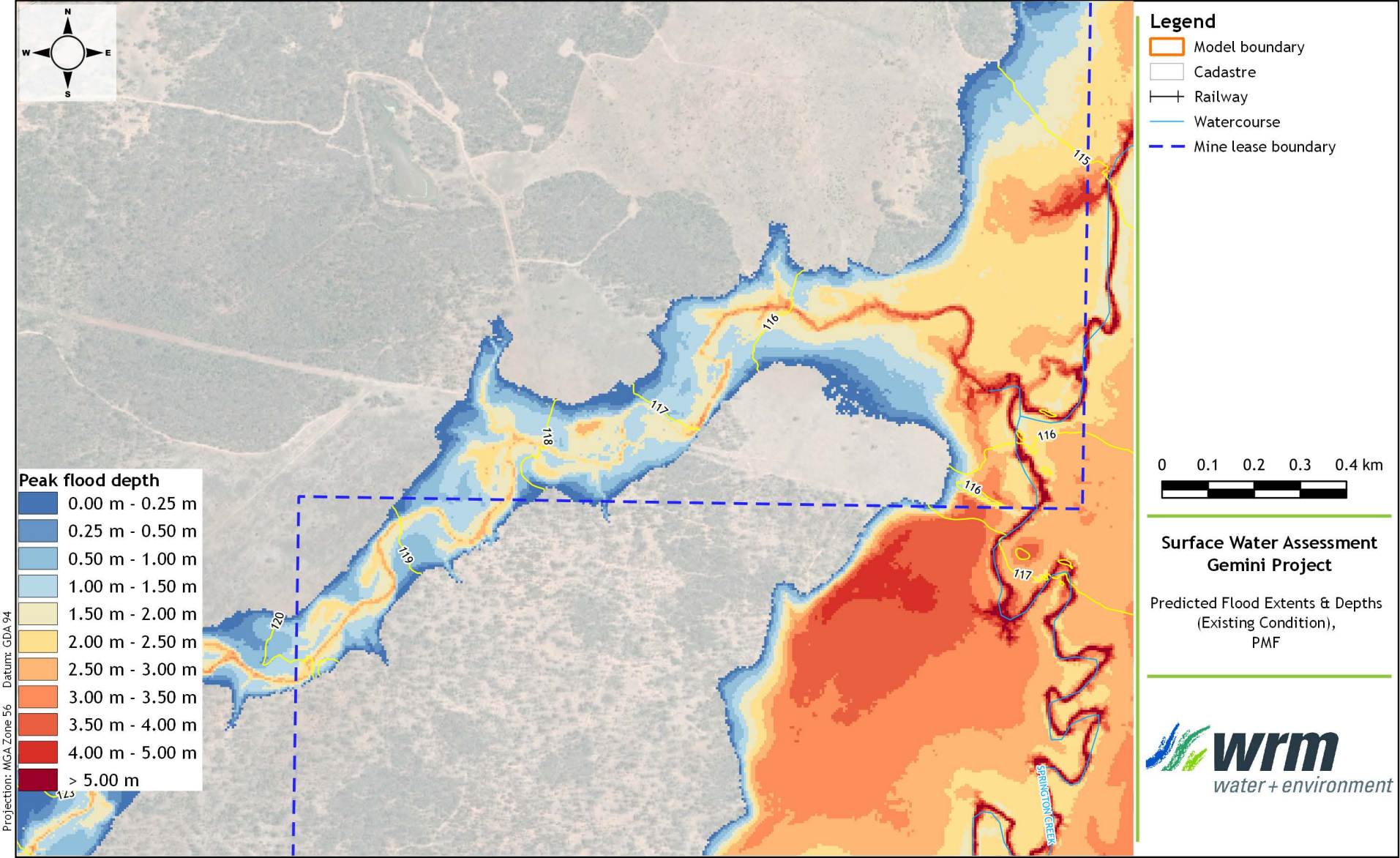
Surface Water Assessment
Gemini Project

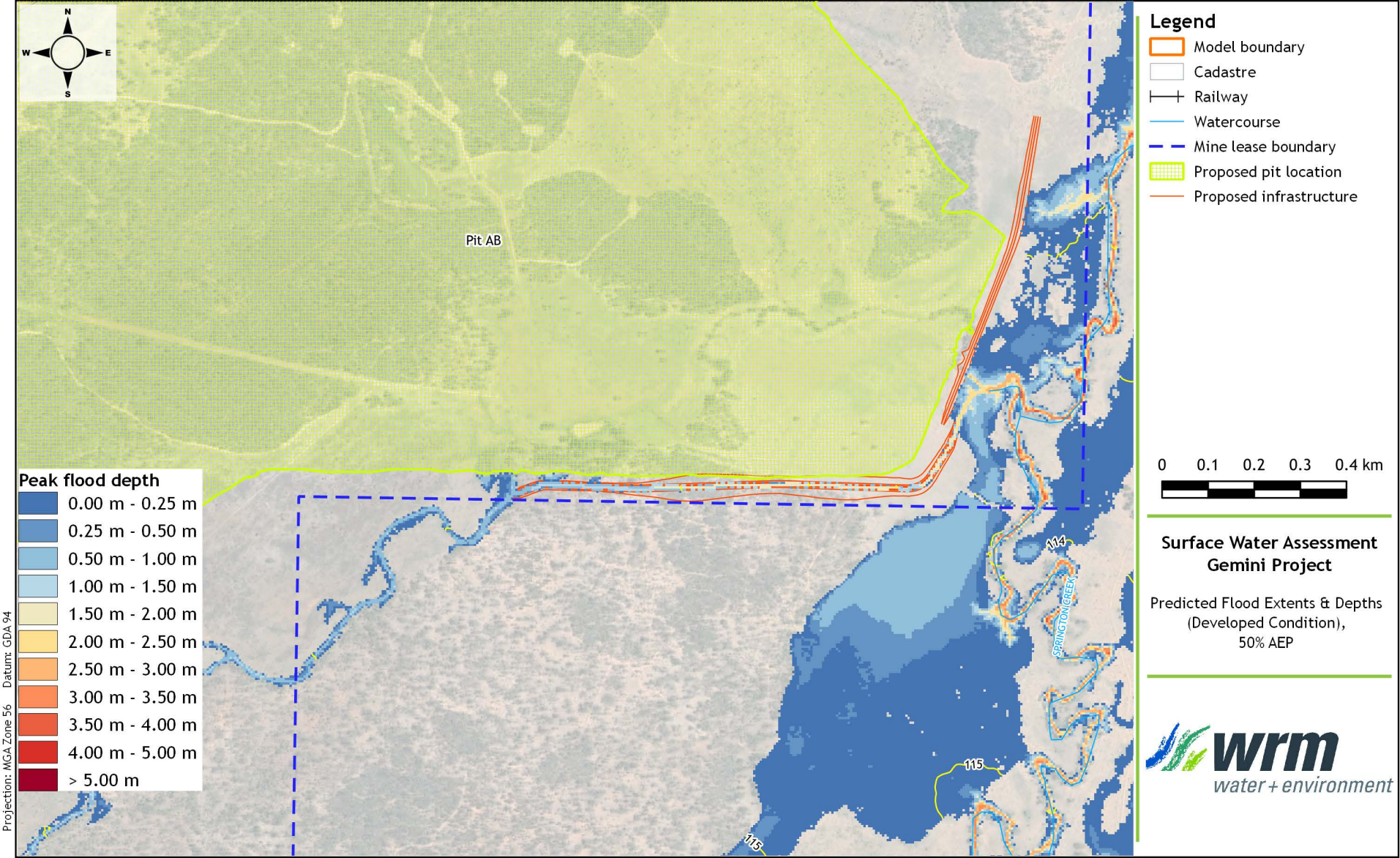
Predicted Flood Extents & Depths
(Existing Condition),
2% AEP

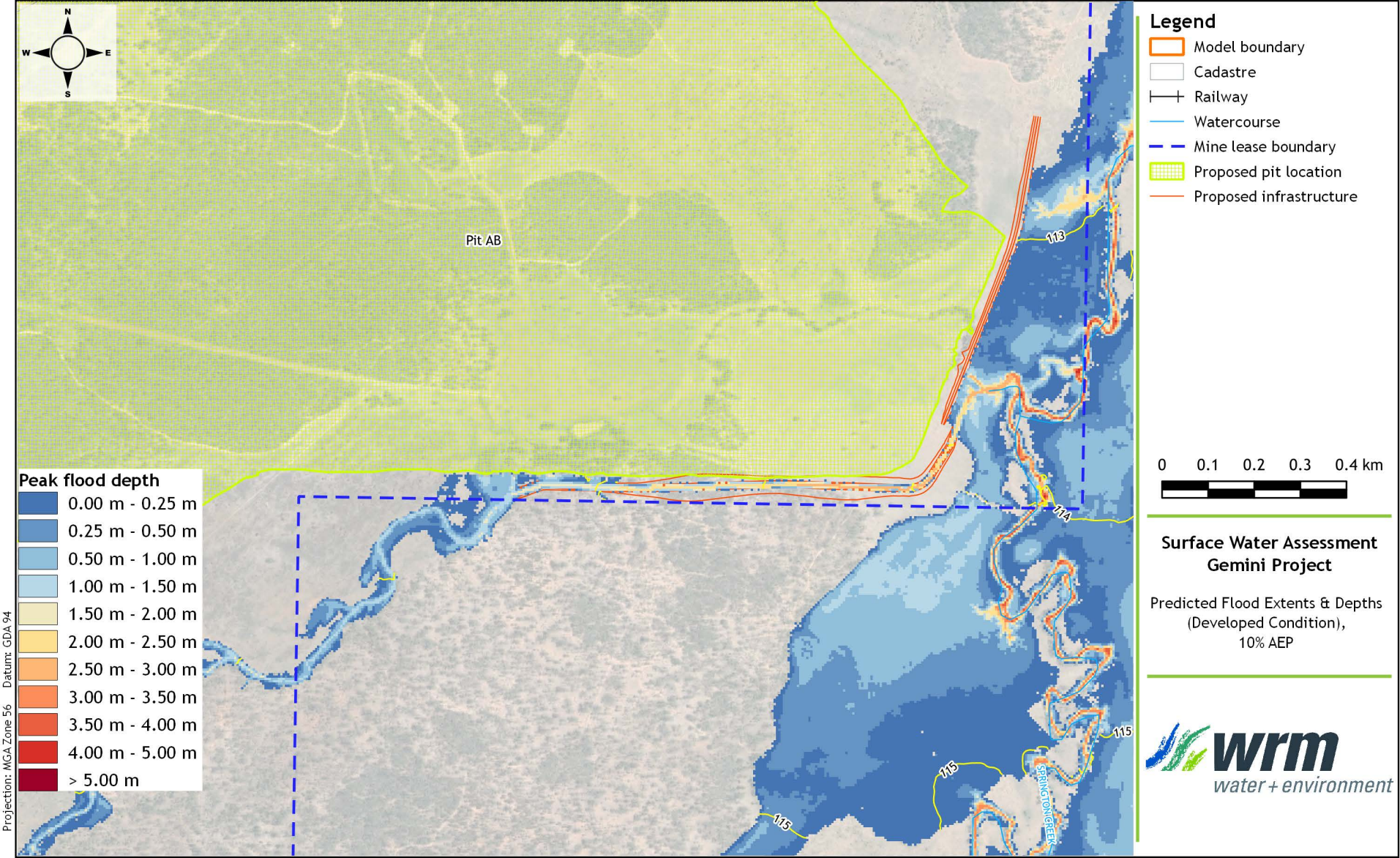
wrm
water + environment

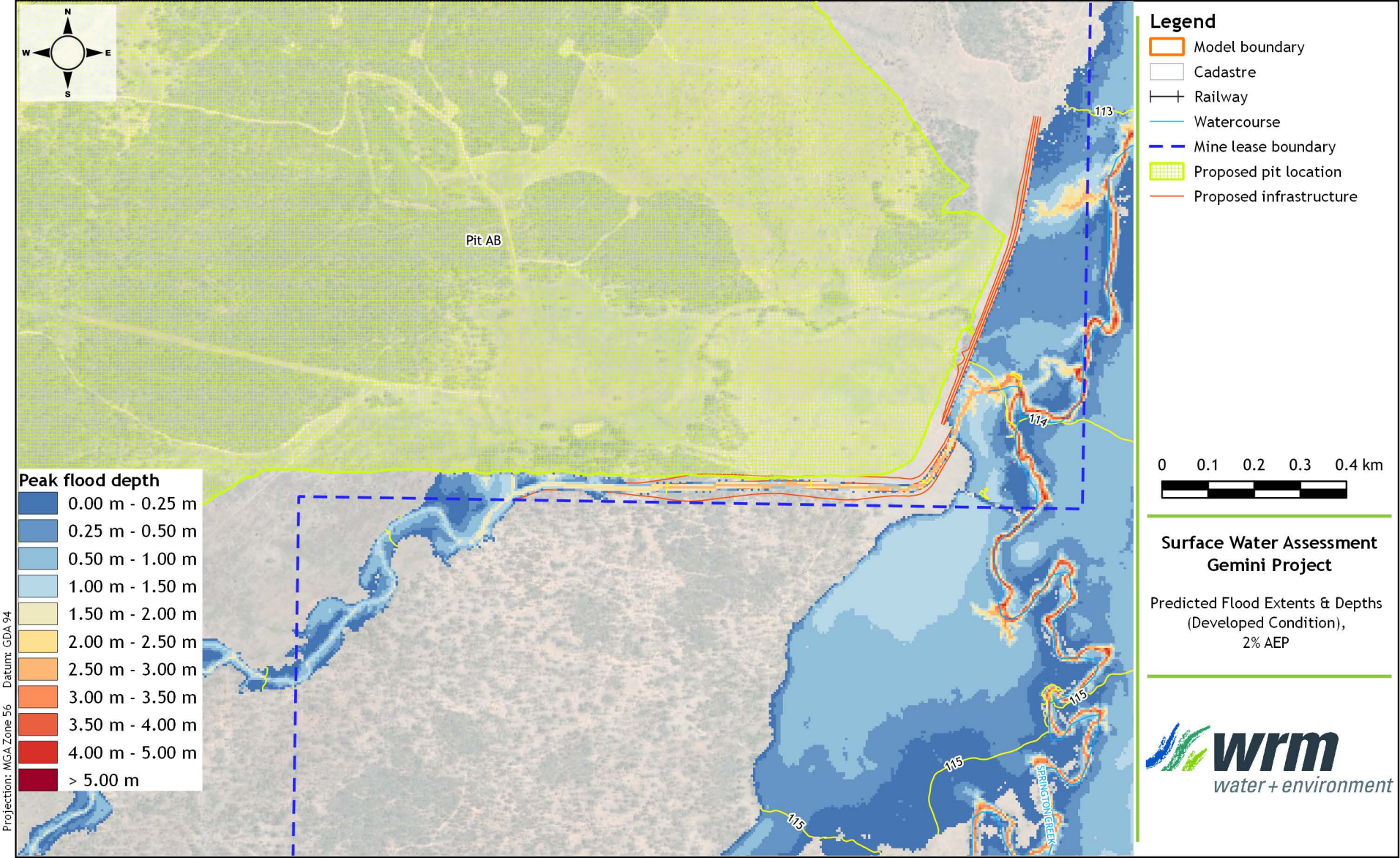

N
W
E
S
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
113
114
115
114
115
115
115
SPRINGTON CREEK
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Existing Condition),
1% AEP
wrm
water + environment

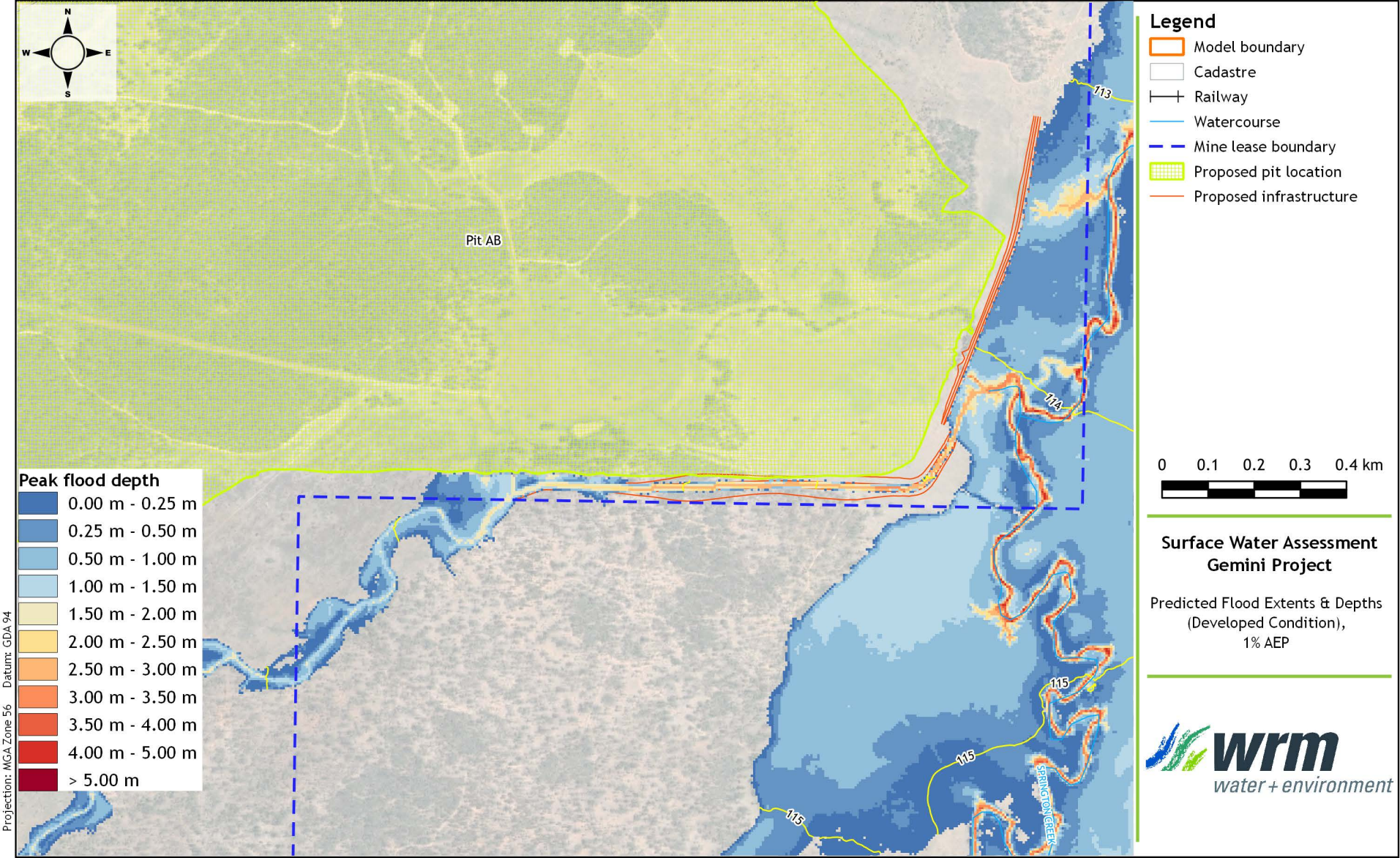

N
W
E
S
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
113
114
115
116
117
115
SPRINGTON CREEK
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Existing Condition),
0.1% AEP
wrm
water + environment


N
W
E
S
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Existing Condition),
PMF
wrm
water + environment
SPRINGTON CREEK


N
W
E
S
Pit AB
114
115
SPRINGTON CREEK
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Developed Condition),
50% AEP
wrm
water + environment


N
W
E
S
Pit AB
113
114
115
115
115
SPRINGTON CREEK
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Developed Condition),
10% AEP
wrm
water + environment
Projection: MGA Zone 56 Datum: GDA 94

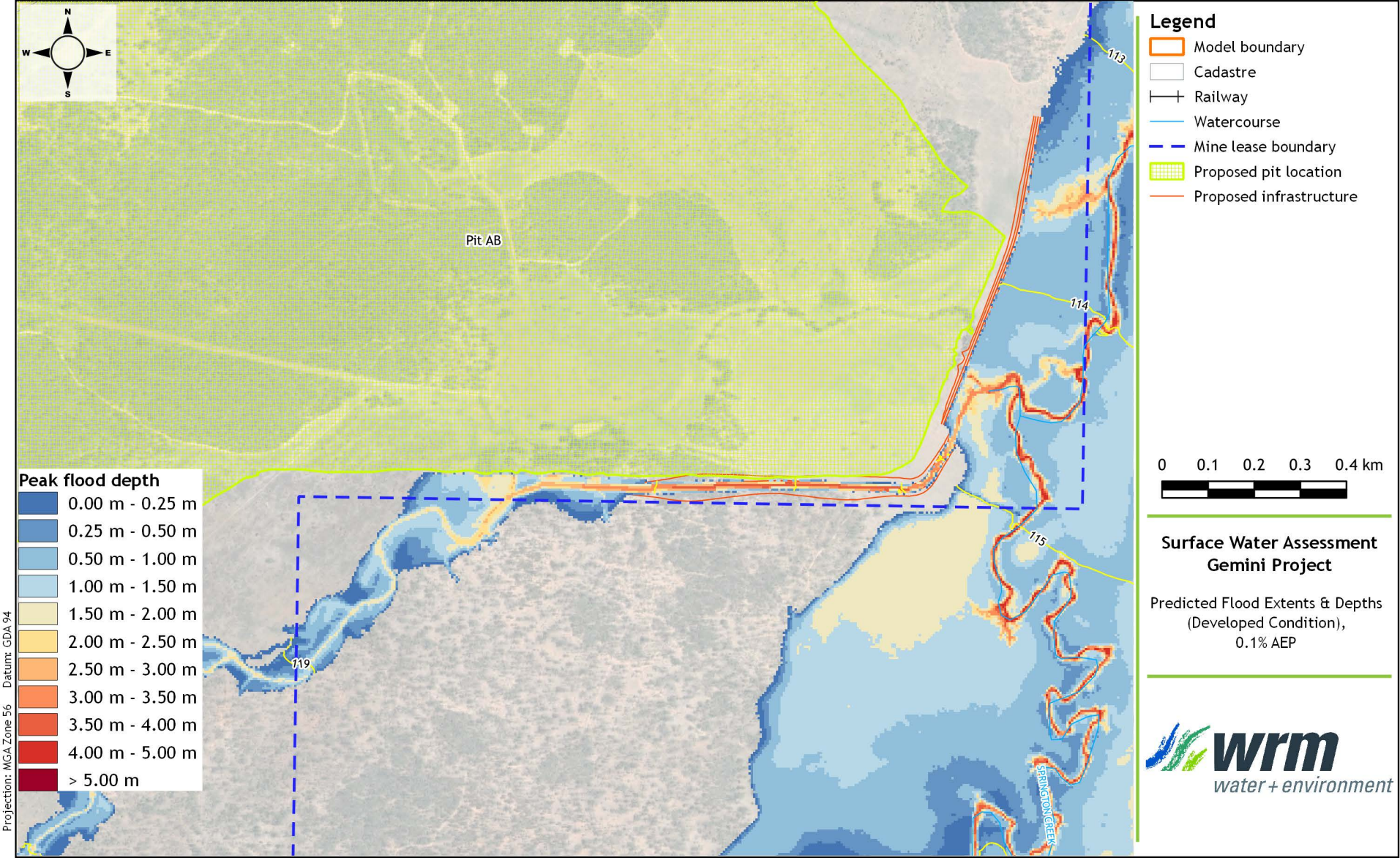

Pit AB
113
114
115
115
115
SPRINGTON CREEK
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Developed Condition),
2% AEP
wrm
water + environment

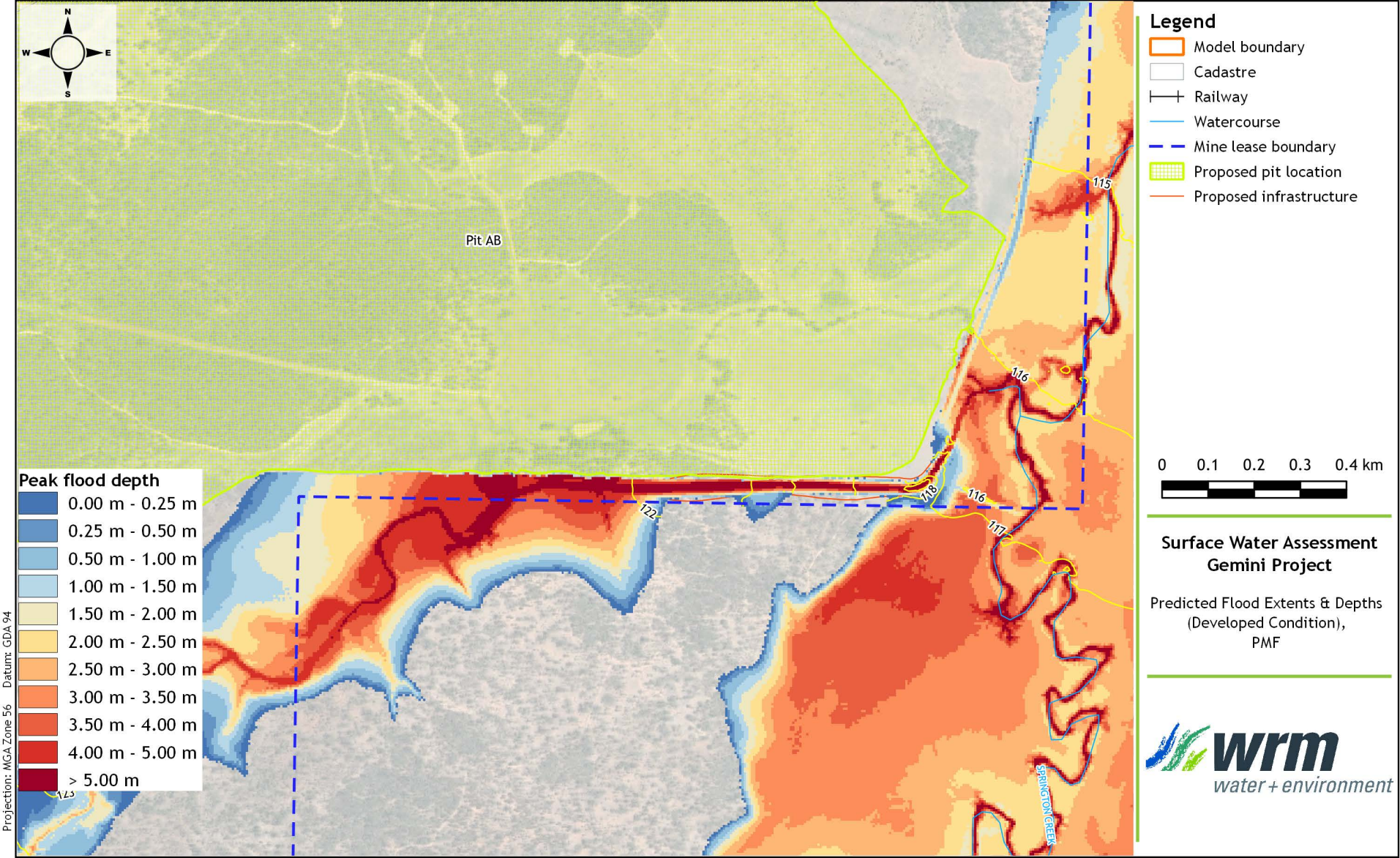


Surface Water Assessment
Gemini Project

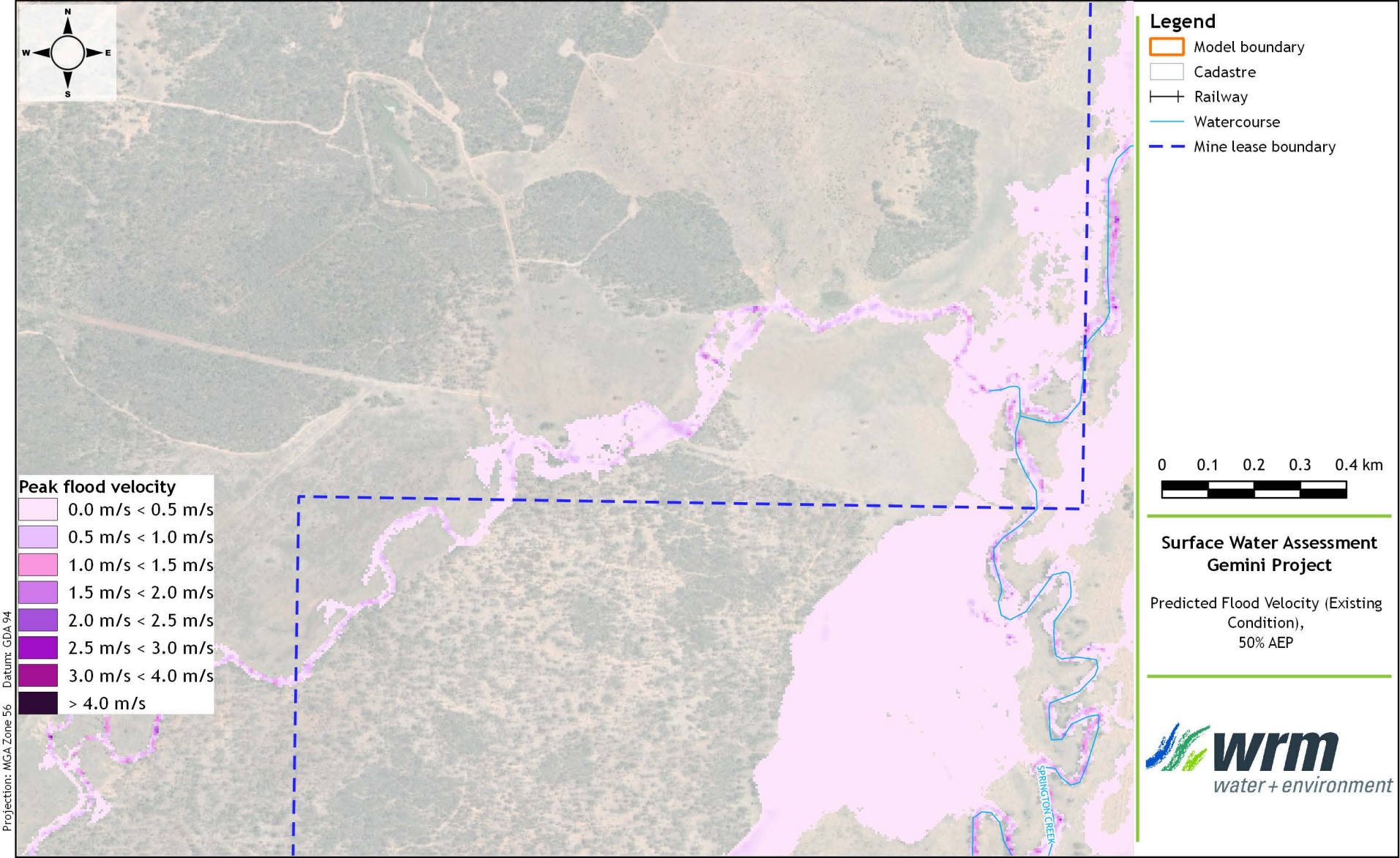
Predicted Flood Extents & Depths
(Developed Condition),
1% AEP

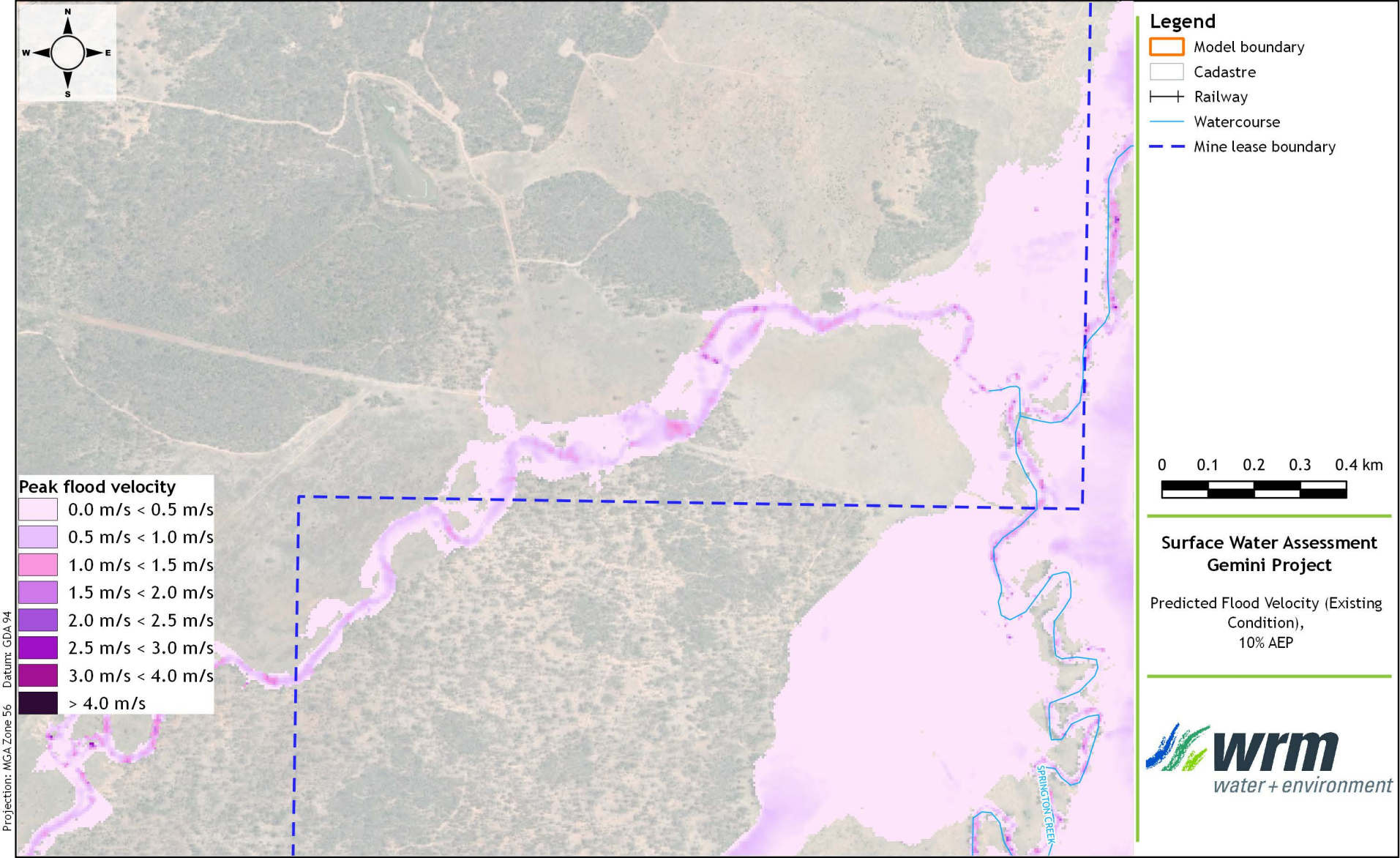
wrm water + environment

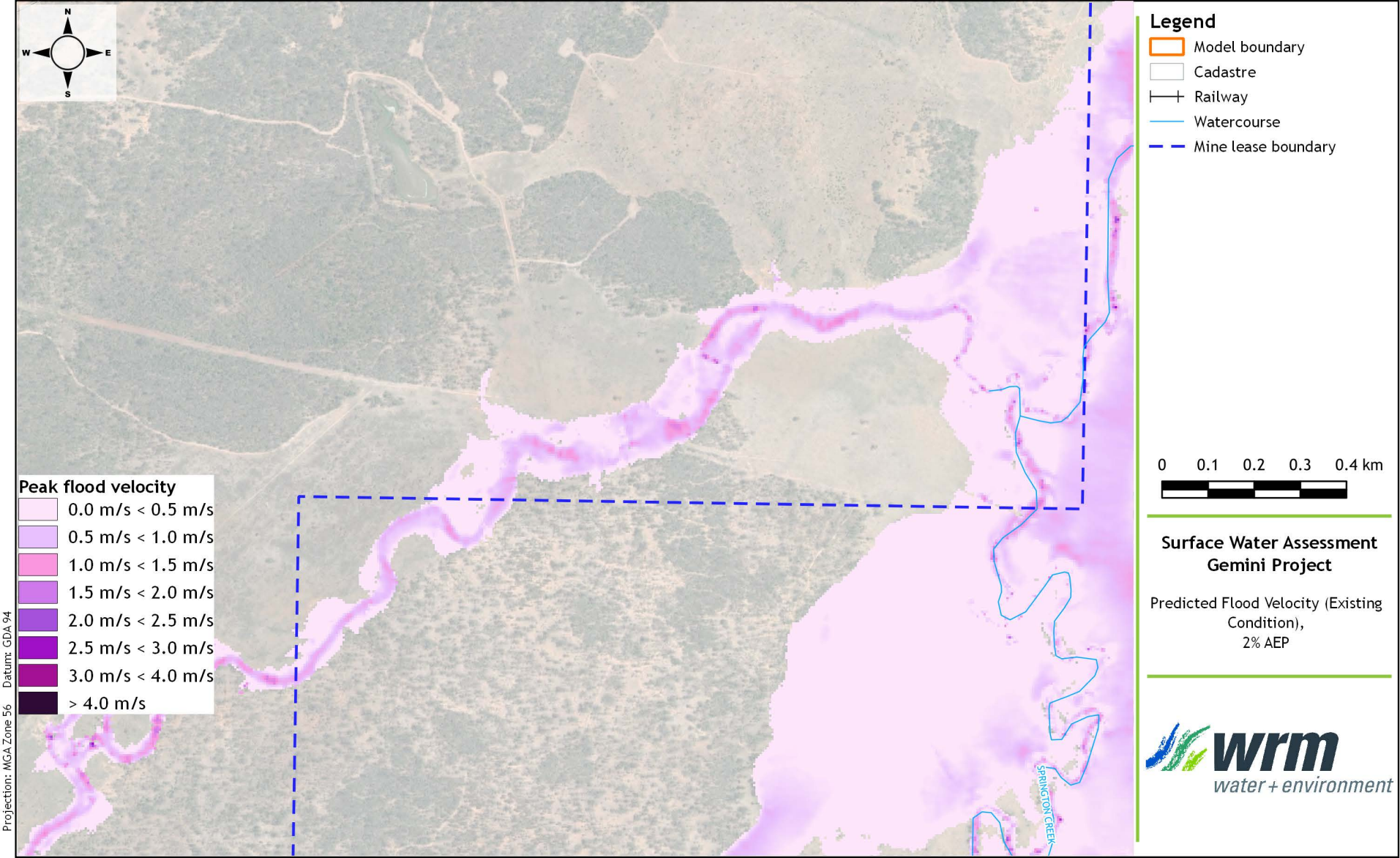

N
W
E
S
Pit AB
113
114
115
119
SPRINGTON CREEK
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Developed Condition),
0.1% AEP
wrm
water + environment



N
W
E
S
Pit AB
115
116
118
116
117
122
123
SPRINGTON CREEK
Peak flood depth
0.00 m - 0.25 m
0.25 m - 0.50 m
0.50 m - 1.00 m
1.00 m - 1.50 m
1.50 m - 2.00 m
2.00 m - 2.50 m
2.50 m - 3.00 m
3.00 m - 3.50 m
3.50 m - 4.00 m
4.00 m - 5.00 m
> 5.00 m
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Extents & Depths
(Developed Condition),
PMF
wrm
water + environment


N
W
E
S
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
Projection: MGA Zone 56 Datum: GDA 94
SPRINGTON CREEK
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity (Existing Condition),
50% AEP
wrm
water + environment


N
W
E
S
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
Projection: MGA Zone 56 Datum: GDA 94
SPRINGTON CREEK
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity (Existing Condition),
10% AEP
wrm
water + environment



Legend

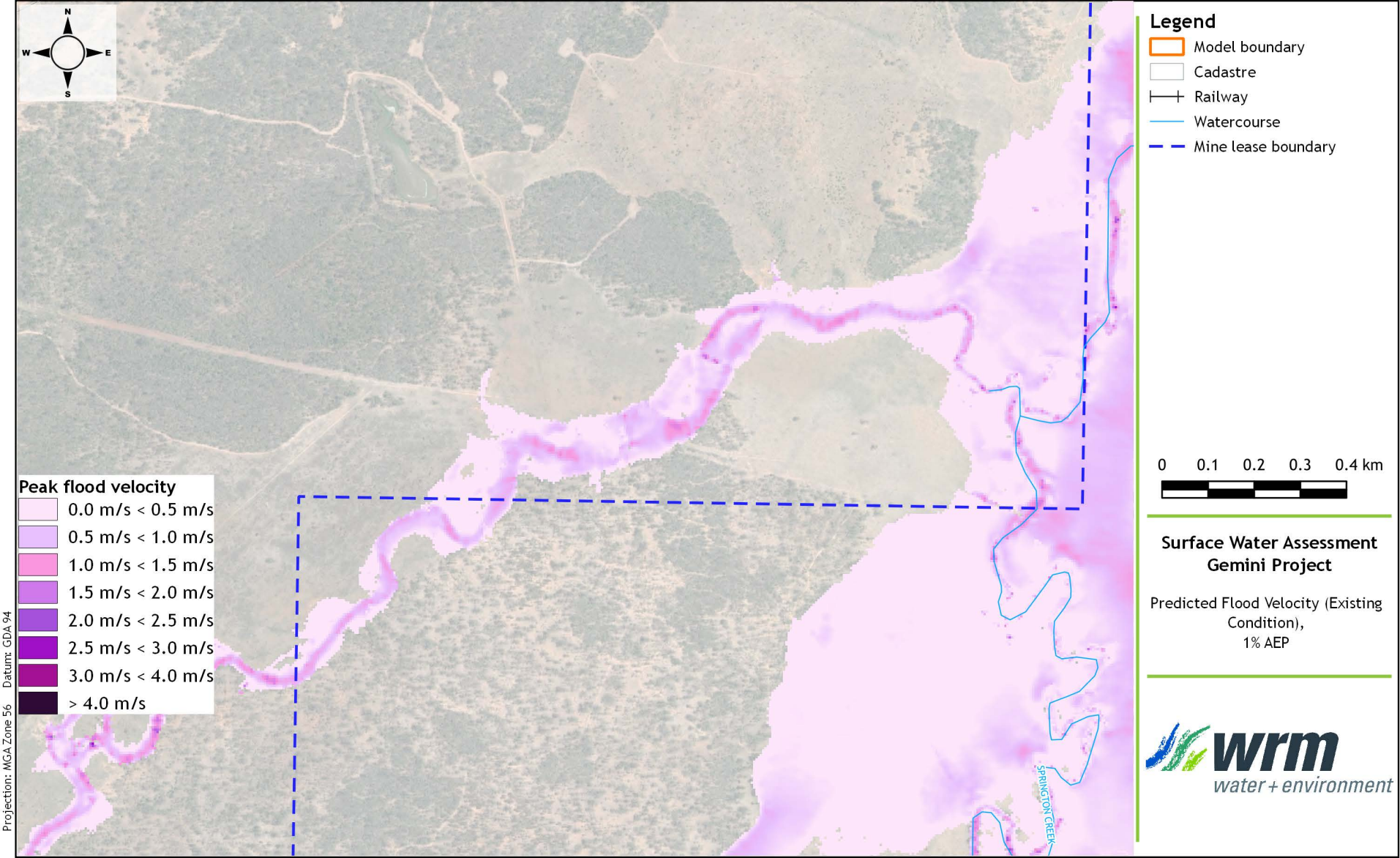
- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

0 0.1 0.2 0.3 0.4 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity (Existing Condition),
2% AEP

wrm water + environment



Projection: MGA Zone 56 Datum: GDA 94

Legend

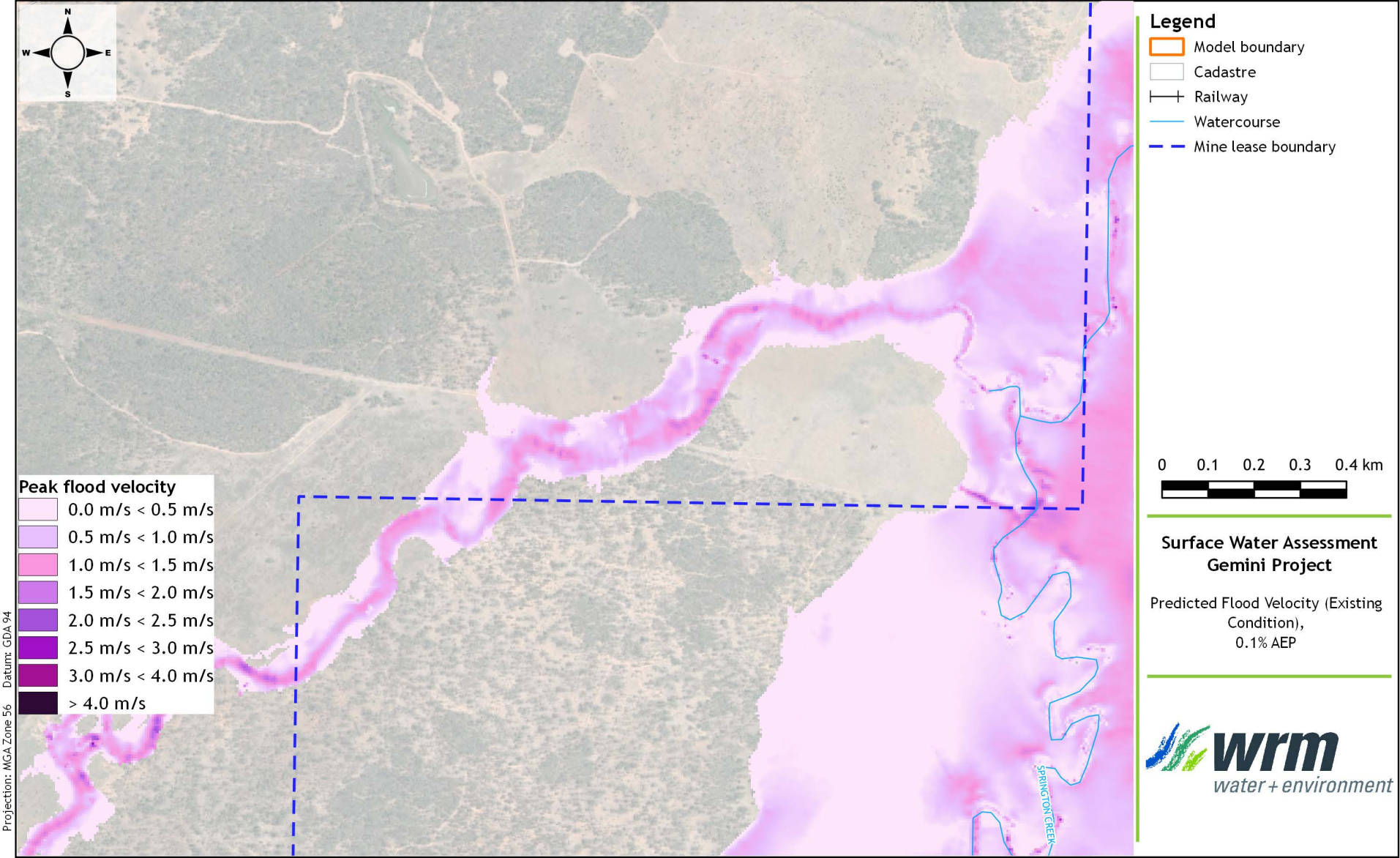
- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary

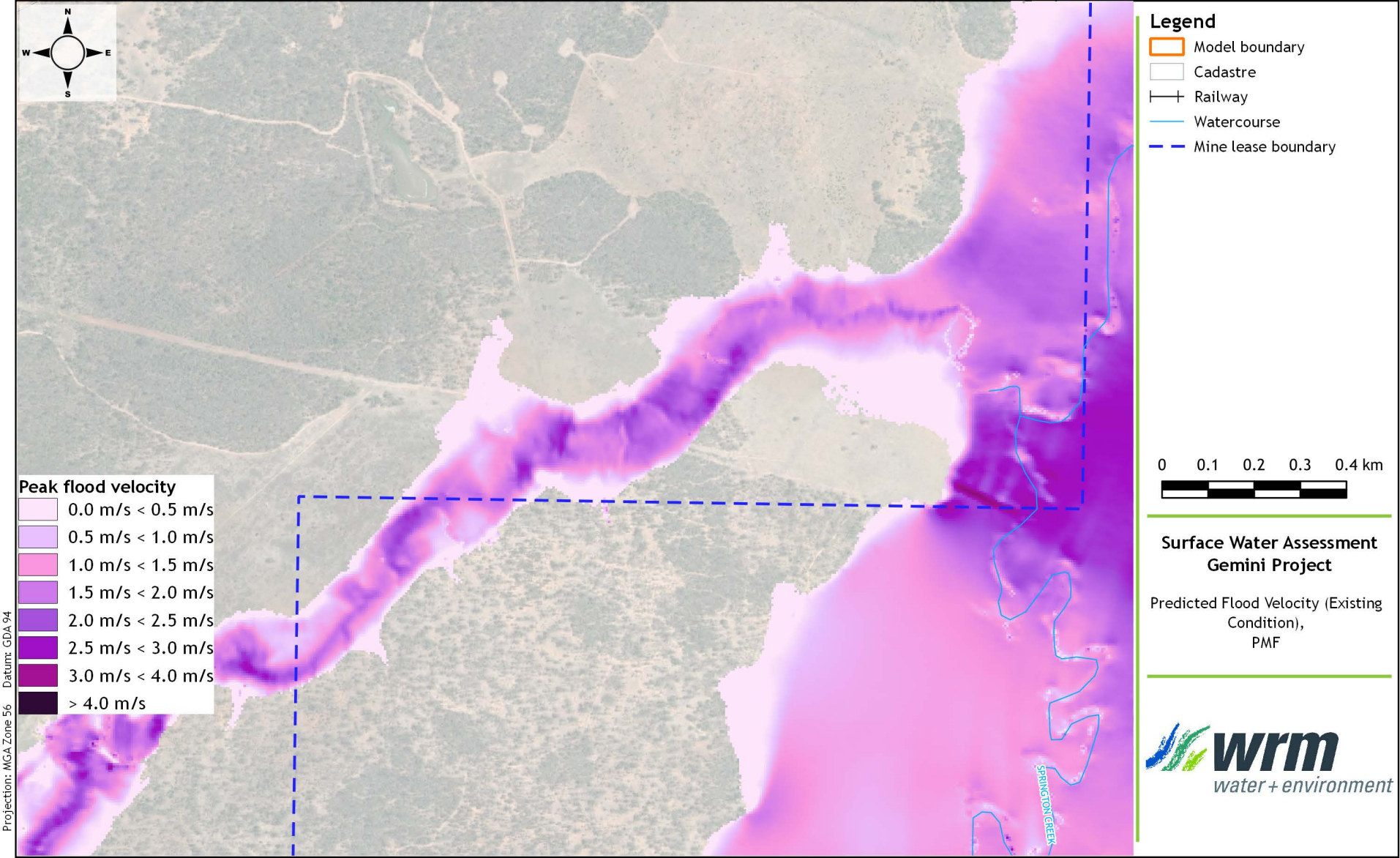
0 0.1 0.2 0.3 0.4 km

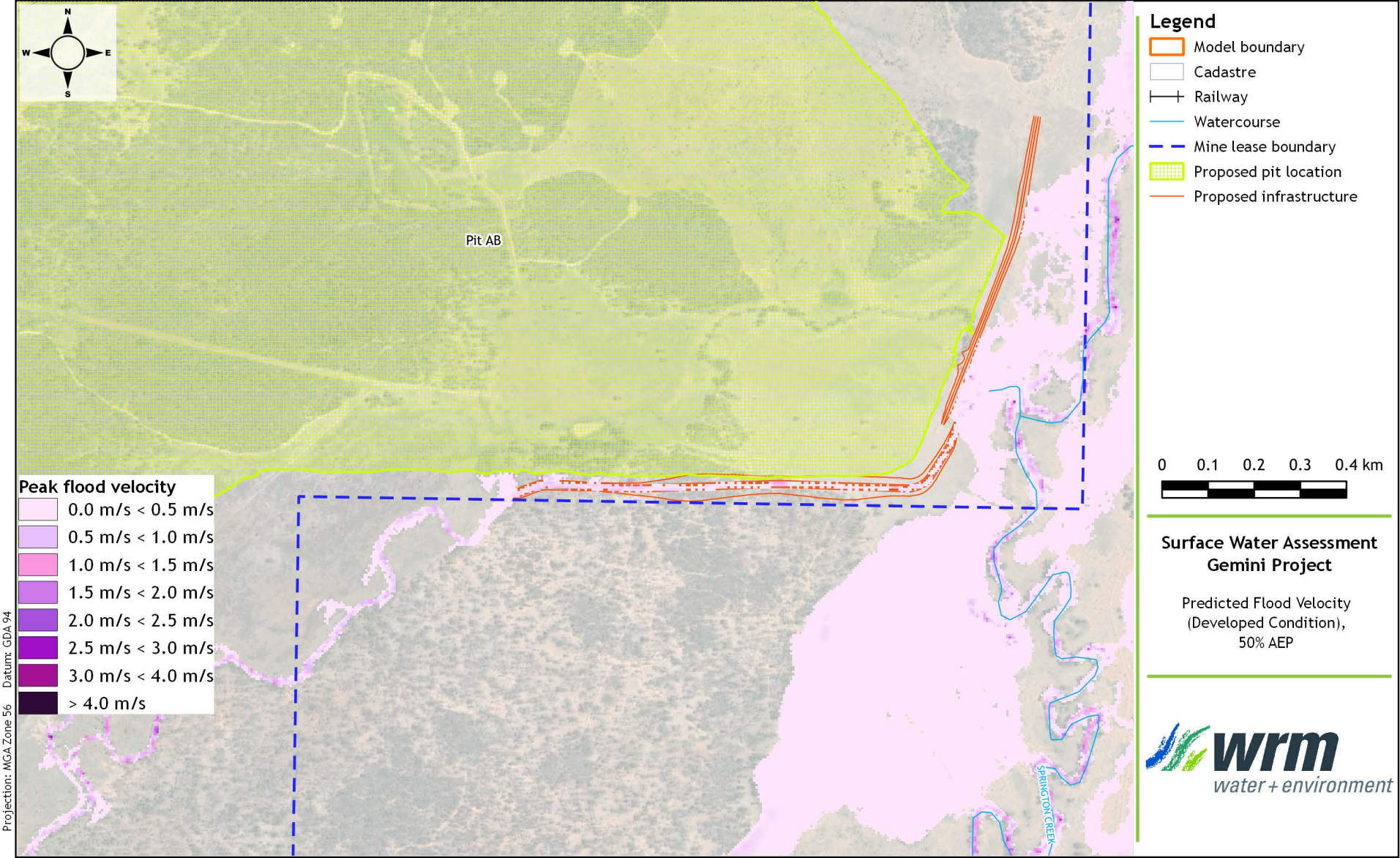
Surface Water Assessment
Gemini Project

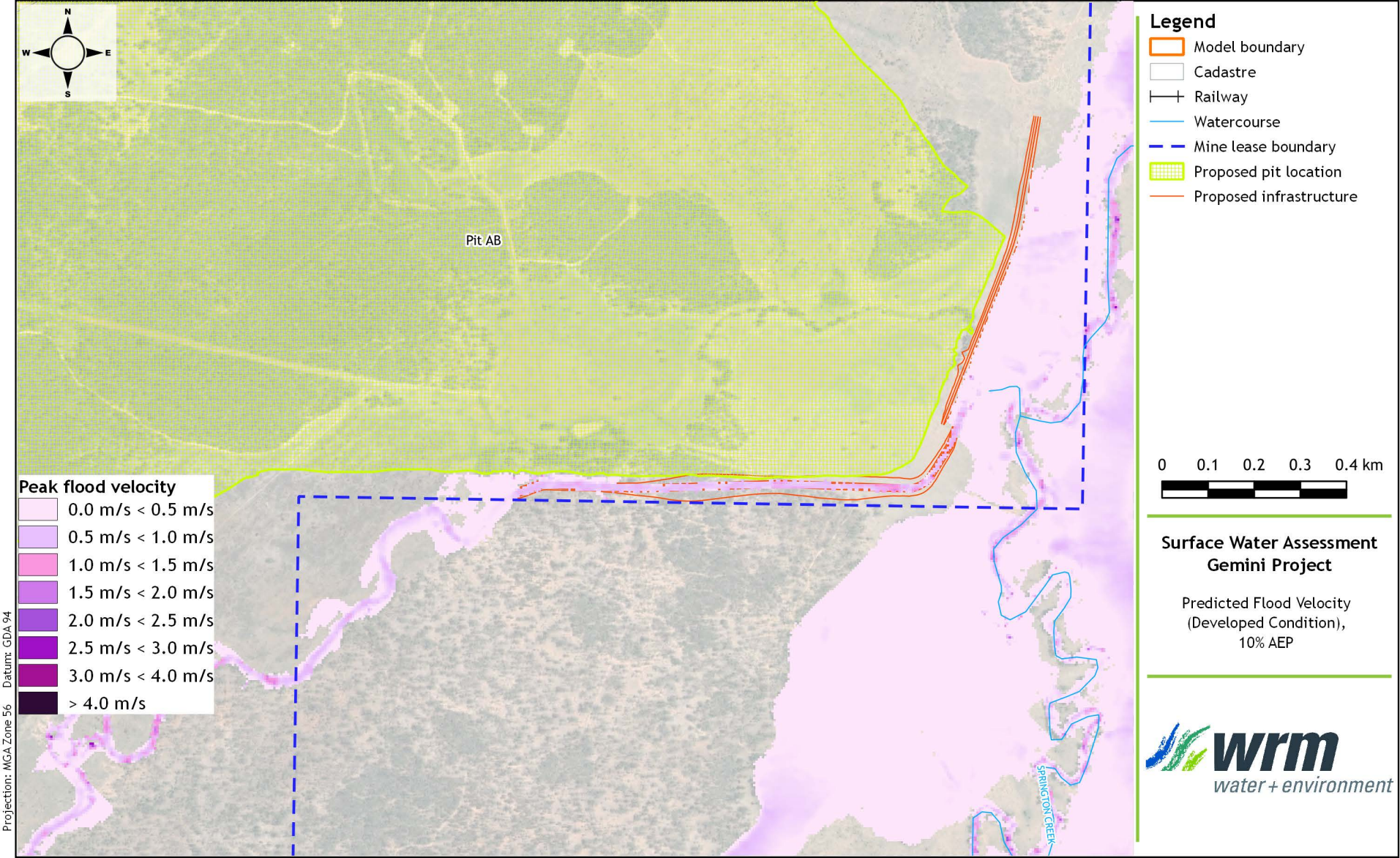
Predicted Flood Velocity (Existing Condition),
1% AEP

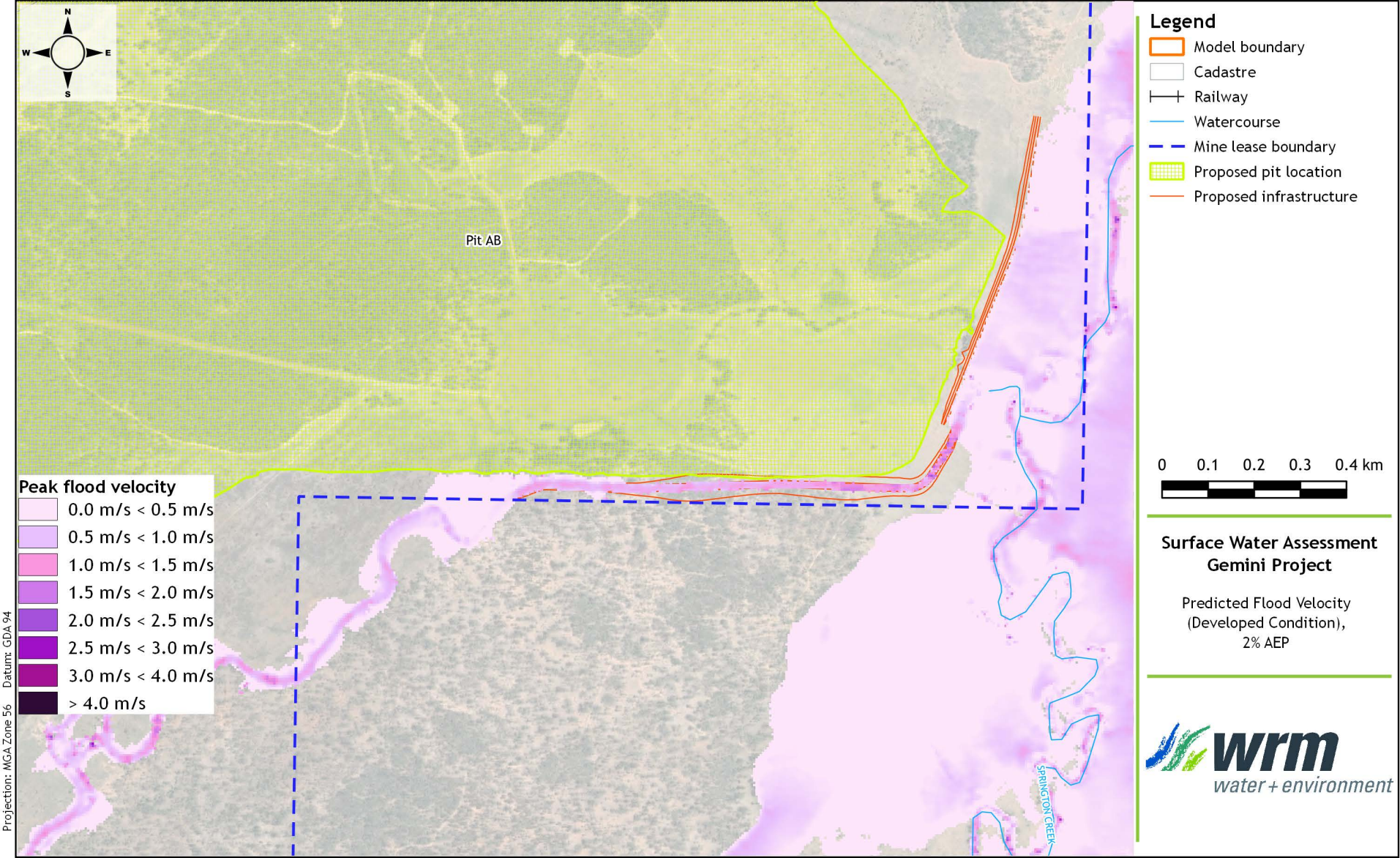
wrm water + environment

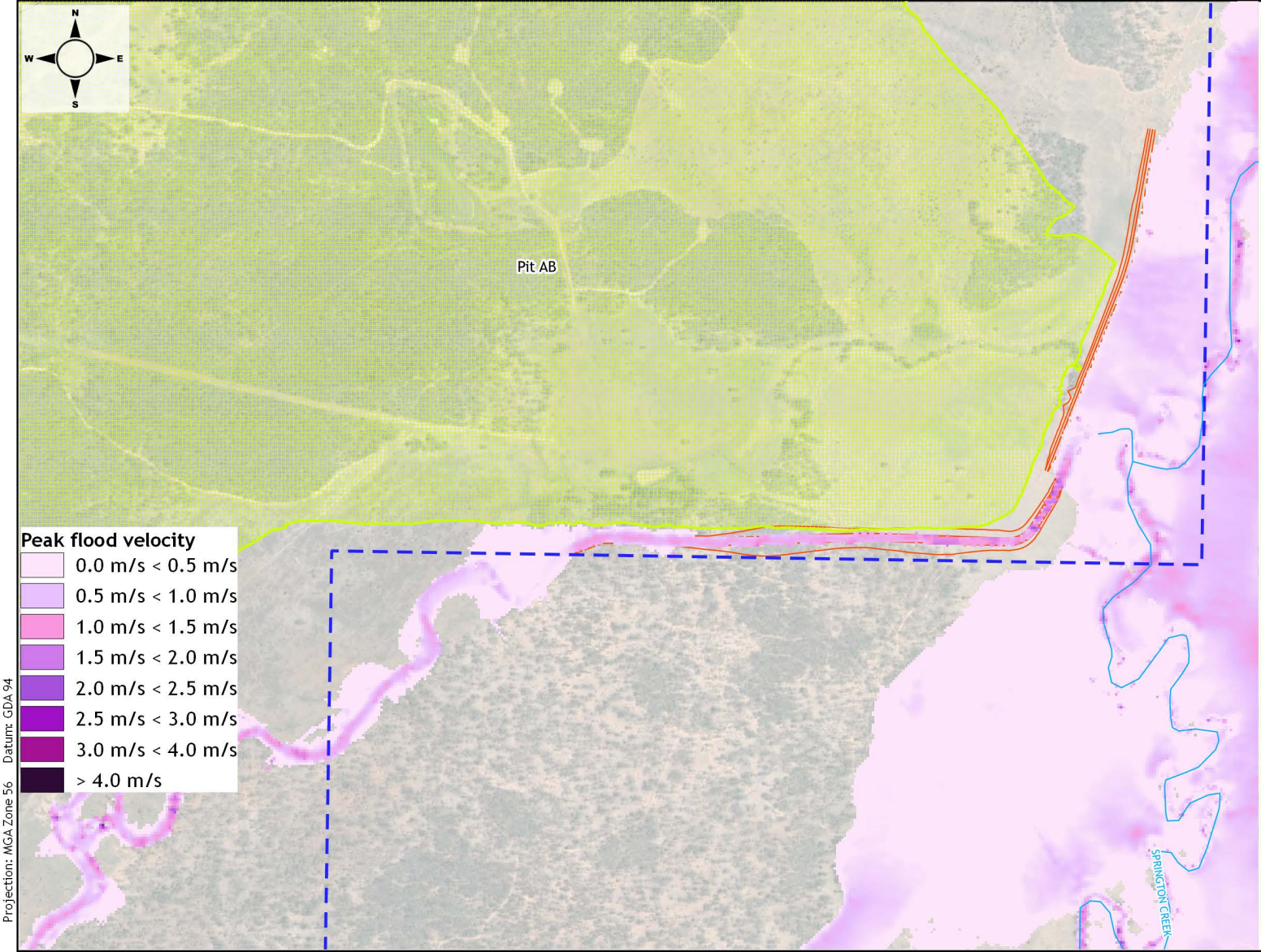

N
W
E
S
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
Projection: MGA Zone 56 Datum: GDA 94
SPRINGTON CREEK
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity (Existing Condition),
0.1% AEP
wrm
water + environment


N
W
E
S
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
Projection: MGA Zone 56 Datum: GDA 94
SPRINGTON CREEK
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity (Existing Condition),
PMF
wrm
water + environment


N
W
E
S
Pit AB
SPRINGTON CREEK
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity
(Developed Condition),
50% AEP
wrm
water + environment


N
W
E
S
Pit AB
SPRINGTON CREEK
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity
(Developed Condition),
10% AEP
wrm
water + environment


N
W
E
S
Pit AB
SPRINGTON CREEK
Peak flood velocity
0.0 m/s < 0.5 m/s
0.5 m/s < 1.0 m/s
1.0 m/s < 1.5 m/s
1.5 m/s < 2.0 m/s
2.0 m/s < 2.5 m/s
2.5 m/s < 3.0 m/s
3.0 m/s < 4.0 m/s
> 4.0 m/s
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Predicted Flood Velocity
(Developed Condition),
2% AEP
wrm
water + environment



Peak flood velocity

- 0.0 m/s < 0.5 m/s
- 0.5 m/s < 1.0 m/s
- 1.0 m/s < 1.5 m/s
- 1.5 m/s < 2.0 m/s
- 2.0 m/s < 2.5 m/s
- 2.5 m/s < 3.0 m/s
- 3.0 m/s < 4.0 m/s
- > 4.0 m/s

Projection: MGA Zone 56 Datum: GDA 94

Legend

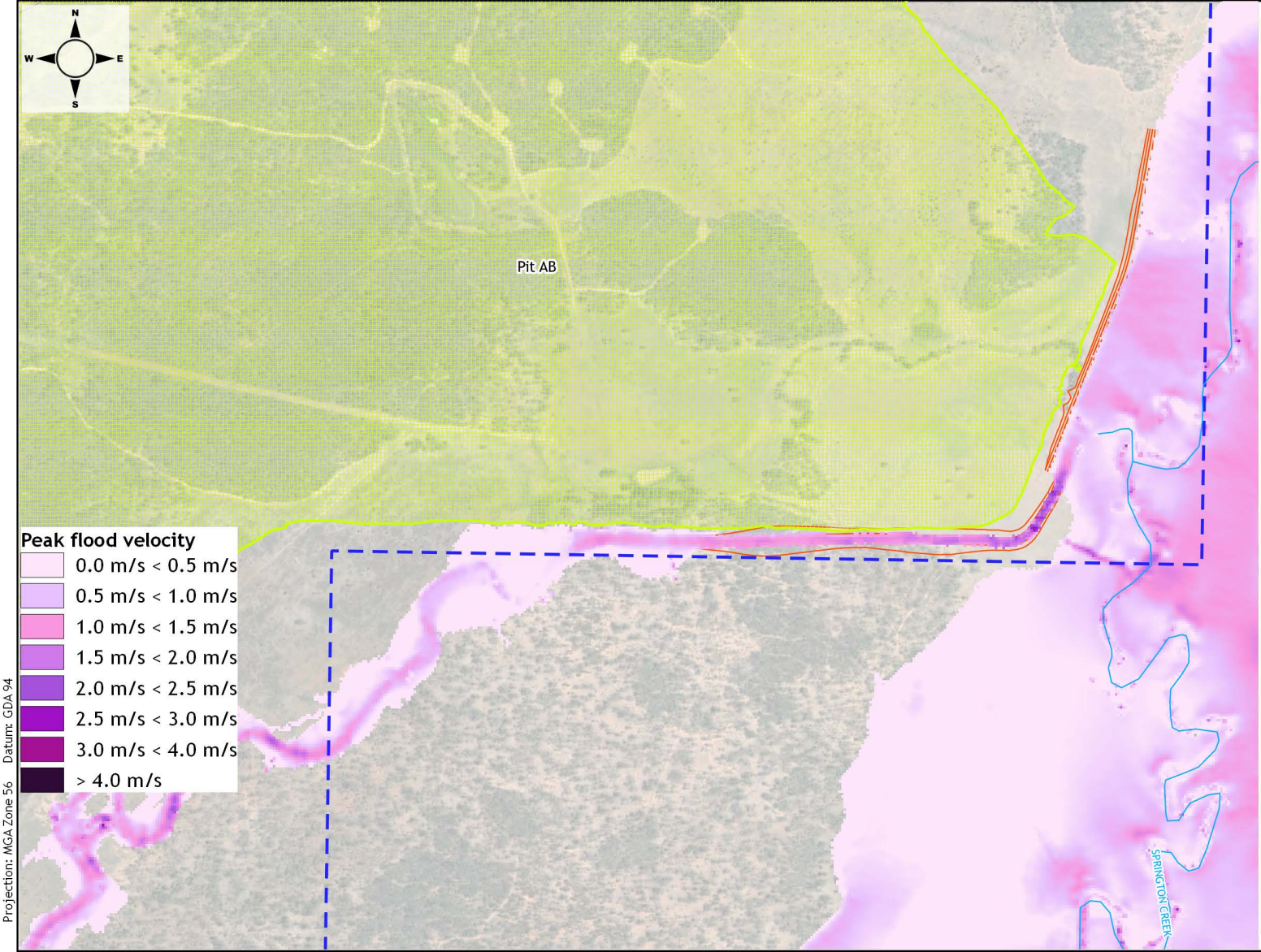
- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

0 0.1 0.2 0.3 0.4 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
1% AEP

wrm water + environment



Legend

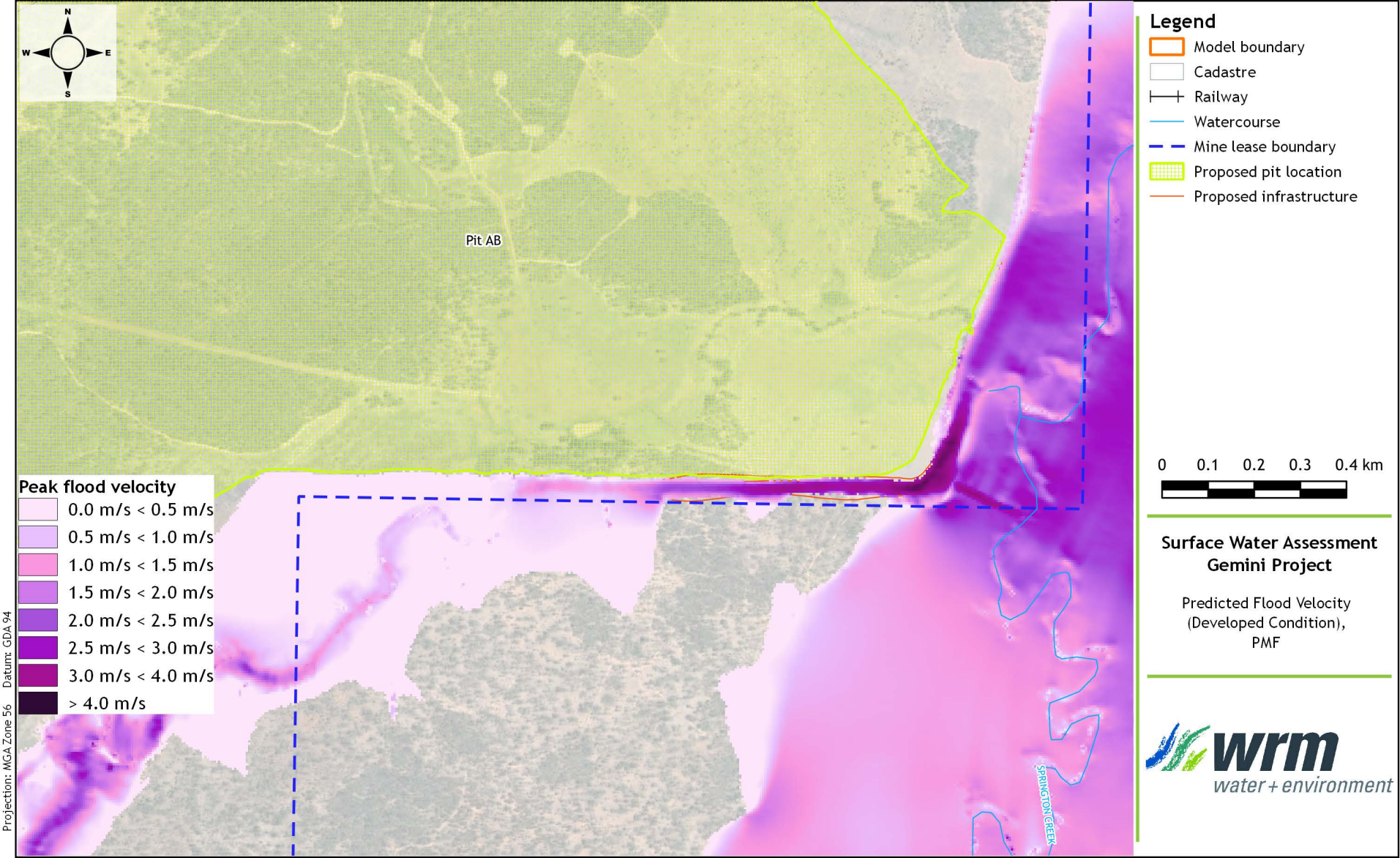
- Model boundary
- Cadastre
- Railway
- Watercourse
- Mine lease boundary
- Proposed pit location
- Proposed infrastructure

0 0.1 0.2 0.3 0.4 km

Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
0.1% AEP

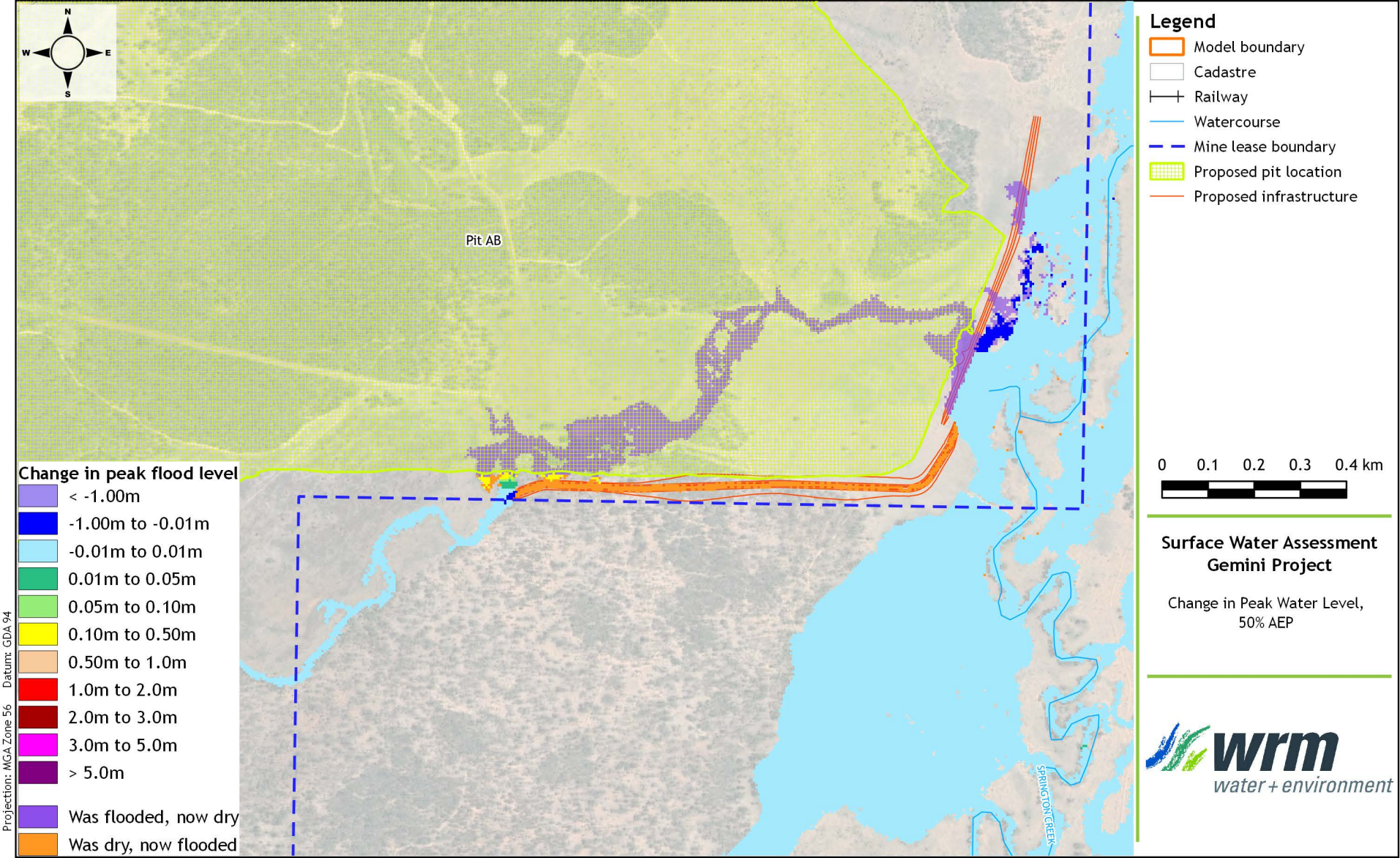
wrm water + environment



Surface Water Assessment
Gemini Project

Predicted Flood Velocity
(Developed Condition),
PMF

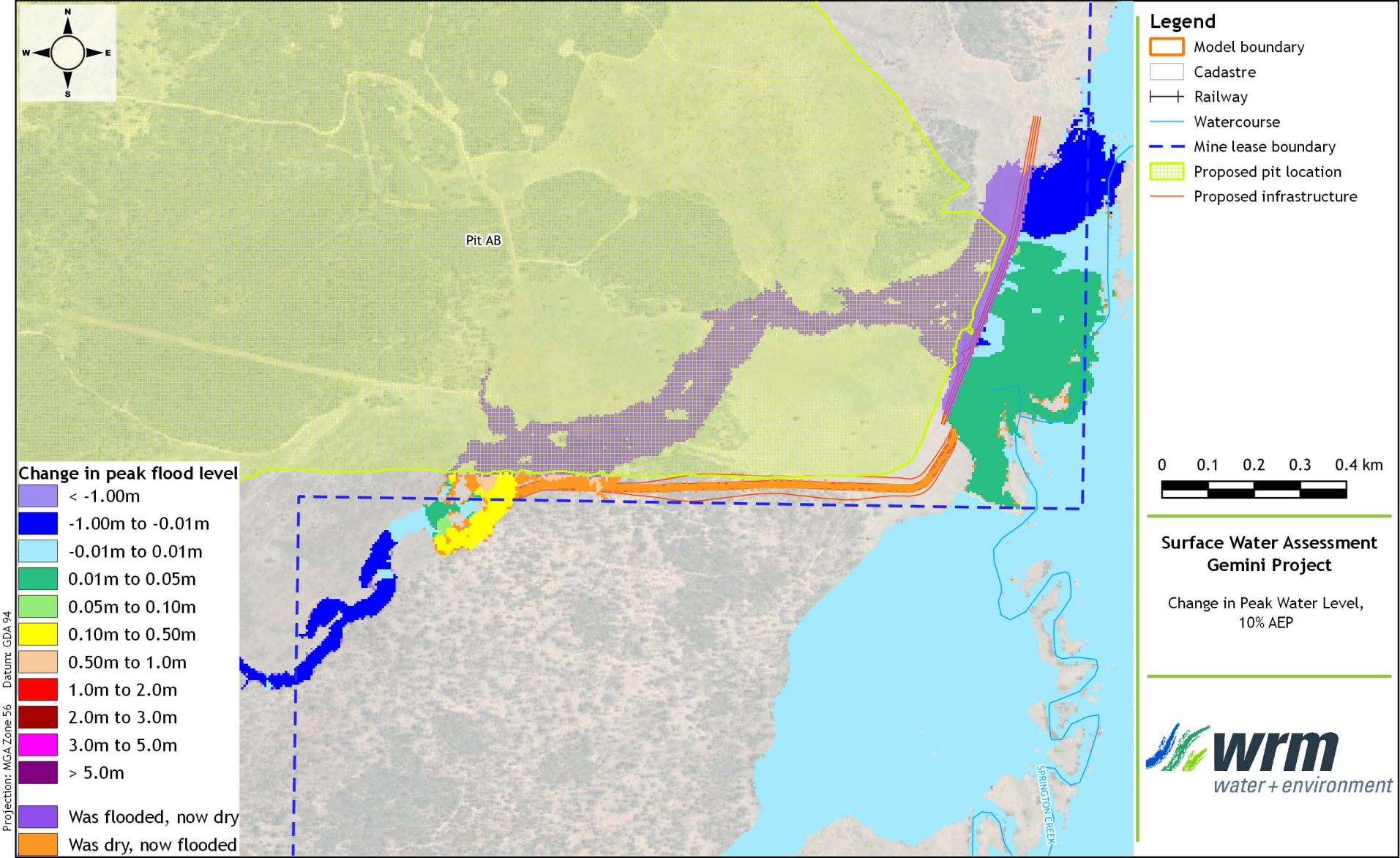
wrm water + environment

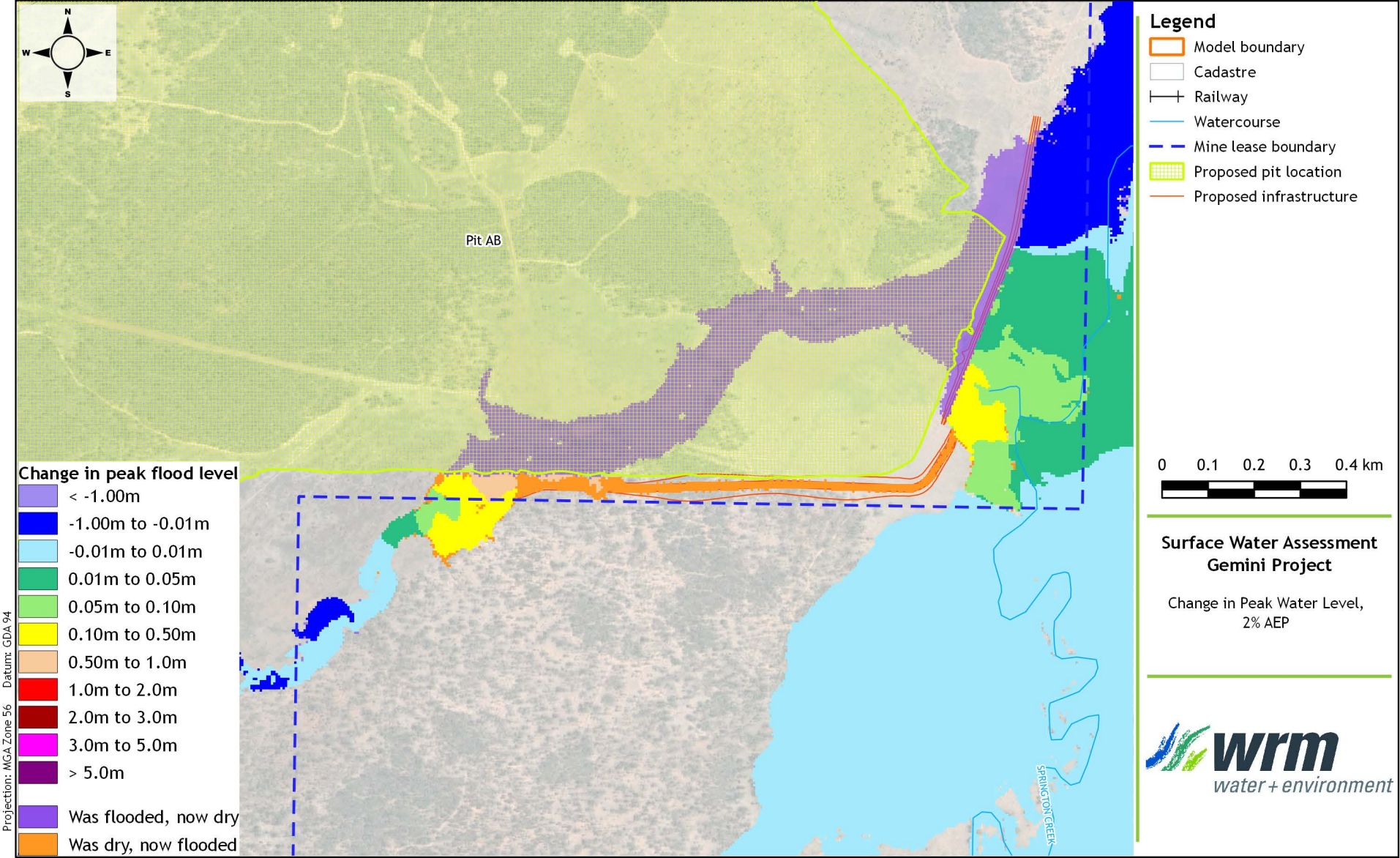


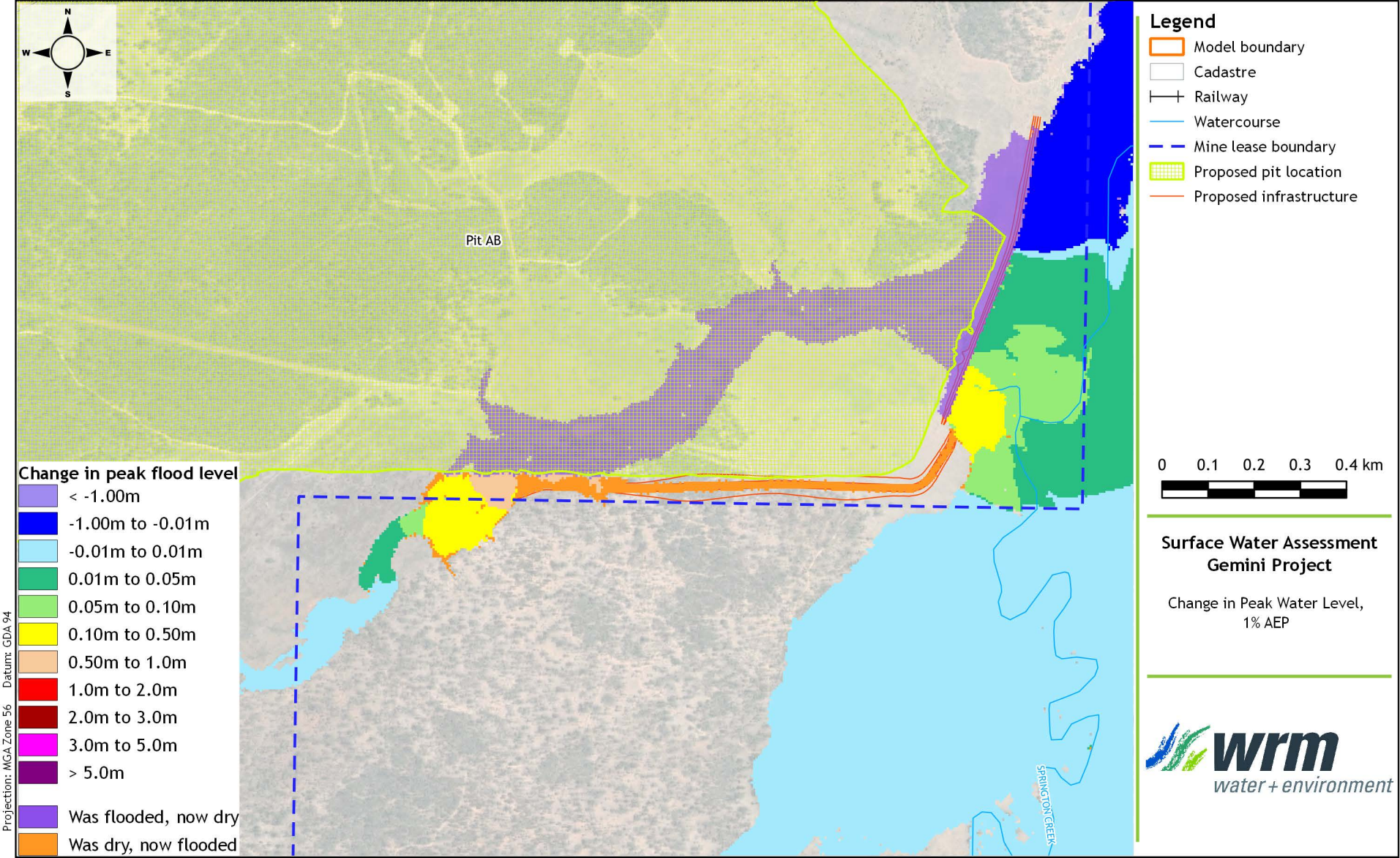
Surface Water Assessment
Gemini Project

Change in Peak Water Level,
50% AEP

wrm water + environment


Pit AB
SPRINGTON CREEK
Change in peak flood level
< -1.00m
-1.00m to -0.01m
-0.01m to 0.01m
0.01m to 0.05m
0.05m to 0.10m
0.10m to 0.50m
0.50m to 1.0m
1.0m to 2.0m
2.0m to 3.0m
3.0m to 5.0m
> 5.0m
Was flooded, now dry
Was dry, now flooded
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Change in Peak Water Level,
10% AEP
wrm
water + environment

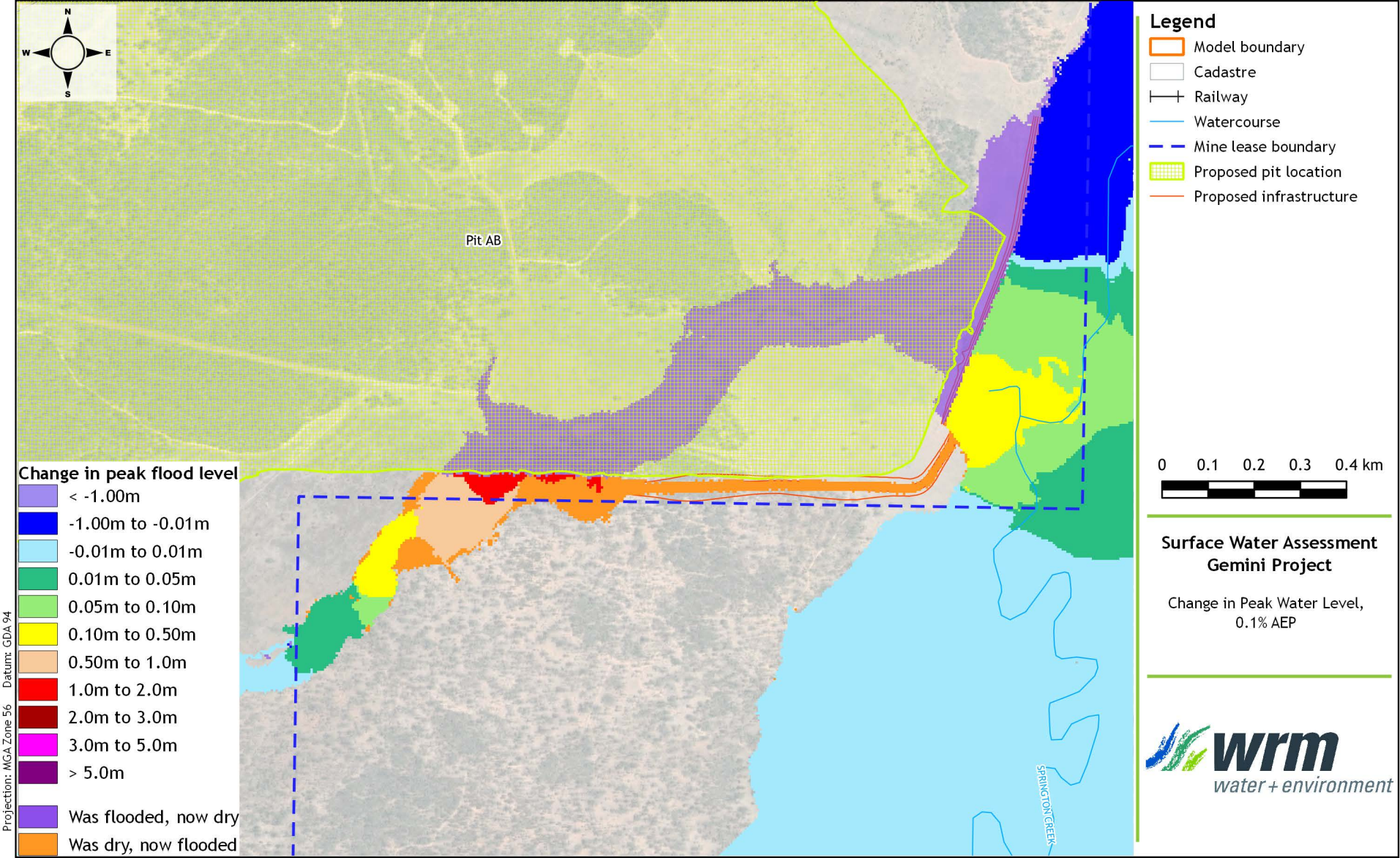

N
W
E
S
Pit AB
SPRINGTON CREEK
Change in peak flood level
< -1.00m
-1.00m to -0.01m
-0.01m to 0.01m
0.01m to 0.05m
0.05m to 0.10m
0.10m to 0.50m
0.50m to 1.0m
1.0m to 2.0m
2.0m to 3.0m
3.0m to 5.0m
> 5.0m
Was flooded, now dry
Was dry, now flooded
Projection: MGA Zone 56 Datum: GDA 94
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Change in Peak Water Level,
2% AEP
wrm
water + environment



Surface Water Assessment
Gemini Project

Change in Peak Water Level,
1% AEP

wrm water + environment


N
W
E
S
Pit AB
SPRINGTON CREEK
Legend
Model boundary
Cadastre
Railway
Watercourse
Mine lease boundary
Proposed pit location
Proposed infrastructure
Change in peak flood level
< -1.00m
-1.00m to -0.01m
-0.01m to 0.01m
0.01m to 0.05m
0.05m to 0.10m
0.10m to 0.50m
0.50m to 1.0m
1.0m to 2.0m
2.0m to 3.0m
3.0m to 5.0m
> 5.0m
Was flooded, now dry
Was dry, now flooded
Projection: MGA Zone 56 Datum: GDA 94
0 0.1 0.2 0.3 0.4 km
Surface Water Assessment
Gemini Project
Change in Peak Water Level,
0.1% AEP
wrm
water + environment

MAGNETIC SOUTH PTY LTD

GROUNDWATER IMPACT ASSESSMENT
GEMINI COAL PROJECT

October 2019

JBT01-071-003

RECORD OF ISSUE

File Name	Version	Issued to:	Date Issued	Method of Delivery
JBT-071-003	Rev 1	G Bramston	7 October 2019	email

JBT Consulting Pty Ltd

John Bradley
PRINCIPAL HYDROGEOLOGIST

TABLE OF CONTENTS

SECTION **PAGE**

1.0 INTRODUCTION 1
2.0 CLIMATIC DATA 3
3.0 GEOLOGY AND HYDROGEOLOGY 5
3.1 Stratigraphy 5
3.2 Igneous Rocks and Intrusions 8
3.3 Structure 8
4.0 GROUNDWATER INVESTIGATIONS AND DATA 9
4.1 Groundwater Monitoring Bores 9
4.2 Groundwater Levels 12
4.3 Groundwater Quality 15
4.4 Hydraulic Conductivity data from Monitoring Bores 18
4.5 Use of Groundwater Quality Data for Estimating Groundwater Recharge 20
4.6 Summary of Observations from Site Data 21
4.7 Regional Groundwater Use 22
5.0 CONCEPTUAL GROUNDWATER MODEL 25
6.0 GROUNDWATER MODELLING 27
6.1 Choice of Numerical Model 27
6.2 Model Locations and Scenarios 28
6.3 Hydraulic Properties 36
6.3.1 Hydraulic Conductivity 36
6.3.2 Volumetric Water Content 36
6.3.2.1 Specific Yield 36
6.3.2.2 Specific Storage 36
6.4 Representation of Faulting 37
6.5 Boundary Conditions 37
6.5.1 Recharge 37
6.5.2 Starting Phreatic Surface 38
6.5.3 Groundwater Seepage to Voids 38
6.6 Model Results 38
6.6.1 Groundwater Level Impacts 38
6.6.2 Groundwater inflow to the Mined Voids 41
6.7 Uncertainty Analysis 42
6.7.1 Introduction 42
6.7.2 Results 43
7.0 GROUNDWATER IMPACTS FROM MINING 47
7.1 Impacts on Existing Groundwater Users 47
7.2 Groundwater Dependant Ecosystems 48
7.2.1 Area of Mapped Potential GDE to East of MLA 48
7.2.2 GDE's Associated with Watercourses and Floodplains 52
7.3 Cumulative Impacts 54
7.4 Impacts on Groundwater Quality 54
8.0 SUMMARY AND CONCUSIONS 57
8.1 Review of Project and Site Data 57
8.2 Groundwater Modelling 58
8.3 Groundwater Impacts from Mining 59
9.0 REFERENCES 62

LIST OF TABLES

Table 2-1: Average Monthly Rainfall and Evaporation (SILO Data) 3
Table 3-1: Summary of Regional and Site Stratigraphy 5
Table 4-1: Summary Details of Groundwater Monitoring Bores 11
Table 4-2: Hydraulic Conductivity and Air Lift Yield Data for Monitoring Bores 18
Table 4-3: Summary of Hydraulic Conductivity and Air-Lift Yield Data per Groundwater Unit 19
Table 4-4: Calculated Recharge via CMB Method 20
Table 4-5: Summary Data from DNRM Groundwater Database for Bores within 10km of EPC Boundary 24
Table 6-1: Hydraulic Properties Used in Model 36
Table 6-2: Specific Yield Values used in Model 36
Table 6-3: Calculated Rates of Inflow to the AB Pit and C Pit 42
Table 6-4: Results of Uncertainty Analysis 45
Table 7-1: Bores from DNRM Groundwater Database within 2m Drawdown Zone 48

LIST OF FIGURES

Figure 1-1: Project Location 2
Figure 2-1: Climatograph for the Gemini Project Site 4
Figure 2-2: Monthly Rainfall and Rainfall Residual Mass Curve 4
Figure 3-1: Project Location and Surface Geology (1:100,000 Scale Digital Geology) 6
Figure 3-2: Project Location and Bowen Basin Solid Geology 7
Figure 4-1: Groundwater Monitoring Bore Locations 10
Figure 4-2: Water Level Data for Coal Seam and Tertiary Groundwater Units 13
Figure 4-3: Water Level as Elevation (mAHD-top plot) and Depth to Water (mbgl-bottom plot) 14
Figure 4-4: Water Level Data for Quaternary Alluvium Bore DW7076W 15
Figure 4-5: Relationship between Hydraulic Conductivity and Depth 19
Figure 4-6: Aquifer Data and Groundwater EC Data from DNRM Groundwater Database 23
Figure 6-1: Representation of Mining Schedule for Selected Years 30
Figure 6-2: Representation of Mining, Long-Section Model, A-B Pit – Start of Mining to Year 7 31
Figure 6-3: Representation of Mining, Long-Section Model, AB Pit – Mining Year 8 to Final Landform 32
Figure 6-4: Representation of Mining in Long-Section Model – Pit C 33
Figure 6-5: Representation of Mining in Cross Section Model through Final Void for AB Pit 34
Figure 6-6: Representation of Mining in Cross Section Model for C Pit 35
Figure 6-7: Extent of 2 m and 5 m Water Level Drawdown – End of Mining 39
Figure 6-8: Extent of 2 m and 5 m Water Level Drawdown – Post-Mining Equilibrium 40
Figure 6-9: Uncertainty Analysis 46
Figure 7-1: Assessment of Potential GDE to East of the Gemini Project MLA 51
Figure 7-2: Alluvium Bore DW7076W and Charlevue Creek adjacent to Bore 53
Figure 7-3: Base of Tertiary Contours and AB Pit Final Void Water Levels 55
Figure 7-4: Base of Tertiary Contours and C Pit Final Void Water Levels 56

APPENDICES

Appendix A Groundwater Monitoring Bore Constuction Logs
Appendix B Summary Groundwater Chemistry Data
Appendix C Slug Test Analysis Sheets

1.0 INTRODUCTION

Magnetic South Pty Ltd is the project proponent and the applicant for the Mining Lease (ML) and Environmental authority (EA) to develop the Gemini Project, a greenfield open cut mine to produce Pulverised Coal Injection (PCI) coal and Coking Coal products for export for steel production. The Project term is anticipated to be 25 years from grant of the ML with this term including initial construction, mine operation and rehabilitation activities. Mining at the Gemini Project is projected to occur over approximately 20 years as a truck and shovel operation at an average of 1.8 million tonnes per annum (Mtpa) ROM coal.

The Project is located approximately 150 km to the east of Rockhampton and 8 km west of the town of Dingo and is accessed by the Capricorn Highway, which transects the northern part of the tenement (Figure 1-1).

This report provides a comprehensive assessment of:

- The regional and mine-scale geology and hydrogeology;
- The installation of a groundwater monitoring bore network that has been designed to provide water level and water quality data from all groundwater units at site;
- A program of hydraulic testing that has been carried out on the groundwater monitoring bores at site in order to provide site-specific hydraulic conductivity data for groundwater modelling;
- Water level and water quality data obtained to date from the site groundwater monitoring bores;
- Regional groundwater occurrence and use;
- A conceptual groundwater model for the site; and,
- Groundwater modelling that has been undertaken to provide predictions of:
    - the rate of groundwater inflow to the mined voids; and
    - the extent of groundwater level impacts from mining, which are used to provide prediction of the potential for impact on sensitive environmental receptors such as landholder bores and groundwater dependent ecosystems (GDEs).

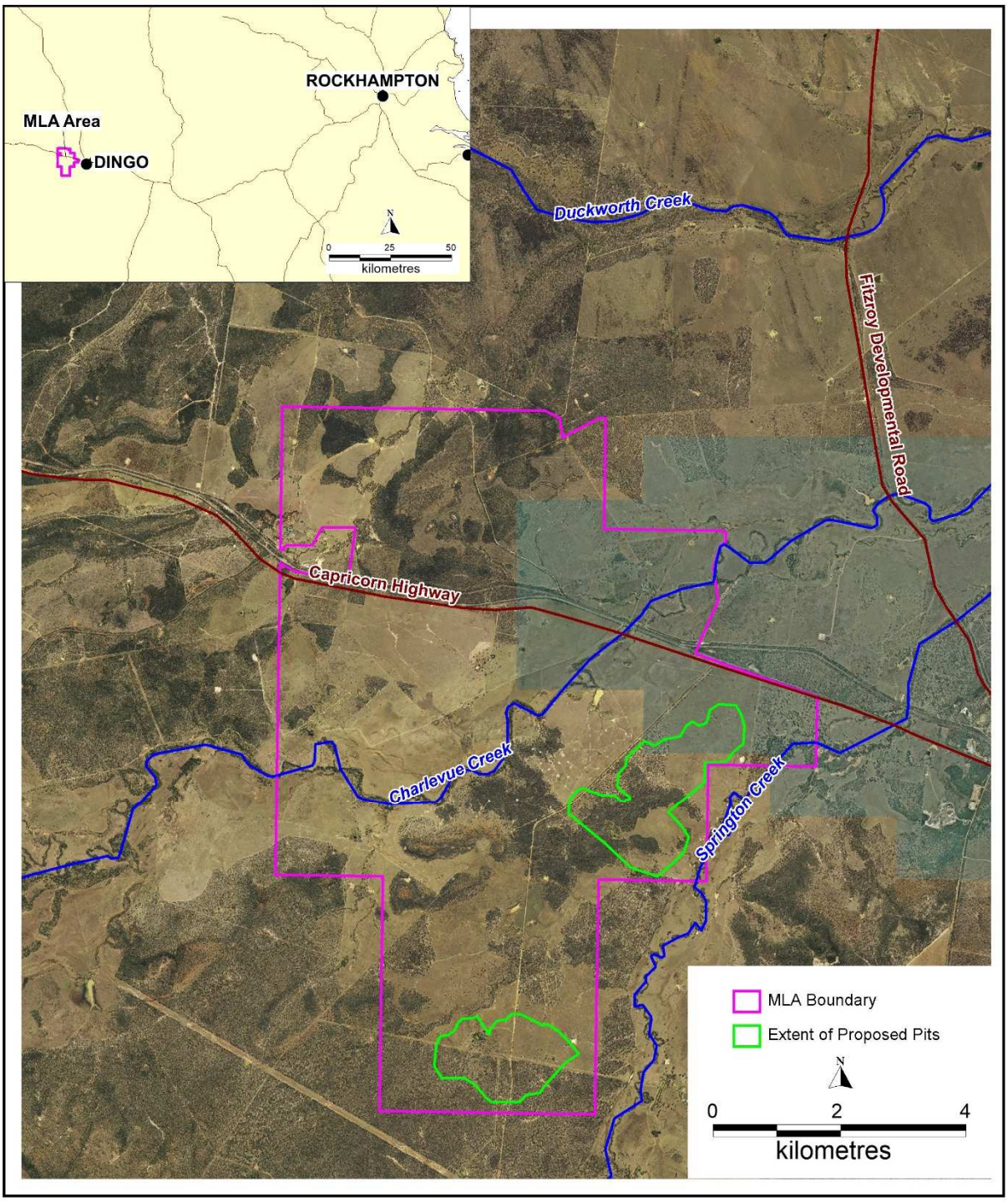


Figure 1-1: Project Location

2.0 CLIMATIC DATA

The climatic description of the region in which the project site is located has been compiled using data from the DNRM SILO Data Drill. The Data Drill accesses grids of climate data available from surrounding Bureau of Meteorology (BoM) point observations and then creates interpolated climate values for the requested location. The SILO climate data was obtained for coordinates that correspond to the approximate centre of the Gemini Project site.

Summary data for rainfall and evaporation is shown in Table 2-1 and indicates that:

- Mean annual rainfall for the site is approximately 678 mm; and,
- Mean annual evaporation is approximately 2024 mm and exceeds rainfall for every month of the year.

The data has been utilised to produce a climatograph for the Gemini Project site (Figure 2-1), which shows that:

- rainfall is highly seasonal, with the dry season from April to September-October, and a wet season from November through to March;
- The coldest month of the year is July, with a mean minimum temperature of 7.7 ºC and a mean maximum temperature of 23.2 ºC; and,
- The hottest month of the year is January, with a mean minimum temperature of 21.6 ºC and a mean maximum temperature of 33.8 ºC.

Figure 2-2 shows the total monthly rainfall for the period 2000 to July 2019 and also presents a rainfall residual mass (RRM) curve for the data. The RRM is calculated by subtracting the long-term average monthly rainfall from the actual monthly rainfall, to provide a monthly "departure" from average conditions. If the monthly rainfall is above average, the resulting rainfall departure number is positive, whereas if the rainfall is below average, the number is negative. A number of below-average rainfall months will result in a falling RRM curve, while a number of above average rainfall months will result in a rising RRM curve. The RRM curve is used extensively in groundwater investigations due to the strong correlation in many locations between the RRM and groundwater level trends. The RRM curve shows a downward trend from 2000 to 2007, an upward trend from 2008 to 2013 and a relatively stable trend from 2013 to present. The downward trend from 2013 to present indicates a potential for falling groundwater levels over that period for shallow aquifers where rainfall recharge is the dominant factor that affects water level rise and water levels tend to fall during periods of below-average rainfall.

Table 2-1: Average Monthly Rainfall and Evaporation (SILO Data)

Month	Average Rainfall (mm)	Average Evaporation (mm)
January	109.9	229.5
February	105.7	186.5
March	76.0	184.2
April	35.8	151.3
May	33.5	117.9
June	34.7	94.2
July	27.5	101.9
August	21.4	129.6
September	23.9	164.1
October	45.7	206.9
November	63.0	220.0
December	101.1	238.1
Total	**678.2**	**2024.2**

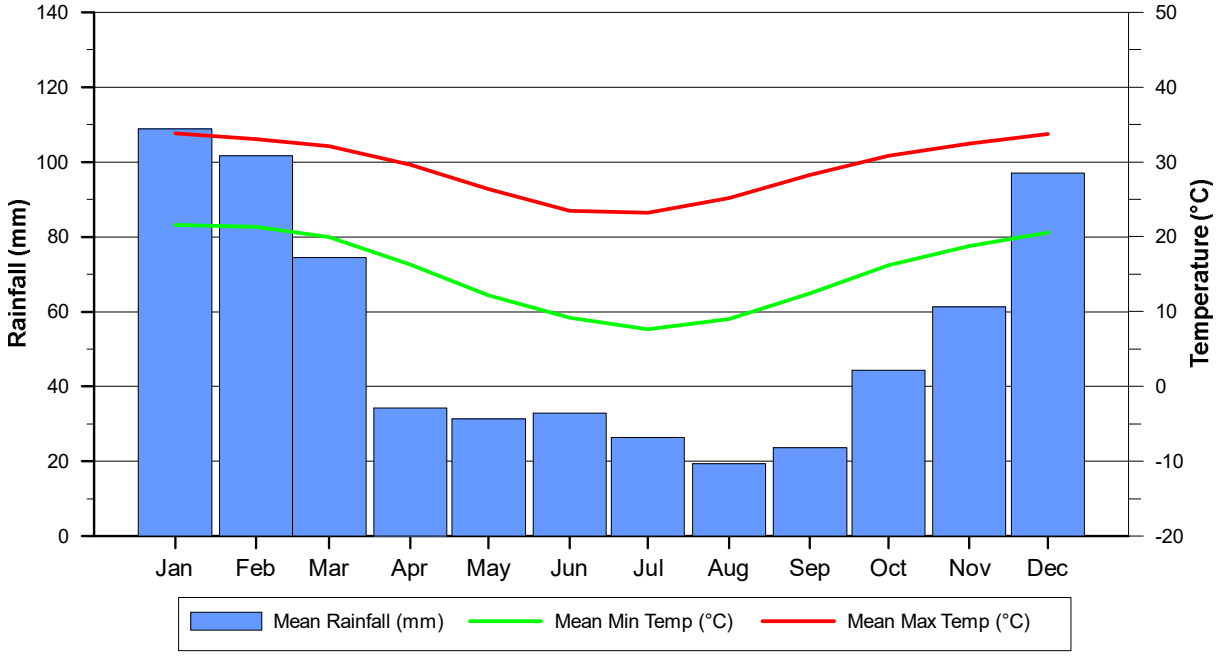


Figure 2-1: Climatograph for the Gemini Project Site

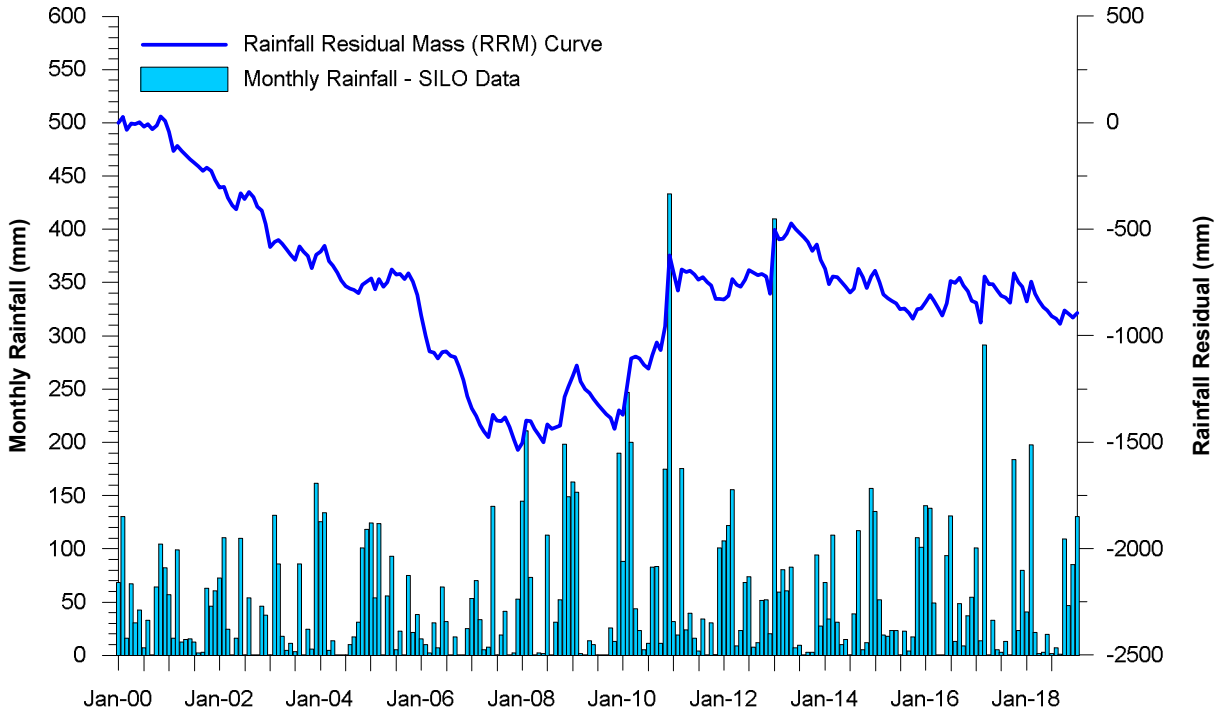


Figure 2-2: Monthly Rainfall and Rainfall Residual Mass Curve

3.0 GEOLOGY AND HYDROGEOLOGY

3.1 Stratigraphy

The Gemini coal deposit is hosted within the Permian Rangal Coal Measures and within the Yarrabee Structural Zone. Seven seams or seam groups have been identified at the Gemini Project site, which belong to either the Rangal Coal Measures or the underlying Burngrove Formation (Boyd 2019). In descending stratigraphic order the seams include the Aries, Castor, Pollux, Orion, Pisces, Virgo and Leo seams. The seams contain a number of individual plies that have identified for mining at site; the main coal seams that are encountered at site and their typical thickness are shown below in Table 3-1.

The surface geology at site is shown in Figure 3-1. It predominantly comprises sediments of the Tertiary Duaringa Formation and Quaternary alluvium associated with ephemeral creeks including Charlevue Creek and Springton Creek. At one location north of Pit C a small area of remnant basalt has been identified from drilling, measuring approximately 600 m long and 200 m wide with a thickness of approximately 20 m (JTB 2019). Bore DW7105W1 (Section 4.1) is located within the basalt and is dry.

Figure 2-2 shows the project location in relation to the underlying Bowen Basin solid geology (i.e. the surficial unconsolidated Quaternary and Tertiary units have been removed, revealing the relationship between the underlying Triassic and Permian sediments as well as the prevalence of regional-scale faults). The two mining areas (A-B Pit and C Pit) are located in areas where folding has brought the coal seams close to surface at depths that can be economically mined. Figures 3-1 and 3-2 also show the locations of east-west cross sections through each mining area and a long section through both mining areas. Data from these sections has been utilised to create cross sectional groundwater models, which are discussed below in Section 6.0.

Table 3-1: Summary of Regional and Site Stratigraphy

Geological Age	Unit	Coal Seams	Description	Typical Thickness at Site (m)
Quaternary	Alluvium		Unconsolidated soil, silt clay, sand and gravel associated with current surface drainage systems, e.g. Charlevue Creek and Springton Creek	1.5
Tertiary	Duaringa Formation		Mudstone, sandstone, conglomerate, siltstone	15 - 30
	Basalt		Minor basalt at one location north of Pit C.	20
Triassic	Rewan Group		Lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate at base	0 - 50
Permian	Rangal Coal Measures	Aries Upper	Feldspathic and lithic sandstone, carbonaceous mudstone, siltstone, tuff and coal seams. Includes the Aries, Castor and Pollux Coal Seam, which are the target coal seam for mining at the Gemini Project	2.1
		Aries Lower		4
		Castor Upper		1.6
		Castor Lower		2
		Pollux Upper		1.9
		Pollux Lower Upper		2.9
		Pollux Lower Lower		3.5
		Orion		6.1
		Pisces Upper		1.7
		Yarrabee Tuff		0.9
		Pisces Lower		0.7
	Burngrove Formation	Virgo	Mudstone, siltstone, sandstone, coal, tuff	2.8
		Leo		4.4
	Gyranda Formation		Siltstone and shale with minor tuff and volcanilithic sandstone and rare coal	0 to 100 m+

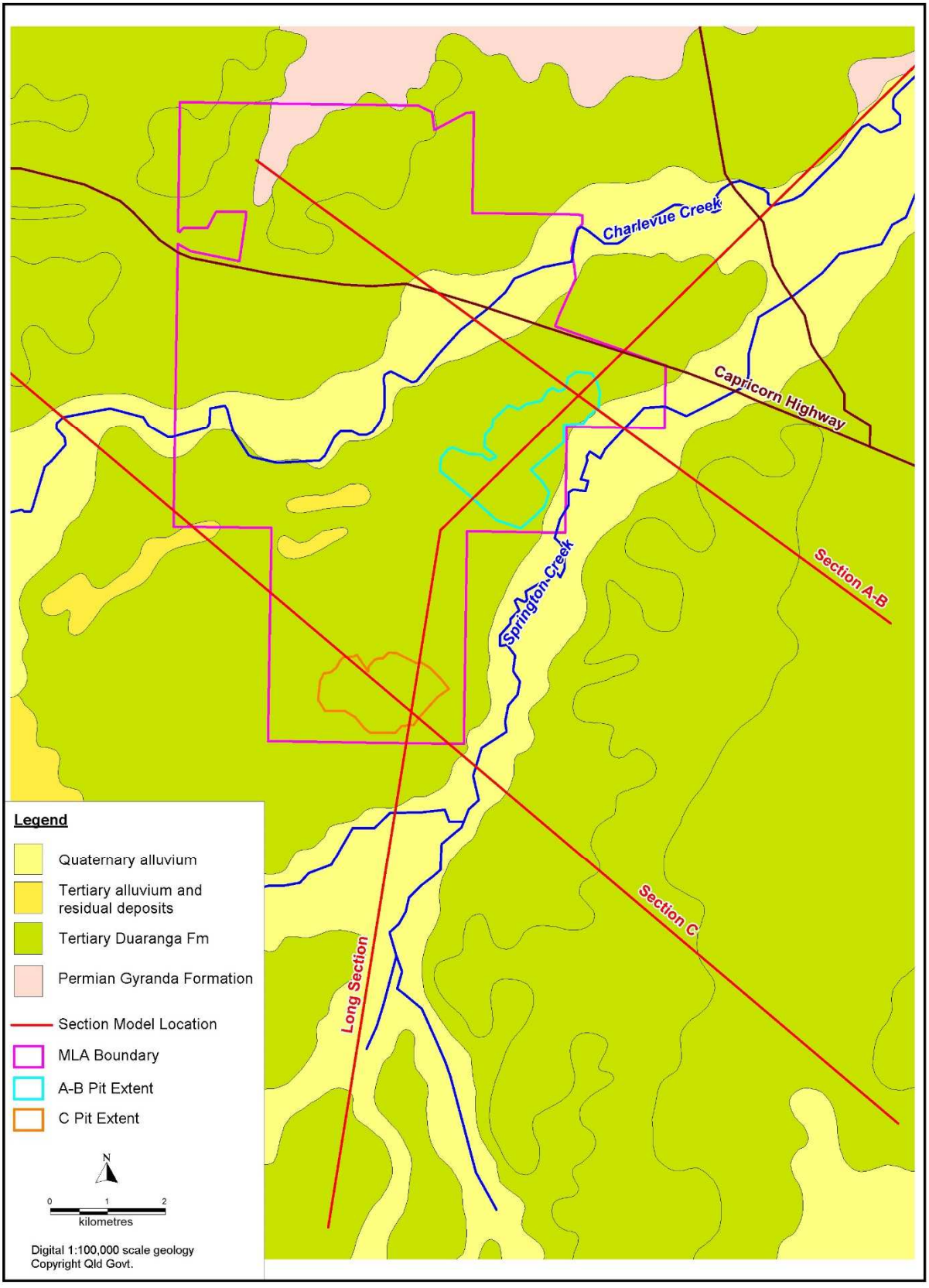


Figure 3-1: Project Location and Surface Geology (1:100,000 Scale Digital Geology)

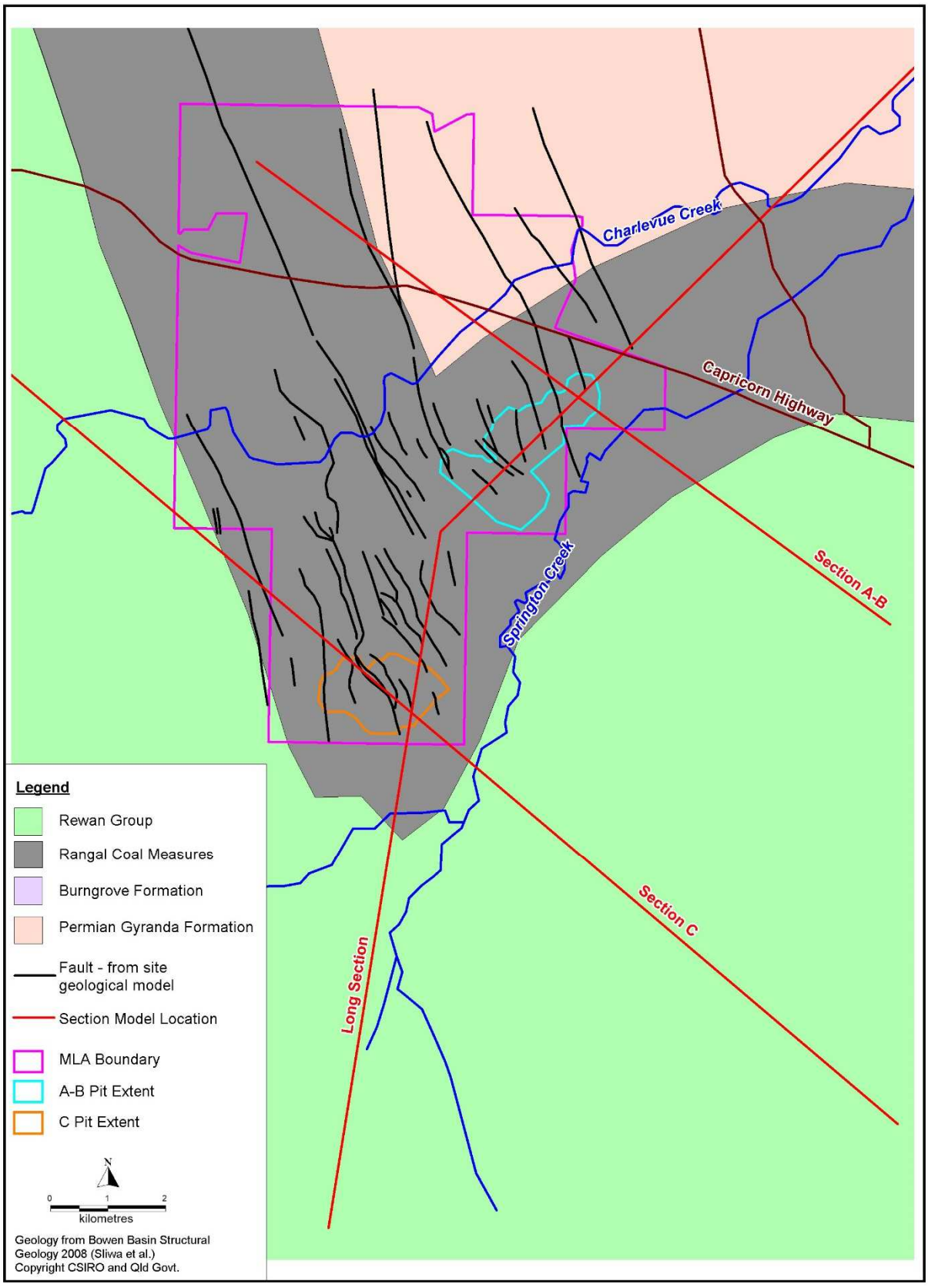


Figure 3-2: Project Location and Bowen Basin Solid Geology

3.2 Igneous Rocks and Intrusions

A minor occurrence of Tertiary basalt has been identified from geological drilling to the north of Pit C. The area of basalt is approximately 600 m long, 200 m wide and 20 m thick and has been interpreted as a localised basalt paleochannel (JTB 2019). One groundwater monitoring bore has been located within the basalt (bore DW7105W1, Section 4.1, Figures 4-1 and 4-2); the bore is 23 m deep and the basalt is dry at the bore location. The basalt flow is interpreted to be dry (as it is above the regional groundwater level) and of limited extent and is therefore not an important groundwater feature within the project area.

Extensive geological drilling across the project area has shown no other evidence of basaltic flows or intrusions (JTB 2019).

3.3 Structure

The Permian coal measures have undergone intense structural deformation, resulting in folding and faulting of the unit. Multiple reverse angle faults are present within the deposit, with displacements on some faults estimated to be in excess of 100 m (Boyd 2019). The location of mapped faults that are included in the site geological model are shown in Figure 3-2. With respect to the potential for impacts on groundwater occurrence and movement, the potential impacts are assessed to be:

- The fault zones may provide localilsed increases in hydraulic conductivity and storage that is associated with the shear zones of each fault; and,
- The faults may act as barriers to groundwater flow at locations where the faults disrupt individual coal seams, which are the main conduits for groundwater flow, especially at locations where the entire thickness of coal is displaced so that the coal seam terminates against lower-permeability interburden (the impacts of faults on groundwater are discussed further in Sections 4.6, 6.0 and 6.4).

4.0 GROUNDWATER INVESTIGATIONS AND DATA

4.1 Groundwater Monitoring Bores

The groundwater monitoring bore network at the Project site comprises 38 monitoring bores at 17 sites; bore locations are shown below in Figure 4-2, with summary details for the bores provided in Table 4-1. The monitoring bore network was designed to allow hydraulic testing as well as water level and water quality monitoring of all groundwater units encountered at site and includes:

- Two (2) bores within Quaternary alluvium;
- Ten (10) bores within Tertiary deposits (9 bores within Tertiary sediments and 1 bore (DW7105W1) in Tertiary basalt;
- Twenty-three (23) bores within Permian coal seams; and,
- Three (3) bores within the Permian overburden/interburden sediments that occur above/between the coal seams.

Bore construction logs for the monitoring bores are provided in Appendix A.

The development and utilisation of the monitoring bore network is summarised as follows:

- The network has been developed in two stages, comprising:
  - Stage 1 – installation of 11 bores at 5 sites (Sites 1 to 5 – refer Figure 4-2 and Table 4-1), with the bores installed in April 2018; and,
  - Stage 2 – Installation of a further 27 bores at 12 sites (Sites 6 to 17), with the bores drilled from May to June 2019.
- The bores at sites 1 to 5 have been monitored for water level and water quality on approximately a monthly basis since December 2018, with data available for this report from 8 sampling events between December 2018 and August 2019. Water level and water quality data is summarised below in Sections 4.2 and 4.3 respectively.
- Bores at Sites 6 to 17 were utilised for hydraulic testing (falling-head slug tests). Hydraulic tests were performed on a total of 25 bores, which provided data for all groundwater units present at site. Results from the hydraulic testing program are presented and discussed in Section 4.4.

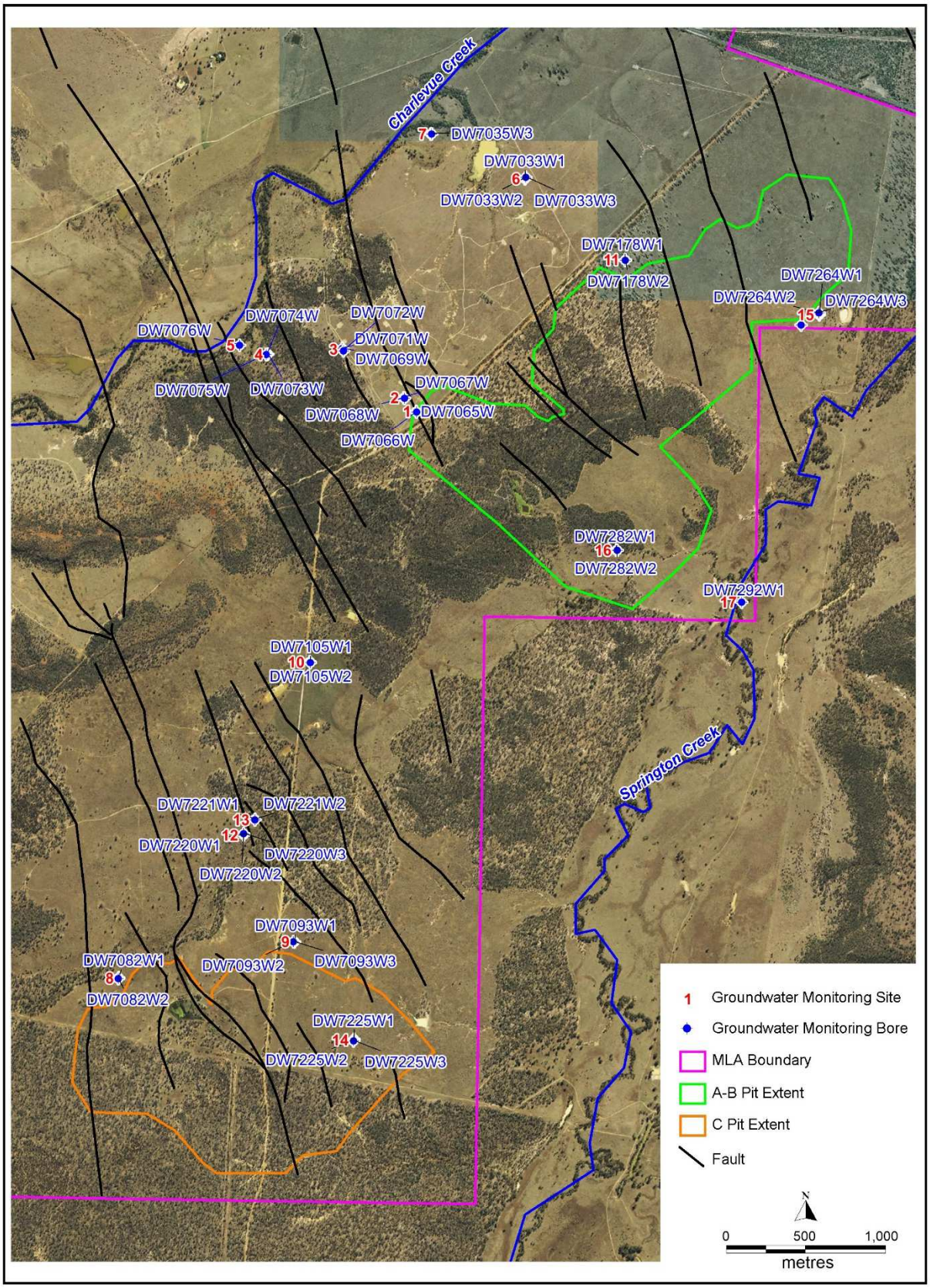


Figure 4-1: Groundwater Monitoring Bore Locations

Table 4-1: Summary Details of Groundwater Monitoring Bores

Site	Bore ID	Unit Monitored	Easting (GDA94)	Northing (GDA94)	RL (mTOC)*	Bore Depth (m)	Gravel Pack		Slotted Interval		Water Level	
							From*	To*	From*	To*	mbgl*	mAHD
1	DW7065W	Aries 3 Seam	730860	7382307	136.65	77.27	70.3	77.3	47.3	77.3	46.62	89.35
	DW7066W	Tertiary sediments	730863	7382304	137.19	17.35	10.35	17.35	Dry	17.35	Dry	-
2	DW7067W	Aries 3 Seam	730781	7382394	134.81	100.14	96.1	100.1	45.05	100.1	44.16	89.76
	DW7068W	Tertiary sediments	730785	7382391	134.94	47.5	42	47.5	45.68	47.5	44.74	89.26
3	DW7069W	Pollux Upper Seam	730397	7382699	133.46	71.38	64.4	71.4	42.73	71.4	41.84	90.73
	DW7071W	Aries 3 Seam	730394	7382703	133.22	31.59	27.6	31.6	Dry	31.6	Dry	-
	DW7072W	Tertiary sediments	730403	7382687	133.14	14.01	10	14	Dry	14	Dry	-
4	DW7073W	Castor/ Pollux Seams	729926	7382666	123.04	82.1	78.1	82.1	32.71	82.1	31.76	90.33
	DW7074W	Castor Upper Seams	729922	7382666	122.94	55.78	53.3	55.8	32.72	55.8	31.82	90.22
	DW7075W	Tertiary sediments	729918	7382666	122.83	14.03	10	14	Dry	14	Dry	
5	DW7076W	Quaternary Alluvium	729750	7382723	120.82	12	8	12	9.78	12	8.77	111.04
6	DW7033W1	Tertiary	731543	7383768	125.44	45.23	38	44.99	30.98	44.99	29.94	94.46
	DW7033W2	Orion 5 Seam	731546	7383773	125.46	74.77	72	74.5	30.02	74.5	29.01	95.44
	DW7033W3	Interburden	731548	7383777	125.47	81	78.5	81	29.97	81	28.93	95.50
7	DW7035W3	Orion 1 Seam	730957	7384050	117.73	48.47	45.9	48.44	22.81	48.44	21.75	94.92
8	DW7082W1	Castor Lower Seam	728989	7378746	136.34	40.58	38.1	40.64	17.99	40.64	16.91	118.35
	DW7082W2	Pollux Upper Seam	728986	7378742	136.32	59.17	57.6	59.17	18.03	59.17	17.04	118.29
9	DW7093W1	Pollux Lower Upper Seam	730096	7378974	140.14	87.3	84.5	87.3	29.58	87.3	28.44	110.56
	DW7093W2	Interburden	730092	7378973	140.14	99.2	97.5	99.2	29.54	99.2	28.45	110.60
	DW7093W3	Pollux Lower Lower Seam	730088	7378974	140.17	123.25	120.7	123.25	29.51	123.25	28.46	110.66
10	DW7105W1	Tertiary Basalt	730192	7380733	129.62	23.04	19	23.04	Dry	23.04	Dry	-
	DW7105W2	Pollux Lower Upper Seam	730193	7380729	129.72	69.25	61.7	64.2	32.2	64.2	31.18	97.52
11	DW7178W1	Tertiary	732174	7383260	129.62	51.15	43	48.5	38.68	48.5	37.71	90.94
	DW7178W2	Pollux Lower Upper Seam	732174	7383256	129.66	58.69	54.4	58.4	39.47	58.4	38.45	90.19
12	DW7220W1	Tertiary	729775	7379648	129.72	26.5	22.5	26.5	16.42	26.5	15.38	113.30
	DW7220W2	Castor Seam	729775	7379651	129.62	38.4	34.4	38.4	20.23	38.4	19.25	109.39
	DW7220W3	Pollux Lower Upper Seam	729774	7379655	129.67	75.08	72.5	75.04	20.03	75.04	19.04	109.64
13	DW7221W1	Aries 3 Seam	729846	7379745	130.34	50.43	46.4	50.43	21.52	50.43	20.50	108.82
	DW7221W2	Castor Seam	729845	7379742	130.32	72.36	69.8	72.36	21.57	72.36	20.50	108.75
14	DW7225W1	Tertiary	730467	7378359	141.70	37	30	37	33.43	37	32.37	108.27
	DW7225W2	Aries 3 Seam	730466	7378355	141.76	78.9	74.2	78.9	33.17	78.9	32.10	108.59
	DW7225W3	Castor Seam	730465	7378351	141.74	112.8	107	112.8	32.64	112.8	31.60	109.10
15	DW7264W1	Tertiary	733392	7382915	113.16	14	11.5	14	Dry	14	Dry	-
	DW7264W2	Aries 1 Seam	733391	7382921	113.22	104.21	101.7	104.21	22.57	104.21	21.59	90.65
	DW7264W3	Aries 3 Seam	733391	7382925	113.24	136.7	134.2	136.7	22.58	136.7	21.58	90.66
16	DW7282W1	Overburden	732119	7381433	116.84	43.03	36	43	27.25	43	26.25	89.59
	DW7282W2	Aries 3 Seam	732123	7381433	116.82	89.91	87.4	89.91	27.31	89.91	26.32	89.51
17	DW7292W1	Quaternary Alluvium	732905	7381108	114.41	15	11	15	12.02	15	11.19	102.39

* RL (mTOC) = elevation in mAHD of the top of bore casing; mbgl = metres below ground level; gravel pack and slotted interval from/to = from/to mbgl

4.2 Groundwater Levels

Available groundwater level data from the site groundwater monitoring bores is summarised as follows:

- For bores at sites 1 to 5 (refer Table 4-1), data is available to date for 9 sampling events between December 2018 and August 2019;
- For bore DW7076W, which is constructed within Quaternary alluvium adjacent to Charlevue Creek (Figure 4-2), a data logger has been fitted to the bore that records data at 3-hourly intervals. A barometric logger is also installed at the site to allow barometric correction of the data;
- For bores at sites 6 to 17, which were drilled in May/June 2019, water level data is available from field testing that was undertaken in July/August 2019.

Table 4-1 provides the most recent water level data (July/August 2019) for all monitoring sites and is summarised as follows:

- Six of the monitoring bores are dry; five of these bores are constructed within Tertiary units at depths of between 14 and 23 m and one bore is constructed with the Aries seam at a depth of 31.6 m;
- Available data for bores within the Tertiary sediments are shown below in Figure 4-2, which is summarised as follows:
    - Data shown in Figure 4-2 includes contours for RL base of Tertiary (mAHD), bore ID, water level (mAHD) and base of bore (mAHD);
    - At a number of sites where the bore is dry, the bore has not been constructed to the full depth of Tertiary sediments. These sites include DW7075W, DW7072W, DW7066W;
    - Two sites that are dry (DW7105W1 and DW7264W1) have been drilled to base of Tertiary, indicating that the Tertiary is dry at these locations. Bore DW7105W1 is constructed within the small area of remnant basalt north of C Pit that has been identified from geological drilling (section 3.1); the bore is 23 m deep and is dry;
    - There is a significant reduction in the level of the base of Tertiary to the west and north-west of AB Pit, where the level of base of Tertiary reduces from approximately 100 mAHD to 70-80 mAHD. The bores within the lower elevation area of base of Tertiary tend to record water levels in the order of 90 to 95 mAHD, whereas the bores in the range of 105 to 113 mAHD; and,
    - The presence of dry bores within the Tertiary, as well as the variation in water level between the topographically elevated base of Tertiary and topographically lower base of Tertiary, suggest that a continuous water surface does not exist in the Tertiary sediments and that the elevation of the base of Tertiary will be a control on the presence of groundwater within the sediments. From review of available data it is assessed that it is probable that the Tertiary sediments are dry above 120 mAHD and likely dry above 110 mAHD (refer Figure 4-2).
- Available data for bores within the coal seams is also shown below in Figure 4-2. In summary:
    - From the data shown in Table 4-1 it is evident that, where multiple coal seam bores exist at the one location, the water level (as mAHD) is almost identical. This suggests that there is no significant trend for upward or downward movement of groundwater between the coal seams at this location;
    - Figure 4-2 also shows groundwater level contours for the coal measures; these indicate a trend for groundwater movement within the coal seams from the southwest to the northeast, and also from the northwest to the southeast, towards a depression that is centred on the area where the AB Pit is proposed to be developed.

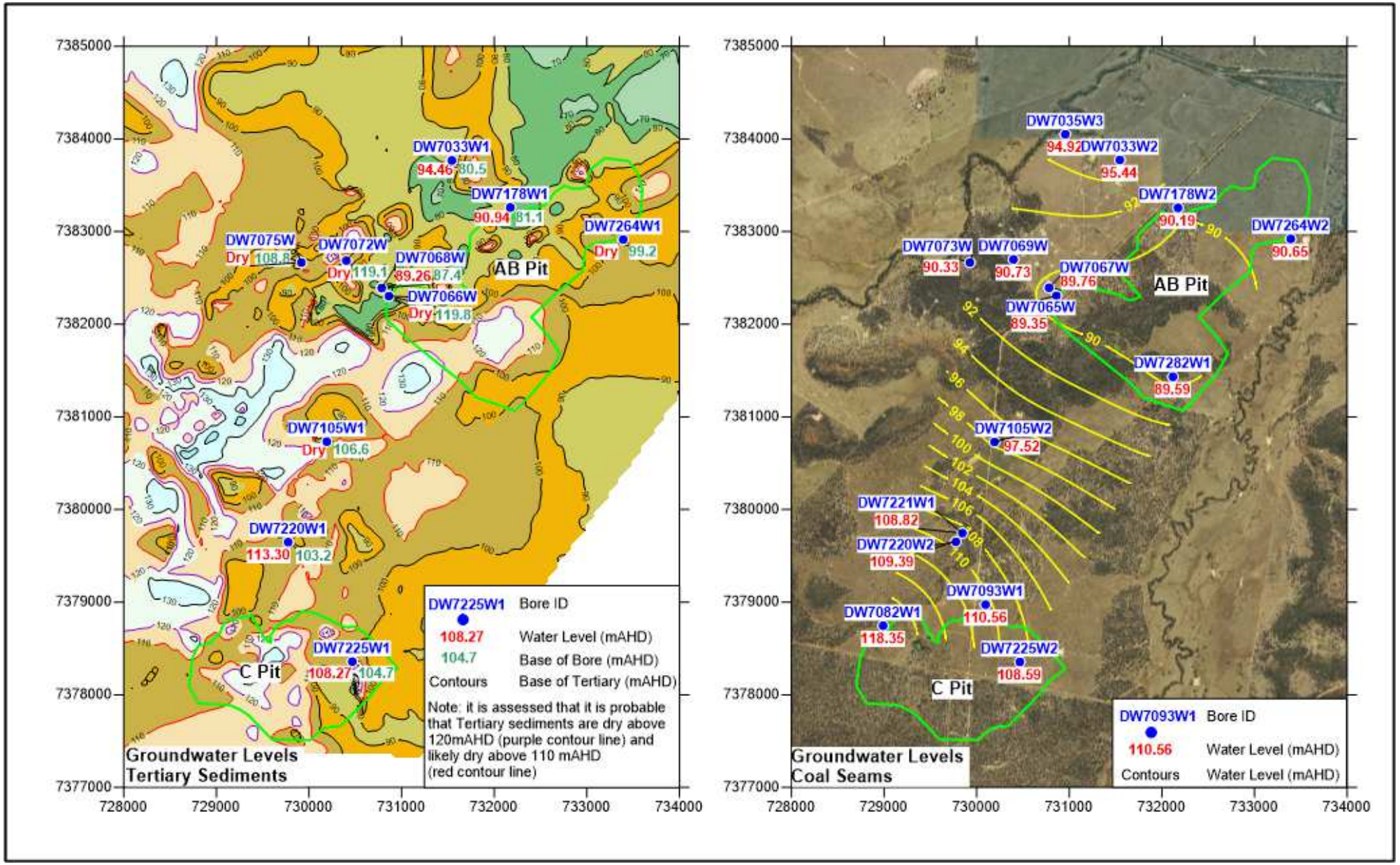


Figure 4-2: Water Level Data for Coal Seam and Tertiary Groundwater Units

For bores at Sites 1 to 5, where water level data is available from December 2018 to August 2019, the data is plotted on bore hydrographs. These are presented below and are summarised as follows:

- The bores shown on the plots below are located to the west of the AB Pit (Figure 4-2);
- When presented as water elevation data (i.e. as water level in mAHD) the data plots within a relatively tight range between approximately 88 to 90 mAHD;
- When presented as depth to water (m below ground level - mbgl), the range is from approximately 33 to 47 mbgl. This serves to highlight that the variability in the depth to groundwater is mainly related to the variation in surface topography, with the groundwater elevation in a particular area being relatively consistent; and,
- Figure 4-2 shows the location of bore DW7073W to the west of the AB Pit. This site also includes bore DW7074W, which is not shown in Figure 4-2. This is because only one coal seam bore was selected for generation of the water level contours shown in Figure 4-2, due to the similarity between the water levels within different coal seams at each site (refer water level data in Table 4-1). This relationship is highlighted in the water level data for bores DW7073W and DW7074W in the depth to water plot below; for these bores it can be seen that the water level is the same (within 0.1 m) for each monitoring event.

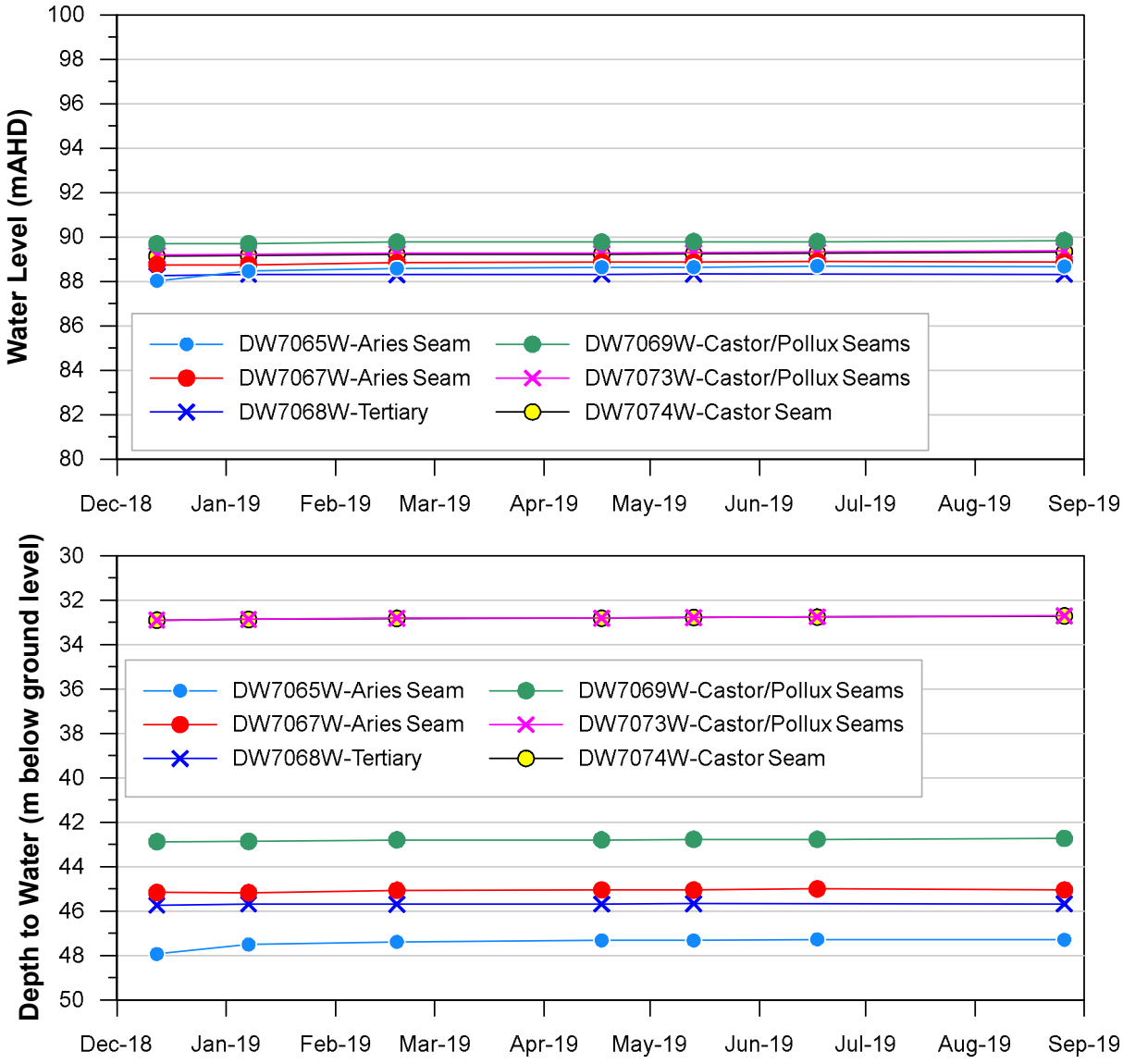


Figure 4-3: Water Level as Elevation (mAHD-top plot) and Depth to Water (mbgl-bottom plot)

Bore DW7076W (refer Figure 4-1 for bore location) is screened within Quaternary alluvium adjacent to Charlevue Creek. The bore has been fitted with a data logger that records water level at 3-hourly intervals, to allow the relationship between creek flow and water level to be established over time. To date the water level has been relatively stable, displaying a slightly downward water level tend between 9 and 10 mbgl. It is uncertain at this stage whether the reduction in water level is related to the ongoing removal of groundwater from the bore during sampling events (with the reduction in water level following sampling being evident in the bore hydrograph. Further data will be required at this site to establish the long-term water level trend.

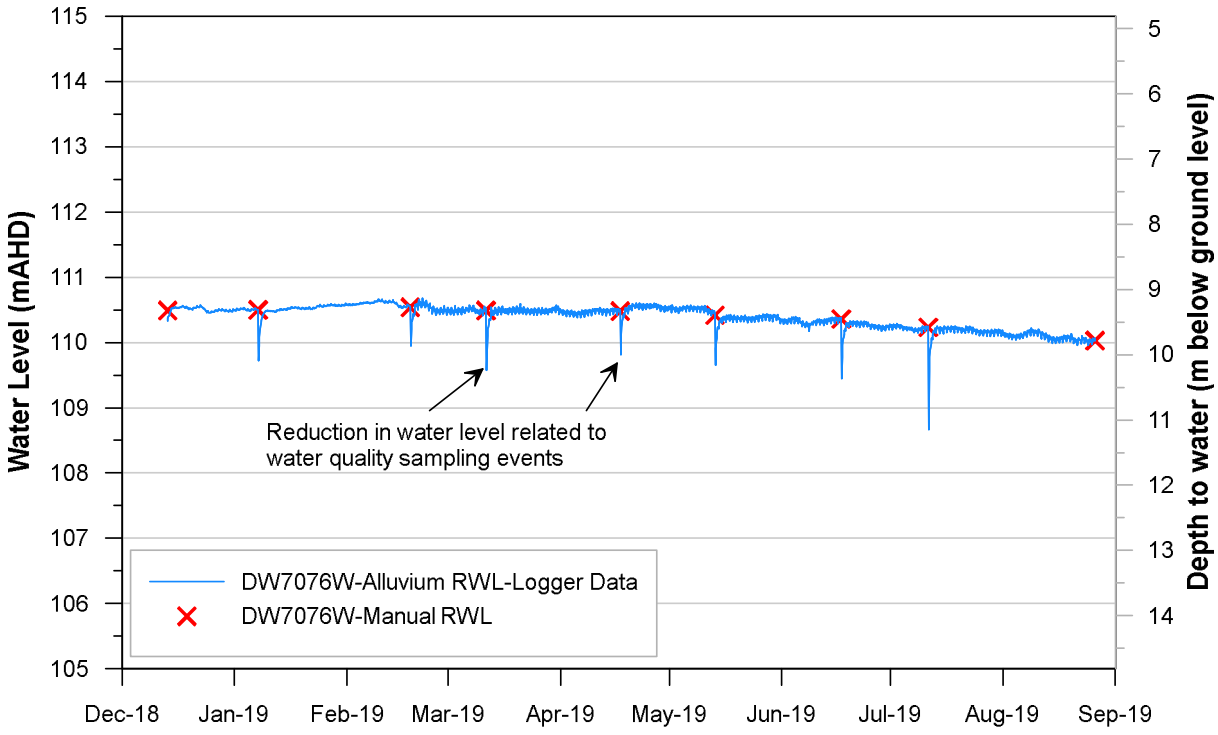


Figure 4-4: Water Level Data for Quaternary Alluvium Bore DW7076W

4.3 Groundwater Quality

Groundwater quality data is available for 8 sampling events that have occurred at approximately monthly intervals between December 2018 and August 2019. Available data includes:

- pH (field and laboratory data);
- Electrical Conductivity (EC – field and laboratory data);
- Total Dissolved Solids (TDS);
- Major ions (sodium, calcium, magnesium, potassium, chloride, sulphate, alkalinity); and,
- Total and dissolved metals/metalloids (aluminium, arsenic, barium, beryllium, boron, cadmium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, uranium, vanadium, zinc).

Available data is included as summary tables in Appendix B. Observations from review of the data area summarised as follows:

- pH (Field)
  - Quaternary alluvium - the pH ranges from 7.05 to 7.49, with a mean of 7.30 and median of 7.33;

- Tertiary sediments - the pH ranges from 6.78 to 7.06, with a mean of 6.93 and median of 6.94; and,
- Coal seams - the pH ranges from 6.21 to 6.84, with a mean of 6.44 and median of 6.42.

- Electrical Conductivity (EC – lab)
  - Quaternary alluvium - the EC at bore DW7076W (Charlevue Creek alluvium) ranges from 15,200 µS/cm to 16,600 µS/cm, with a mean of 15,788 µS/cm and median of 15,700 µS/cm (8 samples). A single field value from bore DW7292W1 (Springton Creek alluvium) recorded an EC of 5,948 µS/cm;
  - Tertiary sediments - the EC ranges from 20,200 µS/cm to 21,900 µS/cm, with a mean of 20,843 µS/cm and median of 20,800 µS/cm; and,
  - Coal seams - the EC ranges from 22,100 µS/cm to 28,500 µS/cm, with a mean of 25,693 µS/cm and median of 25,600 µS/cm.
- Sulphate (SO_4). Due to the high salinity of the groundwater, samples are also relatively high in sulphate, especially for the coal seams, with data summarised as:
  - Quaternary alluvium - the sulphate concentration ranges from 204 mg/L to 249 mg/L, with a mean of 217 mg/L and median of 212 mg/L;
  - Tertiary sediments - the sulphate concentration ranges from 291 mg/L to 635 mg/L, with a mean of 367 mg/L and median of 334 mg/L; and,
  - Coal seams - the sulphate concentration ranges from 341 mg/L to 841 mg/L, with a mean of 622 mg/L and median of 642 mg/L.
- Dissolved metal/metalloid data has been analysed with reference to the ANZECC 2000 95% freshwater ecosystem protection trigger values for parameters where guideline values exist; these include aluminium, arsenic, boron, cadmium, copper, lead, mercury, nickel, selenium, silver and zinc. Observations of note include:
  - All groundwater samples are above the guideline limit for boron of 0.37 mg/L, with data summarised as:
    - Quaternary alluvium – the boron concentration ranges from 0.56 to 4.56 mg/L, with mean of 3.50 mg/L and median of 3.81 mg/L;
    - Tertiary sediments – the boron concentration ranges from 1.14 to 1.52 mg/L, with mean of 1.28 mg/L and median of 1.26 mg/L; and,
    - Coal seams - the boron concentration ranges from 0.88 to 1.49 mg/L, with mean of 1.23 mg/L and median of 1.25 mg/L.
  - The majority of groundwater samples are above the guideline limit for copper of 0.0014 mg/L, with data summarised as:
    - Quaternary alluvium – the copper concentration ranges from 0.002 to 0.023 mg/L, with mean of 0.013 mg/L and median of 0.011 mg/L (9 samples, all samples >LOR);
    - Tertiary sediments – the copper concentration ranges from 0.001 to 0.014 mg/L, with mean of 0.004 mg/L and median of 0.003 mg/L (7 samples, 4 samples >LOR); and,
    - Coal seams - the copper concentration ranges from 0.001 to 0.081 mg/L, with mean of 0.011 mg/L and median of 0.003 mg/L (45 samples, 25 samples >LOR).
  - The majority of groundwater samples are above the guideline limit for zinc of 0.008 mg/L, with data summarised as:

- Quaternary alluvium – the zinc concentration ranges from 0.007 to 0.028 mg/L, with mean of 0.014 mg/L and median of 0.011 mg/L (9 samples, 7 samples >LOR);
- Tertiary sediments – the zinc concentration ranges from 0.017 to 0.096 mg/L, with mean of 0.049 mg/L and median of 0.035 mg/L (7 samples, all >LOR); and,
- Coal seams - the zinc concentration ranges from 0.025 to 0.21 mg/L, with mean of 0.086 mg/L and median of 0.075 mg/L (45 samples, all >LOR).

o A number of samples exceed the guideline values for aluminium, arsenic, lead and nickel.

The samples collected to date represent background water quality for the site. It can therefore be summarised that:

- Groundwater at site records very high EC for all groundwater units (Quaternary alluvium, Tertiary sediments and Permian coal measures). It is noted that the ANZECC 2000 livestock limit for beef cattle is 4,000 mg/L; this corresponds to an EC of approximately 6,000 µS/cm at a conversion factor of EC (µS/cm) x 0.67 = TDS (mg/L) (ANZECC 2000). It is therefore concluded, based on EC data, that groundwater at site is unsuited to stock watering; and,
- Groundwater at site is above the ANZECC 2000 freshwater ecosystem protection trigger value (95% species protection) for boron (all samples), copper and zinc (majority of samples) as well as aluminium, arsenic, lead and nickel (a number of samples for each analyte).

4.4 Hydraulic Conductivity data from Monitoring Bores

Falling head (slug) tests were undertaken on 25 monitoring bores in order to obtain site-specific hydraulic conductivity (K) data from all groundwater units that are encountered at site. The results for each bore are shown below in Table 4-2. Summary data for each groundwater unit are discussed further below and are provided in Table 4-3 and the slug test analysis sheets are included in Appendix C.

Table 4-2: Hydraulic Conductivity and Air Lift Yield Data for Monitoring Bores

Hole	Groundwater Unit	Centre of Screened Interval (mbgl)	SWL (mBTOC)	Hydraulic Conductivity (K) (m/day)	Air Lift Yield (L/s)*
DW7292W1	Alluvium	13.5	12.02	0.097	
DW7220W1	Tertiary	25.0	16.42	0.045	0.010
DW7225W1	Tertiary	34.0	33.43	0.444	0.010
DW7282W1	Tertiary	40.0	27.25	0.027	0.010
DW7033W1	Tertiary	42.0	30.98	0.703	2.250
DW7178W1	Tertiary	46.3	38.68	3.805	0.460
DW7220W2	Castor	35.4	20.23	0.012	0.010
DW7082W1	Castor Lower	39.8	17.99	5.387	2.180
DW7035W3	Orion 1	47.7	22.81	1.593	0.010
DW7221W1	AR3	48.9	21.52	0.286	0.010
DW7178W2	PLU2	56.9	39.47	0.532	0.330
DW7082W2	Pollux Upper	58.4	18.03	1.855	1.840
DW7105W2	PLU1	63.5	32.20	0.066	0.010
DW7221W2	Castor	71.6	21.57	0.243	1.530
DW7033W2	Orion 5	73.8	30.02	0.061	2.180
DW7220W3	PLU1	74.3	20.03	0.293	1.530
DW7225W2	AR3	77.4	33.17	2.141	7.730
DW7093W1	Pollux Upper 2	86.6	29.58	0.022	0.610
DW7282W2	AR3	89.2	27.31	0.245	0.220
DW7264W2	AR1	103.5	22.57	0.009	0.220
DW7225W3	Castor	111.3	32.64	0.002	
DW7093W3	PLL2	122.5	29.51	0.039	0.330
DW7264W3	AR3	136.0	22.58	0.011	0.220
DW7033W3	Interburden	80.3	29.97	0.002	2.250
DW7093W2	Interburden	98.5	29.54	0.001**	

* Air Lift Yield data was obtained from the base of bore prior to bore construction and therefore represents the yield of the entire open interval

** Data could not be analysed due to lack of recovery over test period – K set at low value of 0.001 m/day

The data was also reviewed in association with data from air-lift yield testing of the groundwater monitoring bores, which was undertaken at the completion of drilling (i.e. at the base of the hole) and prior to bore construction. From review of the combined dataset of hydraulic conductivity data and air-lift yield data, and with reference to information contained in Table 4-2, Table 4-3 and Figure 4-2, the following observations are made:

- A total of 17 slug tests were performed on bores that are screened within the coal seams. From review of the data it is evident that the K decreases with depth and that the difference becomes apparent when comparing data for coal seam bores that are screened at a depth of less than 80 metres below ground level (mbgl) to data for bores that are screened at a depth greater than 80 mbgl;

- Table 4-3 contains summary statistics (minimum value, maximum value and geometric mean) for the K of the coal seams, which is summarised as follows:
  - For data for all coal seams (17 data points), the K range is from 0.002 to 5.4 m/day, with a geometric mean of 0.13 m/day
  - For coal seam bores that are screened above 80 mbgl (11 data points) the K range is from 0.012 to 5.4 m/day, with a geometric mean of 0.37 m/day
  - For coal seam bores that are screened below 80 mbgl (6 data points) the K range is from 0.002 to 0.24 m/day, with a geometric mean of 0.02 m/day;
- The relationship between hydraulic conductivity and depth is shown graphically in Figure 4-2. Of particular interest is the data for the coal seam bores, where the trend for the lower K with depth is shown via the trend line and the 95% confidence interval that has been applied to the data (curves have been automatically fit within the software program Grapher).

Table 4-3: Summary of Hydraulic Conductivity and Air-Lift Yield Data per Groundwater Unit

Groundwater Unit	No. of Tests	Hydraulic Conductivity (m/day)			Average Air-Lift Yield (L/s)
		Min	Max	Geometric Mean	
Quaternary Alluvium	1	0.097		-	-
Tertiary	5	0.027	3.805	0.27	0.548
Permian Coal Seams	17	0.002	5.387	0.13	1.185
Coal Seams <80 mbgl	11	0.012	5.387	0.37	1.578
Coal Seams >80 mbgl	6	0.002	0.245	0.02	0.320
Permian Interburden	2	0.001	0.002	-	-

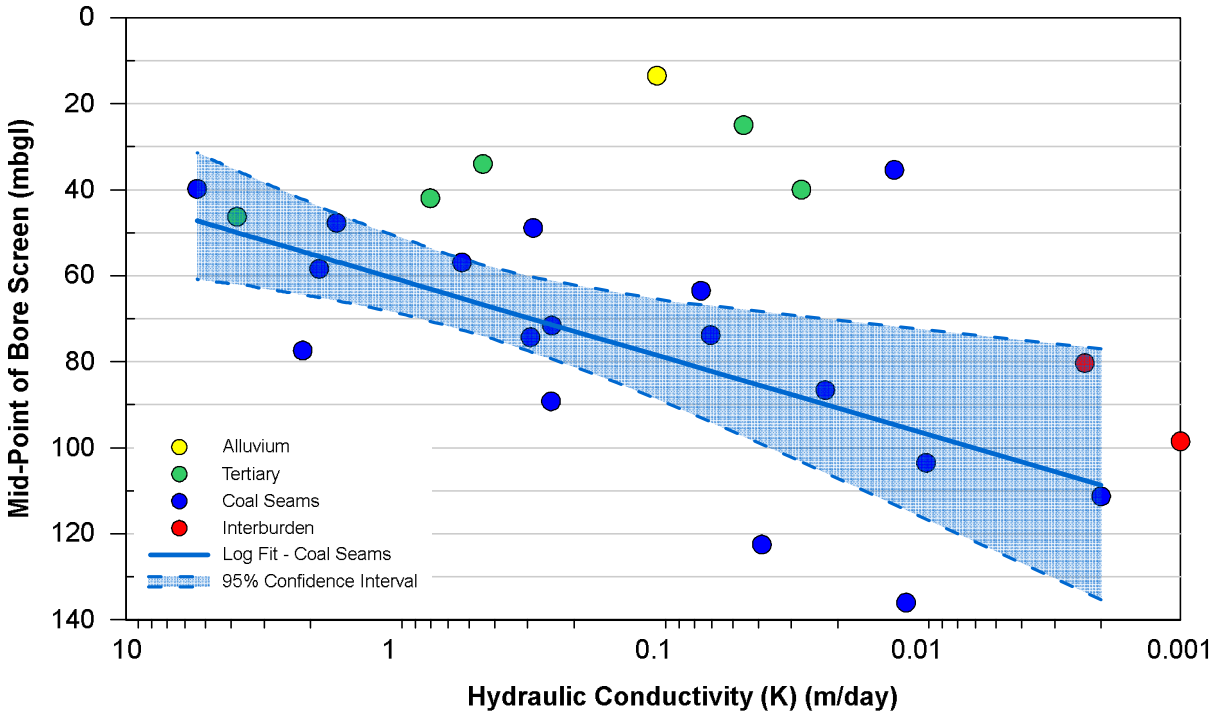


Figure 4-5: Relationship between Hydraulic Conductivity and Depth

4.5 Use of Groundwater Quality Data for Estimating Groundwater Recharge

Groundwater data from site has been utilised to provide an estimate of groundwater recharge based on the chloride mass balance (CMB) method, which utilises the concentration of chloride in rainfall and the concentration of chloride in groundwater to provide an estimate of the net recharge rate to groundwater. The CMB equation is given as:

$$R = \frac{PCp}{Cg}$$

Where:

R = Recharge (mm/year).

P = Rainfall (mm/year).

Cp = Chloride concentration in rainfall (mg/L).

Cg = Chloride concentration in groundwater (mg/L).

Utilising the above formula, the recharge rates for each groundwater unit were calculated using the following input data:

- Mean annual rainfall for the Gemini project site of 678 mm (from SILO data).
- Mean chloride concentration in rainfall for the Gemini project site of 4.9 mg/L (CSIRO 2014[1]).
- Mean chloride concentration of groundwater (refer Appendix B) of:
  - 4,088 mg/L for the alluvium;
  - 7,440 mg/L for Tertiary sediments; and,
  - 9,081 mg/L for the Permian coal seams.

The calculated recharge rates to groundwater are very low, being less than 1 mm of rainfall recharge for each groundwater unit at site and corresponds to approximately 0.05 to 0.12% of average annual rainfall reporting as recharge to the groundwater units.

While the calculated recharge rates are assessed to be low, the low recharge rates are consistent with the high salinity of the groundwater, which is observed for even the shallow alluvial units at site.

Table 4-4: Calculated Recharge via CMB Method

Parameter	Description	Groundwater Unit		
		Alluvium	Tertiary	Coal Seams
Cg	Chloride concentration in groundwater (mg/L)	4088	7440	9081
Cp	mg/L chloride in rainfall	4.9	4.9	4.9
P	Annual average rainfall (mm)	678	678	678
R	Annual average recharge (mm)	0.78	0.43	0.35
	Recharge as % of average annual rainfall	0.12	0.07	0.05

[1] CSIRO 2014 - Australian Chloride Deposition Rate https://doi.org/10.4225/08/545BEE54CD4FC

4.6 Summary of Observations from Site Data

The main observations from review of site data are as follows:

- Groundwater occurs within three main groundwater units at site, including:
  - Quaternary alluvium associated with Charlevue Creek and Springton Creek;
  - Tertiary sediments of the Duaringa Formation; and,
  - The Permian coal measures, where groundwater occurs preferentially within the coal seams.
- The site is heavily faulted and the faults may act to influence groundwater occurrence and movement as follows:
  - Shear zones associated with faulting may act as a store of water and as locally higher hydraulic conductivity zones. As discussed below, recharge to the groundwater system is assessed to be low; therefore the faults may provide initial relatively high inflow rates to the workings (in the order of several L/s), but the total storage within the faults is anticipated to be relatively low, with the initial rates of inflow not able to be sustained in the long-term; and,
  - Where the faults completely disrupt the coal seams, especially for cases where the coal seam terminates against lower-hydraulic conductivity interburden, the faults will act to disrupt groundwater flow.
- Available hydraulic conductivity and air-lift yield data indicates that there is notable reduction in hydraulic conductivity and bore yield for bores that are deeper than 80 mbgl compared to bores that are shallower than 80 mbgl.
- Groundwater level data at site are summarised as:
  - The water level within the alluvium ranges from 8.77 m to 11.19 m below ground level for bores adjacent to the creek channels;
  - The water level with the Tertiary sediments ranges from dry (5 bores, ranging in depth from 14 to 23 m) to 15.38-44.74 mbgl (where water is present). The presence of water within the Tertiary sediments is related to the RL of the base of Tertiary and from review of available data it is assessed that it is probable that the Tertiary sediments are dry above 120 mAHD and likely dry above 110 mAHD; and,
  - The water level in the coal measures ranges from 16.91 to 46.62 mbgl for bore depths of between 38.4 and 136.7 m, with one bore dry at a depth of 31.59 m.
- Groundwater quality data is summarised as:
  - All groundwater units at site record high EC groundwater, as follows:
    - Quaternary alluvium – bore DWDW7076W (Charlevue Creek alluvium) records an EC range from 15,200 µS/cm to 16,600 µS/cm (8 samples). A single field value for bore DW7292W (Springton Creek alluvium) records an EC of 5,948 µS/cm;
    - Tertiary sediments - the EC ranges from 20,200 µS/cm to 21,200 µS/cm; and,
    - Coal seams - the EC ranges from 22,100 µS/cm to 28,500 µS/cm.
  - Groundwater at site is above the ANZECC 2000 freshwater ecosystem protection trigger value (95% species protection) for boron (all samples), copper and zinc (majority of samples) as well as aluminium, arsenic, lead and nickel (a number of samples for each analyte).
  - All groundwater samples collected to date are assessed to represent the background water quality for the site.

- The recharge rate to the groundwater units at site, which has been calculated via the chloride mass balance method, indicates an extremely low recharge rate of less than 1 mm/year for each groundwater unit. The low rate of calculated recharge is consistent with the observation of highly saline groundwater at site, which is present for even the shallow alluvial units.
- The observation of a low recharge rate for groundwater suggests that, even though relatively high rates of groundwater inflow may be observed from faults/shear zones as mining progresses, the inflow rates are likely to be of short duration due to the relatively low volume that can be stored within fractures/faults and the very low rates of recharge observed at site (i.e. once the fault storage is depleted the faults are unlikely to be recharged).
- Because the faults may act as conduits for groundwater movement, the control of surface water around the site will be of particular importance (i.e. water that ponds at surface may recharge the underlying sediments and report as seepage to the pits via movement along faults/fractures. This type of flow would represent infiltrated surface water rather than groundwater.

4.7 Regional Groundwater Use

Data from DNRM groundwater database within a distance of 10 km from the EPC boundary is shown below in Figure 4-6 and summary data is provided in Table 4-4. With reference to the information in Table 4-4 and Figure 4-6 the following observations are made:

- There are 48 registered bores within 10km of EPC881 that are listed as being either existing or abandoned by useable.
- The majority of bores are screened within Tertiary units (26 bores) or Permian coal measures (15 bores).
- The right-hand plot in Figure 4-6 shows the available data classed according to EC range, being:
  - Bores that record an EC <1000 µS/cm. This includes four bores in Tertiary sediments to the east or south of the project area;
  - Bores that record an EC between 1,000 and 6,000 µS/cm. A limit of 6,000 µS/cm was assessed as this EC equates to 4,000 mg/L[2], which is the ANZECC 2000 livestock drinking limit for beef cattle (assessed to the most likely stock use for the area); and,
  - Bores that record an EC >6,000 µS/cm (assessed to be of limited or no use for stock watering).
- The majority of Tertiary bores outside the tenement area record an EC of < 6,000 µS/cm, whereas the majority of bores within or close to the tenement area record and EC in excess of 6,000 µS/cm (from Table 4-4 it is noted that the EC of groundwater within the Tertiary Duaringa Formation is often in excess of 10,000 µS/cm and at some sites in excess of 20,000 µS/cm; this observation is consistent with water quality data from site).

Data from private groundwater bores is discussed further in Sections 7.1 and 7.2.1.

2

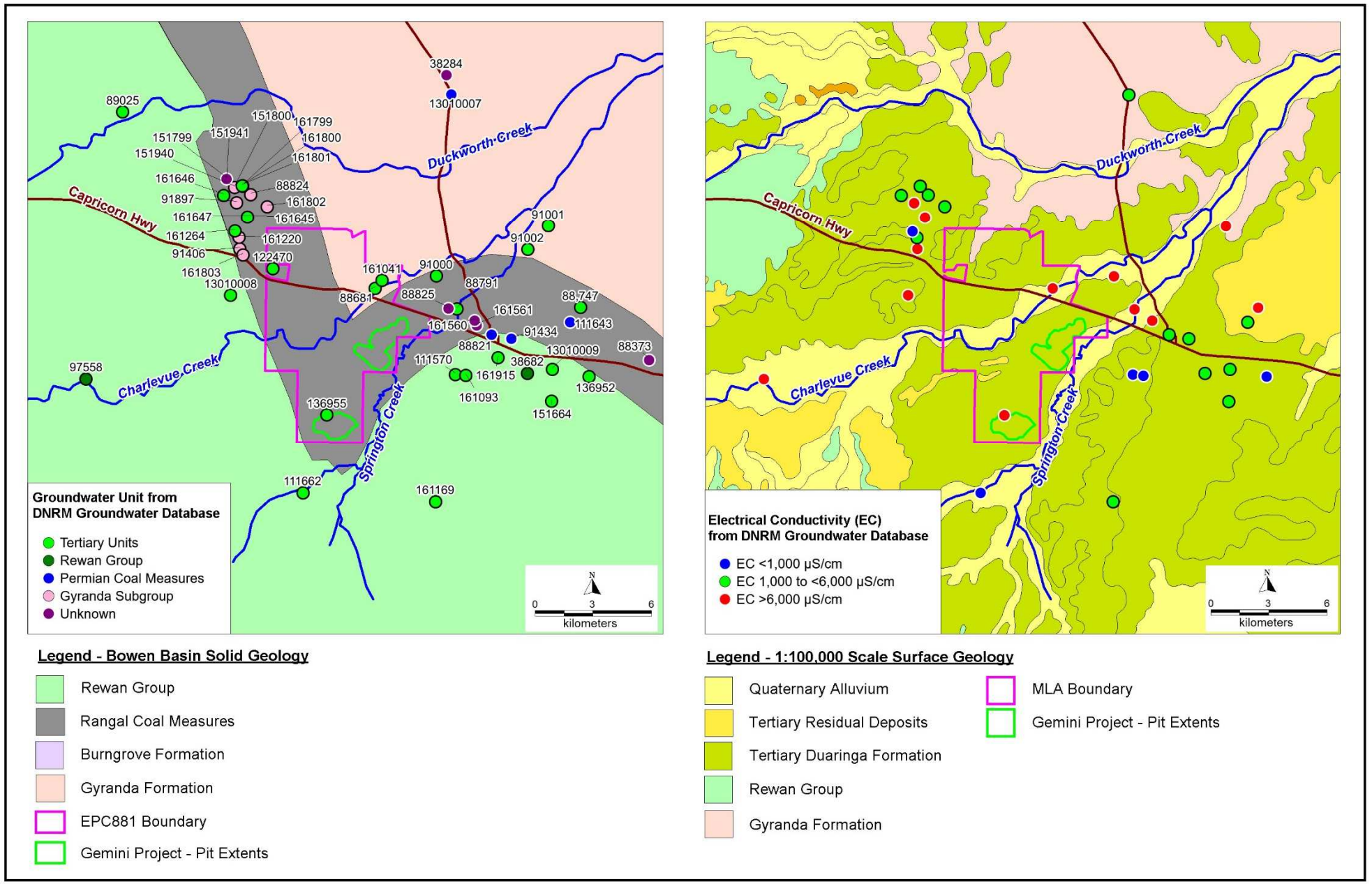


Figure 4-6: Aquifer Data and Groundwater EC Data from DNRM Groundwater Database

Table 4-5: Summary Data from DNRM Groundwater Database for Bores within 10km of EPC Boundary

RN	EASTING GD94	NORTHING GDA94	FACILITY_STATUS	Aquifer	DRILLED_DATE	EC (µS/cm)	Water Quality Description	YIELD (L/s)	SWL (mbgl)	Original Bore Name
38284	735584	7396485	Existing	Unknown						SANDY CREEK BORE
38682	739791	7381024	Existing	DUARINGA FORMATION	31-Oct-72	2370		0.19	-5.3	
88373	746081	7381702	Existing	Unknown	01-Jan-15					GOOWARRA WELL
88681	731897	7385429	Existing	DUARINGA FORMATION	28-Nov-92	10000		2.5		
88747	742541	7384432	Existing	DUARINGA FORMATION	15-Feb-93	10360		1.1		
88791	736137	7384353	Existing	DUARINGA FORMATION	06-Apr-93	19200		0.78	-20	NEW BORE
88821	737932	7383029	Existing	RANGAL COAL MEASURES	03-Apr-93	4510		0.63	-8	FITZGERALDS PLACE
88824	725449	7390299	Existing	GYRANDA SUBGROUP	05-Apr-93	3800		0.78	-15	BORE 3
88825	735685	7384385	Existing	Unknown						WINDMILL
89025	718817	7394577	Existing	BASALT	01-Jan-64			0.4		
91000	735078	7386067	Abandoned but Usable	DUARINGA FORMATION	07-Apr-93	14660		0.75	-20	MACKENZIE OLO
91001	740865	7388678	Abandoned but Usable	DUARINGA FORMATION	18-Apr-93	42000		1.5	-24	MACKENZIE OLO
91002	739796	7387438	Abandoned but Usable	DUARINGA FORMATION	19-Apr-93		SALTY	2.1		MACKENZIE OLO
91406	724894	7387470	Existing	GYRANDA SUBGROUP	04-Aug-94	9240		0.32	-30.5	
91434	738947	7382824	Existing	RANGAL COAL MEASURES	16-Aug-94	1080		2.14		DINGO RACECOURSE
91897	724724	7389881	Existing	GYRANDA SUBGROUP	31-Dec-99	15330		0.65		NAUGHTON (OLO)
97558	716925	7380734	Existing	REWAN GROUP	09-Jul-96	7600		0.36	-27.4	SIMON CATTLE CO
111570	736059	7380966	Existing	TERTIARY - UNDEFINED	02-Nov-01	240		1.2	-16	WARD
111643	741998	7383678	Existing	BLACKWATER GROUP - UNDIFF.	03-Oct-01	4120		4.4	-27.4	G SMITH
111662	728169	7374811	Existing	TERTIARY - UNDEFINED	29-Dec-01	750		2.5	-17	SMITH
122470	726594	7386438	Existing	TERTIARY - UNDEFINED						
136131	707571	7381259	Existing	DUARINGA FORMATION	27-Mar-06	900		1.3	-18	
136952	742978	7380858	Existing	TERTIARY - UNDEFINED	27-Jan-07	848		0.1	-17.37	
136955	729388	7378869	Existing	TERTIARY - UNDEFINED	30-Sep-08	10300		2.2	-21	
151664	741024	7379579	Existing	DUARINGA FORMATION	14-Feb-10	1250	POTABLE	0.25	-26	
151799	724194	7391110	Existing	GYRANDA SUBGROUP	22-Jan-13		POTABLE	2.1	-71	
151800	724628	7390671	Existing	BLACKWATER GROUP	23-Jan-13		POTABLE	0.31	-20	
151940	724627	7390671	Existing	GYRANDA SUBGROUP	28-Sep-13		POTABLE	0.31	-20	
151941	724194	7391113	Existing	Unknown	28-Sep-13		POTABLE	2.1	-71	
161041	732247	7385838	Existing	DUARINGA FORMATION	28-Apr-14		BRACKISH	1	-29	
161093	736592	7380908	Existing	TERTIARY MAFIC VOLCANICS	31-Aug-14	710	FRESH	0.61	-19.5	
161169	735022	7374342	Existing	TERTIARY - UNDEFINED	12-Oct-13	3300		0.25	-15	
161220	724858	7388061	Existing	BANANA FORMATION	21-Dec-14	2400		1.2	-32	
161264	724639	7388396	Existing	DUARINGA FORMATION	30-Mar-15	960		1.5	-54	
161560	737046	7383758	Existing	Unknown	28-Nov-16	28102				DINGO LANDFILL MW2
161561	737159	7383502	Existing	Unknown	29-Nov-16					DINGO LANDFILL MW1
161645	725283	7389134	Existing	DUARINGA FORMATION	06-Jul-17		BRACKISH	1	-27.64	MB01
161646	724053	7390267	Existing	DUARINGA FORMATION	07-Jul-17	2942				MB02
161647	725283	7389134	Existing	DUARINGA FORMATION	09-Jul-17	29000	BRACKISH		-36.87	MB03
161799	725034	7390748	Existing	GYRANDA SUBGROUP	16-Apr-18	4420	BRACKISH	0.4		MB04C (AQ090A)
161800	725026	7390758	Existing	GYRANDA SUBGROUP	16-Apr-18	5459	SALTY	0.6		MB04B (AQ090B)
161801	725020	7390764	Existing	DUARINGA FORMATION	16-Apr-18					AQ090C
161802	726308	7389681	Existing	GYRANDA SUBGROUP	16-Apr-18	1380	SALTY	7.5		MB06 (AQ091)
161803	725061	7387160	Existing	GYRANDA SUBGROUP	16-Apr-18		SALTY-BRACKISH	0.4		QQ092
161915	738258	7381843	Existing	DUARINGA FORMATION	10-Sep-18			1.62	-4.5	
13010007	735835	7395478	Abandoned but Usable	BLACKWATER GROUP	28-Oct-04	1534				
13010008	724410	7385071	Existing	DUARINGA FORMATION	31-Oct-04	16100				
13010009	741076	7381232	Abandoned but Usable	DUARINGA FORMATION	02-Nov-04	3690				

5.0 CONCEPTUAL GROUNDWATER MODEL

Essential elements of the conceptual model that have informed numerical modelling include:

- Quaternary alluvium is present within ephemeral water courses to the east and west of the mining area (Springton Creek and Charlevue Creek respectively);
- Tertiary deposits are present across the project area that comprise mainly sediments of the Duaringa Formation. The Tertiary sediments are variably saturated the elevation of the base of Tertiary being a control on the occurrence of water within the sediments; it is assessed that Tertiary sediment above approximately 110 mAHD are likely to be unsaturated;
- A minor area of Tertiary basalt is present to the north of Pit C; the basalt is interpreted to be dry and of limited extent and is therefore not considered as a groundwater unit at site;
- Recharge to alluvium and Tertiary sediments is via direct rainfall recharge. The rate of recharge to the alluvium and Tertiary sediments is calculated by the chloride mass balance method (Section 4.5) to be in the order of 0.4 to 0.8 mm/year (0.07 to 0.12 % of annual average recharge respectively). The low rate of recharge is consistent with the observation of elevated salinity in the shallow sediments, with an EC range for alluvial sediments from 15,200 µS/cm to 16,600 µS/cm and for Tertiary sediments from 20,200 µS/cm to 21,200 µS/cm. The high EC that is recorded for the shallow sediments (alluvium and Tertiary) is interpreted to be reflective of a low rate of groundwater recharge as well as high residence times for groundwater;
- The coal measures are heavily faulted and folded and mining occurs where folding and faulting has brought the coal seams close to surface, as shown below in Figures 6-2 to 6-6;
- The coal seams are recharged in subcrop areas where the coal seams directly underlay Tertiary and/or Quaternary sediments. The rate of recharge to the coal seams has been calculated by the CMB method (Section 4.5) to be in the order of 0.05% of average annual rainfall. The extremely high salinity of groundwater within the coal measures (range from 22,100 µS/cm to 28,500 µS/cm) supports an interpretation of a low rate of recharge and high groundwater residence times for these units;
- Within the Permian coal measures the coal seams are the primary conduits for groundwater flow. This interpretation is supported by hydraulic conductivity data from site testing, which indicates a much lower hydraulic conductivity of interburden/ overburden units relative to the hydraulic conductivity of the coal seams;
- Hydraulic conductivity data (from testing of completed monitoring bores) and air-lift yield data (from air-lift testing undertaken at the base of the bore on completion of drilling and prior to bore construction) indicates that the shallow coal seams (shallower than approximately 80 mbgl) have a higher hydraulic conductivity and are higher yielding than the coal seams below 80 mbgl;
- The relatively high rates of groundwater flow (from air-lift yield testing) for bores shallower than 80 m may be related in some cases to proximity to faults, as the hydraulic conductivity calculated for some of the coal seams (in excess of 1.5 m/day at four sites) is assessed to be greater (by approximately an order of magnitude) than the geometric mean of the coal seam data;
- However, taken together with the interpreted low rate of recharge and high groundwater salinity it is interpreted that, while the faults may locally increase hydraulic conductivity and storage within the secondary porosity of the shear zones, the faults also act to compartmentalise the groundwater system (for example by truncating the coal seams so that they terminate against lower hydraulic

conductivity interburden); this leads to high residence times for groundwater that contributes to the elevated groundwater salinity;

- The direction of groundwater flow within the coal seams is generally from southwest to northeast; and,
- It is interpreted that a continuous water surface does not exist in the Tertiary sediments and that the elevation of the base of Tertiary will be a control on the presence of groundwater within the sediments. From review of available data it is assessed that it is probable that the Tertiary sediments are dry above 120 mAHD and likely dry above 110 mAHD.

6.0 GROUNDWATER MODELLING

6.1 Choice of Numerical Model

To estimate the extent of water level impact from the proposed project, 2-dimensional seepage modelling has been undertaken using the program Seep/W. The choice of model code has been based on an assessment of the model platform that would be appropriate to the study requirements.

A number of factors are assessed when choosing the appropriate modelling platform for a particular groundwater modelling study. Factors that are relevant to the Gemini Project include:

- The ability of the model to represent the essential elements of the conceptual groundwater model. At the Gemini Project this includes the ability of the model to accurately represent the complexity of the geology including faulting of strata, which acts to compartmentalise the geological and hydrogeological units, as faulting has the potential to significantly impact groundwater occurrence and flow; and,
- The ability of the model to adequately address the requirements of the scope of work. At the Gemini Project this includes assessment of the extent of groundwater level impact from mining, assessment of the potential impact of groundwater level changes on any groundwater dependant ecosystems, and assessment of the rate of groundwater inflow to the active mining area and final voids.

Based on assessment of the model requirements, including representation of the essential elements of the conceptual groundwater model, it was concluded that 2-dimensional cross-section modelling would be appropriate for the Gemini project and on that basis the model Seep/W was selected. The use of a 2-dimensional Seep/W cross-section model was assessed to be appropriate to this investigation for the following reasons:

- The geology of the mining area is complex, and includes a number of local-scale and regional-scale faults which significantly disrupt the strata (refer Figure 2-2 for solid geology). It is possible within a 2-dimensional model to reproduce complex cross-sectional geology, whereas such detail could not be included practically within a 3-dimensional model;
- Seep/W is designed to simulate flow in both the saturated zone and the unsaturated zone. When mining occurs below the phreatic surface[1] an unsaturated zone is induced in the pit walls as seepage to the excavation occurs. Seep/W is well suited to investigation of groundwater level impacts resulting from seepage to open pits, particularly for projects such as Gemini where mine dewatering via bores does not occur, and seepage to the excavation is the only means via which the mine removes water from the groundwater system;
- In open cut mines groundwater storage conditions transition from confined to unconfined in the zone adjacent to the pit walls. Seep/W models the rate of drainage to an excavation via a property called the volumetric water content (refer Section 6.3.2), which is able to accurately account for the rate of groundwater flow and the rate of change of the phreatic surface as groundwater conditions transition from confined to unconfined and gravity drainage of groundwater occurs to the excavation;
- One of the main purposes of the model is to investigate the rate and extent of groundwater level drawdown in response to mining, especially in areas of potentially connected surface water and

[1] The phreatic surface is a line of zero pore water pressure below which all pore spaces are saturated with water, and is analogous to the water table. The term phreatic surface is used throughout this report for consistency with Seep/W modelling terminology.

groundwater systems. This can be readily (and potentially more accurately) achieved through the use of a 2-dimensional cross-section models that are able to accurately represent faulting, relatively thin coal seams and seepage conditions within the mined void;

- The use of 2-dimensional models is valid in cases where the section can be oriented along a groundwater flow line so that all groundwater flow is along the section rather than across it. In open-cut mines where mining occurs below the water table, groundwater flow towards the excavation tends to dominate over the previous regional flow patterns, making it possible to orient a section along a groundwater flow line. Therefore the use of 2-dimensional cross-section models is assessed to be valid for the purposes of this investigation.

The selected modelling platform (Seep/W) is an industry-standard finite-element model capable of modelling groundwater movement and pressure distribution within the saturated/unsaturated zone of porous materials such as soil and rock. Seep/W has been used in this study to predict the rate and extent of change to the phreatic surface in response to the ongoing mining of the already approved Central North Mine, as well as the proposed extension of the operation into the extension area.

Three models were prepared for this study including west-east cross-sectional models through each of the AB and C Pits as well as a long section model that is orientated approximately north-south and represents mining at both pits; the models are described below in Section 6.2. Other details of the models (e.g. hydraulic parameters, boundary conditions, representation of faulting etc.) are discussed in subsequent sections.

6.2 Model Locations and Scenarios

Three models were generated for the study, including:

- A west-east cross section through the C Pit;
- A west-east cross section through the AB Pit; and,
- A long section that runs through the final void of both the C Pit and the AB Pit.

The locations of the sections are shown on Figures 3-1 and 3-2 as well as in Figure 6-1 below.

The models include representation of the mining schedule, including progressive backfilling of the mined areas with spoil, development of the final voids, partial backfilling of the final voids with spoil, and development of the pit void lakes to a level as modelled by WRM (2019). Selected stages in mining are shown below in Figure 6-1 and include:

- Year 1 – Mining commences in the AB Pit in the southwest region of the mining area, with mining progressing to approximately RL-45 in the deepest area, representing a depth of mining of approximately 165 m;
- Year 5 – Mining of the AB Pit has progressed from west to east, to a deepest mined level of approximately -65 mAHD, representing a depth of mining of approximately 185 m. Progressive backfilling of the mined area with spoil has occurred, in conjunction with the development of an out of pit dump;
- Year 9 – Mining of the AB Pit has progressed to the north, with the southern area of mining backfilled with spoil and progressively rehabilitated. The deepest mined area is approximately -65 mAHD, representing a depth of mining of approximately 185 m;
- Year 12 - Mining of the AB Pit has reached the full extent to the north and the floor of the pit is at a level of approximately -45 mAHD, representing a depth of mining in that area of approximately 165 m. Mining of the C Pit has commenced in the west of the mining area;

- Year 16 – Mining of the AB Pit is complete and the final landform has been developed. The final landform includes the partial backfilling of the final void area to a level of approximately 42 mAHD, representing a depth below original ground level of approximately 75 m. Development of the C Pit has progressed to the east and north and the floor is at approximately -50 mAHD, representing a depth below original ground surface of approximately 190 m at that location. Backfilling of the mined area with spoil and development of an out of pit dump has been progressively occurring; and,
- Final Landform (Years 18-20). The final voids are developed for each pit area. The final void levels for the AB Pit are as described above. The final void for C Pit has been partially backfilled with spoil to approximately 65 mAHD, representing a depth below original ground level of approximately 65 m.

The representation of mining in the Seep/W section models is shown on figures from the models and includes:

- Figure 6-2 shows detail of the long section model in the location of the AB Pit, from start of mining to Year 7. Detail from Figure 6-2, which is common to each section model, includes:
  - The coal seams are represented as distinct material types in the model, with the average thickness of each seam represented;
  - Faults are included in the model as they are shown in the sections from the geological model. As discussed in Sections 4.6 and 6.4, the main impact of the faults on groundwater flow occurs when the faults completely truncate the coal seams so that they terminate against lower hydraulic conductivity interburden;
  - The coal measures and overburden are progressively removed from the models in accordance with the mining schedule; and,
  - The mined voids are backfilled with spoil at the rate defined by the mining schedule.
- Figure 6-3 shows detail of the long section model in the location of the AB Pit, from mining Year 8 to end of mining and the final landform. Detail from Figure 6-3, which is common to all model stages that that simulate the final void and final landform, include:
  - The final void is partially backfilled with spoil as a means of reducing groundwater inflow to the final void and reducing the long-term impact on regional groundwater levels (as the water level adjacent to the final void will be to the groundwater level within the spoil and/or final void lake, rather than long-term groundwater drawdown to the base of the final void); and,
  - The average modelled water level within the AB final void of 53.7 mAHD (WRM 2019) has been included as a boundary condition for the post-mining period.
- Figure 6-4 shows detail of the long section model in the location of the C Pit, from commencement of mining in Mining Year 12 to end of mining and the final landform. Detail shown in the model is as described above, with the exception that the final void water level for the C Pit is represented at the average modelled water level of 70.3 mAHD (WRM 2019).
- Figure 6-5 shows the modelled mining sequence at the location of the west-east cross section model through Pit AB, with model detail as described above.
- Figure 6-6 shows the modelled mining sequence at the location of the west-east cross section model through Pit C, with model detail as described above.

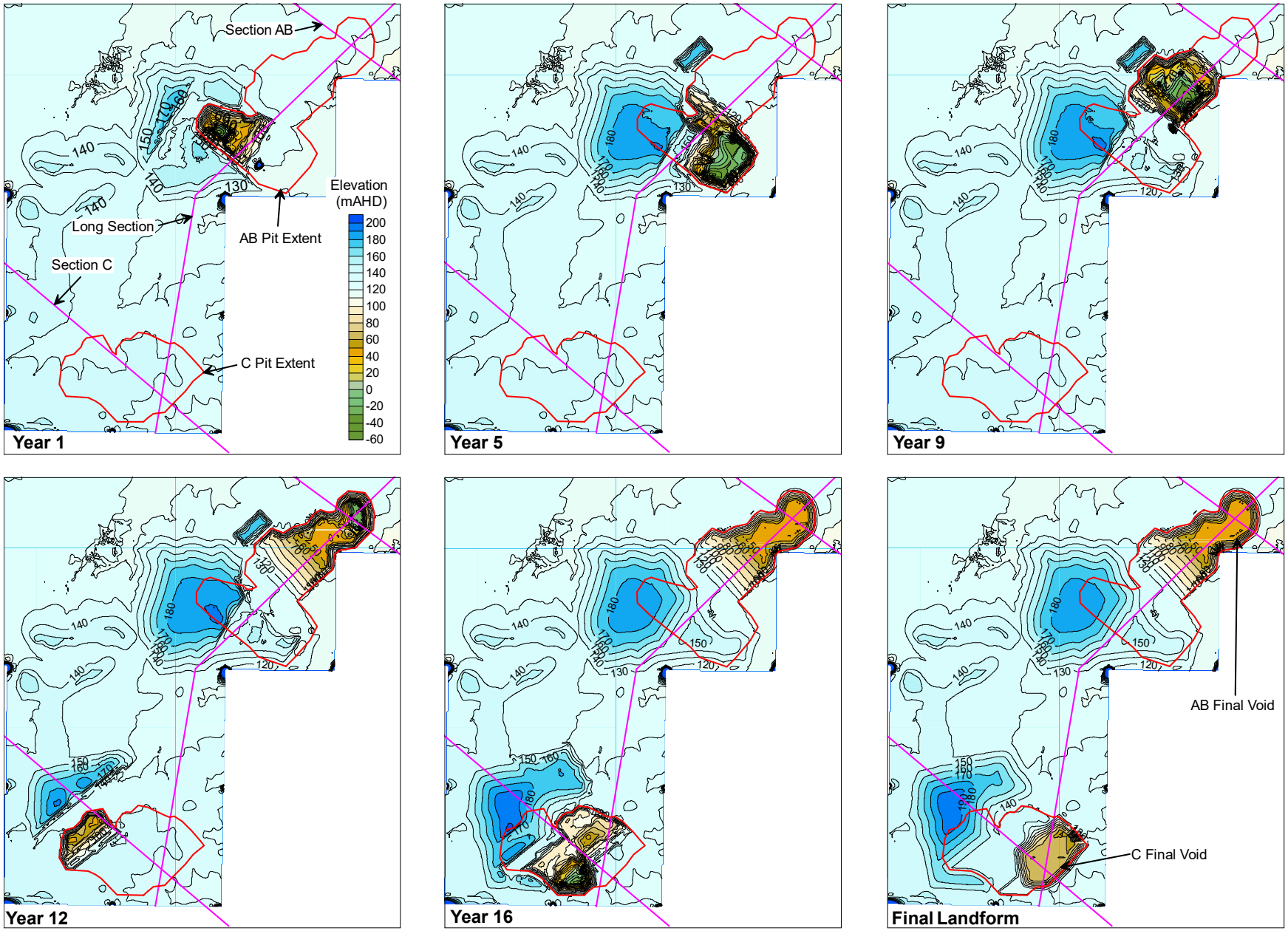


Figure 6-1: Representation of Mining Schedule for Selected Years

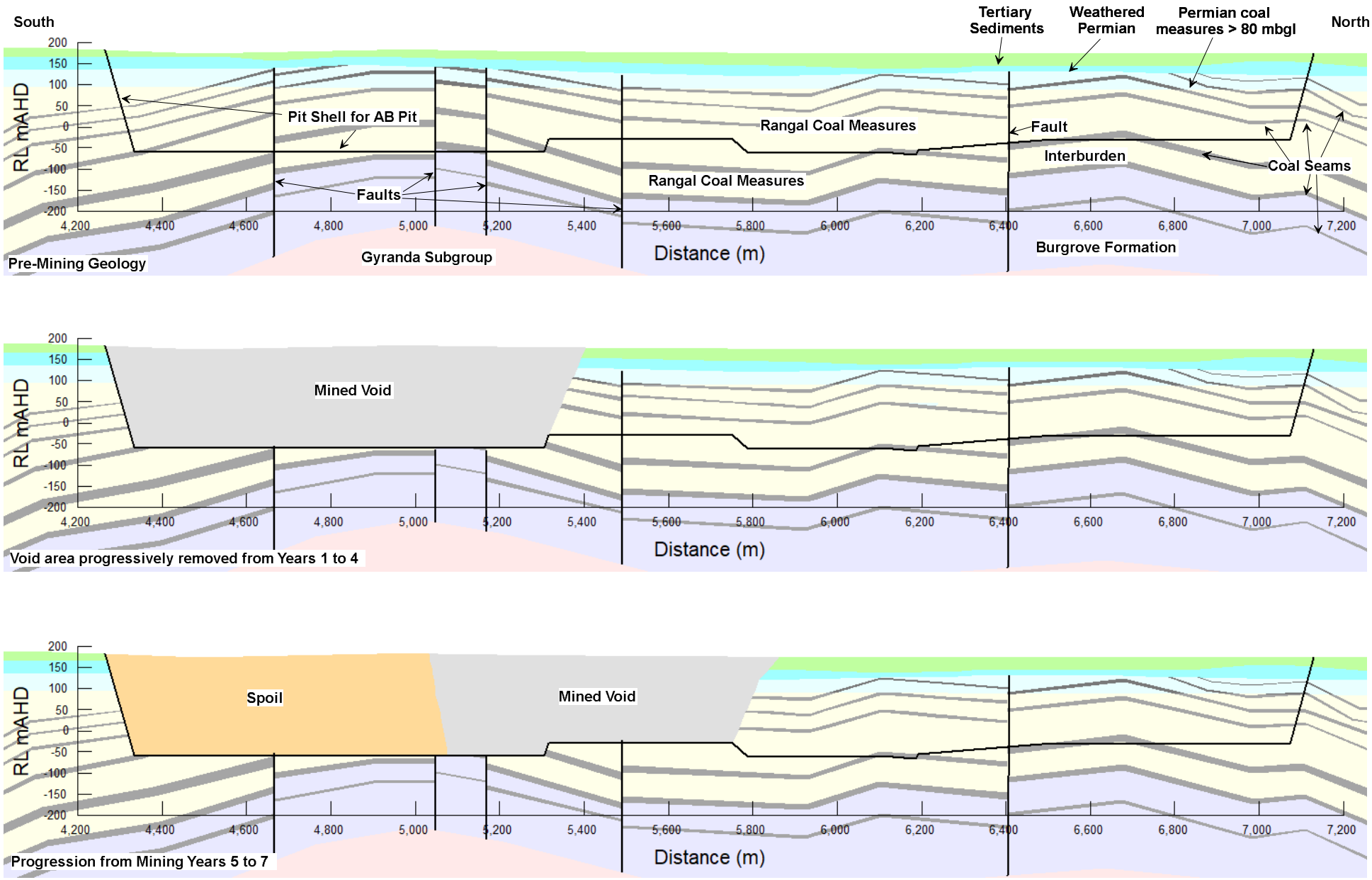


Figure 6-2: Representation of Mining, Long-Section Model, A-B Pit – Start of Mining to Year 7

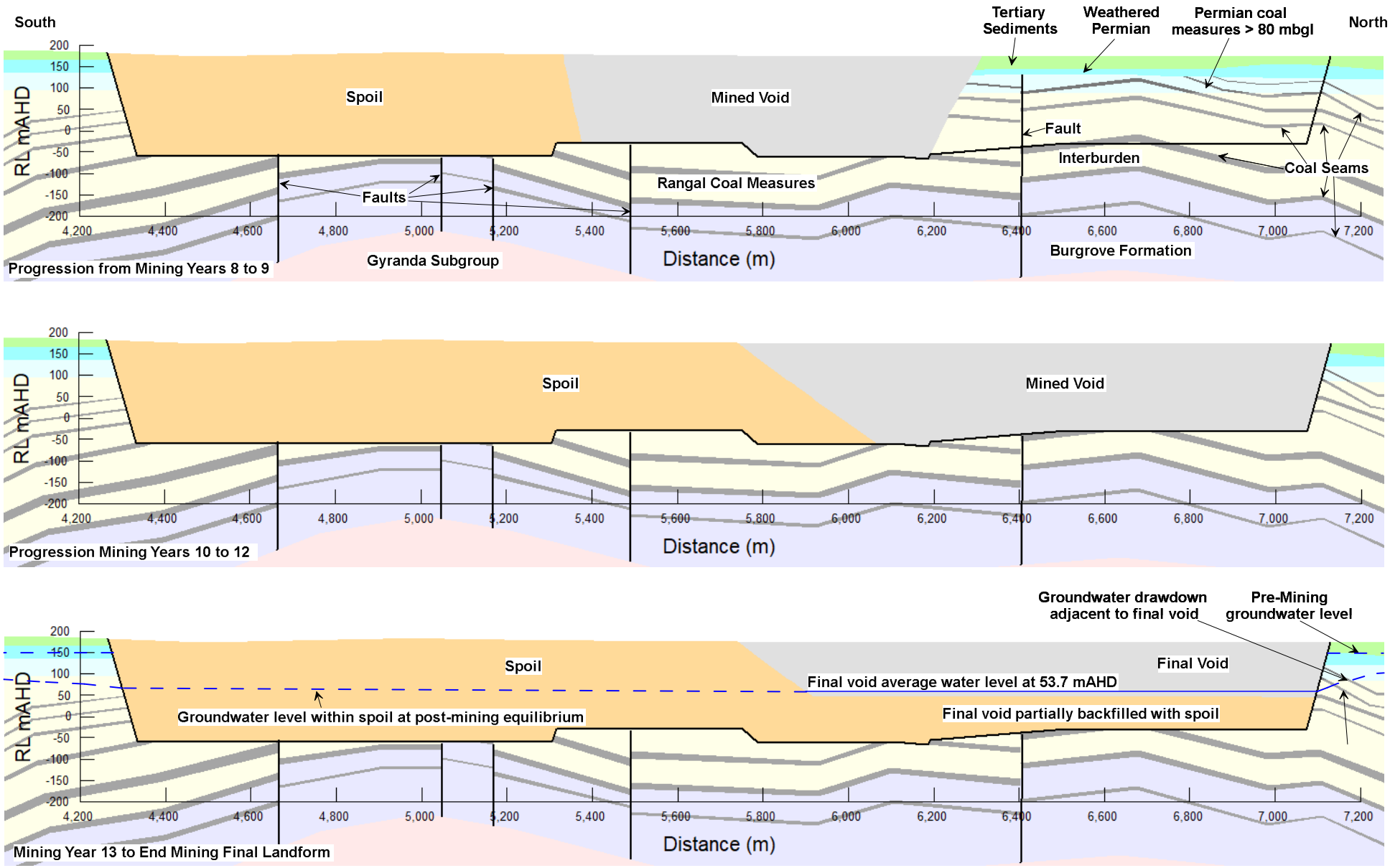


Figure 6-3: Representation of Mining, Long-Section Model, AB Pit – Mining Year 8 to Final Landform

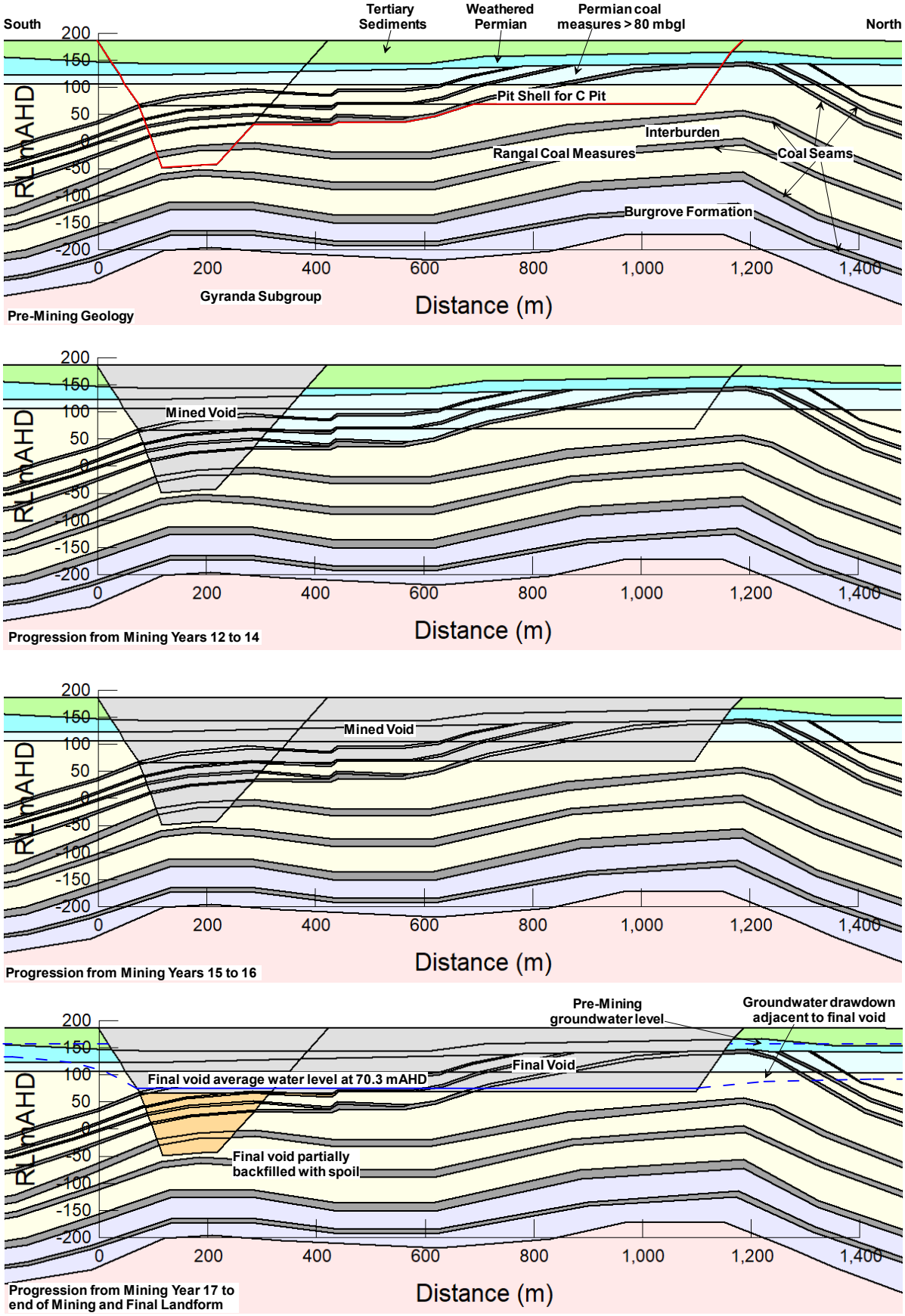


Figure 6-4: Representation of Mining in Long-Section Model – Pit C

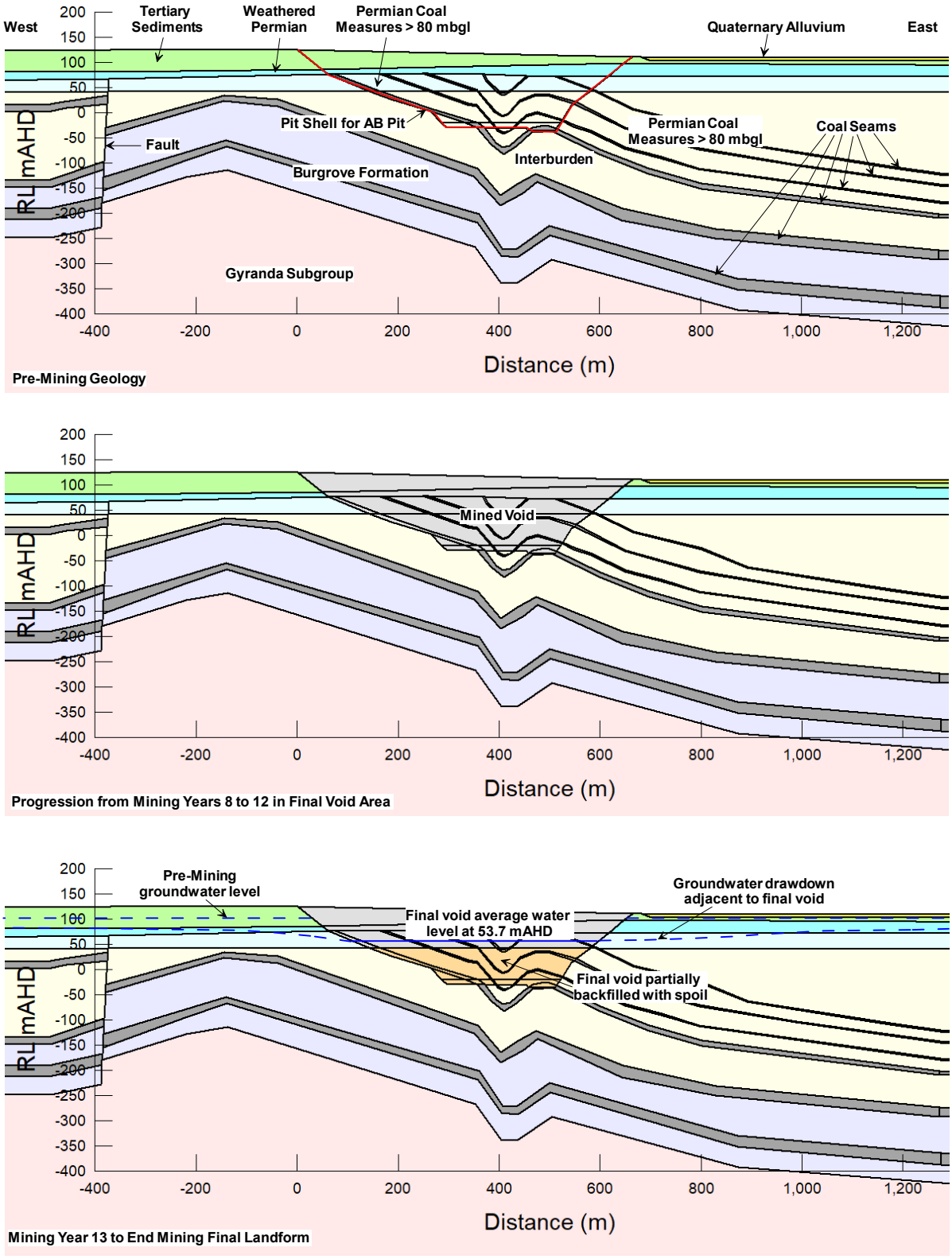


Figure 6-5: Representation of Mining in Cross Section Model through Final Void for AB Pit

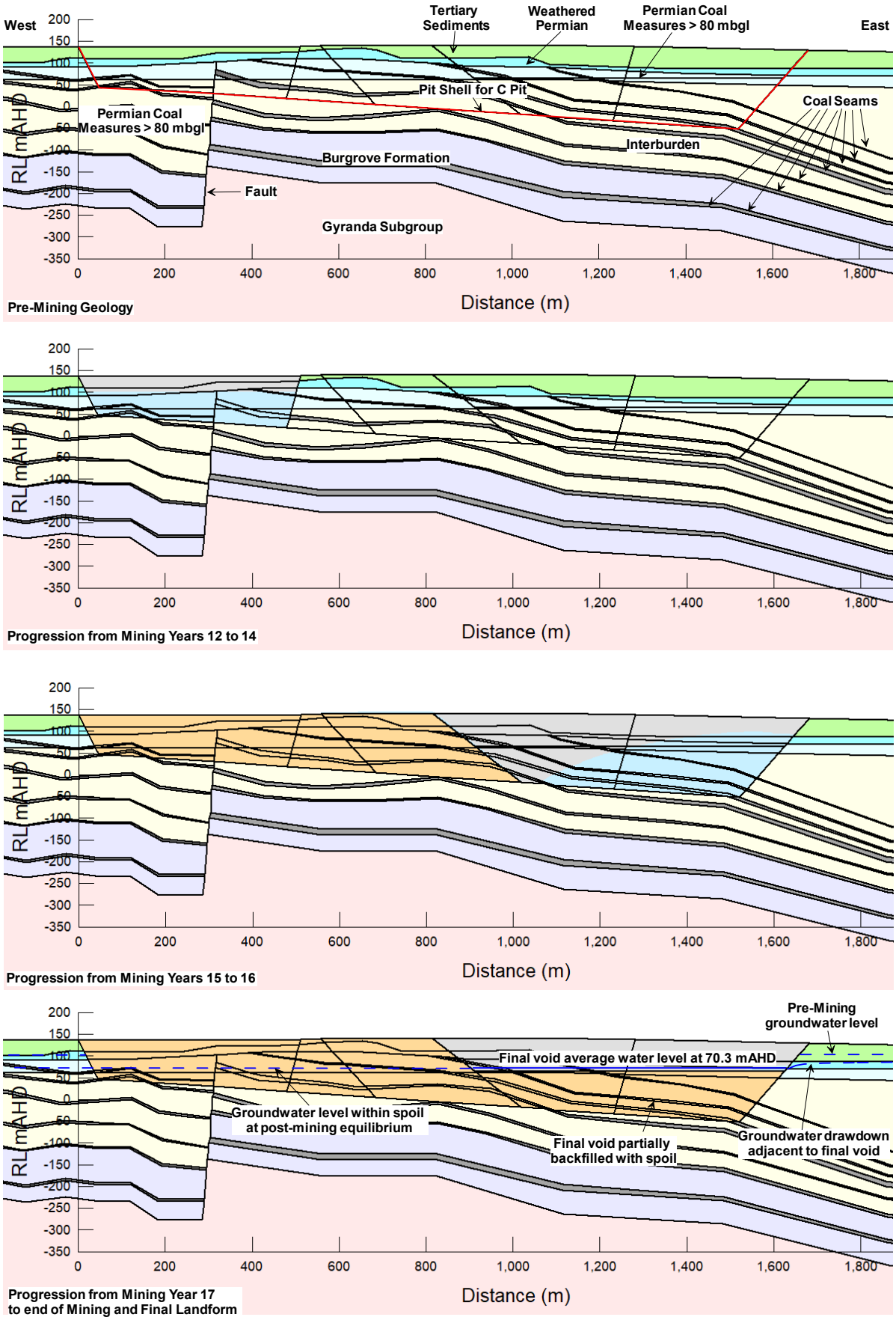


Figure 6-6: Representation of Mining in Cross Section Model for C Pit

6.3 Hydraulic Properties

6.3.1 Hydraulic Conductivity

Based on review and analysis of data discussed in Section 4-4, hydraulic conductivity values have been applied to the base-case model as shown below in Table 6-1.

Table 6-1: Hydraulic Properties Used in Model

Groundwater Unit	K (m/day)	Comment
Quaternary Alluvium	0.1	Value from slug test of bore DW7292W1.
Tertiary	0.27	Geometric mean of data from slug tests (Section 4.4)
Rewan Group	0.002	Estimated K value from other Bowen Basin projects. The Rewan Group is not present in over most of the tenement area but is present in the model area
Coal Seams <80 mbgl	0.37	Geometric mean of slug test data from bores with screened intervals less than 80mbgl
Coal Seams >80 mbgl	0.02	Geometric mean of slug test data from bores with screened intervals greater than 80mbgl
Permian Interburden <80 mbgl	0.01	Value set an order of magnitude higher than the value for interburden below 80 mbgl
Permian Interburden >80 mbgl	0.001	Estimate based on values from slug testing of DW7033W3 (0.002 m/day) and DW7093W2 (recovery rate so slow that the test data could not be analysed)
Mined Spoil	1	Estimate based on professional experience

6.3.2 Volumetric Water Content

6.3.2.1 Specific Yield

Seep/W represents the water content and drainage properties modelled units via a property called volumetric water content, which describes the transition from fully saturated porosity to fully drained porosity. Total porosity comprises specific yield (the volume that will drain from a material under gravity) and specific retention (the volume that will remain within the material following gravity drainage). The specific yield applied to each model unit is shown below in Table 6-2; the specific yield component of the volumetric water content curve is significant for areas close to the open cut void, as previously confined aquifers (such as the Permian coal measures) become unconfined as they drain to the mined void.

Table 6-2: Specific Yield Values used in Model

Lithology	Specific Yield (Sy)
Quaternary Alluvium	0.08 (8%)
Duaringa Formation	0.01 (1%)
Rewan Group	0.01 (1%)
Permian Overburden (weathered)	0.01 (1%)
Permian Overburden (unweathered)	0.01 (1%)
Coal Seams	0.02 (2%)
Permian Interburden	0.01 (1%)
Burngrove Formation and Gyranda Subgroup	0.01 (1%)
Mined Spoil	0.08 (8%)

6.3.2.2 Specific Storage

In Seep/W the specific storage (*Ss*) of the aquifer is accounted for via a related property called the coefficient of volume compressibility (*mv*). In areas where groundwater is draining to the pit void, the

model utilises the specific yield (*Sy*) portion of the volumetric water content curve (as discussed above). With increasing distance from the pit wall the groundwater storage conditions become increasingly confined, Seep/W automatically transitions from unconfined to confined conditions (i.e. from the portion of the volumetric water content curve where pore pressures are at or below atmospheric pressure (and draining to the pit void) to the portion of the curve where pore pressures are positive) using the properties of the Coefficient of Volumetric Compressibility (*mv*). The relationship between the coefficient of volume compressibility (*mv*) and specific storage (*Ss*), can be established from the following equation (Geoslope 2012):

$$S_S = \rho_w g(\alpha + n\beta) = \rho_w g(mv)$$

Where:

Ss	=	Specific Storage
mv	=	Coefficient of volume compressibility
ρw	=	The density of water
g	=	Acceleration due to gravity
α	=	Compressibility of the aquifer skeleton
n	=	The porosity of the aquifer
β	=	Compressibility of water

The value for *mv* generally ranges from 1 x 10^{-6}/ kPa to 1 x 10^{-3}/kPa and for confined aquifers a value of 1 x 10^{-5}/kPa is generally appropriate (Geoslope 2012). An *mv* of 1 x 10^{-5}/kPa has therefore been applied to all groundwater units in the model.

6.4 Representation of Faulting

Faults are represented in the models as follows:

- The site geological model conforms to the solid geology as shown in Figure 2-2. For areas of the model that are beyond the boundaries of the site geological model the solid geology, including fault locations, is consistent with the geology shown on the solid geology map (Figure 2-2).
- Where faults are shown on the sections produced from the site geological model or regional geological data, the location of the faults has been accurately reproduced in the Seep/W models;
- The faults have not been assigned any hydraulic properties, as no quantitative data exists to indicate whether individual faults act as groundwater conduits or as barriers to groundwater flow. Rather, the faults will act as described above, i.e. to allow transmission of groundwater across the fault if more permeable units are connected (such as coal seam to coal seam), and will tend to act as barriers to flow if a conductive unit such as a coal seam is terminated against lower permeability interburden material.

6.5 Boundary Conditions

6.5.1 Recharge

The recharge rate that was applied to the model was based on the recharge calculated via the chloride mass balance (CMB) method, as described above in Section 4.5. The recharge value used was equivalent to 0.1% of average annual rainfall, as an average of the CMB-calculated values for Quaternary sediments of 0.12% of average annual rainfall and the Tertiary sediments of 0.07% of average annual rainfall.

Recharge was applied to transient models as a flux boundary condition applied to the upper layer of the model (representing the ground surface). Rainfall was applied uniformly to the surface formation

(alluvium and Tertiary). Rainfall was not applied to the steady-state model as the starting phreatic surface was generated based on fixed head boundary conditions at the edges of the model.

Rainfall was applied at a rate of 0.678 mm/year, which corresponds to 0.1% of average annual rainfall of 678 mm/year, so that the flux was assigned as:

- 678 mm/year x 0.1% = 0.678 mm/year of recharge = 1.86 x 10^{-6} m/day

6.5.2 Starting Phreatic Surface

The initial phreatic surface was generated in the steady state model by applying fixed heads at the boundaries of the model. The boundaries were set at a distance of approximately 10 km from the edge of mining in order that the boundary conditions did not interfere with the groundwater response to mining, with the boundary conditions set to place the water level within the Tertiary sediments at levels observed from the groundwater monitoring bores for each mining area.

6.5.3 Groundwater Seepage to Voids

Seep/W requires the setting of seepage face review boundary conditions to allow water to leave the model and flow to the mine void. The seepage face boundary a flux boundary with total flux (Q) set at 0 m/day. The area of the mined void is set as a material type with no hydraulic properties; in practice the void is modelled as a zone into which groundwater flow can occur unimpeded through the seepage face boundaries.

6.6 Model Results

6.6.1 Groundwater Level Impacts

The modelled drawdown at the end of mining is shown in Figure 6-7, with the extent of drawdown at post-mining equilibrium (i.e. steady-state post-mining drawdown) shown in Figure 6-8. The contours are shown as the extent of 5 m and 2 m drawdown, based on extrapolation of data points from each of the cross section models (with the location of the data points also shown on Figures 6-7 and 6-8).

These contours have been utilised (refer Section 7.1) to estimate the potential impact on existing groundwater users, based on the definition of bore trigger thresholds for the Queensland *Water Act 2000*. The *Water Act* defines a "bore trigger threshold" (section 362) as *a decline in the water level in the aquifer that is-*

(a) If a regulation prescribes the bore trigger threshold for an area in which the aquifer is situated – the prescribed threshold for the area; or

(b) Otherwise-

i. For a consolidated aquifer – 5 m; or

ii. For an unconsolidated aquifer – 2 m.

The potential for impact on existing groundwater users is discussed in Section 7.1.

The potential for water level impact on environmental values (e.g. groundwater dependent ecosystems) is discussed in Section 7.2.

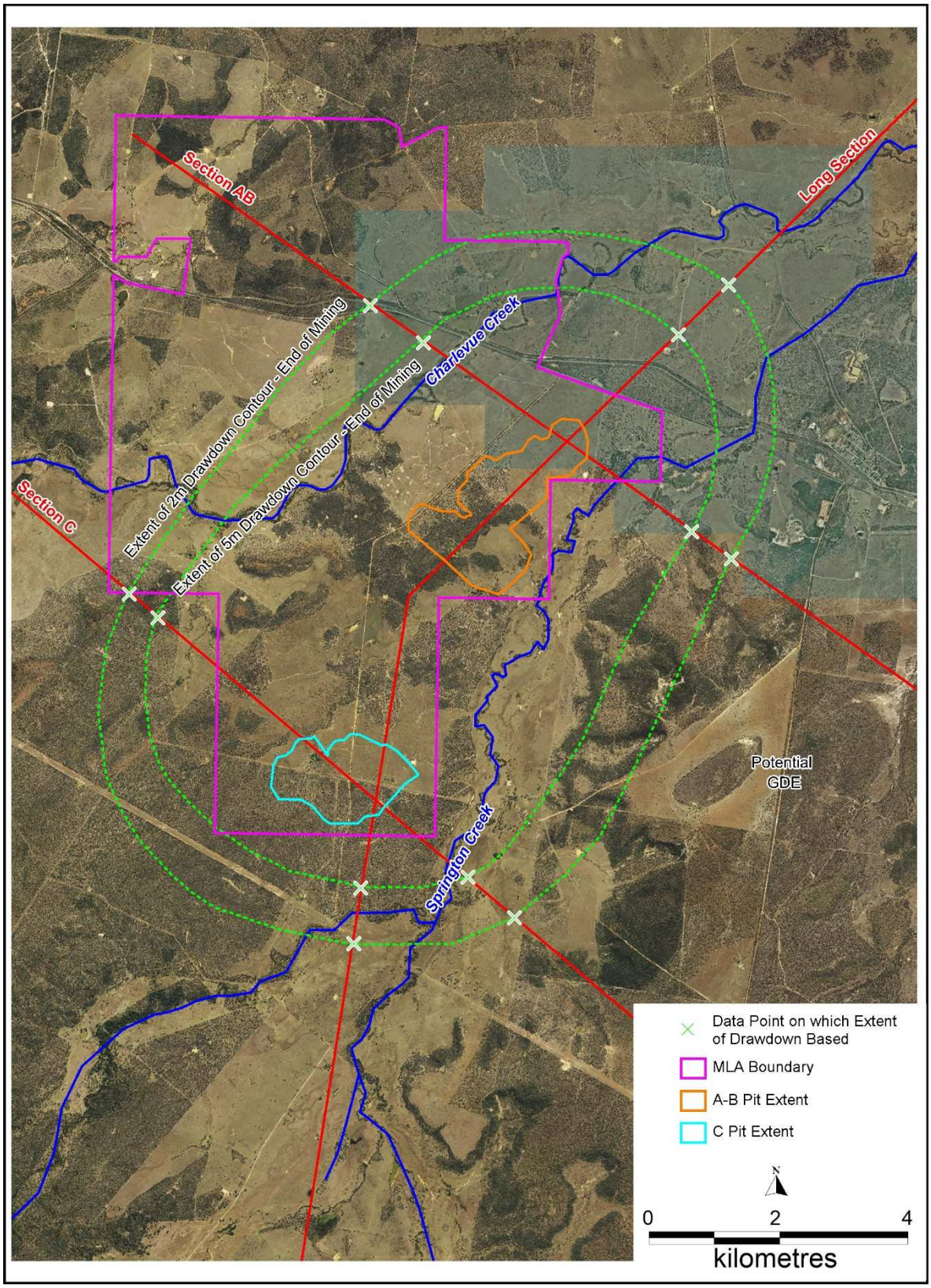


Figure 6-7: Extent of 2 m and 5 m Water Level Drawdown – End of Mining

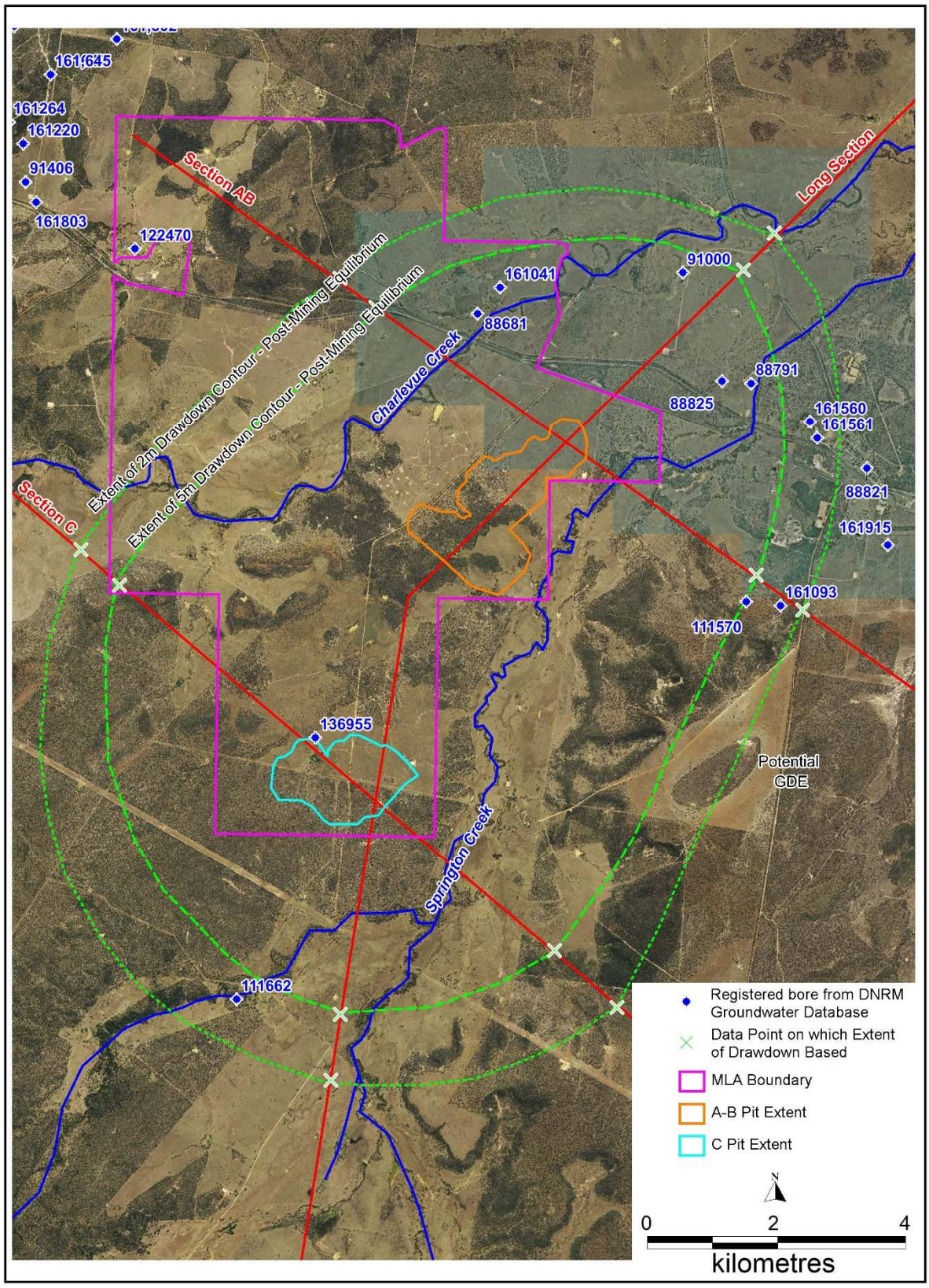


Figure 6-8: Extent of 2 m and 5 m Water Level Drawdown – Post-Mining Equilibrium

6.6.2 Groundwater inflow to the Mined Voids

The rate of groundwater inflow to the mined voids during the operational period of mining has been calculated via the following methodology:

- The seepage rate through the pit walls and floor was calculated within the Seep/W models from the two cross section models (AB Pit Section and C Pit Section) and the long section model for both the AB Pit and C Pit.
- The seepage rate was calculated as the mine development progressed and included the rate of seepage to the mining operation from the backfilled spoil
- The seepage rate, which was calculated on a per-metre basis in the models, was multiplied over the length of pit, using data from the model that was appropriate to each area;
- The modelled inflow rates for each mining year and for each pit are shown below in Table 7-1, in units of both litres per second (L/s) and cubic metres pe day (m^3/day);
- For the purpose of water balance modelling, the effects of evaporation on pit inflows was calculated to provide a value for inflow rates less evaporation (Table 7-1). The evaporation rate was applied using "Morton's estimate of wet environment areal evaporation over land" that was obtained for the project area from the SILO datadrill. This evaporation dataset was used for calculating evaporation from the pit walls and floor, based on advice from the project hydrologist WRM (M Batchelor pers. comm.). Evaporation was applied to the modelled inflow using a pan factor of 0.8 for the surface of the pit, decreasing linearly to a pan factor of 0.5 at the base of the pit (with the lower evaporation at the base of the pit due to shading etc.). The net inflow rate to each pit (modelled inflow less evaporation) is shown in Table 7-1.

Other observations/ notes with respect to the calculated inflow rates are as follows:

- The increase in the modelled and net inflow rate in years 11 and 12 of the AB pit is due to groundwater from the spoil reporting to the final void area. The spoil was modelled as being placed dry (fully-drained but with a residual water content); the groundwater level in the spoil increased over time due to inflow from the floor and walls of the mined area, as this inflow rate was not subject to evaporation. In addition, the rate of recharge to the spoil occurs at a rate that is higher than the natural ground, allowing a water table to develop within the spoil. By mining years 11 and 12 the water level within the spoil had developed to a level that allowed relatively significant rates of inflow to occur.
- For the purpose of future associated water reporting it is concluded that it would be more reasonable to assume the rate of inflow prior to development of the spoil aquifer (i.e. ~5.7 L/s or ~500 m^3/day) as the water that is developed from the spoil is derived mainly from rainfall recharge to the spoil and does not represent water from the natural formation.
- The modelled inflow rate and net inflow rate (less evaporation) reduces significantly in mining years 17 and 18 for the AB Pit and at mining year 18 for the C Pit. This is due to the partial backfilling of the final void area with spoil.
- For the post-mining years the net groundwater inflow rate is zero, as the rate of inflow from the pit walls above the backfilled area of spoil and the final void lake occurs at such a low rate that the rate of evaporation is significantly greater than the modelled rate of inflow.

Table 6-3: Calculated Rates of Inflow to the AB Pit and C Pit

Year	AB Pit				C Pit			
	Modelled Inflow Rate		Less Evaporation		Modelled Inflow Rate		Less Evaporation	
	L/s	m3/day	L/s	m3/day	L/s	m3/day	L/s	m3/day
1	7.2	626	1	86				
2	7.2	626	1	86				
3	5.0	433	1	86				
4	5.0	433	1	86				
5	5.9	508	1	86				
6	5.9	508	1	86				
7	11.0	946	1	86				
8	11.0	946	1	86				
9	5.7	493	1	86				
10	5.7	493	1	86				
11	18.0	1554	7	605				
12	18.0	1554	7	605	1.4	121	0	0
13	13.7	1181	6	518	1.4	121	0	0
14	13.7	1181	6	518	2.8	241	0.5	43
15	5.2	453	0.5	43	2.8	241	0.5	43
16	5.2	453	0.5	43	2.8	239	0.5	43
17	2.9	248	0.5	43	2.8	239	0.5	43
18	2.9	248	0.5	43	1.9	163	1	86

6.7 Uncertainty Analysis

6.7.1 Introduction

A sensitivity analysis of the groundwater model developed for the Gemini Project has been undertaken with reference to the following documents:

- Barnett et al. (2012) *Australian Groundwater Modelling Guidelines*. Sinclair Knight Merz and National Centre for Groundwater Research and Training, Waterline Report Series No. 82, June 2012; and,
- Middlemis, H. & Peeters, L.J.M. (2018) *Explanatory Note, Uncertainty Analysis in Groundwater Modelling*. Report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy (Draft).
- Reilly, T.E. & Harbaugh, A.W. (2004) *Guidelines for Evaluation of Groundwater Flow Models.* United States Geological Survey, Scientific Investigations Report 2004-5038.

A groundwater model sensitivity analysis involves the evaluation of model input parameters to see how much they affect model outputs, which are heads and flows (Reilly & Harbaugh 2004). The process of sensitivity analysis can be conducted manually or automatically; in the manual approach, multiple model simulations are made in which ideally a single parameter is adjusted by an arbitrary amount (Reilly & Harbaugh 2004). The emphasis of sensitivity modelling is on determining how sensitive the model is to each parameter tested, using a non-technical interpretation of “sensitive” (Barnett et al. 2012).

The explanatory notes for uncertainty analysis that were prepared for the IESC (Middlemis & Peeters 2018) outline three general approaches to uncertainty analysis; these are, in order of increasing complexity:

1. Scenario analysis with subjective probability;
2. Deterministic modelling with linear probability quantification; and,
3. Stochastic modelling with Bayesian probability.

The first method (scenario analysis with subjective probability) has been applied to this modelling study. This methodology is judged to be appropriate to the analysis of a Seep/W model, which utilises a single set of parameters for each material type. A sensitivity analysis of the Gemini Project model was undertaken as follows:

- The base-case models were used to establish the extent of 5 m drawdown from the edge of the final voids to the north, south, east and west of the mining area. The location of the section models, as well as detail from the models pre and post-mining, are shown in Figures 3-1 and 3-2. The sections highlight the relationship between the various groundwater units, including the degree to which faulting and folding compartmentalises the units (as shown from Figures 6-1 to 6-6, which show detail of the cross section models in the area of mining);
- The base-case model was altered to make changes to specific parameters (discussed below) and to assess the impact that the change in parameters had on the location of the extent of the 5 m drawdown contour at the post-mining equilibrium.
- The parameters that were selected for the sensitivity analysis are summarised below in Table 6-4 and include:
    - Horizontal hydraulic conductivity (Kh;
    - Vertical hydraulic conductivity (Kz);
    - Specific yield (Sy) and coefficient of volume compressibility (*mv*) (which is related to the aquifer specific storage (Ss), as described in Section 6.3.2.2); and,
    - Recharge.

6.7.2 Results

The results of the sensitivity analysis are discussed below and are presented in Table 6-4 and on Figure 6-8, which shows the extent of the 5 m post-mining equilibrium drawdown contour for each uncertainty analysis parameter. Results are summarised as follows:

- The model is assessed to be most sensitive to changes in horizontal hydraulic conductivity (Kh) and recharge, with results as follows;
    - An increase in the Kh of the Permian coal measures (coal seams and interburden) by a factor of 10 results in an increase in the extent of the 5 m drawdown contour at post-mining equilibrium years post-mining of between 800 m (to the east of C Pit) and 2,000 m (to the south of C Pit), as shown on Figure 6-8. The variability in the extent of the 5 m drawdown contour is related to dominant rock type in each direction and the variability in faulting, folding and dip direction of the coal measures. The drawdown contours also extend further to the north/south than to the east/west. This is interpreted to be related to:
        - The more continuous extension of coal seams along geological strike, as the coal seams have a higher permeability than the interburden and are the main conduits for groundwater flow within the coal measures; and,

        - The steep dip of the coal seams to the east and west, as a component of the drawdown will be acting in a direction that includes a combination of the Kh and the lower hydraulic conductivity Kz of the unit.

    - An increase in the recharge by a factor of 10, from 0.1% of average annual rainfall to 1% of average annual rainfall, results in a reduction in the extent of drawdown of between -550 m (to the west of Pit C) and -1,300 m (to the east of Pit C). The variability in the impact of the change in recharge is interpreted to be related to factors such as the thickness of Tertiary sediments and the weathered Permian sediments, in conjunction with the factors such as folding and faulting that also impact the other parameters tested.

- The model is relatively sensitive to changes in vertical hydraulic conductivity (Kz); an increase in the Kz of the Permian coal measures (interburden and coal seams) by a factor of 10 results in an increase in the extent of 5 m drawdown of between approximately 100 m (to the west of C Pit) to 670 m (to the south of C Pit);
- An increase in the storage properties (specific yield (Sy) by a factor of 2 and coefficient of volume compressibility (*mv*) by a factor of 10) results in a decrease in the extent of the 5 m drawdown contour relative to the base case of between -330 m (to the north of AB Pit) and -1,200 m (to the east of C Pit).

  Because the specific yield component of storage only acts locally (i.e. close to the walls of the open cut), the main impact on drawdown is related to the change in the coefficient of volume compressibility (*mv*). A lower value for *mv* (and hence *Ss*) indicates a geotechnically stiffer (less compressible) aquifer; by contrast an increase in the aquifer *mv* (and hence *Ss*), as undertaken in the uncertainty analysis, will result in a more compressible aquifer, which in turn will act to decrease the extent of drawdown.

Table 6-4: Results of Uncertainty Analysis

Scenario	Description	Base Case	Sensitivity Model	Change (m) in extent of 5 m drawdown contour*	
Long Section Model through AB Pit and C Pits				**North of AB Pit**	**South of C Pit**
1	Increase Kh of Permian Interburden <80 mbgl x 10	0.01 m/day	0.1 m/day	1,800	2,000
	Increase Kh of Coal Seams < 80 mbgl x 10	0.37 m/day	3.7 m/day		
	Increase Kh of Permian Interburden >80 mbgl x 10	0.001 m/day	0.01 m/day		
	Increase Kh of Coal Seams >80 mbgl x 10	0.02 m/day	0.2 m/day		
2	Increase Kz of Permian Interburden <80 mbgl x 10	0.001 m/day	0.01 m/day	450	670
	Increase Kz of Coal Seams < 80 mbgl x 10	0.037 m/day	0.37 m/day		
	Increase Kz of Permian Interburden >80 mbgl x 10	0.0001 m/day	0.001 m/day		
	Increase Kz of Coal Seams >80 mbgl x 10	0.002 m/day	0.02 m/day		
3	Increase specific yield (*Sy*) of Permian Interburden x 2	0.02 (2%)	0.04 (4%)	-330	-430
	Increase specific yield (*Sy*) of coal seams x 2	0.01 (1%)	0.02 (2%)		
	Increase storage coefficient (*Ss*) of Permian coal seams and Interburden x 10	1×10^{-5}	1×10^{-4}		
4	Increase Recharge x 10	0.1% of rainfall	1% of rainfall	-650	-1200
AB Pit Cross Section Model				**West of AB Pit**	**East of AB Pit**
1	Increase Kh as described above	As above	As above	1,000	1,200
2	Increase Kz as described above	As above	As above	350	440
3	Increase Sy and Ss as described above	As above	As above	-930	-700
4	Increase recharge as described above	As above	As above	-1,400	-1,200
C Pit Cross Section Model				**West of C Pit**	**East of C Pit**
1	Increase Kh as described above	As above	As above	900	800
2	Increase Kz as described above	As above	As above	100	210
3	Increase Sy and Ss as described above	As above	As above	-800	-1200
4	Increase recharge as described above	As above	As above	-550	-1,300

* A positive value indicates an increase in the extent of drawdown, a negative value indicates a decrease in the extent of drawdown

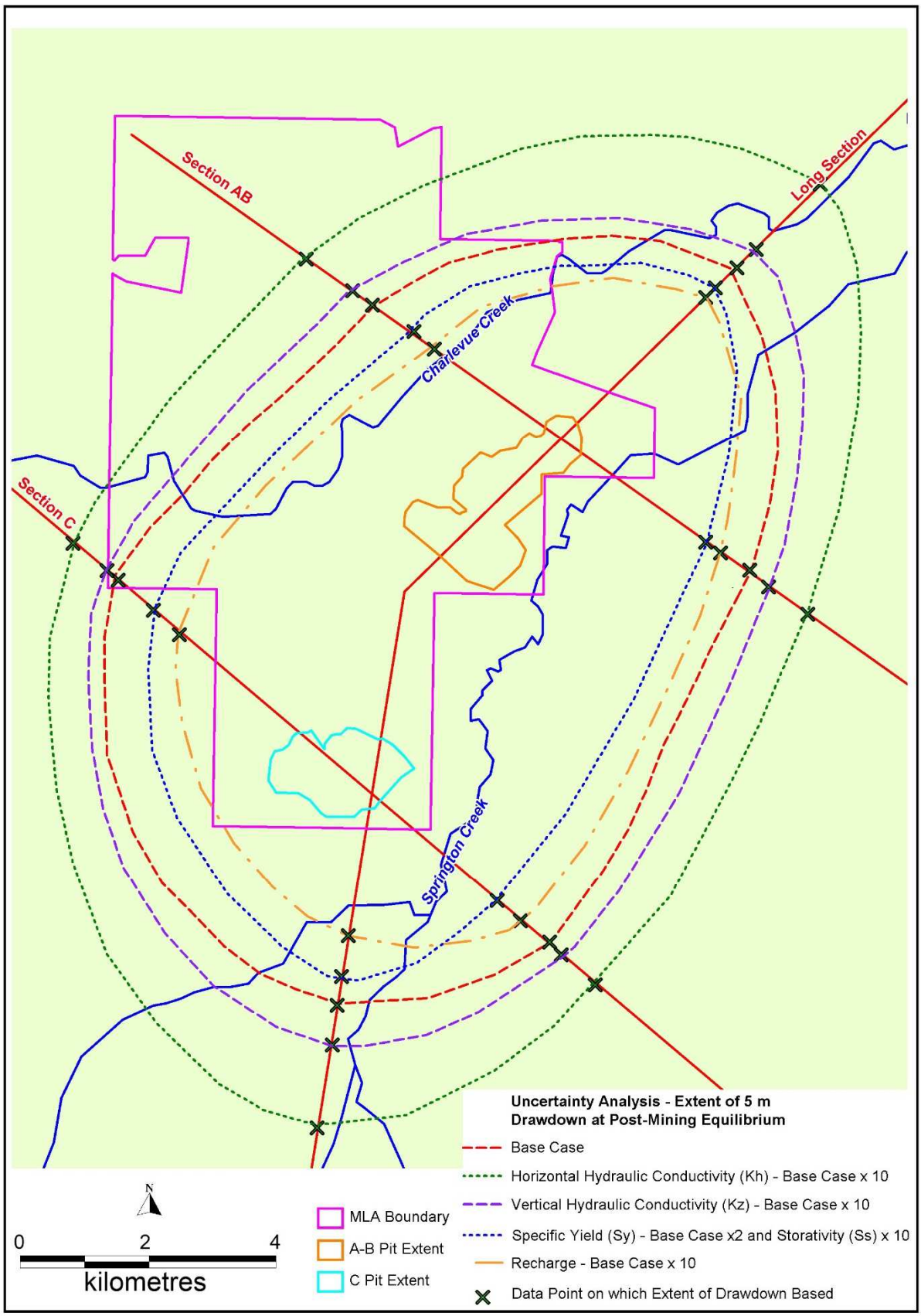


Figure 6-9: Uncertainty Analysis

7.0 GROUNDWATER IMPACTS FROM MINING

7.1 Impacts on Existing Groundwater Users

Figures 6-7 and 6-8 show the location of eleven (11) registered groundwater bores (bores from the DNRM groundwater database that are listed as being either existing or abandoned but useable) within the 2 m drawdown zone at end of mining (Figure 6-7) and/or at post-mining equilibrium (Figure 6-8). Summary data for the bores within this zone are shown below in Table 7-1. In summary:

- Bores 136955 and 11662 are located on land that is owned by Magnetic South (the proponent for the Gemini project);
- Two bores (161560 and 161561) appear to be monitoring bores for the Dingo Landfill;
- A number of bores record groundwater that is highly saline and assessed to be of no beneficial use (as discussed in Section 4.3, an EC of 6,000 µS/cm is assessed to be the upper limit of salinity tolerance for beef cattle, sheep, horses and pigs with no loss of production (ANZECC 2000), with a decline in animal health at progressively higher salinity values. Bores 88681, 88791 and 91000 record EC values of 10,000 µS/cm, 19,200 µS/cm and 14,660 µS/cm respectively, and on this basis are assessed to have little to no beneficial use);
- Bores that remain in the area of potential impact (i.e. that are not discussed in the above dot points) include:
    - Bores 88825 and 161041, which are sites with relatively little available data, but which are located within the zone of potential impact to the northeast and west-northwest of AB Pit respectively;
    - Bores 111570 and 161093 also record relatively fresh groundwater (<1,000 µS/cm) at shallow depth. While these bores are located within the extent of 2 m drawdown, these bores are also assessed to be isolated from the regional groundwater system (refer discussion in Section 7.2.1 below)

At sites including 111570 and 161093 it is noted that the sites are not located within the zone of potential impact at end of mining, but are within the zone of potential impact at post-mining equilibrium.

Notwithstanding the time that it may take for drawdown impacts to be observed at the private groundwater bores listed in Table 7-1, it is recommended that a bore survey be undertaken on the potentially impacted properties (as defined by the extent of 2 m drawdown contour on Figure 6-8).

It is further noted that make-good agreements may be required for groundwater bores within the zone of potential impact in the event that groundwater level drawdown affects the utility of the bores.

Table 7-1: Bores from DNRM Groundwater Database within 2m Drawdown Zone

RN	Aquifer	EC (µS/cm)	SWL (mbgl)	Original Bore Name	Comment
88681	Duaringa Formation	10000			Located within MLA - land owned by Magnetic South
88791	Duaringa Formation	19200	-20	New Bore	Extremely saline - no beneficial use based on water quality
88825	Unknown			Windmill	
91000	Duaringa Formation	14660	-20	Mackenzie OLO	Extremely saline - no beneficial use based on water quality
111570	Tertiary-Undefined	240	-16	Ward	Refer Section 7.2.1 for discussion
111662	Tertiary-Undefined	750	-17	Smith	Located within land owned by Magnetic South
136955	Tertiary-Undefined	10300	-21		Located within MLA - land owned by Magnetic South
161041	Duaringa Formation		-29		
161093	Tertiary Mafic Volcanics	710	-19.5		Refer Section 7.2.1 for discussion
161560	Unknown	28102		Dingo Landfill MW2	Assumed to be monitoring bore at Dingo Landfill
161561	Unknown			Dingo Landfill MW1	Assumed to be monitoring bore at Dingo Landfill

7.2 Groundwater Dependant Ecosystems

7.2.1 Area of Mapped Potential GDE to East of MLA

A potential groundwater dependant ecosystem (GDE) has been mapped to the east of the MLA and is shown below in Figure 7-1. The following observations and comments are made with respect to the potential GDE:

- The top plot on Figure 7-1 shows the potential GDE from an aerial photograph as an ovaloid feature with an area of approximately 82 ha that is located approximately 4 km east of the MLA boundary.
- The bottom plot on Figure 7-1 shows the potential GDE underlain by contours of surface topography and includes water level data from available groundwater bores. From this plot it is noted that:
  - The surface elevation of the eastern area of the MLA is in the range 125 to 135 mAHD, with the elevation of the Springton Creek floodplain dropping below 120 mAHD in the area between the MLA boundary and the potential GDE;
  - The potential GDE is located on an elevated ridgeline; the feature is located within a shallow depression on the ridgeline that is surrounded to the south, west and east by elevation contours at 170 mAHD, with the central of the depression falling below 165 mAHD. This area drains to the northeast via a narrow zone that is at a surface elevation of approximately 167 mAHD.
- The potential GDE is therefore located within a shallow depression on the ridgeline that is likely to be internally draining under average rainfall conditions and that only discharges to the northeast under high rainfall conditions. It is interpreted that, under average rainfall conditions and at the tail end of high rainfall conditions, surface runoff within the relatively small catchment that reports to this area will pond in the area of the shallow depression and provide localised recharge to an

underlying groundwater lens that is likely to be disconnected from the regional groundwater system (discussed further below).

- The bottom plot on Figure shows available groundwater level data from site monitoring bores (water levels from July/August 2019 – refer Table 4-1) as well as from two registered groundwater bores from the DNRM groundwater database). The date of the groundwater measurement for the two registered bores is likely to be from the time of drilling/construction; bore 111570 was constructed in November 2001 and bore 161093 was constructed in August 2014 (refer Table 4-5 of this report). From the water level data shown on Figure 7-1 it is observed that:
  - The depth to water for bores constructed within Tertiary sediments and Permian coal measures ranges from 26.25 to 32.37 mbgl in this area (Figure 7-1 shows data for the shallowest bore in this area; the Tertiary bore at the location of DW7105W2 is dry). Based on the elevation at these sites, this equates to a groundwater elevation of 108-110 mAHD for bores in topographically elevated areas (DW7093W1 and DW7225W1) to 89.59 mAHD at bore DW7282W1 (located in a topographically lower area of the MLA adjacent to Springton Creek).
  - The water level in alluvium bore DW7292W1 is 11.19 mbgl, which equates to an elevation of 102.39 mAHD;
  - The water level in the site monitoring bores, which are assessed to be representative of the regional groundwater level, are therefore considerably lower than the elevation of the base of the potential GDE, which is at an elevation approximately 165 mAHD;
- The water level in the two private bores to the north of the potential GDE (16 mbgl at 111570 and 19.5 mbgl at 161093) equates to a groundwater elevation of 132 to 144 mAHD at these sites.
- Based on the observations discussed above, it is concluded that:
  - The potential GDE is located on an elevated ridgeline, but within a shallow depression that is likely to drain internally under average rainfall conditions but drains to the northeast under high rainfall conditions;
  - The drainage of surface runoff to the shallow depression is likely to result in localised recharge to a perched lens of groundwater that is disconnected from the regional groundwater system;
  - It is probable that this perched groundwater lens provides water to vegetation within the depression during the dry season, but that the groundwater lens is an extremely localised system that relies on replenishment by seasonal rainfall rather than being maintained by the regional groundwater system
- It is noted the EC of site groundwater monitoring bores, which are interpreted to be within the regional groundwater system, is high (15,000 µS/cm to 29,000 µS/cm – refer Section 4.3). However it is also noted that the EC of the registered bores to the north of the potential GDE is very low, with bore 111570 recording an EC of 240 µS/cm and bore 161093 recording an EC of 710 µS/cm. This is interpreted to provide further evidence that the groundwater system in this area is perched above the regional groundwater system, with the flowline from the area of the potential GDE (where recharge is interpreted to occur) to the area where these bores are located being very short.
- From the groundwater modelling data presented in Section 6.7.2 and Figure 6-8, it is noted that the 2 m drawdown contour at post-mining equilibrium extends under the area where the potential GDE is located. It is interpreted that the risk posed by drawdown from the mining operation to the potential GDE is very low, as:
  - It is interpreted that the potential GDE exists in an area where the groundwater system is very localised and is perched above the regional groundwater system; and,

  - The groundwater lens that is interpreted to be located beneath the potential GDE is likely to be maintained by seasonal surface water runoff rather than the regional groundwater system.

- It is noted that, based on the evidence available to date, it cannot be conclusively stated that the groundwater system is not continuously saturated from the area below the potential GDE (at RL165 mAHD to the regional groundwater system (at an elevation of 110 to 89 mAHD). However, based on professional experience and judgement, it is considered that:
  - It is most probable that the ridgeline and the potential GDE is underlain by a perched groundwater system and,
- In any case it is interpreted that the potential GDE is maintained by localised runoff and shallow recharge and that a reduction in the regional groundwater level of approximately 2 m, at a vertical distance of approximately 50 to 60 m below the base of the potential GDE, has a very low risk of impacting groundwater levels beneath the potential GDE.

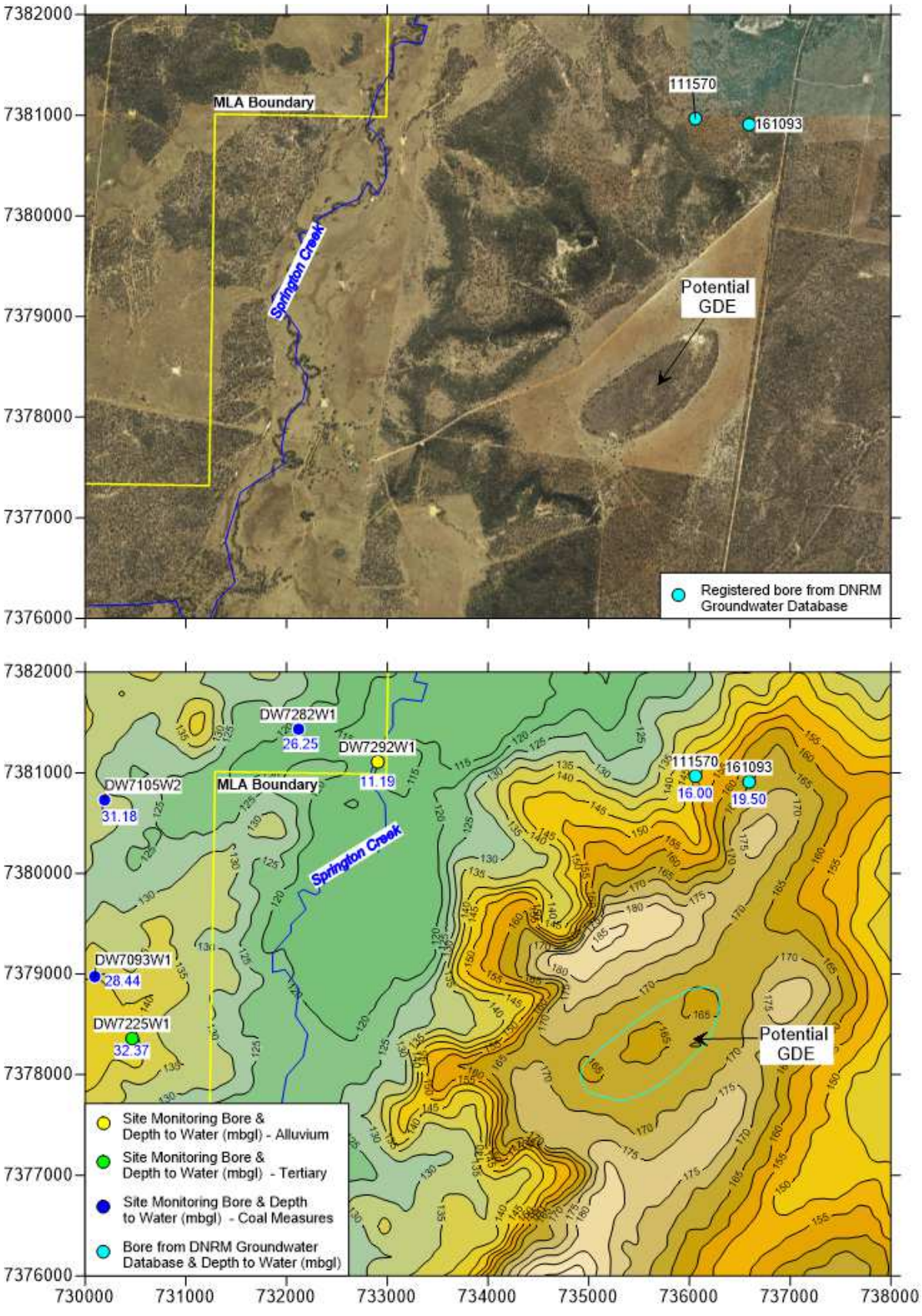


Figure 7-1: Assessment of Potential GDE to East of the Gemini Project MLA

7.2.2 GDE's Associated with Watercourses and Floodplains

A number of potential GDE's in the Project area are riverine-type wetlands that include riparian vegetation on watercourses and floodplains. It is understood from the ecological assessment (reference) that the riverine vegetation includes tree species such as blue gum (*Eucalyptus tereticornis*) and River oak (*Casuarina cunninghamiana*). With respect to the potential for the mining operation to impact this type of potential GDE the following observations are made:

- The water level drawdown associated with mining is predicted to be in excess of 5 m at some locations below both Charlevue Creek and Springton Creek (Section 6.6.1, Figures 6-7 and 6-8). It cannot be ruled out that drawdown from mining may affect water levels in the alluvium at some locations.
- This section therefore considers the potential for vegetation within the Project area to be currently dependent on groundwater, either totally or partially, which will then inform the risk to vegetation in the event that groundwater level drawdown from mining does impact groundwater levels within the alluvium.
- The assessment of current dependence of vegetation on groundwater considers both groundwater level and groundwater quality; these considerations are summarised as follows:
  - Groundwater level considerations:
    - It is understood from the ecological assessment (reference) that blue gum has a rooting depth of up to 10 m.
    - The measured depth to groundwater in the alluvium bores close to the creeks is between 8.77 m (DW7076W, adjacent to Charlevue Creek) and 11.19 m (bore DW7292W1, adjacent to Springton Creek). It is noted that the groundwater level is likely to be somewhat closer to ground surface at the invert (i.e. central line) of the creeks than in the bores, which are constructed outside the main creek channel.
    - Therefore, while the groundwater level is assessed as being close to the maximum depth that could be accessible by vegetation, it cannot be conclusively ruled out that the groundwater level is beyond the depth that is accessible to the root zone of some plants.
    - In addition, the seasonal range of water level within the alluvium is currently unknown. However, it is noted that bore DW7076W (adjacent to Charlevue Creek) is currently fitted with a datalogger (refer Section 4.2 and Figure 4-4) and that bore DW7292W1 (adjacent to Springton Creek) is programmed to be fitted with a datalogger; this data will allow assessment of the range of water level within the alluvium and the response of groundwater levels within the alluvium to rainfall recharge and stream flow events.
  - Groundwater quality considerations
    - As noted above, the riverine vegetation includes tree species such as blue gum (*Eucalyptus tereticornis*) and River oak (*Casuarina cunninghamiana*). With reference to available online information[1] it is noted that the species listed above are described as being tolerant of moderately saline conditions, which are defined[1] as being in the range of 4,000 to 8,000 µS/cm;
    - The measured EC of groundwater within the alluvium is relatively high, with a range from 15,200 µS/cm to 16,600 µS/cm for bore DW7076W (adjacent to Charlevue Creek) and a single field value for bore DW7292W1 of 5,948 µS/cm (adjacent to Springton Creek).

[1] http://www.plantstress.com/articles/salinity_m/salinity_m_files/salt%20tol%20australia.htm

- It is therefore assessed that, based on available EC data, the groundwater within the Charlevue Creek alluvium is too saline to be useable by the vegetation that occurs along the creek.
- The EC at bore DW7292W1 is within the range that is potentially useable by moderately salt-tolerant plants, but it is also noted that the depth to groundwater in that area (11.19 mbgl) is potentially beyond the depth that is accessible by vegetation.

Figure 7-2 (below) shows two photos that were taken at the time of airlift development of bore DW7076W, which is constructed within alluvium adjacent to Charlevue Creek. With reference to the photos in Figure 7-2 and the information outlined above, it is observed that:

- The photo on the left of Figure 7-2 shows bore DW7076W, with the trees in the background located within the or adjacent to the channel of Charlevue Creek;
- The photo on the right of Figure 7-2 shows vegetation within the channel of Charlevue Creek;
- Noting that the EC of groundwater in the Charlevue Creek alluvium at bore DW7076W is within the range of 15,200 µS/cm to 16,600 µS/cm, it is concluded that the groundwater at this site is too saline for use by the vegetation within the creek;
- However, the vegetation within and adjacent to Charlevue Creek appears healthy; on this basis it could be concluded that the vegetation is likely to subsist on water that becomes available following wet-season flow events in Charlevue Creek, and the soil moisture and/or perched groundwater that may exist for some time after flow events in the creek, rather than on the water table that exists at greater depth where the water is highly saline.

Figure 7-2: Alluvium Bore DW7076W and Charlevue Creek adjacent to Bore

On the basis of the above assessment, it is concluded that:

- Groundwater level drawdown from the proposed mining operation will extend beneath Charlevue Creek and Springton Creek and it cannot be ruled out that drawdown from mining may affect water levels in the alluvium at some locations.

- The riparian vegetation at site (within both Charlevue Creek and Springton Creek) is likely to subsist on water that becomes available following wet-season flow events in the creeks, and on the soil moisture and/or perched groundwater that may exist for some time after flow events in the creek, rather than on the water table that exists at greater depth (in the range of 9 to 11 m, based on available data) where the water is moderately to highly saline (and in the case of data for the Charlevue Creek alluvium, too saline to be tolerated by the vegetation species that line the creek);
- Therefore, even if mining does impact on groundwater levels within the alluvium, the risk of impacts to existing riparian vegetation is assessed to be very low, as it is assessed that it is unlikely that the vegetation is dependent on groundwater for survival.

Notwithstanding the above assessment, ongoing monitoring of groundwater levels is recommended, with a recommendation that bores within the alluvium are monitored via water level dataloggers to allow assessment of the range of seasonal water level variation at these sites. It is noted that a data logger is already fitted to bore DW7076W and that it is planned to install a logger in bore DW7292W1

7.3 Cumulative Impacts

There are no mining operations within the zone of predicted drawdown from mining at the Gemini Project site; it is therefore concluded that there are no cumulative impacts to assess.

7.4 Impacts on Groundwater Quality

Groundwater modelling (Section 6.0) predicts that a permanent cone of depression will develop that will direct groundwater flow towards the final voids; therefore, the risk of the project impacting on water quality (via outflow to the groundwater system) is assessed to be low.

It is, however, assessed that the Project could impact groundwater quality if the water within the final void were able to exit the void via unconsolidated sediments (i.e. the base of Tertiary) and flow via the groundwater system towards sensitive environmental receptors such as Springton Creek. For this reason, an assessment of the potential for water within the final voids to exit the void via the base of Tertiary sediments has been undertaken as follows:

- Contours for the base of Tertiary sediments was obtained for the area of the AB Pit and C Pit from the site geological model;
- The final void water level was obtained for each of the final voids from the WRM surface water assessment report (WRM 2019) and was assessed for:
  - The maximum final void water level for the Base Case; and,
  - The maximum final void water level for the High Inflow Case.
- The data for each mining area was assessed to establish whether any pathways existed for water to exit the final void via the base of Tertiary sediments, for the maximum Base Case and maximum High Inflow Case final void water levels.

The results of the assessment are summarised as follows:

- Assessment of the AB Pit:
  - Figure 7-3 shows the base of Tertiary contours for the area around the AB Pit and includes:
    - The limit of mining within the AB Pit;
    - The location of the final void;
    - The area of the final void that is within the area of inundation at the maximum water level for the High Inflow Case of 64.7 mAHD;

- The location of the closest environmental receptor (Springton Creek), which occurs to the east of the AB Pit.

- From the assessment it is concluded that:
  - The lowest level for the base of Tertiary adjacent to the AB Pit mining area and final void area is approximately 70.5 mAHD (as shown on Figure 7-3);
  - The base of Tertiary is therefore approximately 6 m higher than the maximum water level for the High Inflow Case;
  - There is no outlet for water within the final void of the AB Pit via the base of Tertiary sediments

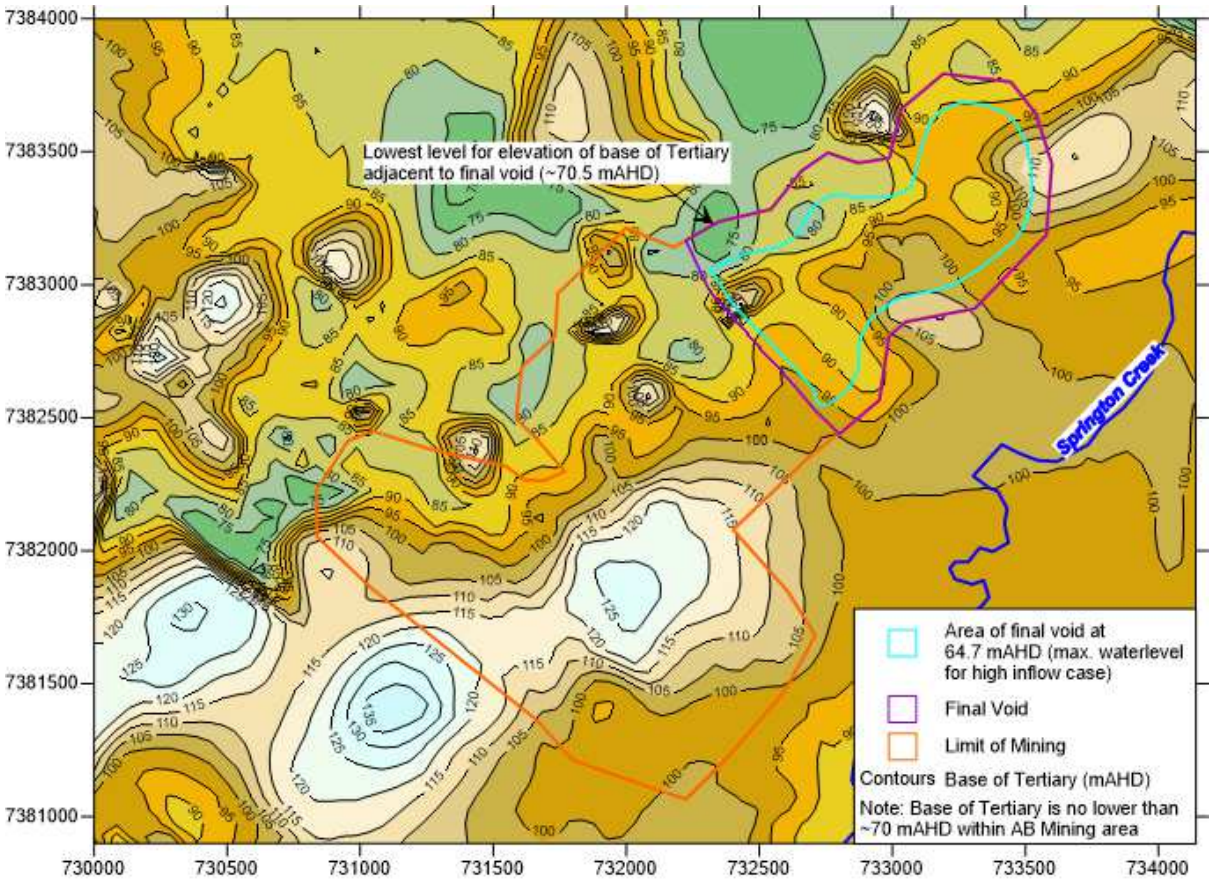


Figure 7-3: Base of Tertiary Contours and AB Pit Final Void Water Levels

- Assessment of the C Pit:
  - Figure 7-4 shows the base of Tertiary contours for the area around the C Pit and includes:
    - The limit of mining within the C Pit;
    - The location of the final void;
    - The area of the final void that is within the area of inundation at the maximum water level for the High Inflow Case of 80.0 mAHD;
    - The contour line for the base of Tertiary at the Base Case maximum water level of 73.6 mAHD;
    - The contour line for the base of Tertiary at the High Inflow Case maximum water level of 80.0 mAHD

- The location of the closest environmental receptor (Springton Creek), which occurs to the east of the C Pit.

- From the assessment it is concluded that:
  - The areas where the base of Tertiary is at or below the Base Case or High Inflow Case water levels in within the final void area, i.e. an area that will be removed by mining;
  - The lowest level for the base of Tertiary adjacent to the C Pit mining area and final void area is approximately 82.5 mAHD (as shown on Figure 7-4), which is approximately 2.5 m above the maximum water level for the High Inflow Case;
  - The elevation of the base of Tertiary increases away from the area described above to an elevation of approximately 88.5 mAHD, before the elevation of base of Tertiary reduces again towards Springton Creek
  - Therefore, there is no outlet for water within the final void of the C Pit via the base of Tertiary sediments

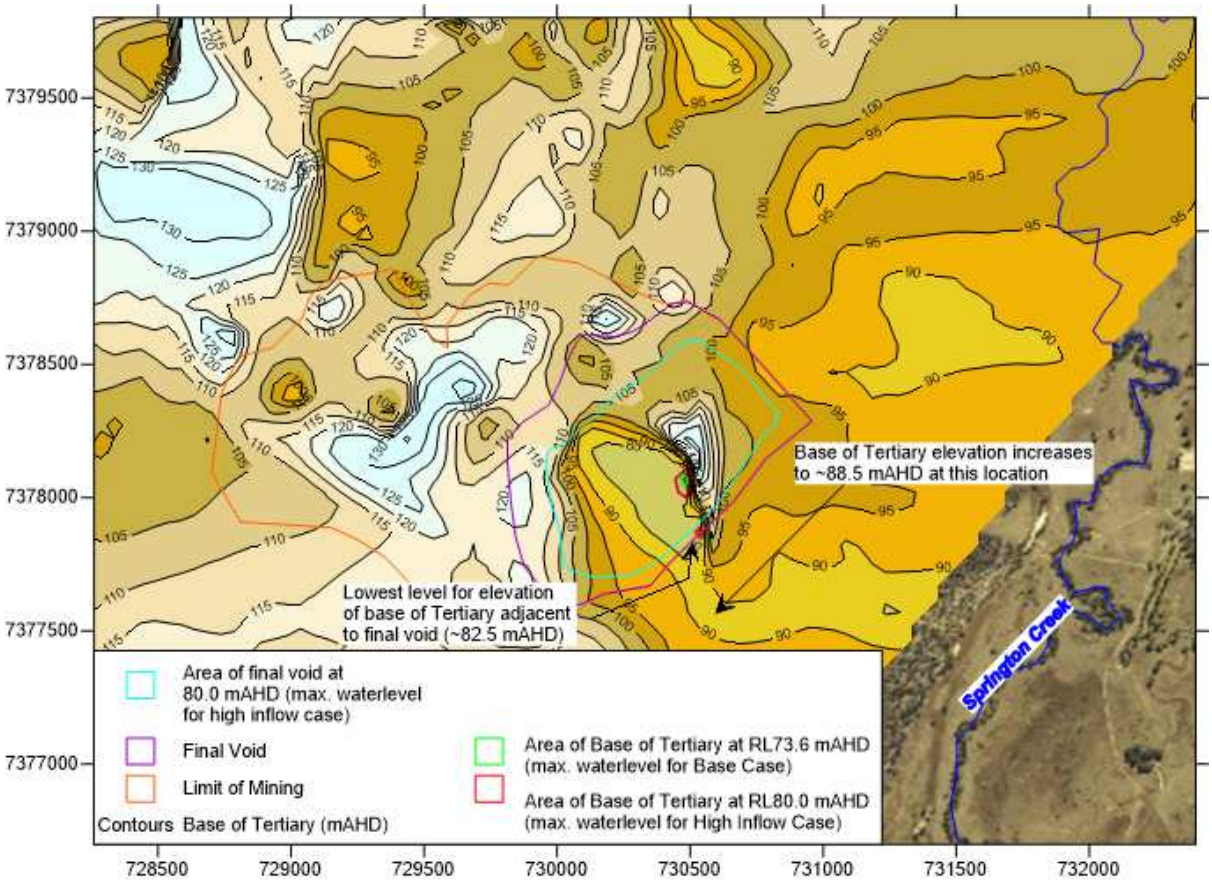


Figure 7-4: Base of Tertiary Contours and C Pit Final Void Water Levels

Based on the assessment undertaken above it is concluded that there is a very low risk of water within the final voids of the AB and C Pits impacting the surrounding groundwater system

.

8.0 SUMMARY AND CONCUSIONS

8.1 Review of Project and Site Data

- The Gemini Project proposes to mine coal from the Aries, Castor and Pollux coal seams of the Rangal Coal Measures, at depths of up to 185 mbgl;
- The mined voids will be progressively backfilled with waste rock (spoil) and the final voids will be backfilled with spoil to approximately 80 mbgl; this backfilling is being undertaken to reduce groundwater seepage to the final void and to limit the impact of mining on groundwater levels;
- Groundwater occurs within three main groundwater units at site, including:
  - Quaternary alluvium associated with Charlevue Creek and Springton Creek
  - Tertiary sediments of the Duaringa Formation; and,
  - The Permian Rangal Coal Measures, where groundwater occurs preferentially within the coal seams
- The site is heavily faulted and the faults may act to influence groundwater occurrence and movement as follows:
  - Shear zones associated with faulting may act as a store of water and as locally higher hydraulic conductivity zones. As discussed below, recharge to the groundwater system is assessed to be low; therefore the faults may provide initial relatively high inflow rates to the workings (in the order of several L/s), but the total storage within the faults is anticipated to be relatively low, with the initial rates of inflow not able to be sustained in the long-term; and,
  - Where the faults completely disrupt the coal seams, especially for cases where the coal seam terminates against lower-hydraulic conductivity interburden, the faults will act to disrupt groundwater flow.
- Available hydraulic conductivity and air-lift yield data indicates that there is notable reduction in hydraulic conductivity and bore yield for bores that are deeper than 80 mbgl compared to bores that are shallower than 80 mbgl.
- Groundwater level data at site are summarised as:
  - The water level within the alluvium ranges from 8.77 to 11.19 m below ground level for bores adjacent to the creek channels;
  - The water level with the Tertiary sediments ranges from dry (5 bores, ranging in depth from 14 to 23 m) to 15.38-44.74 mbgl (where water is present). The presence of water within the Tertiary sediments is related to the RL of the base of Tertiary and from review of available data it is assessed that it is probable that the Tertiary sediments are dry above 120 mAHD and likely dry above 110 mAHD; and,
  - The water level in the coal measures ranges from 16.91 to 46.62 mbgl for bore depths of between 38.4 and 136.7 m, with one bore dry at a depth of 31.59 m. The groundwater flow direction for groundwater within the coal measures is from southwest to northeast and from northwest to southeast, towards a depression that is centred on the area where the AB Pit is proposed to be developed.
- Groundwater quality data is summarised as:
  - All groundwater units at site record high EC groundwater, as follows:
    - Alluvial sediments – EC data is available from:

- A bore adjacent to Charlevue Creek (DW7076W), where the recorded EC range is from 15,200 µS/cm to 16,600 µS/cm; and,
- A bore adjacent to Springton Creek (DW7292W1) has recorded an EC value of 5,948 µS/cm from a single field value (sampling of the recently-drilled monitoring bores commenced in September 2019 with no laboratory data available to date);

▪ Tertiary sediments - the EC ranges from 20,200 µS/cm to 21,900 µS/cm;

▪ Coal seams - the EC ranges from 22,100 µS/cm to 28,500 µS/cm.

- Groundwater at site is above the ANZECC 2000 freshwater ecosystem protection trigger value (95% species protection) for boron (all samples), zinc (majority of samples) as well as aluminium, arsenic, copper, lead and nickel (a number of samples for each analyte).
- All groundwater samples collected to data are assessed to represent the background water quality for the site.
- The recharge rate to the groundwater units at site, which has been calculated via the chloride mass balance method, indicates an extremely low recharge rate of less than 1 mm/year for each groundwater unit. The low rate of calculated recharge is consistent with the observation of highly saline groundwater at site, which is present for even the shallow alluvial units.
- The observation of a low recharge rate for groundwater suggests that, even though relatively high rates of groundwater inflow may be observed from faults/shear zones as mining progresses, especially for the zone above 80 mbgl, the inflow rates are likely to be of short duration due to the relatively low volume that can be stored within fractures/faults and the very low rates of recharge observed at site (i.e. once the fault storage is depleted the faults are unlikely to be recharged).
- Because the faults may act as conduits for groundwater movement, the control of surface water around the site will be of particular importance (i.e. water that ponds at surface may recharge the underlying sediments and report as seepage to the pits via movement along faults/fractures). This mode of inflow would represent infiltrated surface water rather than groundwater from the formations.

8.2 Groundwater Modelling

- 2-dimensional groundwater models have been developed within the program Seep/W for three locations, including
  - A west-east cross section through the C Pit;
  - A west-east cross section through the AB Pit; and,
  - A long section that runs through the final void of both the C Pit and the AB Pit.
- The models take into account:
  - the mining schedule (progression of mining, depth of mining);
  - the progressive backfilling of the pits with waste rock (spoil); and,
  - The backfilling of the final voids to a dept that corresponds to approximately 80 mbgl.
- The models have been utilised to provide the following output:
  - Inflow rates over time to the mine throughout the mining period and to the final void, including inflow rates from the natural groundwater units (Permian coal measures, Tertiary sediments) as well as the spoil aquifer. Groundwater inflow rates to the final voids took into account the partial backfilling of the voids with spoil and the average level of the final void lakes.

- The predicted extent of drawdown (2 m and 5 m drawdown contours) at end of mining and post-mining equilibrium (i.e. steady-state)

- Observations with respect to the calculated inflow rates are as follows:
  - The highest inflow rates to the AB Pit occur in mining years 11 and 12 and are due to groundwater from the spoil reporting to the final void area;
  - For the purpose of future associated water licence reporting it is concluded that it would be more reasonable to assume the rate of inflow prior to development of the spoil aquifer (i.e. ~5.7 L/s or ~500 m^3/day) as the water that is developed from the spoil is derived mainly from rainfall recharge to the spoil and does not represent water from the natural formation;
  - The modelled inflow rates and net inflow rates (i.e. modelled inflow less evaporation) reduces significantly in mining years 17 and 18 for the AB Pit and at mining year 18 for the C Pit. This is due to the partial backfilling of the final void area with spoil; and,
  - For the post-mining years the net groundwater inflow rate is zero, as the rate of inflow from the pit walls above the backfilled area of spoil and the final void lake occurs at such a low rate that the rate of evaporation is significantly greater than the modelled rate of inflow.

8.3 Groundwater Impacts from Mining

Observations with respect to potential groundwater impacts from mining include:

- Impacts on existing groundwater users:
  - There are a total of eleven registered groundwater bores (listed from the DNRM groundwater database as either existing or abandoned but useable) within the zone of 2 m drawdown at post-mining equilibrium.
  - A number of sites are either located within land that is owned by Magnetic South (the project proponent) or record an EC >10,000 µS/cm, making the groundwater quality of little or no beneficial use.
  - Two bores that record an EC <1,000 µS/cm are assessed to be in an elevated area that is potentially disconnected from the regional groundwater system that the mining project is developed within. At these sites it is also noted that the sites are not located within the zone of potential impact at end of mining, but are within the zone of potential impact at post-mining equilibrium.
  - Notwithstanding the time that it may take for drawdown impacts to be observed at the private groundwater bores, it is recommended that a bore survey be undertaken on the potentially impacted properties (as defined by the extent of 2 m drawdown contour on Figure 6-8).
  - It is further noted that make-good agreements may be required for groundwater bores within the zone of potential impact, in the event that groundwater level drawdown affects the utility of the bores.
- Impacts on groundwater dependent ecosystems:
  - A potential groundwater dependant ecosystem (GDE) has been mapped to the east of the MLA and is discussed in Section 7.2.1. The potential GDE is located on an elevated ridgeline but in an area where surface water drainage is internal towards the potential GDE. It is therefore interpreted that the vegetation at this location may be groundwater dependent, but that the site is perched above the regional groundwater system and may be maintained in the dry season by a shallow groundwater lens that is seasonally replenished by surface flow and localised recharge. It is therefore interpreted that, although the site is located within the 2 m zone of

drawdown impacts from mining, there is a low risk of impact due to the perched nature of the system and the assessment that the site is likely to be disconnected from the regional groundwater system.

- A number of potential GDE's in the Project area are riverine-type wetlands that include riparian vegetation on watercourses and floodplains. With respect to the potential for the mining operation to impact this type of potential GDE, it is concluded that:
  - Groundwater level drawdown from the proposed mining operation will extend beneath Charlevue Creek and Springton Creek and it cannot be ruled out that drawdown from mining may affect water levels in the alluvium at some locations;
  - The riparian vegetation at site (within both Charlevue Creek and Springton Creek) is likely to subsist on water that becomes available following wet-season flow events in the creeks, and on the soil moisture and/or perched groundwater that may exist for some time after flow events in the creek, rather than on the water table that exists at greater depth (in the range of 9 to 11 m, based on available data) where the water is moderately to highly saline (and in the case of data for the Charlevue Creek alluvium, too saline to be tolerated by the vegetation species that line the creek); and,
  - Therefore, even if mining does impact on groundwater levels within the alluvium, the risk of impacts to existing riparian vegetation is assessed to be very low, as it is assessed that it is unlikely that the vegetation is dependent on groundwater for survival.
- Notwithstanding the above assessment, ongoing monitoring of groundwater levels is recommended, with a recommendation that bores within the alluvium are monitored via water level dataloggers to allow assessment of the range of seasonal water level variation at these sites. It is noted that a data logger is already fitted to bore DW7076W and that it is planned to install a logger in bore DW7292W1.

- Cumulative Impacts
  - There are no mining operations within the zone of predicted drawdown from mining at the Gemini Project site; it is therefore concluded that there are no cumulative impacts to assess.
- Impacts on Groundwater Quality
  - Groundwater modelling undertaken for this report predicts that a permanent cone of depression will develop that will direct groundwater flow towards the final voids; therefore, the risk of the project impacting on water quality (via outflow to the groundwater system) is assessed to be low.
  - It is, however, assessed that the Project could impact groundwater quality if the water within the final void were able to exit the void via unconsolidated sediments (i.e. the base of Tertiary) and flow via the groundwater system towards sensitive environmental receptors such as Springton Creek. For this reason, an assessment of the potential for water within the final voids to exit the void via the base of Tertiary sediments has been undertaken as follows:
    - Contours for the base of Tertiary sediments was obtained for the area of the AB Pit and C Pit from the site geological model;
    - The final void water level was obtained for each of the final voids from the WRM surface water assessment report (WRM 2019) and was assessed for:
      - The maximum final void water level for the Base Case; and,
      - The maximum final void water level for the High Inflow Case.

- The data for each mining area was assessed to establish whether any pathways existed for water to exit the final void via the base of Tertiary sediments, for the maximum Base Case and maximum High Inflow Case final void water levels.

- Based on the assessment described above it is concluded that there is no outlet via the base of Tertiary for water within the final void of either the AB Pit or the C Pit, for either the maximum Base Case water level or the maximum High Inflow Case water level.
- It is therefore concluded that there is a low risk of the Project impacting on groundwater quality.

9.0 REFERENCES

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A & Boronkay A *Australian Groundwater Modelling Guidelines*. Waterline Report Series No. 82, June 2012

Geoslope (2012) *Seepage Modelling with Seep/W*, July 2012.

Middlemis, H. & Peeters, L.J.M. (2018) Explanatory Note, Uncertainty Analysis in Groundwater Modelling. Report prepared for the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development through the Department of the Environment and Energy (Draft).

JTB (2019) Coal Resource Report – Dingo West Coal Deposit, Queensland Australia. Report prepared by John T Boyd Company to Magnetic South Pty Ltd. Report No. 5171.000, February 2019.

Reilly, T.E. & Harbaugh, A.W. (2004) *Guidelines for Evaluation Groundwater Flow Models*. United States Geological Survey, Scientific Investigations Report 2004-5038.

WRM (2019) Gemini Project Surface Water Assessment. Report prepared for Magnetic South Pty Ltd by WRM Water & Environment. Report No. 1238-01-G1, 26 September 2019.

APPENDIX A

BORE CONSTRUCTION LOGS

Project: Gemini Project

Bore ID: DW7033W1

Drilled Date: 30-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, light to medium greyish brown, sandy		0	124		Stickup to Lip of Steel Monument - 1.04 m
SAND, light creamy white, clayey with limonitic traces					
SAND, light creamy white, clayey		4	120		Grout from surface to 37 mbgl
CLAY, silty, light greyish-white, sandy		8	116		50 mm Class 18 PVC Environmental Casing
CLAY, silty, light to medium brownish-white, with ferruginous traces near base of unit		12	112		
FERRICRETE, dark reddish-brown		16	108		
CLAY, silty, lightish-white		20	104		
FERRICRETE, dark reddish-brown		24	100		
CLAY, silty, light white, ferruginous lenses near top of unit		28	96		Water level - 29.94 mbgl - 17/7/2019
SAND, clayey, light creamy-white, coarse					
CLAY, light to medium greyish-white, ferruginous lenses near middle of unit		32	92		
		36	88		Bentonite Seal - 37 to 38 mbgl
SAND, light to medium orangey grey, limonitic traces, base of Tertiary at 42.5 mbgl		40	84		Gravel Pack - 38 to 45 mbgl
SILTSTONE, light to medium orangey brown		44	80		Screen - machine-slotted 50 mm PVC - 39 to 45 mbgl
		48			

JBT consulting

Easting: 731543.2

Northing: 7383768

Collar RL (mAHD): 124.4

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 45.23

Project: Gemini Project

Bore ID: DW7033W2

Drilled Date: 29-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, light to medium greyish-brown, sandy		0	124		Stickup to Lip of Steel Monument - 1.01 m
Sand, light greyish-white, clayey		4	120		Grout from surface to 71 mbgl
Clay, silty, light to medium brownish white, ferruginous traces near base of unit		8	116		50 mm Class 18 PVC Environmental Casing
		12	112		
		16	108		
FERRICRETE, dark reddish-brown					
Clay, silty, lightish white		20	104		
FERRICRETE, dark reddish-brown					
CLAY, silty, lightish-white, ferruginous lenses near top of unit		24	100		
		28	96		Water level - 29.01 mbgl - 17/7/2019
SAND, clayey, light creamy white					
CLAY, lightish white		32	92		
SAND, light to medium greyish-white, clayey		36	88		
CLAY, light to medium greyish-white, limonitic traces, base of Tertiary at 42.5 mbgl		40	84		
SILTSTONE, medium to dark orangey-brown		44	80		
		48	76		
		52	72		
SANDSTONE, fine to medium, light to medium grey					
COAL, Orion 4 Seam, fresh		56	68		
SILTSTONE, medium grey, minor sandstone					
SANDSTONE, fine to medium, light to medium grey, common siltstone fragments		60	64		
SANDSTONE, fine to coarse, light to medium grey					
		64	60		
SILTSTONE, dark grey		68	56		
		72	52		Bentonite Seal - 71 to 72 mbgl Gravel Pack - 72 to 74.5 mbgl Screen - machine-slotted 50 mm PVC - 73 to 74.5 mbgl
COAL, Orion 5 Seam, fresh					
		76	48		
		80			

JBT consulting

Easting: 731546.2

Northing: 7383773.1

Collar RL (mAHD): 124.45

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 74.77

Project: Gemini Project

Bore ID: DW7033W3

Drilled Date: 28-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, light to medium greyish-brown, sandy		0	125		Stickup to Lip of Steel Monument - 1.04 m
SAND, light greyish-white, clayey		5	120		Grout from surface to 77.5 mbgl
CLAY, silty, light to medium brownish white, ferruginous traces near base of unit		10	115		50 mm Class 18 PVC Environmental Casing
		15	110		
FERRICRETE, dark reddish-brown CLAY, silty, lightish white		20	105		
FERRICRETE, dark reddish-brown CLAY, silty, lightish-white, ferruginous lenses near top of unit		25	100		
SAND, clayey, light creamy white		30	95		Water level - 28.93 mbgl - 17/7/2019
CLAY, lightish white		35	90		
SAND, light to medium greyish-white, clayey		40	85		
CLAY, light to medium greyish-white, limonitic traces, base of Tertiary at 42.5 mbgl		45	80		
SILTSTONE, medium to dark orangey-brown		50	75		
SANDSTONE, fine to medium, light to medium grey COAL, Orion 4 Seam, fresh		55	70		
SILTSTONE, medium grey, minor sandstone		60	65		
SANDSTONE, fine to medium, light to medium grey, common siltstone fragments SANDSTONE, fine to coarse, light to medium grey		65	60		
SILTSTONE, dark grey		70	55		
COAL, Orion 5 Seam, fresh		75	50		
CARBONACEOUS SILTSTONE, black		80	45		
SILTSTONE, medium grey, abundant sandstone near base of unit					Bentonite Seal - 77.5 to 78.5 mbgl Gravel Pack - 78.5 to 81.0 mbgl Screen - machine-slotted 50 mm PVC - 79.5 to 81.0 mbgl

JBT consulting

Easting: 731548.4

Northing: 7383777.5

Collar RL (mAHD): 124.43

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 81

Project: Gemini Project

Bore ID: DW7035W3

Drilled Date: 31-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, dark brown, clayey and silty		0	116		Stickup to Lip of Steel Monument - 1.06 m
CLAY, dark reddish-brown, silty, sandy near base of unit					
SAND, medium to dark reddish-brown		4	112		
		8	108		Grout from surface to 44.9 mbgl
SAND, medium brownish-red		12	104		
IRONSTONE, medium to dark reddish-brown					
SAND, medium brownish-red					
FERRICRETE, dark reddish-brown					
GRAVEL, medium to dark brownish grey, sandy with ferruginous grains		16	100		50 mm Class 18 PVC Environmental Casing
SAND, medium brownish-red					
CLAY, light to medium brownish-white, sandy near base of unit		20	96		Water level - 21.75 mbgl - 16/7/2019
SAND, silty, light greyish-white		24	92		
CLAY, sandy, light yellowish-brown, base of Tertiary at 33 mbgl		28	88		
		32	84		
SILTSTONE, medium to dark orangey-brown, clayey					
LIMONITE, medium to dark reddish-brown, ferruginous					
SILTSTONE, light to medium brownish-grey		36	80		
SILTSTONE, medium to dark greyish0brown					
SANDSTONE, light to medium brownish-grey		40	76		
SILTSTONE, medium grey, sandstone near base of unit		44	72		Bentonite Seal - 44.9 to 45.9mbgl Gravel Pack - 45.9 to 48.4 mbgl
COAL, Orion 1 seam, black, fresh		48	68		
SANDSTONE, fine-grained, medium grey					Screen - machine-slotted 50 mm PVC - 46.9 to 48.4 mbgl
		52			

JBT consulting

Easting: 730957.4

Northing: 7384050

Collar RL (mAHD): 116.67

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 48.47

Project: Gemini Project

Bore ID: DW7065W

Drilled Date: 05-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL: medium to dark grey, loose, earthy		0	136		Stickup to Lip of Steel Monument - 1.0 m
CLAY: light brownish-white, firm, chalky.		4	132		
CLAY, sandy : light orangey-white, with ferruginous traces, firm, chalky, haematitic.		8	128		
SAND: light yellowish-white, loose.		12	124		
CLAY: light white, sandy ferruginous bands near middle of unit, stiff, chalky, haematitic		16	120		
SAND, clayey: light greyish-white, very clayey, medium dense.		20	116		Grout from surface to 69.3 mbgl
GRAVEL, clayey: medium to dark reddish-brown, very clayey, dense.		24	112		
CLAY: light brown, sandy, stiff.		28	108		
CLAY, silty : medium to dark orangey-brown, stiff, chalky, haematitic.		32	104		
Base of Tertiary at 54 mbgl.		36	100		
SILTSTONE : medium to dark reddish-brown, clayey, weathered.		40	96		50 mm Class 18 PVC Environmental Casing
Base of Weathering at 61.5 mbgl		44	92		
SILTSTONE : medium to dark grey.		48	88		Water level - 47.30 mbgl - 26/8/2019
SILTSTONE : black, fresh.		52	84		
COAL: black, fresh, Aries 3 Upper Seam		56	80		
SILTSTONE : medium to dark grey, fresh.		60	76		
COAL: black, fresh, Aries 3 Seam.		64	72		
SILTSTONE : medium to dark grey.		68	68		Bentonite Seal - 69.3 to 70.3 mbgl
COAL: black, Aries 3 Lower Seam.		72	64		Gravel Pack - 70.3 to 77.3 mbgl
SILTSTONE : medium to dark grey.		76	60		Screen - machine-slotted 50 mm PVC - 71.3 to 77.3 mbgl
		80	56		

JBT consulting

Easting: 730860.4

Northing: 7382307.1

Collar RL (mAHD): 135.97

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig: Gardner Denver 1400

Hole Diameter (mm): 120

Total Depth (m): 77.27

Project: Gemini Project

Bore ID: DW7066W

Drilled Date: 05-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
		1	137		Stickup to Lip of Steel Monument - 0.94 m
SOIL: medium to dark grey, loose, earthy.		0	136		
		1	135		Grout from surface to 9.35 mbgl
		2	134		
		3	133		
		4	132		
CLAY : light brownish-white, firm, chalky.		5	131		50 mm Class 18 PVC Environmental Casing
		6	130		
		7	129		
		8	128		
		9	127		
		10	126		
CLAY, sandy : light yellowish-white, with limonitic traces, firm, chalky, haematitic.		11	125		Bentonite Seal - 9.35 to 10.35 mbgl
		12	124		
		13	123		
		14	122		
		15	121		Gravel Pack - 10.35 to 17.35 mbgl
SAND: light white, loose.		16	120		
		17	119		Screen - machine-slotted 50 mm PVC - 11.35 to 17.35 mbgl
		18	118		
		19			Bore Dry - 26/8/2019

JBT consulting

Easting: 730863.1

Northing: 7382304.1

Collar RL (mAHD): 136.37

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig: Gardner Denver 1400

Hole Diameter (mm): 120

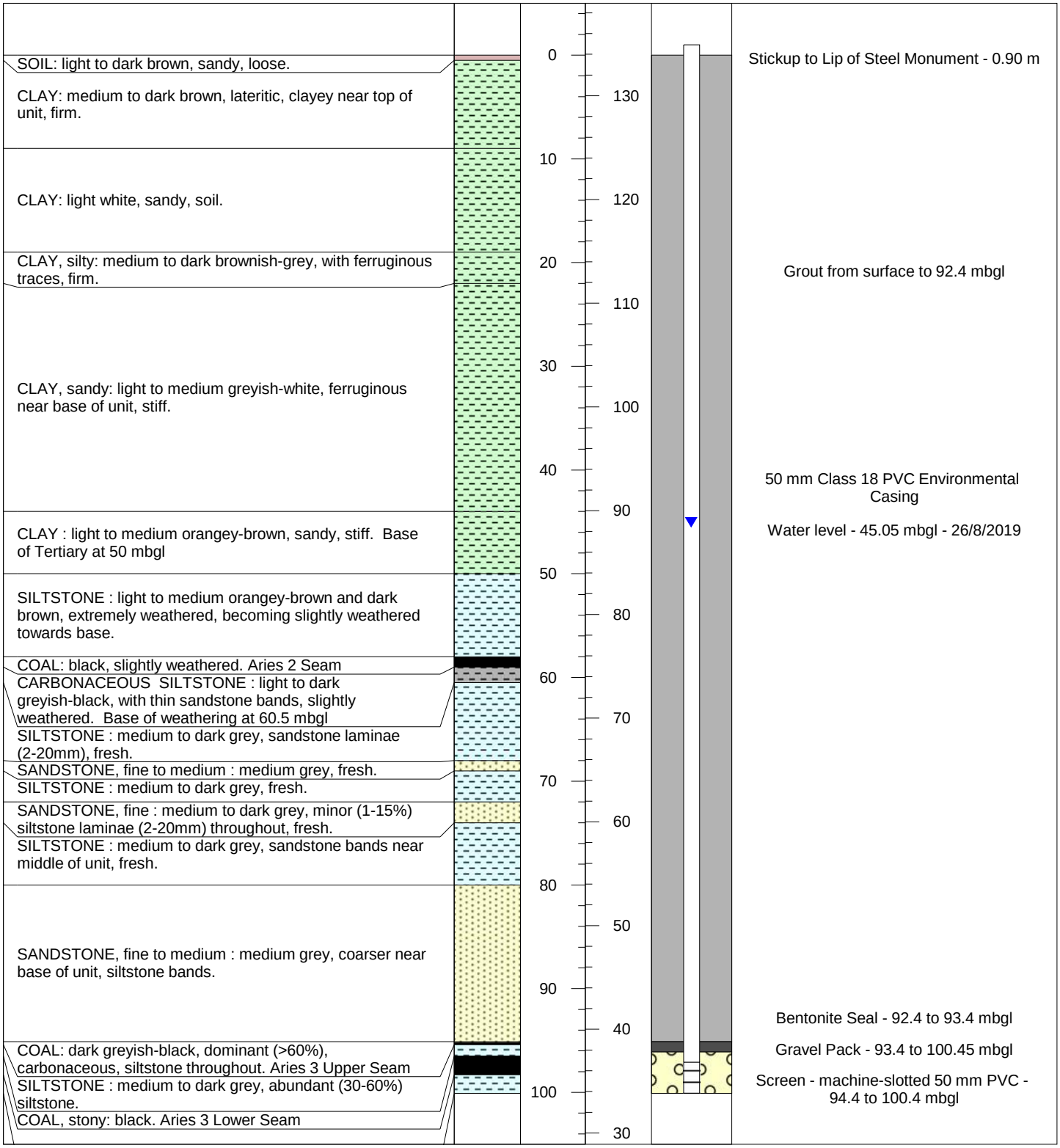
Total Depth (m): 17.35

Project: Gemini Project

Bore ID: DW7067W

Drilled Date: 06-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes



Easting: 730781.2	Drilling Company: Hodge Drilling
Northing: 7382393.8	Drill Rig: Gardner Denver 1400
Collar RL (mAHD): 133.92	Hole Diameter (mm): 120
Co-ord System: GDA94	Total Depth (m): 100.14

Project: Gemini Project

Bore ID: DW7068W

Drilled Date: 06-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL: light to dark brown, sandy, loose.		0	134		Stickup to Lip of Steel Monument - 0.94 m
CLAY: medium to dark greyish-brown, lateritic and clayey near top of unit, firm.		4	132		
CLAY: light brownish-white, firm.		8	128		
SAND: light white, clayey, dense		12	124		Grout from surface to 41 mbgl
CLAY: light greyish-white, sandy with ferruginous traces.		20	120		50 mm Class 18 PVC Environmental Casing
CLAY: light white, sandy, firm.		28	112		
CLAY, sandy: light to medium brownish-grey, ferruginous near base of unit, stiff.		36	104		
CLAY, sandy: light to medium reddish-brown, sandy, stiff.		40	96		Bentonite Seal - 41 to 42 mbgl Gravel Pack - 42 to 47.5 mbgl Screen - machine-slotted 50 mm PVC - 43 to 47.5 mbgl
SAND, clayey: light to medium greyish-white, with ferruginous traces, dense.		44	92		
		48	88		Water level - 45.68 mbgl - 26/8/2019

JBT consulting

Easting: 730785.4

Northing: 7382391.3

Collar RL (mAHD): 134

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig: Gardner Denver 1400

Hole Diameter (mm): 120

Total Depth (m): 47.5

Project: Gemini Project

Bore ID: DW7069W

Drilled Date: 07-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL: light to dark brown, sandy, loose.		0	132		Stickup to Lip of Steel Monument - 0.95 m
CLAY : light to medium brown, silty and laminae (2-20mm), firm, finer near top of unit. Base of Tertiary at 16 mbgl.		4 8 12	128 124 120		
SILTSTONE : light to medium orangey-brown, with clayey bands, extremely weathered.		16 20	116 112		Grout from surface to 63.4 mbgl
SILTSTONE : medium to dark grey, slightly weathered.		24 28	108 104		
COAL, weathered : black, slightly weathered. Aries 3 Upper Seam		28	104		
SILTSTONE : grey, slightly weathered, very low strength rock		32	100		50 mm Class 18 PVC Environmental Casing
COAL, weathered : black, slightly weathered. Aries 3 Seam		32	100		
CARBONACEOUS SILTSTONE: light to dark greyish-black, with siltstone bands, slightly weathered, very low strength rock		36	96		
COAL, weathered: black, Aries 3 Lower Seam		40	92		
SILTSTONE: medium to dark grey, thin sandstone laminae (2-20mm) near base of unit, fresh		40 44	92 88		Water level - 42.73 mbgl - 26/8/2019
SANDSTONE, medium: light to medium grey, fresh		48	84		
SILTSTONE: medium to dark grey, fresh		48 52	84 80		
COAL: black, fresh. Castor Upper Seam		56	76		
SANDSTONE, fine to medium: light to medium grey, with common (15-30%) siltstone bands, fresh		56 60	76 72		
SILTSTONE: medium to dark grey, fresh		64	68		Bentonite Seal - 63.4 to 64.4 mbgl
COAL: black, fresh. Castor Lower Seam.		64	68		Gravel Pack - 64.4 to 71.4 mbgl
SILTSTONE: medium to dark grey, carbonaceous in part, fresh		68	64		
COAL: black, fresh. Pollux Upper Seam		68	64		Screen - machine-slotted 50 mm PVC - 65.4 to 71.4 mbgl
SILTSTONE: medium to dark grey, fresh		72	60		
COAL: black, thin siltstone bands near base of unit, fresh. Pollux Upper 1 Seam		72 76	60		

JBT consulting

Easting: 730397.1

Northing: 7382699

Collar RL (mAHD): 132.57

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig: Gardner Denver 1400

Hole Diameter (mm): 120

Total Depth (m): 71.38

Project: Gemini Project

Bore ID: DW7071W

Drilled Date: 08-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL: light to medium reddish-brown, very loose		0	132		Stickup to Lip of Steel Monument - 0.97 m
CLAY : light to medium brown, silty and laminae (2-20mm)		2	130		
CLAY : light white, ferruginous, granules traces near top of unit, firm		4	128		Grout from surface to 26.6 mbgl
		6	126		
		8	124		
		10	122		50 mm Class 18 PVC Environmental Casing
CLAY, sandy : light to medium reddish-brown, ferruginous, firm, haematitic. Base of Tertiary at 18 mbgl.		12	120		
		14	118		
		16	116		
		18	114		
SILTSTONE : light to medium greyish-brown, clayey, extremely weathered		20	112		
		22	110		
		24	108		Bore Dry - 26/8/2019
		26	106		Bentonite Seal - 26.6 to 27.6 mbgl
		28	104		Gravel Pack - 27.6 to 31.6 mbgl
COAL: black, extremely weathered. Aries 3 Upper Seam		30	102		Screen - machine-slotted 50 mm PVC - 28.6 to 31.6 mbgl
SILTSTONE : medium to dark greyish-grey, extremely weathered.					
COAL: extremely weathered. Aries 3 Seam					
SILTSTONE : medium to dark brownish-grey, soil and clayey, slightly weathered.		32			

JBT consulting

Easting: 730394.4

Northing: 7382702.7

Collar RL (mAHD): 132.4

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig: Gardner Denver 1400

Hole Diameter (mm): 120

Total Depth (m): 31.59

Project: Gemini Project

Bore ID: DW7072W

Drilled Date: 08-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
		1	133		Stickup to Lip of Steel Monument - 0.93 m
SOIL: light to medium reddish-brown, very loose.		0	132		
CLAY: light to medium brown, silty		1	131		Grout from surface to 9 mbgl
		2	130		
		3	129		
		4	128		
CLAY: light greyish-white, lateritic		5	127		50 mm Class 18 PVC Environmental Casing
		6	126		
		7	125		
		8	124		
CLAY, silty: light white		9	123		Bentonite Seal - 9 to 10 mbgl
		10	122		
		11	121		Gravel Pack - 10 to 14 mbgl
CLAY, silty: light creamy-white, rare (<1%) ferruginous traces, firm.		12	120		
		13	119		Screen - machine-slotted 50 mm PVC - 11 to 14 mbgl
CLAY: medium to dark reddish-brown, ferruginous with limonitic traces, firm, haematitic. Base of Tertiary at 14 mbgl		14			Bore Dry - 26/8/2019

JBT consulting

Easting: 730403.1

Northing: 7382686.8

Collar RL (mAHD): 132.3

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig: Gardner Denver 1400

Hole Diameter (mm): 120

Total Depth (m): 14.01

Project: Gemini Project

Bore ID: DW7073W

Drilled Date: 11-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL: light brownish-red, lithic, oxidised, medium dense, earthy, haematitic		0	125		Stickup to Lip of Steel Monument - 0.90 m
SAND, clayey: light brownish-red, oxidised, ferruginous, firm, haematitic		5	120		
SAND, clayey: light creamy-white, firm, chalky		10	115		
CLAY: light greyish-white, firm, light reddish-brown and ferruginous towards base of unit. Base of Tertiary at 16 mbgl.		15	110		
SILTSTONE: light to medium greyish-brown, clayey bands near base of unit, extremely weathered,		20	105		Grout from surface to 77.1 mbgl
SILTSTONE: medium to dark greyish-brown, carbonaceous, extremely weathered		25	100		
SILTSTONE: medium to dark grey, oxidised, ferruginous in part, slightly weathered, haematitic. Base of weathering at 35 mbgl		30	95		
SILTSTONE: medium to dark grey, shaly near base of unit, fresh.		35	90		Water level - 32.71 mbgl - 26/8/2019
COAL: black, fresh, Aries Seam. Ground water observed by the driller.		40	85		
SILTSTONE: medium to dark grey, claystone bands near top of unit, fresh		45	80		50 mm Class 18 PVC Environmental Casing
COAL: black, fresh, Castor Upper Seam		50	75		
SILTSTONE: light to dark grey, carbonaceous, fresh, low strength rock, common (15-30%) plant fragments		55	70		
SANDSTONE, fine to medium: light to medium grey, with siltstone laminae (2-20mm)		60	65		
SILTSTONE: medium to dark grey		65	60		
COAL: black, Castor Lower Seam		70	55		
SILTSTONE: medium to dark grey.		75	50		
COAL: black, Pollux Upper Seam		80	45		Bentonite Seal - 77.1 to 78.1 mbgl
SILTSTONE: medium to dark grey		85	40		Gravel Pack - 78.1 to 82.1 mbgl
COAL: black, Pollux Upper 1 Seam			35		Screen - machine-slotted 50 mm PVC - 79.1 to 82.1 mbgl
SILTSTONE: medium to dark grey					

JBT consulting

Easting: 729925.9

Northing: 7382666

Collar RL (mAHD): 122.09

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig: Gardner Denver 1400

Hole Diameter (mm): 120

Total Depth (m): 82.1

Project: Gemini Project

Bore ID: DW7074W

Drilled Date: 11-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL: light brownish-red, lithic, oxidised, medium dense, earthy, haematitic		0	124		Stickup to Lip of Steel Monument - 0.91 m
SAND, clayey: light brownish-red, oxidised, ferruginous, firm, haematitic.					
SAND, clayey: light creamy-white, firm, chalky		4	120		
CLAY: light greyish-white, firm, chalky			116		
CLAY: mottled yellowish-brown, firm		8			Grout from surface to 52.3 mbgl
CLAY: light reddish-white, oxidised, ferruginous near middle of unit. Base of Tertiary at 16 mbgl.		12	112		
SILTSTONE: light to medium greyish-brown, clayey bands near base of unit, extremely weathered		16	108		50 mm Class 18 PVC Environmental Casing
SILTSTONE: medium to dark reddish-brown, extremely weathered		20	104		
SILTSTONE: medium to dark grey, oxidised, ferruginous in part, slightly weathered. Base of Weathering at 35 mbgl		24	100		
SILTSTONE: medium to dark grey, shaly near base of unit		28	96		
COAL: black, Aries 3 Seam		32	92		Water level - 32.72 mbgl - 26/8/2019
SILTSTONE: medium to dark grey		36	88		
COAL: black, Aries 3 Lower Seam		40	84		
SILTSTONE: medium to dark grey		44	80		
COAL: black, Castor Upper Seam		48	76		
SILTSTONE: light to dark grey, carbonaceous, fresh, low strength rock, common (15-30%) plant fragments		52	72		Bentonite Seal - 52.3 to 53.3 mbgl Gravel Pack - 53.3 to 55.8 mbgl Screen - machine-slotted 50 mm PVC - 54.3 to 55.8 mbgl
		56	68		
		60	64		

JBT consulting

Easting: 729921.7

Northing: 7382665.9

Collar RL (mAHD): 122.04

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig: Gardner Denver 1400

Hole Diameter (mm): 120

Total Depth (m): 55.78

Project: Gemini Project

Bore ID: DW7075W

Drilled Date: 11-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
		1	122		Stickup to Lip of Steel Monument - 1.09 m
SOIL: light brownish-red, lithic, oxidised, medium dense, earthy, haematitic		0			
SAND, clayey: light brownish-red, oxidised, ferruginous, firm, haematitic		1	121		
SAND, clayey: light creamy-white, firm, chalky		2	120		Grout from surface to 9 mbgl
		3	119		
		4	118		
		5	117		50 mm Class 18 PVC Environmental Casing
CLAY: light greyish-white, firm, chalky		6	116		
		7	115		
CLAY: mottled yellowish-brown, limonitic traces near top of unit, firm.		8	114		
		9	113		Bentonite Seal - 9 to 10 mbgl
CLAY: medium to dark greyish-brown, oxidised, ferruginous, firm, haematitic		10	112		
		11	111		Gravel Pack - 10 to 14 mbgl
		12	110		
CLAY: light greyish-white, minor (1-15%) limonitic traces, firm.		13	109		Screen - machine-slotted 50 mm PVC - 11 to 14 mbgl
		14	108		Bore Dry - 26/8/2019
		15	107		

JBT consulting

Easting: 729917.9

Northing: 7382665.7

Collar RL (mAHD): 121.83

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig: Gardner Denver 1400

Hole Diameter (mm): 120

Total Depth (m): 14.03

Project: Gemini Project

Bore ID: DW7076W

Drilled Date: 12-Apr-2018

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
		1	120		Stickup to Lip of Steel Monument - 1.14 m
SOIL: medium to dark brown, loose.		0			
		1	119		
		2	118		Grout from surface to 7 mbgl
		3	117		
SAND: medium to dark reddish-brown, clayey near top of unit near base of unit, medium dense.		4	116		
		5	115		50 mm Class 18 PVC Environmental Casing
		6	114		
		7	113		Bentonite Seal - 7 to 8 mbgl
CLAY: light to medium whitish-grey, ferruginous, granules throughout, firm.		8	112		
		9	111		
CLAY, sandy: light to medium white, minor (1-15%) limonitic traces, stiff.		10	110		Water level - 9.78 mbgl - 26/8/2019 Gravel Pack - 8 to 12 mbgl
		11	109		Screen - machine-slotted 50 mm PVC - 9 to 12 mbgl
		12	108		

JBT consulting

Easting: 729749.5

Northing: 7382722.8

Collar RL (mAHD): 119.81

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig: Gardner Denver 1400

Hole Diameter (mm): 120

Total Depth (m): 12

Project: Gemini Project

Bore ID: DW7082W1

Drilled Date: 16-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, dark brownish-grey		0	136		Stickup to Lip of Steel Monument - 1.08 m
CLAY, silty, medium to dark		4	132		
SAND		8	128		
CLAY, sandy, medium greyish-brown		12	124		Grout from surface to 37 mbgl
CLAY, light to medium brownish-grey, sandy		16	120		Water level - 16.91 mbgl - 22/8/2019
		20	116		50 mm Class 18 PVC Environmental Casing
SILTSTONE, light to medium brownish-grey, sandy towards base of unit		24	112		
		28	108		
		32	104		
		36	100		Bentonite Seal - 37 to 38 mbgl
COAL, Castor Lower Seam		40	96		Gravel Pack - 38 to 40.6 mbgl Screen - machine-slotted 50 mm PVC - 39 to 40.5 mbgl

JBT consulting

Easting: 728989.3

Northing: 7378745.8

Collar RL (mAHD): 135.26

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 40.58

Project: Gemini Project

Bore ID: DW7082W2

Drilled Date: 16-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, dark brownish-grey		0	136		Stickup to Lip of Steel Monument - 0.99 m
CLAY, silty, medium to dark		4	132		
SAND		8	128		
CLAY, sandy, medium greyish-brown		12	124		Grout from surface to 55.7 mbgl
CLAY, light to medium brownish-grey, sandy		16	120		Water level - 17.04 mbgl - 22/8/2019
		20	116		50 mm Class 18 PVC Environmental Casing
SILTSTONE, light to medium brownish-grey, sandy towards base of unit		24	112		
		28	108		
		32	104		
		36	100		
COAL, Castor Lower Seam		40	96		
SILTSTONE		44	92		
CARBONACEOUS MUDSTONE, black		48	88		
SILTSTONE					
COALY SHALE, black					
CARBONACEOUS SILTSTONE, black					
SANDSTONE, fine to medium grained, light to medium grey					
SILTSTONE, light to dark grey		52	84		
SANDSTONE, light to medium grey					
SILTSTONE, sandstone bands					
SANDSTONE, fine to medium grained, grey		56	80		Bentonite Seal - 55.7 to 56.7 mbgl
SILTSTONE, light to dark grey					Gravel Pack - 56.7 to 59.2 mbgl
COAL, Pisces Upper Seam		60	76		Screen - machine-slotted 50 mm PVC - 57.7 to 59.2 mbgl
SILTSTONE, light to dark grey					
		64	72		

JBT consulting

Easting: 728986.3

Northing: 7378742.2

Collar RL (mAHD): 135.33

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

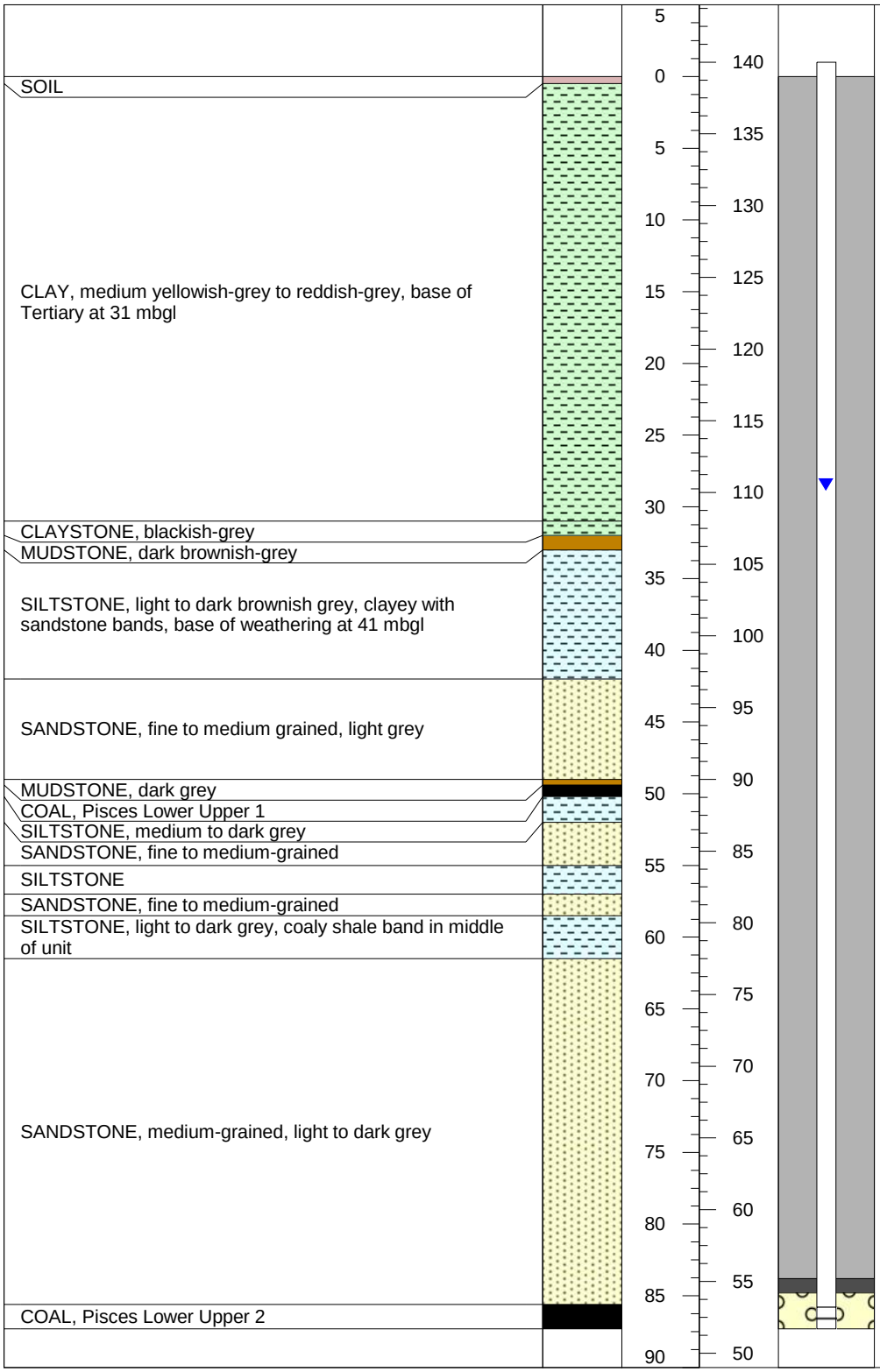
Total Depth (m): 59.17

Project: Gemini Project

Bore ID: DW7093W1

Drilled Date: 13-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL					Stickup to Lip of Steel Monument - 1.14 m
CLAY, medium yellowish-grey to reddish-grey, base of Tertiary at 31 mbgl					Grout from surface to 83.8 mbgl
					50 mm Class 18 PVC Environmental Casing
					Water level - 28.44 mbgl - 2/9/2019
CLAYSTONE, blackish-grey					
MUDSTONE, dark brownish-grey					
SILTSTONE, light to dark brownish grey, clayey with sandstone bands, base of weathering at 41 mbgl					
SANDSTONE, fine to medium grained, light grey					
MUDSTONE, dark grey					
COAL, Pisces Lower Upper 1					
SILTSTONE, medium to dark grey					
SANDSTONE, fine to medium-grained					
SILTSTONE					
SANDSTONE, fine to medium-grained					
SILTSTONE, light to dark grey, coaly shale band in middle of unit					
SANDSTONE, medium-grained, light to dark grey					
COAL, Pisces Lower Upper 2					Bentonite Seal - 83.8 to 84.8 mbgl Gravel Pack - 84.8 to 87.3 mbgl Screen - machine-slotted 50 mm PVC - 85.8 to 87.3 mbgl



JBT consulting

Easting: 730095.9

Northing: 7378973.6

Collar RL (mAHD): 139

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 87.3

Project: Gemini Project

Bore ID: DW7093W2

Drilled Date: 12-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL		0	140		Stickup to Lip of Steel Monument - 1.14 m
CLAY, medium yellowish-grey to reddish-grey, base of Tertiary at 31 mbgl		10	130		Grout from surface to 95.7 mbgl
		20	120		50 mm Class 18 PVC Environmental Casing
		30	110		Water level - 28.45 mbgl - 2/9/2019
CLAYSTONE, blackish-grey					
MUDSTONE, dark brownish-grey					
SILTSTONE, light to dark brownish grey, clayey with sandstone bands, base of weathering at 41 mbgl		40	100		
SANDSTONE, fine to medium grained, light grey					
MUDSTONE, dark grey		50	90		
COAL, Pisces Lower Upper 1					
SILTSTONE, medium to dark grey					
SANDSTONE, fine to medium-grained					
SILTSTONE					
SANDSTONE, fine to medium-grained					
SILTSTONE, light to dark grey, coaly shale band in middle of unit		60	80		
SANDSTONE, medium-grained, light to dark grey		70	70		
		80	60		
COAL, Pisces Lower Upper 2					
SILTSTONE, light to dark grey					
SANDSTONE, medium-grained		90	50		
SILTSTONE, light to dark grey					
		100	40		Bentonite Seal - 95.7 to 96.7 mbgl Gravel Pack - 96.7 to 99.2 mbgl Screen - machine-slotted 50 mm PVC - 97.7 to 99.2 mbgl

JBT consulting

Easting: 730095.9

Northing: 7378973.6

Collar RL (mAHD): 139

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 87.3

Project: Gemini Project

Bore ID: DW7093W3

Drilled Date: 11-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL		0	140		Stickup to Lip of Steel Monument - 1.05 m
CLAY, medium yellowish-grey to reddish-grey, base of Tertiary at 31 mbgl		10	130		Grout from surface to 119.8 mbgl
		20	120		50 mm Class 18 PVC Environmental Casing
		30	110		Water level - 28.46 mbgl - 2/9/2019
CLAYSTONE, blackish-grey					
MUDSTONE, dark brownish-grey					
SILTSTONE, light to dark brownish grey, clayey with sandstone bands, base of weathering at 41 mbgl		40	100		
SANDSTONE, fine to medium grained, light grey		50	90		
MUDSTONE, dark grey					
COAL, Pisces Lower Upper 1					
SILTSTONE, medium to dark grey					
SANDSTONE, fine to medium-grained		60	80		
SILTSTONE					
SANDSTONE, fine to medium-grained					
SILTSTONE, light to dark grey, coaly shale band in middle of unit		70	70		
SANDSTONE, medium-grained, light to dark grey		80	60		
COAL, Pisces Lower Upper 2					
SILTSTONE, light to dark grey		90	50		
SANDSTONE, medium-grained					
SILTSTONE, light to dark grey		100	40		
SANDSTONE, fine-grained					
SILTSTONE, light to dark grey		110	30		
COAL, Pisces Lower Lower 1					
SILTSTONE, light to dark grey		120	20		Bentonite Seal - 119.8 to 120.8 mbgl Gravel Pack - 120.8 to 123.3 mbgl Screen - machine-slotted 50 mm PVC - 121.8 to 123.3 mbgl
COAL, Pisces Lower Lower 2		130	10		

JBT consulting

Easting: 730088

Northing: 7378973.6

Collar RL (mAHD): 139.12

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 123.25

Project: Gemini Project

Bore ID: DW7105W1

Drilled Date: 17-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
		2	130		Stickup to Lip of Steel Monument - 0.95 m
SOIL, medium to dark brown		0	128		
CLAY, medium to dark brown		2	126		
		4	124		Grout from surface to 18 mbgl
BASALT, medium to dark yellowish brown, highly weathered		6	122		
		8	120		
		10	118		50 mm Class 18 PVC Environmental Casing
		12	116		
		14	114		
BASALT, medium to dark orangey grey, common ferruginous lenses		16	112		Water level - DRY - 25/7/2018
		18	110		Bentonite Seal - 18 to 19 mbgl
BASALT, sandy beneath base of unit, base of Tertiary at 23 mbgl		20	108		Gravel Pack - 19 to 23 mbgl
		22	106		Screen - machine-slotted 50 mm PVC - 20 to 23 mbgl
		24			

JBT consulting

Easting: 730192.1

Northing: 7380733

Collar RL (mAHD): 128.67

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 23.04

Project: Gemini Project

Bore ID: DW7105W2

Drilled Date: 16-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, medium to dark brown		0	128		Stickup to Lip of Steel Monument - 1.02 m
CLAY, medium to dark brown		4	124		
BASALT, medium to dark yellowish brown, highly weathered		8	120		Grout from surface to 60.7 mbgl
BASALT, medium to dark orangey grey, common ferruginous lenses		12	116		
BASALT, sandy beneath base of unit, base of Tertiary at 23 mbgl		16	112		
SILTSTONE, medium to dark brown and orangey-brown		20	108		50 mm Class 18 PVC Environmental Casing
COAL, Pisces Upper Seam		24	104		
SANDSTONE, fine-grained, light to dark grey to black		28	100		
CARBONACEOUS SILTSTONE		32	96		Water level - 31.08 mbgl - 22/8/2019
COALY SHALE		36	92		
SILTSTONE		40	88		
COALY SHALE		44	84		
SANDSTONE, fine-grained, light to dark grey		48	80		
CARBONACEOUS SILTSTONE		52	76		
SANDSTONE, fine to medium-grained, medium to dark grey		56	72		
CARBONACEOUS SILTSTONE		60	68		Bentonite Seal - 60.7 to 61.7 mbgl
SANDSTONE, grey					Gravel Pack - 61.7 to 64.2 mbgl
SILTSTONE, light to dark grey		64	64		Screen - machine-slotted 50 mm PVC - 62.7 to 64.2 mbgl
COAL, Pisces Lower Upper 1 Seam		68	60		Bentonite seal in overdrilled zone below casing
SILTSTONE, grey		72			
COAL, Pisces Lower Upper 1 Seam					
SILTSTONE, light to dark grey					

Easting: 730193	Drilling Company: Hodge Drilling
Northing: 7380729	Drill Rig:
Collar RL (mAHD): 128.7	Hole Diameter (mm): 120
Co-ord System: GDA94	Total Depth (m): 69.25

Project: Gemini Project

Bore ID: DW7178W1

Drilled Date: 24-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, medium to dark brown		0	128		Stickup to Lip of Steel Monument - 0.97 m
CLAY					
CLAY, lateritic		4	124		
FERRICRETE, dark reddish-brown					
CLAY		8	120		
SAND, fine-grained, light to medium yellow					
CLAY, sandy, light to medium whitish-cream		12	116		Grout from surface to 42 mbgl
CLAY, lateritic		16	112		
		20	108		50 mm Class 18 PVC Environmental Casing
FERRICRETE, dark reddish-brown					
CLAY, ferruginous traces		24	104		
CLAY, sandy, light to medium whitish-cream		28	100		
		32	96		
CLAY, light to medium pinkish cream, lateritic		36	92		Water level - 37.17 mbgl - 16/7/2019
		40	88		Bentonite Seal - 42 to 43 mbgl
SAND, fine to medium-grained, orangey-cream		44	84		Gravel Pack - 43 to 48.5 mbgl
GRAVEL, sandy, base of Tertiary at 47.5 mbgl					Screen - machine-slotted 50 mm PVC - 44 to 48.5 mbgl
SILTSTONE, medium to dark orangey-brown		48	80		Bentonite seal in overdrilled zone below casing
		52			

JBT consulting

Easting: 732173.7

Northing: 7383260

Collar RL (mAHD): 128.65

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 51.15

Project: Gemini Project

Bore ID: DW7178W2

Drilled Date: 24-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, medium to dark brown		0	128		Stickup to Lip of Steel Monument - 1.02 m
CLAY					
CLAY, lateritic		4	124		
FERRICRETE, dark reddish-brown					
CLAY		8	120		
SAND, fine-grained, light to medium yellow					
CLAY, sandy, light to medium whitish-cream		12	116		Grout from surface to 53.4 mbgl
CLAY, lateritic		16	112		
		20	108		50 mm Class 18 PVC Environmental Casing
FERRICRETE, dark reddish-brown					
CLAY, ferruginous traces		24	104		
CLAY, sandy, light to medium whitish-cream		28	100		
		32	96		
CLAY, light to medium pinkish cream, lateritic		36	92		Water level - 38.45 mbgl - 16/7/2019
		40	88		
SAND, fine to medium-grained, orangey-cream		44	84		
GRAVEL, sandy					
SILTSTONE, medium to dark orangey-brown		48	80		
		52	76		
CARBONACEOUS SILTSTONE, black					Bentonite Seal - 53.4 to 54.4 mbgl
SILTSTONE, brownish-grey					
COAL, Pisces Upper Seam					Gravel Pack - 54.4 to 58.4 mbgl
SILTSTONE, brownish-grey		56	72		
COAL, Pisces Lower Upper 1 Seam					
SILTSTONE, light to dark grey					Screen - machine-slotted 50 mm PVC - 55.4 to 58.4 mbgl
COAL, Pisces Lower Upper 2 Seam		60			

JBT consulting

Easting: 732174.4

Northing: 7383256

Collar RL (mAHD): 128.64

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 58.69

Project: Gemini Project

Bore ID: DW7220W1

Drilled Date: 02-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL		0	128		Stickup to Lip of Steel Monument - 1.04 m
CLAY, medium to dark brown		2	126		
CLAY, sandy, medium to dark orangey-brown		4	124		
CLAY, light to medium yellowish-white		6	122		Grout from surface to 21.5 mbgl
		8	120		
		10	118		50 mm Class 18 PVC Environmental Casing
		12	116		
		14	114		
SAND		16	112		Water level - 15.38 mbgl - 19/7/2019
CLAY, light white		18	110		
CLAY, sandy, light to medium yellowish-cream		20	108		
CLAY, light to medium reddish-cream		22	106		Bentonite Seal - 21.5 to 22.5 mbgl
		24	104		Gravel Pack - 22.5 to 26.5 mbgl
GRAVEL, sandy, base of Tertiary at 26.5 mbgl		26	102		Screen - machine-slotted 50 mm PVC - 23.5 to 26.5 mbgl
		28			

JBT consulting

Easting: 729775

Northing: 7379648

Collar RL (mAHD): 128.68

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 26.5

Project: Gemini Project

Bore ID: DW7220W2

Drilled Date: 02-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL		0	128		Stickup to Lip of Steel Monument - 0.98 m
CLAY, medium to dark brown		2	126		
CLAY, sandy, medium to dark orangey-brown		4	124		
CLAY, light to medium yellowish-white		6	122		Grout from surface to 30.4 mbgl
		8	120		
		10	118		
		12	116		
		14	114		
SAND		16	112		50 mm Class 18 PVC Environmental Casing
CLAY, light white		18	110		
CLAY, sandy, light to medium yellowish-cream		20	108		Water level - 19.25 mbgl - 19/7/2019
CLAY, light to medium reddish-cream		22	106		
		24	104		
GRAVEL, sandy, base of Tertiary at 27 mbgl		26	102		
SILTSTONE, light to medium orangey-grown, clayey bands throughout		28	100		
		30	98		Bentonite Seal - 30.4 to 31.4 mbgl
		32	96		Gravel Pack - 31.4 to 38.4 mbgl
SANDSTONE, medium-grained, medium to dark orangey-brown		34	94		
		36	92		Screen - machine-slotted 50 mm PVC - 32.4 to 38.4 mbgl
COAL, Castor Seam, weathered		38	90		
SILTSTONE, medium to dark grey		40			

JBT consulting

Easting: 729774.5

Northing: 7379651

Collar RL (mAHD): 128.64

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 38.4

Project: Gemini Project

Bore ID: DW7220W3

Drilled Date: 02-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL		0	128		Stickup to Lip of Steel Monument - 0.99 m
CLAY, medium to dark brown					
CLAY, sandy, medium to dark orangey-brown		4	124		
CLAY, light to medium yellowish-white		8	120		Grout from surface to 71.5 mbgl
		12	116		
SAND		16	112		
CLAY, light white					
CLAY, sandy, light to medium yellowish-cream		20	108		Water level - 19.04 mbgl - 23/8/2019
CLAY, light to medium reddish-cream		24	104		
GRAVEL, sandy, base of Tertiary at 27 mbgl		28	100		
SILTSTONE, light to medium orangey-grown, clayey bands throughout		32	96		50 mm Class 18 PVC Environmental Casing
SANDSTONE, medium-grained, medium to dark orangey-brown		36	92		
COAL, Castor Seam, weathered					
SILTSTONE, medium to dark grey		40	88		
COAL, Castor Seam		44	84		
SILTSTONE, medium to dark grey, sandy bands		48	80		
SANDSTONE, fine to medium grained, medium to dark grey		52	76		
SILTSTONE, light to dark grey, sandy bands		56	72		
SANDSTONE, fine to medium grained, medium to dark grey		60	68		
CARBONACEOUS SILTSTONE, black		64	64		
COAL, Pisces Upper Seam		68	60		
SILTSTONE, medium to dark grey		72	56		Bentonite Seal - 71.5 to 72.5 mbgl
SANDSTONE, fine to medium grained, medium to dark grey		76	52		Gravel Pack - 72.5 to 75 mbgl
SANDSTONE, medium to coarse-grained, light to dark grey		80			Screen - machine-slotted 50 mm PVC - 73.5 to 75 mbgl
COAL, Pisces Lower Upper 1 Seam					
CARBONACEOUS SILTSTONE, black					

JBT consulting

Easting: 729774.4

Northing: 7379655

Collar RL (mAHD): 128.68

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 75.08

Project: Gemini Project

Bore ID: DW7221W1

Drilled Date: 03-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, medium brown		0	128		Stickup to Lip of Steel Monument - 1.02 m
CLAY, sandy, medium to dark orangey-brown		4	124		
CLAY, medium orangey-cream to purplish-cream		8	120		Grout from surface to 45.4 mbgl
CLAY, sandy, medium to dark creamy-white		12	116		
SAND, clayey, light to medium yellowish-cream		16	112		50 mm Class 18 PVC Environmental Casing
CLAY, sandy, medium to dark purplish-cream		20	108		Water level - 20.5 mbgl - 23/8/2019
SILTSTONE, medium to dark orangey-brown		24	104		
SANDSTONE, medium-grained, medium to dark orangey-brown		28	100		
COAL, weathered		32	96		
SANDSTONE, medium to dark orangey-brown		36	92		
SILTSTONE, medium to dark orangey-brown		40	88		
SANDSTONE		44	84		Bentonite Seal - 45.4 to 46.4 mbgl
SILTSTONE, medium to dark brownish-grey		48	80		Gravel Pack - 46.4 to 50.4 mbgl
COAL		52			Screen - machine-slotted 50 mm PVC - 47.4 to 50.4 mbgl
CARBONACEOUS SILTSTONE, black					
COAL, Aries 3 Seam					
SILTSTONE					

JBT consulting

Easting: 729846.2

Northing: 7379745

Collar RL (mAHD): 129.32

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 50.43

Project: Gemini Project

Bore ID: DW7221W2

Drilled Date: 03-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, medium brown		0	132		Stickup to Lip of Steel Monument - 1.07 m
CLAY, sandy, medium to dark orangey-brown		4	128		
CLAY, medium orangey-cream to purplish-cream		8	124		Grout from surface to 68.9 mbgl
CLAY, sandy, medium to dark creamy-white		12	120		
SAND, clayey, light to medium yellowish-cream		16	116		
CLAY, sandy, medium to dark purplish-cream		20	112		Water level - 20.5 mbgl - 23/8/2019
SILTSTONE, medium to dark orangey-brown		24	108		
SANDSTONE, medium-grained, medium to dark orangey-brown		28	104		
COAL, weathered		32	100		50 mm Class 18 PVC Environmental Casing
SANDSTONE, medium to dark orangey-brown		36	96		
SILTSTONE, medium to dark orangey-brown		40	92		
SANDSTONE		44	88		
SILTSTONE, medium to dark brownish-grey		48	84		
COAL		52	80		
CARBONACEOUS SILTSTONE, black		56	76		
COAL, Aries 3 Seam		60	72		
SILTSTONE		64	68		
SANDSTONE, fine to medium grained, dark grey, silty and sandy bands		68	64		
SANDSTONE, medium to coarse-grained, light to medium grey		72	60		Bentonite Seal - 68.9 to 69.9 mbgl
SANDSTONE, fine to medium grained, dark grey, silty and sandy bands		76	56		Gravel Pack - 69.9 to 72.4 mbgl
SILTSTONE, light to dark grey					Screen - machine-slotted 50 mm PVC - 70.9 to 72.4 mbgl
COAL					
SANDSTONE, medium to dark grey					
CARBONACEOUS SILTSTONE, black					
COAL, Castor Seam					
CARBONACEOUS SILTSTONE, black					

JBT consulting

Easting: 729844.6

Northing: 7379742

Collar RL (mAHD): 129.25

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 72.36

Project: Gemini Project

Bore ID: DW7225W1

Drilled Date: 14-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, medium to dark brown		0	140		Stickup to Lip of Steel Monument - 1.06 m
CLAY, mottled purplish-cream		0 to 20	140 to 120		Grout from surface to 29 mbgl
CLAY, medium purplish-cream, lateritic		20 to 24	120 to 116		50 mm Class 18 PVC Environmental Casing
SAND, fine to medium-grained, light yellowish-brown, becoming medium to coarse near base		24 to 30	116 to 110		Bentonite Seal - 29 to 30 mbgl
CLAY, medium purplish-cream, lateritic		30 to 32	110 to 108		Gravel Pack - 30 to 37 mbgl
SAND, medium to coarse, light creamy-brown		32 to 34	108 to 106		Water level - 32.37 mbgl - 3/9/2019
CLAY, medium purplish-cream. Base of Tertiary at 37 mbgl		34 to 36	106 to 104		Screen - machine-slotted 50 mm PVC - 31 to 37 mbgl

JBT consulting

Easting: 730467.5

Northing: 7378359

Collar RL (mAHD): 140.64

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 37

Project: Gemini Project

Bore ID: DW7225W2

Drilled Date: 14-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, medium to dark brown		0	140		Stickup to Lip of Steel Monument - 1.07 m
CLAY, mottled purplish-cream		5	135		
		10	130		Grout from surface to 73.9 mbgl
		15	125		
		20	120		50 mm Class 18 PVC Environmental Casing
CLAY, medium purplish-cream, lateritic		25	115		
SAND, fine to medium-grained, light yellowish-brown, becoming medium to coarse near base		30	110		
CLAY, medium purplish-cream, lateritic					
SAND, medium to coarse, light creamy-brown					Water level - 32.1 mbgl - 3/9/2019
CLAY, medium purplish-cream. Base of Tertiary at 37 mbgl		35	105		
SILTSTONE, medium to dark orangey-brown, becoming sandy towards base		40	100		
SANDSTONE, fine-grained, medium grey		45	95		
SILTSTONE, medium greyish-brown					
COAL, weathered		50	90		
CARBONACEOUS MUDSTONE					
SANDSTONE, fine to medium-grained, medium to dark grey					
SILTSTONE, medium grey, common sandstone bands		55	85		
SANDSTONE, medium grained, light grey					
SILTSTONE, medium grey		60	80		
SANDSTONE, fine to medium-grained, light to medium grey, abundant siltstone bands		65	75		
		70	70		
SILTSTONE, medium grey					
SANDSTONE, fine grained, medium to dark grey					Bentonite Seal - 73.9 to 74.9 mbgl
SILTSTONE, medium to dark grey		75	65		Gravel Pack - 74.9 to 78.9 mbgl
COAL, Aries 3 Seam					Screen - machine-slotted 50 mm PVC - 75.9 to 78.9 mbgl
CARBONACEOUS SILTSTONE, blackish-grey		80	60		

JBT consulting

Easting: 730465.7

Northing: 7378355

Collar RL (mAHD): 140.69

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 78.9

Project: Gemini Project

Bore ID: DW7225W3

Drilled Date: 13-Jun-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, medium to dark brown		0	140		Stickup to Lip of Steel Monument - 1.04 m
CLAY, mottled purplish-cream		10	130		Grout from surface to 107.8 mbgl
CLAY, medium purplish-cream, lateritic		20	120		50 mm Class 18 PVC Environmental Casing
SAND, fine to medium-grained, light yellowish-brown, becoming medium to coarse near base					
CLAY, medium purplish-cream, lateritic		30	110		Water level - 31.6 mbgl - 3/9/2019
SAND, medium to coarse, light creamy-brown					
CLAY, medium purplish-cream. Base of Tertiary at 37 mbgl					
SILTSTONE, medium to dark orangey-brown, becoming sandy towards base		40	100		
SANDSTONE, fine-grained, medium grey					
SILTSTONE, medium greyish-brown		50	90		
COAL, weathered					
CARBONACEOUS MUDSTONE					
SANDSTONE, fine to medium-grained, medium to dark grey					
SILTSTONE, medium grey, common sandstone bands					
SANDSTONE, medium grained, light grey		60	80		
SILTSTONE, medium grey					
SANDSTONE, fine to medium-grained, light to medium grey, abundant siltstone bands		70	70		
SILTSTONE, medium grey					
SANDSTONE, fine grained, medium to dark grey					
SILTSTONE, medium to dark grey					
COAL, Aries 3 Seam					
CARBONACEOUS SILTSTONE, blackish-grey		80	60		
SILTSTONE, dark grey					
SANDSTONE, fine grained, light to medium grey					
SILTSTONE, medium grey, common sandstone bands					
SANDSTONE, fine grained, common siltstone bands		90	50		
SANDSTONE, fine grained, light to medium grey		100	40		
COAL, Castor Seam		110	30		Bentonite Seal - 107.8 to 108.8 mbgl Gravel Pack - 108.8 to 112.8 mbgl Screen - machine-slotted 50 mm PVC - 109.8 to 112.8 mbgl
CARBONACEOUS SILTSTONE, blackish-grey					
		120			

JBT consulting

Easting: 730464.7

Northing: 7378351

Collar RL (mAHD): 140.7

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 112.8

Project: Gemini Project

Bore ID: DW7264W1

Drilled Date: 14-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
		1	113		Stickup to Lip of Steel Monument - 0.98 m
SOIL, medium to dark brown		0	112		
CLAY		1	111		
SILCRETE, medium to dark orangey-brown		2	110		
CLAY, sandy, medium to dark brown		3	109		Grout from surface to 10.5 mbgl
		4	108		
		5	107		
		6	106		50 mm Class 18 PVC Environmental Casing
		7	105		
		8	104		Water level - DRY - 25/7/2018
CLAY, medium to dark orangey-brown, base of Tertiary at 14 mbgl		9	103		
		10	102		
		11	101		Bentonite Seal - 10.5 to 11.5 mbgl
		12	100		Gravel Pack - 11.5 to 14 mbgl
		13	99		Screen - machine-slotted 50 mm PVC - 12.5 to 14 mbgl
		14			

JBT consulting

Easting: 733392.2

Northing: 7382915

Collar RL (mAHD): 112.18

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 14

Project: Gemini Project

Bore ID: DW7264W2

Drilled Date: 14-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, medium to dark brown CLAY SILCRETE, medium to dark orangey-brown CLAY, sandy, medium to dark brown CLAY, medium to dark orangey-brown, base of Tertiary at 14 mbgl		0 10	110 100		Stickup to Lip of Steel Monument - 0.98 m Grout from surface to 100.7 mbgl
SILTSTONE, medium to dark brownish-grey		20	90		Water level - 21.59 mbgl - 15/7/2019
SANDSTONE, fine grained, medium to dark brownish grey, minor siltstone bands, base of weathering at 42 mbgl		30 40	80 70		50 mm Class 18 PVC Environmental Casing
SANDSTONE, fine to medium-grained, medium to dark grey, fresh		50	60		
SILTSTONE, light to dark grey, minor sandstone bands					
SANDSTONE, fine to medium-grained, medium to dark grey		60	50		
SILTSTONE, light to dark grey		70	40		
SANDSTONE, fine grained, medium to dark grey, minor siltstone bands		80	30		
SILTSTONE, light to dark grey, minor sandstone bands		90	20		
COAL, Aries 1 Upper Seam SILTSTONE, light to dark grey COAL, Aries 1 Lower Seam SILTSTONE, light to dark grey		100 110	10		Bentonite Seal - 100.7 to 101.7 mbgl Gravel Pack - 101.7 to 104.2 mbgl Screen - machine-slotted 50 mm PVC - 102.7 to 104.2 mbgl

JBT consulting

Easting: 733391.5

Northing: 7382921

Collar RL (mAHD): 112.24

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 104.21

Project: Gemini Project

Bore ID: DW7264W3

Drilled Date: 13-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, medium to dark brown		0	110		Stickup to Lip of Steel Monument - 1.00 m
CLAY					
SILCRETE, medium to dark orangey-brown					
CLAY, sandy, medium to dark brown		10	100		Grout from surface to 133.2 mbgl
CLAY, medium to dark orangey-brown, base of Tertiary at 14 mbgl					
SILTSTONE, medium to dark brownish-grey		20	90		Water level - 21.58 mbgl - 15/7/2019
		30	80		50 mm Class 18 PVC Environmental Casing
SANDSTONE, fine grained, medium to dark brownish grey, minor siltstone bands, base of weathering at 42 mbgl		40	70		
SANDSTONE, fine to medium-grained, medium to dark grey, fresh		50	60		
SILTSTONE, light to dark grey, minor sandstone bands		60	50		
SANDSTONE, fine to medium-grained, medium to dark grey					
SILTSTONE, light to dark grey		70	40		
SANDSTONE, fine grained, medium to dark grey, minor siltstone bands		80	30		
SILTSTONE, light to dark grey, minor sandstone bands		90	20		
COAL, Aries 1 Upper Seam		100	10		
SILTSTONE, light to dark grey					
COAL, Aries 1 Lower Seam					
SILTSTONE, light to dark grey					
SANDSTONE, medium to dark grey, fine to medium-grained, becoming medium to coarse-grained at base		110	0		
SILTSTONE, light to dark grey					
COAL, Aries 2 Seam					
SILTSTONE, light to dark grey		120	10		
SANDSTONE, medium to dark grey, fined to medium grained, medium to coarse-grained in middle of unit					
SILTSTONE, light to dark grey		130	20		
COAL, Aries 3 Seam					Bentonite Seal - 133.2 to 134.2 mbgl
CARBONACEOUS SILTSTONE, black		140	30		Gravel Pack - 134.2 to 136.7 mbgl Screen - machine-slotted 50 mm PVC - 135.2 to 136.7 mbgl
		150			

JBT consulting

Easting: 733390.9

Northing: 7382925

Collar RL (mAHD): 112.24

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 136.7

Project: Gemini Project

Bore ID: DW7282W1

Drilled Date: 26-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, light brown SAND, light creamy-white CLAY, light whitish-grey, lithic traces		0	116		Stickup to Lip of Steel Monument - 1.00 m
FERRICRETE, dark reddish-brown CLAY		4	112		
SILCRETE, light brownish-grey CLAY, light to medium brownish grey with lithic traces and ferruginous lenses, base of Tertiary at 13 mbgl		8	108		Grout from surface to 35 mbgl
		12	104		
SILTSTONE, medium to dark brownish-grey		16	100		
		20	96		50 mm Class 18 PVC Environmental Casing
LIMONITE, light to medium brownish-yellow		24	92		
SILTSTONE, medium to dark brownish-grey, base of weathering at 29 mbgl		28	88		Water level - 26.25 mbgl - 18/7/2019
SANDSTONE, fine to medium-grained, medium to dark grey		32	84		
SILTSTONE, medium to dark grey		36	80		Bentonite Seal - 35 to 36 mbgl
		40	76		Gravel Pack - 36 to 43 mbgl Screen - machine-slotted 50 mm PVC - 37 to 43 mbgl
		44	72		

JBT consulting

Easting: 732118.6

Northing: 7381433

Collar RL (mAHD): 115.84

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 43.03

Project: Gemini Project

Bore ID: DW7282W2

Drilled Date: 25-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
SOIL, light brown		0	115		Stickup to Lip of Steel Monument - 0.99 m
SAND, light creamy-white					
CLAY, light whitish-grey, lithic traces		5	110		
FERRICRETE, dark reddish-brown					
CLAY					
SILCRETE, light brownish-grey					
CLAY, light to medium brownish grey with lithic traces and ferruginous lenses, base of Tertiary at 13 mbgl		10	105		Grout from surface to 86.4 mbgl
SILTSTONE, medium to dark brownish-grey		15	100		
		20	95		50 mm Class 18 PVC Environmental Casing
LIMONITE, light to medium brownish-yellow		25	90		Water level - 26.32 mbgl - 18/7/2019
SILTSTONE, medium to dark brownish-grey, base of weathering at 29 mbgl					
SANDSTONE, fine to medium-grained, medium to dark grey		30	85		
SILTSTONE, medium to dark grey		35	80		
		40	75		
SANDSTONE, fine to medium-grained, light to dark grey					
SILTSTONE, dark grey		45	70		
SANDSTONE, fine to medium-gained, light to medium grey					
SILTSTONE, medium to dark grey, with sandstone and siderite bands		50	65		
COAL, Aries 1 Seam					
CARBONACEOUS SILTSTONE, black					
SILTSTONE, medium to dark grey		55	60		
SANDSTONE, fine to medium grained, becoming medium to coarse grained towards base, light to dark grey with carbonaceous claystone and siderite bands		60	55		
		65	50		
		70	45		
SILTSTONE, medium to dark grey					
COAL, Aries 2 Seam		75	40		
SILTSTONE, medium to dark grey					
SANDSTONE, medium to coarse-grained, light to dark grey					
SILTSTONE, medium to dark grey					
SANDSTONE, fine-grained, medium to dark grey		80	35		
SILTSTONE, medium to dark grey					
SANDSTONE, fine to medium-grained, medium to dark grey					
SILTSTONE, dark grey		85	30		Bentonite Seal - 86.4 to 87.4 mbgl
COAL, Aries 3 Seam					Gravel Pack - 87.4 to 89.9 mbgl
SILTSTONE, dark blackish-grey		90	25		Screen - machine-slotted 50 mm PVC - 88.4 to 89.9 mbgl
		95			

JBT consulting

Easting: 732122.9

Northing: 7381433

Collar RL (mAHD): 115.83

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 89.91

Project: Gemini Project

Bore ID: DW7292W1

Drilled Date: 26-May-2019

Lithological Description	Graphic Log	Depth (m)	Elevation (mAHD)	Bore Design	Bore Construction/ General Drilling Notes
		1	114		Stickup to Lip of Steel Monument - 0.83 m
SOIL, medium to dark brown		0			
		1	113		
CLAY, medium to dark orangey-brown		2	112		
		3	111		Grout from surface to 10 mbgl
		4	110		
Silty CLAY, light to dark grey		5	109		
		6	108		
		7	107		50 mm Class 18 PVC Environmental Casing
Sandy CLAY, medium to dark brownish-orange		8	106		
		9	105		
FERRICRETE, dark reddish-brown		10	104		
		11	103		Bentonite Seal - 10 to 11 mbgl
Silty CLAY, light white, lithic traces		12	102		Water level - 11.19 mbgl - 23/8/2019
		13	101		Gravel Pack - 11 to 15 mbgl
FERRICRETE, dark reddish-brown		14	100		Screen - machine-slotted 50 mm PVC - 12 to 15 mbgl
Silty CLAY, light white, lithic traces		15	99		

JBT consulting

Easting: 732904.7

Northing: 7381108

Collar RL (mAHD): 113.58

Co-ord System: GDA94

Drilling Company: Hodge Drilling

Drill Rig:

Hole Diameter (mm): 120

Total Depth (m): 15

APPENDIX B

GROUNDWATER CHEMISTRY DATA

Appendix B1: pH, EC, TDS, Major Ion Data

Site	Groundwater Unit	Date	pH (Lab)	pH (Field)	EC (Lab)	EC (Field)	TDS	Na	Ca	Mg	K	Cl	SO4	Alkalinity			
														Carbonate	Bicarbonate	Hydroxide	Total
			Unit	Unit	µS/cm	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
DW7065W	AR3	12-Dec-2018	8.21	6.33	28400	27187	19800	4720	439	724	24	9380	679	<1	608	<1	608
DW7065W	AR3	07-Jan-2019	6.85	6.37	27300	28450	19700	5190	456	849	24	9470	711	<1	589	<1	589
DW7065W	AR3	18-Feb-2019	6.81	6.42	28200	28360	19100	5100	458	774	23	9720	789	<1	568	<1	568
DW7065W	AR3	11-Mar-2019	7.01	6.46	28100	27619	19700	5390	508	846	24	9970	781	<1	583	<1	583
DW7065W	AR3	17-Apr-2019	7.03	6.45	26800	27639	19200	5000	551	815	24	9750	733	<1	599	<1	599
DW7065W	AR3	13-May-2019	7.11	6.48	25800	27367	19300	5010	442	792	24	9620	776	<1	610	<1	610
DW7065W	AR3	19-Jun-2019		6.59		27033		4820	516	760	22	9730	763	<1	592	<1	592
DW7065W	AR3	11-Jul-2019	7.78		27400		18100	4860	482	757	26	9120	741	<1	654	<1	654
DW7065W	AR3	26-Aug-2019	7.05	6.47	27400	27509	18900	4740	488	752	24	10200	826	<1	614	<1	614
DW7067W	AR3	12-Dec-2018	8.21	6.29	28500	27457	19900	4660	421	729	26	9590	716	<1	589	<1	589
DW7067W	AR3	07-Jan-2019	6.86	6.29	28000	29175	19900	5040	471	863	28	9720	767	<1	599	<1	599
DW7067W	AR3	18-Feb-2019	6.79	6.38	28500	28613	19300	5160	456	793	27	9820	841	<1	580	<1	580
DW7067W	AR3	11-Mar-2019	6.99	6.45	28500	28023	20500	5480	494	865	26	10100	780	<1	603	<1	603
DW7067W	AR3	17-Apr-2019	6.98	6.41	27200	28021	18600	5060	540	820	27	9750	746	<1	597	<1	597
DW7067W	AR3	13-May-2019	7.01	6.43	26300	28004	20100	5130	435	816	27	9840	764	<1	608	<1	608
DW7067W	AR3	19-Jun-2019		6.84		27800		4900	508	808	26	10100	798	<1	583	<1	583
DW7067W	AR3	11-Jul-2019	7.73		28400		19000	4930	462	784	26	9400	777	<1	634	<1	634
DW7067W	AR3	26-Aug-2019	7.04	6.43	27700	27930	19200	4740	482	769	27	10400	837	<1	614	<1	614
DW7069W	Castor Lower/Pollux Upper	12-Dec-2018	8.28	6.3	25500	24484	17600	4590	349	627	23	8490	623	<1	587	<1	587
DW7069W	Castor Lower/Pollux Upper	07-Jan-2019	6.87	6.25	25000	25868	17700	4500	321	636	21	8670	610	<1	580	<1	580
DW7069W	Castor Lower/Pollux Upper	18-Feb-2019	6.77	6.33	22100	22731	14500	4210	312	553	20	7720	645	<1	530	<1	530
DW7069W	Castor Lower/Pollux Upper	11-Mar-2019	6.92	6.38	23500	23087	16300	4590	352	634	22	8590	387	<1	566	<1	566
DW7069W	Castor Lower/Pollux Upper	17-Apr-2019	7.02	6.33	23000	23682	14900	4300	396	612	21	8210	618	<1	578	<1	578
DW7069W	Castor Lower/Pollux Upper	13-May-2019	6.91	6.39	22600	23989	16000	4110	299	574	20	8470	653	<1	595	<1	595
DW7069W	Castor Lower/Pollux Upper	19-Jun-2019		6.51		24483		4280	388	622	21	8800	671	<1	573	<1	573
DW7069W	Castor Lower/Pollux Upper	11-Jul-2019	7.67		24800		16400	4340	343	606	21	8270	642	<1	606	<1	606
DW7069W	Castor Lower/Pollux Upper	26-Aug-2019	6.98	6.36	24500	24741	16800	4350	379	615	23	9090	762	<1	599	<1	599
DW7073W	Castor Lower/Pollux Upper	13-Dec-2018	8.23	6.26	24500	23392	17100	4340	423	485	21	8240	341	<1	411	<1	411
DW7073W	Castor Lower/Pollux Upper	07-Jan-2019	6.84	6.21	24100	25049	16800	4380	401	512	20	8150	346	<1	423	<1	423
DW7073W	Castor Lower/Pollux Upper	18-Feb-2019	6.77	6.32	24100	24459	16000	4530	432	502	21	8180	404	<1	414	<1	414
DW7073W	Castor Lower/Pollux Upper	11-Mar-2019	6.97	6.39	24300	23980	17200	4930	483	557	22	9080	550	<1	436	<1	436
DW7073W	Castor Lower/Pollux Upper	17-Apr-2019	6.98	6.33	23100	23847	16400	4380	514	517	21	8470	387	<1	423	<1	423
DW7073W	Castor Lower/Pollux Upper	13-May-2019	6.94	6.38	22600	23963	15900	4180	367	477	20	8510	388	<1	449	<1	449
DW7073W	Castor Lower/Pollux Upper	19-Jun-2019		6.52		23989		4230	476	501	20	8780	383	<1	422	<1	422
DW7073W	Castor Lower/Pollux Upper	11-Jul-2019	7.64		24400		15800	4300	430	498	20	8160	373	<1	452	<1	452
DW7073W	Castor Lower/Pollux Upper	26-Aug-2019	6.98	6.35	24000	24057	15800	4280	452	491	21	8730	417	<1	460	<1	460
DW7074W	Castor Upper	13-Dec-2018	8.34	6.71	26100	25085	18000	4720	327	606	25	8670	488	20	585	<1	605
DW7074W	Castor Upper	07-Jan-2019	7.18	6.57	25500	26576	18200	4650	302	616	23	8890	511	<1	624	<1	624
DW7074W	Castor Upper	18-Feb-2019	6.99	6.55	25700	26043	16900	4880	329	605	24	8920	600	<1	605	<1	605
DW7074W	Castor Upper	11-Mar-2019	7.23	6.65	26000	25523	18000	5060	350	654	23	9220	574	<1	642	<1	642
DW7074W	Castor Upper	17-Apr-2019	7.19	6.56	24500	25280	17000	4700	380	619	23	8850	546	<1	620	<1	620
DW7074W	Castor Upper	13-May-2019	7.17	6.59	24200	25440	16900	4450	285	571	22	8980	570	<1	637	<1	637
DW7074W	Castor Upper	19-Jun-2019		6.69		25929		4640	372	612	22	9080	560	<1	635	<1	635
DW7074W	Castor Upper	11-Jul-2019	7.8		25800		16900	4790	332	612	23	8570	528	<1	661	<1	661
DW7074W	Castor Upper	26-Aug-2019	7.2	6.55	25300	25483	17000	4570	358	587	24	9180	578	<1	634	<1	634
DW7076W	Alluvium	12-Dec-2018	8.04	7.24	16200	14782	10600	2410	42	279	10	4170	214	<1	3600	<1	3600
DW7076W	Alluvium	07-Jan-2019	8.04	7.05	16600	17106	10500	3720	62	407	15	4290	205	<1	3620	<1	3620
DW7076W	Alluvium	18-Feb-2019	7.57	7.2	16000	16262	10000	3490	67	368	13	4140	231	<1	3480	<1	3480
DW7076W	Alluvium	11-Mar-2019	7.66	7.37	16200	16145	10400	3760	65	383	14	4190	249	<1	3540	<1	3540
DW7076W	Alluvium	17-Apr-2019	7.37	7.38	15400	15760	10300	3420	73	357	14	4060	212	<1	3510	<1	3510

Appendix B1: pH, EC, TDS, Major Ion Data

Site	Groundwater Unit	Date	pH (Lab)	pH (Field)	EC (Lab)	EC (Field)	TDS	Na	Ca	Mg	K	Cl	SO4	Alkalinity			
														Carbonate	Bicarbonate	Hydroxide	Total
			Unit	Unit	µS/cm	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
DW7076W	Alluvium	13-May-2019	7.84	7.36	15200	15632	10100	3370	47	329	15	4120	204	<1	3680	<1	3680
DW7076W	Alluvium	19-Jun-2019		7.49		15602		3340	49	335	13	4030	220	<1	3480	<1	3480
DW7076W	Alluvium	11-Jul-2019	7.76		15400		9980	3410	48	317	15	3750	210	<1	1840	<1	1840
DW7076W	Alluvium	26-Aug-2019	7.79	7.29	15300	14975	9200	3170	45	292	16	4040	209	562	2960	<1	3520
DW7068W	Tertiary	12-Dec-2018	8.29	6.86	20200	19273	14000	3530	216	523	101	6940	291	<1	607	<1	607
DW7068W	Tertiary	07-Jan-2019	7.26	6.78	20600	21433	14300	3710	211	575	82	7240	295	<1	601	<1	601
DW7068W	Tertiary	18-Feb-2019	7.23	6.98	21000	21493	13400	3880	226	563	77	7390	344	<1	578	<1	578
DW7068W	Tertiary	11-Mar-2019	7.38	6.95	21200	20960	14900	4040	234	596	73	8160	635	<1	593	<1	593
DW7068W	Tertiary	17-Apr-2019	7.57	7.06	20800	21270	13700	3780	259	577	72	7480	338	<1	600	<1	600
DW7068W	Tertiary	13-May-2019	7.42	6.93	20200	21301	14700	3790	202	568	72	7650	334	<1	602	<1	602
DW7068W	Tertiary	11-Jul-2019	7.89		21900		14300	4120	246	647	68	7220	334	<1	619	<1	619
Alluvium	Count			8	8	8	8	9	9	9	9	9	9	1	9	0	9
	Min			7.05	15200	14782	9200	2410	42	279	10	3750	204	562	1840		1840
	Max			7.49	16600	17106	10600	3760	73	407	16	4290	249	562	3680		3680
	Mean			7.2975	15788	15783	10135	3343	55	341	14	4088	217		3301		3363
	Median			7.325	15700	15696	10200	3410	49	335	14	4120	212		3510		3520
	StDev			0.13	491	691	413	373	11	40	2	142	14		553		542
Tertiary	Count			6	7	6	7	7	7	7	7	7	7	0	7	0	7
	Min			6.78	20200	19273	13400	3530	202	523	68	6940	291		578		578
	Max			7.06	21900	21493	14900	4120	259	647	101	8160	635		619		619
	Mean			6.93	20843	20955	14186	3836	228	578	78	7440	367		600		600
	Median			6.94	20800	21286	14300	3790	226	575	73	7390	334		601		601
	StDev			0.09	555	771	491	185	19	35	10	360	111		12		12
Coal Seams	Count			40	40	40	40	45	45	45	45	45	45	1	45	0	45
	Min			6.21	22100	22731	14500	4110	285	477	20	7720	341	20	411		411
	Max			6.84	28500	29175	20500	5480	551	865	28	10400	841		661		661
	Mean			6.44	25693	25934	17760	4694	417	663	23	9081	622		568		569
	Median			6.42	25600	25696	17650	4700	430	622	23	9080	642		592		595
	StDev			0.14	1913	1823	1573	343	72	121	2	661	153		73		73

Appendix B2: Dissolved Metals/ Metalloid Data

Site	Groundwater Unit	Date	Al (diss)	As (diss)	Ba (diss)	Be (diss)	B (diss)	Cd (diss)	Cr (diss)	Co (diss)	Cu (diss)	Fe (diss)	Pb (diss)	Mn (diss)	Hg (diss)	Mo (diss)	Ni (diss)	Se (diss)	Ag (diss)	U (diss)	V (diss)	Zn (diss)
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC 2000 - 95% Freshwater Species Protection			**0.055**	**0.013**			**0.37**	**0.0002**	**0.001**		**0.0014**		**0.0034**	**1.9**	**0.0006**		**0.011**	**0.011**	**0.00005**			**0.008**
DW7065W	AR3	12-Dec-2018	0.01	0.023	0.076	<0.001	1.22	0.0002	<0.001	0.019	0.081	2.48	0.007	0.312	<0.0001	0.002	0.022	<0.01	<0.001	0.016	<0.01	0.21
DW7065W	AR3	07-Jan-2019	<0.01	0.029	0.168	<0.001	1.2	0.0001	<0.001	0.011	0.005	2.82	<0.001	0.247	<0.0001	0.002	0.015	<0.01	<0.001	0.01	<0.01	0.176
DW7065W	AR3	18-Feb-2019	<0.01	0.02	0.117	<0.001	1.37	<0.0001	<0.001	0.009	0.002	4.41	<0.001	0.227	<0.0001	0.001	0.017	<0.01	<0.001	0.008	<0.01	0.03
DW7065W	AR3	11-Mar-2019	<0.05	0.012	0.075	<0.005	1.21	<0.0005	<0.005	0.009	<0.005	3.99	<0.005	0.295	<0.0001	<0.005	0.011	<0.05	<0.005	<0.005	<0.05	0.075
DW7065W	AR3	17-Apr-2019	<0.01	0.019	0.105	<0.001	1.27	<0.0001	<0.001	0.007	0.001	3.43	<0.001	0.249	<0.0005	0.001	0.009	<0.01	<0.001	0.007	<0.01	0.094
DW7065W	AR3	13-May-2019	<0.01	0.019	0.279	<0.001	1.25	<0.0001	<0.001	0.007	0.003	3.74	<0.001	0.327	<0.0001	<0.001	0.013	<0.01	<0.001	0.008	<0.01	0.136
DW7065W	AR3	19-Jun-2019	<0.01	0.018	0.184	<0.001	1.1	<0.0001	<0.001	0.008	<0.001	3.99	<0.001	0.318	<0.0001	<0.001	0.013	<0.01	<0.001	0.008	<0.01	0.103
DW7065W	AR3	11-Jul-2019	<0.05	0.006	0.276	<0.005	1.29	<0.0005	<0.005	0.005	<0.005	1.55	<0.005	0.397	<0.0001	<0.005	0.013	<0.05	<0.005	0.005	<0.05	0.105
DW7065W	AR3	26-Aug-2019	<0.01	0.018	0.477	<0.001	1.25	<0.0001	<0.001	0.006	<0.001	4.37	<0.001	0.293	<0.0001	0.006	0.01	<0.01	<0.001	0.008	<0.01	0.07
DW7067W	AR3	12-Dec-2018	<0.01	0.006	0.06	<0.001	1.26	<0.0001	<0.001	0.005	0.047	1.99	0.004	0.107	<0.0001	0.001	0.007	<0.01	<0.001	0.004	<0.01	0.105
DW7067W	AR3	07-Jan-2019	<0.05	0.012	0.087	<0.005	1.48	<0.0005	<0.005	<0.005	0.009	2.85	<0.005	0.119	<0.0001	<0.005	<0.005	<0.05	<0.005	<0.005	<0.05	0.147
DW7067W	AR3	18-Feb-2019	<0.01	0.012	0.077	<0.001	1.44	<0.0001	<0.001	0.002	0.002	4.23	<0.001	0.104	<0.0001	0.001	0.007	<0.01	<0.001	0.003	<0.01	0.047
DW7067W	AR3	11-Mar-2019	<0.05	0.008	0.066	<0.005	1.22	<0.0005	<0.005	<0.005	<0.005	3.61	<0.005	0.103	<0.0001	<0.005	<0.005	<0.05	<0.005	<0.005	<0.05	0.062
DW7067W	AR3	17-Apr-2019	<0.01	0.008	0.068	<0.001	1.34	<0.0001	<0.001	0.001	<0.001	3.35	<0.001	0.105	<0.0001	<0.001	0.003	<0.01	<0.001	0.002	<0.01	0.066
DW7067W	AR3	13-May-2019	<0.01	0.007	0.133	<0.001	1.23	<0.0001	<0.001	0.001	0.014	3.02	<0.001	0.114	<0.0001	<0.001	0.005	<0.01	<0.001	0.002	<0.01	0.094
DW7067W	AR3	19-Jun-2019	<0.01	0.004	0.096	<0.001	1.2	<0.0001	<0.001	0.002	0.005	0.43	<0.001	0.087	<0.0001	0.001	0.006	<0.01	<0.001	0.002	<0.01	0.088
DW7067W	AR3	11-Jul-2019	<0.05	<0.005	0.129	<0.005	1.38	<0.0005	<0.005	<0.005	<0.005	2.16	<0.005	0.151	<0.0001	<0.005	0.009	<0.05	<0.005	<0.005	<0.05	0.143
DW7067W	AR3	26-Aug-2019	<0.01	0.006	0.183	<0.001	1.32	<0.0001	<0.001	0.001	<0.001	3	<0.001	0.114	<0.0001	0.002	0.006	<0.01	<0.001	0.002	<0.01	0.059
DW7069W	Castor Lower/Pollux Upper	12-Dec-2018	<0.01	0.003	0.059	<0.001	1.25	0.0001	<0.001	0.002	0.067	2.16	0.003	0.19	<0.0001	0.002	0.005	<0.01	<0.001	0.002	<0.01	0.146
DW7069W	Castor Lower/Pollux Upper	07-Jan-2019	<0.01	0.004	0.066	<0.001	1.15	<0.0001	<0.001	<0.001	0.024	2.45	<0.001	0.168	<0.0001	0.002	0.003	<0.01	<0.001	0.001	<0.01	0.124
DW7069W	Castor Lower/Pollux Upper	18-Feb-2019	<0.01	0.003	0.072	<0.001	1.4	<0.0001	<0.001	<0.001	0.008	2.37	<0.001	0.157	<0.0001	0.001	0.005	<0.01	<0.001	<0.001	<0.01	0.085
DW7069W	Castor Lower/Pollux Upper	11-Mar-2019	<0.05	<0.005	0.062	<0.005	1.11	<0.0005	<0.005	<0.005	<0.005	2.31	<0.005	0.173	<0.0001	<0.005	<0.005	<0.05	0.007	<0.005	<0.05	0.068
DW7069W	Castor Lower/Pollux Upper	17-Apr-2019	<0.01	0.002	0.06	<0.001	1.3	<0.0001	<0.001	<0.001	0.002	2.38	<0.001	0.162	<0.0001	0.001	0.002	<0.01	<0.001	<0.001	<0.01	0.064
DW7069W	Castor Lower/Pollux Upper	13-May-2019	<0.01	0.003	0.104	<0.001	1.23	<0.0001	<0.001	<0.001	0.011	2.22	<0.001	0.161	<0.0001	0.002	0.003	<0.01	<0.001	<0.001	<0.01	0.07
DW7069W	Castor Lower/Pollux Upper	19-Jun-2019	<0.01	0.003	0.081	<0.001	1.18	<0.0001	<0.001	<0.001	0.005	2.34	<0.001	0.157	<0.0001	0.001	0.004	<0.01	<0.001	<0.001	<0.01	0.101
DW7069W	Castor Lower/Pollux Upper	11-Jul-2019	<0.05	<0.005	0.085	<0.005	1.34	<0.0005	<0.005	<0.005	<0.005	1.83	<0.005	0.159	<0.0001	<0.005	0.007	<0.05	<0.005	<0.005	<0.05	0.129
DW7069W	Castor Lower/Pollux Upper	26-Aug-2019	<0.01	0.003	0.103	<0.001	1.3	<0.0001	<0.001	<0.001	0.002	2.63	<0.001	0.158	<0.0001	0.001	0.004	<0.01	<0.001	<0.001	<0.01	0.045
DW7073W	Castor Lower/Pollux Upper	13-Dec-2018	<0.01	<0.001	0.116	<0.001	1.04	<0.0001	<0.001	<0.001	0.047	1.13	<0.001	0.306	<0.0001	0.002	0.004	<0.01	<0.001	<0.001	<0.01	0.103
DW7073W	Castor Lower/Pollux Upper	07-Jan-2019	<0.01	<0.001	0.118	<0.001	0.94	<0.0001	<0.001	<0.001	0.018	1.85	<0.001	0.325	<0.0001	0.002	0.002	<0.01	<0.001	<0.001	<0.01	0.096
DW7073W	Castor Lower/Pollux Upper	18-Feb-2019	<0.01	0.001	0.132	<0.001	1.18	<0.0001	<0.001	<0.001	0.013	3.52	<0.001	0.339	<0.0001	0.002	0.005	<0.01	<0.001	<0.001	<0.01	0.097
DW7073W	Castor Lower/Pollux Upper	11-Mar-2019	<0.05	<0.005	0.122	<0.005	0.88	<0.0005	<0.005	<0.005	0.008	3.99	<0.005	0.352	<0.0001	<0.005	<0.005	<0.05	<0.005	<0.005	<0.05	0.068
DW7073W	Castor Lower/Pollux Upper	17-Apr-2019	<0.01	0.002	0.11	<0.001	1.05	<0.0001	<0.001	<0.001	0.002	4.22	<0.001	0.337	<0.0001	0.002	0.002	<0.01	<0.001	<0.001	<0.01	0.058
DW7073W	Castor Lower/Pollux Upper	13-May-2019	<0.01	0.002	0.153	<0.001	0.99	<0.0001	<0.001	<0.001	0.007	3.95	<0.001	0.323	<0.0001	0.002	0.002	<0.01	<0.001	<0.001	<0.01	0.048
DW7073W	Castor Lower/Pollux Upper	19-Jun-2019	<0.01	0.002	0.119	<0.001	1.07	<0.0001	<0.001	<0.001	0.003	3.94	<0.001	0.334	<0.0001	0.002	0.002	<0.01	<0.001	<0.001	<0.01	0.084
DW7073W	Castor Lower/Pollux Upper	11-Jul-2019	<0.05	<0.005	0.123	<0.005	1.15	<0.0005	<0.005	<0.005	<0.005	3.37	<0.005	0.335	<0.0001	<0.005	0.005	<0.05	<0.005	<0.005	<0.05	0.118
DW7073W	Castor Lower/Pollux Upper	26-Aug-2019	<0.01	0.001	0.137	<0.001	1.02	<0.0001	<0.001	<0.001	<0.001	3.84	<0.001	0.315	<0.0001	0.002	0.003	<0.01	<0.001	<0.001	<0.01	0.038
DW7074W	Castor Upper	13-Dec-2018	0.02	0.001	0.079	<0.001	1.33	<0.0001	<0.001	0.001	0.032	<0.05	0.002	0.216	<0.0001	0.01	0.004	<0.01	<0.001	0.002	<0.01	0.087
DW7074W	Castor Upper	07-Jan-2019	<0.01	0.001	0.086	<0.001	1.19	<0.0001	<0.001	0.001	0.015	0.08	<0.001	0.24	<0.0001	0.008	0.003	<0.01	<0.001	0.003	<0.01	0.065
DW7074W	Castor Upper	18-Feb-2019	<0.01	0.002	0.086	<0.001	1.45	<0.0001	<0.001	0.002	0.013	0.29	<0.001	0.243	<0.0001	0.007	0.006	<0.01	<0.001	0.003	<0.01	0.065
DW7074W	Castor Upper	11-Mar-2019	<0.05	<0.005	0.072	<0.005	1.13	<0.0005	<0.005	<0.005	<0.005	1.47	<0.005	0.249	<0.0001	<0.005	<0.005	<0.05	<0.005	<0.005	<0.05	0.043
DW7074W	Castor Upper	17-Apr-2019	<0.01	0.005	0.068	<0.001	1.3	<0.0001	<0.001	0.001	<0.001	1.74	<0.001	0.228	<0.0001	0.005	0.003	<0.01	<0.001	0.002	<0.01	0.042
DW7074W	Castor Upper	13-May-2019	<0.01	0.005	0.104	<0.001	1.28	<0.0001	<0.001	<0.001	0.008	2.41	<0.001	0.251	<0.0001	0.004	0.004	<0.01	<0.001	0.003	<0.01	0.046
DW7074W	Castor Upper	19-Jun-2019	<0.01	0.006	0.083	<0.001	1.34	<0.0001	<0.001	<0.001	0.006	1.8	<0.001	0.237	<0.0001	0.006	0.005	<0.01	<0.001	0.002	<0.01	0.073
DW7074W	Castor Upper	11-Jul-2019	<0.05	<0.005	0.094	<0.005	1.49	<0.0005	<0.005	<0.005	<0.005	0.96	<0.005	0.258	<0.0001	<0.005	0.008	<0.05	<0.005	<0.005	<0.05	0.067
DW7074W	Castor Upper	26-Aug-2019	0.01	0.002	0.106	<0.001	1.31	<0.0001	<0.001	<0.001	<0.001	1.68	<0.001	0.258	<0.0001	0.004	0.005	<0.01	<0.001	0.002	<0.01	0.025
DW7068W	Tertiary	12-Dec-2018	<0.01	<0.001	0.203	<0.001	1.16	<0.0001	<0.001	0.002	0.008	<0.05	<0.001	0.035	<0.0001	0.008	0.006	<0.01	<0.001	0.012	<0.01	0.017
DW7068W	Tertiary	07-Jan-2019	0.02	<0.001	0.199	<0.001	1.15	<0.0001	<0.001	0.002	0.014	<0.05	<0.001	0.036	<0.0001	0.005	0.005	<0.01	<0.001	0.01	<0.01	0.086
DW7068W	Tertiary	18-Feb-2019	<0.01	<0.001	0.216	<0.001	1.37	<0.0001	<0.001	0.002	0.002	<0.05	<0.001	0.032	<0.0001	0.006	0.004	<0.01	0.001	0.011	<0.01	0.035
DW7068W	Tertiary	11-Mar-2019	<0.05	<0.005	0.186	<0.005	1.14	<0.0005	<0.005	<0.005	<0.005	<0.05	<0.005	0.025	<0.0001	<0.005	<0.005	<0.05	<0.005	0.009	<0.05	0.03
DW7068W	Tertiary	17-Apr-2019	<0.01	<0.001	0.192	<0.001	1.34	<0.0001	<0.001	0.002	<0.001	0.08	<0.001	0.038	<0.0001	0.005	0.006	<0.01	<0.001	0.01	<0.01	0.032
DW7068W	Tertiary	13-May-2019	<0.01	0.001	0.201	<0.001	1.26	<0.0001	<0.001	0.001	0.001	<0.05	<0.001	0.039	<0.0001	0.005	0.006	<0.01	<0.001	0.011	<0.01	0.047
DW7068W	Tertiary	11-Jul-2019	<0.05	<0.005	0.198	<0.005	1.52	<0.0005	<0.005	<0.005	<0.005	0.08	<0.005	0.059	<0.0001	0.006	0.012	<0.05	<0.005	0.01	<0.05	0.096
DW7076W	Alluvium	12-Dec-2018	0.02	0.002	0.181	<0.001	0.56	<0.0001	<0.001	0.003	0.006	0.09	<0.001	0.112	<0.0001	<0.001	0.004	<0.01	<0.001	0.01	<0.01	<0.005
DW7076W	Alluvium	07-Jan-2019	<0.01	0.002	0.278	<0.001	3.81	<0.0001	<0.001	0.004	0.011	<0.05	<0.001	0.118	<0.0001	0.004	0.004	<0.01	<0.001	0.058	0.01	0.007
DW7076W	Alluvium	18-Feb-2019	<0.01	0.002	0.344	<0.001	3.94	<0.0001	<0.001	0.002	0.019	0.12	<0.001	0.072	<0.0001	0.002	0.004	<0.01	<0.001	0.058	0.03	0.007
DW7076W	Alluvium	11-Mar-2019	<0.05	<0.005	0.26	<0.005	3.3	<0.0005	<0.005	<0.005	0.023	0.13	<0.005	0.075	<0.0001	<0.005	<0.005	<0.05	<0.005	0.051	<0.05	0.028
DW7076W	Alluvium	17-Apr-2019	<0.01	0.002	0.233	<0.001	3.62	<0.0001	<0.001	0.002	0.01	0.05	<0.001	0.059	<0.0001	0.002	0.003	<0.01	<0.001	0.034	0.01	0.012
DW7076W	Alluvium	13-May-2019	0.01	0.002	0.232	<0.001	4.03	<0.0001	<0.001	0.002	0.015	0.13	<0.001	0.063	<0.0001	0.002	0.002	<0.01	<0.001	0.053	0.01	0.01
DW7076W	Alluvium	19-Jun-2019	0.05	0.003	0.186	<0.001	3.69	<0.0001	<0.001	0.004	0.018	0.15	<0.001	0.09	<0.0001	0.002	0.006	<0.01	<0.001	0.058	0.02	0.025
DW7076W	Alluvium	11-Jul-2019	<0.05	<0.005	0.2	<0.005	4.56	<0.0005	<0.005	<0.005	0.009	<0.05	<0.005	0.064	<0.0001	<0.005	<0.005	<0.05	<0.005	0.041	<0.05	<0.025
DW7076W	Alluvium	26-Aug-2019	0.06	0.002	0.189	<0.001	3.98	<0.0001	<0.001	0.002	0.002	<0.05	<0.001	0.07	<0.0001	0.002	0.004	<0.01	<0.001	0.04	0.01	0.019
Alluvium	Count		9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
	Count >LOR		4	7	9	0	9	0	0	7	9	6	0	9	0	6	7	0	0	9	6	7
	Min		0.01	0.002	0.181		0.56			0.002	0.002	0.05		0.059		0.002	0.002			0.01	0.01	0.007
	Max		0.06	0.003	0.344		4.56			0.004	0.023	0.15		0.118		0.004	0.006			0.058	0.03	0.028
	Mean		0.035	0.002	0.234		3.50			0.003	0.013	0.083		0.080		0.002	0.004			0.045	0.016	0.014
	Median		0.035	0.002	0.232		3.81			0.002	0.011	0.090		0.072		0.002	0.004			0.051	0.010	0.011
	StDev		0.024	0.0004	0.054		1.15			0.001	0.007	0.052		0.022		0.001	0.001			0.016	0.009	0.009

Appendix B2: Dissolved Metals/ Metalloid Data

Site	Groundwater Unit	Date	Al (diss)	As (diss)	Ba (diss)	Be (diss)	B (diss)	Cd (diss)	Cr (diss)	Co (diss)	Cu (diss)	Fe (diss)	Pb (diss)	Mn (diss)	Hg (diss)	Mo (diss)	Ni (diss)	Se (diss)	Ag (diss)	U (diss)	V (diss)	Zn (diss)
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC 2000 - 95% Freshwater Species Protection			**0.055**	**0.013**			**0.37**	**0.0002**	**0.001**		**0.0014**		**0.0034**	**1.9**	**0.0006**		**0.011**	**0.011**	**0.00005**			**0.008**
Tertiary	Count		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Count >LOR		1	1	7	0	7	0	0	5	4	2	0	7	0	6	6	0	1	7	0	7
	Min		0.02	0.001	0.186	0	1.14			0.001	0.001	0.08		0.025		0.005	0.004		0.001	0.009		0.017
	Max		0.02	0.001	0.216		1.52			0.002	0.014	0.08		0.059		0.008	0.012		0.001	0.012		0.096
	Mean				0.199		1.28			0.002	0.004			0.038		0.005	0.006			0.010		0.049
	Median				0.199		1.26			0.002	0.003			0.036		0.005	0.006			0.010		0.035
	StDev				0.009		0.14			0.001	0.005			0.010		0.002	0.003			0.001		0.030
Coal Seams	Count		45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
	Count >LOR		3	36	45	0	45	3	0	20	29	44	4	45	0	30	40	0	1	23	0	45
	Min		0.01	0.001	0.059	0	0.88	0.0001		0.001	0.001	0.08	0.002	0.087		0.001	0.002		0.007	0.001		0.025
	Max		0.02	0.029	0.477		1.49	0.0002		0.019	0.081	4.41	0.007	0.397		0.01	0.022		0.007	0.016		0.21
	Mean*			0.007	0.117		1.23			0.003	0.011	2.59	0.004	0.229		0.003	0.006			0.003		0.086
	Median*			0.003	0.103		1.25			0.002	0.003	2.45	0.004	0.240		0.002	0.005			0.003		0.075
	Standard Deviation*			0.007	0.073		0.14			0.004	0.018	1.20	0.002	0.086		0.002	0.005			0.003		0.039

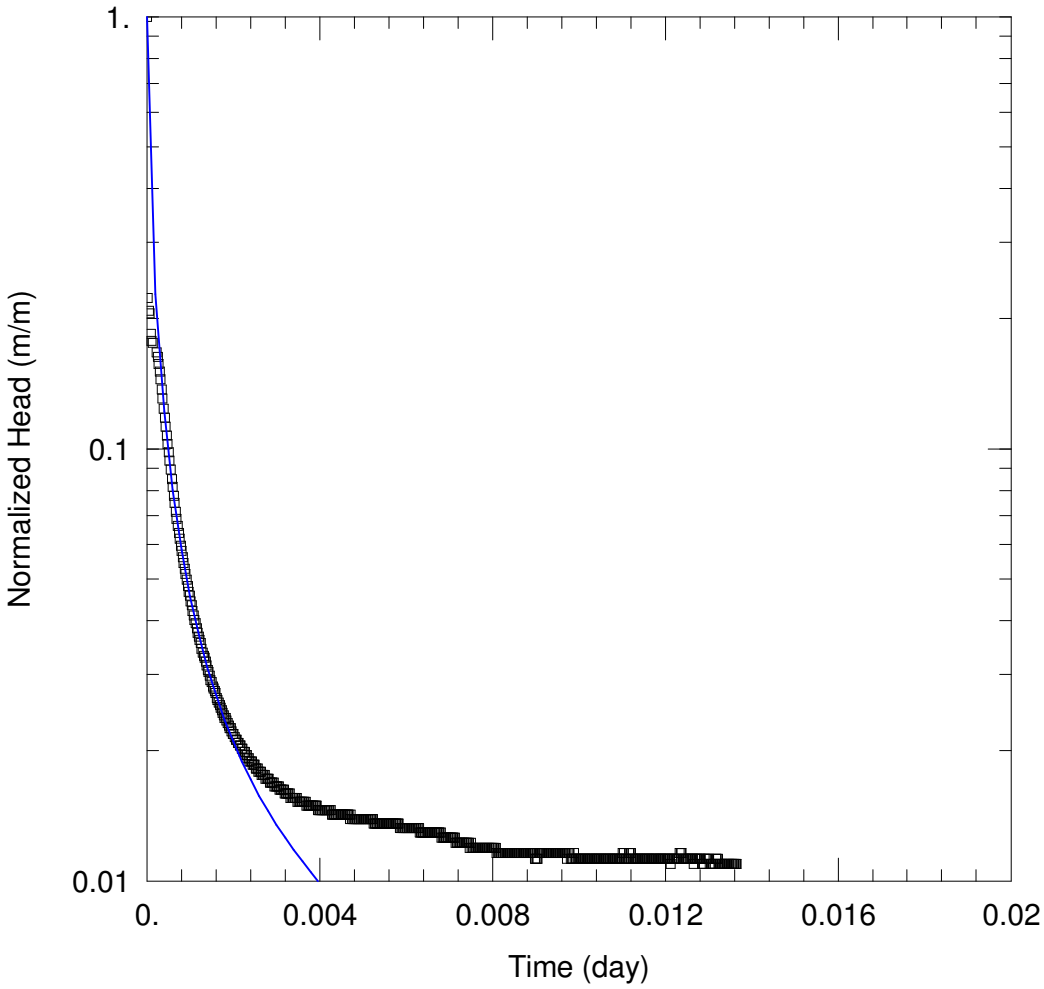
* For the purpose of statistical analysis, samples <LOR were converted to 0.5 x the LOR value

Appendix B3: Total Metals/ Metalloid Data

Site	Groundwater Unit	Date	Al (tot)	As (tot)	Ba (tot)	Be (tot)	B (tot)	Cd (tot)	Cr (tot)	Co (tot)	Cu (tot)	Fe (tot)	Pb (tot)	Mn (tot)	Hg (tot)	Mo (tot)	Ni (tot)	Se (tot)	Ag (tot)	U (tot)	V (tot)	Zn (tot)
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
DW7065W	AR3	12-Dec-2018	0.33	0.022	0.082	<0.001	1.33	0.0002	<0.001	0.018	0.102	2.82	0.012	0.316	<0.0001	0.001	0.022	<0.01	<0.001	0.013	<0.01	0.19
DW7065W	AR3	07-Jan-2019	0.1	0.033	0.204	<0.001	1.58	0.0002	<0.001	0.012	0.057	3.24	0.002	0.264	<0.0001	0.003	0.015	<0.01	<0.001	0.011	<0.01	0.204
DW7065W	AR3	18-Feb-2019	0.11	0.025	0.12	<0.001	1.29	0.0002	<0.001	0.009	0.03	4.66	<0.001	0.238	<0.0001	0.001	0.016	<0.01	<0.001	0.007	<0.01	0.124
DW7065W	AR3	11-Mar-2019	0.28	0.017	0.094	<0.005	1.64	<0.0005	<0.005	0.01	0.045	5.39	<0.005	0.362	<0.0001	<0.005	0.014	<0.05	<0.005	0.006	<0.05	0.09
DW7065W	AR3	17-Apr-2019	0.06	0.017	0.106	<0.001	1.13	<0.0001	<0.001	0.006	0.031	3.37	<0.001	0.231	<0.0005	0.001	0.008	<0.01	<0.001	0.007	<0.01	0.1
DW7065W	AR3	13-May-2019	0.06	0.022	0.32	<0.001	1.37	<0.0001	<0.001	0.008	0.039	4.15	<0.001	0.35	<0.0001	0.001	0.014	<0.01	<0.001	0.008	<0.01	0.149
DW7065W	AR3	19-Jun-2019	0.04	0.018	0.178	<0.001	1.14	<0.0001	<0.001	0.006	0.006	3.87	<0.001	0.295	<0.0001	<0.001	0.011	<0.01	<0.001	0.008	<0.01	0.103
DW7065W	AR3	11-Jul-2019	0.12	0.008	0.284	<0.005	1.47	<0.0005	<0.005	0.006	0.01	2.12	<0.005	0.406	<0.0001	<0.005	0.011	<0.05	<0.005	0.006	<0.05	0.121
DW7065W	AR3	26-Aug-2019	0.17	0.019	0.474	<0.001	1.52	<0.0001	<0.001	0.006	0.008	4.39	0.001	0.279	<0.0001	<0.001	0.01	<0.01	<0.001	0.009	<0.01	0.42
DW7067W	AR3	12-Dec-2018	0.06	0.006	0.059	<0.001	1.44	<0.0001	<0.001	0.005	0.046	2.32	0.005	0.11	<0.0001	0.001	0.006	<0.01	<0.001	0.004	<0.01	0.111
DW7067W	AR3	07-Jan-2019	<0.05	0.012	0.089	<0.005	1.47	<0.0005	<0.005	<0.005	0.027	3.23	<0.005	0.122	<0.0001	<0.005	0.006	<0.05	<0.005	<0.005	<0.05	0.149
DW7067W	AR3	18-Feb-2019	0.01	0.013	0.077	<0.001	1.36	<0.0001	<0.001	0.002	0.021	4.31	<0.001	0.112	<0.0001	0.002	0.007	0.01	<0.001	0.002	<0.01	0.067
DW7067W	AR3	11-Mar-2019	<0.05	0.01	0.079	<0.005	1.76	<0.0005	<0.005	<0.005	0.014	3.88	<0.005	0.119	<0.0001	<0.005	<0.005	<0.05	<0.005	<0.005	<0.05	0.09
DW7067W	AR3	17-Apr-2019	0.02	0.008	0.069	<0.001	1.19	<0.0001	<0.001	0.001	0.012	3.38	<0.001	0.102	<0.0001	<0.001	0.002	<0.01	<0.001	0.002	<0.01	0.063
DW7067W	AR3	13-May-2019	0.01	0.008	0.156	<0.001	1.44	<0.0001	<0.001	0.001	0.022	3.34	<0.001	0.121	<0.0001	<0.001	0.006	<0.01	<0.001	0.002	<0.01	0.098
DW7067W	AR3	19-Jun-2019	0.02	0.004	0.11	<0.001	1.24	<0.0001	<0.001	0.002	0.007	0.52	<0.001	0.092	<0.0001	<0.001	0.006	<0.01	<0.001	0.002	<0.01	0.092
DW7067W	AR3	11-Jul-2019	<0.05	<0.005	0.134	<0.005	1.5	<0.0005	<0.005	<0.005	0.013	2.35	<0.005	0.154	<0.0001	<0.005	0.008	<0.05	<0.005	<0.005	<0.05	0.148
DW7067W	AR3	26-Aug-2019	0.04	0.007	0.184	<0.001	1.6	<0.0001	<0.001	0.001	0.007	2.98	<0.001	0.107	<0.0001	<0.001	0.006	<0.01	<0.001	0.002	<0.01	0.06
DW7068W	Tertiary	12-Dec-2018	1.27	<0.001	0.186	<0.001	1.26	<0.0001	0.004	0.002	0.004	0.53	0.001	0.036	<0.0001	0.007	0.005	<0.01	<0.001	0.011	<0.01	0.019
DW7068W	Tertiary	07-Jan-2019	1.82	<0.001	0.268	<0.001	1.48	0.0002	0.006	0.002	0.017	0.91	0.002	0.044	<0.0001	0.007	0.006	<0.01	<0.001	0.012	<0.01	0.106
DW7068W	Tertiary	18-Feb-2019	4.11	0.002	0.234	<0.001	1.3	<0.0001	0.013	0.002	0.01	2.2	0.003	0.045	<0.0001	0.005	0.006	<0.01	<0.001	0.009	0.02	0.067
DW7068W	Tertiary	11-Mar-2019	3.12	<0.005	0.214	<0.005	1.48	<0.0005	0.009	<0.005	0.007	1.5	<0.005	0.033	<0.0001	<0.005	0.006	<0.05	<0.005	0.012	<0.05	<0.026
DW7068W	Tertiary	17-Apr-2019	2.43	<0.001	0.237	<0.001	1.16	<0.0001	0.008	0.002	0.008	1.55	0.002	0.041	<0.0001	0.005	0.006	<0.01	<0.001	0.01	<0.01	0.043
DW7068W	Tertiary	13-May-2019	2.81	0.002	0.242	<0.001	1.4	<0.0001	0.01	0.002	0.028	2	0.003	0.054	<0.0001	0.005	0.009	<0.01	<0.001	0.011	<0.01	0.094
DW7068W	Tertiary	11-Jul-2019	3.9	<0.005	0.22	<0.005	1.55	<0.0005	0.009	<0.005	0.007	1.24	<0.005	0.063	<0.0001	0.006	0.014	<0.05	<0.005	0.01	<0.05	0.126
DW7069W	Castor Lower/Pollux Upper	12-Dec-2018	0.1	0.003	0.056	<0.001	1.37	0.0001	<0.001	0.002	0.06	2.4	0.005	0.174	<0.0001	0.001	0.004	<0.01	<0.001	0.002	<0.01	0.137
DW7069W	Castor Lower/Pollux Upper	07-Jan-2019	0.07	0.004	0.083	<0.001	1.41	0.0001	<0.001	<0.001	0.028	2.86	0.001	0.184	<0.0001	0.002	0.003	<0.01	<0.001	0.002	<0.01	0.144
DW7069W	Castor Lower/Pollux Upper	18-Feb-2019	0.09	0.003	0.072	<0.001	1.31	<0.0001	<0.001	<0.001	0.02	2.4	<0.001	0.158	<0.0001	0.002	0.005	<0.01	<0.001	<0.001	<0.01	0.089
DW7069W	Castor Lower/Pollux Upper	11-Mar-2019	0.08	<0.005	0.069	<0.005	1.73	<0.0005	<0.005	<0.005	0.014	2.48	<0.005	0.188	<0.0001	<0.005	<0.005	<0.05	<0.005	<0.005	<0.05	0.088
DW7069W	Castor Lower/Pollux Upper	17-Apr-2019	0.04	0.002	0.064	<0.001	1.14	<0.0001	<0.001	<0.001	0.01	2.42	<0.001	0.154	<0.0001	<0.001	0.002	<0.01	<0.001	<0.001	<0.01	0.064
DW7069W	Castor Lower/Pollux Upper	13-May-2019	0.03	0.004	0.117	<0.001	1.41	0.0002	<0.001	<0.001	0.02	2.64	<0.001	0.185	<0.0001	0.001	0.005	<0.01	<0.001	<0.001	<0.01	0.082
DW7069W	Castor Lower/Pollux Upper	19-Jun-2019	0.02	0.002	0.084	<0.001	1.21	<0.0001	<0.001	<0.001	0.014	2.38	<0.001	0.153	<0.0001	<0.001	0.003	<0.01	<0.001	<0.001	<0.01	0.104
DW7069W	Castor Lower/Pollux Upper	11-Jul-2019	0.13	<0.005	0.087	<0.005	1.5	<0.0005	<0.005	<0.005	0.012	2.05	<0.005	0.168	<0.0001	<0.005	0.008	<0.05	<0.005	<0.005	<0.05	0.133
DW7069W	Castor Lower/Pollux Upper	26-Aug-2019	0.12	0.003	0.113	<0.001	1.56	<0.0001	<0.001	<0.001	0.006	2.57	<0.001	0.147	<0.0001	0.001	0.004	<0.01	<0.001	<0.001	<0.01	0.045
DW7073W	Castor Lower/Pollux Upper	13-Dec-2018	0.3	0.001	0.108	<0.001	1.14	<0.0001	<0.001	<0.001	0.05	3.61	0.005	0.288	<0.0001	0.002	0.002	<0.01	<0.001	<0.001	<0.01	0.097
DW7073W	Castor Lower/Pollux Upper	07-Jan-2019	0.64	0.001	0.149	<0.001	1.26	0.0001	<0.001	<0.001	0.02	4.59	0.003	0.36	<0.0001	0.003	0.002	<0.01	<0.001	<0.001	<0.01	0.115
DW7073W	Castor Lower/Pollux Upper	18-Feb-2019	0.23	0.002	0.129	<0.001	1.08	0.0001	<0.001	<0.001	0.017	4.16	<0.001	0.35	<0.0001	0.002	0.005	<0.01	<0.001	<0.001	<0.01	0.104
DW7073W	Castor Lower/Pollux Upper	11-Mar-2019	0.23	<0.005	0.142	<0.005	1.39	<0.0005	<0.005	<0.005	0.011	5.2	<0.005	0.405	<0.0001	<0.005	<0.005	<0.05	<0.005	<0.005	<0.05	0.097
DW7073W	Castor Lower/Pollux Upper	17-Apr-2019	0.18	0.001	0.115	<0.001	0.94	<0.0001	<0.001	<0.001	0.009	4.31	<0.001	0.318	<0.0001	0.002	0.002	<0.01	<0.001	<0.001	<0.01	0.055
DW7073W	Castor Lower/Pollux Upper	13-May-2019	0.27	0.003	0.167	<0.001	1.1	<0.0001	<0.001	<0.001	0.015	4.66	<0.001	0.345	<0.0001	0.002	0.003	<0.01	<0.001	<0.001	<0.01	0.054
DW7073W	Castor Lower/Pollux Upper	19-Jun-2019	0.15	0.002	0.128	<0.001	1.02	<0.0001	<0.001	<0.001	0.015	4.2	<0.001	0.325	<0.0001	0.002	0.002	<0.01	<0.001	<0.001	<0.01	0.065
DW7073W	Castor Lower/Pollux Upper	11-Jul-2019	0.22	<0.005	0.133	<0.005	1.2	<0.0005	<0.005	<0.005	0.011	3.83	<0.005	0.347	<0.0001	<0.005	0.006	<0.05	<0.005	<0.005	<0.05	0.116
DW7073W	Castor Lower/Pollux Upper	26-Aug-2019	0.23	0.001	0.14	<0.001	1.21	<0.0001	<0.001	<0.001	0.006	4.01	<0.001	0.301	<0.0001	0.002	0.003	<0.01	<0.001	<0.001	<0.01	0.037
DW7074W	Castor Upper	13-Dec-2018	0.05	0.001	0.073	<0.001	1.45	<0.0001	<0.001	0.001	0.034	0.09	0.003	0.203	<0.0001	0.009	0.003	<0.01	<0.001	0.002	<0.01	0.078
DW7074W	Castor Upper	07-Jan-2019	0.03	0.001	0.112	<0.001	1.52	0.0001	<0.001	0.002	0.016	0.22	0.001	0.274	<0.0001	0.012	0.003	<0.01	<0.001	0.003	<0.01	0.082
DW7074W	Castor Upper	18-Feb-2019	0.02	0.003	0.087	<0.001	1.34	<0.0001	<0.001	0.002	0.019	0.43	<0.001	0.26	<0.0001	0.008	0.005	<0.01	<0.001	0.002	<0.01	0.071
DW7074W	Castor Upper	11-Mar-2019	<0.05	<0.005	0.084	<0.005	1.64	<0.0005	<0.005	<0.005	0.012	1.63	<0.005	0.264	<0.0001	0.007	<0.005	<0.05	<0.005	<0.005	<0.05	<0.026
DW7074W	Castor Upper	17-Apr-2019	0.03	0.005	0.078	<0.001	1.18	<0.0001	<0.001	<0.001	0.008	1.86	<0.001	0.227	<0.0001	0.006	0.003	<0.01	<0.001	0.002	<0.01	0.043
DW7074W	Castor Upper	13-May-2019	0.06	0.006	0.117	<0.001	1.45	<0.0001	<0.001	<0.001	0.016	2.77	<0.001	0.27	<0.0001	0.005	0.005	<0.01	<0.001	0.003	<0.01	0.054
DW7074W	Castor Upper	19-Jun-2019	0.02	0.004	0.088	<0.001	1.27	<0.0001	<0.001	<0.001	0.014	1.87	<0.001	0.227	<0.0001	0.005	0.004	<0.01	<0.001	0.002	<0.01	0.059
DW7074W	Castor Upper	11-Jul-2019	0.07	<0.005	0.1	<0.005	1.53	<0.0005	<0.005	<0.005	0.006	1.11	<0.005	0.256	<0.0001	<0.005	0.008	<0.05	<0.005	<0.005	<0.05	0.068
DW7074W	Castor Upper	26-Aug-2019	0.21	0.003	0.119	<0.001	1.52	<0.0001	<0.001	<0.001	0.008	2.01	<0.001	0.245	<0.0001	0.004	0.005	<0.01	<0.001	0.002	<0.01	0.04
DW7076W	Alluvium	12-Dec-2018	2.06	0.002	0.301	<0.001	3.87	<0.0001	0.001	0.005	0.002	0.89	0.001	0.17	<0.0001	0.002	0.005	<0.01	<0.001	0.062	<0.01	0.009
DW7076W	Alluvium	07-Jan-2019	7.22	0.003	0.389	<0.001	4.43	<0.0001	0.011	0.007	0.098	2.93	0.005	0.291	<0.0001	0.004	0.007	<0.01	<0.001	0.073	0.04	0.05
DW7076W	Alluvium	18-Feb-2019	2.86	0.002	0.352	<0.001	3.56	<0.0001	0.006	0.004	0.103	1.28	0.002	0.154	<0.0001	0.003	0.005	<0.01	<0.001	0.053	0.04	0.024
DW7076W	Alluvium	11-Mar-2019	6.6	<0.005	0.331	<0.005	4.71	<0.0005	0.009	0.006	0.308	2.52	0.006	0.236	<0.0001	<0.005	0.006	<0.05	<0.005	0.065	<0.05	<0.026
DW7076W	Alluvium	17-Apr-2019	3.88	0.002	0.31	<0.001	3.41	<0.0001	0.008	0.004	0.164	1.92	0.003	0.158	<0.0001	0.002	0.004	<0.01	<0.001	0.053	0.02	0.041
DW7076W	Alluvium	13-May-2019	4.8	0.003	0.27	<0.001	4.2	0.0001	0.007	0.004	0.313	2.22	0.003	0.176	<0.0001	0.002	0.004	<0.01	<0.001	0.055	0.02	0.036
DW7076W	Alluvium	19-Jun-2019	2.05	0.002	0.209	<0.001	3.82	<0.0001	0.005	0.004	0.232	1.24	0.002	0.144	<0.0001	0.002	0.005	<0.01	<0.001	0.05	0.02	0.035
DW7076W		11-Jul-2019	4.96	<0.005	0.224	<0.005	4.61	<0.0005	0.006	<0.005	0.452	2.2	<0.005	0.154	<0.0001	<0.005	0.007	<0.05	<0.005	0.044	<0.05	0.058
DW7076W	Alluvium	26-Aug-2019	20.1	0.004	0.318	0.004	4.57	<0.0001	0.02	0.008	0.37	6.91	0.02	0.29	<0.0001	0.001	0.013	<0.01	<0.001	0.046	0.04	0.124

APPENDIX C

SLUG TEST ANALYSIS SHEETS



WELL TEST ANALYSIS

Data Set: D:\...\DW7033W1_KGS Model.aqt
Date: 09/07/19 Time: 15:12:19

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7033W1
Test Date: 17 July 2019

AQUIFER DATA

Saturated Thickness: 14.81 m

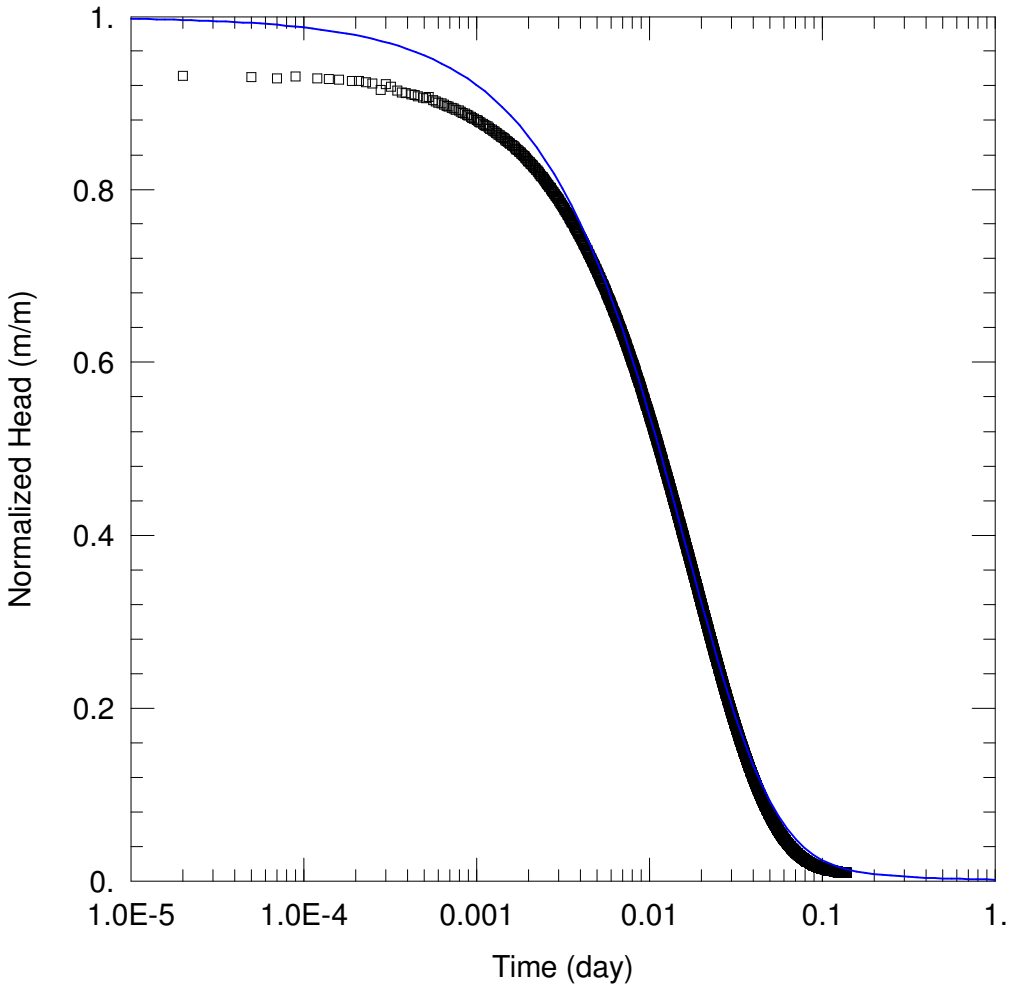
WELL DATA (DW7033W1)

Initial Displacement: 30.18 m
Total Well Penetration Depth: 14.81 m
Casing Radius: 0.025 m
Static Water Column Height: 14.81 m
Screen Length: 6. m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 0.7028 m/day
Kz/Kr = 0.1
Ss = 0.02476 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7033W2_KGS Model.aqt
Date: 09/07/19 Time: 15:14:31

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7033W2
Test Date: 17 July 2019

AQUIFER DATA

Saturated Thickness: 2. m

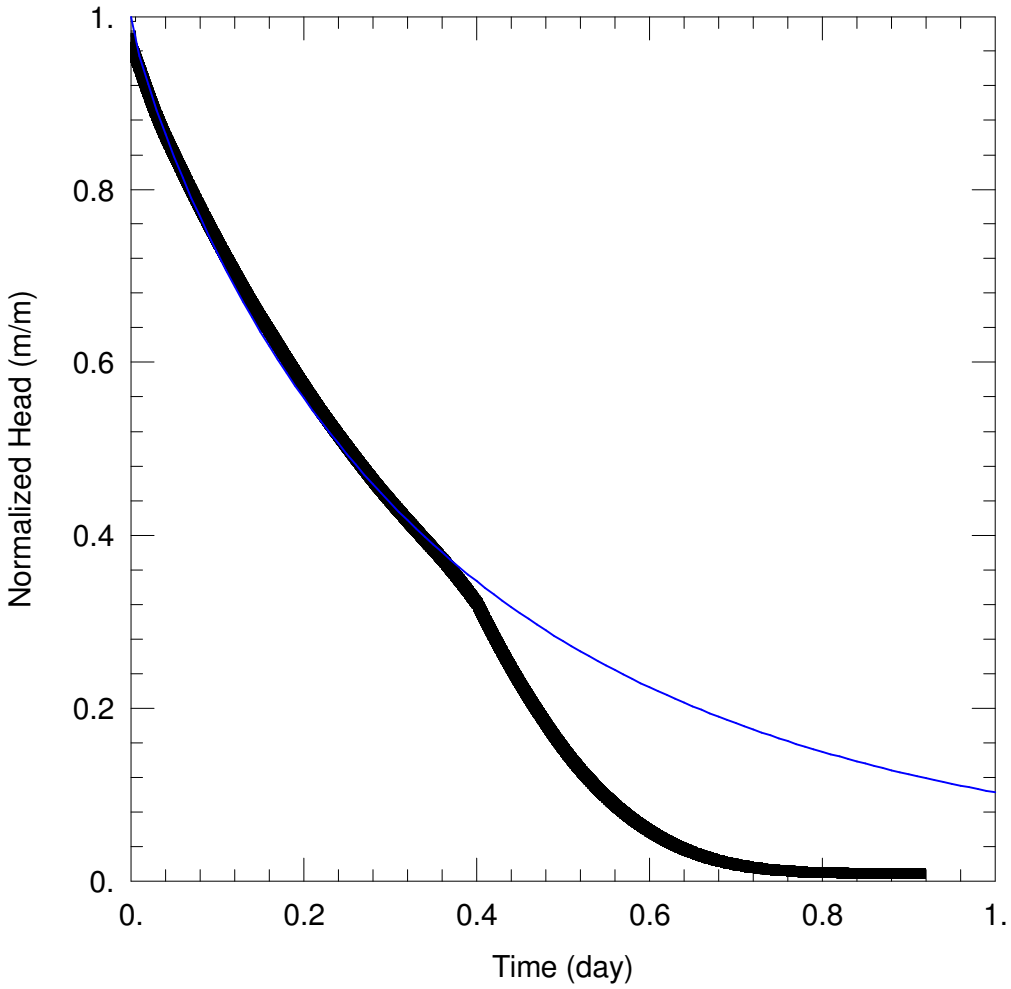
WELL DATA (DW7033W2)

Initial Displacement: 29.22 m
Total Well Penetration Depth: 45.28 m
Casing Radius: 0.025 m
Static Water Column Height: 45.28 m
Screen Length: 1.5 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.06068 m/day
Kz/Kr = 1.
Ss = 0.0002924 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7033W3_KGS Model.aqt
Date: 09/07/19 Time: 17:55:00

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7033W3
Test Date: 17 July 2019

AQUIFER DATA

Saturated Thickness: 6.7 m

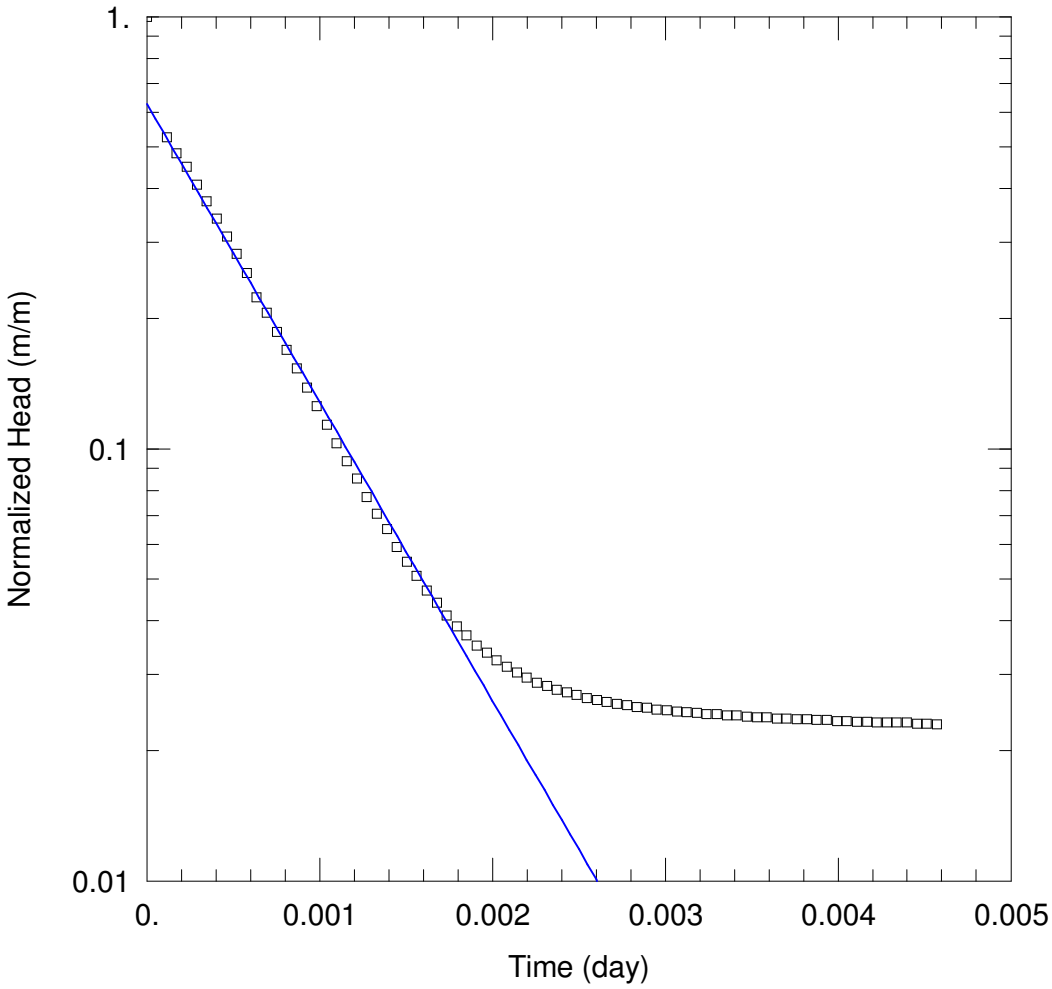
WELL DATA (DW7033W3)

Initial Displacement: 29.17 m
Total Well Penetration Depth: 51.83 m
Casing Radius: 0.025 m
Static Water Column Height: 51.83 m
Screen Length: 1.5 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.002308 m/day
Kz/Kr = 0.1
Ss = 0.0002924 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7035W3_Bouwer-Rice.aqt
Date: 09/07/19 Time: 15:25:54

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7035W3
Test Date: 16 July 2019

AQUIFER DATA

Saturated Thickness: 2. m Anisotropy Ratio (Kz/Kr): 1.

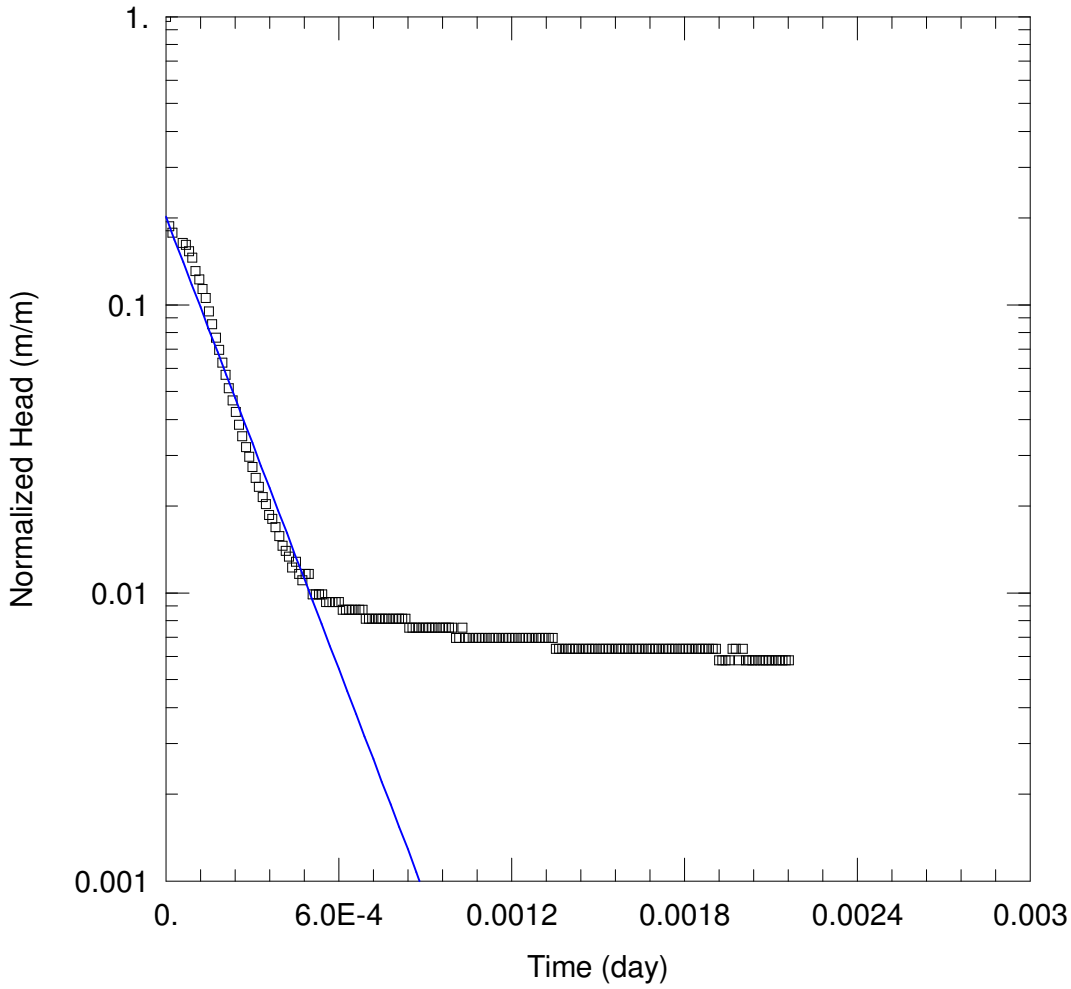
WELL DATA (DW7035W3)

Initial Displacement: 22.01 m Static Water Column Height: 26.43 m
Total Well Penetration Depth: 26.43 m Screen Length: 1.5 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.593 m/day y0 = 13.82 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7082W1_Bouwer-Rice.aqt
Date: 09/07/19 Time: 15:24:28

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7082W1
Test Date: 22 August 2019

AQUIFER DATA

Saturated Thickness: 2. m Anisotropy Ratio (Kz/Kr): 1.

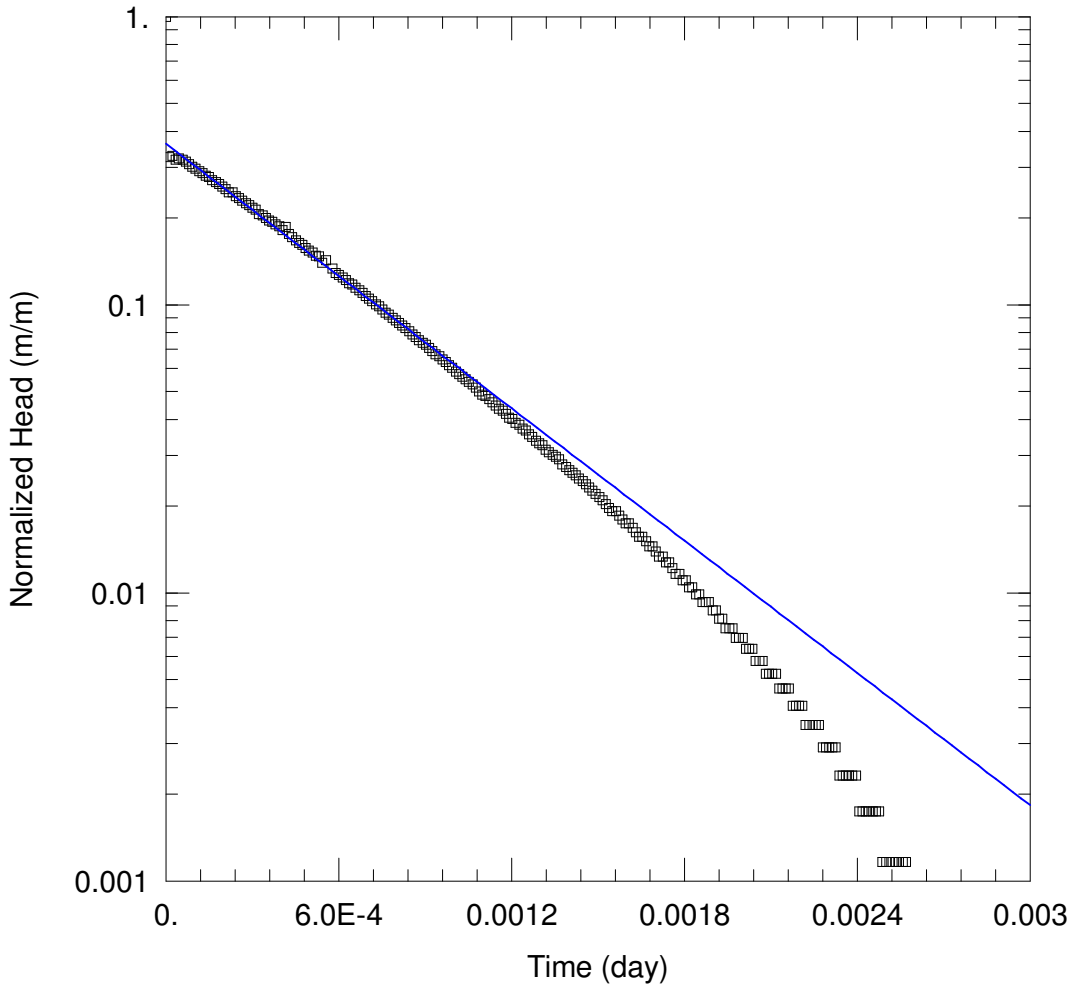
WELL DATA (DW7082W1)

Initial Displacement: 17.19 m Static Water Column Height: 23.39 m
Total Well Penetration Depth: 23.39 m Screen Length: 1.67 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 5.387 m/day y0 = 3.468 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7082W2_Bouwer-Rice.aqt
Date: 09/07/19 Time: 15:30:14

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7082W2
Test Date: 22 August 2019

AQUIFER DATA

Saturated Thickness: 2. m Anisotropy Ratio (Kz/Kr): 1.

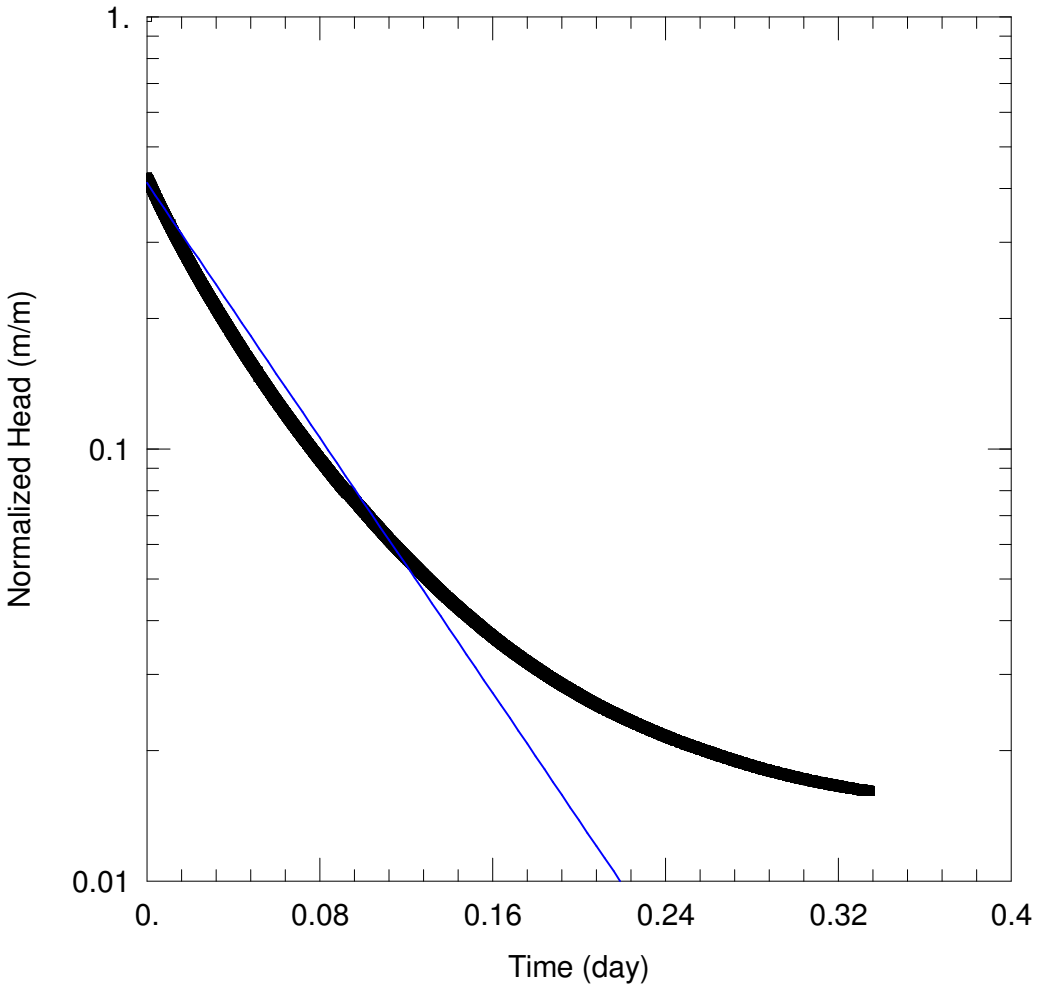
WELL DATA (DW7082W2)

Initial Displacement: 17.23 m Static Water Column Height: 41.94 m
Total Well Penetration Depth: 41.94 m Screen Length: 1.5 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 1.855 m/day y0 = 6.243 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7093W1_Bouwer-Rice.aqt
Date: 09/07/19 Time: 15:36:35

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7092W1
Test Date: 2 September 2019

AQUIFER DATA

Saturated Thickness: 2. m Anisotropy Ratio (Kz/Kr): 0.1

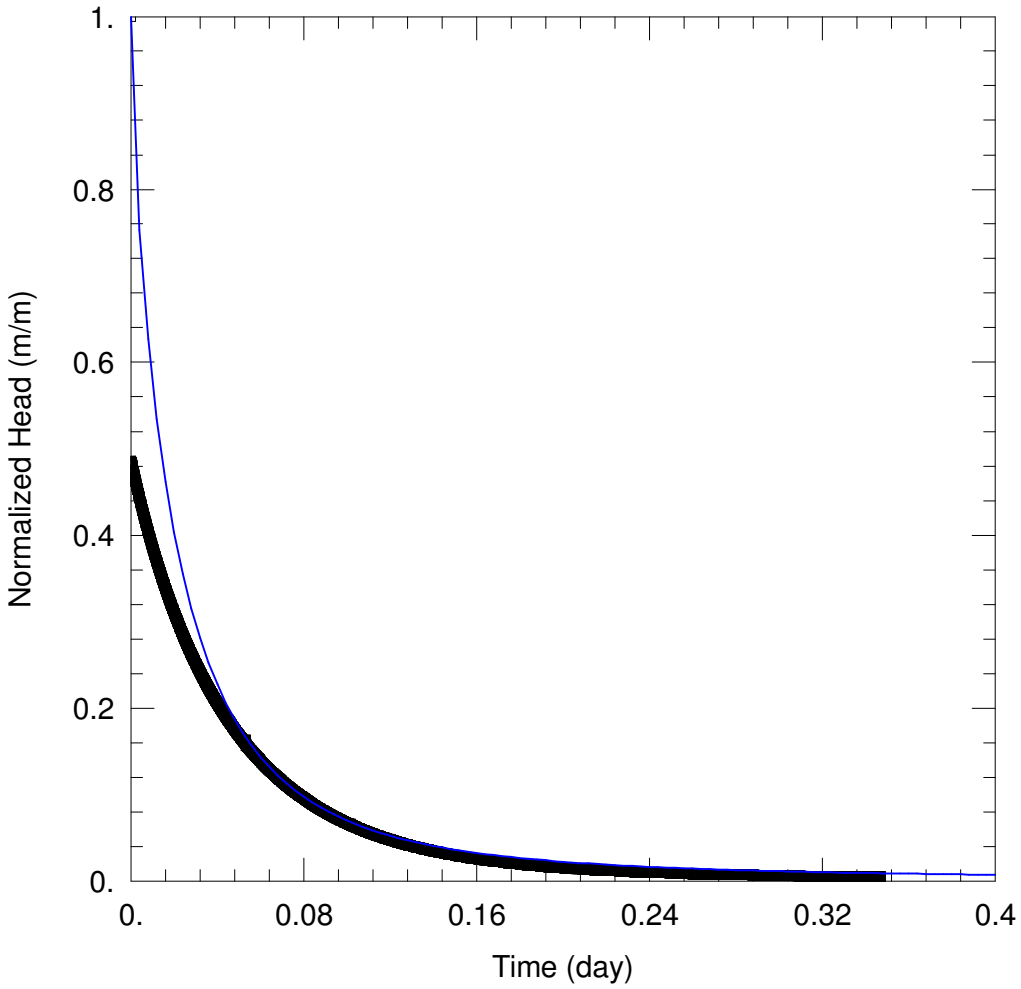
WELL DATA (DW7093W1)

Initial Displacement: 28.78 m Static Water Column Height: 58.52 m
Total Well Penetration Depth: 58.52 m Screen Length: 1.5 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.02229 m/day y0 = 11.88 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7093W3_KGS Model.aqt
Date: 09/07/19 Time: 15:40:14

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7092W3
Test Date: 2 September 2019

AQUIFER DATA

Saturated Thickness: 2. m

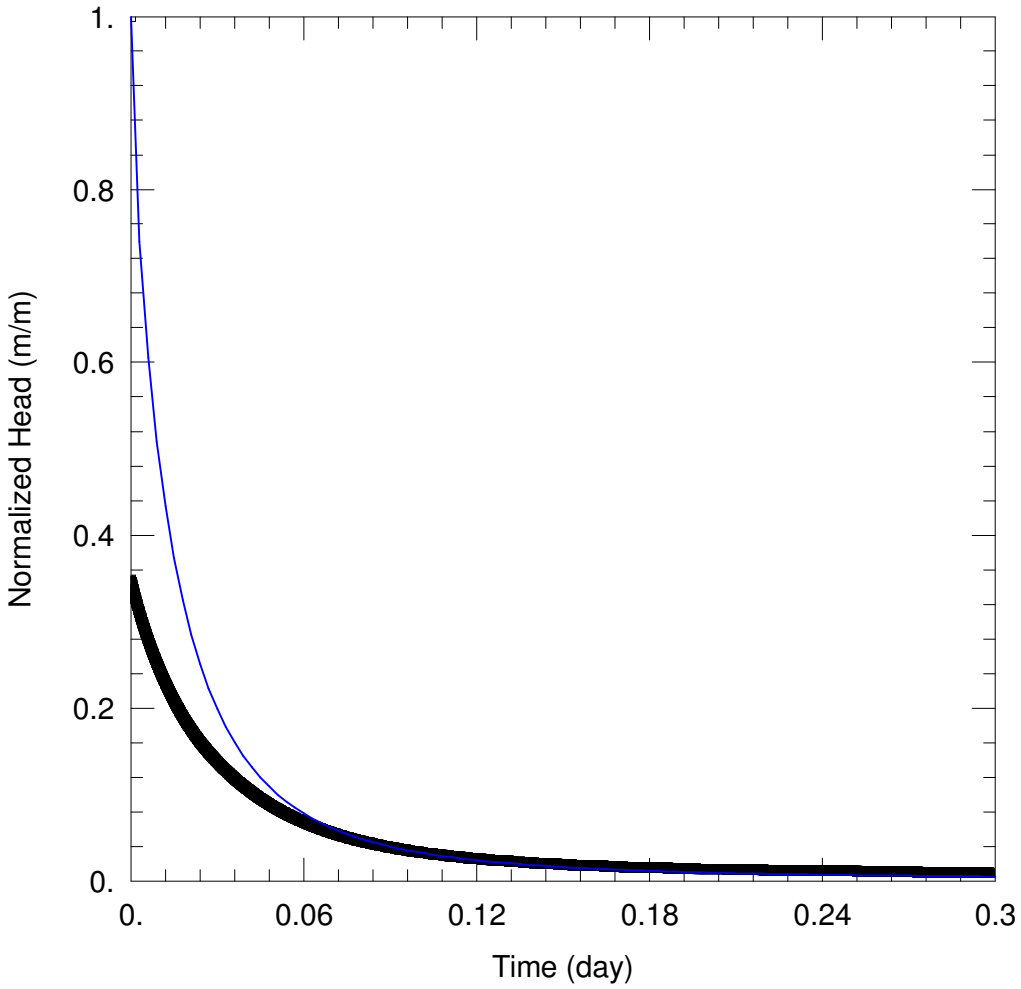
WELL DATA (DW7093W3)

Initial Displacement: 28.71 m
Total Well Penetration Depth: 94.54 m
Casing Radius: 0.025 m
Static Water Column Height: 94.54 m
Screen Length: 1.5 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.03877 m/day
Kz/Kr = 1.
Ss = 0.01774 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7105W2_KGS Model.aqt
Date: 09/07/19 Time: 15:47:39

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7105W2
Test Date: 22 August 2019

AQUIFER DATA

Saturated Thickness: 2. m

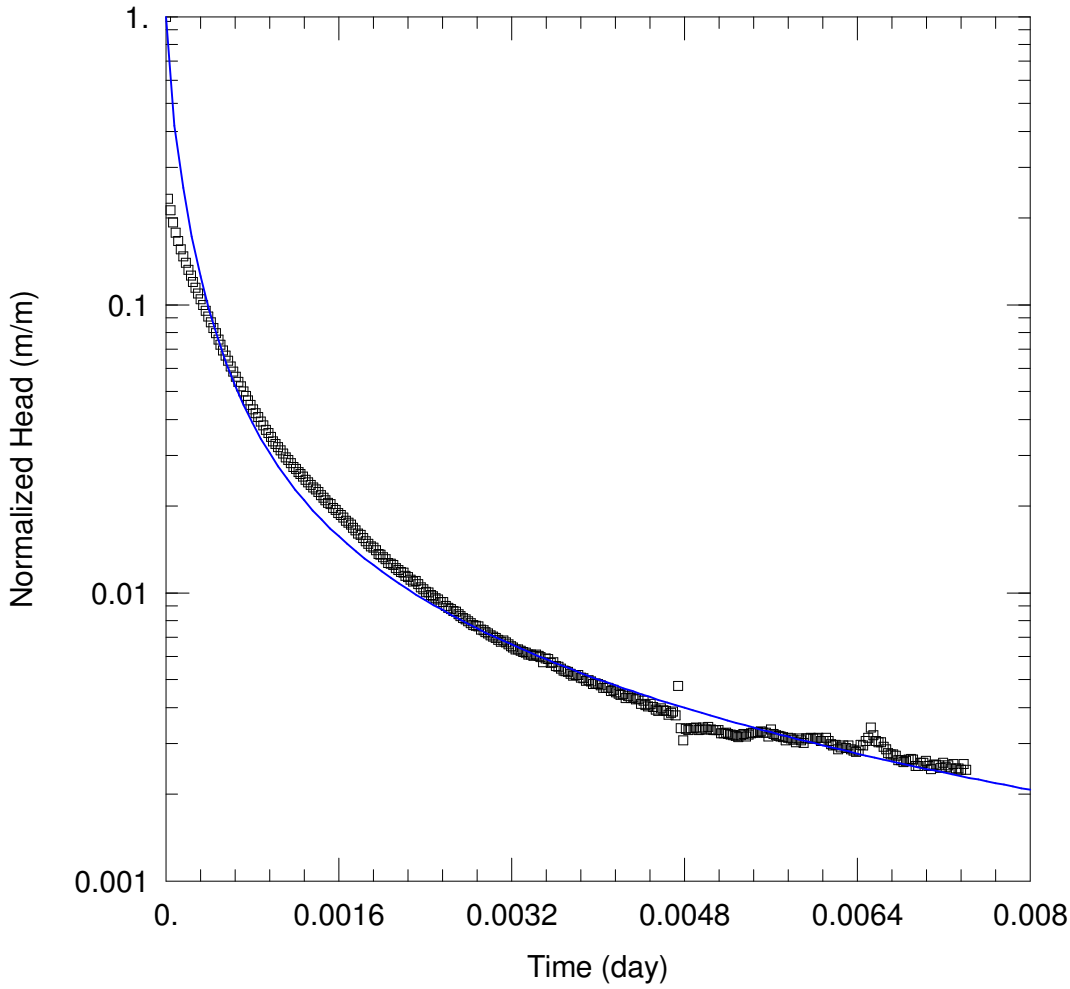
WELL DATA (DW7105W2)

Initial Displacement: 31.4 m
Total Well Penetration Depth: 32.8 m
Casing Radius: 0.025 m
Static Water Column Height: 32.8 m
Screen Length: 1.5 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.066 m/day
Kz/Kr = 1.
Ss = 0.01774 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7178W1_KGS Model.aqt
Date: 09/07/19 Time: 15:50:25

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7178W1
Test Date: 16 July 2019

AQUIFER DATA

Saturated Thickness: 23.39 m

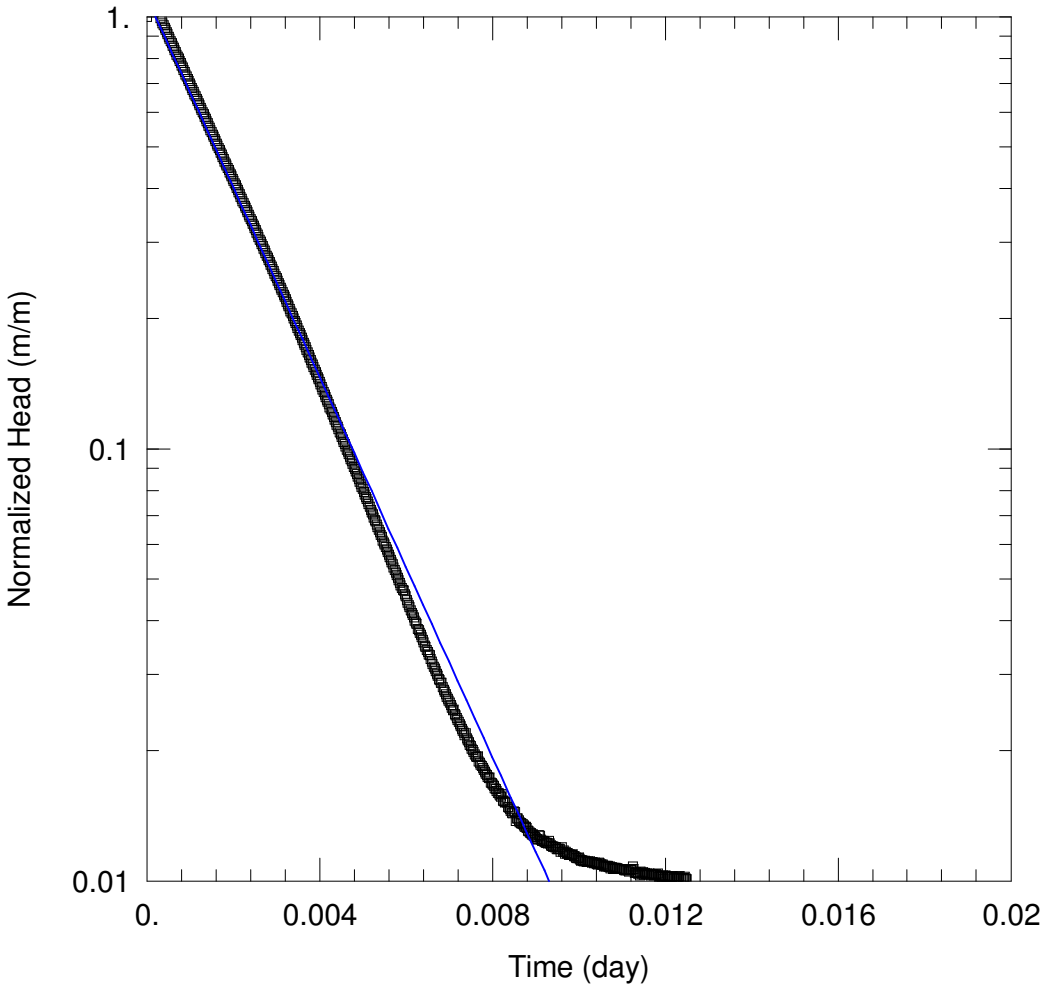
WELL DATA (DW7178W1)

Initial Displacement: 17.19 m
Total Well Penetration Depth: 23.42 m
Casing Radius: 0.025 m
Static Water Column Height: 23.39 m
Screen Length: 1.7 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 3.805 m/day
Kz/Kr = 1.
Ss = 0.02476 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7178W2_KGS Model.aqt
Date: 09/07/19 Time: 16:23:06

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7178W2
Test Date: 16 July 2019

AQUIFER DATA

Saturated Thickness: 3. m Anisotropy Ratio (Kz/Kr): 1.

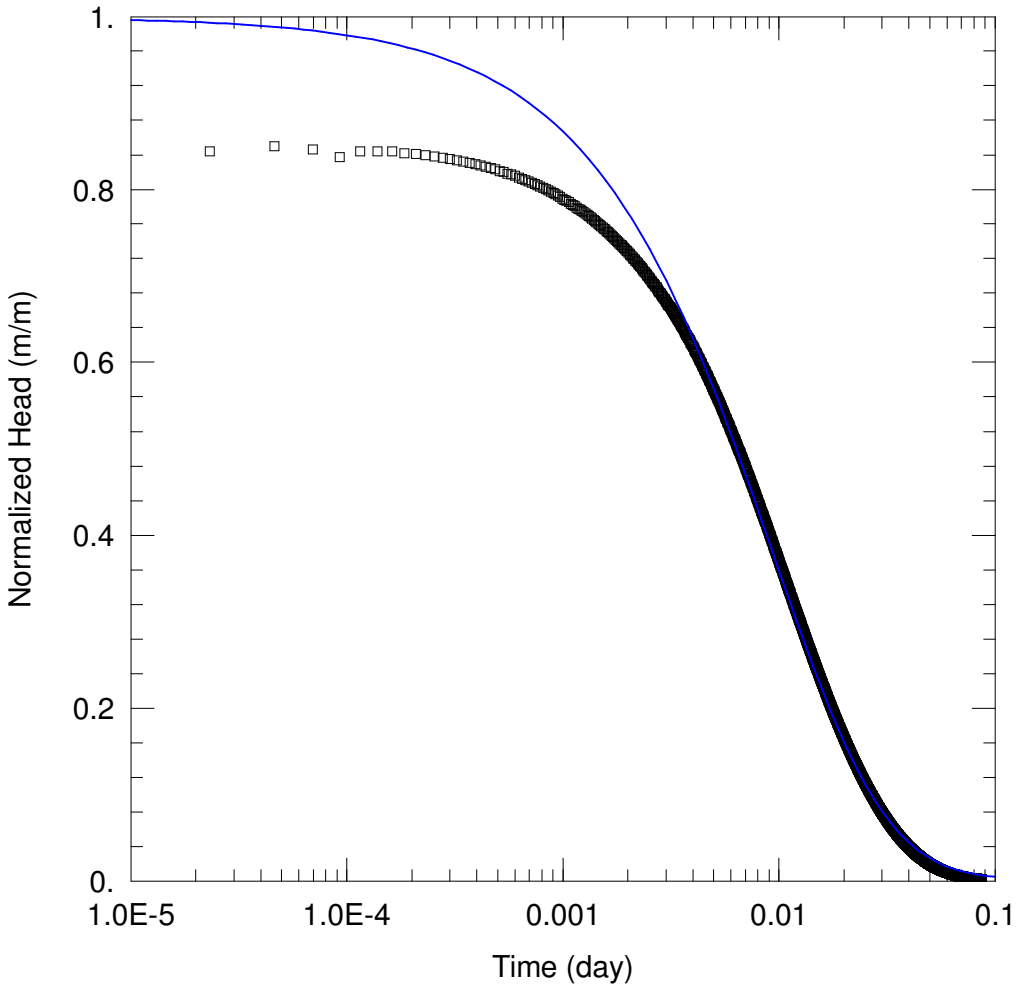
WELL DATA (DW7178W2)

Initial Displacement: 17.23 m Static Water Column Height: 41.94 m
Total Well Penetration Depth: 41.94 m Screen Length: 1.5 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.5322 m/day y0 = 19.08 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7220W1_KGS Model.aqt
Date: 09/07/19 Time: 16:59:12

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7220W1
Test Date: 19 July 2019

AQUIFER DATA

Saturated Thickness: 10.88 m

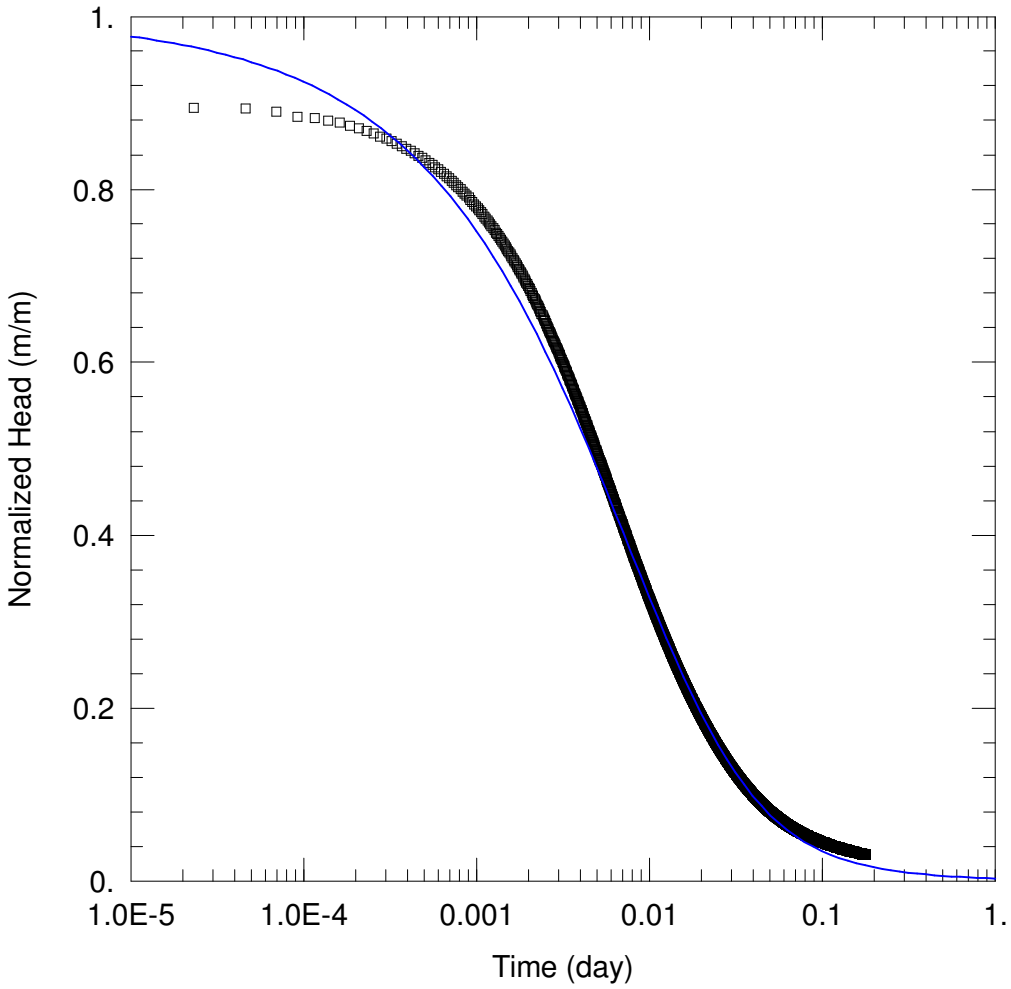
WELL DATA (DW7220W1)

Initial Displacement: 15.62 m
Total Well Penetration Depth: 10.88 m
Casing Radius: 0.025 m
Static Water Column Height: 10.88 m
Screen Length: 3. m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 0.04546 m/day
Kz/Kr = 1.
Ss = 0.0001408 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7220W2_KGS Model.aqt
Date: 09/07/19 Time: 17:03:33

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7220W2
Test Date: 19 July 2019

AQUIFER DATA

Saturated Thickness: 6. m

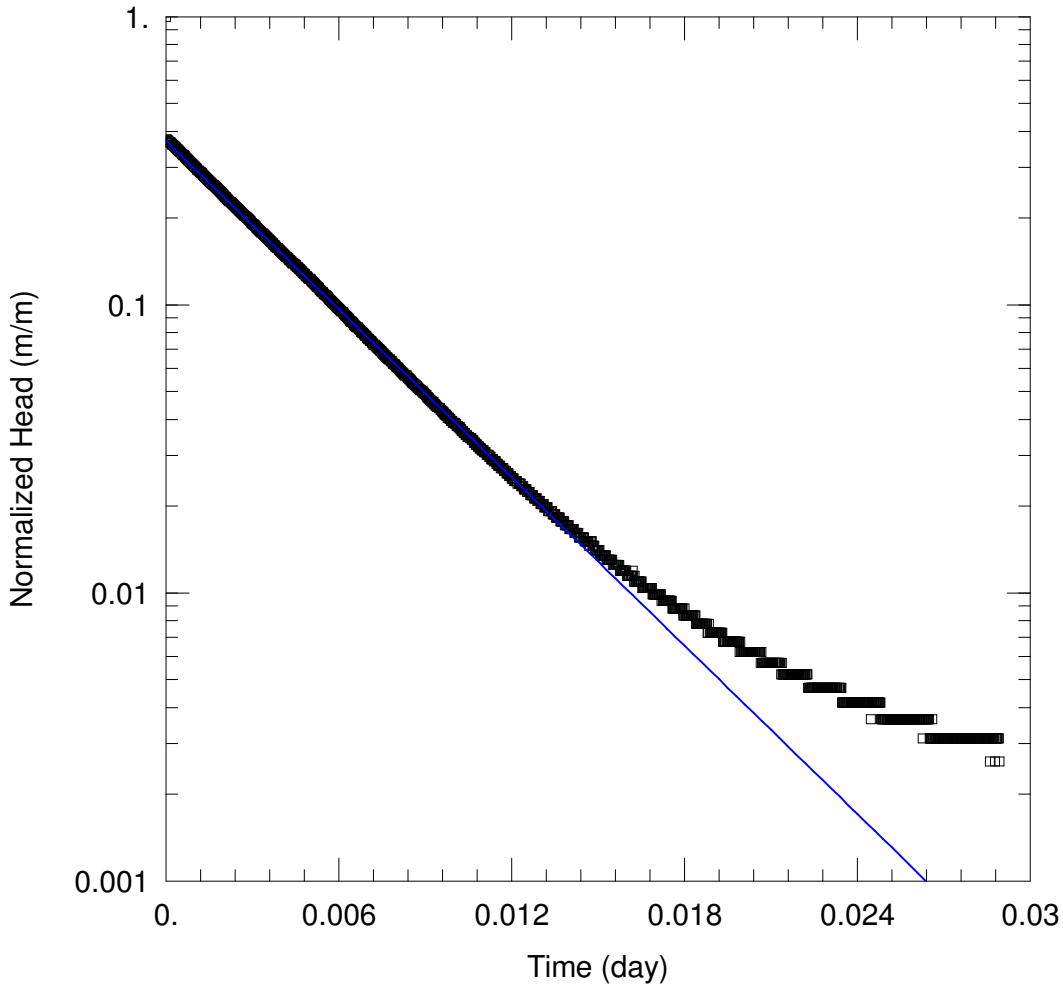
WELL DATA (DW7220W2)

Initial Displacement: 19.43 m
Total Well Penetration Depth: 18.97 m
Casing Radius: 0.025 m
Static Water Column Height: 18.97 m
Screen Length: 6. m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.01219 m/day
Kz/Kr = 0.1
Ss = 0.02476 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7220W3_Bouwer-Rice.aqt
Date: 09/07/19 Time: 16:57:40

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7220W3
Test Date: 23 August 2019

AQUIFER DATA

Saturated Thickness: 2. m Anisotropy Ratio (Kz/Kr): 0.1

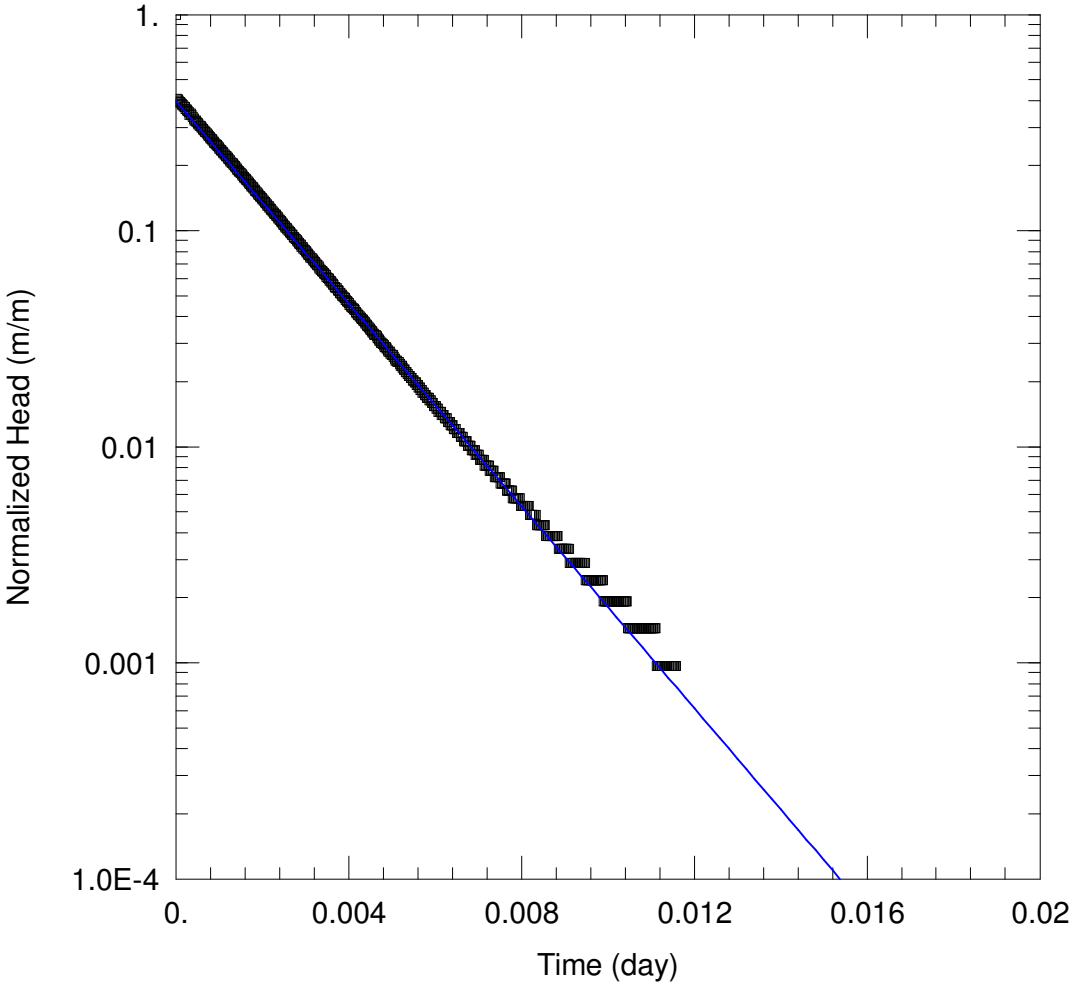
WELL DATA (DW7220W3)

Initial Displacement: 19.23 m Static Water Column Height: 55.81 m
Total Well Penetration Depth: 55.81 m Screen Length: 1.5 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.293 m/day y0 = 7.131 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7221W1_Bouwer-Rice.aqt
Date: 09/07/19 Time: 17:12:37

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7221W1
Test Date: 23 August 2019

AQUIFER DATA

Saturated Thickness: 3. m Anisotropy Ratio (Kz/Kr): 1.

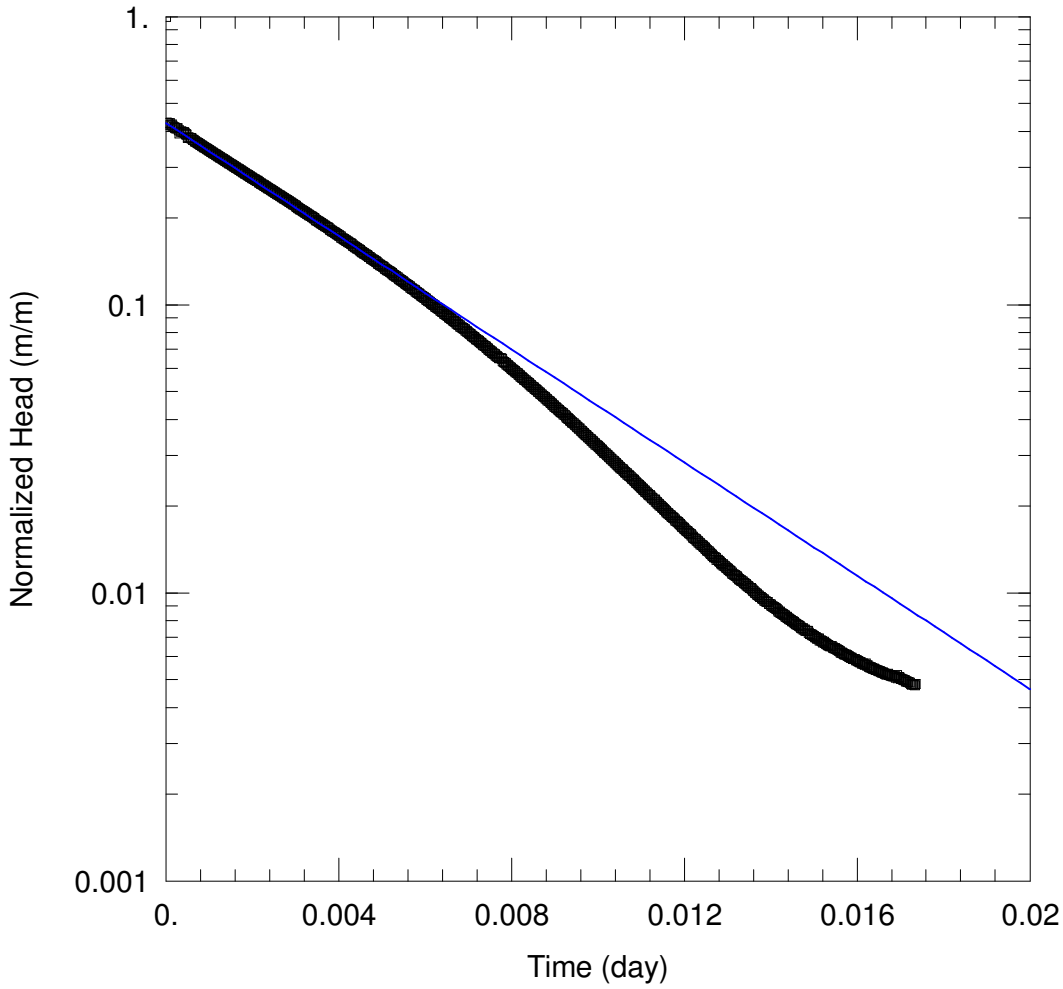
WELL DATA (DW7221W1)

Initial Displacement: 20.72 m Static Water Column Height: 29.71 m
Total Well Penetration Depth: 29.71 m Screen Length: 3. m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.2859 m/day y0 = 8.245 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7221W2_Bouwer-Rice.aqt
Date: 09/07/19 Time: 17:11:22

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7221W2
Test Date: 23 August 2019

AQUIFER DATA

Saturated Thickness: 2. m Anisotropy Ratio (Kz/Kr): 1.

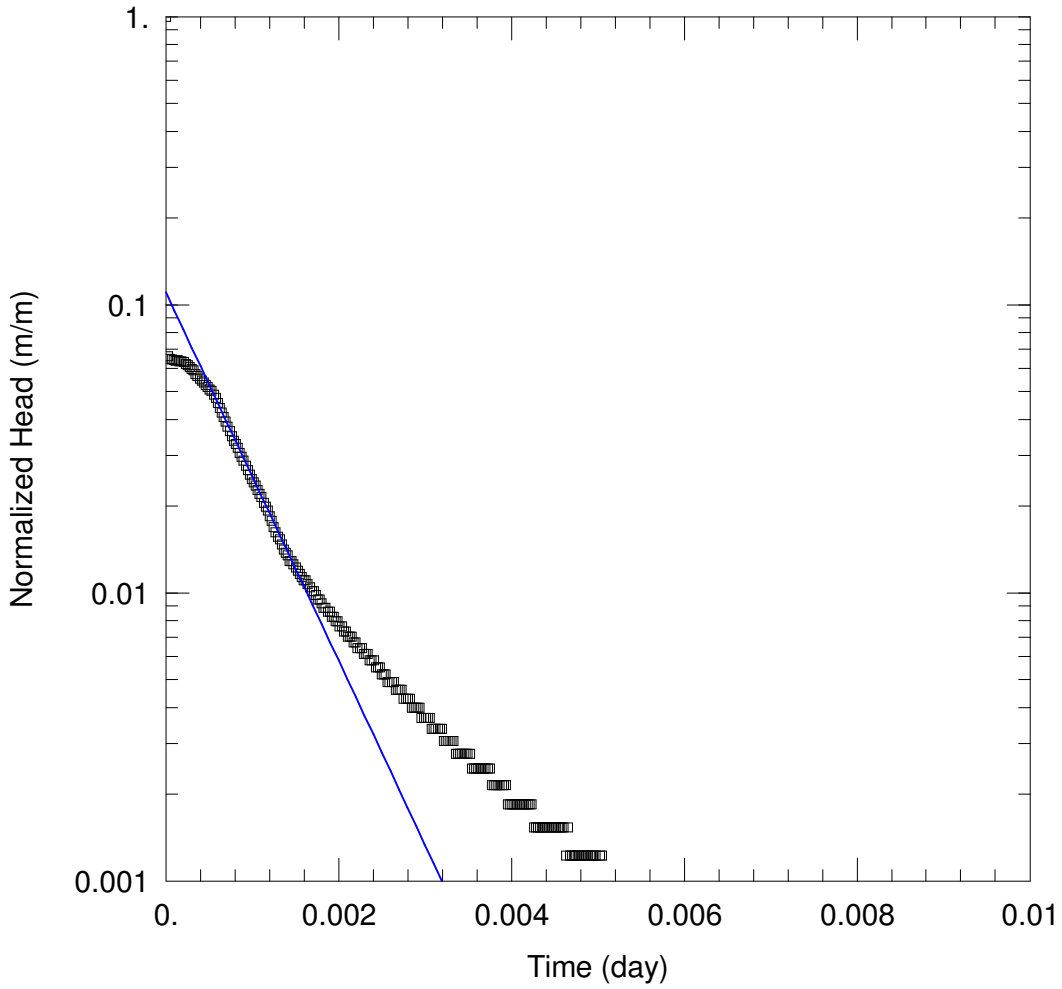
WELL DATA (DW7221W2)

Initial Displacement: 20.77 m Static Water Column Height: 51.59 m
Total Well Penetration Depth: 51.59 m Screen Length: 1.5 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.2429 m/day y0 = 8.882 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7225W1 Bouwer-Rice.aqt
Date: 09/07/19 Time: 17:14:14

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7225W1
Test Date: 3 September 2019

AQUIFER DATA

Saturated Thickness: 4.37 m Anisotropy Ratio (Kz/Kr): 1.

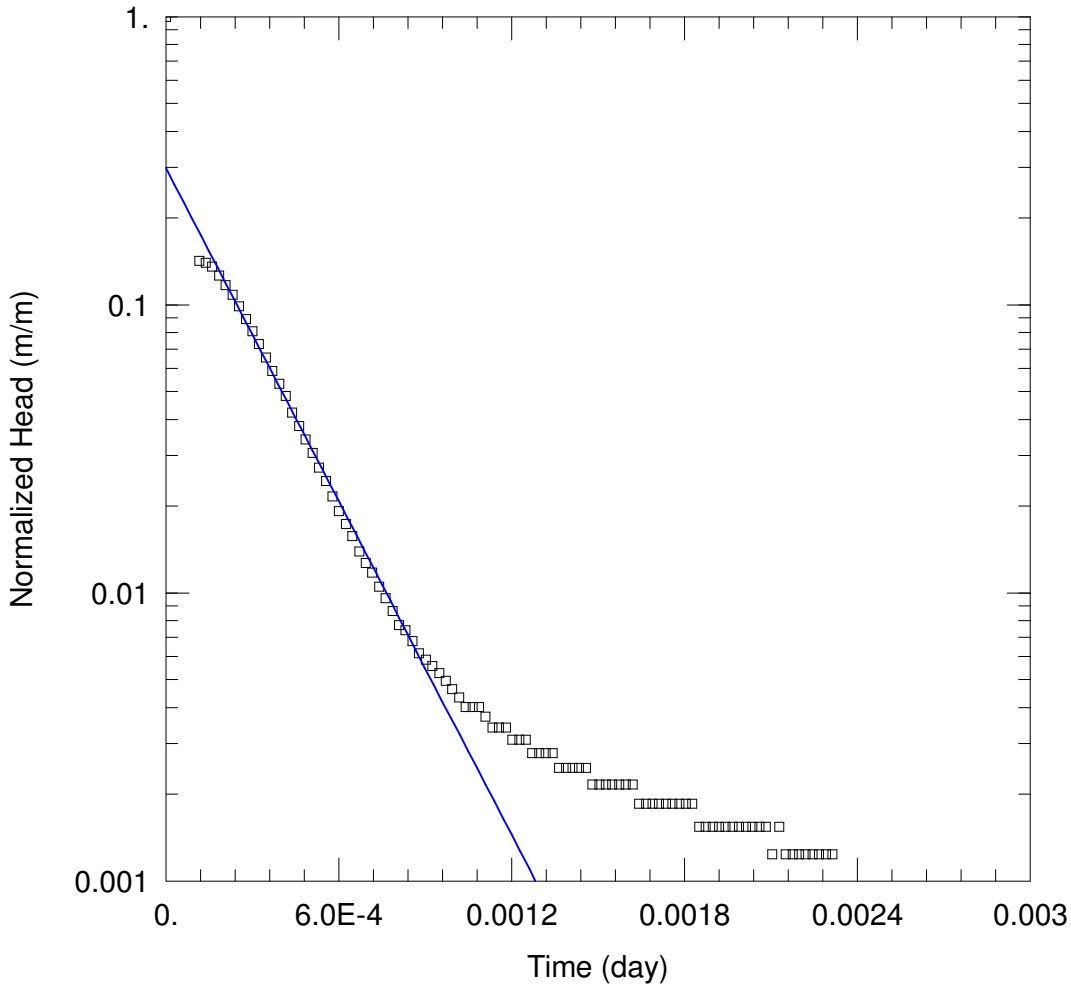
WELL DATA (DW7225W1)

Initial Displacement: 32.63 m Static Water Column Height: 4.37 m
Total Well Penetration Depth: 6. m Screen Length: 6. m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.4438 m/day y0 = 3.6 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7225W2 Bouwer-Rice.aqt
Date: 09/07/19 Time: 17:16:29

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7225W2
Test Date: 3 September 2019

AQUIFER DATA

Saturated Thickness: 3.5 m Anisotropy Ratio (Kz/Kr): 1.

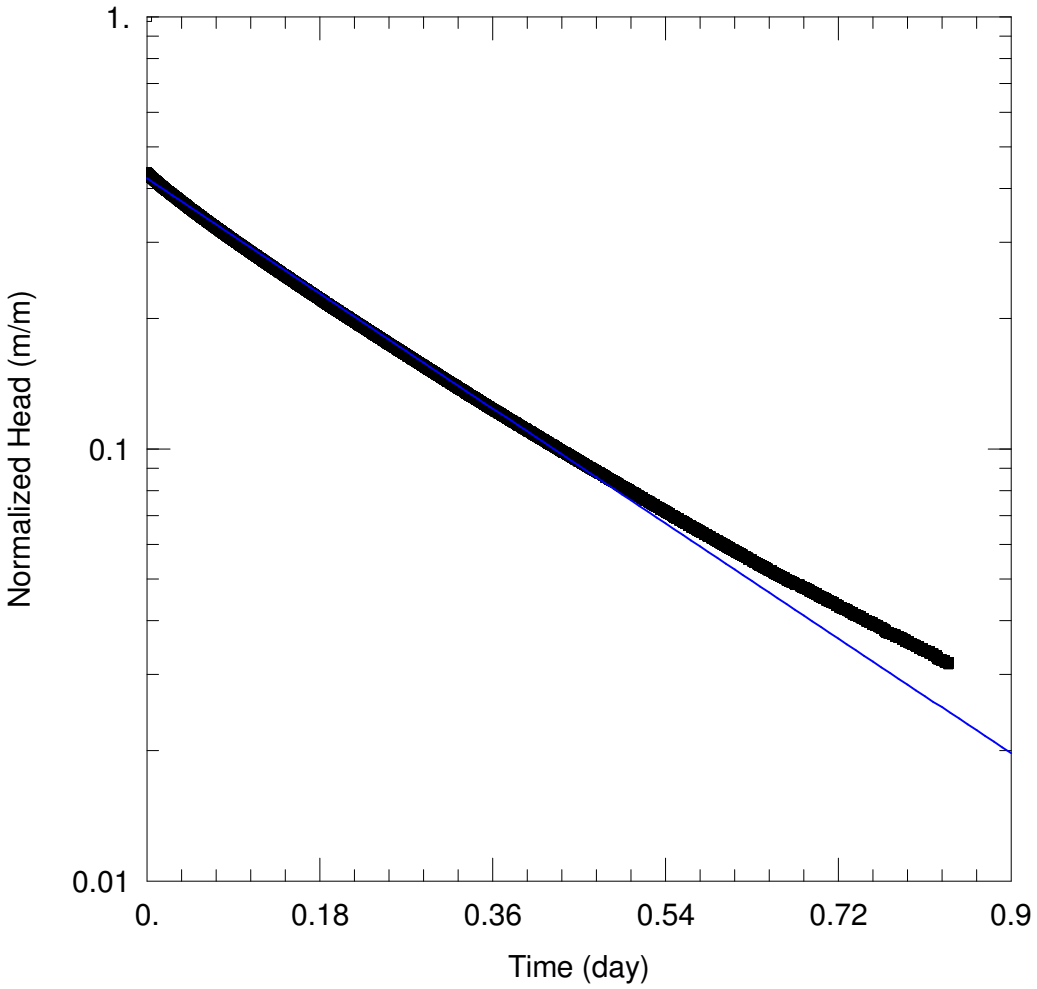
WELL DATA (DW7225W2)

Initial Displacement: 32.37 m Static Water Column Height: 46.53 m
Total Well Penetration Depth: 47.03 m Screen Length: 3.5 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 2.141 m/day y0 = 9.66 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7225W3 Bouwer-Rice.aqt
Date: 09/07/19 Time: 17:17:59

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7225W3
Test Date: 3 September 2019

AQUIFER DATA

Saturated Thickness: 3. m Anisotropy Ratio (Kz/Kr): 1.

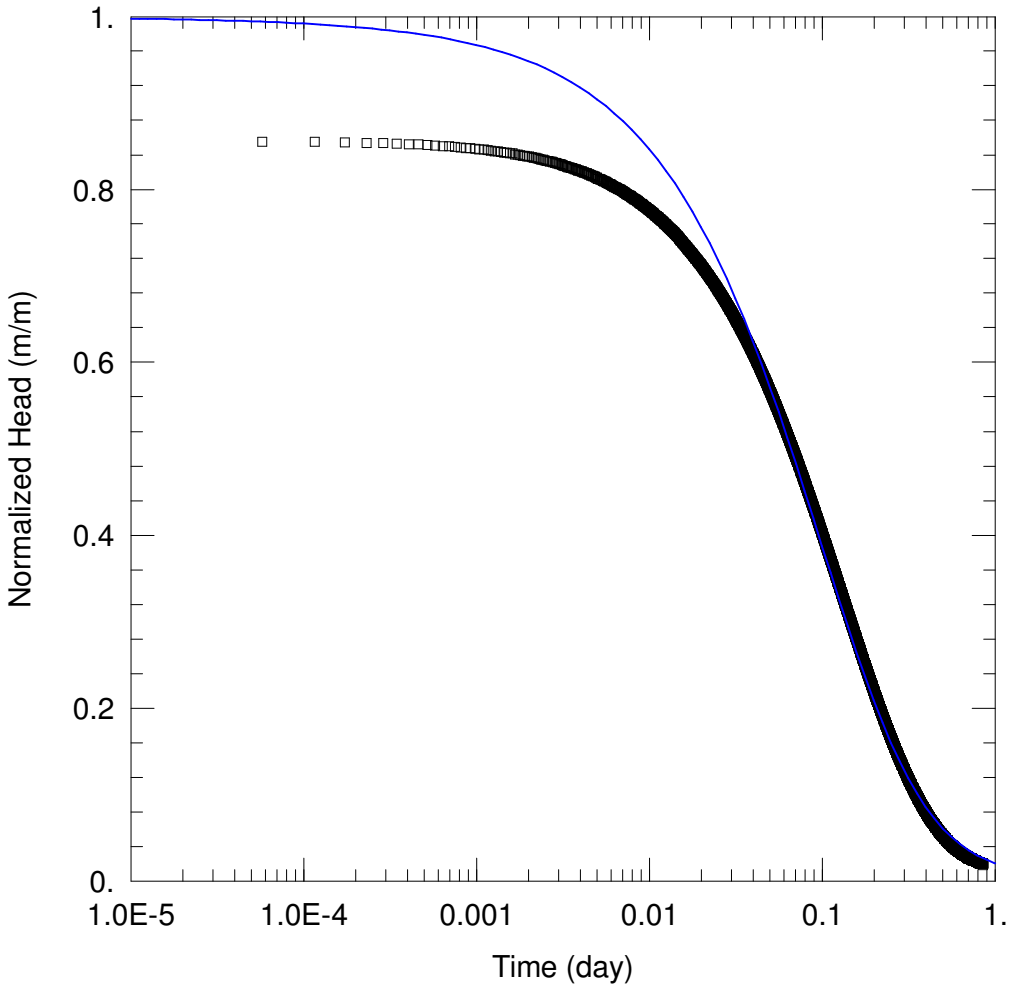
WELL DATA (DW7225W3)

Initial Displacement: 31.84 m Static Water Column Height: 80.96 m
Total Well Penetration Depth: 80.96 m Screen Length: 3. m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.002001 m/day y0 = 13.44 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7264W2.aqt
Date: 09/07/19 Time: 12:00:13

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7265W2
Test Date: 15 July 2019

AQUIFER DATA

Saturated Thickness: 2. m

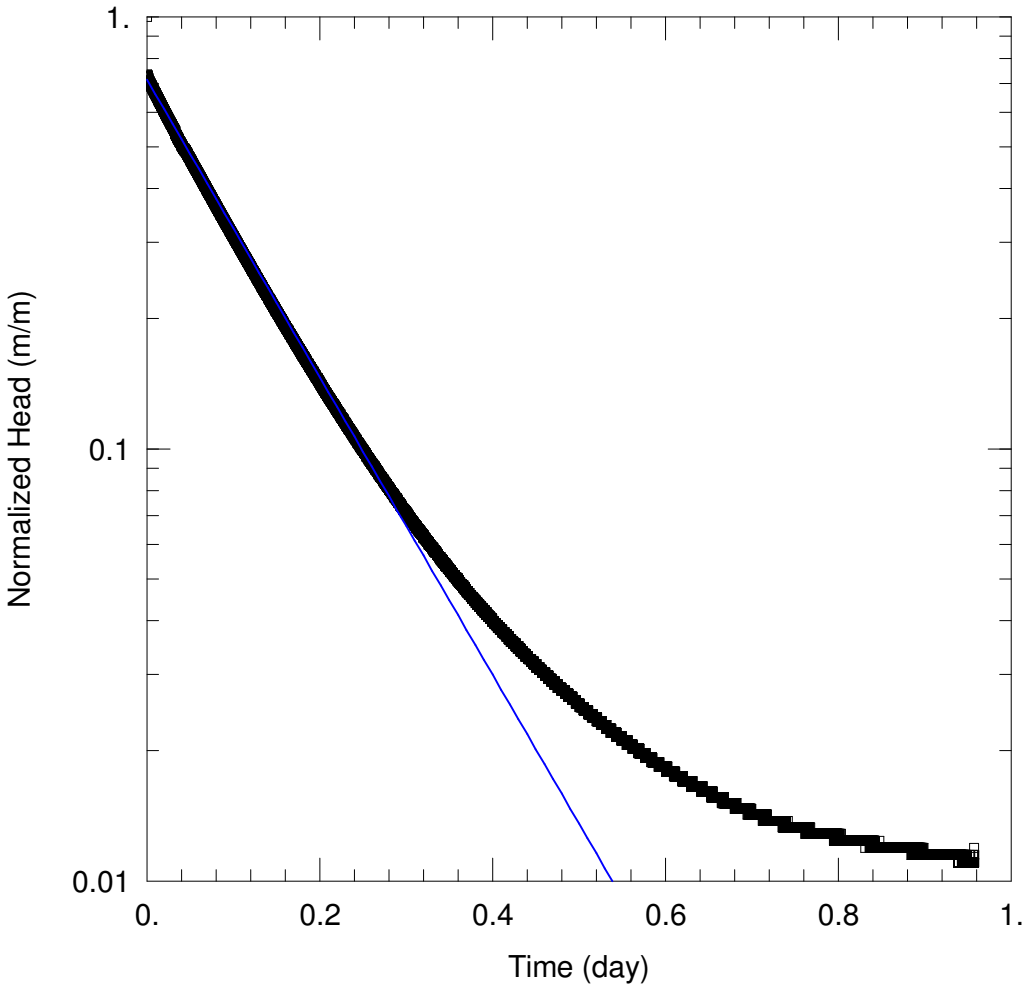
WELL DATA (DW7264W2)

Initial Displacement: 21.77 m
Total Well Penetration Depth: 82.44 m
Casing Radius: 0.025 m
Static Water Column Height: 82.44 m
Screen Length: 1.5 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.009237 m/day
Kz/Kr = 0.1
Ss = 0.006874 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7264W3.aqt
Date: 09/07/19 Time: 12:22:15

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7265W3
Test Date: 15 July 2019

AQUIFER DATA

Saturated Thickness: 2. m Anisotropy Ratio (Kz/Kr): 0.1

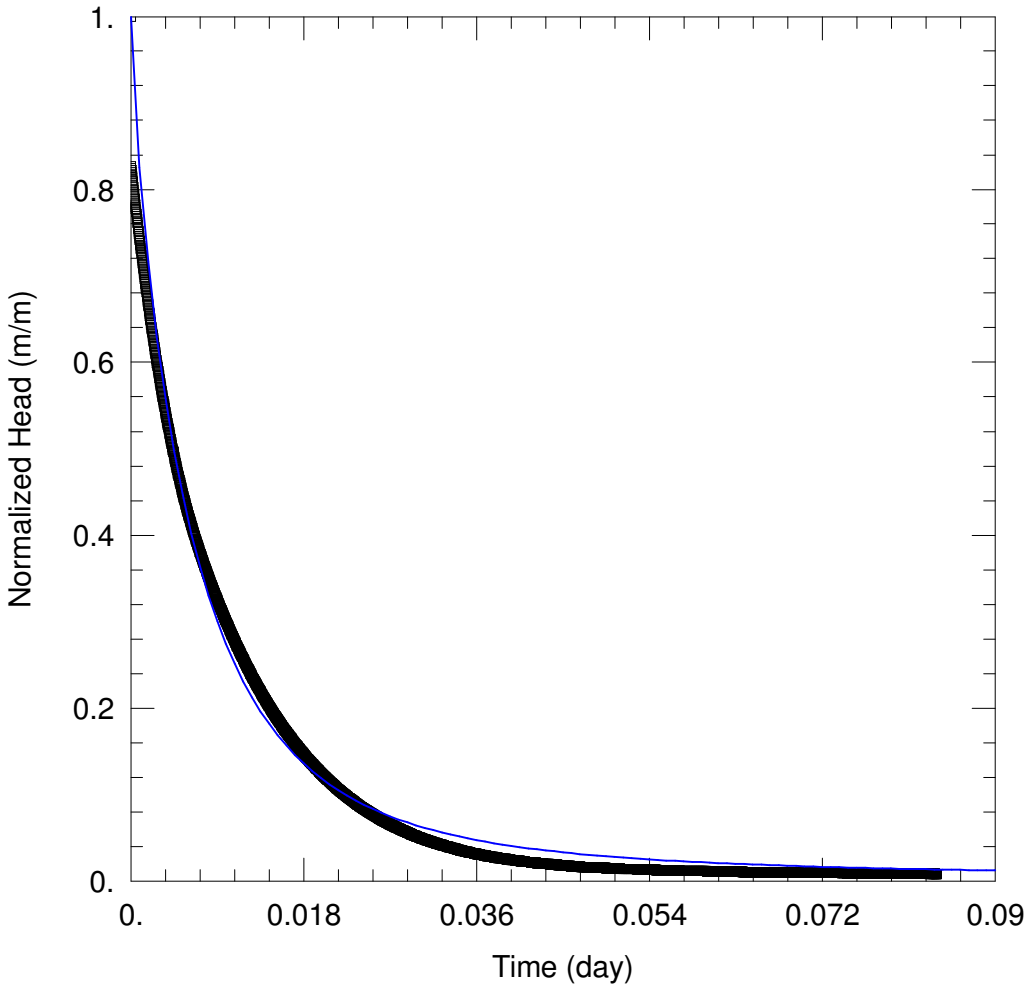
WELL DATA (DW7264W3)

Initial Displacement: 21.78 m Static Water Column Height: 114.9 m
Total Well Penetration Depth: 114.9 m Screen Length: 1.5 m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.01101 m/day y0 = 15.58 m



WELL TEST ANALYSIS

Data Set: D:\...\DW7282W1_KGS Model.aqt
Date: 09/07/19 Time: 14:33:09

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7282W1
Test Date: 18 July 2019

AQUIFER DATA

Saturated Thickness: 16.58 m

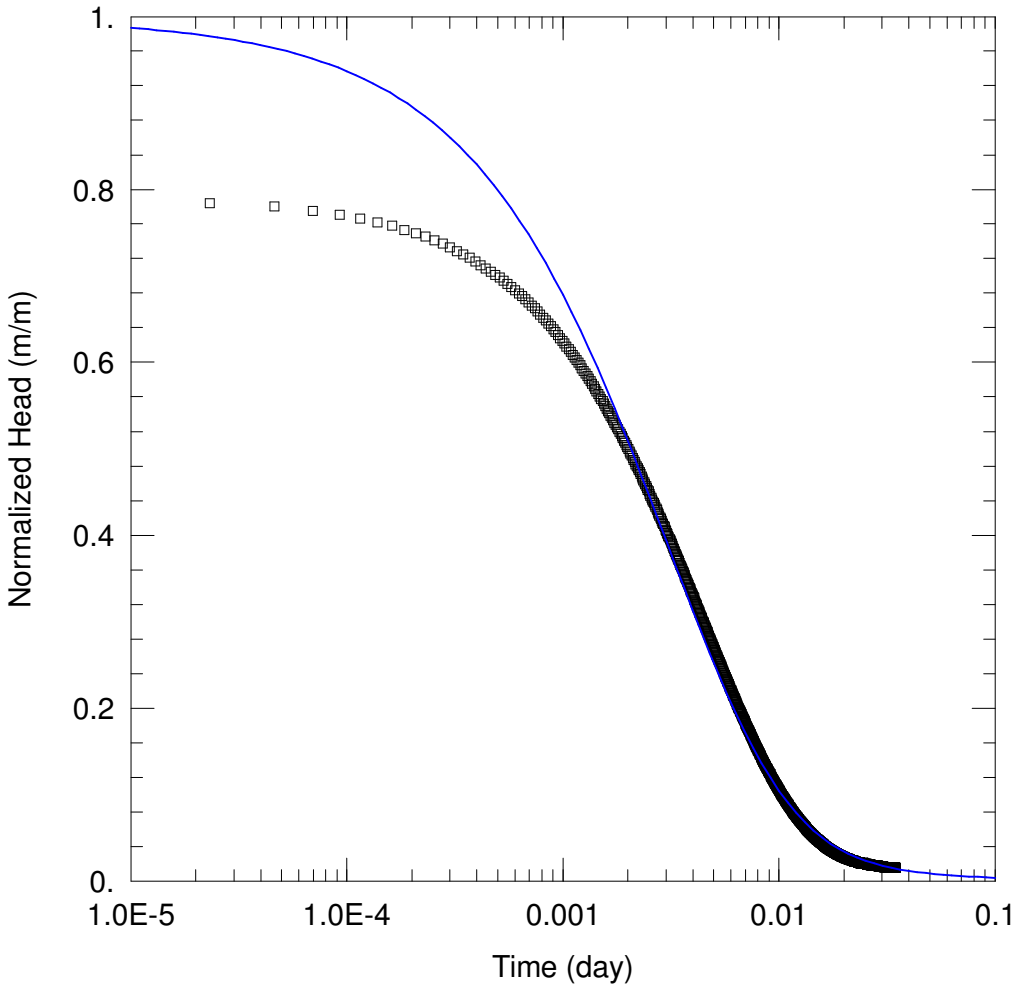
WELL DATA (DW7282W1)

Initial Displacement: 26.45 m
Total Well Penetration Depth: 16.58 m
Casing Radius: 0.025 m
Static Water Column Height: 16.58 m
Screen Length: 6. m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.02744 m/day
Kz/Kr = 0.1
Ss = 0.0003112 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7282W2_KGS Model.aqt
Date: 09/07/19 Time: 14:51:10

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7282W2
Test Date: 18 July 2019

AQUIFER DATA

Saturated Thickness: 2. m

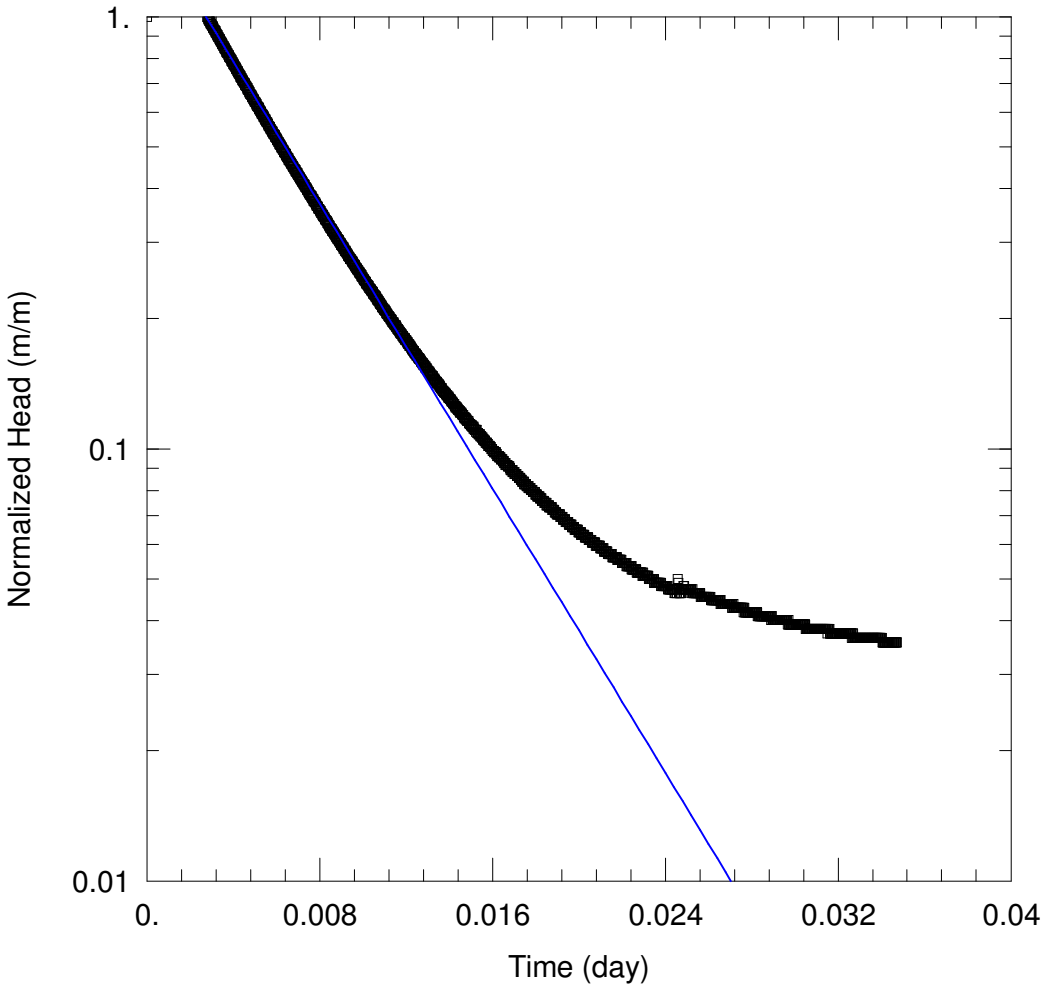
WELL DATA (DW7282W2)

Initial Displacement: 26.51 m
Total Well Penetration Depth: 63.4 m
Casing Radius: 0.025 m
Static Water Column Height: 63.4 m
Screen Length: 1.5 m
Well Radius: 0.025 m

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

Kr = 0.2446 m/day
Kz/Kr = 0.1
Ss = 0.00214 m^{-1}



WELL TEST ANALYSIS

Data Set: D:\...\DW7291W1.aqt
Date: 09/07/19 Time: 15:07:11

PROJECT INFORMATION

Company: Gemini Project
Test Well: DW7292W1
Test Date: 23 August 2019

AQUIFER DATA

Saturated Thickness: 3.78 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (DW7292W1)

Initial Displacement: 11.22 m Static Water Column Height: 3.78 m
Total Well Penetration Depth: 3.78 m Screen Length: 3. m
Casing Radius: 0.025 m Well Radius: 0.025 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.09701 m/day y0 = 18.86 m

GEMINI PROJECT
TERRESTRIAL ECOLOGY ASSESSMENT

PREPARED FOR
MAGNETIC SOUTH PTY LTD

SEPTEMBER 2019

BRISBANE OFFICE
Suite 5, 1 Swann Road
Taringa, QLD 4068
P +61 7 3217 8772

CAIRNS OFFICE
PO Box 4887
Cairns, QLD 4879
P +61 7 4057 9402

E info@aarc.net.au
AARC.NET.AU

ACN. 620 818 920
ABN. 71 620 818 920

AARC Environmental Solutions Pty Ltd

Document History and Status

Issue	Rev.	Issued To	Qty	Date	Reviewed	Approved
Draft	0.1	SG	1	09/2019	SG	SG
Final	0.2	Magnetic South	1	09/2019	PI	PI
Final	0.3	GB	1	09/2019	GB	GB

Author: Lucia Lopez
Project Manager: Gareth Bramston
Name of Client: Magnetic South Pty Ltd
Name of Project: Gemini Project
Title of Document: Ecology Terrestrial Assessment
Document Version: Final

This controlled document is the property of AARC Environmental Solutions Pty Ltd and all rights are reserved in respect of it. This document may not be reproduced or disclosed in any manner whatsoever, in whole or in part, without the prior written consent of AARC Environmental Solutions Pty Ltd. AARC Environmental Solutions Pty Ltd expressly disclaims any responsibility for or liability arising from the use of this document by any third party.

Opinions and judgments expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal opinions. Information obtained from interviews and contained in the documentation has been assumed to be correct and complete. AARC Environmental Solutions Pty Ltd does not accept any liability for misrepresentation of information or for items not visible, accessible, nor able to be inspected at the sites at the time of the site visits.

GEMINI PROJECT
TERRESTRIAL ECOLOGY
ASSESSMENT

INDEX

1.0 INTRODUCTION 1
1.1 SCOPE OF STUDY 1
1.2 PROJECT OVERVIEW 1
1.3 CURRENT LAND USE 2
1.4 LOCAL WATERWAYS AND TOPOGRAPHY 3
1.5 GEOLOGY 6
1.6 REGIONAL CLIMATE 6
2.0 RELEVANT LEGISLATION AND POLICY 8
2.1 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 8
2.2 NATURE CONSERVATION ACT 1992 8
2.2.1.1 Nature Conservation (Wildlife) Regulation 2006 9
2.2.1.2 Nature Conservation (Wildlife Management) Regulation 2006 9
2.3 BIOSECURITY ACT 2014 9
2.4 VEGETATION MANAGEMENT ACT 1999 9
2.5 BIODIVERSITY STATUS 10
2.6 QUEENSLAND ENVIRONMENTAL OFFSETS FRAMEWORK 11
3.0 DESKTOP ASSESSMENT 12
3.1 REGULATED VEGETATION 13
3.1.1 Threatened Ecological Communities 13
3.1.2 Regional Ecosystems 13
3.2 SPECIES OF CONSERVATION SIGNIFICANCE 17
3.2.1 Flora 17
3.2.1.1 State and Commonwealth Listed Flora Species 17
3.2.1.2 Back on Track Flora Species Prioritisation 18
3.3 FAUNA 19
3.3.1 State and Commonwealth Listed Fauna Species 19
3.3.1.1 Listed Migratory and Marine Species 20
3.3.1.2 Back on Track Fauna Species Prioritisation 21
3.4 ENVIRONMENTALLY SENSITIVE AREAS 22
3.5 WETLANDS 23
3.5.1 Groundwater Dependant Ecosystem 23

4.0 METHODOLOGY 28
4.1 BIOREGION 28
4.2 FIELD SURVEY GUIDELINES 28
4.3 SURVEY SEASONALITY 28
4.4 FLORA 29
4.4.1 Vegetation Mapping and Community Description 30
4.4.2 Targeted Searches for Species of Conservation Significance 31
4.5 FAUNA 33
4.5.1 Fauna Trapping Sites and Survey Locations 33
4.5.2 Fauna Survey Sites 33
4.5.3 Detection Techniques 36
4.5.4 Fauna Survey Effort 39
5.0 FLORA RESULTS AND DISCUSSION 41
5.1 FLORA SURVEY RESULTS 41
5.1.1 VC 1: Narrow-leaved ironbark and Clarkson's bloodwood woodland with a sparse shrub layer on sand plains 43
5.1.2 VC 2: Lancewood (*Acacia shirleyi)* and/or Rosewood (*Acacia rodoxylon)* woodland on lateritic duricrust 45
5.1.3 VC 3: Blue gum (*Eucalyptus tereticornis)* with *Bauhinia* spp. and *Casuarina cunninghamiana* fringing woodland on drainage features 47
5.1.4 VC 4: Poplar box *(Eucalyptus populnea)* woodland on alluvial plains 49
5.1.5 VC 5: Mixed polygon: Ironbark, Bloodwood and Blue gum woodland along ephemeral creeks 51
5.1.6 VC 6: Mixed polygon: Blue gum, Poplar box and Ironbark woodland along ephemeral creeks 52
5.1.7 Non-remnant and Regrowth Vegetation 53
5.2 WEEDS OF MANAGEMENT CONCERN 53
5.3 FLORA OF CONSERVATION SIGNIFICANCE 55
5.3.1 Threatened Ecological Communities not identified on the study area 55
5.3.2 Flora Species of Conservation Significance Identified on the Study Area 57
5.3.3 Flora Species of Conservation Significance Not Identified on the Study Area 58
5.4 WETLANDS 59
5.4.1 Groundwater Dependent Ecosystems 60
6.0 FAUNA RESULTS AND DISCUSSION 64
6.1 FAUNA SURVEY RESULTS 64
6.1.1 Amphibians 64
6.1.2 Reptiles 65
6.1.3 Birds 67
6.1.4 Mammals 70
6.2 PEST SPECIES 74

6.3 FAUNA SPECIES OF CONSERVATION SIGNIFICANCE 75
6.3.1 Fauna Species of Conservation Significance Identified on the Study Area 75
6.3.2 Fauna Species of Conservation Significance Not Identified on the Study Area 76
7.0 POTENTIAL IMPACTS 81
7.1 TERRESTRIAL FLORA 81
7.1.1 Vegetation Communities 81
7.1.2 Flora Species of Conservation Significance and Habitat 81
7.1.3 Weed Species 81
7.1.4 Wetlands 81
7.1.5 Groundwater Dependant Ecosystems 82
7.2 TERRESTRIAL FAUNA 83
7.2.1 Fauna Species of Conservation Significance and Habitat 83
7.2.2 Migratory Fauna Species 85
7.2.3 Pest Species 85
8.0 MITIGATION AND MANAGEMENT STRATEGIES 87
8.1.1 Terrestrial Flora 87
8.1.1.1 Vegetation Communities 87
8.1.1.2 Flora Species of Conservation Significance 87
8.1.1.3 Weed Species 87
8.1.1.4 Wetlands / GDEs 88
8.1.2 Terrestrial Fauna 88
8.1.2.1 Fauna Species of Conservation Significance 88
8.1.2.2 Pest Species 88
9.0 PROJECT ENVIRONMENTAL OFFSETS 90
9.1 ASSESSMENT OF PRESCRIBED MATTERS IDENTIFIED IN THE STUDY AREA 90
9.1.1 Regulated Vegetation 90
9.1.2 Conservation Significant Species, Protected Wildlife Habitat and Essential Habitat 91
9.1.3 HES Wetland 98
9.2 OFFSETS REQUIREMENTS 98
10.0 REFERENCES 101

LIST OF FIGURES

Figure 1 Project and Study Area Location 4
Figure 2 Waterways and topography associated with the Study Area 5
Figure 3 Mean temperature and rainfall data for the region (Source: SILO) 7
Figure 4 Regulated Vegetation (VM Act) classed as Endangered or Of Concern 15
Figure 5 Regional Ecosystems Vegetation Management Map for the study area 16
Figure 6 Wetland Habitats 24
Figure 7 Potential Terrestrial GDEs (BoM) 25
Figure 8 Potential Aquatic GDEs (BoM) 26
Figure 9 Potential Terrestrial GDEs (DNRME) 27
Figure 10 Gemini Project flora survey sites 32
Figure 11 Gemini Project Fauna sites 35
Figure 12 Vegetation Communities within the study area 42
Figure 13 Wetland Habitats Identified in the Study Area 62
Figure 14 Species of Conservation Significance observed within the study area 63
Figure 15 Conceptual Project Layout 86
Figure 16 Vegetation Communities and Disturbance 92
Figure 17 Regulated Vegetation Offsets Requirements 93
Figure 18 Essential Habitat (VM Act) 94

LIST OF TABLES

Table 1 VM Class listing criteria for regional ecosystems 10
Table 2 Biodiversity Status additional listing criteria for regional ecosystems 10
Table 3 Regional Ecosystems mapped within the study area 14
Table 4 Criteria adopted for likelihood of occurrence determination 17
Table 5 Flora Species of Conservation Significance with the potential to occur within the study area 18
Table 6 Back on Track Priority Flora Species for the Fitzroy NRM Region 18
Table 7 EVNT Fauna species with potential to occur within the study area 19
Table 8 Back on Track Fauna Species from the Fitzroy NRM Region 21
Table 9 Survey effort 40
Table 10 Vegetation Community Overview 41
Table 11 Vegetation Community 1 Profile 43
Table 12 Vegetation Community 2 Profile 46
Table 13 Vegetation Community 3 Profile 47

Table 14 Vegetation Community 4 Profile 49
Table 15 Weed species of management concern identified on the study area 54
Table 16 Flora Species of Conservation Significance not identified on the study area 59
Table 17 Introduced species identified on the study area 75
Table 18 Fauna Species of Conservation Significance not identified on the study area 77
Table 19 Summary of regulated vegetation within the proposed disturbance 91
Table 20 MSES Impact Assessment of the Project on the southern Squatter pigeon 95
Table 21 MSES Impact Assessment of the Project on the Greater glider 96
Table 22 MSES Impact Assessment of the Project on the *Cerbera dumicola* 96
Table 23 MSES Impact Assessment of the Project on the Short-beaked echidna 97
Table 24 MSES Wetland Significant Residual Impact Assessment 98
Table 25 Summary of Assessment of Prescribed Matters 99
Table 26 MSES Offset Requirements 100

LIST OF PHOTO PLATES

Photo Plate 1 Ironbark and Bloodwood woodland on sand plains 44
Photo Plate 2 VC 1 regrowth patch with *Acacia spp.* 45
Photo Plate 3 Lancewood woodland within the study area 46
Photo Plate 4 Blue gum (*Eucalyptus tereticornis)* woodland along the Charlevue Creek 48
Photo Plate 5 Poplar box *(Eucalyptus populnea)* woodland on alluvial plains 50
Photo Plate 6 VC 5 – RE 11.5.2/11.3.25 51
Photo Plate 7 VC 6 – RE 11.3.25/11.3.2/11.5.2 52
Photo Plate 8 Non-remnant *Acacia* spp regrowth 53
Photo Plate 9 *Cryptostegia grandiflora* identified on the study area 55
Photo Plate 10 *Cerbera dumicola* at the study area 58
Photo Plate 11 *Melaleuca spp.* dominated HES wetland 60
Photo Plate 12 Common green tree frog (*Litoria caerulea*) observed at DF02 65
Photo Plate 13 *Box-patterned gecko (Lucasium steindachneri)* observed at DF09 66
Photo Plate 14 Freckled monitor (*Varanus tristis orientalis*) observed at DF10 66
Photo Plate 15 Pale-headed snake (*Hoplocephalus bitorquatus*) observed at DF01 67
Photo Plate 16 Brown falcon (*Falco berigora*) observed on the study area 68
Photo Plate 17 Squatter Pigeon (*Geophaps scripta scripta*) observed at the study area 69
Photo Plate 18 Rufous bettong (*Aepyprymnus rufescens*) observed in the study area 72
Photo Plate 19 Short-beaked Echidna (*Tachyglossus aculeatus*) observed at the study area 73
Photo Plate 20 Greater glider (*Petauroides volans*) observed at the study area 74
Photo Plate 21 Feral cat (*Felis catus*) recorded on the camera trap at DF05 75

LIST OF APPENDICES

Appendix A	Database Searches	A
Appendix B	Likelihood of Occurrence for Threatened Ecological Communities (TEC)	B
Appendix C	Likelihood of Occurrence for Flora Species of Conservation Significance	C
Appendix D	Likelihood of Occurrence for Fauna Species of Conservation Significance	D
Appendix E	Fauna Survey Sites	E
Appendix F	Herbarium Identifications	F
Appendix G	Bat Call Analysis	G
Appendix H	Flora Species List	H
Appendix I	Fauna Species List	I
Appendix J	Weed Species and Management Plans	J
Appendix K	Pest Species and Management Plans	K

LIST OF ABBREVIATIONS

°C	Degrees Celsius
%	Percent
AARC	AARC Environmental Solutions Pty Ltd
ALA	Atlas of Living Australia
BCA	Biodiversity and Conservation Values report
BOM	Bureau of Meteorology
BoT	Back on Track
BVG	Broad Vegetation Group
C	Least Concern
CE	Critically Endangered
cm	Centimetre
DES	Department of Environment and Science
E	Endangered
EA	Environmental Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPC	Exploration Permit Coal
ESA	Environmental Sensitive Area
ERE	Endangered Regional Ecosystem
EVNT	Endangered, Vulnerable or Near Threatened species
GDE	Groundwater Dependent Ecosystem(s)
GDE Atlas	National Atlas of Groundwater Dependent Ecosystems
GIS	Geographical Information System
GPS	Geographical Positioning System
ha	hectares
HES	High Ecological Significance

km	kilometres
km^2	square kilometres
LC	Least Concern
m	metre(s)
mbgl	metre(s) below ground level
mAHD	metre(s) Australian height datum
Ma	Marine
Mi	Migratory
MLES	Matters of Local Environmental Significance
mm	millimetres
MNES	Matters of National Environmental Significance
MSES	Matters of State Environmental Significance
NC Act	Nature Conservation Act 1992
NCWR	Nature Conservation (Wildlife) Regulation 2006
NP	National Park
NRM	Natural Resource Management
NT	Near Threatened
PMAV	Property Maps of Assessible Vegetation
RAD	Recovery Actions Database
ROM	Run of mine
RE	Regional Ecosystem
REDD	Regional Ecosystem Description Database
SILO	Scientific Information for Land Owners
SL	Special Least Concern
SPRAT	Species Profile and Threats Database
TEC	Threatened Ecological Community
V	Vulnerable
VM Act	Vegetation Management Act 1999

VMR	Vegetation Management Regulation 2000
WoNS	Weeds of National Significance

1.0 INTRODUCTION

AARC Environmental Solutions Pty Ltd (AARC) was commissioned by Magnetic South Pty Ltd (Magnetic South) to prepare a terrestrial ecology assessment for the Gemini Project, located approximately 110 km east of Emerald and 125 km west of Rockhampton in the Bowen Basin of Central Queensland (Figure 1). The Project is a proposed metallurgical open-cut coal mine and associated infrastructure, producing Pulverised Coal Injection (PCI) coal Coking Coal products for export for steel production.

An assessment of the terrestrial ecological values was conducted within Exploration Permit Coal (EPC) 881 (herein referred to as the study area). This assessment forms part of the supporting studies required for the Project's approval processes.

1.1 SCOPE OF STUDY

To assess the ecological values of terrestrial ecosystems within the study area, the following scope of works was undertaken:

- Database searches to identify species of conservation significance known from the region (provided in Appendix A). These species were targeted during the field survey component of the study;
- Field surveys employing standard methodologies such as the *Terrestrial Vertebrate Fauna Survey Guidelines of Queensland* (Eyre *et al.* 2018) and *Queensland Herbarium Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland Version 4.0* (Neldner *et al.* 2017) to identify terrestrial flora and fauna species inhabiting the study area, particularly species of conservation significance[1]; and
- Preparation of an assessment report describing the terrestrial ecological values identified on site, potential impacts of the Project, management strategies to minimise the impacts associated with the proposed mining activities and offset requirements.

1.2 PROJECT OVERVIEW

The main activities associated with the Project include:

- Exploration activities continuing in order to support mine planning;
- Development of a Mine Infrastructure Area (MIA) including mine offices, bathhouse, crib rooms, warehouse/stores, workshop, fuel storage, refuelling facilities, explosives magazine and sewage, effluent and liquid waste storage;
- Construction and operation of a Coal Handling Preparation Plant (CHPP) and coal handling facilities adjacent to the MIA (including Run-of-Mine (ROM) coal and, product stockpiles and rejects bin/overflow [coarse and fine rejects]);

[1] 'Species of conservation significance' or 'threatened species' when referred to within this document are references to species listed as Near Threatened, Vulnerable or Endangered under the Queensland *Nature Conservation Wildlife Regulation 2006* or Vulnerable, Endangered, Critically Endangered or Migratory under the *Environmental Protection and Biodiversity Conservation Act 1999*.

- Construction and operation of a surface conveyor from the product stockpiles to a Train Load Out (TLO) facility and rail loop connecting to the Blackwater-Gladstone Branch Rail to transport product coal to coal terminals at Gladstone for export;
- Construction of access roads from the Capricorn Highway to the MIA, and to the TLO facility;
- Installation of a raw water supply pipeline to connect to the Blackwater Pipeline network;
- Construction of a 66 kilovolt (kV) transmission line and switching/substation to connect to the existing regional network;
- Other associated minor infrastructure, plant, equipment and activities;
- Development of mine areas (open cut pits) and out-of-pit waste rock emplacements;
- Drilling and blasting of competent waste material;
- Mine operations using conventional surface mining equipment (excavators, front end loaders, rear dump trucks, dozers);
- Mining up to 1.9 Million tonnes per annum (Mtpa) ROM Coal – average 1.8 Mtpa for a construction/production period of approximately 20 years;
- Progressive placement of waste rock in:
  - Emplacements, adjacent to and near the open cut voids;
  - Mine voids, behind the advancing open cut mining operations;
- Progressive rehabilitation of waste rock emplacement areas and mined voids;
- Progressive establishment of soil stockpiles, laydown area and borrow pits (for road base and civil works). Material will be sourced from local quarries where required;
- Disposal of CHPP rejects (coarse and fine rejects) in out of pit spoil dumps, and in-pit behind the mining void;
- Progressive development of internal roads and haul roads including a causeway over Charlevue Creek to enable coal haulage and pit access; and
- Development of water storage dams and sediment dams, and the installation of pumps, pipelines, and other water management equipment and structures including temporary levees, diversions and drains.

Existing local and regional infrastructure, facilities and services would be used to support Project activities. These include the SunWater water distribution network, the Aurizon rail network, Ergon's electricity network, the Capricorn Highway, and Gladstone export coal terminals.

1.3 CURRENT LAND USE

The land within the study area is currently used for low intensity cattle grazing and resource exploration activities. The Capricorn Highway and a number of publicly gazetted roads including Charlevue, Cooinda, Red Hill, Normanby, and Ellesmere roads dissect the study area.

Located directly north of the study area is the Taunton National Park (Scientific), (Taunton Nation Park), a scientific reserve under the *Land Act 1994 (Queensland)*, with the aim of protecting a population of Bridled nail-tail wallabies. A small section of the Taunton National Park of around 2.5 hectares (ha) within the study area.

1.4 LOCAL WATERWAYS AND TOPOGRAPHY

The study area lies within the Fitzroy River Basin, which encompasses an area of 142,545 square kilometres (km^2) and contains the Comet, Connors, Dawson, Don, Nogoa and Mackenzie Rivers, which make up its six sub-catchment areas (BoM 2018; DES 2018a). The study area lies within the Mackenzie River sub-catchment, which covers a total area of 12,985 km^2, and is situated in the centre of the Fitzroy River catchment.

The major water body associated with the study area is Charlevue Creek, which traverses the study area in a north-easterly direction. This creek begins within the boundaries of Blackdown Tablelands National Park, flowing north-east before joining with Springton Creek and the Fitzroy River, eventually emptying into the Pacific Ocean approximately 46 km north of Gladstone. Stanley Creek and Springton Creek cross the study area in the north-west and south-east, respectively. These two creeks also eventually converge with the Mackenzie River. First and second order streams associated with Charlevue Creek and Springton Creek also occur in the study area. Figure 2 shows the extent and location of the waterways within the study area.

Springton Creek and Charlevue Creek are defined watercourses under the *Water Act 2000 (Queensland).* Springton Creek and Charlevue Creek within the study area are 5th order streams. Stanley Creek is considered a 2nd order stream.

Topography of the land varies from flat to undulating, with elevation within the study area ranging between 120 metres (m) and 150 m. The landscape is influenced by Charlevue Creek, which has a lower elevation than the surrounding landscape. The topography of the study area is representative of the surrounding region.

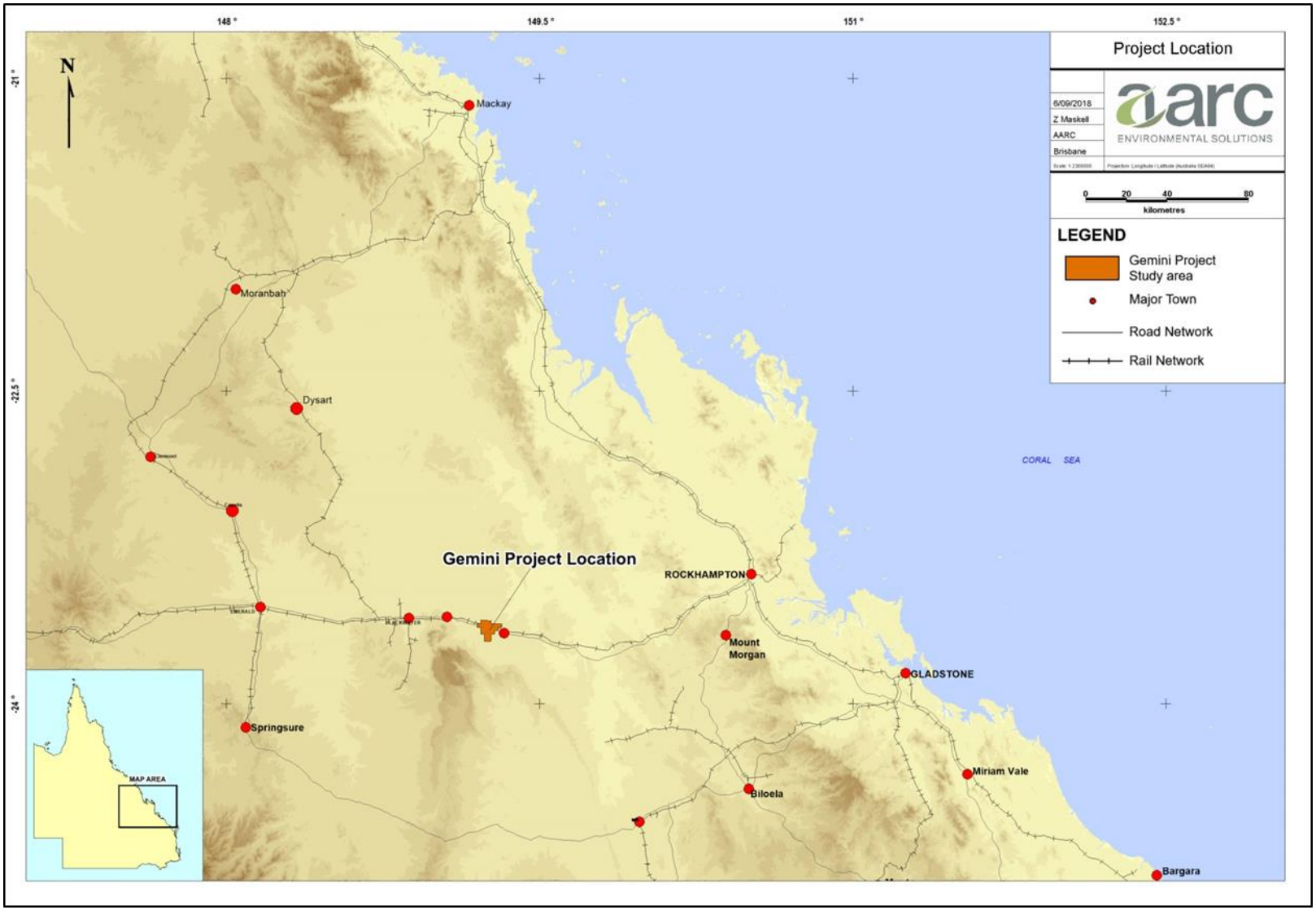


Figure 1 Project and Study Area Location

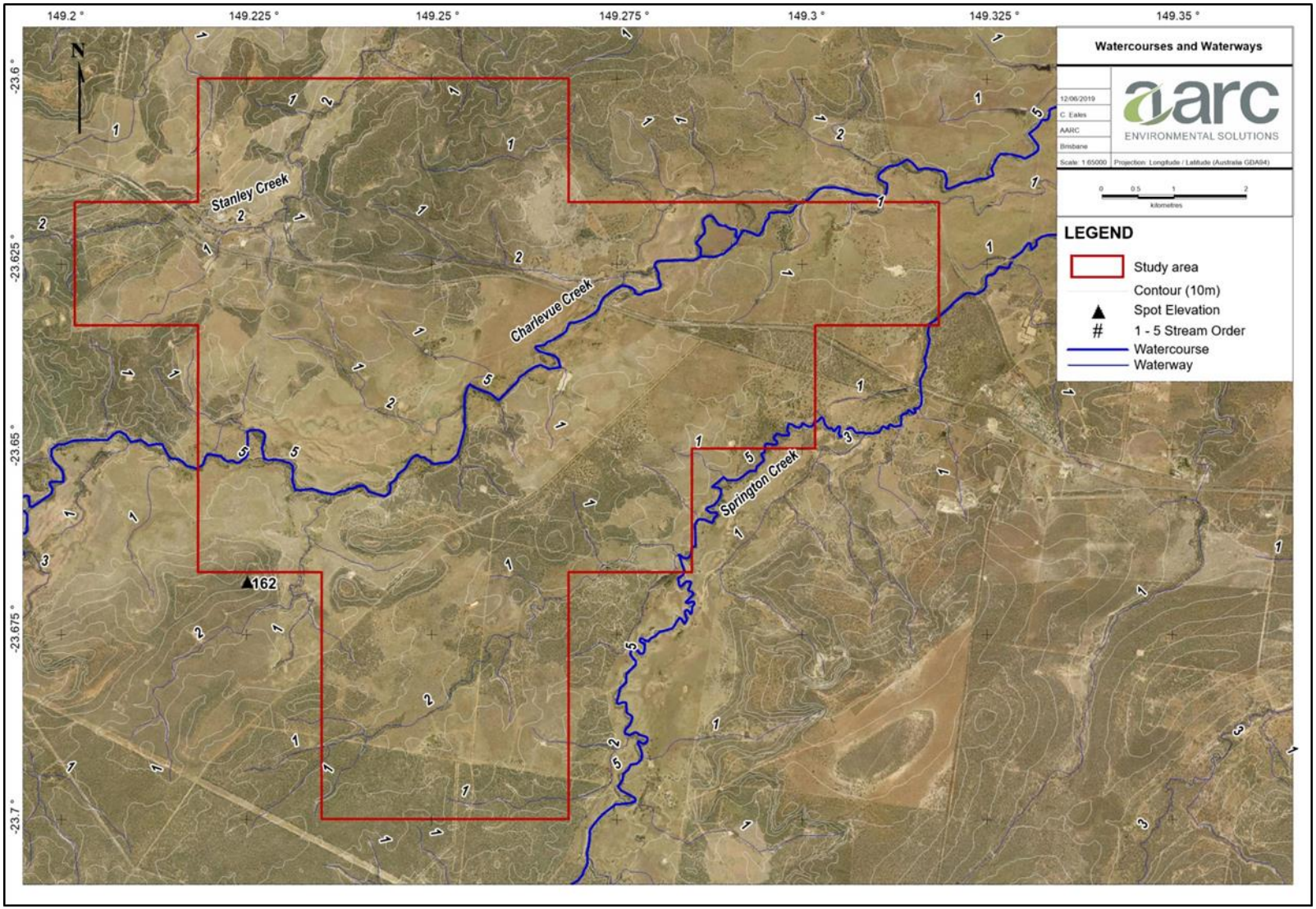


Figure 2 Waterways and topography associated with the Study Area

1.5 GEOLOGY

The geology of the region is dominated by its position within the Bowen Basin, one of Queensland's largest depositional regions, which formed through a period of rifting and subsidence lasting from the Early Permian - Mid-Triassic. The area is dominated by clastic sedimentary rocks of marine and lacustrine origin, including sandstones, conglomerates, mudstones, siltstones and coal (Geoscience Australia 2018).

The coastal and inland depositional environments which created these deposits allowed for the formation of extensive coal seams throughout the Bowen Basin, with the anoxic deposition of organic matter subsequently compacted and de-volatised through compression and increased temperatures (Brooks & Smith 1969).

Generally, coal seams found in the east-central part of the basin contain higher quality coking coal deposits, with rank falling below coking range farther south and west (Hutton 2009). The high-quality coal measures are of Permian age, buried less than 60 m from the surface (Mutton 2003).

1.6 REGIONAL CLIMATE

The regional climate is classified as semi-arid, characterised with warm dry summers and warm winters. Climate data for the study area has been sourced from Scientific Information for Land Owners (SILO) climate database (Queensland Government), which operates by interpolating data from the Commonwealth Bureau of Meteorology (BoM) into a single point data drill.

Figure 3 shows predicted average temperature and rainfall for the area from January 1999 to July 2019. The data indicates the annual mean rainfall for the region is highest between December and March with the maximum average occurring in December (111.5 millimetres (mm)).

The hottest months typically occur between October and March while the coolest months occur between May and September. The highest mean maximum temperature typically occurs in December (34.2 degrees Celsius (°C)) and the lowest mean minimum temperature in July (8.5°C). The mean annual maximum temperature for the region is predicted to be 29.8°C and the mean annual minimum temperature is predicted to be 16°C.

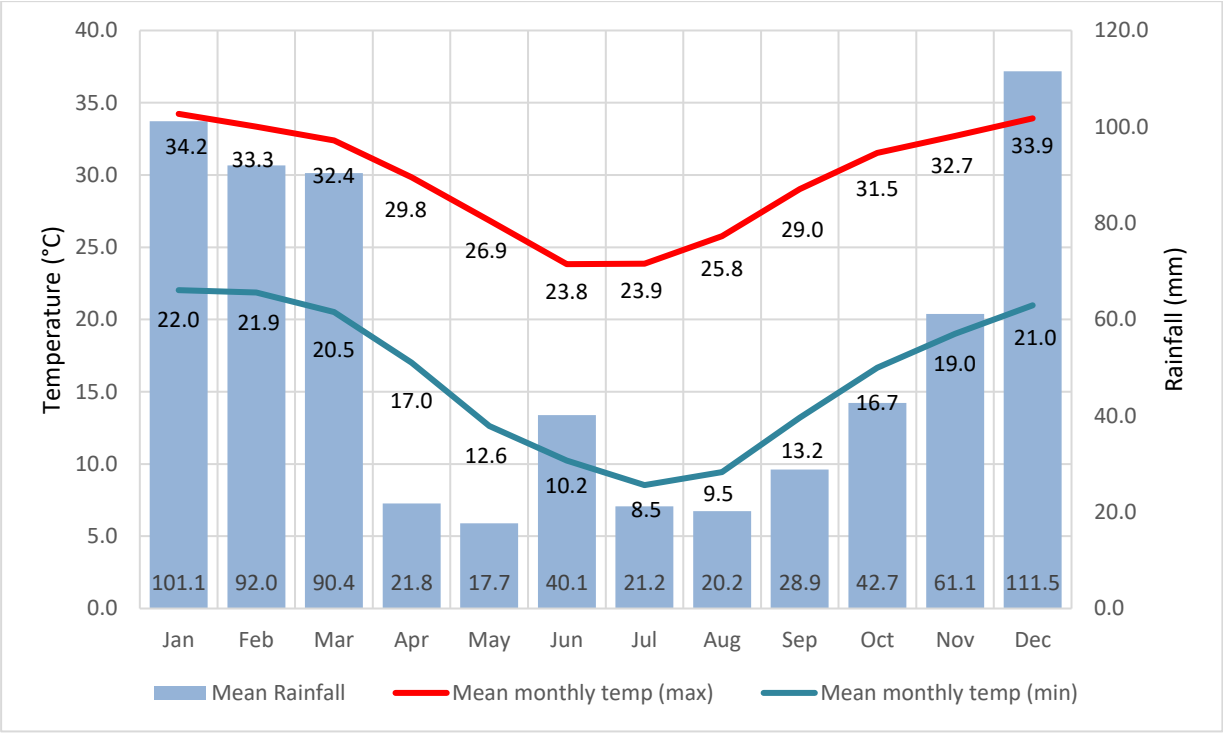


Figure 3 Mean temperature and rainfall data for the region (Source: SILO)

2.0 RELEVANT LEGISLATION AND POLICY

Commonwealth and State legislation and policies relevant to the assessment of terrestrial ecological values on the study area is discussed below.

2.1 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

Under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), an action requires approval from the Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a Matter of National Environmental Significance (MNES).

An EPBC Referral (2010/5775) was lodged in 2010 for the Gemini Project previously known as the Dingo West Project by Dingo West Pty Ltd, which was declared 'Not a Controlled Action if undertaken in a Particular Manner' in July 2011.

The Particular Manner Decision conditions (EPBC 2010/5775) are as follows:

1. *To prevent downstream impacts to the Fitzroy River Turtle (Rheodytes leukops) the person taking the action must appropriately bund or locate pits in a manner that prevents surface water from entering the pit during a 1:1000 year flood event (as indicated in flood modelling at Attachment A).*

2. *To prevent downstream impacts to the Fitzroy River Turtle (Rheodytes leukops) the person taking the action must appropriately bund or locate dams in a manner that prevents surface water from entering or damaging the dams during a during a 1:1000 year flood event (as indicated in flood modelling at Attachment A).*

The Gemini Project complies with the Particular Manner Decision (EPBC 2010/5775). Furthermore, the level of impact to MNES have been assessed to be no greater than those described in the EPBC Referral (20105775).

The potential impact of the Project on the Fitzroy River Turtle is addressed in the Aquatic Ecology Assessment (AARC 2019).

2.2 NATURE CONSERVATION ACT 1992

The most relevant components of the Queensland *Nature Conservation Act 1992* (NC Act) to the Project, are the sections which pertain to Wildlife and Habitat Conservation. The classes of wildlife to which the NC Act applies includes protected wildlife, which is defined as Extinct wildlife; Endangered wildlife; Vulnerable wildlife; Near Threatened wildlife; and Least Concern wildlife.

'Threatening processes' are also relevant to wildlife and habitat conservation. The NC Act defines 'threatening processes' as any process that is capable of:

a) threatening the survival of any protected area, area of major interest, protected wildlife, community of native wildlife or native wildlife habitat; or

b) affecting the capacity of any protected area, area of major interest, protected wildlife, community of native wildlife or native wildlife habitat to sustain natural processes.

The NC Act is relevant to the Project for any protected flora or fauna species (as detailed in the NCWR) found in the study area.

2.2.1.1 Nature Conservation (Wildlife) Regulation 2006

Species listed under the above threatened species classes are published in the associated Nature Conservation (Wildlife) Regulation 2006 (NCWR). This report has considered the recent amendments made to listed threatened species in 2019.

2.2.1.2 Nature Conservation (Wildlife Management) Regulation 2006

The *Nature Conservation (Wildlife Management) Regulation 2006* provides for the management of wildlife, other than wildlife in a protected area.

This regulation also pertains to the clearing, growing, harvesting and trading of protected plants in Queensland. As per Section 282 of the Regulation, a protected plant clearing permit for protected plants (other than in a protected area) may be required for any vegetation clearing of an area containing EVNT species (DES 2019a).

2.3 BIOSECURITY ACT 2014

The Queensland *Biosecurity Act 2014* (Biosecurity Act) provides comprehensive biosecurity measures to safeguard our economy, agricultural and tourism industries, environment and way of life, from pests (e.g. wild dogs and weeds), diseases (e.g. foot-and-mouth disease), and contaminants (e.g. lead on grazing land).

Biosecurity matters are separated into three broad categories:

- A '**prohibited matter'** is a biosecurity matter that is not found in Queensland but would have a significant adverse impact on our health, way of life, and the economy or the environment if it entered the State. Prohibited matters must be reported to Biosecurity Queensland within 24 hours and all reasonable steps taken to minimise the risks of the prohibited matter and not make the situation worse.

- A '**restricted matter'** is a biosecurity matter found in Qld and has a significant impact on human health, social amenity, the economy or the environment. Restricted matters are further broken down into seven categories, with each category placing restrictions on the dealings with the biosecurity matter or actions required to be taken to minimise the spread and adverse impact of the biosecurity matter.

- An '**other matter'** is a biosecurity matter that is not a prohibited or restricted matter. Everyone is obligated to take all reasonable and practical steps to minimise the risks associated with other biosecurity matters under their control.

The Biosecurity Act is relevant to the Project in regard to the control and management of invasive plant and animal species.

2.4 VEGETATION MANAGEMENT ACT 1999

The *Vegetation Management Act 1999 (Qld)* (VM Act) is a part of a planning framework for the management of native vegetation across Qld. The *Vegetation Management Regulation 2012* (VMR) prescribes the status (otherwise known as the Vegetation Management Class (VM Class)) of each of the Regional Ecosystems (RE) identified within Qld.

The specific criteria used to assess the VM Class of RE are defined in Table 1. 'Remnant Vegetation' for an area of Queensland for which there is no RE map or remnant vegetation map, is any vegetation where the predominant canopy:

- covers more than 50% of the undisturbed predominant canopy;
- averages more than 70% of the vegetation's undisturbed height; and
- is composed of species characteristic of the vegetation's undisturbed dominant canopy.

Table 1 VM Class listing criteria for regional ecosystems

VM Class	Criteria
Endangered	• remnant vegetation is less than 10 % of its pre-clearing extent across the bioregion; or • 10–30% of its pre-clearing extent remains and the remnant vegetation is less than 10,000 ha.
Of Concern	• remnant vegetation is 10–30% of its pre-clearing extent across the bioregion; or • more than 30% of its pre-clearing extent remains and the remnant extent is less than 10,000 ha.
Least Concern	• remnant vegetation is over 30% of its pre-clearing extent across the bioregion, and the remnant area is greater than 10,000 ha.

2.5 BIODIVERSITY STATUS

The Department of Environment and Science (DES) Biodiversity Status is a classification assigned to REs and is used for a range of planning and management applications. These applications include the Biodiversity Planning Assessments and the determination of environmentally sensitive areas that are used for regulation of the mining industry through provisions in the *Environmental Protection Act 1994* (EP Act).

The biodiversity status is based on an assessment of the condition of remnant vegetation in addition to the criteria used to determine the class under the VM Act; including other threatening processes, such as reduction in biodiversity; weed invasion; grazing pressures; inappropriate fire management; fragmentation; and infrastructure development.

Table 2 Biodiversity Status additional listing criteria for regional ecosystems

Biodiversity Status	Criteria in addition to VM Class listing
Endangered	• less than 10% of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss; or • 10–30% of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss and the remnant vegetation is less than 10,000ha; or • it is a rare RE subject to a threatening process.
Of Concern	• 10–30% of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss.
No Concern at Present	• the degradation criteria listed above for 'endangered' or 'of concern' RE are not met.

2.6 QUEENSLAND ENVIRONMENTAL OFFSETS FRAMEWORK

The Queensland environmental offsets framework consists of the *Environmental Offsets Act 2014*, *Environmental Offsets Regulation 2014*, and the *Queensland Environmental Offsets Policy (*Version 1.6) (DES 2018b). The offsets framework requires environmental offsets to be delivered where an activity is likely to result in a significant residual impact on a prescribed environmental matter. The *Significant Residual Impact Guideline* (DES 2014a) is used to determine whether the residual impacts are significant.

Prescribed Environmental Matters include:

- Matters of National Environmental Significance (MNES);
- Matters of State Environmental Significance (MSES) (outlined below); and
- Matters of Local Environmental Significance (MLES).

MSES are defined in Schedule 2 of the *Environmental Offsets Regulation 2014*, and comprise:

- Regulated vegetation including:
    i. Endangered and Of Concern regional ecosystems;
    ii. Regional ecosystems (REs) that intersect areas shown as wetlands on the Vegetation Management Wetlands map;
    iii. REs located within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature; or
    iv. REs mapped as essential habitat for endangered and vulnerable flora and fauna;
- Areas that provide connectivity and maintain ecosystem functioning;
- Mapped wetlands and watercourses including:
    i. Wetland protection areas, or areas of high ecological significance as shown on the Map of referable wetlands; or
    ii. High ecological value waters (as defined under the *Environmental Protection (Water) Policy 2009*);
- Designated precincts in a strategic environmental area under the *Regional Planning Interests Regulation 2014*;
- Protected wildlife habitat, which includes;
    i. High risk areas on the flora survey trigger map;
    ii. Areas that contain endangered or vulnerable plants;
    iii. Non-juvenile koala habitat trees in certain areas of south-east Queensland; or
    iv. Habitat for endangered, vulnerable and special least concern animals;
- Protected areas and highly protected zones of State marine parks;
- Fish habitat areas;
- Waterways providing for fish passage;
- Marine plants; and
- Legally secured offsets.

3.0 DESKTOP ASSESSMENT

Several desktop assessments were conducted to collate information on terrestrial ecological values identified in the region. These searches include previous surveys, community records and other sources. A review of databases facilitates the formulation of specific field survey techniques to target certain flora and fauna species known from the region.

All database searches were based on either the Lot/Plan, study area, or the central coordinate point (-23.6380 149.2514), depending on the database search undertaken. Database search results can be found in Appendix A. The following database searches were undertaken:

1. Environmental Reports Online (search based on EPC boundary);
    a. Biodiversity Planning Assessments;
    b. Matters of State Environmental Significance, including the regulated vegetation map;
    c. Regional Ecosystems;
2. Environmentally Sensitive Area (ESA) Mapping (search based on EPC boundary);
3. Regional Ecosystems Report (search based on EPC boundary);
4. Protected Plants Flora Survey Trigger Map (search based on central coordinate point);
5. EPBC Act Protected Matters Search Tool (PMST) (two searches based on central coordinate point with 10 km and 50 km buffers);
6. Wildlife Online Species List Request (two searches based on central coordinate point with 10 km and 50 km buffers);
    a. Rare and Threatened Species (two searches based on central coordinate point with 10 km and 50 km buffers);
    b. Introduced Species (search based on central coordinate point with 50 km buffer); and
7. Department of Environment and Science (DES) interactive Wetland*Maps* database and Map of Referable Wetlands;
8. Bureau of Meteorology (BoM) and Department of Natural Resources Mines and Energy (DNRME) mapping of Groundwater Dependent Ecosystems (GDEs); and
9. 'Back on Track' Species Prioritisation Framework Recovery Actions Database (RAD) for Queensland for the Fitzroy Natural Resource Management Region.

Additional resources that provide species records and related information such as the Atlas of Living Australia (ALA) and Queensland Museum were consulted where appropriate, such as to support determinations of the likelihood of individual species occurring (Appendix A).

The following sections address items of nature conservation relevant to the study area, that have been identified within the desktop assessment.

3.1 REGULATED VEGETATION

The Regulated Vegetation Management Map was consulted, and the following regulated vegetation categories have been identified within the Project:

- Category B: Remnant vegetation.
- Category C: High-value regrowth vegetation.
- Category R: Regrowth within 50 m of a watercourse or drainage feature located in Great Barrier Reef catchment areas.
- Category X: Non-remnant vegetation.

Figure 4 outlines the Endangered or Of Concern Regulated Vegetation identified as likely to occur within the study area.

3.1.1 Threatened Ecological Communities

The EPBC Act PMST identified three TECs that could potentially occur within 10 km of the study area (1 to 3), and two additional TECs potentially occurring within 50 km of the study area (4 and 5).

1. Brigalow (*Acacia harpophylla* dominant and co-dominant);
2. Coolabah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions;
3. Weeping Myall Woodlands;
4. Natural Grasslands of the Qld Central Highlands and the northern Fitzroy Basin; and
5. Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions.

On the 4th July 2019, the Commonwealth government amended the list of threatened species and communities protected by the EPBC Act. Amongst numerous amendments, one was considered relevant to the study area, being the listing of a new TEC:

6. Poplar Box Grassy Woodland on Alluvial Plains.

The *Conservation Advice (including listing advice) for the Poplar Box Grassy Woodland on Alluvial Plains* (TSSC n.d.) outlines five REs in Queensland that correspond fully or partly with the Poplar box TEC. Of these, RE 11.3.2 (*Eucalyptus populnea* woodland on alluvial plains) is mapped (desktop) as occurring within the study area. Consequently, the Poplar Box TEC has been added to the list of TECs potentially occurring within 50 km of the study area.

Each TEC, PMST type of presence and desktop assessment of likelihood of occurrence is outlined in Appendix B.

3.1.2 Regional Ecosystems

Current DES mapping identifies six remnant REs occurring within the study area (Table 3, Figure 5).

Table 3 Regional Ecosystems mapped within the study area

Regional Ecosystem	Description	VM Act Status	DES Biodiversity Status	EPBC Act
11.3.1	*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains	Endangered	Endangered	Brigalow (*Acacia harpophylla* dominant and co-dominant)
11.3.2	*Eucalyptus populnea* woodland on alluvial plains	Of concern	Of concern	Poplar Box grassy woodland on alluvial plains Weeping Myall (*Acacia pendula)* Woodland
11.3.25	*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines	Least concern	Of concern	
11.5.2	*Eucalyptus crebra, Corymbia spp.,* with *E. moluccana* woodland on lower slopes of Cainozoic sand plains and/or remnant surfaces	Least concern	No concern at present	
11.5.9b	*Eucalyptus crebra* and other *Eucalyptus spp.* and *Corymbia spp.* woodland on Cainozoic sand plains and/or remnant surfaces	Least concern	No concern at present	
11.7.2	*Acacia spp.* woodland on Cainozoic lateritic duricrust. Scarp retreat zone	Least concern	No concern at present	

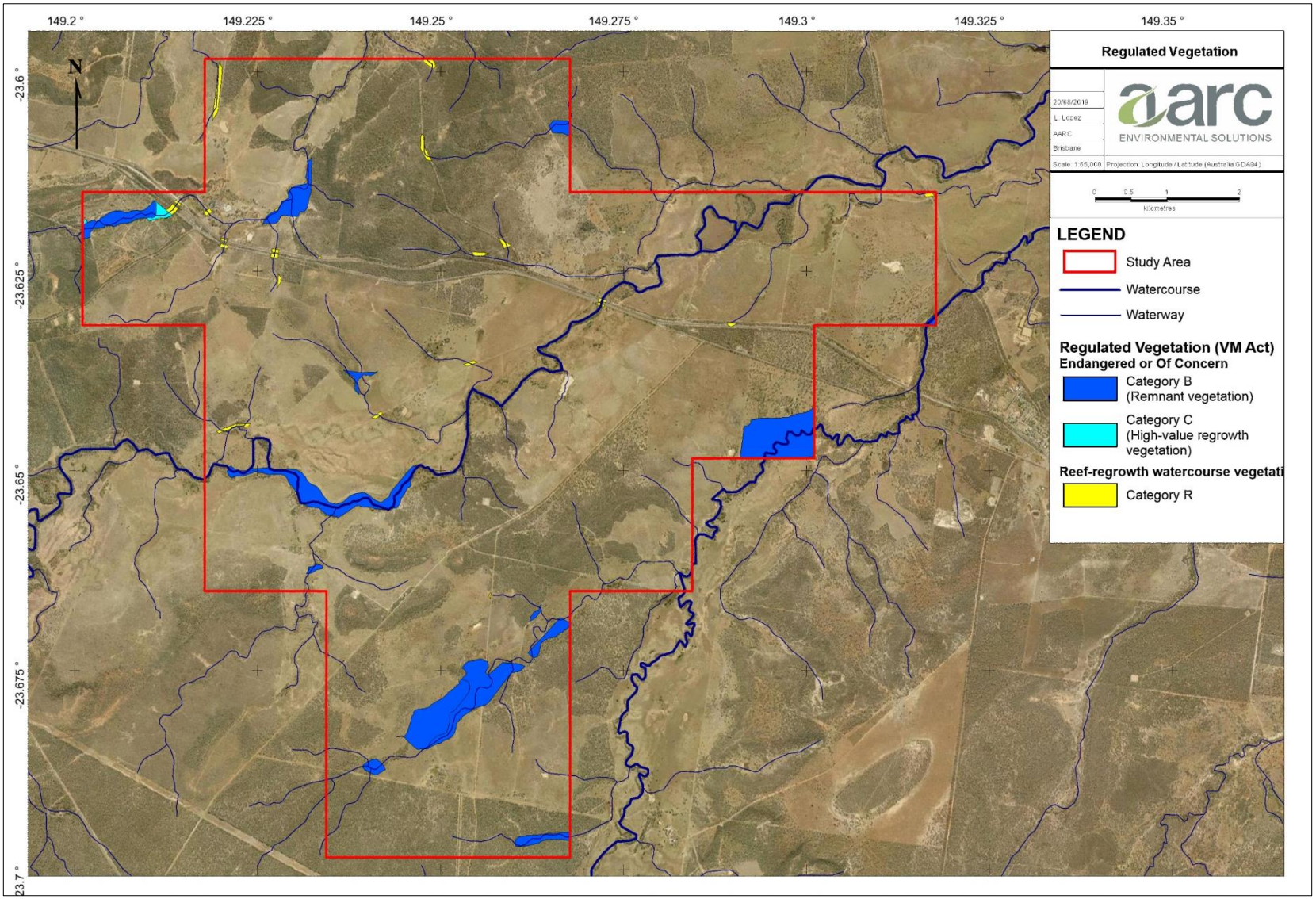


Figure 4 Regulated Vegetation (VM Act) classed as Endangered or Of Concern

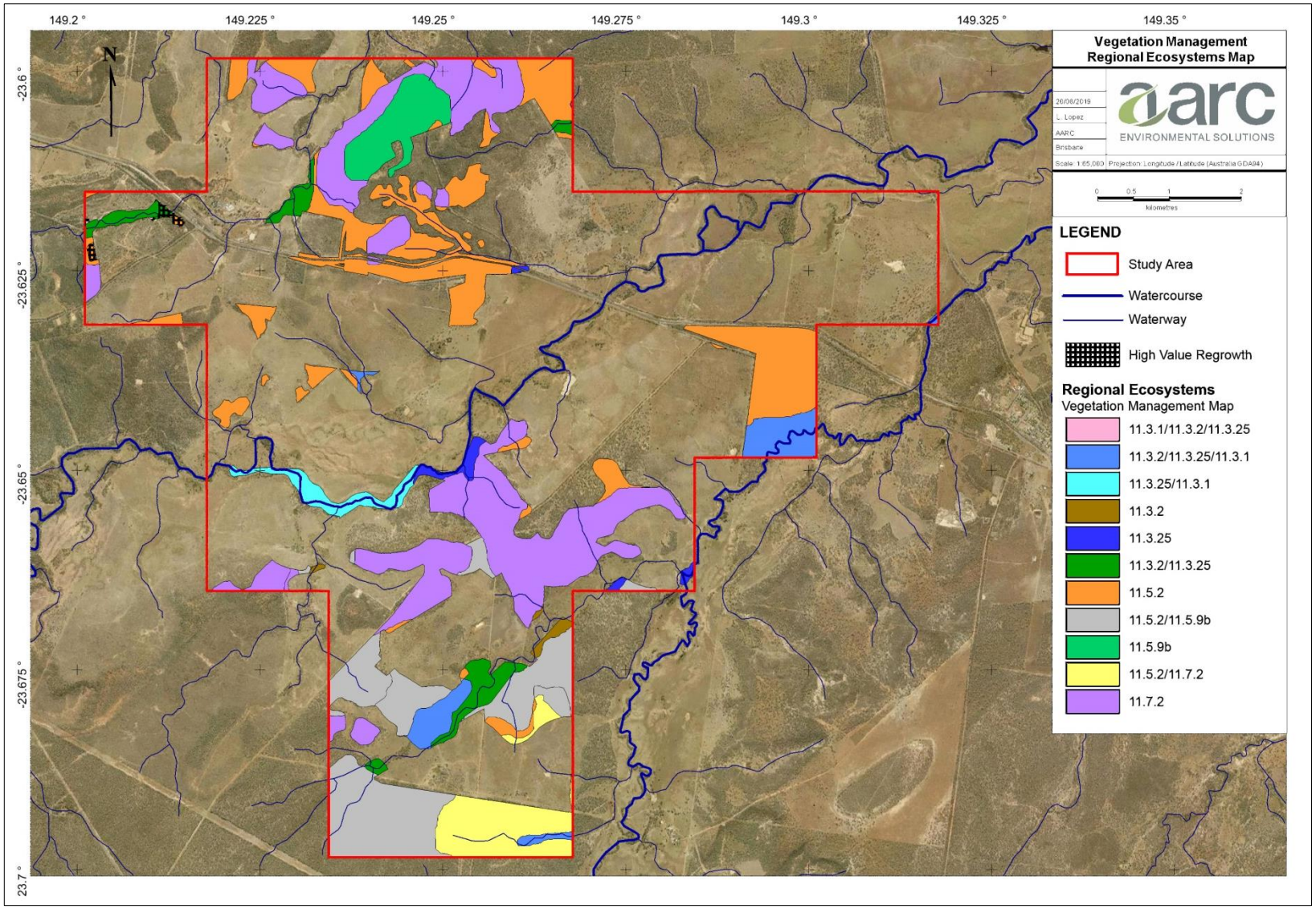


Figure 5 Regional Ecosystems Vegetation Management Map for the study area

3.2 SPECIES OF CONSERVATION SIGNIFICANCE

Species of conservation significance identified from the desktop assessment were assigned a likelihood of occurrence based on the criteria identified in Table 4. The assessment was based on the knowledge of ecologists, habitat suitability, previous surveys conducted near the study area and scientific literature.

Desktop assessments to determine the likelihood of each species identified during the database searches, with potential to occur on the study area, were undertaken prior to conducting the field surveys.

Targeted searches were undertaken in the field for species identified as either being likely to occur, or having potential to occur, within the study area, based on the desktop sources. The methodology was applied again after surveys to determine the likelihood of occurrence once additional site-based information became available.

Table 4 Criteria adopted for likelihood of occurrence determination

Likelihood of Occurrence	Criteria
Unlikely	• Species or species habitat may occur, is likely to occur or is known to occur from the broader search area (based on database searches); **but** ○ preferred habitat has not been identified within the study area; **and** there are no confirmed species records within 10 km of the study area; **or** ○ preferred habitat occurs within the study area, **but** there are no confirmed species records within 50 km of the study area.
Potential	• Species or species habitat may occur, is likely to occur or is known to occur from the broader search area (based on database searches); **and** ○ preferred habitat occurs within the study area; **but** there are no confirmed species records within 10 km of the study area; **however**, there are confirmed species records within 50 km of the study area; **or** • Species indicated as likely during desktop assessment, but field surveys revealed no evidence of occurrence in the study area.
Likely	• Preferred habitat occurs within the study area; **and** confirmed species records within 10 km of the study area; **however**, species not yet confirmed as occurring within the study area.
Known	• Confirmed species records within the study area (generally as a result of subsequent field survey).

3.2.1 Flora

3.2.1.1 State and Commonwealth Listed Flora Species

The PMST and the Wildlife Online Database identified 33 Endangered, Vulnerable or Near Threatened (EVNT) flora species with potential to occur within the 50 km buffer zone (Appendix A).

Each flora species, its protection status, habitat requirements, and assessment of likelihood of occurrence is provided in Appendix C.

Out of the 33 species identified by the desktop assessment six were considered to have the potential to occur within the study area and were targeted during the field survey. These six species and their conservation status under Commonwealth and State legislation are listed in Table 5.

Table 5 Flora Species of Conservation Significance with the potential to occur within the study area

Scientific Name	EPBC status	NC Act status	Potential Presence in Buffer Area	
			10 km	50 km
Bertya opponens	V	LC	-	-
Bertya pedicellata	-	NT	-	x
Cerbera dumicola	-	NT	x	x
Solanum adenophorum	-	NT	-	x
Solanum dissectum	E	E	-	x
Solanum elachophyllum	-	E	x	x

EPBC – *Environment Protection and Biodiversity Conservation Act 1999*
NC Act – *Nature Conservation Act 1992*
NT – Near Threatened
E – Endangered

3.2.1.2 Back on Track Flora Species Prioritisation

A RAD database search identified 35 Back on Track flora species ranked as either 'high' or 'critical' from the Fitzroy NRM Region. Of these 35 species, 30 are listed as EVNT under the NC Act and 16 are listed as EVNT under the EPBC Act. A list of these species and their relevant state and Commonwealth listings is presented in Table 6.

Table 6 Back on Track Priority Flora Species for the Fitzroy NRM Region

Species Name	Common Name	Fitzroy NRM Region	State BoT Rank	NC Act Status	EPBC Act Status
Apatophyllum olsenii		High	High	E	V
Atalaya collina		High	Medium	E	E
Bowenia serrulata	Byfield fern	Critical	Critical	LC	-
Cadellia pentastylis	Ooline	Critical	Critical	E	-
Capparis humistrata		High	Medium	E	-
Comesperma oblongatum		High	High	V	V
Commersonia pearnii		Critical	High	E	-
Cupaniopsis shirleyana	Wedge-leaf tuckeroo	High	High	V	V
Cycas megacarpa		Critical	Critical	E	E
Cycas ophiolitica	Marlborough blue	Critical	Critical	E	E
Eleocharis blakeana		High	Medium	LC	-
Eriocaulon carsonii		High	High	E	E
Eucalyptus pachycalyx subsp. waajensis		High	High	E	-
Eucalyptus raveretiana	Black ironbox	High	High	LC	-
Grevillea venusta	Grevillea	High	High	V	-
Hakea trineura		High	High	V	V
Homoranthus decumbens		High	High	V	E
Lissanthe brevistyla		High	High	V	-

Species Name	Common Name	Fitzroy NRM Region	State BoT Rank	NC Act Status	EPBC Act Status
Logania diffusa		High	High	V	V
Macrozamia platyrhachis		Critical	Critical	E	E
Macrozamia serpentina		Critical	Critical	E	-
Marsdenia brevifolia		High	High	V	V
Melaleuca groveana		High	Medium	NT	-
Melaleuca irbyana		High	Medium	E	-
Myriophyllum artesium		High	High	E	-
Olde-andia gibsonii		Critical	Critical	E	-
Olearia macdonnellensis		High	High	-	V
Phaius australis		Critical	Critical	E	E
Pisonia grandis		High	High	LC	-
Plectranthus graniticola		High	High	V	-
Rhaponticum australe		High	High	V	V
Rhodamnia angustifolia		High	Medium	E	-
Solanum adenophorum		High	High	E	-
Solanum dissectum		High	Medium	E	E
Trioncinia retroflexa		Critical	High	E	-

EPBC – *Environment Protection and Biodiversity Conservation Act 1999*
NC Act – *Nature Conservation Act 1992*
E – Endangered
V – Vulnerable
NT – Near Threatened
LC – Least Concern

3.3 FAUNA

3.3.1 State and Commonwealth Listed Fauna Species

Database searches identified 29 EVNT fauna species with potential to occur within the 50 km of the study area (Appendix A).

A detailed assessment to determine the likelihood of EVNT species to occur on the study area was completed prior to conducting the field survey, for the purpose of determining targeted species and to guide field survey methodology. The detailed assessment was based on the knowledge of ecologists, habitat suitability and scientific literature. This assessment is provided in Appendix D.

The detailed assessment of likelihood of occurrence considered that 16 of the 29 species identified by the desktop assessment had the potential to occur within the study area and were targeted during the field survey. These 16 species and their conservation status under Commonwealth and State legislation are listed in Table 7.

Table 7 EVNT Fauna species with potential to occur within the study area

Scientific Name	Common Name	EPBC status	NC Act status
Amphibians			
Adelotus brevis	Tusked frog	-	V
Reptiles			

Scientific Name	Common Name	EPBC status	NC Act status
Delma torquata	Collared delma	V	V
Strophurus taenicauda	Golden-tailed gecko	-	NT
Birds			
Calyptorhynchus lathami erebus	Glossy black-cockatoo (northern)	-	V
Erythrotriorchis radiatus	Red goshawk	V	E
Geophaps scripta scripta	Squatter pigeon (southern subspecies)	V	V
Grantiella picta	Painted honeyeater	V	V
Lathamus discolor	Swift parrot	C	E
Ninox strenua	Powerful owl	-	V
Pedionomus torquatus	Plains-wanderer	C	V
Poephila cincta cincta	Black-throated finch (white-rumped subspecies)	E	E
Turnix melanogaster	Black-breasted button quail	V	V
Mammals			
Chalinolobus dwyeri	Large-eared pied bat	V	V
Onychogalea fraenata	Bridled nailtail wallaby	E	E
Petauroides volans	Greater glider	V	V
Phascolarctos cinereus	Koala	V	V

EPBC – *Environment Protection and Biodiversity Conservation Act 1999*
NC Act – *Nature Conservation Act 1992*
NT – Near Threatened
V – Vulnerable
C – Critically Endangered
E – Endangered

3.3.1.1 Listed Migratory and Marine Species

The EBPC PMST indicated 21 marine and/or migratory species known from 50 km of the study area (Appendix A).

The assessment of likelihood of occurrence (Appendix D) considered that nine of the 21 species had the potential to occur within the study area.

Scientific Name	Common Name	EPBC status	NC Act status
Ardea alba	Great egret	Ma	-
Ardea ibis	Cattle egret	Ma	-
Calidris acuminata	Sharp-tailed sandpiper	Ma, Mi	SL
Chrysococcyx osculans	Black-eared cuckoo	Ma	-
Hirundapus caudacutus	White-throated needletail	Ma, Mi	-
Merops ornatus	Rainbow bee-eater	Ma	-

Scientific Name	Common Name	EPBC status	NC Act status
Monarcha melanopsis	Black-faced Monarch	Ma, Mi	SL
Motacilla flava	Yellow wagtail	Ma, Mi	SL
Myiagra cyanoleuca	Satin flycatcher	Ma, Mi	SL

EPBC – *Environment Protection and Biodiversity Conservation Act 1999*
NC Act – *Nature Conservation Act 1992*
Ma – Marine
Mi – Migratory
SL – Special Least Concern

3.3.1.2 Back on Track Fauna Species Prioritisation

A RAD database search identified 35 Back on Track fauna species ranked as either 'high' or 'critical' from the Fitzroy NRM Region. A list of these species and their relevant State and Commonwealth listings is presented in Table 8.

Table 8 Back on Track Fauna Species from the Fitzroy NRM Region

Species Name	Common Name	Fitzroy NRM Region	State BoT Rank	NC Act Status	EPBC Act Status
Amphibians					
Taudactylus pleione	Kroombit tinkerfrog	High	High	E	CE
Reptiles					
Phyllurus caudiannulatus	Ringed thin-tailed gecko	High	Medium	V	-
Phyllurus championae		Critical	Critical	LC	-
Elseya albagula	Southern snapping turtle	High	High	E	CE
Rheodytes leukops	Fitzroy River turtle	High	High	V	V
Caretta caretta	Loggerhead turtle	Critical	Critical	E	E
Strophurus taenicauda	Golden-tailed gecko	High	Medium	NT	-
Acanthophis antarcticus	Common death adder	High	Medium	V	-
Denisonia maculata	Ornamental snake	High	Medium	V	V
Hoplocephalus stephensii	Stephens' banded snake	High	High	LC	-
Delma inornata		High	High	LC	-
Delma torquata	Collared delma	High	High	V	V
Anomalopus brevicollis		High	High	LC	-
Egernia rugosa	Yakka skink	High	Medium	V	V
Lerista allanae	Allan's lerista	High	High	E	E
Varanus semiremex	Rusty monitor	High	High	LC	-
Birds					
Erythrotriorchis radiatus	Red goshawk	High	High	E	V
Esacus magnirostris	Beach stone-curlew	High	High	V	-
Stagonopleura guttata	Diamond firetail	High	High	LC	-
Sternula albifrons	Little tern	High	High	SL	-
Epthianura crocea macgregori	Yellow chat (Dawson)	High	High	E	CE

Species Name	Common Name	Fitzroy NRM Region	State BoT Rank	NC Act Status	EPBC Act Status
Grantiella picta	Painted honeyeater	High	High	V	V
Turnix melanogaster	Black-breasted button quail	Critical	Critical	V	V
Mammals					
Dasyurus maculatus maculatus	Spotted-tailed quoll (southern subspecies)	High	High	V	E
Dugong dugon	Dugong	Critical	Critical	V	-
Taphozous australis	Coastal sheathtail bat	High	High	NT	-
Onychogalea fraenata	Bridled nailtail wallaby	Critical	Critical	E	E
Petrogale penicillata	Brush-tailed rock-wallaby	High	High	V	V
Macroderma gigas	Ghost bat	Critical	Critical	E	V
Xeromys myoides	Water mouse	Critical	High	V	V
Petaurus australis australis	Yellow-bellied glider (southern subspecies)	High	High	LC	-
Bettongia tropica	Northern bettong	Critical	Critical	E	E
Pteropus poliocephalus	Grey-headed flying-fox	Critical	Critical	LC	V
Kerivoula papuensis	Golden-tipped bat	High	Medium	LC	-
Nyctophilus corbeni	Eastern long-eared bat	High	Medium	V	V
Arachnids					
Selenocosmia crassipes		Critical	Critical	LC	-
Selenotypus plumipes		Critical	Critical	LC	-
Gastropods					
Adclarkia dawsonensis	Boggomoss snail	Critical	Critical	E	CE
Billordia nicoletteae		High	High	-	-
Perioinsolita pokryszkoae		High	High	-	-
Sphaerospira mossmani		High	High	-	-
Dimidarion slatyeri		Critical	High	-	-

EPBC – *Environment Protection and Biodiversity Conservation Act 1999*
NC Act – *Nature Conservation Act 1992*
CE – Critically Endangered
E – Endangered
V – Vulnerable
NT – Near Threatened
LC – Least Concern

3.4 ENVIRONMENTALLY SENSITIVE AREAS

ESA mapping presents Category A, B, and C areas of conservation significance, including those under international agreements (e.g. Ramsar sites), fish habitat areas, declared catchment areas, Wild River nominated waterways and areas listed under the Directory of Important Wetlands. ESA mapping indicates that several ESAs occur within the study area (Appendix A).

A small section of (around 2.5 ha) of Taunton NP, falls within the study area, on the north west corner of the study area. This NP is identified as Category A ESA. Category B ESA, Endangered Regional Ecosystems is mapped as potentially occupying several parcels of land within the study area. These areas of Category B ESA represent the Endangered RE 11.3.1 (*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains) as a mixed polygon, as mapped by the QLD Government in Figure 5.

3.5 WETLANDS

A review of the DES interactive Wetland*Maps* database and the Map of Referable Wetlands indicated three types of waterbodies are present within the study area. Riverine wetlands have been identified in association with the Charlevue Creek. Several small riverine, palustrine and lacustrine wetlands also mapped as potentially present within the study area (Figure 6). No wetlands of national or international importance have been recorded within the study area or surrounds. One High Ecological Significance (HES) wetland occurs approximately 4 km east of the study area (Figure 6).

The Aquatic Conservation Assessments defines the study area as having a sub-catchment conservation significance of medium, indicating that these wetlands have varied combinations of high and medium values amongst the assessment criteria.

3.5.1 Groundwater Dependant Ecosystem

Groundwater Dependant Ecosystems (GDEs) are ecosystems that are reliant on groundwater for their survival; they can be solely reliant on groundwater such as ecosystems relying on aquifers or may intermittently depend on groundwater, which would be the case of riparian vegetation, particularly on ephemeral river systems (IESC 2019). GDEs are grouped according to the 'Groundwater dependant ecosystem typology framework' which separates GDEs based on their type of groundwater reliance (DSITI 2015). The three GDE types include:

- surface expression GDEs, associated with springs, both permanent and non-permanent;
- terrestrial GDEs, reliant on the sub-surface presence of groundwater and their ability to draw upon this resource; and
- subterranean GDEs, wetland systems that occur below the surface of the ground and can include aquifer ecosystems and cave ecosystems.

The BoM has developed an interactive tool for assistance in the identification of GDEs, the National Atlas of GDEs (GDE Atlas) (BoM 2019a). GDE Atlas is a tool used for planning, management and development and incorporates a national dataset of GDEs throughout Australia. The GDE Atlas supplies information to support the identification of GDEs but does not provide a definitive map of GDEs. The BoM mapped both terrestrial and surface expression (aquatic) GDEs as having the potential to occur within the study area (Figure 7 and Figure 8). Within the study area high potential terrestrial GDEs were mapped in association with Charlevue Creek and Springton Creek and moderate with some of the smaller waterways.

The Department of Natural Resources, Mining and Energy (DNRME) also has developed mapping of potential GDEs throughout Queensland. No surface expression GDEs or Subterranean GDEs were mapped by DNRME as occurring or having the potential to occur within the study area. Within the study area there are several 'low-confidence' potential terrestrial GDE areas along Charlevue Creek, Springton Creek and Stanley Creek (Figure 9). According to Government RE mapping these are in association with RE 11.3.2, 11.3.25 and 11.3.1.

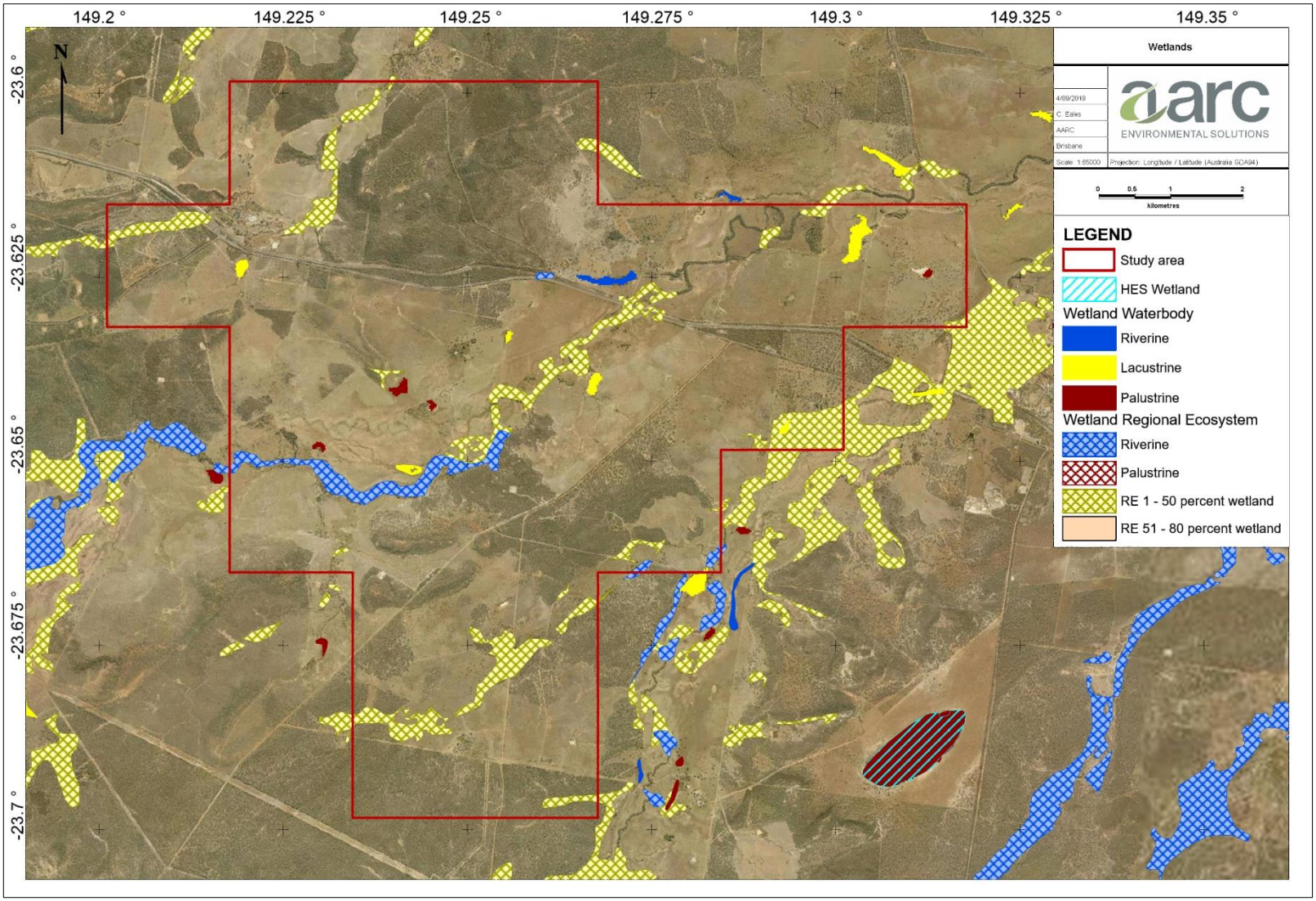


Figure 6 Wetland Habitats

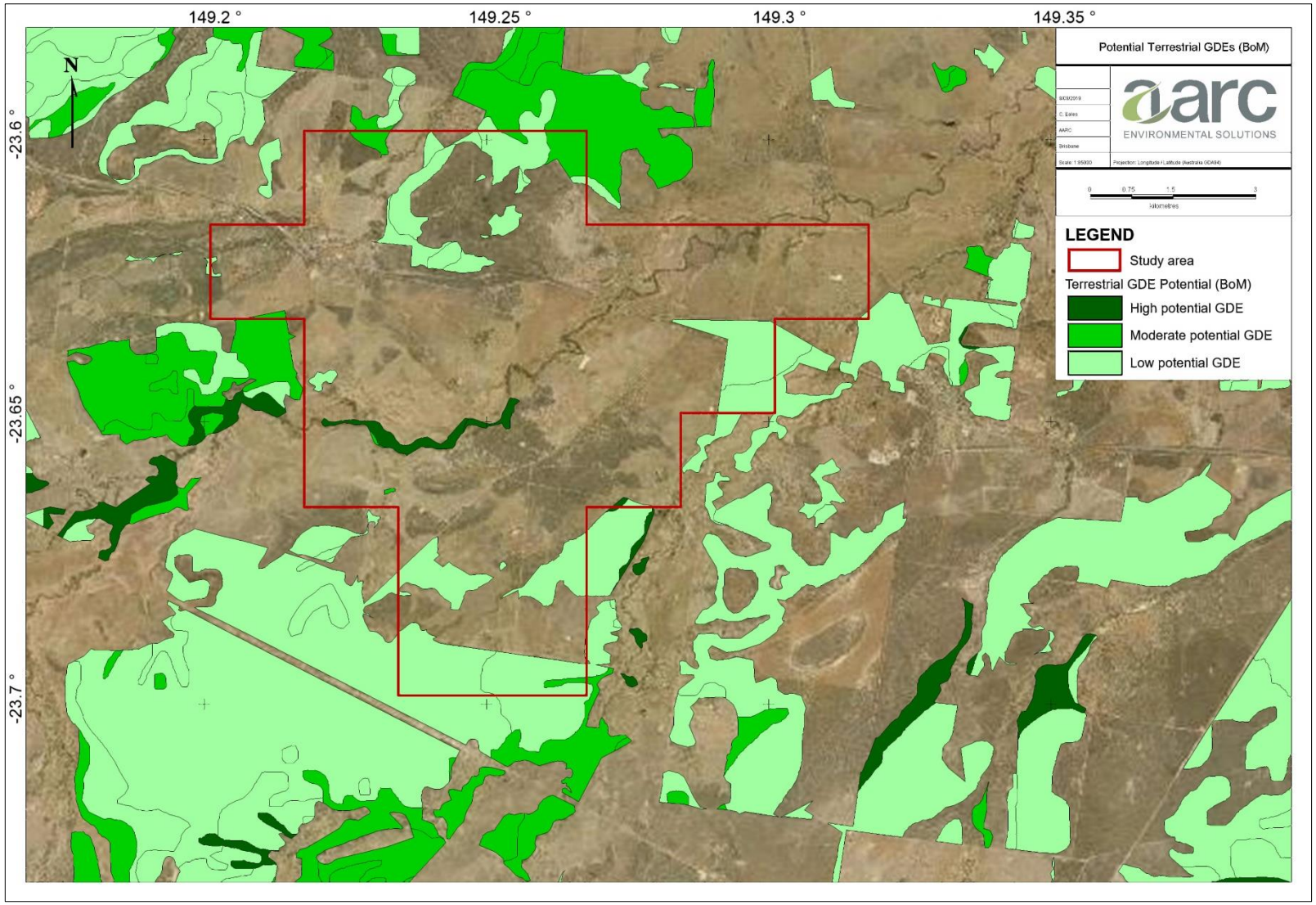


Figure 7 Potential Terrestrial GDEs (BoM)

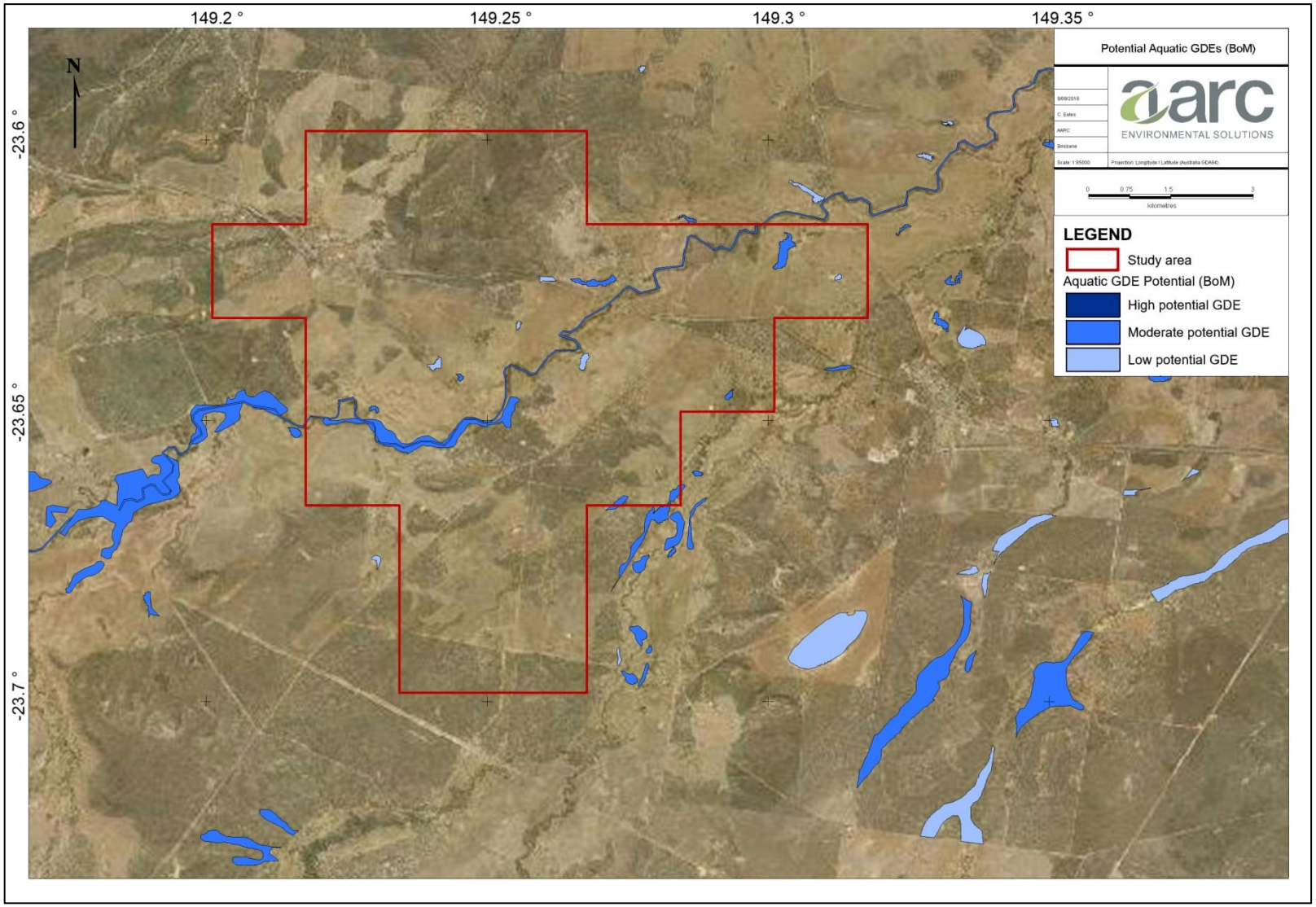


Figure 8 Potential Aquatic GDEs (BoM)

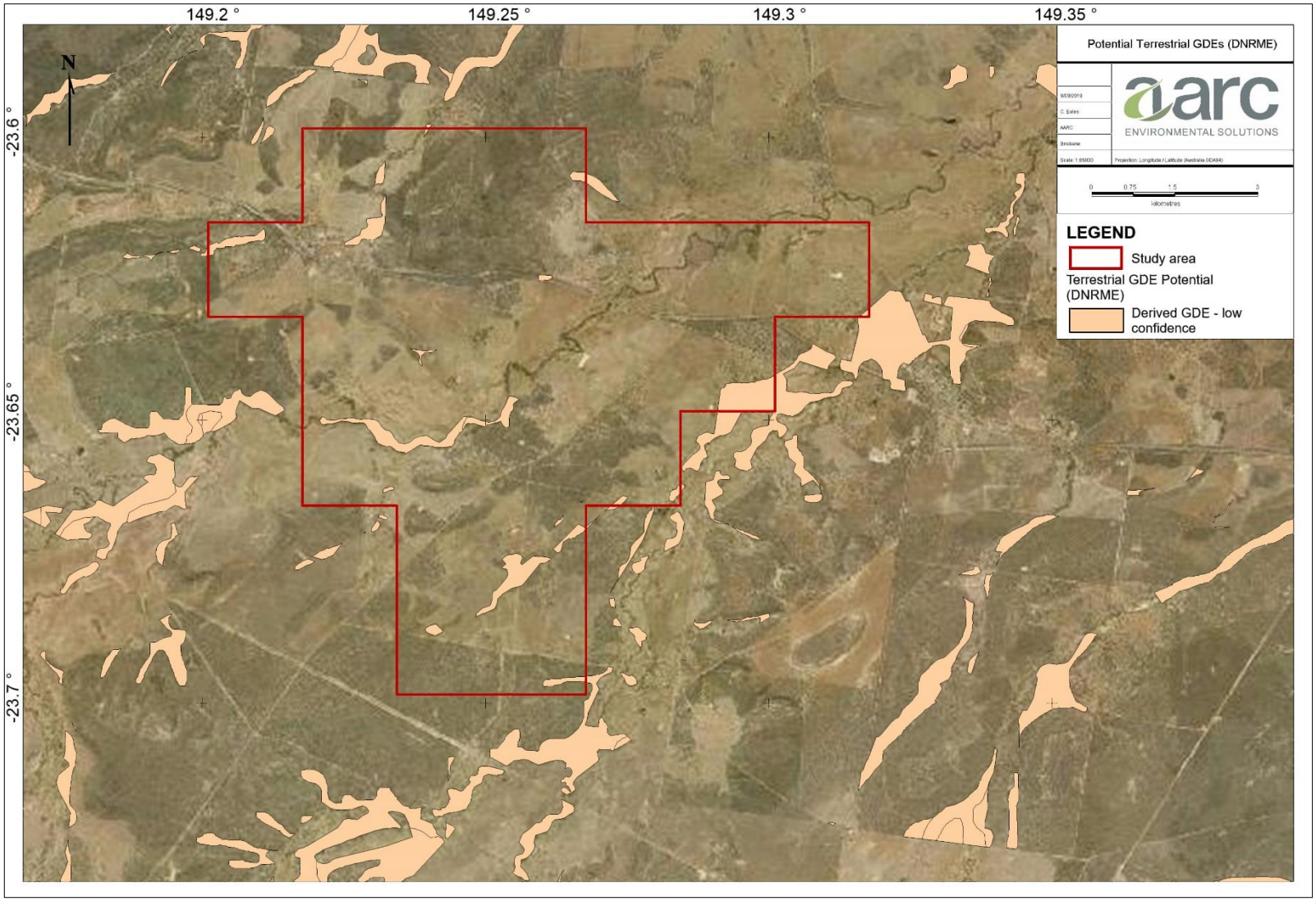


Figure 9 Potential Terrestrial GDEs (DNRME)

4.0 METHODOLOGY

4.1 BIOREGION

The study area is located within the Brigalow Belt bioregion. This bioregion occupies over a fifth of Queensland; from Townsville in the north to near the border of New South Wales in the south. The Brigalow Belt bioregion is characterised by Brigalow (*Acacia harpophylla*) woodland but presents other vegetation such as semi evergreen vine thickets, dry eucalypt woodlands and native Bluegrass (*Dichanthium* sp) grasslands. Due to the size of Brigalow Belt bioregion, it covers a broad climatic gradient as well as a diversity of soils and topography, the Brigalow Belt hosts a high diversity flora and fauna (Young et al 1999; McFarland et al. 1999 cited in DES 2018c).

As a result of agricultural and development activities, most of the relatively undisturbed areas is confined to the rugged parts of the landscape with less development value (DES 2018c), parks and reserve areas.

4.2 FIELD SURVEY GUIDELINES

Field surveys have been undertaken since 2017 covering a range of seasonal and climatic conditions. Over the study period several updates to existing survey guideline material occurred, as well as the introduction of entirely new material.

At the time of reporting the material that has guided methodology is as follows:

- *Site examination for threatened and endangered plant species* (Goff, Dawson & Rochow 1982);
- *Management of endangered plants* (Cropper 1993);
- *Survey guidelines for Australia's threatened bats* (DoEE 2010a);
- *Survey guidelines for Australia's threatened birds* (DoEE 2010b);
- *Survey guidelines for Australia's threatened mammals* (DoEE 2011a);
- *Survey guidelines for Australia's threatened reptiles* (DoEE 2011b);
- *Survey Standards: Greater Glider, Petauroides volans* (MacHunter, Brown, Loyn & Lumsden 2011);
- *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (V3.0)* (Eyre *et al.* 2018);
- *Methodology for surveying and mapping regional ecosystems and vegetation communities in Queensland (V5.0)* (Neldner *et al.* 2019); and

4.3 SURVEY SEASONALITY

Survey timing was selected in accordance with the *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland V3.0* (Eyre *et al.* 2018). These guidelines recommend that fauna surveys within the Brigalow Belt bioregion should be conducted during spring to early summer (i.e. September to mid-November) and during autumn (i.e. March to mid-May).

The autumn survey should be undertaken after summer as the temperatures decrease but before the onset of cold winter nights. This coincides with another active period including dispersal and migration of many species (Eyre *et al.* 2018). The first and third ecological survey for the study area was undertaken during autumn, from the 4th - 12th May 2017 and from the 16th - 23rd February 2018.

The spring season timing provides ideal survey conditions as temperatures begin to rise and a peak in vertebrate activity is observed with the commencement of the breeding period for many species (Eyre *et al.* 2018). The second survey was undertaken during spring, from the 18th - 30th September 2017.

A fourth survey targeting Microchiroptera bat species and vegetation mapping took place from the 22nd - 29th March 2018, meeting the requirements for the *Survey Guidelines for Australia's Threatened Bats* (DoEE 2010a).

The final surveys to finalise the vegetation mapping took place on the 1st, 2nd and 19th August 2019.

Autumn 2017 Survey

Mild conditions were recorded on the study area during the May 2017 ecology survey according to data obtained with SILO and personal observations. Throughout the survey period, a total of 20.2 mm of rainfall was recorded within the region, however, within the study area the rain was only registered on the evening of the 9th and during the day on the 10th. Maximum daily temperatures were slightly lower than average for the study area's locality reaching only 28.5°C and dropping to 11°C at night.

Spring 2017 Survey

No rainfall was registered during the spring survey period. There was some fluctuation on the temperature throughout the fieldwork, with the highest temperature of 38.5°C recorded and a minimum temperature of 13°C in the region.

Autumn 2018 Surveys

Hot and wet conditions were recorded on the study area (SILO) during the autumn 2018 Ecology survey. Throughout the survey period, 61.5 mm of rainfall was recorded within the region, with most of the rainfall in the study area registered on the 20th February. Maximum daily temperatures reached 35.5°C, dropping to 19.5°C at night.

During the second autumn 2018 survey (consistent on targeted micro-bat and vegetation mapping survey) the conditions were mild, with 6.1 mm of rainfall registered in the region. Maximum temperatures of 34.5°C reached on the 28th of March and minimum temperatures reached 18°C.

Winter Surveys 2019

No rainfall was registered during the spring survey period. The field observations recorded as overcast the 1st of August and sunny and warm the 2nd and the 19th of August. The temperatures registered during the day in the region reached 29°C as maximum and 20°C as the minimum.

4.4 FLORA

The flora survey regime was designed to meet the following objectives:

1. Obtain a detailed floristic summary of the study area through the compilation of a flora species list;

2. Define distinct vegetation communities and compile detailed descriptions of the floristic assemblages in each community;

3. Detect and identify EVNT flora species and threatened ecological communities; and

4. Produce a comprehensive site vegetation map at a 1:10,000 scale.

Plants species were identified using several taxonomic keys, field guides and online reference material. For any plant species that could not be identified in the field, a sample was collected and sent to the Queensland Herbarium.

4.4.1 Vegetation Mapping and Community Description

Methods used to produce a vegetation map and define communities were in accordance with those described in *Methodology for surveying and mapping regional ecosystems and vegetation communities in Queensland* (V5.0) (Neldner *et al.* 2019). Version 1.0 of this document was first released by the Qld Herbarium in 1999, with further additions and refinement to the methodology documented in subsequent versions (2004, 2005, 2017, 2019). Field mapping and community description was undertaken in accordance with the version of this guideline that was current at the time of each flora survey.

All RE's are described in this consolidated report in accordance with the Qld RE Description Database (REDD) (DES 2019c). The use of the terms 'remnant' and 'non-remnant vegetation' are as per the definitions of the VM Act. Neldner *et al.* (2019) describes four levels of floristic sampling, two of which were utilised in the study area assessment and defined below.

Secondary Transects: were used for classification and detailed descriptions of regional ecosystems and vegetation communities. Each site consisted of a 50 m long transect specifically marked using a Global Positioning System (GPS) at the start and end points, each accompanied by a photograph taken with a viewpoint of the transect. Foliage projection cover was measured along the transect and calculated as a percentage. Percentage composition of each ground cover species was recorded in five 1 m x 1 m quadrats located at 10 m intervals along the transect line. Within the 50 m x 10 m plot, each species present was recorded including relative abundance within each stratum, height of each stratum, and stem density (for woody stems only). Species representative of the community but located outside of the plot were also recorded. Where a plant could not be positively identified to species level, a voucher specimen was collected for identification by the Qld Herbarium.

Quaternary Sites: are rapid vegetation assessments primarily used to verify regional ecosystem / vegetation community mapping. Each site consisted of a rapid assessment of the vegetation within an approximately 20 m by 20 m plot. Data collected included marking the GPS location, taking photographs, recording the dominant species in the characteristic stratum as well as stratum height. Soil and landform data was recorded to confirm land zone, as many REs can only be differentiated by the land zone they occur on, due to their floristic assemblage descriptions being virtually identical.

Flora was sampled in autumn, spring and winter season to best account for both annual and perennial species assemblages. Sampling was undertaken at a minimum density of 25 observations per 100 ha to complete mapping at the 1:10,000 scale. Subsequently, the flora sites were projected on a Geographical Information System (GIS), and used in conjunction with satellite images, aerial photographs, topographical and geological maps to effectively produce a ground verified vegetation map.

A total of 28 secondary transects and over 1000 quaternary sites were sampled across the study area. The locations of all the flora secondary transects and quaternary sites are shown in Figure 10.

4.4.2 Targeted Searches for Species of Conservation Significance

To gain an understanding of each EVNT species, preferred habitat and ecology, several resources were consulted to pre-determine habitat to be targeted during the field surveys. This included, but was not limited to:

- Commonwealth Listing Advice;
- Commonwealth Approved Conservation Advice;
- Species Profile and Threats Database (SPRAT); and
- WetlandInfo: Plants, Animals, Soils, Water and More Search Tool.

The predominant survey technique utilised for targeted species across the cumulative survey effort was the 'timed meander' technique (Cropper 1993; Goff 1982). This technique involved traversing suitable habitat in a random manner so as to maximise the coverage of habitat and the encounter rate of different species. For any EVNT plants observed the location recorded using a GPS. If there was any uncertainty in identification of a species, a representative voucher specimen was collected for identification by the Queensland Herbarium in accordance with the Herbarium procedures (DSITI 2016).

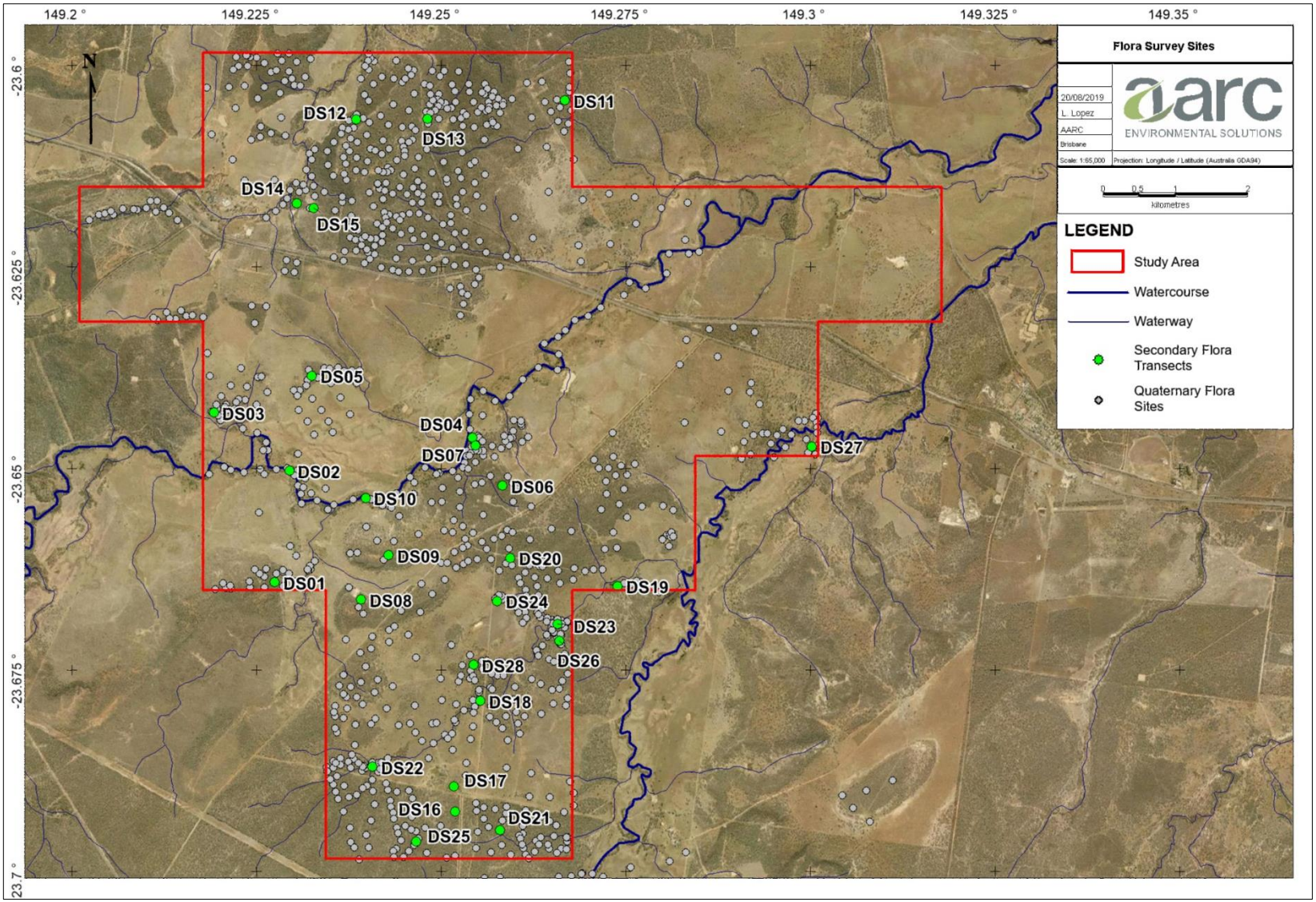


Figure 10 Gemini Project flora survey sites

4.5 FAUNA

4.5.1 Fauna Trapping Sites and Survey Locations

Site scoping was conducted prior to each survey by undertaking a desktop assessment to determine habitat types of the intended study area in accordance with survey objectives. Examination of satellite imagery, topographical features, broad vegetation group (BVG) guided the location of baseline fauna trapping efforts ensuring adequate distribution across, and representation of fauna habitat types. Preferred habitat of targeted species was identified in the same manner to locate targeted trapping and survey effort in suitable locations.

Vehicle-based reconnaissance was carried out, where possible, to assist in locating suitable survey sites, maximising the representative vegetation and fauna habitat survey coverage. This also aided in targeting habitats potentially occupied by species of conservation significance. Vegetation communities optimal for installing fauna sites were then surveyed on foot to allow further ecological familiarisation and comprehensive survey coverage.

The fauna survey methodology employed for the study area was based on the *Survey Guidelines for Australia's Threatened Bats* (DoEE 2010a) and the *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland V2.0* (Eyre *et al.* 2014) which was the current version at the time of all surveys. The survey was conducted in compliance with AARC's scientific purposes permit and animal ethics approval. All fauna trapping efforts were conducted over four consecutive nights (unless otherwise stated).

All fauna survey locations are illustrated in Figure 7 and Figure 8 and described in Table 7. The detection techniques employed at each site is defined in Appendix E, and for descriptions of each technique refer to Section 4.5.2. Total survey effort undertaken during each survey is detailed in Table 9, and total survey effort accumulated across all surveys is summarised in Table 10.

Sampling of vertebrate fauna was conducted primarily along transects established in each of the major fauna habitat types and at changes in vegetation community groups. During all surveys, observations of species outside the specific fauna study locations but within the survey area were noted as incidental observations.

Many fauna species, notably frogs and reptiles, do not have widely accepted common names. Scientific names for species often change with taxonomic revisions. For the purpose of this report, all nomenclature used will follow that used in the ALA database (ALA 2019).

4.5.2 Fauna Survey Sites

Fauna sampling was conducted amongst representative areas of the main habitat types on the study area site to maximise the potential for sampling all wildlife present:

- Habitat type 1: Woodlands dominated *Eucalyptus crebra* (Narrow-leaved red ironbark) frequently with *Corymbia spp.* or *Callitris spp.* on flat to undulating plains.
- Habitat type 2: Low woodlands to tall shrublands dominated by *Acacia* spp. on residuals. Species include *A. shirleyi* (Lancewood) and *A. rhodoxylon* (Rosewood).
- Habitat type 3: Open forests and woodlands dominated by *Eucalyptus tereticornis* (Blue gum) fringing drainage lines.
- Habitat type 4: Woodlands dominated by *Eucalyptus populnea* (Poplar box) on alluvium, sand plains and foot slopes of hills and ranges

A total of 15 full fauna survey sites, 8 harp trap sites and 3 mist nets were established across the study area during the ecology survey period.

Descriptions and photos of the survey sites are provided in Appendix E whereas all fauna survey locations indicating the habitat type where they were located and targeted micro-bat trapping sites are shown in Figure 11.

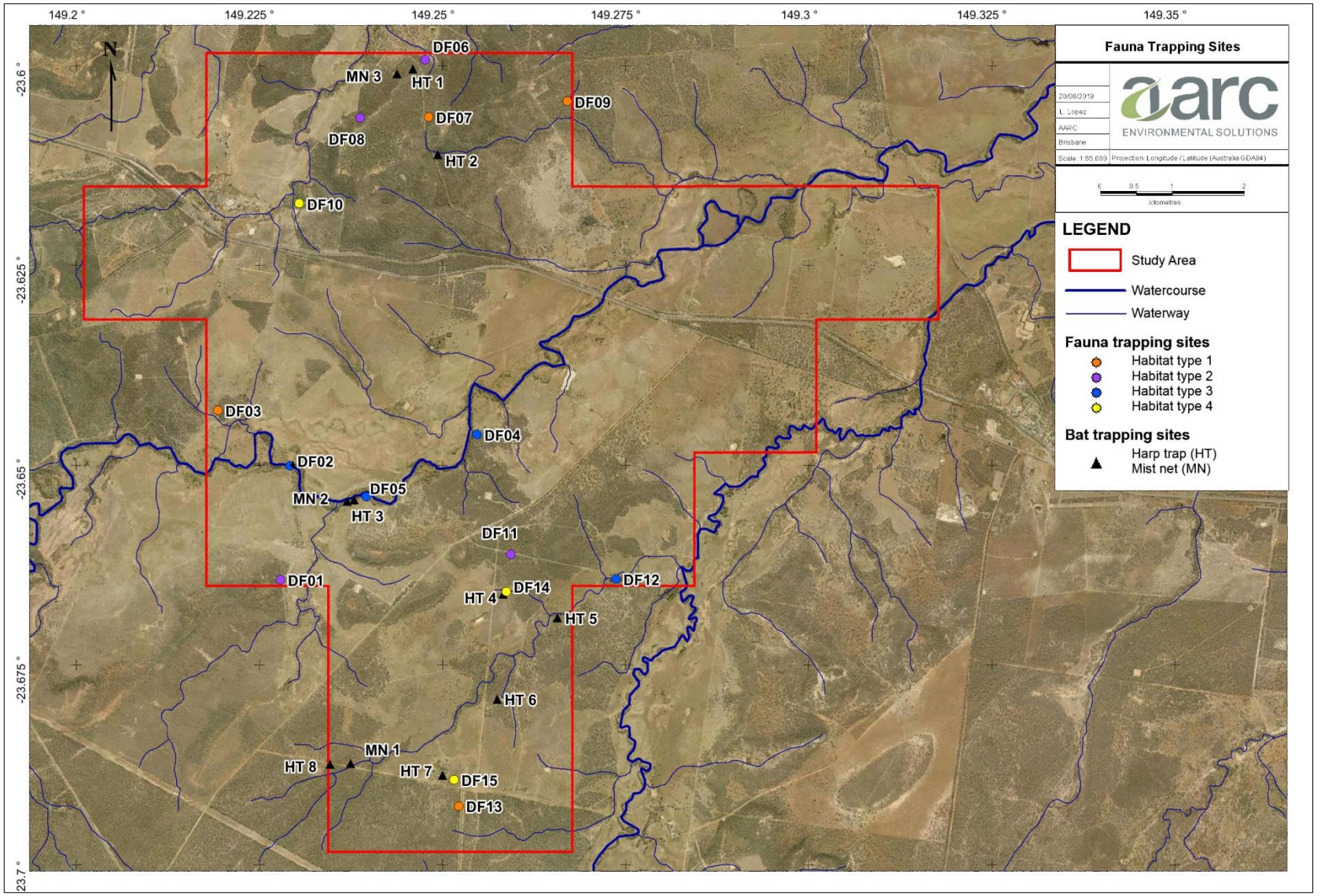


Figure 11 Gemini Project Fauna sites

4.5.3 Detection Techniques

A description of the techniques employed to survey the fauna occurring on the study area site (unless otherwise stated in the site description in Appendix E) is provided below:

Elliott trapping

Elliott traps are aluminium boxes with doors triggered by a floor treadle that are used to target small ground-dwelling mammals inhabiting the study area site. Traps were baited with a mixture of oats, peanut butter, and vanilla essence (referred to here-in as 'mammal bait'). At each site, two parallel lines each with 10 Elliott traps were placed at 10 m intervals. Alternatively, where fauna sites were established in linear riparian habitats, traps were positioned at 10 m intervals along a single central transect. Traps were strategically positioned under shrubs or beside logs to reduce exposure of trapped animals to the sun, wind and rain and maximise trap success.

Automated Camera Trapping

Automated camera trapping is a less invasive method of surveying medium and large-sized nocturnal terrestrial species. Cameras are usually attached to a tree in a position that offers an unobstructed view over a track or clearing. A bait tube constructed with PVC and filled with bait (on this occasion chicken necks), is pegged to the ground and positioned in clear view of the camera. Motion-sensing technology in the camera detect movement and trigger a photographic response. This is a highly effective survey method and is now widely used instead of cage trapping (Eyre *et al.* 2018). Automated cameras were deployed for four nights at all fauna survey locations during the survey period.

Pitfall Trapping

To target small ground-dwelling taxa (e.g. reptiles, mammals and amphibians), a pitfall trap line was established at all fauna sites. Each line consisted of a 30 centimetre (cm) tall drift fence running along the ground and crossing the middle of four 20 litre buckets buried flush with the soil surface. Each pitfall trapping line was constructed in a T-shape design with 45 m of drift fence and buckets placed at approximately 7.5 m intervals. The bottom edge of each drift fence was buried to guide target animals towards the buckets. A small amount of soil, vegetation litter, a damp sponge and a small plastic pipe were placed in the bottom of each bucket to provide shelter and moisture for captured wildlife.

Funnel Trapping

Funnel traps are elongated box-shaped traps made of wire and fine mesh. Six funnel traps were positioned at each fauna site in order to catch medium and large-sized terrestrial reptiles, snakes and some species of medium-sized skinks, dragons and geckos. Funnel traps were also set with a damp sponge and covered with hessian bags to provide shelter and moisture for captured wildlife. Where pitfall trapping lines were established at a fauna site, funnel traps were placed at the end of each drift fence. In the absence of a pitfall line, funnel traps were placed in suitable habitat along fallen timber or rocky outcrops throughout the fauna site (100 by 100 m plot).

Microbat Surveying

Micro-bats (Microchiropterans) form an extremely diverse group of wildlife and the identification of individual species requires the use of specialised survey methods due to the superficial similarity of many species, their small size, and largely inaudible calls.

The QLD Government *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland v3.0* recommended method for bat survey is the use of a bat recorder (i.e. ANABAT). These are automated

devices that record the echolocation calls of microbat species. The majority of microbat species in Australia can be identified from a species specific 'call signature'. However, there is a small selection of species that cannot be reliably identified to species level by call signature. The *Nyctophilus* genus has several species in Australia and cannot be identified further than the genus level. Corben's long-eared bat (*Nyctophilus corbeni*) is listed as Vulnerable under both the EPBC Act and the NC Act. The distribution of *Nyctophilus corbeni* overlies much of central Queensland, including the study area.

A Long-eared bat (*Nyctophilus* sp.) was detected via echolocation records on the study area during surveys but could not be identified to species level. Ecologists completed a targeted micro-bat survey in order to correctly identify the *Nyctophilus* species to adequately satisfy the *Survey Guidelines for Australia's Threatened Bats* (DoEE 2010a). This targeted micro-bat survey utilised Harp Traps and Mist Nets in addition to ANABAT recorder.

The use of the following methodology was conducted in accordance with the *Survey Guidelines for Australia's Threatened Bats* and the *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (Eyre et. al 2018).* These fauna survey methods were only adopted for the specialised Micro-bat 2018 autumn survey conducted by AARC ecologists.

ANABAT Recorders

In order to navigate and hunt at night micro-bats use high frequency echolocation calls, most of which are above the frequency range audible to humans (i.e. ultrasound). These echolocation calls provide an opportunity to unobtrusively survey and identify micro-bats through the use of a specialised ultrasonic recorders. During the survey event, bat call detection devices (i.e. Songmeter or ANABAT recorder) were strategically positioned to detect micro-bat calls at all fauna trapping sites. A bat call detector was left at each site for a minimum of 3 nights. This specialised micro-bat survey was utilised during all terrestrial surveys. A bat call detector was left at each site for 3 nights, and bat call analysis performed by Greg Ford of Balance Environmental (Appendix G).

Mist Net

Mist nets are more versatile than harp traps and can be used in a wider variety of habitat types and locations to capture bats, including open areas. The mist net consisted of fine monofilament net approximately 12 m wide by 5 m tall with a mesh size of 19 mm and was held in tension using rope rigging between two trees. The height of the net is divided into 'benches' or 'shelves', each with a loose pocket of netting that helps entangle the captured bats.

A single Mist Net was deployed at three locations over the second autumn survey. They were generally set several hours after sunset, these nets remained raised for a minimum of 1 hour at each survey site. The position of each Mist Net was marked using a handheld GPS. Photographs of each of these sites were taken with a digital camera and site data (such as vegetation type, weather conditions and habitat condition) was recorded.

Harp Trap

Harp trapping is employed for resolving the presence of species whose calls cannot be separated or identified using bat detectors, such as the *Nyctophilus* genus, and for collecting abundance and demographic information such as sex, age or breeding condition, which cannot be determined from call echolocation. Harp traps consisted of two or three banks of vertically strung nylon lines held in a rigid aluminium frame above a large calico holding bag and mounted on adjustable legs. Harp traps are most suited to restricted flyways in well vegetated areas, such as along creeks and tracks, preferably placed where fringing vegetation abuts the trap edges on both sides and above. Bats flying along a flyway are

typically unable to detect the lines and get caught between the banks of nylon line and slide down into the large, plastic-lined cloth holding bag, where the bats are unable to climb out.

A single two bank harp trap was deployed at eight sites. Traps were deployed for four nights per site. They were set up shortly before dusk each night and packed up either at dawn or in the early morning. Traps were checked several hours after dusk and again before dawn each night. The position of each trap was marked with a handheld GPS. Photographs of each trap site were taken with a digital camera and site data (such as vegetation type, weather conditions and habitat condition) was recorded.

Bird Surveying

Dedicated searches for birds was conducted visually and aurally during early mornings during peak avian activity. A dedicated search for diurnal birds was conducted visually and aurally at each fauna site. A minimum of one hour of bird surveying per fauna site was conducted in the early morning or late afternoon when bird activity was highest. In addition, opportunistic diurnal searches were also conducted on foot in areas considered likely to have high avian diversity (e.g. vegetated watercourses or dams), or likely to contain cryptic or threatened bird species.

Spotlighting

Spotlighting was carried out in the early evenings (before midnight) during all surveys to maximise encounter rate of nocturnal wildlife such as night birds and arboreal mammals primarily active at night. Two spotlighting techniques were employed:

1. Foot traverses: Dedicated spotlighting events were undertaken on foot at each fauna site. Searches were undertaken over two events where possible, one within the first hour following nightfall, and one after the first hour. Two ecologists randomly traversed the area with spotlights and binoculars, and wherever possible, bark crevices and tree hollows were examined. A slow walking speed (approximately 1 km per hour) was maintained across the length of the survey area to fully facilitate intensive listening and thorough visual searching.

2. Vehicle searches: During any driving on the study area after dark, spotlighting was conducted by the passenger/s from the slow-moving vehicle, to maximise study area coverage that cannot be achieved with foot traverses alone. Spotlights were used to scan trackside vegetation for arboreal and ground-dwelling wildlife.

Call Playback

Several nocturnal bird species are highly cryptic; occurring in naturally low population densities, are wide-ranging, and call infrequently. Detection rates are typically low without solicitation in the form of playback of pre-recorded calls to elicit a response (Kavanagh and Peake 1993; Debus 1995). Detectability of smaller nocturnal bird species such as the Southern Boobook *Ninox novaeseelandiae* and Australian owlet nightjar (*Aegotheles cristatus*), and the arboreal marsupial Yellow-bellied glider (*Petaurus australis*) also increase with playback of large owl calls. Smaller, cryptic arboreal species such as Squirrel glider (*P. norfolcensis*) and Sugar glider (*P. breviceps*) can also respond to owl call playback.

Call playback is undertaken prior to spotlighting foot traverses to minimise the chance of spooking species capable of leaving the area undetected. A series of species call would be selected depending on the surrounding habitat suitability, and each would be played for three minutes, followed by a two-minute listening period, with the cycle repeated three times for each species. Calls were played using a megaphone and loud enough so that the softest call could be heard 100-200 m away. Following the completion of all playback cycles, the area would then be spotlighted as described above.

Habitat Searching

To further enhance the likelihood of detecting small cryptic species, dedicated diurnal searches were conducted at each fauna site. This was spread over several events, two per site, during the survey period. Additional habitat searches were carried out during trap checks and while doing the flora surveys. Searches were typically undertaken during the late morning, allowing for reptile activity to increase with rising temperatures, but before the maximum heat of the day. Searching techniques involve the careful rolling of rocks and logs, rustling through leaf litter, and peeling back of exfoliating bark from standing trees. For targeted reptile species, dedicated searches were conducted opportunistically when preferred habitat was encountered (e.g. Gilgai formations or dense ground debris).

Evidence of wildlife was also searched for during these surveys' identification of tracks, scats and other signs of occupation (e.g. tree trunk scratches). For scats not identifiable in the field, they were collected and sent to a scat analysis expert (Barbara Triggs) for identification of the species responsible for the scat and/or where possible, the identification of prey species material present in predator scats.

Incidental Recordings

Throughout each survey period, ecologists were traversing the study area on foot and by vehicle every day for numerous hours whilst conducting routine survey activities (e.g. driving between sites, checking traps, vegetation surveys etc.). The ecologists remained alert and would record numerous wildlife species as observed or heard during the survey period. As with the habitat searches, this included signs or evidence of wildlife, and included constant vigilance for raptor nests. All areas of the study area have been visited by ecologists throughout the surveys.

4.5.4 Fauna Survey Effort

Survey effort undertaken during each survey event is detailed in Table 9 for each fauna sampling technique.

Table 9 Survey effort

Sampling Technique	Survey Effort				
	Autumn Survey 2017	Spring Survey 2017	Autumn Survey 2018	Micro-bat Survey 2018	Total Survey effort
Elliott Trapping	4 sites x 20 traps x 4 nights = 320 trap nights	6 sites x 20 traps x 4 nights = 480 trap nights	5 sites x 20 traps x 4 nights = 400 trap nights	-	1,200 TTN
Automated Camera Trapping	4 sites x 1 camera x 4 nights = 16 trap nights	6 sites x 1 camera x 4 nights = 24 trap nights	5 sites x 1 camera x 4 nights = 20 trap nights	-	60 TTN
Pitfall Trapping	4 sites x 4 pitfalls x 4 nights = 64 trap nights	6 sites x 4 pitfalls x 4 nights = 96 trap nights	5 sites x 4 pitfalls x 4 nights = 80 trap nights	-	240 TTN
Funnel Trapping	4 sites x 6 funnels x 4 nights = 96 trap nights	6 sites x 6 funnels x 4 nights = 144 trap nights	5 sites x 6 funnels x 4 nights = 120 trap nights	-	360 TTN
ANABAT	(3 sites x 1 bat detector x 3 nights) + (1 site x 1 bat detector x 2 nights) = 11 trap nights	(3 sites x 1 bat detector x 3 nights) + (1 site x 1 bat detector x 2 nights) + (1 site x 1 bat detector x 4 nights) = 15 trap nights	4 sites x 1 bat detector x 3 nights = 12 trap nights	-	38 TTN
Harp Trapping	-	-	2 sites x 1 harp x 4 nights = 8 trap nights	8 sites x 1 harp x 7 nights = 56 trap nights	64 TTN
Mist Netting	-	-	-	3 sites x 1 mist net = 3 trap nights	3 TTN
Call Playback (CPB) (30 minutes per session 2 sessions)	4 sites x 5 CPB x 2 nights = 40 CPB	6 sites x 4 CPB x 2 nights = 48 CPB	(4 sites x 4 CPB x 2 nights) + (1 site x 3 CPB x 1 night) + (1 site x 4 CPB x 1 night) = 39 CPB	-	127 CPB
Bird Surveying (60 minutes per session 2 sessions)	8 person hours at fauna sites 15 person hours of opportunistic bird surveying	12 person hours at fauna sites 20 person hours of opportunistic bird surveying	10 person hours at fauna sites 15 person hours of opportunistic bird surveying	-	80 TPH
Spotlighting (30 minutes per session 2 sessions)	4 person hours at fauna sites 4 person hours of opportunistic spot lighting	6 person hours at fauna sites 5 person hours of opportunistic spot lighting	5 person hours at fauna sites 5 person hours of opportunistic spot lighting	-	29 TPH
Habitat Searching (60 minutes per session 2 sessions)	8 person hours at fauna sites 12 person hours of opportunistic habitat searching	12 person hours at fauna sites 15 person hours of opportunistic habitat searching	10 person hours at fauna sites 10 person hours of opportunistic habitat searching	-	67 TPH

TTN: Total trap nights
TPH: Total person hours

5.0 FLORA RESULTS AND DISCUSSION

5.1 FLORA SURVEY RESULTS

A total of 207 flora species were identified in the study area. One flora species listed as Near Threatened under the NC Act but not listed under the EPBC Act, was observed on the Central East of the study area; *Cerbera dumicola*. A total of 33 introduced species were recorded on the study area, of which five are listed as weed species under the Queensland Biosecurity Act and/or classified by the Australian Government as a Weed of National Significance (WoNS). All four are listed as Restrictive Invasive plants for Queensland and only three of them are also classified as WoNS; Parthenium weed (*Parthenium hysterophorus*) and Velvety tree pear (*Opuntia tomentosa)*. A full flora list for the study area is provided in Appendix H. Weed species fact sheets for these species are attached in Appendix J.

Six vegetation communities classed as Remnant Vegetation as defined by the VM Act were identified on the study area during the field surveys. The vegetation communities have been mapped when possible as homogeneous polygons with the exception of some “mixed polygons” which consisted of two or more vegetation communities that were mapped together due to the impracticability in clearly delineating each RE.

Associations within the communities reflect different vegetation structures and compositions, which occur on different geophysical locations. Table 10 outlines the RE characteristic of each vegetation community, where applicable, as well as a short description of the vegetation present. A description is provided in Sections 5.1.1 to 5.1.7 whilst Figure 12 shows the distribution of vegetation communities on the study area.

Analysis of the vegetation communities recorded within the study area confirm that none meet the condition thresholds to constitute a TEC, listed as threatened at the national level (see Section 5.3.1).

Table 10 Vegetation Community Overview

Vegetation Community	Regional Ecosystem	Community Description
VC 1	11.5.2	Narrow-leaved ironbark and Clarkson’s bloodwood woodland with a sparse shrub layer on sand plains.
VC 2	11.7.2	Lancewood (*Acacia shirleyi*) and/or Rosewood (*Acacia rhodoxylon)* woodland on lateritic duricrust.
VC 3	11.3.25	Blue gum (*Eucalyptus tereticornis)* with *Bauhinia* spp. and *Casuarina cunninghamiana* fringing woodland on drainage features.
VC 4	11.3.2	Poplar box (*Eucalyptus populnea)* woodland on alluvial plains.
VC 5	11.5.2/11.3.25	Mixed polygon where the dominant vegetation community was VC 1 (*Eucalyptus crebra* and *Corymbia clarksoniana* woodland) but along ephemeral creeks and with an important presence of Blue gums.
VC 6	11.3.25/11.3.2/11.5.2	Mixed polygon as a result of combination of VC 3 with elements of VC 4 and some elements of VC 1 due to edge effect.
Non-Remnant	NA	Non-remnant vegetation

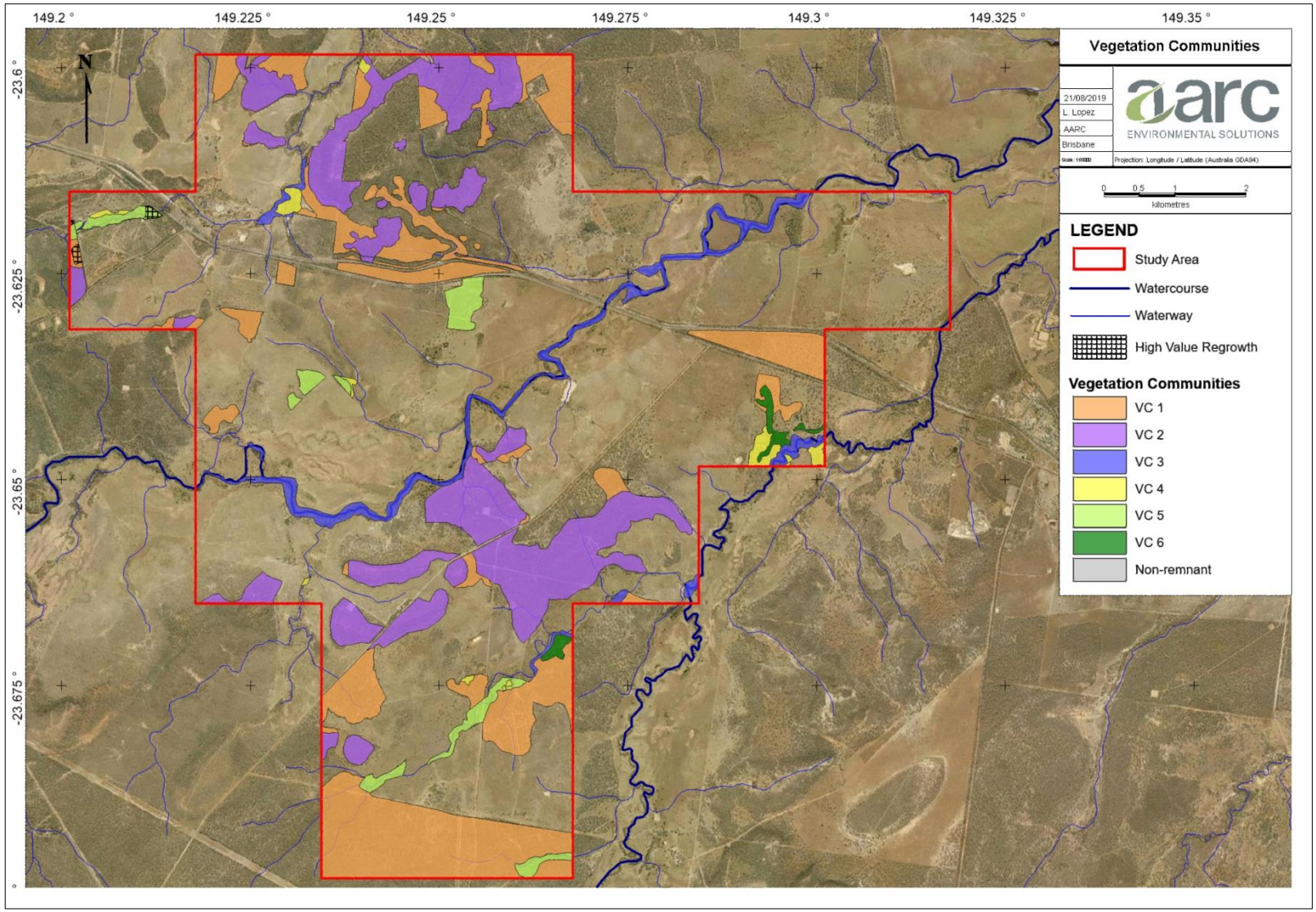


Figure 12 Vegetation Communities within the study area

5.1.1 VC 1: Narrow-leaved ironbark and Clarkson's bloodwood woodland with a sparse shrub layer on sand plains

VC 1 consists of Narrow-leaved ironbark (*Eucalyptus crebra)* and Clarkson's bloodwood (*Corymbia clarksoniana)* woodland with a sparse shrub layer on sand plains and is consistent with RE 11.5.2. *Allocasuarina luehmannii* is dominant in some sandy patches throughout the study area.

VC 1 is the most abundant vegetation community, covering a total of 872.23 ha (12.02%) of the study area. Table 11 provides a summary of community structure and corresponding conservation status.

Table 11 Vegetation Community 1 Profile

Associated Regional Ecosystem	11.5.2: *Eucalyptus crebra*, *Corymbia* spp., with *E. moluccana* woodland on lower slopes of Cainozoic sand plains and/or remnant surfaces
Extent within Project	872.23 ha
Remnant Status	Remnant and 2.71 ha mapped as High Value Regrowth
EPBC Act	Not listed
VM Act Status	Least Concern
Biodiversity Status	No concern at present
Tree Layer	*Eucalyptus crebra* and *Corymbia clarksonia* (12 - 14 m) and occasionally *Allocasuarina luehmannii* dominant on the tree layer. *Alphitonia excelsa* and *Petalostigma pubescens* are dominant in a smaller tree layer.
Shrub Layer	The 0.5 m to 2 m tall shrub layer is normally dominated by *Erythroxylum australe, Petalostigma pubescens, Psydrax johnsonii* and *Carissa spinarum.*
Ground Layer	The ground layer is typically dominated by *Cleistochloa sp. (*Duaringa K.B.Adison 42*)*, *Eragrostis lacunaria, Aristida calycina, Aristida caput-medusae*, and sometimes exotics such as *Melinis repens* and *Urochloa mosambicensis.*
Structure Category	Sparse
Biosecurity Act and/or WoNS Weed Species	*Opuntia tomentosa*
Crown Cover (%)	Average of 60% canopy cover
Ground Cover (%)	On average, bare ground comprised 29% of the total area, whilst organic litter comprised 60%

Photo Plate 1 Ironbark and Bloodwood woodland on sand plains

Conservation Value

No species of conservation significance were recorded in this vegetation community.

The following exotic species were recorded in VC 1 during the ecology surveys: Velvety tree pear (*Opuntia tomentosa),* Red natal grass (*Melinis repens*), Paddy's lucerne (*Sida rhombifolia*) and Green panic (*Megathyrsus maximum*). Velvety Tree Pear is classified as a WoNS.

Vegetation Condition and Habitat Value

RE 11.5.2 is listed as Least Concern under the VM Act and the DES's Biodiversity Status. The extent of this community in reserve areas is low (DES 2019c).

VC 1 presents patches of regrowth vegetation thorough the study area. Areas that have been subjected to past disturbance such as fire, dieback and selective logging now hold coloniser species. Patches of *Acacia cretata* and *Acacia rhodoxylon* young trees of about 1.5-2m dominate the shrub layer across the study area (Photo Plate 2).

Photo Plate 2 VC 1 regrowth patch with *Acacia spp.*

5.1.2 VC 2: Lancewood (*Acacia shirleyi)* and/or Rosewood (*Acacia rodoxylon)* woodland on lateritic duricrust

VC 2 consists of *Acacia* monospecific woodland on lateritic soil, mainly Lancewood (*Acacia shirleyi*) and Rosewood (*Acacia rhodoxylon).* It occurs around rocky areas in the North of the study area but also on flat lateritic areas in the centre and south, covering approximately 734.23 ha (10.12%) of the study area. This community occurs on lateralised mesa slopes, breakaways, scree slopes and remnant colluvium. A summary of VC 2 is presented below in Table 12.

Table 12 Vegetation Community 2 Profile

Associated Regional Ecosystem	11.7.2*: Acacia spp.* woodland on Cainozoic lateritic duricrust. Scarp retreat zone.
Extent within the study area	734.23 ha
Remnant Status	Remnant
EPBC Act	Not listed
VM Act Status	Least Concern
Biodiversity Status	Of Concern
Tree Layer	*Eucalyptus crebra* as occasional emergent tree with *Acacia shirleyi* or *Acacia rhodoxylum* monospecific dominant in the tree layer.
Shrub Layer	Very sparse shrub layer with dominance of *Acacia rhodoxylum, Erythroxylum australe, Alstonia constricta, Psydrax forsteri* and *Carissa spinarum.*
Ground Layer	The ground layer is typically dominated by *Entolasia stricta* (D)*, Calyptochloa gracilima* (D)*, Aristida caput-medusae* (D) *and Paspalidium caespitosum* (D)*.*
Structure Category	Sparse
Biosecurity Act and/or WoNS Weed Species	None
Crown Cover (%)	Average of 70% canopy cover
Ground Cover (%)	On average, bare ground comprised 15.5% of the total area, whilst organic litter comprised 65%

D – Dominant

Photo Plate 3 Lancewood woodland within the study area

Conservation Value

Cerbera dumicola, listed as NT under the NC Act was recorded in two locations within the study area, both of them associated with VC 2. Section 5.3 below discusses this listed species in further detail.

The following exotic species were recorded in VC 2 during the ecology surveys: Sabi grass (*Urochloa mosambicensis*), *Sida cordifolia,* Red natal (*Melinis repens), Malvastrum americanum* and Shrubby stylo *(Stylosanthes scabra)*.

Vegetation Condition and Habitat Value

RE 11.7.2 is listed as Least Concern under the VM Act and the DES's Biodiversity Status. The extent of this community in reserve areas is low (DES 2019c).

VC 2 presents different degrees of disturbance thorough the study area. As per VC 1, areas that have been subjected to past fire, dieback and selective logging. Rosewood has been targeted for logging due to its high value as fence post. Lancewood, on the other hand, has been left relatively undisturbed due to its value stabilising the soil in an area highly susceptible to erosion. *Acacia rhodoxylon* young and thin trees of about 1.5-2m can be found in patches across the study area.

5.1.3 VC 3: Blue gum (*Eucalyptus tereticornis)* with *Bauhinia* spp. and *Casuarina cunninghamiana* fringing woodland on drainage features

This community is located along Charlevue Creek and other ephemeral creeks within the study area. It covers approximately 143.74 ha, close to 2% of the study area, and occurs on alluvial plains. Table 13 provides a detailed description of VC 3. Occasional small patches of *Corymbia tessellaris* or *Eucalyptus populnea* were present on adjacent alluvial floodplains.

Table 13 Vegetation Community 3 Profile

Associated Regional Ecosystem	11.3.25: *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines.
Extent within Project	143.74 ha
EPBC Act	Not listed
VM Act Status	Least Concern
Biodiversity Status	Of Concern
Tree Layer	*Eucalyptus tereticornis* dominant species with occasional *Eucalyptus crebra, Eucalyptus populnea, Corymbia tessellaris and Corymbia clarksoniana.* In a lower tree layer, the dominant species are *Bauhinia carronii* and *Cassia brewsterii* and occasionally *Melaleuca nervosa* would be the dominant species.
Shrub Layer	The 0.5 m to 2 m tall shrub layer is normally dominated by *Carissa spinarum, Terminalia oblongata, Melaleuca nervosa* and *Alphitonia constricta.*
Ground Layer	The ground layer is typically dominated by *Dichantium sericeum* (D)*, Megathyrsus maximus* (D)*, Cenchrus ciliaris* (D)*, Urochloa mosambicensis* (D) and *Bothriochloa ewartiana* (D)*.*
Structure Category	Mid-dense

Biosecurity Act and/or WoNS Weed Species	*Cryptostegia grandiflora*, *Parthenium hysteropus* and *Opuntia tomentosa*
Crown Cover (%)	Average of 58% canopy cover
Ground Cover (%)	On average, bare ground comprised 8.5% of the total area, whilst organic litter comprised 53%

D – Dominant

Photo Plate 4 Blue gum (*Eucalyptus tereticornis)* woodland along the Charlevue Creek

Conservation Value

No species of conservation significance were recorded within VC 3.

The weed species Rubber vine (*Cryptostegia grandiflora*), Parthenium weed (*Parthenium hysteropus*) and Velvety tree pear (*Opuntia tomentosa)* were recorded in this community, along the Charlevue Creek.

Introduced species Buffel grass *(Cenchrus ciliaris),* Green panic *(Megathyrsus maximus*), Sabi grass *(Urochloa mosambicensis) Sida cordifolia, Malvastrum americanum* and *Bidens pilosa* were recorded in VC 3. Buffel grass and Green panic were occasionally recorded as the dominant species in the ground layer.

Vegetation Condition and Habitat Value

RE 11.3.25 is listed as Least Concern under the VM Act and Of Concern under DES's Biodiversity Status. The extent of this RE in reserves is low (DES 2019c).

Often associated with regional ecosystems 11.3.2 and 11.3.4, elements of which such as *Corymbia tessellaris* and *Eucalyptus populnea* may occur on adjacent alluvial plains. In highly cleared areas, in particular north of the Capricorn Highway, a narrow fringe of riparian vegetation is often the only surviving woody vegetation and it is not mapped as remnant in the Government vegetation map. This RE is impacted by grazing pressure and edge effects, where the dominant ground layer is dominated by the exotic pasture species that grow in the grazing area.

The presence of large, remnant, hollow-bearing trees such as *Eucalyptus tereticornis* provides important denning and breeding habitat for a variety of arboreal mammals and birds.

5.1.4 VC 4: Poplar box *(Eucalyptus populnea)* woodland on alluvial plains

This community is located in small patches within the study area. It covers approximately 36.52 ha (0.5%) of the study area on alluvial soils. Table 14 provides a summary of conservation status and vegetative structure for VC 4.

Table 14 Vegetation Community 4 Profile

Associated Regional Ecosystem	11.3.2: *Eucalyptus populnea* woodland on alluvial plains.
Extent within Project	36.52 ha
EPBC Act	Analysis of this vegetation (Section 5.3.1) confirms that VC4 does not meet the condition thresholds to constitute a TEC.
VM Act Status	Of Concern
Biodiversity Status	Of Concern
Tree Layer	Tree layer dominated by *Eucalyptus populnea* (in some occasions *E. melanophloia*) (12-14m), with occasional *Corymbia dallachiana, C. clarksoniana* and *C. tessellaris.*
Shrub Layer	Very spare shrub layer dominated by *Atalaya hemiglauca, Archidendropsis basaltica, Flindersia dissosperma, Carissa spinarum* (dominant in the lower shub layer) and occasionally *Alphitonia excelsa.*
Ground Layer	The ground layer is typically dominated by *Bothriochloa ewartiana, Aristida calycina, Aristida perniciosa* (D)*, Eragrostis sororia, Eragrostis lacunaria, Cynodon dactylon, Urochloa mosambicensis* (D)*, Heteropogon contortus* (D) and *Themeda triandra,*
Structure Category	Sparse
Biosecurity Act and/or WoNS Weed Species	*Harrisia martini* and *Vachellia farnesiana*
Crown Cover (%)	Average of 53% canopy cover
Ground Cover (%)	On average, bare ground comprised 12.5% of the total area, whilst organic litter comprised 34%

D - Dominant

Photo Plate 5 Poplar box *(Eucalyptus populnea)* woodland on alluvial plains

Conservation Value

No species of conservation significance were recorded within VC 4.

The exotic species Sabi grass (*Urochloa mosambicensis*), *Sida cordifolia*, Shrubby stylo (*Stylosanthes scabra*), Red natal (*Melinis repens*), *Malvastrum americanum*, *Bidens pilosa,* Mimosa bush (*Vachellia farnesiana*) and Harrisia cactus (*Harrisia martinii*) were recorded in VC 4.

VC4 is most consistent with RE 11.3.2, which is an associated RE of the Poplar box grassland on alluvial plains and Weeping myall woodland TEC. None of these TECs were identified within the study area. A summary of the survey effort to determine the presence of both TECs is detailed in Section 5.3.1.

Vegetation Condition and Habitat Value

RE 11.3.2 is classified as Of Concern under the VM Act and Of Concern at present under DES's Biodiversity Status. The extent of this RE in reserves is low.

VC 4 was only present in small patches within the study area, some of them too small to map. This community presented evidence of edge effect with exotic pasture species such as *Urochloa mosambicensis* occasionally dominating the ground layer. Regrowth of VC 4 was recorded in the south of the study area and along Cooinda road, in the middle of the study area. Recruitment of Poplar box was observed across the study area, with sections within VC 4 of very young and thin trunks.

5.1.5 VC 5: Mixed polygon: Ironbark, Bloodwood and Blue gum woodland along ephemeral creeks

VC 5 is limited to small patches within the study area and consist on a combination of VC 1 with elements of VC 3 (Blue gums, 20% of the vegetation community) due to the presence of ephemeral drainage features in the vicinity of VC 1. *Melaleuca nervosa* is occasionally present as dominant species on the tree and shrub layers. It covers approximately 96.71 ha (1.33%) of the study area.

VC 5 is illustrated in Photo Plate 6.

Conservation Value

No species of conservation significance were recorded within VC 5. The same exotic pasture species recorded in VC 1 where observed in the ground layer of this community throughout the study area.

Vegetation Condition and Habitat Value

This community was only present in three patches within the study area, where it was not possible to separate the vegetation into two defined communities. There is evidence of edge effect, where exotic pasture species are present in the groundcover. Regrowth of VC 5 was similar to the regrowth of VC 1, with the same pioneer *Acacia* spp. as described before. Both RE's, 11.5.2 and 11.3.25 are classified as Least Concern under the VM Act but while RE 11.5.2 is classified as Least Concern under the DES's Biodiversity Status, RE 11.3.25 is classified as Of Concern. The extent of these REs in reserves is low (DES 2019c).

Photo Plate 6 VC 5 – RE 11.5.2/11.3.25

5.1.6 VC 6: Mixed polygon: Blue gum, Poplar box and Ironbark woodland along ephemeral creeks

VC 6 is located in small patches within the study area and consist on a combination of VC 3 (Blue gums) along several small ephemeral drainage channels, with elements of VC 4 (Poplar box), present in the alluvial plains between the channels and VC 1 (Ironbark) due to edge effect. VC 6 covers a total of 21.83 ha (0.3%) of the study area.

VC 5 is illustrated in Photo Plate 7.

Conservation Value

No species of conservation significance occurred within VC 6.

Habitat Value

VC 6 was only present in two patches within the study area, where it was not possible to separate the vegetation into three defined communities. As per VC 5, there is evidence of edge effect, with exotic pasture species present in the groundcover and occasionally dominant. The RE classification for the three REs present is as follows: 11.3.25 is listed as Least Concern under the VM Act and Of Concern under DES's Biodiversity Status; 11.3.2 is listed as Of Concern under the VM Act and the DES's Biodiversity Status; and 11.5.2 is listed as Least Concern under the VM Act and the DES's Biodiversity Status. The extent of these RE in reserves is low (DES 2019c).

Photo Plate 7 VC 6 – RE 11.3.25/11.3.2/11.5.2

5.1.7 Non-remnant and Regrowth Vegetation

Non-remnant regrowth vegetation is present in areas that have been disturbed by human activities, such as logging and preparation for grazing through the entire study area. There are numerous patches of regrowth vegetation, including areas that are mapped as remnant in the Vegetation Management Regional Ecosystem Map but have been assessed as non-remnant as a result of the field surveys.

This vegetation is not classed as remnant vegetation, therefore is not defined by an RE.

There is one large patch of vegetation north of the study area mapped as remnant which vegetation consists on *Acacia* spp regrowth. According to local knowledge (farmers) around six years ago there was a fire that affected the north part of the EPC, the area north of the Capricorn Highway. As a result of that fire, there is regrowth across all the vegetation communities, especially VC 1 and VC 4. A large patch of woodland originally mapped as 11.5.9b is now categorised as non-remnant vegetation. This particular area presents only an extremely sparse tree layer (*Eucalyptus crebra* and *Corymbia clarksoniana*) and a dense shrub layer of pioneer *Acacia* spp. mainly *Acacia cretata.*

Photo Plate 8 Non-remnant *Acacia* spp regrowth

The areas of the study area not mapped in Figure 12 are mainly pasture land with more or less evidence of regrowth, or dead vegetation. This regrowth corresponds with early stages of V4, V1 or V2. Regrowth of *Acacia cretata* is especially abundant within several vegetation communities, such V1, but also in pasture area. Evidence of burning and ring barking has been recorded thorough these pasture areas.

The ground layer of the non-remnant vegetation is dominated by exotic pasture grasses such as Buffel grass (*Cenchrus ciliaris*), Indian bluegrass (*Bothriochloa pertusa*), Sabi grass (*Urochlora mosambicensis*) and Red natal grass (*Melinis repens).*

5.2 WEEDS OF MANAGEMENT CONCERN

A total of 33 introduced species were identified onsite. The exotic pasture grasses dominate the ground layer of the study area, particularly in cleared areas. A range of other exotic grasses and forbs are also

present across the study area in low to moderate abundance. A complete list of the flora species, indicating their native or introduced status can be found in Appendix H.

Three of these introduced species are classed as WoNS; Parthenium weed (*Parthenium hysterophorus*), Rubber vine (*Cryptostegia grandiflora)* and Velvety tree pear (*Opuntia tomentosa*). Introduced plant species are classified by the Commonwealth Government as WoNS if they present a serious threat to industry, water supply, human health/safety, plant communities and/or cultural values.

The above mentioned three species, together with Harrisia cactus *(Harrisia martini)* are similarly classed as Restricted Invasive Species under the Biosecurity Act (DAF 2018).

Vachellia farnesiana, also found in the study area, is not a prohibited or restricted invasive plant under the Biosecurity Act. However, by law, everyone has a general biosecurity obligation (GBO) to take reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control (DAF 2016).

Weed species of management concern found in the study area are listed in Table 15. All species present are known to occur commonly throughout the broader region.

Table 15 Weed species of management concern identified on the study area

Scientific name	Common name	WoNS Status	*Biosecurity Act 2014* Category 3
Harrisia martinii	Harrisia cactus	-	x
Cryptostegia grandiflora	Rubber vine	Yes	x
Opuntia tomentosa	Velvety tree pear	Yes	x
Parthenium hysterophorus	Parthenium	Yes	x
Bryophyllum sp	Mother of millions	-	x
*Vachellia farnesiana**	Mimosa bush	-	-

Note: * Considered a noxious weed of management concern.
Category 3: A person must not distribute the invasive plant either by sale or gift, release it into the environment.

Photo Plate 9 *Cryptostegia grandiflora* identified on the study area

5.3 FLORA OF CONSERVATION SIGNIFICANCE

5.3.1 Threatened Ecological Communities not identified on the study area

Brigalow (*Acacia harpophylla dominant and co-dominant)*

The Brigalow (*Acacia harpophylla* dominant and co-dominant) TEC comprises patches of vegetation in which *Acacia harpophylla* is one of the most abundant tree species. The tree layer may be dominated by *Acacia harpophylla* or have a co-dominant presence with other species such as Belah (*Casuarina cristata*) and other species of Acacia or Eucalyptus. Within Queensland, the Brigalow TEC is consistent with 16 RE described by the Queensland Herbarium, including RE 11.3.1, originally mapped within the study area.

A patch must meet the following condition thresholds to be considered the Brigalow TEC:

- The patch is 0.5 ha or more in size; and
- Exotic perennial plants comprise less than 50% of the total vegetation cover of the patch, as assessed over a minimum sample area of 0.5 ha (100 m by 50 m), that is representative of the patch.

Despite being mapped as present along the Charlevue and Springton Creeks in association with RE 11.3.1, Brigalow (*Acacia harpophylla)* was only recorded within the study area as a few individual stands. Two trees were recorded along the Charlevue Creek and a small patch with six trees was recorded on the bank of Springton Creek, close to the eastern boundary of the study area.

The sparse Brigalow individuals do not form a clear vegetation community, not reaching dominance in the canopy nor the minimum size of 0.5 ha specified as condition thresholds to qualify as Brigalow TEC.

Weeping myall *(Acacia pendula)* Woodland

Weeping myall woodlands often occur as monotypic stands generally 4 – 12 m high in which Weeping myall trees are the sole or dominant overstorey species. Other canopy species such as Western rosewood (*Alectryon oleifolius* subsp. elongatus), Poplar box (*Eucalyptus populnea*), or Black box (*Eucalyptus largiflorens*) may occur in association with this community.

Within Queensland, this community is known to occur in association with two REs including RE 11.3.2 (*Eucalyptus populnea* woodland on alluvial plains) and 11.3.28 (*Eucalyptus coolabah* +/- *Casuarina cristata* open woodland on alluvial plains). Of the extent of these REs throughout Queensland, it is estimated that only 5% supports the Weeping myall woodlands community. Most patches of the TEC are less than 1 or 2 ha in area.

This TEC has been previously described as potentially occurring on the study area based on the mapping of Poplar box woodlands on alluvial plains (11.3.2), has been ground-truthed as non-remnant based on the negligible canopy cover. However, due to the cycles of senescence that affect the dominant species Weeping myall, the criteria used to assess a vegetation community includes canopy cover as sparse as 5% and dominated by living, dead or defoliated Weeping myall trees (DEWHA 2009). As a result, additional survey effort was employed in this area, to identify any dead and/or defoliated trees. This area was dominated by *Acacia cretata* regrowth, confirming the absence of Weeping myall woodland TEC on the study area.

Poplar box Grassy Woodland on Alluvial Plains

Assessments of the RE 11.3.2 present within the study area (VC 4) have concluded that the TEC Poplar box Grassy Woodland is not present within the study area.

To be listed as TEC, the Poplar box in alluvial plains is to meet certain thresholds, such as size and vegetation condition. The following thresholds have been sourced from the *Draft Conservation Advice (including listing advice) for the Poplar Box Grassy Woodland on Alluvial Plains* (TSSC n. d.):

Class A Highest Quality

- **Category A1:** Patch equal or larger than 1 ha: The patch has little or no perennial weeds and a diverse native understorey. 90% or more of the perennial vegetation cover is native species **and** with 30 or more native plant species in the ground layer per ha.

- **Category A2:** Patch equal or larger than 5 ha. A large patch with low perennial weeds and diverse native understorey. 70% or more of the perennial vegetation cover is ground layer is native **and** with 30 or more native plant species in the ground layer per ha.

- **Category A3:** Patch equal or larger than 5 ha. A large patch with high quality habitat features. 10 trees per ha that either are large (30 cm or more in diameter at breast height) and/or have developed hollows **and** smaller trees, saplings or seedlings suggesting of periodic recruitment **and** with 20 or more native plant species in the ground layer per ha.

Class B Moderate Quality

- A large patch with moderate quality native understorey. 50% of perennial vegetation cover in ground layer is native **and** 20 or more native plant species per ha in the ground layer **or** 10 trees per ha that either are large (30 cm or more in diameter at breast height) and/or have developed hollows

VC 4 does not meet the threshold to constitute a TEC due to the size of the patches and poor condition of the community with a high presence of exotic pastures, occasionally dominant. Some trees recorded from the largest patch of VC 4 within the study area were larger than 30cm in diameter at breast height, however, some sections of the same patch presented younger and smaller specimens, not meeting the average of 10 or more per ha.

5.3.2 Flora Species of Conservation Significance Identified on the Study Area

Targeted searches across the study area detected the presence of one flora species of conservation significance in several of the seasonal surveys, *Cerbera dumicola* (Photo Plate 10). This species is listed as NT under the NC Act.

Cerbera dumicola is a shrub or small tree growing to 4 m high (DES 2018b). The species occurs across a range of habitats in central and southern Queensland. This species is associated with a range of vegetation communities such as sandstone hills in open *Eucalyptus umbra* subsp. *carnea*; woodlands of *Acacia shirleyi* with *Corymbia dolichocarpa*; acidic soils in mine rehabilitation area; woodland of *A. catenulata* and *A. shirleyi* with *E. thozetiana* on a slope of sand/clay soil; semi-deciduous notophyll-microphyll vine forest of *Brachychiton australis*, *Gyrocarpus americanus*, *Flindersia australis*, *Pleiogynium timorense*, *Drypetes deplanchei* and *Sterculia quadrifida* on rhyolite hillslopes; open-woodland of *E. melanophloia* with occasional *Acacia shirleyi*, *E. populnea* and *E. brownii*; semi-evergreen vine thicket with *Corymbia citriodora* and *Corymbia aureola emergents*; woodland of *A. rhodoxylon* on brown, sandy loam; and in *Corymbia tessellaris* - *Acacia aneura* open woodland (DES 2018b).

Cerbera dumicola has been severely impacted by land clearing with extensive fragmentation of its original habitat. While it can be very common at some of its known localities, many of the remnant populations comprise few individuals. It is likely to be more widespread than is currently known as these eucalypt dominated woodlands are poorly surveyed in southern Queensland. Threatening processes include:

- Land clearing for agriculture, which has undoubtedly been the main reason in the past for reductions in the area of occupancy, number of populations, number of individuals. Many populations are in areas mapped as 'non-remnant vegetation', hence are still able to be cleared; and

- Land clearing for mining. Several populations have been recorded from mining leases in the central highlands coalfields and are presumed lost (DES 2018b).

Cerbera dumicola has been identified during the vegetation surveys in two very localised rocky areas associated with vegetation community VC 2 and VC 1 (on an ecotone with VC 2) (Figure 14). This species was not identified elsewhere in the study area, within similar habitat types, during targeted searches.

The species is regionally abundant, having been recorded outside of the study area on multiple occasions (AVH 2019).

It is not expected that the proposed Project will impact on the known *Cerbera dumicola* individuals due to their location. The species has been recorded at the boundary of the study area and adjacent to areas of existing disturbance. Suitable habitat is extensive throughout the local area including immediately east of the study area.

Photo Plate 10 ***Cerbera dumicola*** **at the study area**

5.3.3 Flora Species of Conservation Significance Not Identified on the Study Area

Table 16 below discusses EVNT species that are known from the broader region and have been identified from desktop searches but were not observed on site during surveys.

The assessment of potential for presence and impact on each species is based on the knowledge of ecologists, information obtained from field surveys on the study area, previous surveys conducted on or near the study area and scientific literature. This assessment revealed that of the four species previously assessed with potential to occur within the study area, three were considered unlikely to occur within the study area.

Table 16 Flora Species of Conservation Significance not identified on the study area

Scientific Name Common Name	Status		Likelihood of Occurrence Post Survey
	EPBC Act	NC Act	
Bertya opponens	V	C	Potential The study area contained suitable habitat. However, there are no records of the species within 50 km of the study area and the species was not identified during the field survey. It is therefore considered unlikely the Project will impact on this species.
Bertya pedicellata	-	NT	Potential The study area contained suitable habitat. However, the species was not identified during the field survey, it is considered unlikely the Project will impact on this species.
Solanum adenophorum	-	V	Unlikely The study area did not contain suitable habitat for this species in the form of cracking clay soils and Brigalow woodland. The species was not detected during the field survey, indicating potential for Project impact to be low.
Solanum dissectum	E	E	Unlikely The study area did not contain suitable habitat for this species in the form of cracking clay soils and Brigalow woodland. The species was not detected during the field survey, indicating potential for Project impact to be low.
Solanum elachophyllum	-	E	Unlikely The study area did not contain suitable habitat for this species in the form of cracking clay soils. Further, the species was not detected during the field survey, indicating potential for Project impact to be low.

EPBC – *Environment Protection and Biodiversity Conservation Act 1999*
NC Act – *Nature Conservation Act 1992*
CE – Critically Endangered
NT – Near Threatened
V – Vulnerable
E – Endangered
C – Least Concern

5.4 WETLANDS

Field surveys concluded that all the potential lacustrine and palustrine wetlands within the study area (Figure 6) are either not present or have been identified as artificial (farm) dams. The only wetlands confirmed within the study area in accordance to the DES interactive Wetland*Maps* database are riverine wetlands and have been mapped as VC 3, VC 5 and VC 6.

Outside the study area, there is a large palustrine wetland (approximately 82 ha in area) located about 4 km to the east of the boundary. This wetland, identified as HES, is not connected to the study area through any waterbodies or watercourses and does not occur on the same drainage system that flow through the study area. This wetland has been identified as Category X vegetation under the Regulated Vegetation The pre-clearing Government RE mapping (Appendix A) of this wetland identified it as RE 11.3.27. RE 11.3.27 is described as freshwater wetland; with variable vegetation compositions including; open water with or without aquatic species and fringing sedge lands and eucalypt woodlands (DES 2019c). Current Government mapping and field inspections of the mapped wetlands identify the

vegetation as non-remnant. No water was observed during the site inspection (Photo Plate 11). Assessment of potential impact to this wetland as an MSES have been addressed in Section 9.1.3.

Field surveys concluded that all the potential lacustrine and palustrine wetlands identified within the study area from desktop searches (Figure 6) are either not present or have been identified as artificial (farm) dams. The only natural wetlands within the study area are riverine wetlands associated with riparian and vegetation along Charlevue Creek and have been mapped as VC 3, VC 5 and VC 6 (Figure 12).

Outside the study area, there is a large palustrine wetland (approximately 82 ha in area) located about 4 km to the east of the boundary. This wetland, identified as High Ecological Significance (HES) under the *Environmental Protection (Water and Wetland Biodiversity) Policy* 2019, is not connected to the study area through any waterbodies or watercourses. Current Government mapping and field inspections of the mapped wetlands identified the vegetation as non-remnant. Field assessment identified the presence of lfora species known to inhabit wetland environements. No water was observed during the site inspection.

Photo Plate 11 *Melaleuca spp.* dominated HES wetland

5.4.1 Groundwater Dependent Ecosystems

The above-mentioned wetlands have the potential to be partially dependent on groundwater (BoM 2019). Within the study area high potential terrestrial Groundwater Dependent Ecosystems (GDEs) and moderate potential aquatic GDEs were identified by database searches in association with Charlevue Creek and Springton Creek. Moderate potential terrestrial GDEs were also mapped in association with some of the smaller waterways.

The groundwater within the study area has been assessed and the bores located in close proximity of Charlevue Creek show a below surface depth of groundwater of 8.77 meters below ground level (mbgl)

while Springton Creek has a below surface depth of groundwater of 11.19 mbgl. The bores within the study area along the associated tributaries have a groundwater depth of over 16 mbgl. Based on the known rooting depth of dominant tree species, the assessment concluded thatThe potential GDEs within the study area are in only riverine ecosystems located in close proximity to Charlevue Creek and Springton Creek have potential dependency on groundwater.

Wetland habitats identified within the study area are mapped in Figure 13.

The HES wetland located 4 km to the east of the study area is also potentially groundwater dependant; however, it is noted that this wetlands isare ephemeral and does not hold water throughout the year.

Assessment of the GDEs has been addressed in Section 7.1.5 of this report.

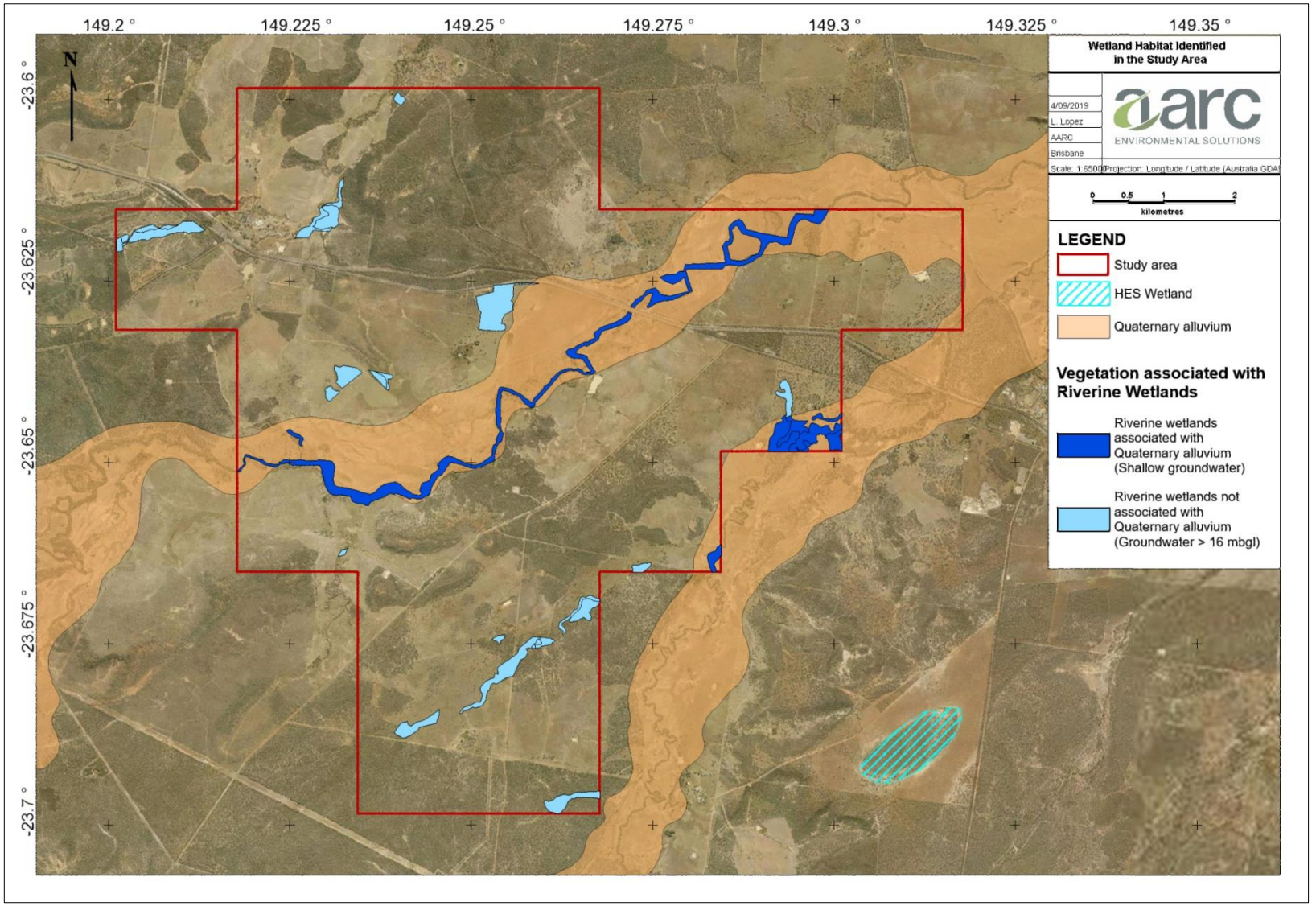


Figure 13 Wetland Habitats Identified in the Study Area

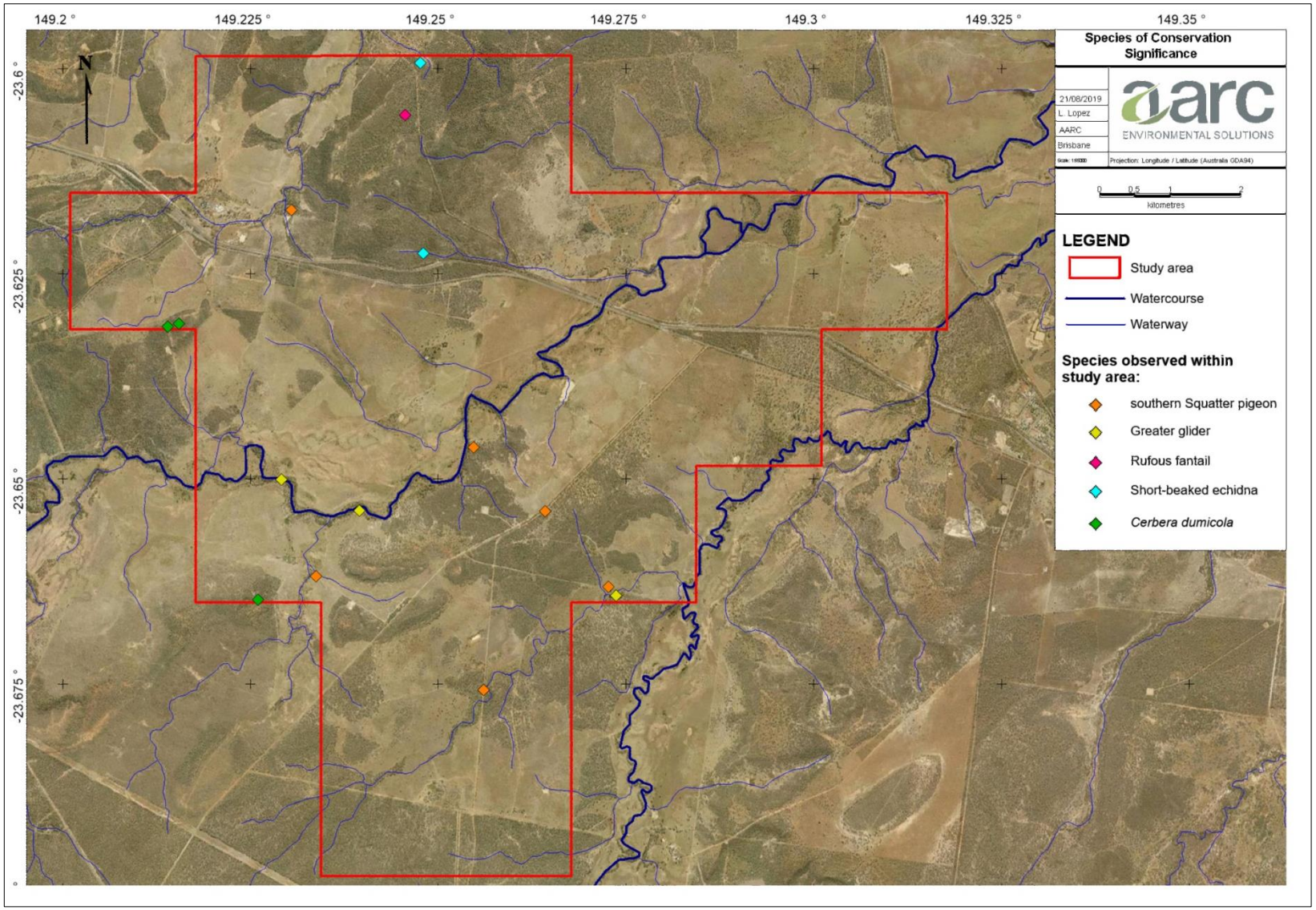


Figure 14 Species of Conservation Significance observed within the study area

6.0 FAUNA RESULTS AND DISCUSSION

6.1 FAUNA SURVEY RESULTS

A total of 145 vertebrate species were positively identified on the study area during the surveys, comprising 8 amphibians, 83 birds, 33 mammals and 21 reptiles. Six of these species are introduced. One migratory and marine species and one marine species were recorded during the survey. Two threatened fauna species were observed on site. A complete list of the fauna species recorded on the study area is included in Appendix I.

During the conduction of the aquatic ecology assessment (AARC 2019), a number of vertebrate fauna species were recorded in the study area. These are detailed in the aquatic ecology assessment. One species recorded by the aquatic ecology survey was not recorded by the terrestrial ecology survey, namely the Keelback snake (*Tropidonophis mairii*), which was identified along Charlevue Creek.

6.1.1 Amphibians

Habitat Values

The species recorded within the study area are well adapted to the habitats identified, with permanent water sources and areas subject to seasonal inundation. These species employ periods of dormancy to contend with drier, less favourable conditions. Habitat variation and suitability increase in response to increased rainfall during the wet season (November - March) providing viable breeding opportunities.

The amphibian species identified are all common species and impacts from the Project are likely to be localised with minimal effects to broader populations.

Observed Species

A total of 8 amphibian species were recorded during the surveys, comprising seven native species and the introduced Cane toad (*Rhinella marina*). The Cane toad is listed as an invasive biosecurity matter under the revised version of the Biosecurity Actand are a major pest species that compete for food with native species.

The native species recorded on site were Ornate burrowing frog (*Platypectrum ornatum*), Common green tree frog (*Litoria caerulea*) Photo Plate 12, Naked tree frog (*Litoria rubella*), Broad-palmed frog (*Litoria latopalmata*), Bumpy rocket frog (*Litoria inermis*), Salmon-striped frog (*Limnodynastes salmini*) and Spotted grass frog (*Limnodynastes tasmaniensis*).

Photo Plate 12 Common green tree frog (*Litoria caerulea*) observed at DF02

Amphibians of Conservation Significance

No amphibian species of conservation significance were observed on the study area during field surveys. However, the Tusked frog (*Adelotus brevis*) has been identified as potentially occurring within the study area due to the proximity of its known range and the presence of suitable habitat (such as dams).

6.1.2 Reptiles

Habitat Values

The study area provided a variety of habitat types such as vegetated drainage features, woodlands to open forests and rocky areas to promote reptile diversity. This included several microhabitats such as tree hollows, fallen timber, dense leaf litter, soil cracks and rock crevices which provide shelter from extreme climates, protection from aerial predators and as habitat for hunting and foraging for food.

Observed Species

A total of 21 reptile species were recorded within the study area during the field surveys, all of which are listed in Appendix I.

The suite of reptiles occurring on the study area included seven species of skink and one species of legless lizard. These species include the Eastern striped skink (*Ctenotus robustus*), Elegant snake-eyed skink (*Cryptoblepharus pulcher*), Shaded litter rainbow-skink (*Carlia munda*), South-eastern morethia skink (*Morethia boulengeri)*, Fire-tailed skink (*Morethia taeniopleura*), the Orange-flanked Rainbow skink (*Carlia rubigo*) and Burton's legless lizard (*Lialis burtonis).*

Five gecko species were identified on the study area, including the Eastern stone gecko (*Diplodactylus vittatus*), Dubious dtella *(Gehyra dubia),* Bynoe's Gecko *(Heteronotia binoei),* Box-patterned gecko *(Lucasium steindachneri)* (Photo Plate 13) and the Prickly knob-tailed gecko (*Nephrurus asper*).

Photo Plate 13 *Box-patterned gecko (Lucasium steindachneri)* observed at DF09

Field surveys also detected the presence of three dragon species, Bearded dragon (*Pogona barbata*), Tommy roundhead (*Diporophora australia*) and Freckled monitor (*Varanus tristis orientalis*).

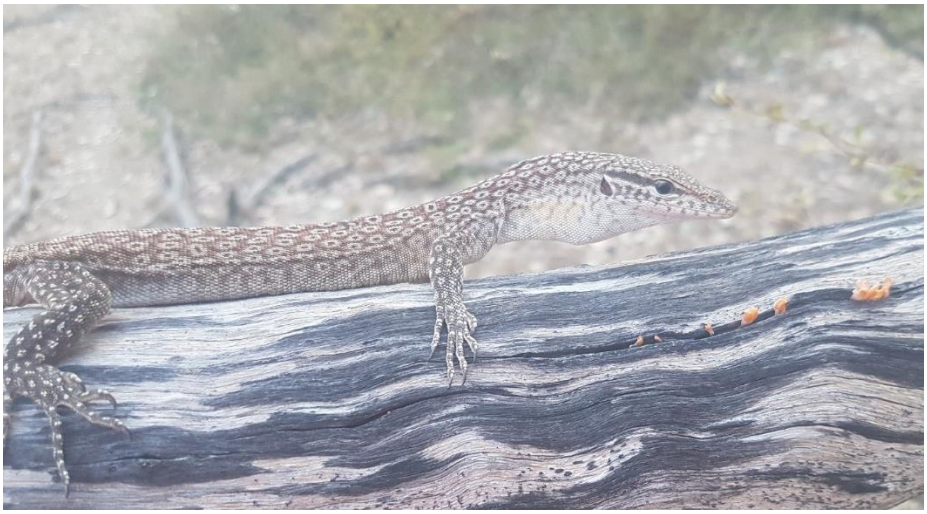


Photo Plate 14 Freckled monitor (*Varanus tristis orientalis*) observed at DF10

Six snake species namely the Black headed python (*Aspidites melanocephalus*), Eastern brown snake (*Pseudonaja textilis*), Pale-headed snake (*Hoplocephalus bitorquatus*) (Photo Plate 15), Carpentaria snake (*Cryptophis boschmai*), Yellow-faced whip snake (*Demansia psammophis)* and Orange-naped snake (*Furina ornata*) were recorded within the study area.

Photo Plate 15 Pale-headed snake (*Hoplocephalus bitorquatus*) observed at DF01

Reptile Species of Conservation Significance

No reptiles of conservation significance were observed on the study area during the survey period. Database searches identified seven reptile species of conservation significance within the region. The habitat requirements and likelihood of each conservation significance species occurring on the study area are described in Appendix D.

6.1.3 Birds

Habitat Values

Avian assemblages are generally determined by factors such as food sources (e.g. fruit, nectar, seeds, and insects), as well as a mosaic of habitat structures such as grasses, thick understorey, mid-storey and canopy vegetation (i.e. vertical habitat complexity). Generally, the more food sources available and the more complex the structure of the vegetation, the more diverse the avifauna will be.

Food sources across the study area comprised seeds, fruit, nectar, insects and vertebrate prey items (or carrion). The diversity of forage resources available in the surveyed habitats suggests that the Project can support a variety of native avian species.

Observed Species

A total of 83 bird species were observed on the study area. Most species observed were common species representative of the dry woodland habitat dominating the study area, however, two species of conservation significance were identified in the study area during the survey period. These species are discussed in more detail in Section 6.3. A full list of bird species observed on the study area is presented in Appendix I.

A variety of granivorous birds were found to be present including the Sulphur-crested cockatoo (*Cacatua galerita*), Crested pigeon (*Ocyphaps lophotes lophotes*), Peaceful dove (*Geopelia striata placida*), southern squatter pigeon (*Geophaps scripta scripta*), Bar-shouldered dove (*Geopelia humeralis*), and Double-barred finch (*Taeniopygia bichenovii*).

The study area was found to support a number of honeyeaters including the White-throated honeyeater (*Melithreptus albogularis*), Brown honeyeater (*Lichmera indistincta ocularis*), Blue-faced honeyeater (*Entomyzon cyanotis*) and Noisy friarbird (*Philemon corniculatus*).

The suite of insectivorous birds recorded on site included the Grey fantail (*Rhipidura albiscapa*), Magpie-lark (*Grallina cyanoleuca*), Black-faced cuckoo-shrike (*Coracina novaehollandiae*), Grey-crowned babbler (*Pomatostomus temporalis*) and Striated pardalote (*Pardalotus striatus*).

A large diversity of omnivorous and carnivorous species was detected on the study area, including the Apostlebird (*Struthidea cinerea*), Pheasant coucal (*Centropus phasianinus*), Grey butcherbird (*Cracticus torquatus*), Australian magpie (*Cracticus tibicen*), Australian raven (*Corvus coronoides*), Laughing kookaburra (*Dacelo novaeguineae*) and Emu (*Dromaius novaehollandiae*).

Several nocturnal bird species including the Tawny Frogmouth (*Podargus strigoides*), Barn owl (*Tyto alba*) and Southern boobook (*Ninox boobook*) were observed during field surveys. Five raptor species, including Whistling kite (*Haliastur sphenurus*) and Brown falcon (*Falco berigora*) (Photo Plate 16) were also recorded on the study area.

Photo Plate 16 Brown falcon (*Falco berigora*) observed on the study area

Aquatic bird species such as the Brolga (*Grus rubicunda*) were also recorded during field surveys.

Birds of Conservation Significance

Threatened Species

The southern subspecies of the Squatter pigeon (*Geophaps scripta scripta*) was recorded in several locations (Figure 14) on the study area at the time of the surveys (Photo Plate 17).

The southern Squatter pigeon occurs along the inland slopes of the Great Dividing Range with a distribution from the Burdekin-Lynd divide in central Queensland, west to Charleville and Longreach, east to the coastline between Proserpine and Gladstone, and south to scattered sites throughout south-eastern Queensland (Cooper *et al.* 2004).

Suitable habitat for the southern Squatter Pigeon exists in open grassy woodland throughout the study area. Within this suitable habitat, fifteen birds were observed during the ecological survey period, the majority of them observed during the spring survey in September 2017. The species is regionally abundant, having been observed outside of the study area on multiple occasions, with AARC ecologists observing the species multiple times on local roads and elsewhere while traversing the local area. No breeding activity was observed within the study area.

It is unlikely that the proposed Project will have a significant impact on the local population of the southern Squatter Pigeon; either the local population or the population in its entirety due to:

- the abundance of more suitable habitat outside of the study area in connected woodland; and
- the local abundance of the southern Squatter pigeon.

A *Significant Residual Impact Assessment* (DEHP 2014a) for the southern Squatter pigeon can be found in Section 9.1.2 of this report.

Photo Plate 17 Squatter Pigeon (*Geophaps scripta scripta*) observed at the study area

Marine and Migratory Species

The EPBC Act lists bird species that are classified as migratory and/or marine. Two migratory and/or marine birds were identified on the study area (Figure 14), comprising of the Rufous fantail (*Rhipidura rufifrons*) which is a migratory and marine species and the Rainbow bee-eater (*Merops ornatus*) which is a marine species.

The Rufous fantail (also listed as Special Least Concern under the NC Act) is found in northern and eastern coastal Australia, being more common in the north. It is also found in New Guinea, the Solomon Islands, Sulawesi and Guam. The Rufous fantail is found in rainforest, dense wet forests, swamp woodlands and mangroves, preferring deep shade, and is often seen close to the ground. During migration, it may be found in more open habitats or urban areas. The Rufous fantail is a common and secure species (Blakers *et al.* 1984).

The Rainbow bee-eater inhabits all of mainland Queensland, as well as Indonesia, New Guinea and the Solomon Islands. This species is widespread and breeds throughout most of its range, with the exception of southern birds, which move north to breed.

None of the marine species which utilise the study area are at the extent of their known range and the local populations do not constitute an 'ecologically significant proportion' of the total population of the species. While these marine species do inhabit the site, the surrounding region provides suitable habitat that can be utilised and impacts from the study area are unlikely to significantly impact the habitat or distribution of this species in the region. Due to the ephemeral nature of the waterways identified onsite it is unlikely that the Project provides year-round habitat for these species.

6.1.4 Mammals

Habitat Values

Mammal morphology varies widely from small rodents to larger kangaroos to bats. The ecology of each of these groups is equally variable and they are assessed separately in the following sections.

Small Mammals

Habitats suitable for small mammals include areas that provide a plentiful food source and suitable shelter sites. The highest density of small mammal species is usually associated with reliable rainfall which is reflected in a reliable source of food and dense ground vegetation, particularly shrubs and grasses.

The diversity of small mammals is often limited by the lack of a predictable food supply and open ground vegetation. Consequently, small mammal populations can fluctuate dramatically in response to rainfall which increases seed production and insect abundance. During less favourable periods, small mammal populations can be very low.

The study area provides a variety of habitat types suitable for small ground-dwelling mammals, including vegetated woodlands, open forests and watercourses, found in vegetation communities VC 1, VC 2 and VC 3. The majority of the study area is comprised of non-remnant vegetation which is mostly utilized as grazing pasture. This community reduces the availability of shelter.

Medium and Large Mammals

Factors affecting the occurrence of medium and large sized mammals are varied. Important factors can include land-clearing, feral animal predation and grazing pressures. Regardless of the clearing that has occurred on the Project, larger macropods have been much less affected than some other mammals. Larger macropods are considered generalists, likely to thrive and flourish in response to areas of grasslands and open vegetation, as they are less vulnerable to small predators such as foxes and cats. They are also highly opportunistic breeders, especially in the presence of permanent water sources such as the dams found onsite.

Most of the study area habitats include pastural land and large areas of low open woodlands. These habitats are likely to support most medium mammals occurring in the region. In particular, the riparian habitats along waterways and watercourses are likely to provide important corridor values for this mammal group.

Larger mammals such as kangaroos have been much less affected by predation than other mammals and by land clearing activities. In fact, many species have flourished in response to increased areas of grassland and open vegetation caused by land clearing activities.

Arboreal Mammals

The majority of arboreal mammals that occur in Australia utilise tree hollows for nesting and shelter (Menkhorst and Knight 2011). A shortage of nest hollows is likely to limit arboreal mammal populations where the density of hollow bearing trees is less than two to eight trees per ha (Smith and Lindenmayer 1988).

Hollow-bearing trees on the study area generally occur along creek-lines or in adjoining vegetation communities. Away from the waterway corridors, hollow-bearing trees are few and are separated by vast open areas that would be difficult for arboreal mammals to cross without venturing onto the ground. Due to the previously cleared and disturbed nature of the study area, arboreal mammal habitat is largely restricted to the waterway corridors of the study area.

Bats

The density and diversity of Australian bat species is determined primarily by the availability of suitable nesting and roosting sites. Roosting sites can include locations such as thick foliage, loose exfoliating bark, rock caves or cavities, tree hollows or even fabricated structures such as old buildings and culverts (Churchill 2008).

Consequently, areas with a large number of hollow-bearing trees that occur within remnant vegetation are of high value to many bat species. As bats have a small body size, these hollows can be much smaller in size than required by some arboreal mammals. Possible roosting sites observed on the study area included tree hollows and exfoliating bark, particularly in VC 1, VC 2 and VC 3.

Potential roosting habitat including rocky areas and drainage areas on the study area were surveyed with an ANABAT echolocation call recorder. Riparian zones with large hollow bearing trees located adjacent to the study area were also surveyed.

Observed Species

In total, 33 mammal species were recorded in the study area, comprising 28 native species and five introduced species, all listed in Appendix I. All introduced species recorded are discussed in Section 6.2.

The suite of native mammal species recorded as having a presence on the study area included the Red-necked wallaby (*Macropus rufogriseus*), Short-beaked echidna (*Tachyglossus aculeatus*), Common brushtail possum (*Trichosurus vulpecula*), Water rat (*Hydromys chrysogaster*), Swamp wallaby (*Wallabia bicolor*), Greater glider (*Petauroides volans volans*), Rufous bettong (*Aepyprymnus rufescens*) (Photo Plate 18), Wallaroo (*Macropus robustus*), Eastern grey kangaroo (*Macropus giganteus*), Black-striped wallaby (*Notamacropus dorsalis*) and Delicate mouse (*Pseudomys delicatulus*).

Photo Plate 18 Rufous bettong (*Aepyprymnus rufescens*) observed in the study area

A total of 17 bat species were positively identified on the study area, none of which are listed under the EPBC Act. Those bat species positively identified on the study area included the Gould's wattled bat (*Chalinolobus gouldii*), Little pied bat (*Chalinolobus picatus*), Hoary wattled bat (*Chalinolobus nigrogriseus*), Northern free-tailed bat (*Chaerephon jobensis*), Eastern bentwing bat (*Miniopterus schreibersii oceanensis*), Inland forest bat (*Vespadelus baverstocki*), Rides free-tailed bat (*Ozimops ridei*), Inland free-tailed bat (*Ozimops petersi*), Northern free-tailed bat (*Ozimops lumsdenae*), Western broad-nosed bat (*Scotorepens balstoni*), Little broad-nosed bat (*Scotorepens greyii*), White-striped Free-tailed bat (*Austronomus australis*), Troughton's Sheath-tailed bat (*Taphozous troughtoni*), Lesser long-eared bat (*Nyctophilus geoffroyi*) and Yellow-bellied sheathtail bat (*Saccolaimus flaviventris*).

A Long-eared bat (Nyctophilus sp.) was also detected through the use of ANABAT recorders on the study area; but could not be identified to species level. The Nyctophilus genus has several species in Australia and cannot be identified further then the genus level through ANABATs and a positive identification requires active trapping. The region is known to form part of the distribution of the Vulnerable *Nyctophilus corbeni* (EPBC Act, NC Act). In response to this, ecologists conducted a targeted micro-bat survey in line with the *Survey Guidelines for Australia's Threatened Bats* (DoEE 2010a). The targeted micro-bat survey utilised Harp Traps and Mist Nets. The targeted micro-bat survey did not identify the Vulnerable species *Nyctophilus corbeni* within the study area but trapped the Lesser long-eared bat (*Nyctophilus geoffroyi*). It is highly likely that the *Nyctophilus* sp. call registered in the ANABAT belonged to the Least Concern *Nyctophilus geoffroyi.*

Several other species of bats not listed as threatened, could not be reliably identified from call analysis due to either poor data quality and/or similarities in call characteristics between species known to occur in the region. Unconfirmed species records include species that could not be distinguished between a group of two to three species. The bat call analysis results are detailed in Appendix G.

Mammals of Conservation Significance

The Short-beaked echidna (*Tachyglossus aculeatus*) (Photo Plate 19) was recorded in the study area across several sites (Figure 14). This species is not an EVNT species but is listed under the NC Act as Special Least Concern and is not listed under the EPBC Act.

The Short-beaked echidna is found in a variety of habitat types including open forests, grasslands and heavily vegetated woodlands. It's distribution spans across Australia, including Tasmania and is considered a habitat generalist. This species presence relies on the abundance of ants which are its only food source (Van Dyck *et al.* 2013). Due to the generality and wide distribution of this species, it is not expected that mining activity will have an impact of this species.

A *Significant Residual Impact Assessment* (DEHP 2014a) for the Short-beaked echidna can be found in Section 9.1.2 of this report.

Photo Plate 19 Short-beaked Echidna (*Tachyglossus aculeatus*) observed at the study area

The Greater glider (*Petauroides volans*) (Photo Plate 20), was detected during the field survey of the study area (Figure 14). The Greater glider is listed under the EPBC Act 1999 as a "Vulnerable" species (DoEE, 2018).

The Greater glider is restricted to eastern Australia, occurring from the Windsor Tableland in north Queensland through to central Victoria, with an elevational range from sea level to 1200 m above sea level. The broad extent of occurrence is unlikely to have changed appreciably since European settlement, however the area of occupancy has decreased substantially, mostly due to land clearing (TSSC 2016a).

The Greater glider is an arboreal nocturnal marsupial, largely restricted to eucalypt forests and woodlands. It is primarily folivorous, with a diet mostly comprising eucalypt leaves, and occasionally flowers. Preferred habitat consists of taller, montane, moist eucalypt forests with relatively old trees and abundant hollows. It also favours forests with a diversity of eucalypt species, due to seasonal variation in its preferred tree species (TSSC 2016a).

Critical microhabitat is an abundance of large hollows of large, old trees for daily denning shelters and breeding purposes. The species is absent from cleared areas and has little ability to disperse between fragments across cleared areas, with habitat connectivity critical to species survival (TSSC 2016a).

Major threats include habitat loss from clearing, high intensity fires, and logging and woodland thinning practices (TSSC 2016a).

Some of the study area has been subject to vegetation clearing to allow cattle grazing. Consequently, only small areas of suitable habitat remain on the site. Generally, habitat of the Great glider is confined to the Eucalypt riparian woodlands such as along the Charlevue Creek. This woodland suits the Greater glider's preferred habitat of tall open woodland with a sparse shrub layer. Vegetation community mapping identified this suitable habitat as VC 3.

Habitat values of the study area are limited by the large areas of non-remnant vegetation and the impacts of grazing. Considering the extent and connection to surrounding good quality habitat and the minimal disturbance caused by the Project to Charlevue Creek, impacts on a local population of Greater glider is unlikely to be significant.

A *Significant Residual Impact Assessment* (DEHP 2014a) for the Greater glider can be found in Section 9.1.2 of this report.

Photo Plate 20 Greater glider (*Petauroides volans*) observed at the study area

6.2 PEST SPECIES

Field surveys positively identified six introduced and/or pest fauna species as having a presence within the study area. Introduced species were recorded through detection of scats, tracks or other traces (e.g. skulls), sensor camera detection and/or direct observation. The suite of introduced species includes the Cane toad (*Rhinella marina*), Wild dog/Dingo (*Canis familiaris/Canis lupus dingo*), Feral cat (*Felis catus*), Rabbit (*Oryctolagus cuniculus*), House mouse (*Mus musculus*) and Feral pig (*Sus scrofa*).

All the non-native fauna species reported from the study area, with the exception of the Cane toad and the House mouse are listed as restricted species under the Biosecurity Act 2014 (DAF 2019) as shown in Table 17.

Table 17 Introduced species identified on the study area

Scientific name	Common name	*Biosecurity Act 2014*			
		Category 3	Category 4	Category 5	Category 6
Canis familiaris or Canis lupus dingo	Wild dog/Dingo	x	x	x	x
Oryctolagus cuniculus	Rabbit	x	x	x	x
Felis catus	Feral cat	x	x	-	x
Sus scrofa	Feral pig	x	x	-	x

Category 3: the invasive animal must not be distributed either by sale or gift or released into the environment.
Category 4: the invasive animal must not be moved.
Category 5: the invasive animal must not be kept.
Category 6: the invasive animal must not be fed.

Photo Plate 21 Feral cat (*Felis catus*) recorded on the camera trap at DF05

The Cane toad and the House mouse are not a prohibited or restricted invasive animal under the Biosecurity Act 2014; however, everyone has a general biosecurity obligation (GBO) to take reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control (DAF 2016b). Cane Toads are recognised as an invasive species, as they present a serious threat to native wildlife. The Cane Toad consumes a wide variety of native animals including frogs, small reptiles, mammals and birds and cause the death of native predators that consume their toxins.

6.3 FAUNA SPECIES OF CONSERVATION SIGNIFICANCE

6.3.1 Fauna Species of Conservation Significance Identified on the Study Area

Field surveys across the study area detected the presence of five fauna species of conservation significance:

- The southern Squatter pigeon (*Geophaps scripta scripta*) and Greater glider (*Petauroides volans*), both species are listed as Vulnerable under the EPBC Act and the NC Act;

- The short beaked Short-beaked echidna (*Tachyglossus aculeatus*) This species is not an EVNT species but is listed under the NC Act as Special Least Concern; and

- The Rufous fantail (*Rhipidura rufifrons*) listed as migratory and marine species, was identified on the study area.

A description of the four species is included in Sections 6.1.3 and 6.1.4, respectively.

6.3.2 Fauna Species of Conservation Significance Not Identified on the Study Area

Table 18 discusses EVNT and Migratory species that are known from the broader region and have been identified from desktop searches already identified as likely or potential to occur within the study area but were not observed on site during surveys.

The assessment of potential for presence and impact on each species is based on the knowledge of ecologists, information obtained from field surveys on the study area, previous surveys conducted on or near the study area and scientific literature. This assessment indicated that only 11 of the 19 species were considered as possible to occur on the Project.

The distribution of the marine and migratory species identified from desktop searches is widespread in eastern Australia (Simpson and Day, 2010). The study area is not at the limit of these species' range, nor are these species considered to be declining within the region. Therefore, it is unlikely that the study area will have a significant impact on the regional populations of these species.

Table 18 Fauna Species of Conservation Significance not identified on the study area

Species Name **Common Name**	**EVNT Listing**		**Likelihood of Occurrence Post Survey**
	EPBC Act	**NC Act**	
Amphibians			
Adelotus brevis Tusked frog	NL	V	Potential The study area occurs within the vicinity of the known range of the Tusked frog and suitable habitat is available year-round due to the presence of dams. Despite not being found during targeted field surveys (Aquatic survey, AARC 2019), it is a potential that the study area can support a population of Tusked frogs.
Reptiles			
Delma torquata Adorned delma	V	V	Potential Suboptimal habitat is present within the study area. However, field surveys revealed no evidence of this species occurring within the study area site.
Strophurus taenicauda *Golden-tailed gecko*	NL	NT	Potential Suitable habitat is present within the study area. However, field surveys revealed no evidence of this species occurring within the study area site.
Birds			
Calidris acuminate Sharp-tailed Sandpiper	Ma, Mi	SL	Potential There is the potential for this species to utilise the study area due to the presence of suitable habitat within the study area's boundary.

Species Name **Common Name**	**EVNT Listing**		**Likelihood of Occurrence Post Survey**
	EPBC Act	**NC Act**	
Calyptorhynchus lathami erebus Glossy black-cockatoo (northern)	-	V	Potential Suitable habitat occurs in the broader region and within the study area. This species is highly reliant on fodder species (*Allocasuarina* and *Casuarina* species). Within the study areas the species *Allocasuarina luehmannii* (Bull oak) was identified as present dominant in small patches. As such it is potential that the study area provides suitable habitat or food sources for this species.
Erythrotriorchis radiatus Red goshawk	V	E	Potential There is the potential for this species to utilise the study area due to the presence of suitable habitat within the study area's boundary. Additional suitable habitat is found throughout the surrounding region.
Hirundapus caudacutus White-throated needletail	Ma, Mi	SL	Potential There is the potential for this species to utilise the study area due to the presence of suitable habitat within the study area's boundary.
Grantiella picta Painted honeyeater	E	V	Unlikely This species is highly reliant on the presence of mistletoes in the canopy strata, no mistletoes were recorded during the terrestrial or aquatic field surveys. The study area is unlikely to provide suitable habitat for this species.
Lathamus discolour Swift Parrot	CE	E	Unlikely Limited suitable habitat occurs for this species was recorded along the watercourses within the study area. The study area occurs at the most upper limit of this species distribution.

Species Name **Common Name**	**EVNT Listing**		**Likelihood of Occurrence Post Survey**
	EPBC Act	**NC Act**	
Monarcha melanopsis Black-faced Monarch	Ma, Mi	SL	Potential There is the potential for this species to utilise the study area due to the presence of suitable habitat within the study area's boundary.
Motacilla flava Yellow wagtail	Ma, Mi	SL	Potential There is the potential for this species to utilise the study area due to the presence of suitable habitat within the study area's boundary.
Myiagra cyanoleuca Satin flycatcher	Ma, Mi	SL	Potential There is the potential for this species to utilise the study area due to the presence of suitable habitat within the study area's boundary.
Ninox strenua Powerful owl	-	V	Unlikely While there are hollow bearing trees along the watercourses within the study area, these hollows are generally small in nature and are unlikely to be of value to Powerful owls for nesting/shelter. Limited remnant vegetation has been mapped within the study area due to extensive clearing.
Pedionomus torquatus Plains wanderer	CE	V	Unlikely No native grasslands occur within the study areas boundary. This species is often absent from areas that are too dense or sparse. All open areas are heavily grazed and dominated by introduced pasture species.

Species Name Common Name	EVNT Listing		Likelihood of Occurrence Post Survey
	EPBC Act	NC Act	
Poephila cincta cincta Black-throated finch (white-rumped subspecies)	E	E	Unlikely No suitable habitat for this species occurs within the study area. Additionally, this species is not known from the area and was not detected during ecological surveys on site.
Turmix melanogaster Black-breasted button-quail	V	V	Unlikely No suitable habitat for this species was recorded within the study areas boundary.
Mammals			
Chalinolobus dwyeri *Large-eared pied bat*	V	V	Unlikely No sandstone gorges were recorded within the study area, the study area has also undergone extensive clearing limiting the extent of suitable habitat.
Onychogalea fraenata Bridle nailtail wallaby	E	E	Potential No preferred habitat such as Brigalow woodland and only small disconnected patches of Poplar box woodland have been identified in the study area. However, the only native population of this species is located directly north of the study area. This species could potentially utilise the habitat in the study area for foraging.
Phascolarctos cinereus Koala	V	V	Unlikely Suitable habitat is present within the study area. However, the amount of suitable habitat is limited on the study area and displays limited connectivity to the other known habitat preferences for the species. Field surveys revealed no evidence of this species occurring within the study area.

EPBC – *Environment Protection and Biodiversity Conservation Act 1999*
NC Act – *Nature Conservation Act 1992*
CE – Critically Endangered
V – Vulnerable
E – Endangered
C – Least Concern
SL – Special Least Concern
Mi - Migratory

7.0 POTENTIAL IMPACTS

Potential impacts of the Project (Figure 15) on terrestrial ecology values are described below. Mitigation measures and management strategies for the potential impacts are described in Section 8.0.

7.1 TERRESTRIAL FLORA

7.1.1 Vegetation Communities

The Project will include vegetation clearance and land disturbance during the construction and operation of the mine. The extent of land disturbance would be approximately 1961 ha, of which, approximately 720 ha of remnant vegetation clearing is required over the life of the Project.

Other potential impacts to vegetation communities include:

- Removal of habitat for terrestrial flora and fauna.
- Further habitat fragmentation and loss of connectivity. It is noted that existing vegetation clearing due to agricultural land use has already limited connectivity within this community;
- Potential for reduced condition of neighbouring vegetation communities due to the introduction of weeds or the release of contaminants associated with mine operations.

7.1.2 Flora Species of Conservation Significance and Habitat

Cerbera dumicola has been identified during the vegetation surveys in two very localised rocky areas associated with vegetation community VC 2 and VC 1 (Figure 14). This species was not identified elsewhere in the study area, within similar habitat types, during targeted searches.

The proposed mining activity proposes no impacts to populations of *Cerbera dumicola*. The nearest land disturbance is located 1.3 km to the east.

7.1.3 Weed Species

Project development has the potential to create or enhance conditions for invasive weed species, that may spread and out-compete native and pasture species. Weed species may be introduced via the spread of seed on persons, vehicles and equipment. Weed species may quickly colonise disturbed areas if left untreated.

The introduction of weed species can reduce native species abundance and diversity through competition. Ultimately this can lead to the reduced condition of vegetation and native fauna habitat.

7.1.4 Wetlands

The Project has potential to impact on wetlands via

- Direct clearing;
- Changes in hydrology;
- Erosion and sedimentation; and
- Contaminant release.

7.1.5 Groundwater Dependant Ecosystems

Where wetlands exhibit a degree of dependence on groundwater for survival, drawdown from the mine can result in a reduced ecosystem condition, changes to vegetation composition or die back.

A groundwater assessment was undertaken by JBT Consulting (2019) in the study. Data obtained in this study, such as water quality, groundwater level and groundwater drawdown estimation were used in the assessment of the GDEs and the associated impact of drawdown.

Potential Impacts to GDEs within the study area

The potential GDEs within the study area are riverine type wetlands including riparian vegetation on watercourses and floodplains. The dominant species of this vegetation is Blue gum (*Eucalyptus tereticornis*), with *Bauhinia* spp., River oak (*Casuarina cunninghamiana*), Paperbark tea-tree (*Melaleuca* spp.) and Poplar box (*Eucalyptus populnea)* as associated species. Published research has identified the rooting depth of the Blue gum as 10 m (Boland *et al* 2006).

Groundwater modelling estimated that the Project has the potential to cause a maximum drawdown of 5 m (steady-state post-mining drawdown) at some locations below the Charlevue and Springton Creeks (JBT 2019). The groundwater adjacent to Charlevue Creek has been recorded at a depth of 8.8 mbgl with an Electrical Conductivity (EC) range from 15,200 µS/cm to 16,600 µS/cm, whilst Springton Creek registered a depth of 11.2 mbgl with a recorded EC of 5,948 µS/cm (from a single bore) (JBT 2019).

Considering Blue gum and River oak have moderate salinity tolerance of 4,000 to 8,000 µS/cm (DA 2002), it is concluded that the groundwater within the Charlevue Creek alluvium is too saline to be useable by the vegetation along the Charlevue Creek.

The salinity recorded adjacent to Springton Creek alluvium is within the tolerance level of the dominant species (DA 2002). However, it is also noted that the depth to groundwater in that area (11.19 mbgl) is potentially beyond the depth that is accessible by vegetation.

Charlevue and Springton Creeks are highly ephemeral watercourses subject to occasional flow events that replenish the alluvial aquifers. As a result, fluctuations in the groundwater level throughout the year are likely within these riverine ecosystems. Based on the existing condition of the riverine vegetation communities within the study area, it is highly likely that this vegetation has a very low reliance on groundwater aquifers for survival, if any at all. Rather the riverine communities represent facultative GDEs, capable of surviving on soil moisture present in unsaturated shallow soil layers.

It is therefore concluded that there is a very low risk that groundwater drawdown would result in a significant impact to these riverine communities.

Potential impacts to the HES wetland outside the study area

The groundwater assessment (Appendix E) included an assessment of the potential GDE / wetland located to the south east of study area. The groundwater study predicted a 2m drawdown within the community, post mining.

The potential GDE is located on an elevated ridgeline; the feature is located within a shallow depression on the ridgeline that is surrounded to the south, west and east by elevation contours at 170 m Australian height datum (AHD), with the central of the depression falling below 165 mAHD. The feature is well above the natural ground surface within the MLA, which ranges from 125 to 135 mAHD, with the elevation of the Springton Creek floodplain dropping below 120 mAHD.

The potential GDE is therefore located within a shallow depression on the ridgeline that is likely to be internally draining under average rainfall conditions and that only discharges to the northeast under high rainfall conditions. It is interpreted that, under average rainfall conditions and at the tail end of high rainfall conditions, surface runoff within the relatively small catchment that reports to this area will pond in the area of the shallow depression and provide localised recharge to an underlying groundwater lens that is likely to be disconnected from the regional groundwater system.

Registered bores indicate the depth to water for bores constructed within Tertiary sediments and Permian coal measures ranges from 26.25 to 32.37 mbgl in this area. This equates to a groundwater elevation of 108-110 mAHD for bores in topographically elevated areas. The water level in the site monitoring bores, which were assessed to be representative of the regional groundwater level, are therefore considerably lower than the elevation of the base of the potential GDE, which is at an elevation approximately 165 mAHD.

Based on the observations discussed above, it is concluded that:

- The potential GDE is located on an elevated ridgeline, but within a shallow depression that is likely to drain internally under average rainfall conditions but drains to the northeast under high rainfall conditions;
- The drainage of surface runoff to the shallow depression is likely to result in localised recharge to a perched lens of groundwater that is disconnected from the regional groundwater system;
- It is probable that this perched groundwater lens provides water to vegetation within the depression during the dry season, but that the groundwater lens is an extremely localised system that relies on replenishment by seasonal rainfall rather than being maintained by the regional groundwater system.

It is noted the EC of site groundwater monitoring bores, which are interpreted to be within the regional groundwater system, is high (15,000 µS/cm to 29,000 µS/cm – refer Section 4.3). However, it is also noted that the EC of the registered bores to the north of the potential GDE is very low, with bore 111570 recording an EC of 240 µS/cm and bore 161093 recording an EC of 710 µS/cm. This provide further evidence that the groundwater system in this area is perched above the regional groundwater system, with the flowline from the area of the potential GDE (where recharge is interpreted to occur) to the area where these bores are located being very short.

It is concluded that the potential GDE is maintained by localised runoff and shallow recharge and that a reduction in the regional groundwater level of approximately 2 m, at a vertical distance of approximately 50 to 60 m below the base of the potential GDE, has a very low risk of impacting groundwater levels beneath the potential GDE.

7.2 TERRESTRIAL FAUNA

7.2.1 Fauna Species of Conservation Significance and Habitat

Field surveys across the study area detected the presence of three fauna species of conservation significance; the southern Squatter pigeon (*Geophaps scripta scripta*), the Greater glider (*Petauroides volans*) and the Short-beaked echidna (*Tachyglossus aculeatus*).

Potential impacts of the Project to threatened fauna species include:

- Direct clearing of habitat within the Project defined impact areas;

- Further habitat fragmentation and loss of connectivity, particularly along Charlevue Creek which provides partial connectivity to larger downstream riparian communities. It is noted that existing vegetation clearing due to agricultural land use has already limited connectivity within this community;

- Potential for fauna mortality through interactions with vehicles on roads and/or heavy machinery used for land clearing;

- Potential for habitat degradation through increased risk of release of contaminants or sediments into receiving environments within and downstream of the Project; and

- Potential for increased invasive flora and fauna.

Southern Squatter Pigeon (*Geophaps scripta scripta*)

Suitable habitat for the southern Squatter Pigeon exists in open grassy woodland throughout the study area. Within this suitable habitat, fifteen birds were observed during the ecological survey period, the majority were observed during the spring survey in September 2017. The species is regionally abundant, having been observed outside of the study area on multiple occasions, with ecologists observing the species multiple times on local roads and elsewhere while traversing the local area. No breeding activity was observed within the study area.

It is unlikely that the proposed Project will have a significant impact on the southern Squatter Pigeon; either the local population or the population in its entirety due to:

- The species being highly mobile;

- The abundance of equivalent and more suitable habitat outside of the study area in adjacent areas;

- The observed high local abundance of the southern Squatter pigeon within and surrounding the study area; and

- The likely suitable habitat to be provided by rehabilitated land, post mining.

Greater glider (*Petauroides volans*)

The Greater glider preferred habitat consists of taller, montane, moist eucalypt forests with relatively old trees and abundant hollows. It also favours forests with a diversity of eucalypt species, due to seasonal variation in its preferred tree species (TSSC 2016a). Critical microhabitat is an abundance of large hollows of large, old trees for daily denning shelters and breeding purposes. The species is absent from cleared areas and has little ability to disperse between fragments across cleared areas, with habitat connectivity critical to species survival (TSSC 2016a).

Habitat of the Great glider within the study area is confined to the Eucalypt riparian woodlands such as along the Charlevue Creek. This woodland suits the Greater glider's preferred habitat of tall open woodland containing hollows with a sparse shrub layer.

It is unlikely that the proposed Project will have a significant impact on the Greater glider; either the local population or the population in its entirety due to:

- No significant impact proposed to habitat within the study area, specifically Charlevue Creek. Proposed disturbance within this habitat is limited to the development of a small culvert crossing;

- The observed abundance of Greater Gliders within the study area and within the broader Central Queensland region; and
- The abundance of equivalent and more suitable habitat outside of the study area in adjacent areas.

Short-beaked echidna (*Tachyglossus aculeatus)*

The Short-beaked echidna is found in a variety of habitat types including open forests, grasslands and heavily vegetated woodlands. Suitable habitat for the species exists across the study area.

It is unlikely that the proposed Project will have a significant impact on the Short-beaked echidna (*Tachyglossus aculeatus)*; either the local population or the population in its entirety due to:

- The known abundance and wide-ranging distribution of the species;
- The presence of ample equivalent or better suited habitat surrounding the Project;
- The relatively small extent of impact proposed by the Project; and
- The likely suitable habitat to be provided by rehabilitated land, post mining.

7.2.2 Migratory Fauna Species

The Rufous fantail (*Rhipidura rufifrons*), a listed migratory bird species under the EPBC Act, was identified within the study area. The Rufous fantail is generally found in rainforest, dense wet forests, swamp woodlands and mangroves, preferring deep shade, and is often seen close to the ground. During migration, it may be found in more open habitats, such as those within the study area.

It is unlikely that the proposed Project will have a significant impact on the Rufous fantail (*Rhipidura rufifrons*); either the local population or the population in its entirety due to:

- The Rufous fantail is a common and secure species (Blakers *et al.* 1984);
- The study area does not contain the preferred habitat type for the species;
- The species is highly mobile and likely only passing through the Project site on its migratory path;
- No known breeding sites or nesting habitat was identified on the study area; and
- Ample equivalent or higher quality habitat exists surrounding the study area.

7.2.3 Pest Species

Pest species compete with and prey on native fauna. Construction and operation of the Project increases the risk of pest species on the study area through:

- Generation of food and other waste that may attract pests; and
- Creation of artificial ponding areas providing habitat for pest species such as cane toads.

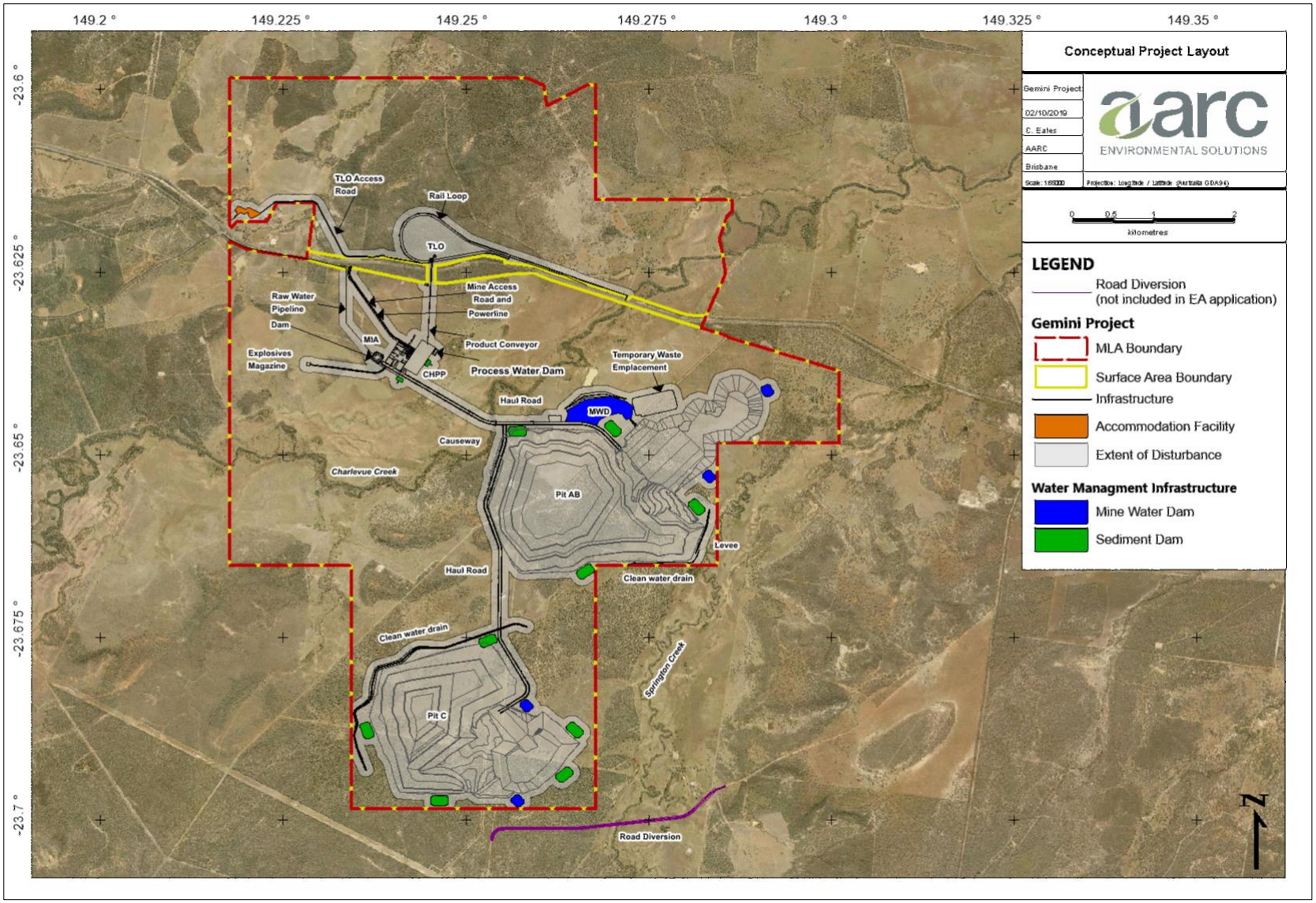


Figure 15 Conceptual Project Layout

8.0 MITIGATION AND MANAGEMENT STRATEGIES

8.1.1 Terrestrial Flora

8.1.1.1 Vegetation Communities

To minimise and mitigate impacts to vegetation communities on the Project area the following management strategies will be implemented:

- Clearing of land and vegetation will be limited to areas defined in the Project approval and required for safe operation.
    - An internal Permit to Disturb system will be implemented to minimise the chances of unauthorised clearing;
    - Areas to be cleared will be clearly defined and demarked to equipment operators;
- Inductions and training materials provided to employees will identify the environmental values of the site as well as the company procedures for managing impacts within its authority;
- Rehabilitation will be undertaken progressively and will aim to return the land to the pre-mining land use where possible;
- Where impact to Matters of State Environmental Significance cannot be avoided and are authorised by the Project approval, environmental offsets will be provided.

8.1.1.2 Flora Species of Conservation Significance

Suitable habitat for the *Cerbera dumicola* exists to the west of the Project, within the MLA. The proposed mine construction and development will not impact on the populations.

- An internal Permit to Disturb system will be implemented to minimise the chances of unauthorised clearing and impacts to the populations within the MLA;
- Inductions and training materials provided to employees will identify the environmental values of the site as well as the company procedures for managing impacts within its authority; and
- Existing populations will be monitored for abundance, distribution and health over the mine life.

8.1.1.3 Weed Species

To control the abundance and spread of weed species the following management strategies will be implemented:

- A pest and weed management plan will be prepared and implemented prior to construction;
- As required, weeds within the MLA will be controlled using herbicides and other recommended methods;
- Inductions and training materials provided to employees will assist the identification of common weeds and will include procedures for reporting; and
- Access to vehicle wash down facilities will be provided for vehicles at risk of spreading weeds.

8.1.1.4 Wetlands / GDEs

Wetlands / GDEs include Riverine vegetation on the MLA, particularly riparian vegetation associated with Charlevue and Springton Creeks. In addition, a HES wetland is located to the south east of the Project. To manage potential impacts on wetlands, the following will be undertaken:

- Sediment and erosion control structures will be installed and maintained near all at risk areas to prevent sediment release to wetlands;
- A Receiving Environment Monitoring Program (REMP) will be implemented and will include monitoring of water, sediments, riparian / riverine vegetation health and biological indicators in aquatic environments;
- The release of Mine Affected Water, will be in accordance with the quality controls provided by the model mining conditions; and
- Groundwater bores adjacent to Charlevue Creek (DW7076W) and Springton Creek (DW7292W1), will be fitted with dataloggers. This data will allow the assessment of the range of water levels within the alluvium and the response of groundwater levels within the alluvium to rainfall recharge, stream flow events and mining activities.

8.1.2 Terrestrial Fauna

8.1.2.1 Fauna Species of Conservation Significance

Fauna species of conservation significance associated with the Project site include; the southern Squatter pigeon (*Geophaps scripta scripta*), the Greater glider (*Petauroides volans*), the Short-beaked echidna (*Tachyglossus aculeatus*) and the Rufous fantail (*Rhipidura rufifrons*) (Migratory). To ensure no significant impact to these species, the following strategies will be implemented:

- An internal Permit to Disturb system will be implemented to minimise the chances of unauthorised clearing and impacts to the threatened fauna within the MLA;
- Inductions and training materials provided to employees will identify the environmental values of the site as well as the company procedures for managing impacts within its authority;
- Vehicles speeds will be limited within the MLA, to minimise the risk of collision;
- Vegetation clearing will be done in a staged manner, allowing time for fauna to escape the area; and
- Pre-clearing inspections will be undertaken by qualified staff to minimise the risk of fauna mortality.

8.1.2.2 Pest Species

To prevent the introduction of pest species and to control their spread, the following management strategies will be implemented for the Project:

- A pest and weed management plan will be prepared and implemented prior to construction;
- Rubbish and food scraps will be managed so as not to encourage pest species;

- Inductions and training materials provided to employees will assist the identification of common pests and will include procedures for reporting; and

- Control of feral cats and other animals will be undertaken within the MLA.

9.0 PROJECT ENVIRONMENTAL OFFSETS

The offsets framework requires environmental offsets to be delivered where an activity is likely to result in a significant residual impact on a prescribed environmental matter. The *QEOP Significant Residual Impact Guideline* (DES 2014b) is used to determine whether residual impacts are considered to be significant.

Prescribed environmental matters (MSES) are listed in Schedule 2 of the Environmental Offsets Regulation. The following prescribed matters were mapped or identified within the Project area by the terrestrial ecology surveys:

- Regulated vegetation including:
    - Regional Ecosystems (REs) that are listed as Endangered or Of Concern (under the *Vegetation Management Act 1999* (VM Act));
    - REs located within the defined distance from the defining banks of a relevant watercourse or relevant drainage feature identified on the Regulated Vegetation Management Watercourse and Drainage Feature Map (as certified under the VM Act);
    - REs mapped as essential habitat on the Essential Habitat Map (as certified under the VM Act) for flora and fauna listed as Endangered and Vulnerable (under the *Nature Conservation Act 1992* (NC Act)); or
    - With specific application to the prescribed activity of 'native vegetation clearing' a RE mapped as essential habitat on the Essential Habitat Map (as certified under the VM Act) for flora and fauna listed as Near Threatened (under the NC Act);
- Remnant REs that contain an area of land required for ecosystem functioning (a connectivity area);
- Protected wildlife habitat, which includes;
    - Habitat for Endangered, Vulnerable and Special Least Concern animals (under the NC Act);

9.1 ASSESSMENT OF PRESCRIBED MATTERS IDENTIFIED IN THE STUDY AREA

9.1.1 Regulated Vegetation

The ground verified vegetation map identified the following regulated vegetation categories, under the VM Act:

- REs that are listed as Of Concern (under the VM Act);
- REs that are located within the prescribed distance from the defining banks of a relevant VM Act watercourse; and

The *QEOP Significant Residual Impact Guideline* (DES 2014a) covers vegetation clearing in excess of thresholds of between 0.5 ha and 5 ha, depending on the structural category of the vegetation. All regulated vegetation proposed to be cleared for the Project is in excess of the larger 5 ha threshold, and no further breakdown is defined (Table 19).

Figure 16 illustrates the distribution of vegetation in relation to proposed disturbance areas, whilst Figure 17 summarises the regulated vegetation present within the proposed disturbance.

Table 19 Summary of regulated vegetation within the proposed disturbance

RE	VM Act Status	Proposed Disturbance (ha)	Significant Residual Impact
RE 11.3.2	OC	7.53	Yes
REs located within the defined distance from the defining banks of a VM Act watercourse	-	59.79	Yes

Notes: * within complete study area

The Project is likely to result in a significant residual impact to MSES, through the clearing of regulated vegetation above the significant residual impact thresholds.

9.1.2 Conservation Significant Species, Protected Wildlife Habitat and Essential Habitat

The *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (DEHP 2014a) outlines the criteria for identifying when an impact on prescribed environmental matters (MSES) may be significant. The significant impact criteria provide a trigger for consideration of offsets (DEHP 2014a).

As stated in the *Environmental Offsets Regulation 2014* an area of habitat (e.g. foraging, roosting, nesting or breeding habitat) for an animal that is endangered, vulnerable or a special least concern is considered Protected Wildlife Habitat under the *Environmental Offsets Regulation 2014* (DEHP 2014a).

As previously discussed, three listed EVNT species under the NC Act were present within the study area, Greater glider, southern Squatter pigeon and the plant species *Cerbera dumicola.* Essential habitat for all three species has been mapped by the DES in accordance to the VM Act (Figure 18).

An assessment following the Significant residual impact criteria for vulnerable wildlife habitat (including essential habitat) has been conducted for the Greater glider and the southern Squatter pigeon. Similarly, an assessment for the special least concern animal wildlife habitat has been conducted for the Short-beaked echidna, also identified within the study area.

The *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (DEHP 2014a) does not include specific criteria for assessing impacts to Near Threatened wildlife. An assessment of the significant residual impact for *Cerbera dumicola* has been carried out in accordance with the criteria for Vulnerable wildlife, as described in Section 5.1 of the guideline.

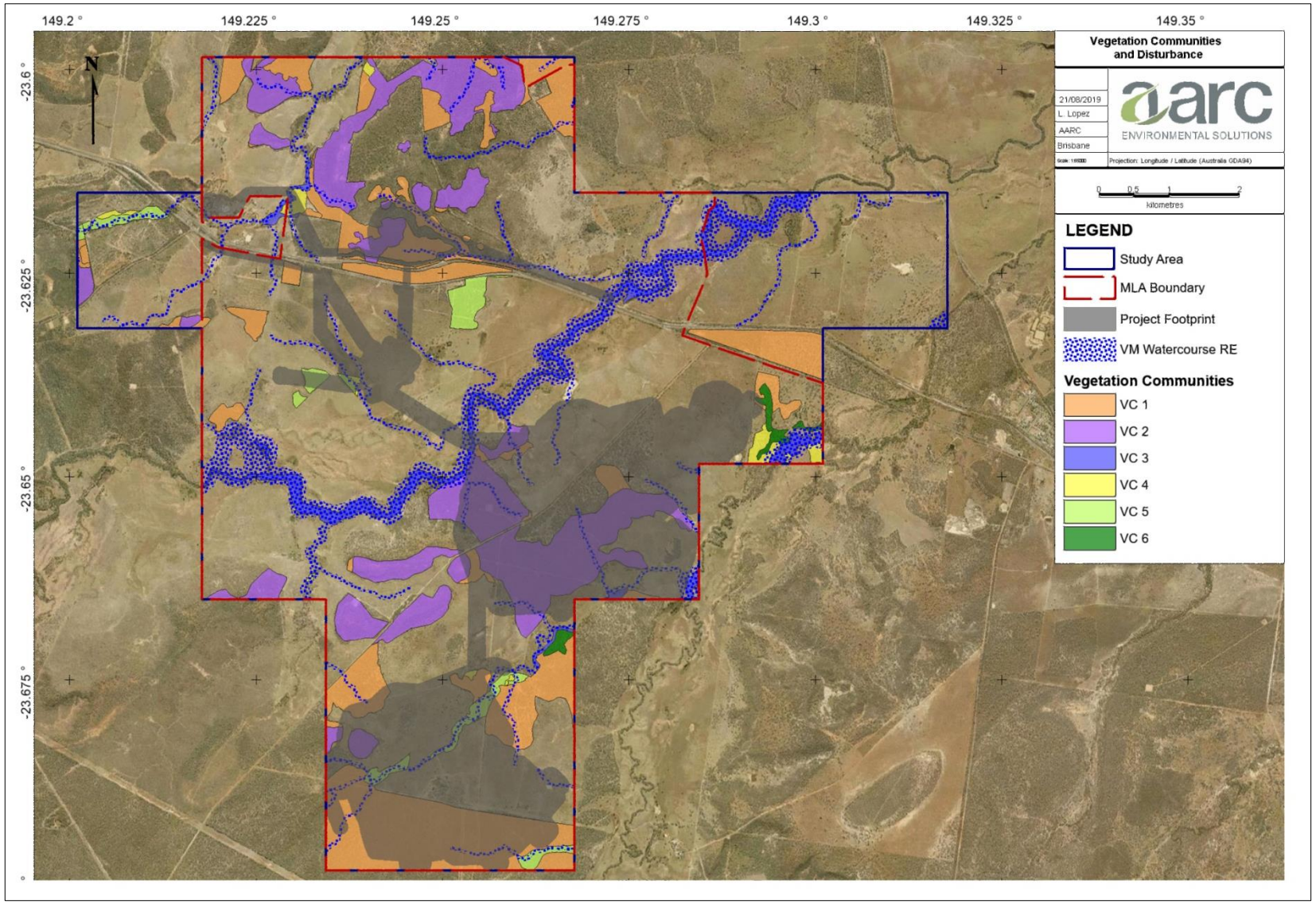


Figure 16 Vegetation Communities and Disturbance

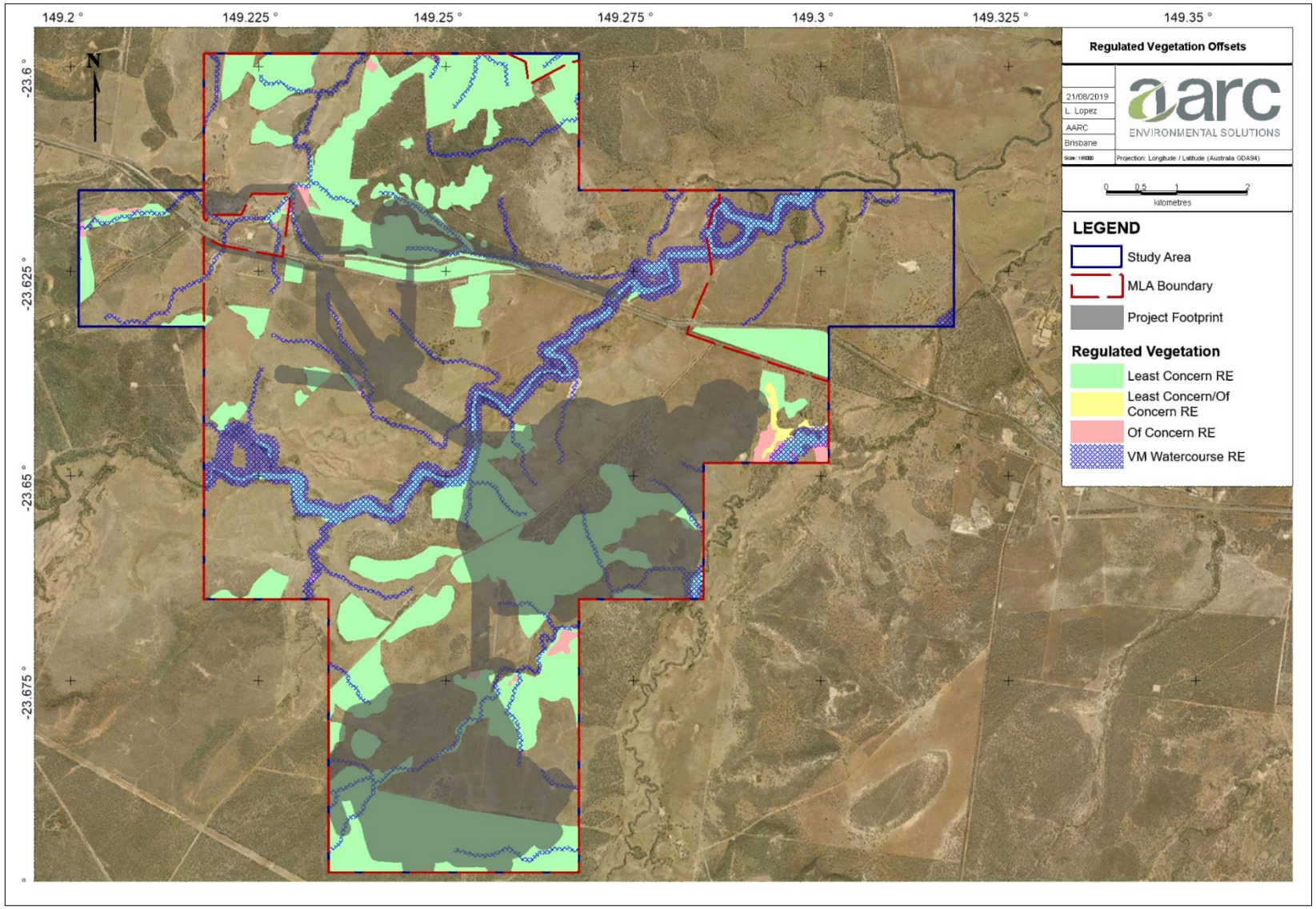


Figure 17 Regulated Vegetation Offsets Requirements

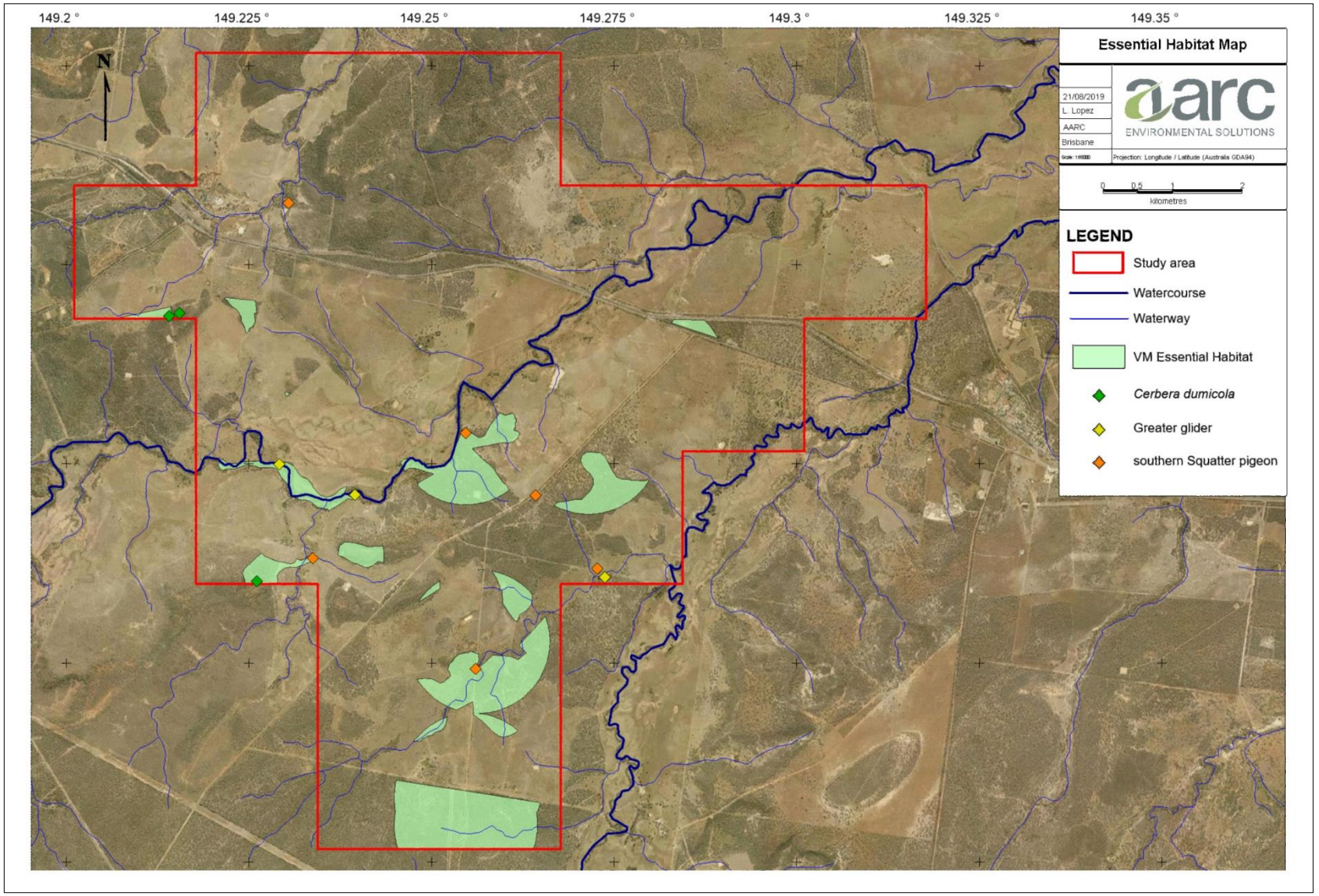


Figure 18 Essential Habitat (VM Act)

Significant Residual Impact Assessment on Vulnerable Species Under the NC Act

When assessed against the significant residual impact criteria, the Project is considered unlikely to result in any significant impact on the southern Squatter pigeon. An assessment of the potential impact of the Project on the southern Squatter pigeon using significant residual impact criteria is presented in Table 20.

When assessed against the significant impact guidelines (Table 21), the Project is considered unlikely to result in a significant impact on the Greater glider. The Project will not fragment available habitat to the extent of fragmenting the Greater glider population. There is considerable alternative habitat available in the surrounding region, and dispersal opportunities will not be impacted as habitat corridors will be retained.

Table 20 MSES Impact Assessment of the Project on the southern Squatter pigeon

Significant Impact Criteria	Impact Assessment
Will the action lead to a long-term decrease in the size of a local population of a species?	No, the Project would not fragment potential habitat for this species to the extent that it would decrease the size of local population of the species.
Will the action reduce the extent of occurrence of the species?	No, the species is highly mobile and individuals in the same area would have access to more suitable habitat through connecting open grasslands. The Project would not fragment potential habitat for this species to the extent that it would reduce the extent of occurrence of the species.
Will the action fragment an existing population?	No, this species is highly mobile and individuals in the same area would have access to more suitable habitat through connecting open grasslands. The Project includes measures to prevent significant impacts on this species. This Project will not result in the fragmentation of an existing population into two or more populations.
Will the action result in genetically distinct populations forming as a result of habitat isolation adversely?	No, the Project would not result in habitat isolation for the southern Squatter pigeon to the extent that this species will form genetically distinct populations.
Will the action disrupt ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species?	No, this species is mobile, and the surrounding habitat provides suitable sites for breading, feeding, nesting, migration or resting activities. Given the minimal disturbance to suitable habitat for this species and the interconnectedness of habitats, the Project would not disrupt ecologically significant locations for this species.
Will the action result in invasive species that are harmful to the species becoming established in the species habitat?	No, while the southern Squatter pigeon is vulnerable to predation from introduced pest species; pest management strategies will be implemented to minimise the risk of introduced pest species predating on this species.
Will the action introduce disease that may cause the population to decline, or interfere with the recovery of the species?	No diseases are known for the species that could be caused by mining activities and cause the species' population to decline, nor would actions associated with mining activities interfere substantially with the recovery of the species.

Table 21 MSES Impact Assessment of the Project on the Greater glider

Significant Impact Criteria	Impact Assessment
Will the action lead to a long-term decrease in the size of a local population of a species?	No, the Project would not fragment potential habitat for this species to the extent that it would decrease the size of local population of the species.
Will the action reduce the extent of occurrence of the species?	No, the Project would not fragment potential habitat for this species to the extent that it would reduce the extent of occurrence of the species.
Will the action fragment an existing population?	No, the clearance of suitable habitat will impact individuals of a local population. This Project will not result in the fragmentation of an existing population into two or more populations.
Will the action result in genetically distinct populations forming as a result of habitat isolation adversely?	No, the Project would not result in habitat isolation for the Greater glider to the extent that this species will form genetically distinct populations.
Will the action disrupt ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species?	No, this species is mobile, and the surrounding habitat provides suitable sites for breading, feeding, nesting, migration or resting activities. *E. tereticornis* (Blue gum) provides hollows and offers optimal habitat for Greater gliders. Given the minimal disturbance to suitable habitat for this species and the interconnectedness of habitats, the Project would not disrupt ecologically significant locations for this species.
Will the action result in invasive species that are harmful to the species becoming established in the species habitat?	No, while the Greater glider is vulnerable to predation from introduced pest species; pest management strategies will be implemented to minimise the risk of introduced pest species predating on this species.
Will the action introduce disease that may cause the population to decline, or interfere with the recovery of the species?	No diseases are known for the species that could be caused by mining activities and cause the species' population to decline, nor would actions associated with mining activities interfere substantially with the recovery of the species.

Significant Residual Impact Assessment for Near Threatened Species Under the NC Act

When assessed against the significant residual impact criteria, the Project is considered unlikely to result in any significant impact on *Cerbera dumicola*. An assessment of the potential impact of the Project on *Cerbera dumicola* using significant residual impact criteria is presented in Table 22.

Table 22 MSES Impact Assessment of the Project on the *Cerbera dumicola*

Significant Impact Criteria	Impact Assessment
Will the action lead to a long-term decrease in the size of a local population of a species?	No, *Cerbera dumicola* was not recorded within the proposed disturbance area following targeted surveys, nor is this area regarded as most suitable habitat for this species.

Significant Impact Criteria	Impact Assessment
Will the action reduce the extent of occurrence of the species?	No, the species was not recorded within the proposed disturbance area following targeted surveys, nor is this area regarded as most suitable habitat for this species.
Will the action fragment an existing population?	No, the proposed disturbance area is already moderately disturbed due to grazing. Suitable habitat for the species exists within the surrounding woodland.
Will the action result in genetically distinct populations forming as a result of habitat isolation adversely?	No, the proposed disturbance area will cover land where no *Cerbera dumicola* was not recorded.
Will the action disrupt ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species?	No, *Cerbera dumicola* is capable of producing suckers (plant growth that develops from the rootstock of a plant).
Will the action result in invasive species that are harmful to the species becoming established in the species habitat?	No, invasive species management strategies will be implemented to minimise the risk that introduced species pose for the native wildlife.
Will the action introduce disease that may cause the population to decline, or interfere with the recovery of the species?	No diseases are known for the species that could be caused by mining activities and cause the species' population to decline, nor would actions associated with mining activities interfere substantially with the recovery of the species.

Significant Residual Impact Assessment for Special Least Concern (non-migratory) Species Under the NC Act

When assessed against the significant residual impact criteria, the Project is considered unlikely to result in any significant impact on the Short-beaked echidna. An assessment of the potential impact of the Project on the Short-beaked echidna using significant residual impact criteria is presented in Table 23.

Table 23 MSES Impact Assessment of the Project on the Short-beaked echidna

Significant Impact Criteria	Impact Assessment
Will the action lead to a long-term decrease in the size of a local population of a species?	No, the Project would not fragment potential habitat for this species to the extent that it would decrease the size of local population of the species.
Will the action reduce the extent of occurrence of the species?	No, the species can be found in a variety of habitat types including open forests, grasslands and heavily vegetated woodlands. It's distribution spans across Australia, including Tasmania and is classified as a habitat generalist (Van Dyck *et al.* 2013). Suitable alternative habitat occurs throughout the broader region and immediately surrounding the study area.
Will the action fragment an existing population?	No, this Project will not result in the fragmentation of an existing population into two or more populations.
Will the action result in genetically distinct populations forming as a result of habitat isolation adversely?	No, the Project would not result in habitat isolation for the species to the extent that this species will form genetically distinct populations.

Significant Impact Criteria	Impact Assessment
Will the action disrupt ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species?	No, the surveys did not identify any unique habitat or significant breeding populations on the study area. This species presence relies on the abundance of ants which are its only food source.

9.1.3 HES Wetland

One HES wetland was identified to occur approximately 4 km east of the study area (Section 5.4). The *Queensland Environmental Offsets Policy: Significant Residual Impact Guideline* (DEHP 2014) is designed to assist in determining whether or not the impacts of a project will or is likely to have a significant residual impact on a MSES.

When assessed against the MSES significant residual impact guidelines, the Project is considered unlikely to result in a significant residual impact on the HES wetland to the east of the study area.

Table 24 MSES Wetland Significant Residual Impact Assessment

Significant Residual Impact Criteria	Ecological Assessment
Will the action result in areas of the wetland being destroyed or artificially modified?	No, the Project will not result in the wetland being destroyed or artificially modified. The HES wetland is located approximately 3.6 km east of the Project.
Will the action result in a measurable change in water quality of the wetland, for example a change in the level of the physical and/or chemical characteristics to a level that exceeds the water quality guidelines for the waters?	No, the Project will not result in a measurable change in water quality of the wetland. The wetland is not connected to the surface waters of the Project and does not have the potential to be affected by controlled water releases from the Project.
Will the action impact on the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland being seriously affected?	No, the Project will not impact the habitat or lifecycle of native species dependent upon the wetland given there would not be any impacts to the wetland habitat as a result of the Project.
Will the action result in a substantial and measurable change in the hydrological regime or recharge zones of the wetland? For example a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland?	No, the Project will not result in a substantial and measurable change in the hydrological regime of this wetland. Potential groundwater drawdown is not likely to affect this site since the wetland groundwater system is very localised and it perched above the regional groundwater system (JBT 2019).
Will the action result in an invasive species that is harmful to the environmental values of the wetland being established (or an existing invasive species being spread) in the wetland?	No, while the wetland is vulnerable to impacts from invasive species; pest and weed management strategies will be implemented to minimise the risk of introduced pest species (such as feral pigs, *Sus scrofa*) and invasive weed species (such as parthenium (*Parthenium hysterophorus)* impacting upon the HES wetland.

9.2 OFFSETS REQUIREMENTS

The prescribed matters identified within the Project area and potentially impacted by the proposed disturbance are summarised in Table 25 to determine the Project's MSES offset requirements.

Table 25 Summary of Assessment of Prescribed Matters

MSES	Total Impact Area (ha)	Impact Assessment	Offset Requirement
Of Concern RE11.3.2	7.53	Clearing is non-linear and exceeds the clearing threshold.	Offsetting Required
REs located within the defined distance from the defining banks of a VM Act watercourse	59.79	Clearing of watercourse vegetation is required. The clearing widths and areas exceed significant impact guidelines. REs supporting watercourse vegetation includes RE 11.3.25, 11.5.2, 11.3.2 and 11.7.2	Offsetting Required
Essential habitat	197.23	Greater glider: Significant impact assessment for the greater glider was completed under *MSES: Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (DEHP 2014a). It was found there would be no significant impact to the species and its habitat (Section 9.1.2).	Not Required
	303.88	southern Squatter pigeon: Significant impact assessment for the southern Squatter pigeon was completed under *MSES: Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (DEHP 2014a). It was found there would be no significant impact to the species and its habitat (Section 9.1.2).	Not Required
	106.65	Clearing of the regional ecosystem 11.7.2 mapped in the essential habitat map for the *Cerbera dumicola* is required.	Not Required
Connectivity area*	720.74	The Landscape Fragmentation and Connectivity Tool* was applied to the proposed extent of disturbance area. The results found that significant impact would occur to connectivity at both local scale and to core remnant areas.	Offsetting Required
Wildlife Habitat for Vulnerable species	13.35	Greater glider: 13.35 ha of suitable habitat is proposed to be cleared, which is 7.9% of the suitable habitat available within the study area. The Project will not fragment the habitat or local population, there is considerable habitat available in the surrounding region, and dispersal opportunity will not be impacted; by retaining corridors. Significant impact assessment for the greater glider was completed under *MSES: Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (DEHP 2014a). It was found there would be no significant impact to the species and its habitat (Section 9.1.2).	Not Required

MSES	Total Impact Area (ha)	Impact Assessment	Offset Requirement
	720.74	southern Squatter pigeon: Significant impact assessment for the southern Squatter pigeon was completed under *MSES: Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (DEHP 2014a). It was found there would be no significant impact to the species and its habitat (Section 9.1.2).	Not Required
Wildlife Habitat for Special Least Concern species.	720.74	Short-beaked echidna: Significant impact assessment for the Short-beaked echidna was completed under *MSES: Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (DEHP 2014a). It was found there would be no significant impact to the species and its habitat (Section 9.1.2).	Not Required

* Landscape Fragmentation and Connectivity Tool is based on current government mapping.

A summary of MSES environmental offset requirements to be delivered under the QEOP is provided in Table 26, including the total extent of impact area to be offset.

Table 26 MSES Offset Requirements

MSES	Area to be Impacted (ha)	Habitat Description
RE 11.3.2 *Eucalyptus populnea* (Poplar box) woodland on alluvial plains	7.53	This vegetation community was characterised by *Eucalyptus populnea* (Poplar box) woodland on alluvial plains. It was represented in several small to moderate patches within the study area and is subject to pressures from grazing, exotic species invasion.
REs located within the defined distance from the defining banks of a VM Act watercourse.	59.79	A number of VM Act watercourses traverse the Project area. Impacts will occur to watercourse vegetation that is associated with RE 11.3.25, 11.5.2, 11.3.2 and 11.7.2
RE mapped as essential habitat on the Essential Habitat Map (as certified under the VM Act) for flora and fauna listed as Near Threatened (under the NC Act)	106.65	Clearing of RE 11.7.2 within the mapped essential habitat map for the *Cerbera dumicola* will require an offset.
Connectivity area*	720.74	The Landscape Fragmentation and Connectivity Tool determined that there is significant impact to the connectivity of the remnant vegetation within the Project.

* Landscape Fragmentation and Connectivity Tool is based on current government mapping.

Distribution of MSES requiring offsets in association with the footprint of Gemini Project is illustrated in Figure 17.

It is recommended that Magnetic South deliver the offset requirements agreed in the EA prior to disturbance of the area. Offsets may be delivered as a financial settlement, proponent-driven offset (i.e. a land-based offset or Direct Benefit Management Plan) or a combination of proponent-driven offset and financial settlement offset.

10.0 REFERENCES

AARC Environmental Solutions Pty Ltd (AARC) (2019) 'Gemini Project: Aquatic Ecology Assessment', prepared for Magnetic South Pty Ltd.

Atlas of Living Australia (ALA) (2018). *Atlas of Living Australia website.* Available from: <http://www.ala.org.au>

AVH (2019). The Australasian Virtual Herbarium, Council of Heads of Australasian Herbaria, <http://avh.chah.org.au>

Barker, M. (1995). Phaius australis, in Species Management Manual. Department of Natural Resources, Brisbane.

Blakers, M., S.J.J.F. Davies & P.N. Reilly (1984). The Atlas of Australian Birds. Melbourne, Victoria: Melbourne University Press.

Boland D.J., Brooker M.I.H., Chippendale G.M., Hall N., Hyland B.P.M., Johnson R.D., Kleinig D.A., McDonald M.W., Turner J.D. (2006) Forest Trees of Australia. CSIRO Publishing, Collingwood.

Brophy J.J., Craven L.A. and Doran J.C. 2013. Melaleucas: their botany, essential oils and uses. ACIAR Monograph No. 156. Australian Centre for International Agricultural Research: Canberra. 415 pp.

Brooks J.D. & Smith J.W. (1969). *The diagenesis of plant lipids during the formation of coal, petroleum and natural gas—II. Coalification and the formation of oil and gas in the Gippsland Basin*. Geochimica et Cosmochimica Acta, 33(10), 1183-1194.

Bureau of Meteorology (BOM) (2018). *Queensland River Basins*. Available from: <http://www.bom.gov.au/qld/flood/brochures/qld/map.pdf>

Bureau of Meteorology (BoM) (2019a) Groundwater Dependant Ecosystem Atlas, Commonwealth of Australia, Canberra, available from <http://www.bom.gov.au/water/groundwater/gde/map.shtml>, accessed May 2019.

Churchill, S. (2008). *Australian Bats,* Reed New Holland, Sydney.

Cooper RM, McAllan IAW and Curtis BR (2014). The Atlas of the Birds of NSW and the ACT. Mini-Publishing, Gordon, New South Wales.

Cropper, S (1993), *Management of endangered plants*, CSIRO Publications, Melbourne.

Department of Agriculture - Western Australia (DA) (2002), *Salinity tolerance of plants for agriculture and revegetation*, Department of Agriculture, Western Australia.

Department of Agriculture and Fisheries (DAF) (2016), *Mimosa bush, Vachellia farnesiana*, Department of Agriculture and Fisheries, Queensland Government.

Department of Agriculture and Fisheries (DAF) (2016b), *Cane toad, Buffo marinus*, Department of Agriculture and Fisheries, Queensland Government.

Department of Agriculture and Fisheries (DAF) (2018), *Restricted invasive plants of Queensland*, Department of Agriculture and Fisheries, Queensland Government.

Department of Agriculture and Fisheries (DAF) (2019) Invasive plant and animal fact sheets Available from: <https://www.daf.qld.gov.au/business-priorities/biosecurity/invasive-plants-animals/fact-sheets#pest_animals>

Department of Environment and Heritage Protection (DEHP) (2014a). *Queensland Environmental Offsets Policy, Significant Residual Impact Guideline,* Department of Environment and Science, Brisbane. Available from: < https://environment.des.qld.gov.au/assets/documents/pollution/management/offsets/significant-residual-impact-guide.pdf>

Department of Environment and Heritage Protection (DEHP) (2014b). *Species Profile Search*. Department of Environment and Science, Brisbane. Available from: <https://environment.ehp.qld.gov.au/species-search/>

Department of Environment and Science (DES) (2018a). *Queensland Environmental Offsets Policy (Version 1.6),* Biodiversity Integration and Offsets, Ecosystem Outcomes, Department of Environment and Science, State of Queensland. https://ehp.qld.gov.au/assets/documents/pollution/management/offsets/offsets-policyv1-6

Department of Environment and Science (DES) (2018b). *Plants, animals, soils, water and more, WetlandInfo,* Department of Environment and Science, State of Queensland., Available from: <https://wetlandinfo.des.qld.gov.au/wetlands/ecology/components/>

Department of Environment and Science (DES) (2018c). *A Biodiversity Planning Assessment for the Brigalow Belt Bioregion. Version 2.1, Summary Report.* Department of Environment and Science, State of Queensland. Available from: <https://www.qld.gov.au/__data/assets/pdf_file/0029/68186/bb-bpa-summary-report.pdf>

Department of Environment and Science (DES) (2019a), *Protected plants flora survey trigger map*, Department of Environment and Science, State of Queensland. Available from: <https://apps.des.qld.gov.au/map-request/flora-survey-trigger/>

Department of Environment and Science (DES) (2019b), *Wetland maps under the Environmental Protection Act 1994*, Department of Environment and Science, State of Queensland. Available from: <https://environment.des.qld.gov.au/ecosystems/wetlands/referable-wetlands-maps.html>

Department of Environment and Science (DES), Queensland Herbarium (2019c), *Regional Ecosystem Description Database (REDD) (V 11.1)*, Department of Environment and Science, Queensland Government, Brisbane.

Department of Environment and Science (DES) (2019d), *Flora Survey Guidelines - Protected Plants; Nature Conservation Act 1992*, Department of Environment and Science, Queensland Government, Brisbane.

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2009), *Weeping Myall Woodlands - EPBC Act policy statement 3.17 - Nationally threatened species and ecological communities*. Department of the Environment, Water, Heritage and the Arts, Commonwealth of Australia, Canberra.

Department of Science, Information Technology and Innovation (DSITI) (2015), *Queensland Groundwater Dependant Ecosystem Mapping Method, Version 1.1*, Department of Science, Information Technology and Innovation, Queensland Government, Brisbane.

Department of Natural Resources, Mines and Energy (DNRME) (2018), *General guide to the vegetation clearing codes Accepted development vegetation clearing codes*, Queensland Government. Available from: <https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0008/1396988/landholders-guide-to-veg-clearing-codes.pdf>

Department of Environment (DoE) (2013), *Significant impact guidelines 1.1: Matters of National Environmental Significance,* Department of Environment and Energy, Commonwealth of Australia, Canberra.

Department of the Environment and Energy (DoEE) (2010a), *Survey guidelines for Australia's threatened bats; Guidelines for detecting bats listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*, Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Department of the Environment and Energy (DoEE) (2010b), *Survey guidelines for Australia's threatened birds: Guidelines for detecting birds listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*, Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Department of the Environment and Energy (DoEE) (2011a), *Survey guidelines for Australia's threatened mammals: Guidelines for detecting mammals listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*, Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Department of the Environment and Energy (DoEE) (2011b), *Survey guidelines for Australia's threatened reptiles: Guidelines for detecting reptiles listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999*, Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Department of the Environment and Energy (DoEE) (2015). *Environment Protection and Biodiversity Conservation Act 1999: Protected Matters Search Tool*. Department of the Environment, Canberra. Available from: <http://www.environment.gov.au/topics/about-us/legislation/environment-protection-and-biodiversity-conservation-act-1999/protected>

Department of the Environment and Energy (DoEE) (2018), *Species Profile and Threats Database*, Department of the Environment, Canberra. Available from:<http://www.environment.gov.au/sprat

Eyre T.J., Ferguson D.J., Hourigan C.L., Smith G.C., Mathieson M.T., Kelly A.L., Venz M.F., Hogan L.D. & Rowland J. (2018). Terrestrial Vertebrate Fauna Survey Guidelines for Queensland Version 3.0. Department of Science, Information Technology, Innovation and the Arts, Queensland Government, Brisbane.

Ford, G. (2017-2018) Microbat Call Identification Report – prepared for AARC Environmental Solutions, Balance Environmental, Toowoomba.

Geoscience Australia (2018) Province and Sedimentary Basin Geology - Bowen Basin. Available from: http://www.ga.gov.au/scientific-topics/energy/province-sedimentary-basin-geology/petroleum/onshore-australia/bowen-basin

Glossy Black Conservancy (2010). Glossy black-cockatoo Conservation Guidelines for South-Eastern Queensland and far North-Eastern New South Wales. Glossy Black Conservancy.

Goff FG, Dawson GA & Rochow JJ (1982), *Site examination for threatened and endangered plant species*, Environmental Management, vol. 6: 307-316.

Hutton A.C. (2009). *Geological Setting of Australasian Coal Deposits.* Australasian Coal Mining Practice, pp. 40-84.

Independent Expert Scientific Committee (IESC) (2019) Assessing Groundwater-Dependent Ecosystems: IESC Information Guidelines Explanatory Note, Department of Environment and Energy, Commonwealth of Australia, Canberra.

JBT Consulting Pty Ltd, (2019) 'Groundwater Impact Assessment Gemini Coal Project', prepared for Magnetic South Pty Ltd.

JSTOR, Global Plants (2018), Herbarium collections, http://plants.jstor.org/

Lundie-Jenkins, G and Lowry, J 2005. Recovery plan for the bridled nailtail wallaby (Onychogalea fraenata) 2005-2009. Report to the Department of Environment and Heritage (DEH), Canberra.

Mutton A.J. (2003). Queensland Coals - Physical and Chemical Properties, Colliery and Company Information. Department of Natural Resources and Mines, Queensland Government, Brisbane. Available from: <https://www.dnrm.qld.gov.au/?a=267497>

Morcombe, M. 2002. Field Guide to Australian Birds. Steve Parish Publishing, Archerfield, Queensland.

Menkhorst P. & Knight F. (2011). *A field guide to the mammals of Australia*, Third Edition. Oxford University Press. South Melbourne, Victoria.

Nature Conservation Act 1992, Department of Environment and Science (DES), Queensland Government

Nature Conservation (Wildlife) Regulation 2006. Department of Environment and Science (DES), Queensland Government.

Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S. and Butler, D.W. (2019) Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland. Version 5.0. Updated April 2019. Queensland Herbarium, Queensland Department of Science, Information Technology and Innovation, Brisbane. 124 pp.

Pizzey, G. and Knight, F (2007). The Field Guide to the Birds of Australia, HarperCollins Publishers, Pty, Ltd., Pymble, New South Wales.

Rowland, J. 2013. Tusked frog, Adelotus brevis. Targeted species survey guidelines. Queensland Herbarium, Department of Environment and Science, Brisbane. Available from: < https://www.qld.gov.au/__data/assets/pdf_file/0014/67100/tusked-frog.pdf>

Smith A.P. Lindenmayer D (1988) Tree Hollow Requirements of Leadbeater's Possum and Other Possums and Gliders in Timber Production Ash Forests of the Victorian Central Highlands. Wildlife Research 15, 347-362.

Threatened Species Scientific Committee (TSSC) (2008), *Commonwealth Conservation Advice Delma torquata*. *(Collared Delma)*. Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Threatened Species Scientific Committee (TSSC) (2016a), *Commonwealth Conservation Advice Petauroides volans*. Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Threatened Species Scientific Committee (TSSC) (2016b), *Commonwealth Conservation Advice Macroderma gigas*. Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Threatened Species Scientific Committee (TSSC) (2018), *Commonwealth Conservation Advice Antechinus argentus silver-headed antechinus*. Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Threatened Species Scientific Committee (TSSC) (no date), *Draft Conservation Advice (incorporating listing advice) for the Poplar Box Grassy Woodlands on Alluvial Plains,* Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Van Dyck, S., Gynther, I. and Baker, A. (eds.) (2013). *Field Companion to The Mammals of Australia*. New Holland; Sydney.

Vegetation Management Act 1999, Department of Environment and Science (DES), Queensland Government

Wang, J. (1995). *Homoranthus decumbens* Species Management Profile, Flora and Fauna Information System. 2. Queensland Department of Natural Resources, Brisbane.

Wilson, S. (2005). *A Field Guide to the Reptiles of Queensland*. Reed New Holland, Sydney.

Appendix A Database Searches

Queensland Government

Department of Environment and Heritage Protection

Environmental Reports

Biodiversity and Conservation Values

Biodiversity Planning Assessments and Aquatic Conservation Assessments

Area of Interest: epc: 881

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or Area of Interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "Central co-ordinates" option, the resulting assessment area encompasses an area extending from 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Please direct queries about these reports to: biodiversity.planning@ehp.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

Table of Contents

Summary Information 4
Biodiversity Planning Assessments 6
Introduction 6
Diagnostic Criteria 6
Other Essential Criteria 8
Aquatic Conservation Assessments 14
Introduction 14
Explanation of Criteria 14
Riverine Wetlands 15
Non-riverine Wetlands 16
Threatened and Priority Species 19
Introduction 19
Threatened Species 19
BPA Priority Species 19
ACA Priority Species 20
Maps 21
Map 1 - Locality Map 21
Map 2 - Biodiversity Planning Assessment (BPA) 22
Map 3 - Corridors 23
Map 4 - Wetlands and waterways 24
Map 5 - Aquatic Conservation Assessment (ACA) - riverine 25
Map 6 - Aquatic Conservation Assessment (ACA) - non-riverine 26
References 27
Appendices 28
Appendix 1: Source Data 28
Appendix 2 - Acronyms and Abbreviations 29

Summary Information

Tables 1 to 8 provide an overview of the AOI with respect to selected topographic and environmental values.

Table 1: Area of interest details

Area of Interest	EPC881
Size (ha)	7219.6
Local Government(s)	CENTRAL HIGHLANDS REGIONAL
Bioregion(s)	Brigalow Belt
Subregion(s)	Woorabinda
Catchment(s)	Fitzroy

The following table identifies available Biodiversity Planning Assessments (BPAs) and Aquatic Conservation Assessments (ACAs) with respect to the AOI.

Table 2: Available Biodiversity Planning and Aquatic Conservation Assessments

Assessment Type	Assessment Area and Version
Biodiversity Planning Assessment(s)	Brigalow Belt v1.3
Aquatic Conservation Assessment(s) (riverine)	Great Barrier Reef Catchment v1.1
Aquatic Conservation Assessment(s) (non-riverine)	Great Barrier Reef Catchment v1.3

Table 3: Remnant regional ecosystems within the AOI as per the Qld Herbarium's 'biodiversity status'

Biodiversity Status	Area (Ha)	% of AOI
Endangered	6.4	0.1%
Of Concern	237.3	3.3%
No concern at present	1842.0	25.5%

The following table identifies the extent and proportion of the user specified area of interest (AOI) which is mapped as being of "State", "Regional" or "Local" significance via application of the Queensland Department of Environment and Heritage Protection's *Biodiversity Assessment and Mapping Methodology* (BAMM).

Table 4: Summary table, biodiversity significance

Biodiversity significance	Area (Ha)	% of AOI
State Habitat for EVNT taxa	0.0	0.0%
State	759.7	10.5%
Regional	167.0	2.3%
Local or Other Values	1232.6	17.1%

Table 5: Non-riverine wetlands intersecting the AOI

Non-riverine wetland types intersecting the area of interest	#
Number of Palustrine wetlands	4
Number of Lacustrine wetlands	2
Total number of non-riverine wetlands	6

NB. The figures presented in the table above are derived from the relevant non-riverine Aquatic Conservation Assessment(s). Later releases of wetland mapping produced via the Queensland Wetland Mapping Program may provide more recent information in regards to wetland extent.

Table 6: Named waterways intersecting the AOI

Name	Permanency
CHARLEVUE CREEK	Non-perennial
SPRINGTON CREEK	Non-perennial
STANLEY CREEK	Non-perennial

Refer to **Map 1** for general locality information.

The following two tables identify the extent and proportion of the user specified AOI which is mapped as being of "Very High", "High", "Medium", "Low", or "Very Low" aquatic conservation value for riverine and non-riverine wetlands via application of the Queensland Department of Environment and Heritage Protection's *Aquatic Biodiversity Assessment and Mapping Method* (AquaBAMM).

Table 7: Summary table, aquatic conservation significance (riverine)

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
Very High	0.0	0.0%
High	0.0	0.0%
Medium	7219.6	100.0%
Low	0.0	0.0%
Very Low	0.0	0.0%

Table 8: Summary table, aquatic conservation significance (non-riverine)

Aquatic conservation significance (non-riverine wetlands)	Area (Ha)	% of AOI
Very High	0.0	0.0%
High	0.0	0.0%
Medium	10.9	0.2%
Low	0.0	0.0%
Very Low	0.0	0.0%

Biodiversity Planning Assessments

Introduction

The department of Environment and Heritage Protection (EHP) attributes biodiversity significance on a bioregional scale through a Biodiversity Planning Assessment (BPA). A BPA involves the integration of ecological criteria using the *Biodiversity assessment and Mapping Methodology* (BAMM) and is developed in two stages: 1) **diagnostic criteria**, and 2) **expert panel criteria**. The diagnostic criteria are based on existing data which is reliable and uniformly available across a bioregion, while the expert panel criteria allows for the refinement of the mapped information from the diagnostic output by incorporating local knowledge and expert opinion.

The BAMM methodology has application for identifying areas with various levels of significance solely for biodiversity reasons. These include threatened ecosystems or taxa, large tracts of habitat in good condition, ecosystem diversity, landscape context and connection, and buffers to wetlands or other types of habitat important for the maintenance of biodiversity or ecological processes. While natural resource values such as dryland salinity, soil erosion potential or land capability are not dealt with explicitly, they are included to some extent within the biodiversity status of regional ecosystems recognised by the EHP.

Biodiversity Planning Assessments (BPAs) assign three levels of overall biodiversity significance.

- **State significance** - areas assessed as being significant for biodiversity at the bioregional or state scales. They also include areas assessed by other studies/processes as being significant at national or international scales. In addition, areas flagged as being of State significance due to the presence of endangered, vulnerable and/or near threatened taxa, are identified as "State Habitat for EVNT taxa".
- **Regional significance** - areas assessed as being significant for biodiversity at the subregional scale. These areas have lower significance for biodiversity than areas assessed as being of State significance.
- **Local significance and/or other values** - areas assessed as not being significant for biodiversity at state or regional scales. Local values are of significance at the local government scale.

For further information on released BPAs and a copy of the underlying methodology, go to:

http://www.qld.gov.au/environment/plants-animals/biodiversity/planning/

The GIS results can be downloaded from the Queensland Spatial Catalogue at:

http://qspatial.information.qld.gov.au/geoportal/

The following table identifies the extent and proportion of the user specified AOI which is mapped as being of "State", "Regional" or "Local" significance via application of the BAMM.

Table 9: Summary table, biodiversity significance

Biodiversity significance	Area (Ha)	% of AOI
State Habitat for EVNT taxa	0.0	0.0%
State	759.7	10.5%
Regional	167.0	2.3%
Local or Other Values	1232.6	17.1%

Refer to **Map 2** for further information.

Diagnostic Criteria

Diagnostic criteria are based on existing data which is reliable and uniformly available across a bioregion. These criteria are diagnostic in that they are used to filter the available data and provide a "first-cut" or initial determination of biodiversity significance. This initial assessment is then combined through a second group of other essential criteria.

A description of the individual diagnostic criteria is provided in the following sections.

Criteria A. Habitat for EVNT taxa: Classifies areas according to their significance based on the presence of endangered, vulnerable and/or rare (EVNT) taxa. EVNT taxa are those scheduled under the *Nature Conservation Act 1992* and/or the *Environment Protection and Biodiversity Conservation Act 1999*. It excludes highly mobile fauna taxa which are instead

considered in Criterion H and brings together information on EVNT taxa using buffering of recorded sites or habitat suitability models (HSM) where available.

Criteria B. Ecosystem value: Classifies on the basis of biodiversity status of regional ecosystems, their extent in protected areas (presence of poorly conserved regional ecosystems), the presence of significant wetlands and intertidal zones; and areas of national importance such as World Heritage areas and Ramsar sites. Ecosystem value is applied at a bioregional (**B1**) and regional (**B2**) scale.

Criteria C. Tract size: Measures the relative size of tracts of vegetation in the landscape. The size of any tract is a major indicator of ecological significance, and is also strongly correlated with the long-term viability of biodiversity values. Larger tracts are less susceptible to ecological edge effects and are more likely to sustain viable populations of native flora and fauna than smaller tracts.

Criteria D. Relative size of regional ecosystems: Classifies the relative size of each regional ecosystem unit within its bioregion (**D1**) and its subregion (**D2**). Remnant units are compared with all other occurrences with the same regional ecosystem. Large examples of a regional ecosystem are more significant than smaller examples of the same regional ecosystem because they are more representative of the biodiversity values particular to the regional ecosystem, are more resilient to the effects of disturbance, and constitute a significant proportion of the total area of the regional ecosystem.

Criteria F. Ecosystem diversity: Is an indicator of the number of regional ecosystems occurring within an area. An area with high ecosystem diversity will have many regional ecosystems and ecotones relative to other areas within the bioregion.

Criteria G. Context and connection: Represents the extent to which a remnant unit incorporates, borders or buffers areas such as significant wetlands, endangered ecosystems; and the degree to which it is connected to other vegetation.

A summary of the biodiversity status based upon the diagnostic criteria is provided in the following table.

Table 10: Summary of biodiversity significance based upon diagnostic criteria with respect to the AOI

Biodiversity significance	Description	Area (Ha)	% of AOI
Regional	Remnant contains at least one Of Concern RE (B1)	274.7	3.8
Local or Other Values	Refer to diagnostic data for additional information	1884.7	26.1

Assessment of diagnostic criteria with respect to the AOI

The following table reflects an assessment of the individual diagnostic criteria noted above in regards to the AOI.

Table 11: Assessment of individual diagnostic criteria with respect to the AOI

Diagnostic Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
A: Habitat for EVNT Taxa					427.6	5.9	1731.7	24.0
B1: Ecosystem Value (Bioregion)			274.6	3.8	1884.7	26.1		
B2: Ecosystem Value (Subregion)					2159.3	29.9		
C: Tract Size			1868.8	25.9	194.1	2.7	96.4	1.3
D1: Relative RE Size (Bioregion)							2159.3	29.9
D2: Relative RE Size (Subregion)							2159.3	29.9
F: Ecosystem Diversity	32.2	0.4	795.7	11.0	1206.0	16.7	125.4	1.7
G: Context and Connection	225.3	3.1	576.7	8.0	1294.0	17.9	63.3	0.9

Other Essential Criteria

Other essential criteria (also known as expert panel criteria) are based on non-uniform information sources and which may rely more upon expert opinion than on quantitative data. These criteria are used to provide a "second-cut" determination of biodiversity significance, which is then combined with the diagnostic criteria for an overall assessment of relative biodiversity significance. A summary of the biodiversity status based upon the other essential criteria is provided in the following table.

Table 12: Summary of biodiversity significance based upon other essential criteria with respect to the AOI

Biodiversity significance	Description	Area (Ha)	% of AOI
State	Remnant contains Special Biodiversity Values (view Expert Panel data for further information) (I)	239.1	3.3
State	Remnant contains Special Biodiversity Values (view Expert Panel data for further information) (I) Remnant forms part of a bioregional corridor (J)	369.1	5.1
State	Remnant forms part of a bioregional corridor (J)	151.3	2.1
Regional	Remnant forms part of a bioregional corridor (J)	1.0	0.0

A description of each of the other essential criteria and associated assessment in regards to the AOI is provided in the following sections.

Criteria H. Essential and general habitat for priority taxa: Priority taxa are those which are at risk or of management concern, taxa of scientific interest as relictual (ancient or primitive), endemic taxa or locally significant populations (such as a flying fox camp or heronry), highly specialised taxa whose habitat requirements are complex and distributions are not well correlated with any particular regional ecosystem, taxa important for maintaining genetic diversity (such as complex spatial patterns of genetic variation, geographic range limits, highly disjunct populations), taxa critical for management or monitoring of biodiversity (functionally important or ecological indicators), or economic and culturally important taxa.

This criterion can be used to identify essential and general habitat for EVNT and other priority taxa additional to that derived under Diagnostic Criterion A. Information sources include expert and local knowledge, technical reports and papers, and modelled maps of essential and general habitat.

Criteria I. Special biodiversity values: areas with special biodiversity values are important because they contain multiple taxa in a unique ecological and often highly biodiverse environment. Areas with special biodiversity values can include the following:

- Ia - centres of endemism - areas where concentrations of taxa are endemic to a bioregion or subregion are found.
- Ib - wildlife refugia (Morton *et al*. 1995), for example, islands, mound springs, caves, wetlands, gorges, mountain ranges and topographic isolates, ecological refuges, refuges from exotic animals, and refuges from clearing. The latter may include large areas that are not suitable for clearing because of land suitability/capability.
- Ic - areas with concentrations of disjunct populations.
- Id - areas with concentrations of taxa at the limits of their geographic ranges.
- Ie - areas with high species richness.
- If - areas with concentrations of relictual populations (ancient and primitive taxa).
- Ig - areas containing REs with distinct variation in species composition associated with geomorphology and other environmental variables.
- Ih - an artificial waterbody or managed/manipulated wetland considered by the panel/s to be of ecological significance.
- Ii - areas with a high density of hollow-bearing trees that provide habitat for animals.
- Ij - breeding or roosting sites used by a significant number of individuals.
- Ik - climate change refuge.

The following table identifies the value and extent area of the Other Essential Criteria H and I within the AOI.

Table 13: Relative importance of expert panel criteria (H and I) used to access overall biodiversity significance with respect to the AOI

Expert Panel	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
H: Core Habitat Priority Taxa	520.5	7.2						

Expert Panel	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
Ia: Centres of Endemism								
Ib: Wildlife Refugia	608.4	8.4						
Ic: Disjunct Populations								
Id: Limits of Geographic Ranges								
Ie: High Species Richness								
If: Relictual Populations								
Ig: Variation in Species Composition								
Ih: Artificial Wetland								
Ii: Hollow Bearing Trees								
Ij: Breeding or Roosting Site								
Ik: Climate Refugia								

NB. Whilst biodiversity values associated with Criteria I may be present within the site (refer to tables 12 and 15), for the New England Tableland and Central Queensland Coast BPAs, area and % area figures associated with Criteria Ia through to Ij cannot be listed in the table above (due to slight variations in data formats between BPAs).

Criteria J. Corridors: areas identified under this criterion qualify either because they are existing vegetated corridors important for contiguity, or cleared areas that could serve this purpose if revegetated. Some examples of corridors include riparian habitats, transport corridors and "stepping stones".

Bioregional and subregional conservation corridors have been identified in the more developed bioregions of Queensland through the BPAs, using an intensive process involving expert panels. Map 3 displays the location of corridors as identified under the Statewide Corridor network. The Statewide Corridor network incorporates BPA derived corridors and for bioregions where no BPA has been assessed yet, corridors derived under other planning processes. *Note: as a result of updating and developing a statewide network, the alignment of corridors may differ slightly in some instances when compared to those used in individual BPAs.*

The functions of these corridors are:

- **Terrestrial** Bioregional corridors, in conjunction with large tracts of remnant vegetation, maintain ecological and evolutionary processes at a landscape scale, by:

  • Maintaining long term evolutionary/genetic processes that allow the natural change in distributions of species and connectivity between populations of species over long periods of time;

  • Maintaining landscape/ecosystems processes associated with geological, altitudinal and climatic gradients, to allow for ecological responses to climate change;

  • Maintaining large scale seasonal/migratory species processes and movement of fauna;

  • Maximising connectivity between large tracts/patches of remnant vegetation;

  • Identifying key areas for rehabilitation and offsets; and

- **Riparian** Bioregional Corridors also maintain and encourage connectivity of riparian and associated ecosystems.

The location of the corridors is determined by the following principles:

- Terrestrial
    - Complement riparian landscape corridors (i.e. minimise overlap and maximise connectivity);
    - Follow major watershed/catchment and/or coastal boundaries;
    - Incorporate major altitudinal/geological/climatic gradients;
    - Include and maximise connectivity between large tracts/patches of remnant vegetation;
    - Include and maximise connectivity between remnant vegetation in good condition; and

- Riparian
    - Located on the major river or creek systems within the bioregion in question.

The total extent of remnant vegetation triggered as being of "State", "Regional" or "Local" significance due to the presence of an overlying BPA derived terrestrial or riparian corridor within the AOI, is provided in the following table. For further information on how remnant vegetation is triggered due to the presence of an overlying BPA derived corridor, refer to the relevant landscape BPA expert panel report(s).

Table 14: Extent of triggered remnant vegetation due to the presence of BPA derived corridors with respect to the AOI

Biodiversity Significance	Area (Ha)	% of AOI
State	520.5	7.2%
Regional	1.0	0.0%
Local or Other Values	0.0	0.0%

NB: area figures associated with the extent of corridor triggered remnant vegetation are only available for those bioregions where a BPA has been undertaken.

Refer to **Map 3** for further information.

Threatening process/condition (Criteria K) - areas identified by experts under this criterion may be used to amend (upgrade or downgrade) biodiversity significance arising from the "first-cut" analysis. The condition of remnant vegetation is affected by threatening processes such as weeds, ferals, grazing and burning regime, selective timber harvesting/removal, salinity, soil erosion, and climate change.

Assessment of Criteria K with respect to the AOI is not currently included in the "Biodiversity and Conservation Values" report, as it has not been applied to the majority of Queensland due to data/information limitations and availability.

Special Area Decisions

Expert panel derived "Special Area Decisions" are used to assign values to Other Essential Criteria. The specific decisions which relate to the AOI in question are listed in the table below.

Table 15: Expert panel decisions for assigning levels of biodiversity significance with respect to the AOI

Decision Number	Description	Panel Recommended Significance	Criteria Values
brbn_l_17	Terrestrial corridors	State Regional	J (Terrestrial Corridor): STATE J (Terrestrial Corridor): REGIONAL
brbn_l_62	Taunton Scientific Reserve and remnants around it, especially riparian vegetation	State	J (wildlife corridor): STATE H (core habitat for priority taxa): VERY HIGH

Decision Number	Description	Panel Recommended Significance	Criteria Values
brbn_l_69	Core areas in fragmented subregions: Dawson River Downs Callide Creek Downs Isaac - Comet Downs Upper Belyando Floodout	State	Ib (wildlife refugia): VERY HIGH
brbs_l_17	Terrestrial Bioregional Corridors	State or Regional	J (Terrestrial Corridor): STATE or J (Terrestrial Corridor): REGIONAL

Expert panel decision descriptions:

brbn_l_17

The corridors along the Great Dividing Range Corridor and the eastern ranges, which span large distances, are mapped by including remnant vegetation within a 5 kilometre buffer either side of a centre line. Some of the other more significant corridors that cross bioregions are also mapped in this way. Where corridors are shorter and more numerous the corridors are mapped by including remnant vegetation within a 2.5 kilometre buffer either side of a centre line.

More information for this decision exists in the BRB BPA North Landscape Report.

brbn_l_62

Taunton National Park (Scientific) is essential habitat for the conservation of the endangered Bridled nail-tail wallaby. The surrounding landscape is extensively cleared, however, Bridled nail-tail wallabies have been recorded in remnant vegetation surrounding the park. Dispersal of wallabies to suitable habitat relies on retaining connectivity from the park, particularly along the following creeks: Five Mile, Duckworth, Walton, Iguana, Stanley, Charlevue, Spectacle, Lagoon and Wild Horse.

Regrowth and remnant vegetation along creek lines in the vicinity of Taunton should be considered essential habitat.

brbn_l_69

Tracts are patches of continuous remnant vegetation. The size of any tract is a major indicator of ecological significance, and is also strongly correlated with the long-term viability of biodiversity values. The northern Brigalow Belt has some very large tracts of vegetation. Based on the Tract Size analysis (Criterion C), the following core areas are identified for the northern Brigalow Belt. They are the fragmented subregions:

More information for this decision exists in the BRB BPA North Landscape Report.

brbs_l_17

Maintaining connectivity across a landscape, either through corridors or "stepping-stones" of remnant vegetation, is important for the long-term conservation of biodiversity.

The corridors along the Great Dividing Range and the eastern ranges, which span large distances, are mapped by including remnant vegetation within a 5 kilometre buffer either side of a centre line. Some of the other more significant corridors that cross bioregions are also mapped in this way. Remnant ecosystem polygons which had 30% or more of its total area within the 5km buffered zone were included within the corridor and assigned a J Rating. The significance of this J Rating was based on the significance given to that corridor by the Expert Panel. Where corridors are shorter and more numerous (i.e. between the ranges and the coastline) the corridors are mapped by including remnant vegetation within a 2.5 kilometre buffer either side of a centre line.

More information for this decision exists in the BRB BPA South Landscape Report.

Aquatic Conservation Assessments

Introduction

The Aquatic Biodiversity Assessment and Mapping Method or AquaBAMM (Clayton *et al.* 2006), was developed to assess conservation values of wetlands in queensland, and may also have application in broader geographical contexts. It is a comprehensive method that uses available data, including data resulting from expert opinion, to identify relative wetland conservation/ecological values within a specified study area (usually a catchment). The product of applying this method is an Aquatic Conservation Assessment (ACA) for the study area.

An ACA using AquaBAMM is non-social, non-economic and identifies the conservation/ecological values of wetlands at a user-defined scale. It provides a robust and objective conservation assessment using criteria, indicators and measures that are founded upon a large body of national and international literature. The criteria, each of which may have variable numbers of indicators and measures, are naturalness (aquatic), naturalness (catchment), diversity and richness, threatened species and ecosystems, priority species and ecosystems, special features, connectivity and representativeness. An ACA using AquaBAMM is a powerful decision support tool that is easily updated and simply interrogated through a geographic information system (GIS).

Where they have been conducted, ACAs can provide a source of baseline wetland conservation/ecological information to support natural resource management and planning processes. They are useful as an independent product or as an important foundation upon which a variety of additional environmental and socio-economic elements can be added and considered (i.e. an early input to broader 'triple-bottom-line' decision-making processes). An ACA can have application in:

- determining priorities for protection, regulation or rehabilitation of wetlands and other aquatic ecosystems
- on-ground investment in wetlands and other aquatic ecosystems
- contributing to impact assessment of large-scale development (e.g. dams)
- water resource and strategic regional planning prcesses

For a detailed explanation of the methodology please refer to the summary and expert panel reports relevant to the ACA utilised in this assessment. These reports can be accessed at Wetland*Info*:

http://wetlandinfo.ehp.qld.gov.au/wetlands/assessment/assessment-methods/aca

The GIS results can be downloaded from the Queensland Spatial Catalogue at:

http://qspatial.information.qld.gov.au/geoportal/

Explanation of Criteria

Under the AquaBAMM, eight criteria are assessed to derive an overall conservation value. Similar to the Biodiversity Assessment and Mapping Methodology, the criteria may be primarily diagnostic (quantitative) or primarily expert opinion (qualitative) in nature. The following sections provide a brief description of each of the 8 criteria.

Criteria 1. Naturalness - Aquatic: This attribute reflects the extent to which a wetland's (riverine, non-riverine, estuarine) aquatic state of naturalness is affected through relevant influencing indicators which include: presence of exotic flora and fauna; presence of aquatic communities; degree of habitat modification and degree of hydrological modification.

Criteria 2. Naturalness - Catchment: The naturalness of the terrestrial systems of a catchment can have an influence on many wetland characteristics including: natural ecological processes e.g. nutrient cycling, riparian vegetation, water chemistry, and flow. The indicators utilised to assess this criterion include: presence of exotic flora and/or fauna; riparian, catchment and flow modification.

Criteria 3. Naturalness - Diversity and Richness: This criterion is common to many ecological assessment methods and can include both physical and biological features. It includes such indicators as species richness, riparian ecosystem richness and geomorphological diversity.

Criteria 4. Threatened Species and Ecosystems: This criterion evaluates ecological rarity characteristics of a wetland. This includes both species rarity and rarity of communities / assemblages. The communities and assemblages are best represented by regional ecosystems. Species rarity is determined by NCA and EPBC status with Endangered, Vulnerable or Near-threatened species being included in the evaluation. Ecosystem rarity is determined by regional ecosystem biodiversity status i.e. Endangered, Of Concern, or Not of Concern.

Criteria 5. Priority Species and Ecosystems: Priority flora and fauna species lists are expert panel derived. These are aquatic, semi-aquatic and riparian species which exhibit at least 1 particular trait in order to be eligible for consideration. For flora species the traits included:

- It forms significant macrophyte beds (in shallow or deep water).
- It is an important food source.
- It is important/critical habitat.
- It is implicated in spawning or reproduction for other fauna and/or flora species.
- It is at its distributional limit or is a disjunct population.
- It provides stream bank or bed stabilisation or has soil binding properties.
- It is a small population and subject to threatening processes.

Fauna species are included if they meet at least one of the following traits:

- It is endemic to the study area (>75 per cent of its distribution is in the study area/catchment).
- It has experienced, or is suspected of experiencing, a serious population decline.
- It has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area/catchment.
- It is currently a small population and threatened by loss of habitat.
- It is a significant disjunct population.
- It is a migratory species (other than birds).
- A significant proportion of the breeding population (>one per cent for waterbirds, >75 per cent other species) occurs in the waterbody (see Ramsar criterion 6 for waterbirds).
- Limit of species range.

See the individual expert panel reports for the priority species traits specific to an ACA.

Criteria 6. Special Features: Special features are areas identified by flora, fauna and ecology expert panels which exhibit characteristics beyond those identified in other criteria and which the expert panels consider to be of the highest ecological importance. Special feature traits can relate to, but are not solely restricted to geomorphic features, unique ecological processes, presence of unique or distinct habitat, presence of unique or special hydrological regimes e.g. spring-fed streams. Special features are rated on a 1 - 4 scale (4 being the highest).

Criteria 7. Connectivity: This criterion is based on the concept that appropriately connected aquatic ecosystems are healthy and resilient, with maximum potential biodiversity and delivery of ecosystem services.

Criteria 8. Representativeness: This criterion applies primarily to non-riverine assessments, evaluates the rarity and uniqueness of a wetland type in relation to specific geographic areas. Rarity is determined by the degree of wetland protection within "protected Areas" estate or within an area subject to the *Fisheries Act 1994*, *Coastal Protection and Management Act 1995*, or *Marine Parks Act 2004*. Wetland uniqueness evaluates the relative abundance and size of a wetland or wetland management group within geographic areas such as catchment and subcatchment.

Riverine Wetlands

Riverine wetlands are all wetlands and deepwater habitats within a channel. The channels are naturally or artificially created, periodically or continuously contain moving water, or connecting two bodies of standing water. AquaBAMM, when applied to riverine wetlands uses a discrete spatial unit termed subsections. A subsection can be considered as an area which encompasses discrete homogeneous stream sections in terms of their natural attributes (i.e. physical, chemical, biological and utilitarian values) and natural resources. Thus in an ACA, an aquatic conservation significance score is calculated for each subsection and applies to all streams within a subsection, rather than individual streams as such.

Please note, the area figures provided in Tables 16 and 17, are derived using the extent of riverine subsections within the AOI. Refer to **Map 5** for further information. A summary of the conservation significance of riverine wetlands within the AOI is provided in the following table.

Table 16: Overall level/s of riverine aquatic conservation significance

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
Very High	0.0	0.0%
High	0.0	0.0%

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
Medium	7219.6	100.0%
Low	0.0	0.0%
Very Low	0.0	0.0%

The individual aquatic conservation criteria ratings for riverine wetlands within the AOI are listed below.

Table 17: Level/s of riverine aquatic conservation significance based on selected criteria

Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
1. Naturalness aquatic					1273.2	17.6	5946.3	82.4
2. Naturalness catchment	2.5		7217.0	100.0				
3. Diversity and richness	1273.2	17.6	2074.2	28.7	3872.1	53.6		
4. Threatened species and ecosystems			7219.5	100.0				
5. Priority species and ecosystems	7217.0	100.0						
6. Special features								
7. Connectivity			5946.3	82.4	1273.2	17.6		

The table below lists and describes the relevant expert panel decisions used to assign conservation significance values to riverine wetlands within the AOI.

Table 18: Expert panel decisions for assigning overall levels of riverine aquatic conservation significance

(No Records)

4 is the highest rating/value

Expert panel decision descriptions:

(No Records)

Non-riverine Wetlands

Non-riverine wetlands include both lacustrine and palustrine wetlands, however, do not currently incorporate estuarine, marine or subterranean wetland types. A summary of the conservation significance of non-riverine wetlands within the AOI is provided in the following table. Refer to **Map 6** for further information.

Table 19: Overall level/s of non-riverine aquatic conservation significance

Aquatic conservation significance (non-riverine wetlands)	Area (Ha)	% of AOI
Very High	0.0	0.0%
High	0.0	0.0%
Medium	10.9	0.2%
Low	0.0	0.0%
Very Low	0.0	0.0%

The following table provides an assessment of non-riverine wetlands within the AOI and associated aquatic conservation criteria values.

Table 20: Level/s of non-riverine aquatic conservation significance based on selected criteria

Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
1. Naturalness aquatic	4.7	0.1			6.2	0.1		
2. Naturalness catchment					10.9	0.2		
3. Diversity and richness			6.9	0.1	3.7	0.1	0.3	
4. Threatened species and ecosystems	2.5		4.4	0.1				
5. Priority species and ecosystems			10.9	0.2				
6. Special features								
7. Connectivity								
8. Representative-ness					6.9	0.1		

The table below lists and describes the relevant expert panel decisions used to assign conservation significance values to non-riverine wetlands within the AOI.

Table 21: Expert panel decisions for assigning overall levels of non-riverine aquatic conservation significance.

Decision number	Special feature	Catchment	Criteria/Indicator/Measure	Conservation rating (1-4)
ma_nr_fl_02	Regional ecosystems 8.3.4 11.3.27	Mackenzie	5.2.1	3

4 is the highest rating/value

Expert panel decision descriptions:

ma_nr_fl_02

These regional ecosystems contain significant habitat values that are under threat from threatening processes such as physical alteration/ destruction and invasion by **hymenachne**.

Note: This priority ecosystem decision applies to the following catchments: Calliope, Comet, Dawson, Fitzroy, Isaac, Mackenzie, Misc Other Islands, Nogoa, O'Connell, Pioneer, Plane, Proserpine, Shoalwater, Styx and Waterpark.

Threatened and Priority Species

Introduction

This chapter contains a list of threatened and priority flora and/or fauna species that have been recorded on, or within 4km of the Assessment Area.

The information presented in this chapter with respect to species presence is derived from compiled databases developed primarily for the purpose of BPAs and ACAs. Data is collated from a number of sources and is updated periodically.

It is important to note that the list of species provided in this report, may differ when compared to other reports generated from other sources such as the State government's WildNet, Herbrecs or the federal government's EPBC database for a number of reasons.

Records for threatened and priority species are filtered and checked based on a number of rules including:

- Taxonomic nomenclature - current scientific names and status,
- Location - cross-check co-ordinates with location description,
- Taxon by location - requires good knowledge of the taxon and history of the record,
- Duplicate records - identify and remove,
- Expert panels - check records and provide new records,
- Flora cultivated records excluded,
- Use precise records less than or equal to 2000m,
- Use recent records greater than or equal to 1975 animals, greater than or equal to 1950 plants.

Threatened Species

Threatened species are those species classified as "Endangered" or "Vulnerable" under the *Environment Protection and Biodiversity Conservation Act 1999* or "Endangered", "Vulnerable" or "Near threatened" under the *Nature Conservation Act 1992*.

The following threatened species have been recorded on, or within approximately 4km of the AOI.

Table 22: Threatened species recorded on, or within 4km of the AOI

Species	Common name	NCA status	EPBC status	Back on Track rank	Migratory species*	Wetland species**	Identified flora/fauna
Geophaps scripta scripta	squatter pigeon (southern subspecies)	V	V	Medium			FA
Dichanthium setosum		C	V	Low			FL
Onychogalea fraenata	bridled nailtail wallaby	E	E	Critical			FA
Solanum elachophyllum		E		Medium			FL

NB. Please note that the threatened species listed in this section are based upon the most recently compiled DEHP internal state-wide threatened species dataset. This dataset may contain additional records that were not originally available for inclusion in the relevant individual BPAs and ACAs.

**JAMBA - Japan-Australia Migratory Bird Agreement; CAMBA - China-Australia Migratory Bird Agreement; ROKAMBA - Republic of Korea-Australia Migratory Bird Agreement; CMS - Convention on the Conservation of Migratory Species*.

***Y - wetland indicator species*.

BPA Priority Species

A list of BPA priority species that have been recorded on, or within approximately 4km of the AOI is contained in the following table.

Table 23: Priority species recorded on, or within 4km of the AOI

(no results)

NB. Please note that the list of priority species is based on those species identified in the BPAs, however records for these species may be more recent than the originals used. furthermore, the BPA priority species databases are updated from time to time. At each update, the taxonomic details for all species are amended as necessary to reflect current taxonomic name and/or status changes.

ACA Priority Species

A list of ACA priority species used in riverine and non-riverine ACAs that have been recorded on, or within approximately 4km of the AOI are contained in the following tables.

Table 24: Priority species recorded on, or within 4 km of the AOI - riverine

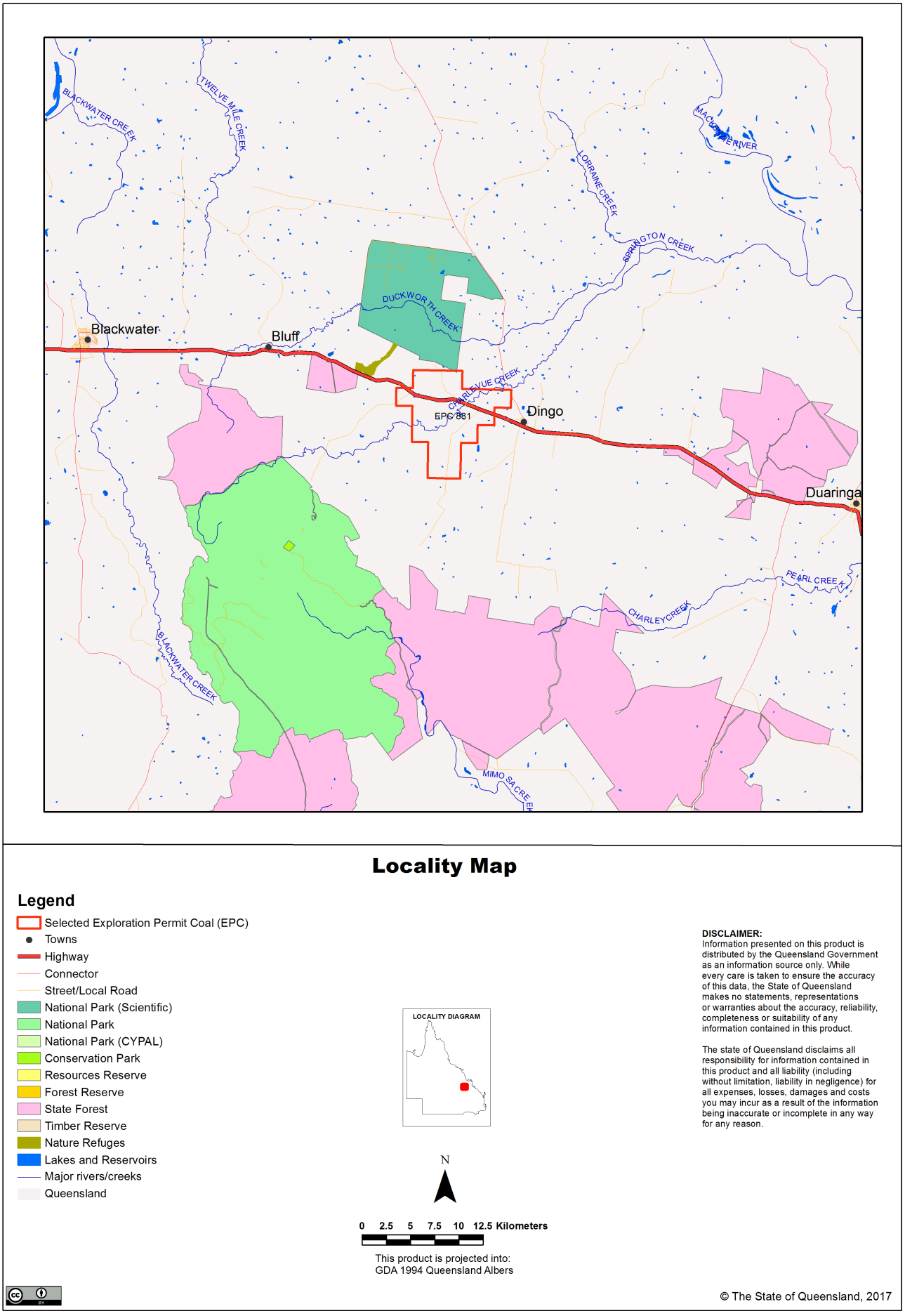
Species	Common name	Back on Track rank	Identified flora/fauna
Eucalyptus tereticornis			FL
Lomandra longifolia			FL
Eucalyptus camaldulensis			FL

Table 25: Priority species recorded on, or within 4 km of the AOI - non-riverine

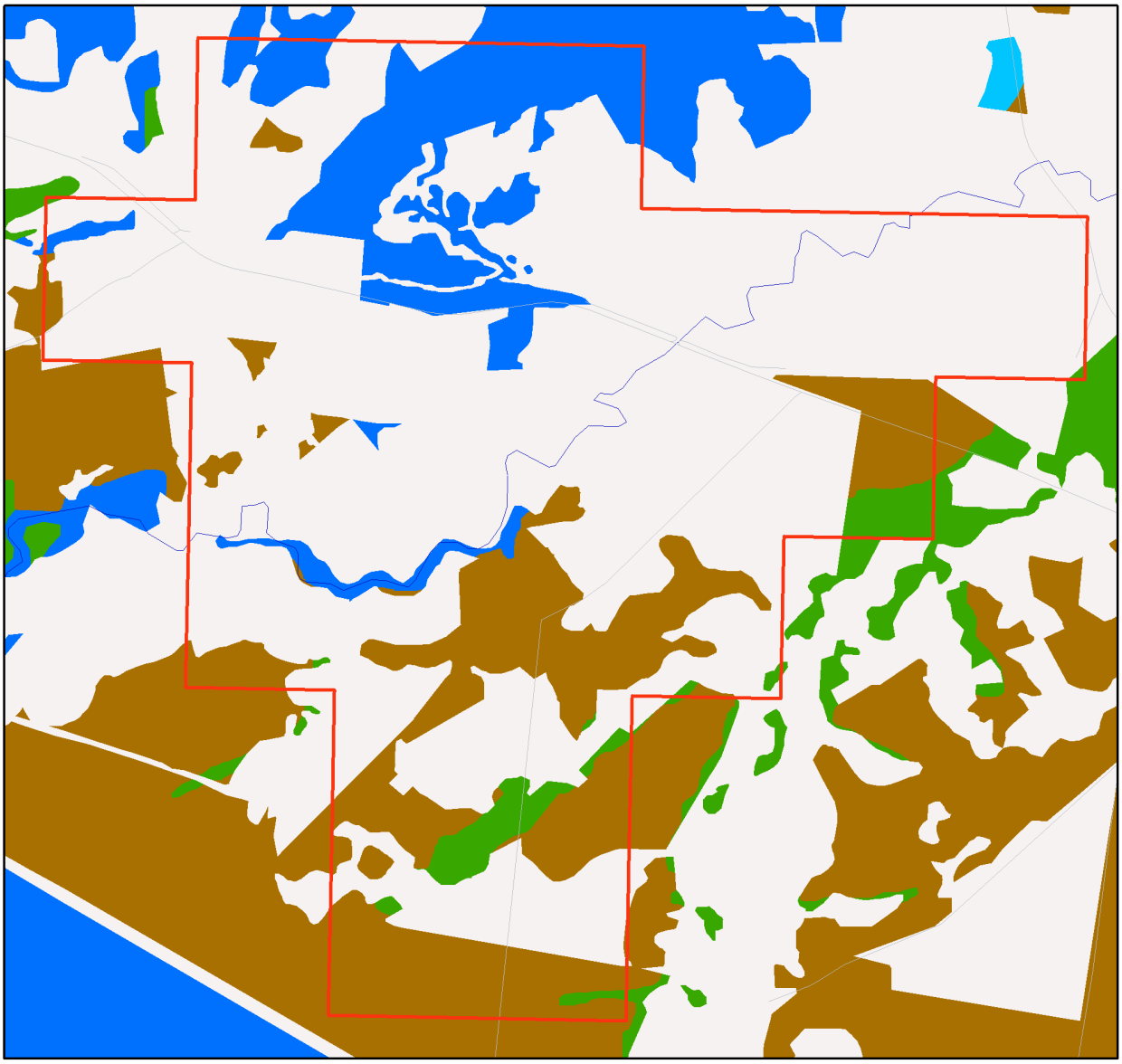
Species	Common name	Back on Track rank	Identified flora/fauna
Eucalyptus tereticornis			FL

NB. Please note that the priority species records used in the above two tables are comprised of those adopted for the released individual ACAs. The ACA riverine and non-riverine priority species databases are updated from time to time to reflect new release of ACAs. At each update, the taxonomic details for all ACAs records are amended as necessary to reflect current taxonomic name and/or status changes.

Maps
Map 1 - Locality Map



Map 2 - Biodiversity Planning Assessment (BPA)



Biodiversity Planning Assessments

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Roads
- Major rivers/creeks
- Queensland

Biodiversity Planning Assessment

- State Habitat for EVNT taxa
- State
- Regional
- Local or Other Values
- Non Bioregion Ecosystem

LOCALITY DIAGRAM

N

0 0.45 0.9 1.35 1.8 2.25 Kilometers

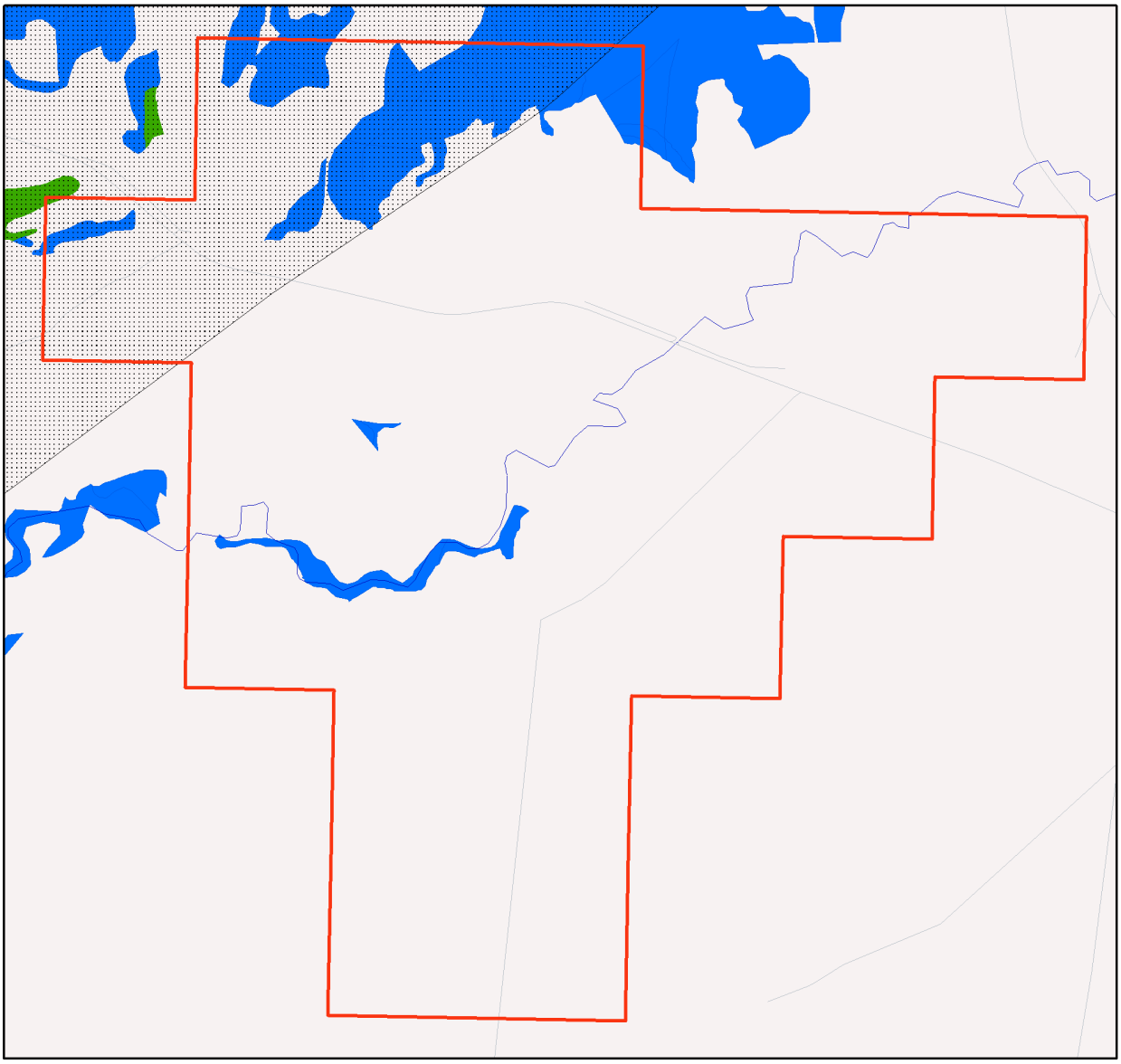
This product is projected into:
GDA 1994 Queensland Albers

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Map 3 - Corridors



Corridors

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Roads
- Major rivers/creeks
- Queensland

Corridors

- State
- Regional

Corridor Triggered Vegetation

- State
- Regional
- Local

LOCALITY DIAGRAM

N

0 0.45 0.9 1.35 1.8 2.25 Kilometers

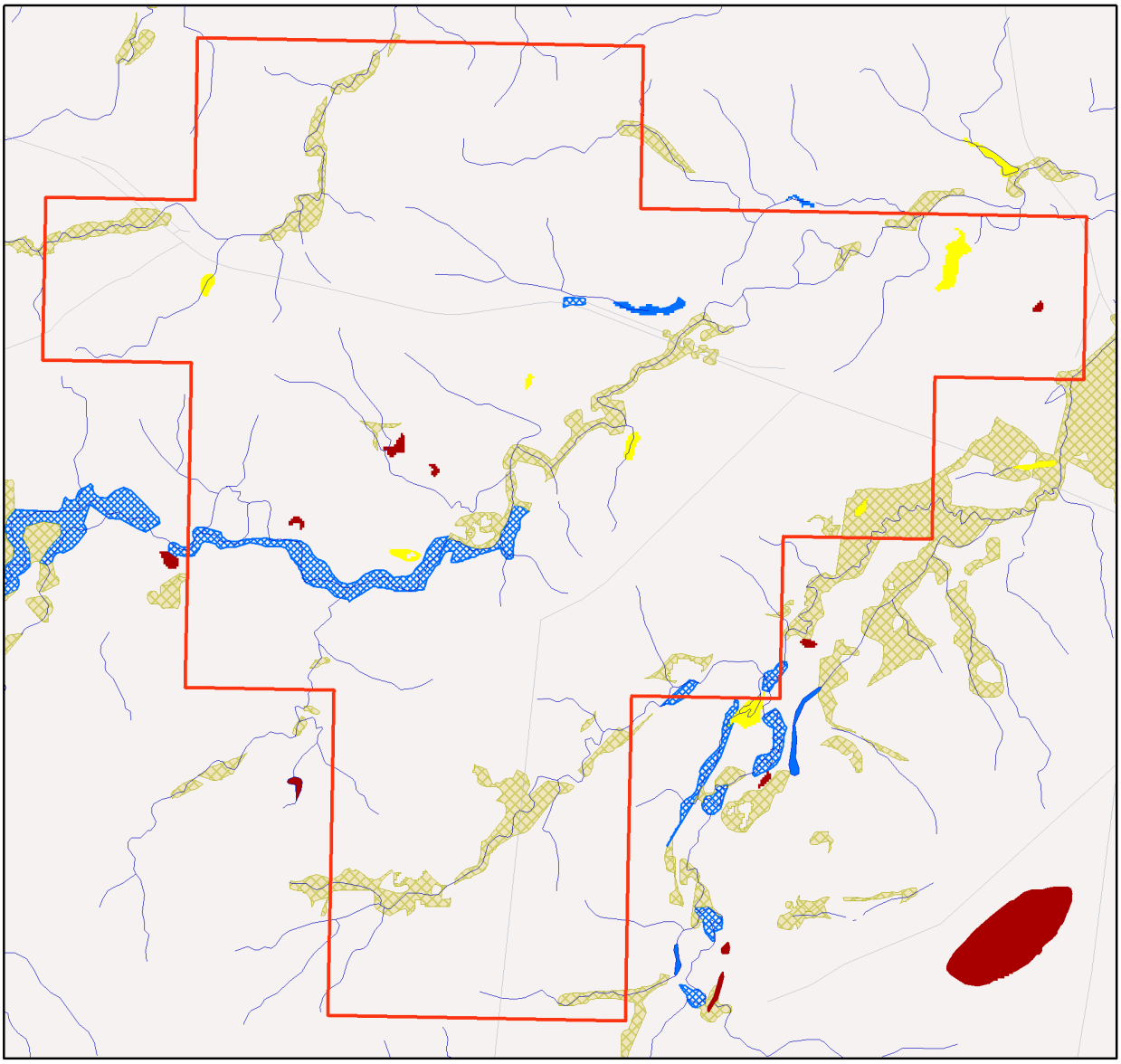
This product is projected into:
GDA 1994 Queensland Albers

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Map 4 - Wetlands and waterways



Wetlands and Waterways

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Roads
- Springs
- Rivers/Creeks
- Directory of Important Wetlands
- Ramsar Sites - QLD
- Queensland

Wetland Type

- Marine Waterbodies
- Estuarine Waterbodies
- Riverine Waterbodies
- Lacustrine Waterbodies
- Palustrine Waterbodies
- Marine RE
- Estuarine RE
- Riverine RE
- Lacustrine RE
- Palustrine RE
- RE 51-80% wetland (mosaic units)
- RE 1-50% wetland (mosaic units)

LOCALITY DIAGRAM

N

0 0.45 0.9 1.35 1.8 2.25 Kilometers

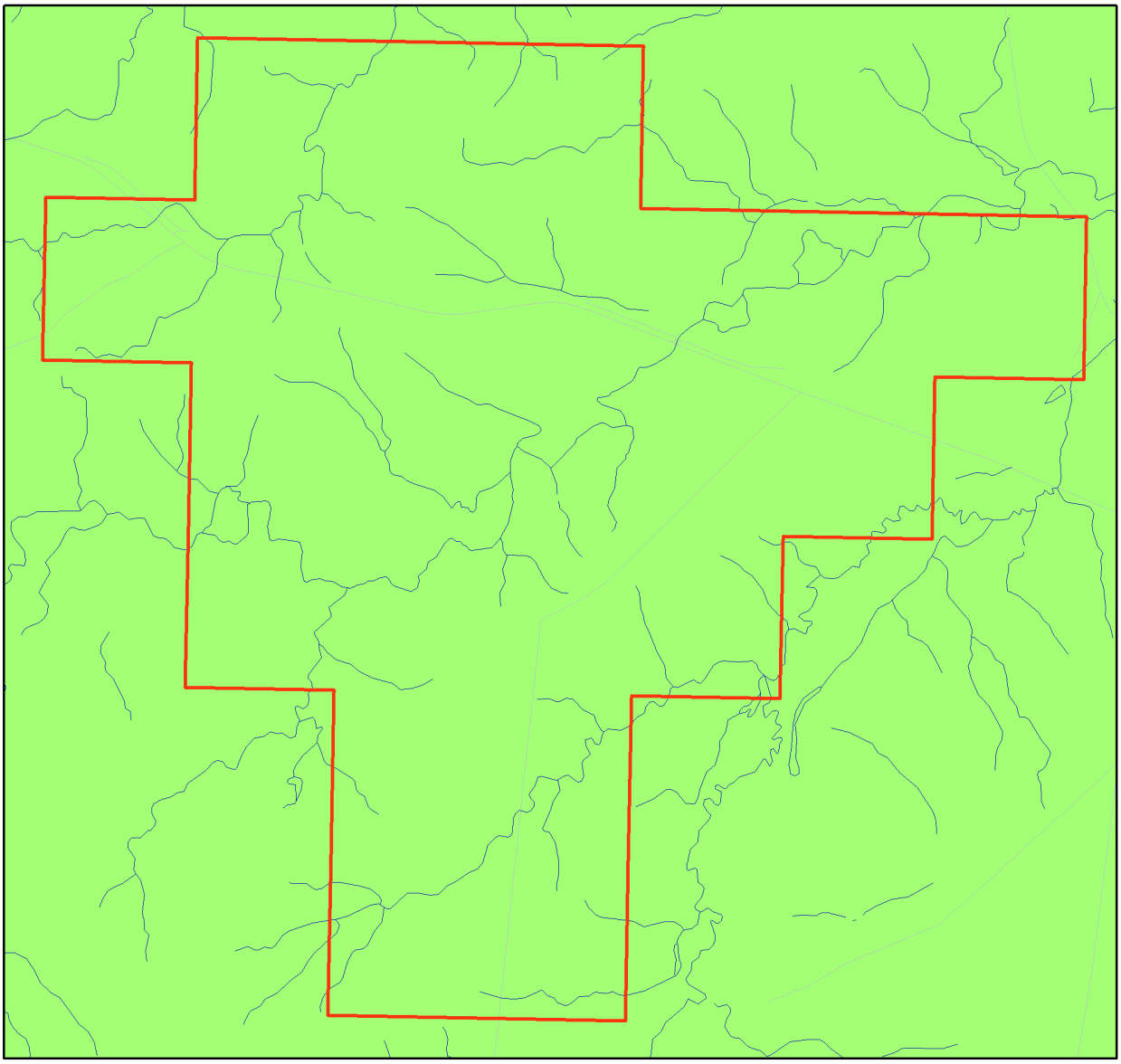
This product is projected into:
GDA 1994 Queensland Albers

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Map 5 - Aquatic Conservation Assessment (ACA) - riverine



Aquatic Conservation Assessment (ACA) - riverine

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Roads
- Rivers/Creeks
- Queensland

ACA Riverine - Subcatchment Significance

- Very High
- High
- Medium
- Low
- Very Low

LOCALITY DIAGRAM

N

0 0.45 0.9 1.35 1.8 2.25 Kilometers

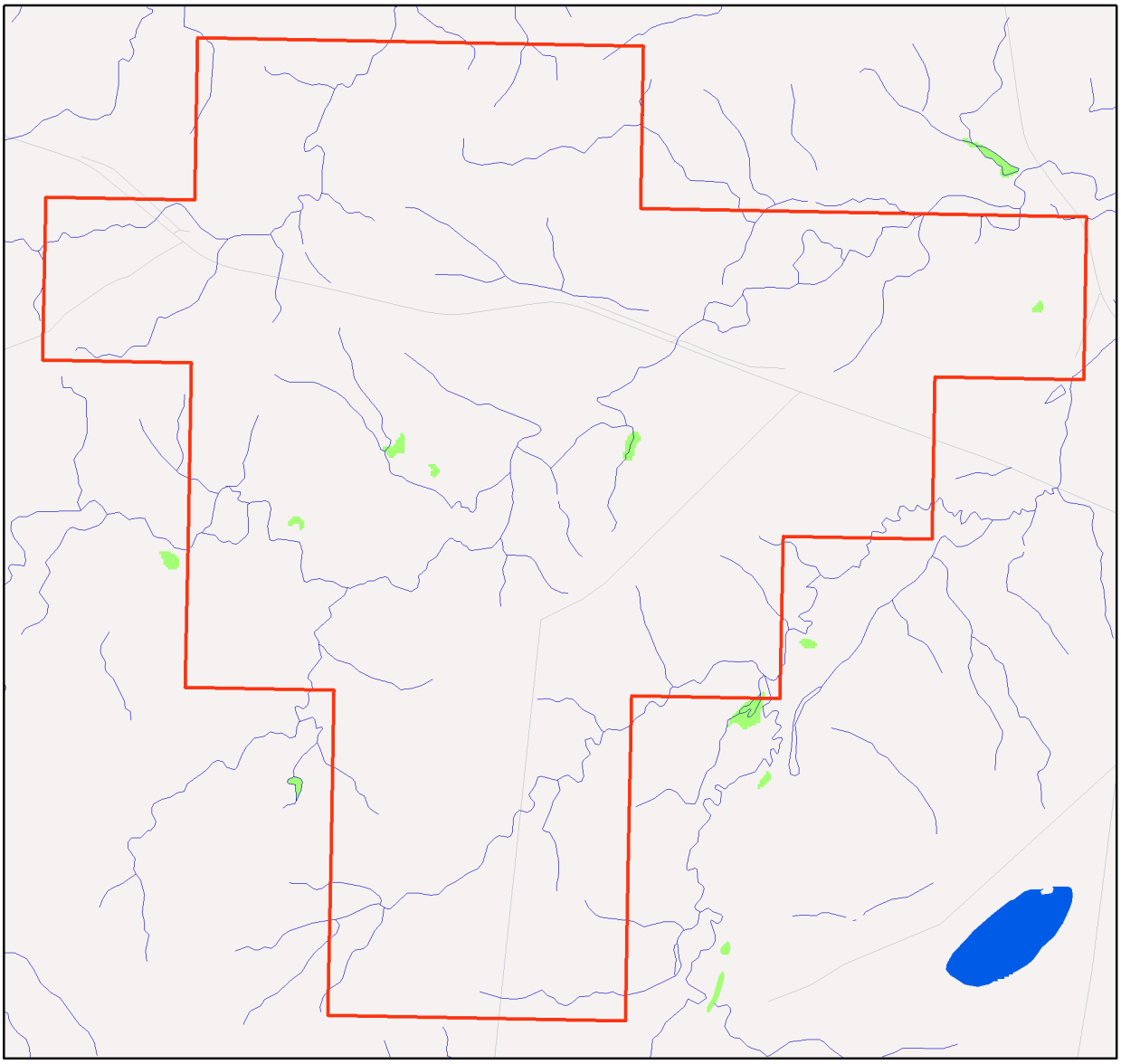
This product is projected into:
GDA 1994 Queensland Albers

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Map 6 - Aquatic Conservation Assessment (ACA) - non-riverine



Aquatic Conservation Assessment (ACA) - nonriverine

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Roads
- Rivers/Creeks
- Queensland

ACA Non-riverine

- Very High
- High
- Medium
- Low
- Very Low

LOCALITY DIAGRAM

N

0 0.45 0.9 1.35 1.8 2.25 Kilometers

This product is projected into:
GDA 1994 Queensland Albers

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

References

Clayton, P.D., Fielder, D.F., Howell, S. and Hill, C.J. (2006) *Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool for wetlands with trial application in the Burnett River catchment.* Published by the Environmental Protection Agency, Brisbane. ISBN 1-90928-07-3. Available at

http://wetlandinfo.ehp.qld.gov.au/wetlands/assessment/assessment-methods/aca/

Environmental Protection Agency (2002) *Biodiversity Assessment and Mapping Methodology. Version 2.1, July 2002.* (Environmental Protection Agency, Brisbane).

Morton, S. R., Short, J. and Barker, R. D. with an Appendix by G.F. Griffin and G. Pearce (1995). *Refugia for Biological Diversity in Arid and Semi-arid Australia. Biodiversity Series*, Paper No. 4, Biodiversity Unit, Environment Australia.

Sattler, P.S. and Williams, R.D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Brisbane.

Appendices

Appendix 1: Source Data

Theme	Datasets
Aquatic Conservation Assessments Non-riverine*	Combination of the following datasets: Cape York Peninsula Non-riverine v1.1 Great Barrier Reef Catchment Non-riverine v1.3 QMDB Non-riverine ACA version 1.4 WBB Non-riverine ACA version 1.1
Aquatic Conservation Assessments Riverine*	Combination of the following datasets: Cape York Peninsula Riverine v1.1 Great Barrier Reef Catchment Riverine v1.1 QMDB Riverine ACA version 1.4 WBB Riverine ACA version 1.1
Biodiversity Planning Assessments*	Combination of the following datasets: Brigalow Belt BPA v1.3 Cape York Peninsula BPA v1.1 Central Queensland Coast BPA v1.3 Channel Country BPA v1.1 Desert Uplands BPA v1.3 Einasleigh Uplands BPA v1.1 Mitchell Grass Downs BPA v1.1 Mulga Lands BPA v1.4 New England Tableland v2.3 Southeast Queensland v3.5
Statewide BPA Corridors*	Statewide corridors v1.1
Threatened Species	An internal DEHP database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.
BPA Priority Species	An internal DEHP database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.
ACA Priority Species	An internal DEHP database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.

***These datasets are available at:**

http://dds.information.qld.gov.au/DDS

Appendix 2 - Acronyms and Abbreviations

AOI	- Area of Interest
ACA	- Aquatic Conservation Assessment
AQUABAMM	- Aquatic Biodiversity Assessment and Mapping Methodology
BAMM	- Biodiversity Assessment and Mapping Methodology
BoT	- Back on Track
BPA	- Biodiversity Planning Assessment
CAMBA	- China-Australia Migratory Bird Agreement
EHP	- Department of Environment and Heritage Protection
EPBC	- *Environment Protection and Biodiversity Conservation Act 1999*
EVNT	- Endangered, Vulnerable, Near Threatened
GDA94	- Geocentric Datum of Australia 1994
GIS	- Geographic Information System
JAMBA	- Japan-Australia Migratory Bird Agreement
NCA	- *Nature Conservation Act 1992*
RE	- Regional Ecosystem
REDD	- Regional Ecosystem Description Database
ROKAMBA	- Republic of Korea-Australia Migratory Bird Agreement

Queensland Government

Department of Environment and Heritage Protection

Environmental Reports

Matters of State Environmental Significance

Area of Interest: epc: 881

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "Central co-ordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Please direct queries about these reports to: Planning.Support@ehp.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

Table of Contents

Assessment Area Details 4
Matters of State Environmental Significance (MSES) 5
MSES Categories 5
MSES Values Present 6
Additional Information with Respect to MSES Values Present 6
Maps 9
Map 1 - Location 9
Map 2 - MSES Criteria 1 - State Conservation Areas 10
Map 3 - MSES Criteria 2 - Wetlands and Waterways 11
Map 4 - MSES Criteria 3 - Species 12
Map 5 - MSES Criteria 4 - Regulated Vegetation 13
Map 6 - MSES Criteria 5 - Offset Areas 14
Map 7 - Matters of State Environmental Significance 15
Appendices 16
Appendix 1 - Matters of State Environmental Significance (MSES) Criteria 16
Appendix 2 - Source Data 17
Appendix 3 - Acronyms and Abbreviations 18

Assessment Area Details

The following table provides an overview of the area of interest (AOI) with respect to selected topographic and environmental values.

Table 1: Summary table, AOI details

Area of Interest	EPC881
Size (ha)	7219.6
Local Government(s)	CENTRAL HIGHLANDS REGIONAL
Bioregion(s)	Brigalow Belt
Subregion(s)	Woorabinda
Catchment(s)	Fitzroy

Refer to **Map 1** for locality information.

Matters of State Environmental Significance (MSES)

MSES Categories

Queensland's State Planning Policy (SPP) includes a biodiversity State interest that states:

'The sustainable, long-term conservation of biodiversity is supported. Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset.'

The MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

The SPP defines matters of state environmental significance as:

- Protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992*;

- Marine parks and land within a 'marine national park', 'conservation park', 'scientific research', 'preservation' or 'buffer' zone under the *Marine Parks Act 2004*;

- Areas within declared fish habitat areas that are management A areas or management B areas under the Fisheries Regulation 2008;

- Threatened wildlife under the *Nature Conservation Act 1992* and special least concern animals under the Nature Conservation (Wildlife) Regulation 2006;

- Regulated vegetation under the *Vegetation Management Act 1999* that is:

  • Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems;

  • Category C areas on the regulated vegetation management map that are 'endangered' or 'of concern' regional ecosystems;

  • Category R areas on the regulated vegetation management map;

  • Regional ecosystems that intersect with watercourses identified on the vegetation management watercourse and drainage feature map;

  • Regional ecosystems that intersect with wetlands identified on the vegetation management wetlands map;

- Strategic Environmental Areas under the *Regional Planning Interests Act 2014*;

- Wetlands in a wetland protection area of wetlands of high ecological significance shown on the Map of Referable Wetlands under the Environmental Protection Regulation 2008;

- Wetlands and watercourses in high ecological value waters defined in the Environmental Protection (Water) Policy 2009, schedule 2;

- Legally secured offset areas.

Refer to **Appendix 1** for a description of MSES categories.

MSES Values Present

The MSES values that are present in the area of interest are summarised in the table below:

Table 2: Summary of MSES present within the AOI

MSES Criteria 1 - STATE CONSERVATION AREAS	3.7 ha	0.1%
1.1 Protected Areas	3.7 ha	0.1%
1.2 Marine Parks	0.0 ha	0.0%
1.3 Fish Habitat Areas	0.0 ha	0.0%
MSES Criteria 2 - WETLANDS AND WATERWAYS - area features	0.0 ha	0.0%
MSES Criteria 2 - WETLANDS AND WATERWAYS - linear features	0.0 km	Not applicable
2.1 High Ecological Significance wetlands on the map of Referable Wetlands	0.0 ha	0.0%
2.2 High Ecological Value (HEV) wetlands	0.0 ha	0.0%
2.2 High Ecological Value (HEV) waterways **	0.0 km	Not applicable
2.3 Strategic Environmental Areas (SEA)	0.0 ha	0.0%
MSES Criteria 3 - SPECIES	0.0 ha	0.0%
3.1 Threatened species and Iconic species	0.0 ha	0.0%
MSES Criteria 4 - REGULATED VEGETATION - area features	252.2 ha	3.5%
MSES Criteria 4 - REGULATED VEGETATION - linear features	81.4 km	Not applicable
4.1 Vegetation Management Regional Ecosystems and Remnant Map *	252.2 ha	3.5%
4.2 Vegetation Management Wetland Map *	0.0 ha	0.0%
4.3 Vegetation Management Watercourse Map **	81.4 km	Not applicable
MSES Criteria 5 - OFFSET AREAS	0.0 ha	0.0%
5.1 Legally secured offset areas	0.0 ha	0.0%
Total MSES (criteria 1.1, 1.2, 1.3, 2.1, part of 2.2, 2.3, 3.1, 4.1, 4.2 and 5.1) calculated for area features only	255.9 ha	3.5%

Please note that the area and percent area figures in the table above will not necessarily add up to the "Total MSES" figures due to overlapping values.

**The total extent area of regulated vegetation (Criteria 4.1) may be overestimated due to the presence of dominant and/or subdominant non-regulated regional ecosystems in mixed patches of vegetation, i.e. the total area of mixed vegetated patches is included irrespective of whether the patch consists only partly of endangered, of concern or wetland regional ecosystems.*

***The total linear extent of watercourses may be overestimated in some instances, as both banks (rather than the centreline) of waterbodies and larger watercourses where present are mapped by the State, increasing the extent of linear features*.

Additional Information with Respect to MSES Values Present

Criteria 1 - State Conservation Areas

1.1 Protected Areas

Protected Area Names
Taunton National Park

1.2 Marine Parks

(no results)

1.3 Fish Habitat Areas

(no results)

Refer to **Map 2 - MSES Criteria 1 - State Conservation Areas** for an overview of the relevant MSES.

Criteria 2 - Wetlands and Waterways

2.1 High Ecological Significance wetlands on the Map of Referable Wetlands

(no results)

2.2 High Ecological Value (HEV) wetlands

(no results)

2.2 High Ecological Value (HEV) waterways

(no results)

2.3 Strategic Environmental Areas

(no results)

Refer to **Map 3 - MSES Criteria 2 - Wetlands and Waterways** for an overview of the relevant MSES.

Criteria 3 - Species

3.1 Threatened species and Iconic species

Threatened and/or iconic species habitat within the AOI (derived from records/essential habitat mapping)

(no results)

**NCA E or V - Endangered or Vulnerable status under the NCA; VMA ehab - VMA essential habitat; Iconic - Iconic species.*

To request a species list for an area, or search for a species profile, access Wildlife Online at:
https://www.qld.gov.au/environment/plants-animals/species-list/

Koala bushland habitat

(no results)

Dugong areas

(no results)

Refer to **Map 4 - MSES Criteria 3 - Species** for an overview of the relevant MSES.

Criteria 4 - Regulated Vegetation

4.1 Endangered and Of Concern regional ecosystems and Category R Regulated Vegetation

Regulated Vegetation Description	Regional Ecosystem Patch	VMA status
rem_oc	11.3.2/11.3.25	O-dom
hvr_end	11.3.1/11.3.2/11.3.25	E-dom
rem_end	11.3.2/11.3.25/11.3.1	E-subdom
rem_oc	11.3.2	O-dom
rem_end	11.3.25/11.3.1	E-subdom

For further information relating to regional ecosystems in general, go to:
https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/
For a more detailed description of a particular regional ecosystem, access the regional ecosystem search page at:
https://environment.ehp.qld.gov.au/regional-ecosystems/

4.2 Vegetation Management Wetlands

(no results)

Wetlands datasource

Not applicable

4.3 Watercourses shown on the Vegetation Management Watercourse and Drainage Feature Map

A vegetation management watercourse is mapped as present

Watercourses datasource

Vegetation Management Watercourse Map

Refer to **Map 5 - MSES Criteria 4 - Regulated Vegetation** for an overview of the relevant MSES.

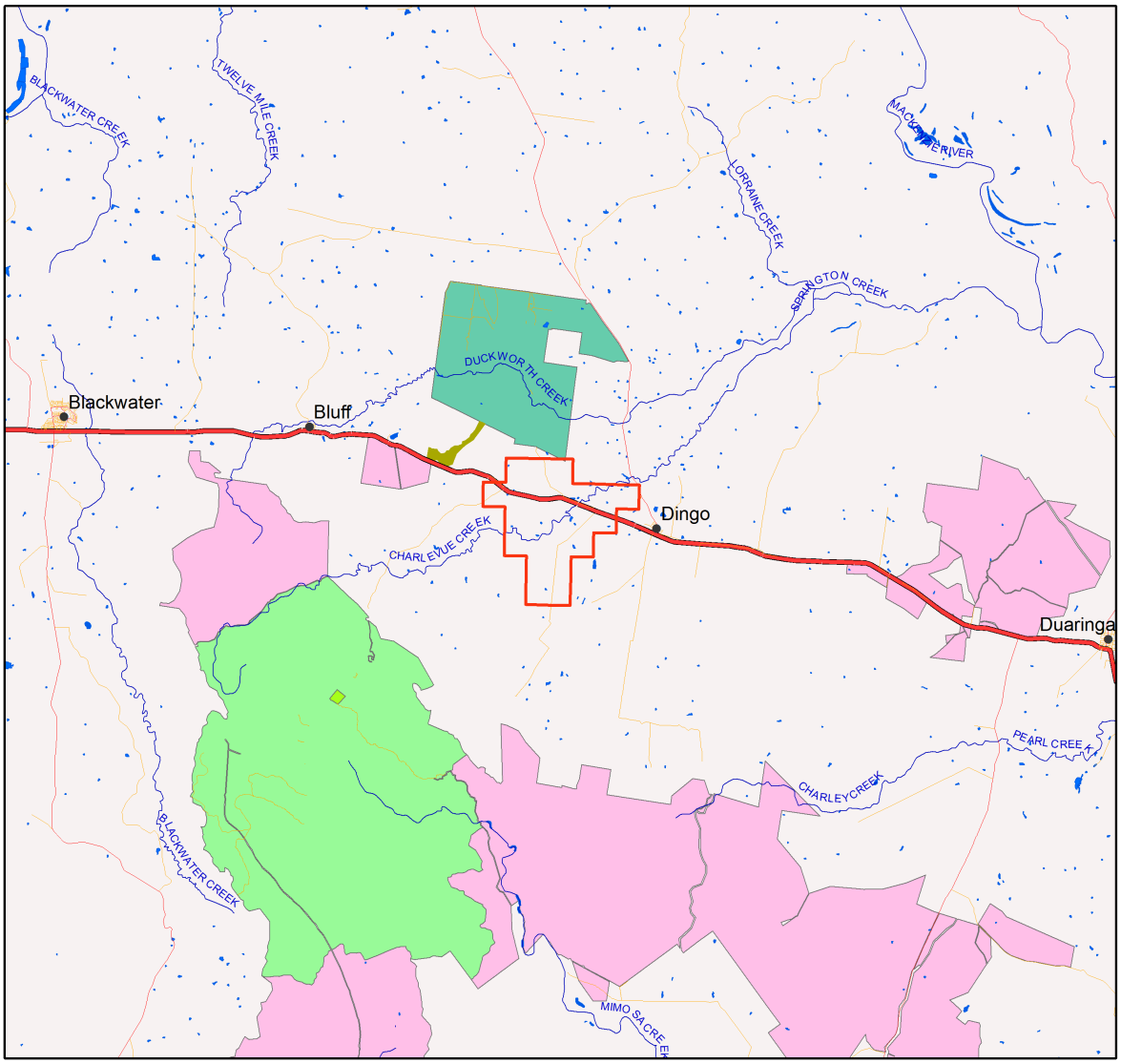
Criteria 5 - Offset Areas

5.1 Legally secured offset areas

(no results)

Refer to **Map 6 - MSES Criteria 5 - Offset Areas** for an overview of the relevant MSES.

Maps
Map 1 - Location



Locality Map

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Highway
- Connector
- Street/Local Road
- National Park (Scientific)
- National Park
- National Park (CYPAL)
- Conservation Park
- Resources Reserve
- Forest Reserve
- State Forest
- Timber Reserve
- Nature Refuges
- Lakes and Reservoirs
- Major rivers/creeks
- Queensland

N

0 2.5 5 7.5 10 12.5 Kilometers

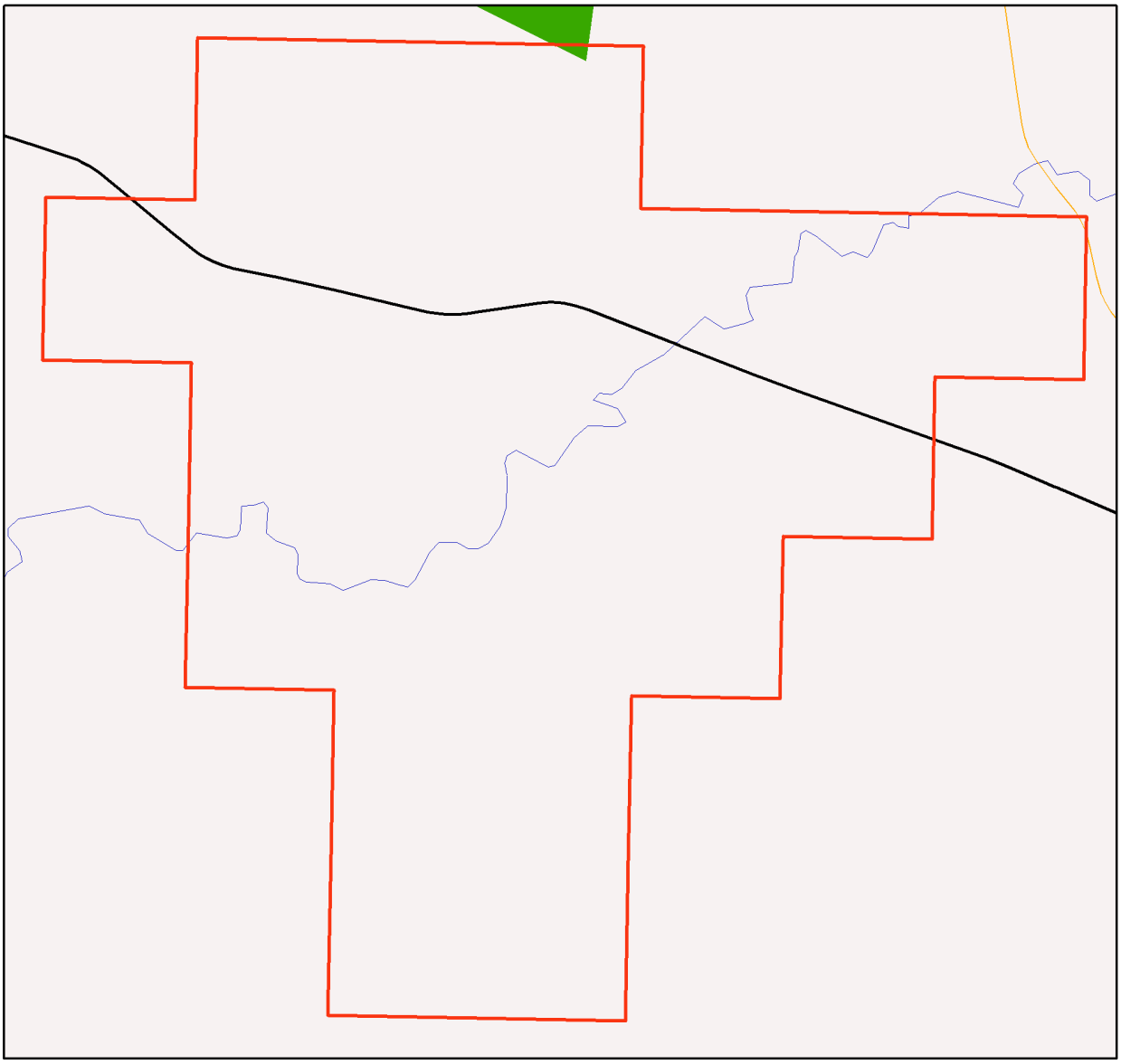
This product is projected into:
GDA 1994 Queensland Albers

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Map 2 - MSES Criteria 1 - State Conservation Areas



MSES Criteria 1- State Conservation Areas

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- MSES Protected area
- MSES Declared fish habitat area
- MSES Marine park

N

0 0.5 1 1.5 2 2.5 Kilometers

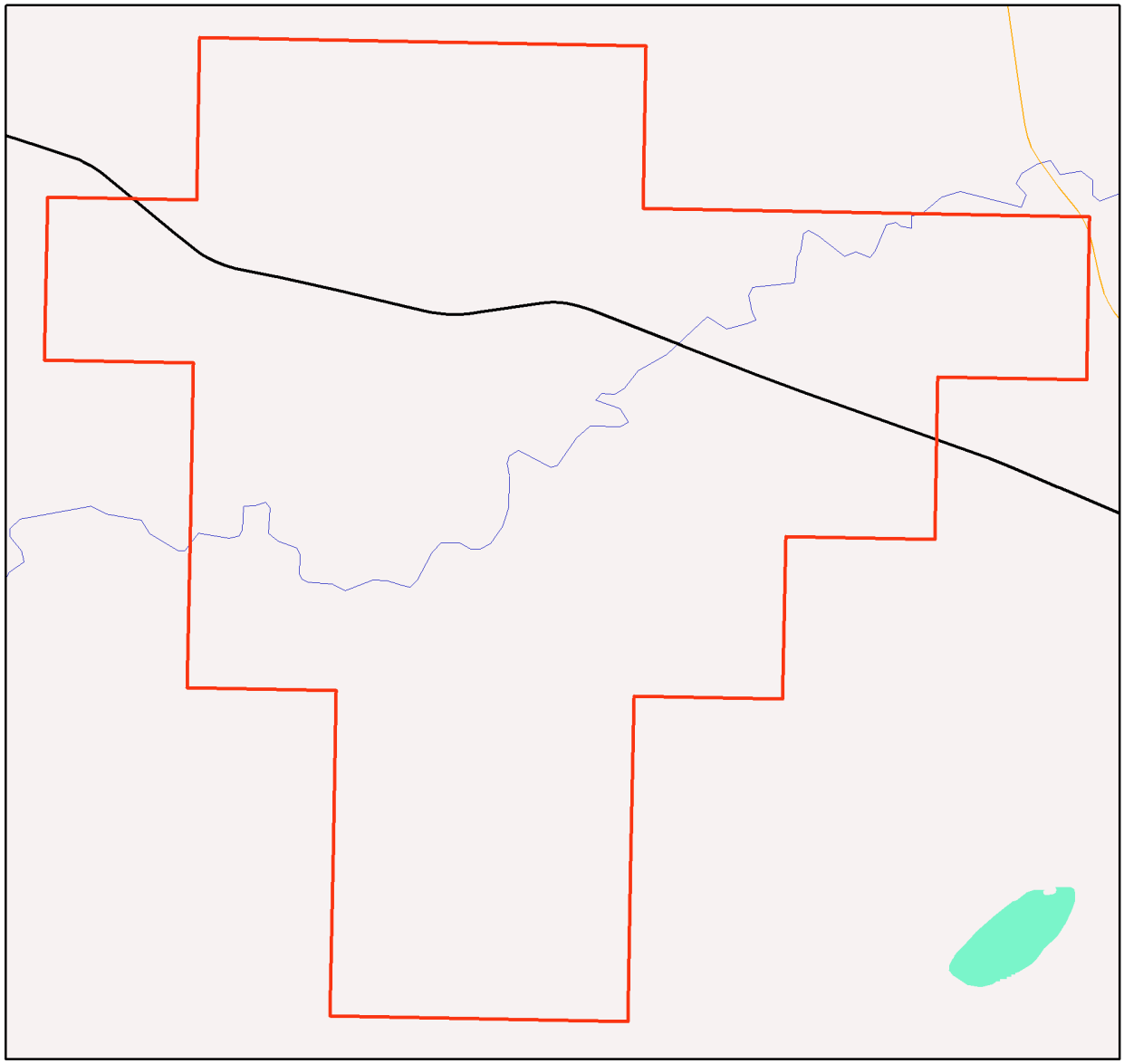
This product is projected into:
GDA 1994 Queensland Albers

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Map 3 - MSES Criteria 2 - Wetlands and Waterways



MSES Criteria 2 - Wetlands and Waterways

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- MSES - High ecological value waters (watercourses)
- MSES - Strategic environmental area (designated precinct)
- MSES - High ecological value waters (wetland)
- MSES - High ecological significance wetlands

N

0 0.5 1 1.5 2 2.5 Kilometers

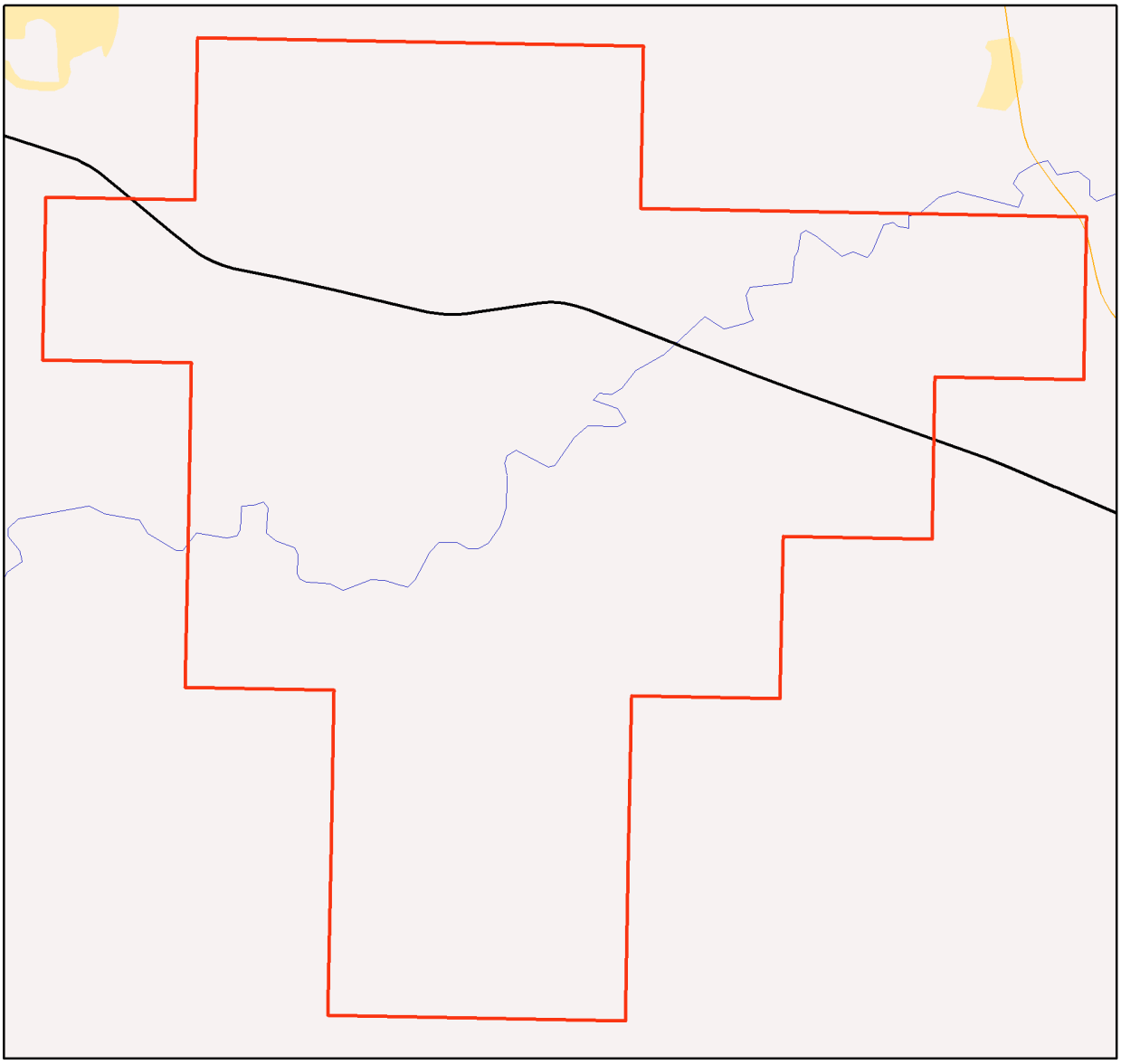
This product is projected into:
GDA 1994 Queensland Albers

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the state of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Map 4 - MSES Criteria 3 - Species



MSES Criteria 3 - Species

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- MSES - Wildlife habitat

N

0 0.5 1 1.5 2 2.5 Kilometers

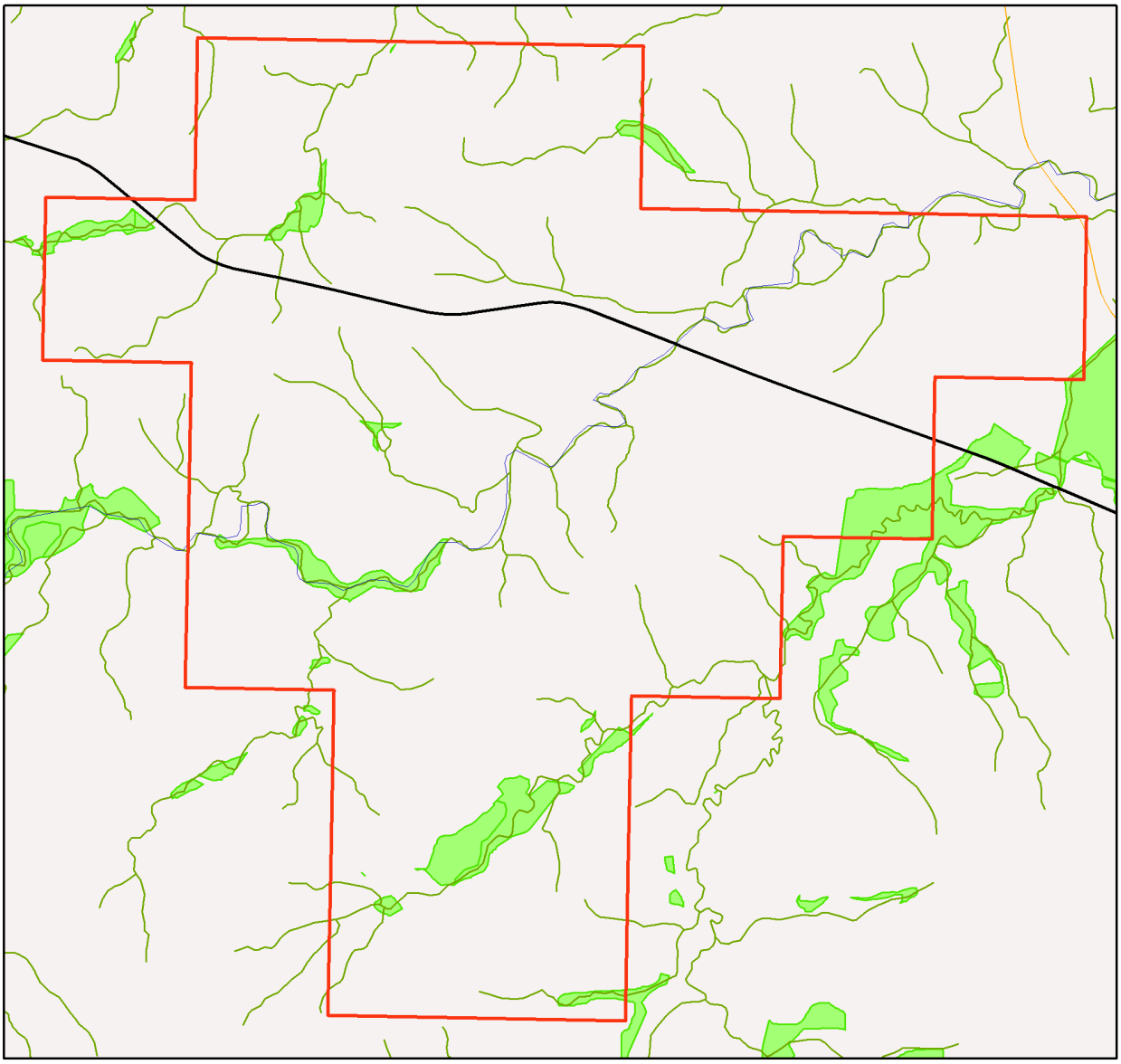
This product is projected into:
GDA 1994 Queensland Albers

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the state of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Map 5 - MSES Criteria 4 - Regulated Vegetation



MSES Criteria 4 - Regulated Vegetation

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- MSES - Regulated vegetation (intersecting a watercourse)
- MSES - Regulated vegetation

N

0 0.5 1 1.5 2 2.5 Kilometers

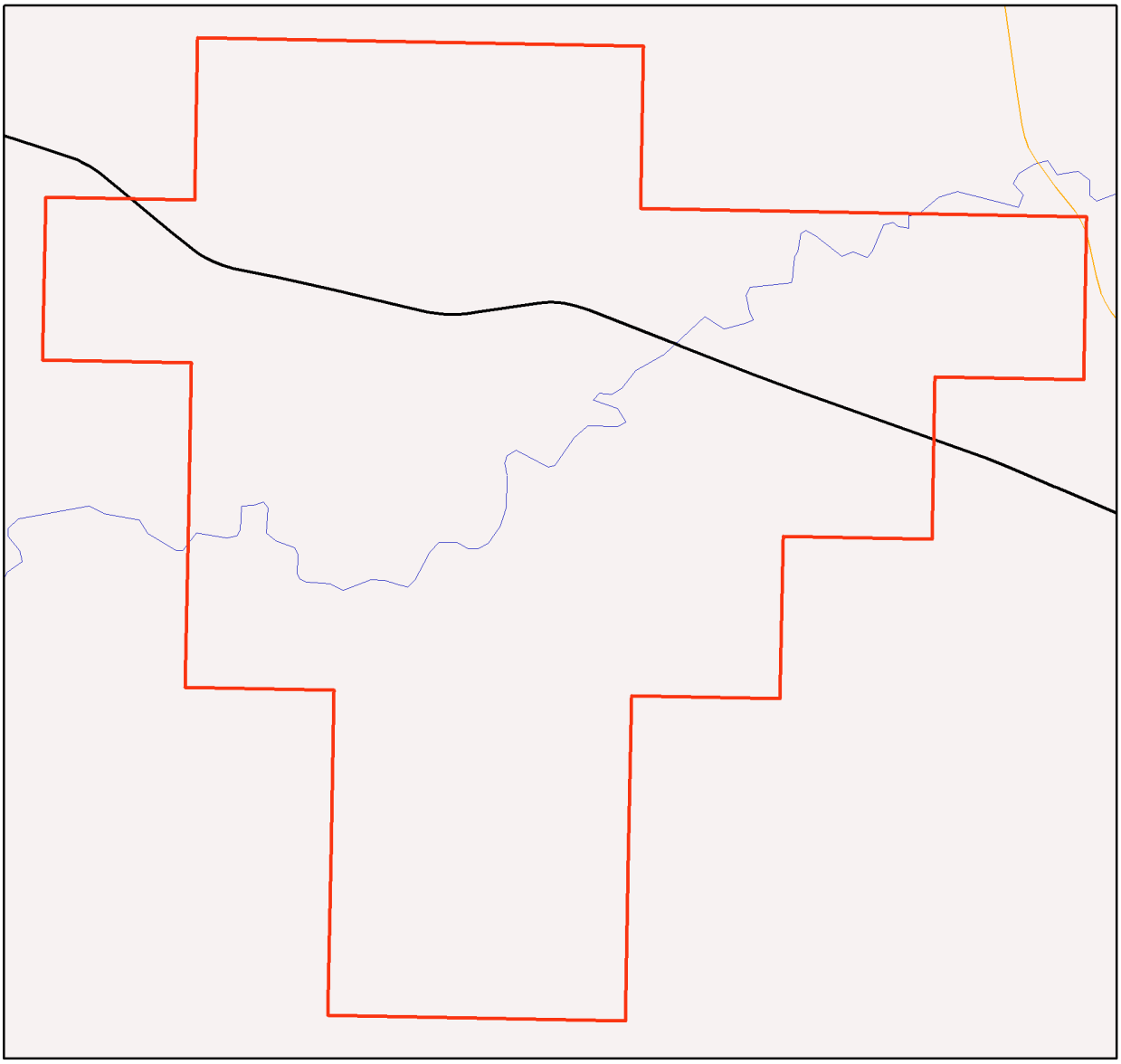
This product is projected into:
GDA 1994 Queensland Albers

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the state of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Map 6 - MSES Criteria 5 - Offset Areas



MSES Criteria 5 - Offset Areas

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- MSES - Legally secured offset area

N

0 0.5 1 1.5 2 2.5 Kilometers

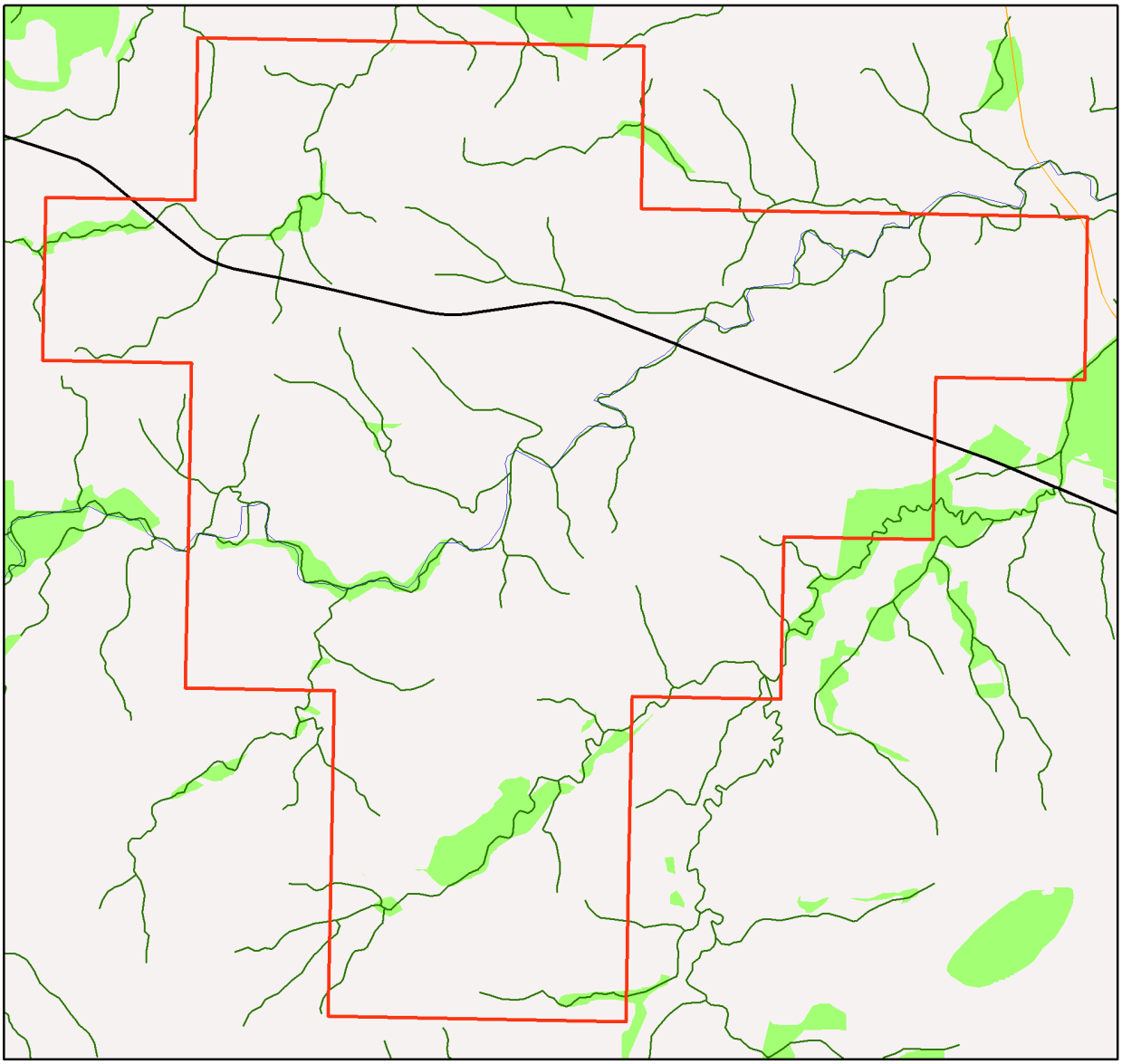
This product is projected into:
GDA 1994 Queensland Albers

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Disclaimer
Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Map 7 - Matters of State Environmental Significance



Matters of State Environmental Significance

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Matters of State Environmental Significance (watercourses)
- Matters of State Environmental Significance (areas)

LOCALITY DIAGRAM

N

0 0.35 0.7 1.05 1.4 1.75 Kilometers

This product is projected into:
GDA 1994 Queensland Albers

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Disclaimer
Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

Appendices

Appendix 1 - Matters of State Environmental Significance (MSES) Criteria

Feature Name	Description
1.1 Protected Areas (NCA)	Protected areas under the *Nature Conservation Act 1992*, except coordinated conservation areas.
1.2 Marine Parks (MPA)	The following State marine parks zones under the *Marine Parks Act 2004*: - Marine National Park zone; - Marine Conservation Park zone; - Scientific Research zone; - Preservation zone; - Buffer zone.
1.3 Fish Habitat Areas (FA)	The following areas under the *Fisheries Act 1994* including: All fish habitat areas.
2.1 'High Ecological Significance' wetlands on the Map of Referable Wetlands	All natural wetlands that are 'High Ecological Significance' (HES) on the Map of Referable Wetlands. Exclude: any amendments to the Map of Referable Wetlands.
2.2 High Ecological Value (HEV) wetlands and waterways (EP Act)	Natural wetlands and waterways that occur in HEV (maintain) freshwater and estuarine areas under the Environmental Protection (Water) Policy.
2.3 Strategic Environmental Areas (RPI Act)	Designated precinct areas under the *Regional Planning Interests Act 2014*.
3.1 Threatened species and Iconic species (NCA)	Habitat for: Threatened wildlife under *Nature Conservation Act 1992* including: 'Endangered' and 'Vulnerable' species. Special least concern animals under the *Nature Conservation Act 1992* including: Koala (outside SEQ); Echidna and Platypus.
4.1 Vegetation Management Regional Ecosystem and Remnant Map (VMA)	Include VMA 'Endangered' and 'Of Concern' remnant (Category A and B) and high value regrowth (Category C) REs and Category R (GBR regrowth watercourse) areas from the Regulated Vegetation Management Map.
4.2 Vegetation Management Wetland Map (VMA)	Wetlands that are lakes and swamps shown on the Vegetation Management Wetlands Map.
4.3 Vegetation Management Watercourse and Drainage Feature Map (VMA)	Watercourses shown on the Vegetation Management Watercourse and Drainage Feature Map.
5.1 Legally secured offset areas (VMA, EP Act, SPA, TIA, EA)	Offset areas legally secured under a covenant, conservation agreement or development approval condition.

The Queensland Government's "Method for mapping - matters of state environmental significance for use in land use planning and development assessment" can be downloaded from:

http://www.ehp.qld.gov.au/land/natural-resource/method-mapping-mses.html.

Appendix 2 - Source Data

The datasets listed below are available on request from:

http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

- Matters of State environmental significance
- Matters of State environmental significance drainage lines
- Boundaries of the Great Barrier Reef Marine Park

Note: MSES mapping is a regional-scale representation of the definition for MSES under the State Planning Policy (SPP). The compiled MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

MSES mapping is not based on new or unique data. The primary mapping product draws data from a number of underlying environment databases and geo-referenced information sources. MSES mapping is a versioned product that is updated generally on a twice-yearly basis to incorporate the changes to underlying data sources. Several components of MSES mapping made for the current version may differ from the current underlying data sources. To ensure accuracy, or proper representation of MSES values, it is strongly recommended that users refer to the underlying data sources and review the current definition of MSES in the State Planning Policy, before applying the MSES mapping.

Underlying data sources used to develop individual releases of complied MSES mapping include, but are not limited to:

- Regulated vegetation including:
  - Regulated Regional Ecosystems and Regrowth
  - Regulated Essential habitat
  - Regulated Wetlands
  - Regulated Watercourses and Drainage
  - Former Regrowth

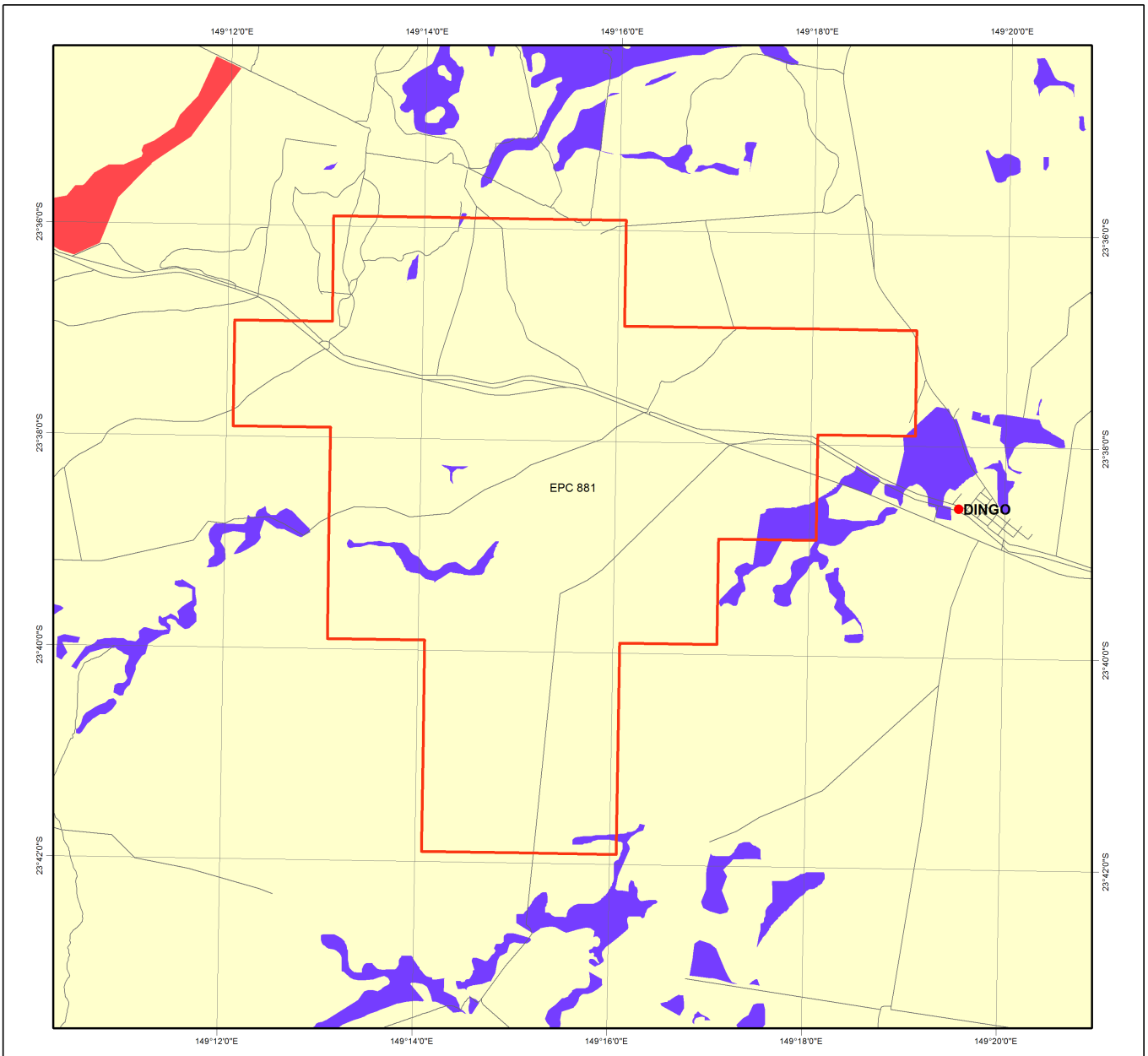
- Queensland Wetland Mapping (v3)
- Essential Habitat Mapping
- Protected Areas
- Marine Parks
- Fish Habitat Areas
- Strategic Environmental Areas
- The Map of Referable Wetlands:
  - Wetland Protection Areas (HES wetlands in the GBR)
  - Wetland Management Areas (contains other HES wetlands)

Datasets reflective of the above matters can be downloaded via the Queensland Spatial Catalogue:

http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

Appendix 3 - Acronyms and Abbreviations

AOI	- Area of Interest
EHP	- Department of Environment and Heritage Protection
EP Act	- *Environmental Protection Act 1994*
EPP	- Environmental Protection Policy
GDA94	- Geocentric Datum of Australia 1994
GEM	- General Environmental Matters
GIS	- Geographic Information System
MSES	- Matters of State Environmental Significance
NCA	- *Nature Conservation Act 1992*
RE	- Regional Ecosystem
SPP	- State Planning Policy
VMA	- *Vegetation Management Act 1999*



ENVIRONMENTALLY SENSITIVE AREAS - Mining Activities

- Selected Exploration Permit Coal (EPC)

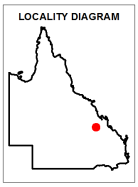
CATEGORY A
- National Parks
- Conservation Parks
- Forest Reserves
- Wet Tropics World Heritage Area
- Great Barrier Reef Marine Park Area
- Marine Parks other than General Use Zones

CATEGORY B
- World Heritage Areas
- Queensland Heritage Register Places
- Ramsar Sites
- Cultural Heritage Registered Areas and DLA's other than Stanbroke
- Special Forestry Areas
- Fish Habitat Areas
- Koala Plan
- Coordinated Conservation Areas
- Endangered Regional Ecosystems (Biodiversity Status)
- Marine Parks other than General Use Zones
- Marine Plants

CATEGORY C
- Nature Refuges
- Resources Reserve
- State Forests
- Timber Reserves
- Declared Catchment Areas
- Declared Irrigation Areas
- Drainage Areas
- River Improvement Areas
- Stanbroke DLA
- Coastal Management District
- Dams and Weirs

OTHERS
- Towns
- Roads
- Repealed Wild River Nominated Waterways
- Repealed Wild River Preservation Areas
- Repealed Wild River High Preservation Areas
- Mahogany Glider Habitat
- Directory of Important Wetlands
- Queensland

LOCALITY DIAGRAM



N

0 990 1,980 2,970 3,960 4,950 m

This product is projected into GDA 1994 MGA Zone 55

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, The State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The State of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or ncomplete in any way for any reason.

External contributors (non-government parties) of the data for this product are: Great Barrier Reef Marine Park Authority

Regional ecosystem mapping (remnant biodiversity status) may incorporate amendments, resulting from property level assessments, to the release version of the mapping available on QSpatial.

NOTE TO USER: Themes presented in this map are indicative only. Field survey may be required to verify the 'true' spatial extent and value. Not all environmentally sensitive areas are presented in this map. A user should refer to the particular circumstances relevant to their situation to assess the 'completeness' of themes provided.

The user should note that some boundaries and indicated values are ambient and may change over time (e.g. regional ecosystem boundaries and conservation status, watercourse mapping etc).

The user should be aware that due to multiple overlapping themes/ layers present, some themes/layers may be obscured by others. Ordering in the Legend does not accurately reflect the order by which themes/layers are displayed.

© The State of Queensland, 2017

Queensland Government

Queensland Government

Department of Environment and Heritage Protection

Environmental Reports

Regional Ecosystems

Biodiversity Status

Area of Interest: epc: 881

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "Central co-ordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the input coordinates.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no matters of interest have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Important Note to User

Information presented in this report is based upon the Queensland Herbarium's Regional Ecosystem framework. The Biodiversity Status has been used to depict the extent of "Endangered", "Of Concern" and "No Concern at Present" regional ecosystems in all cases, rather than the status used for the purposes of the *Vegetation Management Act 1999* (VMA). Mapping and figures presented in this document reflect the Queensland Herbarium's Remnant and Pre-clearing Regional Ecosystem Datasets, and not the certified mapping used for the purpose of the VMA.

For matters relevant to vegetation management under the VMA, please refer to the Department of Natural Resources and Mines website

https://www.dnrm.qld.gov.au/

Please direct queries about these reports to: Queensland.Herbarium@dsitia.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

Table of Contents

Summary Information 4
Regional Ecosystems 5
1. Introduction 5
2. Remnant Regional Ecosystems 6
3. Remnant Regional Ecosystems by Broad Vegetation Group 7
4. Technical and BioCondition Benchmark Descriptions 8
Maps 10
Map 1 - Location 10
Map 2 - Remnant regional ecosystems 11
Map 3 - Pre-clearing remnant regional ecosystems 12
Map 4 - Remnant regional ecosystems by BVG (5M) 13
Map 5 - Pre-clearing remnant regional ecosystems by BVG (5M) 14
Map 6 - Wetlands and waterways 15
Links and Other Information Sources 16
References 16
Appendices 17
Appendix 1: Source Data 17
Appendix 2 - Acronyms and Abbreviations 18

Summary Information

The following table provides an overview of the AOI with respect to selected topographic and environmental themes. Refer to **Map 1** for locality information.

Table 1: Area of interest details

Area of Interest	EPC881
Size (ha)	7219.6
Local Government(s)	CENTRAL HIGHLANDS REGIONAL
Bioregion(s)	Brigalow Belt
Subregion(s)	Woorabinda
Catchment(s)	Fitzroy

The table below summarizes the extent of remnant vegetation classed as "Endangered", "Of concern" and "No concern at present" classified by Biodiversity Status within the area of interest (AOI).

Table 2: Summary table, biodiversity status of regional ecosystems within the AOI

Biodiversity Status	Area (Ha)	% of AOI
Endangered	6.4	0.1
Of concern	237.5	3.3
No concern at present	1842.1	25.5
Total remnant vegetation	2086.0	28.9

Refer to **Map 2** for further information.

Regional Ecosystems

1. Introduction

Regional ecosystems are vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. Descriptions of Queensland's Regional ecosystems are available online from the Regional Ecosystem Description Database (REDD). Descriptions are compiled from a broad range of information sources including vegetation, land system and geology survey and mapping and detailed vegetation site data. The regional ecosystem is regularly reviewed as new information becomes available. A number of vegetation communities may form a single regional ecosystem and are usually distinguished by differences in dominant species, frequently in the shrub or ground layers and are denoted by a letter following the regional ecosystem code (e.g. a, b, c).

The Queensland Herbarium has developed a methodology for mapping regional ecosystems across Queensland. As new information is obtained, the descriptions and status of regional ecosystems is updated. Regional ecosystems and broad vegetation groups descriptions in the format of Sattler and Williams (1999) are maintained in the Regional Ecosystem Description Database (REDD). Vegetation communities and regional ecosystems are amalgamated into the higher level classification of broad vegetation groups (BVGs).

This report provides information on the type, status, and extent of vegetation communities, regional ecosystems and broad vegetation groups present within a user specified area of interest. Please note, for the purpose of this report, the Biodiversity Status is used. This report has not been developed for application of matters relevant to the *Vegetation Management Act 1999* (VMA). Additionally, information generated in this report has been derived from the Queensland Herbarium's Regional Ecosystem Mapping, and not mapping certified for the purposes of the VMA. If your interest/matter relates to regional ecosystems and the VMA, users should refer to the Department of Natural Resources and Mines website.

https://www.dnrm.qld.gov.au/

With respect to the Queensland Biodiversity Status,

"Endangered" regional ecosystems are described as those where:

- remnant vegetation is less than 10 per cent of its pre-clearing extent across the bioregion; or 10-30% of its pre-clearing extent remains and the remnant vegetation is less than 10,000 hectares, or
- less than 10 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss*, or
- 10-30 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss and the remnant vegetation is less than 10,000 hectares; or
- it is a rare** regional ecosystem subject to a threatening process.***

"Of concern" regional ecosystems are described as those where:

- the degradation criteria listed above for 'Endangered' regional ecosystems are not met and,
- remnant vegetation is 10-30 per cent of its pre-clearing extent across the bioregion; or more than 20 per cent of its pre-clearing extent remains and the remnant extent is less than 10,000 hectares, or
- 10-30 percent of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss.****

and "No concern at present" regional ecosystems are described as those where:

- remnant vegetation is over 30 per cent of its pre-clearing extent across the bioregion, and the remnant area is greater than 10,000 hectares, and
- the degradation criteria listed above for 'Endangered' or 'Of concern' regional ecosystems are not met.

**Severe degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 50 years even with the removal of threatening processes; or soil surface is severely degraded, for example, by loss of A horizon, surface expression of salinity; surface compaction, loss of organic matter or sheet erosion.*

***Rare regional ecosystem: pre-clearing extent (1000 ha); or patch size (100 ha and of limited total extent across its range).*

****Threatening processes are those that are reducing or will reduce the biodiversity and ecological integrity of a regional ecosystem. For example, clearing, weed invasion, fragmentation, inappropriate fire regime or grazing pressure, or infrastructure development.*

*****Moderate degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 20 years even with the removal of threatening processes; or soil surface is moderately degraded.*

2. Remnant Regional Ecosystems

The following table identifies the remnant regional ecosystems and vegetation communities mapped within the AOI, the associated short description, Biodiversity Status using the Queensland Herbarium's framework and the extent area present within the selected AOI. Please note, where heterogeneous vegetated patches (mixed patches of remnant vegetation mapped as containing multiple regional ecosystems) occur within the AOI, they have been split and listed as individual regional ecosystems (or vegetation communities where present) for the purposes of the table below. In such instances, associated area figures have been generated based upon the estimated proportion of each regional ecosystem (or vegetation community) predicted to be present within the larger mixed patch.

Table 3: Remnant regional ecosystems, description and status within the AOI

Regional Ecosystem	Short Description	BD Status	Area (Ha)	% of AOI
11.3.1	Acacia harpophylla and/or Casuarina cristata open forest on alluvial plains	Endangered	6.4	0.1
11.3.2	Eucalyptus populnea woodland on alluvial plains	Of concern	125.3	1.7
11.3.25	Eucalyptus tereticornis or E. camaldulensis woodland fringing drainage lines	Of concern	112.1	1.6
11.5.2	Eucalyptus crebra, Corymbia spp., with E. moluccana woodland on lower slopes of Cainozoic sand plains and/or remnant surfaces	No concern at present	1004.5	13.9
11.5.9b	Eucalyptus crebra and other Eucalyptus spp. and Corymbia spp. woodland on Cainozoic sand plains and/or remnant surfaces	No concern at present	142.9	2.0
11.7.2	Acacia spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone	No concern at present	694.7	9.6
non-rem	None	None	5133.6	71.1

Refer to **Map 2** for further information. **Map 3** also provides a visual estimate of the distribution of regional ecosystems present before European settlement.

Table 4 provides further information in regards to the remnant regional ecosystems present within the site with respect to the extent of remnant vegetation remaining within the bioregion, the 1:1,000,000 broad vegetation group (BVG) classification, whether the regional ecosystem is identified as a wetland, and extent of representation in Queensland's Protected Area Estate. For a description of the vegetation communities within the AOI and classified according to the 1:1,000,000 BVG, refer to **Table 6**.

Table 4: Remnant regional ecosystems within the AOI, additional information

Regional Ecosystem	Remnant Extent	BVG (1 Million)	Wetland	Representation in protected estate
11.3.1	In 2013, remnant extent was > 10,000 ha and 10-30% of the pre-clearing area remained	25a	None	Low
11.3.2	In 2013, remnant extent was > 10,000 ha and 10-30% of the pre-clearing area remained	17a	Contains palustrine wetland (e.g. in swales).	Low

Regional Ecosystem	Remnant Extent	BVG (1 Million)	Wetland	Representation in protected estate
11.3.25	In 2013, remnant extent was > 10,000 ha and >30% of the pre-clearing area remained	16a	Riverine wetland or fringing riverine wetland.	Low
11.5.2	In 2013, remnant extent was > 10,000 ha and >30% of the pre-clearing area remained	18b	None	Low
11.5.9b	In 2013, remnant extent was > 10,000 ha and >30% of the pre-clearing area remained	18b	None	Low
11.7.2	In 2013, remnant extent was > 10,000 ha and >30% of the pre-clearing area remained	24a	None	Low
non-rem	None	None	None	None

Representation in Protected Area Estate: High greater than 10% of pre-clearing extent is represented; Medium 4 - 10% is represented; Low less than 4% is represented, No representation.

Map 6 displays the distribution of mapped wetland systems within the area of interest.

The following table lists known special values associated with a regional ecosystem type.

Table 5: Remnant regional ecosystems within the AOI, special values

Regional Ecosystem	Special Values
11.3.1	Habitat for threatened fauna species including painted honeyeater, Grantiella picta particularly in subregion 35 (Oliver et al. 2003).
11.3.2	Habitat for threatened flora species Homopholis belsonii.
11.3.25	Habitat for threatened flora species including Eucalyptus raveretiana. Shown to be associated with a high fauna species richness in the Taroom area (Venz et al. 2002). Within parts of the Fitzroy catchment, this RE is known habitat for the threatened freshwater turtle Rheodytes leukops. Known to be important habitat for other riparian freshwater turtle species.
11.5.2	None
11.5.9b	None
11.7.2	Habitat for threatened flora species including Acacia wardellii.
non-rem	None

3. Remnant Regional Ecosystems by Broad Vegetation Group

BVGs are a higher-level grouping of vegetation communities. Queensland encompasses a wide variety of landscapes across temperate, wet and dry tropics and semi-arid climatic zones. BVGs provide an overview of vegetation communities across the state or a bioregion and allow comparison with other states. There are three levels of BVGs which reflect the approximate scale at which they are designed to be used: the 1:5,000,000 (national), 1:2,000,000 (state) and 1:1,000,000 (regional).

A comprehensive description of BVGs is available at:

https://publications.qld.gov.au/dataset/vegetation-qld/resource/921fa786-e6d5-4a8a-9b0c-e532d2ce3f32

The following table provides a description of the 1:1,000,000 BVGs present and their associated extent within the AOI.

Table 6: Broad vegetation groups (1 million) within the AOI

BVG (1 Million)	Description	Area (Ha)	% of AOI
None	None	5133.6	71.1
16a	Open forest and woodlands dominated by Eucalyptus camaldulensis (river red gum) (or E. tereticornis (blue gum)) and/or E. coolabah (coolabah) (or E. microtheca (coolabah)) fringing drainage lines. Associated species may include Melaleuca spp., Corymbia tessellaris (carbeen), Angophora spp., Casuarina cunninghamiana (riveroak). Does not include alluvial areas dominated by herb and grasslands or alluvial plains that are not flooded. (land zone 3) (MGD, BRB, GUP, CHC, MUL, DEU, EIU, NWH, SEQ, [NET, WET]) (All bioregions except CYP and CQC)	112.1	1.6
17a	Woodlands dominated by Eucalyptus populnea (poplar box) (or E. brownii (Reid River box)) on alluvium, sand plains and footslopes of hills and ranges. (land zones 3, 5, 10, 9, 4, 11, 12, [8]) (BRB, MUL, DEU, MUL, EIU)	125.3	1.7
18b	Woodlands dominated Eucalyptus crebra (sens. lat.) (narrow-leaved red ironbark) frequently with Corymbia spp. or Callitris spp. on flat to undulating plains. (land zones 5, 3) (BRB, DEU, EIU, GUP, CYP)	1147.4	15.9
24a	Low woodlands to tall shrublands dominated by Acacia spp. on residuals. Species include A. shirleyi (lancewood), A. catenulata (bendee), A. microsperma (bowyakka), A. clivicola, A. sibirica, A. rhodoxylon (rosewood) and A. leptostachya (Townsville wattle). (land zones 7, 10, 5, 12, 11, [9, 3]) (MUL, CHC, BRB, GUP, EIU, MGD, DEU, NWH, [CYP])	694.7	9.6
25a	Open forests to woodlands dominated by Acacia harpophylla (brigalow) sometimes with Casuarina cristata (belah) on heavy clay soils. Includes areas co-dominated with A. cambagei (gidgee) and/or emergent eucalypts (land zones 4, 9, 3, 11, 7, 12, [5, 8]) (BRB, MUL, MGD, DEU, [SEQ])	6.4	0.1

Refer to **Map 4** for further information. **Map 5** also provides a representation of the distribution of vegetation communities as per the 1:5,000,000 BVG believed to be present prior to European settlement.

4. Technical and BioCondition Benchmark Descriptions

Technical descriptions provide a detailed description of the full range in structure and floristic composition of regional ecosystems (e.g. 11.3.1) and their component vegetation communities (e.g. 11.3.1a, 11.3.1b). See:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

The descriptions are compiled using site survey data from the Queensland Herbarium's CORVEG database. Distribution maps, representative images (if available) and the pre-clearing and remnant area (hectares) of each vegetation community derived from the regional ecosystem mapping (spatial) data are included. The technical descriptions should be used in conjunction with the fields from the regional ecosystem description database (REDD) for a full description of the regional ecosystem.

Quantitative site data from relatively undisturbed sites are extracted from CORVEG and summarized to provide information specific to each vegetation community.

Technical descriptions include the attributes: tree canopy height and cover and native plant species composition of the predominant layer, which are used to assess the remnant status of vegetation under the *Vegetation Management Act 1999*.

However, as technical descriptions reflect the full range in structure and floristic composition across the climatic, natural disturbance and geographic range of the regional ecosystem, local reference sites should be used where possible (Neldner et al. 2012 (PDF)* section 3.3.1 of:

http://www.qld.gov.au/environment/assets/documents/plants-animals/herbarium/herbarium-mapping-methodology.pdf

The technical descriptions are subject to review and are updated as additional data becomes available.

When conducting a BioCondition assessment, these technical descriptions should be used in conjunction with BioCondition benchmarks for the specific regional ecosystem, or component vegetation community.

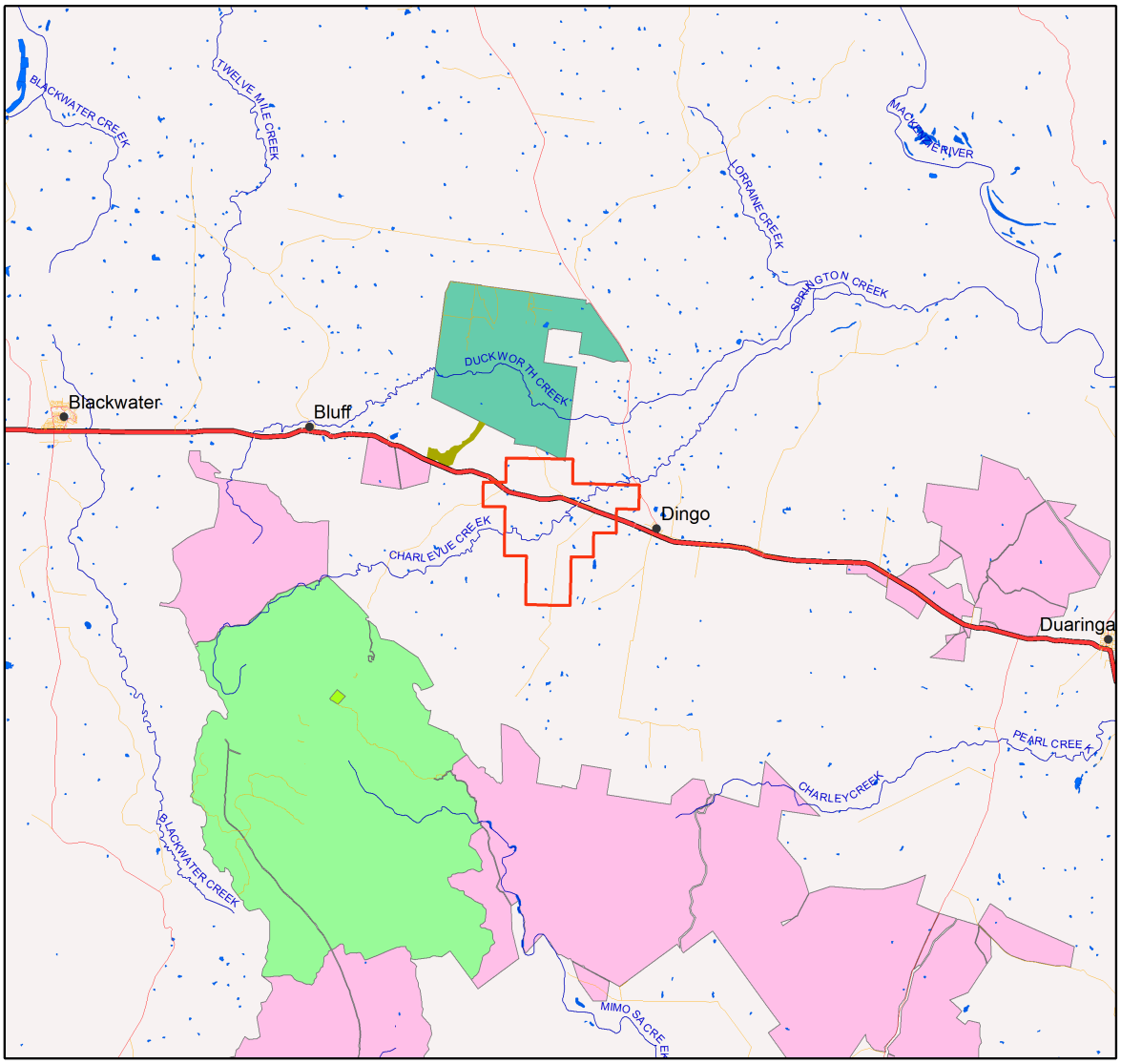
http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

Benchmarks are subject to review based on additional data and expert opinion. Benchmarks are based on a combination of quantitative and qualitative information and should be used as a guide only. Benchmarks are specific to one regional ecosystem vegetation community, however, the natural variability in structure and floristic composition under a range of climatic and natural disturbance regimes has been considered throughout the geographic extent of the regional ecosystem. Local reference sites should be used for this spatial and temporal (seasonal and annual) variability.

Table 7: List of remnant regional ecosystems within the AOI for which technical and biocondition benchmark descriptions are available

Regional ecosystems mapped as within the AOI	Technical Descriptions	Biocondition Benchmarks
11.3.1	Not currently available	Available
11.3.2	Not currently available	Available
11.3.25	Not currently available	Available
11.5.2	Not currently available	Not currently available
11.5.9b	Not currently available	Not currently available
11.7.2	Not currently available	Not currently available
non-rem	Not currently available	Not currently available

Maps
Map 1 - Location



Locality Map

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Highway
- Connector
- Street/Local Road
- National Park (Scientific)
- National Park
- National Park (CYPAL)
- Conservation Park
- Resources Reserve
- Forest Reserve
- State Forest
- Timber Reserve
- Nature Refuges
- Lakes and Reservoirs
- Major rivers/creeks
- Queensland

N

0 2.5 5 7.5 10 12.5 Kilometers

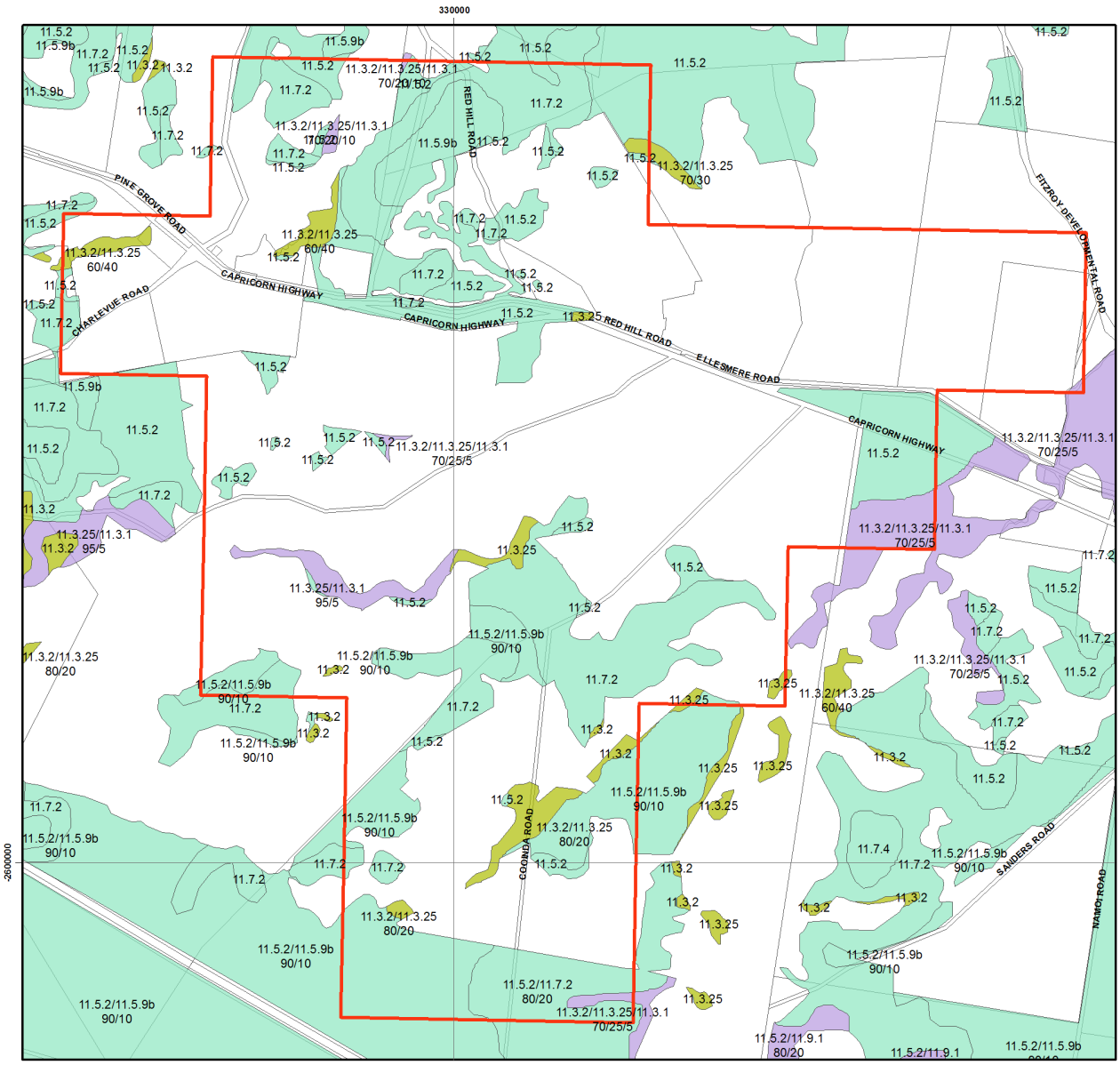
This product is projected into:
GDA 1994 Queensland Albers

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2017

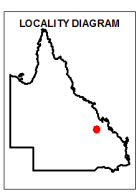
Map 2 - Remnant regional ecosystems

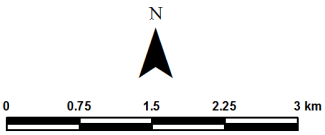


Remnant 2015 Regional Ecosystems

Biodiversity Status

- Selected Exploration Permit Coal (EPC)
- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Non-remnant vegetation, cultivated or built environment
- Plantation
- Water
- Cadastral Boundaries





This product is projected into GDA 1994 Queensland Albers

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.

Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".

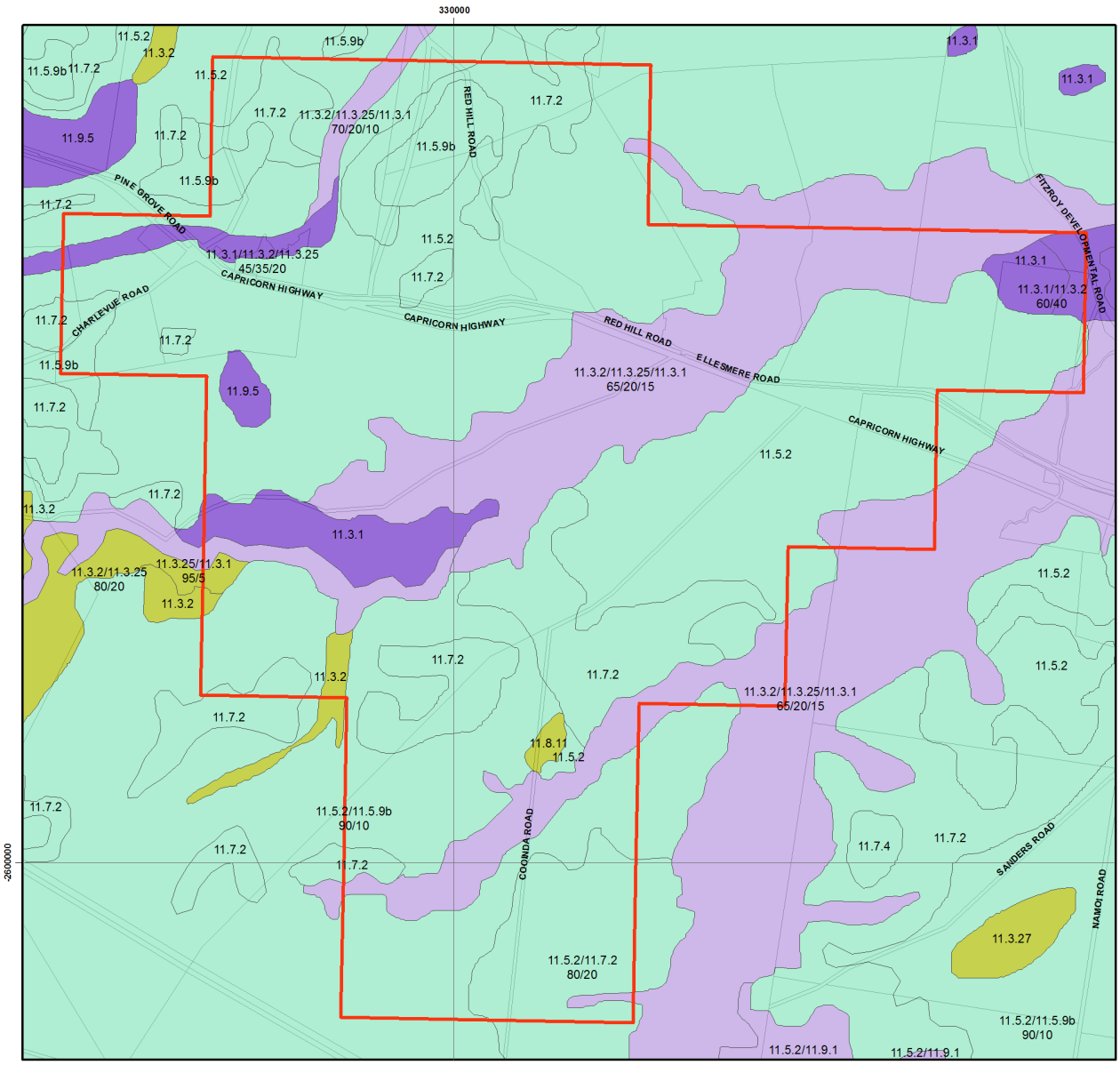
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.

Non-remnant vegetation includes regrowth and disturbed native vegetation.

© The State of Queensland, 2017

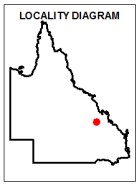
Map 3 - Pre-clearing remnant regional ecosystems

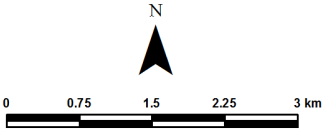


Pre-clearing Regional Ecosystems

Biodiversity Status

- Selected Exploration Permit Coal (EPC)
- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Water
- Cadastral Boundaries





This product is projected into GDA 1994 Queensland Albers

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.

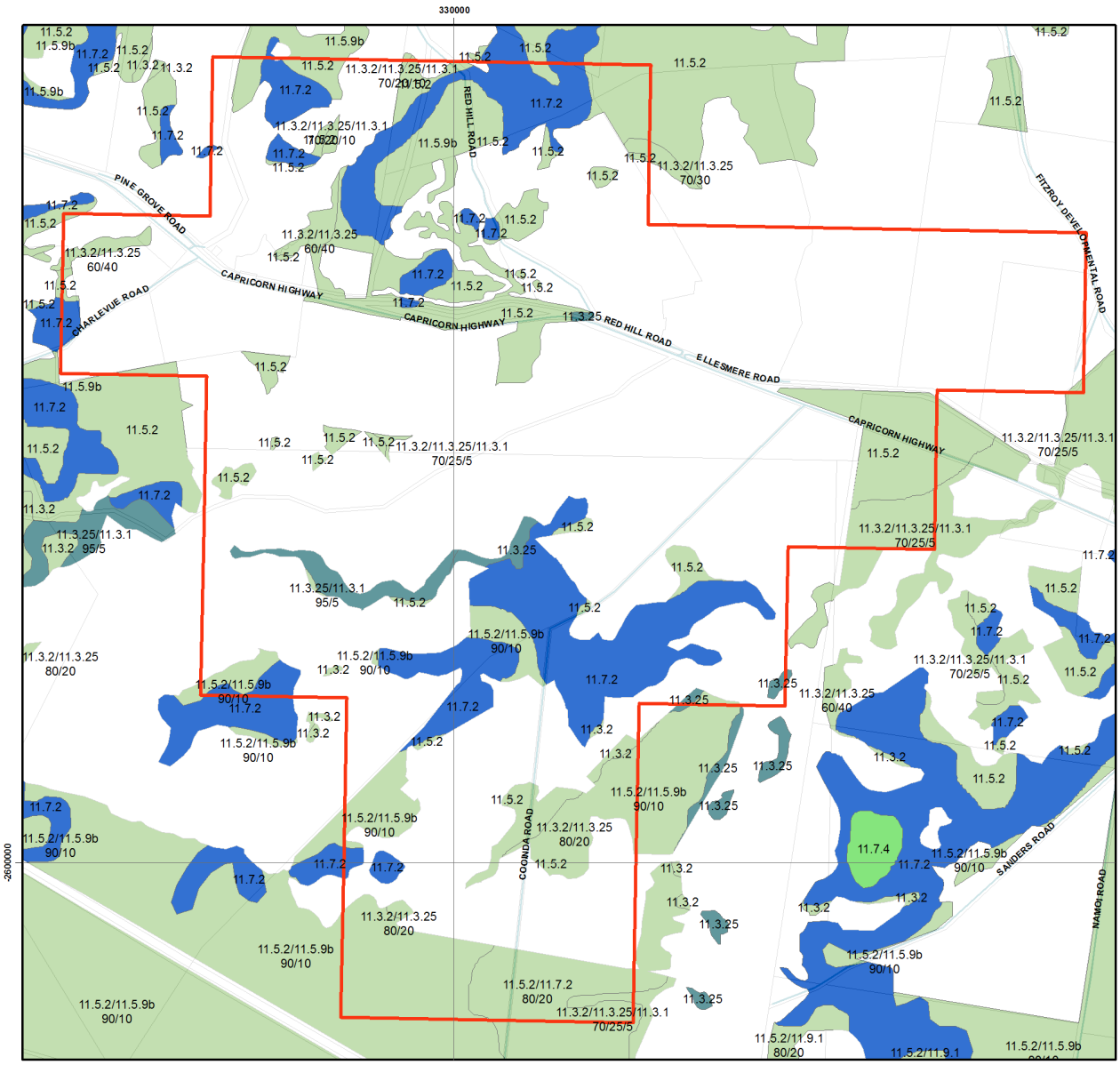
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.

The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".

Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

© The State of Queensland, 2017

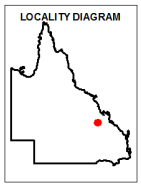
Map 4 - Remnant regional ecosystems by BVG (5M)



Remnant 2015 Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

- Selected Exploration Permit Coal (EPC)
- 1. Rainforests and scrubs (1-7b)
- 2. Wet eucalypt open forests (8-8b)
- 3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
- 4. Eucalypt open forests to woodlands on floodplains (16-16d)
- 5. Eucalypt dry woodlands on inland depositional plains (17-18d)
- 6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
- 7. Callitris woodland - open forests (20a)
- 8. Melaleuca open woodlands on depositional plains (21-22c)
- 9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
- 10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
- 11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
- 12. Other coastal communities or heaths (28-29b)
- 13. Tussock grasslands, forblands (30-32b)
- 14. Hummock grasslands (33-33b)
- 15. Wetlands (swamps and lakes) (34-34g)
- 16. Mangroves and saltmarshes (35-35b)
- Non-remnant vegetation, cultivated or built environment
- Water
- Cadastral Boundaries



N

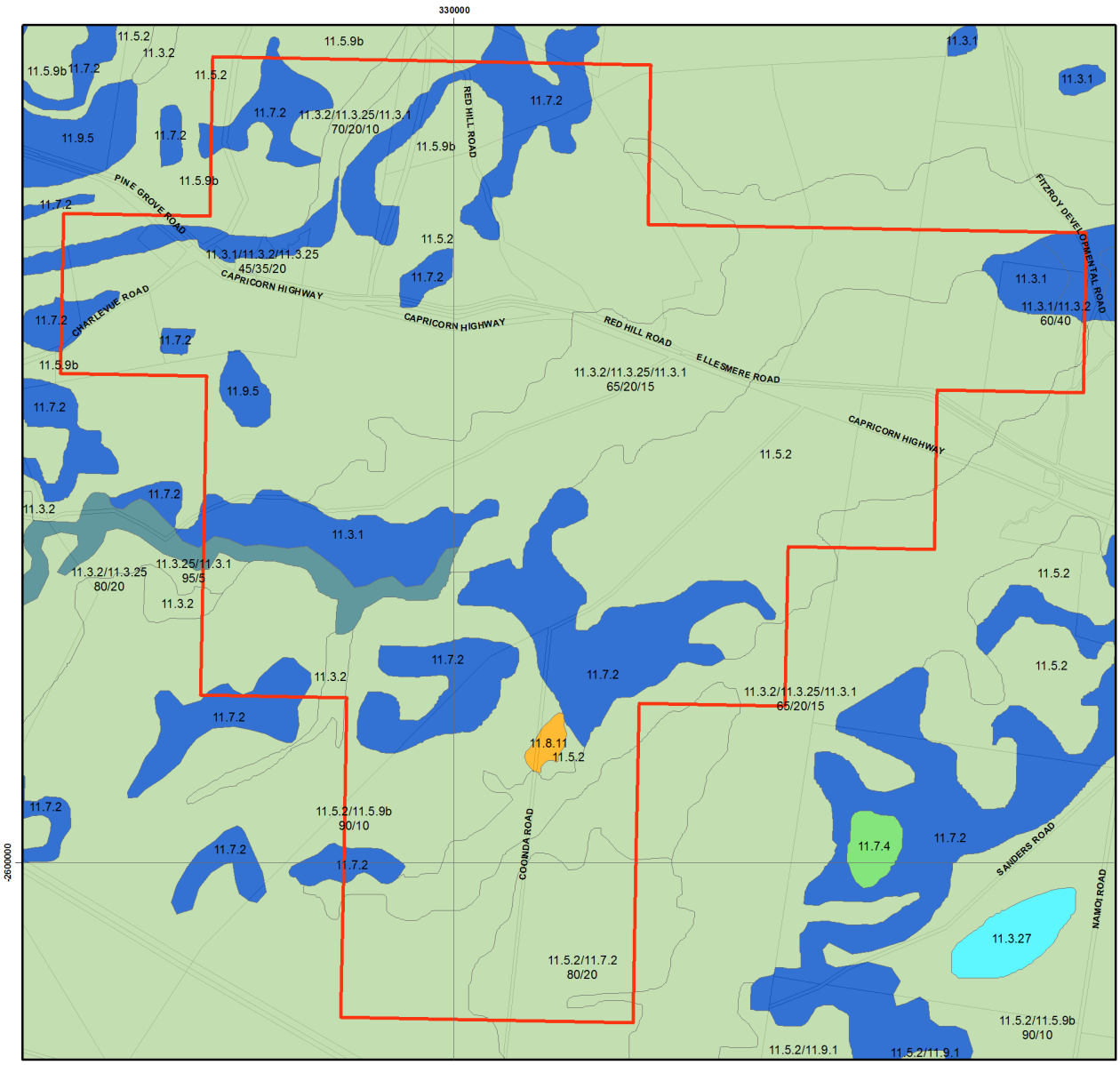
0 0.75 1.5 2.25 3 km

This product is projected into GDA 1994 Queensland Albers

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.
Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.
Non-remnant vegetation includes regrowth and disturbed native vegetation.

© The State of Queensland, 2017

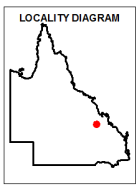
Map 5 - Pre-clearing remnant regional ecosystems by BVG (5M)



Pre-clearing Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

- Selected Exploration Permit Coal (EPC)
- 1. Rainforests and scrubs (1-7b)
- 2. Wet eucalypt open forests (8-8b)
- 3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
- 4. Eucalypt open forests to woodlands on floodplains (16-16d)
- 5. Eucalypt dry woodlands on inland depositional plains (17-18d)
- 6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
- 7. Callitris woodland - open forests (20a)
- 8. Melaleuca open woodlands on depositional plains (21-22c)
- 9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
- 10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
- 11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
- 12. Other coastal communities or heaths (28-29b)
- 13. Tussock grasslands, forblands (30-32b)
- 14. Hummock grasslands (33-33b)
- 15. Wetlands (swamps and lakes) (34-34g)
- 16. Mangroves and saltmarshes (35-35b)
- Water
- Cadastral Boundaries



N

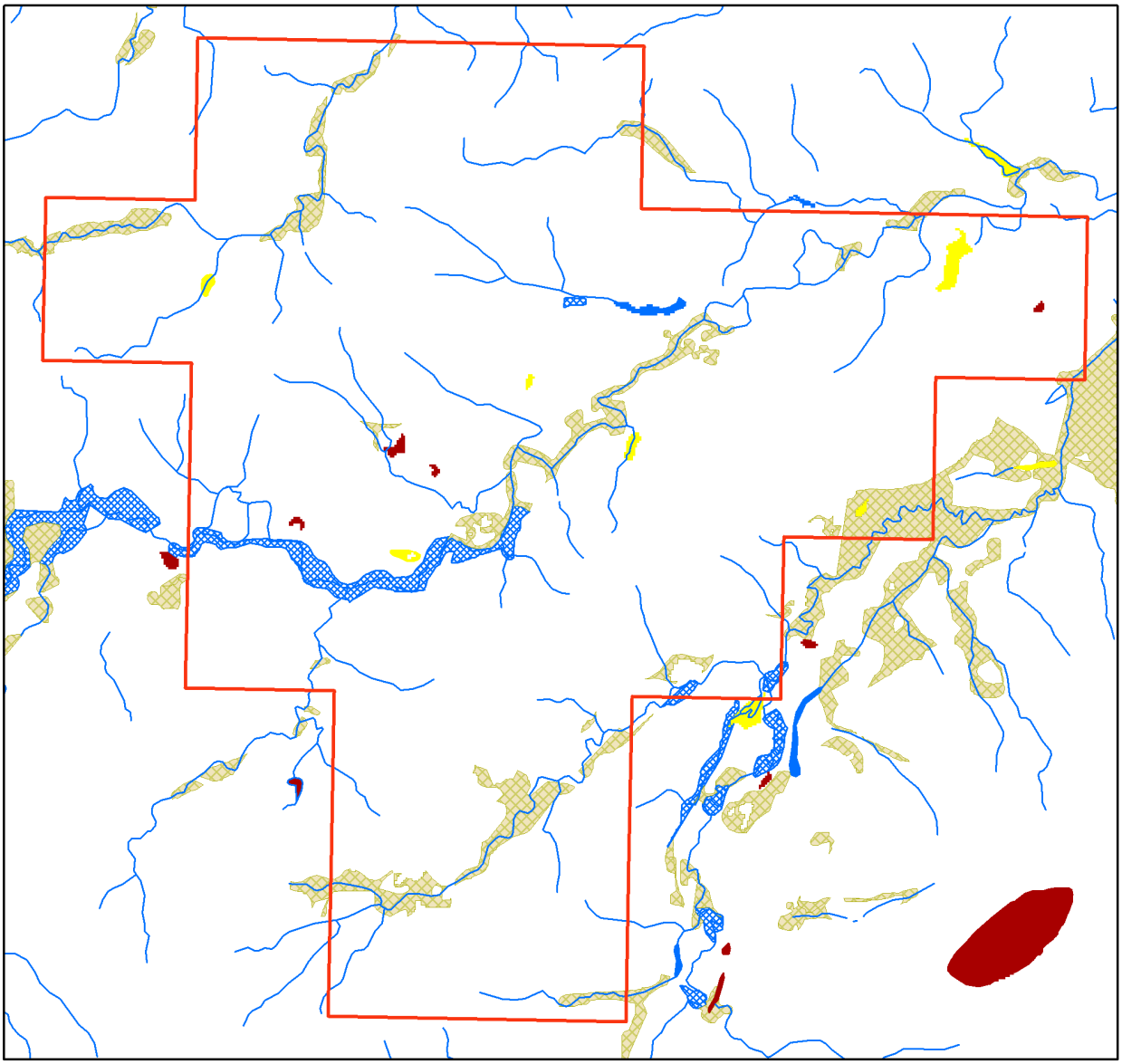
0 0.75 1.5 2.25 3 km

This product is projected into GDA 1994 Queensland Albers

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.
The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

© The State of Queensland, 2017

Map 6 - Wetlands and waterways



Queensland Wetland Data

Legend

- Selected Exploration Permit Coal (EPC)
- Towns (gazateer)

Queensland Wetland Data

- Riverine Drainage Lines
- Springs

Wetland System - Water Bodies

- Marine Waterbodies
- Estuarine Waterbodies
- Riverine Waterbodies
- Lacustrine Waterbodies
- Palustrine Waterbodies

Wetland System - Regional Ecosystems

- Marine RE
- Estuarine RE
- Riverine RE
- Lacustrine RE
- Palustrine RE
- RE 51-80% wetland (mosaic units)
- RE 1-50% wetland (mosaic units)

N

0 490 980 1,470 1,960 2,450 m

This product is projected into:
GDA 1994 Queensland Albers

Accuracy information: The positional accuracy of wetland data mapped at a scale of 1:100,000 is +/-100m with a minimum polygon size of 5ha or 75m wide for linear features, except for areas along the east coa st which are mapped at the 1:50,000 scale with a positional accuracy of +/-50m, with a minimum polygon size of 1ha or 35m wide for linear features. Wetlands smaller than 1ha are not delineated on the wetland data. Consideration of the effects of mapped scale is necessary when interpret ing data at a larger scale, e.g. 1:25,000. For property assessment, digital linework should be used as a guide only. The extent of wetlands depicted on this map is based on rectified 2013 Landsat ETM+ imagery supplied by Statewide Landcover and Trees Study (SLATS), Department of Science, Information Technology and Innovation (DSITI). The extent of water bodies is based on the maximum extent of inundation derived from available Landsat imagery up to and including the 2013 imagery.

© The State of Queensland, 2017

Links and Other Information Sources

The Department of Environment and Heritage's Website -

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/

provides further information on the regional ecosystem framework, including access to links to the Regional Ecosystem Database, Broad Vegetation Group Definitions, Regional Ecosystem and Land zone descriptions.

Descriptions of the broad vegetation groups of Queensland can be downloaded from:

https://publications.qld.gov.au/dataset/vegetation-qld/resource/921fa786-e6d5-4a8a-9b0c-e532d2ce3f32

The methodology for mapping regional ecosystems can be downloaded from:

http://www.qld.gov.au/environment/assets/documents/plants-animals/herbarium/herbarium-mapping-methodology.pdf

Technical descriptions for regional ecosystems can be obtained from:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

Benchmarks can be obtained from:

http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

For further information associated with the remnant regional ecosystem dataset used by this report, such as the year at which the extent of remnant is reflective of, refer to the metadata associated with the relevant Remnant Regional Ecosystems of Queensland dataset (version listed in **Appendix 1**) and which is available through the Queensland Government Information System portal,

http://dds.information.qld.gov.au/dds/

The Queensland Globe is a mapping and data application implemented inside the Google Earth TM application. As an interactive online tool, Queensland Globe allows you to view and explore Queensland maps, imagery (including up-to-date satellite images) and other spatial data, including regional ecosystem mapping. To further view and explore regional ecosystems over an area of interest, access the Biota Globe (a component of the Queensland Globe). The Queensland Globe can be accessed via the following link:

http://www.dnrm.qld.gov.au/mapping-data/queensland-globe

References

Neldner, V.J., Wilson, B.A., Thompson, E.J., and Dillewaard, H.A. (2012). *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland*. Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts.

(http://www.qld.gov.au/environment/assets/documents/plants-animals/herbarium/herbarium-mapping-methodology.pdf)

Neldner, V.J., Niehus R.E., Wilson, B.A. McDonald, W.J.F. and Ford, A.J. (2014). The Vegetation of Queensland. Descriptions of Broad Vegetation Groups. Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts.

(https://publications.qld.gov.au/dataset/vegetation-qld/resource/921fa786-e6d5-4a8a-9b0c-e532d2ce3f32)

Sattler, P.S. and Williams, R.D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Brisbane.

Appendices

Appendix 1: Source Data

The dataset listed below is available for download from:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/download/

- Regional Ecosystem Description Database

The datasets listed below are available for download from:

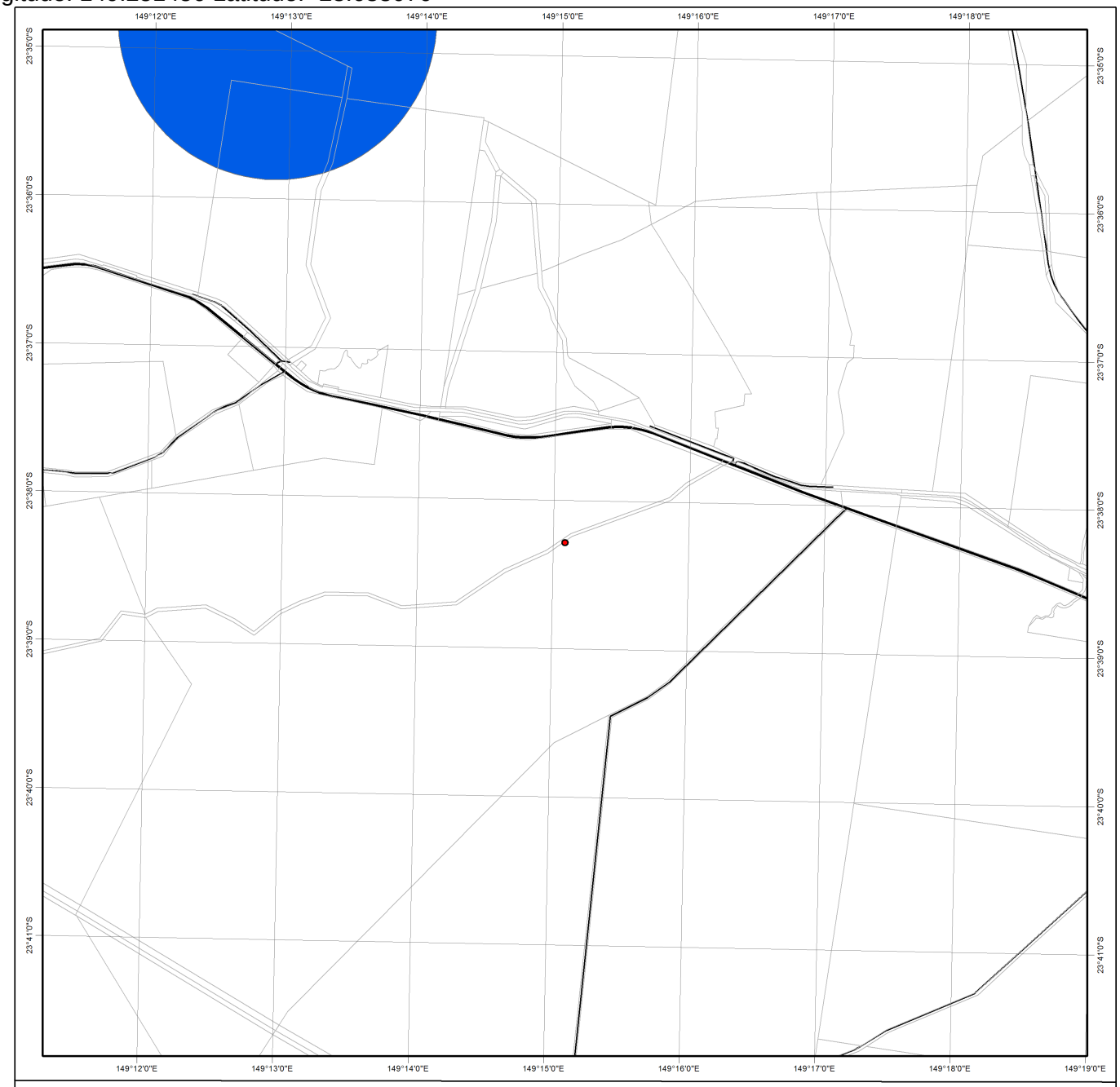
http://dds.information.qld.gov.au/dds/

- Remnant Regional Ecosystems of Queensland
- Pre-clearing Vegetation Communities and Regional Ecosystems of Queensland
- Queensland Wetland Data Version - Wetland lines
- Queensland Wetland Data Version - Wetland points
- Queensland Wetland Data Version - Wetland areas

Appendix 2 - Acronyms and Abbreviations

AOI	- Area of Interest
DNRM	- Department of Natural Resources and Mines
EHP	- Department of Environment and Heritage Protection
GDA94	- Geocentric Datum of Australia 1994
GIS	- Geographic Information System
RE	- Regional Ecosystem
REDD	- Regional Ecosystem Description Database
VMA	- *Vegetation Management Act 1999*

17/11/2017 10:20:58
Longitude: 149.251456 Latitude: -23.638076



Protected Plants Flora Survey Trigger Map

Legend

- Coordinates
- High risk area
- Cadastral line
  Property boundaries shown are provided as a locational aid only
- Freeways / motorways / highways
- Secondary roads / streets

LOCALITY DIAGRAM

N

0 480 960 1,440 1,920 2,400 m

This product is projected into:
GDA 1994 Queensland Albers

This map shows areas where particular provisions of the Nature Conservation Act 1992 apply to the clearing of protected plants.

This map is produced at a scale relevant to the size of the area selected and should be printed as A4 size in portrait orientation.

For further information or assistance with interpretation of this product, please contact the Department of Environment and Heritage Protection at palm@ehp.qld.gov.au

Disclaimer:
While every care is taken to ensure the accuracy of the data used to generate this product, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaim all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damages) and costs which might be incurred as a consequence of reliance on the data, or as a result of the data being inaccurate or incomplete in any way and for any reason.

© The State of Queensland (Department of Environment and Heritage Protection), 2017

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

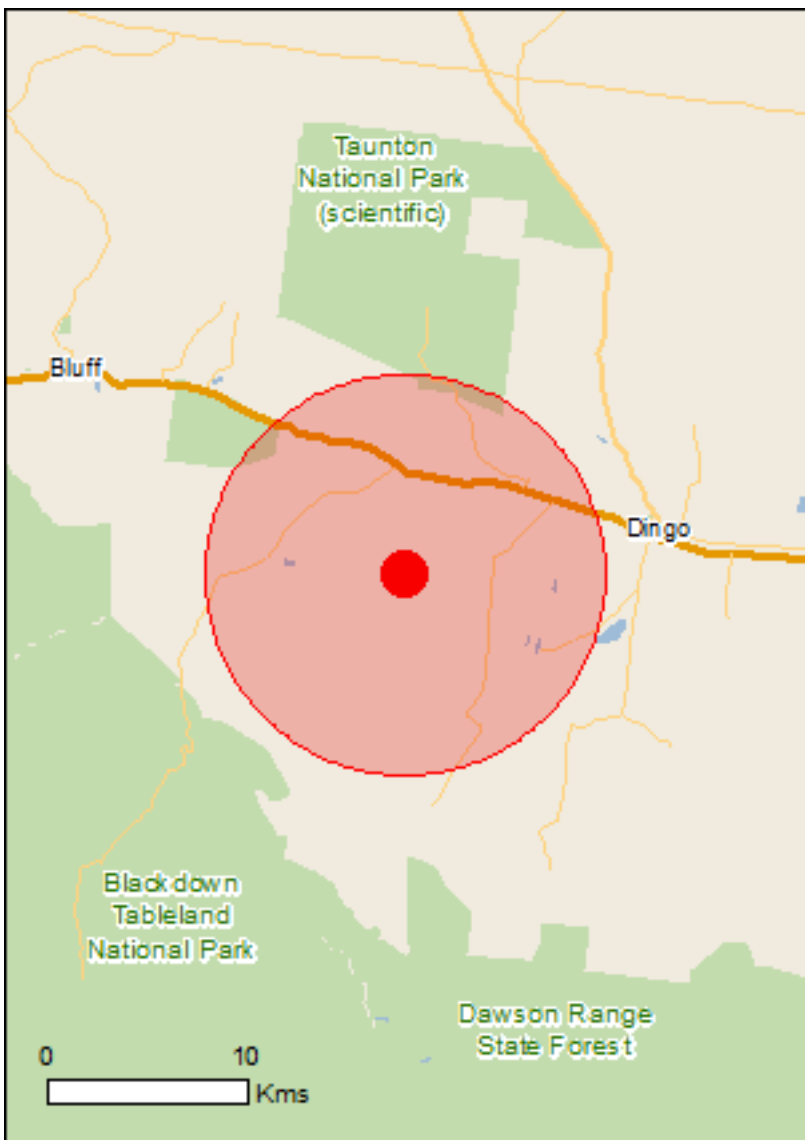
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 03/06/19 10:44:27

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

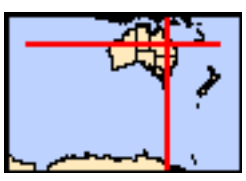
Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	25
Listed Migratory Species:	12

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	18
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	2
Regional Forest Agreements:	None
Invasive Species:	21
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area
Weeping Myall Woodlands	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat known to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species habitat may occur within area
Fish		
Maccullochella peelii Murray Cod [66633]	Vulnerable	Species or species habitat may occur within area
Mammals		

Name	Status	Type of Presence
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat likely to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Nyctophilus corbeni Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat may occur within area
Onychogalea fraenata Bridled Nail-tail Wallaby, Bridled Nailtail Wallaby [239]	Endangered	Species or species habitat known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Cadellia pentastylis Ooline [9828]	Vulnerable	Species or species habitat likely to occur within area
Dichanthium setosum bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area
Logania diffusa [24159]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat likely to occur within area
Denisonia maculata Ornamental Snake [1193]	Vulnerable	Species or species habitat may occur within area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat may occur within area
Elseya albagula Southern Snapping Turtle, White-throated Snapping Turtle [81648]	Critically Endangered	Species or species habitat likely to occur within area
Furina dunmalli Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area
Rheodytes leukops Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver [1761]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		

Name	Threatened	Type of Presence
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat likely to occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur

Name	Threatened	Type of Presence within area
[Ardea alba](#) Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
[Ardea ibis](#) Cattle Egret [59542]		Species or species habitat may occur within area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat may occur within area
[Chrysococcyx osculans](#) Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
[Gallinago hardwickii](#) Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
[Haliaeetus leucogaster](#) White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
[Merops ornatus](#) Rainbow Bee-eater [670]		Species or species habitat may occur within area
[Monarcha melanopsis](#) Black-faced Monarch [609]		Species or species habitat likely to occur within area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat may occur within area
[Myiagra cyanoleuca](#) Satin Flycatcher [612]		Species or species habitat may occur within area
[Pandion haliaetus](#) Osprey [952]		Species or species habitat likely to occur within area
[Rhipidura rufifrons](#) Rufous Fantail [592]		Species or species habitat may occur within area
[Rostratula benghalensis (sensu lato)](#) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Taunton	QLD
Wallaby Lane	QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Vachellia nilotica Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-23.66512 149.21782

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

© Commonwealth of Australia
Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

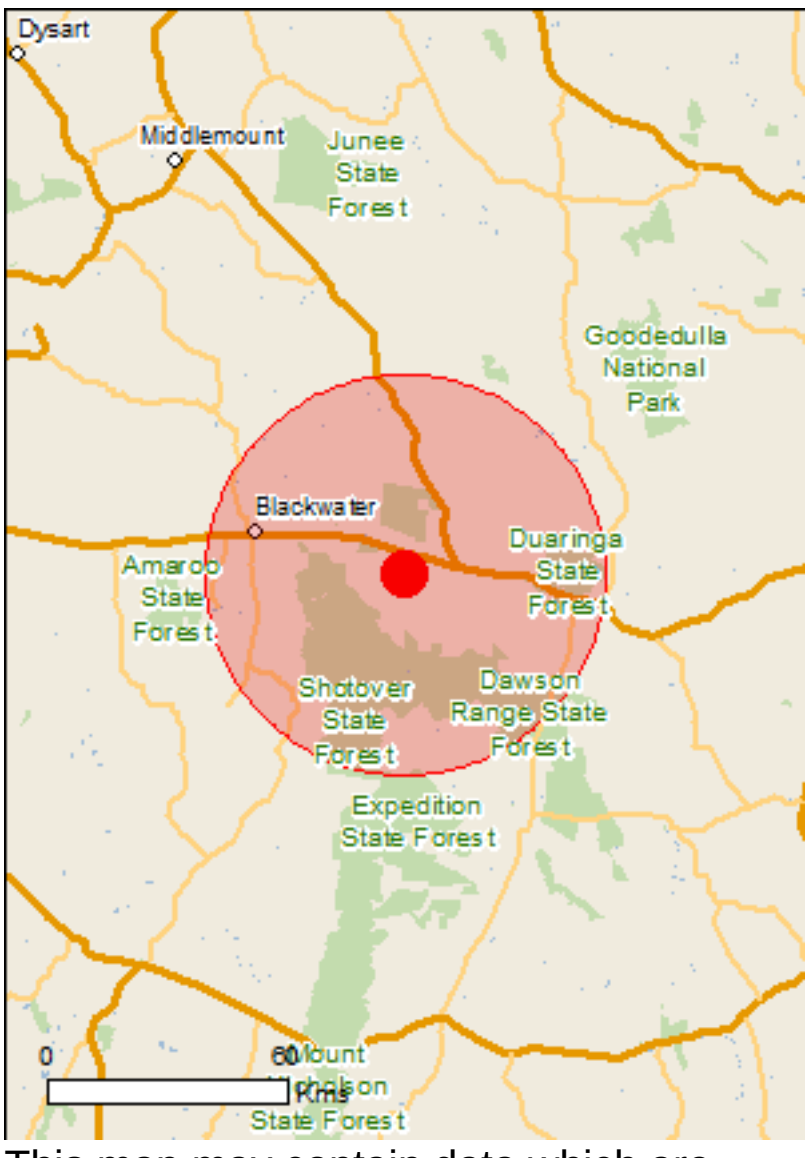
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 03/06/19 09:45:56

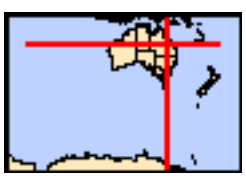
Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 50.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	39
Listed Migratory Species:	16

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	22
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	5
Regional Forest Agreements:	None
Invasive Species:	27
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area
Natural Grasslands of the Queensland Central Highlands and northern Fitzroy Basin	Endangered	Community likely to occur within area
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Endangered	Community likely to occur within area
Weeping Myall Woodlands	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat known to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Fish		
Maccullochella peelii		
Murray Cod [66633]	Vulnerable	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus hallucatus		
Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat likely to occur within area
Macroderma gigas		
Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Nyctophilus corbeni		
Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat may occur within area
Onychogalea fraenata		
Bridled Nail-tail Wallaby, Bridled Nailtail Wallaby [239]	Endangered	Species or species habitat known to occur within area
Petauroides volans		
Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Plants		
Acacia grandifolia		
[3566]	Vulnerable	Species or species habitat known to occur within area
Aristida annua		
[17906]	Vulnerable	Species or species habitat likely to occur within area
Bertya opponens		
[13792]	Vulnerable	Species or species habitat likely to occur within area
Cadellia pentastylis		
Ooline [9828]	Vulnerable	Species or species habitat likely to occur within area
Cycas ophiolitica		
[55797]	Endangered	Species or species habitat likely to occur within area
Daviesia discolor		
[3567]	Vulnerable	Species or species habitat likely to occur within area
Dichanthium queenslandicum		
King Blue-grass [5481]	Endangered	Species or species habitat may occur within area
Dichanthium setosum		
bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Eucalyptus raveretiana Black Ironbox [16344]	Vulnerable	Species or species habitat likely to occur within area
Homoranthus decumbens a shrub [55186]	Endangered	Species or species habitat known to occur within area
Logania diffusa [24159]	Vulnerable	Species or species habitat likely to occur within area
Macrozamia platyrhachis cycad [3412]	Endangered	Species or species habitat likely to occur within area
Phaius australis Lesser Swamp-orchid [5872]	Endangered	Species or species habitat known to occur within area
Solanum dissectum [75720]	Endangered	Species or species habitat known to occur within area
Solanum johnsonianum [84820]	Endangered	Species or species habitat may occur within area
Reptiles		
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat known to occur within area
Denisonia maculata Ornamental Snake [1193]	Vulnerable	Species or species habitat known to occur within area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat known to occur within area
Elseya albagula Southern Snapping Turtle, White-throated Snapping Turtle [81648]	Critically Endangered	Species or species habitat known to occur within area
Furina dunmalli Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area
Rheodytes leukops Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver [1761]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Marine Species		
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat known to occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat likely to occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat likely to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Defence - BLACKWATER TRAINING DEPOT

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		

Name	Threatened	Type of Presence
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat likely to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
[Rhipidura rufifrons](#) Rufous Fantail [592]		Species or species habitat may occur within area
[Rostratula benghalensis (sensu lato)](#) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Reptiles		
[Crocodylus porosus](#) Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Blackdown Tableland	QLD
Blackwater	QLD
Ghungalu	QLD
Taunton	QLD
Wallaby Lane	QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering		Species or species habitat likely to occur

Name	Status	Type of Presence
Cypress, Salt Cedar [16018] Vachellia nilotica		within area
Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-23.66512 149.21782

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

© Commonwealth of Australia
Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Status: Rare and threatened species
Records: All
Date: All
Latitude: -23.6381
Longitude: 149.2514
Distance: 10
Email: llopez@aarc.net.au
Date submitted: Thursday 13 Jun 2019 10:03:40
Date extracted: Thursday 13 Jun 2019 10:10:12

The number of records retrieved = 7

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Columbidae	*Geophaps scripta scripta*	squatter pigeon (southern subspecies)		V	V	17
animals	mammals	Macropodidae	*Onychogalea fraenata*	bridled nailtail wallaby		E	E	15
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		V	V	1
animals	mammals	Pseudocheiridae	*Petauroides volans volans*	southern greater glider		V	V	2
plants	Equisetopsida	Apocynaceae	*Cerbera dumicola*			NT		2/2
plants	Equisetopsida	Solanaceae	*Solanum elachophyllum*			E		1
plants	Equisetopsida	Solanaceae	*Solanum adenophorum*			E		1/1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Status: All
Records: All
Date: All
Latitude: -23.6381
Longitude: 149.1514
Distance: 10
Email: llopez@aarc.net.au
Date submitted: Thursday 13 Jun 2019 10:54:38
Date extracted: Thursday 13 Jun 2019 11:00:02

The number of records retrieved = 397

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Bufonidae	*Rhinella marina*	cane toad	Y			4
animals	amphibians	Hylidae	*Litoria latopalmata*	broad palmed rocketfrog		C		1
animals	amphibians	Hylidae	*Cyclorana alboguttata*	greenstripe frog		C		1
animals	amphibians	Hylidae	*Litoria caerulea*	common green treefrog		C		1
animals	amphibians	Limnodynastidae	*Limnodynastes tasmaniensis*	spotted grassfrog		C		1
animals	amphibians	Limnodynastidae	*Limnodynastes salmini*	salmon striped frog		C		1
animals	amphibians	Limnodynastidae	*Platyplectrum ornatum*	ornate burrowing frog		C		5
animals	birds	Acanthizidae	*Acanthiza nana*	yellow thornbill		C		1
animals	birds	Acanthizidae	*Smicrornis brevirostris*	weebill		C		3
animals	birds	Acanthizidae	*Gerygone olivacea*	white-throated gerygone		C		7
animals	birds	Accipitridae	*Milvus migrans*	black kite		C		1
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		3
animals	birds	Accipitridae	*Aquila audax*	wedge-tailed eagle		C		6
animals	birds	Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar		C		2
animals	birds	Alaudidae	*Mirafra javanica*	Horsfield's bushlark		C		1
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		1
animals	birds	Anatidae	*Cygnus atratus*	black swan		C		1
animals	birds	Anatidae	*Anas rhynchotis*	Australasian shoveler		C		1
animals	birds	Anatidae	*Aythya australis*	hardhead		C		2
animals	birds	Anatidae	*Dendrocygna arcuata*	wandering whistling-duck		C		1
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		3
animals	birds	Anatidae	*Chenonetta jubata*	Australian wood duck		C		1
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		1
animals	birds	Anseranatidae	*Anseranas semipalmata*	magpie goose		C		1
animals	birds	Ardeidae	*Egretta novaehollandiae*	white-faced heron		C		1
animals	birds	Ardeidae	*Nycticorax caledonicus*	nankeen night-heron		C		1
animals	birds	Ardeidae	*Ardea alba modesta*	eastern great egret		C		1
animals	birds	Ardeidae	*Ardea intermedia*	intermediate egret		C		1
animals	birds	Ardeidae	*Bubulcus ibis*	cattle egret		C		1
animals	birds	Ardeidae	*Ardea pacifica*	white-necked heron		C		2
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		10
animals	birds	Artamidae	*Cracticus torquatus*	grey butcherbird		C		6
animals	birds	Artamidae	*Artamus leucorynchus*	white-breasted woodswallow		C		1
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		8
animals	birds	Artamidae	*Artamus cinereus*	black-faced woodswallow		C		3
animals	birds	Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo		C		3
animals	birds	Cacatuidae	*Eolophus roseicapilla*	galah		C		2
animals	birds	Cacatuidae	*Calyptorhynchus banksii*	red-tailed black-cockatoo		C		1
animals	birds	Campephagidae	*Lalage tricolor*	white-winged triller		C		1
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		6
animals	birds	Campephagidae	*Coracina papuensis*	white-bellied cuckoo-shrike		C		1
animals	birds	Casuariidae	*Dromaius novaehollandiae*	emu		C		1
animals	birds	Charadriidae	*Vanellus miles*	masked lapwing		C		1
animals	birds	Charadriidae	*Elseyornis melanops*	black-fronted dotterel		C		2
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		4
animals	birds	Columbidae	*Geophaps scripta scripta*	squatter pigeon (southern subspecies)		V	V	8

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Columbidae	*Geopelia humeralis*	bar-shouldered dove		C		4
animals	birds	Columbidae	*Phaps chalcoptera*	common bronzewing		C		2
animals	birds	Columbidae	*Geopelia striata*	peaceful dove		C		5
animals	birds	Columbidae	*Geopelia cuneata*	diamond dove		C		1
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		3
animals	birds	Corcoracidae	*Struthidea cinerea*	apostlebird		C		5
animals	birds	Corcoracidae	*Corcorax melanorhamphos*	white-winged chough		C		2
animals	birds	Corvidae	*Corvus coronoides*	Australian raven		C		3
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		9
animals	birds	Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo		C		1
animals	birds	Cuculidae	*Chalcites lucidus*	shining bronze-cuckoo		C		1
animals	birds	Cuculidae	*Scythrops novaehollandiae*	channel-billed cuckoo		C		1
animals	birds	Cuculidae	*Cacomantis pallidus*	pallid cuckoo		C		1
animals	birds	Cuculidae	*Centropus phasianinus*	pheasant coucal		C		3
animals	birds	Cuculidae	*Eudynamys orientalis*	eastern koel		C		1
animals	birds	Dicruridae	*Dicrurus bracteatus*	spangled drongo		C		1
animals	birds	Estrildidae	*Taeniopygia guttata*	zebra finch		C		1
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		9
animals	birds	Eurostopodidae	*Eurostopodus mystacalis*	white-throated nightjar		C		1
animals	birds	Falconidae	*Falco cenchroides*	nankeen kestrel		C		2
animals	birds	Falconidae	*Falco berigora*	brown falcon		C		4
animals	birds	Gruidae	*Grus rubicunda*	brolga		C		3
animals	birds	Halcyonidae	*Dacelo novaeguineae*	laughing kookaburra		C		7
animals	birds	Halcyonidae	*Todiramphus macleayii*	forest kingfisher		C		2
animals	birds	Halcyonidae	*Dacelo leachii*	blue-winged kookaburra		C		2
animals	birds	Halcyonidae	*Todiramphus pyrrhopygius*	red-backed kingfisher		C		1
animals	birds	Halcyonidae	*Todiramphus sanctus*	sacred kingfisher		C		1
animals	birds	Hirundinidae	*Petrochelidon nigricans*	tree martin		C		2
animals	birds	Hirundinidae	*Hirundo neoxena*	welcome swallow		C		1
animals	birds	Jacanidae	*Irediparra gallinacea*	comb-crested jacana		C		1
animals	birds	Maluridae	*Malurus cyaneus*	superb fairy-wren		C		1
animals	birds	Maluridae	*Malurus melanocephalus*	red-backed fairy-wren		C		7
animals	birds	Maluridae	*Malurus lamberti*	variegated fairy-wren		C		2
animals	birds	Megaluridae	*Cincloramphus mathewsi*	rufous songlark		C		1
animals	birds	Meliphagidae	*Manorina flavigula*	yellow-throated miner		C		3
animals	birds	Meliphagidae	*Gavicalis virescens*	singing honeyeater		C		3
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		3
animals	birds	Meliphagidae	*Philemon corniculatus*	noisy friarbird		C		7
animals	birds	Meliphagidae	*Ptilotula penicillata*	white-plumed honeyeater		C		1
animals	birds	Meliphagidae	*Manorina melanocephala*	noisy miner		C		5
animals	birds	Meliphagidae	*Myzomela sanguinolenta*	scarlet honeyeater		C		1
animals	birds	Meliphagidae	*Philemon citreogularis*	little friarbird		C		7
animals	birds	Meliphagidae	*Melithreptus albogularis*	white-throated honeyeater		C		11
animals	birds	Meliphagidae	*Plectorhyncha lanceolata*	striped honeyeater		C		2
animals	birds	Meliphagidae	*Entomyzon cyanotis*	blue-faced honeyeater		C		7
animals	birds	Meropidae	*Merops ornatus*	rainbow bee-eater		C		11

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		11
animals	birds	Monarchidae	*Myiagra inquieta*	restless flycatcher		C		3
animals	birds	Monarchidae	*Myiagra rubecula*	leaden flycatcher		C		3
animals	birds	Motacillidae	*Anthus novaeseelandiae*	Australasian pipit		C		2
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		2
animals	birds	Neosittidae	*Daphoenositta chrysoptera*	varied sittella		C		1
animals	birds	Oriolidae	*Oriolus sagittatus*	olive-backed oriole		C		7
animals	birds	Oriolidae	*Sphecotheres vieilloti*	Australasian figbird		C		2
animals	birds	Otididae	*Ardeotis australis*	Australian bustard		C		5
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		5
animals	birds	Pachycephalidae	*Colluricincla megarhyncha*	little shrike-thrush		C		1
animals	birds	Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush		C		6
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		11/1
animals	birds	Pelecanidae	*Pelecanus conspicillatus*	Australian pelican		C		1
animals	birds	Petroicidae	*Eopsaltria australis*	eastern yellow robin		C		1
animals	birds	Petroicidae	*Microeca fascinans*	jacky winter		C		4
animals	birds	Phalacrocoracidae	*Phalacrocorax varius*	pied cormorant		C		1
animals	birds	Phalacrocoracidae	*Microcarbo melanoleucos*	little pied cormorant		C		1
animals	birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant		C		1
animals	birds	Phasianidae	*Coturnix ypsilophora*	brown quail		C		1
animals	birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe		C		3
animals	birds	Podicipedidae	*Podiceps cristatus*	great crested grebe		C		1
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		4
animals	birds	Psittacidae	*Trichoglossus chlorolepidotus*	scaly-breasted lorikeet		C		2
animals	birds	Psittacidae	*Trichoglossus haematodus moluccanus*	rainbow lorikeet		C		8
animals	birds	Psittacidae	*Aprosmictus erythropterus*	red-winged parrot		C		2
animals	birds	Psittacidae	*Melopsittacus undulatus*	budgerigar		C		1
animals	birds	Psittacidae	*Platycercus adscitus*	pale-headed rosella		C		7
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus maculatus*	spotted bowerbird		C		5
animals	birds	Rallidae	*Porphyrio melanotus*	purple swamphen		C		1
animals	birds	Rallidae	*Fulica atra*	Eurasian coot		C		1
animals	birds	Rallidae	*Gallinula tenebrosa*	dusky moorhen		C		1
animals	birds	Recurvirostridae	*Himantopus himantopus*	black-winged stilt		C		1
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		10
animals	birds	Rhipiduridae	*Rhipidura albiscapa*	grey fantail		C		6
animals	birds	Strigidae	*Ninox boobook*	southern boobook		C		1
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		4
animals	birds	Threskiornithidae	*Threskiornis molucca*	Australian white ibis		C		1
animals	birds	Threskiornithidae	*Platalea regia*	royal spoonbill		C		1
animals	birds	Threskiornithidae	*Platalea flavipes*	yellow-billed spoonbill		C		1
animals	birds	Timaliidae	*Zosterops lateralis*	silvereye		C		1
animals	birds	Tytonidae	*Tyto delicatula*	eastern barn owl		C		3
animals	mammals	Bovidae	*Bos taurus*	European cattle	Y			1
animals	mammals	Canidae	*Vulpes vulpes*	red fox	Y			1
animals	mammals	Canidae	*Canis lupus dingo*	dingo				6
animals	mammals	Equidae	*Equus caballus*	horse	Y			1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	mammals	Felidae	*Felis catus*	cat	Y			3
animals	mammals	Hipposideridae	*Hipposideros ater aruensis*	eastern dusky leaf-nosed bat		C		1
animals	mammals	Leporidae	*Oryctolagus cuniculus*	rabbit	Y			2
animals	mammals	Leporidae	*Lepus europaeus*	European brown hare	Y			2
animals	mammals	Macropodidae	*Macropus dorsalis*	black-striped wallaby		C		5
animals	mammals	Macropodidae	*Onychogalea fraenata*	bridled nailtail wallaby		E	E	13
animals	mammals	Macropodidae	*Macropus giganteus*	eastern grey kangaroo		C		2
animals	mammals	Macropodidae	*Macropus robustus*	common wallaroo		C		1
animals	mammals	Macropodidae	*Wallabia bicolor*	swamp wallaby		C		1
animals	mammals	Miniopteridae	*Miniopterus schreibersii oceanensis*	eastern bent-wing bat		C		1
animals	mammals	Muridae	*Mus musculus*	house mouse	Y			5
animals	mammals	Muridae	*Pseudomys delicatulus*	delicate mouse		C		1
animals	mammals	Peramelidae	*Perameles nasuta*	long-nosed bandicoot		C		1
animals	mammals	Phalangeridae	*Trichosurus vulpecula*	common brushtail possum		C		4
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		V	V	1
animals	mammals	Potoroidae	*Aepyprymnus rufescens*	rufous bettong		C		2
animals	mammals	Pseudocheiridae	*Petauroides volans volans*	southern greater glider		V	V	2
animals	mammals	Suidae	*Sus scrofa*	pig	Y			1
animals	mammals	Tachyglossidae	*Tachyglossus aculeatus*	short-beaked echidna		SL		4
animals	mammals	Vespertilionidae	*Nyctophilus gouldi*	Gould's long-eared bat		C		1
animals	mammals	Vespertilionidae	*Myotis macropus*	large-footed myotis		C		2
animals	ray-finned fishes	Terapontidae	*Leiopotherapon unicolor*	spangled perch				1
animals	reptiles	Agamidae	*Pogona barbata*	bearded dragon		C		2/1
animals	reptiles	Agamidae	*Diporiphora australis*	tommy roundhead		C		1/1
animals	reptiles	Boidae	*Aspidites melanocephalus*	black-headed python		C		1
animals	reptiles	Carphodactylidae	*Nephrurus asper*	spiny knob-tailed gecko		C		2/1
animals	reptiles	Diplodactylidae	*Lucasium steindachneri*	Steindachner's gecko		C		1
animals	reptiles	Diplodactylidae	*Oedura monilis*	ocellated velvet gecko		C		1/1
animals	reptiles	Diplodactylidae	*Strophurus taenicauda*	golden-tailed gecko		NT		3
animals	reptiles	Elapidae	*Demansia vestigiata*	lesser black whipsnake		C		2
animals	reptiles	Elapidae	*Demansia psammophis*	yellow-faced whipsnake		C		1
animals	reptiles	Elapidae	*Hoplocephalus bitorquatus*	pale-headed snake		C		1/1
animals	reptiles	Gekkonidae	*Gehyra catenata*	chain-backed dtella		C		1/1
animals	reptiles	Gekkonidae	*Gehyra dubia*	dubious dtella		C		32
animals	reptiles	Gekkonidae	*Heteronotia binoei*	Bynoe's gecko		C		6
animals	reptiles	Pygopodidae	*Lialis burtonis*	Burton's legless lizard		C		2
animals	reptiles	Scincidae	*Cryptoblepharus pulcher pulcher*	elegant snake-eyed skink		C		1
animals	reptiles	Scincidae	*Cryptoblepharus virgatus sensu lato*			C		1
animals	reptiles	Scincidae	*Carlia pectoralis sensu lato*			C		2/1
animals	reptiles	Scincidae	*Cryptoblepharus australis*	inland snake-eyed skink		C		1
animals	reptiles	Scincidae	*Cyclodomorphus gerrardii*	pink-tongued lizard		C		1
animals	reptiles	Scincidae	*Morethia taeniopleura*	fire-tailed skink		C		2
animals	reptiles	Scincidae	*Ctenotus taeniolatus*	copper-tailed skink		C		1
animals	reptiles	Scincidae	*Concinnia brachysoma*	northern bar-sided skink		C		1/1
animals	reptiles	Scincidae	*Morethia boulengeri*	south-eastern morethia skink		C		1
animals	reptiles	Scincidae	*Lygisaurus foliorum*	tree-base litter-skink		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	reptiles	Scincidae	*Lerista fragilis*	eastern mulch slider		C		2
animals	reptiles	Scincidae	*Carlia rubigo*	orange-flanked rainbow skink		C		6
animals	reptiles	Scincidae	*Carlia vivax*	tussock rainbow-skink		C		1
plants	Equisetopsida	Acanthaceae	*Pseuderanthemum variabile*	pastel flower		C		1
plants	Equisetopsida	Amaranthaceae	*Alternanthera pungens*	khaki weed	Y			1/1
plants	Equisetopsida	Amaranthaceae	*Ptilotus polystachyus*			C		1/1
plants	Equisetopsida	Amaryllidaceae	*Crinum flaccidum*	Murray lily		C		1
plants	Equisetopsida	Apocynaceae	*Carissa ovata*	currantbush		C		20
plants	Equisetopsida	Apocynaceae	*Cerbera dumicola*			NT		2/2
plants	Equisetopsida	Apocynaceae	*Alstonia constricta*	bitterbark		C		10/1
plants	Equisetopsida	Apocynaceae	*Parsonsia straminea*	monkey rope		C		6
plants	Equisetopsida	Apocynaceae	*Cryptostegia grandiflora*	rubber vine	Y			1
plants	Equisetopsida	Apocynaceae	*Parsonsia eucalyptophylla*	gargaloo		C		1
plants	Equisetopsida	Asteraceae	*Blumea saxatilis*			C		1/1
plants	Equisetopsida	Asteraceae	*Parthenium hysterophorus*	parthenium weed	Y			1
plants	Equisetopsida	Asteraceae	*Cyanthillium cinereum*			C		5
plants	Equisetopsida	Asteraceae	*Coronidium glutinosum*			C		2/2
plants	Equisetopsida	Boraginaceae	*Ehretia membranifolia*	weeping koda		C		2
plants	Equisetopsida	Cactaceae	*Harrisia martinii*		Y			1
plants	Equisetopsida	Cactaceae	*Opuntia tomentosa*	velvety tree pear	Y			2
plants	Equisetopsida	Caesalpiniaceae	*Lysiphyllum hookeri*	Queensland ebony		C		1
plants	Equisetopsida	Caesalpiniaceae	*Lysiphyllum carronii*	ebony tree		C		1
plants	Equisetopsida	Caesalpiniaceae	*Cassia brewsteri*			C		21/1
plants	Equisetopsida	Capparaceae	*Capparis*			C		1
plants	Equisetopsida	Capparaceae	*Capparis mitchellii*			C		1
plants	Equisetopsida	Capparaceae	*Capparis loranthifolia*			C		1
plants	Equisetopsida	Capparaceae	*Capparis lasiantha*	nipan		C		5/1
plants	Equisetopsida	Capparaceae	*Capparis canescens*			C		5
plants	Equisetopsida	Casuarinaceae	*Allocasuarina luehmannii*	bull oak		C		1
plants	Equisetopsida	Casuarinaceae	*Casuarina cunninghamiana subsp. cunninghamiana*			C		1/1
plants	Equisetopsida	Celastraceae	*Elaeodendron australe var. integrifolium*			C		1
plants	Equisetopsida	Chenopodiaceae	*Maireana*			C		2
plants	Equisetopsida	Chenopodiaceae	*Sclerolaena*			C		1/1
plants	Equisetopsida	Chenopodiaceae	*Salsola australis*			C		1
plants	Equisetopsida	Chenopodiaceae	*Enchylaena tomentosa*			C		1
plants	Equisetopsida	Chenopodiaceae	*Maireana microphylla*			C		2/2
plants	Equisetopsida	Clusiaceae	*Hypericum gramineum*			C		1
plants	Equisetopsida	Colchicaceae	*Iphigenia indica*			C		2/2
plants	Equisetopsida	Combretaceae	*Terminalia oblongata*			C		7
plants	Equisetopsida	Commelinaceae	*Commelina diffusa*	wandering jew		C		1
plants	Equisetopsida	Convolvulaceae	*Evolvulus alsinoides*			C		2
plants	Equisetopsida	Convolvulaceae	*Evolvulus alsinoides var. decumbens*			C		2
plants	Equisetopsida	Crassulaceae	*Bryophyllum x houghtonii*		Y			1/1
plants	Equisetopsida	Crassulaceae	*Bryophyllum delagoense*		Y			9
plants	Equisetopsida	Cupressaceae	*Callitris glaucophylla*	white cypress pine		C		1
plants	Equisetopsida	Cyperaceae	*Cyperaceae*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Cyperaceae	*Cyperus fulvus*			C		1/1
plants	Equisetopsida	Cyperaceae	*Fimbristylis aestivalis*			C		1/1
plants	Equisetopsida	Cyperaceae	*Cyperus conicus*			C		1/1
plants	Equisetopsida	Cyperaceae	*Cyperus alterniflorus*			C		2/1
plants	Equisetopsida	Dipterocarpaceae	*Shorea*			C		1/1
plants	Equisetopsida	Erythroxylaceae	*Erythroxylum australe*	cocaine tree		C		18/2
plants	Equisetopsida	Euphorbiaceae	*Mallotus philippensis*	red kamala		C		1/1
plants	Equisetopsida	Euphorbiaceae	*Euphorbia tannensis subsp. eremophila*			C		2
plants	Equisetopsida	Fabaceae	*Daviesia filipes*			C		1/1
plants	Equisetopsida	Fabaceae	*Jacksonia scoparia*			C		1
plants	Equisetopsida	Fabaceae	*Medicago polymorpha*	burr medic	Y			1/1
plants	Equisetopsida	Fabaceae	*Stylosanthes scabra*		Y			4
plants	Equisetopsida	Fabaceae	*Hovea linearis x Hovea planifolia*			C		1/1
plants	Equisetopsida	Fabaceae	*Desmodium macrocarpum*			C		1
plants	Equisetopsida	Fabaceae	*Jacksonia rhadinoclona*	Miles dogwood		C		1
plants	Equisetopsida	Fabaceae	*Macroptilium atropurpureum*	siratro	Y			1
plants	Equisetopsida	Fabaceae	*Daviesia filipes subsp. filipes*			C		1/1
plants	Equisetopsida	Fabaceae	*Crotalaria verrucosa*			C		1/1
plants	Equisetopsida	Goodeniaceae	*Goodenia rotundifolia*			C		2
plants	Equisetopsida	Goodeniaceae	*Scaevola spinescens*	prickly fan flower		C		1/1
plants	Equisetopsida	Lamiaceae	*Plectranthus parviflorus*			C		1/1
plants	Equisetopsida	Loganiaceae	*Mitrasacme oasena*			C		1/1
plants	Equisetopsida	Malvaceae	*Hibiscus divaricatus*			C		1
plants	Equisetopsida	Malvaceae	*Sida sp. (Aramac E.J.Thompson+ JER192)*			C		5/4
plants	Equisetopsida	Malvaceae	*Abutilon*			C		1
plants	Equisetopsida	Malvaceae	*Sida cordifolia*		Y			5/1
plants	Equisetopsida	Malvaceae	*Sida atherophora*			C		3
plants	Equisetopsida	Malvaceae	*Sida hackettiana*			C		3
plants	Equisetopsida	Malvaceae	*Hibiscus splendens*	pink hibiscus		C		1/1
plants	Equisetopsida	Malvaceae	*Malvastrum americanum*		Y			2
plants	Equisetopsida	Malvaceae	*Sida aprica var. aprica*			C		1/1
plants	Equisetopsida	Malvaceae	*Hibiscus sturtii var. sturtii*			C		1
plants	Equisetopsida	Malvaceae	*Sida rohlenae subsp. rohlenae*			C		1/1
plants	Equisetopsida	Malvaceae	*Malvastrum americanum var. americanum*		Y			1
plants	Equisetopsida	Meliaceae	*Owenia acidula*	emu apple		C		2/1
plants	Equisetopsida	Meliaceae	*Melia azedarach*	white cedar		C		1/1
plants	Equisetopsida	Mimosaceae	*Acacia leiocalyx subsp. leiocalyx*			C		2/2
plants	Equisetopsida	Mimosaceae	*Leucaena leucocephala subsp. leucocephala*		Y			1/1
plants	Equisetopsida	Mimosaceae	*Acacia blakei subsp. blakei*			C		2/1
plants	Equisetopsida	Mimosaceae	*Vachellia farnesiana*		Y			1/1
plants	Equisetopsida	Mimosaceae	*Acacia bancroftiorum*			C		3/3
plants	Equisetopsida	Mimosaceae	*Acacia harpophylla*	brigalow		C		10
plants	Equisetopsida	Mimosaceae	*Acacia rhodoxylon*	ringy rosewood		C		26
plants	Equisetopsida	Mimosaceae	*Albizia lebbeck*	Indian siris		C		1/1
plants	Equisetopsida	Mimosaceae	*Acacia shirleyi*	lancewood		C		10/4
plants	Equisetopsida	Mimosaceae	*Acacia salicina*	doolan		C		10

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Mimosaceae	*Acacia caroleae*			C		1
plants	Equisetopsida	Mimosaceae	*Acacia excelsa*			C		4
plants	Equisetopsida	Mimosaceae	*Acacia cretata*			C		8/6
plants	Equisetopsida	Moraceae	*Ficus opposita*			C		2/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus thozetiana*			C		2/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus chloroclada*	Baradine red gum		C		1
plants	Equisetopsida	Myrtaceae	*Eucalyptus tereticornis*			C		5
plants	Equisetopsida	Myrtaceae	*Corymbia citriodora subsp. citriodora*			C		1/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus camaldulensis subsp. acuta*			C		2
plants	Equisetopsida	Myrtaceae	*Lophostemon grandiflorus subsp. riparius*			C		1/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus crebra x Eucalyptus thozetiana*			C		1/1
plants	Equisetopsida	Myrtaceae	*Corymbia clarksoniana*			C		8/1
plants	Equisetopsida	Myrtaceae	*Corymbia tessellaris*	Moreton Bay ash		C		7/1
plants	Equisetopsida	Myrtaceae	*Corymbia dallachiana*			C		3
plants	Equisetopsida	Myrtaceae	*Eucalyptus populnea*	poplar box		C		30
plants	Equisetopsida	Myrtaceae	*Corymbia intermedia*	pink bloodwood		C		1
plants	Equisetopsida	Myrtaceae	*Angophora leiocarpa*	rusty gum		C		1
plants	Equisetopsida	Myrtaceae	*Melaleuca groveana*			NT		2/2
plants	Equisetopsida	Myrtaceae	*Eucalyptus exserta*	Queensland peppermint		C		3
plants	Equisetopsida	Myrtaceae	*Melaleuca nervosa*			C		1/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus crebra*	narrow-leaved red ironbark		C		21/2
plants	Equisetopsida	Myrtaceae	*Eucalyptus*			C		1
plants	Equisetopsida	Myrtaceae	*Melaleuca*			C		1
plants	Equisetopsida	Myrtaceae	*Eucalyptus cambageana*	Dawson gum		C		14
plants	Equisetopsida	Myrtaceae	*Eucalyptus suffulgens*			C		1/1
plants	Equisetopsida	Oleaceae	*Jasminum didymum subsp. lineare*			C		2
plants	Equisetopsida	Orchidaceae	*Dendrobium speciosum*			C		1/1
plants	Equisetopsida	Oxalidaceae	*Oxalis corniculata*		Y			1
plants	Equisetopsida	Passifloraceae	*Passiflora foetida*		Y			1/1
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus*			C		1/1
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus virgatus*			C		6
plants	Equisetopsida	Picrodendraceae	*Petalostigma pubescens*	quinine tree		C		6
plants	Equisetopsida	Pittosporaceae	*Pittosporum angustifolium*			C		1/1
plants	Equisetopsida	Poaceae	*Aristida*			C		9
plants	Equisetopsida	Poaceae	*Cymbopogon*			C		1
plants	Equisetopsida	Poaceae	*Enneapogon*			C		1
plants	Equisetopsida	Poaceae	*Eragrostis*			C		2
plants	Equisetopsida	Poaceae	*Oplismenus*					1
plants	Equisetopsida	Poaceae	*Paspalidium*			C		3
plants	Equisetopsida	Poaceae	*Perotis rara*	comet grass		C		1
plants	Equisetopsida	Poaceae	*Eulalia aurea*	silky browntop		C		1
plants	Equisetopsida	Poaceae	*Chloris gayana*	rhodes grass	Y			2/2
plants	Equisetopsida	Poaceae	*Melinis repens*	red natal grass	Y			1
plants	Equisetopsida	Poaceae	*Aristida ingrata*			C		1/1
plants	Equisetopsida	Poaceae	*Dinebra ligulata*			C		2
plants	Equisetopsida	Poaceae	*Themeda triandra*	kangaroo grass		C		2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Poaceae	*Aristida calycina*			C		2
plants	Equisetopsida	Poaceae	*Cenchrus ciliaris*		Y			5
plants	Equisetopsida	Poaceae	*Chloris pectinata*	comb chloris		C		1/1
plants	Equisetopsida	Poaceae	*Entolasia stricta*	wiry panic		C		2
plants	Equisetopsida	Poaceae	*Eragrostis pilosa*	soft lovegrass	Y			1/1
plants	Equisetopsida	Poaceae	*Sporobolus caroli*	fairy grass		C		5
plants	Equisetopsida	Poaceae	*Aristida latifolia*	feathertop wiregrass		C		1
plants	Equisetopsida	Poaceae	*Chrysopogon fallax*			C		3/1
plants	Equisetopsida	Poaceae	*Digitaria diminuta*			C		2
plants	Equisetopsida	Poaceae	*Eragrostis sororia*			C		3/2
plants	Equisetopsida	Poaceae	*Eriachne mucronata*			C		2
plants	Equisetopsida	Poaceae	*Paspalum dilatatum*	paspalum	Y			1/1
plants	Equisetopsida	Poaceae	*Eragrostis elongata*			C		1/1
plants	Equisetopsida	Poaceae	*Megathyrsus maximus*		Y			1
plants	Equisetopsida	Poaceae	*Bothriochloa pertusa*		Y			1
plants	Equisetopsida	Poaceae	*Eragrostis lacunaria*	purple lovegrass		C		7/1
plants	Equisetopsida	Poaceae	*Tripogon loliiformis*	five minute grass		C		1/1
plants	Equisetopsida	Poaceae	*Alloteropsis cimicina*			C		2/1
plants	Equisetopsida	Poaceae	*Aristida jerichoensis*			C		2
plants	Equisetopsida	Poaceae	*Heteropogon contortus*	black speargrass		C		4
plants	Equisetopsida	Poaceae	*Aristida caput-medusae*			C		6/1
plants	Equisetopsida	Poaceae	*Bothriochloa decipiens*			C		2
plants	Equisetopsida	Poaceae	*Enneapogon lindleyanus*			C		2
plants	Equisetopsida	Poaceae	*Paspalidium spartellum*			C		1
plants	Equisetopsida	Poaceae	*Thyridolepis xerophila*			C		1/1
plants	Equisetopsida	Poaceae	*Urochloa mosambicensis*	sabi grass	Y			6
plants	Equisetopsida	Poaceae	*Eragrostis leptostachya*			C		1/1
plants	Equisetopsida	Poaceae	*Paspalidium caespitosum*	brigalow grass		C		3
plants	Equisetopsida	Poaceae	*Digitaria divaricatissima*	spreading umbrella grass		C		1/1
plants	Equisetopsida	Poaceae	*Aristida calycina var. calycina*			C		1/1
plants	Equisetopsida	Poaceae	*Aristida holathera var. holathera*			C		1/1
plants	Equisetopsida	Poaceae	*Chloris divaricata var. divaricata*	slender chloris		C		1/1
plants	Equisetopsida	Poaceae	*Megathyrsus maximus var. pubiglumis*		Y			1
plants	Equisetopsida	Poaceae	*Panicum decompositum var. decompositum*			C		1/1
plants	Equisetopsida	Poaceae	*Calyptochloa gracillima subsp. gracillima*			C		7/1
plants	Equisetopsida	Poaceae	*Cleistochloa sp. (Duaringa K.B.Addison 42)*			C		3/1
plants	Equisetopsida	Poaceae	*Digitaria divaricatissima var. divaricatissima*			C		1
plants	Equisetopsida	Poaceae	*Eriachne mucronata forma (Alpha C.E.Hubbard 7882)*			C		1/1
plants	Equisetopsida	Portulacaceae	*Portulaca filifolia*			C		1
plants	Equisetopsida	Potamogetonaceae	*Potamogeton octandrus*			C		1/1
plants	Equisetopsida	Proteaceae	*Persoonia falcata*			C		1
plants	Equisetopsida	Proteaceae	*Grevillea longistyla*			C		1
plants	Equisetopsida	Proteaceae	*Grevillea striata*	beefwood		C		4
plants	Equisetopsida	Proteaceae	*Hakea lorea*			C		2
plants	Equisetopsida	Proteaceae	*Grevillea parallela*			C		1/1
plants	Equisetopsida	Pteridaceae	*Cheilanthes sieberi subsp. sieberi*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Pteridaceae	*Cheilanthes*			C		1
plants	Equisetopsida	Rhamnaceae	*Alphitonia excelsa*	soap tree		C		15
plants	Equisetopsida	Rhamnaceae	*Ventilago viminalis*	supplejack		C		4
plants	Equisetopsida	Rubiaceae	*Oldenlandia galioides*			C		1/1
plants	Equisetopsida	Rubiaceae	*Oldenlandia mitrasacmoides subsp. trachymenoides*			C		1/1
plants	Equisetopsida	Rubiaceae	*Everistia vacciniifolia*			C		1
plants	Equisetopsida	Rubiaceae	*Psydrax oleifolia*			C		2
plants	Equisetopsida	Rubiaceae	*Spermacoce brachystema*			C		2
plants	Equisetopsida	Rutaceae	*Geijera parviflora*	wilga		C		8
plants	Equisetopsida	Rutaceae	*Citrus x limon*		Y			1/1
plants	Equisetopsida	Rutaceae	*Philotheca difformis subsp. difformis*			C		1/1
plants	Equisetopsida	Sapindaceae	*Dodonaea viscosa subsp. spatulata*			C		1/1
plants	Equisetopsida	Sapindaceae	*Alectryon diversifolius*	scrub boonaree		C		3
plants	Equisetopsida	Sapindaceae	*Alectryon oleifolius*			C		2
plants	Equisetopsida	Sapindaceae	*Atalaya hemiglauca*			C		3/1
plants	Equisetopsida	Sapindaceae	*Dodonaea*			C		3
plants	Equisetopsida	Scrophulariaceae	*Myoporum acuminatum*	coastal boobialla		C		1
plants	Equisetopsida	Scrophulariaceae	*Eremophila mitchellii*			C		9
plants	Equisetopsida	Solanaceae	*Solanum parvifolium*			C		1
plants	Equisetopsida	Solanaceae	*Solanum adenophorum*			E		1/1
plants	Equisetopsida	Solanaceae	*Solanum ellipticum*	potato bush		C		1
plants	Equisetopsida	Solanaceae	*Solanum ferocissimum*			C		2
plants	Equisetopsida	Solanaceae	*Solanum elachophyllum*			E		1
plants	Equisetopsida	Sparrmanniaceae	*Grewia latifolia*	dysentery plant		C		4
plants	Equisetopsida	Sparrmanniaceae	*Grewia retusifolia*			C		3/1
plants	Equisetopsida	Stylidiaceae	*Stylidium eriorhizum*			C		2/1
plants	Equisetopsida	Verbenaceae	*Phyla canescens*		Y			1/1
plants	Equisetopsida	Verbenaceae	*Stachytarpheta jamaicensis*	Jamaica snakeweed	Y			1
plants	Equisetopsida	Violaceae	*Afrohybanthus stellarioides*			C		2

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Status: Rare and threatened species
Records: All
Date: All
Latitude: -23.6380
Longitude: 149.2514
Distance: 50
Email: llopez@aarc.net.au
Date submitted: Thursday 13 Jun 2019 10:03:05
Date extracted: Thursday 13 Jun 2019 10:10:15

The number of records retrieved = 50

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Limnodynastidae	*Adelotus brevis*	tusked frog		V		10
animals	birds	Accipitridae	*Erythrotriorchis radiatus*	red goshawk		E	V	15
animals	birds	Cacatuidae	*Calyptorhynchus lathami*	glossy black-cockatoo		V		4
animals	birds	Cacatuidae	*Calyptorhynchus lathami erebus*	glossy black-cockatoo (northern)		V		19/2
animals	birds	Columbidae	*Geophaps scripta scripta*	squatter pigeon (southern subspecies)		V	V	47
animals	birds	Estrildidae	*Poephila cincta cincta*	black-throated finch (white-rumped subspecies)		E	E	4/1
animals	birds	Meliphagidae	*Grantiella picta*	painted honeyeater		V	V	3
animals	birds	Pedionomidae	*Pedionomus torquatus*	plains-wanderer		V	CE	1
animals	birds	Psittacidae	*Psephotus pulcherrimus*	paradise parrot		PE	EX	9/2
animals	birds	Psittacidae	*Lathamus discolor*	swift parrot		E	CE	1
animals	birds	Strigidae	*Ninox strenua*	powerful owl		V		3
animals	birds	Turnicidae	*Turnix melanogaster*	black-breasted button-quail		V	V	7
animals	insects	Lycaenidae	*Jalmenus eubulus*	pale imperial hairstreak		V		5
animals	mammals	Dasyuridae	*Antechinus argentus*	silver-headed antechinus		V	E	23
animals	mammals	Macropodidae	*Onychogalea fraenata*	bridled nailtail wallaby		E	E	41
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		V	V	13
animals	mammals	Potoroidae	*Bettongia gaimardi gaimardi*	eastern bettong		PE	EX	4
animals	mammals	Pseudocheiridae	*Petauroides volans volans*	southern greater glider		V	V	69
animals	mammals	Pseudocheiridae	*Petauroides volans*	greater glider		V	V	3
animals	mammals	Vespertilionidae	*Chalinolobus dwyeri*	large-eared pied bat		V	V	2
animals	reptiles	Chelidae	*Elseya albagula*	southern snapping turtle		E	CE	3
animals	reptiles	Chelidae	*Rheodytes leukops*	Fitzroy River turtle		V	V	1
animals	reptiles	Diplodactylidae	*Strophurus taenicauda*	golden-tailed gecko		NT		10/1
animals	reptiles	Elapidae	*Denisonia maculata*	ornamental snake		V	V	2
animals	reptiles	Pygopodidae	*Delma torquata*	collared delma		V	V	1
plants	Equisetopsida	Apocynaceae	*Cerbera dumicola*			NT		6/6
plants	Equisetopsida	Arecaceae	*Livistona fulva*			V		16/12
plants	Equisetopsida	Asteraceae	*Rutidosis glandulosa*			NT		7/7
plants	Equisetopsida	Byttneriaceae	*Commersonia pearnii*			E		2/2
plants	Equisetopsida	Combretaceae	*Macropteranthes leiocaulis*			NT		1/1
plants	Equisetopsida	Euphorbiaceae	*Bertya pedicellata*			NT		3
plants	Equisetopsida	Fabaceae	*Daviesia discolor*			V	V	8/6
plants	Equisetopsida	Fabaceae	*Daviesia quoquoversus*			V		7/2
plants	Equisetopsida	Lamiaceae	*Plectranthus blakei*			NT		10/10
plants	Equisetopsida	Loganiaceae	*Logania diffusa*			V	V	4/2
plants	Equisetopsida	Mimosaceae	*Acacia storyi*			NT		21/17
plants	Equisetopsida	Myrtaceae	*Sannantha brachypoda*			V		1/1
plants	Equisetopsida	Myrtaceae	*Melaleuca pearsonii*			NT		13/12
plants	Equisetopsida	Myrtaceae	*Baeckea trapeza*			V		7/7
plants	Equisetopsida	Myrtaceae	*Melaleuca groveana*			NT		6/4
plants	Equisetopsida	Orchidaceae	*Phaius australis*			E	E	5/3
plants	Equisetopsida	Orchidaceae	*Corunastylis valida*			V		1/1
plants	Equisetopsida	Orchidaceae	*Gastrodia crebriflora*			V		1/1
plants	Equisetopsida	Orchidaceae	*Corunastylis pedersonii*			V		1/1
plants	Equisetopsida	Picrodendraceae	*Pseudanthus pauciflorus subsp. arenicola*			NT		2/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Solanaceae	*Solanum dissectum*			E	E	3/3
plants	Equisetopsida	Solanaceae	*Solanum adenophorum*			E		12/10
plants	Equisetopsida	Solanaceae	*Solanum elachophyllum*			E		17/14
plants	Equisetopsida	Surianaceae	*Cadellia pentastylis*	ooline		V	V	4/4
plants	Equisetopsida	Zamiaceae	*Macrozamia platyrhachis*			E	E	55/30

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Status: All
Records: All
Date: All
Latitude: -23.6381
Longitude: 149.1514
Distance: 50
Email: llopez@aarc.net.au
Date submitted: Thursday 13 Jun 2019 10:01:50
Date extracted: Thursday 13 Jun 2019 10:10:02

The number of records retrieved = 2173

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Bufonidae	*Rhinella marina*	cane toad	Y			75/1
animals	amphibians	Hylidae	*Cyclorana cultripes*	grassland collared frog		C		3/3
animals	amphibians	Hylidae	*Cyclorana alboguttata*	greenstripe frog		C		16/1
animals	amphibians	Hylidae	*Cyclorana novaehollandiae*	eastern snapping frog		C		12/1
animals	amphibians	Hylidae	*Cyclorana verrucosa*	rough collared frog		C		3/2
animals	amphibians	Hylidae	*Litoria latopalmata*	broad palmed rocketfrog		C		48/1
animals	amphibians	Hylidae	*Cyclorana brevipes*	superb collared frog		C		5/2
animals	amphibians	Hylidae	*Litoria wilcoxii*	eastern stony creek frog		C		15/1
animals	amphibians	Hylidae	*Litoria caerulea*	common green treefrog		C		41/1
animals	amphibians	Hylidae	*Litoria rubella*	ruddy treefrog		C		20/1
animals	amphibians	Hylidae	*Litoria peronii*	emerald spotted treefrog		C		5/1
animals	amphibians	Hylidae	*Litoria inermis*	bumpy rocketfrog		C		22/1
animals	amphibians	Hylidae	*Litoria rothii*	northern laughing treefrog		C		6
animals	amphibians	Hylidae	*Litoria fallax*	eastern sedgefrog		C		17/1
animals	amphibians	Limnodynastidae	*Adelotus brevis*	tusked frog		V		10
animals	amphibians	Limnodynastidae	*Limnodynastes peronii*	striped marshfrog		C		11
animals	amphibians	Limnodynastidae	*Limnodynastes terraereginae*	scarlet sided pobblebonk		C		28/2
animals	amphibians	Limnodynastidae	*Limnodynastes tasmaniensis*	spotted grassfrog		C		14/1
animals	amphibians	Limnodynastidae	*Platyplectrum ornatum*	ornate burrowing frog		C		35/1
animals	amphibians	Limnodynastidae	*Limnodynastes salmini*	salmon striped frog		C		13
animals	amphibians	Myobatrachidae	*Crinia signifera*	clicking froglet		C		5
animals	amphibians	Myobatrachidae	*Pseudophryne sp.*					1
animals	amphibians	Myobatrachidae	*Uperoleia rugosa*	chubby gungan		C		2/1
animals	amphibians	Myobatrachidae	*Pseudophryne major*	great brown broodfrog		C		20/1
animals	amphibians	Myobatrachidae	*Uperoleia laevigata*	eastern gungan		C		10
animals	amphibians	Myobatrachidae	*Uperoleia sp.*					3
animals	amphibians	Myobatrachidae	*Crinia parinsignifera*	beeping froglet		C		17
animals	birds	Acanthizidae	*Acanthiza nana*	yellow thornbill		C		27
animals	birds	Acanthizidae	*Gerygone fusca*	western gerygone		C		3
animals	birds	Acanthizidae	*Acanthiza lineata*	striated thornbill		C		28/9
animals	birds	Acanthizidae	*Acanthiza pusilla*	brown thornbill		C		6
animals	birds	Acanthizidae	*Gerygone olivacea*	white-throated gerygone		C		90
animals	birds	Acanthizidae	*Acanthiza apicalis*	inland thornbill		C		8
animals	birds	Acanthizidae	*Sericornis citreogularis*	yellow-throated scrubwren		C		1
animals	birds	Acanthizidae	*Sericornis frontalis*	white-browed scrubwren		C		25
animals	birds	Acanthizidae	*Acanthiza chrysorrhoa*	yellow-rumped thornbill		C		10
animals	birds	Acanthizidae	*Acanthiza uropygialis*	chestnut-rumped thornbill		C		1
animals	birds	Acanthizidae	*Chthonicola sagittata*	speckled warbler		C		8
animals	birds	Acanthizidae	*Smicrornis brevirostris*	weebill		C		129
animals	birds	Acanthizidae	*Acanthiza reguloides*	buff-rumped thornbill		C		80/8
animals	birds	Accipitridae	*Accipiter fasciatus*	brown goshawk		C		10
animals	birds	Accipitridae	*Aviceda subcristata*	Pacific baza		C		14
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		52
animals	birds	Accipitridae	*Haliaeetus leucogaster*	white-bellied sea-eagle		C		3
animals	birds	Accipitridae	*Hieraaetus morphnoides*	little eagle		C		3
animals	birds	Accipitridae	*Accipiter cirrocephalus*	collared sparrowhawk		C		6

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Accipitridae	*Erythrotriorchis radiatus*	red goshawk		E	V	13
animals	birds	Accipitridae	*Aquila audax*	wedge-tailed eagle		C		46
animals	birds	Accipitridae	*Milvus migrans*	black kite		C		14
animals	birds	Accipitridae	*Circus assimilis*	spotted harrier		C		1
animals	birds	Accipitridae	*Elanus axillaris*	black-shouldered kite		C		5
animals	birds	Accipitridae	*Pandion cristatus*	eastern osprey		SL		1
animals	birds	Accipitridae	*Circus approximans*	swamp harrier		C		1
animals	birds	Accipitridae	*Lophoictinia isura*	square-tailed kite		C		2
animals	birds	Acrocephalidae	*Acrocephalus australis*	Australian reed-warbler		C		8
animals	birds	Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar		C		61
animals	birds	Alaudidae	*Mirafra javanica*	Horsfield's bushlark		C		11
animals	birds	Alcedinidae	*Ceyx azureus*	azure kingfisher		C		4
animals	birds	Anatidae	*Aythya australis*	hardhead		C		17
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		60
animals	birds	Anatidae	*Chenonetta jubata*	Australian wood duck		C		31
animals	birds	Anatidae	*Dendrocygna eytoni*	plumed whistling-duck		C		6
animals	birds	Anatidae	*Dendrocygna arcuata*	wandering whistling-duck		C		7
animals	birds	Anatidae	*Nettapus coromandelianus*	cotton pygmy-goose		C		5
animals	birds	Anatidae	*Malacorhynchus membranaceus*	pink-eared duck		C		3
animals	birds	Anatidae	*Anas rhynchotis*	Australasian shoveler		C		3
animals	birds	Anatidae	*Tadorna radjah*	radjah shelduck		C		1
animals	birds	Anatidae	*Cygnus atratus*	black swan		C		14
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		27
animals	birds	Anatidae	*Anas castanea*	chestnut teal		C		1
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		27
animals	birds	Anseranatidae	*Anseranas semipalmata*	magpie goose		C		4
animals	birds	Apodidae	*Hirundapus caudacutus*	white-throated needletail		SL		6
animals	birds	Apodidae	*Apus pacificus*	fork-tailed swift		SL		2
animals	birds	Ardeidae	*Ardea alba modesta*	eastern great egret		C		17
animals	birds	Ardeidae	*Ixobrychus flavicollis*	black bittern		C		2
animals	birds	Ardeidae	*Nycticorax caledonicus*	nankeen night-heron		C		13
animals	birds	Ardeidae	*Egretta novaehollandiae*	white-faced heron		C		33
animals	birds	Ardeidae	*Ardea pacifica*	white-necked heron		C		26
animals	birds	Ardeidae	*Egretta picata*	pied heron		C		1
animals	birds	Ardeidae	*Ardea intermedia*	intermediate egret		C		13
animals	birds	Ardeidae	*Egretta garzetta*	little egret		C		4
animals	birds	Ardeidae	*Bubulcus ibis*	cattle egret		C		3
animals	birds	Artamidae	*Strepera graculina*	pied currawong		C		141/3
animals	birds	Artamidae	*Artamus cyanopterus*	dusky woodswallow		C		4
animals	birds	Artamidae	*Cracticus torquatus*	grey butcherbird		C		174
animals	birds	Artamidae	*Artamus leucorynchus*	white-breasted woodswallow		C		15
animals	birds	Artamidae	*Artamus superciliosus*	white-browed woodswallow		C		16
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		206
animals	birds	Artamidae	*Artamus cinereus dealbatus*	black-faced woodswallow (east-central Queensland)		C		4
animals	birds	Artamidae	*Artamus minor*	little woodswallow		C		7

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Artamidae	*Artamus cinereus*	black-faced woodswallow		C		15
animals	birds	Artamidae	*Artamus personatus*	masked woodswallow		C		12
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		128
animals	birds	Burhinidae	*Burhinus grallarius*	bush stone-curlew		C		10
animals	birds	Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo		C		108
animals	birds	Cacatuidae	*Cacatua sanguinea*	little corella		C		2
animals	birds	Cacatuidae	*Calyptorhynchus banksii banksii*	red-tailed black-cockatoo (Cape York & Eastern Aust)		C		1
animals	birds	Cacatuidae	*Calyptorhynchus lathami erebus*	glossy black-cockatoo (northern)		V		19/2
animals	birds	Cacatuidae	*Calyptorhynchus funereus*	yellow-tailed black-cockatoo		C		3
animals	birds	Cacatuidae	*Calyptorhynchus lathami*	glossy black-cockatoo		V		4
animals	birds	Cacatuidae	*Calyptorhynchus banksii*	red-tailed black-cockatoo		C		6
animals	birds	Cacatuidae	*Nymphicus hollandicus*	cockatiel		C		8
animals	birds	Cacatuidae	*Eolophus roseicapilla*	galah		C		29
animals	birds	Campephagidae	*Lalage tricolor*	white-winged triller		C		34
animals	birds	Campephagidae	*Lalage leucomela*	varied triller		C		1
animals	birds	Campephagidae	*Coracina papuensis*	white-bellied cuckoo-shrike		C		27
animals	birds	Campephagidae	*Coracina tenuirostris*	cicadabird		C		42
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		93
animals	birds	Campephagidae	*Coracina maxima*	ground cuckoo-shrike		C		5
animals	birds	Casuariidae	*Dromaius novaehollandiae*	emu		C		10
animals	birds	Charadriidae	*Elseyornis melanops*	black-fronted dotterel		C		15
animals	birds	Charadriidae	*Vanellus miles novaehollandiae*	masked lapwing (southern subspecies)		C		23
animals	birds	Charadriidae	*Charadrius ruficapillus*	red-capped plover		C		1
animals	birds	Charadriidae	*Erythrogonys cinctus*	red-kneed dotterel		C		1
animals	birds	Charadriidae	*Vanellus tricolor*	banded lapwing		C		2
animals	birds	Charadriidae	*Vanellus miles*	masked lapwing		C		7
animals	birds	Ciconiidae	*Ephippiorhynchus asiaticus*	black-necked stork		C		1
animals	birds	Cisticolidae	*Cisticola exilis*	golden-headed cisticola		C		12
animals	birds	Climacteridae	*Climacteris picumnus*	brown treecreeper		C		7
animals	birds	Climacteridae	*Cormobates leucophaea metastasis*	white-throated treecreeper (southern)		C		84/8
animals	birds	Climacteridae	*Cormobates leucophaea*	white-throated treecreeper		C		19
animals	birds	Columbidae	*Geophaps scripta scripta*	squatter pigeon (southern subspecies)		V	V	44
animals	birds	Columbidae	*Leucosarcia melanoleuca*	wonga pigeon		C		1
animals	birds	Columbidae	*Geopelia humeralis*	bar-shouldered dove		C		25
animals	birds	Columbidae	*Geopelia cuneata*	diamond dove		C		9
animals	birds	Columbidae	*Geopelia striata*	peaceful dove		C		67
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		43
animals	birds	Columbidae	*Phaps chalcoptera*	common bronzewing		C		13
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		47
animals	birds	Corcoracidae	*Struthidea cinerea*	apostlebird		C		82
animals	birds	Corcoracidae	*Corcorax melanorhamphos*	white-winged chough		C		31
animals	birds	Corvidae	*Corvus coronoides*	Australian raven		C		31
animals	birds	Corvidae	*Corvus sp.*					7
animals	birds	Corvidae	*Corvus bennetti*	little crow		C		1
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		209

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Cuculidae	*Chalcites lucidus*	shining bronze-cuckoo		C		12
animals	birds	Cuculidae	*Chalcites osculans*	black-eared cuckoo		C		2
animals	birds	Cuculidae	*Cacomantis pallidus*	pallid cuckoo		C		25
animals	birds	Cuculidae	*Chalcites minutillus*	little bronze-cuckoo		C		2
animals	birds	Cuculidae	*Eudynamys orientalis*	eastern koel		C		12
animals	birds	Cuculidae	*Cacomantis variolosus*	brush cuckoo		C		2
animals	birds	Cuculidae	*Centropus phasianinus*	pheasant coucal		C		53
animals	birds	Cuculidae	*Cacomantis flabelliformis*	fan-tailed cuckoo		C		35
animals	birds	Cuculidae	*Scythrops novaehollandiae*	channel-billed cuckoo		C		33
animals	birds	Cuculidae	*Chalcites minutillus barnardi*	Eastern little bronze-cuckoo		C		5
animals	birds	Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo		C		16
animals	birds	Dicruridae	*Dicrurus bracteatus bracteatus*	spangled drongo (eastern Australia)		C		4
animals	birds	Dicruridae	*Dicrurus bracteatus*	spangled drongo		C		18
animals	birds	Estrildidae	*Neochmia modesta*	plum-headed finch		C		8
animals	birds	Estrildidae	*Neochmia temporalis*	red-browed finch		C		17
animals	birds	Estrildidae	*Taeniopygia guttata*	zebra finch		C		11
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		73
animals	birds	Estrildidae	*Lonchura castaneothorax*	chestnut-breasted mannikin		C		5
animals	birds	Eurostopodidae	*Eurostopodus argus*	spotted nightjar		C		3
animals	birds	Eurostopodidae	*Eurostopodus mystacalis*	white-throated nightjar		C		11
animals	birds	Falconidae	*Falco sp.*					1
animals	birds	Falconidae	*Falco berigora*	brown falcon		C		36
animals	birds	Falconidae	*Falco longipennis*	Australian hobby		C		6
animals	birds	Falconidae	*Falco peregrinus*	peregrine falcon		C		12
animals	birds	Falconidae	*Falco cenchroides*	nankeen kestrel		C		28
animals	birds	Falconidae	*Falco subniger*	black falcon		C		4
animals	birds	Gruidae	*Grus rubicunda*	brolga		C		19
animals	birds	Haematopodidae	*Haematopus longirostris*	Australian pied oystercatcher		C		1
animals	birds	Halcyonidae	*Dacelo novaeguineae*	laughing kookaburra		C		189
animals	birds	Halcyonidae	*Todiramphus sanctus*	sacred kingfisher		C		28
animals	birds	Halcyonidae	*Todiramphus macleayii*	forest kingfisher		C		35
animals	birds	Halcyonidae	*Dacelo leachii*	blue-winged kookaburra		C		25
animals	birds	Halcyonidae	*Todiramphus pyrrhopygius*	red-backed kingfisher		C		8
animals	birds	Hirundinidae	*Petrochelidon ariel*	fairy martin		C		18
animals	birds	Hirundinidae	*Cheramoeca leucosterna*	white-backed swallow		C		1
animals	birds	Hirundinidae	*Petrochelidon nigricans*	tree martin		C		27
animals	birds	Hirundinidae	*Hirundo neoxena*	welcome swallow		C		25
animals	birds	Jacanidae	*Irediparra gallinacea*	comb-crested jacana		C		11
animals	birds	Laridae	*Hydroprogne caspia*	Caspian tern		SL		4
animals	birds	Laridae	*Chlidonias hybrida*	whiskered tern		C		1
animals	birds	Maluridae	*Malurus cyaneus*	superb fairy-wren		C		34
animals	birds	Maluridae	*Malurus lamberti*	variegated fairy-wren		C		118/1
animals	birds	Maluridae	*Malurus melanocephalus*	red-backed fairy-wren		C		199
animals	birds	Megaluridae	*Megalurus timoriensis*	tawny grassbird		C		2
animals	birds	Megaluridae	*Cincloramphus cruralis*	brown songlark		C		5
animals	birds	Megaluridae	*Cincloramphus mathewsi*	rufous songlark		C		24

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Megapodiidae	*Alectura lathami*	Australian brush-turkey		C		2
animals	birds	Meliphagidae	*Manorina flavigula*	yellow-throated miner		C		42
animals	birds	Meliphagidae	*Melithreptus gularis gularis*	black-chinned honeyeater (eastern)		C		2
animals	birds	Meliphagidae	*Acanthorhynchus tenuirostris*	eastern spinebill		C		14/1
animals	birds	Meliphagidae	*Melithreptus brevirostris*	brown-headed honeyeater		C		4
animals	birds	Meliphagidae	*Plectorhyncha lanceolata*	striped honeyeater		C		41/1
animals	birds	Meliphagidae	*Melithreptus albogularis*	white-throated honeyeater		C		113
animals	birds	Meliphagidae	*Acanthagenys rufogularis*	spiny-cheeked honeyeater		C		6
animals	birds	Meliphagidae	*Philemon citreogularis*	little friarbird		C		70
animals	birds	Meliphagidae	*Ptilotula fusca*	fuscous honeyeater		C		12
animals	birds	Meliphagidae	*Grantiella picta*	painted honeyeater		V	V	3
animals	birds	Meliphagidae	*Meliphaga lewinii*	Lewin's honeyeater		C		7
animals	birds	Meliphagidae	*Caligavis chrysops*	yellow-faced honeyeater		C		79/4
animals	birds	Meliphagidae	*Entomyzon cyanotis*	blue-faced honeyeater		C		123
animals	birds	Meliphagidae	*Phylidonyris niger*	white-cheeked honeyeater		C		18
animals	birds	Meliphagidae	*Epthianura tricolor*	crimson chat		C		1
animals	birds	Meliphagidae	*Gavicalis virescens*	singing honeyeater		C		43
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		90
animals	birds	Meliphagidae	*Melithreptus gularis*	black-chinned honeyeater		C		1
animals	birds	Meliphagidae	*Melithreptus lunatus*	white-naped honeyeater		C		48/4
animals	birds	Meliphagidae	*Nesoptilotis leucotis*	white-eared honeyeater		C		50
animals	birds	Meliphagidae	*Philemon corniculatus*	noisy friarbird		C		223/4
animals	birds	Meliphagidae	*Ptilotula penicillata*	white-plumed honeyeater		C		4
animals	birds	Meliphagidae	*Lichenostomus melanops*	yellow-tufted honeyeater		C		17
animals	birds	Meliphagidae	*Manorina melanocephala*	noisy miner		C		225
animals	birds	Meliphagidae	*Myzomela sanguinolenta*	scarlet honeyeater		C		23
animals	birds	Meropidae	*Merops ornatus*	rainbow bee-eater		C		65
animals	birds	Monarchidae	*Monarcha melanopsis*	black-faced monarch		SL		3
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		101
animals	birds	Monarchidae	*Myiagra cyanoleuca*	satin flycatcher		SL		1
animals	birds	Monarchidae	*Myiagra rubecula*	leaden flycatcher		C		62
animals	birds	Monarchidae	*Myiagra inquieta*	restless flycatcher		C		22
animals	birds	Monarchidae	*Myiagra alecto*	shining flycatcher		C		1
animals	birds	Motacillidae	*Anthus novaeseelandiae*	Australasian pipit		C		17
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		74
animals	birds	Neosittidae	*Daphoenositta chrysoptera*	varied sittella		C		25/1
animals	birds	Oriolidae	*Oriolus sagittatus*	olive-backed oriole		C		45/1
animals	birds	Oriolidae	*Sphecotheres vieilloti*	Australasian figbird		C		8
animals	birds	Otididae	*Ardeotis australis*	Australian bustard		C		22/1
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		170
animals	birds	Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush		C		124
animals	birds	Pachycephalidae	*Pachycephala pectoralis*	golden whistler		C		9/1
animals	birds	Pachycephalidae	*Colluricincla megarhyncha*	little shrike-thrush		C		2
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		271/1
animals	birds	Pardalotidae	*Pardalotus punctatus*	spotted pardalote		C		56/2
animals	birds	Pardalotidae	*Pardalotus rubricatus*	red-browed pardalote		C		2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Passeridae	*Passer domesticus*	house sparrow	Y			7
animals	birds	Pedionomidae	*Pedionomus torquatus*	plains-wanderer		V	CE	1
animals	birds	Pelecanidae	*Pelecanus conspicillatus*	Australian pelican		C		15
animals	birds	Petroicidae	*Petroica rosea*	rose robin		C		3
animals	birds	Petroicidae	*Petroica goodenovii*	red-capped robin		C		3
animals	birds	Petroicidae	*Microeca fascinans*	jacky winter		C		32/2
animals	birds	Petroicidae	*Eopsaltria australis*	eastern yellow robin		C		44/4
animals	birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant		C		15
animals	birds	Phalacrocoracidae	*Microcarbo melanoleucos*	little pied cormorant		C		33
animals	birds	Phalacrocoracidae	*Phalacrocorax varius*	pied cormorant		C		9
animals	birds	Phalacrocoracidae	*Phalacrocorax carbo*	great cormorant		C		3
animals	birds	Phasianidae	*Coturnix pectoralis*	stubble quail		C		1
animals	birds	Phasianidae	*Coturnix ypsilophora*	brown quail		C		15
animals	birds	Podargidae	*Podargus strigoides*	tawny frogmouth		C		40
animals	birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe		C		32
animals	birds	Podicipedidae	*Poliocephalus poliocephalus*	hoary-headed grebe		C		1
animals	birds	Podicipedidae	*Podiceps cristatus*	great crested grebe		C		4
animals	birds	Pomatostomidae	*Pomatostomus temporalis temporalis*	grey-crowned babbler (eastern)		C		10
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		78
animals	birds	Psittacidae	*Lathamus discolor*	swift parrot		E	CE	1
animals	birds	Psittacidae	*Parvipsitta pusilla*	little lorikeet		C		49
animals	birds	Psittacidae	*Platycercus elegans*	crimson rosella		C		2
animals	birds	Psittacidae	*Alisterus scapularis*	Australian king-parrot		C		17
animals	birds	Psittacidae	*Platycercus adscitus*	pale-headed rosella		C		143/1
animals	birds	Psittacidae	*Psephotus pulcherrimus*	paradise parrot		PE	EX	6/1
animals	birds	Psittacidae	*Melopsittacus undulatus*	budgerigar		C		9
animals	birds	Psittacidae	*Trichoglossus haematodus moluccanus*	rainbow lorikeet		C		270/4
animals	birds	Psittacidae	*Platycercus adscitus adscitus*	pale-headed rosella (northern form)		C		1
animals	birds	Psittacidae	*Aprosmictus erythropterus*	red-winged parrot		C		61
animals	birds	Psittacidae	*Trichoglossus chlorolepidotus*	scaly-breasted lorikeet		C		86
animals	birds	Psittacidae	*Platycercus adscitus palliceps*	pale-headed rosella (southern form)		C		10
animals	birds	Psophodidae	*Psophodes olivaceus*	eastern whipbird		C		6
animals	birds	Psophodidae	*Cinclosoma punctatum*	spotted quail-thrush		C		15
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus maculatus*	spotted bowerbird		C		149
animals	birds	Rallidae	*Gallinula tenebrosa*	dusky moorhen		C		17
animals	birds	Rallidae	*Tribonyx ventralis*	black-tailed native-hen		C		4
animals	birds	Rallidae	*Fulica atra*	Eurasian coot		C		9
animals	birds	Rallidae	*Porphyrio melanotus*	purple swamphen		C		8
animals	birds	Recurvirostridae	*Himantopus himantopus*	black-winged stilt		C		12
animals	birds	Rhipiduridae	*Rhipidura leucophrys leucophrys*	willie wagtail (southern)		C		12
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		95
animals	birds	Rhipiduridae	*Rhipidura rufifrons*	rufous fantail		SL		6
animals	birds	Rhipiduridae	*Rhipidura albiscapa*	grey fantail		C		166/1
animals	birds	Scolopacidae	*Gallinago hardwickii*	Latham's snipe		SL		1
animals	birds	Scolopacidae	*Calidris acuminata*	sharp-tailed sandpiper		SL		2
animals	birds	Scolopacidae	*Tringa stagnatilis*	marsh sandpiper		SL		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Strigidae	*Ninox boobook*	southern boobook		C		51
animals	birds	Strigidae	*Ninox strenua*	powerful owl		V		3
animals	birds	Strigidae	*Ninox connivens*	barking owl		C		5
animals	birds	Sulidae	*Morus serrator*	Australasian gannet		C		1
animals	birds	Threskiornithidae	*Platalea regia*	royal spoonbill		C		12
animals	birds	Threskiornithidae	*Platalea flavipes*	yellow-billed spoonbill		C		14
animals	birds	Threskiornithidae	*Plegadis falcinellus*	glossy ibis		SL		1
animals	birds	Threskiornithidae	*Threskiornis molucca*	Australian white ibis		C		12
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		24
animals	birds	Timaliidae	*Zosterops lateralis*	silvereye		C		24
animals	birds	Timaliidae	*Zosterops lateralis cornwalli*	silvereye (eastern)		C		1
animals	birds	Turnicidae	*Turnix velox*	little button-quail		C		4
animals	birds	Turnicidae	*Turnix varius*	painted button-quail		C		5
animals	birds	Turnicidae	*Turnix melanogaster*	black-breasted button-quail		V	V	7
animals	birds	Tytonidae	*Tyto delicatula*	eastern barn owl		C		13
animals	birds	Tytonidae	*Tyto novaehollandiae*	masked owl		C		2
animals	insects	Hesperiidae	*Ocybadistes hypomeloma hypomeloma*	white-margined grass-dart (eastern subspecies)				1
animals	insects	Hesperiidae	*Cephrenes augiades sperthias*	orange palm-dart				1
animals	insects	Hesperiidae	*Ocybadistes walkeri sothis*	green grass-dart				1
animals	insects	Hesperiidae	*Hesperilla ornata ornata*	spotted sedge-skipper (southern subspecies)				1
animals	insects	Hesperiidae	*Badamia exclamationis*	narrow-winged awl				1
animals	insects	Hesperiidae	*Hesperilla malindeva*	two-spotted sedge-skipper				1
animals	insects	Hesperiidae	*Trapezites phigalia*	heath ochre				1
animals	insects	Hesperiidae	*Toxidia peron*	dingy grass-skipper				1
animals	insects	Hesperiidae	*Hesperilla furva*	grey sedge-skipper				2
animals	insects	Hesperiidae	*Mesodina halyzia*	eastern iris-skipper				1
animals	insects	Hesperiidae	*Trapezites taori*	sandstone ochre				1
animals	insects	Hesperiidae	*Trapezites eliena*	orange ochre				1
animals	insects	Hesperiidae	*Trapezites maheta*	northern silver ochre				1
animals	insects	Hesperiidae	*Parnara bada*	grey swift				1
animals	insects	Lycaenidae	*Nacaduba biocellata biocellata*	two-spotted line-blue				1
animals	insects	Lycaenidae	*Candalides cyprotus pallescens*	copper pencilled-blue				1
animals	insects	Lycaenidae	*Theclinesthes miskini miskini*	wattle blue (Australian subspecies)				1
animals	insects	Lycaenidae	*Neolucia agricola agricola*	fringed heath-blue				1
animals	insects	Lycaenidae	*Zizina otis labradus*	common grass-blue (Australian subspecies)				2
animals	insects	Lycaenidae	*Nesolycaena albosericea*	satin opal				39
animals	insects	Lycaenidae	*Euchrysops cnejus cnidus*	spotted pea-blue				1
animals	insects	Lycaenidae	*Zizeeria karsandra*	spotted grass-blue				1
animals	insects	Lycaenidae	*Candalides geminus*	twin dusky-blue				1
animals	insects	Lycaenidae	*Lampides boeticus*	long-tailed pea-blue				1
animals	insects	Lycaenidae	*Jalmenus eubulus*	pale imperial hairstreak		V		1
animals	insects	Nymphalidae	*Hypocysta metirius*	brown ringlet				1
animals	insects	Nymphalidae	*Hypocysta sp.*					1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	insects	Nymphalidae	*Melanitis leda bankia*	evening brown				4
animals	insects	Nymphalidae	*Tirumala hamata hamata*	blue tiger				3
animals	insects	Nymphalidae	*Junonia villida villida*	meadow argus				4
animals	insects	Nymphalidae	*Ypthima arctous arctous*	dusky knight				1
animals	insects	Nymphalidae	*Hypolimnas bolina nerina*	varied eggfly				3
animals	insects	Nymphalidae	*Hypocysta adiante adiante*	orange ringlet				2
animals	insects	Nymphalidae	*Junonia orithya albicincta*	blue argus				5
animals	insects	Nymphalidae	*Acraea andromacha andromacha*	glasswing				2
animals	insects	Nymphalidae	*Charaxes sempronius sempronius*	tailed emperor				2
animals	insects	Nymphalidae	*Hypocysta pseudirius*	grey ringlet				1
animals	insects	Nymphalidae	*Danaus petilia*	lesser wanderer				3
animals	insects	Nymphalidae	*Euploea corinna*	common crow				5
animals	insects	Nymphalidae	*Hypocysta irius*	orange-streaked ringlet				1
animals	insects	Nymphalidae	*Vanessa kershawi*	Australian painted lady				1
animals	insects	Papilionidae	*Graphium eurypylus lycaon*	pale triangle				1
animals	insects	Papilionidae	*Cressida cressida cressida*	clearwing swallowtail				2
animals	insects	Papilionidae	*Papilio aegeus aegeus*	orchard swallowtail (Australian subspecies)				4
animals	insects	Pieridae	*Appias paulina ega*	yellow albatross				1
animals	insects	Pieridae	*Elodina angulipennis*	southern pearl-white				1
animals	insects	Pieridae	*Belenois java teutonia*	caper white				3
animals	insects	Pieridae	*Delias argenthona argenthona*	scarlet jezebel				1
animals	insects	Pieridae	*Catopsilia gorgophone gorgophone*	yellow migrant				2
animals	insects	Pieridae	*Eurema hecabe*	large grass-yellow				1
animals	insects	Pieridae	*Eurema herla*	pink grass-yellow				1
animals	insects	Pieridae	*Catopsilia pomona*	lemon migrant				3
animals	insects	Pieridae	*Elodina parthia*	striated pearl-white				1
animals	insects	Pieridae	*Eurema smilax*	small grass-yellow				2
animals	insects	Pieridae	*Cepora perimale scyllara*	caper gull (Australian subspecies)				3
animals	mammals	Acrobatidae	*Acrobates pygmaeus*	feathertail glider		C		11
animals	mammals	Bovidae	*Bos sp.*	cattle	Y			4
animals	mammals	Bovidae	*Bos taurus*	European cattle	Y			18
animals	mammals	Canidae	*Vulpes vulpes*	red fox	Y			1
animals	mammals	Canidae	*Canis lupus dingo*	dingo				22
animals	mammals	Canidae	*Canis lupus familiaris*	dog	Y			11
animals	mammals	Dasyuridae	*Dasyurus sp.*					1
animals	mammals	Dasyuridae	*Antechinus flavipes flavipes*	yellow-footed antechinus (south-east Queensland)		C		8
animals	mammals	Dasyuridae	*Sminthopsis macroura*	stripe-faced dunnart		C		2
animals	mammals	Dasyuridae	*Antechinus argentus*	silver-headed antechinus		V	E	23
animals	mammals	Dasyuridae	*Sminthopsis murina*	common dunnart		C		3
animals	mammals	Dasyuridae	*Planigale maculata*	common planigale		C		4
animals	mammals	Dasyuridae	*Planigale ingrami*	long-tailed planigale		C		1
animals	mammals	Emballonuridae	*Saccolaimus flaviventris*	yellow-bellied sheathtail bat		C		16
animals	mammals	Emballonuridae	*Taphozous troughtoni*	Troughton's sheathtail bat		C		5
animals	mammals	Equidae	*Equus caballus*	horse	Y			2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	mammals	Felidae	*Felis catus*	cat	Y			26
animals	mammals	Hipposideridae	*Hipposideros ater aruensis*	eastern dusky leaf-nosed bat		C		3
animals	mammals	Leporidae	*Oryctolagus cuniculus*	rabbit	Y			20
animals	mammals	Leporidae	*Lepus europaeus*	European brown hare	Y			9
animals	mammals	Macropodidae	*Onychogalea fraenata*	bridled nailtail wallaby		E	E	42
animals	mammals	Macropodidae	*Lagorchestes conspicillatus*	spectacled hare-wallaby		C		2
animals	mammals	Macropodidae	*Macropus parryi*	whiptail wallaby		C		3
animals	mammals	Macropodidae	*Wallabia bicolor*	swamp wallaby		C		9
animals	mammals	Macropodidae	*Macropus dorsalis*	black-striped wallaby		C		19
animals	mammals	Macropodidae	*Macropus robustus*	common wallaroo		C		9/1
animals	mammals	Macropodidae	*Macropus giganteus*	eastern grey kangaroo		C		30
animals	mammals	Macropodidae	*Petrogale herberti*	Herbert's rock-wallaby		C		6/3
animals	mammals	Macropodidae	*Petrogale inornata*	unadorned rock-wallaby		C		3
animals	mammals	Macropodidae	*Macropus rufogriseus*	red-necked wallaby		C		2
animals	mammals	Miniopteridae	*Miniopterus schreibersii oceanensis*	eastern bent-wing bat		C		2
animals	mammals	Molossidae	*Mormopterus petersi*	inland free-tailed bat		C		1
animals	mammals	Molossidae	*Tadarida australis*	white-striped freetail bat		C		4
animals	mammals	Molossidae	*Mormopterus lumsdenae*	northern free-tailed bat		C		2
animals	mammals	Molossidae	*Mormopterus sp.*					7
animals	mammals	Muridae	*Mus musculus*	house mouse	Y			69
animals	mammals	Muridae	*Rattus sp.*					1
animals	mammals	Muridae	*Rattus tunneyi*	pale field-rat		C		16/1
animals	mammals	Muridae	*Melomys burtoni*	grassland melomys		C		1/1
animals	mammals	Muridae	*Rattus fuscipes*	bush rat		C		2
animals	mammals	Muridae	*Rattus sordidus*	canefield rat		C		2
animals	mammals	Muridae	*Zyzomys argurus*	common rock-rat		C		1
animals	mammals	Muridae	*Rattus lutreolus*	swamp rat		C		1
animals	mammals	Muridae	*Pseudomys patrius*	eastern pebble-mound mouse		C		2
animals	mammals	Muridae	*Leggadina forresti*	Forrest's mouse		C		2
animals	mammals	Muridae	*Melomys cervinipes*	fawn-footed melomys		C		27
animals	mammals	Muridae	*Hydromys chrysogaster*	water rat		C		5
animals	mammals	Muridae	*Pseudomys delicatulus*	delicate mouse		C		11
animals	mammals	Muridae	*Pseudomys gracilicaudatus*	eastern chestnut mouse		C		7
animals	mammals	Muridae	*Melomys sp.*					3
animals	mammals	Muridae	*Pseudomys sp.*					1/1
animals	mammals	Ornithorhynchidae	*Ornithorhynchus anatinus*	platypus		SL		2
animals	mammals	Peramelidae	*Isoodon macrourus*	northern brown bandicoot		C		7
animals	mammals	Peramelidae	*Perameles nasuta*	long-nosed bandicoot		C		3
animals	mammals	Petauridae	*Petaurus breviceps*	sugar glider		C		22
animals	mammals	Petauridae	*Petaurus norfolcensis*	squirrel glider		C		12
animals	mammals	Petauridae	*Petaurus australis australis*	yellow-bellied glider (southern subspecies)		C		42
animals	mammals	Phalangeridae	*Trichosurus vulpecula*	common brushtail possum		C		23
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		V	V	12
animals	mammals	Potoroidae	*Aepyprymnus rufescens*	rufous bettong		C		15
animals	mammals	Potoroidae	*Bettongia gaimardi gaimardi*	eastern bettong		PE	EX	4

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	mammals	Pseudocheiridae	*Petauroides volans*	greater glider		V	V	3
animals	mammals	Pseudocheiridae	*Petauroides volans volans*	southern greater glider		V	V	69
animals	mammals	Pteropodidae	*Pteropus sp.*					1
animals	mammals	Pteropodidae	*Pteropus scapulatus*	little red flying-fox		C		4
animals	mammals	Rhinolophidae	*Rhinolophus megaphyllus*	eastern horseshoe-bat		C		5
animals	mammals	Suidae	*Sus scrofa*	pig	Y			9
animals	mammals	Tachyglossidae	*Tachyglossus aculeatus*	short-beaked echidna		SL		24
animals	mammals	Vespertilionidae	*Scotorepens sp.*					8
animals	mammals	Vespertilionidae	*Chalinolobus morio*	chocolate wattled bat		C		9
animals	mammals	Vespertilionidae	*Nyctophilus gouldi*	Gould's long-eared bat		C		16
animals	mammals	Vespertilionidae	*Scotorepens greyii*	little broad-nosed bat		C		4
animals	mammals	Vespertilionidae	*Chalinolobus dwyeri*	large-eared pied bat		V	V	2
animals	mammals	Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat		C		17
animals	mammals	Vespertilionidae	*Chalinolobus picatus*	little pied bat		C		7
animals	mammals	Vespertilionidae	*Scotorepens balstoni*	inland broad-nosed bat		C		4
animals	mammals	Vespertilionidae	*Nyctophilus geoffroyi*	lesser long-eared bat		C		5
animals	mammals	Vespertilionidae	*Vespadelus troughtoni*	eastern cave bat		C		5
animals	mammals	Vespertilionidae	*Vespadelus baverstocki*	inland forest bat		C		2
animals	mammals	Vespertilionidae	*Chalinolobus nigrogriseus*	hoary wattled bat		C		7
animals	mammals	Vespertilionidae	*Nyctophilus sp.*					1
animals	mammals	Vespertilionidae	*Myotis macropus*	large-footed myotis		C		2
animals	mammals	Vespertilionidae	*Vespadelus sp.*					2
animals	mammals	Vespertilionidae	*Vespadelus pumilus*	eastern forest bat		C		1
animals	ray-finned fishes	Ambassidae	*Ambassis agassizii*	Agassiz's glassfish				3
animals	ray-finned fishes	Anguillidae	*Anguilla reinhardtii*	longfin eel				4
animals	ray-finned fishes	Apogonidae	*Glossamia aprion*	mouth almighty				5
animals	ray-finned fishes	Ariidae	*Neoarius graeffei*	blue catfish				135
animals	ray-finned fishes	Atherinidae	*Craterocephalus stercusmuscarum*	flyspecked hardyhead				6
animals	ray-finned fishes	Belonidae	*Strongylura krefftii*	freshwater longtom				18
animals	ray-finned fishes	Clupeidae	*Nematalosa erebi*	bony bream				136
animals	ray-finned fishes	Eleotridae	*Hypseleotris klunzingeri*	western carp gudgeon				3
animals	ray-finned fishes	Eleotridae	*Philypnodon grandiceps*	flathead gudgeon				1
animals	ray-finned fishes	Eleotridae	*Hypseleotris species 1*	Midgley's carp gudgeon				4
animals	ray-finned fishes	Eleotridae	*Hypseleotris compressa*	empire gudgeon				3
animals	ray-finned fishes	Eleotridae	*Oxyeleotris lineolata*	sleepy cod				8
animals	ray-finned fishes	Eleotridae	*Mogurnda adspersa*	southern purplespotted gudgeon				1
animals	ray-finned fishes	Megalopidae	*Megalops cyprinoides*	oxeye herring				3
animals	ray-finned fishes	Melanotaeniidae	*Melanotaenia splendida splendida*	eastern rainbowfish				5
animals	ray-finned fishes	Osteoglossidae	*Scleropages leichardti*	southern saratoga				22
animals	ray-finned fishes	Percichthyidae	*Macquaria ambigua*	golden perch				10
animals	ray-finned fishes	Plotosidae	*Tandanus tandanus*	freshwater catfish				5
animals	ray-finned fishes	Plotosidae	*Neosilurus hyrtlii*	Hyrtl's catfish				6
animals	ray-finned fishes	Pseudomugilidae	*Pseudomugil signifer*	Pacific blue eye				1
animals	ray-finned fishes	Terapontidae	*Leiopotherapon unicolor*	spangled perch				5
animals	ray-finned fishes	Terapontidae	*Scortum hillii*	leathery grunter				9
animals	ray-finned fishes	Terapontidae	*Amniataba percoides*	barred grunter				17

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	reptiles	Agamidae	*Amphibolurus muricatus*	jacky lizard		C		1
animals	reptiles	Agamidae	*Pogona barbata*	bearded dragon		C		7/1
animals	reptiles	Agamidae	*Diporiphora sp.*					1
animals	reptiles	Agamidae	*Diporiphora australis*	tommy roundhead		C		6/1
animals	reptiles	Agamidae	*Chlamydosaurus kingii*	frilled lizard		C		1
animals	reptiles	Agamidae	*Lophognathus gilberti sensu lato*	Gilbert's dragon		C		1
animals	reptiles	Agamidae	*Diporiphora lalliae*	Lally's two-line dragon		C		1
animals	reptiles	Agamidae	*Diporiphora nobbi*	nobbi		C		19
animals	reptiles	Agamidae	*Intellagama lesueurii*	eastern water dragon		C		9
animals	reptiles	Boidae	*Aspidites melanocephalus*	black-headed python		C		6
animals	reptiles	Boidae	*Morelia spilota*	carpet python		C		6
animals	reptiles	Boidae	*Antaresia maculosa*	spotted python		C		8/1
animals	reptiles	Carphodactylidae	*Underwoodisaurus milii*	thick-tailed gecko		C		4
animals	reptiles	Carphodactylidae	*Nephrurus asper*	spiny knob-tailed gecko		C		17/2
animals	reptiles	Carphodactylidae	*Saltuarius salebrosus*	rough-throated leaf-tailed gecko		C		17
animals	reptiles	Chelidae	*Chelodina expansa*	broad-shelled river turtle		C		1
animals	reptiles	Chelidae	*Wollumbinia latisternum*	saw-shelled turtle		C		3
animals	reptiles	Chelidae	*Chelodina longicollis*	eastern snake-necked turtle		C		1
animals	reptiles	Chelidae	*Elseya albagula*	southern snapping turtle		E	CE	2
animals	reptiles	Chelidae	*Emydura macquarii krefftii*	Krefft's river turtle		C		8
animals	reptiles	Chelidae	*Rheodytes leukops*	Fitzroy River turtle		V	V	1
animals	reptiles	Colubridae	*Dendrelaphis punctulatus*	green tree snake		C		6
animals	reptiles	Colubridae	*Tropidonophis mairii*	freshwater snake		C		7
animals	reptiles	Colubridae	*Boiga irregularis*	brown tree snake		C		7
animals	reptiles	Diplodactylidae	*Oedura sp.*					1
animals	reptiles	Diplodactylidae	*Oedura tryoni*	southern spotted velvet gecko		C		27/1
animals	reptiles	Diplodactylidae	*Oedura monilis*	ocellated velvet gecko		C		16/3
animals	reptiles	Diplodactylidae	*Amalosia rhombifer*	zig-zag gecko		C		3/1
animals	reptiles	Diplodactylidae	*Diplodactylus platyurus*	eastern fat-tailed gecko		C		6/1
animals	reptiles	Diplodactylidae	*Strophurus williamsi*	soft-spined gecko		C		3
animals	reptiles	Diplodactylidae	*Strophurus taenicauda*	golden-tailed gecko		NT		10/1
animals	reptiles	Diplodactylidae	*Diplodactylus vittatus*	wood gecko		C		14
animals	reptiles	Diplodactylidae	*Lucasium steindachneri*	Steindachner's gecko		C		7/1
animals	reptiles	Diplodactylidae	*Nebulifera robusta*	robust velvet gecko		C		15
animals	reptiles	Elapidae	*Suta suta*	myall snake		C		8/1
animals	reptiles	Elapidae	*Furina ornata*	orange-naped snake		C		1
animals	reptiles	Elapidae	*Furina diadema*	red-naped snake		C		4/1
animals	reptiles	Elapidae	*Denisonia maculata*	ornamental snake		V	V	1
animals	reptiles	Elapidae	*Cryptophis boschmai*	Carpentaria whip snake		C		1
animals	reptiles	Elapidae	*Demansia psammophis*	yellow-faced whipsnake		C		5
animals	reptiles	Elapidae	*Hoplocephalus bitorquatus*	pale-headed snake		C		5/2
animals	reptiles	Elapidae	*Pseudonaja textilis*	eastern brown snake		C		4
animals	reptiles	Elapidae	*Vermicella annulata*	bandy-bandy		C		5
animals	reptiles	Elapidae	*Pseudechis australis*	king brown snake		C		1
animals	reptiles	Elapidae	*Cryptophis nigrescens*	eastern small-eyed snake		C		7
animals	reptiles	Elapidae	*Brachyurophis australis*	coral snake		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	reptiles	Elapidae	*Demansia vestigiata*	lesser black whipsnake		C		2
animals	reptiles	Gekkonidae	*Gehyra sp.*					1
animals	reptiles	Gekkonidae	*Gehyra dubia*	dubious dtella		C		115/1
animals	reptiles	Gekkonidae	*Hemidactylus frenatus*	house gecko	Y			2
animals	reptiles	Gekkonidae	*Gehyra versicolor*			C		2
animals	reptiles	Gekkonidae	*Heteronotia binoei*	Bynoe's gecko		C		113/2
animals	reptiles	Gekkonidae	*Gehyra catenata*	chain-backed dtella		C		25/1
animals	reptiles	Pygopodidae	*Delma torquata*	collared delma		V	V	1
animals	reptiles	Pygopodidae	*Paradelma orientalis*	brigalow scaly-foot		C		9
animals	reptiles	Pygopodidae	*Pygopus lepidopodus*	common scaly-foot		C		1
animals	reptiles	Pygopodidae	*Lialis burtonis*	Burton's legless lizard		C		6
animals	reptiles	Scincidae	*Ctenotus strauchii*	eastern barred wedgesnout ctenotus		C		1
animals	reptiles	Scincidae	*Ctenotus spaldingi*	straight-browed ctenotus		C		6
animals	reptiles	Scincidae	*Cryptoblepharus sp.*					2
animals	reptiles	Scincidae	*Ctenotus leonhardii*	Leonhardi's ctenotus		C		1/1
animals	reptiles	Scincidae	*Lygisaurus foliorum*	tree-base litter-skink		C		25/1
animals	reptiles	Scincidae	*Morethia boulengeri*	south-eastern morethia skink		C		17
animals	reptiles	Scincidae	*Concinnia brachysoma*	northern bar-sided skink		C		4/1
animals	reptiles	Scincidae	*Ctenotus taeniolatus*	copper-tailed skink		C		59/3
animals	reptiles	Scincidae	*Lampropholis amicula*	friendly sunskink		C		9
animals	reptiles	Scincidae	*Lampropholis delicata*	dark-flecked garden sunskink		C		22/1
animals	reptiles	Scincidae	*Morethia taeniopleura*	fire-tailed skink		C		29/3
animals	reptiles	Scincidae	*Anomalopus brevicollis*	short-necked worm-skink		C		2
animals	reptiles	Scincidae	*Lerista punctatovittata*	eastern robust slider		C		3
animals	reptiles	Scincidae	*Cryptoblepharus pannosus*	ragged snake-eyed skink		C		15
animals	reptiles	Scincidae	*Cyclodomorphus gerrardii*	pink-tongued lizard		C		1
animals	reptiles	Scincidae	*Cryptoblepharus australis*	inland snake-eyed skink		C		1
animals	reptiles	Scincidae	*Cryptoblepharus metallicus*	metallic snake-eyed skink		C		1
animals	reptiles	Scincidae	*Glaphyromorphus punctulatus*	fine-spotted mulch-skink		C		5
animals	reptiles	Scincidae	*Carlia pectoralis sensu lato*			C		64/2
animals	reptiles	Scincidae	*Cryptoblepharus pulcher pulcher*	elegant snake-eyed skink		C		17
animals	reptiles	Scincidae	*Cryptoblepharus virgatus sensu lato*			C		45
animals	reptiles	Scincidae	*Carlia sp.*					5
animals	reptiles	Scincidae	*Lerista sp.*					1
animals	reptiles	Scincidae	*Menetia sp.*					1
animals	reptiles	Scincidae	*Carlia munda*	shaded-litter rainbow-skink		C		4
animals	reptiles	Scincidae	*Carlia vivax*	tussock rainbow-skink		C		2
animals	reptiles	Scincidae	*Ctenotus sp.*					4
animals	reptiles	Scincidae	*Carlia rubigo*	orange-flanked rainbow skink		C		8
animals	reptiles	Scincidae	*Eulamprus sp.*					3/1
animals	reptiles	Scincidae	*Egernia rugosa*	yakka skink		V	V	1/1
animals	reptiles	Scincidae	*Menetia greyii*	common dwarf skink		C		4
animals	reptiles	Scincidae	*Concinnia tenuis*	bar-sided skink		C		6/2
animals	reptiles	Scincidae	*Ctenotus ingrami*	unspotted yellow-sided ctenotus		C		2
animals	reptiles	Scincidae	*Eulamprus quoyii*	eastern water skink		C		11
animals	reptiles	Scincidae	*Lampropholis sp.*			C		5

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	reptiles	Scincidae	*Lerista fragilis*	eastern mulch slider		C		30
animals	reptiles	Scincidae	*Carlia pectoralis*	open-litter rainbow skink		C		11
animals	reptiles	Scincidae	*Carlia schmeltzii*	robust rainbow-skink		C		18/2
animals	reptiles	Scincidae	*Concinnia martini*	dark bar-sided skink		C		1
animals	reptiles	Scincidae	*Egernia striolata*	tree skink		C		1
animals	reptiles	Scincidae	*Concinnia sokosoma*	stout bar-sided skink		C		3/1
animals	reptiles	Scincidae	*Tiliqua scincoides*	eastern blue-tongued lizard		C		1/1
animals	reptiles	Typhlopidae	*Anilios sp.*					1
animals	reptiles	Typhlopidae	*Anilios affinis*	small-headed blind snake		C		1
animals	reptiles	Typhlopidae	*Anilios bituberculatus*	prong-snouted blind snake		C		1
animals	reptiles	Typhlopidae	*Anilios nigrescens*	blackish blind snake		C		1/1
animals	reptiles	Typhlopidae	*Anilios proximus*	proximus blind snake		C		1/1
animals	reptiles	Varanidae	*Varanus tristis*	black-tailed monitor		C		10/1
animals	reptiles	Varanidae	*Varanus varius*	lace monitor		C		7
animals	uncertain	Indeterminate	*Indeterminate*	Unknown or Code Pending		C		15
bacteria	blue-green algae	Aphanothecaceae	*Aphanothece stagnina*			C		1/1
bacteria	blue-green algae	Scytonemataceae	*Scytonema hofman-bangii*			C		2/2
bacteria	blue-green algae	Stigonemataceae	*Stigonema hormoides*			C		1/1
bacteria	blue-green algae	Stigonemataceae	*Stigonema multipartitum*			C		1/1
fungi	Agaricomycetes	Polyporaceae	*Polyporus*			C		1/1
fungi	Agaricomycetes	Stereaceae	*Stereum*			C		1/1
fungi	lecanoromycetes	Cladoniaceae	*Cladonia rigida var. rigida*			C		1/1
fungi	lecanoromycetes	Cladoniaceae	*Cladonia*			C		2/2
fungi	lecanoromycetes	Cladoniaceae	*Cladonia ochrochlora*			C		1/1
fungi	lecanoromycetes	Collemataceae	*Collema*			C		1/1
fungi	lecanoromycetes	Graphidaceae	*Diploschistes euganeus*			C		1/1
fungi	lecanoromycetes	Lecanoraceae	*Lecanora elatinoides*			C		1/1
fungi	lecanoromycetes	Leprocaulaceae	*Leprocaulon microscopicum*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Parmotrema tinctorum*			C		2/2
fungi	lecanoromycetes	Parmeliaceae	*Usnea scabrida subsp. elegans*			C		5/5
fungi	lecanoromycetes	Parmeliaceae	*Xanthoparmelia antleriformis*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Xanthoparmelia stuartioides*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Xanthoparmelia neoquintaria*			C		3/3
fungi	lecanoromycetes	Parmeliaceae	*Usnea*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Usnea baileyi*			C		6/6
fungi	lecanoromycetes	Parmeliaceae	*Usnea rubicunda*			C		3/3
fungi	lecanoromycetes	Parmeliaceae	*Relicina limbata*			C		3/3
fungi	lecanoromycetes	Parmeliaceae	*Parmelia erumpens*			C		2/2
fungi	lecanoromycetes	Parmeliaceae	*Parmelia signifera*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Parmotrema cooperi*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Punctelia subflava*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Usnea trichodeoides*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Parmotrema eurysacum*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Relicina sydneyensis*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Flavoparmelia rutidota*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Pannoparmelia wilsonii*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
fungi	lecanoromycetes	Parmeliaceae	*Parmotrema lobulascens*			C		4/4
fungi	lecanoromycetes	Parmeliaceae	*Hypotrachyna immaculata*			C		2/2
fungi	lecanoromycetes	Parmeliaceae	*Parmotrema subcaperatum*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Xanthoparmelia amplexula*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Xanthoparmelia tasmanica*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Xanthoparmelia isidiigera*			C		2/2
fungi	lecanoromycetes	Parmeliaceae	*Austroparmelina conlabrosa*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Punctelia pseudocoralloidea*			C		1/1
fungi	lecanoromycetes	Parmeliaceae	*Xanthoparmelia australasica*			C		1/1
fungi	lecanoromycetes	Pertusariaceae	*Pertusaria*			C		1/1
fungi	lecanoromycetes	Physciaceae	*Rinodina williamsii*			C		1/1
fungi	lecanoromycetes	Physciaceae	*Heterodermia obscurata*			C		1/1
fungi	lecanoromycetes	Psoraceae	*Protoblastenia*			C		2/2
fungi	lecanoromycetes	Stereocaulaceae	*Lepraria jackii*			C		1/1
plants	Conjugatophyceae	Zygnemataceae	*Zygogonium ericetorum*			C		1/1
plants	Equisetopsida	Acanthaceae	*Pseuderanthemum*			C		1
plants	Equisetopsida	Acanthaceae	*Ruellia simplex*		Y			1/1
plants	Equisetopsida	Acanthaceae	*Brunoniella australis*	blue trumpet		C		8
plants	Equisetopsida	Acanthaceae	*Pseuderanthemum tenellum*			C		1
plants	Equisetopsida	Acanthaceae	*Rostellularia adscendens*			C		12/2
plants	Equisetopsida	Acanthaceae	*Acanthaceae*			C		1/1
plants	Equisetopsida	Acanthaceae	*Dipteracanthus australasicus*			C		1
plants	Equisetopsida	Acanthaceae	*Asystasia gangetica subsp. gangetica*		Y			1/1
plants	Equisetopsida	Acanthaceae	*Rostellularia adscendens var. adscendens*			C		2
plants	Equisetopsida	Acanthaceae	*Dipteracanthus australasicus subsp. corynothecus*			C		4/2
plants	Equisetopsida	Acanthaceae	*Pseuderanthemum variabile*	pastel flower		C		9/2
plants	Equisetopsida	Agavaceae	*Agave vivipara var. vivipara*		Y			1/1
plants	Equisetopsida	Aizoaceae	*Trianthema triquetra*	red spinach		C		13/1
plants	Equisetopsida	Aizoaceae	*Zaleya galericulata subsp. galericulata*			C		3/2
plants	Equisetopsida	Aizoaceae	*Trianthema portulacastrum*	black pigweed	Y			8
plants	Equisetopsida	Alismataceae	*Caldesia oligococca*			C		1
plants	Equisetopsida	Alismataceae	*Damasonium minus*	starfruit		C		1/1
plants	Equisetopsida	Amaranthaceae	*Ptilotus nobilis*			C		1
plants	Equisetopsida	Amaranthaceae	*Alternanthera denticulata*	lesser joyweed		C		7
plants	Equisetopsida	Amaranthaceae	*Achyranthes aspera*			C		8/2
plants	Equisetopsida	Amaranthaceae	*Nyssanthes erecta*			C		4/2
plants	Equisetopsida	Amaranthaceae	*Alternanthera nana*	hairy joyweed		C		6
plants	Equisetopsida	Amaranthaceae	*Amaranthus viridis*	green amaranth	Y			1
plants	Equisetopsida	Amaranthaceae	*Nyssanthes diffusa*	barbed-wire weed		C		1
plants	Equisetopsida	Amaranthaceae	*Ptilotus semilanatus*			C		1/1
plants	Equisetopsida	Amaranthaceae	*Alternanthera pungens*	khaki weed	Y			1/1
plants	Equisetopsida	Amaranthaceae	*Gomphrena celosioides*	gomphrena weed	Y			4
plants	Equisetopsida	Amaranthaceae	*Ptilotus polystachyus*			C		1/1
plants	Equisetopsida	Amaranthaceae	*Amaranthus macrocarpus*	dwarf amaranth		C		1
plants	Equisetopsida	Amaranthaceae	*Ptilotus macrocephalus*	green pussytails		C		2/1
plants	Equisetopsida	Amaranthaceae	*Alternanthera nodiflora*	joyweed		C		4/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Amaranthaceae	*Deeringia amaranthoides*	redberry		C		2/1
plants	Equisetopsida	Amaryllidaceae	*Crinum flaccidum*	Murray lily		C		4
plants	Equisetopsida	Anacardiaceae	*Euroschinus falcatus*			C		1
plants	Equisetopsida	Anacardiaceae	*Pleiogynium timorense*	Burdekin plum		C		1
plants	Equisetopsida	Anacardiaceae	*Schinus terebinthifolius*		Y			1/1
plants	Equisetopsida	Annonaceae	*Melodorum leichhardtii*			C		1
plants	Equisetopsida	Apiaceae	*Platysace ericoides*	heath platysace		C		6/3
plants	Equisetopsida	Apiaceae	*Actinotus helianthi*	flannel flower		C		1
plants	Equisetopsida	Apiaceae	*Actinotus gibbonsii*	dwarf flannel flower		C		1
plants	Equisetopsida	Apiaceae	*Centella asiatica*			C		2/1
plants	Equisetopsida	Apocynaceae	*Alyxia magnifolia*			C		1
plants	Equisetopsida	Apocynaceae	*Alyxia ruscifolia*			C		1
plants	Equisetopsida	Apocynaceae	*Cascabela thevetia*	yellow oleander	Y			1/1
plants	Equisetopsida	Apocynaceae	*Cynanchum viminale*			C		3
plants	Equisetopsida	Apocynaceae	*Parsonsia lilacina*	crisped silkpod		C		1
plants	Equisetopsida	Apocynaceae	*Secamone elliptica*			C		2
plants	Equisetopsida	Apocynaceae	*Alstonia constricta*	bitterbark		C		30/1
plants	Equisetopsida	Apocynaceae	*Marsdenia australis*	doubah		C		1
plants	Equisetopsida	Apocynaceae	*Parsonsia straminea*	monkey rope		C		9/1
plants	Equisetopsida	Apocynaceae	*Vincetoxicum ovatum*			C		1
plants	Equisetopsida	Apocynaceae	*Marsdenia micradenia*	gymnema		C		1
plants	Equisetopsida	Apocynaceae	*Marsdenia microlepis*			C		3/1
plants	Equisetopsida	Apocynaceae	*Marsdenia pleiadenia*			C		1
plants	Equisetopsida	Apocynaceae	*Parsonsia lanceolata*	northern silkpod		C		12/2
plants	Equisetopsida	Apocynaceae	*Asclepias curassavica*	red-head cottonbush	Y			1/1
plants	Equisetopsida	Apocynaceae	*Parsonsia plaesiophylla*			C		1
plants	Equisetopsida	Apocynaceae	*Cryptostegia grandiflora*	rubber vine	Y			8/2
plants	Equisetopsida	Apocynaceae	*Gomphocarpus physocarpus*	balloon cottonbush	Y			1
plants	Equisetopsida	Apocynaceae	*Parsonsia eucalyptophylla*	gargaloo		C		3
plants	Equisetopsida	Apocynaceae	*Hoya australis subsp. australis*			C		5/5
plants	Equisetopsida	Apocynaceae	*Cynanchum viminale subsp. australe*			C		2
plants	Equisetopsida	Apocynaceae	*Cynanchum viminale subsp. brunonianum*			C		7/2
plants	Equisetopsida	Apocynaceae	*Marsdenia viridiflora subsp. viridiflora*			C		7/3
plants	Equisetopsida	Apocynaceae	*Cerbera dumicola*			NT		6/6
plants	Equisetopsida	Apocynaceae	*Hoya australis*			C		1
plants	Equisetopsida	Apocynaceae	*Carissa ovata*	currantbush		C		87
plants	Equisetopsida	Apocynaceae	*Marsdenia*			C		3
plants	Equisetopsida	Apocynaceae	*Parsonsia*			C		8
plants	Equisetopsida	Araliaceae	*Polyscias elegans*	celery wood		C		2/1
plants	Equisetopsida	Araliaceae	*Astrotricha cordata*			C		7/1
plants	Equisetopsida	Araliaceae	*Hydrocotyle acutiloba*			C		1
plants	Equisetopsida	Araliaceae	*Trachymene procumbens*	creeping wild parsnip		C		2/1
plants	Equisetopsida	Araliaceae	*Astrotricha intermedia*			C		1
plants	Equisetopsida	Araliaceae	*Astrotricha longifolia*	star hair bush		C		1
plants	Equisetopsida	Arecaceae	*Livistona*			C		6
plants	Equisetopsida	Arecaceae	*Livistona fulva*			V		16/12

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Arecaceae	*Livistona australis*	cabbage tree palm		C		2
plants	Equisetopsida	Asteraceae	*Acmella grandiflora var. brachyglossa*			C		1
plants	Equisetopsida	Asteraceae	*Ageratum conyzoides subsp. conyzoides*		Y			1/1
plants	Equisetopsida	Asteraceae	*Pterocaulon serrulatum var. serrulatum*			C		4/4
plants	Equisetopsida	Asteraceae	*Verbesina encelioides var. encelioides*		Y			3/3
plants	Equisetopsida	Asteraceae	*Crassocephalum crepidioides*	thickhead	Y			1
plants	Equisetopsida	Asteraceae	*Pseudognaphalium luteoalbum*	Jersey cudweed		C		1
plants	Equisetopsida	Asteraceae	*Vittadinia dissecta var. hirta*			C		5/3
plants	Equisetopsida	Asteraceae	*Lactuca serriola forma serriola*		Y			1/1
plants	Equisetopsida	Asteraceae	*Peripleura hispidula var. setosa*			C		3/3
plants	Equisetopsida	Asteraceae	*Gynura drymophila var. drymophila*			C		1/1
plants	Equisetopsida	Asteraceae	*Conyza*					1
plants	Equisetopsida	Asteraceae	*Calotis*			C		1
plants	Equisetopsida	Asteraceae	*Olearia*			C		1
plants	Equisetopsida	Asteraceae	*Senecio*			C		1
plants	Equisetopsida	Asteraceae	*Vittadinia*			C		1
plants	Equisetopsida	Asteraceae	*Brachyscome*			C		1
plants	Equisetopsida	Asteraceae	*Bidens pilosa*		Y			2/1
plants	Equisetopsida	Asteraceae	*Blumea lacera*			C		1/1
plants	Equisetopsida	Asteraceae	*Centipeda minima subsp. minima*			C		2/2
plants	Equisetopsida	Asteraceae	*Peripleura hispidula var. hispidula*			C		1
plants	Equisetopsida	Asteraceae	*Sonchus asper*	rough sowthistle	Y			1
plants	Equisetopsida	Asteraceae	*Calotis dentex*	white burr daisy		C		8/7
plants	Equisetopsida	Asteraceae	*Tagetes minuta*	stinking roger	Y			1/1
plants	Equisetopsida	Asteraceae	*Calotis cuneata*			C		1
plants	Equisetopsida	Asteraceae	*Cassinia laevis*			C		1
plants	Equisetopsida	Asteraceae	*Bidens bipinnata*	bipinnate beggar's ticks	Y			2/1
plants	Equisetopsida	Asteraceae	*Blumea saxatilis*			C		1/1
plants	Equisetopsida	Asteraceae	*Centipeda minima*			C		2
plants	Equisetopsida	Asteraceae	*Olearia nernstii*	Ipswich daisy		C		1
plants	Equisetopsida	Asteraceae	*Pluchea dunlopii*			C		1/1
plants	Equisetopsida	Asteraceae	*Pluchea xanthina*			C		1/1
plants	Equisetopsida	Asteraceae	*Camptacra barbata*			C		1
plants	Equisetopsida	Asteraceae	*Eclipta prostrata*	white eclipta	Y			3/2
plants	Equisetopsida	Asteraceae	*Gynura drymophila*			C		2
plants	Equisetopsida	Asteraceae	*Olearia canescens*			C		1
plants	Equisetopsida	Asteraceae	*Olearia xerophila*			C		1/1
plants	Equisetopsida	Asteraceae	*Sonchus oleraceus*	common sowthistle	Y			4/2
plants	Equisetopsida	Asteraceae	*Tridax procumbens*	tridax daisy	Y			1/1
plants	Equisetopsida	Asteraceae	*Calotis cuneifolia*	burr daisy		C		1
plants	Equisetopsida	Asteraceae	*Coronidium cymosum*			C		5/5
plants	Equisetopsida	Asteraceae	*Emilia sonchifolia*		Y			1
plants	Equisetopsida	Asteraceae	*Flaveria trinervia*		Y			1/1
plants	Equisetopsida	Asteraceae	*Vittadinia sulcata*	native daisy		C		3/2
plants	Equisetopsida	Asteraceae	*Coronidium rupicola*			C		1
plants	Equisetopsida	Asteraceae	*Euchiton sphaericus*			C		3/2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Asteraceae	*Glossocardia bidens*	native cobbler's pegs		C		2/1
plants	Equisetopsida	Asteraceae	*Minuria integerrima*	smooth minuria		C		5/3
plants	Equisetopsida	Asteraceae	*Olearia microphylla*			C		2/1
plants	Equisetopsida	Asteraceae	*Rutidosis leucantha*			C		1/1
plants	Equisetopsida	Asteraceae	*Calyptocarpus vialis*	creeping cinderella weed	Y			1
plants	Equisetopsida	Asteraceae	*Erigeron bonariensis*		Y			2/1
plants	Equisetopsida	Asteraceae	*Lagenophora gracilis*			C		1
plants	Equisetopsida	Asteraceae	*Peripleura hispidula*			C		1
plants	Equisetopsida	Asteraceae	*Pterocaulon redolens*			C		2
plants	Equisetopsida	Asteraceae	*Rhodanthe polyphylla*			C		3/2
plants	Equisetopsida	Asteraceae	*Rutidosis glandulosa*			NT		7/7
plants	Equisetopsida	Asteraceae	*Senecio depressicola*			C		1/1
plants	Equisetopsida	Asteraceae	*Vittadinia pustulata*			C		1
plants	Equisetopsida	Asteraceae	*Xanthium occidentale*		Y			7/2
plants	Equisetopsida	Asteraceae	*Coronidium glutinosum*			C		7/5
plants	Equisetopsida	Asteraceae	*Cyanthillium cinereum*			C		16/4
plants	Equisetopsida	Asteraceae	*Lagenophora stipitata*			C		1
plants	Equisetopsida	Asteraceae	*Podolepis longipedata*	tall copper-wire daisy		C		2/1
plants	Equisetopsida	Asteraceae	*Rutidosis murchisonii*			C		1
plants	Equisetopsida	Asteraceae	*Senecio bathurstianus*			C		1
plants	Equisetopsida	Asteraceae	*Senecio brigalowensis*			C		4/4
plants	Equisetopsida	Asteraceae	*Senecio prenanthoides*			C		1/1
plants	Equisetopsida	Asteraceae	*Verbesina encelioides*	crownbeard	Y			1
plants	Equisetopsida	Asteraceae	*Brachyscome dalbyensis*			C		1
plants	Equisetopsida	Asteraceae	*Pterocaulon serrulatum*			C		1
plants	Equisetopsida	Asteraceae	*Senecio quadridentatus*	cotton fireweed		C		1
plants	Equisetopsida	Asteraceae	*Sigesbeckia orientalis*	Indian weed		C		1
plants	Equisetopsida	Asteraceae	*Gamochaeta pensylvanica*		Y			1
plants	Equisetopsida	Asteraceae	*Isoetopsis graminifolia*	grass cushion		C		1
plants	Equisetopsida	Asteraceae	*Ozothamnus cassinioides*			C		2/1
plants	Equisetopsida	Asteraceae	*Pterocaulon sphacelatum*	applebush		C		1/1
plants	Equisetopsida	Asteraceae	*Parthenium hysterophorus*	parthenium weed	Y			14/6
plants	Equisetopsida	Asteraceae	*Symphyotrichum subulatum*		Y			1/1
plants	Equisetopsida	Asteraceae	*Chrysocephalum apiculatum*	yellow buttons		C		7/2
plants	Equisetopsida	Asteraceae	*Sphaeromorphaea australis*			C		4/1
plants	Equisetopsida	Asteraceae	*Sphaeromorphaea subintegra*			C		1
plants	Equisetopsida	Asteraceae	*Synedrellopsis grisebachii*		Y			1/1
plants	Equisetopsida	Bignoniaceae	*Pandorea pandorana*	wonga vine		C		4/1
plants	Equisetopsida	Blechnaceae	*Blechnum indicum*	swamp water fern		C		2
plants	Equisetopsida	Blechnaceae	*Doodia media*			C		1
plants	Equisetopsida	Blechnaceae	*Blechnum nudum*	fishbone water fern		C		5
plants	Equisetopsida	Blechnaceae	*Blechnum cartilagineum*	gristle fern		C		2/1
plants	Equisetopsida	Blechnaceae	*Blechnum ambiguum*			C		4/3
plants	Equisetopsida	Blechnaceae	*Doodia caudata*			C		2
plants	Equisetopsida	Boraginaceae	*Heliotropium moorei*			C		1/1
plants	Equisetopsida	Boraginaceae	*Heliotropium indicum*		Y			2/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Boraginaceae	*Ehretia membranifolia*	weeping koda		C		9
plants	Equisetopsida	Boraginaceae	*Heliotropium ovalifolium*			C		1/1
plants	Equisetopsida	Burmanniaceae	*Burmannia disticha*			C		3/1
plants	Equisetopsida	Byttneriaceae	*Commersonia pearnii*			E		2/2
plants	Equisetopsida	Byttneriaceae	*Seringia corollata*			C		7/2
plants	Equisetopsida	Byttneriaceae	*Waltheria indica*			C		3/2
plants	Equisetopsida	Byttneriaceae	*Seringia collina*			C		1/1
plants	Equisetopsida	Byttneriaceae	*Melochia pyramidata*		Y			1
plants	Equisetopsida	Byttneriaceae	*Commersonia dasyphylla*			C		1
plants	Equisetopsida	Byttneriaceae	*Hannafordia shanesii*			C		1/1
plants	Equisetopsida	Byttneriaceae	*Seringia lanceolata*			C		4/2
plants	Equisetopsida	Byttneriaceae	*Seringia hookeriana*			C		4/4
plants	Equisetopsida	Byttneriaceae	*Commersonia leichhardtii*			C		2
plants	Equisetopsida	Cactaceae	*Harrisia*			C		1
plants	Equisetopsida	Cactaceae	*Opuntia stricta*		Y			14
plants	Equisetopsida	Cactaceae	*Harrisia martinii*		Y			18/2
plants	Equisetopsida	Cactaceae	*Opuntia tomentosa*	velvety tree pear	Y			23/1
plants	Equisetopsida	Cactaceae	*Opuntia*			C		8
plants	Equisetopsida	Cactaceae	*Harrisia pomanensis*		Y			2/2
plants	Equisetopsida	Cactaceae	*Opuntia leucotricha*		Y			1/1
plants	Equisetopsida	Cactaceae	*Opuntia streptacantha*	cardona pear	Y			12
plants	Equisetopsida	Cactaceae	*Acanthocereus tetragonus*	sword pear	Y			1
plants	Equisetopsida	Cactaceae	*Opuntia aurantiaca*	tiger pear	Y			1
plants	Equisetopsida	Caesalpiniaceae	*Senna aciphylla*	Australian senna		C		2/2
plants	Equisetopsida	Caesalpiniaceae	*Cassia brewsteri*			C		54/8
plants	Equisetopsida	Caesalpiniaceae	*Senna barclayana*			C		2/1
plants	Equisetopsida	Caesalpiniaceae	*Senna circinnata*			C		1
plants	Equisetopsida	Caesalpiniaceae	*Cassia tomentella*			C		1
plants	Equisetopsida	Caesalpiniaceae	*Labichea rupestris*			C		2/2
plants	Equisetopsida	Caesalpiniaceae	*Senna coronilloides*			C		3
plants	Equisetopsida	Caesalpiniaceae	*Lysiphyllum carronii*	ebony tree		C		31/1
plants	Equisetopsida	Caesalpiniaceae	*Parkinsonia aculeata*	parkinsonia	Y			14/9
plants	Equisetopsida	Caesalpiniaceae	*Petalostylis labicheoides*			C		4/3
plants	Equisetopsida	Caesalpiniaceae	*Chamaecrista nomame var. nomame*			C		1/1
plants	Equisetopsida	Caesalpiniaceae	*Senna artemisioides subsp. coriacea*			C		2
plants	Equisetopsida	Caesalpiniaceae	*Chamaecrista rotundifolia var. rotundifolia*		Y			1
plants	Equisetopsida	Caesalpiniaceae	*Senna*			C		4
plants	Equisetopsida	Caesalpiniaceae	*Cassia*			C		2
plants	Equisetopsida	Caesalpiniaceae	*Lysiphyllum*			C		2
plants	Equisetopsida	Caesalpiniaceae	*Petalostylis*			C		1
plants	Equisetopsida	Caesalpiniaceae	*Delonix regia*	poinciana	Y			1/1
plants	Equisetopsida	Caesalpiniaceae	*Senna gaudichaudii*			C		1
plants	Equisetopsida	Caesalpiniaceae	*Senna occidentalis*	coffee senna	Y			4/2
plants	Equisetopsida	Caesalpiniaceae	*Chamaecrista nomame*			C		1/1
plants	Equisetopsida	Caesalpiniaceae	*Lysiphyllum hookeri*	Queensland ebony		C		19/3
plants	Equisetopsida	Campanulaceae	*Lobelia quadrangularis*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Campanulaceae	*Lobelia trigonocaulis*	forest lobelia		C		2/1
plants	Equisetopsida	Campanulaceae	*Wahlenbergia gracilis*	sprawling bluebell		C		1
plants	Equisetopsida	Campanulaceae	*Lobelia purpurascens*	white root		C		1
plants	Equisetopsida	Campanulaceae	*Isotoma gulliveri*			C		1
plants	Equisetopsida	Campanulaceae	*Isotoma axillaris*	australian harebell		C		1
plants	Equisetopsida	Campanulaceae	*Lobelia concolor*			C		1
plants	Equisetopsida	Campanulaceae	*Lobelia gibbosa*	native lobelia		C		1
plants	Equisetopsida	Campanulaceae	*Wahlenbergia*			C		3
plants	Equisetopsida	Capparaceae	*Capparis mitchellii*			C		7
plants	Equisetopsida	Capparaceae	*Capparis loranthifolia*			C		12
plants	Equisetopsida	Capparaceae	*Capparis loranthifolia var. bancroftii*			C		2/2
plants	Equisetopsida	Capparaceae	*Capparis loranthifolia var. loranthifolia*			C		3/3
plants	Equisetopsida	Capparaceae	*Apophyllum anomalum*	broom bush		C		24
plants	Equisetopsida	Capparaceae	*Capparis lasiantha*	nipan		C		22/3
plants	Equisetopsida	Capparaceae	*Capparis canescens*			C		14/1
plants	Equisetopsida	Capparaceae	*Capparis arborea*	brush caper berry		C		1
plants	Equisetopsida	Capparaceae	*Capparis ornans*			C		1
plants	Equisetopsida	Capparaceae	*Capparis*			C		10
plants	Equisetopsida	Carpodetaceae	*Cuttsia viburnea*	silver-leaf cuttsia		C		3/2
plants	Equisetopsida	Caryophyllaceae	*Polycarpaea spirostylis subsp. compacta*			C		2
plants	Equisetopsida	Caryophyllaceae	*Cerastium glomeratum*	mouse ear chickweed	Y			1
plants	Equisetopsida	Caryophyllaceae	*Polycarpaea corymbosa var. minor*			C		2/2
plants	Equisetopsida	Casuarinaceae	*Casuarina cristata*	belah		C		4/2
plants	Equisetopsida	Casuarinaceae	*Allocasuarina torulosa*			C		151/1
plants	Equisetopsida	Casuarinaceae	*Allocasuarina inophloia*			C		1
plants	Equisetopsida	Casuarinaceae	*Allocasuarina littoralis*			C		6
plants	Equisetopsida	Casuarinaceae	*Allocasuarina luehmannii*	bull oak		C		22/2
plants	Equisetopsida	Casuarinaceae	*Casuarina cunninghamiana*			C		2
plants	Equisetopsida	Casuarinaceae	*Casuarina cunninghamiana subsp. cunninghamiana*			C		1/1
plants	Equisetopsida	Celastraceae	*Denhamia disperma*			C		3
plants	Equisetopsida	Celastraceae	*Denhamia oleaster*			C		11/1
plants	Equisetopsida	Celastraceae	*Denhamia bilocularis*			C		1
plants	Equisetopsida	Celastraceae	*Elaeodendron australe var. integrifolium*			C		2/1
plants	Equisetopsida	Celastraceae	*Denhamia cunninghamii*			C		6/1
plants	Equisetopsida	Celastraceae	*Elaeodendron australe*			C		5
plants	Equisetopsida	Celastraceae	*Siphonodon australis*	ivorywood		C		2
plants	Equisetopsida	Chenopodiaceae	*Maireana*			C		4
plants	Equisetopsida	Chenopodiaceae	*Salsola australis*			C		39/1
plants	Equisetopsida	Chenopodiaceae	*Sclerolaena*			C		1/1
plants	Equisetopsida	Chenopodiaceae	*Einadia nutans*			C		7
plants	Equisetopsida	Chenopodiaceae	*Einadia hastata*			C		5/1
plants	Equisetopsida	Chenopodiaceae	*Atriplex muelleri*	lagoon saltbush		C		8
plants	Equisetopsida	Chenopodiaceae	*Dysphania carinata*			C		4/2
plants	Equisetopsida	Chenopodiaceae	*Rhagodia spinescens*	thorny saltbush		C		2
plants	Equisetopsida	Chenopodiaceae	*Atriplex semibaccata*	creeping saltbush		C		3/1
plants	Equisetopsida	Chenopodiaceae	*Einadia polygonoides*	knotweed goosefoot		C		4

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Chenopodiaceae	*Enchylaena tomentosa*			C		30
plants	Equisetopsida	Chenopodiaceae	*Maireana microphylla*			C		5/3
plants	Equisetopsida	Chenopodiaceae	*Sclerolaena muricata*			C		4
plants	Equisetopsida	Chenopodiaceae	*Sclerolaena ramulosa*			C		2/1
plants	Equisetopsida	Chenopodiaceae	*Atriplex elachophylla*			C		1
plants	Equisetopsida	Chenopodiaceae	*Sclerolaena calcarata*	red burr		C		3
plants	Equisetopsida	Chenopodiaceae	*Dysphania ambrosioides*		Y			1
plants	Equisetopsida	Chenopodiaceae	*Sclerolaena tetracuspis*	brigalow burr		C		4/1
plants	Equisetopsida	Chenopodiaceae	*Sclerolaena anisacanthoides*	yellow burr		C		4
plants	Equisetopsida	Chenopodiaceae	*Einadia nutans subsp. nutans*			C		1/1
plants	Equisetopsida	Chenopodiaceae	*Einadia nutans subsp. linifolia*			C		2/2
plants	Equisetopsida	Chenopodiaceae	*Sclerolaena bicornis var. horrida*			C		2
plants	Equisetopsida	Chenopodiaceae	*Enchylaena tomentosa var. tomentosa*			C		1
plants	Equisetopsida	Chenopodiaceae	*Sclerolaena muricata var. semiglabra*			C		1/1
plants	Equisetopsida	Chenopodiaceae	*Dysphania melanocarpa forma melanocarpa*			C		1/1
plants	Equisetopsida	Chenopodiaceae	*Dysphania glomulifera subsp. glomulifera*			C		3/3
plants	Equisetopsida	Chenopodiaceae	*Chenopodium desertorum subsp. anidiophyllum*			C		1
plants	Equisetopsida	Chenopodiaceae	*Chenopodium*			C		1
plants	Equisetopsida	Cleomaceae	*Cleome viscosa*	tick-weed		C		3/1
plants	Equisetopsida	Clusiaceae	*Hypericum gramineum*			C		8/4
plants	Equisetopsida	Colchicaceae	*Iphigenia indica*			C		2/2
plants	Equisetopsida	Combretaceae	*Terminalia oblongata*			C		62
plants	Equisetopsida	Combretaceae	*Terminalia porphyrocarpa*			C		1
plants	Equisetopsida	Combretaceae	*Macropteranthes fitzalanii*			C		1
plants	Equisetopsida	Combretaceae	*Terminalia oblongata subsp. oblongata*			C		10
plants	Equisetopsida	Commelinaceae	*Commelina*			C		1
plants	Equisetopsida	Commelinaceae	*Commelina diffusa*	wandering jew		C		9
plants	Equisetopsida	Commelinaceae	*Murdannia graminea*	murdannia		C		3/1
plants	Equisetopsida	Commelinaceae	*Commelina ensifolia*	scurvy grass		C		2
plants	Equisetopsida	Convolvulaceae	*Evolvulus alsinoides var. decumbens*			C		3/1
plants	Equisetopsida	Convolvulaceae	*Ipomoea polpha subsp. weirana*			C		1
plants	Equisetopsida	Convolvulaceae	*Convolvulus graminetinus*			C		1/1
plants	Equisetopsida	Convolvulaceae	*Jacquemontia paniculata*			C		1
plants	Equisetopsida	Convolvulaceae	*Evolvulus alsinoides*			C		12
plants	Equisetopsida	Convolvulaceae	*Convolvulus arvensis*		Y			2
plants	Equisetopsida	Convolvulaceae	*Polymeria calycina*	pink bindweed		C		2/1
plants	Equisetopsida	Convolvulaceae	*Ipomoea polymorpha*			C		3/2
plants	Equisetopsida	Convolvulaceae	*Polymeria pusilla*			C		2
plants	Equisetopsida	Convolvulaceae	*Ipomoea calobra*			C		1/1
plants	Equisetopsida	Convolvulaceae	*Ipomoea plebeia*	bellvine		C		5
plants	Equisetopsida	Crassulaceae	*Crassula colorata*			C		1
plants	Equisetopsida	Crassulaceae	*Bryophyllum x houghtonii*		Y			2/2
plants	Equisetopsida	Crassulaceae	*Bryophyllum delagoense*		Y			28/5
plants	Equisetopsida	Crassulaceae	*Crassula sieberiana*			C		1
plants	Equisetopsida	Cucurbitaceae	*Cucumis melo*			C		1
plants	Equisetopsida	Cucurbitaceae	*Diplocyclos palmatus*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Cucurbitaceae	*Zehneria cunninghamii*	slender cucumber		C		1
plants	Equisetopsida	Cucurbitaceae	*Neoalsomitra capricornica*			C		1
plants	Equisetopsida	Cucurbitaceae	*Cucumis anguria var. anguria*	West Indian gherkin	Y			3/2
plants	Equisetopsida	Cucurbitaceae	*Cucumis myriocarpus subsp. myriocarpus*	prickly pademelon	Y			1
plants	Equisetopsida	Cucurbitaceae	*Diplocyclos palmatus subsp. palmatus*			C		1/1
plants	Equisetopsida	Cupressaceae	*Callitris endlicheri*	black cypress pine		C		6/2
plants	Equisetopsida	Cupressaceae	*Callitris glaucophylla*	white cypress pine		C		1
plants	Equisetopsida	Cyatheaceae	*Cyathea australis*			C		2/1
plants	Equisetopsida	Cyatheaceae	*Cyathea cooperi*			C		2
plants	Equisetopsida	Cyperaceae	*Schoenus apogon var. apogon*			C		1/1
plants	Equisetopsida	Cyperaceae	*Cyperus betchei subsp. betchei*			C		1/1
plants	Equisetopsida	Cyperaceae	*Lepidosperma laterale var. laterale*			C		2
plants	Equisetopsida	Cyperaceae	*Cyperus gunnii subsp. novae-hollandiae*			C		4/1
plants	Equisetopsida	Cyperaceae	*Caustis sp. (Robinson Gorge P.I.Forster+ PIF11256)*			C		6/3
plants	Equisetopsida	Cyperaceae	*Gahnia*			C		1/1
plants	Equisetopsida	Cyperaceae	*Caustis*			C		4
plants	Equisetopsida	Cyperaceae	*Cyperus*			C		3
plants	Equisetopsida	Cyperaceae	*Scleria*			C		1
plants	Equisetopsida	Cyperaceae	*Schoenus*			C		4/3
plants	Equisetopsida	Cyperaceae	*Cyperaceae*			C		1
plants	Equisetopsida	Cyperaceae	*Cyperus iria*			C		5/1
plants	Equisetopsida	Cyperaceae	*Cyperus bifax*	western nutgrass		C		1/1
plants	Equisetopsida	Cyperaceae	*Gahnia aspera*			C		3/1
plants	Equisetopsida	Cyperaceae	*Scleria levis*			C		2/1
plants	Equisetopsida	Cyperaceae	*Cyperus fulvus*			C		6/4
plants	Equisetopsida	Cyperaceae	*Cyperus haspan*			C		7/2
plants	Equisetopsida	Cyperaceae	*Cyperus laevis*			C		1
plants	Equisetopsida	Cyperaceae	*Cyperus betchei*			C		6
plants	Equisetopsida	Cyperaceae	*Cyperus conicus*			C		1/1
plants	Equisetopsida	Cyperaceae	*Cyperus lucidus*			C		3/2
plants	Equisetopsida	Cyperaceae	*Schoenus apogon*			C		1
plants	Equisetopsida	Cyperaceae	*Schoenus kennyi*			C		3/3
plants	Equisetopsida	Cyperaceae	*Caustis flexuosa*			C		3/1
plants	Equisetopsida	Cyperaceae	*Cyperus gracilis*			C		9
plants	Equisetopsida	Cyperaceae	*Eleocharis plana*	ribbed spikerush		C		1
plants	Equisetopsida	Cyperaceae	*Fuirena ciliaris*			C		2
plants	Equisetopsida	Cyperaceae	*Baumea planifolia*			C		5/3
plants	Equisetopsida	Cyperaceae	*Baumea rubiginosa*	soft twigrush		C		6/3
plants	Equisetopsida	Cyperaceae	*Caustis pentandra*	thick twistrush		C		5/3
plants	Equisetopsida	Cyperaceae	*Caustis recurvata*			C		1
plants	Equisetopsida	Cyperaceae	*Cyperus concinnus*			C		3/1
plants	Equisetopsida	Cyperaceae	*Cyperus difformis*	rice sedge		C		3
plants	Equisetopsida	Cyperaceae	*Cyperus exaltatus*	tall flatsedge		C		2
plants	Equisetopsida	Cyperaceae	*Cyperus javanicus*			C		1
plants	Equisetopsida	Cyperaceae	*Gahnia sieberiana*	sword grass		C		3/1
plants	Equisetopsida	Cyperaceae	*Isolepis inundata*	swamp club rush		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Cyperaceae	*Schoenus sparteus*			C		3/2
plants	Equisetopsida	Cyperaceae	*Schoenus villosus*			C		1
plants	Equisetopsida	Cyperaceae	*Cyperus rigidellus*			C		3/1
plants	Equisetopsida	Cyperaceae	*Eleocharis atricha*	tuber spikerush		C		3/1
plants	Equisetopsida	Cyperaceae	*Scleria sphacelata*			C		6/2
plants	Equisetopsida	Cyperaceae	*Cyperus brevifolius*	Mullumbimby couch	Y			2/2
plants	Equisetopsida	Cyperaceae	*Cyperus curvistylis*			C		2/2
plants	Equisetopsida	Cyperaceae	*Cyperus gymnocaulos*	spiny flatsedge		C		1
plants	Equisetopsida	Cyperaceae	*Tetraria capillaris*			C		2/1
plants	Equisetopsida	Cyperaceae	*Cyperus involucratus*		Y			1/1
plants	Equisetopsida	Cyperaceae	*Cyperus polystachyos*			C		5
plants	Equisetopsida	Cyperaceae	*Rhynchospora brownii*	beak rush		C		2/2
plants	Equisetopsida	Cyperaceae	*Scleria mackaviensis*			C		1/1
plants	Equisetopsida	Cyperaceae	*Cyperus alterniflorus*			C		2/1
plants	Equisetopsida	Cyperaceae	*Eleocharis sphacelata*	tall spikerush		C		3/1
plants	Equisetopsida	Cyperaceae	*Isolepis subtilissima*			C		1/1
plants	Equisetopsida	Cyperaceae	*Lepidosperma laterale*			C		4/1
plants	Equisetopsida	Cyperaceae	*Cyperus sanguinolentus*			C		2/1
plants	Equisetopsida	Cyperaceae	*Fimbristylis dichotoma*	common fringe-rush		C		11/3
plants	Equisetopsida	Cyperaceae	*Schoenus melanostachys*			C		4/2
plants	Equisetopsida	Cyperaceae	*Fimbristylis aestivalis*			C		1/1
plants	Equisetopsida	Cyperaceae	*Lipocarpha microcephala*			C		1
plants	Equisetopsida	Cyperaceae	*Schoenoplectiella erecta*		Y			2/1
plants	Equisetopsida	Cyperaceae	*Schoenoplectiella laevis*			C		1/1
plants	Equisetopsida	Cyperaceae	*Eleocharis cylindrostachys*			C		1/1
plants	Equisetopsida	Cyperaceae	*Schoenoplectiella mucronata*			C		4/2
plants	Equisetopsida	Davalliaceae	*Davallia pyxidata*			C		2
plants	Equisetopsida	Dennstaedtiaceae	*Histiopteris incisa*	bats-wing fern		C		4/1
plants	Equisetopsida	Dennstaedtiaceae	*Pteridium esculentum*	common bracken		C		10
plants	Equisetopsida	Dicksoniaceae	*Calochlaena dubia*			C		7
plants	Equisetopsida	Dilleniaceae	*Hibbertia*			C		4/2
plants	Equisetopsida	Dilleniaceae	*Hibbertia linearis var. obtusifolia*			C		7/2
plants	Equisetopsida	Dilleniaceae	*Hibbertia stricta var. stricta*			C		1/1
plants	Equisetopsida	Dilleniaceae	*Hibbertia hendersonii*			C		4/4
plants	Equisetopsida	Dilleniaceae	*Hibbertia oligodonta*			C		11/5
plants	Equisetopsida	Dilleniaceae	*Hibbertia acicularis*			C		1
plants	Equisetopsida	Dilleniaceae	*Hibbertia cistoidea*			C		3/1
plants	Equisetopsida	Dilleniaceae	*Hibbertia linearis*			C		3/1
plants	Equisetopsida	Dilleniaceae	*Hibbertia stricta*			C		5
plants	Equisetopsida	Dilleniaceae	*Hibbertia sp. (Isla Gorge P.Sharpe 598)*			C		1/1
plants	Equisetopsida	Dilleniaceae	*Hibbertia ferox*			C		1/1
plants	Equisetopsida	Dilleniaceae	*Hibbertia aspera*			C		4
plants	Equisetopsida	Dilleniaceae	*Hibbertia diffusa*			C		1
plants	Equisetopsida	Dilleniaceae	*Hibbertia riparia*			C		4
plants	Equisetopsida	Dioscoreaceae	*Dioscorea transversa*	native yam		C		2
plants	Equisetopsida	Dipterocarpaceae	*Shorea*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Droseraceae	*Drosera burmanni*			C		2/2
plants	Equisetopsida	Droseraceae	*Drosera binata*	forked sundew		C		4/2
plants	Equisetopsida	Droseraceae	*Drosera*			C		3
plants	Equisetopsida	Droseraceae	*Drosera spatulata*			C		2
plants	Equisetopsida	Droseraceae	*Drosera spatulata var. spatulata*			C		3/3
plants	Equisetopsida	Droseraceae	*Drosera lunata*			C		1/1
plants	Equisetopsida	Dryopteridaceae	*Arachniodes aristata*	prickly shield fern		C		1
plants	Equisetopsida	Ebenaceae	*Diospyros humilis*	small-leaved ebony		C		17/1
plants	Equisetopsida	Ebenaceae	*Diospyros geminata*	scaly ebony		C		3
plants	Equisetopsida	Elaeocarpaceae	*Elaeocarpus reticulatus*	ash quandong		C		3/2
plants	Equisetopsida	Elatinaceae	*Elatine gratioloides*	waterwort		C		2
plants	Equisetopsida	Ericaceae	*Leucopogon*			C		1
plants	Equisetopsida	Ericaceae	*Melichrus*			C		4/3
plants	Equisetopsida	Ericaceae	*Monotoca scoparia*	prickly broom heath		C		5/2
plants	Equisetopsida	Ericaceae	*Leucopogon muticus*			C		5/4
plants	Equisetopsida	Ericaceae	*Acrotriche aggregata*	red cluster heath		C		6/4
plants	Equisetopsida	Ericaceae	*Leucopogon biflorus*			C		10/8
plants	Equisetopsida	Ericaceae	*Epacris obtusifolia*	common heath		C		2/1
plants	Equisetopsida	Ericaceae	*Agiortia pleiosperma*			C		1
plants	Equisetopsida	Ericaceae	*Melichrus procumbens*	jam tarts		C		1
plants	Equisetopsida	Ericaceae	*Melichrus urceolatus*	honey gorse		C		3/2
plants	Equisetopsida	Ericaceae	*Melichrus sp. (Isla Gorge P.Sharpe+ 601)*			C		6/4
plants	Equisetopsida	Ericaceae	*Brachyloma daphnoides subsp. daphnoides*			C		1/1
plants	Equisetopsida	Ericaceae	*Leucopogon mitchellii*			C		3/1
plants	Equisetopsida	Ericaceae	*Leucopogon cuspidatus*			C		1/1
plants	Equisetopsida	Ericaceae	*Brachyloma daphnoides*			C		4
plants	Equisetopsida	Eriocaulaceae	*Eriocaulon nanum*			C		1/1
plants	Equisetopsida	Eriocaulaceae	*Eriocaulon scariosum*			C		5/2
plants	Equisetopsida	Erythroxylaceae	*Erythroxylum australe*	cocaine tree		C		43/3
plants	Equisetopsida	Erythroxylaceae	*Erythroxylum*			C		1
plants	Equisetopsida	Euphorbiaceae	*Euphorbia hirta*		Y			1/1
plants	Equisetopsida	Euphorbiaceae	*Croton insularis*	Queensland cascarilla		C		5/3
plants	Equisetopsida	Euphorbiaceae	*Ricinus communis*	castor oil bush	Y			2/2
plants	Equisetopsida	Euphorbiaceae	*Acalypha eremorum*	soft acalypha		C		12/2
plants	Equisetopsida	Euphorbiaceae	*Bertya pedicellata*			NT		3
plants	Equisetopsida	Euphorbiaceae	*Acalypha capillipes*	small-leaved acalypha		C		6
plants	Equisetopsida	Euphorbiaceae	*Beyeria viscosa*			C		2/1
plants	Equisetopsida	Euphorbiaceae	*Bertya opponens*			C	V	4/3
plants	Equisetopsida	Euphorbiaceae	*Ricinocarpos*			C		2
plants	Equisetopsida	Euphorbiaceae	*Euphorbia*			C		6
plants	Equisetopsida	Euphorbiaceae	*Acalypha*			C		1
plants	Equisetopsida	Euphorbiaceae	*Ricinocarpos ledifolius*	scrub wedding bush		C		1
plants	Equisetopsida	Euphorbiaceae	*Ricinocarpos ruminatus*			C		4
plants	Equisetopsida	Euphorbiaceae	*Excoecaria dallachyana*	scrub poison tree		C		1
plants	Equisetopsida	Euphorbiaceae	*Euphorbia hyssopifolia*		Y			1/1
plants	Equisetopsida	Euphorbiaceae	*Claoxylon tenerifolium*	Queensland brittlewood		C		2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Euphorbiaceae	*Mallotus philippensis*	red kamala		C		3/1
plants	Equisetopsida	Euphorbiaceae	*Mallotus claoxyloides*	green kamala		C		1
plants	Equisetopsida	Euphorbiaceae	*Euphorbia dallachyana*			C		2/1
plants	Equisetopsida	Euphorbiaceae	*Croton acronychioides*	thick-leaved croton		C		1
plants	Equisetopsida	Euphorbiaceae	*Euphorbia drummondii*			C		2
plants	Equisetopsida	Euphorbiaceae	*Alchornea ilicifolia*	native holly		C		2
plants	Equisetopsida	Euphorbiaceae	*Euphorbia tannensis*			C		1
plants	Equisetopsida	Euphorbiaceae	*Euphorbia tannensis subsp. eremophila*			C		4/1
plants	Equisetopsida	Euphorbiaceae	*Euphorbia tannensis subsp. tannensis*			C		2
plants	Equisetopsida	Euphorbiaceae	*Homalanthus stillingiifolius*			C		1/1
plants	Equisetopsida	Euphorbiaceae	*Ricinocarpos linearifolius*			C		14/10
plants	Equisetopsida	Euphorbiaceae	*Homalanthus populifolius*			C		1
plants	Equisetopsida	Euphorbiaceae	*Tragia novae-hollandiae*	stinging-vine		C		1
plants	Equisetopsida	Euphorbiaceae	*Croton phebalioides*	narrow-leaved croton		C		16/4
plants	Equisetopsida	Fabaceae	*Mirbelia rubiifolia*	heathy mirbelia		C		3/1
plants	Equisetopsida	Fabaceae	*Stylosanthes scabra*		Y			16/3
plants	Equisetopsida	Fabaceae	*Crotalaria verrucosa*			C		1/1
plants	Equisetopsida	Fabaceae	*Indigofera australis*			C		5
plants	Equisetopsida	Fabaceae	*Indigofera brevidens*			C		4/3
plants	Equisetopsida	Fabaceae	*Indigofera linifolia*			C		1
plants	Equisetopsida	Fabaceae	*Indigofera pratensis*			C		3/1
plants	Equisetopsida	Fabaceae	*Phyllota phylicoides*	yellow peabush		C		5/3
plants	Equisetopsida	Fabaceae	*Pultenaea petiolaris*			C		14/9
plants	Equisetopsida	Fabaceae	*Tephrosia brachyodon*			C		1
plants	Equisetopsida	Fabaceae	*Daviesia quoquoversus*			V		7/2
plants	Equisetopsida	Fabaceae	*Desmodium brachypodum*	large ticktrefoil		C		4/1
plants	Equisetopsida	Fabaceae	*Desmodium macrocarpum*			C		8/4
plants	Equisetopsida	Fabaceae	*Dillwynia phylicoides*			C		5/4
plants	Equisetopsida	Fabaceae	*Erythrina vespertilio*			C		4
plants	Equisetopsida	Fabaceae	*Gompholobium pinnatum*	poor mans gold		C		3/1
plants	Equisetopsida	Fabaceae	*Hardenbergia violacea*			C		5/1
plants	Equisetopsida	Fabaceae	*Crotalaria medicaginea*	trefoil rattlepod		C		2
plants	Equisetopsida	Fabaceae	*Jacksonia rhadinoclona*	Miles dogwood		C		3/1
plants	Equisetopsida	Fabaceae	*Pultenaea cunninghamii*	prickly pea		C		7/7
plants	Equisetopsida	Fabaceae	*Hovea*			C		6/1
plants	Equisetopsida	Fabaceae	*Glycine*			C		1/1
plants	Equisetopsida	Fabaceae	*Galactia*			C		1
plants	Equisetopsida	Fabaceae	*Kennedia*			C		1
plants	Equisetopsida	Fabaceae	*Mirbelia*			C		1/1
plants	Equisetopsida	Fabaceae	*Pultenaea*			C		1
plants	Equisetopsida	Fabaceae	*Swainsona*			C		1
plants	Equisetopsida	Fabaceae	*Tephrosia*			C		3/1
plants	Equisetopsida	Fabaceae	*Indigofera*			C		2
plants	Equisetopsida	Fabaceae	*Cullen tenax*	emu-foot		C		4/1
plants	Equisetopsida	Fabaceae	*Stylosanthes*			C		1
plants	Equisetopsida	Fabaceae	*Hovea linearis*	erect hovea		C		3/2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Fabaceae	*Hovea longipes*	brush hovea		C		4/1
plants	Equisetopsida	Fabaceae	*Aotus subglauca*			C		1
plants	Equisetopsida	Fabaceae	*Cullen cinereum*			C		1/1
plants	Equisetopsida	Fabaceae	*Glycine falcata*			C		1
plants	Equisetopsida	Fabaceae	*Lotus australis*	Australian trefoil		C		1
plants	Equisetopsida	Fabaceae	*Medicago sativa*	lucerne	Y			1
plants	Equisetopsida	Fabaceae	*Pultenaea borea*			C		1/1
plants	Equisetopsida	Fabaceae	*Vigna vexillata*			C		1
plants	Equisetopsida	Fabaceae	*Zornia areolata*			C		1/1
plants	Equisetopsida	Fabaceae	*Bossiaea brownii*			C		6
plants	Equisetopsida	Fabaceae	*Daviesia filipes*			C		4/1
plants	Equisetopsida	Fabaceae	*Glycine tabacina*	glycine pea		C		1
plants	Equisetopsida	Fabaceae	*Hovea lanceolata*			C		1
plants	Equisetopsida	Fabaceae	*Hovea planifolia*			C		11/3
plants	Equisetopsida	Fabaceae	*Mirbelia pungens*			C		2/1
plants	Equisetopsida	Fabaceae	*Tephrosia rufula*			C		1
plants	Equisetopsida	Fabaceae	*Vigna lanceolata*			C		1
plants	Equisetopsida	Fabaceae	*Bossiaea concolor*			C		5/2
plants	Equisetopsida	Fabaceae	*Canavalia papuana*	wild jack bean		C		1/1
plants	Equisetopsida	Fabaceae	*Clitoria ternatea*	butterfly pea	Y			1
plants	Equisetopsida	Fabaceae	*Crotalaria brevis*			C		1/1
plants	Equisetopsida	Fabaceae	*Daviesia discolor*			V	V	8/6
plants	Equisetopsida	Fabaceae	*Desmodium varians*	slender tick trefoil		C		6
plants	Equisetopsida	Fabaceae	*Hovea tholiformis*			C		5/3
plants	Equisetopsida	Fabaceae	*Mirbelia aotoides*			C		2/2
plants	Equisetopsida	Fabaceae	*Aeschynomene brevifolia*			C		1/1
plants	Equisetopsida	Fabaceae	*Pultenaea spinosa*			C		15/1
plants	Equisetopsida	Fabaceae	*Rhynchosia minima*			C		3
plants	Equisetopsida	Fabaceae	*Austrosteenisia blackii*	bloodvine		C		1
plants	Equisetopsida	Fabaceae	*Desmodium campylocaulon*			C		1
plants	Equisetopsida	Fabaceae	*Gompholobium foliolosum*	fern-leaved burtonia		C		2
plants	Equisetopsida	Fabaceae	*Desmodium rhytidophyllum*			C		5/2
plants	Equisetopsida	Fabaceae	*Macroptilium lathyroides*		Y			4/4
plants	Equisetopsida	Fabaceae	*Hardenbergia perbrevidens*			C		4/4
plants	Equisetopsida	Fabaceae	*Macroptilium atropurpureum*	siratro	Y			4/2
plants	Equisetopsida	Fabaceae	*Rhynchosia minima var. minima*			C		1
plants	Equisetopsida	Fabaceae	*Aotus subglauca var. filiformis*			C		1
plants	Equisetopsida	Fabaceae	*Crotalaria incana subsp. incana*		Y			1/1
plants	Equisetopsida	Fabaceae	*Daviesia filipes subsp. filipes*			C		4/4
plants	Equisetopsida	Fabaceae	*Glycine clandestina var. sericea*			C		1
plants	Equisetopsida	Fabaceae	*Pultenaea millarii var. millarii*			C		9/7
plants	Equisetopsida	Fabaceae	*Tephrosia filipes subsp. filipes*			C		3/1
plants	Equisetopsida	Fabaceae	*Hovea linearis x Hovea planifolia*			C		3/3
plants	Equisetopsida	Fabaceae	*Sesbania cannabina var. cannabina*			C		3
plants	Equisetopsida	Fabaceae	*Mirbelia speciosa subsp. ringrosei*			C		2/1
plants	Equisetopsida	Fabaceae	*Zornia muriculata subsp. angustata*			C		3/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Fabaceae	*Crotalaria medicaginea var. neglecta*			C		1/1
plants	Equisetopsida	Fabaceae	*Glycine clandestina var. clandestina*			C		1
plants	Equisetopsida	Fabaceae	*Hovea planifolia x Hovea tholiformis*			C		1/1
plants	Equisetopsida	Fabaceae	*Erythrina vespertilio subsp. vespertilio*			C		1
plants	Equisetopsida	Fabaceae	*Macroptilium lathyroides var. semierectum*		Y			1
plants	Equisetopsida	Fabaceae	*Crotalaria dissitiflora subsp. dissitiflora*			C		1
plants	Equisetopsida	Fabaceae	*Kennedia sp. (Blackdown Tableland R.J.Henderson+ H747)*			C		1/1
plants	Equisetopsida	Fabaceae	*Templetonia egena*	desert broombush		C		1/1
plants	Equisetopsida	Fabaceae	*Zornia muriculata*			C		2
plants	Equisetopsida	Fabaceae	*Bossiaea carinalis*			C		12/7
plants	Equisetopsida	Fabaceae	*Crotalaria montana*			C		3
plants	Equisetopsida	Fabaceae	*Daviesia villifera*	prickly daviesia		C		1
plants	Equisetopsida	Fabaceae	*Daviesia wyattiana*	long-leaved bitter pea		C		8/5
plants	Equisetopsida	Fabaceae	*Glycine tomentella*	woolly glycine		C		5/1
plants	Equisetopsida	Fabaceae	*Indigofera hirsuta*	hairy indigo		C		2/2
plants	Equisetopsida	Fabaceae	*Indigofera linnaei*	Birdsville indigo		C		1
plants	Equisetopsida	Fabaceae	*Jacksonia scoparia*			C		17/2
plants	Equisetopsida	Fabaceae	*Pultenaea millarii*			C		2/1
plants	Equisetopsida	Fabaceae	*Pultenaea paleacea*			C		1
plants	Equisetopsida	Fabaceae	*Sesbania cannabina*			C		2
plants	Equisetopsida	Fabaceae	*Zornia dyctiocarpa*			C		1
plants	Equisetopsida	Fabaceae	*Aeschynomene indica*	budda pea		C		2
plants	Equisetopsida	Fabaceae	*Daviesia acicularis*			C		1
plants	Equisetopsida	Fabaceae	*Daviesia ulicifolia*	native gorse		C		3
plants	Equisetopsida	Fabaceae	*Glycine clandestina*			C		3
plants	Equisetopsida	Fabaceae	*Medicago polymorpha*	burr medic	Y			1/1
plants	Equisetopsida	Fissidentaceae	*Fissidens asplenioides*			C		1/1
plants	Equisetopsida	Fissidentaceae	*Fissidens*			C		1/1
plants	Equisetopsida	Gentianaceae	*Schenkia australis*			C		1/1
plants	Equisetopsida	Gentianaceae	*Centaurium erythraea*	common centaury	Y			1
plants	Equisetopsida	Gleicheniaceae	*Gleichenia dicarpa*	pouched coral fern		C		6/2
plants	Equisetopsida	Gleicheniaceae	*Sticherus flabellatus var. flabellatus*			C		7/1
plants	Equisetopsida	Gleicheniaceae	*Dicranopteris linearis var. linearis*			C		1
plants	Equisetopsida	Gleicheniaceae	*Dicranopteris linearis*			C		3
plants	Equisetopsida	Gleicheniaceae	*Sticherus flabellatus*			C		1/1
plants	Equisetopsida	Gleicheniaceae	*Gleichenia rupestris*			C		2/1
plants	Equisetopsida	Goodeniaceae	*Scaevola spinescens*	prickly fan flower		C		3/2
plants	Equisetopsida	Goodeniaceae	*Goodenia grandiflora*			C		7/6
plants	Equisetopsida	Goodeniaceae	*Scaevola ramosissima*	purple fan flower		C		2/1
plants	Equisetopsida	Goodeniaceae	*Goodenia fascicularis*			C		1
plants	Equisetopsida	Goodeniaceae	*Goodenia rotundifolia*			C		9/3
plants	Equisetopsida	Goodeniaceae	*Goodenia racemosa var. racemosa*			C		1
plants	Equisetopsida	Goodeniaceae	*Goodenia racemosa var. latifolia*			C		1
plants	Equisetopsida	Goodeniaceae	*Goodenia bellidifolia subsp. argentea*			C		3/2
plants	Equisetopsida	Goodeniaceae	*Goodenia sp. (Mt Castletower M.D.Crisp 2753)*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Goodeniaceae	*Goodenia hederacea*			C		1
plants	Equisetopsida	Goodeniaceae	*Goodenia*			C		3
plants	Equisetopsida	Goodeniaceae	*Goodenia rosulata*			C		1/1
plants	Equisetopsida	Goodeniaceae	*Goodenia racemosa*			C		2
plants	Equisetopsida	Goodeniaceae	*Dampiera discolor*			C		6/2
plants	Equisetopsida	Goodeniaceae	*Dampiera adpressa*			C		4/3
plants	Equisetopsida	Goodeniaceae	*Dampiera stricta*			C		1
plants	Equisetopsida	Goodeniaceae	*Goodenia glabra*			C		3/2
plants	Equisetopsida	Goodeniaceae	*Brunonia australis*	blue pincushion		C		3
plants	Equisetopsida	Goodeniaceae	*Dampiera*			C		1
plants	Equisetopsida	Gyrostemonaceae	*Codonocarpus attenuatus*			C		1
plants	Equisetopsida	Gyrostemonaceae	*Codonocarpus cotinifolius*			C		1
plants	Equisetopsida	Haemodoraceae	*Haemodorum austroqueenslandicum*			C		4/2
plants	Equisetopsida	Haloragaceae	*Gonocarpus*			C		2/1
plants	Equisetopsida	Haloragaceae	*Haloragis stricta*			C		1
plants	Equisetopsida	Haloragaceae	*Gonocarpus micranthus subsp. ramosissimus*			C		2/1
plants	Equisetopsida	Haloragaceae	*Myriophyllum simulans*			C		3/2
plants	Equisetopsida	Haloragaceae	*Haloragis heterophylla*	rough raspweed		C		1
plants	Equisetopsida	Haloragaceae	*Myriophyllum verrucosum*	water milfoil		C		1/1
plants	Equisetopsida	Haloragaceae	*Gonocarpus chinensis subsp. verrucosus*			C		2/1
plants	Equisetopsida	Haloragaceae	*Haloragis aspera*	raspweed		C		1/1
plants	Equisetopsida	Haloragaceae	*Gonocarpus humilis*			C		1/1
plants	Equisetopsida	Hemerocallidaceae	*Dianella longifolia var. stenophylla*			C		1/1
plants	Equisetopsida	Hemerocallidaceae	*Dianella caerulea var. petasmatodes*			C		1/1
plants	Equisetopsida	Hemerocallidaceae	*Dianella caerulea var. protensa*			C		1/1
plants	Equisetopsida	Hemerocallidaceae	*Dianella revoluta var. tenuis*			C		2/2
plants	Equisetopsida	Hemerocallidaceae	*Geitonoplesium cymosum*	scrambling lily		C		2
plants	Equisetopsida	Hemerocallidaceae	*Dianella longifolia*			C		3/1
plants	Equisetopsida	Hemerocallidaceae	*Dianella revoluta*			C		8
plants	Equisetopsida	Hemerocallidaceae	*Dianella caerulea*			C		3
plants	Equisetopsida	Hemerocallidaceae	*Dianella*			C		4
plants	Equisetopsida	Hemerocallidaceae	*Dianella rara*			C		2/2
plants	Equisetopsida	Hernandiaceae	*Gyrocarpus americanus*			C		1
plants	Equisetopsida	Hydrocharitaceae	*Ottelia ovalifolia subsp. ovalifolia*			C		2/2
plants	Equisetopsida	Hydrocharitaceae	*Ottelia ovalifolia*	swamp lily		C		3
plants	Equisetopsida	Hydrocharitaceae	*Vallisneria nana*			C		1/1
plants	Equisetopsida	Hymenophyllaceae	*Abrodictyum caudatum*			C		1
plants	Equisetopsida	Hymenophyllaceae	*Abrodictyum brassii*			C		1
plants	Equisetopsida	Hypoxidaceae	*Hypoxis hygrometrica var. villosisepala*			C		1
plants	Equisetopsida	Iridaceae	*Patersonia sericea*			C		1
plants	Equisetopsida	Iridaceae	*Patersonia sericea var. sericea*			C		2/1
plants	Equisetopsida	Iridaceae	*Patersonia glabrata*			C		3/2
plants	Equisetopsida	Johnsoniaceae	*Tricoryne anceps*			C		1
plants	Equisetopsida	Johnsoniaceae	*Caesia parviflora var. parviflora*			C		3/1
plants	Equisetopsida	Johnsoniaceae	*Tricoryne muricata*			C		4/1
plants	Equisetopsida	Johnsoniaceae	*Tricoryne elatior*	yellow autumn lily		C		6

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Johnsoniaceae	*Caesia parviflora*			C		1
plants	Equisetopsida	Johnsoniaceae	*Caesia chlorantha*			C		1
plants	Equisetopsida	Juncaceae	*Juncus prismatocarpus*	branching rush		C		3/1
plants	Equisetopsida	Juncaceae	*Juncus planifolius*			C		1
plants	Equisetopsida	Juncaceae	*Juncus continuus*			C		7/2
plants	Equisetopsida	Juncaceae	*Juncus aridicola*	tussock rush		C		2
plants	Equisetopsida	Juncaceae	*Juncus usitatus*			C		3
plants	Equisetopsida	Juncaceae	*Juncus*			C		1
plants	Equisetopsida	Juncaginaceae	*Cycnogeton procerus*			C		1
plants	Equisetopsida	Lamiaceae	*Plectranthus*			C		1
plants	Equisetopsida	Lamiaceae	*Prostanthera cryptandroides subsp. euphrasioides*			C		5/1
plants	Equisetopsida	Lamiaceae	*Prostanthera*			C		3/2
plants	Equisetopsida	Lamiaceae	*Ajuga australis*	Australian bugle		C		3/1
plants	Equisetopsida	Lamiaceae	*Teucrium argutum*			C		1
plants	Equisetopsida	Lamiaceae	*Teucrium junceum*			C		3/1
plants	Equisetopsida	Lamiaceae	*Mentha grandiflora*			C		1
plants	Equisetopsida	Lamiaceae	*Ocimum tenuiflorum*			C		4
plants	Equisetopsida	Lamiaceae	*Teucrium daucoides*			C		1/1
plants	Equisetopsida	Lamiaceae	*Teucrium puberulum*			C		1/1
plants	Equisetopsida	Lamiaceae	*Plectranthus blakei*			NT		10/10
plants	Equisetopsida	Lamiaceae	*Prostanthera collina*			C		2/2
plants	Equisetopsida	Lamiaceae	*Chloanthes parviflora*			C		6/2
plants	Equisetopsida	Lamiaceae	*Glossocarya hemiderma*			C		2
plants	Equisetopsida	Lamiaceae	*Ocimum caryophyllinum*			C		1/1
plants	Equisetopsida	Lamiaceae	*Pityrodia salviifolia*	pityrodia		C		3/1
plants	Equisetopsida	Lamiaceae	*Plectranthus diversus*			C		1/1
plants	Equisetopsida	Lamiaceae	*Prostanthera oleoides*			C		2/2
plants	Equisetopsida	Lamiaceae	*Basilicum polystachyon*			C		2/1
plants	Equisetopsida	Lamiaceae	*Prostanthera parvifolia*			C		3/3
plants	Equisetopsida	Lamiaceae	*Clerodendrum floribundum*			C		6/2
plants	Equisetopsida	Lamiaceae	*Plectranthus parviflorus*			C		4/2
plants	Equisetopsida	Lamiaceae	*Prostanthera suborbicularis*			C		2/2
plants	Equisetopsida	Lamiaceae	*Ocimum*					1
plants	Equisetopsida	Lauraceae	*Cassytha filiformis*	dodder laurel		C		2
plants	Equisetopsida	Lauraceae	*Cassytha pubescens*	downy devil's twine		C		1
plants	Equisetopsida	Lauraceae	*Cassytha glabella forma glabella*			C		2/1
plants	Equisetopsida	Laxmanniaceae	*Lomandra multiflora subsp. multiflora*			C		4
plants	Equisetopsida	Laxmanniaceae	*Lomandra leucocephala*			C		2
plants	Equisetopsida	Laxmanniaceae	*Lomandra confertifolia subsp. pallida*			C		7/3
plants	Equisetopsida	Laxmanniaceae	*Lomandra confertifolia*			C		1
plants	Equisetopsida	Laxmanniaceae	*Thysanotus tuberosus subsp. tuberosus*			C		1/1
plants	Equisetopsida	Laxmanniaceae	*Lomandra*			C		5
plants	Equisetopsida	Laxmanniaceae	*Laxmannia*			C		1/1
plants	Equisetopsida	Laxmanniaceae	*Lomandra laxa*	broad-leaved matrush		C		1
plants	Equisetopsida	Laxmanniaceae	*Lomandra obliqua*			C		9/4
plants	Equisetopsida	Laxmanniaceae	*Laxmannia compacta*			C		3/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Laxmanniaceae	*Laxmannia gracilis*	slender wire lily		C		3
plants	Equisetopsida	Laxmanniaceae	*Lomandra filiformis*			C		3
plants	Equisetopsida	Laxmanniaceae	*Lomandra longifolia*			C		12
plants	Equisetopsida	Laxmanniaceae	*Lomandra ramosissima*			C		1/1
plants	Equisetopsida	Laxmanniaceae	*Thysanotus tuberosus*			C		1
plants	Equisetopsida	Laxmanniaceae	*Eustrephus latifolius*	wombat berry		C		9
plants	Equisetopsida	Laxmanniaceae	*Lomandra filiformis subsp. filiformis*			C		8/1
plants	Equisetopsida	Lentibulariaceae	*Utricularia lateriflora*	small bladderwort		C		1
plants	Equisetopsida	Lentibulariaceae	*Utricularia blackmanii*			C		1/1
plants	Equisetopsida	Lentibulariaceae	*Utricularia dichotoma*	fairy aprons		C		2/1
plants	Equisetopsida	Lentibulariaceae	*Utricularia aurea*	golden bladderwort		C		1/1
plants	Equisetopsida	Lentibulariaceae	*Utricularia bifida*			C		3
plants	Equisetopsida	Leucobryaceae	*Leucobryum aduncum*			C		2/2
plants	Equisetopsida	Leucobryaceae	*Leucobryum chlorophyllosum*			C		1/1
plants	Equisetopsida	Lindsaeaceae	*Lindsaea ensifolia*			C		1/1
plants	Equisetopsida	Lindsaeaceae	*Lindsaea microphylla*	lacy wedge fern		C		3/1
plants	Equisetopsida	Loganiaceae	*Logania*			C		1
plants	Equisetopsida	Loganiaceae	*Logania diffusa*			V	V	4/2
plants	Equisetopsida	Loganiaceae	*Logania albiflora*			C		8/5
plants	Equisetopsida	Loganiaceae	*Mitrasacme oasena*			C		1/1
plants	Equisetopsida	Loganiaceae	*Orianthera pusilla*			C		1
plants	Equisetopsida	Loganiaceae	*Mitrasacme paludosa*			C		6/5
plants	Equisetopsida	Loganiaceae	*Mitrasacme prolifera*			C		1
plants	Equisetopsida	Loganiaceae	*Mitrasacme alsinoides*			C		3/2
plants	Equisetopsida	Loganiaceae	*Strychnos psilosperma*	strychnine tree		C		1
plants	Equisetopsida	Loranthaceae	*Amyema cambagei*			C		1
plants	Equisetopsida	Loranthaceae	*Amyema quandang var. quandang*			C		2/1
plants	Equisetopsida	Loranthaceae	*Dendrophthoe glabrescens*			C		1/1
plants	Equisetopsida	Loranthaceae	*Dendrophthoe vitellina*	long-flowered mistletoe		C		2/1
plants	Equisetopsida	Loranthaceae	*Muellerina bidwillii*			C		1
plants	Equisetopsida	Loranthaceae	*Lysiana subfalcata*			C		6
plants	Equisetopsida	Loranthaceae	*Lysiana filifolia*			C		4/3
plants	Equisetopsida	Loranthaceae	*Amyema*			C		1
plants	Equisetopsida	Loranthaceae	*Amyema quandang var. bancroftii*	broad-leaved grey mistletoe		C		2
plants	Equisetopsida	Loranthaceae	*Amyema quandang*			C		1
plants	Equisetopsida	Lycopodiaceae	*Lycopodiella cernua*			C		2/1
plants	Equisetopsida	Lygodiaceae	*Lygodium microphyllum*	snake fern		C		7/4
plants	Equisetopsida	Lygodiaceae	*Lygodium flexuosum*			C		1
plants	Equisetopsida	Lythraceae	*Ammannia multiflora*	jerry-jerry		C		2/2
plants	Equisetopsida	Lythraceae	*Lythrum paradoxum*			C		1
plants	Equisetopsida	Lythraceae	*Rotala mexicana*			C		1/1
plants	Equisetopsida	Lythraceae	*Rotala*			C		1
plants	Equisetopsida	Macarthuriaceae	*Macarthuria ephedroides*			C		11/8
plants	Equisetopsida	Malvaceae	*Urena lobata*	urena weed	Y			1
plants	Equisetopsida	Malvaceae	*Sida rohlenae*			C		4
plants	Equisetopsida	Malvaceae	*Sida corrugata*			C		3/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Malvaceae	*Abutilon nobile*			C		1/1
plants	Equisetopsida	Malvaceae	*Sida cordifolia*		Y			10/3
plants	Equisetopsida	Malvaceae	*Sida fibulifera*			C		2
plants	Equisetopsida	Malvaceae	*Sida trichopoda*			C		9/2
plants	Equisetopsida	Malvaceae	*Abutilon auritum*	Chinese lantern		C		1
plants	Equisetopsida	Malvaceae	*Abutilon fraseri*	dwarf lantern flower		C		1
plants	Equisetopsida	Malvaceae	*Hibiscus sturtii*			C		4/2
plants	Equisetopsida	Malvaceae	*Hibiscus trionum*					3
plants	Equisetopsida	Malvaceae	*Sida atherophora*			C		7/2
plants	Equisetopsida	Malvaceae	*Sida hackettiana*			C		11/1
plants	Equisetopsida	Malvaceae	*Sida rhombifolia*		Y			8/3
plants	Equisetopsida	Malvaceae	*Sida cunninghamii*			C		2
plants	Equisetopsida	Malvaceae	*Abutilon guineense*		Y			3/3
plants	Equisetopsida	Malvaceae	*Abutilon otocarpum*			C		4/1
plants	Equisetopsida	Malvaceae	*Abutilon oxycarpum*			C		1
plants	Equisetopsida	Malvaceae	*Gossypium australe*			C		1/1
plants	Equisetopsida	Malvaceae	*Gossypium hirsutum*		Y			2/2
plants	Equisetopsida	Malvaceae	*Hibiscus splendens*	pink hibiscus		C		2/1
plants	Equisetopsida	Malvaceae	*Abutilon malvifolium*	bastard marshmallow		C		2
plants	Equisetopsida	Malvaceae	*Hibiscus divaricatus*			C		5/4
plants	Equisetopsida	Malvaceae	*Hibiscus meraukensis*	Merauke hibiscus		C		2/1
plants	Equisetopsida	Malvaceae	*Abelmoschus ficulneus*	native rosella		C		1/1
plants	Equisetopsida	Malvaceae	*Abutilon leucopetalum*			C		2/1
plants	Equisetopsida	Malvaceae	*Malvastrum americanum*		Y			9
plants	Equisetopsida	Malvaceae	*Hibiscus heterophyllus*			C		2
plants	Equisetopsida	Malvaceae	*Hibiscus krichauffianus*			C		3/3
plants	Equisetopsida	Malvaceae	*Sida aprica var. aprica*			C		3/3
plants	Equisetopsida	Malvaceae	*Hibiscus brachysiphonius*			C		3
plants	Equisetopsida	Malvaceae	*Hibiscus sturtii var. sturtii*			C		5/2
plants	Equisetopsida	Malvaceae	*Sida rohlenae subsp. rohlenae*			C		5/3
plants	Equisetopsida	Malvaceae	*Abutilon fraseri subsp. fraseri*			C		2/1
plants	Equisetopsida	Malvaceae	*Abutilon oxycarpum var. incanum*			C		1/1
plants	Equisetopsida	Malvaceae	*Sida corrugata var. angustifolia*			C		1/1
plants	Equisetopsida	Malvaceae	*Abutilon oxycarpum var. oxycarpum*			C		1
plants	Equisetopsida	Malvaceae	*Malvastrum americanum var. stellatum*			C		2/2
plants	Equisetopsida	Malvaceae	*Abutilon oxycarpum var. subsagittatum*			C		2
plants	Equisetopsida	Malvaceae	*Malvastrum americanum var. americanum*		Y			19/1
plants	Equisetopsida	Malvaceae	*Sida sp. (Aramac E.J.Thompson+ JER192)*			C		7/5
plants	Equisetopsida	Malvaceae	*Hibiscus sp. (Emerald S.L.Everist 2124)*			C		1/1
plants	Equisetopsida	Malvaceae	*Sida sp. (Musselbrook M.B.Thomas+ MRS437)*			C		5/3
plants	Equisetopsida	Malvaceae	*Sida*			C		21/1
plants	Equisetopsida	Malvaceae	*Abutilon*			C		18
plants	Equisetopsida	Malvaceae	*Malvaceae*			C		2/1
plants	Equisetopsida	Malvaceae	*Sida spinosa*	spiny sida	Y			2
plants	Equisetopsida	Marsileaceae	*Marsilea mutica*	shiny nardoo		C		2/1
plants	Equisetopsida	Marsileaceae	*Marsilea hirsuta*	hairy nardoo		C		2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Marsileaceae	*Marsilea drummondii*	common nardoo		C		1
plants	Equisetopsida	Marsileaceae	*Marsilea costulifera*	narrow-leaved nardoo		C		2
plants	Equisetopsida	Melastomataceae	*Melastoma malabathricum subsp. malabathricum*			C		8/2
plants	Equisetopsida	Meliaceae	*Owenia venosa*	crow's apple		C		2/1
plants	Equisetopsida	Meliaceae	*Owenia acidula*	emu apple		C		15/2
plants	Equisetopsida	Meliaceae	*Melia azedarach*	white cedar		C		4/1
plants	Equisetopsida	Meliaceae	*Turraea pubescens*	native honeysuckle		C		2
plants	Equisetopsida	Menispermaceae	*Tinospora smilacina*	snakevine		C		2/1
plants	Equisetopsida	Menyanthaceae	*Nymphoides crenata*	wavy marshwort		C		2/1
plants	Equisetopsida	Menyanthaceae	*Nymphoides geminata*			C		3/1
plants	Equisetopsida	Menyanthaceae	*Nymphoides indica*	water snowflake		C		5/4
plants	Equisetopsida	Mimosaceae	*Neptunia gracilis forma gracilis*			C		3/1
plants	Equisetopsida	Mimosaceae	*Acacia cretata - Acacia leiocalyx*			C		1/1
plants	Equisetopsida	Mimosaceae	*Acacia cretata x Acacia fodinalis*			C		2/2
plants	Equisetopsida	Mimosaceae	*Acacia leiocalyx subsp. leiocalyx*			C		15/5
plants	Equisetopsida	Mimosaceae	*Acacia victoriae subsp. victoriae*			C		3/3
plants	Equisetopsida	Mimosaceae	*Acacia julifera subsp. curvinervia*			C		1
plants	Equisetopsida	Mimosaceae	*Acacia disparrima subsp. disparrima*			C		1/1
plants	Equisetopsida	Mimosaceae	*Acacia penninervis var. penninervis*			C		2/2
plants	Equisetopsida	Mimosaceae	*Leucaena leucocephala subsp. glabrata*		Y			1/1
plants	Equisetopsida	Mimosaceae	*Acacia bancroftiorum x Acacia falciformis*			C		3/3
plants	Equisetopsida	Mimosaceae	*Leucaena leucocephala subsp. leucocephala*		Y			3/3
plants	Equisetopsida	Mimosaceae	*Acacia*			C		19
plants	Equisetopsida	Mimosaceae	*Acacia blakei*			C		1
plants	Equisetopsida	Mimosaceae	*Acacia decora*	pretty wattle		C		2
plants	Equisetopsida	Mimosaceae	*Acacia storyi*			NT		21/17
plants	Equisetopsida	Mimosaceae	*Acacia cretata*			C		23/15
plants	Equisetopsida	Mimosaceae	*Acacia excelsa*			C		17
plants	Equisetopsida	Mimosaceae	*Acacia implexa*	lightwood		C		3/1
plants	Equisetopsida	Mimosaceae	*Acacia burrowii*			C		5/2
plants	Equisetopsida	Mimosaceae	*Acacia caroleae*			C		6
plants	Equisetopsida	Mimosaceae	*Acacia conferta*			C		2/1
plants	Equisetopsida	Mimosaceae	*Acacia coriacea*			C		1
plants	Equisetopsida	Mimosaceae	*Acacia oswaldii*	miljee		C		8/2
plants	Equisetopsida	Mimosaceae	*Acacia salicina*	doolan		C		25
plants	Equisetopsida	Mimosaceae	*Acacia shirleyi*	lancewood		C		16/5
plants	Equisetopsida	Mimosaceae	*Acacia venulosa*	veined wattle		C		8/7
plants	Equisetopsida	Mimosaceae	*Albizia lebbeck*	Indian siris		C		1/1
plants	Equisetopsida	Mimosaceae	*Acacia amblygona*	fan-leaf wattle		C		1
plants	Equisetopsida	Mimosaceae	*Acacia buxifolia*			C		1
plants	Equisetopsida	Mimosaceae	*Acacia decurrens*		Y			1
plants	Equisetopsida	Mimosaceae	*Acacia everistii*			C		9/8
plants	Equisetopsida	Mimosaceae	*Acacia gittinsii*			C		27/22
plants	Equisetopsida	Mimosaceae	*Acacia leiocalyx*			C		7/1
plants	Equisetopsida	Mimosaceae	*Acacia polifolia*			C		5/4
plants	Equisetopsida	Mimosaceae	*Acacia pubicosta*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Mimosaceae	*Acacia catenulata*	bendee		C		13
plants	Equisetopsida	Mimosaceae	*Acacia complanata*	flatstem wattle		C		10/1
plants	Equisetopsida	Mimosaceae	*Acacia concurrens*			C		1
plants	Equisetopsida	Mimosaceae	*Acacia flavescens*	toothed wattle		C		16
plants	Equisetopsida	Mimosaceae	*Acacia holotricha*			C		5/5
plants	Equisetopsida	Mimosaceae	*Acacia juncifolia*			C		9/6
plants	Equisetopsida	Mimosaceae	*Acacia leptocarpa*	north coast wattle		C		1
plants	Equisetopsida	Mimosaceae	*Acacia macradenia*	zig-zag wattle		C		15/6
plants	Equisetopsida	Mimosaceae	*Acacia neriifolia*	pechey wattle		C		9/7
plants	Equisetopsida	Mimosaceae	*Acacia rhodoxylon*	ringy rosewood		C		43
plants	Equisetopsida	Mimosaceae	*Acacia semirigida*			C		3/2
plants	Equisetopsida	Mimosaceae	*Acacia ulicifolia*			C		3/2
plants	Equisetopsida	Mimosaceae	*Albizia canescens*			C		1
plants	Equisetopsida	Mimosaceae	*Acacia aulacocarpa*			C		3
plants	Equisetopsida	Mimosaceae	*Acacia falciformis*	broad-leaved hickory		C		2/2
plants	Equisetopsida	Mimosaceae	*Acacia glaucocarpa*	hickory wattle		C		15
plants	Equisetopsida	Mimosaceae	*Acacia grandifolia*			C	V	1/1
plants	Equisetopsida	Mimosaceae	*Acacia harpophylla*	brigalow		C		88
plants	Equisetopsida	Mimosaceae	*Acacia hendersonii*			C		5/5
plants	Equisetopsida	Mimosaceae	*Acacia holosericea*			C		1/1
plants	Equisetopsida	Mimosaceae	*Acacia melanoxylon*	blackwood		C		2
plants	Equisetopsida	Mimosaceae	*Acacia penninervis*			C		3
plants	Equisetopsida	Mimosaceae	*Acacia dietrichiana*			C		5/3
plants	Equisetopsida	Mimosaceae	*Acacia leichhardtii*			C		8/5
plants	Equisetopsida	Mimosaceae	*Acacia leptostachya*	Townsville wattle		C		8/4
plants	Equisetopsida	Mimosaceae	*Acacia longispicata*			C		4/4
plants	Equisetopsida	Mimosaceae	*Vachellia bidwillii*			C		1
plants	Equisetopsida	Mimosaceae	*Acacia bancroftiorum*			C		8/7
plants	Equisetopsida	Mimosaceae	*Acacia fasciculifera*	scaly bark		C		1
plants	Equisetopsida	Mimosaceae	*Acacia resinicostata*			C		4
plants	Equisetopsida	Mimosaceae	*Vachellia farnesiana*		Y			6/1
plants	Equisetopsida	Mimosaceae	*Acacia neobrachycarpa*			C		9/5
plants	Equisetopsida	Mimosaceae	*Acacia podalyriifolia*	Queensland silver wattle		C		7/4
plants	Equisetopsida	Mimosaceae	*Desmanthus pernambucanus*		Y			1/1
plants	Equisetopsida	Mimosaceae	*Archidendropsis basaltica*	red lancewood		C		7
plants	Equisetopsida	Mimosaceae	*Archidendropsis thozetiana*			C		2
plants	Equisetopsida	Mimosaceae	*Acacia blakei subsp. blakei*			C		7/6
plants	Equisetopsida	Mimosaceae	*Acacia crassa subsp. crassa*			C		3/2
plants	Equisetopsida	Mimosaceae	*Acacia excelsa subsp. angusta*			C		1/1
plants	Equisetopsida	Mimosaceae	*Acacia excelsa subsp. excelsa*			C		1/1
plants	Equisetopsida	Mimosaceae	*Acacia crassa subsp. longicoma*			C		2/1
plants	Equisetopsida	Mimosaceae	*Acacia julifera subsp. julifera*			C		2/2
plants	Equisetopsida	Mimosaceae	*Acacia sp. (Comet L.Pedley 4091)*			C		7/7
plants	Equisetopsida	Molluginaceae	*Glinus lotoides*	hairy carpet weed		C		3/3
plants	Equisetopsida	Moraceae	*Ficus obliqua*			C		2
plants	Equisetopsida	Moraceae	*Ficus opposita*			C		7/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Moraceae	*Ficus rubiginosa forma rubiginosa*			C		1/1
plants	Equisetopsida	Moraceae	*Ficus virens*			C		1
plants	Equisetopsida	Moraceae	*Ficus coronata*	creek sandpaper fig		C		5/1
plants	Equisetopsida	Myrsinaceae	*Myrsine variabilis*			C		2
plants	Equisetopsida	Myrtaceae	*Eucalyptus coolabah*	coolabah		C		11/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus mensalis*			C		22/15
plants	Equisetopsida	Myrtaceae	*Eucalyptus populnea*	poplar box		C		61
plants	Equisetopsida	Myrtaceae	*Eucalyptus tenuipes*	narrow-leaved white mahogany		C		6/6
plants	Equisetopsida	Myrtaceae	*Harmogia densifolia*			C		3/2
plants	Equisetopsida	Myrtaceae	*Melaleuca bracteata*			C		4
plants	Equisetopsida	Myrtaceae	*Melaleuca lazaridis*			C		6/6
plants	Equisetopsida	Myrtaceae	*Melaleuca pearsonii*			NT		13/12
plants	Equisetopsida	Myrtaceae	*Melaleuca viminalis*			C		3/2
plants	Equisetopsida	Myrtaceae	*Triplarina paludosa*			C		18/14
plants	Equisetopsida	Myrtaceae	*Angophora floribunda*	rough-barked apple		C		48/2
plants	Equisetopsida	Myrtaceae	*Corymbia dallachiana*			C		9/1
plants	Equisetopsida	Myrtaceae	*Corymbia hendersonii*			C		31/9
plants	Equisetopsida	Myrtaceae	*Corymbia tessellaris*	Moreton Bay ash		C		21/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus baileyana*	Bailey's stringybark		C		66/13
plants	Equisetopsida	Myrtaceae	*Eucalyptus cloeziana*	Gympie messmate		C		46/7
plants	Equisetopsida	Myrtaceae	*Eucalyptus mediocris*			C		8/8
plants	Equisetopsida	Myrtaceae	*Eucalyptus moluccana*	gum-topped box		C		74/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus propinqua*	small-fruited grey gum		C		13/8
plants	Equisetopsida	Myrtaceae	*Melaleuca hemisticta*			C		1/1
plants	Equisetopsida	Myrtaceae	*Sannantha brachypoda*			V		1/1
plants	Equisetopsida	Myrtaceae	*Corymbia clarksoniana*			C		32/8
plants	Equisetopsida	Myrtaceae	*Corymbia leichhardtii*	rustyjacket		C		2
plants	Equisetopsida	Myrtaceae	*Corymbia trachyphloia*			C		1
plants	Equisetopsida	Myrtaceae	*Eucalyptus acmenoides*			C		70/12
plants	Equisetopsida	Myrtaceae	*Eucalyptus caliginosa*	broad-leaved stringybark		C		18
plants	Equisetopsida	Myrtaceae	*Eucalyptus cambageana*	Dawson gum		C		48/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus interstans*			C		11/11
plants	Equisetopsida	Myrtaceae	*Eucalyptus suffulgens*			C		36/21
plants	Equisetopsida	Myrtaceae	*Eucalyptus thozetiana*			C		14/4
plants	Equisetopsida	Myrtaceae	*Homoranthus decasetus*			C		1
plants	Equisetopsida	Myrtaceae	*Lophostemon confertus*	brush box		C		6/1
plants	Equisetopsida	Myrtaceae	*Melaleuca leucadendra*	broad-leaved tea-tree		C		6/1
plants	Equisetopsida	Myrtaceae	*Melaleuca tamariscina*			C		3/3
plants	Equisetopsida	Myrtaceae	*Ochrosperma adpressum*			C		1/1
plants	Equisetopsida	Myrtaceae	*Corymbia erythrophloia*	variable-barked bloodwood		C		1
plants	Equisetopsida	Myrtaceae	*Eucalyptus chloroclada*	Baradine red gum		C		1
plants	Equisetopsida	Myrtaceae	*Eucalyptus decorticans*			C		1/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus eugenioides*			C		3
plants	Equisetopsida	Myrtaceae	*Eucalyptus melanoleuca*	Nanango ironbark		C		48/8
plants	Equisetopsida	Myrtaceae	*Eucalyptus raveretiana*	black ironbox		C	V	2/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus tholiformis*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Myrtaceae	*Leptospermum neglectum*			C		1
plants	Equisetopsida	Myrtaceae	*Leptospermum sericatum*			C		3/2
plants	Equisetopsida	Myrtaceae	*Lophostemon suaveolens*	swamp box		C		40/3
plants	Equisetopsida	Myrtaceae	*Melaleuca linariifolia*	snow-in summer		C		4/2
plants	Equisetopsida	Myrtaceae	*Backhousia angustifolia*	narrow-leaved backhousia		C		1
plants	Equisetopsida	Myrtaceae	*Eucalyptus melanophloia*			C		16
plants	Equisetopsida	Myrtaceae	*Eucalyptus sphaerocarpa*	Blackdown stringybark		C		210/29
plants	Equisetopsida	Myrtaceae	*Eucalyptus tereticornis*			C		21
plants	Equisetopsida	Myrtaceae	*Homoranthus brevistylis*			C		2/2
plants	Equisetopsida	Myrtaceae	*Leptospermum lamellatum*			C		19/3
plants	Equisetopsida	Myrtaceae	*Melaleuca montis-zamiae*			C		1/1
plants	Equisetopsida	Myrtaceae	*Melaleuca quinquenervia*	swamp paperbark		C		1
plants	Equisetopsida	Myrtaceae	*Melaleuca trichostachya*			C		4/2
plants	Equisetopsida	Myrtaceae	*Micromyrtus capricornia*			C		9/9
plants	Equisetopsida	Myrtaceae	*Eucalyptus camaldulensis*			C		1
plants	Equisetopsida	Myrtaceae	*Eucalyptus longirostrata*			C		46/6
plants	Equisetopsida	Myrtaceae	*Lophostemon grandiflorus*			C		2
plants	Equisetopsida	Myrtaceae	*Lysicarpus angustifolius*	budgeroo		C		34/4
plants	Equisetopsida	Myrtaceae	*Leptospermum brachyandrum*	weeping tea-tree		C		4/2
plants	Equisetopsida	Myrtaceae	*Leptospermum polygalifolium*	tantoon		C		11/4
plants	Equisetopsida	Myrtaceae	*Eucalyptus saligna subsp. saligna*			C		4/4
plants	Equisetopsida	Myrtaceae	*Corymbia citriodora subsp. variegata*			C		40
plants	Equisetopsida	Myrtaceae	*Corymbia watsoniana subsp. capillata*			C		2/1
plants	Equisetopsida	Myrtaceae	*Corymbia citriodora subsp. citriodora*			C		135/2
plants	Equisetopsida	Myrtaceae	*Corymbia watsoniana subsp. watsoniana*			C		3/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus camaldulensis subsp. acuta*			C		3
plants	Equisetopsida	Myrtaceae	*Lophostemon grandiflorus subsp. riparius*			C		1/1
plants	Equisetopsida	Myrtaceae	*Syncarpia glomulifera subsp. glomulifera*			C		10/4
plants	Equisetopsida	Myrtaceae	*Corymbia trachyphloia subsp. carnarvonica*			C		1/1
plants	Equisetopsida	Myrtaceae	*Corymbia trachyphloia subsp. trachyphloia*			C		17
plants	Equisetopsida	Myrtaceae	*Eucalyptus crebra x Eucalyptus thozetiana*			C		1/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus crebra x Eucalyptus melanophloia*			C		1/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus melanophloia subsp. melanophloia*			C		1/1
plants	Equisetopsida	Myrtaceae	*Eucalyptus tereticornis subsp. tereticornis*			C		49/1
plants	Equisetopsida	Myrtaceae	*Corymbia*			C		2
plants	Equisetopsida	Myrtaceae	*Melaleuca*			C		6/3
plants	Equisetopsida	Myrtaceae	*Eucalyptus*			C		10/6
plants	Equisetopsida	Myrtaceae	*Leptospermum*			C		3/1
plants	Equisetopsida	Myrtaceae	*Baeckea trapeza*			V		7/7
plants	Equisetopsida	Myrtaceae	*Kunzea opposita*			C		1
plants	Equisetopsida	Myrtaceae	*Corymbia aureola*			C		2/2
plants	Equisetopsida	Myrtaceae	*Corymbia bunites*			C		95/22
plants	Equisetopsida	Myrtaceae	*Gossia bidwillii*			C		2
plants	Equisetopsida	Myrtaceae	*Melaleuca nodosa*			C		3/2
plants	Equisetopsida	Myrtaceae	*Angophora costata*			C		1
plants	Equisetopsida	Myrtaceae	*Backhousia kingii*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Myrtaceae	*Eucalyptus carnea*			C		1
plants	Equisetopsida	Myrtaceae	*Eucalyptus crebra*	narrow-leaved red ironbark		C		140/6
plants	Equisetopsida	Myrtaceae	*Melaleuca nervosa*			C		11/2
plants	Equisetopsida	Myrtaceae	*Syzygium australe*	scrub cherry		C		1
plants	Equisetopsida	Myrtaceae	*Corymbia bloxsomei*			C		1
plants	Equisetopsida	Myrtaceae	*Eucalyptus exserta*	Queensland peppermint		C		11/3
plants	Equisetopsida	Myrtaceae	*Eucalyptus saligna*			C		2/1
plants	Equisetopsida	Myrtaceae	*Melaleuca groveana*			NT		6/4
plants	Equisetopsida	Myrtaceae	*Angophora leiocarpa*	rusty gum		C		59/3
plants	Equisetopsida	Myrtaceae	*Corymbia citriodora*	spotted gum		C		12
plants	Equisetopsida	Myrtaceae	*Corymbia intermedia*	pink bloodwood		C		67/6
plants	Equisetopsida	Myrtaceae	*Corymbia watsoniana*			C		1
plants	Equisetopsida	Nyctaginaceae	*Boerhavia*			C		1
plants	Equisetopsida	Nyctaginaceae	*Boerhavia sp. (St George A.Hill AQ399299)*			C		2/2
plants	Equisetopsida	Nyctaginaceae	*Boerhavia pubescens*			C		1
plants	Equisetopsida	Nyctaginaceae	*Boerhavia dominii*			C		10/2
plants	Equisetopsida	Olacaceae	*Ximenia americana*			C		1/1
plants	Equisetopsida	Olacaceae	*Olax stricta*			C		3/1
plants	Equisetopsida	Oleaceae	*Jasminum didymum*			C		9
plants	Equisetopsida	Oleaceae	*Jasminum didymum subsp. racemosum*			C		5
plants	Equisetopsida	Oleaceae	*Notelaea microcarpa*			C		4
plants	Equisetopsida	Oleaceae	*Jasminum simplicifolium*			C		1
plants	Equisetopsida	Oleaceae	*Jasminum didymum subsp. didymum*			C		2
plants	Equisetopsida	Oleaceae	*Jasminum didymum subsp. lineare*			C		12/1
plants	Equisetopsida	Oleaceae	*Jasminum simplicifolium subsp. australiense*			C		2/1
plants	Equisetopsida	Oleaceae	*Notelaea sp. (Barakula A.R.Bean 7553)*			C		2/2
plants	Equisetopsida	Oleaceae	*Notelaea punctata*			C		4
plants	Equisetopsida	Onagraceae	*Ludwigia octovalvis*	willow primrose		C		6
plants	Equisetopsida	Onagraceae	*Ludwigia peploides subsp. montevidensis*			C		1
plants	Equisetopsida	Ophioglossaceae	*Ophioglossum pendulum*	ribbon fern		C		1
plants	Equisetopsida	Ophioglossaceae	*Ophioglossum reticulatum*			C		2/1
plants	Equisetopsida	Orchidaceae	*Erythrorchis cassythoides*	climbing orchid		C		1
plants	Equisetopsida	Orchidaceae	*Bulbophyllum schillerianum*	red rope orchid		C		1
plants	Equisetopsida	Orchidaceae	*Caladenia carnea var. carnea*			C		1/1
plants	Equisetopsida	Orchidaceae	*Thelymitra ixioides var. ixioides*			C		1
plants	Equisetopsida	Orchidaceae	*Cymbidium*			C		4
plants	Equisetopsida	Orchidaceae	*Calochilus*			C		2/1
plants	Equisetopsida	Orchidaceae	*Thelymitra*			C		1/1
plants	Equisetopsida	Orchidaceae	*Prasophyllum*			C		1
plants	Equisetopsida	Orchidaceae	*Caleana major*	flying duck orchid		C		1
plants	Equisetopsida	Orchidaceae	*Diuris luteola*	northern yellow donkeys tails		C		2/2
plants	Equisetopsida	Orchidaceae	*Caladenia carnea*			C		1
plants	Equisetopsida	Orchidaceae	*Corybas barbarae*	helmet orchid		C		1
plants	Equisetopsida	Orchidaceae	*Diuris sulphurea*	tiger orchid		C		1
plants	Equisetopsida	Orchidaceae	*Phaius australis*			E	E	5/3
plants	Equisetopsida	Orchidaceae	*Acianthus exsertus*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Orchidaceae	*Caladenia catenata*			C		3/1
plants	Equisetopsida	Orchidaceae	*Dipodium punctatum*			C		1
plants	Equisetopsida	Orchidaceae	*Pterostylis nutans*			C		1
plants	Equisetopsida	Orchidaceae	*Sarcochilus hillii*			C		1
plants	Equisetopsida	Orchidaceae	*Corunastylis valida*			V		1/1
plants	Equisetopsida	Orchidaceae	*Cryptostylis erecta*	bonnet orchid		C		1
plants	Equisetopsida	Orchidaceae	*Dockrillia bowmanii*	scrub pencil orchid		C		1
plants	Equisetopsida	Orchidaceae	*Microtis parviflora*	slender onion orchid		C		2
plants	Equisetopsida	Orchidaceae	*Acianthus fornicatus*	pixie caps		C		1
plants	Equisetopsida	Orchidaceae	*Chiloglottis reflexa*	autumn bird orchid				1
plants	Equisetopsida	Orchidaceae	*Corunastylis archeri*			C		1
plants	Equisetopsida	Orchidaceae	*Dendrobium speciosum*			C		3/2
plants	Equisetopsida	Orchidaceae	*Gastrodia sesamoides*	cinnamon bells		C		1
plants	Equisetopsida	Orchidaceae	*Sarcochilus ceciliae*	fairy bells		C		1
plants	Equisetopsida	Orchidaceae	*Spiranthes australis*			C		1
plants	Equisetopsida	Orchidaceae	*Calochilus campestris*	copper beard orchid		C		3/2
plants	Equisetopsida	Orchidaceae	*Chiloglottis trullata*			C		2/2
plants	Equisetopsida	Orchidaceae	*Corybas aconitiflorus*			C		1
plants	Equisetopsida	Orchidaceae	*Dendrobium tetragonum*	tree spider orchid		C		2/1
plants	Equisetopsida	Orchidaceae	*Dockrillia cucumerina*			C		1
plants	Equisetopsida	Orchidaceae	*Gastrodia crebriflora*			V		1/1
plants	Equisetopsida	Orchidaceae	*Calochilus robertsonii*	purplish beard orchid		C		1
plants	Equisetopsida	Orchidaceae	*Dipodium hamiltonianum*	yellow hyacinth orchid		C		1
plants	Equisetopsida	Orchidaceae	*Lyperanthus suaveolens*	brown beaks		C		2/1
plants	Equisetopsida	Orchidaceae	*Pterostylis longicurva*			C		1
plants	Equisetopsida	Orchidaceae	*Pterostylis parviflora*	tiny greenhood		C		1
plants	Equisetopsida	Orchidaceae	*Corunastylis pedersonii*			V		1/1
plants	Equisetopsida	Orchidaceae	*Cymbidium canaliculatum*			C		11/1
plants	Equisetopsida	Orchidaceae	*Pterostylis ophioglossa*			C		1/1
plants	Equisetopsida	Orchidaceae	*Thelymitra angustifolia*			C		2/2
plants	Equisetopsida	Orchidaceae	*Bulbophyllum minutissimum*	grain-of-wheat orchid		C		1
plants	Equisetopsida	Orobanchaceae	*Buchnera urticifolia*			C		1
plants	Equisetopsida	Orobanchaceae	*Striga parviflora*			C		2
plants	Equisetopsida	Orobanchaceae	*Buchnera linearis*			C		1
plants	Equisetopsida	Orobanchaceae	*Buchnera gracilis*			C		1
plants	Equisetopsida	Orthotrichaceae	*Macromitrium hemitrichodes*			C		1/1
plants	Equisetopsida	Osmundaceae	*Todea barbara*	king fern		C		3/1
plants	Equisetopsida	Oxalidaceae	*Oxalis corniculata*		Y			6
plants	Equisetopsida	Oxalidaceae	*Oxalis perennans*			C		1/1
plants	Equisetopsida	Oxalidaceae	*Oxalis*			C		3
plants	Equisetopsida	Papaveraceae	*Argemone ochroleuca subsp. ochroleuca*	Mexican poppy	Y			2/1
plants	Equisetopsida	Passifloraceae	*Passiflora aurantia*			C		1
plants	Equisetopsida	Passifloraceae	*Passiflora aurantia var. aurantia*			C		3/3
plants	Equisetopsida	Passifloraceae	*Passiflora foetida*		Y			2/2
plants	Equisetopsida	Pentapetaceae	*Melhania oblongifolia*			C		7/6
plants	Equisetopsida	Pentapetaceae	*Melhania ovata*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Philydraceae	*Philydrum lanuginosum*	frogsmouth		C		8/1
plants	Equisetopsida	Phrymaceae	*Mimulus gracilis*	slender monkey flower		C		1
plants	Equisetopsida	Phrymaceae	*Glossostigma diandrum*			C		2/1
plants	Equisetopsida	Phyllanthaceae	*Glochidion sumatranum*	umbrella cheese tree		C		1
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus mitchellii*			C		18/10
plants	Equisetopsida	Phyllanthaceae	*Poranthera microphylla*	small poranthera		C		3/1
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus fuernrohrii*			C		2
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus carpentariae*			C		1/1
plants	Equisetopsida	Phyllanthaceae	*Synostemon rhytidospermus*			C		1/1
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus maderaspatensis*			C		5/1
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus maderaspatensis var. maderaspatensis*			C		4/1
plants	Equisetopsida	Phyllanthaceae	*Flueggea*					1
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus*			C		4/2
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus gunnii*			C		2
plants	Equisetopsida	Phyllanthaceae	*Poranthera obovata*			C		3/3
plants	Equisetopsida	Phyllanthaceae	*Sauropus hirtellus*			C		1
plants	Equisetopsida	Phyllanthaceae	*Flueggea leucopyrus*			C		3
plants	Equisetopsida	Phyllanthaceae	*Synostemon spinosus*			C		1/1
plants	Equisetopsida	Phyllanthaceae	*Breynia oblongifolia*			C		10
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus collinus*			C		1/1
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus tenellus*		Y			1
plants	Equisetopsida	Phyllanthaceae	*Phyllanthus virgatus*			C		18/3
plants	Equisetopsida	Phyllanthaceae	*Bridelia leichhardtii*			C		1
plants	Equisetopsida	Phyllanthaceae	*Glochidion ferdinandi*			C		1
plants	Equisetopsida	Picrodendraceae	*Pseudanthus pauciflorus subsp. arenicola*			NT		2/1
plants	Equisetopsida	Picrodendraceae	*Petalostigma pachyphyllum*			C		15/5
plants	Equisetopsida	Picrodendraceae	*Pseudanthus orientalis*			C		2/1
plants	Equisetopsida	Picrodendraceae	*Petalostigma pubescens*	quinine tree		C		29/4
plants	Equisetopsida	Piperaceae	*Peperomia blanda var. floribunda*			C		1
plants	Equisetopsida	Pittosporaceae	*Rhytidosporum diosmoides*			C		2/2
plants	Equisetopsida	Pittosporaceae	*Pittosporum angustifolium*			C		7/1
plants	Equisetopsida	Pittosporaceae	*Bursaria incana*			C		5
plants	Equisetopsida	Pittosporaceae	*Billardiera scandens*			C		2/1
plants	Equisetopsida	Pittosporaceae	*Auranticarpa rhombifolia*			C		1
plants	Equisetopsida	Pittosporaceae	*Pittosporum spinescens*			C		12/1
plants	Equisetopsida	Pittosporaceae	*Bursaria spinosa subsp. spinosa*			C		4
plants	Equisetopsida	Plantaginaceae	*Gratiola pedunculata*			C		2
plants	Equisetopsida	Plantaginaceae	*Scoparia dulcis*	scoparia	Y			3/2
plants	Equisetopsida	Plantaginaceae	*Veronica plebeia*	trailing speedwell		C		3/1
plants	Equisetopsida	Plantaginaceae	*Stemodia pubescens*			C		1/1
plants	Equisetopsida	Plantaginaceae	*Plantago cunninghamii*	sago weed		C		1
plants	Equisetopsida	Plumbaginaceae	*Plumbago zeylanica*	native plumbago		C		4/1
plants	Equisetopsida	Poaceae	*Entolasia whiteana*			C		1
plants	Equisetopsida	Poaceae	*Eragrostis brownii*	Brown's lovegrass		C		1
plants	Equisetopsida	Poaceae	*Eragrostis curvula*		Y			1
plants	Equisetopsida	Poaceae	*Eragrostis sororia*			C		9/4

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Poaceae	*Eriachne aristidea*			C		1/1
plants	Equisetopsida	Poaceae	*Eriachne mucronata*			C		3
plants	Equisetopsida	Poaceae	*Ischaemum australe*			C		4
plants	Equisetopsida	Poaceae	*Chloris*			C		10
plants	Equisetopsida	Poaceae	*Panicum*			C		4
plants	Equisetopsida	Poaceae	*Poaceae*			C		7
plants	Equisetopsida	Poaceae	*Aristida*			C		35
plants	Equisetopsida	Poaceae	*Cenchrus*			C		1
plants	Equisetopsida	Poaceae	*Eriachne*			C		2
plants	Equisetopsida	Poaceae	*Paspalum*			C		2
plants	Equisetopsida	Poaceae	*Digitaria*			C		6
plants	Equisetopsida	Poaceae	*Cymbopogon*			C		1
plants	Equisetopsida	Poaceae	*Enneapogon*			C		5
plants	Equisetopsida	Poaceae	*Eragrostis*			C		18
plants	Equisetopsida	Poaceae	*Oplismenus*					1
plants	Equisetopsida	Poaceae	*Sporobolus*			C		5
plants	Equisetopsida	Poaceae	*Dichanthium*			C		1
plants	Equisetopsida	Poaceae	*Echinochloa*			C		1
plants	Equisetopsida	Poaceae	*Paspalidium*			C		19
plants	Equisetopsida	Poaceae	*Perotis rara*	comet grass		C		3/1
plants	Equisetopsida	Poaceae	*Eulalia aurea*	silky browntop		C		3/1
plants	Equisetopsida	Poaceae	*Chloris gayana*	rhodes grass	Y			3/2
plants	Equisetopsida	Poaceae	*Melinis repens*	red natal grass	Y			11/1
plants	Equisetopsida	Poaceae	*Panicum buncei*			C		2/2
plants	Equisetopsida	Poaceae	*Panicum simile*			C		2/1
plants	Equisetopsida	Poaceae	*Aristida ramosa*	purple wiregrass		C		4/2
plants	Equisetopsida	Poaceae	*Aristida vagans*			C		2
plants	Equisetopsida	Poaceae	*Chloris inflata*	purpletop chloris	Y			12/2
plants	Equisetopsida	Poaceae	*Chloris virgata*	feathertop rhodes grass	Y			4
plants	Equisetopsida	Poaceae	*Eriachne obtusa*			C		8/7
plants	Equisetopsida	Poaceae	*Isachne globosa*	swamp millet		C		1
plants	Equisetopsida	Poaceae	*Panicum effusum*			C		6
plants	Equisetopsida	Poaceae	*Setaria surgens*			C		2/2
plants	Equisetopsida	Poaceae	*Sorghum x almum*		Y			1/1
plants	Equisetopsida	Poaceae	*Triodia pungens*			C		2/1
plants	Equisetopsida	Poaceae	*Aristida ingrata*			C		2/2
plants	Equisetopsida	Poaceae	*Aristida lignosa*			C		2/1
plants	Equisetopsida	Poaceae	*Cynodon dactylon*		Y			4
plants	Equisetopsida	Poaceae	*Dinebra ligulata*			C		3/1
plants	Equisetopsida	Poaceae	*Eragrostis minor*	smaller stinkgrass	Y			3/1
plants	Equisetopsida	Poaceae	*Eriochloa crebra*	spring grass		C		7
plants	Equisetopsida	Poaceae	*Leersia hexandra*	swamp rice grass		C		4/1
plants	Equisetopsida	Poaceae	*Sporobolus laxus*			C		1
plants	Equisetopsida	Poaceae	*Themeda triandra*	kangaroo grass		C		21/2
plants	Equisetopsida	Poaceae	*Urochloa foliosa*			C		1/1
plants	Equisetopsida	Poaceae	*Aristida calycina*			C		7

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Poaceae	*Dichanthium sericeum*			C		4/1
plants	Equisetopsida	Poaceae	*Digitaria longiflora*			C		2/2
plants	Equisetopsida	Poaceae	*Digitaria parviflora*			C		1
plants	Equisetopsida	Poaceae	*Digitaria violascens*	bastard summergrass	Y			1/1
plants	Equisetopsida	Poaceae	*Dimorphochloa rigida*			C		2/2
plants	Equisetopsida	Poaceae	*Enneapogon nigricans*	niggerheads		C		2
plants	Equisetopsida	Poaceae	*Enneapogon truncatus*			C		1/1
plants	Equisetopsida	Poaceae	*Eragrostis lacunaria*	purple lovegrass		C		13/3
plants	Equisetopsida	Poaceae	*Eragrostis tenellula*	delicate lovegrass		C		1
plants	Equisetopsida	Poaceae	*Panicum decompositum*			C		6
plants	Equisetopsida	Poaceae	*Paspalum longifolium*			C		3/1
plants	Equisetopsida	Poaceae	*Sporobolus elongatus*			C		4
plants	Equisetopsida	Poaceae	*Sporobolus scabridus*			C		3/2
plants	Equisetopsida	Poaceae	*Tripogon loliiformis*	five minute grass		C		3/2
plants	Equisetopsida	Poaceae	*Alloteropsis cimicina*			C		8/6
plants	Equisetopsida	Poaceae	*Aristida jerichoensis*			C		5
plants	Equisetopsida	Poaceae	*Chionachne cyathopoda*	river grass		C		1/1
plants	Equisetopsida	Poaceae	*Cymbopogon bombycinus*	silky oilgrass		C		1
plants	Equisetopsida	Poaceae	*Dichanthium aristatum*	angleton grass	Y			1/1
plants	Equisetopsida	Poaceae	*Dichelachne micrantha*	shorthair plumegrass		C		3/2
plants	Equisetopsida	Poaceae	*Astrebla lappacea*	curly mitchell grass		C		1
plants	Equisetopsida	Poaceae	*Cenchrus ciliaris*		Y			49/2
plants	Equisetopsida	Poaceae	*Chloris pectinata*	comb chloris		C		2/1
plants	Equisetopsida	Poaceae	*Digitaria brownii*			C		4/2
plants	Equisetopsida	Poaceae	*Digitaria diffusa*			C		6/2
plants	Equisetopsida	Poaceae	*Entolasia stricta*	wiry panic		C		10/1
plants	Equisetopsida	Poaceae	*Eragrostis pilosa*	soft lovegrass	Y			2/2
plants	Equisetopsida	Poaceae	*Eriachne glabrata*			C		1
plants	Equisetopsida	Poaceae	*Holcolemma dispar*			C		1/1
plants	Equisetopsida	Poaceae	*Hyparrhenia hirta*	coolati grass	Y			1
plants	Equisetopsida	Poaceae	*Panicum coloratum*		Y			1
plants	Equisetopsida	Poaceae	*Panicum paludosum*	swamp panic		C		1/1
plants	Equisetopsida	Poaceae	*Setaria apiculata*			C		1/1
plants	Equisetopsida	Poaceae	*Sporobolus caroli*	fairy grass		C		23
plants	Equisetopsida	Poaceae	*Sporobolus creber*			C		6/1
plants	Equisetopsida	Poaceae	*Urochloa piligera*			C		3/3
plants	Equisetopsida	Poaceae	*Urochloa pubigera*			C		2/1
plants	Equisetopsida	Poaceae	*Aristida benthamii*			C		1
plants	Equisetopsida	Poaceae	*Aristida holathera*			C		1
plants	Equisetopsida	Poaceae	*Aristida latifolia*	feathertop wiregrass		C		4/2
plants	Equisetopsida	Poaceae	*Aristida leptopoda*	white speargrass		C		1
plants	Equisetopsida	Poaceae	*Aristida personata*			C		1/1
plants	Equisetopsida	Poaceae	*Astrebla squarrosa*	bull mitchell grass		C		5
plants	Equisetopsida	Poaceae	*Cenchrus echinatus*	Mossman River grass	Y			1
plants	Equisetopsida	Poaceae	*Chloris divaricata*			C		1
plants	Equisetopsida	Poaceae	*Chloris ventricosa*	tall chloris		C		5/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Poaceae	*Chrysopogon fallax*			C		10/2
plants	Equisetopsida	Poaceae	*Digitaria bicornis*			C		4/3
plants	Equisetopsida	Poaceae	*Digitaria ciliaris*	summer grass	Y			2/1
plants	Equisetopsida	Poaceae	*Digitaria diminuta*			C		8/4
plants	Equisetopsida	Poaceae	*Echinochloa colona*	awnless barnyard grass	Y			7/1
plants	Equisetopsida	Poaceae	*Echinopogon ovatus*			C		1
plants	Equisetopsida	Poaceae	*Alloteropsis semialata*	cockatoo grass		C		8/1
plants	Equisetopsida	Poaceae	*Aristida caput-medusae*			C		15/5
plants	Equisetopsida	Poaceae	*Arundinella nepalensis*	reedgrass		C		8/2
plants	Equisetopsida	Poaceae	*Bothriochloa decipiens*			C		4
plants	Equisetopsida	Poaceae	*Bothriochloa ewartiana*	desert bluegrass		C		9/1
plants	Equisetopsida	Poaceae	*Bothriochloa insculpta*		Y			1
plants	Equisetopsida	Poaceae	*Brachyachne convergens*	common native couch		C		6/1
plants	Equisetopsida	Poaceae	*Chrysopogon oliganthus*			C		1/1
plants	Equisetopsida	Poaceae	*Cleistochloa subjuncea*			C		5/2
plants	Equisetopsida	Poaceae	*Enneapogon lindleyanus*			C		7/4
plants	Equisetopsida	Poaceae	*Enneapogon polyphyllus*	leafy nineawn		C		2/1
plants	Equisetopsida	Poaceae	*Enteropogon acicularis*	curly windmill grass		C		6
plants	Equisetopsida	Poaceae	*Enteropogon unispiceus*			C		10/2
plants	Equisetopsida	Poaceae	*Paspalidium criniforme*			C		1/1
plants	Equisetopsida	Poaceae	*Paspalidium globoideum*	sago grass		C		1/1
plants	Equisetopsida	Poaceae	*Paspalidium jubiflorum*	warrego grass		C		2/1
plants	Equisetopsida	Poaceae	*Paspalidium spartellum*			C		1
plants	Equisetopsida	Poaceae	*Paspalum scrobiculatum*	ditch millet		C		5
plants	Equisetopsida	Poaceae	*Setaria paspalidioides*			C		3/3
plants	Equisetopsida	Poaceae	*Thyridolepis xerophila*			C		3/3
plants	Equisetopsida	Poaceae	*Urochloa mosambicensis*	sabi grass	Y			18
plants	Equisetopsida	Poaceae	*Urochloa subquadripara*		Y			1/1
plants	Equisetopsida	Poaceae	*Ancistrachne uncinulata*	hooky grass		C		7/5
plants	Equisetopsida	Poaceae	*Aristida leichhardtiana*			C		1/1
plants	Equisetopsida	Poaceae	*Dactyloctenium australe*	sweet smother grass	Y			1/1
plants	Equisetopsida	Poaceae	*Dactyloctenium radulans*	button grass		C		9/1
plants	Equisetopsida	Poaceae	*Dinebra divaricatissima*			C		1/1
plants	Equisetopsida	Poaceae	*Eragrostis leptostachya*			C		4/2
plants	Equisetopsida	Poaceae	*Eragrostis megalosperma*			C		4/2
plants	Equisetopsida	Poaceae	*Eragrostis spartinoides*			C		1/1
plants	Equisetopsida	Poaceae	*Paspalidium caespitosum*	brigalow grass		C		18/4
plants	Equisetopsida	Poaceae	*Paspalidium constrictum*			C		3/1
plants	Equisetopsida	Poaceae	*Sporobolus actinocladus*	katoora grass		C		7
plants	Equisetopsida	Poaceae	*Austrostipa verticillata*	slender bamboo grass		C		1
plants	Equisetopsida	Poaceae	*Dactyloctenium aegyptium*	coast button grass	Y			1/1
plants	Equisetopsida	Poaceae	*Enteropogon paucispiceus*			C		1/1
plants	Equisetopsida	Poaceae	*Sporobolus australasicus*			C		2
plants	Equisetopsida	Poaceae	*Oplismenus aemulus*	creeping shade grass		C		1
plants	Equisetopsida	Poaceae	*Paspalidium gausum*			C		2/1
plants	Equisetopsida	Poaceae	*Paspalum dilatatum*	paspalum	Y			2/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Poaceae	*Paspalum distichum*	water couch		C		2
plants	Equisetopsida	Poaceae	*Sacciolepis indica*	Indian cupscale grass		C		4/2
plants	Equisetopsida	Poaceae	*Triodia mitchellii*	buck spinifex		C		14/10
plants	Equisetopsida	Poaceae	*Aristida gracilipes*			C		1/1
plants	Equisetopsida	Poaceae	*Aristida polyclados*			C		3
plants	Equisetopsida	Poaceae	*Chrysopogon filipes*			C		2/1
plants	Equisetopsida	Poaceae	*Dichelachne montana*			C		1/1
plants	Equisetopsida	Poaceae	*Digitaria ammophila*	silky umbrella grass		C		1
plants	Equisetopsida	Poaceae	*Digitaria ramularis*			C		1
plants	Equisetopsida	Poaceae	*Enneapogon gracilis*	slender nineawn		C		7/2
plants	Equisetopsida	Poaceae	*Enteropogon ramosus*			C		4/1
plants	Equisetopsida	Poaceae	*Entolasia marginata*	bordered panic		C		3/2
plants	Equisetopsida	Poaceae	*Eragrostis elongata*			C		8/4
plants	Equisetopsida	Poaceae	*Eragrostis speciosa*			C		1/1
plants	Equisetopsida	Poaceae	*Eriachne pallescens*			C		2/1
plants	Equisetopsida	Poaceae	*Imperata cylindrica*	blady grass		C		8
plants	Equisetopsida	Poaceae	*Leptochloa digitata*			C		8
plants	Equisetopsida	Poaceae	*Megathyrsus maximus*		Y			4
plants	Equisetopsida	Poaceae	*Panicum larcomianum*			C		1/1
plants	Equisetopsida	Poaceae	*Paspalidium distans*	shotgrass		C		2
plants	Equisetopsida	Poaceae	*Paspalidium gracile*	slender panic		C		4/1
plants	Equisetopsida	Poaceae	*Tragus australianus*	small burr grass		C		8/1
plants	Equisetopsida	Poaceae	*Bothriochloa pertusa*		Y			5/1
plants	Equisetopsida	Poaceae	*Cymbopogon refractus*	barbed-wire grass		C		13/1
plants	Equisetopsida	Poaceae	*Walwhalleya subxerophila*			C		1/1
plants	Equisetopsida	Poaceae	*Cymbopogon queenslandicus*			C		1
plants	Equisetopsida	Poaceae	*Digitaria divaricatissima*	spreading umbrella grass		C		2/2
plants	Equisetopsida	Poaceae	*Diplachne fusca var. fusca*			C		2/1
plants	Equisetopsida	Poaceae	*Eriochloa pseudoacrotricha*			C		2/2
plants	Equisetopsida	Poaceae	*Eragrostis longipedicellata*			C		2/2
plants	Equisetopsida	Poaceae	*Hyparrhenia rufa subsp. rufa*		Y			2/2
plants	Equisetopsida	Poaceae	*Cynodon dactylon var. dactylon*		Y			2
plants	Equisetopsida	Poaceae	*Aristida calycina var. calycina*			C		4/3
plants	Equisetopsida	Poaceae	*Aristida calycina var. praealta*			C		1/1
plants	Equisetopsida	Poaceae	*Dinebra decipiens var. asthenes*			C		3/2
plants	Equisetopsida	Poaceae	*Dinebra decipiens var. decipiens*			C		4/1
plants	Equisetopsida	Poaceae	*Dinebra decipiens var. peacockii*			C		2/2
plants	Equisetopsida	Poaceae	*Ischaemum australe var. australe*			C		1/1
plants	Equisetopsida	Poaceae	*Megathyrsus maximus var. maximus*		Y			1
plants	Equisetopsida	Poaceae	*Aristida benthamii var. benthamii*			C		3/3
plants	Equisetopsida	Poaceae	*Aristida holathera var. holathera*			C		3/2
plants	Equisetopsida	Poaceae	*Panicum decompositum var. tenuius*			C		2
plants	Equisetopsida	Poaceae	*Chloris divaricata var. divaricata*	slender chloris		C		5/2
plants	Equisetopsida	Poaceae	*Bothriochloa bladhii subsp. bladhii*			C		2
plants	Equisetopsida	Poaceae	*Eriachne pallescens var. pallescens*			C		3/2
plants	Equisetopsida	Poaceae	*Megathyrsus maximus var. pubiglumis*		Y			14/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Poaceae	*Microlaena stipoides var. stipoides*			C		1
plants	Equisetopsida	Poaceae	*Dichanthium sericeum subsp. humilius*			C		1/1
plants	Equisetopsida	Poaceae	*Dichanthium sericeum subsp. sericeum*			C		4/3
plants	Equisetopsida	Poaceae	*Bothriochloa decipiens var. decipiens*			C		6/2
plants	Equisetopsida	Poaceae	*Aristida queenslandica var. dissimilis*			C		7/4
plants	Equisetopsida	Poaceae	*Panicum decompositum var. decompositum*			C		1/1
plants	Equisetopsida	Poaceae	*Aristida jerichoensis var. jerichoensis*			C		5/1
plants	Equisetopsida	Poaceae	*Aristida jerichoensis var. subspinulifera*			C		6/1
plants	Equisetopsida	Poaceae	*Aristida queenslandica var. queenslandica*			C		2/2
plants	Equisetopsida	Poaceae	*Calyptochloa gracillima subsp. gracillima*			C		13/4
plants	Equisetopsida	Poaceae	*Cleistochloa sp. (Duaringa K.B.Addison 42)*			C		11/9
plants	Equisetopsida	Poaceae	*Digitaria divaricatissima var. divaricatissima*			C		1
plants	Equisetopsida	Poaceae	*Eriachne mucronata forma (Alpha C.E.Hubbard 7882)*			C		3/3
plants	Equisetopsida	Poaceae	*Echinochloa esculenta*	Japanese millet	Y			1
plants	Equisetopsida	Poaceae	*Eragrostis microcarpa*			C		1
plants	Equisetopsida	Poaceae	*Eremochloa bimaculata*	poverty grass		C		7
plants	Equisetopsida	Poaceae	*Heteropogon contortus*	black speargrass		C		15
plants	Equisetopsida	Poaceae	*Iseilema vaginiflorum*	red flinders grass		C		2
plants	Equisetopsida	Poaceae	*Schizachyrium fragile*	firegrass		C		1/1
plants	Equisetopsida	Poaceae	*Sporobolus disjunctus*			C		4/4
plants	Equisetopsida	Podocarpaceae	*Podocarpus spinulosus*	dwarf plum-pine		C		2/1
plants	Equisetopsida	Polygalaceae	*Comesperma retusum*			C		1
plants	Equisetopsida	Polygalaceae	*Polygala triflora*			C		3/3
plants	Equisetopsida	Polygalaceae	*Comesperma*			C		1
plants	Equisetopsida	Polygalaceae	*Comesperma sphaerocarpum*			C		6/2
plants	Equisetopsida	Polygalaceae	*Comesperma patentifolium*			C		12/7
plants	Equisetopsida	Polygalaceae	*Comesperma ericinum*			C		1
plants	Equisetopsida	Polygonaceae	*Muehlenbeckia rhyticarya*			C		1
plants	Equisetopsida	Polygonaceae	*Persicaria lapathifolia*	pale knotweed		C		1/1
plants	Equisetopsida	Polygonaceae	*Persicaria orientalis*	princes feathers		C		3/1
plants	Equisetopsida	Polygonaceae	*Polygonum plebeium*	small knotweed		C		2/2
plants	Equisetopsida	Polygonaceae	*Duma florulenta*			C		2
plants	Equisetopsida	Polygonaceae	*Emex*			C		1
plants	Equisetopsida	Polygonaceae	*Persicaria attenuata*			C		2/1
plants	Equisetopsida	Polypodiaceae	*Drynaria rigidula*			C		2/1
plants	Equisetopsida	Polypodiaceae	*Platycerium veitchii*	silver elkhorn		C		4/2
plants	Equisetopsida	Polypodiaceae	*Pyrrosia rupestris*	rock felt fern		C		1
plants	Equisetopsida	Polypodiaceae	*Pyrrosia confluens*			C		1
plants	Equisetopsida	Pontederiaceae	*Monochoria cyanea*			C		3
plants	Equisetopsida	Portulacaceae	*Portulaca pilosa*		Y			3
plants	Equisetopsida	Portulacaceae	*Portulaca bicolor*			C		3/1
plants	Equisetopsida	Portulacaceae	*Portulaca oleracea*	pigweed	Y			12
plants	Equisetopsida	Portulacaceae	*Portulaca filifolia*			C		7
plants	Equisetopsida	Portulacaceae	*Calandrinia pleiopetala*			C		1
plants	Equisetopsida	Portulacaceae	*Portulaca*			C		1
plants	Equisetopsida	Portulacaceae	*Calandrinia pickeringii*			C		4/2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Potamogetonaceae	*Potamogeton octandrus*			C		1/1
plants	Equisetopsida	Potamogetonaceae	*Potamogeton*			C		1/1
plants	Equisetopsida	Potamogetonaceae	*Potamogeton tricarinatus*	floating pondweed		C		2
plants	Equisetopsida	Proteaceae	*Hakea*			C		2/2
plants	Equisetopsida	Proteaceae	*Banksia integrifolia subsp. integrifolia*			C		1
plants	Equisetopsida	Proteaceae	*Hakea lorea*			C		5
plants	Equisetopsida	Proteaceae	*Hakea benthamii*			C		4/1
plants	Equisetopsida	Proteaceae	*Banksia spinulosa*			C		5
plants	Equisetopsida	Proteaceae	*Grevillea striata*	beefwood		C		8
plants	Equisetopsida	Proteaceae	*Persoonia falcata*			C		19/2
plants	Equisetopsida	Proteaceae	*Grevillea helmsiae*			C		2
plants	Equisetopsida	Proteaceae	*Grevillea sessilis*			C		12/6
plants	Equisetopsida	Proteaceae	*Lomatia silaifolia*	crinkle bush		C		8/1
plants	Equisetopsida	Proteaceae	*Persoonia subtilis*			C		8/6
plants	Equisetopsida	Proteaceae	*Grevillea parallela*			C		2/1
plants	Equisetopsida	Proteaceae	*Xylomelum benthamii*			C		1
plants	Equisetopsida	Proteaceae	*Banksia oblongifolia*	dwarf banksia		C		5
plants	Equisetopsida	Proteaceae	*Grevillea floribunda*			C		2
plants	Equisetopsida	Proteaceae	*Grevillea longistyla*			C		14/8
plants	Equisetopsida	Proteaceae	*Petrophile canescens*			C		6/2
plants	Equisetopsida	Proteaceae	*Stenocarpus salignus*	scrub beefwood		C		5/4
plants	Equisetopsida	Proteaceae	*Conospermum taxifolium*	devil's rice		C		1
plants	Equisetopsida	Proteaceae	*Grevillea sinuliflora*			C		2
plants	Equisetopsida	Proteaceae	*Hakea lorea subsp. lorea*			C		3/2
plants	Equisetopsida	Proteaceae	*Xylomelum cunninghamianum*			C		10/1
plants	Equisetopsida	Proteaceae	*Grevillea decora subsp. decora*			C		4/4
plants	Equisetopsida	Proteaceae	*Banksia spinulosa var. spinulosa*			C		3/3
plants	Equisetopsida	Proteaceae	*Grevillea floribunda subsp. floribunda*			C		1/1
plants	Equisetopsida	Proteaceae	*Xylomelum*			C		1
plants	Equisetopsida	Psilotaceae	*Psilotum nudum*	skeleton fork fern		C		3/2
plants	Equisetopsida	Pteridaceae	*Cheilanthes*			C		3
plants	Equisetopsida	Pteridaceae	*Vittaria elongata*			C		1
plants	Equisetopsida	Pteridaceae	*Cheilanthes distans*	bristly cloak fern		C		3/1
plants	Equisetopsida	Pteridaceae	*Cheilanthes sieberi*			C		26
plants	Equisetopsida	Pteridaceae	*Pityrogramma calomelanos var. calomelanos*		Y			1/1
plants	Equisetopsida	Pteridaceae	*Cheilanthes nudiuscula*			C		2
plants	Equisetopsida	Pteridaceae	*Cheilanthes tenuifolia*	rock fern		C		1
plants	Equisetopsida	Pteridaceae	*Cheilanthes sieberi subsp. sieberi*			C		9/1
plants	Equisetopsida	Pteridaceae	*Adiantum hispidulum var. hispidulum*			C		2/1
plants	Equisetopsida	Pteridaceae	*Adiantum aethiopicum*			C		1
plants	Equisetopsida	Putranjivaceae	*Drypetes deplanchei*	grey boxwood		C		1
plants	Equisetopsida	Ranunculaceae	*Clematis glycinoides*			C		6/1
plants	Equisetopsida	Ranunculaceae	*Ranunculus sceleratus*		Y			1
plants	Equisetopsida	Restionaceae	*Baloskion pallens*			C		7/5
plants	Equisetopsida	Rhamnaceae	*Pomaderris*			C		1
plants	Equisetopsida	Rhamnaceae	*Alphitonia excelsa*	soap tree		C		56

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Rhamnaceae	*Pomaderris lanigera*			C		4/2
plants	Equisetopsida	Rhamnaceae	*Ventilago viminalis*	supplejack		C		22/1
plants	Equisetopsida	Rhamnaceae	*Polianthion minutiflorum*			V	V	2/2
plants	Equisetopsida	Rhamnaceae	*Pomaderris queenslandica*			C		4/3
plants	Equisetopsida	Rosaceae	*Rubus probus*			C		1
plants	Equisetopsida	Rubiaceae	*Gynochthodes jasminoides*			C		3/2
plants	Equisetopsida	Rubiaceae	*Coelospermum reticulatum*			C		13/3
plants	Equisetopsida	Rubiaceae	*Everistia vacciniifolia*			C		6
plants	Equisetopsida	Rubiaceae	*Triflorensia ixoroides*			C		2/2
plants	Equisetopsida	Rubiaceae	*Spermacoce multicaulis*			C		2/1
plants	Equisetopsida	Rubiaceae	*Spermacoce brachystema*			C		6/3
plants	Equisetopsida	Rubiaceae	*Richardia brasiliensis*	white eye	Y			1
plants	Equisetopsida	Rubiaceae	*Psychotria daphnoides*			C		3
plants	Equisetopsida	Rubiaceae	*Pavetta australiensis*			C		1
plants	Equisetopsida	Rubiaceae	*Oldenlandia galioides*			C		1/1
plants	Equisetopsida	Rubiaceae	*Opercularia diphylla*			C		2/1
plants	Equisetopsida	Rubiaceae	*Larsenaikia ochreata*			C		3/3
plants	Equisetopsida	Rubiaceae	*Antirhea putaminosa*			C		2/1
plants	Equisetopsida	Rubiaceae	*Psydrax oleifolia*			C		6
plants	Equisetopsida	Rubiaceae	*Psydrax johnsonii*			C		2/2
plants	Equisetopsida	Rubiaceae	*Psydrax attenuata*			C		1
plants	Equisetopsida	Rubiaceae	*Psydrax forsteri*			C		3/2
plants	Equisetopsida	Rubiaceae	*Psydrax odorata*			C		3
plants	Equisetopsida	Rubiaceae	*Pomax umbellata*			C		6
plants	Equisetopsida	Rubiaceae	*Dentella repens*	dentella		C		1/1
plants	Equisetopsida	Rubiaceae	*Psychotria*			C		1
plants	Equisetopsida	Rubiaceae	*Oldenlandia mitrasacmoides subsp. trachymenoides*			C		1/1
plants	Equisetopsida	Rubiaceae	*Everistia vacciniifolia forma vacciniifolia*			C		3/3
plants	Equisetopsida	Rubiaceae	*Psydrax odorata subsp. australiana*			C		1/1
plants	Equisetopsida	Rubiaceae	*Psydrax attenuata forma megalantha*			C		1
plants	Equisetopsida	Rubiaceae	*Psydrax odorata forma buxifolia*			C		3
plants	Equisetopsida	Rubiaceae	*Psydrax saligna forma saligna*			C		1/1
plants	Equisetopsida	Rubiaceae	*Cyclophyllum coprosmoides*			C		1
plants	Equisetopsida	Rubiaceae	*Oldenlandia coerulescens*			C		1/1
plants	Equisetopsida	Rutaceae	*Phebalium glandulosum subsp. glandulosum*			C		1/1
plants	Equisetopsida	Rutaceae	*Zieria minutiflora subsp. trichocarpa*			C		1/1
plants	Equisetopsida	Rutaceae	*Philotheca difformis subsp. smithiana*			C		1
plants	Equisetopsida	Rutaceae	*Philotheca difformis subsp. difformis*			C		7/7
plants	Equisetopsida	Rutaceae	*Zieria fraseri subsp. robusta*			C		5/5
plants	Equisetopsida	Rutaceae	*Murraya paniculata 'Exotica'*		Y			2
plants	Equisetopsida	Rutaceae	*Dinosperma erythrococcum*			C		2/1
plants	Equisetopsida	Rutaceae	*Flindersia dissosperma*			C		21/8
plants	Equisetopsida	Rutaceae	*Acronychia pauciflora*	soft acronychia		C		1
plants	Equisetopsida	Rutaceae	*Philotheca difformis*			C		1
plants	Equisetopsida	Rutaceae	*Boronia occidentalis*			C		3/3
plants	Equisetopsida	Rutaceae	*Melicope micrococca*	white evodia		C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Rutaceae	*Geijera salicifolia*	brush wilga		C		3
plants	Equisetopsida	Rutaceae	*Coatesia paniculata*			C		1
plants	Equisetopsida	Rutaceae	*Zieria minutiflora*			C		1
plants	Equisetopsida	Rutaceae	*Philotheca ciliata*			C		1
plants	Equisetopsida	Rutaceae	*Geijera parviflora*	wilga		C		39/2
plants	Equisetopsida	Rutaceae	*Phebalium woombye*	wallum phebalium		C		1/1
plants	Equisetopsida	Rutaceae	*Boronia splendida*			C		1/1
plants	Equisetopsida	Rutaceae	*Boronia duiganiae*			C		1/1
plants	Equisetopsida	Rutaceae	*Boronia bipinnata*	rock boronia		C		6/2
plants	Equisetopsida	Rutaceae	*Acronychia laevis*	glossy acronychia		C		1
plants	Equisetopsida	Rutaceae	*Phebalium nottii*	pink phebalium		C		5/3
plants	Equisetopsida	Rutaceae	*Boronia odorata*			C		1/1
plants	Equisetopsida	Rutaceae	*Boronia obovata*			C		33/22
plants	Equisetopsida	Rutaceae	*Zieria smithii*			C		3/2
plants	Equisetopsida	Rutaceae	*Zieria fraseri*			C		1
plants	Equisetopsida	Rutaceae	*Citrus x limon*		Y			1/1
plants	Equisetopsida	Rutaceae	*Citrus glauca*			C		18
plants	Equisetopsida	Rutaceae	*Zieria aspalathoides subsp. aspalathoides*			C		5/4
plants	Equisetopsida	Rutaceae	*Boronia*			C		1
plants	Equisetopsida	Santalaceae	*Exocarpos cupressiformis*	native cherry		C		4
plants	Equisetopsida	Santalaceae	*Santalum lanceolatum*			C		13/2
plants	Equisetopsida	Santalaceae	*Exocarpos latifolius*			C		2
plants	Equisetopsida	Sapindaceae	*Dodonaea vestita*			C		9/4
plants	Equisetopsida	Sapindaceae	*Cardiospermum halicacabum var. halicacabum*		Y			1/1
plants	Equisetopsida	Sapindaceae	*Dodonaea lanceolata var. subsessilifolia*			C		1/1
plants	Equisetopsida	Sapindaceae	*Alectryon oleifolius subsp. elongatus*			C		5/1
plants	Equisetopsida	Sapindaceae	*Dodonaea viscosa subsp. burmanniana*			C		1/1
plants	Equisetopsida	Sapindaceae	*Dodonaea viscosa subsp. spatulata*			C		3/1
plants	Equisetopsida	Sapindaceae	*Dodonaea viscosa subsp. viscosa*			C		1
plants	Equisetopsida	Sapindaceae	*Cupaniopsis anacardioides*	tuckeroo		C		2/1
plants	Equisetopsida	Sapindaceae	*Elattostachys xylocarpa*	white tamarind		C		1
plants	Equisetopsida	Sapindaceae	*Alectryon diversifolius*	scrub boonaree		C		45/2
plants	Equisetopsida	Sapindaceae	*Dodonaea triangularis*			C		3/1
plants	Equisetopsida	Sapindaceae	*Dodonaea peduncularis*			C		4/2
plants	Equisetopsida	Sapindaceae	*Alectryon subdentatus*			C		1
plants	Equisetopsida	Sapindaceae	*Dodonaea stenophylla*			C		3
plants	Equisetopsida	Sapindaceae	*Dodonaea macrossanii*			C		1
plants	Equisetopsida	Sapindaceae	*Alectryon oleifolius*			C		5
plants	Equisetopsida	Sapindaceae	*Dodonaea lanceolata*			C		1
plants	Equisetopsida	Sapindaceae	*Dodonaea filifolia*			C		7/2
plants	Equisetopsida	Sapindaceae	*Dodonaea*			C		11/3
plants	Equisetopsida	Sapindaceae	*Dodonaea viscosa*			C		2
plants	Equisetopsida	Sapindaceae	*Alectryon connatus*	grey birds-eye		C		4/1
plants	Equisetopsida	Sapindaceae	*Atalaya hemiglauca*			C		32/2
plants	Equisetopsida	Sapotaceae	*Planchonella cotinifolia*			C		1
plants	Equisetopsida	Sapotaceae	*Planchonella cotinifolia var. pubescens*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Schizaeaceae	*Schizaea bifida*	forked comb fern		C		1
plants	Equisetopsida	Scrophulariaceae	*Eremophila longifolia*	berrigan		C		3/1
plants	Equisetopsida	Scrophulariaceae	*Eremophila maculata*			C		4
plants	Equisetopsida	Scrophulariaceae	*Eremophila latrobei subsp. glabra*			C		2/2
plants	Equisetopsida	Scrophulariaceae	*Eremophila latrobei subsp. latrobei*			C		3/3
plants	Equisetopsida	Scrophulariaceae	*Myoporum acuminatum*	coastal boobialla		C		12
plants	Equisetopsida	Scrophulariaceae	*Eremophila mitchellii*			C		56/1
plants	Equisetopsida	Scrophulariaceae	*Eremophila latrobei*			C		2/1
plants	Equisetopsida	Scrophulariaceae	*Eremophila deserti*			C		18/1
plants	Equisetopsida	Scrophulariaceae	*Eremophila debilis*	winter apple		C		3/2
plants	Equisetopsida	Scrophulariaceae	*Eremophila*			C		1
plants	Equisetopsida	Scrophulariaceae	*Myoporum*			C		1
plants	Equisetopsida	Scrophulariaceae	*Eremophila maculata subsp. maculata*			C		3/3
plants	Equisetopsida	Selaginellaceae	*Selaginella*			C		1/1
plants	Equisetopsida	Simaroubaceae	*Ailanthus triphysa*	white siris		C		1
plants	Equisetopsida	Smilacaceae	*Smilax australis*	barbed-wire vine		C		4/1
plants	Equisetopsida	Solanaceae	*Solanum furfuraceum*			C		2/2
plants	Equisetopsida	Solanaceae	*Solanum parvifolium*			C		2
plants	Equisetopsida	Solanaceae	*Solanum semiarmatum*	prickly nightshade		C		2
plants	Equisetopsida	Solanaceae	*Solanum stelligerum*	devil's needles		C		1
plants	Equisetopsida	Solanaceae	*Physalis lanceifolia*		Y			1
plants	Equisetopsida	Solanaceae	*Solanum ferocissimum*			C		9/3
plants	Equisetopsida	Solanaceae	*Solanum densevestitum*			C		1
plants	Equisetopsida	Solanaceae	*Solanum elachophyllum*			E		17/14
plants	Equisetopsida	Solanaceae	*Solanum mitchellianum*			C		2/2
plants	Equisetopsida	Solanaceae	*Nicotiana megalosiphon*			C		1
plants	Equisetopsida	Solanaceae	*Solanum parvifolium subsp. parvifolium*			C		1/1
plants	Equisetopsida	Solanaceae	*Solanum*			C		27
plants	Equisetopsida	Solanaceae	*Physalis*		Y			1
plants	Equisetopsida	Solanaceae	*Solanum opacum*	green berry nightshade		C		1
plants	Equisetopsida	Solanaceae	*Solanum esuriale*	quena		C		5/2
plants	Equisetopsida	Solanaceae	*Solanum pusillum*			C		2/2
plants	Equisetopsida	Solanaceae	*Physalis angulata*		Y			2/2
plants	Equisetopsida	Solanaceae	*Solanum dissectum*			E	E	3/3
plants	Equisetopsida	Solanaceae	*Solanum gympiense*			C		1
plants	Equisetopsida	Solanaceae	*Solanum americanum*			C		3/3
plants	Equisetopsida	Solanaceae	*Solanum cocosoides*			C		5/5
plants	Equisetopsida	Solanaceae	*Solanum ellipticum*	potato bush		C		9/4
plants	Equisetopsida	Solanaceae	*Solanum nemophilum*			C		6/1
plants	Equisetopsida	Solanaceae	*Datura leichhardtii*	native thornapple	Y			1/1
plants	Equisetopsida	Solanaceae	*Solanum adenophorum*			E		12/10
plants	Equisetopsida	Sparrmanniaceae	*Corchorus tomentellus*			C		3/3
plants	Equisetopsida	Sparrmanniaceae	*Corchorus trilocularis*			C		3/1
plants	Equisetopsida	Sparrmanniaceae	*Grewia retusifolia*			C		4/1
plants	Equisetopsida	Sparrmanniaceae	*Grewia scabrella*			C		8/3
plants	Equisetopsida	Sparrmanniaceae	*Grewia*			C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Sparrmanniaceae	*Grewia latifolia*	dysentery plant		C		19/2
plants	Equisetopsida	Sphagnaceae	*Sphagnum*			C		2/2
plants	Equisetopsida	Stackhousiaceae	*Stackhousia viminea*	slender stackhousia		C		2
plants	Equisetopsida	Stackhousiaceae	*Stackhousia monogyna*	creamy candles		C		1/1
plants	Equisetopsida	Sterculiaceae	*Brachychiton bidwillii*	little kurrajong		C		3/1
plants	Equisetopsida	Sterculiaceae	*Brachychiton australis*	broad-leaved bottle tree		C		2
plants	Equisetopsida	Sterculiaceae	*Sterculia quadrifida*	peanut tree		C		1
plants	Equisetopsida	Sterculiaceae	*Brachychiton rupestris*			C		15/1
plants	Equisetopsida	Sterculiaceae	*Brachychiton populneus subsp. trilobus*			C		1/1
plants	Equisetopsida	Stylidiaceae	*Stylidium graminifolium*	grassy-leaved trigger-flower		C		3/2
plants	Equisetopsida	Stylidiaceae	*Stylidium eglandulosum*			C		2/1
plants	Equisetopsida	Stylidiaceae	*Stylidium eriorhizum*			C		3/2
plants	Equisetopsida	Stylidiaceae	*Stylidium tenerum*			C		1
plants	Equisetopsida	Stylidiaceae	*Stylidium debile*	frail trigger plant		C		8/3
plants	Equisetopsida	Surianaceae	*Cadellia pentastylis*	ooline		V	V	3/2
plants	Equisetopsida	Tamaricaceae	*Tamarix aphylla*	athel pine	Y			1/1
plants	Equisetopsida	Thelypteridaceae	*Christella dentata*	creek fern		C		3
plants	Equisetopsida	Thelypteridaceae	*Cyclosorus interruptus*			C		2/2
plants	Equisetopsida	Thelypteridaceae	*Sphaerostephanos unitus*			C		1/1
plants	Equisetopsida	Thymelaeaceae	*Pimelea mollis*			C		1/1
plants	Equisetopsida	Thymelaeaceae	*Pimelea linifolia*			C		2
plants	Equisetopsida	Thymelaeaceae	*Pimelea haematostachya*			C		2/1
plants	Equisetopsida	Thymelaeaceae	*Pimelea linifolia subsp. linifolia*			C		4/4
plants	Equisetopsida	Typhaceae	*Typha orientalis*	broad-leaved cumbungi		C		1
plants	Equisetopsida	Ulmaceae	*Trema tomentosa var. aspera*			C		1/1
plants	Equisetopsida	Urticaceae	*Dendrocnide photiniphylla*	shiny-leaved stinging tree		C		1
plants	Equisetopsida	Urticaceae	*Pipturus argenteus*	white nettle		C		1
plants	Equisetopsida	Verbenaceae	*Lantana camara*	lantana	Y			1/1
plants	Equisetopsida	Verbenaceae	*Phyla canescens*		Y			1/1
plants	Equisetopsida	Verbenaceae	*Verbena bonariensis*	purpletop	Y			1
plants	Equisetopsida	Verbenaceae	*Lippia alba var. alba*		Y			5/5
plants	Equisetopsida	Verbenaceae	*Glandularia aristigera*		Y			1
plants	Equisetopsida	Verbenaceae	*Stachytarpheta jamaicensis*	Jamaica snakeweed	Y			3/1
plants	Equisetopsida	Violaceae	*Viola betonicifolia subsp. betonicifolia*			C		1/1
plants	Equisetopsida	Violaceae	*Afrohybanthus stellarioides*			C		5
plants	Equisetopsida	Violaceae	*Afrohybanthus enneaspermus*			C		4/2
plants	Equisetopsida	Violaceae	*Hybanthus monopetalus*			C		2/1
plants	Equisetopsida	Violaceae	*Viola perreniformis*			C		1/1
plants	Equisetopsida	Violaceae	*Viola betonicifolia*			C		1
plants	Equisetopsida	Violaceae	*Viola*			C		1
plants	Equisetopsida	Violaceae	*Viola hederacea*			C		1
plants	Equisetopsida	Viscaceae	*Viscum articulatum*	flat mistletoe		C		2/1
plants	Equisetopsida	Viscaceae	*Notothixos cornifolius*	kurrajong mistletoe		C		1
plants	Equisetopsida	Vitaceae	*Cissus oblonga*			C		2/1
plants	Equisetopsida	Vitaceae	*Cayratia clematidea*	slender grape		C		2
plants	Equisetopsida	Vitaceae	*Clematicissus opaca*			C		28

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Vitaceae	*Cissus hypoglauca*			C		2
plants	Equisetopsida	Vitaceae	*Cayratia acris*	hairy grape		C		1
plants	Equisetopsida	Vitaceae	*Cissus repens*			C		1
plants	Equisetopsida	Vitaceae	*Cissus reniformis*			C		1
plants	Equisetopsida	Xanthorrhoeaceae	*Xanthorrhoea*			C		2
plants	Equisetopsida	Xanthorrhoeaceae	*Xanthorrhoea johnsonii*			C		13/1
plants	Equisetopsida	Xyridaceae	*Xyris complanata*	yellow-eye		C		6/4
plants	Equisetopsida	Zamiaceae	*Macrozamia moorei*			C		1
plants	Equisetopsida	Zamiaceae	*Macrozamia platyrhachis*			E	E	55/30
plants	Equisetopsida	Zygophyllaceae	*Tribulus eichlerianus*	bull head		C		3
plants	Equisetopsida	Zygophyllaceae	*Tribulus micrococcus*	yellow vine		C		2/2
plants	Equisetopsida	Zygophyllaceae	*Zygophyllum apiculatum*	gall weed		C		1/1
plants	Equisetopsida	Zygophyllaceae	*Tribulus terrestris*	caltrop		C		2
plants	Florideophyceae	Cystocloniaceae	*Hypnea pannosa*			C		1/1
plants	Ulvophyceae	Trentepohliaceae	*Trentepohlia bosseae var. samoensis*			C		1/1
plants	Ulvophyceae	Ulotrichaceae	*Ulothrix cylindricum*			C		1/1
plants	green algae	Uronemataceae	*Uronema confervicola*			C		1/1
plants	uncertain	Incertae sedis Plantae	*Schizothrix friesii*			C		1/1
plants	uncertain	Incertae sedis Plantae	*Schizothrix calcicola*			C		1/1
plants	uncertain	Indet.	*Indet.*			C		5

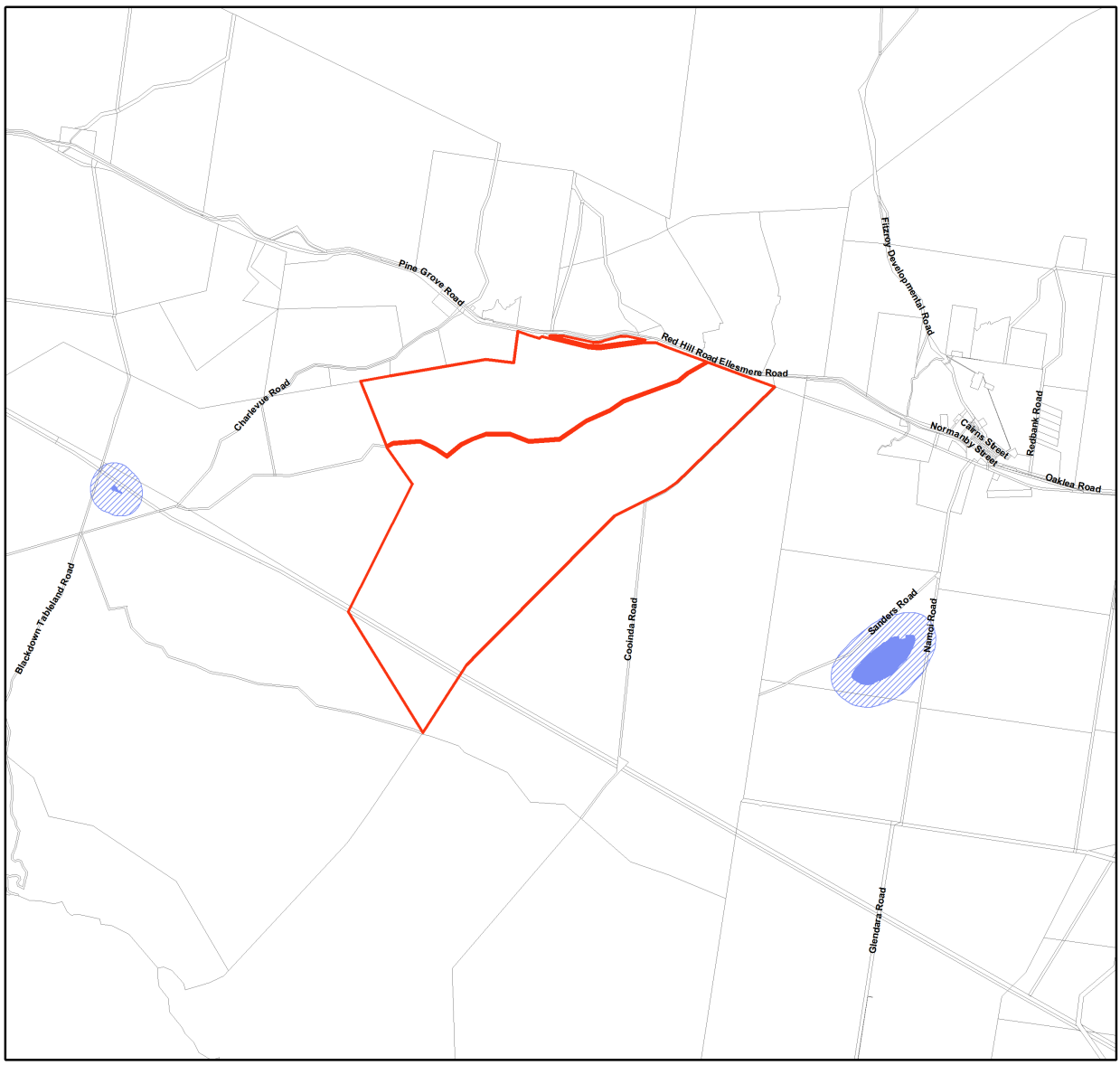
CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

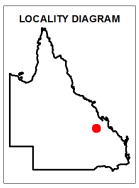
Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.



Map of Referable Wetlands
Wetland Protection Areas

Lot and Plan
Cadastral Boundary
Wetland Protection Areas
Wetland
Trigger Area

LOCALITY DIAGRAM



N

Note:
This map shows the location of wetland protection areas which are defined under the Environmental Protection Regulation 2008. Within wetland protection areas, certain types of development involving high impact earthworks are made assessable under Schedule 3 of the Sustainable Planning Regulation 2009.

The Department of State Development, Manufacturing, Infrastructure and Planning is the State Assessment Referral Agency (SARA) under Schedule 7 of the Sustainable Planning Regulation 2009 for assessable development involving high impact earthworks within wetland protection areas. The Department of Environment and Science is a technical agency.

The policy outcome and assessment criteria for assessing these applications are described in the State Development Assessment Provisions (SDAP) *Module 11: Wetlands and wild rivers.*

This map is produced at a scale relevant to the size of the lot on plan identified and should be printed at A4 size in portrait orientation. Consideration of the effects of mapped scale is necessary when interpreting data at a large scale.

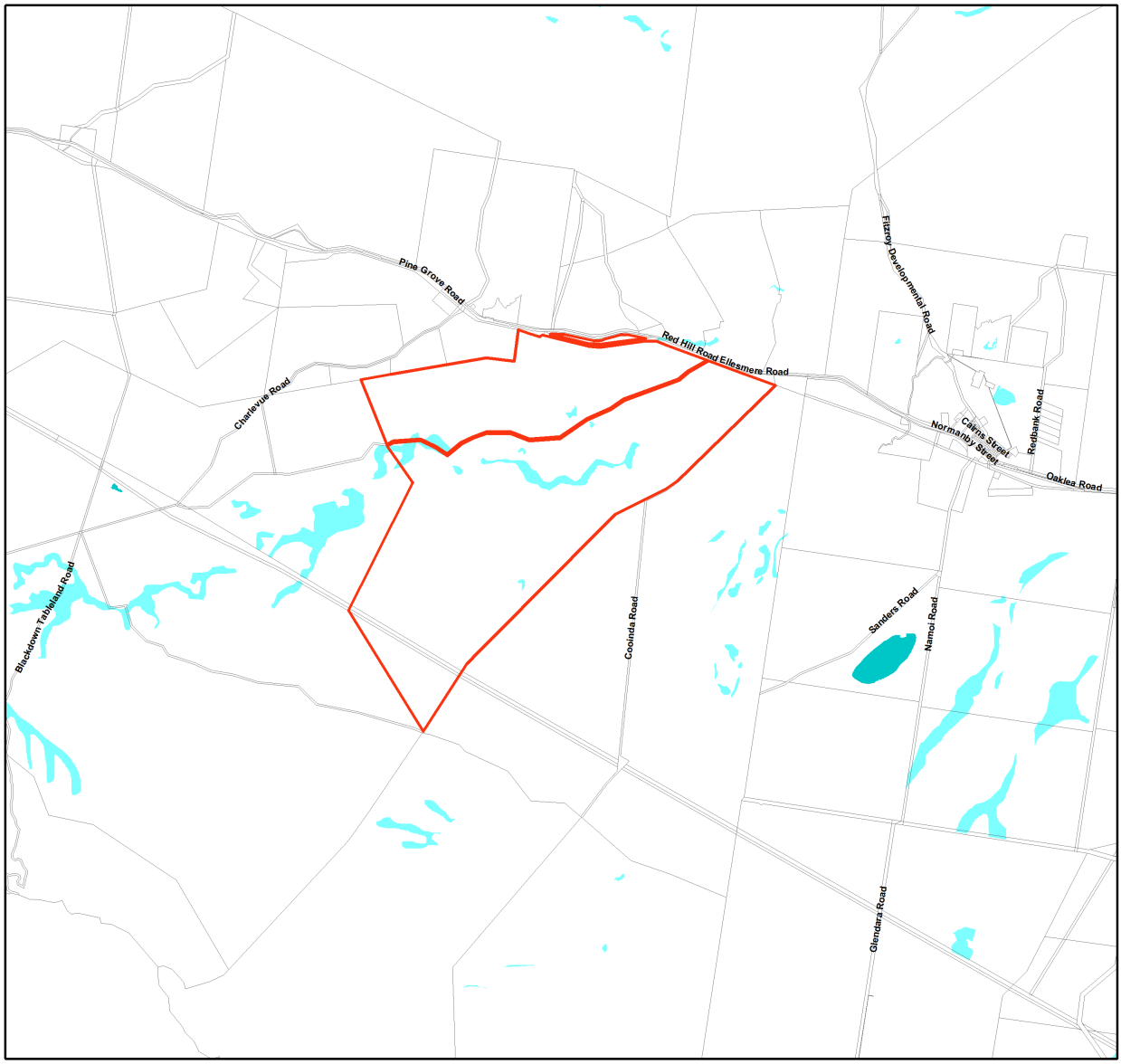
For further information or assistance with interpretation of this product, please contact the Department of Environment and Science, email planning.support@des.qld.gov.au.

0 1300 2600 3900 5200 6500 m

This product is projected into GDA 1994 MGA Zone 55

© The State of Queensland, 2018

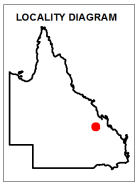
Queensland Government



Map of Referable Wetlands for the Environmental Protection Act 1994

Lot and Plan
Cadastral Boundary
HES Wetland
GES Wetland

LOCALITY DIAGRAM



N

Note:
This map shows the location of wetlands on the Map of Referable Wetlands which are defined under the Environmental Protection Regulation 2008.

Wetlands are assessed for ecological significance using the environmental values for wetlands in section 81A of the Environmental Protection Regulation 2008. Wetlands are considered either High Ecological Significance (HES) or of General Ecological Significance (GES) for the purposes of the environmental values.

This map is produced at a scale relevant to the size of the lot on plan identified and should be printed at A4 size in portrait orientation. Consideration of the effects of mapped scale is necessary when interpreting data at a large scale.

For further information or assistance with interpretation of this product, please contact the Department of Environment and Science, email planning.support@des.qld.gov.au.

0 1300 2600 3900 5200 6500 m

This product is projected into GDA 1994 MGA Zone 55

© The State of Queensland, 2018

Queensland Government

Appendix B Likelihood of Occurrence for Threatened Ecological Communities (TEC)

Likelihood of Occurrence for Threatened Ecological Communities

Community Name	Database searches		Desktop likelihood determination
	PMST	Corresponding REs mapped within EPC	
Brigalow (A*cacia harpophylla* dominant and co-dominant)	**Known** to occur (0-10 km)	11.3.1	Likely Brigalow TEC is common throughout central QLD in small patches. It is known to occur within a 10 km buffer of the study area. One RE that corresponds to the TEC has been mapped by DES as occurring on the study area. It is likely that this TEC will be identified within the study area during RE mapping validation.
Natural grasslands of the Queensland Central Highlands and northern Fitzroy Basin	**May** occur (0-10 km)	None	Unlikely This TEC may occur within a 10 km buffer of the study area according to the PMST. There are no REs corresponding to this TEC mapped by DES within the study area.
Coolabah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	**May** occur (0-10 km)	None	Unlikely Search with PMST has identified that this TEC may occur within a 10 km buffer of the study area. None of the REs identified within the study area correspond with this TEC and therefore it is unlikely that this TEC will be found within the study area.
Weeping Myall Woodlands	**Likely** to occur (0-10 km)	11.3.2	Unlikely Weeping Myall TEC is uncommon and is only known to form minor components of two possible REs. It is considered likely to occur within a 0 – 10 km buffer of the study area. One RE that has the potential to contain minor components corresponding to this TEC has been mapped by DES as occurring on the study area. No records of *Acacia pendula* (Weeping Myall) were returned in a 50 km search of the Project using Wildlife Online. It is considered unlikely that this TEC will occur on the study area.
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	**Likely** to occur (10-50 km)	None	Unlikely Vine thicket TEC is not known to occur within 10 km of the study area and is only considered likely to occur within a 10 – 50 km buffer of the Project. No REs that correspond to the TEC have been mapped by DES as occurring on the study area.

Community Name	Database searches		Desktop likelihood determination
	PMST	Corresponding REs mapped within EPC	
Poplar Box Grassy Woodlands on Alluvial Plains	Not identified at time of search	11.3.2	Likely Poplar Box TEC was added to the list of TECs protected by the EPBC Act effective from 4 July 2019. One RE that corresponds to the TEC has been mapped by DES as occurring on the study area, *Eucalyptus populnea* woodland on alluvial plains (RE 11.3.2).

Appendix C Likelihood of Occurrence for Flora Species of Conservation Significance

Likelihood of Occurrence for Fauna Species of Conservation Significance

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Acacia grandiflora	V	LC	Species or species habitat **known** to occur within area (10 – 50 km)	6 *10 - 50 km*	*Acacia grandifolia* grows in hilly terrain on hillslopes of varying aspects and slope. The species also occurs on hillcrests, gullies and plains. Soil is usually shallow and well drained and is described as sandy loam to clay loam in texture derived from sandstones and acidic volcanics. Altitudes are predominantly between 200 and 370 metres. The vegetation is tall woodland or open forest with a range of floristic associations. The most frequently recorded tree species are *Eucalyptus crebra, Corymbia citriodora, C. trachyphloia, E. maculata* and *E. exserta* (QCRA/FRA, 1998; Queensland Herbarium 2011, cited in DES 2018b).	Unlikely This species has been recorded 6 times within 50 km of the Project. Potential suitable habitat is not likely to occur within the Project due to the elevation requirements of the species. The Project is located outside of the species distribution range.
Acacia storyi	-	NT	-	17 *10 - 50 km*	*Acacia storyi* typically grows on sandy and shallow skeletal soils over sandstone and grows in open forests. This species is associated with *Eucalyptus teriticornis* and *Aristida* spp. The species was considered occasional in two populations from Blackdown Tableland National Park, west of Rockhampton in central Queensland (DES 2018b).	Unlikely This species has been recorded 17 times within 50 km of the Project and potential habitat is likely to occur within the Project. However, the species range is very restricted, and the majority of the known populations protected within the Blackdown Tablelands NP, to the southwest of the Project.
Aristida annua	V	V	Species or species habitat **likely** to occur within area (10 – 50 km)	No Records	This species is restricted to Eucalypt woodland on black clay and basalt soils (DoEE 2018).	Unlikely This species was returned in the 50 km PMST search as likely to occur, however has no records within 50 km of the Project on Wildlife Online or Atlas of Living Australia database (ALA). Potential habitat is unlikely to occur within the Project due to the absence of suitable soil types.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Baeckea trapeza	-	NT	-	7 *10 - 50 km*	*Baeckea trapeza* grows at altitudes around 700 – 800m and on sandy soil in open Eucalyptus forest. This species is confined to the Blackdown Tableland (DES 2018b).	Unlikely This species has been recorded 7 times within 50 km of the Project and potential habitat is likely to occur within the Project. However, the species range is very restricted, and the majority of the known populations area protected within the Blackdown Tablelands NP, to the southwest of the Project.
Bertya opponens	V	V	Species or species habitat **likely** to occur within area (10 – 50 km)	No Records	Recorded growing in a variety of community types including mixed shrubland, Lancewood woodland, Mallee woodland, Eucalyptus / Acacia open forest with shrubby understorey, Eucalyptus / Callitris open woodland and semi-evergreen vine-thicket. Soils are recorded as generally shallow sandy loams or red earths associated mostly with sandstone, but also with rhyolite, shale and metasediments (DoEE 2018).	Potential This species was returned in the 50 km PMST search as likely to occur, however has no records within 50 km of the Project on Wildlife Online, ALA or Australian Virtual Herbarium (AVH). Due to the presence of Lancewood woodland within the study area and the proximity to the edge of the species distribution, the species potentially could be found within the study area.
Bertya pedicellata	-	NT	-	3 *10 - 50 km*	*Bertya pedicellata* grows on rocky hillsides in range of community types including eucalypt forest or woodland, Acacia woodland or shrubland and open heathland or vine thicket communities. The soils on which this species grow on are mainly skeletal to shallow sandy, sandy clay or clay loams overlaying rhyolite, trachyte or sandstone substrates (DES 2018b).	Potential This species has been recorded 3 times within 50 km of the Project. Even though there are no records of the species in the vicinity of the Project, this is located within the species distribution range. Potential suitable habitat may occur within the Project.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Cadellia pentastylis Ooline	V	V	Species or species habitat **likely** to occur within area (0-10 km)	4 *10 - 50 km*	Ooline occurs in a range of vegetation types including dry rainforest, semi-evergreen vine thickets and sclerophyll communities including, Brigalow-Belah, Poplar Box and Bendee communities (Pollock 1999; DEWHA 2008; cited in DES 2014b). Ooline often occurs on the edges of sandstone and basalt escarpments, 200 - 500m above sea level. Ooline grows on the moderately fertile soils preferred for agriculture and pasture development (Pollock 1999; DEWHA 2008; cited in DES 2014b).	Unlikely This species has been recorded four times within 50 km of the Project. Potential suitable habitat is not likely to occur within the Project due to the elevation requirements of the species. The Project is located outside of the species distribution range.
Cerbera dumicola	-	NT	-	2 *0 - 10 km* 6 *10 - 50 km*	*Cerbera dumicola* occurs across a range of habitats in central and southern Queensland. Associated vegetation and species include: sandstone hills in open *E. umbra subsp. carnea*; on plateaus, in woodland of *Acacia shirleyi* with *Corymbia dolichocarpa*; acidic soils in mine rehabilitation area; woodland of *A. catenulata* and *A. shirleyi* with *E. thozetiana* on a slope of sand/clay soil; semi-deciduous notophyll-microphyll vine forest of Brachychiton australis, *Gyrocarpus americanus, Flindersia australis, Pleiogynium timorense, Drypetes deplanchei* and *Sterculia quadrifida* on rhyolite hillslopes; open-woodland of *E. melanophloia* with occasional Acacia shirleyi, E. populnea and *E. brownii*; semi-evergreen vine thicket with *Corymbia citriodora* and *Corymbia aureola* emergents; woodland of *A. rhodoxylon* on brown, sandy loam; and in *Corymbia tessellaris - Acacia aneura* open woodland (Queensland Herbarium, 2011; cited in DES 2018).	Likely This species has been been recorded twice within 10 km of the Project, and six times within 50 km. Potential suitable habitat is likely to occur within the Project.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Commersonia pearnii	-	E	-	2 *10 - 50 km*	*Commersonia pearnii* occurs in open forests and woodlands with a range of canopy species. This species grows on sandstone escarpments and tablelands with shallow, medium to coarse-grained soils. This species is restricted to Blackdown Tableland in central Queensland (DES 2014b).	Unlikely This species is restricted to the Blackdown Tablelands NP. Potential suitable habitat is not likely to occur within the Project.
Corunastylis pedersonii	-	V	-	1 *0 - 50 km*	This species has been recorded in Queensland from a single location in the Blackdown Tableland NP, on coarse decomposed sandstone. Seepage area on rock ledge with sedges, moss and *Drosera* sp. (AVH 2019). Specimens from New South Wales were recorded from Undulating country. Reddish/brown sandy clay loam soil over sandstone. Shrubby *Eucalyptus crebra* woodland with *Melaleuca uncinata.*	Unlikely This species has been recorded once within 50 km of the Project, in the Blackdown Tableland NP. Potential suitable habitat is not likely to occur within the Project due to the absence of suitable soil types.
Corunastylis valida	-	V	-	1 *10 - 50 km*	This species has been recorded in Queensland from a single location in the Blackdown Tableland NP, on coarse decomposed sandstone. Sparse woodland dominated by Banksia sp. (AVH 2019).	Unlikely This species has been recorded once within 50 km of the Project, in the Blackdown Tableland NP. Potential suitable habitat is not likely to occur within the Project due to the absence of suitable soil types.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Cycas ophiolitica Marlborough blue	E	E	Species or species habitat **likely** to occur within area (10 – 50 km)	No Records	*Cycas ophiolitica* inhabits eucalypt open forest and woodland communities with a grassy understorey. They occur on hill tops or steep slopes, at altitudes of 80-620m above sea level. It grows on shallow, stony, red clay loams or sandy soils (DES 2018b).	Unlikely This species was returned in the 50 km PMST search as likely to occur, however has no records within 50 km of the Project on Wildlife Online or ALA. Potential suitable habitat is unlikely to occur within the Project.
Daviesia discolor	V	V	Species or species habitat **likely** to occur within area (10 – 50 km)	6 *10 - 50 km*	This species is distributed in three localities in Queensland; Blackdown Tableland NP, Mount Walsh area near Biggeden, and in Carnarvon National Park (north of Mount Playfair) (DoEE 2018; Queensland Herbarium 2012). *Daviesia discolor* typically occurs from coastal hills to mountain slopes and ridges and grows between 50 – 1100m in altitude, mostly on fine-textured soils, which may be derived from acid volcanic or metamorphic rocks. Specifically, on the Blackdown Tableland NP, this species occurs on sandy soil derived from sandstone and on lateritic clay at altitudes of 600 – 900m, in open eucalypt forest dominated by species such as *Eucalyptus sphaerocarpa* and *E. nigra* (Queensland Herbarium 2012, cited in DES 2018b).).	Unlikely This species has been recorded within 50 km of the Project in the Blackdown Tableland NP. Potential suitable habitat is not likely to occur within the Project due to the absence of suitable soil types and elevation.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Daviesia quoquoversus	-	V	-	2 *10 - 50 km*	*Daviesia quoquoversus* occurs in open forests on sandy soil derived from sandstone. This species is restricted to south-east Queensland and only found in Blackdown Tableland NP (Queensland Herbarium 2012, cited in DES 2018b).	Unlikely This species has been described as restricted to the Blackdown Tableland NP. Potential suitable habitat is not likely to occur within the study area due to the absence of suitable soil types.
Dichanthium queenslandicum King bluegrass	E	V	Species or species habitat **may** occur within area (10 – 50 km)	No Records	This species occurs on black cracking clay in tussock grasslands mainly in association with other species of Bluegrasses. It is mostly confined to the natural Bluegrass grasslands of central and southern Queensland (DoEE 2018).	Unlikely The species has not been recorded within 50 km of the Project. The species is mostly confined to natural Bluegrass grasslands and not in grazed land. The study area lacks on suitable habitat.
Dichanthium setosum Bluegrass	V	-	Species or species habitat **likely** to occur within area (0 – 10 km) Species or species habitat **likely** to occur within area (10 – 50 km)	No Records	Occurs in grassy woodland and open forests in inland Australia. Associated with heavy basaltic black soils and stony red-brown hard-setting loam with clay subsoil and is found in moderately disturbed areas such as cleared woodland, grassy roadside remnants, grazed land and highly disturbed pasture (DoEE 2018).	Unlikely The species has not been recorded within 50 km of the Project. The species is mostly confined to natural Bluegrass grasslands and not in grazed land. The study area lacks on suitable habitat.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Eucalyptus raveretiana Black ironbox	V	LC	Species or species habitat **likely** to occur within area (10 – 50 km)	No Records	Occurs on alluvial soils, loams, light clays or cracking clays in open forests and woodlands along watercourses and occasionally on river flats (DES 2018b).	Unlikely Potential suitable habitat may occur within the study area. This species was returned in the 50 km PMST search as likely to occur, however has not been recorded within 50 km of the Project. The species is unlikely to occur within the study area as it is only known from coastal regions of eastern Queensland, with the nearest records north and east of Coppabella.
Gastrodia crebrifolia	-	V	-	1 *10 - 50 km*	*Gastrodia crebriflora* is an orchid that grows in loose colonies on protected slopes in tall open forest, often close to fallen trees. This species occurs on soils that are sands derived from decomposed sandstone. Endemic to Queensland (Jones 1991 cited in DES 2018b).	Unlikely This species has been recorded once within 50 km of the study area, in the Blackdown Tableland NP. However, the study area is located outside the known distribution of the species.
Homoranthus decumbens	E	V	Species or species habitat **known** to occur within area (10 – 50 km)	No Records	*Homoranthus decumbens* occurs in tall shrubland or heath up to 800m above sea level. It occurs on the edge of sandstone cliffs or in shallow sandy soils containing lateritic (iron-rich) pebbles (Wang 1995).	Unlikely This species was returned in the 50 km PMST search as known to occur, however, it has not been recorded within 50 km of the Project on Wildlife Online or ALA. The closest record of the species is from near Taroom, over 200 km south of the Project. Potential suitable habitat is unlikely to occur within the study area.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Livistona fulva	-	V	-	12 *10 - 50 km*	*Livistona fulva* occurs mainly along sandstone cliff-lines, on rocky foot-slopes below cliffs, in shallow rocky gullies of the Blackdown Tableland NP, and in deep sandstone gorges below major waterfalls around the edge of the plateau. Grows in moderately tall eucalypt forest, typically dominated by *Eucalyptus sphaerocarpa*. Most occurrences are recorded at altitudes 300 – 600m above sea level (DES 2018b). This species is found in the Blackdown Tablelands NP.	Unlikely This species has been described as occur mainly in the Blackdown Tableland NP. Potential suitable habitat is not likely to occur within the study area due to the absence of suitable soil types and low elevation.
Logania diffusa	V	V	Species or species habitat **likely** to occur within area (0-10 km)	2 *10 - 50 km*	*Logania diffusa* occurs in heathland and eucalypt open forest. It grows in sandy or sandy clay soil with sandstone outcropping and loose surface stones on escarpments. This species grows at altitudes of 600 – 780m above sea level. This species is restricted to the Blackdown Tableland NP (DES 2014b).	Unlikely This species has been described as restricted to the Blackdown Tableland NP. Potential suitable habitat is not likely to occur within the Project due to the absence of suitable soil types and low elevation.
Macrozamia platyrhachis	E	E	Species or species habitat **likely** to occur within area (0-10 km)	30 *10 - 50 km*	*Macrozamia platyrhachis* is scattered locally and abundantly in eucalypt woodland or open forest at altitudes between 300 – 780m above sea level. Mid- and under-stories of the vegetation may be relatively dense but is variably dependent on fire history. This species grows on deep sandy soils, derived from sandstone and is mainly found on Blackdown Tableland NP and has occurrence recorded in areas slightly south of township of Dingo (DES 2018b).	Unlikely This species has been recorded mainly within 50 km of the Project, in the Blackdown Tableland NP. The study area with its highest elevation at 200m above sea level, lacks the suitable habitat for this species.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Melaleuca groveana	-	NT	-	4 *10 - 50 km*	*Melaleuca groveana* grows on exposed rocky ridges, high mountain slopes and the summit of mountains at altitudes 340 – 600m above sea level. This species typically occurs on in heaths and eucalypt woodlands and forests with heath understoreys. It is also found in tall open forest with a grassy understorey and in microphyll vine forests. It has been previously recorded growing on red sandy loams, brown loams, skeletal rocky soils and sandy soils over sandstone rock. This species is found in fragments from Port Stephens (NSW) to the Blackdown Tableland NP (DES 2014b).	Unlikely This species has been recorded within 50 km of the Project, in the Blackdown Tableland NP. The study area with its highest elevation at 200m above sea level, lacks the suitable habitat for this species.
Melaleuca pearsonii	-	NT	-	12 *10 - 50 km*	*Melaleuca pearsonii* occurs in Blackdown Tableland NP. Grows near rivers, in rocky gullies and in wallum vegetation in creek beds (Brophy *et al.* 2013).	Unlikely This species has been described as occurring in the Blackdown Tableland NP. Potential suitable habitat is not likely to occur within the study area.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Phaius australis	E	E	Species or species habitat **known** to occur within area (0-10 km)	3 *10 - 50 km*	*Phaius australis* grows in areas where soils are almost always damp, but not flooded for lengthy periods. Sands are generally the underlying soil type. *P. australis* are usually found in coastal habitats between swamps and forests or in suitable areas further inland. This includes swampy sclerophyll forest dominated by melaleucas, swampy forest that often have scleorphyll emergents, or fringing open forest and melaleuca swamp forest associated with rainforest species. *P. australis* has also been recorded in wallum, sedgeland, rainforest and closed forest. They often grow in deep shade but can also occur in full sun. This species occurs at higher altitudes in northern Queensland (Barker 1995).	Unlikely Despite being described from coastal habitats, this species has been recorded 3 times within 50 km of the study area in the Blackdown Tableland NP. Potential suitable habitat is not likely to occur within the Project.
Plectranthus blakei	-	NT	-	10 *10 - 50 km*	*Plectranthus blakei* has been only recorded from sandstone rock outcrops and ledges in association with *Hoya australis* and *Clandrina* in the Blackdown Tableland NP (JSTOR 2018).	Unlikely This species has only been recorded in the Blackdown Tableland NP. However, the study area is located outside the known distribution of the species.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Pseudanthus pauciflorus subsp. arenicola	-	NT	-	1 *10 - 50 km*	This species occurs in crevices on vertical or near vertical rock faces and sandstone cliffs within dry sclerophyll woodland (DSITI 2015) and is endemic to the Blackdown Tableland NP (DES 2018b).	Unlikely This species has been described as being endemic to the Blackdown Tableland NP. Potential suitable habitat does not occur within the study area.
Rutidosis glandulosa	-	NT	-	7 *10 - 50 km*	*Rutidosis glandulosa* is known from approximately 15 populations across six distinct localities, which includes Blackdown Tableland NP. This species mainly occurs on sandy or gravelly well drained soil in grassy open eucalypt woodland. Around Blackdown Tableland NP, this species appears to be growing in open forest dominated by *Eucalyptus interstans, E. sphaerocarpa* and *Angophora leiocarpa*. (DES 2018b).	Unlikely The study area is located outside of the species distribution, which extends from Stanthorpe to the Blackdown Tableland NP, to the west of the study area. Potential suitable habitat is not likely to occur within the Project.
Sannantha brachypoda	-	V	-	1 *10 - 50 km*	*Sannantha brachypoda* has been described from loamy, sandy or rocky soils and from gorges and creek lines (AVH 2019).	Unlikely This species has been recorded once within 50 km of the study area, in the Blackdown Tableland NP. Potential suitable habitat does not occur within the study area.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Solanum adenophorum	-	NT	-	10 *10 - 50 km*	*Solanum adenophorum* occurs mostly in brigalow woodland and on very gently inclined slopes. It also occurs in gidgee (*Acacia cambagei*) scrub on deep cracking clay soils (DES 2018e). Occurrence records show that this species is from south and south-west of Marlborough to Rockhampton and also found in small populations north and north-east of Wagga Wagga, NSW (ALA 2018).	Potential The Project is located south of the distribution range of the species. All records near the Project are located within Taunton NP. Potential suitable habitat may occur within the study area in small patches.
Solanum dissectum	E	E	Species or species habitat **known** to occur within area (0-10 km)	3 *10 - 50 km*	*Solanum dissectum* occurs in open forest and woodland of brigalow (Acacia harpophylla) or *Eucalyptus thozetiana* on solodic clay soils (Queensland Herbarium 2012, cited in DES 2018b).	Potential This species was returned in the 50 km PMST search as known to occur, however, the closest record of the species is from west of Blackdown Tableland NP. Potential suitable habitat may occur within the study area in small patches.
Solanum elachophyllum	-	E	-	1 *0 - 10 km* 14 *10 - 50 km*	*Solanum elachophyllum* grows on fertile cracking-clay soils in open forest of *Eucalyptus thozetiana, Acacia harpophylla,* with understorey *of Geijera parviflora, Casuarina cristata, Macropteranthes leichhardtii, Eucalyptus cambageana*, or woodland of *E. creba* and *E. tenuipes* (DES 2018b). Occurrence of this species has been recorded in areas from south-west of Mackay to south-west of Gladstone.	Likely The Project is located within the species distribution. Potential suitable habitat may occur within the study area in small patches.

C

Species Name Common Name	EVNT Listing		Database Searches		Preferred Habitat	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Solanum johnsonianum	E	E	Species or species habitat **may** occur within area (10 – 50 km)	No Records	*Solanum johnsonianum* is distributed within communities dominated or co-dominated by *Acacia harpophylla* (Brigalow), on heavy cracking soils. Other associated species include *Eucalyptus thozetiana* with understorey of *Geijera parviflora* (Bean, 2004; Queensland Herbarium, 2012, cited in DES 2018b).	Unlikely The Project is located south of the distribution of the species. Potential suitable habitat may occur within the study area in small patches. There are no records of the species within 50 km of the Project.

C

Appendix D Likelihood of Occurrence for Fauna Species of Conservation Significance

Likelihood of Occurrence for Fauna Species of Conservation Significance

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Amphibians						
Adelotus brevis Tusked frog	-	V	-	10 (10-50 km)	The Tusked frog Inhabits wet eucalypt forest, rainforest, and sometimes dry eucalypt forest, where it can be found in close proximity to suitable breeding habitat such as ponds and slow-moving sections of streams. Also recorded from dams and garden ponds in urban and peri-urban areas (Rowland 2013).	Potential The study area occurs within the vicinity of the known range of the Tusked frog and there is a possibly the study area provides areas of suitable habitat. However, the closest records of the species in the area are from Blackdown Tableland NP, located over 20km southwest of the study area.
Reptiles						
Delma torquate Adorned delma	V	V	Species or species habitat **likely** to occur within area (0-10 km)	1 (10-50 km)	The Collared Delma normally inhabits eucalypt dominated woodland and open forest where it is associated with suitable micro-habitats (exposed rocky outcrops). The ground cover is predominantly native grasses, such as Kangaroo Grass (*Themeda triandra*), Barbed-wire Grass (*Cymbopogon refractus*), Wiregrass (*Aristida* sp.) and Lomandra (*Lomandra* sp.) (Peck & Hobson, 2007, cited in TSSC 2008).	Potential This species was returned in the 10 km PMST search as may occur. This species is known to occur between 10 and 50 km, at the Blackdown Tablelands NP. However, desktop searches identified marginal suitable habitat for this species in the study area.
Denisonia maculate Ornamental snake	V	V	Species or species habitat **may** to occur within area (0-10 km)	2 (10-50 km)	The Ornamental Snake's preferred habitat is within, or close to, habitat that is favoured by its prey - frogs. The species is known to prefer woodlands and open forests associated with moist areas, particularly gilgai (melon-hole) mounds and depressions in Queensland Regional Ecosystem Land Zone 4, but also lake margins and wetlands (Agnew 2010 pers. comm.; Brigalow Belt Reptiles Workshop 2010; Wilson & Knowles 1988	Unlikely This species was returned in the 10 km PMST search as may occur, and as known to occur between 10 and 50 km. Desktop searches did not identify suitable habitat for this species.

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
					cited in DEE 2018). Gilgai formations are found where deep-cracking alluvial soils with high clay contents occur (Brigalow Belt Reptiles Workshop 2010, cited in DoEE 2018).	
Egernia rugosa Yakka skink	V	V	Species or species habitat **known** to occur within area (0-10 km)	No records	Dry open forests, woodlands and rocky areas in the Brigalow Belt, where it occurs in fallen timber, wood piles, uprooted trees, deep rock crevices, deeply eroded gullies or disused rabbit warrens (DoEE 2018).	Unlikely This species or species habitat was returned in the 10 km PMST search as known to occur, however no records were returned in the database and online searches. There nearest ALA records are from over 50km west of the study area. Some marginally suitable habitat may be found on the study area.
Furina dunmalli Dunmall's snake	V	V	Species or species habitat **may** occur within area (0-10 km)	No records	Dunmall's Snake inhabits a broad range of habitats including; Forests/woodlands on black alluvial cracking clay/clay loams. Dominant vegetation includes Brigalow *(Acacia harpophylla),* Wattles *(A. burowii, A. deanii, A. leioclyx),* native Cypress *(Callitris spp.) or* Bull-oak *(Allocasuarina luehmannii), Corymbia citriodora, Eucalyptus crebra* and *E. melanophloia, and Callitris glaucophylla* (DoEE 2018).	Unlikely This species was returned in the 10 km PMST search as may occur, however no records were returned in the database and online searches. There nearest ALA records are from over 50km west of the study area. Desktop searches identified potentially suitable habitat for this species on the study area.
Strophurus taenicauda Golden-tailed gecko	-	NT	-	10 (10-50 km)	The Golden-tailed Gecko inhabits dry sclerophyll forests featuring ironbarks, cypress pine and brigalow. It is described as an arboreal species sheltering behind loose dead bark, in hollows, or clinging to exposed slender branches in dapple sunlight (Wilson 2005).	Potential This species has been recorded within 50 km of the study area. The study area contains suitable habitat for this species.
Birds						
Actitis hypoleucos	Ma	SL	Species or species habitat	No records	Varied coastal and interior wetlands – narrow muddy edges of billabongs, river pools,	Unlikely

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Common Sandpiper			**may** occur within area (0-10 km)		mangroves, among rocks and snags, reefs or rocky beaches (Morcombe 2002).	This species has not been recorded on the study area and has no records within 50 km of the study area on Wildlife Online or ALA. Suitable habitat for this species is unlikely to be available on the study area.
Anseranas semipalmata Magpie Goose	Ma	-	Species or species habitat **may** occur within area (0-10 km)	No records	The Magpie Goose occupies large seasonal wetlands and well-vegetated dams with rushes and sedges; wet grasslands and floodplains (Pizzey & Knight 2007).	<u>Unlikely</u> This species has not been recorded within 50 km or the study area. Some seasonal habitat may occur on the study area, however preferred habitat is distributed on coastal margins.
Apus pacificus Fork-tailed swift	Ma, Mi	SL	Species or species habitat **likely** to occur within area (0-10 km)	No records	Low to very high airspace over varied habitat, rainforest to semi-desert, most active just ahead of summer storm fronts (Morcombe 2002).	<u>Unlikely</u> This species has not been recorded within 50 km of the study area on Wildlife Online or ALA. Potential habitat may occur on the study area, however occurrence is highly concentrated on coastal margins, and sporadic through inland Australia.
Ardea alba Great egret	Ma	-	Species or species habitat **likely** to occur within area (0-10 km) Breeding **known** to occur within area (10-50 km)	No records	Common throughout Australia, with the exception of the most arid areas. Known to prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands (Morcombe 2002).	<u>Potential</u> This species has not been recorded within 50 km of the study area on Wildlife Online or ALA. Seasonally suitable habitat is likely to occur on the study area and in the greater region.
Ardea ibis Cattle egret	Ma	-	Species or species habitat **may** occur within area (0-10 km)	No records	Widespread and common in north, north-eastern and south-eastern Australia. The species is found in grasslands, woodlands and wetlands, and is not common in arid areas. Utilises pastures and croplands, especially where drainage is poor. Will also	<u>Potential</u> This species has not been recorded within 50 km of the study area on Wildlife Online or ALA. Potential suitable habitat is

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
					forage in garbage dumps, and often associates with livestock (Morcombe 2002).	available on the study area and in the greater region.
Calidris acuminate Sharp-tailed sandpiper	Ma, Mi	SL	Species or species habitat **may** occur within area (0-10 km) Species or species habitat **likely** to occur within area (10-50 km)	No records	Fresh or salt wetlands – the muddy edges of wetlands and dams (Morcombe 2002). In Queensland, they are recorded in most regions, being widespread along much of the coast and are very sparsely scattered inland, particularly in central and south-western regions (DoEE 2018).	Potential This species was returned in the 10 km PMST search as may occur, and as likely to occur between 10 and 50 km. No records of presence were recorded within 50km of the study area. Species occurrence is concentrated on coastal margins, but still common throughout inland Australia where suitable habitat is available. Limited seasonal habitat may occur in the study area.
Calidris ferruginea Curlew sandpiper	CE, Mi, Ma	E	Species or species habitat **may** occur within area (0-10 km)	No records	Inhabiting wetland environments, the Curlew sandpiper is commonly found on sandy shores, lagoons, tidal mudflats, saltmarshes, swamps, lakes, and sewage farms (Pizzey and Knight 2007). They forage at the edge of shallow pools and can wade through water 15-60 mm deep (DoEE 2018). Whilst small numbers have been recorded living inland around ephemeral and permanent lakes, dams and bores, the majority reside along the coast roosting on dry shingle, sand, or shell beaches. This species is distributed around most of the coastline of Australia.	Unlikely Habitat within the study area is not suited for this species as the study area is not coastal and will not provide the resources required to sustain this species. Although this species has been recorded in association with inland waterbodies, it is very rare.
Calidris melanotos Pectoral sandpiper	Ma, Mi	SL	Species or species habitat **may** occur within area (0-10 km)	No records	Usually coast wetlands, both fresh and saline, but also inland on permanent and temporary wetlands; utilises sites with mudflats, fringing vegetation, swamps with heavy overgrowth of vegetation (Morcombe 2002).	Unlikely This species was returned in the 10 km PMST search as may occur, however as no records were returned in the database and online searches. The nearest ALA records are near Mackay and Yeppoon. Potentially

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
						marginal suitable habitat is likely to occur within the study area.
Calyptorhynchus lathami erebus Glossy black-cockatoo (northern)	-	V	-	19 (10-50 km)	The Glossy black-cockatoo (northern) prefers woodland areas dominated by she-oak Allocasuarina or open sclerophyll forests and woodlands with a stratum of Allocasuarina beneath Eucalyptus, Corymbia or Angophora. This species occurs in the north and central east coast of Queensland, including Blackdown Tableland (Glossy Black Conservancy 2010).	Potential Wildlife online records indicate 19 occurrences of this species within 10 to 50 km of the study area. The PMST did not identify this species as it is not listed under the EPBC Act. Suitable habitat occurs in the broader region but has not been mapped as present within the study area.
Cuculus optatus Oriental Cuckoo	Mi	SL	Species or species habitat **may** occur within area (0-10 km)	No records	Rainforest margins, monsoon forest, vine scrubs, riverine thickets, wetter, densely canopied eucalypt forests, paperbark swamps and mangroves (Morcombe 2002).	Unlikely This species was returned in the 10 km PMST search as may occur, however no records were returned in the database and online searches. Suitable habitat is unlikely to occur within the study area.
Chrysococcyx osculans Black-eared cuckoo	Ma	-	Species or species habitat **likely** to occur within area (0-10 km)	No records	This species inhabits areas of dry open forests, scrublands, mallee, mulga, lignum, and riverside thickets. This species is widespread across the mainland of Australia.	Potential This species was returned in the 10 km PMST search as likely to occur, however no records were returned in the database and online searches. Potential habitat for this species may occur within the study area.
Erythrotriorchis radiatus Red goshawk	V	E	Species or species habitat **known** to occur within area (0-10 km)	15 (10-50km)	The red goshawk prefers a mix of vegetation types with its habitat including tall open forest, woodland, lightly treed savannah and the edge of rainforest. In partly cleared parts of eastern Queensland, it is associated with gorge and escarpment country (DES 2018b).	Potential Wildlife Online records identify 15 occurrences of this species within 10 to 50 km. PMST identified species/species habitat as known to occur within 10 km of the study area.

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Gallinago hardwickii Lathams snipe	Ma, Mi	SL	Species or species habitat **may** occur within area (0-10 km)	-	This species prefers open freshwarer wetlands, typically with low dense vegetation. Can be found in a variety of vegetation communities including but not limited to tussock grasslands, coastal and alpine heathlands, tea-tree scrub and open forests.	Unlikely This species was returned in the 10 km PMST search as may occur, no records were returned in the database and online searches. Limited suitable habitat is likely to occur within the study area.
Geophaps scripta scripta Squatter pigeon (southern)	V	V	Species or species habitat **known** to occur within area (0-10 km)	14 (0-10 km) 44 (10-50 km)	Open grassy woodlands on sandy soils interspersed with low gravelly ridges, never far from water (Morcombe 2002).	Likely This species has been recorded several times within 10 km of the study area. Suitable habitat exists within the study area. The species is typically locally abundant in areas where it is known from and not cryptic in nature.
Grantiella picta Painted honeyeater	V	V	Species or species habitat **may** occur within area (0-10 km)	3 (10-50 km)	The Painted honeyeater typically occupies habitats on deep, productive soils and is reliant on abundant mistletoes as a food source. It favours Acacia dominant woodlands (particularly Brigalow dominant) and often uses Belah and Bulloak woodlands and riparian woodlands of Black Box and River Red Gum. The species' breeding range is largely restricted to inland NSW and south of Roma.	Potential Thre records identified this species as occurring between 10 and 50 km from the study area. Desktop searches identified potential suitable habitat for this species along creek lines/watercourses within the study area.
Haliaeetus leucogaster White-bellied Sea-Eagle	Ma	-	Species or species habitat **likely** to occur within area (0-10 km)	No records	Coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands. Habitat characterised by the presence of large areas of open water (larger rivers, swamps, lakes, the sea). Birds have been recorded in (or flying over) a variety of terrestrial habitats (DoEE 2018).	Unlikely This species was returned in the 10 km PMST search as likely to occur, but no records within 50 km of the study area. Seasonally suitable habitat may occur within the study area.

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Hirundapus caudacutus White-throated needletail	Ma, Mi	SL	Species or species habitat **known** to occur within area (10-50 km)	No records	This species in Australia is primarily aerial but does show preferences for certain habitats. This species is found in associated with wooded areas, including open forests and rainforests.	Potential This species was returned in the 50 km PMST search as known to occur. Database searches did not identify any records of this species occurring within 50 km of the study area.
Lathamus discolor Swift parrot	CE	E	-	1 (10-50 km)	This species distribution covers eastern NSW, South-east Queensland, Victoria and Tasmania. This species migrates to south-eastern Queensland during Autumn and Winter. This species forages within eucalypt forests and woodlands.	Potential This species was not identified by the PMST. One record of this species exists within 10 to 50 km from the study area. Limited suitable habitat occurs for this species along the creek lines and watercourses within the study area. The study area occurs at the most upper limit of this species distribution.
Merops ornatus Rainbow bee-eater	Ma	-	Species or species habitat **may** occur within area (0-10 km)	No records	Open forests and woodlands, shrublands, various cleared or semi-cleared habitats, including farmland and areas of human habitation. Open, cleared or lightly timbered areas that are often located in close proximity to permanent water (DoEE 2018).	Potential This species was listed as may occur within 10 km on the PMST search. Database searches did not identify any records of this species occurring within 50 km of the study area. The study area is likely to contain suitable habitat for this species.
Monarcha melanopsis Black-faced monarch	Ma, Mi	SL	Species or species habitat **likely** to occur within area (0-10 km)	No records	Rainforests, mangroves, eucalypt forests and woodlands (Morcombe 2002).	Potential This species was returned in the 10 km PMST search as likely to occur, however has not been recorded in the 50 km Wildlife Online search. Suitable habitat potentially occurs within the study area.
Monarcha trivirgatus	Ma, Mi	SL	Species or species habitat	No records	Distribution is focused along the eastern coastline of Queensland and NSW. This	Unlikely

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Spectacled monarch			**may** occur within area (10-50 km)		species inhabits areas of wet forests and mangroves.	This species was returned in the 10 km PMST search as may occur, however has not been recorded in the 50 km Wildlife Online search. The study area occurs at the limit of this species range and its preferred habitat is unlikely to occur within the study area.
Motacilla flava Yellow wagtail	Ma, Mi	SL	Species or species habitat **may** occur within area (0-10 km)	No records	Open habitats, often near water; in Queensland it is usually coastal (Morcombe 2002).	Potential This species was returned in the 10 km PMST search as may occur, however no records were returned in the database and online searches. Suitable habitat has the potential to occur within the Project, though likely only seasonally.
Myiagra cyanoleuca Satin flycatcher	Ma, Mi	SL	Species or species habitat **may** occur within area (0-10 km)	No records	Forests and woodlands, mangroves, coastal heath scrubs; in breeding season favours dense, wet gullies of heavy eucalypt forests (Morcombe 2002).	Potential This species was returned in the 10 km PMST search as may occur, but no database records within 50 km. Limited suitable habitat may occur within the study area.
Neochmia ruficauda ruficauda Star finch	E	E	Species or species habitat **likely** to occur within area (0-10 km)	No records	The Star finch occurs in grasslands and grassy woodlands, near permanent water, and often in or near suburban areas (Curtis *et al.* 2012). The Star Finch is endemic to central Queensland (DoEE 2018).	Unlikely This species was returned in the 10 km PMST search as likely to occur, but no database records within 50 km. Limited to no suitable habitat for this species is likely to occur within in the study area.
Ninox strenua Powerful owl	-	V	-	3 (10-50 km)	This species prefers tall open woodlands and forests. Powerful owls require large hollows to nest. This species inhabits areas along watercourses.	Potential Three records of this species have been recorded between 10 and 50 km from the study area. This species is not listed under the EPBC Act as such did not come up in

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
						the PMST. This species is likely to use only marginal habitat features along major watercourses within the study area.
Numenius madagascariensis Eastern curlew	CE, Mi	E	Species or species habitat **may** occur within area (10-50 km)	No records	Tidal mudflats, sand spits of estuaries, mangroves, lake shores and ocean beaches (Morcombe 2002).	Unlikely This species has not been recorded within 50 km of the study area on Wildlife Online. Suitable habitat is unlikely to be present on the study area due to the study area lying outside suitable coastline environs, with only scattered records inland.
Pedionomus torquatus Plains wanderer	CE	V	-	1 (10-50 km)	The Plains wanderer is a ground-dwelling bird species that inhabits native grasslands. This species is often absent from areas that are too dense or sparse.	Potential This species was not identified in the PMST, and only one record of this species was identified within 10 to 50 km from the study area. Desktop searches identified no native grasslands within the study area boundary.
Psephotus pulcherrimus Paradise parrot	PE	EX	-	9 (10-50 km)	Historically this species occurred in central and southern Queensland. This species inhabited undulating river valleys in sparse open eucalypt woodlands and forests.	Unlikely This species is now extinct. Historic records are from over 50 years ago.
Poephila cincta cincta Black-throated finch (white-rumped subspecies)	E	E	Species or species habitat **may** occur within area (0-10 km)	4 (10-50 km)	This species inhabits open grassy woodlands and forests (Curtis *et al.* 2012), scrubby plains and Pandanus flats with deep cover of grasses. Its habitat is never far from water. It is known to occur south of Townsville, particularly around Townsville and Charters Towers (DoEE 2018).	Potential This species was returned in the 10 km PMST search as may occur. Wildlife Online records identify four occurrences of this species within 10 to 50 km.
Rhipidura rufifrons Rufous fantail	Ma	SL	Species or species habitat	No records	In east and southeast Australia, the Rufous Fantail mainly inhabits wet sclerophyll forests. They are also recorded from parks and	Unlikely

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
			may occur within area (0-10 km)		gardens when on passage. In north and northeast Australia, they often occur in tropical rainforest and monsoon rainforests, including semi-evergreen mesophyll vine forests, semideciduous vine thickets or thickets of Melaleuca spp. (DoEE 2018).	This species was returned in the 10 km PMST search as may occur, but no database records within 50 km. Limited suitable habitat is unlikely to occur within the study area.
Rostratula australis Australian painted snipe	E, Ma	V	Species or species habitat **may** occur within area (0-10 km)	No records	This species is found in shallow inland wetlands, either freshwater or brackish, which are either permanently or temporarily filled, throughout many parts of Australia (DoEE 2018).	<u>Unlikely</u> This species was returned in the 10 km PMST search as may occur, and as likely to occur between 10 and 50 km. No records of presence were recorded within 50 km of the study area. The study area is unlikely to provide potential habitat for this species.
Turnix melanogaster Black-breasted button-quail	V	V	Species or species habitat **may** occur within area (0-10 km)	7 (10-50 km)	The preferred habitat for the black-breasted button-quail includes vine thickets and rainforests that are periodically water-stressed such as semi-evergreen vine thicket, low microphyll vine forest, *Araucarian microphyll* or notophyll vine forest, Brigalow and Belah low thickets or woodlands with a dense understorey and little groundcover and littoral habitats.	<u>Potential</u> This species was returned in the 10 km PMST search as may occur, and as likely to occur between 10 and 50 km. Seven records of this species have been registered within 10 to 50 kms. Potential suitable habitat may occur within the study area.
Mammals						
Antechinus argentus Silver-headed antechinus	E	V	-	23 (10-50 km)	The silver-headed antechinus is known from three isolated subpopulations located in centraleastern Queensland - the plateau at the eastern escarpment of Kroombit Tops NP. located 70 km south-west of Gladstone; Blackdown Tableland National Park, located 220 km west of Gladstone (Mason *et al.* 2016); and Bulburin National Park (A Baker pers. comm. 2017b; H Hines pers. comm.	<u>Unlikely</u> Records of this species were reported from within 50 of the Project, however, this species is known from only 3 subpopulations located over 150 km south of the Project. The species was not returned in the PMST search as potential species or habitat occurring within the Project area.

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
					2017), located 80 km south-east of Gladstone (TSSC 2018).	
Chalinolobus dwyeri Large-eared pied bat	V	V	Species or species habitat **may** occur within area (0-10 km)	2 (10-50 km)	This species occurs in areas with extensive cliffs and caves, primarily in the Central Queensland sandstone belt. Suitable habitat consists of sandstone gorges in tall open eucalypt forest, dry sclerophyll forests and woodlands, rainforest edges, wet sclerophyll forest and *Callitris* dominant forest.	Potential This species was returned in the 10 km PMST search as may occur, and as likely to occur between 10 and 50 km. The study area potentially contains suitable habitat for this species.
Dasyurus hallucatus Northern quoll	E	-	Species or species habitat **likely** to occur within area (0-10 km)	No records	The northern quoll lives in a range of open woodland and open forest types preferring rocky areas. Northern quolls have also been recorded in vine forest, mangroves, sugarcane farms and urban areas. Their greatest breeding success is known to occur at sites near water (DES 2018b).	Unlikely This species was returned in the 10 km PMST search as likely to occur. The study area may contain small areas of suitable habitat for this species. No confirmed records of this species have been found to occur within 50 km of the study area.
Macroderma gigas Ghost bat	V	E	Species or species habitat **likely** to occur within area (0-10 km)	No records	Ghost bats currently occupy habitats ranging from the arid Pilbara to tropical savanna woodlands and rainforests. During the daytime they roost in caves, rock crevices and old mines. (TSSC 2016b). They occupy the northern tropical areas of Queensland, Northern Territory and Western Australia.	Unlikely This species was returned in the 10 km PMST search as likely to occur. The study is unlikely to contain suitable habitat for this species and is located outside of the species distribution. No confirmed records of this species have been found to occur within 50 km of the study area.
Nycophilus corbeni Corben's long-eared bat	V	V	Species or species habitat **may** occur within area (0-10 km)	No records	This species is found across semi-arid southern Australia to southern Queensland and inhabits a range of dry woodland and shrubland communities in arid and semi-arid regions. This bat species roosts mostly in tree hollows (Menkhorst & Knight 2011).	Unlikely This species was returned in the 10 km PMST search as may occur, however, the study area is located outside of the species distribution. No records of presence were recorded within 50 km of the study area. Based on desktop mapping investigations areas containing hollow bearing trees are

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
						likely limited to along watercourses within the study area.
Onychogalea fraenata Bridled nail-tail wallaby	E	E	Species or species habitat **known** to occur within area (0-10 km)	15 (0-10 km) 41 (10-50 km)	Within Taunton National Park, bridled nailtail wallabies are found in open grassy eucalypt woodland dominated by poplar box (*Eucalyptus populnea*), dense acacia forest dominated by brigalow (*Acacia harpophylla*), transitional vegetation intermediate between the woodland and forest areas of very dense brigalow regrowth (Lundie-Jenkins, G., & J. Lowry 2005)	<u>Likely</u> Despite not being reported on the Wildlife online search for 10km, this species is known to occur in the Taunton NP. Desktop searches identified potential suitable habitat for this species in small isolated patches throughout the study area.
Petauroides Volans Greater glider	V	V	Species or species habitat **likely** to occur within area (0-10 km)	1 (0-10 km) 71 (10-50 km)	Eucalypt dominated habitats, ranging from low, open forests on the coast to tall forests in the ranges and low woodland westwards of the Dividing Range (DES 2018b).	<u>Likely</u> Based on desktop mapping investigations areas containing hollow bearing trees are likely limited to along watercourses within the study area. One Wildlife online records of presence was recorded within 10 km of the study area, and 71 records exist within 10 to 50 kms.
Phascolarctos cinereus Koala	V	V	Species or species habitat **likely** to occur within area (0-10 km)	1 (0-10 km) 14 (10-50 km)	The Koala inhabits Eucalypt forests and woodlands on the east coast of Australia (Curtis *et al.* 2012). Koalas require areas of eucalypt species that are highly connected, to ensure shelter from predators.	<u>Potential</u> The study area occurs within the known range of the Koala and provides possible areas of suitable habitat along a narrow strip of *Eucalyptus* spp following the watercourses in the study area. One Wildlife online record of presence was recorded within 10 km of the study area, and 14 records exist within 10 to 50 kms.

D

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Pteropus poliocephalus Grey-headed flying-fox	V	-	Foraging, feeding or related behaviour **may** occur within area (10-50 km)	No records	Roost in native vegetation near water, including mangrove, rainforest, melaleuca or casuarina (Churchill 2008). Typically commute within 15 km to feed on flowering and fruiting plants, including blossoms of various species of eucalypt, angophora, tea-tree and banksia (DES 2018b).	Unlikely No records within 50 km of the study area on Wildlife Online or ALA. Seasonally suitable foraging habitat may exist within the study area, however, no known records or roosts occur within 50 km.

D

Appendix E Fauna Survey Sites

Site Name	DF01
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 727223 7381160
Habitat type	Habitat type 2
Associated RE	11.7.2
Habitat Description	*Acacia* spp. woodland with *Eucalyptus crebra* as emergent on lateritic duricrust.
Disturbance Present	Moderate to light grazing and evidence of old fire.
Dominant Vegetation Species	Dominant Trees: *Acacia sherleyi* (Lancewood)*, Acacia rhodoxylon (Rosewood)* and *Eucalyptus crebra* as emergent. Dominant Shrubs: *Erythroxylum australe,* and saplings of the canopy species. Dominant Ground Cover: *Calyptochloa gracilima* and *Aristida caput-medusae*

E

Site Name	DF02
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 727380 7382738
Habitat type	Habitat type 3
Associated RE	11.3.25
Habitat Description	*Eucalyptus tereticornis* open woodland in floodplain between main creek and drainage line.
Disturbance Present	Adjacent land cleared, moderate grazing, erosion nearby and invasive species (Parthenium weed, Rubber vine and Velvet tree pear).
Dominant Vegetation Species	Dominant Trees: *Eucalyptus tereticornis* and *Cassia brewsterii* Dominant Shrub: *Cassia brewsterii* Dominant Ground Cover: *Megathyrsus maximus*

E

Site Name	DF03
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 726387 7383525
Habitat type	Habitat type 1
Associated RE	11.5.2
Habitat Description	*Eucalyptus crebra* and *Acacia rhodoxylon* on sandy plains.
Disturbance Present	Moderate grazing, evidence of old fire and invasive species (Harrisia cactus and Velvet tree pear).
Dominant Vegetation Species	Dominant Trees: *Eucalyptus crebra* and *Acacia rhodoxylon* Dominant Shrubs: *Erythroxylum australe* Dominant Ground Cover: *Cleistochloa sp. (Duaringa K.B.Adison 42)* and *Aristida caput-medusae*

E

Site Name	DF04
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 729993 7383135
Habitat type	Habitat type 3
Associated RE	11.5.2/11.3.25
Habitat Description	Floodplain next to creek line with *Eucalyptus crebra* on the floodplain and *E. tereticornis* woodland by the creek line.
Disturbance Present	Tracks, erosion, moderate grazing and invasive species (Rubber vine)
Dominant Vegetation Species	Dominant Trees: *Eucalyptus tereticornis, Eucalyptus crebra* and *Bauhinia carronii* Dominant Shrubs: *Bauhinia carronii* and *Terminalia oblongata* Dominant Ground Cover: *Dichantium sericeum* and *Megathyrsus maximus*

E

Site Name	DF05
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 728432 7382299
Habitat type	Habitat type 3
Associated RE	11.3.25
Habitat Description	*Eucalyptus tereticornis* and *Bauhinia carronii* woodland on floodplain between creek lines.
Disturbance Present	Moderate grazing and invasive species (Velvet tree pear).
Dominant Vegetation Species	Dominant Trees: *Eucalyptus tereticornis* and *Bauhinia carronii* Dominant Shrubs: *Bauhinia carronii* and *Carissa spinarum* Dominant Ground Cover: *Cenchrus ciliaris*

E

Site Name	DF06
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 729350 7388339
Habitat type	Habitat type 2
Associated RE	11.7.2
Habitat Description	*Acacia rhodoxylon* woodland on undulating soil with ephemeral drainage lines.
Disturbance Present	Road nearby, dieback, invasive species (Velvet tree pear).
Dominant Vegetation Species	Dominant Trees: *Acacia rhodoxylon* Dominant Shrubs: *Owenia acidula, Erythroxylum australe* and *Carissa spinarum* Dominant Ground Cover: *Aristida caput medusae*

E

Site Name	DF07
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 729388 7387547
Habitat type	Habitat type 1
Associated RE	11.5.2
Habitat Description	*Eucalyptus crebra* and *Corymbia clarksoniana* on undulating terrain on top of hill besides an ephemeral drainage feature.
Disturbance Present	Agriculture (clearing prior 1986 pers. comm.), road nearby, evidence of fire (big fire around 2014 less than 100m away, across the road) and invasive species (Velvet tree pear).
Dominant Vegetation Species	Dominant Trees: *Eucalyptus crebra*, *Corymbia clarksoniana*, *Alphitonia excelsa*, *Acacia leiocalyx* subsp. *leiocalyx* and *Acacia rhodoxylon* Dominant Shrubs: *Petalostigma pubescens, Erythroxylum australe* and *Carissa spinarum* Dominant Ground Cover: *Cenchrus ciliaris* and native grasses

E

Site Name	DF08
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 728436 7387550
Habitat type	Habitat type 2
Associated RE	11.7.2
Habitat Description	*Acacia lanceolata* and *Acacia rhodoxylon* woodland with *Eucalyptus crebra* as emergent at foothill of a rocky scarpment.
Disturbance Present	Moderate disturbance due to a nearby track (not in use any longer because of erosion), some evidence of selective logging, moderate grazing and invasive species (Velvet tree pear)
Dominant Vegetation Species	Dominant Trees: *Eucalyptus crebra*, *Acacia shirleyi, Acacia rhodoxylon* Dominant Shrubs: *Psydrax forsteri* Dominant Ground Cover: *Calyptochloa gracilima*

E

Site Name	DF09
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 731322 7387731
Habitat type	Habitat type 1
Associated RE	11.5.2
Habitat Description	*Allocasuarina luehmannii* with *Eucalyptus crebra* and *Corymbia clarksoniana* on sand plains with ephemeral drainage features.
Disturbance Present	Tracks nearby, moderate grazing, clearing land nearby, evidence of fire and invasive species (Velvet tree pear).
Dominant Vegetation Species	Dominant Trees: *Eucalyptus crebra, Allocasuarina luehmannii* and *Corymbia clarksoniana* Dominant Shrubs: *Melaleuca nervosa* and *Petalostigma pubescens* Dominant Ground Cover: *Aristida calycina* and *Eragrostis lacunaria*

E

Site Name	DF10
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 727566 7386375
Habitat type	Habitat type 4
Associated RE	11.3.2
Habitat Description	*Eucalyptus populnea woodland on* alluvial plains.
Disturbance Present	Adjacent to dam for cattle, heavy presence of stock, tracks nearby, erosion on drainage features and invasive species (Harrisia cactus, Velvet tree pear and Mother of Millions (small infestation)).
Dominant Vegetation Species	Dominant Trees: *Eucalyptus populnea* Dominant Shrubs: *Erythroxylum australe, Archidendropsis basaltica* and *Carissa spinarum* Dominant Ground Cover: Poaceae sp. (grazed)

E

Site Name	DF11
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 730436 7381462
Habitat type	Habitat type 2
Associated RE	11.7.2
Habitat Description	*Acacia rhodoxylon* woodland on sandy plains with emergent *Eucalyptus crebra*.
Disturbance Present	Agriculture (clearing) and roads and tracks nearby.
Dominant Vegetation Species	Dominant Trees: *Acacia rhodoxylon* Dominant Shrubs: *Carissa spinarum* Dominant Ground Cover: *Aristida calycina*

E

Site Name	DF12
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 731898 7381098
Habitat type	Habitat type 3
Associated RE	11.3.25
Habitat Description	*Eucalyptus tereticornis* woodland fringing drainage lines.
Disturbance Present	Agriculture (clearing) and roads and tracks nearby and evidence of fire.
Dominant Vegetation Species	Dominant Trees: *Eucalyptus tereticornis* Dominant Shrubs: *Acacia cretata* Dominant Ground Cover: *Bothriochloa ewartiana*

E

Site Name	DF13
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 729657 7377985
Habitat type	Habitat type 1
Associated RE	11.5.2
Habitat Description	*Eucalyptus*.*crebra* woodland with *Allocasuarina luehmannii* in the understorey.
Disturbance Present	Agriculture (clearing) and roads and tracks nearby and evidence of fire.
Dominant Vegetation Species	Dominant Trees: *Eucalyptus crebra* and *Allocasuarina luehmannii* Dominant Shrubs: *Acacia cretata* and *Corymbia clarksoniana* sapplings Dominant Ground Cover: *Themeda triandra*

E

Site Name	DF14
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 730367 7380949
Habitat type	Habitat type 4
Associated RE	11.3.2
Habitat Description	*Eucalyptus populnea* and *Eucalyptus melanophloia* woodland on alluvial plains.
Disturbance Present	Agriculture (clearing) and roads and tracks nearby and evidence of fire.
Dominant Vegetation Species	Dominant Trees: *Eucalyptus crebra* and *Eucalyptus melanophloia* Dominant Shrubs: *Acacia cretata* and *Alphitonia excelsa* Dominant Ground Cover: *Heteropogon contortus*

E

Site Name	DF15
Associated Project Site	Dingo West
Site Location (Zone, Easting, Northing)	55 K 729597 7378351
Habitat type	Habitat type 4
Associated RE	11.3.2
Habitat Description	*Eucalyptus populnea* open woodland on alluvial plains.
Disturbance Present	Agriculture (clearing) and roads and tracks nearby, heavy grazing (farmer's dam in the vicinity) and evidence of fire.
Dominant Vegetation Species	Dominant Trees: *Eucalyptus populnea* and *Atalaya hemiglauca* Dominant Shrubs: *Atalaya hemiglauca* and *Owenia acidula* Dominant Ground Cover: *Aristida perniciosa*

E

Appendix F Herbarium Identifications

Queensland
Government

Queensland Herbarium
Brisbane Botanic Gardens Mt Coot-tha•Toowong 4066 Queensland•Australia
Telephone +61 7 3896 9326 • Facsimile +61 7 3896 9624
e-mail Queensland.Herbarium@qld.gov.au
http://www.qld.gov.au/herbarium

Department of
Science, Information Technology and Innovation

Enquiries Jian Wang
Telephone 07 3896 9318
Your reference
Our reference JW:mh 364/17

31 May 2017

Lucia Lopez
AARC
Suite 56, 1 Swann Road
TARINGA Qld 4068

Dear Lucia

The botanical specimens received by the Queensland Herbarium on 22 May 2017 have been identified as:

DSO2.02; DS04.12; DSO8.12; DSO9,07	*Afrohybanthus stellarioides*
DQ11	#*Cerbera dumicola*, This species is listed as Near Threatened under Queensland's *Nature Conservation Act 1992.*
DSO3.05	*Capparis canescens*
DSO7.09	*Glycine tomentella*
DSO7.23	*Chamaecrista rotundifolia* var. *rotundifolia*
DSO4.16; DSO8.02	*Cyanthillium cinereum*
DSO4.05	*Cyanthillium cinereum*
DSO4.02	Possibly *Glycine* sp. (Marburg K.A.Williams 83006), flowers or fruits required for species confirmation
DSO4.21	*Ipomoea plebeia*
DSO2.05	**Parthenium hysterophorus*. This species is a Restricted Invasive Plant (Category 3) under the Queensland *Biosecurity Act 2014.*
DSO5.03	# *Iphigenia indica*
DSO5.07	*Hypericum gramineum*
DSO5.02	*Stylidium eriorhizum*
DSO7.21	**Senna occidentalis*
DSO4.15	#**Bidens pilosa*
DSO7.27	*Psydrax forsteri*
DSO7.06	#*Polycarpaea corymbosa* var. *minor*

Download a full version of Census of the Queensland Flora 2016
https://data.qld.gov.au/dataset/census-of-the-queensland-flora-2016

DSO7.14	*Melaleuca nervosa*
DSO4.07	Possibly *Paspalidium constrictum*, the specimen has been diseased.
DSO3.01	*Cleistochloa* sp. (Duaringa K.B.Addison 42)
DQ40	*Parsonsia eucalyptophylla*
DQ	*Acacia cretata*
DSO7.16	*Acacia cretata*
DSO8.15	#*Sida* sp. (Aramac E.J.Thompson+ JER192)

*Naturalised, non-native species
These specimens have been kept for incorporation into the Herbarium collection, with thanks.

There is a charge of $640.80 (6 hrs @ $106.80 per hr incl GST) for these identifications and a tax invoice and receipt are enclosed.

Yours sincerely

for G.P.Guymer
Director

Version 11, 2013

QUEENSLAND GOVERNMENT

Botanical specimens – cover sheet

Botanical Specimens for Identification

Complete this form (one for **each** specimen) & send with specimen/s to:

Botanical Information and Advisory Service
Queensland Herbarium, DSITIA
Brisbane Botanic Gardens Mt Coot-tha
Mt Coot-tha Road, TOOWONG QLD 4066
Queensland.Herbarium@science.dsitia.qld.gov.au

Office Use Only	
Date received	22 MAY 2017
Identification no.	364.
Date of despatch	31/5/17

Name: Lucia Lopez

Company / Department: AARC. Australasian Resource Consultants

Postal Address Suite 56, 1 Swann Rd, Taringa

Postcode 4068

Telephone: +61 7 3217 8772 **Fax:**

Email: lpoveda@aarc.net.au

Please send results by: ☐ post ☒ email ☐ fax ☐ telephone

Purpose: ☐ weed detection ☐ poisonous ☐ conservation ☒ commercial

Additional information required:

Label Information: Specimens sent to the Herbarium for identification are frequently retained in the collection for scientific, distribution and voucher records. The label information below when accompanying **each** specimen aids the identification process and greatly increases the scientific value of your specimen.

Collector's Name & No.: Lucia Lopez DS06,02 + DS04,12 DS08,12 + DS09,07 **Date of collection** 08/05/17

Botanical name (if known) Euphorbiaceae? (DS06,02 + DS04,12 + DS08,12 + DS09,07)

Locality (include road name and/or distance and direction from nearest town): 9km W Dingo

Coordinates:

Latitude: °S **Longitude:** °E

(DD MM SS.SSSS – seconds preferred but not compulsory. Please don't supply decimal degrees or decimal minutes)

Or **MGA / AMG Coordinates:**	**DATUM**: GDA94/WGS84 *or* AGD84 (circle)	**Zone:**	**Easting:**	**Northing:**
Or **Map** (e.g. 9442) **and grid reference** (eg 333 666)	**Map number**:		**Grid reference**:	

Source of Coordinates: ☒ GPS ☐ Map ☐ Gazetteer ☐ Other

Situation (e.g. plain, creek bank, mountain) Woodland

Cultivated? ☐ YES ☒ NO

Vegetation type (e.g. forest, heath, woodland) Open Woodland (One in floodplain, transition 11.22→11.3.25)

Soil / geology / regional ecosystem: 11.7.2

Kind of plant (e.g. tree, vine, herb): Herb.

Description (e.g. height, flower or fruit colour:

Abundance: ☐ number of individuals ☐ number seedlings/ juveniles ☐ ha/m² size of clump

Other Notes Lobality from 1 specimen, all in similar habitat/RE, near geographically

Specimens submitted automatically become the property of the Queensland Herbarium

For more information phone 3896 9326 or email Queensland.Herbarium@science.dsitia.qld.gov.au

Queensland Herbarium
Brisbane Botanic Gardens Mt Coot-tha•Toowong 4066 Queensland•Australia
Telephone +61 7 3896 9326 • Facsimile +61 7 3896 9624
e-mail Queensland.Herbarium@qld.gov.au
www.qld.gov.au/herbarium

Queensland Government

Department of
Science, Information Technology and Innovation

Enquiries Dan Kelman
Telephone 07 3896 9318
Your reference
Our reference DTK:ss 802/17

6 November 2017

Ms Lucia Lopez Poveda
AARC Environmental Solutions Pty Ltd
Suite 5
1 Swann Road
TARINGA QLD 4068

Dear Lucia

The botanical specimens received by the Queensland Herbarium on 23 October 2017, have been identified as:

D 10-10	*Ehretia membranifolia*
D 10-11	**Sonchus oleraceus*
D 10-3	*Glycine tabacina*
DS 13-01	*Goodenia* sp.
DS 13-02	*Acacia leiocalyx* subsp. *leiocalyx*
DS 14-8	*Archidendropsis basaltica*, the fruit like structures on this specimen are insect galls
SD 14-4	*Sphaeromorphaea subintegra*

*Naturalised, non-native species

There is a charge of $165.82 (1.5 hrs @ $110.55 per hr incl GST) for these identifications. A tax invoice and receipt are enclosed.

Yours sincerely

G.P. Guymer
Director

Download a full version of Census of the Queensland Flora 2016
https://data.qld.gov.au/dataset/census-of-the-queensland-flora-2016

Queensland Herbarium
Brisbane Botanic Gardens Mt Coot-tha•Toowong 4066 Queensland•Australia
Telephone +61 7 3896 9326 • Facsimile +61 7 3896 9624
e-mail Queensland.Herbarium@qld.gov.au
http://www.qld.gov.au/herbarium

Department of
Environment and Science

Enquiries Tony Bean
Telephone 07 3896 9318
Your reference
Our reference ARB:ABP:RB:mh 341/18

10 May 2018

Lucia Lopez Poveda
AARC Environmental Solutions
Suite 5, 1 Swann Road
TARINGA Qld 4068

Dear Lucia

The botanical specimens received by the Queensland Herbarium on 26 April 2018 have been identified as:

	Dingo Project
PCUS/1	**Sporobolus pyramidalis*. This species is a Restricted Invasive Plant (Category 3) under the Queensland *Biosecurity Act 2014*.
PS17-15	*Aristida gracilipes*
DS21-2	*Panicum effusum*
DS17-22	*Ehretia membranifolia*
DB-3	*Goodenia disperma*
DS17-5	*Eriochloa procera*
DB-1	*Laxmannia gracilis*
DS18-5	*Cyperus concinnus*
RCDS/1	*Cyperus trinervis*
DS17-1	*Enneapogon* sp. probably *Enneapogon lindleyanus*
DB-2	*Cyanthillium cinereum*
DB-4	*Murdannia graminea*
DS19-2	**Emilia sonchifolia* var. *sonchifolia*
DS16-6	Poaceae sp. indeterminate. Fertile material is required for complete identification.

*Naturalised, non-native species
There is a charge of $1216.05 (11 hrs @ $110.55 per hr incl GST) for these identifications.

Yours sincerely

G.P.Guymer
Director

Download a full version of Census of the Queensland Flora 2017
https://data.qld.gov.au/dataset/census-of-the-queensland-flora-2017

Appendix G Bat Call Analysis

Microbat Call Identification Report

Prepared for ("Client"):	AustralAsian Resource Consultants
Survey location/project name:	Dingo area
Survey dates:	5-11 May 2017
Client project reference:	
Job no.:	AARC-1703
Report date:	12 June 2017

DISCLAIMER:

© Copyright – Balance! Environmental, ABN 75 795 804 356. This document and its content are copyright and may not be copied, reproduced or distributed (in whole or part) without the prior written permission of Balance! Environmental other than by the Client for the purposes authorised by Balance! Environmental ("Intended Purpose"). To the extent that the Intended Purpose requires the disclosure of this document and/or its content to a third party, the Client must procure such agreements, acknowledgements and undertakings as may be necessary to ensure that the third party does not copy, reproduce, or distribute this document and its content other than for the Intended Purpose. This disclaimer does not limit any rights Balance! Environmental may have under the Copyright Act 1968 (Cth).

The Client acknowledges that the Final Report is intended for the sole use of the Client, and only to be used for the Intended Purpose. Any representation or recommendation contained in the Final Report is made only to the Client. Balance! Environmental will not be liable for any loss or damage whatsoever arising from the use and/or reliance on the Final Report by any third party.

Methods

Data received and post-processing

This survey was conducted at four sites over six consecutive nights, using two Anabat Express detectors (Titley Scientific, Brisbane) provided by *Balance! Environmental*. Table 1 provides a summary of detector log data, matched to site information provided by the client.

AnalookW (Corben 2015) was used to download the raw ZCA data and log files and to generate Anabat zero-crossing (ZC) call sequence files. This process yielded more than 68,000 sequence files.

Due the large size of the data set, and high noise-to-signal ratio evident in an initial manual scan of the data, a generic noise filter (after Corben 2009) was used to extract only those files that contained recognisable bat call sequences. This reduced the analysable data set to just under 1000 files containing potentially-identifiable bat calls.

Call identification

All sequence files that passed the noise filter were viewed in *AnalookW*, with species identification achieved manually by comparing the call spectrograms with those of reference calls from central and northern Queensland and with reference to published call descriptions (e.g. Reinhold *et al.* 2001; Pennay *et al*. 2004). Calls with fewer than four clearly-defined, non-fragmented pulses were excluded from the analysis.

Species' identification was also guided by considering probability of occurrence based on general distribution information (Churchill 2008; van Dyck *et al.* 2013) and/or *Atlas of Living Australia* on-line database records (http://www.ala.org.au).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/. Species nomenclature follows Reardon *et al.* (2015).

Table 1 Summary of echolocation survey effort at Dingo, 5-11 May 2017.

Detector	Date	Site	GPS coordinate		Time		Battery Volts	
			Latitude	Lonitude	Start	Finish	Start	Finish
Anabat-1	5/05/2017	**FS02**	Incorrectly recorded offsite		17:16	06:54	5.25	4.94
	6/05/2017	**FS02**	-23.6500	149.2288	17:01	06:54	5.00	4.89
	7/05/2017	**FS02**	-23.6503	149.2289	17:01	06:55	4.95	4.86
	8/05/2017	**FS04**	-23.6463	149.2544	17:02	06:57	4.91	4.79
	9/05/2017	**FS04**	-23.6463	149.2546	17:02	06:57	4.86	4.70
	10/05/2017	**FS04**	-23.6463	149.2545	17:01	06:58	4.76	4.56
Anabat-2	5/05/2017	**FS01**	-23.6649	149.2280	17:04	06:55	6.18	5.64
	6/05/2017	**FS01**	-23.6649	149.2281	17:03	06:56	5.76	5.46
	7/05/2017	**FS01**	-23.6649	149.2281	17:02	6:11	5.65	5.34
	8/05/2017	**FS03**	-23.6433	149.2192	17:02	06:57	5.52	5.27
	9/05/2017	**FS03**	-23.6433	149.2192	17:02	06:57	5.41	5.19
	10/05/2017	**FS03**	-23.6433	149.2193	17:01	06:58	5.30	5.09

Results & Discussion

Detector log files indicate that both detectors recorded continuously from sunset to sunrise on each night of survey; however, no sequence files were retrieved from the raw data file recorded on Anabat-2 on the night of 9th May (second night at site FS03). The cause of this failure is not apparent from log data recorded by the detector.

At least thirteen and probably fourteen species were recorded during the Dingo survey of May 2017 (see Table 2).

The only species not positively identified was *Chalinolobus nigrogriseus*, which shares many call characteristics with *Scotorepens greyii*. The latter species was reliably identified for sites FS01, FS02 and FS03, but a number of calls from sites FS02 and FS03 had characteristics intermediate between these two species. All other species were positively identified from at least one call recorded during the survey; although all species were not recorded at every site.

Many calls could not be resolved to species level, due to similarities between the calls of several species that are likely to occur in the study area. These calls were allocated to species groups and each member of the group listed as "possible" unless other calls were unequivocally identified.

The species groups used in this analysis included:

- *Chalinolobus gouldii* / *Mormopterus ridei* / *Scotorepens balstoni*;
- *Chalinolobus nigrogriseus* / *Scotorepens greyii*;
- *Chalinolobus picatus* / *Scotorepens greyii;* and
- *Saccolaimus flaviventris* / *Chaerephon jobensis*.

None of the species recorded in this survey are listed as threatened under State or Commonwealth legislation; however, it was interesting to note the presence of three species that generally rely on subterranean roosts (*Rhinolophus megaphyllus, Vespadelus troughtoni* and *Miniopterus orianae oceanensis*). These three species were all recorded at FS03, with *M. o. oceanensis* also recorded at sites FS01 and FS02. A cursory survey of *Google Earth* imagery suggests that natural subterranean roosts are probably not present in the immediate vicinity of the study area, so it is assumed these bats are roosting in man-made structures (e.g. culverts and bridges along the nearby Capricorn Highway) and then commuting to the study area to forage. All three species are also present in Blackdown Tableland National Park, south of the study area, although it is unlikely that *R. megaphyllus* or *V. troughtoni* would commute 15-20km from there to forage in the study area.

References

Churchill, S. (2008). *Australian Bats*. Jacana Books, Allen & Unwin; Sydney.

Corben, C. (2009). *Basic Use of Filters in AnalookW*. Unpublished technical guide provided with *AnalookW* software.

Corben, C. (2015). *AnalookW for bat call analysis using ZCA.* Version 4.1z, 20 September 2015.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales*. Department of Environment and Conservation, Hurstville.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reardon, T.B., Armstrong, K.N. and Jackson, S.M. (2015). *A current taxonomic list of Australian Chiroptera. Version 2015-05-10.* URL: http://ausbats.org.au/

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.

van Dyck, S., Gynther, I. and Baker, A. (ed.) (2013). *Field Companion to the Mammals of Australia*. New Holland; Sydney.

Table 2 Microbat species recorded during the Dingo survey, 5-11 May 2017.

♦ = 'definite' - at least one call from the site was attributed unequivocally to the species
□ = 'probable' - calls similar to those of the species were recorded, but could not be reliably identified

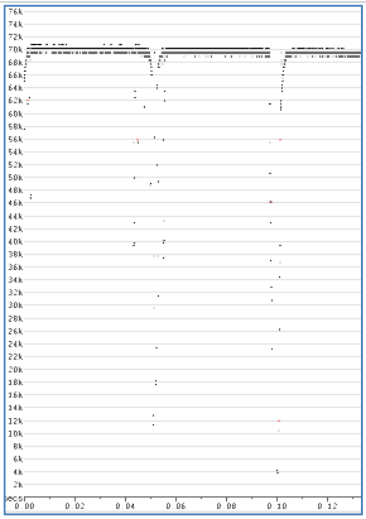
Site	FS01			FS02			FS03			FS04		
Date	5-May	6-May	7-May	5-May	6-May	7-May	8-May	9-May	10-May	8-May	9-May	10-May
Total sequence files	13047	8249	14330	7062	2907	7948	520	0	83	13685	121	81
Calls identified	28	44	28	273	223	174	51	0	57	21	16	40
Rhinolophus megaphyllus									♦			
Chalinolobus gouldii	♦	♦	♦	♦	♦	♦	♦		♦	♦	♦	♦
Chalinolobus morio				♦								
Chalinolobus nigrogriseus				□	□	□	□		□			
Chalinolobus picatus	□	♦	□	□	□	□	♦		♦			♦
Scotorepens balstoni	□	♦	♦	□			♦					
Scotorepens greyii	♦	♦	□	♦	♦	♦	♦		♦			
Vespadelus troughtoni									♦			
Miniopterus orianae oceanensis	♦	♦	♦			♦			♦			
Austronomus australis		♦		♦	♦	♦			♦	♦	♦	♦
Chaerephon jobensis	□	♦	□	♦	♦	♦	♦		♦	♦	♦	♦
Mormopterus lumsdenae				♦	♦	♦	♦		♦	♦		♦
Mormopterus ridei	♦	♦	□	□	□	□	♦		♦	□	□	♦
Saccolaimus flaviventris	□	□	□	♦	♦	□	□		♦	♦	♦	♦

Glossary

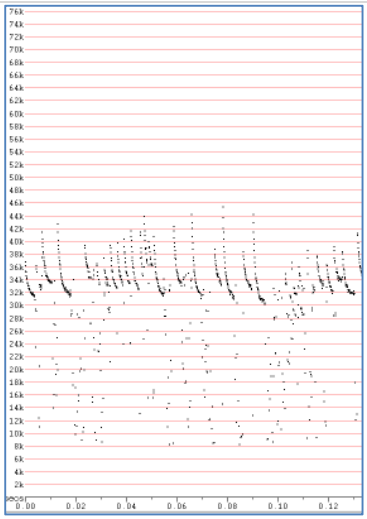
Technical terms used in this report are described in the following table.

Approach phase	The part of a bat *call* emitted as the bat starts to home in on a detected prey item; a transitional series of *pulses* between the *search phase* and *feeding buzz*, that become progressively steeper and shorter in duration.
Call	Refers to a single bat call, made up of a series of individual sound *pulses* in one or more *phases* (*search, approach, feeding buzz*).
CF (=Constant Frequency)	A type of *pulse* in which the dominant component consists of a more-or-less 'pure tone' of sound at a Constant Frequency; with *shape* appearing flat on the sonogram. Often also contains a brief *FM* component at the beginning and/or end of the CF component (*viz.* FM-CF-FM).
Characteristic frequency (Fc)	The frequency of the flattest part of a *pulse*; usually the lowest frequency reached in the *qCF* component of a pulse. This is often the primary diagnostic feature for species identification.
Duration	The time period from the beginning of a *pulse* to the end of the pulse.
Feeding buzz	The terminal part of a *call*, following the *approach phase*, emitted as the bat catches a prey item; a distinctive, rapid series of very steep, very short-duration pulses.
FM (=Frequency Modulated)	A type of *pulse* in which there is substantial change in frequency from beginning to end; *shape* ranges from almost vertical and linear through varying degrees of curvature.
FC range	Refers to the range of frequencies occupied by the *characteristic frequency* section of *pulses* within a call or set of calls.
Frequency sweep or "band-width"	The range of frequencies through which a *pulse* sweeps from beginning to end; Maximum frequency (Fmax) – minimum frequency (Fmin).
Knee	The transitional part of a *pulse* between the initial (usually steeper) frequency sweep and the *characteristic frequency* section (usually flatter); time to knee (Tk) and frequency of knee (Fk) can be diagnostic for some species.
Pulse	An individual pulse of sound within a bat *call*; the *shape*, *duration* and *characteristic frequency* of a pulse are the key diagnostic features used to differentiate species.
Pulse body	The part of the *pulse* between the *knee* and *tail* and containing the *characteristic frequency* section.
Pulse shape	The general appearance of a *pulse* on the sonogram, described using relative terms related to features such as slope and degree of curvature. See also *CF, qCF* and *FM*.
qCF (=quasi Constant Frequency)	A type of *pulse* in which there is very little change in frequency from beginning to end; *shape* appears to be almost flat. Some pulses also contain an *FM* component at the beginning and/or end of the qCF component (*viz.* FM-qCF).
Search phase	The part of a bat *call* generally required for reliable species diagnosis. A consistent series of *pulses* emitted by a bat that is searching for prey or and/or navigating through its habitat. Search phase pulses generally have longer duration, flatter slope and more consistent shape than *approach phase* and *feeding buzz* pulses.
Sequence	Literally, a sequence of *pulses* that may be from one or more bats; but generally refers to a *call* or part (e.g. *phase*) of a call.
Tail	The final component of a *pulse*, following the *characteristic frequency* section; may consist of a short or long sweep of frequencies either upward or downward from the Fc; or may be absent.

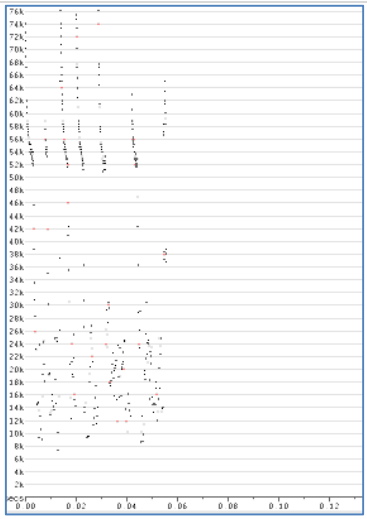
Appendix 1 Representative call sequences from the Dingo survey, 5-11 May 2017.
(AnalookW 'F7 compressed' display: x=time(s); y=frequency(kHz); time between pulses removed)



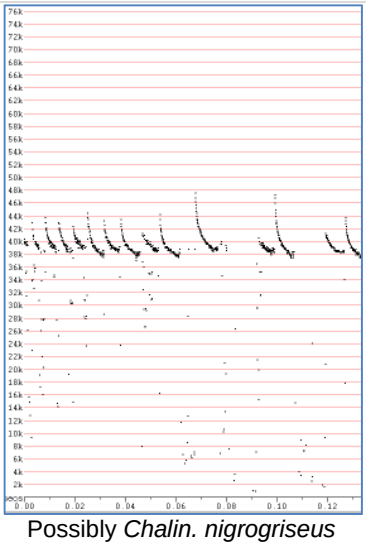
Rhinolophus megaphyllus



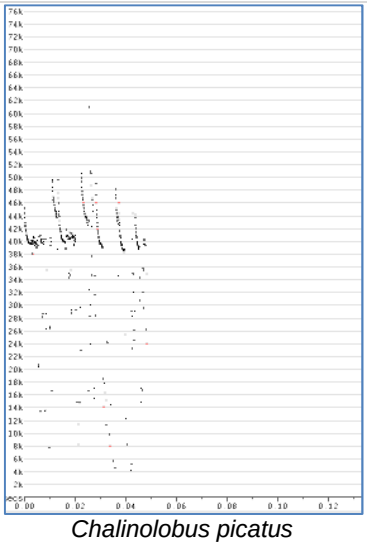
Chalinolobus gouldii



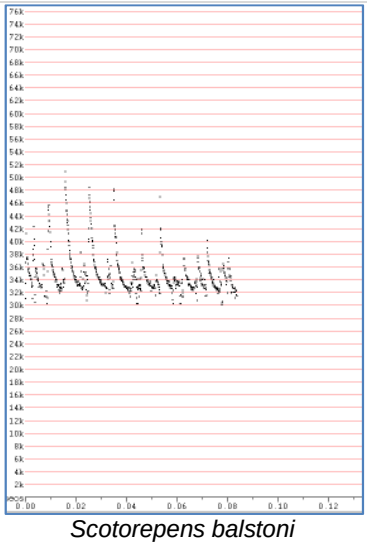
Chalinolobus morio



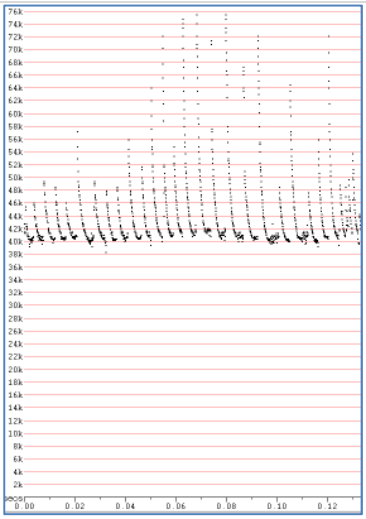
Possibly *Chalin. nigrogriseus*



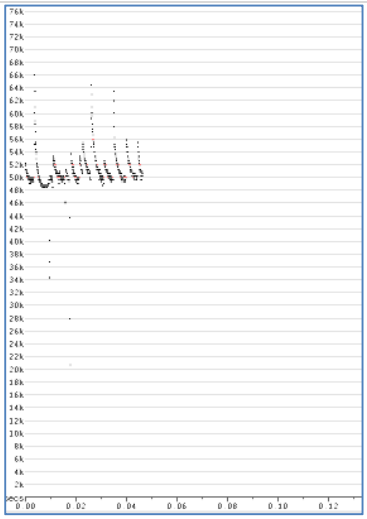
Chalinolobus picatus



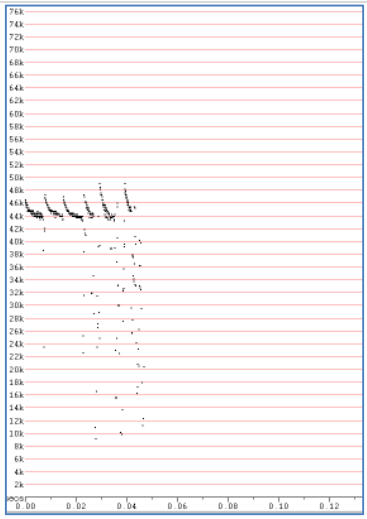
Scotorepens balstoni



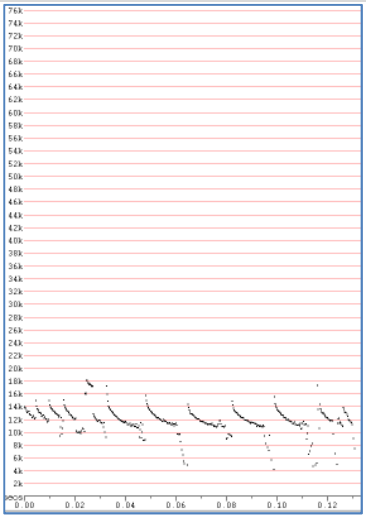
Scotorepens greyii



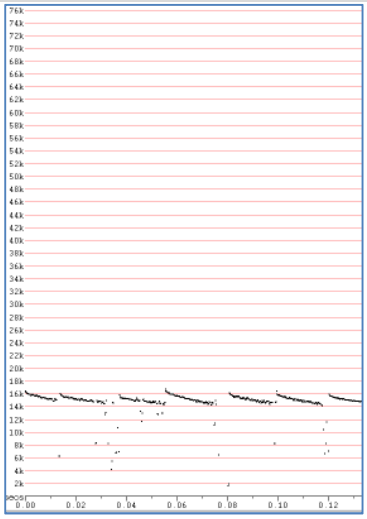
Vespadelus troughtoni



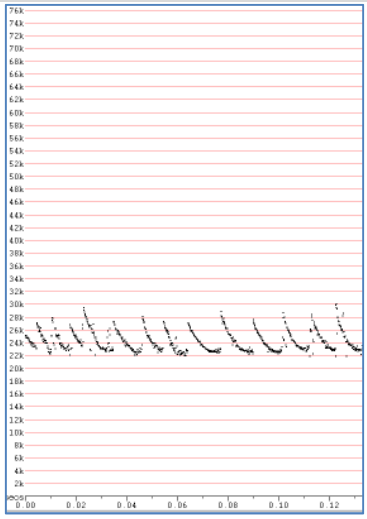
Miniopterus orianae oceanensis



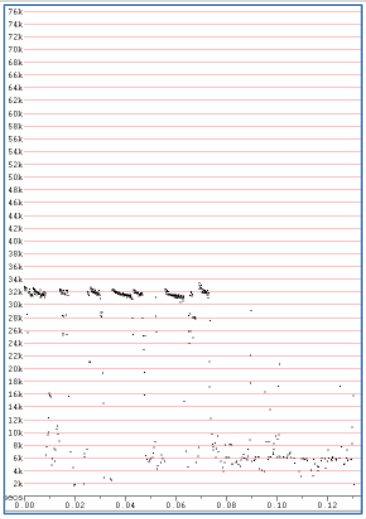
Austronomus australis



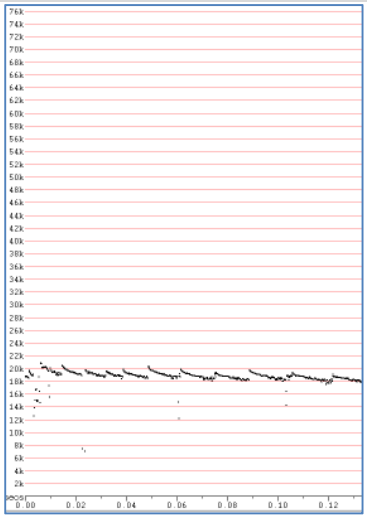
Chaerephon jobensis



Mormopterus lumsdenae



Mormopterus ridei



Saccolaimus flaviventris

Microbat Call Identification Report

Prepared for ("Client"):	AustralAsian Resource Consultants
Survey location/project name:	West of Dingo
Survey dates:	19-29 September 2017
Client project reference:	
Job no.:	AARC-1706
Report date:	12 October 2017

DISCLAIMER:

© Copyright – Balance! Environmental, ABN 75 795 804 356. This document and its content are copyright and may not be copied, reproduced or distributed (in whole or part) without the prior written permission of Balance! Environmental other than by the Client for the purposes authorised by Balance! Environmental ("Intended Purpose"). To the extent that the Intended Purpose requires the disclosure of this document and/or its content to a third party, the Client must procure such agreements, acknowledgements and undertakings as may be necessary to ensure that the third party does not copy, reproduce, or distribute this document and its content other than for the Intended Purpose. This disclaimer does not limit any rights Balance! Environmental may have under the Copyright Act 1968 (Cth).

The Client acknowledges that the Final Report is intended for the sole use of the Client, and only to be used for the Intended Purpose. Any representation or recommendation contained in the Final Report is made only to the Client. Balance! Environmental will not be liable for any loss or damage whatsoever arising from the use and/or reliance on the Final Report by any third party.

Methods

Survey summary

The survey was conducted at six sites (see Figure 1) over 11 consecutive nights, using Anabat Express detectors (Titley Scientific, Brisbane). Deployment details are summarised in Table 1.

Table 1 Deployment schedule for the Dingo bat-detector survey September 2017.

Derived from detector LOG files and survey summary information provided by the client.

Detector name & Serial No.	Site	Latitude & Longitude	Date	Time		Battery Volts	
				Start	Stop	Start	Stop
Anabat 1 SN434354	FS05	-23.6537 149.2393	19/09/2017	17:28:05	6:25:04	6.29	5.79
			20/09/2017	17:28:24	6:24:01	5.87	5.62
			21/09/2017	17:28:44	6:22:59	5.77	5.52
	FS08	-23.6068 149.2386	23/09/2017	17:29:23	6:20:56	5.72	5.42
			24/09/2017	17:29:43	6:19:54	5.61	5.33
			25/09/2017	17:30:03	6:18:52	5.52	5.25
			26/09/2017	17:30:24	6:17:51	5.43	5.20
	FS10	-23.6174 149.2305	27/09/2017	17:30:46	6:16:52	5.36	5.11
			28/09/2017	17:31:07	6:15:50	5.34	5.05
			29/09/2017	17:31:28	6:14:50	5.28	4.96
Anabat 2 SN434344	FS06	-23.5994 149.2475	19/09/2017	17:28:03	6:25:01	6.31	5.76
			20/09/2017	17:28:23	6:23:59	5.83	5.60
			21/09/2017	17:28:42	6:22:57	5.74	5.49
	FS07	-23.6066 149.2481	22/09/2017	17:29:01	6:21:55	6.25	5.71
			23/09/2017	17:29:21	6:20:53	5.84	5.55
			24/09/2017	17:29:41	6:19:52	5.76	5.42
	FS09	-23.6046 149.2692	25/09/2017	17:29:57	6:18:46	5.54	5.33
			26/09/2017	17:30:17	6:17:44	5.57	5.25

Figure 1 *Bat detection sites in the Dingo survey area, 19-29 September 2017*

Data post-processing

Balance! Environmental received eighteen raw Anabat ZCA files and associated LOG files for post-processing and analysis. *AnalookW* (Corben 2015) was used to convert the ZCA files to 4365 Anabat call sequence files for use in species identification.

Call identification

All Anabat sequence files were viewed in *AnalookW*, with a subset of all call types recorded each night at each site selected for further analysis. Species identification was achieved manually by comparing the call spectrograms of the selected files with those of reference calls from central and southern Queensland and to published call descriptions (e.g. Reinhold *et al.* 2001; Pennay *et al*. 2004).

Calls with fewer than four clearly-defined, non-fragmented pulses were excluded from the analysis.

Species' identification was also guided by considering probability of occurrence based on general distribution information (Churchill 2008; van Dyck *et al.* 2013) and/or *Atlas of Living Australia* on-line database records (http://www.ala.org.au).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/.

Species nomenclature follows Jackson & Groves (2015). Note that this treatment of Australian mammal taxonomy elevates the sub-genus names proposed by Reardon *et al.* (2014) for the *Mormopterus* free-tailed bats to genus level, hence *Ozimops* (*O. lumsdenae, O. petersi, O. ridei*) and *Setirostris* (*S. eleryi*) are used herein.

Results & Discussion

Detection success

More than 75% of the sequence files (3374/4365) were recorded by Anabat 1 (SN434354), with sites FS08 and FS10 producing over half of the total recorded bat calls. The detector sensitivity setting was the same (115) on both detectors for all nights, so, assuming microphone equivalence and similar deployment set-up, this marked difference in call detection probably reflects a real difference in bat activity levels related to habitat suitability and, possibly, bat abundance.

Location data show sites sampled by Anabat 1 were near water (FS05 and FS10) or on lateritic escarpment with potential subterranean roosting habitat (FS08); whereas sites FS06, FS07 and FS09 (Anabat 2) were distant from water and in more open vegetation sites (see Figure 1). Proximity to water has been shown to be a key determinant in roost-selection and foraging activity of bats (e.g. see Kalcounis-Rüppell *et al.* 2005; Rainho & Palmeirim 2011; Blakey *et al.* 2017). Furthermore, a significant proportion of the calls recorded at site FS08 were from the Eastern Cave Bat, *Vespadelus troughtoni*, which roosts in shallow caves and overhangs (Parnaby *et al.* 2008), such as those observed by the client in the vicinity of FS08.

Species identified

Species identification was attempted on 227 call sequence files.

At least 14 and up to 19 species were recorded during these surveys (see Table 2). Thirteen call types were positively identified to individual species, while one type was reliably identified to the genus *Nyctophilus* but could not be further differentiated. Two *Nyctophilus* species potentially occur in the study area: *N. geoffroyi* and *N. gouldi*.

Some calls could not be reliably identified due to similarities in the call characteristics of several species that may occur in the study area. Where such unresolved calls were encountered, they were allocated to species groups. All group members are listed as "probable" in Table 1, unless additional calls of one or more group members were positively identified for the same site. The groups used in this analysis included:

- *Chalinolobus gouldii / Ozimops petersi / O. ridei;*
- *C. gouldii / Scotorepens balstoni;*
- *Chalinolobus picatus / Scotorepens greyii / Vespadelus baverstocki;*
- *Scotorepens greyii / Setirostris eleryi;*
- *Vespadelus troughtoni / Chalinolobus morio;* and
- *Taphozous troughtoni / Mormopterus lumsdenae*.

Table 2 Microbat species recorded during the surveys near Dingo, 19-29 September 2017.

♦ = 'definite' - at least one call from the site was attributed unequivocally to the species
□ = 'probable' - calls similar to those of the species were recorded, but could not be reliably identified

Detector:	Anabat 1 (SN434354)			Anabat 2 (SN434344)		
Site:	FS05	FS08	FS10	FS06	FS07	FS09
Total sequence files:	690	1356	1328	240	411	340
Number of calls identified:	42	41	51	27	40	26
Rhinolophus megaphyllus		♦	♦	♦		
Chalinolobus gouldii	♦	□	♦	♦	♦	♦
Chalinolobus morio			♦			
Chalinolobus picatus	♦	♦	♦	□	♦	♦
Nyctophilus sp.	♦	♦	♦	♦	♦	
Scotorepens balstoni	□	□	□		□	□
Scotorepens greyii	♦	♦	♦	□	♦	♦
Vespadelus baverstocki			□	□	□	□
Vespadelus troughtoni	♦	♦	♦			
Miniopterus orianae oceanensis	♦		♦	♦	♦	♦
Austronomus australis	♦					
Chaerephon jobensis	♦	♦	♦	♦	♦	♦
Ozimops lumsdenae	♦	♦	♦	♦	♦	♦
Ozimops petersi	♦	□	♦	♦	□	♦
Ozimops ridei	♦	□	♦	♦	♦	♦
Setirostris eleryi	□		□			□
Saccolaimus flaviventris	♦	♦	♦	♦	♦	♦
Taphozous troughtoni	□		□			

References

Blakey, R.V., Kingsford, R.T., Law, B.S. & Stoklosa, J. (2017). Floodplain habitat is disproportionately important for bats in a large river basin. *Biol. Conserv*. **215**: 1–10.

Churchill, S. (2008). *Australian Bats*. Jacana Books, Allen & Unwin; Sydney.

Corben, C. (2015). *AnalookW for bat call analysis using ZCA.* Version 4.1z, 20 September 2015.

Jackson, S. and Groves, C. (2015). *Taxonomy of Australian Mammals*. CSIRO Publishing, Melbourne.

Kalcounis-Rüppell, M.C., Psyllakis, J.M. & Brigham, R.M. (2005). Tree roost selection by bats: an empirical synthesis using meta-analysis. *Wildl. Soc. Bull.* **33**(3): 1123-1132.

Milne, D.J., Fisher, A., Pavey, C.R. (2006). Models of the habitat associations and distributions of insectivorous bats of the Top End of the Northern Territory, Australia. *Biol. Conserv.* **130**: 370–385.

Parnaby, H., Law, B.S., Pennay, M. & Kutt, A.S. (2008). Eastern Cave Bat *Vespadelus troughtoni*. Pp. 571-572 in *The Mammals of Australia* 3rd Edition (van Dyck, S. & Strahan, R., ed.); Reed New Holland; Sydney.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales*. Department of Environment and Conservation, Hurstville.

Rainho, A. & Palmeirim, J.M. (2011). The Importance of Distance to Resources in the Spatial Modelling of Bat Foraging Habitat. *PLoS ONE*, **6**(4): e19227. doi:10.1371/journal.pone.0019227

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**: 41-43.

Reardon, T. B., McKenzie, N. L., Cooper, S. J. B., Appleton, B., Carthew, S. and Adams, M. (2014). A molecular and morphological investigation of species boundaries and phylogenetic relationships in Australian free-tailed bats *Mormopterus* (Chiroptera : Molossidae). *Aust. J. Zool*. **62**, 109–136.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.

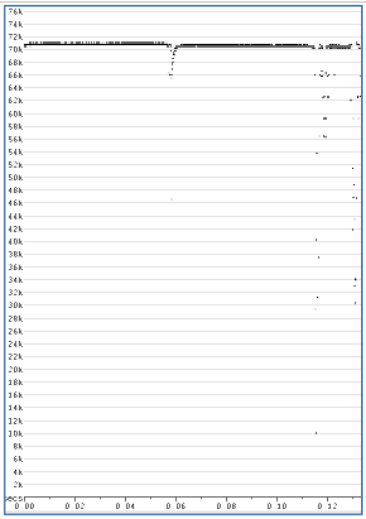
van Dyck, S., Gynther, I. and Baker, A. (ed.) (2013). *Field Companion to the Mammals of Australia*. New Holland; Sydney.

Glossary

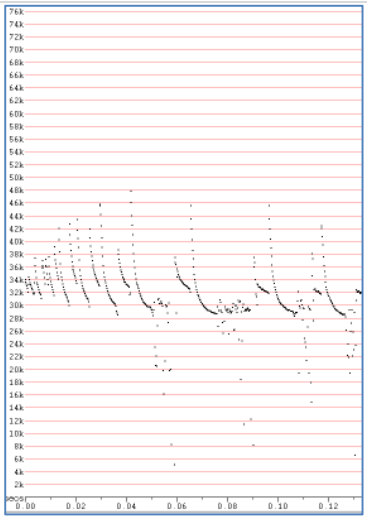
Technical terms used in this report are described in the following table.

Approach phase	The part of a bat *call* emitted as the bat starts to home in on a detected prey item; a transitional series of *pulses* between the *search phase* and *feeding buzz*, that become progressively steeper and shorter in duration.
Call	Refers to a single bat call, made up of a series of individual sound *pulses* in one or more *phases* (*search, approach, feeding buzz*).
CF (=Constant Frequency)	A type of *pulse* in which the dominant component consists of a more-or-less 'pure tone' of sound at a Constant Frequency; with *shape* appearing flat on the sonogram. Often also contains a brief *FM* component at the beginning and/or end of the CF component (*viz.* FM-CF-FM).
Characteristic frequency (Fc)	The frequency of the flattest part of a *pulse*; usually the lowest frequency reached in the *qCF* component of a pulse. This is often the primary diagnostic feature for species identification.
Duration	The time period from the beginning of a *pulse* to the end of the pulse.
Feeding buzz	The terminal part of a *call*, following the *approach phase*, emitted as the bat catches a prey item; a distinctive, rapid series of very steep, very short-duration pulses.
FM (=Frequency Modulated)	A type of *pulse* in which there is substantial change in frequency from beginning to end; *shape* ranges from almost vertical and linear through varying degrees of curvature.
FC range	Refers to the range of frequencies occupied by the *characteristic frequency* section of *pulses* within a call or set of calls.
Frequency sweep or "band-width"	The range of frequencies through which a *pulse* sweeps from beginning to end; Maximum frequency (Fmax) – minimum frequency (Fmin).
Knee	The transitional part of a *pulse* between the initial (usually steeper) frequency sweep and the *characteristic frequency* section (usually flatter); time to knee (Tk) and frequency of knee (Fk) can be diagnostic for some species.
Pulse	An individual pulse of sound within a bat *call*; the *shape*, *duration* and *characteristic frequency* of a pulse are the key diagnostic features used to differentiate species.
Pulse body	The part of the *pulse* between the *knee* and *tail* and containing the *characteristic frequency* section.
Pulse shape	The general appearance of a *pulse* on the sonogram, described using relative terms related to features such as slope and degree of curvature. See also *CF, qCF* and *FM*.
qCF (=quasi Constant Frequency)	A type of *pulse* in which there is very little change in frequency from beginning to end; *shape* appears to be almost flat. Some pulses also contain an *FM* component at the beginning and/or end of the qCF component (*viz.* FM-qCF).
Search phase	The part of a bat *call* generally required for reliable species diagnosis. A consistent series of *pulses* emitted by a bat that is searching for prey or and/or navigating through its habitat. Search phase pulses generally have longer duration, flatter slope and more consistent shape than *approach phase* and *feeding buzz* pulses.
Sequence	Literally, a sequence of *pulses* that may be from one or more bats; but generally refers to a *call* or part (e.g. *phase*) of a call.
Tail	The final component of a *pulse*, following the *characteristic frequency* section; may consist of a short or long sweep of frequencies either upward or downward from the Fc; or may be absent.

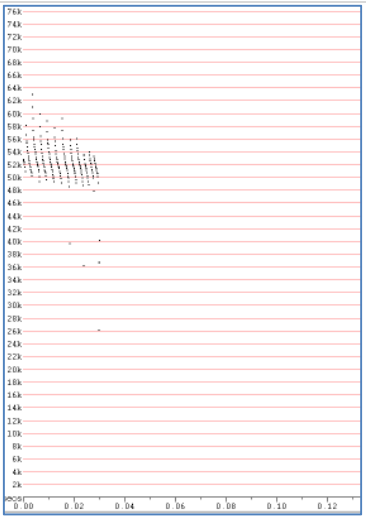
Appendix 1 Representative call sequences from the Dingo area survey, September 2017.
(AnalookW 'F7 compressed' display: x=time(s); y=frequency(kHz); time between pulses removed)



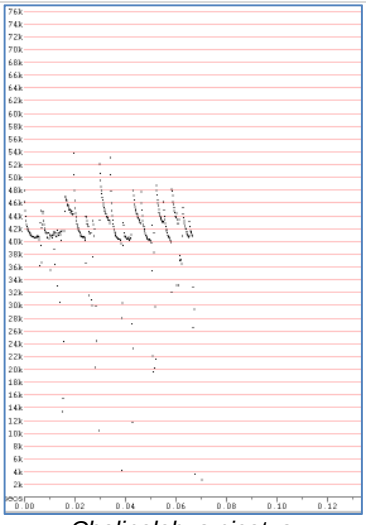
Rhinolophus megaphyllus



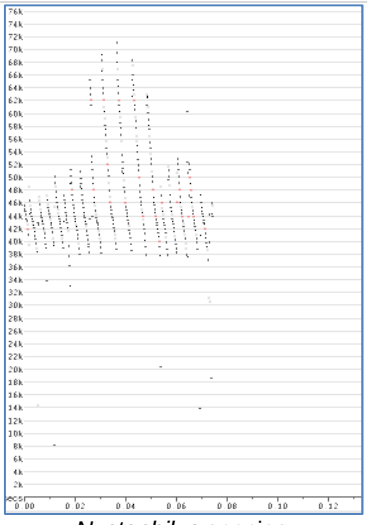
Chalinolobus gouldii



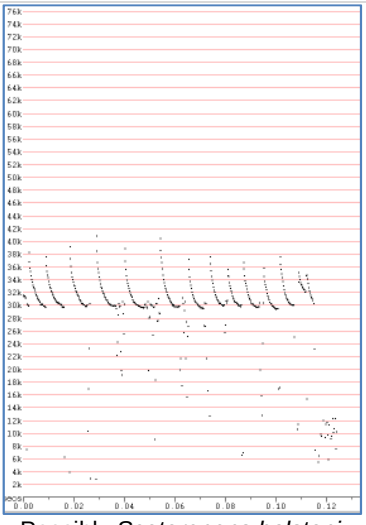
Chalinolobus morio



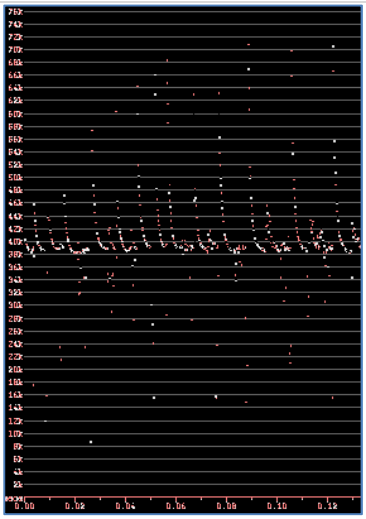
Chalinolobus picatus



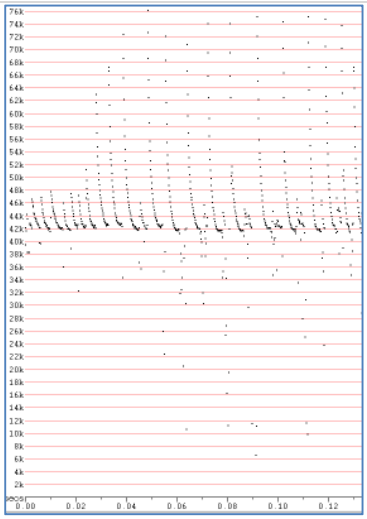
Nyctophilus species



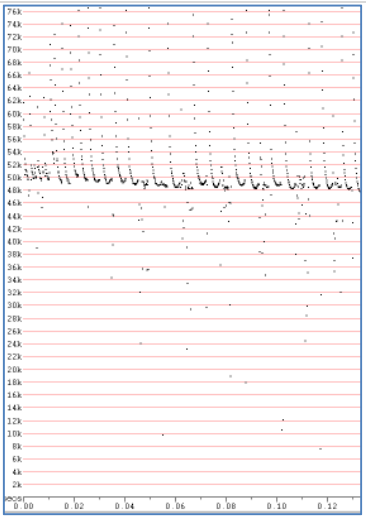
Possibly *Scotorepens balstoni*



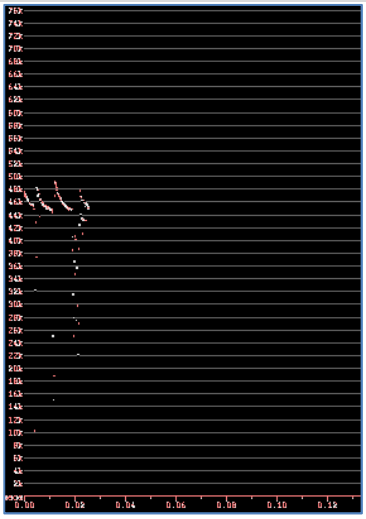
Scotorepens greyii



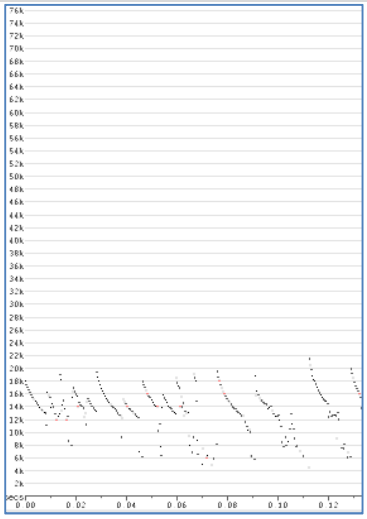
Probably *Vespadelus baverstocki*



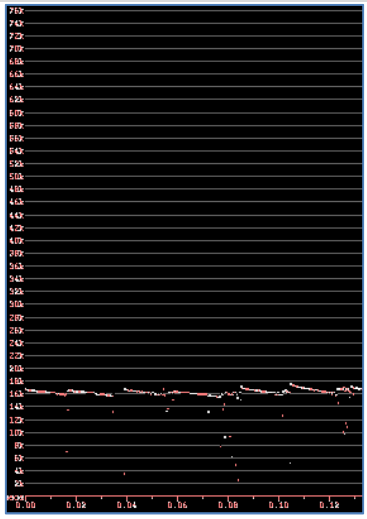
Vespadelus troughtoni



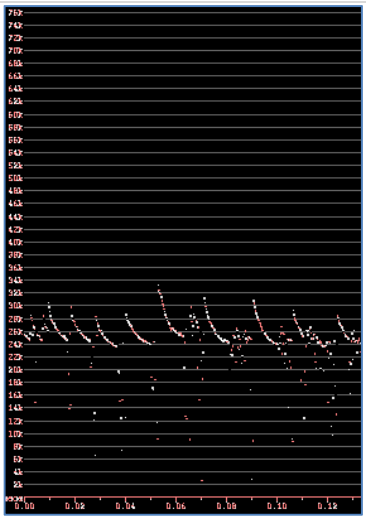
Miniopterus orianae oceanensis



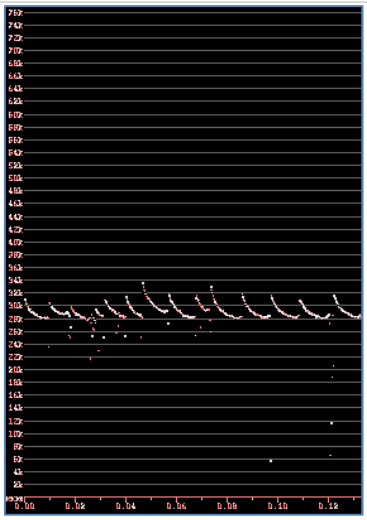
Austronomus australis



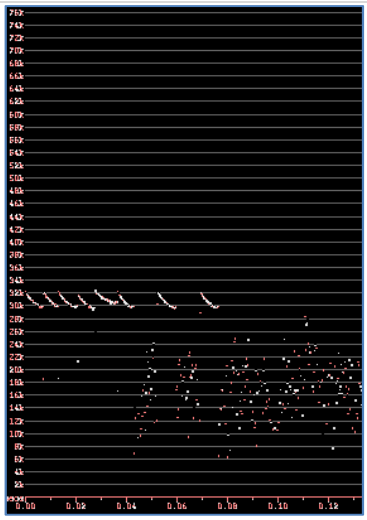
Chaerephon jobensis



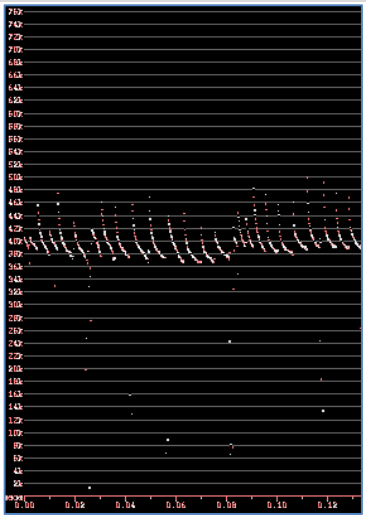
Ozimops lumsdenae



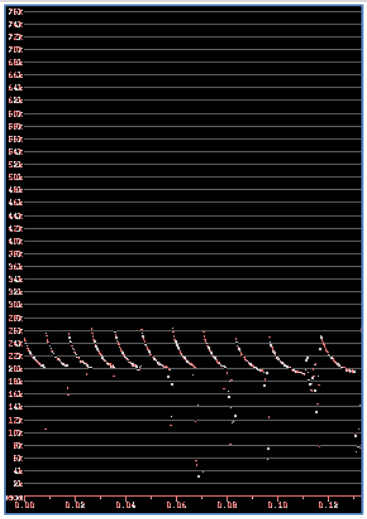
Ozimops petersi



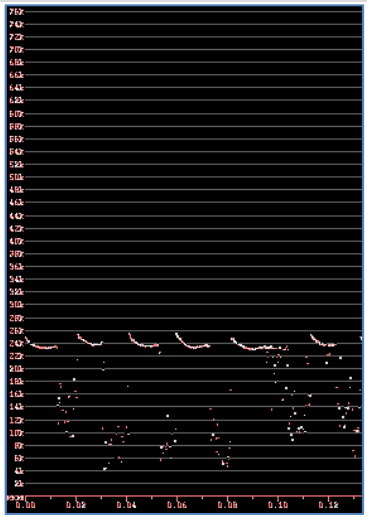
Ozimops ridei



Possibly *Setirostris eleryi*



Saccolaimus flaviventris



Possibly *Taphozous troughtoni*

Microbat Call Identification Report

Prepared for ("Client"):	AustralAsian Resource Consultants
Survey location/project name:	Dingo West Stage 3
Survey dates:	17-22 April 2018
Client project reference:	
Job no.:	AARC-1805
Report date:	30 May 2018

DISCLAIMER:

© Copyright – Balance! Environmental, ABN 75 795 804 356. This document and its content are copyright and may not be copied, reproduced or distributed (in whole or part) without the prior written permission of Balance! Environmental other than by the Client for the purposes authorised by Balance! Environmental ("Intended Purpose"). To the extent that the Intended Purpose requires the disclosure of this document and/or its content to a third party, the Client must procure such agreements, acknowledgements and undertakings as may be necessary to ensure that the third party does not copy, reproduce, or distribute this document and its content other than for the Intended Purpose. This disclaimer does not limit any rights Balance! Environmental may have under the Copyright Act 1968 (Cth).

The Client acknowledges that the Final Report is intended for the sole use of the Client, and only to be used for the Intended Purpose. Any representation or recommendation contained in the Final Report is made only to the Client. Balance! Environmental will not be liable for any loss or damage whatsoever arising from the use and/or reliance on the Final Report by any third party.

Methods

Survey summary

The survey was conducted at four sites (see Figure 1) over six consecutive nights, using Anabat Express detectors (Titley Scientific, Brisbane). Deployment details are summarised in Table 1.

Table 1 Deployment schedule for the Dingo West Stage 3 bat-detector survey, 17-22 April 2018.

Derived from detector LOG files and survey summary information provided by the client.

Site name	Coordinates		Detector Serial No.	Deployment date	Operating time	
	Latitude	Longitude			Start	Finish
FS11	-23.661	149.2592	SN434344	17-Apr	18:11:59	6:22:13
				18-Apr	18:11:16	6:22:47
				19-Apr	18:10:32	6:23:21
FS12	-23.664	149.2731	SN434354	17-Apr	18:11:56	6:22:10
				18-Apr	18:11:12	6:22:44
				19-Apr	18:10:29	6:23:17
FS13	-23.6924	149.2521	SN434354	20-Apr	18:09:49	6:23:54
				21-Apr	18:09:02	6:24:27
				22-Apr	18:08:15	6:24:59
FS14	-23.6659	149.2584	SN434344	20-Apr	18:09:46	6:23:54
				21-Apr	18:08:59	6:24:27
				22-Apr	18:08:12	6:24:59

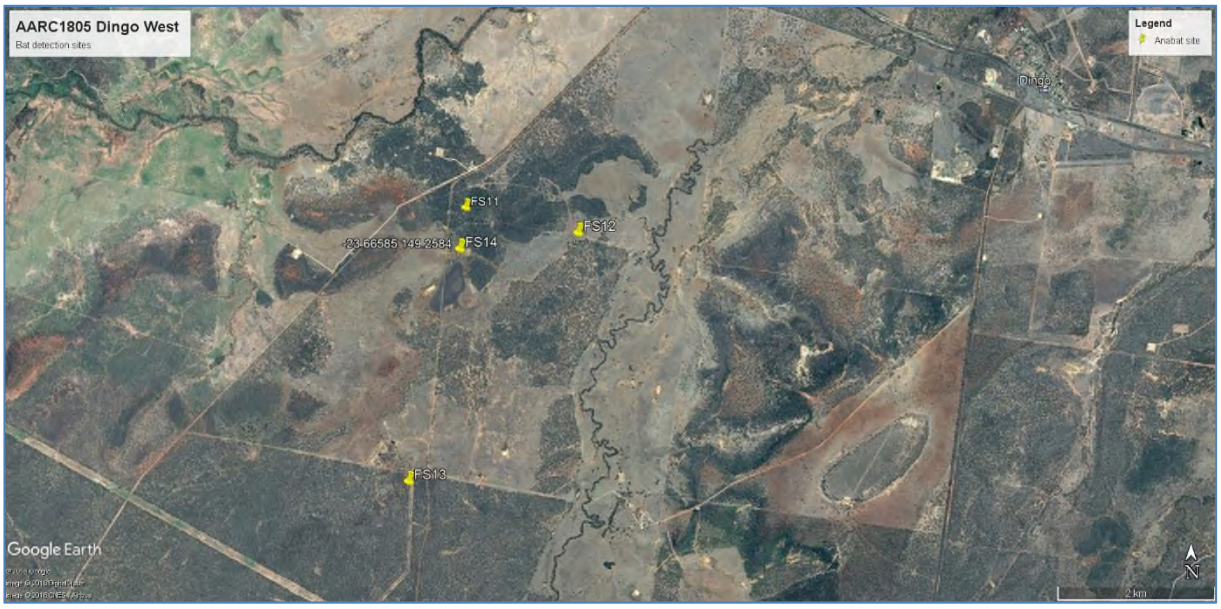


Figure 1 *Bat detection sites in the Dingo West survey area, 17-22 April 2018.*

Data post-processing

Balance! Environmental received 12 raw Anabat ZCA files and associated LOG files for post-processing and analysis. *AnalookW* (Corben 2017) was used to convert the ZCA files to Anabat call sequence files (ZC files). This process yielded 25,023 ZC files, which were passed through a generic noise filter in *AnalookW* to extract only those files that contained potentially-identifiable bat calls. This filtration process extracted 3588 ZC files for analysis.

Call identification

All Anabat sequence files that passed the noise filter were viewed in *AnalookW*, with a subset of all call types recorded at each site selected for further analysis. Species identification was achieved manually by comparing the call spectrograms of the selected files with those of reference calls from central and southern Queensland and to published call descriptions (e.g. Reinhold *et al.* 2001; Pennay *et al*. 2004).

Calls with fewer than four clearly-defined, non-fragmented pulses were excluded from the analysis.

Species' identification was also guided by considering probability of occurrence based on general distribution information (Churchill 2008; van Dyck *et al.* 2013) and/or *Atlas of Living Australia* on-line database records (http://www.ala.org.au).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/.

Species nomenclature follows Jackson & Groves (2015), which elevates the sub-genus names proposed by Reardon *et al.* (2014) for the *Mormopterus* free-tailed bats to genus level, hence *Ozimops* (*O. lumsdenae* and *O. ridei*) is used herein.

Results & Discussion

Species identification was attempted on 658 call sequence files.

Table 2 provides a summary of species recorded at each site. Twelve species were positively identified, with one further call type allocated reliably to the *Nyctophilus* genus, within which species' calls cannot be differentiated. Two *Nyctophilus* species probably occur in the study area: *N. geoffroyi*; and *N. gouldi*.

Nine call types could not be reliably identified due to similarities in the call characteristics of several species that may occur in the study area. These unresolved calls were allocated to species groups (see lower half of Table 2), most of which contained species that were also identified positively (see upper part of Table 2); however, two groups included species that were not otherwise identified in this analysis:

- *Taphozous troughtoni / Ozimops lumsdenae*
    - Calls similar in frequency and pulse-shape to those allocated to *O. lumsdenae*, but more uniform pulse-shape throughout sequence and often much flatter pulse-shape
- *Vespadelus troughtoni / Chalinolobus morio*
    - Just one call allocated to this group, with no other evidence of either species from the entire data set
    - Call was brief and somewhat fragmented, with indeterminate pulse shape

Table 2 Microbat species recorded during the Dingo West Stage 3 survey, 17-22 April 2018.

Number of calls allocated to each species or group

Site name:	FS11	FS12	FS13	FS14	Total calls for species
Species positively identified					
Rhinolophus megaphyllus	1				1
Chalinolobus gouldii	25	64	17	13	119
Chalinolobus nigrogriseus		10	1		11
Chalinolobus picatus	17	25	3	2	47
Nyctophilus species	1	4	3		8
Scotorepens balstoni		5	6		11
Scotorepens greyii	3	25	6	9	43
Vespadelus baverstocki		6	8	5	19
Miniopterus orianae oceanensis	1	6		1	8
Chaerephon jobensis	9	11	22	14	56
Ozimops lumsdenae	19	28	16	19	82
Ozimops ridei	13	3	7	7	30
Saccolaimus flaviventris	24	31	15	8	78
Unresolved calls					
C. gouldii / O. ridei	6	11	1	1	19
C. gouldii / S. balstoni	7	11	1	2	21
C. nigrogriseus / S. greyii	2	16	2	2	22
C. picatus / S. greyii	12	10	4	15	41
C. picatus / V. baverstocki		5		2	7
S. flaviventris / C. jobensis	3		1		4
S. flaviventris / O. lumsdenae	2	1	2	1	6
T. troughtoni / O. lumsdenae	7	8	7	2	24
Vespadelus troughtoni / Chalinolobus morio				1	1
Total calls identified for site	152	280	122	104	658

References

Churchill, S. (2008). *Australian Bats*. Jacana Books, Allen & Unwin; Sydney.

Corben, C. (2017). *AnalookW for bat call analysis using ZCA.* Version 4.2n, 16 March 2017.

Jackson, S. and Groves, C. (2015). *Taxonomy of Australian Mammals*. CSIRO Publishing, Melbourne.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales*. Department of Environment and Conservation, Hurstville.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**: 41-43.

Reardon, T. B., McKenzie, N. L., Cooper, S. J. B., Appleton, B., Carthew, S. and Adams, M. (2014). A molecular and morphological investigation of species boundaries and phylogenetic relationships in Australian free-tailed bats *Mormopterus* (Chiroptera : Molossidae). *Aust. J. Zool*. **62**, 109–136.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.

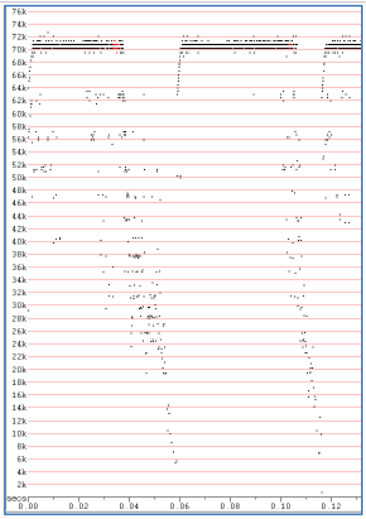
van Dyck, S., Gynther, I. and Baker, A. (ed.) (2013). *Field Companion to the Mammals of Australia*. New Holland; Sydney.

Glossary

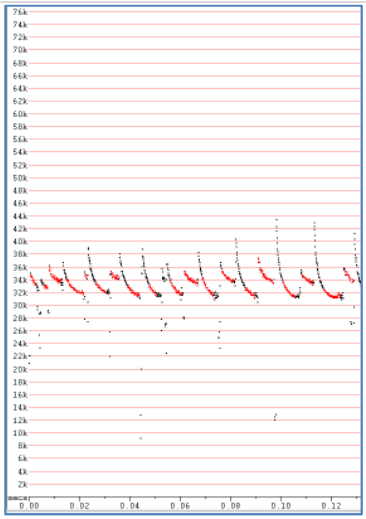
Technical terms used in this report are described in the following table.

Approach phase	The part of a bat *call* emitted as the bat starts to home in on a detected prey item; a transitional series of *pulses* between the *search phase* and *feeding buzz*, that become progressively steeper and shorter in duration.
Call	Refers to a single bat call, made up of a series of individual sound *pulses* in one or more *phases* (*search, approach, feeding buzz*).
CF (=Constant Frequency)	A type of *pulse* in which the dominant component consists of a more-or-less 'pure tone' of sound at a Constant Frequency; with *shape* appearing flat on the sonogram. Often also contains a brief *FM* component at the beginning and/or end of the CF component (*viz.* FM-CF-FM).
Characteristic frequency (Fc)	The frequency of the flattest part of a *pulse*; usually the lowest frequency reached in the *qCF* component of a pulse. This is often the primary diagnostic feature for species identification.
Duration	The time period from the beginning of a *pulse* to the end of the pulse.
Feeding buzz	The terminal part of a *call*, following the *approach phase*, emitted as the bat catches a prey item; a distinctive, rapid series of very steep, very short-duration pulses.
FM (=Frequency Modulated)	A type of *pulse* in which there is substantial change in frequency from beginning to end; *shape* ranges from almost vertical and linear through varying degrees of curvature.
FC range	Refers to the range of frequencies occupied by the *characteristic frequency* section of *pulses* within a call or set of calls.
Frequency sweep or "band-width"	The range of frequencies through which a *pulse* sweeps from beginning to end; Maximum frequency (Fmax) – minimum frequency (Fmin).
Knee	The transitional part of a *pulse* between the initial (usually steeper) frequency sweep and the *characteristic frequency* section (usually flatter); time to knee (Tk) and frequency of knee (Fk) can be diagnostic for some species.
Pulse	An individual pulse of sound within a bat *call*; the *shape*, *duration* and *characteristic frequency* of a pulse are the key diagnostic features used to differentiate species.
Pulse body	The part of the *pulse* between the *knee* and *tail* and containing the *characteristic frequency* section.
Pulse shape	The general appearance of a *pulse* on the sonogram, described using relative terms related to features such as slope and degree of curvature. See also *CF, qCF* and *FM*.
qCF (=quasi Constant Frequency)	A type of *pulse* in which there is very little change in frequency from beginning to end; *shape* appears to be almost flat. Some pulses also contain an *FM* component at the beginning and/or end of the qCF component (*viz.* FM-qCF).
Search phase	The part of a bat *call* generally required for reliable species diagnosis. A consistent series of *pulses* emitted by a bat that is searching for prey or and/or navigating through its habitat. Search phase pulses generally have longer duration, flatter slope and more consistent shape than *approach phase* and *feeding buzz* pulses.
Sequence	Literally, a sequence of *pulses* that may be from one or more bats; but generally refers to a *call* or part (e.g. *phase*) of a call.
Tail	The final component of a *pulse*, following the *characteristic frequency* section; may consist of a short or long sweep of frequencies either upward or downward from the Fc; or may be absent.

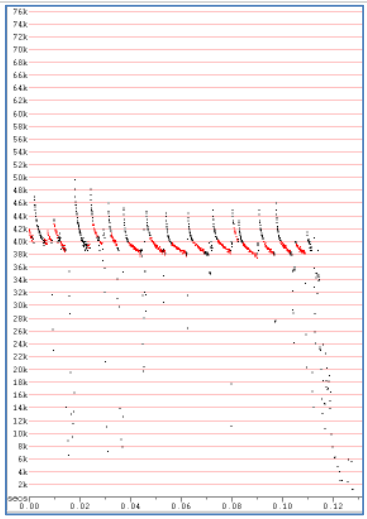
Appendix 1 Representative call sequences from the Dingo West Stage 3 survey, April 2018.
(AnalookW 'F7 compressed' display: x=time(s); y=frequency(kHz); time between pulses removed)



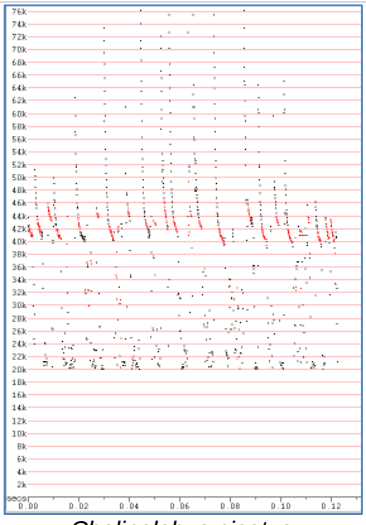
Rhinolophus megaphyllus



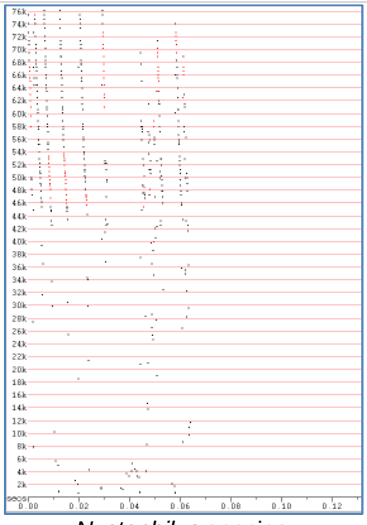
Chalinolobus gouldii



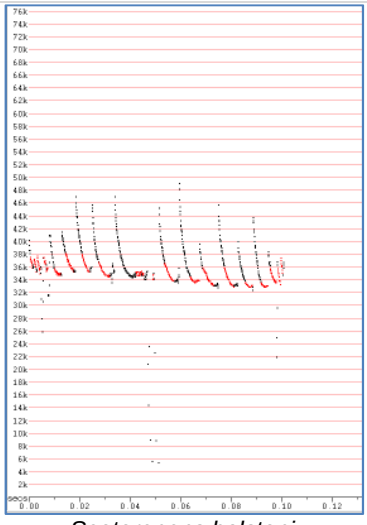
Chalinolobus nigrogriseus



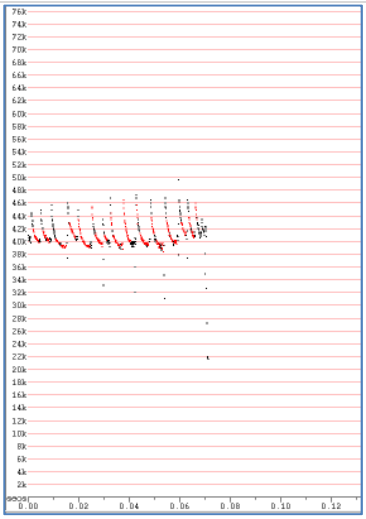
Chalinolobus picatus



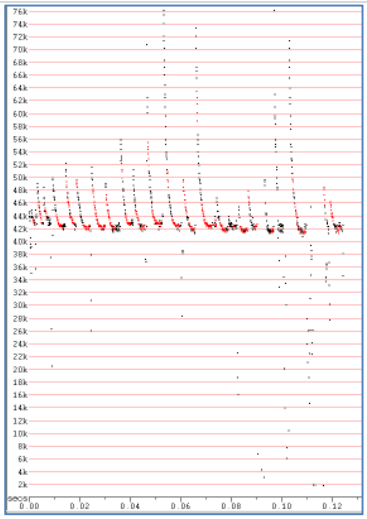
Nyctophilus species



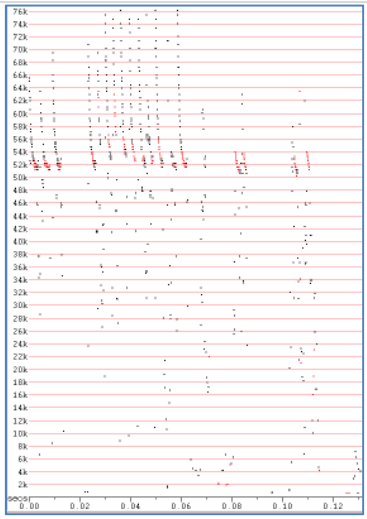
Scotorepens balstoni



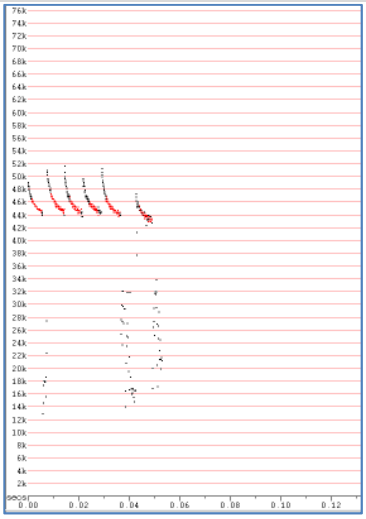
Scotorepens greyii



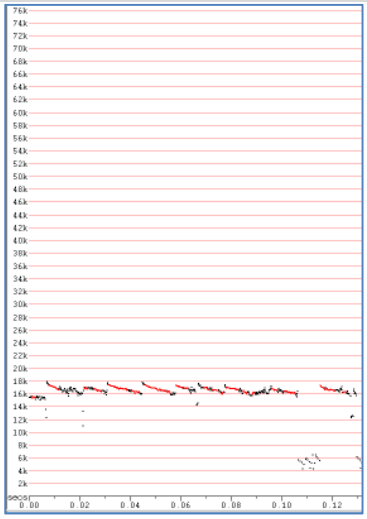
Vespadelus baverstocki



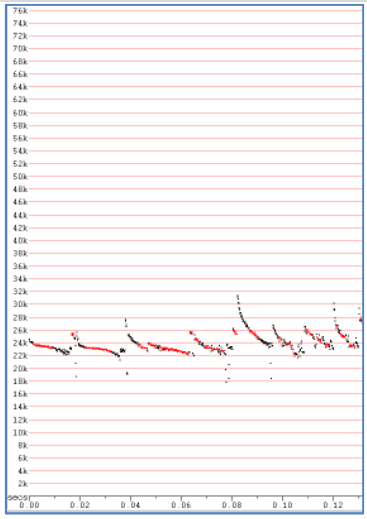
V. troughtoni or *C. morio*



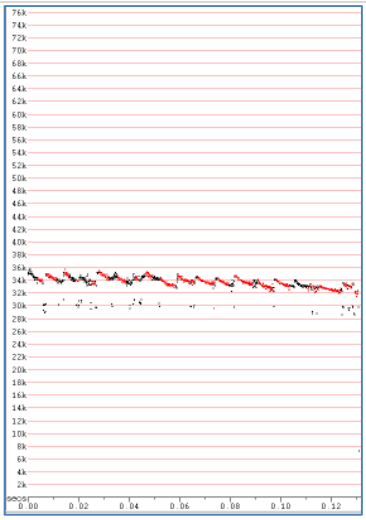
Miniopterus orianae oceanensis



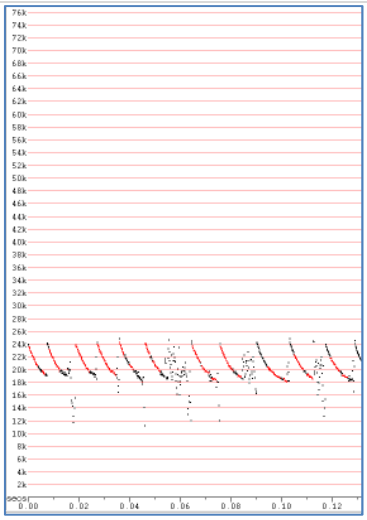
Chaerephon jobensis



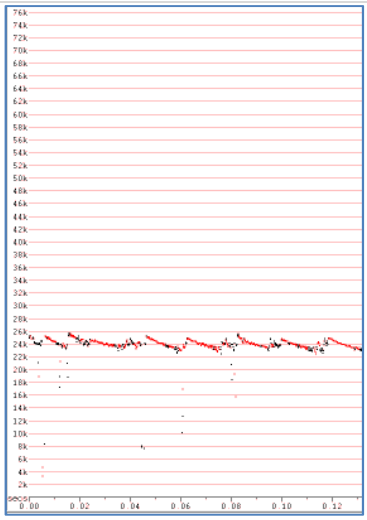
Ozimops lumsdenae



Ozimops ridei



Saccolaimus flaviventris



T. troughtoni / O. lumsdenae

Appendix H Flora Species List

Family	*Scientific Name*	Common Name	NC Act Status	EPBC Act Status	VC1	VC2	VC3	VC4
Acanthaceae	*Brunoniella australis*		LC	-			x	x
Acanthaceae	*Pseuderanhenum variable*	Pastel flower	LC	-		x	x	
Acanthaceae	*Rostellularia adscendens*	Pink tongues	LC	-	x		x	x
Amaranthaceae	*Alternanthera nana*	Hairy joyweed	LC	-	x			
Amaranthaceae	*Gomphrena celosioides*	Gomphrena weed	I	-	x			x
Amaranthaceae	*Sclerolaena birchii*	Galvanised burr	LC	-				x
Amaranthaceae	*Maireana microphylla*		LC	-				x
Amaryllidae	*Crinum flaccidum*	Murray lily	LC	-	x			
Apocynaceae	*Alstonia constricta*	Bitterbark	LC	-		x	x	
Apocynaceae	*Carissa spinarum*	Currant bush	LC	-	x	x	x	x
Apocynaceae	*Cerbera dumicola*		NT	-		x		
Apocynaceae	*Cryptostegia grandiflora*	Rubber vine	RI	-			x	
Apocynaceae	*Parsonsia eucalyptophylla*	Gargaloo	LC	-		x		
Apocynaceae	*Parsonsia straminea*	Monkey rope	LC	-	x	x	x	
Asparagaceae	*Eustrephus latifolius*	Wombat berry	LC	-			x	
Asparagaceae	*Laxmannia gracilis*	Slender wire lily	LC	-	x			
Asparagaceae	*Lomandra longifolia*		LC	-		x	x	x
Asteraceae	*Asteraceae* sp.				x			
Asteraceae	*Bidens pilosa*		I	-			x	
Asteraceae	*Chrysocephalum apiculatum*	Yellow buttons	LC	-	x			
Asteraceae	*Cyanthillium cinereum*		LC	-	x	x	x	x
Asteraceae	*Emilia sonchifolia*		I	-				
Asteraceae	*Emilia sonchifolia var. sonchifolia*		I	-			x	
Asteraceae	*Parthenium hysterophorus*	Parthenium weed	RI	WoNS			x	
Asteraceae	*Pterocaulon redolens*		LC	-	x			
Asteraceae	*Pterocaulon sphacelatum*	Applebush	LC	-			x	
Asteraceae	*Senecio brigalowensis*		LC	-			x	
Asteraceae	*Sonchus oleraceus*	Common sowthistle	I	-			x	
Asteraceae	*Sphaeromorphaea subintegra*		LC	-				x
Boraginaceae	*Ehretia membranifolia*	Weeping koda	LC	-			x	x
Cactaceae	*Harrisia martinii*		RI	-				x

Family	*Scientific Name*	Common Name	NC Act Status	EPBC Act Status	VC1	VC2	VC3	VC4
Cactaceae	*Opuntia tomentosa*	Velvety tree pear	RI	WoNS	x			x
Caesalpiniaceae	*Bauhinia carronii*		LC	-			x	
Caesalpiniaceae	*Cassia brewsterii*		LC	-	x		x	
Caesalpiniaceae	*Senna aciphylla*	Australia senna	LC	-				x
Caesalpiniaceae	*Senna occidentalis*	Coffee senna	I	-	x		x	
Campanulaceae	*Wahlenbergia glabra*		LC	-	x			
Capparaceae	*Capparis canescens*		LC	-	x			
Capparaceae	*Capparis lasiantha*	Nipan	LC	-	x			x
Capparaceae	*Capparis mitchellii*		LC	-				x
Caryophyllaceae	*Polycarpea corymbosa var. minor*		LC	-	x			
Casuarinaceae	*Allocasuarina luehmannii*	Bull oak	LC	-	x			
Celastraceae	*Denhamia cunninghamii*	Yellow berry bush	LC	-				x
Celastraceae	*Denhamia oleaster*		LC	-				x
Chenopodiaceae	*Chenopodiaceae sp.*				x			
Chenopodiaceae	*Enchylaena tomentosa*	Ruby saltbush	LC	-				x
Chenopodiaceae	*Salsola australis*		LC	-				x
Chesalpiniaceae	*Chamaecrista rotundifolia var. rotundifollia*		I	-	x			
Colchicaceae	*Iphigenia indica*		LC	-			x	
Combretaceae	*Terminalia oblongata*		LC	-			x	
Commelinaceae	*Commelina diffusa*	Wandering jew	LC	-	x		x	
Commelinaceae	*Murdannia graminea*	Murdannia	LC	-	x			x
Convolvulaceae	*Evolvulus alsinoides*	Tropical speedwell	LC	-	x	x	x	
Convolvulaceae	*Ipomea polymorpha*	Wooly glycine	LC	-	x			
Convolvulaceae	*Ipomoea plebeia*	Bellvine	LC	-			x	
Crassulaceae	*Bryophyllum sp.*	Mother of millions	RI	-				
Cucurbitaceae	*Cucumis anguria var. anguria*	West Indian gherkin	I	-	x			
Cyperaceae	*Cyperaceae* sp.				x			
Cyperaceae	*Cyperus concinnus*		LC	-				

Family	*Scientific Name*	Common Name	NC Act Status	EPBC Act Status	VC1	VC2	VC3	VC4
Cyperaceae	*Cyperus fulvus*		LC	-	x			
Cyperaceae	*Cyperus gracilis*		LC	-			x	x
Cyperaceae	*Fimbristylis* sp.		LC	-	x			
Cyperaceae	*Fimbristylis dichotoma*	Common fringe-rush	LC	-	x			
Erythroxylaceae	*Erythroxylum australe*	Cocaine bush	LC	-	x	x		x
Euphorbiaceae	*Euphorbia tannensis subsp eremophila*		LC	-	x	x		
Euphorbiaceae	*Ricinus communis*	Castor oil bush	I	-				
Fabaceae	*Crotalaria medicaginea*	Trefoil rattlepod	LC	-	x			
Fabaceae	*Crotalaria pallida**		I	-				x
Fabaceae	*Desmodium macrocarpum*		LC	-	x			
Fabaceae	*Erythrina vespertilio*	Bat wing coral tree	LC	-			x	
Fabaceae	*Glycine sp. (Marburg K.A.Williams 83006)**		LC	-			x	
Fabaceae	*Glycine tabacina*	Glycine pea	LC	-				
Fabaceae	*Glycine tomentella*	Woolly glycine	LC	-	x			
Fabaceae	*Indigofera colutea*	Sticky indigo	LC	-				x
Fabaceae	*Indigofera linnaei*	Birdsville indigo	LC	-				x
Fabaceae	*Jacksonia rhadinochloa*	Miles dogwood	LC	-			x	
Fabaceae	*Macroptilium atropurpureum*	Siratro	I	-			x	
Fabaceae	*Medicago* sp.		I	-				x
Fabaceae	*Neptunia gracilis*		LC	-				x
Fabaceae	*Rhynchosia minima*		LC	-			x	x
Fabaceae	*Stylosanthes aspera*		I	-	x			
Fabaceae	*Stylosanthes glabra*		I	-			x	
Fabaceae	*Stylosanthes scrabra*		I	-	x		x	x
Fabaceae	*Vigna lanceolata*		LC	-	x		x	
Fabaceae	*Zornia* sp.		LC	-	x			
Goodeniaceae	*Goodenia disperma*		LC	-	x			

Family	*Scientific Name*	Common Name	NC Act Status	EPBC Act Status	VC1	VC2	VC3	VC4
Goodeniaceae	*Goodenia rotundifolia*		LC	-	x		x	
Goodeniaceae	*Goodenia* sp.				x			
Hemerocallidaceae	*Dianella longifolia*		LC	-	x			
Hypericaceae	*Hypericum gramineum*		LC	-			x	
Lauraceae	*Cassytha pubescens*	Downy devil's twine	LC	-				x
Malvaceae	*Abutilon oxycarpum*	Straggly lantern-bush	LC	-				x
Malvaceae	*Grewia retusifolia*		LC	-		x		
Malvaceae	*Hibiscus divaricatus*		LC	-	x			
Malvaceae	*Hibiscus sturtii var sturtii*		LC	-	x			
Malvaceae	*Malvastrum americanum*	Malvastrum	I	-	x		x	x
Malvaceae	*Sida atherophora*		LC	-	x	x	x	x
Malvaceae	*Sida playtcalyx**	Lifesaver burr	LC	-				
Malvaceae	*Sida cordifolia*		I	-	x	x	x	x
Malvaceae	*Sida rhombifolia*	Paddy's lucerne	I	-	x		x	
Malvaceae	*Sida sp. (Aramac E.J.Thompson+JER192)*		LC	-	x	x	x	
Malvaceae	*Sida spinosa*	Spiny sida	I	-			x	
Malvaceae	*Sida subspicata*			-	x	x	x	
Meliaceae	*Owenia acidula*	Emu apple	LC	-				
Mimosaceae	*Acacia* sp.					x		
Mimosaceae	*Acacia* (sappling)				x			
Mimosaceae	*Acacia cretata*		LC	-	x	x	x	x
Mimosaceae	*Acacia excelsa*	Ironwood	LC	-	x			
Mimosaceae	*Acacia leiocalyx subsp. leiocalyx*		LC	-	x			
Mimosaceae	*Acacia pendula**	Myall	LC	-				x
Mimosaceae	*Acacia rhodoxylon*	Ring rosewood	LC	-	x	x	x	x
Mimosaceae	*Acacia sherleyi*	Lancewood	LC	-	x	x		
Mimosaceae	*Acalypha eremorum*	Soft acalypha	LC	-			x	

Family	*Scientific Name*	Common Name	NC Act Status	EPBC Act Status	VC1	VC2	VC3	VC4
Mimosaceae	*Archidendropsis basaltica*	Red lancewood	LC	-				x
Mimosaceae	*Vachellia farnesiana*	Mimosa bush	I	-				
Moraceae	*Ficus opposita*	Sandpaper fig	LC	-			x	
Myrtaceae	*Corymbia clarksoniana*		LC	-	x	x	x	x
Myrtaceae	*Corymbia dallachiana*		LC	-				x
Myrtaceae	*Corymbia tesselaris*	Moreton bay ash	LC	-	x		x	x
Myrtaceae	*Eucalyptus* (sappling)		LC	-			x	
Myrtaceae	*E. crebra/E. populnea (hybrid)*		LC	-			x	
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved red ironbark	LC	-	x	x	x	
Myrtaceae	*Eucalyptus exserta*	Queensland peppermint	LC	-	x			
Myrtaceae	*Eucalyptus melanophloia*		LC	-				x
Myrtaceae	*Eucalyptus populnea*	Poplar box	LC	-	x		x	x
Myrtaceae	*Eucalyptus tereticornis*	River blue gum	LC	-			x	x
Myrtaceae	*Melaleuca* sp.			-			x	
Myrtaceae	*Melaleuca nervosa*		LC	-	x			
Nyctaginaceae	*Boerhavia dominii*	Tarvine	LC	-				x
Oleaceae	*Jasminum didymum*		LC	-				x
Oxalidaceae	*Oxalis corniculata*	Yellow wood sorrel	I	-	x	x	x	
Pentapetaceae	*Melhania oblongifolia*		LC	-				x
Phyllanthaceae	*Phyllanthaceae sp.*							
Phyllanthaceae	*Phyllanthus virgatus*		LC	-	x	x	x	x
Picrodendraceae	*Petalostigma pubescens*	Quinine tree	LC	-	x	x	x	x
Poaceae	*Alloteropsis cimicina*		LC	-	x		x	
Poaceae	*Aristida* sp.			-	x			
Poaceae	*Aristida calycina*		LC	-	x	x		x
Poaceae	*Aristida caput-medusae*		LC	-	x	x	x	
Poaceae	*Aristida gracilipes*		LC	-				x

Family	*Scientific Name*	Common Name	NC Act Status	EPBC Act Status	VC1	VC2	VC3	VC4
Poaceae	*Aristida jerichoensis*		LC	-	x		x	
Poaceae	*Aristida perniciosa*		LC	-				x
Poaceae	*Aristida pruinosa*		LC	-				
Poaceae	*Bothriochloa decipiens*		LC	-	x		x	
Poaceae	*Bothriochloa ewartiana*	Desert bluegrass	LC	-			x	x
Poaceae	*Bothriochloa pertusa*		I	-			x	
Poaceae	*Calyptochloa gracilima*		LC	-	x	x	x	
Poaceae	*Cenchrus ciliaris*	Buffel grass	I	-	x	x	x	x
Poaceae	*Chrysopogon fallax*		LC	-	x	x	x	
Poaceae	*Cleistochloa sp. (Duaringa K.B.Adison 42)*		LC	-	x	x		
Poaceae	*Cymbopogon refractus*	Barbed-wire grass	LC	-	x			
Poaceae	*Cynodon dactylon*	Native couch	I	-	x			x
Poaceae	*Dichanthium sericeum*	Queensland bluegrass	LC	-			x	
Poaceae	*Digitaria brownii (dead)**		LC	-	x			
Poaceae	*Digitaria diminuta*		LC	-		x	x	
Poaceae	*Digitaria divaricatissima*	Spreading umbrella grass	LC	-			x	
Poaceae	*Digitaria sp* (not enough material for a positive ID)				x			
Poaceae	*Dinebra ligulata*		LC	-		x		
Poaceae	*Enneapogon lindleyanus*		LC	-		x	x	x
Poaceae	*Enteropogon acicularis*	Curly windmill grass	LC	-	x			
Poaceae	*Entolasia stricta*	Wiry panic	LC	-		x	x	
Poaceae	*Eragrostis sp. (not enough material to ID)*				x			
Poaceae	*Eragrostis elongata*		LC	-	x			
Poaceae	*Eragrostis lacunaria*	Purple lovegrass	LC	-	x	x	x	x
Poaceae	*Eragrostis sororia*	Woodland lovegrass	LC	-	x		x	x
Poaceae	*Eriachne mucronata*		LC	-	x			

Family	*Scientific Name*	Common Name	NC Act Status	EPBC Act Status	VC1	VC2	VC3	VC4
Poaceae	*Eriochloa procera*	Slender cupgrass	LC	-				x
Poaceae	*Eulalia aurea*	Silky browntop	LC	-	x			
Poaceae	*Heteropogon contortus*	Black spear grass	LC	-		x	x	x
Poaceae	*Megathyrsus maximus*		I	-	x		x	
Poaceae	*Melinis repens*	Red natal grass	I	-	x		x	x
Poaceae	*Panicum decompositum*		LC	-			x	
Poaceae	*Panicum effusum*		LC	-			x	x
Poaceae	*Paspalidium caespitosum*	Brigalow grass	LC	-	x	x		x
Poaceae	*Paspalidium constrictum**		LC	-			x	
Poaceae	*Paspalidium* sp.				x			
Poaceae	*Perotis rara*	Comet grass	LC	-	x		x	
Poaceae	*Sporobolus caroli*	Fairy grass	LC	-	x	x	x	x
Poaceae	*Sporobolus creber*	Western rat's tail Grass	LC	-				x
Poaceae	*Themeda triandra*	Kangaroo grass	LC	-			x	x
Poaceae	*Urochloa mosambicensis*	Sabi grass	LC	-	x	x	x	x
Poaceae	*Urochloa* sp.				x		x	
Poaceae	*Poaceae sp. (grazed)*				x			x
Polygonaceae	*Duma florulenta*		LC	-				x
Portulacaceae	*Portulaca bicolor*		LC	-				
Portulacaceae	*Portulaca filifolia*		LC	-			x	
Portulacaceae	*Portulaca pilosa*		I	-				
Proteaceae	*Grevillea striata*	Beefwood	LC	-	x		x	
Pteridaceae	*Cheilanthes sieberi subsp sieberi*	Poison rock fern	LC	-			x	
Pteridaceae	*Cheilanthes* sp.							
Rhamnaceae	*Alphitonia excelsa*	Soap tree	LC	-	x	x	x	x
Rhamnaceae	*Ventilago viminalis*	Supplejack	LC	-				
Rubiaceae	*Coelospermum reticulatum*		LC	-	x	x	x	
Rubiaceae	*Everistia vacciniifolia*		LC	-	x		x	

Family	*Scientific Name*	Common Name	NC Act Status	EPBC Act Status	VC1	VC2	VC3	VC4
Rubiaceae	*Psydrax forsteri*		LC	-	x	x		
Rubiaceae	*Psydrax johnsonii*		LC	-			x	x
Rubiaceae	*Psydrax oleifolia*		LC	-		x		
Rubiaceae	*Spermacoce brachystema*		LC	-	x		x	
Rubiaceae	*Coelospermum reticulatum*		LC	-				x
Rutaceae	*Flindersia dissosperma*		LC	-				
Rutaceae	*Rutaceae* sp.							x
Sapindaceae	*Atalaya hemiglauca*	Whitewood	LC	-			x	x
Scrophulariaceae	*Myoporum acuminatum*	Coastal boobialla	LC	-				
Stylidiaceae	*Stylidium eriorhizum*		LC	-				
Verbenaceae	*Glandularia aristigera*	Mayne's pest	I	-				
Violaceae	*Afrohybanthus stellarioides*		LC	-	x	x	x	
Violaceae	*Afrohybanthus enneaspermus*		LC	-				x

* Possibly this species
LC Least Concern
NT Near Threatened
I Introduced
WoNS Weed of National Significance
RI Restricted invasive plant

H

Appendix I Fauna Species List

Family	*Scientific Name*	Common Name	NC Act/LP Act	EPBC Act	2017 - Autumn						2017 - Spring							2018 - Autumn						
					OPPS	DF01	DF02	DF03	DF04	Total	OPPS	DF05	DF06	DF07	DF08	DF09	DF10	Total	OPPS	DF11	DF12	DF13	DF14	DF15	Total
Amphibians																									
Bufonidae	*Rhinella marina*	Cane toad	I	-			5		8	13		13	4				8	25			5	1		10	16
Hylidae	*Litoria rubella*	Naked tree frog	LC	-						0		1						1			1				1
Hylidae	*Litoria caerulea*	Common green tree frog	LC	-			7		2	9								0			1			1	2
Hylidae	*Litoria latopalmata*	Broad-palmed frog	LC	-			1			1								0							0
Hylidae	*Litoria inermis*	Bumpy rocket frog	LC	-	1					1	1							1			1		2	6	9
Limnodynastidae	*Limnodynastes salmini*	Salmon-striped frog	LC	-						0		1						1							0
Limnodynastidae	*Limnodynastes tasmaniensis*	Spotted grass frog	LC	-						0		2						2			2		3		5
Limnodynastidae	*Platyplectrum ornatum*	Ornate burrowing frog	LC	-			249	2	25	276		1						1			3		5		8
				TOTAL AMPHIBIANS	**1**	**0**	**262**	**2**	**35**	**300**	**1**	**18**	**4**	**0**	**0**	**0**	**8**	**31**	**0**	**0**	**13**	**1**	**10**	**17**	**41**
Reptiles																									
Elapidae	*Cryptophis boschmai*	Carpentaria snake	LC	-						0				2				2					1		1
Elapidae	*Demansia psammophis*	Yellow-faced whip snake	LC	-						0		1						1							0
Elapidae	*Furina ornata*	Orange-naped snake	LC	-						0							1	1							0
Elapidae	*Hoplocephalus bitorquatus*	Pale-headed snake	LC	-					1	1								0							0
Elapidae	*Pseudonaja textilis*	Eastern Brown snake	LC	-	1					1	1	1						2							0
Pythonidae	*Aspidites melanocephalus*	Black headed python	LC	-																					
Agamidae	*Pogona barbata*	Bearded dragon	LC	-		1				1	1							1		1		1			2
Agamidae	*Diporiphora australis*	Tommy roundhead	LC	-						0				2		4		6				3			3
Varanidae	*Varanus tristis orientalis*	Freckled monitor	LC	-						0							1	1							0
Carphodactylidae	*Nephrurus asper*	Prickly knob-tailed gecko	LC	-						0					1			1							0
Diplodactylidae	*Diplodactylus vittatus*	Eastern stone gecko	LC	-						0				1				1							0
Diplodactylidae	*Lucasium steindachneri*	Box-patterned gecko	LC	-						0						2		2							0
Gekkonidae	*Heteronotia binoei*	Bynoe's gecko	LC	-		1		4	2	7			1	2	2	1	2	8		1					1
Gekkonidae	*Gehyra dubia*	Dubious dtella	LC	-				1	1	2					1		1	2						1	1
Pygopodidae	*Lialis burtonis*	Burton's legless lizard	LC	-		1				1								0							0
Scincidae	*Carlia munda*	Shade-litter rainbow skink	LC	-						0								0			1				1
Scincidae	*Carlia rubigo*	Orange-flanked rainbow-ski	LC	-		4	1	4	3	12		3		3	3			9				2			2
Scincidae	*Cryptoblepharus pulcher*	Elegant snake-eyed skink	LC	-				1		1			1					1							0
Scincidae	*Morethia boulengeri*	South-eastern morethia	LC	-						0		1						1							0
Scincidae	*Ctenotus robustus*	Eastern striped skink	LC	-						0								0		1			2	2	5
Scincidae	*Morethia taeniopleura*	Fire-tailed skink	LC	-				2		2								0							0
Scincidae	*Pygmaescincus timlowi*	Dwarf litter-skink	LC	-						0				1				1			2				2
				LIZARDS	**0**	**7**	**1**	**12**	**6**	**26**	**1**	**4**	**2**	**9**	**7**	**7**	**4**	**34**	**0**	**3**	**3**	**6**	**2**	**3**	**17**
				SNAKES	**1**	**0**	**0**	**0**	**1**	**2**	**1**	**2**	**0**	**2**	**0**	**0**	**1**	**6**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
				TOTAL REPTILES	**1**	**7**	**1**	**12**	**7**	**28**	**2**	**6**	**2**	**11**	**7**	**7**	**5**	**40**	**0**	**3**	**3**	**6**	**3**	**3**	**18**

I

Family	*Scientific Name*	Common Name	NC Act/LP Act Status	EPBC Act status	2017 - Autumn						2017 - Spring							2018 - Autumn						
					OPPS	DF01	DF02	DF03	DF04	Total	OPPS	DF05	DF06	DF07	DF08	DF09	DF10	Total	OPPS	DF11	DF12	DF13	DF14	DF15	Total
Birds																									
Acanthizidae	*Gerygone olivaceae*	White-throated gerygone	LC	-		2	2	1	2	7		1	1	1	1	2		6			1				1
Acanthizidae	*Smicrornis brevirostris*	Weebill	LC	-						0				1			1	2		1			1	1	3
Accipitridae	*Aquila audax*	Wedge-tailed eagle	LC	-	1					1	2							2	13		1				14
Accipitridae	*Haliastur sphenurus*	Whistling kite	LC	-	1					1	1							1				1			1
Accipitridae	*Milvus migrans*	Black kite	LC	-	1					1	1							1	10				1		11
Aegothelidae	*Aegotheles cristatus*	Australian owlet nightjar	LC	-						0			1	1	2			4		1		1			2
Alcedinidae	*Todiramphus macleayii*	Forest kingfisher	LC	-						0		2			2	2	2	8			1				1
Anatidae	*Anas superciliosa*	Pacific black duck	LC	-						0		1						1							0
Ardeidae	*Ardea modesta*	Eastern great egret	LC	-	1					1	1							1							0
Ardeidae	*Ardea pacifica*	White-necked heron	LC	-						0		1						1							0
Ardeidae	*Egretta novaehollandiae*	White-faced heron	LC	-	1					1	1							1							0
Artamidae	*Cracticus nigrogularis*	Pied butcherbird	LC	-		2	2			4		1	2		2			5		2			2		4
Artamidae	*Cracticus tibicen*	Australian magpie	LC	-		2	2	1	2	7			1		1	1		3			2	1	1	1	5
Artamidae	*Cracticus torquatus*	Grey butcherbird	LC	-		1		1	2	4		1	2	2	2		2	9		3			1		4
Burninidae	*Burhinus grallarius*	Bush stone-curlew	LC	-						0			1		2			3							0
Cacatuidae	*Cacatua galerita*	Sulphur-crested cockatoo	LC	-			1		1	2				1				1			1				1
Cacatuidae	*Calyptorhynchus banksii*	Red-tailed black-cockatoo	LC	-			1			1								0							0
Cacatuidae	*Eolophus roseicapilla*	Galah	LC	-						0		1						1							0
Cacatuidae	*Nymphicus hollandicus*	Cockatiel	LC	-	1					1	1							1	1						1
Campephagidae	*Coracina novaehollandiae*	Black-faced cuckoo-shrike	LC	-		1				1		1	1					2					1	1	2
Campephagidae	*Coracina papuensis*	White-bellied cuckoo-shrike	LC	-						0					1			1							0
Campephagidae	*Lalage tricolor*	White-winged triller	LC	-						0	1							1							0
Caprimulgidae	*Eurostopodus argus*	Spotted nightjar	LC	-	1					1	1							1							0
Charadriidae	*Vanellus miles*	Masked lapwing	LC	-						0		1						1							0
Contropodidae	*Centropus phasianinus*	Pheasant coucal	LC	-						0						1		1							0
Columbidae	*Geopelia humeralis*	Bar-shouldered dove	LC	-				1	1	2			1	1	1			3							0
Columbidae	*Geopelia striata placida*	Peaceful dove	LC	-		1		2	2	5		1	1	2	2	2	2	10					1		1
Columbidae	***Geophaps scripta scripta***	**southern Squatter pigeon**	**V**	**V**	2				1	3	9						2	11	1						1
Columbidae	*Ocyphaps lophotes*	Crested pigeon	LC	-				1	1	2			2	2	1		1	6							0
Columbidae	*Phaps chalcoptera*	Common bronzewing	LC	-						0					1			1							0
Corcoracidae	*Corcorax melanorhamphos*	White-winged chough	LC	-						0	1							1							0
Corcoracidae	*Struthidea cinerea*	Apostlebird	LC	-	1					1	1			1			2	4			1	1			2
Corvidae	*Corvus coronoides*	Australian raven	LC	-		2	1	2	2	7		2	1		2		1	6					1		1
Cuculidae	*Scythrops novaehollandiae*	Channel-billed cuckoo	LC	-						0				1				1							0

Family	Scientific Name	Common Name	NC Act/LP Act Status	EPBC Act status	2017 - Autumn						2017 - Spring							2018 - Autumn						
					OPPS	DF01	DF02	DF03	DF04	Total	OPPS	DF05	DF06	DF07	DF08	DF09	DF10	Total	OPPS	DF11	DF12	DF13	DF14	DF15	Total
Dromaiidae	*Dromaius novaehollandiae*	Emu	LC	-	1					1	1							1	20						20
Estrildidae	*Taeniopygia bichenovii*	Double-barred finch	LC	-		1	1	2		4		2		1				3			1				1
Estrildidae	*Taeniopygia guttata*	Zebra finch	LC	-						0								0							0
Falconidae	*Falco berigora*	Brown falcon	LC	-	1					1	1							1							0
Falconidae	*Falco cenchroides*	Nankeen kestrel	LC	-	1					1								0							0
Halcyonidae	*Dacelo novaeguineae*	Laughing kookaburra	LC	-			1	1	8	10		1		2	1		1	5			1				1
Maluridae	*Malurus lamberti*	Variegated fairy-wren	LC	-			1			1				1				1							0
Maluridae	*Malurus melanocephalus*	Red-backed fairywren	LC	-						0		2						2					1	1	2
Meliphagidae	*Entomyzon cyanotis*	Blue-faced honeyeater	LC	-		1				1		1						1							0
Meliphagidae	*Lichenostomus virescens*	Singing honeyeater	LC	-				1		1								0							0
Meliphagidae	*Lichmera indistincta*	Brown honeyeater	LC	-						0		1						1							0
Meliphagidae	*Manorina flavigula*	Yellow-throated miner	LC	-	1					1	1							1							0
Meliphagidae	*Manorina melanocephala*	Noisy miner	LC	-		1			2	3		1					2	3		1	1			1	3
Meliphagidae	*Melithreptus albogularis*	White-throated honeyeater	LC	-		1	2	1		4						1		1							0
Meliphagidae	*Philemon citreogularis*	Little friarbird	LC	-						0								0		1		1			2
Meliphagidae	*Philemon corniculatus*	Noisy friarbird	LC	-		2				2		1				2		3		1		1			2
Meropidae	*Merops ornatus*	Rainbow bee-eater	LC	Ma		1				1		2	1	2		1		6							0
Monarchidae	*Grallina cyanoleuca*	Magpie-lark	LC	-		1	1			2		1	1				2	4			2				2
Monarchidae	*Myiagra inquieta*	Restless flycatcher	LC	-				1		1		1						1							0
Monarchidae	*Myiagra rubecula*	Leaden flycatcher	LC	-						0		2	1	2	1	2		8		1				1	2
Neosittidae	*Daphoenositta chrysoptera*	Varied sittella	LC	-						0	1					1		2							0
Oriolidae	*Oriolus sagittatus*	Olive-backed oriole	LC	-		1				1					1	1		2							0
Oriolidae	*Sphecotheres vieilloti*	Australasian figbird	LC	-						0		1						1							0
Otididae	*Ardeotis australis*	Australian bustard	LC	-						0	1							1							0
Pachycephalidae	*Colluricincla harmonica*	Grey shrike-thrush	LC	-		1		1		2		1		1				2				1			1
Pachycephalidae	*Pachycephala rufiventris*	Rufous whistler	LC	-				1		1				2		2		4				2			2
Pardalotidae	*Pardalotus striatus*	Striated pardalote	LC	-		2	1	2	2	7		2	2	1		2		7		2	2		2	1	7
Phasianidae	*Coturnix ypsilophora*	Brown quail	LC	-	1					1	1							1							0
Pelecanidae	*Pelecanus conspicillatus*	Australian pelican	LC	-						0	1							1							0
Petroicidae	*Microeca fascinans*	Jacky winter	LC	-	1					1	1							1							0
Podargidae	*Podargus strigoides*	Tawny frogmouth	LC	-						0	5		1		1			7							0
Pomatostomidae	*Pomatostomus temporalis*	Grey-crowned babbler	LC	-				1		1				1	1	1	1	4				1	1		2
Psittacidae	*Aprosmictus erythropterus*	Red-winged parrot	LC	-	1					1	2							2			1			1	2
Psittacidae	*Platycercus adscitus*	Pale-headed rosella	LC	-				1		1		1	1			1	1	4		1		1			2
Psittaculidae	*Trichoglossus moluccanus*	Rainbow lorikeet	LC	-		2		1	1	4		1	1	1			1	4			2				2
Rhipiduridae	*Rhipidura albiscapa*	Grey fantail	LC	-		2	1	2	2	7		1		1				2							0
Rhipiduridae	***Rhipidura rufifrons***	**Rufous fantail**	SL	Mi, Ma						0	1							1							0
Strigidae	*Ninox boobook*	Southern boobook	LC	-					1	1	1	1		1	1			4				2			2
Alcedinidae	*Dacelo leachii*	Blue-winged kookaburra	LC	-						0								0			1				1
Artamidae	*Artamus leucorynchus*	White-breasted woodswallo	LC	-						0								0			1				1

Family	Scientific Name	Common Name	NC Act/LP Act Status	EPBC Act status	2017 - Autumn						2017 - Spring							2018 - Autumn						
					OPPS	DF01	DF02	DF03	DF04	Total	OPPS	DF05	DF06	DF07	DF08	DF09	DF10	Total	OPPS	DF11	DF12	DF13	DF14	DF15	Total
Corvidae	*Corvus orru*	Torresian crow	LC	-						0								0		1		1	1		3
Gruidae	*Grus rubicunda*	Brolga	LC	-						0								0	4						4
Coraciidae	*Eurystomus orientalis*	Dollarbird	LC	-						0								0						1	1
Megaluridae	*Cincloramphus cruralis*	Brown songlark	LC	-						0								0	2						2
Rhipiduridae	*Rhipidura leucophrys*	Willie wagtail	LC	-		1	1	2		0								0			1		1	1	3
Nectariniidae	*Dicaeum hirundinaceum*	Mistletoe bird	LC	-						0								0			1		1	1	3
Threskiornithidae	*Threskiornis spinicollis*	Straw-necked ibis	LC	-			1			1								0							0
Tytonidae	*Tyto alba*	Barn owl	LC	-		2	2			4								0							0
Tytonidae	*Tyto javanica*	Eastern barn owl	LC	-						0								0					1		1
				TOTAL BIRDS	17	30	21	26	30	120	37	36	22	29	26	22	21	193	51	15	21	14	16	11	128
Mammals																									
Macropodidae	*Macropus giganteus*	Eastern grey kangaroo	LC	-	1			2		3	2							2	128						128
Macropodidae	*Notamacropus dorsalis*	Black-striped wallaby	LC	-						0	1			7				8							0
Macropodidae	*Osphranter robustus*	Wallaroo	LC	-	1					1	1				1		3	5	24						24
Macropodidae	*Notamacropus rufogriseus*	Red-necked wallaby	LC	-						0								0	15						15
Macropodidae	*Wallabia bicolor*	Swamp wallaby	LC	-						0	0						1	1							0
Muridae	*Pseudomys delicatulus*	Delicate mouse	LC	-	1	1				2	0							0							0
Phalangeridae	*Trichosurus vulpecula*	Common brushtail possum	LC	-			1			1								0							0
Muridae	*Hydromys chrysogaster*	Rakali / water rat	LC	-						0								0			1				1
Potoroidae	*Aepyprymnus rufescens*	Rufous rat-kangaroo	LC	-						0	1				3			4							0
Pseudocheiridae	***Petauroides volans***	**Greater glider**	V	V			1			1		1						1			2				2
Tachyglossidae	***Tachyglossus aculeatus***	**Short-beaked echidna**	SL	-	1					1	3		1					4							0
Canidae	*Canis lupus dingo*	Dingo	C2	-	1					1	1							1							0
Felidae	*Felis catus*	Feral cat	C2	-						0	1	2					1	4			1				1
Leporidae	*Oryctolagus cuniculus*	Rabbit	C2	-	1					1	2				2			4							0
Muridae	*Mus musculus*	House mouse	I	-		2	1	1	1	5						1	1	2					1		1
Suidae	*Sus scrofa*	Feral pig	C2	-	1				1	2	1							1							0
Pteropodinae	*Pteropus scapulatus*	Little red flying fox	LC	-						0					3			3							0
Rhinolophidae	*Rhinolophus megaphyllus*	Eastern horseshoe bat	LC	-				U		1			U		U		U	3		U					1
Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat	LC	-		U	U	U	U	4		U	U	U	A	U	U	6		U	U	U	U		4
Vespertilionidae	*Chalinolobus nigrogriseus/Scortorepens greyii*																			A	A	A	A		4
Vespertilionidae	*Vespadelus troughtoni/Chalinolobus morio*																						A		1
	Taphozous troughtoni/Ozimops lumsdenae																			A	A	A	A		4
	Saccolaimus flaviventris/Ozimops lumsdenae																			A	A	A	A		4
	Saccolaimus flaviventris/Chaerephon jobensis																			A		A			1

Family	Scientific Name	Common Name	NC Act/LP Act Status	EPBC Act status	2017 - Autumn						2017 - Spring							2018 - Autumn					
					OPPS	DF01	DF02	DF03	DF04	Total	OPPS	DF05	DF06	DF07	DF08	DF09	DF10	Total	OPPS	DF11	DF12	DF13	DF14	DF15	Total
Vespertilionidae	*Chalinolobus picatus/Vespadelus baverstocki*																				A		A		2
Vespertilionidae	*Chalinolobus picatus/Scotorepens greyii*																			A	A	A	A		4
Vespertilionidae	*Chalinolobus gouldii/Scotorepens balstoni*																			A	A	A	A		4
	Chalinolobus gouldii/Ozimops ridei																			A	A	A	A		4
Vespertilionidae	*Chalinolobus morio*	Chocolate wattled bat	LC	-			U			1							U	1							0
Vespertilionidae	*Chalinolobus nigrogriseus*	Hoary wattled bat	LC	-			A	A		2								0			U	U			2
Vespertilionidae	*Chalinolobus picatus*	Little pied bat	LC	-		U	A	U	U	4		U	A	U	U	U	U	6		U	U	U	U		4
Vespertilionidae	*Nyctophilus geoffroyi*		LC	-																					
Vespertilionidae	*Nyctophilus sp. (N. geoffroyi or N. gouldi)*		LC	-						0		U	U	U	U		U	5		U	U	U			3
Vespertilionidae	*Scotorepens balstoni*	Western broad-nosed bat	LC	-		U	A	U		3		A		A	A	A	A	5			U	U			2
Vespertilionidae	*Scotorepens greyii*	Little broad-nosed bat	LC	-		U	U	U		3		U	A	U	U	U	U	6		U	U	U	U		4
Vespertilionidae	*Vespadelus baverstocki*	Inland forest bat	LC	-						0			A	A		A	A	4			U	U	U		3
Vespertilionidae	*Vespadelus troughtoni*	Eastern cave bat	LC	-				U		1		U			U		U	3							0
Miniopteridae	*Miniopterus orianae oceanensis*		LC	-						0								0		U	U		U		3
Miniopteridae	*Miniopterus schreibersii oceane*	Eastern bent-wing bat	LC	-		U	U	U		3		U	U	U		U	U	5							0
Molossidae	*Austronomus australis*	White-striped free-tailed Bat	LC	-		U	U	U	U	4		U						1							0
Molossidae	*Chaerephon jobensis*	Northern free-tailed bat	LC	-		U	U	U	U	4		U	U	U	U	U	U	6		U	U	U	U		4
Molossidae	*Mormopterus (Setirostris) eleryi*	Hairy-nosed free-tailed bat	LC	-						0		A				A	A	3							0
Molossidae	*Ozimops lumsdenae*	Northern free-tailed bat	LC	-			U	U	U	3		U	U	U	U	U	U	6		U	U	U	U		4
Molossidae	*Ozimops petersi*	Inland free-tailed bat	LC	-						0		U	U	A	A	U	U	6							0
Molossidae	*Ozimops ridei*	Ride's free-tailed bat	LC	-		U	A	U	U	4		U	U	U	A	U	U	6		U	U	U	U		4
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied sheathtail-ba	LC	-		A	U	A	U	4		U	U	U	U	U	U	6		U	U	U	U		4
Emballonuridae	*Taphozous troughtoni*	Troughton's sheathtail-bat	LC	-						0		A					A	2							0
FERAL/DOMESTICATED/INTRODUCED SPECIES					**3**	**2**	**1**	**1**	**2**	**9**		**2**	**0**	**0**	**2**	**1**	**2**	**12**	**5**	**0**	**1**	**0**	**1**	**0**	**2**
NATIVE MAMMALS (NON-BATS)					**4**	**1**	**2**	**2**	**0**	**9**		**1**	**1**	**7**	**4**	**0**	**3**	**24**	**172**	**0**	**3**	**0**	**0**	**0**	**175**
BATS					**0**	**9**	**12**	**13**	**7**	**41**		**15**	**12**	**12**	**15**	**12**	**17**	**83**	**0**	**17**	**19**	**18**	**17**	**0**	**71**
TOTAL MAMMALS					**7**	**12**	**15**	**16**	**9**	**59**		**18**	**13**	**19**	**21**	**13**	**22**	**119**	**167**	**17**	**23**	**18**	**18**	**0**	**243**

LC - Least Concern
SL - Special Least Concern
V - Vulnerable
I - Introduced

Blue - Pests
A - Ambiguous identification
U - Unambiguous identification
- probable identification of species from hair samples

* species identified from tracks, scats or other traces
^ Probable species ID from bat calls

I

Family	*Scientific Name*	Common Name	NC Act/LP Act Status	EPBC Act status	Bat Survey Autumn 2018											
					HP 1	HP 2	HP 3	HP 4	HP 5	HP 6	HP 7	HP 8	MN 1	MN 2	MN 3	Total
Pteropodinae	*Pteropus scapulatus*	Little red flying fox	LC	-												
Rhinolophidae	*Rhinolophus megaphyllus*	Eastern horseshoe bat	LC	-												
Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat	LC	-						1						1
Vespertilionidae	*Chalinolobus nigrogriseus/Scortorepens greyii*															
Vespertilionidae	*Vespadelus troughtoni/Chalinolobus morio*															
	Taphozous troughtoni/Ozimops lumsdenae															
	Saccolaimus flaviventris/Ozimops lumsdenae															
	Saccolaimus flaviventris/Chaerephon jobensis															
Vespertilionidae	*Chalinolobus picatus/Vespadelus baverstocki*															
Vespertilionidae	*Chalinolobus picatus/Scotorepens greyii*															
Vespertilionidae	*Chalinolobus gouldii/Scotorepens balstoni*															
	Chalinolobus gouldii/Ozimops ridei															
Vespertilionidae	*Chalinolobus morio*	Chocolate wattled bat	LC	-							1					1
Vespertilionidae	*Chalinolobus nigrogriseus*	Hoary wattled bat	LC	-												
Vespertilionidae	*Chalinolobus picatus*	Little pied bat	LC	-						1						1
Vespertilionidae	*Nyctophilus geoffroyi*		LC	-							1					1
Vespertilionidae	*Nyctophilus sp. (N. geoffroyi or N. gouldi)*		LC	-												
Vespertilionidae	*Scotorepens balstoni*	Western broad-nosed bat	LC	-												
Vespertilionidae	*Scotorepens greyii*	Little broad-nosed bat	LC	-					5	2	1	1			2	11
Vespertilionidae	*Vespadelus baverstocki*	Inland forest bat	LC	-												
Vespertilionidae	*Vespadelus troughtoni*	Eastern cave bat	LC	-												
Miniopteridae	*Miniopterus orianae oceanensis*		LC	-												
Miniopteridae	*Miniopterus schreibersii oceanensis*	Eastern bent-wing bat	LC	-												
Molossidae	*Austronomus australis*	White-striped free-tailed Bat	LC	-												
Molossidae	*Chaerephon jobensis*	Northern free-tailed bat	LC	-												
Molossidae	*Mormopterus (Setirostris) eleryi*	Hairy-nosed free-tailed bat	LC	-												
Molossidae	*Ozimops lumsdenae*	Northern free-tailed bat	LC	-												
Molossidae	*Ozimops petersi*	Inland free-tailed bat	LC	-												
Molossidae	*Ozimops ridei*	Ride's free-tailed bat	LC	-												
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied sheathtail-ba	LC	-												
Emballonuridae	*Taphozous troughtoni*	Troughton's sheathtail-bat	LC	-												
				BATS					**5**	**4**	**3**	**1**			**2**	**15**
				TOTAL MAMMALS												

LC - Least Concern

Appendix J Weed Species and Management Plans

Department of Agriculture and Fisheries
Biosecurity Queensland

Restricted invasive plant

Harrisia cactus

Moonlight cactus

Harrisia martinii, Harrisia tortuosa and *Harrisia pomanensis*

Harrisia cactus can form dense infestations that will reduce pastures to a level unsuitable for stock. Harrisia cactus will choke out other pasture species when left unchecked.

The spines are a problem for stock management, interfering with mustering and stock movement.

Harrisia cactus produces large quantities of seed that is highly viable and easily spread by birds and other animals. As well as reproducing from seed, harrisia cactus has long trailing branches that bend and take root wherever they touch the ground. Any broken-off portions of the plant will take root and grow.

Legal requirements

Harrisia cactus (*Harrisia martinii, Harrisia tortuosa* and *Harrisia pomanensis*) are restricted invasive plants under the *Biosecurity Act 2014*. It must not be given away, sold, or released into the environment without a permit. The Act requires everyone to take all reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. This is called a general biosecurity obligation (GBO). This fact sheet gives examples of how you can meet your GBO.

Queensland Government

At a local level, each local government must have a biosecurity plan that covers invasive plants and animals in its area. This plan may include actions to be taken on certain species. Some of these actions may be required under local laws. Contact your local government for more information.

Description

Harrisia cactus is a perennial. The spiny fleshy stems are jointed and form tangled mats about half a metre high. Many branches often lie flat and take root where they touch the ground. Each section is ribbed lengthwise with six ribs; each rib has low, thick, triangular humps at regular intervals. These humps have cushions of grey felty hairs, three to five short spines lying flat, and one to three erect, stiff, very sharp spines 2.5–3 cm long.

The large flowers open at night. Flowers are pink and funnel-shaped with a tinge of white. These grow singly near the ends of the stems on a scaly but spineless slender grey-green tube 12–15 cm long.

Round, red fruits 4–5 cm across have scattered bumps with hairs and spines. Numerous small black seeds are embedded in the white, juicy pulp of the fruit, which splits open when ripe.

Harrisia cactus roots are of two types. Shallow feeding roots up to 3 cm thick and 30 cm to 2 m long grow mostly horizontally off a crown, up to 15 cm below ground level. Swollen tuberous storage roots descend to a depth of 15–60 cm.

Life cycle

Harrisia cactus bears a bright red fruit containing 400–1000 small black seeds. Plants are easily established from seed and germinate soon after rain.

Seedlings quickly produce a swollen tuberous food storage root that develops as the plant grows. Branches take root where they touch the ground and new plants will grow from broken branches and sections of underground tubers.

Counts of tubers in dense cactus infestations have shown over 125 000 per hectare. Each plant houses many dormant underground buds that are all capable of reshooting when the tip growth dies; any small portion of the tuberous root left in the soil will grow.

Methods of spread

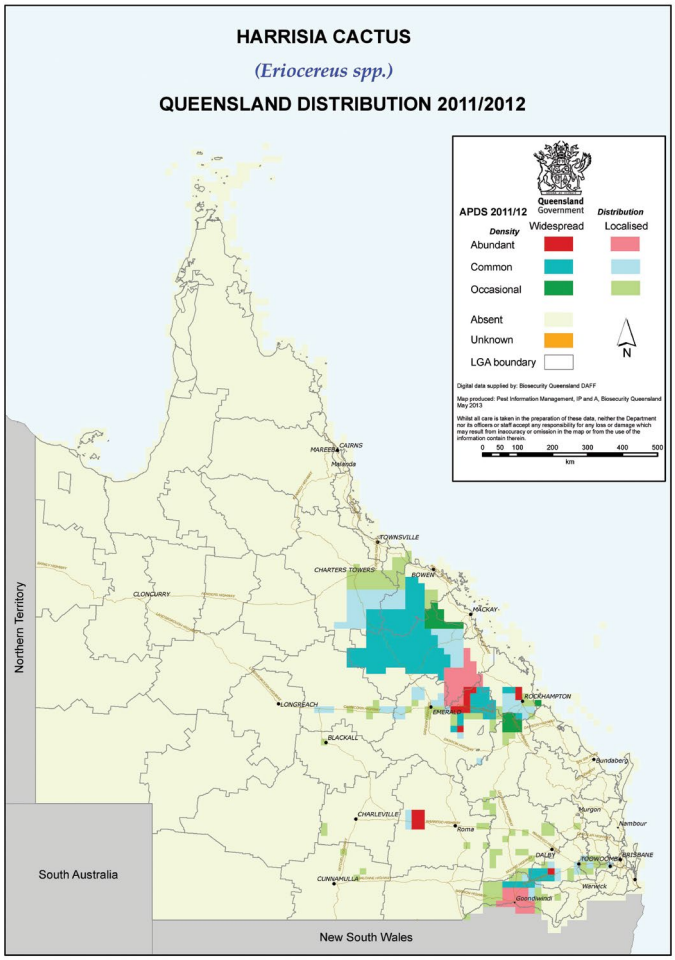
Fruit and seed are readily eaten by birds, mammals and to a lesser extent by feral pigs.

Habitat and distribution

Harrisia cactus is a native of Argentina and Paraguay, South America. It was introduced to Australia as a pot plant in the 1890s. In 1935 it was first recognised as a serious pest in the Collinsville district and by the 1950s was rapidly spreading south.

Harrisia cactus is mainly a pest of brigalow and associated softwood country. However, infestations are now appearing in box and ironbark stands and also in pine forests.

Map 1. Distribution of harrisia cactus in Queensland



The cactus is shade tolerant and reaches its maximum development in the shade and shelter of brigalow scrub, though established infestations can persist once scrub is pulled.

Harrisia cactus is found in the Collinsville, Nebo, Moranbah, Dingo, Blackwater and Goondiwindi districts, with minor infestations occurring at Millmerran, Greenmount, Gatton, Ipswich, Rockhampton, Rannes, Mount Morgan, Alpha and Mitchell.

Control

Managing harrisia cactus

The GBO requires a person to take reasonable and practical steps to minimise the risks posed by harrisia cactus. This fact sheet provides information and some options for controlling harrisia cactus.

Control of this plant is difficult as it has a deep underground tuberous root system and use of a combination of physical, biologic and herbicide controls is recommended.

Physical control

Dig out plants completely and burn. Ensure that all tubers that can grow are removed and destroyed.

Ploughing is not considered an effective means of control unless followed by annual cropping.

Biological control

Two introduced insects have become established in the field:

- a stem-boring longicorn beetle (*Alcidion cereicola)*
- a mealy bug (*Hypogeococcus festerianus*).

The stem-boring beetle only attacks older woody stems. In the Collinsville area, large beetle colonies developed and contributed to the collapse of dense areas of cactus. Populations of *Alcidion cereicola* have declined with the reduction in the cactus in recent years.

The most successful biological control agent is the mealy bug *Hypogeococcus festerianus* which is now present in harrisia cactus in Collinsville, Dingo, Moranbah, Blackwater, Nebo, Charters Towers and Goondiwindi districts, with small colonies established at Alpha, Capella, Rannes, Gatton, Greenmount, Millmerran and Rockhampton.

How mealy bug works

The mealy bug aggregates and feeds in the tips of stems and buds, where it limits growth and causes distortion. This results in the knotting of the stem. The plant's response is to utilise energy reserves within the tuber system to produce new growth. Eventually the plant dies, as it is unable to support the continuous high energy demands.

Dry weather reduces the effectiveness of the mealy bug. When dry, the plant's tuber system becomes dormant. Consequently, mealy bug damage does not result in new growth and the energy reserves within the plant are not affected. Instead the bug may damage all vegetative parts and eventually die out. The tuber will remain dormant until adequate moisture returns, when it will reshoot.

How to spread the bug

Mealy bug disperses naturally via wind, although landholder assistance is necessary for its continuous spread, particularly between patches. The bug is manually spread by cutting infected stems and placing them into healthy plants. The best pieces for starting new colonies are large knobs of twisted and distorted cactus that contain many mealy bugs well protected inside knots. Stem tips covered by white, woolly masses of bug are also good. To collect the bug, cut infected stems approximately 15 cm from the distorted knob and place segments in green, plump sections of the healthy plant. Avoid placing mealy bug in stressed or dried out stems. Small cactus plants require at least one large knot, with larger plants requiring three knots per plant. Where possible, landholders should infest every cactus clump as this ensures a rapid reduction in growth and fruiting potential. When cactus infestations are light, chemical control may be a preferable option.

Cut pieces can be transported in boxes or open vehicles. They are not delicate, but are best kept in the shade. Avoid keeping them in large heaps, in direct sunlight, under tarpaulins or in closed containers for long periods. Such conditions will promote rotting of the stems, leading to poor results or failures. Ideally, stems should be put out within three days and a maximum of five days.

When to infest

Best results come by infesting new areas during spring and early summer, from September to December. Maximum growth and spreading occurs in the summer months of December to February. During the drier and colder months of April to August the mealy bug does not die, but little growth and multiplication occurs. Introduction of mealy bug during autumn and winter will not be lost, but little effect is seen until the following summer.

How soon to expect results

Mealy bugs are generally more active and effective on harrisia cactus growing underneath shrubs and trees, so results will be seen more quickly in these areas than in cactus growing in the open. Best results are obtained when infesting plants that have actively growing new shoots.

During wet summers in northern and central Queensland, the growing points of stems will begin to curl after about six weeks.

By the end of the first summer, damage (severe twisting) will be widespread in infested plants. If the initial infestation was sufficiently heavy, no fruit or growth will occur during the second year, and the cactus will begin to die during the third year. Seedlings and regrowth shoots will continue to be present but by the end of the fourth year there should be very little cactus left.

In the southern portion of the state, where temperatures are lower, the mealy bug still provides control but the process takes longer. However, the mealy bug will do better on cactus in the open, rather than in the shade, as temperatures are higher in the open.

Herbicide control

Foliar application of registered herbicides provides effective control, but can be costly over large areas. Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label (see to Table 1).

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

Table 1. Herbicides for the control of harrisia cactus

Situation	Herbicide	Rate	Comments
Non-crop land and rights-of-way	Dichlorprop as K salt (600 g/L)	1 L/60 L water	Good soil moisture essential Spray plant when actively growing to run-off point A follow-up treatment may be necessary
Native pastures, rights-of-way, commercial and industrial areas	Metsulfuron-methyl (600 g/kg) (e.g. Brush-Off®)	20 g/100 L water + surfactant	Spray plant when actively growing to run-off point A follow-up treatment may be necessary
Agricultural non-crop areas, commercial and industrial areas, fence lines, forestry, pastures and rights-of-way	Triclopyr as butotyl (240 g/L) + Picloram as ioe (120 g/L) (e.g. Access®)	1 L/60 L diesel	Spray plant when actively growing Apply as overall spray, wetting all areas of the plant to ground level
Non-agricultural areas (native pastures), commercial and industrial areas and rights-of-ways	Aminopyralid as K salt 375 g/kg + Metsulfuron methyl 3 g/kg (e.g Stinger)	40 g/100 L water	Spray to thoroughly wet using 1000 to 1400 L/ha Follow-up treatment may be necessary
Commercial and industrial areas, around buildings and rights-of-way	Triclopyr as butotyl 75 g/L + Metsulfuron-methyl 28 g/L (e.g. Zelam Brush Weed®)	500 mL/100 L	Spray to thoroughly wet using 1000 to 1500 L/ha Follow-up treatment may be necessary
Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights-of-way	Triclopyr as tea 200 g/L + Picloram as tipa 100 g/L (e.g. Slasher) or Triclopyr as tea 200 g/L + Picloram as tipa 100 g/L + Aminopyralid 25 g/L (e.g. Tordon RegrowthMaster) (e.g. Tordon DSH®)	2.5 L/100 L water	Spray plant when actively growing (September–March) Treat all stems thoroughly

Read the label carefully before use. Always use the herbicide in accordance with the directions on the label.

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

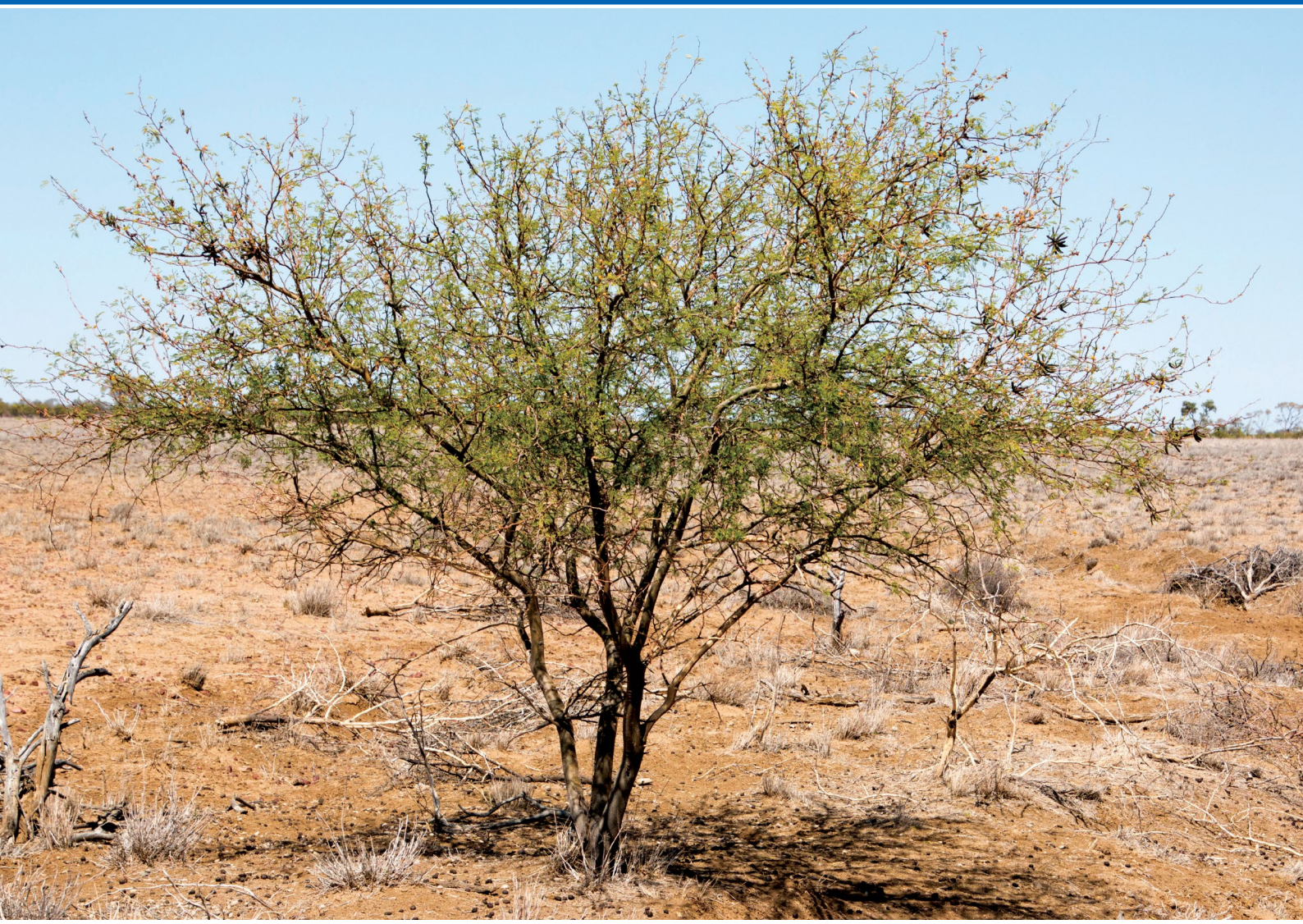
© The State of Queensland, Department of Agriculture and Fisheries, 2017.

Department of Agriculture and Fisheries
Biosecurity Queensland

Invasive plant

Mimosa bush

Acacia farnesiana



Mimosa bush can spread readily and grow quickly. As it often forms thorny thickets, it can be a considerable nuisance during mustering and can also hinder stock access to water.

Mimosa does offer shade in open downs country and can be useful as a supplement to grass during the dry season. It may therefore be a useful plant in some areas if its spread can be controlled to prevent thicket formation. The maintenance of healthy pasture competition is the best mechanism to achieve this.

Legal requirements

Mimosa bush is not a prohibited or restricted invasive plant under the *Biosecurity Act 2014*. However, by law, everyone has a general biosecurity obligation (GBO) to take reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control.

Local governments must have a biosecurity plan that covers invasive plants and animals in their area. This plan may include actions to be taken on certain species. Some of these actions may be required under local laws. Contact your local government for more information.

Queensland Government

Description

Mimosa bush is a rounded shrub or small tree generally growing 2 to 3 m high, occasionally to 5 m. It often forms thorny thickets, and is nearly always multi-stemmed. The branches grow in a zigzag shape and are usually a grey-brown colour with prominent white spots.

Leaves are a ferny type, with 1–6 pairs of leaf 'branches' each with 5–20 pairs of narrow, rounded leaflets 4–8 mm long. Leaves are sometimes more of a yellowish green than a pure green. Thorns are found in pairs at the base of each leaf and can grow up to 10 cm long.

Golden yellow to orangeish flowers are ball-shaped, about 1 cm across, and grow on stalks, usually two stalks at the base of each leaf. Flowers develop into clusters of cigar-shaped pods, slightly curved and up to 6 cm long. The pods are dark brown or black and woody at maturity, with seeds embedded in the pith. Pods do no split open and tend to stay on the plant for a length of time.

Mimosa bush can be confused with the declared weeds mesquite (*Prosopis* spp.) and prickly acacia (*Vachellia nilotica*), particularly when young (see the 'identification of prickle bushes' fact sheet from www.biosecurity.qld.gov.au).

Distribution

Mimosa bush, a native of central and south America, is naturalised in Australia. Mimosa bush is widespread in Queensland, and found in all but the wettest and driest parts of the State. Seeds sprout readily and plants grow rapidly. Mimosa bush does well in dry localities and on loamy or sandy soils, forming thickets along watercourses. Mimosa bush withstands drought well, is readily eaten by stock, and has good regrowth after grazing.

Mimosa bush is not a long-lived plant. It is readily attacked by many native insects and is prone to dieback on an irregular basis. In some parts of the world mimosa bush is cultivated for perfume production.

Control

Basal bark spray

For stems up to 15 cm diameter, carefully spray completely around base of plant to a height of 30 cm above ground level. Thoroughly spray into all crevices. Larger trees may be controlled by spraying to a greater height, up to 100 cm above ground level.

The best time for treatment is during autumn when plants are actively growing and soil moisture is good.

Cut stump treatment

At any time of year, cut stems off horizontally as close to the ground as possible. Immediately (within 15 seconds) swab cut surface with herbicide mixture.

Bore drains

Channels and drains must be empty of water. Spray a one metre strip into the mud in channel or drain. Wait at least three days for diuron to bond to mud before slowly allowing water in again. Water must not be used in domestic water supply or supplied to desirable shade trees for 7–14 days after re-opening the drain.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

Table 1. Herbicides for the control of mimosa bush

Situation	Herbicide	Rate	Optimum time	Comments
Basal bark/ cut stump	Fluroxypyr eg. Starane Advanced®, etc Triclpyr + picloram e.g. Access®	Refer to product label	Basal bark: for plants up to 5 cm basal diameter	
	Triclpyr + picloram e.g. Access®	1 L/60 L diesel	Basal bark: for plants up to 5 cm basal diameter	Ensure all stems on multi-stemmed plants are treated.
Soil application	Tebuthiuron (PERMIT 13891) e.g. Tebulan 200GR herbicide®, Graslan herbicide®, etc	2.0 g/m2 or 20 kg/ha		For use in pastures, roadside and rights of way. Application just prior to rainfall gives best results. Avoid damage to off target species – refer to herbicide label for product restraints and critical comments.
High volume spray	500 g/L clopyralid present as the triisopropanol amine (PERMIT 11638) e.g. Lontrel herbicide®, Nufarm Archer®, Farmoz Victory herbicide®, etc	500 mL of product per 100 L of water (plus non-ionic surfactant at 0.1%)	Spray when plants are actively growing and in full leaf	For use in pastures, rights of way, powerline areas. Full covering of foliage with spray is essential. Withholding period: do not graze treated areas, or cut for stock feed, for seven days after application.
Bore drains	Diuron e.g. Diuron 500SC®, etc	Refer to product label	Do not apply between 1 December and 30 March each year.	Do not apply more than once per calendar year. Do not open drains for 72 hours following treatment. Do not apply if heavy rains are predicted within three days of application. Application should be limited to 1 m strips along the sides of bore drains. Withholding period – do not allow animals to drink water from treated bore drains for three days, before slaughter for human consumption

Read the label carefully before use. Always use the herbicide in accordance with the directions on the label.

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture and Fisheries, 2016.

Department of Agriculture and Fisheries
Biosecurity Queensland

Restricted invasive plant

Mother-of-millions

Bryophyllum delagoense (syn. *B. tubiflorum*, *Kalanchoe delagoensis*) and *Bryophyllum × houghtonii*

Mother-of-millions are native to Madagascar and are escaped ornamental plants. Five species are commonly naturalised in Queensland. It is well adapted to dry areas because of its succulent features.

As the name suggests, one plant can reproduce a new generation from masses of embryoids (plantlets) that are formed on the leaf edges. This makes these plants hard to eradicate and follow up controls are essential.

These plants, especially their flowers, are poisonous to stock and occasionally cause a significant number of cattle deaths. The plant flowers from May to October (during the drier months of the year) and the scarcity of feed at this time may cause cattle to consume lethal amounts of mother-of-millions.

Legal requirements

Mother-of-millions is a restricted invasive plant under the *Biosecurity Act 2014*. It must not be given away, sold, or released into the environment without a permit.

Bryophyllum pinnatum (resurrection plant, live-leaf) is not a restricted invasive plant. However the Act requires everyone to take all reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. This is called a general biosecurity obligation (GBO). This fact sheet gives examples of how you can meet your GBO.

Queensland Government

At a local level, each local government must have a biosecurity plan that covers invasive plants and animals in its area. This plan may include actions to be taken on certain species. Some of these actions may be required under local laws. Contact your local government for more information.

Description

Mother-of-millions are erect, smooth, fleshy succulent plants growing to 1 m or more in height.

All species form tall flower spikes in winter with clusters of bell-shaped flowers. Each species has a distinctive leaf shape, but all produce small plantlets along the edges of the leaves. These plantlets drop readily, develop roots and establish quickly to form a new colony.

Bryophyllum delagoense syn. *B. tubiflorum* and *Kalanchoe delagoensis* (common mother-of-millions, mission bells, Christmas bells) has grey-brown, fleshy, tubular-like leaves with up to seven projections at the tip of each leaf. The flowers are orange-red and occur in a cluster at the top of a single stem. Seeds can germinate for some years.

Bryophyllum × *houghtonii* syn. *B. daigremontianum* × *B. delagoense, Kalanchoe* × *houghtonii* (hybrid or crossbred mother-of-millions) has similar flowers arranged in a branched cluster at the top of the stem. Its leaves are boat shaped with thick stalks and notches along the edges of the leaves.

A third species, *Bryophyllum pinnatum (*resurrection plant, live-leaf) has yellow-green, oval, fleshy leaflets with wavy edges and up to five leaflets per leaf. Its flowers are yellowish-green, often tinged with pink, and occur in loose clusters on stalks growing at intervals along the upper portion of the stem.

Life cycle

Mother-of-millions flowers in Winter and reproduces by seed and by tiny plantlets that are produced at the tips of its fleshy (succulent) leaves. Dislodged leaves and broken leaf parts can also take root and give rise to new plants.

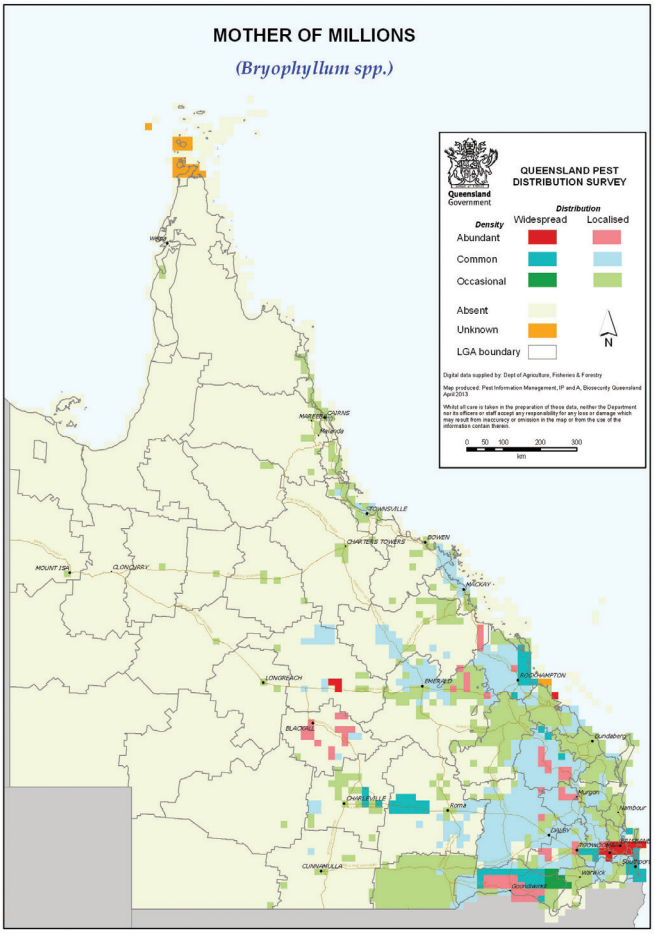
Methods of spread

Mother-of-millions is commonly spread by garners and in garden waste. The tiny seeds are probably wind and water dispersed and its leaves and plantlets may also be dislodged and spread by animals, vehicles, machinery, soil and slashers.

Habitat and distribution

Native to Madagascar, these popular succulent garden plants have escaped culitvation and spread in various areas of Queensland. They have become a problem in pasture lands in the central highlands around Clermont, Emerald and Dingo, and the Burnett, Moreton and Darling Downs scrub regions. The plants establish well in leaf litter or other debris on shallow soils in shady woodlands, and often grow on roadsides, along fence lines and around old rubbish dumps. They can spread from these areas, especially in flood, and establish if pastures are run down.

Map 1. Distribution of mother-of-millions in Queensland



They are adapted to dry conditions and can survive long periods of drought.

Toxicity

These plants are toxic, especially their flowers, and occasionally cause a significant number of cattle deaths. When cattle are under stress or in unusual conditions they are more likely to eat plants that they would not normally eat. Shifting cattle to new paddocks, moving stock through infested rubbish dumps and wastelands, and reduction of availability of feed due to flood or drought can all contribute to cattle eating mother-of-millions and being poisoned.

Poisoned cattle show signs of dullness, loss of appetite, diarrhoea and heart failure. Some cattle may drool saliva or dribble urine. There are two responses to poisoning:

- acute—where cattle die within a day
- chronic—where cattle may take up to five days to die.

Some cattle may make a slow recovery if insufficient plant material was eaten.

Poisoned cattle must be treated within 24 hours of consuming the plant. The treatment is intense and needs to be given by a veterinarian, or under their direction, because of the drugs and materials used.

Control

Managing mother-of-millions

The GBO requires a person to take reasonable and practical steps to minimise the risks posed by mother-of-millions. This fact sheet provides information and some options for controlling mother-of-millions.

Prevention and early detection

The best form of weed control is prevention. Always treat weed new infestations when small—do not allow weeds to establish. Weed control is not cheap, but it is cheaper to do it now rather than next year, or the year after. Proper planning ensures better value for each dollar spent.

Permanent control of mother-of-millions infested areas is best ensured by establishing more desirable plants in that location to compete successfully with future mother-of-millions seedlings and plantlets. This is best achieved through soil preparation, replanting, fertilising and using the area more productively.

Ensure scattered infestations and small dumping areas on properties are regularly checked and cleaned up. Day-today hygiene management will help prevent establishment of these weeds.

Co-operative control upstream and downstream of problem areas will help prevent re-infestation from other areas.

To prevent poisoning, keep stock (especially hungry stock) away from infested areas until the plants are controlled.

Mechanical control

For small areas, pull up plants by hand and burn on a wood heap. Alternatively, bag the plants and dump them in a bin, the contents of which are buried at council refuse tips rather than being recycled into mulch.

Fire

When suitable (e.g. after grading firebreaks), burn infestations and the accompanying debris on which mother-of-millions plants thrive. This is the most economical form of control, encourages grass competition and lessens the problem for following years, requiring only spot spraying with selective herbicides.

Biological control

The South African citrus thrip is present in Queensland and is quite widespread through the south of the state. The thrip damages the outer tissue of the mother-of-millions plant and also lays its eggs under the outer tissue. Where high populations of thrips exist, the number of viable plantlets and flowers forming on mother-of-millions is reduced.

The thrips populations vary from year to year, according to mother-of-millions populations and climate. The South African citrus thrips should not be seen as a long term control strategy—only a control option to complement other techniques such as herbicide treatment and burning.

The department is undertaking further research to identify potential biological control agents to support with management.

Herbicide control

Before using any herbicide always read the label carefully. All herbicides must be applied strictly in accordance with the directions on the label. Where the addition of a wetting agent is recommended, always use a commercial wetting agent or surfactant.

Mother-of-millions may be controlled with herbicides at ny time of the year, but infestations are easiest to see in winter when the plants are in flower. Treating infestations at this time of year also has the benefit of preventing new seeds from developing on common mother-of-millions.

Table 1 details the herbicides registered for mother-of-millions control.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

Bryophyllum x *houghtonii* (left) and *Bryophyllum delagoense* (right)

South African citrus thrips damage to mother-of-millions

Table 1. Herbicides for the control of mother-of-millions

Situation	Herbicide	Rate	Comments
Pastures and non-crop land	2,4-D acid (e.g. Affray 300)	7 L/1000 L water per ha 70 mL/10 L water	High volume foliar spray (handgun) High volume foliar spray (knapsack)
Pastures, rights-of-way and industrial	2,4-D amine 700 g/L (e.g. Amicide Advance 700)	360 mL/100L water	Hand gun and knapsack only. Thorough coverage is essential. Use a surfactant (e.g. Nufarm Activator) (consult label).
Pastures, rights-of-way, non-crop land, forests, non-agricultural land and commercial and industrial areas	Triclopyr 300 g/L + Picloram 100 g/L (e.g. Conqueror) or Triclopyr 300 g/L + Picloram 100 g/L + Aminopyralid 8 g/L (e.g. Grazon Extra)	500 mL/100 L water 50 mL/10 L water	High volume foliar spray (hand gun, knapsack). Always add a wetting agent (e.g. BS-1000 or Chemwet 1000) at 100 mL/100 L water. Apply at flowering.
	Fluroxypyr 200 g/L (e.g. Flagship 200)	600 mL/100 L water + sufactant (consult label)	Apply to seedlings and young plants before flowering.
	Fluroxypyr 333 g/L (e.g. Starane Advanced)	360 mL/100 L water + sufactant (consult label)	
	Fluroxypyr 400 g/L (e.g. Comet 400)	300 mL/100 L water + sufactant (consult label)	

Notes
Thorough, even coverage of leaves and plantlets is necessary.
Note that many 2,4-D products are not registered for control of mother-of-millions in Queensland. Only use products registered for the purpose.

Read the label carefully before use. Always use the herbicide in accordance with the directions on the label.

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture and Fisheries, 2016.

Department of Agriculture and Fisheries
Biosecurity Queensland

Restricted invasive plant

Parthenium

Parthenium hysterophorus

Parthenium is a vigorous species that colonises weak pastures with sparse ground cover. It will readily colonise disturbed, bare areas along roadsides and heavily stocked areas around yards and watering points. Parthenium can also colonise brigalow, gidgee and softwood scrub soils. Its presence reduces the reliability of improved pasture establishment and reduces pasture production potential.

Parthenium is also a health problem as contact with the plant or the pollen can cause serious allergic reactions such as dermatitis and hay fever.

Parthenium is listed as a Weed of National Significance.

Legal requirements

Parthenium is a restricted invasive plant under the *Biosecurity Act 2014*. It must not be given away, sold, or released into the environment without a permit. The Act requires everyone to take all reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. This is called a general biosecurity obligation (GBO). This fact sheet gives examples of how you can meet your GBO.

At a local level, each local government must have a biosecurity plan that covers invasive plants and animals in its area. This plan may include actions to be taken on certain species. Some of these actions may be required under local laws. Contact your local government for more information.

Queensland Government

Description

Parthenium is an annual herb with a deep tap root and an erect stem that becomes woody with age. As it matures, the plant develops many branches in its top half and may eventually reach a height of 2 m.

Its leaves are pale green, deeply lobed and covered with fine soft hairs.

Small creamy white flowers occur on the tips of the numerous stems. Each flower contains four to five black seeds that are wedge-shaped, two millimetres long with two thin, white scales.

Life cycle

Parthenium normally germinates in spring and early summer, produces flowers and seed throughout its life and dies around late autumn. However, with suitable conditions (rain, available moisture, mild temperatures), parthenium can grow and produce flowers at any time of the year. In summer, plants can flower and set seed within four weeks of germination, particularly if stressed.

Methods of spread

Parthenium seeds can spread via water, vehicles, machinery, stock, feral and native animals and in feed and seed. Drought conditions aid the spread of seed with increased movements of stock fodder and transports.

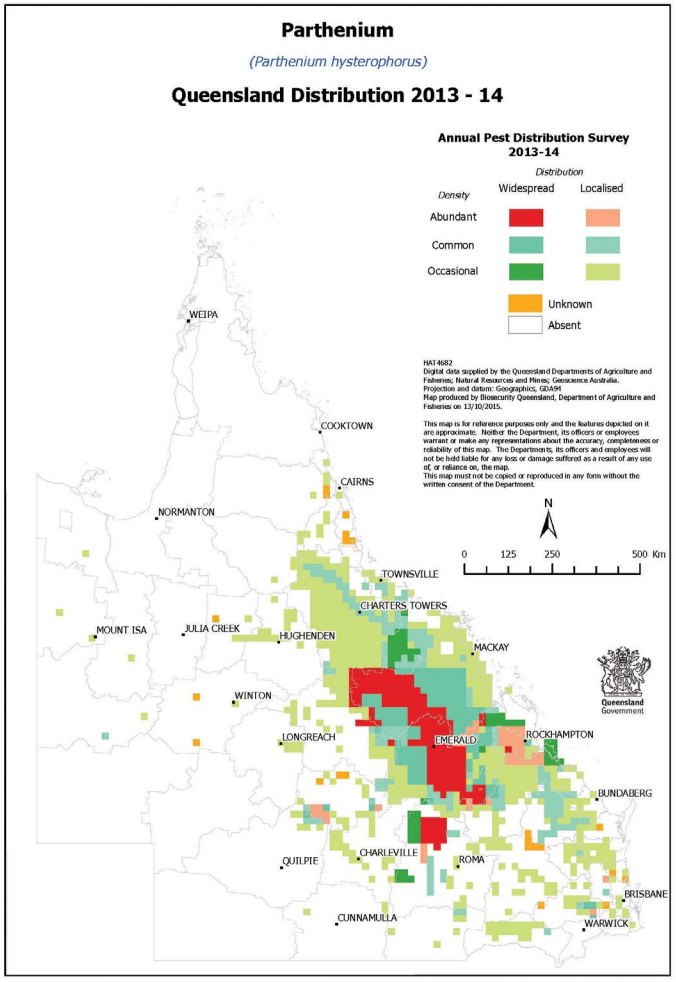
Habitat and distribution

Parthenium is capable of growing in most soil types but becomes most dominant in alkaline, clay loam soils.

The plant is well established in Central Queensland and present in isolated infestations west to Longreach and in northern and southern Queensland.

Infestations have also been found in northern and central parts of New South Wales and it is capable of growing in most states of Australia.

Map 1. Distribution of parthenium in Queensland



Control

Managing parthenium

The GBO requires a person to take reasonable and practical steps to minimise the risks posed by parthenium. This fact sheet provides information and some options for controlling parthenium.

Prevention and weed seed spread

Pastures maintained in good condition, with high levels of grass crown cover, will limit parthenium colonisation. Drought, and the subsequent reduced pasture cover, creates the ideal window of opportunity for parthenium colonisation when good conditions return.

Vehicles and implements passing through parthenium infested areas should be washed down with water. Particular care should be taken with earthmoving machinery and harvesting equipment. The wash down procedure should be confined to one area, so that plants that establish from dislodged seed can be destroyed before they set seed.

Extreme caution should be taken when moving cattle from infested to clean areas. Avoid movement during wet periods as cattle readily transport seed in muddy soil. On arrival, cattle should be held in yards or small paddocks until seed has dropped from their coats and tails prior to their release into large paddocks. Infestations around yards can be easily spotted and controlled whereas infestations can develop unnoticed in large paddocks.

Particular care should be taken when purchasing seed, hay and other fodder materials. Always keep a close watch for the emergence of parthenium or other weeds on areas where hay has been fed out.

Property hygiene is important. Owners of clean properties should ensure that visitors from infested areas do not drive through their properties. If your property has parthenium on it, ensure that it is not spread beyond the boundary or further within the property.

Manual control

Hand pulling of small areas is not recommended. There is a health hazard from allergic reactions and a danger that mature seeds will drop off and increase the area of infestation.

Pasture management

Grazing management is the most useful method of controlling large-scale parthenium infestations. Maintain pastures in good condition with high levels of ground and grass crown cover. This may require rehabilitation of poor pastures, followed by a sound grazing maintenance program.

Sown pasture establishment—Poor establishment of sown pastures can allow parthenium colonisation.

Pasture agronomy—Aerial seeding prior to scrub pulling is normally beneficial.

Overgrazing—High grazing pressure caused by drought or high stock numbers decreases the vigour and competitiveness of pastures and allows the entry and spread of parthenium. Maintenance of correct stock numbers is most important in controlling parthenium.

Pastures spelling—In situations of serious infestation, pasture spelling is essential for rehabilitation. Total spelling is much more effective than simply reducing the stocking rate. However, overgrazing of the remainder of the property must be avoided.

The most appropriate time for pasture spelling is the spring–summer growing period, with the first 6–8 weeks being particularly important. If the condition of perennial grasses (native or sown) is low, spelling for the entire growing season may be required or introduced grasses may need to be re-sown. Herbicide treatment can hasten the rehabilitation process by removing a generation of parthenium seedlings and allowing grass seedlings to establish without competition. In the presence of parthenium, grass establishment is poor.

Grazing during winter should not increase the parthenium risk. Most tropical grasses are dormant and can tolerate moderate grazing during this period. However, parthenium may germinate and grow at this time.

Fencing—One of the main problems in controlling parthenium is the large paddock size and the variability of country within paddocks. The resulting uneven grazing pressures encourage parthenium to colonise the heavily grazed country. Ideally, similar land types should be fenced as single units. Fencing can be used to great effect to break up large paddocks, allowing more flexible management such as pasture spelling or herbicide application, options not available previously.

Burning—Burning is not promoted as a control strategy for parthenium. However, research suggests that burning for pasture management (e.g. woody weed control) should not result in an increased infestation if the pasture is allowed to recover prior to the resumption of grazing. Stocking of recently burnt areas known or suspected to contain parthenium decreases pasture competition and favours parthenium, ultimately creating a more serious infestation.

Biological control

The combined effects of biological control agents reduced the density and vigour of parthenium and increased grass production.

There are currently a number of insect species and two rust pathogens that have been introduced to control parthenium—a selection of these are outlined below. *Epiblema strenuana* is a moth introduced from Mexico established in all parthenium areas. The moth's larvae feed inside the stem, forming galls that stunt the plant's growth, reduce competitiveness and seed production.

Listronotus setosipennis is a stem-boring weevil from Argentina but is of limited success in reducing parthenium infestations.

Zygogramma bicolorata is a defoliating beetle from Mexico which is highly effective where present. It emerges in late spring and is active until autumn.

Smicronyx lutulentus (Mexico) lays eggs in the flower buds where the larvae feed on the seed heads. *Conotrachelus albocinereus* (stem-galling weevil from Argentina) produces small galls and is still becoming established in Queensland.

Bucculatrix parthenica (leaf mining moth from Mexico) larvae feed on leaves, leaving clear windows in the leaf. *Carmentia ithacae* is a stem boring moth from Mexico which is becoming established at favourable sites in the northern Central Highlands.

Puccinia abrupta is a winter rust from Mexico that infects and damages leaves and stems. It is currently established over a wide area from Clermont south. It requires a night temperature of less than 16 degrees and 5–6 hours of leaf wetness (dew). Sporadic outbreaks occur where weather conditions are suitable.

Puccinia melampodii is a summer rust from Mexico that weakens the plant by damaging the leaves over the summer growing season. It is currently established and spreading at a number of sites from north of Charters Towers to Injune in the south.

Herbicide control

Non-crop areas

Parthenium should be sprayed early before it can set seed. A close watch should be kept on treated areas for at least two years.

Small and/or isolated infestations should be treated immediately. Herbicide control will involve a knockdown herbicide to kill plants that are present and a residual herbicide to control future germinations. Repeated spraying may be required even within the one growing season to prevent further seed production.

Extensive infestations will require herbicide treatment in conjunction with pasture management. Timing of spraying is critical so that parthenium is removed when plants are small and before seeding has occurred. Grasses should be actively growing and seeding so that they can recolonise the infested area.

Table 1. shows the herbicides registered for parthenium control and application rates. All herbicides must be applied strictly in accordance with the directions on the label.

Cropping areas
Controlling parthenium in cropland requires selective herbicide use and/or crop rotations. For further information on parthenium control in crops consult your local biosecurity officer.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

Table 1. Herbicides for the control of parthenium

Situation	Herbicide	Rate	Comments
Pastures, rights-of-way and industrial land	2,4-D as amine 625 g/L (e.g. Ken-Amine 625)	320 mL/100 L water	Spot spray Apply to young actively growing plants, ensuring thorough coverage
	2,4-D as amine 700 g/L (e.g. Amicide Advance 700)	285 mL/100L water	
Non agricultural areas (native pastures), commercial and industrial areas, rights-of-way	Aminopyralid 375 g/kg plus metsulfuron-methyl 300 g/kg (Stinger)	10 g/100 L water plus wetting agent Consult label	Spray to thoroughly wet all foliage but not to cause run-off
Fields and fallow, various crops (see label)	Atrazine 500 g/L (e.g. Kenso Atrazine 500)	3.6–6 L/ha Rate varies with situation Consult label	Boom spray. Pre and post emergent application Restrictions apply. Consult label for details of specific conditions. Max 3 kg a.i./ha/yr
Roadside and rights-of-way		6 L/ha	Boom spray. Pre and post emergent application Restrictions apply. Consult label for details of specific conditions. Max 3 kg a.i./ha/yr
Fields and fallow, various crops (see label)	Atrazine 900 g/kg (e.g. Atradex WG)	2–3.3 kg/ha Rate varies with situation Consult label	Boom spray. Pre and post emergent application Restrictions apply. Consult label for details of specific conditions. Max 3 kg a.i./ha/yr
Roadside and rights-of way		3.3 kg/ha	Boom spray. Pre and post emergent application. Restrictions apply. Consult label for details of specific conditions. Max 3 kg a.i./ha/yr
Non-crop areas, commercial and industrial areas, pastures and rights-of-way	2,4-D 300 g/L + picloram 75 g/L (e.g. Tordon 75-D)	125 mL/100 L	Spot spray during rosette stage Use at least 3000 L/ha in dense infestations Consult label
		3 L/ha	Boom spray during rosette stage Consult label
Native pastures, rights-of-way, commercial and industrial land	metsulfuron methyl 600g/L (e.g. Associate)	5 g/100 L water + wetter	Hand gun. Spray to thoroughly wet all foliage but not to cause runoff
		7 g/ha + wetter	Boom spray. For pastures only. Treat in rosette stage. Consult label for details
Wheat, barley, triticale and cereal rye		5–7 g/h	Boom spray. Lower rate up to 4-leaf stage, higher rate 4-leaf stage to rosette
Native pastures, rights-of-way, commercial and industrial land	Triclopyr 75 g/L + metsulfuron-methyl 28 g/L (e.g. Zelam Brush Weed)	125 mL/100 L water	Spot spray plants from rosette to flowering Consult label for critical comments
Commercial and industrial areas, rights-of-way, around agricultural buildings	Hexazinone 750 g/kg (e.g. Velpar DF)	1 kg/ha 2 g/10 L/20 m^2	Boom spray or spot spray
Around agricultural buildings	Hexazinone 250 g/L (e.g. Velpar L)	3.5 L/ha or 7 L/10 L/20 m^2	
Grass pastures, fallows, various crop and non-crop situations (consult label for details	Dicamba 500 g/L (e.g. Kamba 500) Dicamba 700 g/kg	Rates vary with situation Consult label	Boom spray or spot spray Consult label for details and critical comments

A number of the listed herbicides are available as different formulations, but some may not be registered for parthenium. Check the label for registration, rate and critical comments. Only use products that list parthenium on the label. The registered rates are for non-crop uses. Consult label for in-crop recommendations. For power hand spray or knapsack use, spray plants to the point of runoff.

Read the label carefully before use. Always use the herbicide in accordance with the directions on the label.

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture and Fisheries, 2016.

Department of Agriculture and Fisheries
Biosecurity Queensland

Restricted invasive plant

Opuntioid cacti

Austrocylindropuntia, *Cylindropuntia* and *Opuntia* species

Three types (genera) of opuntioid cacti have naturalised in Australia and are now considered Weeds of National Significance: *Austrocylindropuntia, Cylindropuntia* and *Opuntia*. They are drought resistant because of their succulent nature, their lack of leaves and their thick, tough skins. These features result in plants that use the majority of their internal tissues for water storage and their outer parts to reduce water loss and damage by grazing and browsing animals. They can remain vigorous in hot, dry conditions that cause most other plants to lose vigour or even die. Some species develop underground bulbs that enable the plant to resist fire and mechanical damage.

Dense infestations compete with native vegetation, limiting the growth of small shrubs and groundcover species. The plant's sharp spines or barbs can cause injury to stock and native animals and contaminate wool and hides, reducing or preventing grazing activities and productivity.

Large stands of cacti provide harbour for pest animals, such as foxes and rabbits and, due to their spiny nature, can limit access for stock mustering and recreational activities. The spines are capable of causing serious injury to animals and humans.

Queensland Government

Legal requirements

All Cholla cacti (*Cylindropuntia* spp.) and prickly pear (*Opuntia* spp.) not listed below are prohibited invasive plants and the *Biosecurity Act 2014* requires that all sightings to be reported to Biosecurity Queensland within 24 hours. By law, everyone has a general biosecurity obligation (GBO) to take all reasonable and practical steps to minimise the risk of these cacti spreading until they receive advice from an authorised officer.

The following species are restricted invasive plants under the Act. The Act requires that all sightings of these cacti must be reported to Biosecurity Queensland within 24 hours of the sighting. By law, everyone has a GBO to take all reasonable and practical steps to minimise the risk of spread of these cacti until they receive advice from an authorised officer.

- Hudson pear (*Cylindropuntia rosea* and *C. trunicata*)
- Jumping cholla (*Cylindropuntia prolifera*)
- Bunny ears (*Opuntia microdasys*)
- Riverina pear (*Opuntia elata*)

The following species are restricted invasive plants under the *Biosecurity Act 2014*. They must not be given away, sold, or released into the environment without a permit. The Act requires everyone to take all reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. This is called a general biosecurity obligation (GBO). This fact sheet gives examples of how you can meet your GBO.

- Cane cactus (*Austrocylindropuntia cylindrical*)
- Eve's pin cactus (*Austrocylindropuntia subulata*)
- Coral cactus (*Cylindropuntia fulgida*)
- Devil's rope pear (*Cylindropuntia imbricata*)
- Snake cactus (*Cylindropuntia spinosior*)
- Common pest pear, spiny pest pear (*Opuntia stricta* Syn. *O. inermis)*
- Drooping tree pear (*Opuntia monacantha* Syn. *O. vulgaris*)
- Tiger pear (*Opuntia aurantiaca*)
- Velvety tree pear (*Opuntia tomentosa*)
- Westwood pear (*Opuntia streptacantha*)

Indian fig (*Opunia ficus-indica*) is not prohibited or restricted invasive plant.

At a local level, each local government must have a biosecurity plan that covers invasive plants and animals in its area. This plan may include actions to be taken on certain species. Some of these actions may be required under local laws. Contact your local government for more information.

Description

Opuntioid cacti vary significantly in their form and habit, ranging from low-growing shrubs under 50 cm to erect trees up to 8 m tall.

Plants are normally leafless succulent shrubs. Stems are divided into segments (pads or joints) that are flat and often incorrectly called leaves.

Young shoots have true leaves resembling small fleshy scales that fall off as the shoot matures.

Flowers are large, normally seen during spring and can be yellow, orange, red, pink, purple or white depending on the species. Fruits vary between species and can be red, purple, orange, yellow or green.

Areoles (spots with clusters of spines) are found on both the pads (joints, segments) and fruit. In addition to spines, areoles often have clusters of sharp bristles (glochids) and tufts of fibre ('wool'). Each areole contains a growing point that can produce roots or shoots.

Hudson pear *(Cylindropuntia rosea and C. tunicata)*

Densely branched cactus up to 1.5 m tall and 3 m wide. Spines are extremely sharp, 4.5 cm long, enclosed in whitish papery sheaths. Spines on *C. rosea* are white and *C. tunicata* are brown. Flowers on *C. rosea* are pink-purple, and on *C. tunicata* they are pink-yellow, 5 cm wide. Stem segments are green to grey-green, cylindrical, 90 cm long, 4 cm wide. Fruit is oval-shaped, up to 4.5 cm long, yellow when ripe.

Jumping cholla (*Cylindropuntia prolifera*)

Low shrub 0.4 to 1 m tall. Spines 7–11, 1–2 cm long, light to dark brown, interlacing, white to light tan sheath firmly attached. Flowers are rose to magenta, 25–30 mm wide. Stem segments are dull green to greenish grey, whorled or subwhorled, cylindrical, 4–15 cm long, 4–5 cm wide, waxy flaky surface when dry. Prominent tubercles and segments easily detached. Fruit obovoid to globose, solitary or forming chains, up to 20–50 mm long, green. Seed not seen in Australia.

Bunny ears *(Opuntia microdasys)*

Dense shrub 40–60 cm tall, occasionally more. Stems are pad-like, 6–15 cm long, 4–12 cm wide. No central stem, pads always grow in pairs, giving appearance of bunny ears. Has no spines, but instead has numerous white or yellow glochids (hair-like prickles), 2–3 mm long, in dense clusters. Flowers are yellow, 3 cm wide. Fruits are fleshy, globular, 3 cm long, red-purple.

Riverina pear *(Opuntia elata)*

Branched shrub with erect branches to 2 m tall. Spines absent or 1–3 short spines, whitish yellow present at some areoles. Flowers are orange, 3–4 cm wide. Stem segments are glossy green, sometimes with a purple tinge (especially around the areoles and margins). Often more than 2 cm thick, 5–25 cm long. Fruit club shaped, up to 6 cm long, purplish red.

Cane cactus *(Austrocylindropuntia cylindrica)*

Dark green shrub, 0.5–1.5 m tall. Branches 35–40 mm diameter. Leaves on new growth, deciduous, 3–5 mm long, but up to 10 mm on regrowth. Spines without papery sheath, 3–6 major ones per areole, 9–25mm long, and 3–4 minor ones, to 5.5 mm long. Flowers are red to red-orange. Fruit solitary or in small chains of 2–4. 30–60 mm long, dark green to yellow-green.

Eve's pin cactus *(Austrocylindropuntia subulata)*

Robust shrub to 3 m tall. Branches 40–50 mm diameter. Spines without papery sheath, 1 per areole on new growth, additional smaller ones (up to five) developing in successive years, mostly 35–70 mm long. Flowers are pink. Stem segments are glossy green, sometimes with a purple tinge (especially around the areoles and margins). Often more than 2 cm thick, 5–25 cm long. Fruit large, solitary or in small chains of 2–4, green, 50–135 mm long.

Coral cactus *(Cylindropuntia fulgida)*

Coral cactus grows as a branching shrub 1–1.5 m high. The stems of coral cactus are divided into green cylinder-like pads that are fist-like and obtuse at their apex. Mature coral cactus pads widen, become distorted and wavy, and resemble a piece of coral. Areoles along the pads have a number of short white spines.

Coral cactus produces small (1–2 mm wide) scarlet flowers. The fruit is yellow-green and 2–5 cm wide.

Devil's rope pear *(Cylindropuntia imbricata)*

This open-branching shrub grows 1.5–3 m high. The stems are divided into hairless, dull green, cylindrical pads that vary up to 37 cm in length and are 3.5–5 cm thick. The pads have a series of short raised ridges that give them a twined, rope-like appearance. The areoles are found on these ridges and produce 3–11 pale yellow or white spines, with the longest being 2.5 cm long. Papery sheaths cover these spines.

The flowers are a dull, red-purple colour and found at the ends of pads. The yellow fruit resembles a small, 5 cm wide custard apple and has a spineless areole at the top.

Snake cactus *(Cylindropuntia spinosior)*

This open-branching shrub grows 1–2 m high. The stems are divided into hairless, dull green, cylindrical pads that vary up to 20 cm in length and are 3.5–5 cm thick. The pads have a series of short raised ridges that give them a twined rope-like appearance. The areoles are found on the bottom of these ridges and produce 5–10 pale yellow to brown spines, with the longest being 3 cm long.

The flowers are light red to dark rose and commonly 5–7 cm wide. Snake cactus produces fruit that is yellow and 2–5 cm wide.

Common pest pear, Spiny pest pear *(Opuntia stricta)*

This bushy, spreading plant grows up to 1.5 m high and forms large clumps. The stems are divided into oval, blue-green spineless pads 20 cm long and 10 cm wide. Areoles are in diagonal lines along the pads 2.5 cm to 5 cm apart and have a cushion of brown wool containing bristles but usually no spines. When spines occur they are stout, yellow and up to 4 cm long.

Flowers that are 7.5 cm wide, bright lemon yellow and green at the base. The fruit is oval-shaped, has a deep cavity on one end and tapers at the other. It is purple, 6 cm long and 3 cm wide, with carmine-coloured (dark red) seeds and a fleshy pulp.

Drooping tree pear *(Opuntia monacanta)*

This erect succulent shrub with fibrous roots grows up to 5 m high but is usually 2–3 m high. The branches are divided into glossy light green pads up to 45 cm long, 15 cm wide and 1.5 cm thick. The dark grey trunk grows up to 25 cm in diameter. Drooping tree pear gets its name because the upper segments tend to droop. The areoles on the older pads have 1–5 sharp spines about 5 cm long.

Small, scale-like leaves are found on areoles of very young pads and are quickly shed as the pad grows. Drooping tree pear produces yellow flowers that are 6 cm wide and have red markings on the back. The fruit is pear-shaped and 4–7 cm long with a green skin. The flesh of the fruit is red and pulpy and contains round seeds that are yellow or pale brown. The fruits have areoles with tufts of fine, barbed bristles.

Tiger pear *(Opuntia aurantiaca)*

This succulent low shrub with underground tubers usually grows 30–60 cm high. The stems are divided into very spiny, slightly flattened pads that are 1–30 cm long and 1–5 cm wide. The stems are dark green to purple and red in colour. The areoles have 3–7 brown barbed spines up to 4 cm long surrounded by tufts of short, fine bristles. The pads detach easily and are transported on the skins of animals. Small and scale-like leaves are found on areoles of immature pads.

Tiger pear produces 6 cm wide yellow flowers. The rarely formed fruits are pear-shaped and about 2.5 cm long. When ripe, they are red with purple markings.

Velvety tree pear *(Opuntia tomentosa)*

This tree-like plant forms a central woody trunk over 40 cm wide and grows up to 5 m high. The stems are divided into oblong pads that are dull green and velvety to touch due to the dense covering of short fine hairs. The pads are 15–35 cm long, 8–12 cm wide and 1.5–2 cm thick.

Young plants have 2–4 white or pale yellow spines located in the areoles with one spine reaching a length of 2.5 cm. The areoles usually become spineless as the plant matures. A more spiny variety does exist and has more than 50 spines in each areole on the trunk.

The flowers are a deep orange. The fruit is egg-shaped, about 5 cm long and 3 cm wide, and dull red. The top of the fruit is saucer-shaped with circular lines that meet in the centre and give the fruit a shrivelled appearance. The fruit produces many seeds within a reddish pulp.

Westwood pear or Cardona pear *(Opuntia streptacantha)*

Westwood pear is a shrub-like or tree-like plant that forms clumps by branching from the base and is usually 2–4 m high. The stems are divided into almost circular dull green pads, 25–30 cm long and 15–20 cm wide. The areoles have white spines that vary in number and size when the plant matures.

Young pads have 2–5 white spines 1–2 cm long, accompanied by two hair-like spines 0.5 cm long in the lower part of the areole. Spines increase in number (up to 20) and size (5 cm long) in areoles along the trunk of the plant.

The flowers are yellow and fruits are barrel-shaped, 6 cm long and 5 cm wide with a flat top. The fruit has a purple skin and a rind that is 1 cm thick. Fruits contain red seeds buried in a dark red (carmine) pulp.

Habitat and distribution

Native to the Americas, Opuntioid species are found throughout most Australian states and territories and there is potential for further spread.

In Queensland Opuntioid species are mainly found in low rainfall areas but can be are found in gardens,along beaches and on off shore island.

Life cycle

Opuntioids reproduce both sexually and asexually. Birds and other animals readily eat the many seeded fruits and deposit seeds in their droppings. The seeds have hard seed coats that allow them to survive heat and lack of water. Asexual reproduction (cloning) of cacti occurs when pads (joints, segments) or fruits located on the ground take root and produce shoots.

Methods of spread

Animals and floods move broken pads long distances. These pads can survive long periods of drought before weather conditions allow them to set roots. People can spread cacti for ornamental plantings.

Control

Managing opuntioid cacti

The GBO requires a person to take reasonable and practical steps to minimise the risks posed by opuntioid cacti. This fact sheet provides information and some options for controlling opuntioid cacti.

Mechanical and fire control

Mechanical control using machinery is difficult because prickly pear pads can easily re-establish. A hot fire is an effective control method for dense prickly pear infestations. Before burning, consult Biosecurity Queensland to see if this practice is suitable for your pasture and land management practices.

Biological control

Investigations into biological control agents against prickly pear began in 1912. Over 150 insect species were studied throughout the world, with 52 species selected for transport to Queensland. Following intensive host specificity testing, 18 insects and one mite were released in Queensland. Nine insects and the mite remain established in Queensland. These species are:

Cactoblastis cactorum, a stem-boring moth

- *Dactylopius ceylonicus*, a cochineal mealy bug
- *Dactylopius opuntiae*, a cochineal mealy bug
- *Dactylopius confusus*, a cochineal mealy bug
- *Dactylopius tomentosus*, a cochineal mealy bug
- *Dactylopius austrinus*, a cochineal mealy bug
- *Chelinidea tabulata*, a cell-sucking bug
- *Tucumania tapiacola*, a stem-boring moth
- *Archlagocheirus funestus*, a stem-boring beetle
- *Tetranychus opuntiae*, prickly pear red spider mite.

These biological control agents continue to keep several prickly pear species under control. It is important to remember not all the agents attack all species.

The most successful of these agents were the moth *Cactoblastis cactorum* and five cochineal mealy bugs—*Dactylopius ceylonicus, D. opuntiae, D. confusus, D. tomentosus* and *D. austrinus*. The other agents are still around but not in sufficient numbers to provide control.

Cactoblastis cactorum (cactoblastis moth)

Larvae of this moth were introduced from Argentina in 1925. Cactoblastis proved to be the most effective agent against the common and spiny pest pears, destroying massive infestations in Australia. Larvae keeps these two pest pears controlled to an acceptable level most of the time, although it is less effective in some coastal and far western areas.

The larvae collectively eat out the contents of the pads, leaving empty pad skins and piles of mushy droppings. The orange and black larvae are occasionally observed on the outsides of pads. Cactoblastis also attacks most types of prickly pear but is not effective against them.

Dactylopius spp. (cochineal insects)

All female cochineal insects are small, sessile mealy bugs that spend their adult lives permanently attached to their host plants sucking plant juices. They are covered by a fine, white, waxy secretion and when crushed yield a carmine colouring. The adult males are small, free-flying insects that do not feed.

Dactylopius ceylonicus (monacantha cochineal, Argentine cochineal)

This South American mealy bug was released in 1914 and 1915 to control drooping tree pear. It destroyed the dense infestations existing at that time. It is specific to drooping tree pear and today remains the only effective biological control agent for drooping tree pear. This insect needs to be distributed manually.

Dactylopius opuntiae (prickly pear cochineal)

This mealy bug was introduced from Mexico and southern United States between 1920 and 1922. It is effective against common pest pear, spiny pest pear, velvety tree pear and Westwood pear and remains the main biological control agent against velvety tree pear and Westwood pear. This insect spreads slowly in nature and can be assisted manually.

Dactylopius confusus (prickly pear cochineal)

This mealy bug was introduced from Florida and released in 1933 against spiny pest pear. It remains effective against spiny pest pear in central Queensland but spreads slowly. This insect can be spread manually.

Dactylopius tomentosus (devil's rope pear cochineal)

This mealy bug was introduced from southern United States in 1925 and 1926. It is effective against devil's rope pear but works slowly.

Dactylopius austrinus (tiger pear cochineal)

This mealy bug was introduced from Argentina in 1932. It is specific to and effective against tiger pear. It rapidly reduces tiger pear populations but dies out in a paddock after the destruction of tiger pear. It needs to be reintroduced after tiger pear regrows.

Chelinidea tabulata (prickly pear bug)

This plant-sucking bug was introduced from Texas in 1921. It was effective against dense common pest pear before *Cactoblastis cactorum* was but is now relatively ineffective. This insect also attacks most other prickly pears. The adult is a pale brown bug up to 20 mm long that leaves characteristic round bleached spots on the surface of the cactus.

Tucumania tapiacola (prickly pear moth-borer)

This moth was introduced from Argentina in 1934 against tiger pear. Its solitary larvae feed internally and eat out tiger pear pads with limited effect. It has been observed attacking common pest pear and harrisia cactus.

Archlagocheirus funestus (tree pear beetle)

This stem-boring beetle was introduced from Mexico in 1935. It was effective against velvety tree pear and Westwood pear but has become rare since the dense stands of these prickly pears have gone.

Tetranychus opuntiae (prickly pear spider mite)

This mite was introduced from southern United States and Mexico in 1922. It was effective against common pest pear but is now rare and difficult to find. It causes distinctive scar tissue formation around areoles.

Distributing biological control agents

Cactoblastis

Cactoblastis can be spread manually by distributing eggs or larvae. Cactoblastis moths lay chains of eggs (eggsticks) on prickly pear pads from January to February and from September to November. The eggsticks are distinguished from spines by their curved appearance.

1. Collect the fragile eggsticks carefully.
2. Glue single eggsticks to small pieces of paper using a starch-based adhesive.
3. Pin the egg papers to prickly pear pads. (Eggs take up to one month to hatch.)
4. Collect pads or plants in which larvae are obviously still active.
5. At a release site place all the collected plant material in a small part of the infestation.
6. Subsequent generations of moths will disperse through the infestation.
7. Follow up the biological control with either herbicide or mechanical treatment.

Cochineals

Because several cochineal insects affect some prickly pears and not others, it is essential to know what prickly pear you wish to control.

1. Identify your prickly pear type.
2. Find the same prickly pear type which is being attacked by a cochineal.
3. Collect pads of the prickly pear with the insects.
4. Place affected pads against unaffected prickly pears at the release site.
5. Follow up the biological control with either herbicide or mechanical treatment.

Tiger pear cochineal

Tiger pear cochineal is easy to multiply quickly after collection.

1. Carefully collect a reasonable quantity of unaffected tiger pear in a container (box or bucket).
2. Place a few pieces of cochineal-affected tiger pear into the same container.
3. Cover the container with a cloth and store under cover for a few weeks.
4. Check the cactus occasionally.
5. When most of the tiger pear in the container has cochineal, it is ready to distribute.
6. At the release site place affected pads against unaffected prickly pears.
7. Follow up the biological control with either herbicide or mechanical treatment.

Note: It is best to multiply tiger pear cochineal before release.

Herbicide control

Herbicide options available for the control of optuntioid cacti in Queensland are shown in Table 1.

Landholders and contractors should check if the property is in a hazardous area as defined in the *Agricultural Chemicals Distribution Control Act 1966* prior to spraying.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

Table 1. Herbicides for the control of opuntioid cacti

Pest name	Situation	Herbicide	Rate	Method
Common prickly pear	Agricultural non-crop areas, commercial and industrial areas, fence lines, forestry, pastures and rights-of-way	Triclopyr 240 g/L + picloram 120 g/L (e.g. Access)	1 L/60 L diesel	Basal bark/cut stump Apply as an overall spray, wetting all areas of plant to ground level
	Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights-of-way	Triclopyr 300 g/L + picloram 100 g/L (e.g. Conqueror) or Triclopyr 300 g/L + picloram 100 g/L + aminopyralid 8g/L (Grazon Extra)	500 mL/100 L	Apply as a thorough foliage spray
		Triclopyr 600 g/L) e.g. Garlon 600)	3 L/100 L or 0.8 L/60 L diesel	
Coral cactus	Agricultural non-crop areas, commercial and industrial areas, fence lines, forestry, pastures and rights-of-way	Triclopyr 240 g/L + picloram 120 g/L (e.g. Access)	1 L/60 L diesel	Basal bark/cut stump Apply as an overall spray, wetting all areas of the plant to ground level
	Pastures, rights-of-way, commercial/industrial areas	Triclopyr 240 g/L + picloram 120 g/L (e/g/ Access)	1 L/60 L diesel See permit PER13812 (expires 30/11/2017)	Paint stump immediately after cutting or spray basal bark
Tiger pear	Agricultural non-crop areas, commercial and industrial areas, fence lines, forestry, pastures and rights-of-way	Triclopyr 240 g/L + picloram 120 g/L (e.g. Access)	1 L/60 L diesel	Basal bark/cut stump Apply as an overall spray, wetting all areas of plant to ground level
	Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights-of-way	Triclopyr 600 g/L (e.g. Garlon 600)	3 L/100 L water or 0.8 L/60 L diesel	Apply as a thorough foliage spray
Drooping tree pear	Agricultural non-crop areas, commercial and industrial areas, fence lines, forestry, pastures and rights-of-way	Triclopyr 300 g/L + picloram 100 g/L (e.g. Conqueror) or Triclopyr 300 g/L + picloram 100 g/L + aminopyralid 8g/L (Grazon Extra)	500 mL/100L water	
	Non-crop areas around buildings, commercial and industrial areas, domestic and public service areas, rights-of-way	Amitrole 250 g/L + ammonium thiocyanate 220 g/L (e.g. Amitrole T)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	Tree pears may take up to 12 months to die Resparying may be needed in some cases Consult label
Velvety tree pear	Agricultural non-crop areas, commercial and industrial areas, fence lines, forestry, pastures and rights-of-way	Triclopyr 240 g/L + picloram 120 g/L (e.g Access)	1 L/60 L diesel	Basal bark/cut stump Apply as an overall spray, wetting all areas of plant to ground level
	Non-crop areas around buildings, commercial and industrial areas, domestic and public service areas, rights-of-way	Amitrole 250 g/L + ammonium thiocyanate 220 g/L (e.g. Amitrole T)	1 mL/3 cm (inject) or 1 L/25 L (small plants/regrowth)	Tree pears may take up to 12 months to die Resparying may be needed in some cases Consult label
Spiny pest pear Westwood pear Devil's rope pear Snake cactus	Agricultural non-crop areas, commercial and industrial areas, fence lines, forestry, pastures and rights-of-way	Triclopyr 240 g/L + picloram 120 g/L (e.g. Access)	1 L/60 L diesel	Basal bark/cut stump Apply as an overall spray, wetting all areas of plant to ground level

Snake cactus (*Cylindropuntia spinosior*)

Coral cactus (*Cylindropuntia fulgida*)

Hudson pear (*Cylindropuntia rosea*)

Jumping cholla (*Cylindropuntia prolifera*)

Prickly pear (*Opuntia stricta)*

Bunny ears (*Opuntia microdasys*)

Tiger pear (*Opuntia aurantiaca*)

Riveria pear (*Optunia elata*)

Devil's rope pear (*Cylindropuntia imbricata*)

Drooping tree pear (*Opuntia monacanta*)

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture and Fisheries, 2016.

Department of Agriculture and Fisheries
Biosecurity Queensland

Restricted invasive plant

Rubber vine

Cryptostegia grandiflora and *Cryptostegia madagascarensis*

Rubber vine's ability to quickly spread and colonise areas makes it a threat to many areas of northern Australia. Due to this ability, rubber vine is listed as a Weed of National Significance.

Rubber vine generally invades waterways first, where the seeds germinate in moist silt layers after rain. The plant smothers riparian vegetation and forms dense, sometimes impenetrable, thickets.

This decreases biodiversity and prevents access to both stock and native animals. It also creates habitat for feral animals. Infestations expand outward from waterways, hillsides and pastures, resulting in loss of grazing land and increased difficulty in mustering stock.

Rubber vine is poisonous to stock, though seldom eaten. Most deaths due to rubber vine occur after stock have been stressed, or when other feed is scarce.

Queensland Government

Legal requirements

Rubber vine (*Cryptostegia grandiflora*) and ornamental rubber vine (*Cryptostegia madagascarensis*) are restricted invasive plants under the *Biosecurity Act 2014*. They must not be given away, sold, or released into the environment without a permit. The Act requires everyone to take all reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. This is called a general biosecurity obligation (GBO). This fact sheet gives examples of how you can meet your GBO.

At a local level, each local government must have a biosecurity plan that covers invasive plants and animals in its area. This plan may include actions to be taken on certain species. Some of these actions may be required under local laws. Contact your local government for more information.

Description

Rubber vine is a vigorous climber with twining, whip-like shoots that can grow unsupported as an untidy, multi-stemmed shrub 1–2 m high, or it can scramble up to 30 m high in trees. The stems, leaves and unripe pods exude a white, milky sap when broken or cut.

Leaves are dark green and somewhat glossy, 6–10 cm long, 3–5 cm wide, and in opposite pairs.

Flowers are large and showy, with five white to light purple petals arranged in a funnel shape.

The seed pods are rigid and grow in pairs at the end of a short stalk. The pods are 10–12 cm long, 3–4 cm wide and each can contain up to 450 brown seeds. Each seed has a tuft of long, white, silky hairs, which enable easy dispersal by wind and water.

Ornamental rubber vine (*Cryptostegia spilanthoides*) is a shrub up to 3 m tall, if unsupported and stems can climb to 10 m if supported. Bark is sparsely dotted with corky patches. Leaves are dark green, glossy, with pale underside, 2–11 cm long, 1.5–5.5 cm wide, arranged in opposite pairs. Plant produces milky latex sap when leaves, fruit or branches are cut.

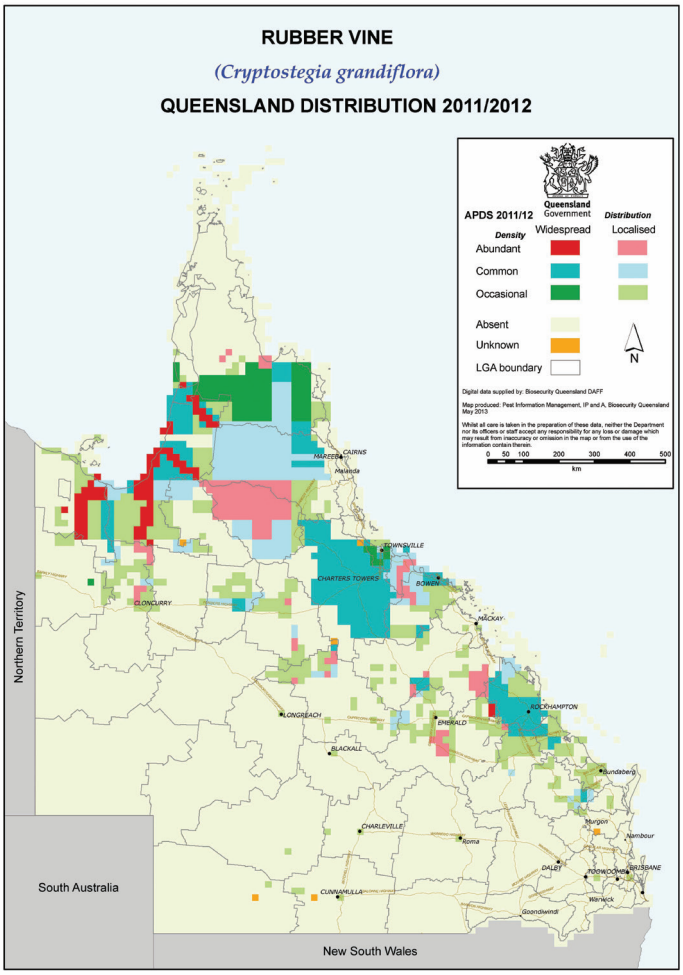
Flowers are pink-purple, 4–6 cm long, found near branchlet ends. Pods are 7–9 cm long, contain seeds 5–5.9 mm long, 1.8–3.5 mm wide, topped with silky tuft of white hairs.

Life cycle

Rubber vine flowers at any time of year if sufficient moisture is available. Usually, June and July are the only non-flowering months. Plant stem diameter must be approximately 20 mm before flowering can occur.

Seed pod formation occurs from spring to late autumn, with peak seed production corresponding to maximum flowering. Eventually, pods dry out and split open, with pod-splitting occurring approximately 200 days after formation.

Map 1. Distribution of rubber vine in Queensland



Seeds are scattered by wind, but also carried downstream by water. Approximately 95% of seed is viable, although germination requires favourable temperature and soil moisture conditions.

Methods of spread

Rubber vine seeds spread by wind and water.

Habitat and distribution

Rubber vine is native to Madagascar, but is now widely distributed throughout tropical and subtropical regions of the world.

The plant was introduced to Australia as an ornamental shrub in 1875 or earlier, and was popular in north Queensland mining settlements due to its luxuriant growth even under harsh conditions. Weedy infestations were recorded around Charters Towers early this century.

Rubber vine prefers areas where annual rainfall is 400–1400 mm, and is well adapted to a monsoonal climate.

Infestations of rubber vine are now found throughout river systems of southern Cape York and the Gulf of Carpentaria, south along the coast to the Burnett River, and isolated infestations occur as far south as Gatton and as far west as the Northern Territory border.

Infestations are common throughout central Queensland, while in western Queensland there are infestations in the Mount Isa, Longreach and Aramac areas. Isolated infestations have been reported in Western Australia.

Control

Managing rubber vine

The GBO requires a person to take reasonable and practical steps to minimise the risks posed by rubber vine. This fact sheet provides information and some options for controlling rubber vine.

Effective control of rubber vine can be achieved by a number of methods, alone or in combination depending on the situation and the severity of infestation. All areas treated must be periodically checked and any regrowth treated or the initial treatment efforts will be wasted.

Rubber vine seed is most commonly spread by wind and running water.

It is thus difficult to prevent seed coming onto uninfested land if there is rubber vine anywhere in the area. Your goal should be to prevent rubber vine from establishing and forming dense infestations. It is essential to regularly inspect all areas of your property, paying particular attention to creeks and gullies.

This is most important where prevailing winds are known to blow from infested areas, or where infestations occur upstream.

Any isolated plants located should be treated promptly.

All control of rubber vine will require follow-up treatments to keep your property clean. As rubber vine spreads quickly, small infestations should be controlled first to prevent them from becoming major problem areas. Dense infestations are difficult and costly to treat.

Follow-up treatment must be budgeted for within the overall control program. Techniques need to be integrated for successful rubber vine management. Consideration should be given to coordinating control over a catchment area.

Five suggested strategies for controlling rubber vine in scattered, medium, and dense infestations are outlined in Table 2.

Fire

Rubber vine infestations can be very effectively controlled by burning. Preparing and managing fuel load prior to burning, and following up in a timely manner after the fires, are critical to the overall success of the program.

It is recommended that you perform two successive annual burns. The first fire will open up the infestation to increase grass growth (fuel load) while killing rubber vine plants. The second fire will clean up the regrowth that occurs after the first fire.

An appropriate fire regime is an effective tool for managing rubber vine over the long term, as well as being an effective follow-up to other control methods.

Mechanical control

Several mechanical techniques are effective in controlling rubber vine. The type of infestation will determine the technique required.

- Scattered or medium-density infestations: Where possible, repeated slashing close to ground level is recommended.
- Dense infestations: During winter, stick-raking or blade-ploughing reduces the bulk of the infestation. Pasture should be sown and windrows burned to kill residual seed. Follow-up treatment is essential. It is important to comply with the relevant state and/or local government native vegetation legislation, and it should be noted that causing even accidental death of vegetation can be a breach of this legislation.

Biological control

Two biological control agents are successfully established, and their impact depends on abundance. Both agents cause abnormal defoliation, creating an ‘energy sink’, which appears to reduce seed production. These agents usually do not kill established rubber vine plants.

Diseases

Rubber vine rust (*Maravalia cryptostegiae*) is established over a wide area. Yellow spores form under the leaves and are spread mainly by the wind.

It is most active over summer, abundance being directly related to leaf wetness, which is dependent on rainfall and dew. Over summer, a generation is completed every seven days. Rust activity is reduced over the dry season.

Continued heavy infection causes defoliation, appears to reduce seed production, can kill small seedlings and causes dieback of the whip-like stems. Established plants are not killed.

Insects

Also established is the moth *Euclasta whalleyi*, whose larvae are leaf feeders. Observation indicates the moth prefers stressed plants, either from limited soil moisture or high levels of rust infection.

The moth’s period of activity is the dry season. A native fly parasite and a disease can reduce the localised abundance of the *Euclasta* larvae.

The larvae are tapered at both ends, grow up to 30 mm long, and are grey-brown with orange dots along their sides. Fine silken threads and black, bead-like droppings are often found near the larval feeding damage.

The creamy-brown moths are active at night and rest at a 45° angle from a surface, with their wings folded. The life cycle from egg to adult takes 21–28 days.

Defoliation reduces the smothering effect on other vegetation and causes an increase in leaf litter and promotes increased grass growth amongst rubber vine, increasing fuel loads required for fire management. Decreased flower and pod production should reduce the ability of rubber vine to spread.

Herbicide control

Basal bark spray

This method gives a high level of control although it is not as effective on multi-stemmed plants as it is difficult to spray each stem completely around the base.

Thoroughly spray around the base of the plant to a height of 20–100 cm above ground level, spraying higher on larger plants.

Optimum results are attained when the plant is actively growing.

Cut stump treatment

This is the most successful method of herbicide control, but also the most labour intensive. The following points should be followed carefully:

- cut the stem off as close to the ground (within 15 cm) as possible; for smaller plants use a machete or similar; larger plants may require a chainsaw
- make sure the cut is horizontal
- immediately spray or swab the cut surface
- a cost-effective method for scattered to medium-density infestations is the use of a brush-cutter.

Soil application

Because of the high risk of killing non-target vegetation, including trees and pasture plants, soil-applied herbicides play a role in controlling rubber vine only in specific situations.

It is important to comply with the relevant state and/or local government native vegetation legislation, and it should be noted that causing even accidental death of vegetation can be a breach of this legislation.

The following points should be followed carefully:

- do not use residual herbicides within a distance of two or three times the height of desirable trees
- do not use Graslan along waterways or land with greater than a 20^0 slope
- a minimum of 50–80 mm of rainfall is required before residual herbicides are taken up by the plant.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

Table 1. Herbicides for the control of rubber vine

Situation	Herbicide	Rate	Comments
Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights-of-way	Triclopyr 300 g/L + Picloram 100 g/L + Aminopyralid 8 g/L (Grazon Extra) or Triclopyr 300 g/L + Picloram 100 g/L (e.g. Conqueror)	350–500 mL/ 100 L water	High volume spray Actively growing plants not infected with rust Use the higher rate for dense stands higher than 1.5 m tall at flowering (consult label)
Native pastures, rights-of-way, commercial and industrial areas	Metsulfuron-methyl 600 g/kg (e.g. Associate, Ken-Met 600)	15 g/100 L water	High volume spray on actively growing plants Apply to actively growing bushes up to 3 m tall, October through April Wetting agent is critical Complete coverage is essential May damage pasture legumes (consult label)
Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights-of-way	2,4 D 300 g/L + Picloram 75 g/L (e.g. Tordon 75-D, Commander 75-D)	1.3 L/100 L water	Treat actively growing plants Thoroughly wet leaves and soil around base of plant Less effective than other treatments
Around agricultural buildings and other farm non-crop situations, commercial, industrial, and public service areas, rights-of-way and waster land, away from desirable vegetation	Imazapyr 250 g/L (e.g. Unimaz 250 SL)	4 mL/L water	High volume application to actively growing plants (consult label)
Non agricultural areas (native pastures) commercial and industrial areas and rights-of-way	Aminopyralid 375 g/kg plus Metsulfuron-methyl 300 g/kg (e.g. Stinger)	30 g/100L water plus wetting agent (consult label)	Apply to bushes up to 3 m in height Apply from October to April when bushes are actively growing. Ensure thorough spray coverage of all foliage and leaders Incomplete coverage will result in regrowth
Native pastures, rights-of-way, commercial and industrial areas	Triclopyr 75 g/L + Metsulfuron-methyl 28 g/L (e.g. Zelam Brush Weed)	375 mL/100L	Spray actively growing plants up to 3 m tall, from October to April. Thoroughly spray all foliage and leaders. Incomplete coverage will result in regrowth
Agricultural non-crop areas, commercial and industrial areas, fencelines, forestry, pastures and rights-of-way	Triclopyr 240 g/L + Picloram 120 g/L (e.g. Access)	1 L/60 L diesel	Basal bark plants up to 5 cm basal diameter Treat at any time Thoroughly spray around base of plant
Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights-of-way	Triclopyr 600 g/L (e.g. Garlon 600, Triclopyr 600)	1 L/60 L diesel	Basal bark Treat at any time Thoroughly spray around base of plant
Agricultural non-crop areas, commercial and industrial areas, fencelines, forestry, pastures and rights-of-way	Triclopyr 240 g/L + Picloram 120 g/L (e.g. Access)	1 L/60 L diesel	Cut stump Apply immediately cut is made
Agricultural non-crop areas, commercial and industrial areas, forests, pastures and rights-of-way	Triclopyr 600 g/L (e.g. Garlon 600, Triclopyr 600)	1 L/60 L diesel	Basal bark size and larger plants
Non-crop areas, including: native vegetation, conservation areas, gullies, reserves and parks	Picloram 44.7 g/L + aminopyralid 4.47 g/L (Vigilant II)	Undiluted	Cut stump as close to the ground as possible. Apply immediately according to label instructions
Pastures, rights-of-way and industrial	2,4-D as amine 700 g/L (e.g. Amicide Advance 700)	145 mL/10L water	Cut stump Apply immediately
Other formulations of 2,4-D are also registered for cut-stump treatment of rubber vine. Consult labels for registration details, rates and critical comments.			
	Hexazinone# 250g /L (e.g. Bobcat®SL, Velpar®L)	2 mL/spot, 3 spots for each bush (tree)	Soil application# prior to rain See warning below. #Must place spots around bush. Less effective on sandy soils
	Tebuthiuron# 200 g/kg (e.g. Graslan, Tebuthiuron 200)	1.5 g/m^2	Soil application# prior to rain Application prior to rain by hand or backpack spreader
	Triclopyr 300 g/L + Picloram 100 g/L+ Aminopyralid 8 g/L (Grazon Extra) or Triclopyr 300 g/L + Picloram 100 g/L (e.g. Conqueror, Grass-up)	3–5 L/ha	Aerial application (helicopter only) to actively growing plants Triclopyr 300 g/L + Picloram 100 g/L
	Tebuthiuron# 200 g/kg registered for aerial application (e.g. Graslan)	7.5–15 kg/ha	Aerial application prior to rain Triclopyr 300 g/L + Picloram 100 g/L

Warning: Soil testing is highly recommended prior to application of these herbicides, as rate and efficacy are dependant on soil type.
DO NOT USE SOIL APPLIED HERBICIDES (HEXAZINONE AND GRASLAN) WITHIN A DISTANCE OF TWO TO THREE TIMES THE HEIGHT OF DESIRABLE TREES.
DO NOT USE GRASLAN NEAR WATERWAYS OR LAND WITH GREATER THAN A 20° SLOPE.

Read the label carefully before use. Always use the herbicide in accordance with the directions on the label.

Table 2. Suggested strategies for the control of rubber vine

Situation	Initial treatment	Follow-up	Comments
Scattered infestations	Basal bark/ cut stump	Follow-up with basal bark/ cut stump as necessary	Cut stump method preferred where possible
	Foliar spray	Follow-up basal bark/ cut stump/foliar spray as necessary	Only foliar spray when there is nil to little rust on the leaves of the plants
	Fire	Follow-up basal bark/ cut stump/foliar spray as necessary	For scattered infestations usually recommended only if herbicides not desired, or if have other weeds can be controlled by fire or if fire is utilised to improve pastures
	Repeated slashing		
Medium infestations	Foliar spray	Treat regrowth, seedlings with basal bark/cut stump/ foliar spray	Fire and follow-up with basal bark/cut stump/foliar spray as necessary
	Fire	Fire 1 year later and follow-up basal bark/cut stump/ foliar spray as necessary	If fuel load is sufficient **CAUTION:** There are some native tree species which are susceptible to fire Check before burning
	Repeated slashing		
Dense infestations previously cleared areas	Stick rake or blade plough	Sow pasture – basal bark/ foliar spray – fire and basal bark/cut stump/foliar spray as necessary	First treatment clears bulk of rubber vine and kills roots; any regrowth or seedlings can then be treated; when grass growth allows fuel build up, fire used as control and individual plants later treated
	Fire	Fire one year later and follow-up basal bark/ cut stump/foliar spray as necessary	If fuel load is sufficient **CAUTION:** There are some native tree species which are susceptible to fire Check before burning
	Aerial spray	Fire 1–2 years later or follow-up with basal bark spray	Bulk of rubber vine killed with aerial spray; allow build up of fuel for fire or treat remaining plants with basal bark spray Contact 13 25 23 before use of this method
	Graslan		Where situation and soil type are suitable
Dense infestations along creeks and rivers	Basal bark/ cut stump	Fire or basal bark/cut stump/foliar spray	When bulk of rubber vine killed, allow fuel build up for fire or treat remaining plants individually
	Fire and sow pasture	Fire one year later and follow-up basal bark/cut stump/foliar spray as necessary	If there is a sufficient fuel load to carry a fire, it can open up dense infestations **CAUTION:** There are some native tree species which are susceptible to fire Check before burning

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture and Fisheries, 2017.

Appendix K Pest Species and Management Plans

Department of Agriculture and Fisheries
Biosecurity Queensland

Invasive animal

Cane toad

Bufo marinus

The cane toad is not a declared pest in Queensland, so there is no legal requirement to control them.

Their original introduction in 1935 was to control agricultural pests, but they proved ineffective.

For the past 60 years, cane toads have been expanding their territory in Australia, and are capable of colonising at least four of the mainland Australian states.

As the toad's geographical range continues to expand, concern has increased about their detrimental environmental effects, particularly on the wetlands of the Northern Territory.

Studies into the feasibility of biological control have commenced.

Legal requirements

The cane toad is not a prohibited or restricted invasive animal under the *Biosecurity Act 2014,* however everyone has a general biosecurity obligation (GBO) to take reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control.

Local governments have a biosecurity plan that covers invasive plants and animals in their area and may require additional actions to be taken on certain species; some of these may be applied under local laws. Refer to your local government for more information.

Queensland Government

History of introduction and spread

The cane toad or giant toad is an amphibian, native to Central and South America. Cane toads have been introduced throughout the world as a biological control for insect pests of agriculture, most notably sugarcane.

A consignment of cane toads from Hawaii was released into Queensland cane fields in 1935. The introduction was surrounded by controversy as to the potential costs and benefits to Australia.

It was hoped that the toad would control Frenchi and greyback beetles—pests of economic importance to the sugarcane industry.

By 1941, however, it had become evident that the cane toad was exerting only limited control over its intended prey. There were two main reasons for this:

- Greyback beetles are only rarely in contact with the ground and Frenchi beetles invade cane fields at a time when the toads are absent due to a lack of protective cover.
- The cane toad has a wide-ranging and indiscriminate diet, and it was not solely dependant upon its intended prey.

The unlimited food source, suitable environment and low rates of predation allowed dynamic reproduction and spread. Toads were recorded in Brisbane only 10 years after release. The toad continues to thrive and has now invaded the Northern Territory and New South Wales (see Map 1).

Map 1. Distribution of the cane toad in Australia

The cane toad's advance is only limited by environmental factors, such as the availability of water for breeding, tolerable temperatures, suitable shelter and availability of food.

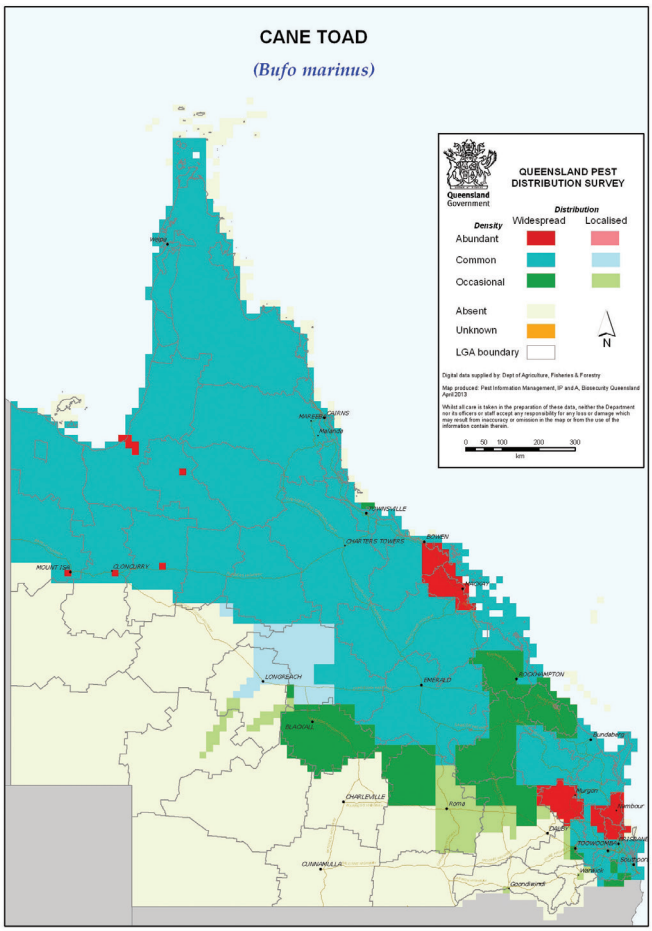
Toads at the frontier of their range of expansion may be larger than those in established populations. This is most probably due to greater food supply, combined with a lower incidence of disease.

Description

In comparison with native frog and toad species, adult cane toads have a distinctive head and face, and are large and heavily built creatures (adults may grow to 20 cm).

Following their aquatic larval stages (eggs and tadpoles), cane toads are generally encountered at night near any

Map 2. Distribution of the cane toad in Queensland

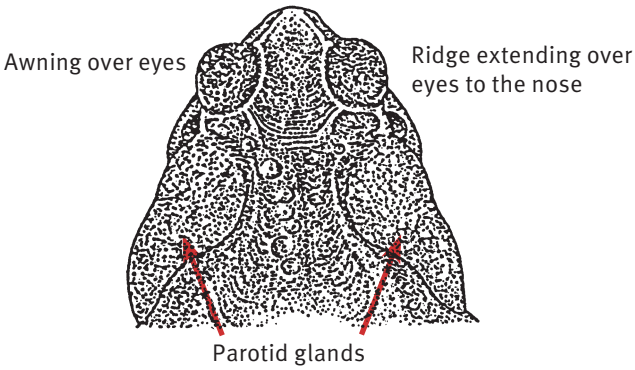


source of light. Cane toads are ground-dwelling—they are poor climbers and unable to jump very high.

A definite visor or awning extends over each eye and a high angular bony ridge extends from the eyes to the nose.

The parotid glands (see Figure 1) are perhaps the most characteristic feature of the adult cane toad. These glands are large, protuberant, and are situated on the head behind each ear. These glands carry a toxin.

Figure 1. Distinguishing features of the cane toad



The cane toad's hands and feet are relatively small and lack discs at the tips of the digits. Webbing is absent between the fingers but is distinct and leathery between the toes.

Colouring on the dorsal (upper) surface may be brown, olive-brown or reddish-brown. The ventral (under) surface varies from white to yellow and is usually mottled with brown.

Warts are present on all cane toads; however, males possess more than females. Warts are dark brown at the caps.

Mating

Mating can occur at any time of the year and depends only on available food and permanent water. The mating call is a continuous purring trill that sounds like a running motor.

In situations where females are scarce or absent, male cane toads may have the ability to undergo a sex change to become fertile females; however, this has not been proved.

Eggs

Both cane toads and native frogs spawn in slow-moving or still water, but their eggs can be easily distinguished.

Cane toad eggs are laid in long, gelatinous 'strings' with the developing tadpoles appearing as a row of small black dots along the length. The strings are unique to cane toads, generally appearing as blobs of jelly attached to water plants or debris. Native frogs generally produce egg clusters as mounds of foam floating on the water surface.

Compared with native species, cane toad egg production is dynamic and a single clutch can contain up to 35 000 eggs. Remove any cane toad eggs found in the water and allow to dry out.

Figure 2. Drawing of toad spawn from Wildlife of greater Brisbane

Tadpoles

The cane toad is the only species in Australia that has a pure black tadpole. Native frogs have lighter-coloured undersides with a great range of colours and markings—cane toad tadpoles may turn paler colours to almost transparent at night.

Cane toad tadpoles are small and usually congregate in vast, slow-moving shoals. This 'shoaling' behaviour is uncharacteristic of most native species.

Unlike cane toad tadpoles, native species develop lungs at an early stage and periodically rise to the surface in order to exchange their lung gasses. Large groupings of tadpoles that do not break the water surface for air indicate cane toads.

Young toads

Following emergence from the water, the young toadlets usually congregate around the moist perimeter of the water body for about a week before they eventually disperse.

Young toads are very difficult to distinguish from the native *Uperoleiea* species, which also have parotid glands, but all *Uperolelea* species have bright red patches in the groin area.

Under ideal conditions toadlets may reach adult size within a year.

Toxicity

Bufo marinus produce venom in glands occurring in most of the skin on their upper surface. The venom is concentrated in the parotid glands as a creamy-white solution, which is released when the animal experiences extreme provocation or direct localised pressure (e.g. grasped by the mouth of a predator).

The parotid solution is highly toxic and when ingested it produces drastic acceleration of the heartbeat, shortness of breath, salivation and prostration. It is extremely painful if accidentally rubbed into the eye.

Ingestion of toads by domestic and most native animals can result in death. In some recorded cases, death has occurred within 15 minutes.

Field observations suggest that some predatory Australian species have learned how to feed safely on cane toads.

Birds have been observed flipping toads over to avoid the parotid glands. Predatory reptiles may have more trouble adapting, being unable to remove a toad from the mouth once they start feeding.

Impacts on wildlife

The cane toad is poisonous at all stages of its life cycle and most native frog larvae and many aquatic invertebrates are dramatically affected by their presence.

Cane toads are voracious feeders that consume a wide variety of insects, frogs, small reptiles, mammals and even birds. Perhaps the only limiting factor to the prey taken is the width of the cane toad's mouth.

It has been suggested that cane toad competition for food and breeding grounds has been responsible for reducing the populations of some native frogs. However, many native frogs are arboreal (tree-dwelling) and occupy different niches. Cane toads don't have the native frogs' ability to 'shut down' during dry seasons when resources are limited.

Pressure from cane toads may displace native animals (frogs and other species) where they are already suffering due to manipulation of their habitat by humans and grazing animals. Animals that use waterholes as retreat sites during the dry season are especially vulnerable—toads will congregate here in large numbers.

Public health

Cane toads readily eat animal and human faecal material and, in areas of poor hygiene, they have been known to transmit disease such as salmonella.

Control

Control of cane toads is not enforced as there is currently no available effective broad scale control. Individuals and community groups have carried out removal campaigns to decrease numbers and slow the invasion front.

Fencing is recommended to keep toads out of ponds intended for native fish and frogs; a height of 50 cm is sufficient. Bird wire with 1 cm holes may keep toads out of an area.

Research indicates that spread can be delayed in semi-arid areas by blocking access to water holes.

Individual toads may be killed relatively humanely using a commercial spray available from hardware stores or may be stunned and decapitated (only by experienced operators). The removal of eggs from small water bodies such as frog ponds can be effective.

Researchers have successfully mitigated impacts in recently colonised areas by 'training' predators however, large scale application of this technique is difficult.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture and Fisheries, 2016.

Restricted invasive animal

Dingo

Canis familiaris dingo

The dingo is a primitive canid related to wolves and coyote. The dingo was not a part of the ancestral fauna of Australia. Though its origins are not clear, it is thought to have arrived in Australia 3500–4000 years ago.

It is the largest mammalian carnivore remaining in mainland Australia, and as such fills an important ecological niche. Females weigh about 12 kg and males 15 kg.

The dingo has been regarded as a serious predator of domestic stock since early European settlement in Australia.

Since European settlement domestic dogs have been released or escaped into the environment to cross with dingoes. These hybrids or crosses are colloquially call wild dogs (*Canis lupus familiaris*). Often the term wild dog covers both dingoes and dingo hybrids.

Wild dogs predate on livestock, native fauna and domestic pets.

Queensland Government

Legal requirements

The dingo is a restricted invasive animal under the *Biosecurity Act 2014*. It must not be moved, kept, fed, given away, sold, or released into the environment without a permit. The wild dog must not be moved, fed, given away, sold, or released into the environment without a permit.

The Act requires everyone to take all reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. This is called a general biosecurity obligation (GBO).

At a local level, each local government must have a biosecurity plan that covers invasive plants and animals in its area. This plan may include actions to be taken on certain species. Some of these actions may be required under local laws. Contact your local government for more information.

Description

Red, ginger and sandy-yellow are the dominant coat colours, though dingoes can also be pure white, black and tan or solid black.

It is not difficult to distinguish between most dingoes and hybrids. The presence of domestic genes is suggested by broken colours—brindling and patchiness in the normally pure white feet and chest patch and sable colouration (black hairs along the back and sides).

Dingoes have a more heavily boned skull and larger teeth (especially the canine) than domestic dogs of similar size.

Life cycle

Dingoes have only one breeding season per year (usually April to June), whereas domestic bitches have two or more oestrus cycles per year. However, unless seasons are particularly favourable, or human sources of food are intentionally or inadvertently provided, feral domestic dogs are unlikely to successfully rear two litters per year.

After a nine-week gestation, dingo pups (usually four to six) are born in a hollow log or cave den. Bitches tend to use the same den each year. Pups are suckled at four to six weeks and generally weaned at four months. When large enough to travel, pups are taken from the den to kills, and other dens many be used. The range of pups is increased as they are moved from den to den. In this way the pups are gradually moved around the bitch's home range.

Independence may occur as early as six months of age when parents abandon them, but this results in high juvenile mortality. Pups that become independent around 12 months appear to disperse voluntarily. Being larger and more experienced, mortality is then usually low.

Where dingoes live alone or in small groups (most pastoral and semi-settled areas), mature females will breed successfully each year.

By contrast, dominant female infanticide results in only one litter being successfully raised each year within groups containing several adult females (e.g. undisturbed areas such as the Simpson Desert). The dominant (alpha) female will kill all pups of the other females, and then use subordinate females to suckle and rear her litter.

Methods of spread

Dingoes in an undisturbed area generally belong to discrete packs (3–12 members), which occupy long-term, non-overlapping territories. The group rarely moves as a pack—rather, members meet and separate again throughout the day. Dingoes are most gregarious during the breeding season.

There is overlap of home ranges within a group. In contrast, boundaries between groups are more rigid, actively defended and infrequently crossed.

Olfactory communication (smell) is important in dingo social organisation. Dingo droppings are deposited along pads in specific areas where other dingoes will encounter them (creek crossings, intersections of roads and fences).

These 'scent posts' appear to delineate the home range boundary and act as a warning to neighbouring groups and individuals.

This strong site attachment of dingoes is contrary to the notion commonly held by property owners that dingoes will travel large distances to kill stock.

Habitat and distribution

Dingo numbers are believed to be higher today than in pre-European times. This is thought to be due to increased food availability via the introduced rabbit and cattle carcasses, and the development of permanent waters in arid areas of the state.

Dingoes/wild dogs are present in all parts of the state.

The distribution of the wild dog in relation to purebred dingoes varies throughout the state. In far western areas, most dingoes sighted appear to be 'pure', with characteristic white points and broad heads. Closer to settled areas a greater number of feral domestic dogs produce a generally hybrid population. It has been estimated that dingoes are 50% pure in south-eastern Queensland and 90–95% pure in south-western and central Queensland.

Radio tracking studies show dingoes occupy a discrete area known as a 'home range'. The dingo visits the edge of this area frequently.

The home range can vary in size according to the productivity of the country—from 9 km² in rainforest areas to 300 km² on the Nullarbor Plain.

The edge of the home range is commonly associated with a major topographic feature (e.g. an escarpment, a major ridge or stream).

The home range is not used uniformly. Activity is centred on areas with highest food density.

Hunting movement is slow and exploratory, in contrast to frequent rapid movement around the home range boundary.

Pads follow well defined paths and are most likely associated with sociality and home range boundary maintenance. Activity is highest at dusk and dawn.

Diet

Dietary research of stomach content and faecal scats has shown dingoes are opportunistic predators.

Medium-size animals such as kangaroos, wallabies, rabbits and possums consistently form the major part of the dingo diet.

Studies by the Western Australia Agriculture Protection Board show dingoes in undisturbed refuge areas killed and ate kangaroos strictly according to need.

On grazing country, however, 'dingoes harassed, bit or killed sheep in large numbers, often without eating any'. The consumption of these sheep carcasses was the exception rather than the rule. Even kangaroos in these areas were sometimes killed in 'play' type behaviour rather than for food.

Such dietary studies could suggest dingo predation of domestic stock is low. There is, however, a need for caution in using such studies to assess dingo impact on stock.

Grouping increases foraging efficiency and appears necessary to exploit larger prey. Dingoes cooperating in groups are more successful in hunting kangaroos than lone dingoes are. While lone dingoes can easily kill sheep, it is less likely a solitary dingo would successfully attack a calf in the presence of a defending cow.

Disease threat

Dingoes are vectors of canid diseases (e.g. distemper, parvovirus) and parasites. The hydatid parasite *Echinococcus granulosus* is a major problem of dogs and domestic stock. It can cause illness and occasionally death in humans.

The dingo could pose a serious risk if the exotic disease rabies was introduced to Australia.

Beneficial considerations

The establishment of watering points during post-European settlement has resulted in a huge increase in the kangaroo population, with consequent strong pasture competition with domestic livestock.

Though it is widely accepted that sheep production is near impossible in the presence of dingoes, many cattle producers will tolerate dingoes because of their believed suppression of kangaroo numbers.

Research has shown that in some cases the dingo has the potential to mitigate population growth of native species during abundant seasons and it could also be an important limiting factor for many feral animal populations (e.g. feral pigs and goats).

There is some evidence that destruction of the dingo could cause increases in other pests to the grazing industry and result in widespread degradation of environmentally sensitive areas. However, this has not been proven.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture and Fisheries, 2016.

Restricted invasive animal

Feral cat

Felis catus

A descendant of the African wild cat (*Felis silvestris lybica*), the common 'house' cat (*Felis catus*) has now been domesticated for about 4000 years. Although the domestic cat has a long history of association with humans, it retains a strong hunting instinct and can easily revert to a wild (feral) state when abandoned or having strayed from a domestic situation.

Semi-feral cats live around dump sites, alleys or abandoned buildings, relying on humans by scavenging rubbish scraps and sheltering in abandoned structures. The true feral cat does not rely on humans at all, obtaining its food and shelter from the natural environment.

Legal requirements

The feral cat is a restricted invasive animal under the *Biosecurity Act 2014*. This is a cat that is not domesticated. The feral cat must not be moved, fed, given away, sold, or released into the environment without a permit. The Act requires everyone to take all reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. This is called a general biosecurity obligation (GBO). This fact sheet gives examples of how you can meet your GBO.

Queensland Government

At a local level, each local government must have a biosecurity plan that covers invasive plants and animals in its area. This plan may include actions to be taken on certain species. Some of these actions may be required under local laws. Contact your local government for more information.

Description

The feral cat differs little in appearance from its domestic counterpart; however, when in good condition, the feral cat displays increased overall muscle development, especially noticeable around the head, neck and shoulders, which gives the animal a more robust appearance. The average body weight of male feral cats is 3–6 kg, while females weigh 2–4 kg. Body weights vary with condition, with some extremely large specimens documented.

Australian feral cats are predominantly short-haired, with coat colours that range between ginger, tabby, tortoiseshell, grey and black. White markings may be present on the feet, belly, chest and throat; completely white feral cats are extremely rare. In established populations, coat colours are the result of a natural, genetically selective process. Terrain, predators and the ability to capture prey limit coat colours to those that provide the most suitable camouflage and cause a predominance of these colours in subsequent offspring. Ginger cats are more likely to be found in the semi-arid and desert areas, while grey and black specimens generally predominate in scrub and more heavily timbered habitats.

The feral cat is most active at night, with peak hunting activity occurring soon after sunset and in the early hours before sunrise. At night the cat displays a distinctive green eyeshine under spotlight, making it easily distinguishable from other animals. During the day it will rest in any number of den sites, which may include hollow logs, dense clumps of grass, piles of debris, rabbit burrows, and even the hollow limbs of standing trees.

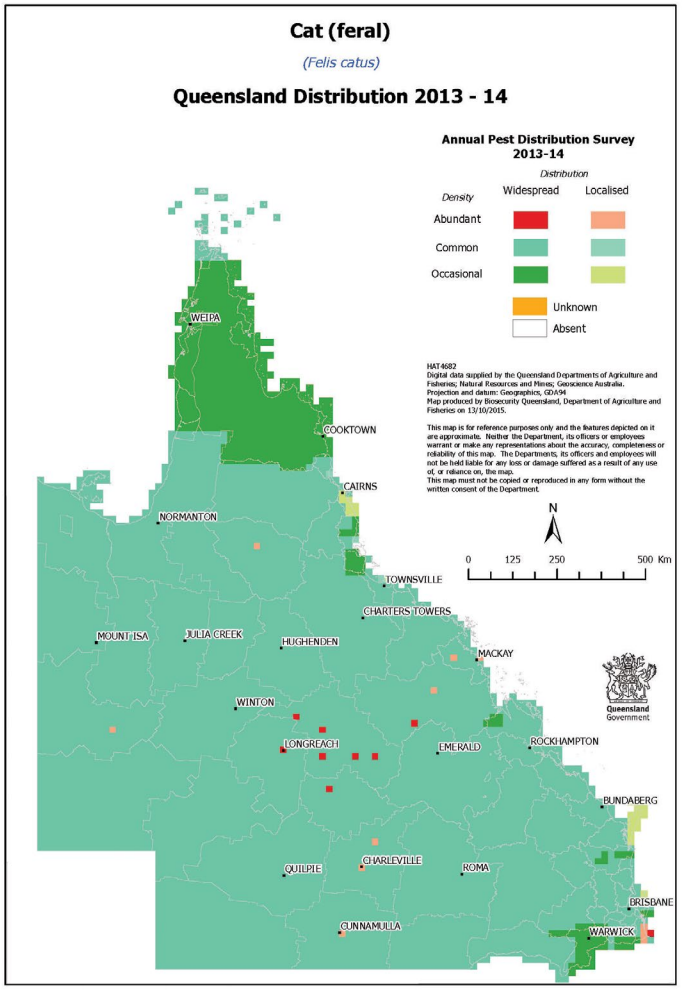
The most obvious and characteristic field signs of feral cats are their scats (droppings). Unlike the domestic cat, the feral cat does not bury its scats, but leaves them exposed at prominent sites to warn other cats of its territorial boundary.

Life cycle

Male cats attain sexual maturity at about 12 months, whereas females are capable of reproduction at approximately seven months. Annually, and under ideal conditions, an adult female can produce up to three litters—each of usually four kittens, but varying from two to seven.

As the breeding instinct is triggered by the increasing length of daylight, litters are less frequent in winter. Most reproduction occurs during the spring and summer months, and is generally limited to two litters per year. Birth follows a gestation period of 65 days, and kittens may be reared in a single den site or may be frequently shifted to other sites within the female's home range. Family and litter bonding begin to break down when the

Map 1. Distribution of feral cats in Queensland



kittens are approximately seven months old. The female's ability to bear litters does not decrease with age, so reproduction continues for the course of her life.

Habitat and distribution

There is some evidence to suggest that the cat was present in Australia long before European settlement. This may have occurred as a result of Dutch shipwrecks and regular visits to northern Australia by early South-East Asian vessels as long as 500 years ago.

Post-settlement dispersal resulted from cats straying from areas of early colonisation. In the late 19th and early 20th centuries, large numbers of cats were purposely released in many rural areas to combat plague numbers of rabbits. Unwanted cats continue to be released into urban and rural areas by irresponsible pet owners.

The feral cat is now present Australia-wide, thriving under all climatic extremes and in vastly different types of terrain.

Feral cats maintain stable home ranges, the sizes of which depend upon the relative abundance of food and the availability of suitable den sites. Dominant male cats may have territories of up to 8 km^2, while the territories of females are smaller and may even be halved while kittens are being reared.

Scent glands are present on the chin, at the corners of the mouth, and in the anal region. Territorial boundaries are maintained by scent marking with the cheek glands,

pole-clawing, urinating and leaving exposed faecal deposits.Although feral cats are often thought of as being solitary animals, studies show this behaviour is generally limited to hunting activities. At other times feral cats display a degree of social interaction that peaks during the breeding season. Group behaviour has been observed in semi-feral populations, and it has been suggested that such behaviour is exhibited also in feral populations.

Groups usually comprise several related adult females, their young of both sexes, and an adult male—whose range may include other groups of females. Young females usually remain in a group, while young males either leave or are driven from the group as they reach sexual maturity.

Impacts

Effects on wildlife

The energy expended by an adult male cat requires it to consume 5–8% of its body weight in prey per day, while females raising kittens require 20%. Based on these figures, one study concluded that 375 feral cats on Macquarie Island would consume 56 000 rabbits and 58 000 sea birds per year. Where present on the mainland, rabbits may comprise up to 40% of a feral cat's diet. Cats are successful as a control mechanism only when rabbit densities are low. At other times cat predation does little to halt the build-up or spread of rabbit populations; rabbits merely help to support a larger number of cats. When seasonal shortages of rabbits occur there is a corresponding rise in the number of native animals taken by cats.

The feral cat is an opportunistic predator, and dietary studies have shown that small mammals, birds, reptiles, amphibians, insects and even fish can be taken as prey. Cat predation is particularly harmful in island situations, and a number of species have become extinct due to the introduction of cats by early sealers and lighthouse keepers. On the mainland, native animals—which already suffer due to the destruction of their habitats by man and other introduced animals—may be endangered further by cat predation. Actual competition for prey can cause a decline in the numbers of native predatory species such as quolls, eagles, hawks and reptiles. Not only do native animals bear the brunt of predation, but they also suffer the effects of a parasite that reproduces only in the intestine of the cat. This disease (toxoplasmosis) is particularly harmful to marsupials, which may develop blindness, respiratory disorders, paralysis, and suffer the loss of offspring through abortion and stillbirths.

Exotic disease—rabies

Due to their widespread distribution, feral cats may prove to be a major vector for this fatal viral disease if it ever enters Australia. Overseas studies have revealed that wounds inflicted by rabid cats are more dangerous than those caused by rabid dogs. While the bites of rabid dog are generally inflicted on the arms and legs, the cat attacks the head of its victim, biting and clawing viciously. These head and facial bites reduce the time taken for the virus to enter the central nervous system, lessening the chance of success from subsequent remedial treatment.

Control

Managing feral cats

The GBO requires a person to take reasonable and practical steps to minimise the risks posed by feral cats. This fact sheet provides information and some options for controlling cats.

Exclusion fencing

Fencing is the only feasible method of control when special areas need protection from cats. Feral cats have been successfully prevented from climbing over netted fences that use an electrified wire mounted 15 cm from the top and 10 cm outward from the fence. Non-electrified fencing should incorporate a netted ceiling, or a curved overhang, which prevents the cat from climbing straight up and over the fence.

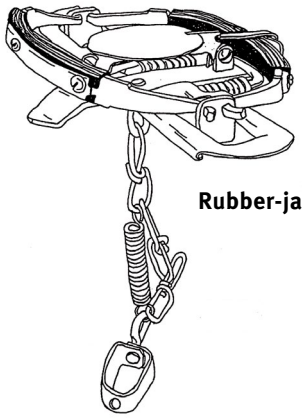
Trapping

Rubber-jawed, leg-hold traps (see below) can be laid in the same manner as they are laid for dingoes and foxes. Leg-hold traps can work well with true feral cats, which would normally avoid the live-capture box traps.

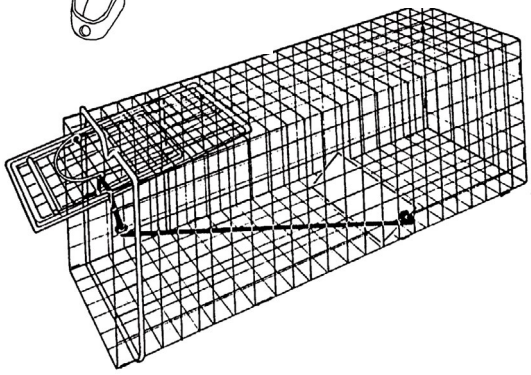
Ideal sites are those where territorial markers, such as faecal deposits and pole-clawing, are noticed. Tuna fish oil has shown some success as an attractant; however, feral cats seem more readily attracted to a site by some visual stimulus such as a bunch of bird feathers hung from a bush or stick.

Semi-feral urban cats are easily trapped in wire 'treadle-type' box traps (see diagram at right). Attractants/lures may be of meat or fish and should be placed so that they cannot be reached through the wire and be retrieved by clawing.

A number of local governments hire cat traps for the purpose of removing stray and feral cats in urban situations.



Rubber-jawed leg-hold trap



Treadle box trap

Lures

Audible recorded lures for feral cats and other predators are available through a number of sources. These recordings mimic the distress call of a small animal and can be used to draw a predator to a bait or trap site.

Shooting

Night shooting is assisted by the cat's distinctive, green eyeshine. Cats have been successfully attracted by the use of a fox whistle.

Poisoning

Fresh meat baits containing 1080 may be used for controlling feral cats under APVMA PERMIT14015.
To obtain a copy of this permit visit www.apvma.gov.au.

Only authorised persons can supply 1080 baits to landholders.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture and Fisheries, 2016.

Restricted invasive animal

Feral pig

Sus scrofa

Pigs were introduced to Australia by early settlers. Subsequent accidental and deliberate releases resulted in the wild (feral) population establishing throughout Australia.

Feral pigs cause environmental and agricultural damage, spread weeds and can transmit exotic diseases such as leptospirosis and could spread foot-and-mouth disease.

Legal requirements

The feral pig is a restricted invasive animal under the *Biosecurity Act 2014*. It must not be moved, fed, given away, sold, or released into the environment without a permit. The Act requires everyone to take all reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. This is called a general biosecurity obligation (GBO). This fact sheet gives examples of how you can meet your GBO.

At a local level, each local government must have a biosecurity plan that covers invasive plants and animals in its area. This plan may include actions to be taken on certain species. Some of these actions may be required under local laws. Contact your local government for more information.

An animal ceases being considered an invasive restricted animal (feral) if a person is keeping it and has become a registerable biosecurity entity (RBE) to keep that designated animal. Feral pigs can be considered as designated animals if a person keeps them.

Description

Feral pigs are typically smaller, leaner and more muscular than domestic pigs with well developed shoulders and necks, and smaller, shorter hindquarters.

The body is usually covered in sparse, coarse hair and they have a longer, larger snout, longer tusks, a straighter tail and narrower back than domestic pigs. Feral pigs are mostly black, buff-coloured or spotted black and white.

Growth potential is similar to domestic pigs, although harsh environmental conditions tend to stunt development. Adult female feral pigs usually weigh 60–75 kg, while males usually weigh 90–110 kg. Older boars (razorbacks) can have massive heads and shoulders and a raised and prominent back bone that slopes steeply down to small hams and short hind legs. Some boars develop a crest or mane of stiff bristles extending from their neck down the middle of their back.

Life cycle

Under good seasonal conditions, breeding occurs all year and sows can produce two litters per year. Adult females have a 21–day oestrus cycle, with a gestation period of about 113 days, producing a litter of 4–10 piglets. Sows can make nests of available vegetation just before farrowing. Nests sometimes have a domed roof and are usually less than 2 km from available water. Piglets normally spend the first 1–5 days of life inside the nest, with the sow nearby. Weaning occurs after 2–3 months. Sexual maturity is reached when sows weigh about 25 kg, usually around six months of age.

Mortality of juveniles is high if the mother's dietary protein intake is low (up to 100% mortality in dry seasons). Adult mortality does not vary as much with seasonal conditions, but few animals live more than five years.

Social behaviour

Feral pigs are generally nocturnal, spending daylight hours sheltering in dense cover. Pigs are omnivorous, eating plants and animals and are extremely opportunistic feeders, exploiting any temporarily abundant food.

They prefer green feed and will eat grains, sugarcane and other crops, fruit and vegetables. They root extensively for tubers, worms and soil invertebrates.

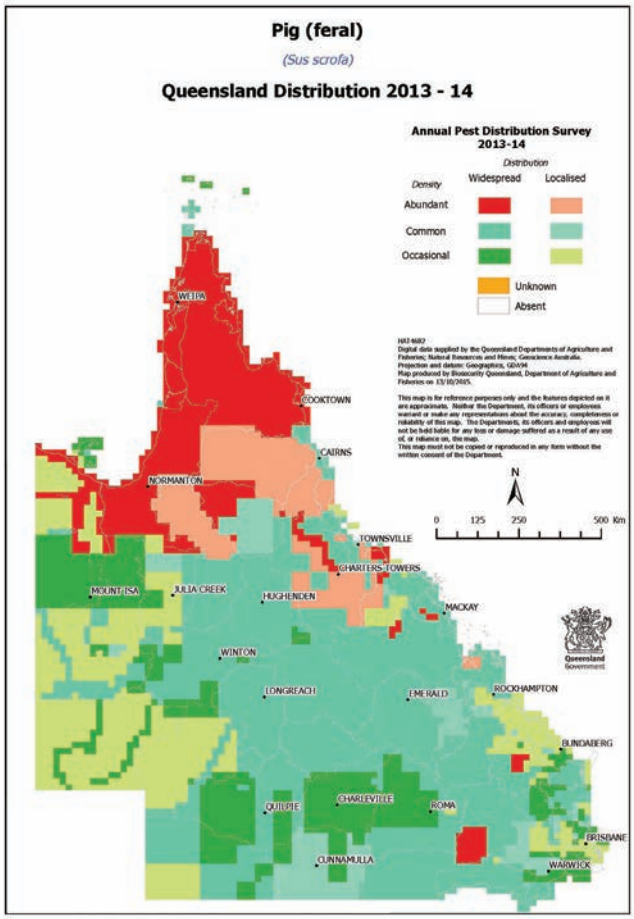
Feral pigs have relatively high energy and protein requirements, particularly during pregnancy and lactation and often move to other parts of their home range during pregnancy.

Habitat and distribution

Feral pigs are found in all habitat types in Queensland. The greatest concentrations of feral pigs are on the larger drainage basins and swamp areas of the coast and inland. In hot weather, pigs need to remain near water.

Population estimates can be achieved by spotlighting, aerial survey or the use of motion cameras.

Map 1. Distribution of feral pigs in Queensland



Evidence of feral pigs includes fresh digging or rooting of the ground, tracks and faeces on and off pads, mud or hair at holes in fences where pigs have pushed through, wallows, tusk marking and mud rubs on trees and fence posts and nests in vegetation made by sows before farrowing.

Female and juvenile pigs usually live in small family groups with a home range of 2–20 km^2. Adult males are typically solitary, with a home range of 8–50 km^2. Range size varies with season, habitat, food availability and disturbance. Herds of 400 pigs have been recorded in Cape York.

Impacts

Pigs can damage almost all crops from sowing to harvest, starting with uprooting seed and seedlings to feeding on or trampling mature crop.

They feed on seed, sugar cane and grain crops (except safflower), fruit (especially banana, mango, papaw, macadamia and lychee) and vegetable crops. Research has shown feral pigs can take up to 40% of lambs.

Pastures are damaged by grazing and rooting and pigs can also transport weeds. Wallowing pigs damage and foul the water in tanks and bore drains and silt up troughs. They can also damage fences and dam walls.

Pig activity degrades water quality and the habitat for small terrestrial and aquatic animals. It also creates erosion and allows exotic weeds to establish. Predation of native fauna does occur and examination of faeces has shown remains of marsupials, reptiles, insects, and ground-nesting birds and their eggs.

Feral pig wallow

Feral pig rooting

Feral pig damage to river banks

Feral pig damage to sugar cane

Diseases and parasites

Feral pigs can carry many infectious diseases and internal and external parasites. Some are endemic (already present), while others are exotic to Australia.

Many of the diseases can spread to domestic pigs, other livestock and humans. Feral pigs can transmit sparganosis, melioidosis, leptospirosis, Q fever and brucellosis to humans.

To prevent contracting these diseases it is advisable to either avoid handling feral pigs or use suitable protective clothing (mask, goggles, strong rubber gloves and plastic apron and boots) to minimise contamination with blood, urine and faeces. Rare or undercooked meat should not be eaten; thoroughly cook meat to avoid contracting pathogens. Raw feral pig meat and offal should not be fed to dogs as dogs can be infected with swine brucellosis. Dogs infected with swine brucellosis can also transmit the disease to humans.

Control

Managing feral pigs

The GBO requires a person to take reasonable and practical steps to minimise the risks posed by feral pigs. This fact sheet provides information and some options for controlling feral pigs.

Feral pigs are difficult to control because they are primarily nocturnal, breed rapidly, are generalist omnivores and have large home ranges and thus control programs need to be conducted over a wide area (often including several properties) to be effective.

Effective control requires an integrated, collaborative approach where all stakeholders participate in planning, implementation and evaluation of the actions taken.

Fencing

Though an expensive option, fencing can offer successful pig control especially for high value crops grown on small areas. Research has indicated that the most successful pig-proof fences are also the most expensive.

The most effective pig-proof fences use fabricated sheep mesh held close to the ground by plain or barbed wire and supported on steel posts.

Electrifying a conventional fence greatly improves its effectiveness if used before pigs have established a path through the fence.

Pigs will often charge an electric fence and unless the fence incorporates fabricated netting they often successfully breach the fence.

For crop protection or to avoid lamb predation, pig-proof fences need to be constructed before the pigs become a problem. Once pigs have adjusted to feeding on grain or lambs in a particular paddock fencing may be ineffective.

Trapping

Trapping is an important technique that is most useful in populated areas, on smaller properties (‹5000 ha), and where there are low pig numbers. Trapping can be particularly useful in 'mopping up' survivors from baiting programs. It is most successful when food resources are limited.

Trigger mechanisms for pig traps can be made pig-specific and therefore pose little danger to wildlife or domestic animals.

Advantages

- This is the safest form of control and can be safely undertaken on closely populated areas.
- It's flexible and can be incorporated into routine property activities, making economical use of labour and materials.
- Carcasses can be safely disposed.
- Traps can be moved and re-used; good trapping makes use of opportunities as they arise.
- Normal pig behaviour is not altered, which allows a greater number of the total population in an area to be targeted.
- More humane to pigs and non-target species.
- The number of animals removed can be easily monitored.

Disadvantages

- Can be time consuming and expensive to construct and maintain.
- Must be checked regularly.
- Not practical for large-scale control.
- Some pigs are trap shy.

Tips

- Stop all activities that will disturb normal feeding (i.e. do not undertake any shooting or dogging).
- Pre-feeding (i.e. ensure that pigs are visiting trap and consuming bait) prior to activating traps is an essential part of successful trapping.
- Feeding sites should be placed where feral pigs are active (i.e. water points, holes in fences, areas containing old carcasses on which pigs have been feeding).
- Bait for traps must be food that pigs usually eat in that area. Pigs feeding on one crop (e.g. sugarcane) will often not take to alternative foods. However, new, novel baits are sometimes attractive (e.g. fermented grains).
- The trap can be built around the feeding site, with feeding within the trap undertaken for several nights before it is set.
- Set the trap every night and check each day. If the trap cannot be checked daily then shade and water must be provided.
- Continue to trap until no more pigs are caught. A change of bait can be tried. Again, feed for one or two nights before re-setting the trap.
- Traps may be left permanently in locations used by pigs and can be utilised when fresh signs of pigs appear.
- If the trap is to be moved, start feeding at the new site before re-locating the trap.

Design

There are several trap designs but all are principally an enclosed area with one-way gates (see Figure 1).

The main area of the trap can be any shape and be made from materials on the property. The best material is steel mesh with a grid 100 × 100 mm, with a minimum height of at least 1.5 m. Star pickets need to be placed no more than 1.5 m apart and imbedded far enough to ensure that adult pigs cannot push them over or lift them up out of the ground.

Alternative trap entrances

Funnel entrance

Formed by the two ends of the mesh forming a funnel, the ends are tied together at the top with wire or rope. The pig moves through the funnel forcing the bottom of the mesh ends apart and once it is in the trap the ends spring back together (see Figures 1 and 2).

Tripped gate entrance

A side-hinged gate is pulled shut by springs and is held open by many systems that can be triggered to allow the gate to swing shut. Often trip wires or other systems are used; most of these systems are not selective for feral pigs and can be triggered by any animal attracted to the bait. Once triggered the trap is no longer effective in trapping pigs.

Pig-specific trigger

By far the simplest and most effective trigger system has the gate held open by a bar (often a branch or piece of wood) which is hooked over the wire on the gate and on the side panel (see Figure 3). For a close up of the pig specific trigger (see Figure 4).

Pigs rooting for feed in the trap lift the bar allowing the gate to swing shut. The specific feeding habit of pigs insures they are the only animals that lift the trigger bar.

The gate may be latched to prevent pigs from opening the door once triggered. However, this will prevent more pigs pushing their way in to join those inside.

Shooting

Shooting pigs by helicopter is effective in areas where pigs exist in reasonable numbers and are observable from the air.

Ground shooting is not effective in reducing the pig population unless intense shooting is undertaken on a small, isolated and accessible population of pigs.

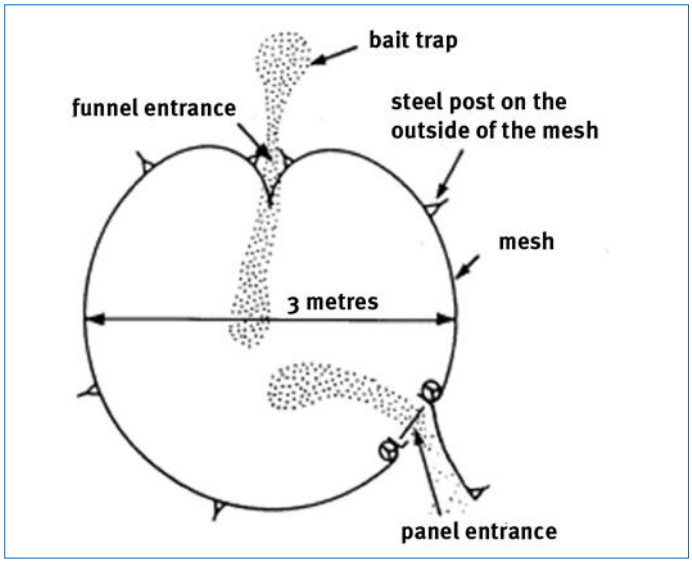


Figure 1. Alternative trap entrances – funnel entrance

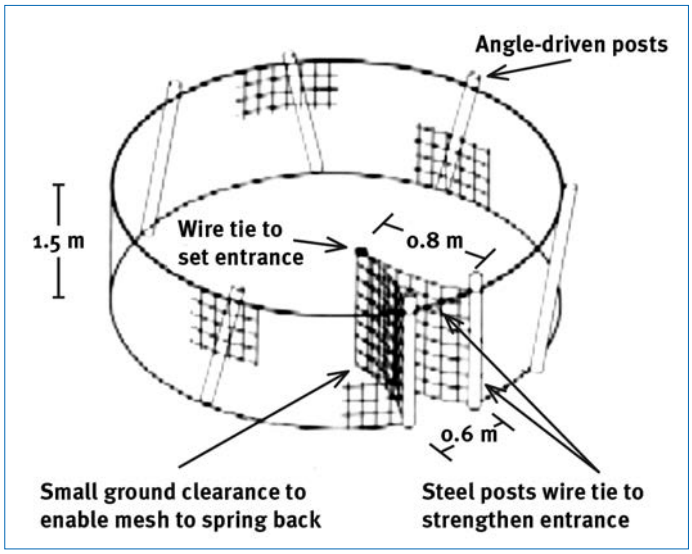


Figure 2. Silo trap with funnel entrance (14 m of silo mesh diameter about 4.5 m

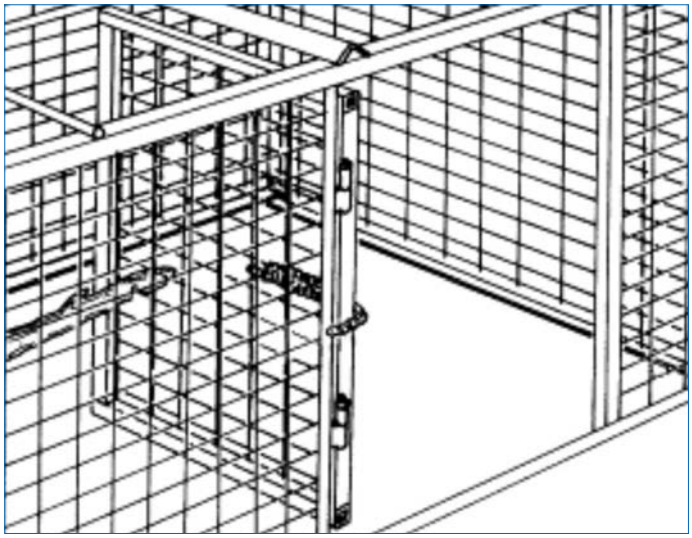


Figure 3. Pig-specific trigger

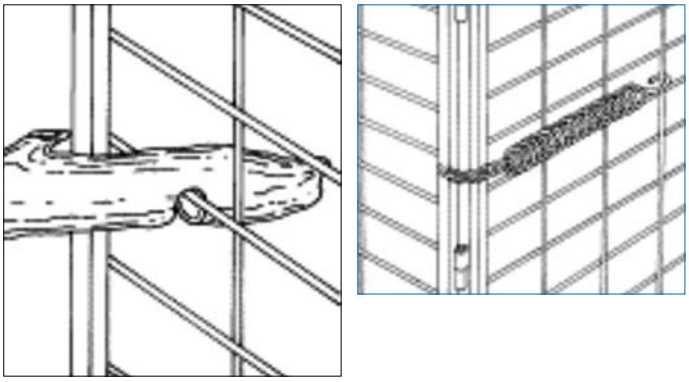


Figure 4. Close up of pig-specific trigger

Feral pig trap

Trapped feral pigs

Hog hopper – pig specific bait station

Poisoning

Poisoning is the most effective control method available that can quickly reduce a pig population.

Sodium fluoroacetate (1080) can only be supplied by people approved under the Health (Drugs & Poisons) Regulation 1996 for the purpose of controlling declared pest animals. Your local government office should be able to assist you.

Pre-feeding is the most important step in ground-based poisoning operations. Free feeding with non-poisoned bait should be performed for several days prior to laying poisoned baits.

By selecting bait wisely, landholders can be species-selective in their poisoning program and avoid many of the unintentional effects of secondary poisoning.

Bait material such as fermented grains are very attractive to pigs. It is a good idea to establish a free feeding routine so that pigs are the only animals feeding, which helps to keep other non-targets away from the feeding site.

Other options (like pig-specific feeders) are now commercially available, and can assist in reducing non-target species access to bait. Other options include burying baits; feral pigs are one of the few animals that will dig up bait.

Aerial poisoning is also available and typically used for broadscale control in western and northern regional areas. Bait is distributed from an aircraft. This is particularly useful for covering large, remote, areas or restricted ground access. Aerial poisoning is a proven and cost-effective method for reducing pig populations.

A phosphorous-based poison is also available for use in Queensland.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

Biosecurity Queensland gratefully acknowledges the contribution from Choquenot, D., McIlroy, J. and Korn T. (1996) Managing Vertebrate Pests: Feral Pigs, Bureau of Resource Sciences, AGPS, Canberra. Commonwealth of Australia copyright reproduced by permission.

Feral pig exclusion fencing

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture and Fisheries, 2016.

Department of Agriculture, Fisheries and Forestry
Biosecurity Queensland

Restricted invasive animal

Rabbit

Oryctolagus cuniculus

Rabbits are one of Australia's major agricultural and environmental animal pests, costing the country between $600 million and $1 billion annually. They compete with native animals, destroy the landscape and are a primary cause of soil erosion by preventing regeneration of native vegetation.

Legal requirements

The rabbit is a restricted invasive animal under the *Biosecurity Act 2014*. It must not be moved, kept, fed, given away, sold, or released into the environment without a permit. The Act requires everyone to take all reasonable and practical steps to minimise the risks associated with invasive plants and animals under their control. This is called a general biosecurity obligation (GBO). This fact sheet gives examples of how you can meet your GBO.

At a local level, each local government must have a biosecurity plan that covers invasive plants and animals in its area. This plan may include actions to be taken on certain species. Some of these actions may be required under local laws. Contact your local government for more information.

Queensland Government

Pet rabbits

Introducing and selling rabbits in Queensland is not permitted (penalties apply). Limited numbers of permits for domestic rabbits are only available from Biosecurity Queensland for research purposes, public display, magic acts or circuses. Before a permit is granted, a number of guidelines need to be fulfilled.

Description

Rabbits are small mammals around 34–45 cm in length usually grey brown with pale belly fur, other colours include piebald, black and ginger. They have long ears 10 cm long and big eyes. They have long hind legs with hind feet measuring 9–11 cm and shor t front legs. The tail is fluffy brown with white underneath, 4–8 cm. Adult rabbits usually weigh around 1–2.1 kg. The male is called a buck, the female a doe and her young are called kittens.

Life cycle

Does (females) are pregnant for 28–30 days, but are able to mate within hours of giving birth. The average litter is 3–4 kittens but varies from two in a young doe, up to eight or more in a mature doe, and depends on the amount and quality of food available.

Five to six litters are possible in a good season. Young does can breed at four months of age if conditions are suitable.

Habitat and distribution

Rabbits prefer to live in warrens as protection against predators and extremes in temperature. However, they will sur vive in above-ground harbours such as logs, windrows and dense thickets of scrub (e.g. blackberr y and lantana) or under built harbour, old sheds and machiner y etc.

In newly colonised areas without warrens, rabbits tend to live in 'scrapes' (or 'squats')

Rabbits are adaptable and sometimes live in close association with people. They live in built environments such as:

- in and under buildings
- old machinery and storage containers
- in old dumps.

In rural environments rabbits frequently live in:

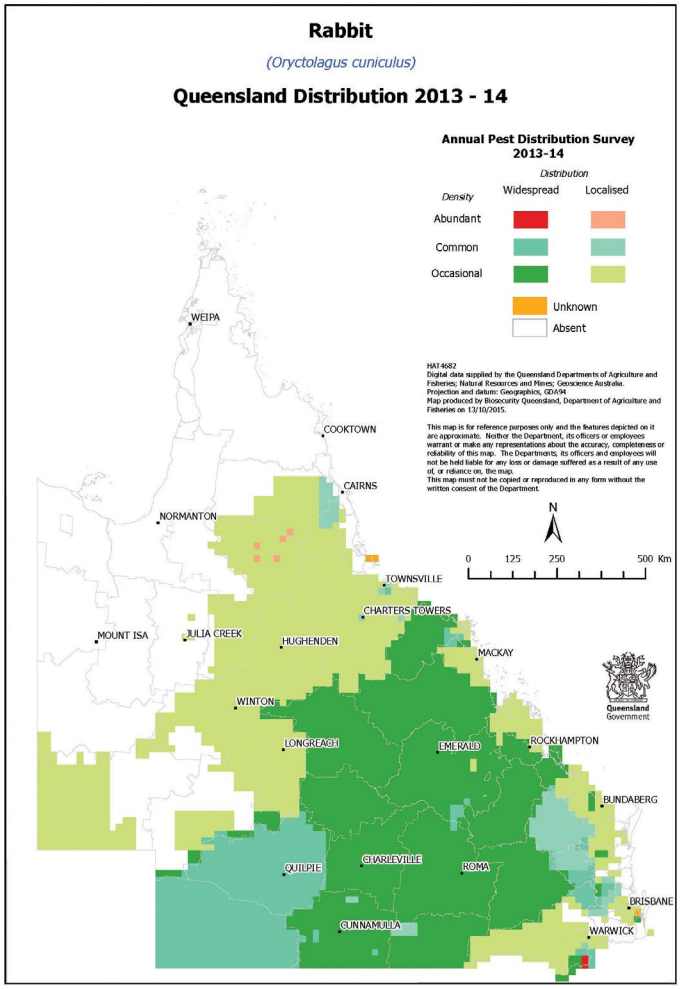
- felled timber and associated windrows
- tussock grasses and rocky areas
- warrens (if soils are easy to dig).

Control

Managing rabbits

The GBO requires a person to take reasonable and practical steps to minimise the risks posed by rabbits. This factsheet information and some options for controlling rabbits.

Map 1. Distribution of rabbits in Queensland



Effective rabbit control cycle

Rabbit control is best done as a joint exercise involving all land managers in the district. Integrated control methods, such as fumigating, ripping warrens and harbour destruction, are essential for the continued long-term reduction of rabbit numbers. Cost-effective, long-term results can be achieved in rabbit control by following a combination of the methods outlined below.

Prevention and early detection

Rabbits will generally eat around 15% of their body weight per day—approximately 250 g. This compares dramatically with the averages for stock—sheep and cattle eat around 3% of their body weight per day. So even a low number of rabbits can be removing large amounts of livestock feed.

For effective long-term rabbit control, concentrate on destroying source areas. Source areas will all have well-established warrens or ready-made structures that are cool and provide protection from predators. A source area must also have a good supply of green feed during the cooler seasons.

Manual control

Harbour destruction

Where there is abundant surface harbour, a high proportion of rabbits may live above ground rather than in underground warrens. Rabbits can make their homes in windrows, dense thickets of shrubs (such as blackberries and lantana) and even in old machinery.

To eliminate these above-ground breeding areas, it may be necessary to:

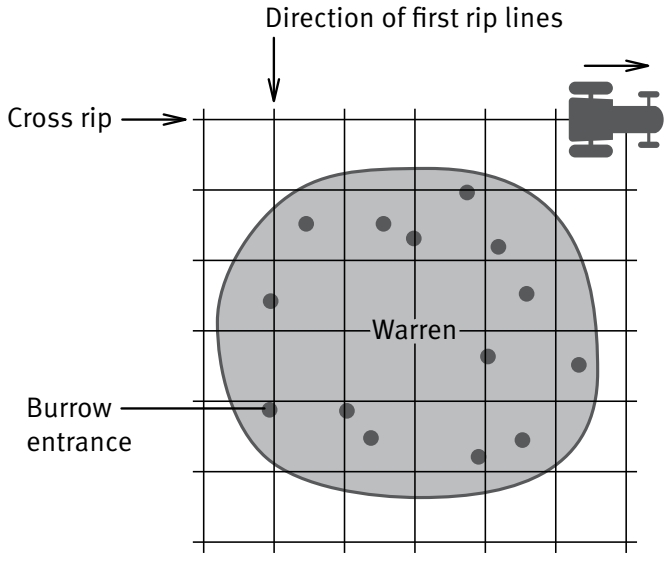
- burn windrows and log piles
- remove noxious weeds through chemical and physical control
- remove movable objects (such as old machinery) from paddocks.

Sometimes removing harbour can expose warrens underneath. If this happens, the warrens need to be ripped.

Mechanical control

Warren ripping

In areas where rabbits live in warrens, ripping is the most effective method of long-term control. Ripping is so successful because warrens can rarely be reopened and rabbits are unable to recolonise these areas.

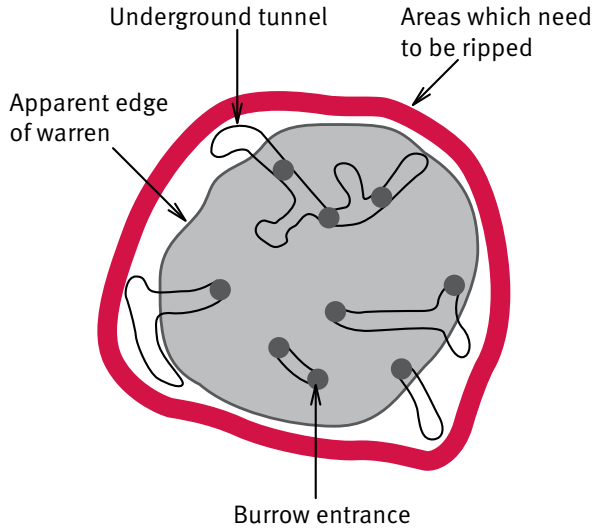


Direction to rip warrens (illustration courtesy Will Dobbie)

Tyne for ripping warrens (photo courtesy Mark Ridge)

To get the best results it is important to chase as many of the rabbits inside the warren as possible. Dogs can be used to drive rabbits into the warren before ripping starts.

The aim of ripping is to completely destroy the warren. It involves using a tractor with a tyned (sharp-pronged) implement—one tyne or many—that rips through the warren and collapses it. Larger tractors and dozers are more appropriate for properties with many warrens as they are able to move faster and rip wider.



Extent to rip warrens (illustration courtesy Will Dobbie)

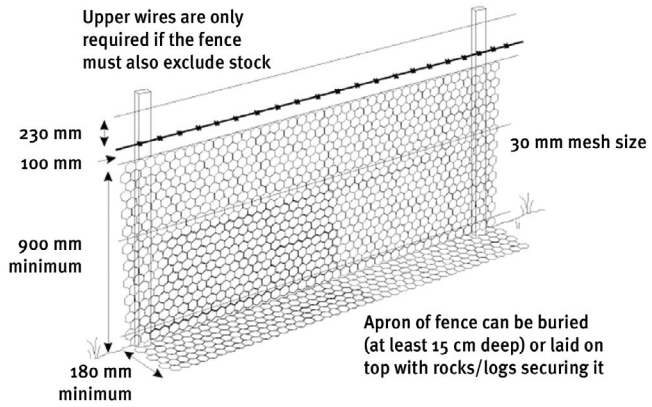
Obviously, ripping is not suitable for warrens located underneath buildings or on steep rocky country. In such cases, other methods (poison baiting, releasing virus or fumigating burrows) should instead be used to reduce rabbit numbers. Warrens should then be either filled in or covered to stop rabbits from re-establishing. Burrows can be blocked with small boulders or rocks.

Rock blocking rabbit hole

Exclusion fencing

Rabbit exclusion fences are built with the aim of keeping rabbits out of a particular area. It is appropriate for small, high-value areas that require protection. A fully fenced area will only remain rabbit-free in the long term if all rabbits are removed from the enclosed area after fencing and the fence is regularly maintained and checked for holes.

Electric fencing is a cheaper alternative, but it is not a complete physical barrier and is also prone to damage from other pest animals and stock.



Exclusion fence for rabbits (illustration courtesy DEWHA)

A rabbit-proof fence should be made of wire mesh netting (40 mm or smaller) and needs to be at least 900 mm high. The netting should also be buried to depth of at least 150 mm. Gates into the fenced area need to be rabbit-proof as well.

Trapping

Trapping is an extremely labour-intensive control method and requires a skilled operator to set the traps to successfully capture rabbits.

If you do plan to trap rabbits on your property, common sense and respect for animal welfare are essential. While there are currently no strict guidelines for the use of traps in Queensland, it is an area of growing concern for animal welfare advocates.

Cage trap

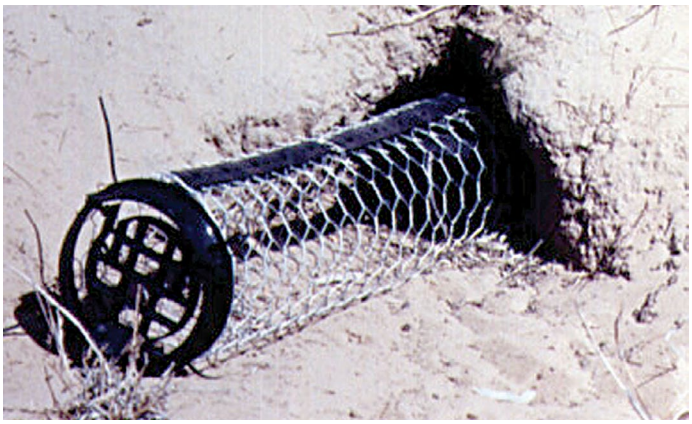
A cage trap has a lever that closes the cage when a rabbit steps on it. The rabbits are lured into the cage with bait—usually diced carrot. Traps need to be disabled and left open for two or three nights with bait leading into the cage. This entices rabbits to enter. A trap can be set once a rabbit has consumed a trail of bait all the way into that trap. Traps should be checked and emptied regularly—usually a couple of times a night.

This effective and humane technique is most useful for removing any remaining rabbits from places like hay sheds and after the shed has been fenced to prevent additional rabbits from entering and leaving. Free-feed then trap, and keep the shed rabbit-proof to prevent rabbits recolonising.

Barrel trap

A barrel trap is designed specifically for rabbits. It is cylindrical, made of light mesh, and is about 1 m long and 15 cm in diameter. The trap has one open end with two hinged trap doors along its side. The open end is placed in the burrow, and the hinged gates close and trap the rabbit after it enters from the burrow.

The trap can be left in the burrow entrance for a number of days. However, it must be checked at least daily so that if a rabbit has been caught it does not suffer and animal welfare responsibilities are met.



Barrel rabbit trap in hole

Biological controls

Rabbit hemorrhagic disease virus (also known as rabbit calicivirus disease)

RHDV is a virus specific to rabbits which works by infecting the lining of the throat, lungs, gut and liver.

RHDV relies primarily on direct rabbit-to-rabbit contact in order to spread. High rabbit numbers are therefore needed before this control method will be effective.

After RHDV has infected an area, it is important to use another method for follow-up control to increase the likelihood that the population is eradicated before it is able to develop resistance and increase its numbers again.

Resistance to RHDV depends primarily on the age of the rabbit. Therefore, it is better for RHDV to go through a rabbit population after rabbits have bred and the young are old enough to be affected by the virus. Rabbits that survive RHDV develop antibodies against the virus. Breeding females can also pass these antibodies on to the young (through antibodies in their milk), conferring temporary protection on rabbits up to 12 weeks old.

Myxomatosis

Myxomatosis is no longer produced as a laboratory strain but field strains are still known to recur and affect rabbit populations.

RHDV1-K5

Recent research by state and federal agencies has identified a new strain of RHDV (called RHDV-K5) that will aid in controlling rabbits that have immunity to current strains.

Shooting

Shooting is most useful when used to ‘mop up’ after other control methods (such as ripping). To get the best results, shoot at the time of day when rabbits are active. This is usually in the early morning, late afternoon or at night. The best and most economical firearm to use is a .22 calibre rifle.

If your property is within an urban area, you will need to comply with local government regulations and the *Police Powers and Responsibilities Act 2000*, which restrict the use of firearms.

Poison baiting

Baiting is not effective as a sole control method and will not eradicate an entire rabbit population. Numbers will quickly increase again, and you will have to continue baiting year after year with no permanent overall change in the rabbit population.

Rabbits can also become 'bait shy' and this method becomes less and less effective over time. Ideally, baiting is best used either before ripping/fumigation to reduce a population, or after ripping/fumigation as a 'mop-up'.

Baiting works best when rabbits are not breeding. During breeding season the majority of the population feeds over a larger-than-normal area, and it is the young rabbits that are most likely to take baits. While numbers will be reduced, animals of breeding age are not likely to be affected.

1080—sodium fluouroacetate

Pre-feeding is required when using 1080 because rabbits will not readily take new feed. The poison-free bait should be laid at least three times over a one-week period before the poisoned bait is laid. (1080-impregnated carrot baits are the most common form of bait used.) The practice helps to ensure that, when the poisoned bait is laid, it will be eaten by most of the rabbit population.

1080 can only be supplied through persons authorised under the Health Act. Your local Biosecurity officer or your local government office should be able to assist you.

Pindone

Pindone is an anticoagulant registered for rabbit control. This poison works by preventing blood from clotting. In Queensland, it is not recommended for broadacre use and is mainly used in urban areas and near farm buildings.

Pindone works best when given as a series of small doses/feeds over a period of three days. Although pre-feeding is not essential, it does enhance the bait uptake by shy rabbits as they get used to the feed prior to any poison bait being laid. To be effective, pindone requires multiple feeds so that the poison can build up to fatal levels in the rabbit's body. Feeding over a number of nights provides plenty of opportunity for most of the rabbit population to consume the required lethal dose. Rabbits poisoned with pindone will usually die within 10–20 days.

Pindone baiting does not work well when there is a lot of green pick around for rabbits.

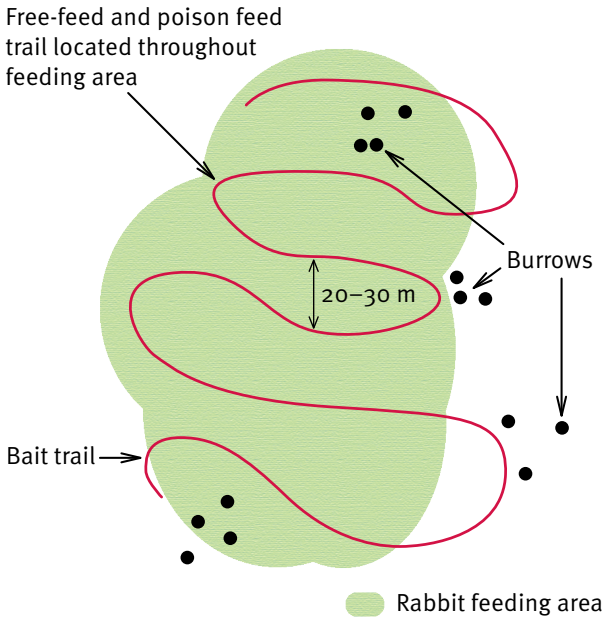
Poison bait trails

It is important that bait trails are laid properly to ensure the best results. 'Baitlayers' make it easier to put out bait trails at the correct rate, and they can be towed behind most 4WD vehicles, quad bikes and tractors.

When scratching and laying a trail, consider the following:

- Rabbits like freshly scratched/disturbed soil—this may be because rabbits are territorial and inspect newly disturbed soil, and/or the disturbed vegetation smell attracts them.
- Lay trails around warrens and in the areas where rabbits most often feed.
- Laying trails on slopes and hills requires care—it can cause erosion in some soils types (e.g. granite and traprock). Trails are best laid in a zigzag pattern in steep terrain to minimise erosion.
- A trail that has been scratched for the first feed is easy to follow for the rest of the baiting program.
- The soil should be turned only enough to scratch the surface—don't plough the ground.
- A trail that has been scratched too deep will spook the rabbits because they will not have full sight of their predators.
- Where vegetation is thick, or it is difficult to find the main feeding areas, lay bait trails in a grid pattern across the site.

As a general rule, avoid crossing the bait trail—it can cause confusion when you try to follow the same trail on subsequent occasions.



Method for laying a bait trail (illustration courtesy Animal Control Technologies)

Bait trials will be most effective if you follow these guidelines:

- Use good quality, non-contaminated bait material. (Simple rule: if you wouldn't eat it, the rabbit won't either.)
- Use enough feed to bait all the rabbits in the area. (The pre-feed will give an indication of the potential bait take.)
- Expect a greater uptake of pre-feed and bait material when vegetation is scarce, dried off or soured.
- Ensure that all the preparation equipment is clean and free of any chemical residues or smells—rabbits can be very shy of unusual odours.
- When there are kittens in a warren, lay the bait trail close to the warrens.

Fumigation

Fumigation is labour intensive and time consuming, and is not usually an effective method if used alone. However, as a 'mop-up' technique or control method for use in areas

where ripping is not practical (e.g. steep and rocky terrain), it may be a good alternative.

Because this technique relies on directly affecting the rabbits, and does not affect the structure of the warren, it is crucial that as many rabbits as possible are underground when fumigation is carried out. Rabbits usually take refuge in their burrows from mid-morning to mid-afternoon and during hot weather so these are the best times to fumigate. Dogs can also be used to drive rabbits into their warrens.

For best results, fumigation should be carried out in two stages—initially, before the breeding season starts (as this reduces the breeding stock), and then again during the breeding season.

There are two types of warren fumigation—static and pressure. In Queensland, static fumigants are a more popular and safer option for controlling rabbits and will be explained below.

Static fumigation

This method is easy to use, and time- and cost-effective. Static fumigation comes in the form of aluminium phosphide (phosphine) tablets, which can be purchased from most agricultural suppliers. These tablets are small and round (about the size of a marble), and weigh 3 g. Trade names for phosphine include Pestex®, Quickphos® and Gastion®. General directions for the use of phosphine tablets appear below, but always refer to the manufacturer's specific recommendations for use.

To fumigate warrens using phosphine tablets:

1. Find all warren entrances—both active and inactive.
2. Cut back the warren entrance at right angles using a shovel.
3. Separately wrap two tablets in moistened absorbent paper (toilet paper/paper towels).
4. Insert the tablets as far down into the entrance as possible (polypipe and a push rod can be used to help push the tablets down).
5. Push some scrunched-up newspaper down the hole to block the entrance and then cover it up with soil and, if possible, a rock.
6. Treat all entrances to the warren (active and inactive) the same way.
7. Check warrens about a week after fumigation and re-fumigate any reopened entrances.

Once in the warren, the moistened tablets react with air to release a toxic gas, which spreads quickly throughout the warren. The phosphine gas itself is invisible and odourless but leakages from the warren can be detected by the smell of ammonia. (This is a safety mechanism that is built into the tablet.) Any leakages need to be blocked immediately.

Shooting

Shooting is most useful when used to 'mop up' after other control methods (such as ripping). To get the best results, shoot at the time of day when rabbits are active. This is usually in the early morning, late afternoon or at night. The best and most economical firearm to use is a .22 calibre rifle.

If your property is within an urban area, you will need to comply with local government regulations and the *Police Powers and Responsibilities Act 2000*, which restrict the use of firearms.

Further information

For further detailed reading information on specific rabbit control techniques or costing your rabbit control please refer to Rabbit control in Queensland; a guide for land managers. Download from the Biosecurity Queensland website at www.biosecurity.qld.gov.au

Further information is available from your local government office, or by contacting Biosecurity Queensland on 13 25 23 or visit www.biosecurity.qld.gov.au.

Wild rabbit

Escaped or dumped pet rabbits

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture and Fisheries (DAF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture and Fisheries, 2016.

GEMINI PROJECT
AQUATIC ECOLOGY ASSESSMENT

PREPARED FOR
MAGNETIC SOUTH PTY LTD

SEPTEMBER 2019

BRISBANE OFFICE
Suite 5, 1 Swann Road
Taringa, QLD 4068
P +61 7 3217 8772

CAIRNS OFFICE
PO Box 4887
Cairns, QLD 4879
P +61 7 4057 9402

E info@aarc.net.au
AARC.NET.AU

ACN. 620 818 920
ABN. 71 620 818 920

AARC Environmental Solutions Pty Ltd

Document History and Status

Issue	Rev.	Issued To	Qty	Date	Reviewed	Approved
Draft	0.1	SG	1	09/2019	SG	SG
Draft	0.2	SG	1	09/2019	SG	SG
Draft	0.3	Magnetic South	1	09/2019	PI	PI
Draft	0.3	GB	1	09/2019	GB	GB

Author: Caitlin Eales
Project Manager: Gareth Bramston
Name of Client: Magnetic South Pty Ltd
Name of Project: Gemini Project
Title of Document: Aquatic Ecology Assessment
Document Version: Final

This controlled document is the property of AARC Environmental Solutions Pty Ltd and all rights are reserved in respect of it. This document may not be reproduced or disclosed in any manner whatsoever, in whole or in part, without the prior written consent of AARC Environmental Solutions Pty Ltd. AARC Environmental Solutions Pty Ltd expressly disclaims any responsibility for or liability arising from the use of this document by any third party.

Opinions and judgments expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal opinions. Information obtained from interviews and contained in the documentation has been assumed to be correct and complete. AARC Environmental Solutions Pty Ltd does not accept any liability for misrepresentation of information or for items not visible, accessible, nor able to be inspected at the sites at the time of the site visits.

GEMINI PROJECT
AQUATIC ECOLOGY
ASSESSMENT

INDEX

1.0 INTRODUCTION 1
1.1 SCOPE OF STUDY 1
1.2 PROJECT OVERVIEW 2
1.3 CURRENT LAND USE 3
1.4 LOCAL WATERWAYS AND TOPOGRAPHY 3
1.5 GEOLOGY 6
1.6 REGIONAL CLIMATE 6
2.0 RELEVANT LEGISLATION AND POLICY 8
2.1 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 8
2.2 NATURE CONSERVATION ACT 1992 8
2.3 BIOSECURITY ACT 2014 9
2.4 QUEENSLAND ENVIRONMENTAL OFFSETS FRAMEWORK 9
2.5 FISHERIES ACT 1994 10
2.6 ENVIRONMENTAL PROTECTION (WATER AND WETLAND BIODIVERSITY) POLICY 2019 10
3.0 DESKTOP ASSESSMENT 12
3.1 SPECIES OF CONSERVATION SIGNIFICANCE 12
3.2 WETLAND HABITATS 15
3.3 WATERWAYS FOR FISH HABITAT 15
4.0 ENVIRONMENTAL VALUES AND OBJECTIVES 17
4.1 ENVIRONMENTAL VALUES 17
4.1.1 Water Quality Objectives 17
4.1.2 Stream Sediment Quality Objectives 19
5.0 METHODOLOGY 20
5.1 FIELD SURVEY WEATHER CONDITIONS 20
5.2 SAMPLING SITES 21
5.3 SURFACE WATER SAMPLING 26
5.4 STREAM SEDIMENT QUALITY 26
5.5 CREEK ECOLOGY 26
5.5.1 Physical Assessment 26

5.5.2 Habitat Bioassessment 27
5.5.3 Condition Assessment 28
5.5.4 Macroinvertebrate Sampling 29
5.5.5 Fish and Crustacean Sampling 29
5.6 RIPARIAN AND AQUATIC VEGETATION 29
5.7 RIPARIAN ZONE VERTEBRATE FAUNA 29
6.0 RESULTS AND DISCUSSION 32
6.1 SURFACE WATER QUALITY 32
6.2 STREAM SEDIMENT QUALITY 42
6.3 CREEK ECOLOGY 45
6.3.1 Physical Assessment 45
6.3.2 Habitat Bioassessment 47
6.3.3 Condition Assessment 47
6.3.4 Macroinvertebrate Sampling 48
6.3.4.1 Total Abundance 48
6.3.4.2 Taxonomic Richness 49
6.3.4.3 PET Taxa Richness 50
6.3.4.4 SIGNAL 2 Scores 50
6.3.4.5 SIGNAL 2 Bi-Plot 51
6.3.4.6 Percent Tolerant Taxa 52
6.3.4.7 Community Composition – AusRivAS Predictive Modelling 53
6.3.5 Fish and Crustacean Sampling 54
6.3.5.1 Crustaceans 54
6.3.5.2 Fish 54
6.4 RIPARIAN AND AQUATIC VEGETATION 55
6.4.1 Vegetation Assessment 55
6.4.2 Flora of Conservation Significance 57
6.5 WETLANDS 57
6.6 RIPARIAN ZONE VERTEBRATE FAUNA 57
6.7 SUMMARY OF AQUATIC VALUES 58
7.0 POTENTIAL IMPACTS 60
8.0 MITIGATION STRATEGIES 62
9.0 PROJECT ENVIRONMENTAL OFFSETS 63
9.1 ASSESSMENT OF PRESCRIBED MATTERS IDENTIFIED IN THE STUDY AREA 63
9.1.1 Fish Passage 63
9.1.2 Fitzroy River Turtle 65
9.1 OFFSETS REQUIREMENTS 66
10.0 REFERENCES 67

LIST OF APPENDICES

Appendix A Database Searches ..... A
Appendix B AARC AusRivAS Physical Assessment Results ..... B
Appendix C Macroinvertebrate Sampling Results C
Appendix D Riparian and Aquatic Vegetation Species List ..... D
Appendix E Riparian Zone Vertebrate Fauna Species List ..... F
Appendix F Fish and Crustacean Species List ..... F
Appendix G Queensland Herbarium Identification Results ..... F

LIST OF FIGURES

Figure 1 Project and Study Area Location 4
Figure 2 Waterways and topography associated with the study area 5
Figure 3 Mean temperature and rainfall data for the region (Source: SILO) 7
Figure 4 Wetland Habitats 16
Figure 5 Regional Seasonal Rainfall Trends for 2013 – 2018 (Source: BoM 2019) 21
Figure 6 Location of Survey Sites 25
Figure 7 Stream Sediment Particle Size Analysis 45
Figure 8 Habitat Bioassessment Scores 47
Figure 9 Condition Assessment Scores 48
Figure 10 Macroinvertebrate Abundance 49
Figure 11 Macroinvertebrate Taxonomic Richness 49
Figure 12 PET Taxonomic Richness 50
Figure 13 Macroinvertebrate SIGNAL 2 Site Scores 51
Figure 14 Macroinvertebrate SIGNAL 2 Bi-Plot 52
Figure 15 Percentage of Tolerant Macroinvertebrate Taxa 53
Figure 16 Vegetation Species Richness 56
Figure 17 Vegetation Species Composition 57
Figure 18 Conceptual Project Layout 61

LIST OF TABLES

Table 1 Fauna Species of Conservation Significance identified by Desktop Searches 14

Table 2 WQO Guideline Values 17
Table 3 ANZECC Stream Sediment Quality Guideline Objectives 19
Table 4 Sampling Site Locations 22
Table 5 Survey Methods 23
Table 6 Physical Assessment Methodology 27
Table 7 Key to AusRivAS Habitat Assessment Scores 28
Table 8 Physico-Chemical Parameters (Charlevue Creek) 34
Table 9 Physico-Chemical Parameters (Stanley Creek, Springton Creek) 35
Table 10 Dissolved Metals (Charlevue Creek) 36
Table 11 Dissolved Metals (Stanley Creek, Springton Creek) 37
Table 12 Total Metals (Charlevue Creek) 38
Table 13 Total Metals (Stanley Creek, Springton Creek) 39
Table 14 Petroleum Hydrocarbons (Charlevue Creek) 40
Table 15 Petroleum Hydrocarbons (Stanley Creek, Springton Creek) 41
Table 16 Stream Sediment Total Metals Results 42
Table 17 Stream Sediment Particle Size Analysis 43
Table 18 Stream Sediment Particle Size Classification 44
Table 19 Erosion Observations at AARC 2019 Sites 46
Table 20 AusRivAS Predictive Modelling Results 54
Table 21 Vegetation Assessment 56
Table 22 MSES Residual Impact Assessment of Waterways providing for Fish Passage 64
Table 23 Fitzroy River turtle MSES Significant Residual Impact Assessment 65

LIST OF ABBREVIATIONS

%	percent
>	greater than
<	less than
°C	degrees Celsius
µS	micro Siemens
µg	microgram(s)
AARC	AARC Environmental Solutions Pty Ltd
ALA	Atlas of Living Australia
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZECC Guidelines	ANZECC Guidelines for Fresh and Marine Water Quality
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AusRivAS	Australian River Assessment System
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Method
Biosecurity Act	*Biosecurity Act 2014*
BoM	Bureau of Meteorology
CIM	Criteria, Indicators and Measures
cm	centimetre(s)
CHPP	Coal Handling Preparation Plant
DAF	Department of Agriculture and Fisheries
DES	Department of Environment and Science
DO	dissolved oxygen
DoEE	Department of the Environment and Energy
DNRME	Department of Natural Resources, Mining and Energy
EA	Environmental Authority
EC	electrical conductivity

EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPC	Exploration Permit Coal
EPP (Water and Wetland Biodiversity)	Environmental Protection (Water and Wetland Biodiversity) Policy 2019
ESA	Environmentally Sensitive Area(s)
Ext	Extensive
EV	environmental values
Fisheries Act	*Fisheries Act 1994*
g	gram(s)
ha	hectare(s)
kg	kilogram(s)
kV	kilovolt(s)
km	kilometre(s)
km^2	square kilometre(s)
m	metre(s)
Magnetic South	Magnetic South Pty Ltd
Mtpa	Million tonnes per annum
Mod	Moderate
mg	milligram(s)
MLES	Matter of Local Environmental Significance
MIA	Mine Infrastructure Area
mm	millimetre(s)
MNES	Matter of National Environmental Significance
MSES	Matter of State Environmental Significance
ND	No Data
NATA	National Association of Testing Authorities
NC Act	*Nature Conservation Act 1992*
NCWR	*Nature Conservation (Wildlife) Regulation 2006*

NTU	Nephelometric Turbidity Unit
N	Nitrogen
O/E	Observed versus Expected Macroinvertebrate Taxa
PCI	Pulverised Coal Injection
PET	Plecoptera, Ephemeroptera and Trichoptera
PMST	Protected Matters Search Tool
PIA	Potential Impact Area
the Project	Gemini Project
RE	Regional Ecosystem(s)
ROM	Run-of-Mine
REMP	Receiving Environment Monitoring Program
SILO	Scientific Information for Land Owners
SQG	ANZECC/ARMCANZ Sediment Quality Guidelines
TLO	Train Load Out
WoNS	Weeds of National Significance
WQO	Water Quality Objective(s)
Taunton National Park	Taunton National Park (Scientific)

1.0 INTRODUCTION

AARC Environmental Solutions Pty Ltd (AARC) was commissioned by Magnetic South Pty Ltd (Magnetic South) to prepare an Aquatic Ecology Assessment for the Gemini Project (the Project), located approximately 110 kilometres (km) east of Emerald and 125 km west of Rockhampton in the Bowen Basin of Central Queensland (Figure 1). The small rural townships of Bluff and Dingo are located approximately 15 km east and 3 km west of the Project, respectively (Figure 1). The Project is a proposed metallurgical open-cut coal mine and associated infrastructure, producing Pulverised Coal Injection (PCI) coal and Coking Coal products for export for steel production.

An assessment of aquatic ecological values was conducted within Exploration Permit Coal (EPC) 881 (herein referred to as the study area). This assessment forms part of the supporting studies required for the Project's approval processes.

1.1 SCOPE OF STUDY

To assess the ecological values of aquatic ecosystems within the study area, the following scope of works was undertaken:

- Database searches to identify aquatic species of conservation significance known or with potential to occur in the region (Appendix A);
- Field surveys employing standard methodologies derived from the *Terrestrial Vertebrate Fauna Survey Guidelines of Queensland* (Eyre et al. 2018) and *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland Version 4.0* (Neldner et al. 2017) to identify aquatic flora and fauna species inhabiting the study area, particularly species of conservation significance[1];
- Surface water quality, stream sediment sampling, macroinvertebrate sampling, fish and crustacean sampling and analyses in accordance to the *Australian River Assessment System (AusRivAS) Physical Assessment Protocol* (Parsons et al. 2002b), the *Queensland AusRivAS Sampling and Processing Manual* (DNRM 2001) and the *Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009* (DES 2018b); and
- Preparation of an assessment report describing the aquatic ecological values identified on site, potential impacts of the Project, management strategies to minimise the impacts associated with the proposed mining activities, and offset requirements.

[1] 'Species of conservation significance' or 'threatened species' when referred to within this document are references to species listed as Near Threatened, Vulnerable or Endangered under the Queensland *Nature Conservation Wildlife Regulation 2006* or Vulnerable, Endangered, Critically Endangered, migratory under the *Environmental Protection and Biodiversity Conservation Act 1999*.

1.2 PROJECT OVERVIEW

The main activities associated with the Project include:

- Exploration activities continuing in order to support mine planning;
- Development of a Mine Infrastructure Area (MIA) including mine offices, bathhouse, crib rooms, warehouse/stores, workshop, fuel storage, refuelling facilities, explosives magazine and sewage, effluent and liquid waste storage;
- Construction and operation of a Coal Handling Preparation Plant (CHPP) and coal handling facilities adjacent to the MIA (including Run-of-Mine (ROM) coal and, product stockpiles and rejects bin/overflow [coarse and fine rejects]);
- Construction and operation of a surface conveyor from the product stockpiles to a Train Load Out (TLO) facility and rail loop connecting to the Blackwater-Gladstone Branch Rail to transport product coal to coal terminals at Gladstone for export;
- Construction of access roads from the Capricorn Highway to the MIA, and to the TLO facility;
- Installation of a raw water supply pipeline to connect to the Blackwater Pipeline network;
- Construction of a 66 kilovolt (kV) transmission line and switching/substation to connect to the existing regional network;
- Other associated minor infrastructure, plant, equipment and activities;
- Development of mine areas (open cut pits) and out-of-pit waste rock emplacements;
- Drilling and blasting of competent waste material;
- Mine operations using conventional surface mining equipment (excavators, front end loaders, rear dump trucks, dozers);
- Mining up to 1.9 Million tonnes per annum (Mtpa) ROM Coal – average 1.8 Mtpa for a construction/production period of approximately 20 years;
- Progressive placement of waste rock in:
    - Emplacements, adjacent to and near the open cut voids;
    - Mine voids, behind the advancing open cut mining operations;
- Progressive rehabilitation of waste rock emplacement areas and mined voids;
- Progressive establishment of soil stockpiles, laydown area and borrow pits (for road base and civil works). Material will be sourced from local quarries where required;
- Disposal of CHPP rejects (coarse and fine rejects) in out of pit spoil dumps, and in-pit behind the mining void;
- Progressive development of internal roads and haul roads including a causeway over Charlevue Creek to enable coal haulage and pit access; and

- Development of water storage dams and sediment dams, and the installation of pumps, pipelines, and other water management equipment and structures including temporary levees, and drains.

Existing local and regional infrastructure, facilities and services would be used to support Project activities. These include the SunWater water distribution network, the Aurizon rail network, Ergon's electricity network, the Capricorn Highway, and Gladstone export coal terminals.

1.3 CURRENT LAND USE

The land within the study area is currently used for low intensity cattle grazing and resource exploration activities. The Capricorn Highway and a number of publicly gazetted roads including Charlevue, Cooinda, Red Hill, Normanby, and Ellesmere roads dissect the study area.

Located directly north of the study area is the Taunton National Park (Scientific), (Taunton Nation Park), a scientific reserve under the *Land Act 1994 (Queensland)*, with the aim of protecting a population of Bridled nail-tail wallabies. A small section of the Taunton National Park of around 2.5 hectares (ha) occurs within the study area.

1.4 LOCAL WATERWAYS AND TOPOGRAPHY

The study area lies within the Fitzroy River Basin, which encompasses an area of 142,545 square kilometres (km^2) and contains the Comet, Connors, Dawson, Don, Nogoa and Mackenzie Rivers, which make up its six sub-catchment areas (BoM 2018; DES 2018a). The study area lies within the Mackenzie River sub-catchment, which covers a total area of 12,985 km^2, and is situated in the centre of the Fitzroy River catchment.

Charlevue Creek traverses the study area in a north-easterly direction. This watercourse begins within the boundaries of Blackdown Tablelands National Park, flowing north-east before joining with Springton Creek and the Fitzroy River, and eventually into the Pacific Ocean approximately 46 km north of Gladstone. Stanley Creek and Springton Creek cross the study area in the north-west and south-east, respectively. These two creeks also eventually converge with the Mackenzie River. First and second order streams associated with Charlevue Creek and Springton Creek also occur in the study area. Figure 2 shows the extent and location of the waterways within the study area.

Springton Creek and Charlevue Creek are defined watercourses under the *Water Act 2000 (Queensland).* Springton Creek and Charlevue Creek within the study area are 5th order streams. Stanley Creek is a 2nd order stream.

Topography of the land varies from flat to undulating, with elevation within the study area ranging between 120 metres (m) and 150 m. The landscape is influenced by Charlevue Creek, which has a lower elevation than the surrounding landscape. The topography of the study area is representative of the surrounding region.

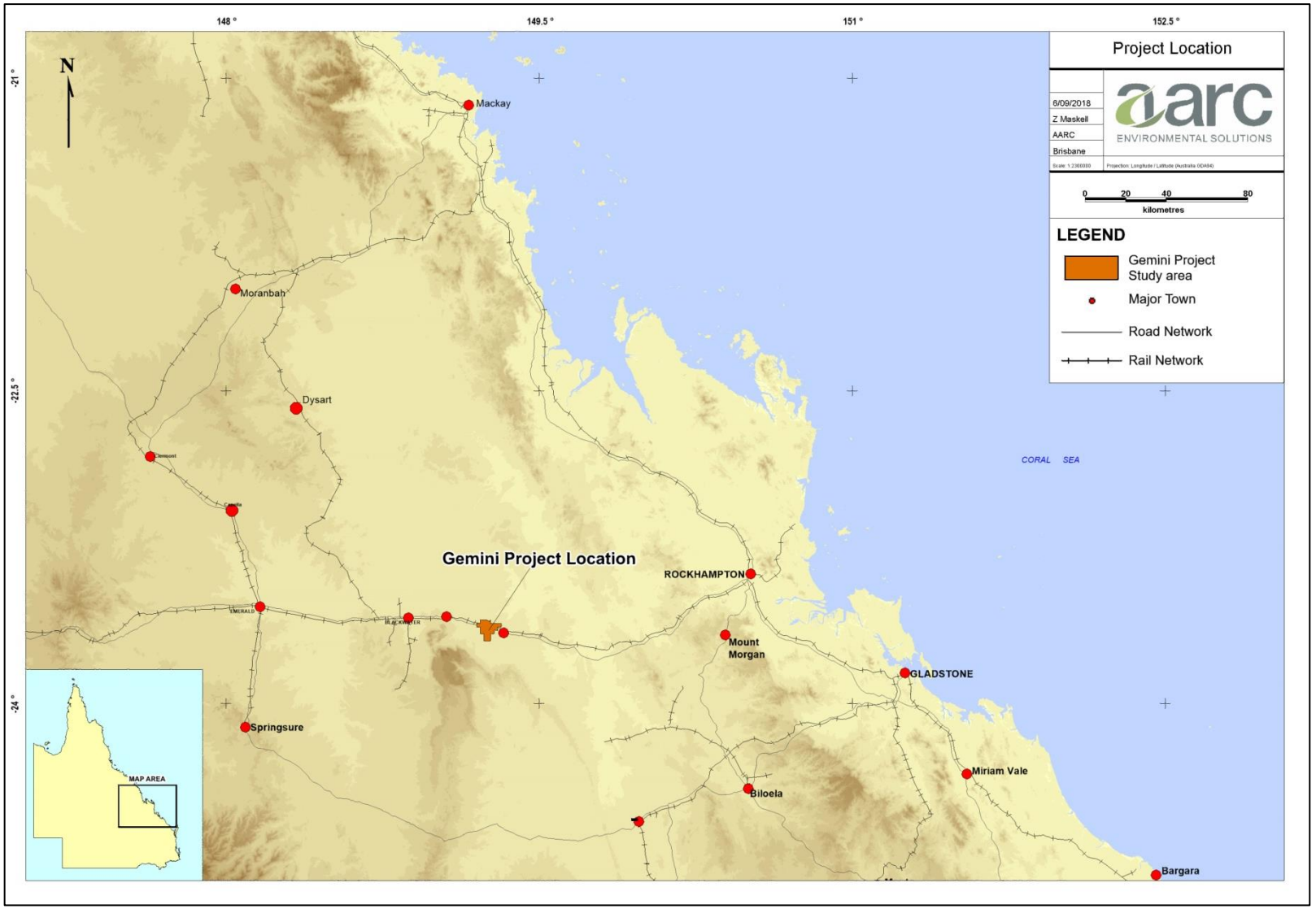


Figure 1 Project and Study Area Location

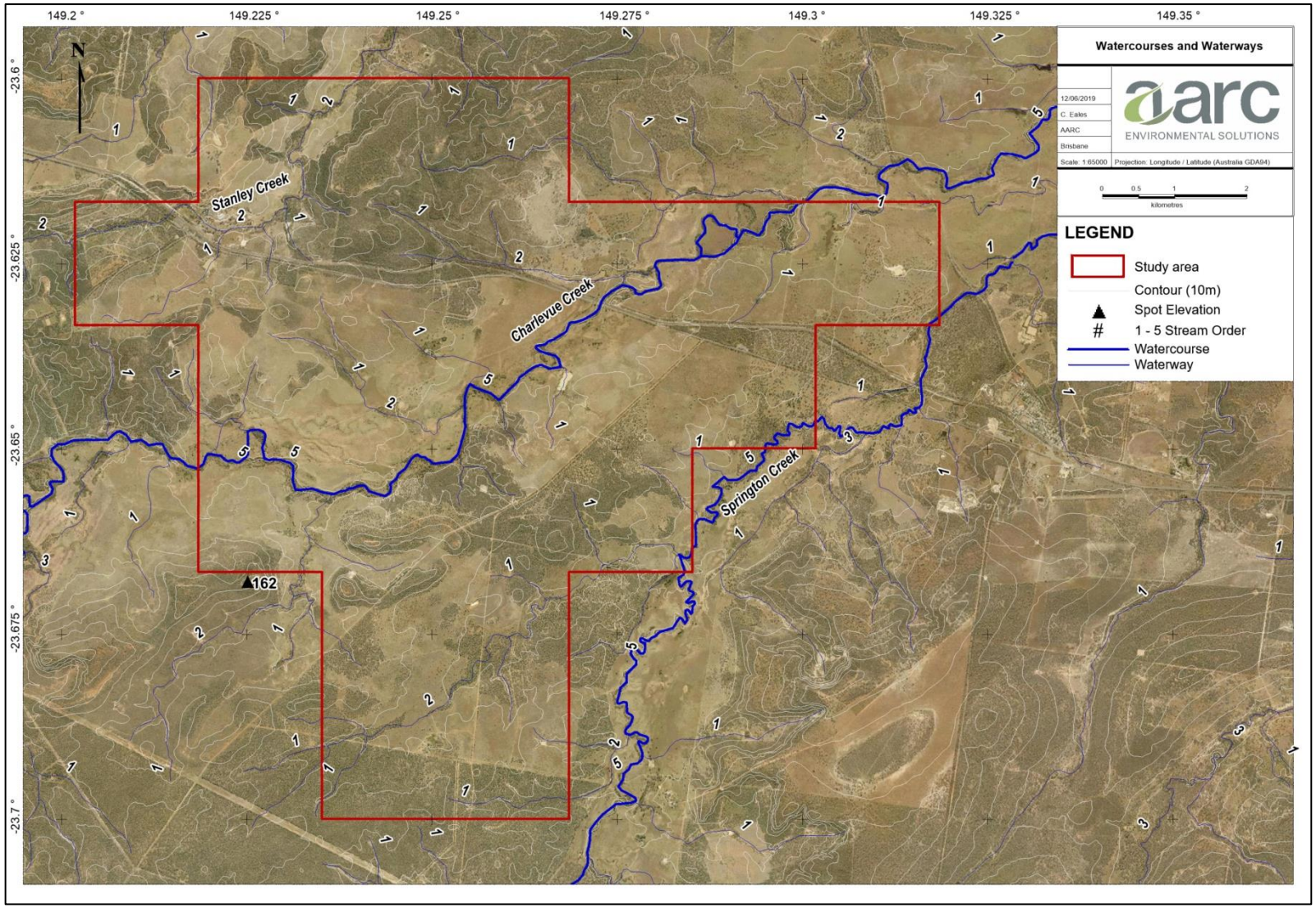


Figure 2 Waterways and topography associated with the study area

1.5 GEOLOGY

The geology of the region is dominated by its position within the Bowen Basin, one of Queensland's largest depositional regions, which formed through a period of rifting and subsidence lasting from the Early Permian - Mid-Triassic. The area is dominated by clastic sedimentary rocks of marine and lacustrine origin, including sandstones, conglomerates, mudstones, siltstones and coal (Geoscience Australia 2018).

The coastal and inland depositional environments which created these deposits allowed for the formation of extensive coal seams throughout the Bowen Basin, with the anoxic deposition of organic matter subsequently compacted and de-volatised through compression and increased temperatures (Brooks & Smith 1969).

Generally, coal seams found in the east-central part of the basin contain higher quality coking coal deposits, with rank falling below coking range farther south and west (Hutton 2009). The high-quality coal measures are of Permian age, buried less than 60 m from the surface (Mutton 2003).

1.6 REGIONAL CLIMATE

The regional climate is classified as semi-arid, characterised with warm dry summers and warm winters. Climate data for the study area has been sourced from Scientific Information for Land Owners (SILO) climate database (Queensland Government), which operates by interpolating data from the Commonwealth Bureau of Meteorology (BoM) into a single point data drill.

Figure 3 shows predicted average temperature and rainfall for the area from January 1999 to July 2019. The data indicates the annual mean rainfall for the region is highest between December and March with the maximum average occurring in December (111.5 millimetres (mm)).

The hottest months typically occur between October and March while the coolest months occur between May and September. The highest mean maximum temperature typically occurs in December (34.2 degrees Celsius (°C)) and the lowest mean minimum temperature in July (8.5°C). The mean annual maximum temperature for the region is predicted to be 29.8°C and the mean annual minimum temperature is predicted to be 16°C.

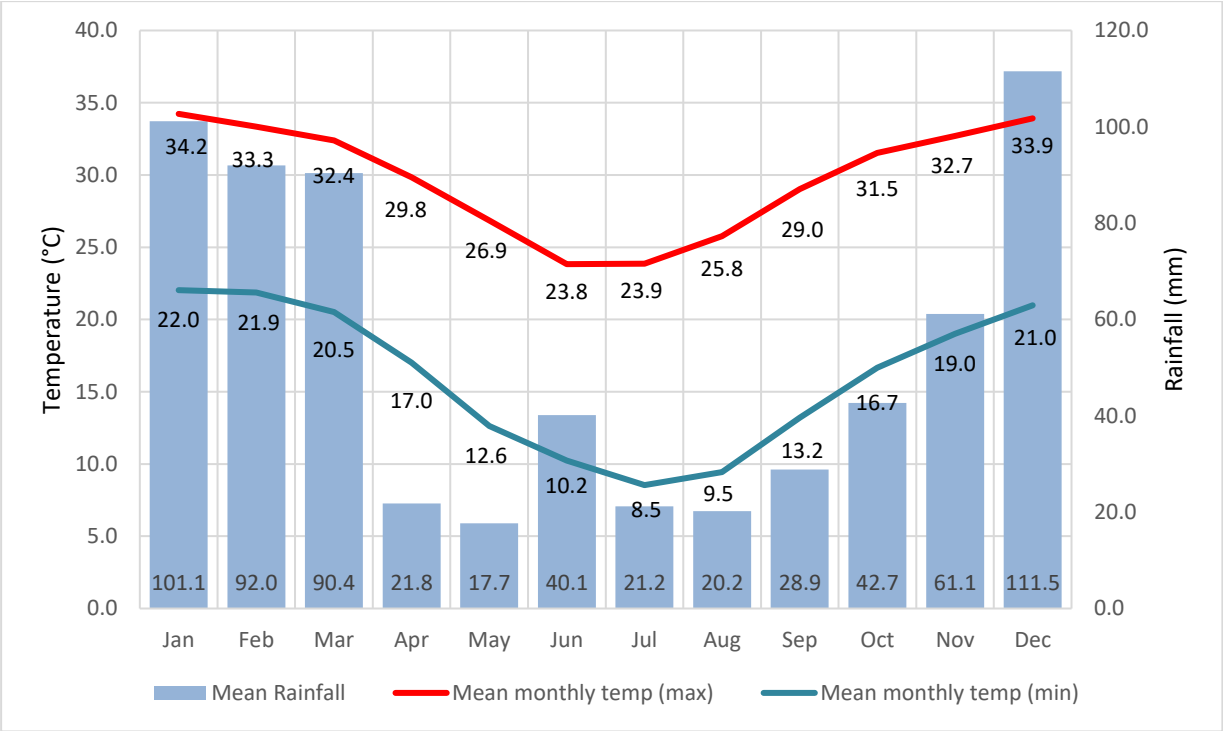


Figure 3 Mean temperature and rainfall data for the region (Source: SILO)

2.0 RELEVANT LEGISLATION AND POLICY

Commonwealth and State legislation and policies relevant to the assessment of aquatic ecological values on the study area are discussed below.

2.1 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

Under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), an action requires approval from the Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a Matter of National Environmental Significance (MNES).

An EPBC Referral (2010/5775) was lodged in 2010 for the Gemini Project previously known as the Dingo West Project by Dingo West Pty Ltd, which was declared 'Not a Controlled Action if undertaken in a Particular Manner' in July 2011.

The Particular Manner Decision conditions (EPBC 2010/5775) are as follows:

1. *To prevent downstream impacts to the Fitzroy River Turtle (Rheodytes leukops) the person taking the action must appropriately bund or locate pits in a manner that prevents surface water from entering the pit during a 1:1000 year flood event (as indicated in flood modelling at Attachment A).*

2. *To prevent downstream impacts to the Fitzroy River Turtle (Rheodytes leukops) the person taking the action must appropriately bund or locate dams in a manner that prevents surface water from entering or damaging the dams during a during a 1:1000 year flood event (as indicated in flood modelling at Attachment A).*

The Gemini Project complies with the Particular Manner Decision (EPBC 2010/5775). Furthermore, the level of impact to MNES have been assessed to be no greater than those described in the EPBC Referral (20105775).

2.2 NATURE CONSERVATION ACT 1992

The most relevant components of the Queensland *Nature Conservation Act 1992* (NC Act) to the Project, are the sections which pertain to Wildlife and Habitat Conservation. The classes of wildlife to which the NC Act applies includes protected wildlife, which is defined as Extinct wildlife; Endangered wildlife; Vulnerable wildlife; Near Threatened wildlife; and Least Concern wildlife. Species listed under the above classes are published in the associated *Nature Conservation (Wildlife) Regulation 2006* (NCWR).

'Threatening processes' are also relevant to wildlife and habitat conservation. The NC Act defines 'threatening processes' as any process that is capable of:

a) threatening the survival of any protected area, area of major interest, protected wildlife, community of native wildlife or native wildlife habitat; or

b) affecting the capacity of any protected area, area of major interest, protected wildlife, community of native wildlife or native wildlife habitat to sustain natural processes.

The NC Act is relevant to the Project for any protected flora or fauna species (as detailed in the NCWR) found in the study area.

2.3 BIOSECURITY ACT 2014

The Queensland *Biosecurity Act 2014* (Biosecurity Act) provides comprehensive biosecurity measures to safeguard our economy, agricultural and tourism industries, environment and way of life, from pests (e.g. wild dogs and weeds), diseases (e.g. foot-and-mouth disease), and contaminants (e.g. lead on grazing land).

Biosecurity matters are separated into three broad categories:

- A '**prohibited matter'** is a biosecurity matter that is not found in Queensland but would have a significant adverse impact on our health, way of life, and the economy or the environment if it entered the State. Prohibited matters must be reported to Biosecurity Queensland within 24 hours and all reasonable steps taken to minimise the risks of the prohibited matter and not make the situation worse;

- A '**restricted matter'** is a biosecurity matter found in Qld and has a significant impact on human health, social amenity, the economy or the environment. Restricted matters are further broken down into seven categories, with each category placing restrictions on the dealings with the biosecurity matter or actions required to be taken to minimise the spread and adverse impact of the biosecurity matter;

- An '**other matter'** is a biosecurity matter that is not a prohibited or restricted matter. Everyone is obligated to take all reasonable and practical steps to minimise the risks associated with other biosecurity matters under their control.

The Biosecurity Act is relevant to the Project in regard to the control and management of invasive plant and animal species.

2.4 QUEENSLAND ENVIRONMENTAL OFFSETS FRAMEWORK

The Queensland environmental offsets framework consists of the *Environmental Offsets Act 2014*, *Environmental Offsets Regulation 2014*, and the *Queensland Environmental Offsets Policy (Version 1.7*) (DES 2019). The offsets framework requires environmental offsets to be delivered where an activity is likely to result in a significant residual impact on a prescribed environmental matter. The *Significant Residual Impact Guideline* (DEHP 2014) is used to determine whether the residual impacts are significant.

Prescribed Environmental Matters include:

- Matters of National Environmental Significance (MNES);
- Matters of State Environmental Significance (MSES) (outlined below); and
- Matters of Local Environmental Significance (MLES).

MSES are defined in Schedule 2 of the *Environmental Offsets Regulation 2014*, and comprise:

- Regulated vegetation including:
    i. Endangered and Of Concern regional ecosystems;
    ii. Regional ecosystems (REs) that intersect areas shown as wetlands on the Vegetation Management Wetlands map;
    iii. REs located within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature; or

iv. REs mapped as essential habitat for endangered and vulnerable flora and fauna;

- Areas that provide connectivity and maintain ecosystem functioning;
- Mapped wetlands and watercourses including:
    i. Wetland protection areas, or areas of high ecological significance as shown on the Map of referable wetlands; or
    ii. High ecological value waters (as defined under the *Environmental Protection (Water) Policy 2009*);
- Designated precincts in a strategic environmental area under the *Regional Planning Interests Regulation 2014*;
- Protected wildlife habitat, which includes;
    i. High risk areas on the flora survey trigger map;
    ii. Areas that contain endangered or vulnerable plants;
    iii. Non-juvenile koala habitat trees in certain areas of south-east Queensland; or
    iv. Habitat for endangered, vulnerable and special least concern animals;
- Protected areas and highly protected zones of State marine parks;
- Fish habitat areas;
- Waterways providing for fish passage;
- Marine plants; and
- Legally secured offsets.

2.5 FISHERIES ACT 1994

This state legislation protects all aquatic ecosystems from unauthorised disturbance. The main purpose of the Queensland *Fisheries Act 1994* (Fisheries Act) is to provide for:

- the protection of fisheries;
- the protection of marine fish;
- the protection of marine plants; and
- the facilitation of management plans.

As of the 3rd July 2017, the Fisheries Act requires waterway barrier works to be developed in accordance with the accepted development requirements. The accepted development requirements are those outlined in *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018).

2.6 ENVIRONMENTAL PROTECTION (WATER AND WETLAND BIODIVERSITY) POLICY 2019

The *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP (Water and Wetland Biodiversity)) is subordinate legislation under the *Environmental Protection Act 1994*. The EPP (Water and Wetland Biodiversity) provides a framework for:

1. identifying environmental values (EVs) for Queensland waters, and deciding water quality objectives (WQOs) to protect or enhance those EVs; and

2. including the identified EVs and WQOs under Schedule 1 of the EPP (Water and Wetland Biodiversity).

The EPP (Water and Wetland Biodiversity) is relevant to the Project with regard to the protection of EVs occurring in the Mackenzie River sub-basin and associated tributaries.

The EVs and WQOs for waters occurring on or surrounding the study area are provided in the document titled *Environmental Protection (Water) Policy 2009; EPP (Water) for the Mackenzie River Sub-basin EVs and WQO Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin'* (DEHP 2011a).

3.0 DESKTOP ASSESSMENT

A desktop assessment was conducted to collate information on aquatic ecological values identified in the region. These searches include previous surveys, community records and other sources. A review of databases was conducted to inform the specific field survey techniques to target certain aquatic flora and fauna species known from the region.

All database searches were based on either the Lot/Plan, the study area, or a central coordinate point, depending on the database search undertaken. Database search results can be found in Appendix A. The following databases searches were undertaken:

1. Environmental Reports Online (search based on study area);
    a. Aquatic Conservation Assessments;
    b. Matters of State Environmental Significance;
    c. Regional Ecosystems;
2. Environmentally Sensitive Area (ESA) Mapping (search based on study area);
3. Protected Plants Flora Survey Trigger Map (search based on central coordinate point);
4. EPBC Act Protected Matters Search Tool (PMST) (two searches based on central coordinate point with 20 km and 50 km buffers);
5. Regulated Vegetation Management Report (search based on Lot/Plan);
6. Wildlife Online Species List Request (two searches based on central coordinate point with 10 km and 50 km buffers);
    a. Rare and Threatened Species;
    b. Introduced Species; and
7. Department of Environment and Science (DES) interactive Wetland*Maps* database and Map of Referable Wetlands; and
8. WildNet Records Conservation Significant Species List (search based on circular area selected over the study area to reflect a 'central point with buffer'; area selected was roughly equivalent to a 20 km buffer with a report area of greater than 285,000 ha).

Additional resources that provide species records and related information such as the Atlas of Living Australia (ALA) and Queensland Museum were consulted where appropriate to support likelihood desktop study.

The following sections address items of nature conservation relevant to the study area identified within the desktop assessment.

3.1 SPECIES OF CONSERVATION SIGNIFICANCE

No aquatic flora species of conservation significant were identified by the desktop searches. Database searches identified four fauna species of conservation significance with potential to occur within 50 km of the study area.

A detailed assessment of the likelihood of species of conservation significance occurring within the study area was completed prior to conducting the field survey, for the purpose of determining targeted species and to guide field survey methodology. The detailed assessment was based on the knowledge of ecologists, habitat suitability and scientific literature.

The detailed assessment of likelihood of occurrence considered that all four of the species identified by the desktop assessment were unlikely to occur within the study area (Table 1).

The Fitzroy River turtle was previously identified as potentially being impacted by the Dingo West Project by the EPBC Referral Decision (2010/5775). The potential impact of the Gemini Project on the Fitzroy River turtle is assessed in Section 9.1.2.

Table 1 Fauna Species of Conservation Significance identified by Desktop Searches

Scientific Name Common Name	Status		Database Searches		Habitat and Distribution	Desktop Likelihood of Occurrence
	EPBC Act	NC Act	PMST	Wildlife Online Records		
Fish						
Maccullochella peelii Murray cod	V	NL	Species or species habitat **may** occur within area (0-10 km)	No records	The species lives in a wide range of habitats, from clear, rocky streams to slow flowing, turbid rivers and billabongs (DoEE 2018a).	Unlikely This species was returned in the 10 km PMST search as may occur. No records of this species were recorded within 50 km of the study area. The watercourses present within the study area are ephemeral in nature and only run during periods of high rainfall.
Reptiles						
Crocodylus porosus Salt water crocodile	Ma, Mi	V	Species or species habitat **likely** to occur within area (10-50 km)	No records	Salt-water crocodiles are restricted to coastal waterways and floodplain wetlands within Queensland.	Unlikely Only ephemeral waterways are present within the study area with limited to no water persisting throughout the year. Salt-water crocodiles are known to inhabit the lower reaches of rivers. This species was returned in the 10 km PMST search as likely to occur. There are no records of this species have occurred within 50 km of the study area. Given the habitat requirements of this species it would not occur within the study area.
Elseya albagula Southern snapping turtle	CE	E	Species or species habitat **likely** to occur within area (0-10 km) Species or species habitat **known** to occur within area (10-50 km)	2 (10-50 km)	The Southern snapping turtle is only found in the Burnett, Fitzroy, Raglan and Mary river drainages of south-east Queensland. It prefers permanent flowing water habitats where there are suitable shelters and refuges (e.g. fallen trees) (DES, 2017). Found only in Queensland in the Fitzroy, Mary and Burnett Rivers and associated smaller drainages in south eastern Queensland (DoEE, 2018b).	Unlikely No permanent watercourses occur within the study area. No records within 10 km of the Project on Wildlife Online, ALA, or WildNet but 2 records occur between 10 and 50 km. However, this species was returned in the 10 km PMST search as likely occur, and as known to occur between 10 and 50 km. Given the habitat requirements of this species it would not occur within the study area.
Rheodytes leukops Fitzroy River turtle	V	V	Species or species habitat **likely** to occur within area (0-10 km) Species or species habitat **known** to occur within area (10-50 km)	1 (10-50 km)	The Fitzroy River turtle is limited to the Fitzroy River catchment in central Queensland. Previously thought to prefer shallow (<2.0 m) riffle zones with high water velocities, the species is now known to occupy large pools (>1 km long; >2 m deep) and reservoirs. This species will nest in alluvial sand-loam riverbanks (Curtis et al. 2012).	Unlikely No suitable habitat for this species occurs in the study area. No records within 10 km of the study area on Wildlife Online, ALA, or WildNet however, 1 record occurs between 10 and 50 km. A review of ALA records indicate this species is associated with the waters of the Mackenzie River and Fitzroy River.

3.2 WETLAND HABITATS

A review of the Department of Environment and Science (DES) interactive Wetland*Maps* database and the Map of Referable Wetlands indicated three types of waterbodies are potentially present within the study area. Riverine wetlands have been identified in association with the Charlevue Creek. Several small riverine, palustrine and lacustrine wetlands are mapped as potentially present within the study area (Figure 4). All of the lacustrine and palustrine wetlands within the study area have been identified as artificial (farm) dams or not present during previous terrestrial ecology surveys (AARC 2019). Riverine wetlands (corresponding with riverine vegetation) have been discussed in the Terrestrial Ecology Assessment (AARC 2019). No wetlands of national or international importance have been recorded within the study area or surrounds. One High Ecological Significance (HES) wetland occurs approximately 4 km east of the study area (Figure 4). The potential impact on this HES wetland has been addressed in the Terrestrial Ecology Assessment (AARC 2019).

The Aquatic Conservation Assessments defines the study area as having a sub-catchment conservation significance of medium, indicating that these wetlands have varied combinations of high and medium values amongst the assessment criteria.

3.3 WATERWAYS FOR FISH HABITAT

Waterways, as defined by the Fisheries Act, include rivers, creeks, streams, watercourses or inlets of the sea.

The *Queensland Waterways for Waterway Barrier Works* (DAF 2013) mapping indicates the level of 'risk' associated with undertaking waterway barrier works within Queensland waterways. Waterways with higher stream orders, steeper slopes, higher flow rates, greater number of fish present and fish with stronger swimming abilities obtain a higher level of risk.

Charlevue Creek and Springton Creek are mapped as being at major risk of adverse impact from waterway barrier works on fish movement. Stanley Creek is mapped as being of moderate risk of adverse impact. Tributaries of the streams are mapped within the study area as being of either low, moderate or high risk of adverse impact from waterway barrier works on fish movement.

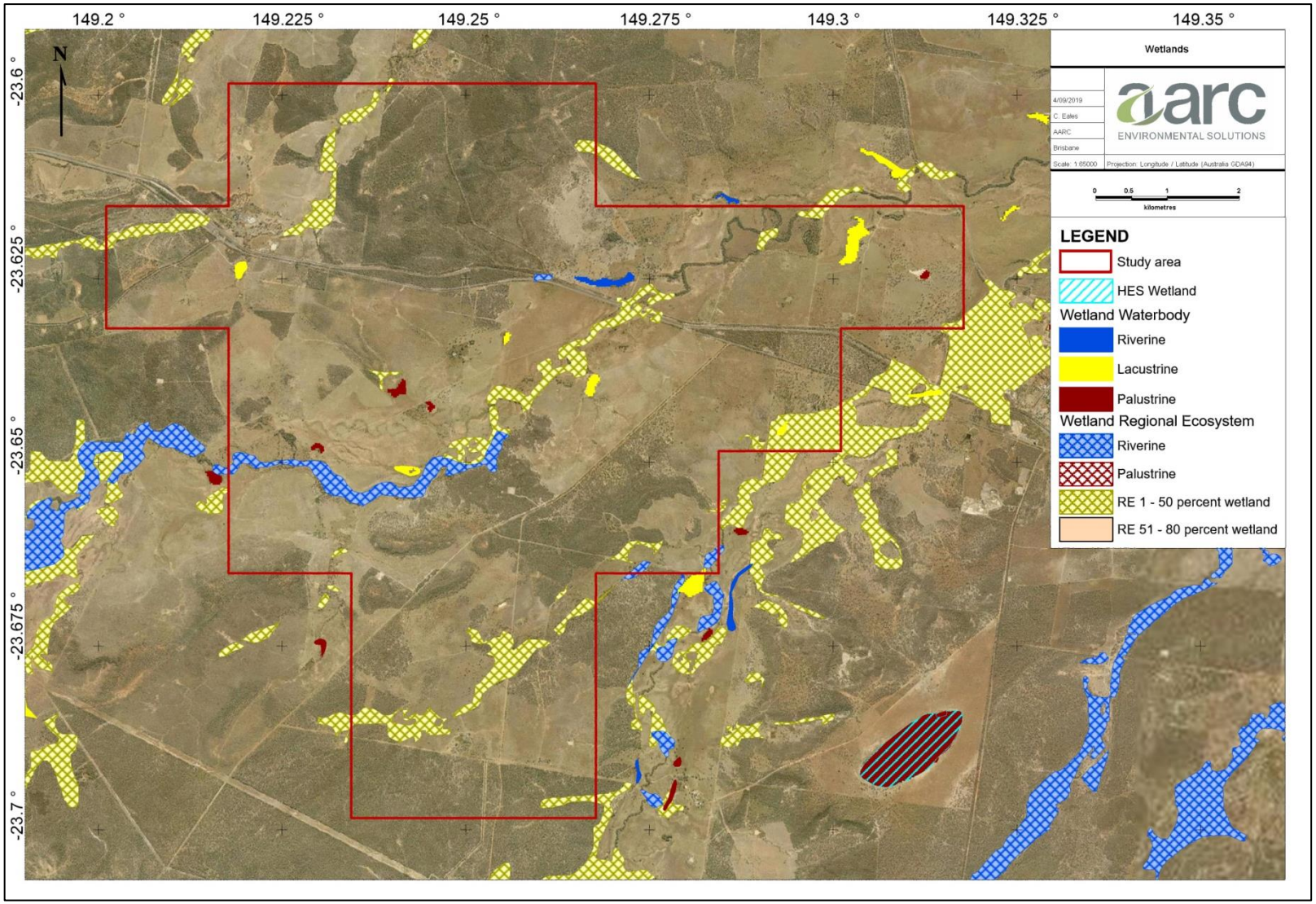


Figure 4 Wetland Habitats

4.0 ENVIRONMENTAL VALUES AND OBJECTIVES

4.1 ENVIRONMENTAL VALUES

The waterways of the Project fall within the Mackenzie River catchment. The *EPP (Water) Central Queensland Map Series (WQ1304 – Mackenzie River Sub-basin)* (DEHP 2011b) identifies several waterways on and surrounding the study area.

Environmental Values are defined as the qualities of water that make it suitable for supporting aquatic ecosystems and a variety of human water uses (DEHP 2013a). The EPP (Water and Wetland Biodiversity) specifies that the EVs for this catchment are those set out in the '*EPP (Water) for the Mackenzie River Sub-basin EVs and WQO Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin'* (DEHP 2011a).

This document identifies ten EVs in the Mackenzie River sub-basin, two of which are deemed as relevant EVs for the waters surrounding the study area; namely protection of aquatic ecosystem values, and suitability for stock watering. The waters within and directly surrounding the study area are defined as moderately disturbed waters by the '*EPP (Water) for the Mackenzie River Sub-basin EVs and WQO Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin'* (DEHP 2011a).

4.1.1 Water Quality Objectives

The *EPP (Water) for the Mackenzie River Sub-basin EVs and WQO Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin* provides WQOs to support and protect the different EVs identified for waters within the Mackenzie River southern tributaries. WQOs are provided in two main parts;

1. For the purposes of protecting the aquatic ecosystem EV; and
2. For EVs other than aquatic ecosystems (human use EVs such as stock watering).

The guideline WQOs for the protection of aquatic ecosystems and for stock watering are provided in Table 2.

Table 2 WQO Guideline Values

Mackenzie River Sub-basin EVs and WQO Basin No. 130 (part)		
Management Intent (level of protection)	**WQOs to protect EV**	
	Parameter	**Water Quality Objective**
	Water	
Aquatic ecosystem *(moderately disturbed)*	Ammonia N	<20 µg/L
	Oxidised N	<60 µg/L
	Organic N	<420 µg/L
	Total nitrogen	<7 µg/L
	Filterable reactive phosphorus	<20 µg/L
	Total phosphorus	<160 µg/L
	Chlorophyll a	<5.0 µg/L
	Dissolved oxygen	85% – 110% saturation
	Turbidity	<50 NTU
	Suspended solids	<110 mg/L

Mackenzie River Sub-basin EVs and WQO Basin No. 130 (part)		
Management Intent (level of protection)	**WQOs to protect EV**	
Aquatic ecosystem *(moderately disturbed)*	pH	6.5 – 8.5
	Conductivity (EC) baseflow	<310 µS/cm
	Conductivity (EC) high flow	<210 µS/cm
	Sulphate	<10 mg/L
	Macroinvertebrates	
	Taxa richness (composite)	12–21
	Taxa richness (edge habitat)	23–33
	PET taxa richness (composite)	2–5
	PET taxa richness (edge habitat)	2–5
	SIGNAL index (composite)	3.33–3.85
	SIGNAL index (edge habitat)	3.31–4.20
	% tolerant taxa (composite)	25–50%
	% tolerant taxa (edge habitat)	44–56%
Stock watering	**Water**	
	Total Dissolved Solids	3000 mg/L
	Aluminium	5 mg/L
	Arsenic	0.5 (up to 5) mg/L
	Beryllium	ND
	Boron	5 mg/L
	Cadmium	0.01 mg/L
	Chromium	1 mg/L
	Cobalt	1 mg/L
	Copper	0.4 (sheep), 1 (cattle), 5 (pigs), 5 (poultry)
	Fluoride	2 mg/L
	Iron	not sufficiently toxic
	Lead	0.1 mg/L
	Manganese	not sufficiently toxic
	Mercury	0.002 mg/L
	Molybdenum	0.15 mg/L
	Nickel	1 mg/L
	Selenium	0.02 mg/L
	Uranium	0.2 mg/L
	Vanadium	ND
	Zinc	20 mg/L

Notes:
N nitrogen
EC electrical conductivity
ND no data
µg/L micrograms per litre
mg/L milligrams per litre
NTU Nephelometric Turbidity Units
µS/cm microSiemens per centimetre
PET – Plecoptera, Ephemeroptera, Trichoptera

4.1.2 Stream Sediment Quality Objectives

Baseline levels of metals in stream sediments are important, to investigate the accrual of any pollutants. Stream sediment quality objectives for the study area are adopted from the *Default Sediment Quality Guideline values* (SQG) (ANZECC & ARMCANZ 2000a) (Table 3).

Table 3 ANZECC Stream Sediment Quality Guideline Objectives

Contaminant	Sediment Quality Guideline Value (mg/kg)	
	Low Value	High Value
Arsenic	20	70
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Nickel	21	52
Mercury	0.15	1
Zinc	200	410

Note: mg/kg – milligrams per kilogram

5.0 METHODOLOGY

Two field surveys were undertaken by AARC ecologists within the study area on the 23rd and 24th February 2018, and from the 3rd to 9th of April 2019.

The standard methodologies described in Sections 5.3 to 5.7 were used to survey:

- Surface Water Quality;
- Stream Sediment Quality;
- Creek Ecology;
    - Physical Assessment;
    - Habitat Bioassessment;
    - Condition Assessment;
    - Macroinvertebrate Sampling;
    - Fish and Crustacean Sampling
- Riparian and Aquatic Vegetation; and
- Riparian Zone Vertebrate Fauna.

Only surface water sampling and stream sediment sampling was conducted in February 2018; all other methods were employed by the April 2019 survey.

5.1 FIELD SURVEY WEATHER CONDITIONS

February 2018 Survey

In the week preceding the February 2018 survey a total of 76.8 mm of rainfall was recorded (February 2018) at the Blackdown Tablelands AL weather station (035186) located approximately 14.2 km south-west of the study area. A total of 470.6 mm of rain fell in the preceding three months to the survey.

April 2019 Survey

Conditions during the subsequent survey (April 2019) were mostly fine, with no rainfall occurring during the survey. In the preceding three months a total of 349.6 mm was recorded by the Blackdown Tablelands AL weather station, of which 93.4 mm fell in the two weeks leading up to the survey.

In the preceding six years (2013 to 2018) rainfall varied across both the wet and dry seasons (Figure 5). The total annual rainfall for 2013, 2015, 2016 and 2017 was fairly consistent, whilst 2014 and 2018 saw a drop in both the wet season rainfall and the total annual rainfall.

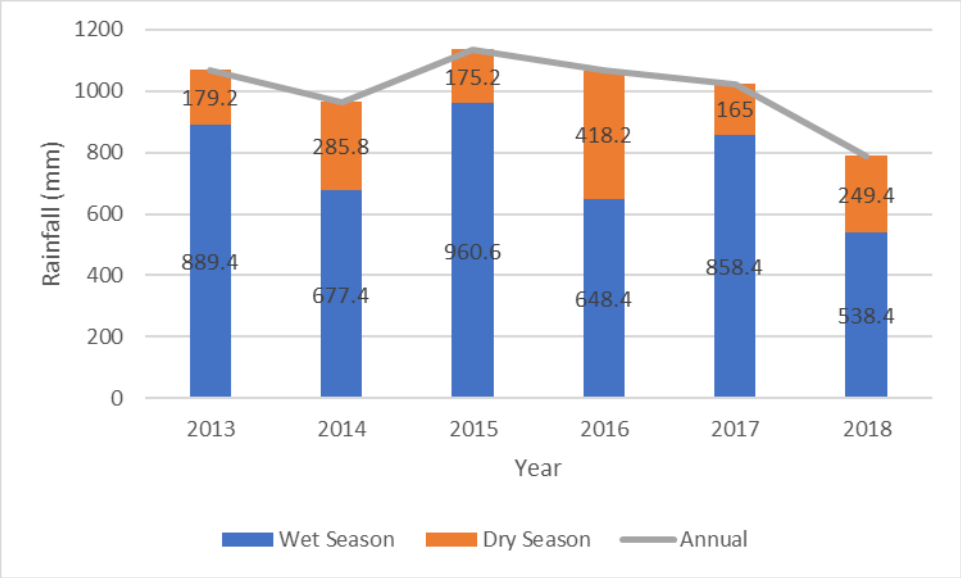


Figure 5 Regional Seasonal Rainfall Trends for 2013 – 2018 (Source: BoM 2019)

5.2 SAMPLING SITES

The desktop selection of sampling sites was based on two primary objectives:

- Spatial distribution across the study area; and
- Capturing ‘entry’ and ‘exit’ points of waterways traversing the Project, to collect suitable baseline data for ‘reference’ and 'impact’ sites that could be utilised in any long-term monitoring programs.

Table 4 describes each sampling site and sampling location (Table 5), details the survey methods used at each sampling site. The location of the aquatic sampling sites and the surface water sampling sites are shown in Figure 6.

Table 4 Sampling Site Locations

Site Code	Reference Location	Easting	Northing
DWR1	Located on southern side of highway along Stanley Creek. Upstream of DWI1.	0725805	7386321
DWR4	Located along depression on intermittent creek.	0729204	7383227
DWR5	Located along unnamed waterway that flows into Charlevue Creek in south-western boundary of the EPC.	0727640	7381080
DWR6	In south-western area of EPC, located along a depression area on unnamed waterway that feeds into Springton Creek.	0728513	7378595
DWI1	Located along Stanley Creek, northern side of highway at northern boundary of EPC. Downstream of DWR1.	0728501	7388431
DWI3	Located along unnamed waterway that flows into Charlevue Creek. North-eastern boundary of EPC.	0731394	7387482
DWI6	Located along Springton Creek, outside of EPC. Located at bridge along highway.	0736131	7383371
DWI8	Located along upstream of Springton Creek along unnamed waterway.	0731237	7378414
DWI9	South-eastern boundary of EPC, on unnamed waterway that feeds into Springton Creek eventually.	0731262	7377611
DAR1	Upstream site along Charlevue Creek, on western EPC boundary	0726345	7382842
DAI1	Located along Charlevue Creek, downstream of DAR1.	0728076	7382226
DAI2	Located along Charlevue Creek, downstream of DAR1 and DWI1.	0729813	7382850
DAI3	Located along Charlevue creek, downstream of DAR1, DAI2 and DWI1. Upstream of DAI4. South of highway.	0730973	7384370
DAI4	Located along Charlevue creek, downstream of DAR1, DAI2, DAI3. North of highway.	0732590	7385626
DAI5	Located along Springton Creek, at most eastern point creek leaves the EPC. Downstream of DWI8 and DWI9.	0732951	7381182

Note: All sample site locations are in Geocentric Datum of Australia (GDA) 94 Zone 55K

Table 5 Survey Methods

Site Code		Surface Water Sampling	Sediment Sampling	Creek Ecology					Riparian Vegetation	Riparian Zone Fauna			
				Physical Assessment	Habitat Bioassessment	Condition Assessment	Macroinvertebrate Sampling	Fish and Crustacean Trapping		Bird Survey	Spotlighting	Call Play Backs	Habitat Searches
DWR1	2018	✓	✓										
	2019		✓	✓	✓	✓			✓				
DWR4	2018		✓										
	2019		✓	✓	✓	✓			✓				
DWR5	2018	✓	✓										
	2019	✓	✓	✓	✓	✓	✓		✓				
DWR6	2018		✓										
	2019		✓	✓	✓	✓			✓				
DWI1	2018		✓										
	2019		✓	✓	✓	✓			✓				
DWI3	2018		✓										
	2019		✓	✓	✓	✓			✓				
DWI6	2018	✓	✓										
	2019	✓	✓	✓	✓	✓	✓		✓				
DWI8	2018		✓										
	2019		✓	✓	✓	✓			✓				
DWI9	2018		✓										
	2019	✓	✓	✓	✓	✓	✓		✓				
DAR1	2018	✓	✓										
	2019	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DAI1	2018	✓	✓										
	2019	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DAI2	2018	✓	✓										
	2019	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DAI3	2018	✓	✓										

Site Code		Surface Water Sampling	Sediment Sampling	Creek Ecology					Riparian Vegetation	Riparian Zone Fauna			
				Physical Assessment	Habitat Bioassessment	Condition Assessment	Macroinvertebrate Sampling	Fish and Crustacean Trapping		Bird Survey	Spotlighting	Call Play Backs	Habitat Searches
	2019	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
DAI4	2018	✓	✓										
	2019	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DAI5	2018	✓	✓										
	2019	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

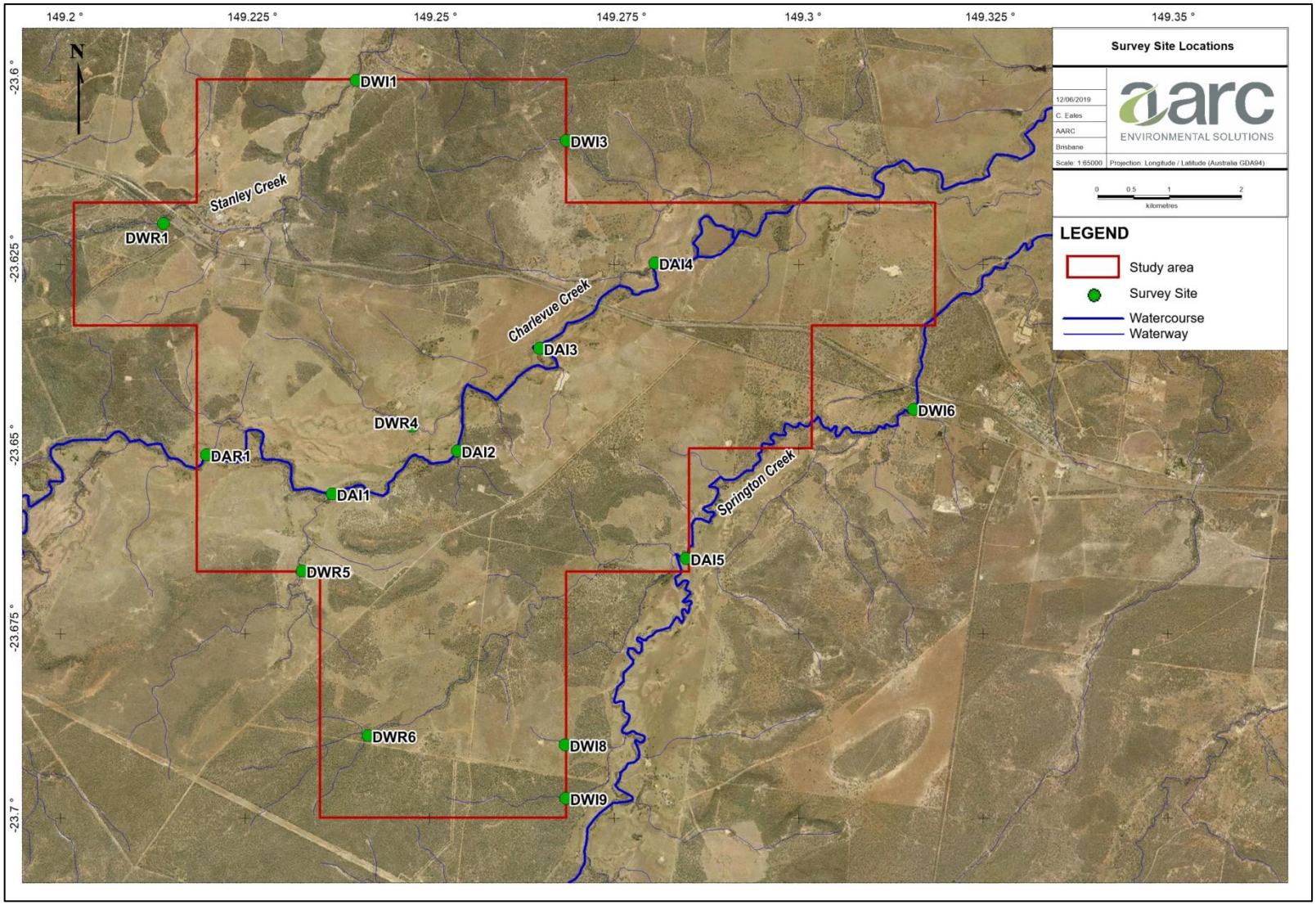


Figure 6 Location of Survey Sites

5.3 SURFACE WATER SAMPLING

Water quality sampling was carried out in accordance with the *Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009* (DES 2018b) methodology. Field readings of pH, dissolved oxygen (DO), turbidity, electrical conductivity (EC) and temperature were also recorded. In-situ measurements were collected using a multi-parameter water quality meter that is laboratory calibrated to the manufacturers' specifications.

Grab samples were collected at a depth of 10 to 20 cm where sufficient water was available. Several water samples were collected at each site (where possible) in analyte specific sterilised collection bottles and a suite of parameters tested. All water samples were kept on ice or refrigerated during storage and transport to a National Association of Testing Authorities (NATA) accredited laboratory for analysis.

5.4 STREAM SEDIMENT QUALITY

Stream sediment quality sampling was undertaken in accordance with the *Monitoring and Sampling Manual EPP (Water) 2009* (DES 2018b). Five sub-samples (approximately 500 grams (g)) each) of stream-bed substrate was taken at 10 m intervals along a 50 m transect in the river bed. Sub-samples were collected using a non-metallic shovel and mixed in a plastic bucket to obtain a composite sample. A representative 500 g sample is taken from the sub-sample composite and sent to a NATA accredited laboratory for analysis of trace metals and particle size.

5.5 CREEK ECOLOGY

5.5.1 Physical Assessment

This assessment method utilises monitoring techniques adapted from the following environmental sampling manuals:

- *AusRivAS Physical Assessment Protocol* (Parsons et al. 2002b, p.5); and
- *Queensland AusRivAS Sampling and Processing Manual* (DNRM 2001).

The monitoring methodologies utilised in the aquatic ecology assessments are presented in Table 6. The physical assessment does not require the presence of water and was consequently undertaken at all sampling sites.

Table 6 Physical Assessment Methodology

Characteristic	Monitoring Methodology
Bank Shape	Categorise the predominant shape of the left and right banks along the length of the monitoring site in accordance with the AusRivAS physical assessment categories for bank shape (i.e. concave, convex, stepped, wide lower bench or undercut).
Bank Slope	Categorise the predominant slope of the left and right banks along the length of the monitoring site in accordance with the AusRivAS physical assessment categories for bank slope (i.e. vertical, steep, moderate, low or flat).
Factors Affecting Bank Stability	Identify disturbance factors present that may negatively influence bank stability of either the left or right bank.
Artificial Bank Stability Features	Note the presence of any artificial bank protection measures.
Large Woody Debris	Visually estimate the percent cover of large woody debris within the lower embankment and channel area, along a length of stream that is equal to the length of the monitoring site. Large woody debris includes logs and branches greater than 10 centimetre (cm) in diameter.
Turbidity, Water and Sediment Oils and Odours	Visually assess and categorise the presence of oily residues or odours in surface water and stream sediments at the aquatic sites.
Bare Ground	Note the extent of bare ground including eroded areas or those not supporting vegetation, due to some form of disturbance that would otherwise be expected to be vegetated.
Exposed Tree Roots	Note whether tree roots are exposed due to any disturbances.
Gully Erosion	Record any visible gully erosion adjacent to the watercourse.
Bank Slumping	Record any evidence of slumping banks along the watercourse.
Local Catchment Erosion	Note the erosion in the surrounding catchment on the approach to the site.

5.5.2 Habitat Bioassessment

A habitat assessment was performed at selected sites using a modified version of the AusRivAS protocols developed by the former Department of Natural Resources and Mines (Conrick & Cockayne 2001). AusRivAS is a nationally standardised method for undertaking an assessment of the biological health of inland rivers within Australia.

The assessment considers morphological characteristics of waterways only; including the broad habitat type, channel pattern, water level and flow, substrate character and cover, bed and bank stability, and riparian cover at each site. Each surveyed site was given a score out of 135, with higher numbers indicating favourable habitats normally associated with healthy waterways. Habitat assessments were completed at all sites in 2019. Table 7 provides a framework for interpreting habitat assessment scores.

Table 7 Key to AusRivAS Habitat Assessment Scores

Habitat Assessment Score	Interpretation
0 – 35	Habitat is poor. There is limited habitat availability for in-stream fauna. There is little variation in velocity and depth of water, and the creek bed consists of a single sediment type. The water body typically consists of a small, shallow pool. Streamside vegetation, if present, consists of grasses and sedges. There is moderate to significant erosion on the banks.
36 – 70	Habitat variety is moderate. This could be due to leaf litter and other vegetation or detritus in the water, or the presence of boulders and rocks. The streamside vegetation consists mainly of grasses and sedges. There is moderate evidence of bank erosion, and the percentage of vegetative cover on the banks is less than 50%.
71 – 100	Habitat is relatively good. The bank is stable, there is variety in depth and velocity within the water body and substrate type is variable and tending towards boulders and rocks. Streamside vegetation is of trees and shrubs, adding to the bank stability. The percentage of streamside cover by vegetation is relatively high.
101 – 135	Indicates a pristine and favourable habitat. There is no bank erosion and the dominant vegetation is trees. There is great variety in depth and velocity, and the habitat is quite complex, offering many types of protection for fauna. This is usually afforded by logs and branches, leaf litter, variety in substrate type, variety in water depth, and presence of vegetation living within the water body.

5.5.3 Condition Assessment

The condition assessment is an evaluation of the possible impacts to aquatic environmental values caused by major disturbances within the waterway. Each category is scored from one to five, one indicating a ‘very major’ disturbance, and five indicating an ‘indiscernible’ disturbance. This assessment evaluated the influence of:

- agriculture upstream;
- major extractive industry (current or historical) upstream;
- major urban area upstream;
- major point source wastewater discharge upstream;
- dam or major weir;
- alteration to seasonal flow regime;
- alteration to the riparian zone;
- erosion and damage by stock on riparian zone and banks;
- major geomorphological change on stream channel; and
- alteration to instream conditions and habitats.

5.5.4 Macroinvertebrate Sampling

Macroinvertebrate sampling was conducted in accordance with the AusRivAS sampling and assessment methodology as outlined by the *Queensland Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009* (DES 2018b).

Along a ten metre stretch of the waterbody, a 250 micrometre D-frame net was used to sample macroinvertebrates at each sampling site containing sufficient suitable aquatic habitat (refer Table 5). The nets were checked thoroughly for damage before use and washed between sites to ensure no cross contamination of samples. This procedure targets various micro-habitats where available, including riffles, runs, pools and edge/backwaters. Due to the ephemeral nature of the creeks and in the receiving environment, micro-habitats available for sampling were limited to pool and edge habitats. Ideally site sampling should include sampling in shallow and deep sections to target the various micro-habitats, however this was not possible in any of the sites due to the limited water levels. Macroinvertebrates were live picked on-site, samples preserved, and sent for taxonomic identification to an AusRivAS accredited laboratory.

Data collected was assessed using a range of indices including:

- Total Abundance;
- Taxa Richness;
- Plecoptera, Ephemeroptera and Trichoptera (PET) Richness;
- SIGNAL 2 Biotic Index;
- Community composition; and
- Percentage Tolerance Taxa.

5.5.5 Fish and Crustacean Sampling

Fish and crustacean sampling was conducted at five sites in April 2019 using box traps and opera house traps.

- Baited aquatic traps (three opera house traps and three box traps per site) (0.5 mm mesh) were deployed at the sites detailed in Table 5 to sample small bodied fish and crustaceans. A total of 30 collapsible, baitfish traps were deployed within the range of microhabitat types present within the site (i.e. littoral margin, among snags, open water) for four nights across the sites.

All captured aquatic fauna were identified, counted and measured for total length. Any exotic species captured were euthanized in accordance with permit conditions, and all native species were released at the site of capture. No wounds, lesions or deformities on captured aquatic fauna were recorded.

5.6 RIPARIAN AND AQUATIC VEGETATION

The *Gemini Project Terrestrial Ecology Assessment* (AARC 2019) conducted for the Project has surveyed and described the flora values of the study area including vegetation communities identified. For the aquatic ecology assessment, a meandering 100 m transect in the riparian corridor at each sampling site was walked recording the riparian vegetation species encountered.

5.7 RIPARIAN ZONE VERTEBRATE FAUNA

The *Gemini Project Terrestrial Ecology Assessment* (AARC 2019) conducted for the Project has surveyed and described the vertebrate fauna values of the study area. For the aquatic ecology

assessment several fauna surveying methodologies were undertaken in the riparian zone across several sites (DAR1, DAI1, DAI2, DAI3, DAI4, and DAI5). Survey effort was consistent across these six sites. A description of the additional techniques employed to survey the fauna occurring within the riparian zones in the study area are detailed below.

Bird Surveying

Dedicated searches for birds were conducted visually and aurally during early mornings during peak avian activity. A minimum of one hour of bird surveying at each of the six sites was conducted in the early morning or late afternoon when bird activity was highest. In addition, opportunistic diurnal searches were also conducted on foot in areas considered likely to have high avian diversity (e.g. vegetated watercourses or dams), or likely to contain cryptic or threatened bird species.

Spotlighting

Spotlighting was carried out in the early evenings (before midnight) during the April 2019 to maximise encounter rate of nocturnal wildlife such as night birds and arboreal mammals primarily active at night. Two spotlighting techniques were employed:

1. Foot traverses: Dedicated spotlighting events were undertaken on foot at each of the six sites. Searches were undertaken over two events where possible, one within the first hour following nightfall, and one after the first hour. Two ecologists randomly traversed the area with spotlights and binoculars, and wherever possible, bark crevices and tree hollows were examined. A slow walking speed (approximately 1 km per hour) was maintained across the length of the survey area to fully facilitate intensive listening and thorough visual searching.

2. Vehicle searches: During any driving on the study area after dark, spotlighting was conducted by the passenger/s from the slow-moving vehicle, to maximise study area coverage that cannot be achieved with foot traverses alone. Spotlights were used to scan trackside vegetation for arboreal and ground-dwelling wildlife.

Call Playback

Several nocturnal bird species are highly cryptic; occurring in naturally low population densities, are wide-ranging, and call infrequently. Detection rates are typically low without solicitation in the form of playback of pre-recorded calls to elicit a response (Kavanagh and Peake 1993; Debus 1995). Detectability of smaller nocturnal bird species such as the Southern boobook (*Ninox novaeseelandiae)* and Australian owlet nightjar (*Aegotheles cristatus)*, and the arboreal marsupial Yellow-bellied glider (*Petaurus australis)* also increase with playback of large owl calls. Smaller, cryptic arboreal species such as Squirrel glider (*P. norfolcensis)* and Sugar glider (*P. breviceps)* can also respond to owl call playback. In addition, call playbacks can be utilised for the identification of cryptic amphibian species such as the Tusked frog (*Adelotus brevis*). During the 2019 survey call playbacks were conducted at sites specified in Table 5, the species targeted included:

- Tusked frog *(Adelotus brevis);*
- Powerful owl *(Ninox strenua);*
- Australian owlet nightjar *(Aegotheles cristatus);*
- Southern boobook *(Ninox novaeseelandiae)*; and
- Greater glider *(Petaurus volans).*

Call playback is undertaken prior to spotlighting foot traverses to minimise the chance of spooking species capable of leaving the area undetected. A series of species call would be selected depending on the surrounding habitat suitability, and each would be played for three minutes, followed by a two-minute listening period, with the cycle repeated three times for each species. Calls were played using a megaphone and loud enough so that the softest call could be heard 100-200 m away. Following the completion of all playback cycles, the area would then be spotlighted as described above.

Habitat Searching

To further enhance the likelihood of detecting small cryptic species, dedicated diurnal searches were conducted at each of the six sites. This was spread over several events, two per site, during the survey period. Additional habitat searches were carried out during aquatic trap checks and while conducting vegetation transects. Searches were typically undertaken during the late morning, allowing for reptile activity to increase with rising temperatures, but before the maximum heat of the day. Searching techniques involve the careful rolling of rocks and logs, rustling through leaf litter, and peeling back of exfoliating bark from standing trees. For targeted reptile species, dedicated searches were conducted opportunistically when preferred habitat was encountered (e.g. Gilgai formations or dense ground debris).

Evidence of wildlife such as the identification of tracks, scats and other signs of occupation (e.g. tree trunk scratches) was also conducted during these habitat searches. For scats not identifiable in the field, they were collected and sent to a scat analysis expert (Barbara Triggs) for identification of the species responsible for the scat and/or where possible, the identification of prey species material present in predator scats.

Incidental Recordings

Throughout the April 2019 survey, ecologists were traversing the study area on foot and by vehicle every day for numerous hours whilst conducting routine survey activities (e.g. driving between sites, checking traps, vegetation transects, sampling etc.). The ecologists remained alert and would record numerous wildlife species as observed or heard during the survey period. As with the habitat searches, this included signs or evidence of wildlife, and included constant vigilance for raptor nests. All areas of the study area have been visited by ecologists throughout the surveys.

6.0 RESULTS AND DISCUSSION

6.1 SURFACE WATER QUALITY

The results from the 2018 and 2019 analysis were compared to the EPP (Water) WQOs (Table 8 to Table 15). Data analysis and interpretation of surface water quality results were referred to the *EPP (Water) WQO for the protection of aquatic ecosystems in the Mackenzie River Sub-basin Waters – southern tributaries (WQ130)*. Exceedances of the EPP WQO are highlighted orange in the tables below. In order to assess the health of each watercourse, the analysis results were compared within each major watercourse and drainage feature ;Charlevue Creek, Stanley Creek and Springton Creek.

The following parameters exceeded the WQO at the Project:

Charlevue Creek:

- Physico-chemical parameters;
    - pH (2019), turbidity (2018, 2019), sulphate (2019), ammonia (2018, 2019), dissolved oxygen (2018, 2019)
- Petroleum hydrocarbons (2018).

Stanley Creek:

- Physico-chemical parameters;
    - Turbidity (2018); sulphate (2018); ammonia (2018), dissolved oxygen (2018)
- Dissolved Metals;
    - Chromium (2018)
- Petroleum hydrocarbons (2018).

Springton Creek:

- Physico-chemical parameters;
    - pH (2019); turbidity (2018, 2019); ammonia (2019), dissolved oxygen (2018-2019)
- Dissolved metals;
    - Manganese (2018);
- Petroleum hydrocarbons (2018).

Exceedances of WQOs for turbidity across all sites and years were observed. Turbidity is an indicator of water quality, where clear water is typically considered part of a healthy system. Exceedances of this parameter can indicate soil erosion, runoff, pollution, and algal blooms; however, some waterways can have naturally high levels of suspended solids and turbidity (Fondriest Environmental Inc. 2014). However, the WQO set for the Mackenzie River Sub-basin indicate that high levels of turbidity are not natural, and increased levels can lead to impaired water quality for both aquatic flora and fauna.

Low levels of DO were observed across all sample sites and occurred in 2018 and 2019 at a variety of sites. These low levels of dissolved oxygen were recorded in stagnant pools along ephemeral waterways. Stagnant pools in intermittent streams naturally experience values of DO below 50 per cent saturation (DEHP 2011a). As such the exceedances observed in relation to the study area are not a reliable indicator of system long term health.

Analysis showed that petroleum hydrocarbons for Charlevue Creek (DWR5, DAI1, DAI2, DAI3, and DAI4), Stanley Creek (DWR1) and Springton Creek (DAI5 and DWI6) exceeded WQO values. At Charlevue Creek the upstream site along an unnamed waterway; DWR5 had the highest exceedance of petroleum hydrocarbons. This unnamed waterway feeds into Charlevue Creek at site DAI1. Only the sites located downstream of DWR5 on Charlevue Creek exceeded this parameter. Sites DAR1

(upstream) and DWR4 (on a neighbouring waterway) did not exceed the WQOs. This indicates that DWR5 may be a source of the petroleum hydrocarbons recorded further downstream. These areas are currently used for agricultural and pastoral purposes and the presence of petroleum hydrocarbons may have been the result of those practices. These results represent important baseline data for future monitoring as repeat exceedances in petroleum hydrocarbons may indicate an existing and consistent local source of petroleum hydrocarbons.

Given the higher carbon chain fractions being reported, possible sources include; crude oil, heavy fuel oils, lubricating oils, asphalts and pitch and even waxes and other related products. Sites DWR1 and DWI6 occur along the Capricorn Highway and are possible point sources for the petroleum hydrocarbons observed at these locations.

Macroinvertebrate sampling provides a good indication of aquatic ecosystem health due to their sensitivity to a variety of factors such as turbidity, DO, pollutants and salinity. Water quality at the study area had high turbidity, presence of petroleum hydrocarbon pollutants and very low levels of DO. It is anticipated that macroinvertebrate sampling results will be consistent with a degraded system.

Table 8 Physico-Chemical Parameters (Charlevue Creek)

Parameter	WQO	DAR1		DWR5		DAI1		DAI2		DAI3		DAI4	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
pH	6.5 - 8.5[a]	7.27	7.12	7.28	6.27	6.63	6.24	6.91	6.37	6.92	6.78	6.87	6.58
Temperature (°C)	n/a	27.1	20.5	29.5	21.2	30.8	20.7	26	21	26.8	20.1	26.3	21.2
EC (µS/cm)	<310[a]	73.1	120.6	209.5	211.2	74.1	113.9	67	128.1	83.6	124.4	70.3	105.4
Suspended Solids (mg/L)	n/a	58	172	8660	43	2080	131	880	228	6170	103	168	152
Total Dissolved Solids (mg/L)	3000[b]	45.6	85.8	125.3	147.9	43.5	80.6	42.8	90.1	51.9	89.3	44.6	73.8
Dissolved Oxygen (DO) (%)	85-110[a]	87	28	88	61	67	58	80	15	80	46	81	56
Oxygen Reduction Potential (millivolts)	n/a	140.5	179.8	205.4	203.8	228.7	197.8	269.3	160.6	198.3	184	137.4	210.8
Turbidity (NTU)	<50[a]	387	12154.4	1231.6	23199	2050.3	13046.2	831.2	13896.6	2582.6	16031.5	506.3	13455.6
Sulphate as SO_4 - Turbidimetric (mg/L)	<10[a]	2	<1	5	15	2	<1	<1	<1	2	<1	<1	1
Fluoride (mg/L)	2[ab]	0.1	0.2	0.1	0.1	0.1	0.3	0.1	0.3	0.2	0.2	0.1	0.2
Ammonia (mg/L)	<0.02[a]	0.02	0.1	0.28	0.43	0.04	0.23	0.09	0.07	0.08	0.14	0.14	0.13

a – EPP (Water) 2009
b – Livestock Drinking
c – ANZECC Guidelines

Table 9 Physico-Chemical Parameters (Stanley Creek, Springton Creek)

Parameter	WQO	Stanley Creek		Springton Creek				
		DWR1 - 2018		DWI9	DAI5		DWI6	
		South	North	2019	2018	2019	2018	2019
pH	6.5 - 8.5[a]	6.61	7.61	6.11	6.84	6.28	7.34	5.95
Temperature (°C)	n/a	28.1	31.4	22.9	27.8	21	24.6	23.2
EC (µS/cm)	<310[a]	113.8	0.4	140.7	121.2	137.2	0.3	65
Suspended Solids (mg/L)	n/a	106	145	238	852	68	215	86
Total Dissolved Solids (mg/L)	3000[b]	69.9	0.25	95.4	74.8	96.6	0.197	43.8
Dissolved Oxygen (DO) (%)	85-110[a]	4	98	17.1	53	46	95	50
Oxygen Reduction Potential (millivolts)	n/a	98.2	147.1	116.5	242.5	220.9	158.6	222.8
Turbidity (NTU)	<50[a]	155.3	4.1	44098.4	3734.08	30580.5	21.4	10730.4
Sulphate as SO_4 - Turbidimetric (mg/L)	<10[a]	10	2	4	7	4	<1	2
Fluoride (mg/L)	2[ab]	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Ammonia (mg/L)	<0.02[a]	0.12	0.13	0.9	<0.01	0.2	0.02	0.12

a – EPP (Water) 2009
b – Livestock Drinking
c – ANZECC Guidelines

Table 10 Dissolved Metals (Charlevue Creek)

Parameter	WQO	DAR1		DWR5		DAI1		DAI2		DAI3		DAI4	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Arsenic (mg/L)	0.5[b]	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001
Beryllium (mg/L)	ND	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron (mg/L)	5[b]	0.08	0.06	0.26	0.1	0.13	<0.05	0.07	<0.05	0.1	<0.05	0.1	<0.05
Cadmium (mg/L)	0.01[a]	0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/L)	1[b]	<0.001	<0.001	0.002	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Cobalt (mg/L)	1[b]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (mg/L)	0.4[b]	0.004	0.003	0.003	0.003	0.004	0.003	0.004	0.003	0.004	0.003	0.004	0.003
Iron (mg/L)	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (mg/L)	0.1[a]	0.003	0.005	0.002	0.002	0.002	0.007	0.002	0.004	0.004	0.006	0.002	0.006
Manganese (mg/L)	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mercury (mg/L)	0.002[b]	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.002
Nickel (mg/L)	1[b]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium (mg/L)	0.02[b]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium (mg/L)	ND	<0.005	<0.005	0.018	<0.005	0.082	0.005	0.053	<0.005	0.028	0.006	0.056	<0.005
Zinc (mg/L)	20[b]	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001

a – EPP (Water) 2009
b – Livestock Drinking
c – ANZECC Guidelines

Table 11 Dissolved Metals (Stanley Creek, Springton Creek)

Parameter	WQO	Stanley Creek		Springton Creek				
		DWR1 - 2018		DWI9	DAI5		DWI6	
		South	North	2019	2018	2019	2018	2019
Arsenic (mg/L)	0.5[b]	0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
Beryllium (mg/L)	ND	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron (mg/L)	5[b]	0.06	0.13	0.07	0.21	0.07	0.06	<0.05
Cadmium (mg/L)	0.01[a]	0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/L)	1[b]	6	5	<0.001	<0.001	0.003	0.002	<0.001
Cobalt (mg/L)	1[b]	0.002	0.002	0.001	<0.001	<0.001	0.005	<0.001
Copper (mg/L)	0.4[b]	0.001	<0.001	0.002	0.004	0.003	0.008	0.001
Lead (mg/L)	-	0.002	<0.001	<0.001	<0.001	<0.001	0.004	<0.001
Manganese (mg/L)	0.1[a]	0.055	0.003	0.041	0.021	0.009	0.562	0.037
Mercury (mg/L)	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel (mg/L)	0.002[b]	0.005	0.004	0.002	0.002	0.004	0.005	0.002
Selenium (mg/L)	1[b]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium (mg/L)	0.02[b]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (mg/L)	ND	0.044	<0.005	<0.005	0.056	0.005	0.039	<0.005

a – EPP (Water) 2009
b – Livestock Drinking
c – ANZECC Guidelines

Table 12 Total Metals (Charlevue Creek)

Parameter	WQO	DAR1		DWR5		DAI1		DAI2		DAI3		DAI4	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Arsenic (mg/L)	0.5[b]	0.003	0.005	0.011	0.005	0.007	0.004	0.004	0.006	0.013	0.005	0.003	0.005
Barium (mg/L)	-	0.114	0.47	1.72	0.576	0.612	0.492	0.358	0.544	1.74	0.616	0.173	0.547
Beryllium (mg/L)	ND	<0.001	0.001	0.014	0.004	0.003	0.002	0.002	0.002	0.008	0.002	<0.001	0.002
Boron (mg/L)	5[b]	<0.05	0.06	0.12	0.15	<0.05	0.05	<0.05	0.05	0.07	0.06	<0.05	0.06
Cadmium (mg/L)	0.01[b]	<0.0001	<0.0001	0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001
Chromium (mg/L)	1[b]	0.011	0.025	0.223	0.061	0.05	0.025	0.027	0.028	0.112	0.029	0.019	0.031
Cobalt (mg/L)	1[b]	0.007	0.011	0.119	0.024	0.026	0.011	0.016	0.016	0.081	0.014	0.007	0.013
Copper (mg/L)	0.4[b]	0.012	0.032	0.181	0.057	0.053	0.034	0.03	0.038	0.149	0.041	0.018	0.039
Iron (mg/L)	-	0.09	0.45	<0.05	0.16	<0.05	0.47	0.12	1.21	0.08	0.48	0.07	0.44
Lead (mg/L)	0.1[b]	0.008	0.014	0.084	0.026	0.029	0.014	0.016	0.016	0.082	0.018	0.008	0.017
Manganese (mg/L)	-	0.113	0.566	3.45	0.388	1.07	0.423	0.712	1.06	4.03	0.689	0.198	0.446
Mercury (mg/L)	0.002[b]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001
Nickel (mg/L)	1[b]	0.008	0.029	0.252	0.04	0.051	0.028	0.027	0.032	0.0124	0.034	0.016	0.033
Selenium (mg/L)	0.02[b]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium (mg/L)	ND	0.04	0.07	0.48	0.13	0.11	0.07	0.06	0.08	0.24	0.08	0.04	0.08
Zinc (mg/L)	20[b]	0.018	0.082	0.286	0.049	0.11	0.133	0.058	0.093	0.248	0.076	0.026	0.096

a – EPP (Water) 2009
b – Livestock Drinking
c – ANZECC Guidelines

Table 13 Total Metals (Stanley Creek, Springton Creek)

Parameter	WQO	Stanley Creek		Springton Creek				
		DWR1 - 2018		DWI9	DAI5		DWI6	
		South	North	2019	2018	2019	2018	2019
Arsenic (mg/L)	0.5[b]	0.004	0.003	0.004	0.006	0.007	0.006	0.002
Barium (mg/L)	-	0.26	0.269	0.904	0.974	0.748	0.182	0.19
Beryllium (mg/L)	ND	0.002	0.002	0.008	0.004	0.006	0.001	0.001
Boron (mg/L)	5[b]	0.06	0.06	0.13	<0.05	0.11	0.06	<0.05
Cadmium (mg/L)	0.01[b]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (mg/L)	1[b]	0.036	0.033	0.064	0.039	0.078	0.039	0.033
Cobalt (mg/L)	1[b]	0.013	0.018	0.054	0.024	0.026	0.013	0.009
Copper (mg/L)	0.4[b]	0.024	0.024	0.056	0.058	0.085	0.024	0.021
Iron (mg/L)	-	0.61	0.17	2.2	0.18	0.94	0.34	0.4
Lead (mg/L)	0.1[b]	0.01	0.013	0.035	0.033	0.038	0.012	0.011
Manganese (mg/L)	-	0.28	0.349	0.776	1.15	1.16	0.758	0.42
Mercury (mg/L)	0.002[b]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel (mg/L)	1[b]	0.036	0.033	0.042	0.043	0.076	0.029	0.023
Selenium (mg/L)	0.02[b]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium (mg/L)	ND	0.06	0.08	0.11	0.1	0.16	0.07	0.05
Zinc (mg/L)	20[b]	0.053	0.059	0.046	0.095	0.209	0.049	0.039

a – EPP (Water) 2009
b – Livestock Drinking
c – ANZECC Guidelines

Table 14 Petroleum Hydrocarbons (Charlevue Creek)

Parameter	WQO	DAR1		DWR5		DAI1		DAI2		DAI3		DAI4	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
C6 – C9 Fraction (µg/L)	20[c]	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C10 – C14 Fraction (µg/L)	100[c]	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15 – C28 Fraction (µg/L)	100[c]	<100	<100	120	<100	120	<100	<100	<100	<100	<100	<100	<100
C29 – C36 Fraction (µg/L)	100[c]	<50	<50	90	<50	60	<50	<50	<50	<50	<50	<50	<50
C10 – C36 Fraction (sum) (µg/L)	100[c]	<50	<50	210	<50	180	<50	<50	<50	<50	<50	<50	<50
C6 - C10 Fraction (µg/L)	20[c]	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C6 - C10 Fraction minus BTEX (F1) (µg/L)	100[c]	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
>C10 - C16 Fraction (µg/L)	100[c]	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C16 - C34 Fraction (µg/L)	100[c]	<100	<100	180	<100	140	<100	110	<100	120	<100	120	<100
>C34 - C40 Fraction (µg/L)	100[c]	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum) (µg/L)	100[c]	<100	<100	180	<100	140	<100	110	<100	120	<100	120	<100
>C10 - C16 Fraction minus Naphthalene (F2) (µg/L)	100[c]	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100

a – EPP (Water) 2009
b – Livestock Drinking
c – ANZECC Guidelines

Table 15 Petroleum Hydrocarbons (Stanley Creek, Springton Creek)

Parameter	WQO	Stanley Creek		Springton Creek				
		DWR1 - 2018		DWI9	DAI5		DWI6	
		South	North	2019	2018	2019	2018	2019
C6 – C9 Fraction (µg/L)	20[c]	<20	<20	<20	<20	<20	<20	<20
C10 – C14 Fraction (µg/L)	100[c]	<50	<50	<50	<50	<50	<50	<50
C15 – C28 Fraction (µg/L)	100[c]	140	190	<100	180	<100	230	<100
C29 – C36 Fraction (µg/L)	100[c]	60	70	<50	70	<50	90	<50
C10 – C36 Fraction (sum) (µg/L)	100[c]	200	260	<50	250	<50	320	<50
C6 - C10 Fraction (µg/L)	20[c]	<20	<20	<20	<20	<20	<20	<20
C6 - C10 Fraction minus BTEX (F1) (µg/L)	100[c]	<20	<20	<20	<20	<20	<20	<20
>C10 - C16 Fraction (µg/L)	100[c]	<100	<100	<100	<100	<100	<100	<100
>C16 - C34 Fraction (µg/L)	100[c]	170	230	<100	220	<100	280	<100
>C34 - C40 Fraction (µg/L)	100[c]	<100	<100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum) (µg/L)	100[c]	170	230	<100	220	<100	280	<100
>C10 - C16 Fraction minus Naphthalene (F2) (µg/L)	100[c]	<100	<100	<100	<100	<100	<100	<100

a – EPP (Water) 2009
b – Livestock Drinking
c – ANZECC Guidelines

6.2 STREAM SEDIMENT QUALITY

Analytical results produced for the stream sediment samples have been compared against SQG values for stream sediment quality at all sampling sites (Table 16, Table 17, Table 18).

The chemistry of all stream sediment sample sites is well below the relevant SQG low and high trigger values for all parameters except nickel (Table 16). Nickel results only exceeded the SQG low trigger value at DWR6 during the 2018 and 2019 sampling. This site is located along an unnamed waterway which feeds into Springton Creek at DAI5. The results for cadmium, and mercury were below the limit of reporting (and SQG values).

Table 16 Stream Sediment Total Metals Results

Site		Total Metals (mg/kg)							
		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
SQG-Low		**20**	**1.5**	**80**	**65**	**50**	**0.15**	**21**	**200**
SQG-High		**70**	**10**	**370**	**270**	**220**	**1**	**52**	**410**
Stanley Creek									
DWR1	**South 2018**	2.64	<0.1	16.8	11.4	7.3	0.01	15.9	18.3
	North 2018	2.14	<0.1	19.2	8.9	4.8	0.01	15.5	1.7
	2019	2.02	<0.1	9.1	4.8	4.3	<0.01	5.3	9.4
DWI1	**2018**	1.23	<0.1	7.3	1.1	1.7	<0.01	1.3	1.7
	2019	4.71	<0.1	10.2	5.4	4.8	<0.01	2.5	4.1
Springton Creek									
DWR6	**2018**	2.51	<0.1	23.5	12.2	8	0.02	28.1	23.5
	2019	2.33	<0.1	19.7	10.4	7.9	0.01	21.9	16.8
DWI9	**2018**	4.7	<0.1	25.2	2.8	8.8	<0.01	1.8	2.3
	2019	2.06	<0.1	13.6	3.4	7.4	<0.01	1.8	2.3
DWI8	**2018**	3.2	<0.1	11.8	3.1	6.2	<0.01	1.5	2
	2019	1.06	<0.1	7.9	1.6	2.3	<0.01	1.1	<1.0
DAI5	**2018**	3.56	<0.1	15.8	10.8	11.7	0.01	9.2	15.8
	2019	2.92	<0.1	13.1	11.2	9.8	0.01	9.4	15.2
DWI6	**2018**	2.54	<0.1	15.7	10.8	8.8	0.01	10.3	17.9
	2019	2.53	<0.1	13.4	10.9	9.3	0.01	9.2	14.2
Charlevue Creek									
DAR1	**2018**	1.23	<0.1	4.2	1.4	2.4	<0.01	1.4	3.1
	2019	1	<0.1	4.4	2.4	3.5	<0.01	2.8	4.6
DWR5	**2018**	6.73	<0.1	35.2	4.9	11.7	<0.01	4.7	5.3
	2019	2.84	<0.1	18.4	5.5	5.3	<0.01	5	4.9
DAI1	**2018**	3.08	<0.1	15.3	12.1	8.8	0.01	11.3	22.2
	2019	3	<0.1	12.1	15.2	10	0.02	11.7	23.5
DWR4	**2018**	1.63	<0.1	12.9	12.3	11.1	0.02	8	31.5
	2019	1.37	<0.1	11.7	13.9	11.7	0.002	7.4	30.5
DAI2	**2018**	3.42	<0.1	14.3	17.6	11.4	<0.01	15.8	33.9
	2019	1.03	<0.1	4.9	5	3.4	<0.01	4	9.6
DAI3	**2018**	2.33	<0.1	7	4	7.9	<0.01	4.8	6.14
	2019	2.07	<0.1	8.4	6.6	11.8	<0.01	6.6	9.3
DAI4	**2018**	3.7	<0.1	14	15.1	10.6	<0.01	13.7	28
	2019	1.54	<0.1	6.8	5.1	6.8	<0.01	5.1	8.9
DWI3	**2018**	<1.0	<0.1	3.3	<1.0	1.2	<0.01	<1.0	<1.0
	2019	1.12	<0.1	6.3	1.2	1.3	<0.01	1.4	1.8

Table 17 Stream Sediment Particle Size Analysis

Site		Particle Sizing (%)											
		µm					mm						
		+75	+150	+300	+425	+600	+1.18	+2.36	+4.75	+9.5	+19.0	+37.5	+75
Stanley Creek													
DWR1	South 2018	39	30	16	9	4	1	<1	<1	<1	<1	<1	<1
	North 2018	48	38	19	12	8	4	1	<1	<1	<1	<1	<1
	2019	74	69	53	40	26	7	1	<1	<1	<1	<1	<1
DWI1	2018	98	97	57	29	14	5	2	<1	<1	<1	<1	<1
	2019	98	97	64	39	23	9	5	3	<1	<1	<1	<1
Charlevue Creek													
DAR1	2018	97	94	92	87	68	22	2	<1	<1	<1	<1	<1
	2019	86	81	68	49	25	3	<1	<1	<1	<1	<1	<1
DWR5	2018	94	92	75	54	39	23	11	3	<1	<1	<1	<1
	2019	67	63	52	38	25	9	3	<1	<1	<1	<1	<1
DAI1	2018	41	30	19	14	11	6	1	<1	<1	<1	<1	<1
	2019	57	51	45	40	27	7	1	<1	<1	<1	<1	<1
DWR4	2018	31	21	10	6	5	3	<1	<1	<1	<1	<1	<1
	2019	23	14	6	4	3	2	<1	<1	<1	<1	<1	<1
DAI2	2018	7	3	2	2	1	<1	<1	<1	<1	<1	<1	<1
	2019	78	77	74	65	41	6	<1	<1	<1	<1	<1	<1
DAI3	2018	88	86	77	60	38	12	2	<1	<1	<1	<1	<1
	2019	81	72	53	35	12	1	<1	<1	<1	<1	<1	<1
DAI4	2018	31	20	12	8	5	3	2	<1	<1	<1	<1	<1
	2019	83	78	69	52	22	2	<1	<1	<1	<1	<1	<1
DWI3	2018	95	84	40	21	9	2	<1	<1	<1	<1	<1	<1
	2019	94	82	29	12	4	<1	<1	<1	<1	<1	<1	<1
Springton Creek													
DWR6	2018	23	15	9	7	6	3	<1	<1	<1	<1	<1	<1
	2019	33	20	8	6	5	3	2	<1	<1	<1	<1	<1
DWI9	2018	97	97	82	65	48	24	9	2	<1	<1	<1	<1
	2019	68	51	48	30	16	4	1	<1	<1	<1	<1	<1
DWI8	2018	79	65	41	29	21	15	11	8	5	<1	<1	<1
	2019	94	81	41	28	20	14	9	4	<1	<1	<1	<1
DAI5	2018	31	17	7	6	5	4	2	<1	<1	<1	<1	<1
	2019	51	35	12	6	3	1	<1	<1	<1	<1	<1	<1
DWI6	2018	26	16	7	3	2	<1	<1	<1	<1	<1	<1	<1
	2019	39	26	9	5	4	2	<1	<1	<1	<1	<1	<1

Table 18 Stream Sediment Particle Size Classification

Site		Classification Based on Particle Size (%)				
		Clay (<2µm)	Silt (2-60 µm)	Sand (0.06-2 mm)	Gravel (>2 mm)	Cobbles (>6 cm)
Stanley Creek						
DWR1	**South 2018**	33	27	39	1	<1
	North 2018	26	23	49	2	<1
	2019	17	7	73	3	<1
DWI1	**2018**	<1	1	96	3	<1
	2019	2	<1	92	6	<1
Charlevue Creek						
DAR1	**2018**	1	2	89	8	<1
	2019	11	3	85	1	<1
DWR5	**2018**	2	4	79	15	<1
	2019	15	17	63	5	<1
DAI1	**2018**	27	29	42	2	<1
	2019	24	17	56	3	<1
DWR4	**2018**	37	17	45	1	<1
	2019	41	35	23	1	<1
DAI2	**2018**	25	66	9	<1	<1
	2019	9	10	79	2	<1
DAI3	**2018**	7	3	85	5	<1
	2019	13	6	80	1	<1
DAI4	**2018**	26	41	31	2	<1
	2019	12	5	82	1	<1
DWI3	**2018**	4	1	94	1	<1
	2019	4	2	94	<1	<1
Springton Creek						
DWR6	**2018**	35	25	38	2	<1
	2019	38	28	32	2	<1
DWI9	**2018**	2	<1	85	13	<1
	2019	19	13	66	2	<1
DWI8	**2018**	16	5	66	13	<1
	2019	5	1	83	11	<1
DAI5	**2018**	30	34	34	2	<1
	2019	29	19	51	1	<1
DWI6	**2018**	38	31	31	<1	<1
	2019	32	27	39	2	<1

Stream sediment was collected from Stanley Creek, Charlevue Creek and Springton Creek at all sites across 2018 and 2019. Particle size analysis (Table 17) and particle size classification (Table 18 and Figure 7) show Stanley Creek at the site DWR1 the stream sediment is predominantly sand, with small amounts of clay (17-33%) and silt (7-27%). However further downstream along Stanley Creek, the stream sediment is characterised as sand (92-96%) with minor contributions of gravel, silt and clay.

Along Springton Creek stream sediment levels vary between sites but remain consistent across sample years. Springton Creek itself is characterised by predominantly sand, with consistent levels of clay and silt.

Charlevue Creek stream sediment is characterised by high percentages of sand (56-94%) at the majority of sites (excluding DAI1, DWR4, DAI2, and DAI4) with variable levels of clay (1-24%) and silt (1-17%). Though minor, the presence of gravel was recorded across the sites along Charlevue Creek. Sites DAI1, DWR4, DAI2, and DAI4 presented lower levels of sand (9-45%) and higher percentages of fine sediments (clay 25-41% and silt 17-66%). Of these sites only DWR4 had higher levels of fine particles

during both the 2018 and 2019 sample periods. This site was located along a natural depression which flows into Charlevue Creek.

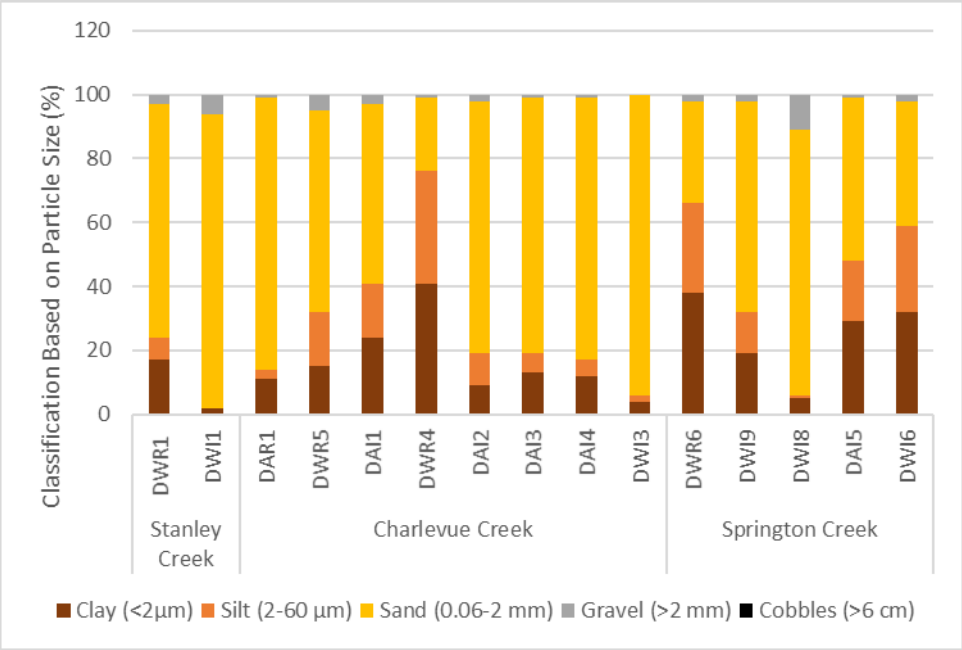


Figure 7 Stream Sediment Particle Size Analysis

6.3 CREEK ECOLOGY

6.3.1 Physical Assessment

At all sites the full AusRivAS Physical Assessment Protocol (Parsons et al. 2002a) was followed, and the data collected at each site along with photos of each site is provided in Appendix B. Table 19 provides the erosion specific observations at each site. No flow was recorded at most sites with baseline flow recorded only at site DWI6.

The effects of erosion on the banks of the receiving waters was evident across all survey sites. The leading cause of local erosion appeared to be stock access, with runoff and the influence of edge effects from historic clearing also promoting degradation. Large rainfall events each year would cause increased runoff, potentially washing sediment away from the bank and depositing it into the creeks. Cattle compact soil structures and trample vegetation; both leading to increased erosion. The impact of large woody debris at the sites was minimal and not considered significant.

Table 19 Erosion Observations at AARC 2019 Sites

Site	DWR1	DWR4	DWR5	DWR6	DWI1	DWI3	DWI6	DWI8	DWI9	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5
Bare Ground	Low	Low	Low	None	None	Low	Low	*Mod	Low	*Mod	*Mod	Low	Low	Some	Low
Exposed Tree Roots	Low	None	Low	None	None	Low	Some	*Mod	None	Low	Low	*Mod	Some	*Mod	Low
Gully Erosion	Low	None	Low	Low	None	Some	*Mod	^Ext	Low	None	Low	Some	Some	Some	Some
Bank Slumping	None	None	Some	None	None	*Mod	*Mod	*Mod	Low	Some	Low	Some	*Mod	*Mod	Low
Local Catchment Erosion	None	None	*Mod	Low	Some	*Mod	Some	Some	Some	Low	^Ext	Low	Some	Some	Some

*Mod – Moderate
^Ext – Extensive
Note: Observations were scored according to the following categories [None, Low (1-10%), Some (10-50%), Moderate (50-75%), or Extensive (>75%).

6.3.2 Habitat Bioassessment

This assessment considered the morphological characteristics of waterways (as specified in Section 5.5.2), with 135 representing a perfect score for a healthy waterway. Habitat assessments were completed at all sites.

The habitat bioassessment scores from the aquatic sites within the sampling environment primarily fell into the moderate and good categories (Figure 8), with the exception of one site DWR1 which was classed as excellent. These results are indicative of the general health of the river and the surrounding systems, it does not consider the quality of the water present. The following broad habitat types were recorded in and adjacent to the study area; non-riverine wetlands, ephemeral streams and farm dams.

Figure 8 Habitat Bioassessment Scores

6.3.3 Condition Assessment

The condition assessment considered the impact/influence of ten different upstream activities on the waterways (as outlined in Section 5.5.3) with 50 representing the maximum score (no impact) and ten representing the minimum score (full impact). Impact assessments were completed at all sites and site assessment scores are presented in Figure 9.

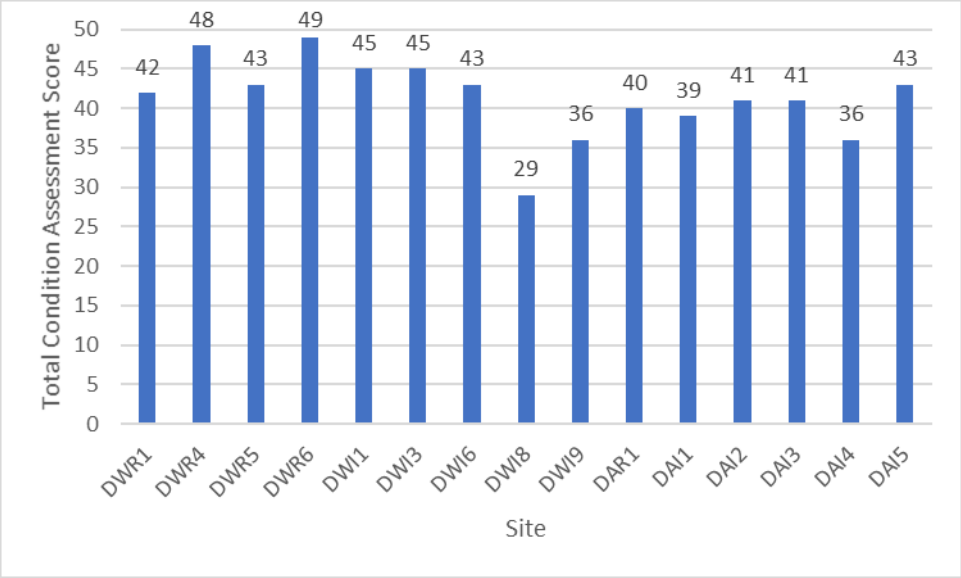


Figure 9 Condition Assessment Scores

DWI8 had the lowest rating of 29, indicating that this site was influenced by upstream activities to a higher degree than the other sites. This site was one of two sites that received a rating of 1 (very major impact). DWI8 received a rating of 1 for the influence of alterations to the riparian zone. This site had been heavily cleared and showed signs of significant erosion. DAI1 was the other site that received the rating of 1, this was for the impact of erosion and damage from stock on the riparian zone. DWR6 had the highest rating of 49 indicating that the influence of activities upstream of this site had minimal impact.

6.3.4 Macroinvertebrate Sampling

Macroinvertebrate results from the 2019 survey have been summarised by calculating total abundance, taxonomic richness, PET taxa richness, SIGNAL 2 scores, community composition and percent tolerant taxa. Where applicable, these indices have been compared to relevant WQO for macroinvertebrates in the Mackenzie River Sub-basin. Nine sites were sampled for macroinvertebrates during the 2019 survey (DAI1, DAI2, DAI3, DAI4, DAI5, DAR1, DWR5, DWI6, and DWI9).

During sampling baseline flow was present at one site (DWI6), with the remaining sites having only standing pools of water with no flow, conditions which can impact the abundance and richness of macroinvertebrate taxa found. Due to the ephemeral nature of the waterways being sampled, habitats for macroinvertebrate sampling were limited to only edge (or bank) habitats during the 2019 survey.

The taxa composition of macroinvertebrates is used to provide an estimate of a waterbody's health. Macroinvertebrates are sensitive to a variety of factors such as turbidity, DO, pollutants in waterways and salinity. The surface water quality results support the low macroinvertebrate diversity, lack of PET taxa and low Signal 2 scores recorded across the study area.

6.3.4.1 Total Abundance

Total abundance of macroinvertebrates sampled at aquatic sites within the 2019 survey varied significantly between sites. A complete list of all identified macroinvertebrates is available in Appendix C.

Macroinvertebrate abundance ranged from three (DAI3) to 625 (DWR5) (Figure 10). Fluctuation in total abundance is expected due to habitat availability for macroinvertebrates and the varying nature of the waterways sampled. Sites DWR5, DAR1, DAI1, DAI2, DAI3 and DAI4 all occur along or in close relation

to Charlevue Creek. DAI5, DWI6 and DWI9 occur along Springton Creek or a tributary that flows into Springton Creek.

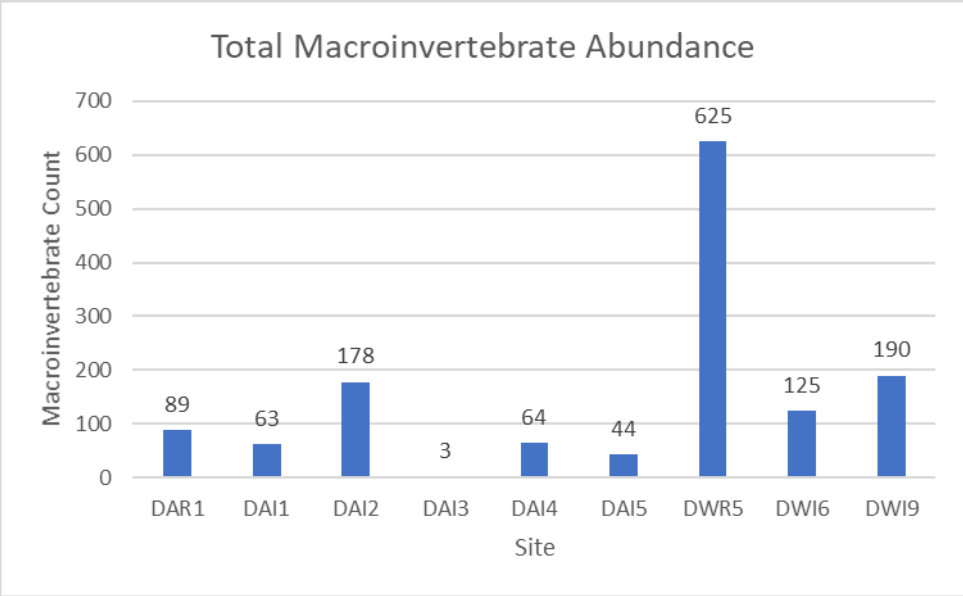


Figure 10 Macroinvertebrate Abundance

6.3.4.2 Taxonomic Richness

Taxonomic richness recorded at the sites is shown in Figure 11; none of the sites sampled reached the lower WQO for taxonomic richness. The site that came closest was DAI2 which occurs along Charlevue Creek. This is an indicator of poor habitat quality and only a small number of macroinvertebrate taxa were recorded in the available habitat. Two sites had very low taxonomic richness with only three (DAI3) and four (DAI5) taxa recorded.

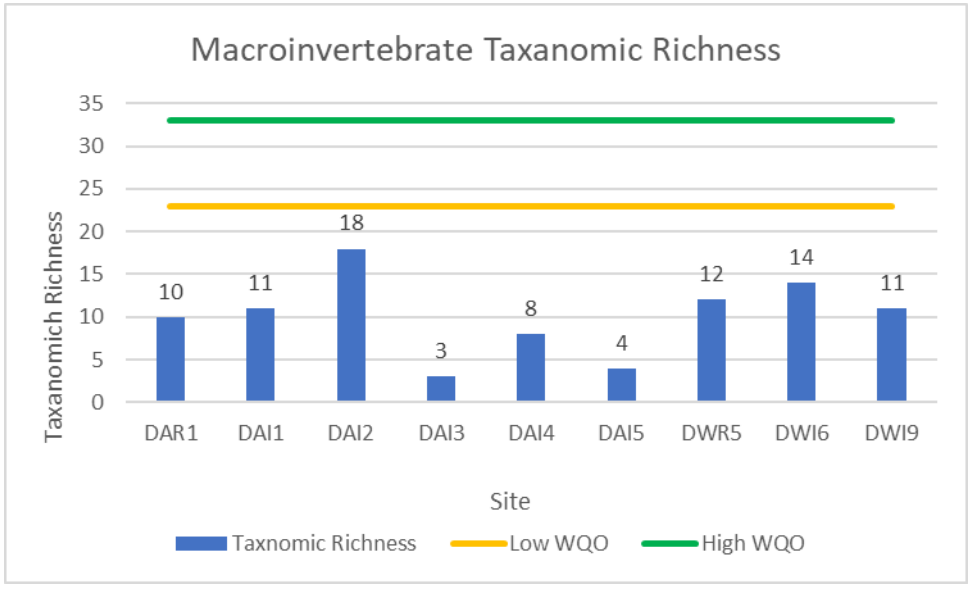


Figure 11 Macroinvertebrate Taxonomic Richness

6.3.4.3 PET Taxa Richness

The PET taxa are three orders of macroinvertebrate that are particularly sensitive to disturbance. They require favourable water quality conditions and diverse habitat to survive. PET taxa richness in ephemeral waterbodies tends to be low, due to the naturally harsh conditions in these waterways (i.e. poor water quality and low habitat diversity). However, trending declines in the number of PET taxa at a site may be an indication of pollution or poor water quality. Only four sites were found to support PET taxa (DAR1, DAI1, DAI2 and DAI4). These sites were found to only contain one PET taxa from the Ephemeroptera order. No other PET taxa were identified at the other sites. No sites were found to meet the lower WQO for PET taxa richness. The low levels of PET taxa sampled is likely due to the lack of available habitats during the sampling events and a lowered health of the water available for sampling.

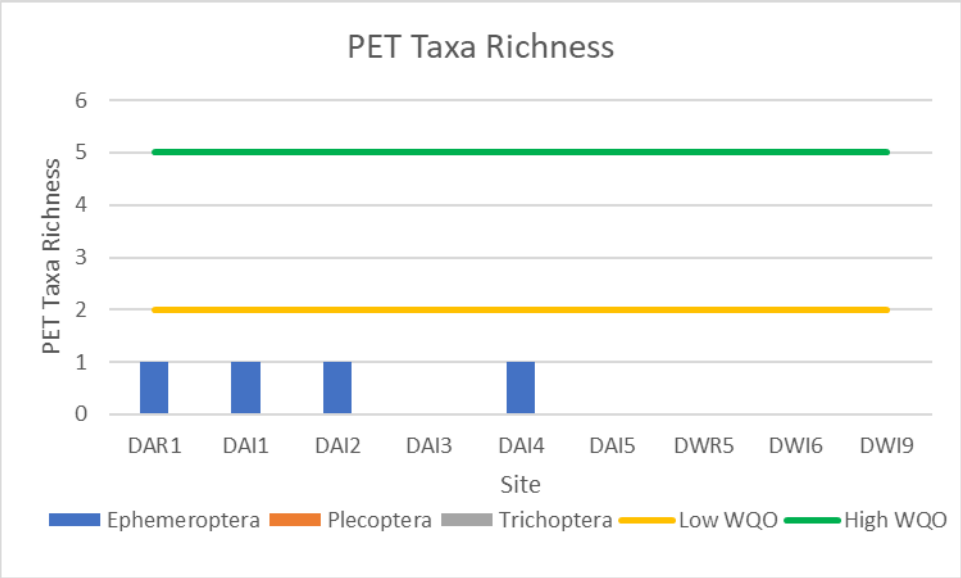


Figure 12 PET Taxonomic Richness

6.3.4.4 SIGNAL 2 Scores

Each macroinvertebrate family is allocated a score between 1 and 10 to represent their sensitivity to specific environmental conditions and varying levels of pollution. A lower score indicates that the macroinvertebrate family can tolerate a range of environmental conditions and common forms of water pollution; while a higher grade indicates that the macroinvertebrate family is sensitive to most forms of pollution.

The SIGNAL 2 scores recorded (Figure 13) indicated poor habitat availability and environmental conditions. All sites except one (DAI3) site fell below the lower WQO. Factors that would have influenced these results include the flow conditions at the site and the ephemeral nature of the waterways. Taxa found in ephemeral waters vary largely with rainfall events and as flow conditions change. Low abundance of sensitive macroinvertebrate taxa is likely to result from the environmental conditions.

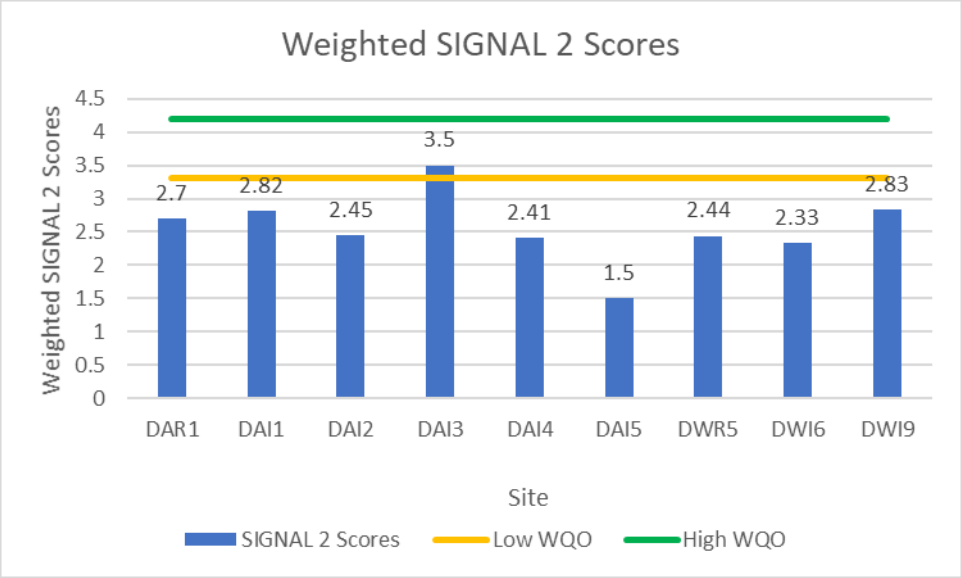


Figure 13 Macroinvertebrate SIGNAL 2 Site Scores

6.3.4.5 SIGNAL 2 Bi-Plot

A SIGNAL 2 bi-plot was created for the aquatic sites to demonstrate the level of pollution and suitability of the site for macroinvertebrate habitation (Figure 14). Sites that fall into quadrant 4 exhibit levels of pollutants that reflect urban, industrial, or agricultural pollution. Sites in quadrant 3 indicate the presence of harsh physical environments or toxic pollution. Sites in quadrant 2 reflect waters which are high in nutrients or salinity. Sites in quadrant 1 are indicative of favourable water quality and minimal levels of disturbance. All sites fell within quadrant 4 which is consistent with what the sites are exposed to, as the sites are exposed to anthropogenic pollutions (urban/industrial developments), agricultural pollution, and downstream effects of dams.as all were open to human and livestock access.

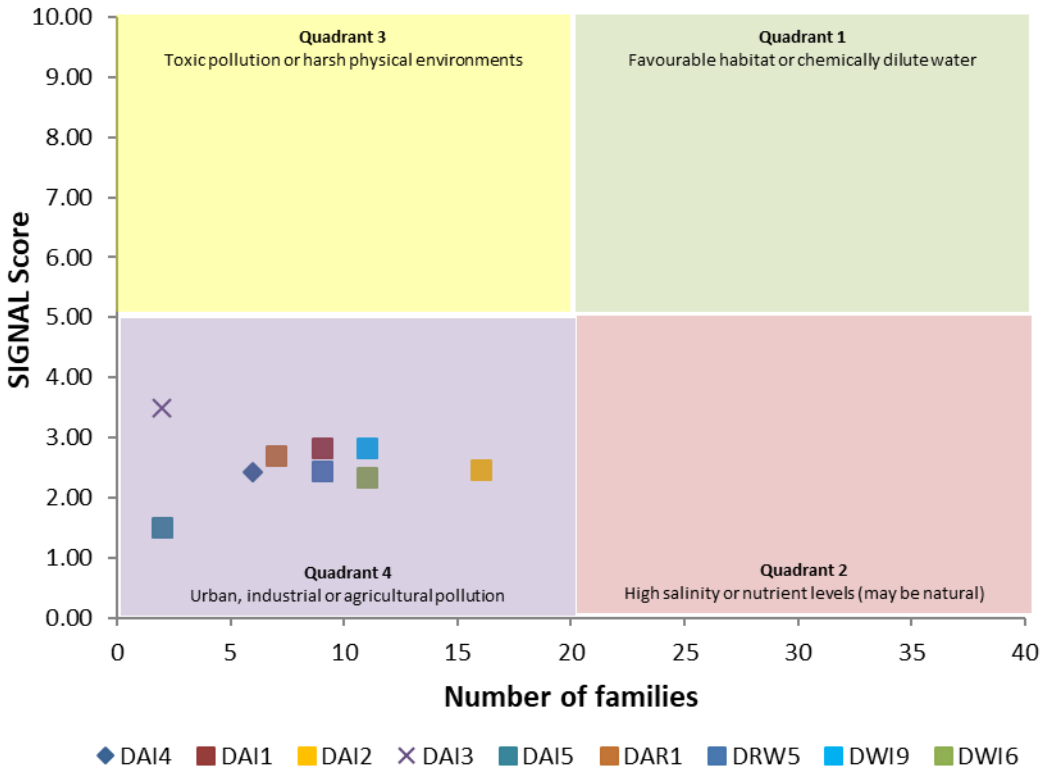


Figure 14 Macroinvertebrate SIGNAL 2 Bi-Plot

6.3.4.6 Percent Tolerant Taxa

This index is based on the proportion of taxa that are rated as having a tolerant sensitivity grade (SIGNAL grades 1, 2 and 3). A higher proportion of tolerant taxa were recorded than the WQOs at all sites, only one site did not exceed the high WQO (DAI3). It should be noted that DAI3 had only 3 macroinvertebrates recorded, as such this result is not a true reflection of the macroinvertebrate population present at DAI3.

Typically, high proportions of tolerant taxa are reflective of poor health in the creek. This is indicative of ephemeral creeks; as the more resilient macroinvertebrate taxa survive. Figure 15 compares the percentage of tolerant taxa found at each site. Most of the taxa sampled were generalist taxa that are tolerant to higher levels of disturbance and higher salinity concentrations.

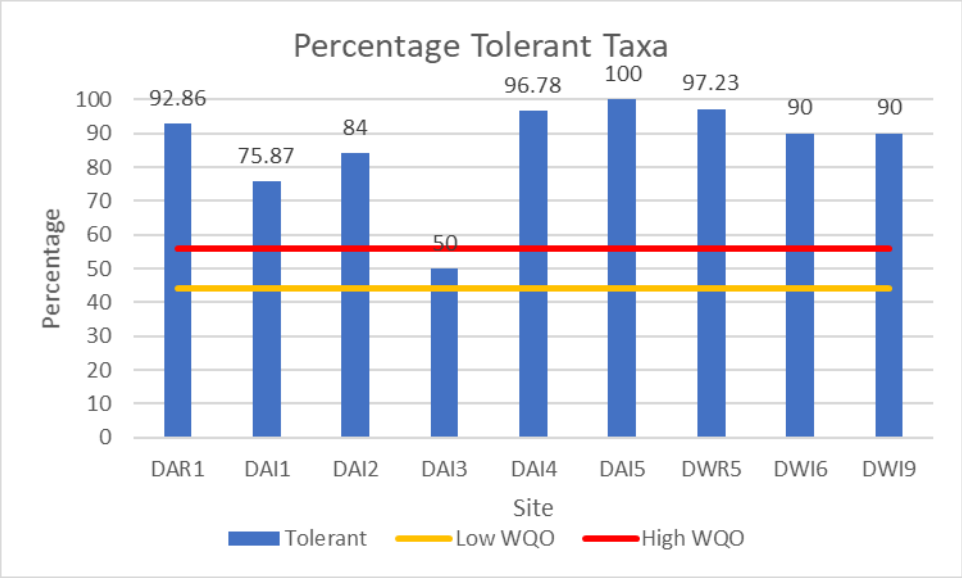


Figure 15 Percentage of Tolerant Macroinvertebrate Taxa

6.3.4.7 Community Composition – AusRivAS Predictive Modelling

Macroinvertebrate community composition was interpreted by running data through an AusRivAS predictive modelling program. This model is used to predict macroinvertebrate assemblages that are expected to occur within a site in the absence of impact. This model is then used to compare the expected macroinvertebrate assemblage to that of the assemblage of macroinvertebrates collected during site sampling.

Observed versus Expected (O/E) taxa score is a ratio of the number of macroinvertebrate families observed onsite to that of the number of families expected; this provides a measure of biological impairment at the sample site. Five bands are used to categorise O/E taxa scores based on their biological condition;

- Band X indicates that the site is more biologically diverse than anticipated;
- Band A indicates that the site is similarly biologically diverse as expected and is therefore not negatively impacted by any conditions onsite; and
- Bands B, C, and D reflect environments with increasingly impaired health impacting on the diversity of macroinvertebrate assemblages.

Table 20 show the results of the AusRivAS predictive modelling assessment. All sample sites fell within or below Band B, indicating that the sites are potentially impacted either by water quality and/or the availability of macroinvertebrate habitats.

DAI1, DAI2, DAI5 and DWI9 received scores within the assessment Band B indicating that these sites are significantly impaired and exhibit fewer than expected taxa. Evidence of disturbance from cattle grazing was recorded at these sites and is likely the major contributor to the impaired scores. Sites DAR1, DAI4, DWR5 and DWI6 fell within Band C indicating that these habitats are severely impaired resulting in a lowered macroinvertebrate biodiversity. DAI3 received the lowest score falling within Band D, indicating that it is highly degraded and has extremely poor water and/or habitat quality. This site had the lowest macroinvertebrate abundance and macroinvertebrate taxa recorded.

Table 20 AusRivAS Predictive Modelling Results

Sample ID	O/E Taxa Score (OE50)	Habitat used for overall site assessment	Overall sample assessment band	Bandwidth-Upper limit
DAR1	0.29	Edge	C	0.37
DAI1	0.40	Edge	B	0.79
DAI2	0.70	Edge	B	0.79
DAI3	0.00	Edge	D	0
DAI4	0.10	Edge	C	0.37
DAI5	0.50	Edge	B	0.79
DWR5	0.30	Edge	C	0.37
DWI6	0.30	Edge	C	0.37
DWI9	0.40	Edge	B	0.79

6.3.5 Fish and Crustacean Sampling

6.3.5.1 Crustaceans

Blue claw crayfish (*Cherax destructor*) were captured at all aquatic trap sites, except one (DAI3). The Inland freshwater crab (*Austrothelphusa transversa*) was captured at DAR1, DAI1, DAI2, and DAI5. The Inland freshwater crab can burrow up to one metre deep in heavy clay to avoid desiccation during periods of prolonged estivation (Nathan 2016). Two Freshwater shrimp (*Paratya australiensis*) were captured at DAI4.

Crustacean species living in highly ephemeral waterways display their own unique adaptation to cope with the harsh environment. Many crustaceans can survive long periods outside of a waterbody by extracting oxygen from air with their gills. This can only occur if the gills are kept moist so many species dig burrows to avoid desiccation and remain underground in estivation until water returns to the system. Mechanisms for desiccation resistance are observed in many species, including those that were identified during field surveys.

6.3.5.2 Fish

Australia yields a low diversity of fish species predominantly due to its large areas of arid and semi-arid land, as well as the ephemeral nature of large areas of catchments (Allen et al. 2002). Due to the ephemeral nature of the waterways present within the study area the overall habitat available to freshwater species is relatively low. For most of the year, the waterways onsite are vastly unconnected with other aquatic habitats. Resulting in shallow still pools of water with limited refuge, breeding or feeding areas.

The 2019 aquatic survey identified two species of fish; Agassiz's glassfish (*Ambassis agassizii*), and Spangled perch (*Leiopotherapon unicolor*). The Agassiz's glassfish was recorded at DAI4 and DAI5, while the Spangled perch was recorded at DAI2 and DAI4.

All fish species recorded in the study area are considered to be common or widespread species in the Mackenzie River Sub-basin. Fish species of the study area can be generally considered either a 'small-bodied' species (Agassiz's glassfish) or a moderately sized species (Spangled perch). Most of the fish species recorded in the study have adaptations that allow rapid colonization and/or exploitation of ephemeral pool habitats;

- they are all generalist species (i.e. flexible dietary and habitat requirements); and/or
- some species (e.g. Spangled perch and Agassiz's glassfish) are able to move rapidly to newly created pools.

Such adaptations are necessary for exploiting the temporary habitat resources within the study area.

6.4 RIPARIAN AND AQUATIC VEGETATION

Riparian vegetation condition, species presence and plant health were assessed at each aquatic site. For the purposes of this survey, vegetation monitoring at each site was conducted along a 50 m transect, recording aquatic and riparian species within the riparian zone.

6.4.1 Vegetation Assessment

A full list of species is provided in Appendix D and photos of the sites are provided in Appendix B with the AusRivAS Physical Assessment Site information.

The total number of flora species sampled across the surveys at all the sites was 111. A total of 40 species were introduced species; eight of which are commonly used as pasture grasses or livestock feed. Of the remaining introduced species, the Velvety tree pear (*Opuntia tomentosa)*, Mimosa (*Mimosa pigra*), Lantana (*Lantana camara*) and Parthenium weed (*Parthenium hysterophorus*) are declared Weeds of National Significance (WoNS) and Restricted Invasive species under the Biosecurity Act. Three additional flora species recorded within the study area are classed as Restricted Invasive species under the Biosecurity Act, these include Mother of millions (*Bryophyllum delagoense*), Mother of thousands (*Bryophyllum daigremontianum*) and Rubber vine (*Cryptostegia grandiflora*). Noogoora burr (*Xanthium pungens*) is classed as other Invasive Plants under the Biosecurity Act.

The riparian vegetation exhibited no signs of dieback, and constituted a mixture of low to moderate disturbance, and were located within both remnant and non-remnant environs (Table 21). Total species richness at each site varied between 11 and 30 species, incorporating between three and twelve introduced species (Figure 16). There was a fairly consistent species composition present with a mix of sedges, grasses, forbs, and trees and shrubs present at all sites, except for DWR4 which lacked any tree or shrub species (Figure 17). No in-stream aquatic macrophytes were recorded within the study area.

Table 21 Vegetation Assessment

Parameter	Remnant Riparian Vegetation	Level of Disturbance	Presence of Dieback
DWR1	Yes	High	No
DWI1	Yes	Low	No
DWR4	No	Low	No
DWR5	Yes	Moderate	No
DWR6	Yes	Low	No
DAR1	Yes	Low	No
DAI1	Yes	Low	No
DAI2	Yes	Moderate	No
DAI3	Yes	Moderate	No
DAI4	Yes	Moderate	No
DWI3	Yes	Low	No
DAI5	Yes	Moderate	No
DWI6	Yes	Moderate	No
DWI9	Yes	Low	No
DWI8	No	Moderate	No

Note the level of disturbance was categories based on observed levels of human impact (including land clearing), pastoral animal and feral animal impacts, disturbance from agriculture and riparian vegetation alteration (including the presence of introduced species). Categories included low, moderate and high.

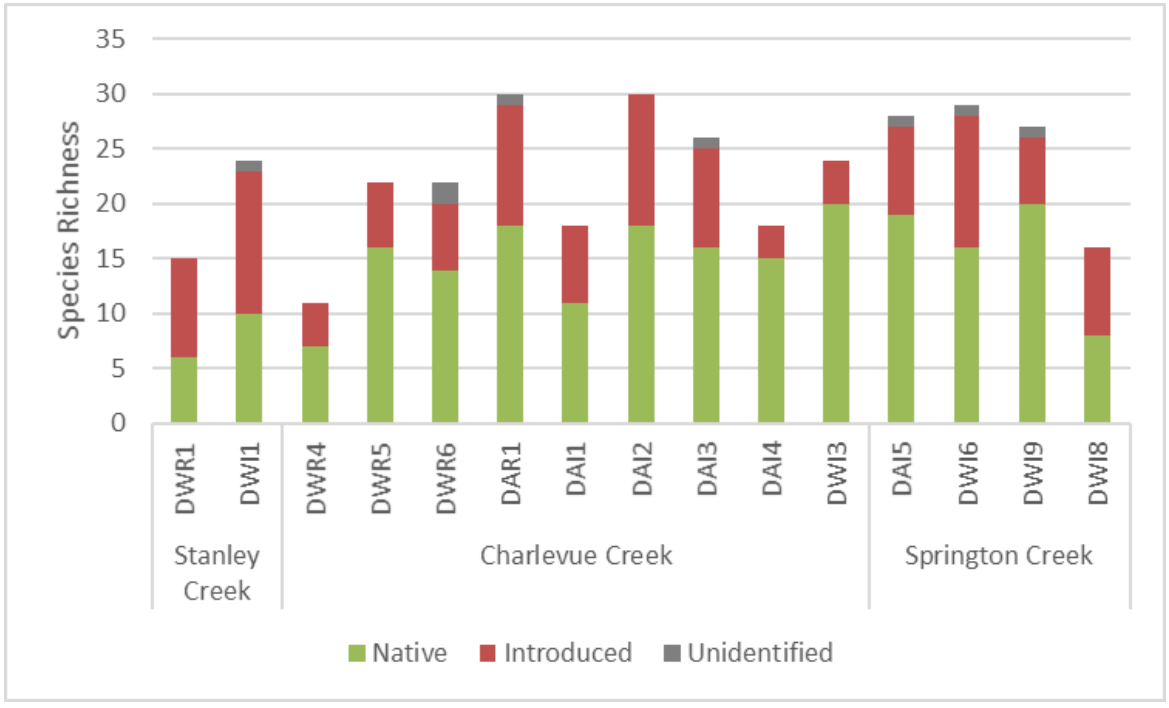


Figure 16 Vegetation Species Richness

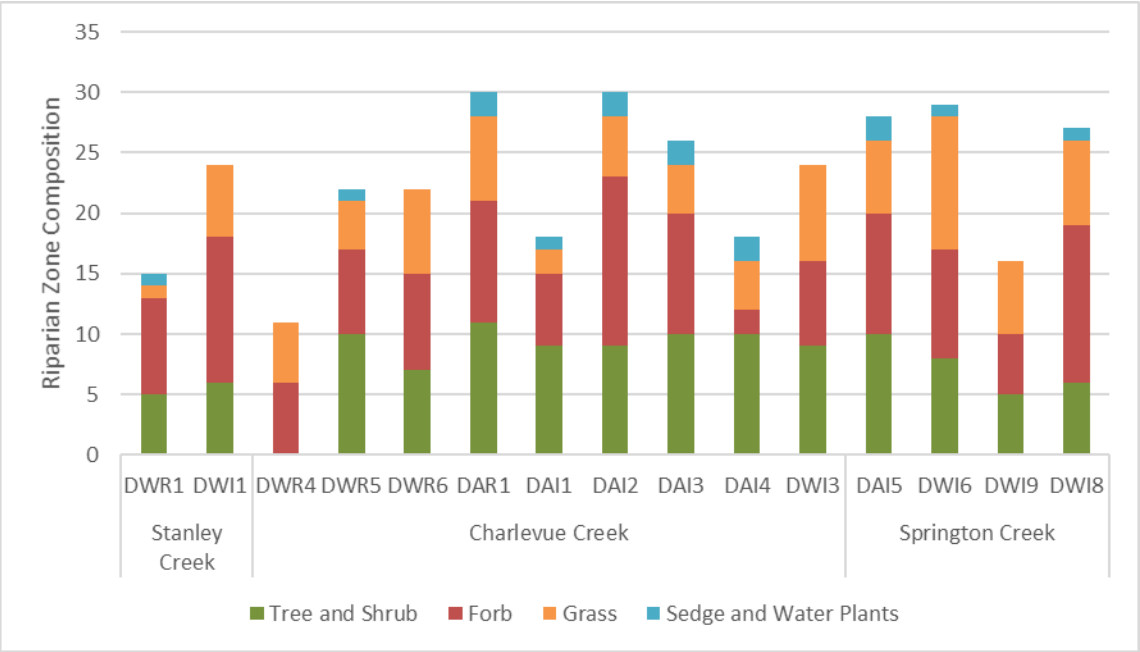


Figure 17 Vegetation Species Composition

6.4.2 Flora of Conservation Significance

No flora species of conservation significance were observed within the riparian zone during the surveys.

6.5 WETLANDS

There are several small non-riverine wetlands of medium conservation significance mapped by the Department of Environment and Science (DES) within the study area. These all occur in close association with Charlevue Creek which runs through the centre of the study area. These wetlands are ephemeral and do not hold water throughout the year. At the time of the 2019 sampling no water was present within the mapped wetland areas and therefore no aquatic assessment was able to be completed.

6.6 RIPARIAN ZONE VERTEBRATE FAUNA

Two amphibian species were identified during the surveys including one introduced species, the Cane toad (*Rhinella marina*), and one native species, the Bumpy rocket frog (*Litoria inermis*) (Photo Plate 1). The Cane toad was identified at DAI1 and the Bumpy rocket frog was observed at DAI5.

Eight reptile species were identified during the field surveys, including the Keelback snake (*Tropidonophis mairii*) (Photo Plate 2), Tommy Roundhead (*Diporiphora australis*), Dubious dtella (*Gehyra dubia*) and several skink species (Appendix E).

A total of 54 bird species representing 31 families were identified by the surveys. A list of the bird species recorded is provided in Appendix E. No migratory bird species were identified during the field survey within the study area. One Marine species was detected during the field surveys; the Rainbow bee-eater (*Merops ornatus*).

Two mammal species were identified rarely, the Common brushtail possum (*Trichosurus vulpecula*) and Greater glider (*Petauroides volans volans*). Greater gliders are classified as Vulnerable under both the EPBC Act and the NC Act. The Greater glider was recorded along Charlevue Creek at DAI1 and DAI2.

No aquatic fauna species of conservation significance were observed during surveys.

Photo Plate 1 Bumpy rocket frog

Photo Plate 2 Keelback snake at DAI2

6.7 SUMMARY OF AQUATIC VALUES

The waterways of the study area are ephemeral, experiencing periodic flows. Charlevue Creek and Springton Creek are determined watercourses under the *Water Act 2000*. Extensive clearing for agricultural purposes has been undertaken across much of the study area including the removal of riparian vegetation. The removal of riparian vegetation and direct stock access to the waterways has resulted in bank instability, erosion and occurrence of weeds.

Surface water quality was found to be generally poor. At the time of sampling there was no surface flow. Results for physico-chemical parameters were outside the WQO guideline values for the protection of aquatic ecosystems at many sites including pH, dissolved oxygen, turbidity, ammonia, and sulphate (as SO_4^{2}). Petroleum hydrocarbons were found to exceed WQO guideline values at several sites, considered likely due to the highway and agricultural practices.

Stream sediments were found to contain a high proportion of sand particles with some sites containing a mixture of silt and clay. Metal concentrations in stream sediment were generally low, except for nickel levels at site DWR6.

Macroinvertebrate diversity, abundance and PET richness were generally low. SIGNAL scores were correspondingly low and consistent with the expected results for ephemeral streams in an agricultural setting. The AusRivAS predictive modelling assessed the aquatic environments at the sample sites as significantly impaired to highly degraded. While impaired habitats is common in ephemeral creeks, the extent and severity of the impairment indicates low waterway health.

The diversity and abundance of fish and crustaceans was found to be low.

7.0 POTENTIAL IMPACTS

The aquatic ecology values within the study area are limited to riverine ecosystems including Charlevue and Springton Creeks and some tributaries. The creeks are highly ephemeral, experiencing periodic flows only following rainfall events. Past clearing for agricultural purposes has been undertaken across much of the study area including the removal of riparian vegetation. The removal of riparian vegetation and direct stock access to the waterways has resulted in bank instability, erosion and occurrence of weeds.

The Project (Figure 18) has potential to impact on aquatic ecology values through:

- The release of mine affected water to the receiving waterways and associated impacts to ecosystem health;
- Potential for spills and leaks from the mining operation to cause contamination in the receiving waterways;
- Direct impacts to riverine ecosystems via land disturbance for vehicle crossings or diversions of drainage features;
- Risk of increased erosion from cleared lands or mine infrastructure such as spoil dumps, resulting in increased sediment loads entering the aquatic ecosystems; and
- Impediments to fish or other aquatic fauna movements due to the construction of crossings or other infrastructure.

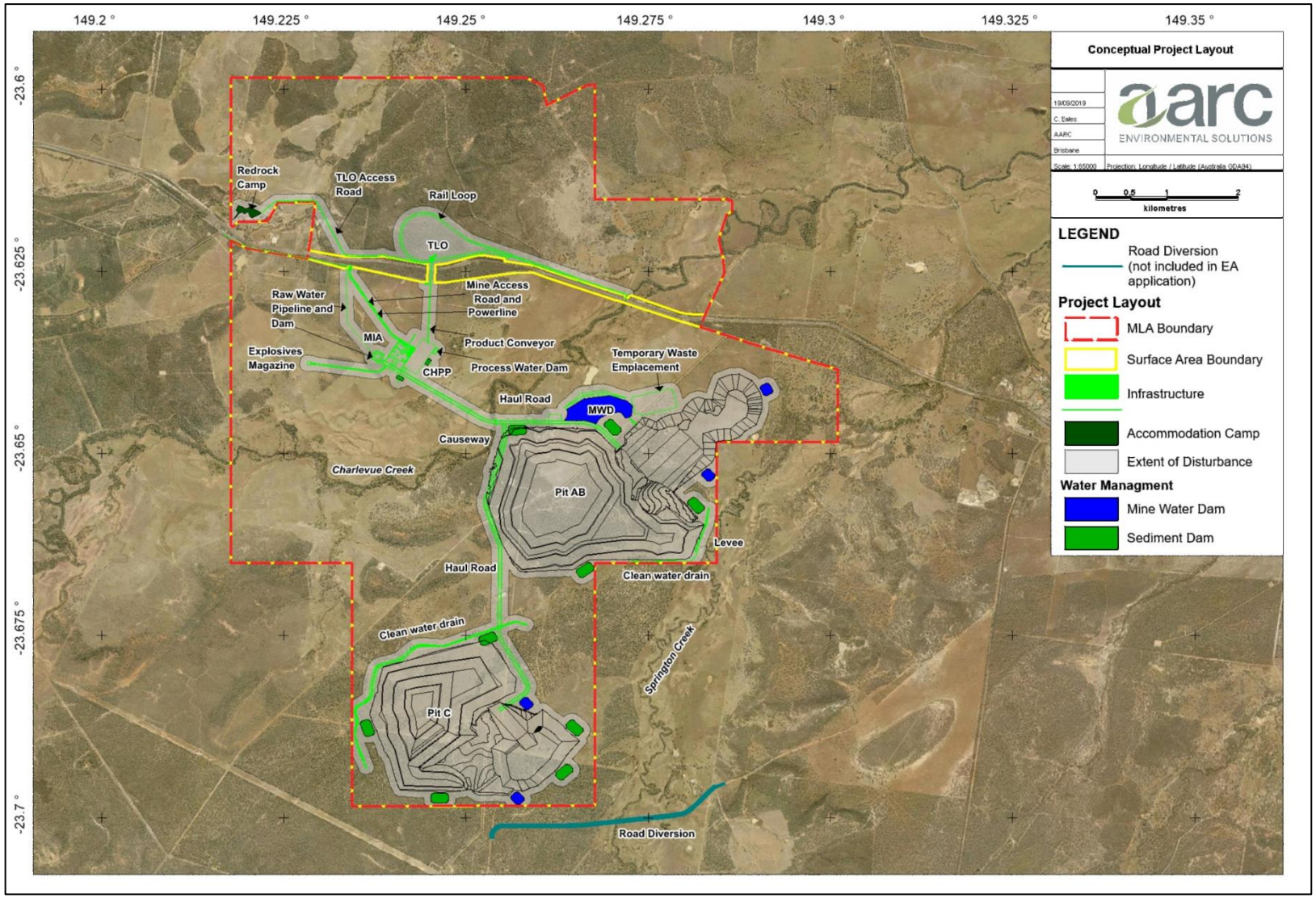


Figure 18 Conceptual Project Layout

8.0 MITIGATION STRATEGIES

Aquatic ecology values are primarily attributed to Charlevue and Springton Creeks within the MLA. The following mitigation measures will be implemented to protect existing values:

- Sediment and erosion control structures will be installed and maintained near all at risk areas to prevent sediment release to wetlands;
- Crossing design should provide for the fish passage during low and high flow events;
- The release of Mine Affected Water, will be in accordance with the quality controls provided by the model mining conditions;
- Fuel and hazardous liquids will be stored in a bunded facility, in accordance with Australian Standards;
- A Spill and Emergency Management plan will be implemented during construction and operation to minimise the risk of contaminant release to aquatic ecosystems;
- The Project open pits will be appropriately bunded or located in a manner that prevents surface water from entering the open pits during a 1:1000 year flood event and the Project dams will be appropriately bunded or located in a manner that prevents surface water from entering or damaging the dams during a 1:1000 year flood event (consistent with the 'Not a Controlled Action if undertaken in a particular manner' EPBC Referral decision); and
- A Receiving Environment Monitoring Program (REMP) will be implemented and will include monitoring of water, sediments, riparian / riverine vegetation health and biological indicators in aquatic environments.

9.0 PROJECT ENVIRONMENTAL OFFSETS

The offsets framework requires environmental offsets to be delivered where an activity is likely to result in a significant residual impact on a prescribed environmental matter. The *QEOP Significant Residual Impact Guideline* (DES 2014b) is used to determine whether residual impacts are considered to be significant.

Prescribed environmental matters (MSES) are listed in Schedule 2 of the Environmental Offsets Regulation. The following prescribed matters were mapped or identified within the Project area by the aquatic ecology surveys:

- Fish habitat areas and waterways providing for fish passage (under the *Fisheries Act 1994*);
- A habitat for an animal that is endangered wildlife or vulnerable wildlife, or a special least concern animal is a matter of State environmental significance; and
- a wetland—of high ecological significance shown on the map of Queensland wetland environmental values.

9.1 ASSESSMENT OF PRESCRIBED MATTERS IDENTIFIED IN THE STUDY AREA

9.1.1 Fish Passage

Charlevue Creek is mapped as being at major risk of adverse impact from waterway barrier works on fish movement. Stanley Creek is mapped as being of moderate risk of adverse impact. Tributaries of the streams are mapped within the study area as being of either low, medium or high risk of adverse impact from waterway barrier works on fish movement. As described above, the Project will require:

- The crossing of Charlevue Creek (mapped as major risk);
- The Stanley Creek crossing (mapped as moderate risk);
- The development of clean water drains along a tributary of Springton Creek (and/or its tributaries) (mapped as low to moderate risk); and
- The disturbance of first and second order waterways (mapped as low to moderate risk).

The *Queensland Environmental Offsets Policy: Significant Residual Impact Guideline* (DEHP 2014) is designed to assist in determining whether or not the impacts of a project will, or is likely, to have a significant residual impact on a MSES.

As stated in the significant residual impact guidelines:

> ***Passage*** *for fish, means the natural movement patterns of fish species required to maintain the biological integrity of the species.*

When assessed against the MSES significant residual impact guidelines (Table 22), the Project is considered unlikely to result in a significant residual impact on the waterways providing for fish passage. Based on the assessment, no offsets under the *Environmental Offset Regulation 2014* for waterways providing for fish passage are considered to be required for the Project.

Table 22 MSES Residual Impact Assessment of Waterways providing for Fish Passage

Significant Residual Impact Criteria	Ecological Assessment
Will the action result in the mortality or injury of fish?	No, the Project would not result in the mortality or injury of fish • The habitat within the study area offers limited habitat for fish species as the water systems are ephemeral and only flow during high rainfall events. • All waterway crossings (Charlevue Creek and Stanley Creek) would be constructed in consideration of the *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018), so as not to create a barrier to fish movement; and • The development of the clean water drains along the Springton Creek tributary would be designed to replicate natural features where possible with the aim of providing similar conditions to the original waterway, so as to provide habitat and refuge for fish inhabiting or passing through the diversion.
Will the action result in conditions that substantially increase risks to the health, wellbeing, and productivity of fish seeking passage such as through the depletion of fishes energy reserves, stranding, increased predation risks, entrapment or confined schooling behaviour in fish?	No, the Project will not result in conditions that substantially increase risks to the health, wellbeing and productivity of fish seeking passage within the site. Given the intended design of the waterway crossings and the design of the Springton Creek tributary clean water drains that will be implemented, the Project is unlikely to result in the depletion of fishes' energy reserves, stranding fish, increase the risk of predation, entrapment or confined schooling behaviour in fish.
Will the action reduce the extent, frequency or duration of fish passage previously found at a site?	No, the habitat within the study area offers limited habitat for fish species as the water systems are ephemeral and only flow during high rainfall events. The Project will not reduce the extent, frequency or duration of fish passage within the site because the Project will ensure that: • All waterway crossings (Charlevue Creek and Stanley Creek) would be constructed in consideration of the *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018), so as not to create a barrier to fish movement; and • The development of the clean water drains along the Springton Creek tributary would be designed to replicate natural features where possible with the aim of providing similar conditions to the original waterway, so as to provide habitat and refuge for fish inhabiting or passing through the diversion.
Will the action substantially modify, destroy or fragment areas of fish habitat (including, but not limited to in-stream vegetation, snags and woody debris, substrate, bank or riffle formations) necessary for the breeding and/or survival of fish?	No, the Project will not substantially modify, destroy or fragment areas of fish habitat necessary for breeding and/or the survival of fish, as the Project will ensure that: • All waterway crossings (Charlevue Creek and Stanley Creek) would be constructed in consideration of the *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018), so as not to create a barrier to fish movement; and • The development of the clean water drains along the Springton Creek tributary would be designed to replicate natural features where possible with the

Significant Residual Impact Criteria	Ecological Assessment
	aim of providing similar conditions to the original waterway, so as to provide habitat and refuge for fish inhabiting or passing through the diversion. Several unnamed tributaries of the Springton Creek and Charlevue Creek are expected to be removed or otherwise impacted by mining activities. These waterways have been mapped as low to moderate risk of impact of fish passage. These waterways are of low stream orders (1 or 2) and are ephemeral. These waterways are not considered to provide fish habitat necessary for the breeding and/or the survival of fish.
Will the action result in a substantial and measurable change in the hydrological regime of the waterway, for example, a substantial change to the volume, depth, timing, duration and frequency of flows?	No, The Project is unlikely to result in substantial and measurable changes in the hydrological regime of the waterways within and around the study area. The volume, depth, timing, duration and frequency of flows are anticipated continue to reflect the ephemeral and variable flow nature of the waterways around the study area.
Will the action lead to significant changes in water quality parameters such as temperature, dissolved oxygen, pH and conductivity that provide cues for movement in local fish species?	No, given the water management measures that will be implemented (Section 8.0), the Project is unlikely to decrease the quality of habitat for fish utilising the study area or lead to a significant change in water quality parameters. The Project will also ensure that any water releases will be managed in accordance with the EA conditions (once developed).

9.1.2 Fitzroy River Turtle

The *Queensland Environmental Offsets Policy: Significant Residual Impact Guideline* (DEHP 2014) is designed to assist in determining whether or not the impacts of a Project will, or is likely to, have a significant residual impact on a MSES.

An assessment of the potential impact of the Project on the Fitzroy River turtle using the MSES significant impact criteria is presented in Table 23.

Table 23 Fitzroy River turtle MSES Significant Residual Impact Assessment

Significant Residual Impact Criteria	Ecological Assessment
Will the action lead to a long-term decrease in the size of local population of a species?	No, the habitat within the study area is not suitable for this species as the water systems are ephemeral and only flow during high rainfall events. The Project includes measures to prevent downstream impacts to the Fitzroy River turtle, specifically the: • appropriately bunding or location of pits in a manner that prevents surface water from entering the pit during a 1:1000 year flood event; • appropriately bunding or location of dams in a manner that prevents surface water from entering or damaging the dams during a during a 1:1000 year flood event.
Will the action reduce the extent of occurrence of the species ?	No, the proposed Project disturbance and downstream water releases are unlikely to reduce the potential area of occupancy for the Fitzroy River turtle.

Significant Residual Impact Criteria	Ecological Assessment
Will the action fragment an existing population into two or more populations?	No, the Project would not fragment an existing population into two or more populations.
Will the action result in genetically distinct populations forming as a result of habitat isolation adversely?	No, given the water management measures to prevent downstream impacts to the Fitzroy River turtle the Project is unlikely to result in genetically distinct populations forming.
Will the action disrupt ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species?	No, given the water management measures to prevent downstream impacts to the Fitzroy River turtle the Project is unlikely to disrupt an ecologically significant location of this species.
Will the action result in invasive species that are harmful to the species becoming established in the species habitat?	No, while the Fitzroy River turtle is vulnerable to predation on nests from introduced pest species; pest management strategies will be implemented to minimise the risk of introduced pest species (such as feral pigs, *Sus scrofa*) predating on the Fitzroy River turtle.
Will the action introduce disease that may cause the population to decline, or interfere with the recovery of the species?	No diseases are known for the species that could be caused by mining activities and cause the species' population to decline, nor would actions associated with mining activities interfere substantially with the recovery of the species.

When assessed against the MSES significant residual impact guidelines, the Project is considered unlikely to result in a significant residual impact on the Fitzroy River turtle. Based on the assessment, no offsets under the *Environmental Offset Regulation 2014* for the Fitzroy River turtle are considered to be required for the Project.

9.1 OFFSETS REQUIREMENTS

There are no aquatic MSES environmental offset requirements to be delivered under the Queensland legislation as part of this Project.

10.0 REFERENCES

AARC Environmental Solutions Pty Ltd (AARC) (2019) 'Gemini Project: Terrestrial Ecology Assessment', prepared for Magnetic South Pty Ltd.

Allen GR, Allen M & Midgley SH (2002) Field guide to the freshwater fishes of Australia, Western Australian Museum, Western Australia.

ANZECC & ARMCANZ (2000a) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1: The Guidelines (Chapters 1-7), prepared by ANZECC and ARMCANZ for the National Water Quality Management Strategy, Department of Agriculture and Water Resources, Commonwealth of Australia, Canberra.

Brooks JD & Smith JW (1969) The diagenesis of plant lipids during the formation of coal, petroleum and natural gas—II. Coalification and the formation of oil and gas in the Gippsland Basin, Geochimica et Cosmochimica Acta, 33(10), 1183-1194.

Bureau of Meteorology (BoM) (2018) Queensland River Basins, Available from: <http://www.bom.gov.au/qld/flood/brochures/qld/map.pdf>, accessed May 2019.

Conrick D & Cockayne B (eds.) (2001) QLD AusRivAS Sampling and Processing Manual, I Department of Natural Resources, Mines and Energy, Queensland Government, Brisbane.

Curtis LK, Dennis AJ, McDonald KR, Kyne PM, and Debus SJS, (2012) Queensland's Threatened Animals, CSIRO Publishing, Collingwood.

Debus SJS (1995) Surveys of large forest owls in northern New South Wales: methodology, calling behaviour and owl responses. Corella 19, 38–50.

Department of Agriculture and Fisheries (DAF) (2013) Guide for the determination of waterways using the spatial data layer Queensland waterways for waterway barrier works, Queensland Government, Brisbane.

Department of Agriculture and Fisheries (DAF) (2018) Accepted development requirements for operational work that is constructing or raising waterway barrier works, Queensland Government, Brisbane.

Department of Environment and Heritage Protection (DEHP) (2011a) Environmental Protection (Water) Policy 2009; Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin, Department of Environment and Science, Queensland Government, Brisbane.

Department of Environment and Heritage Protection (DEHP) (2011b) WQ130 Mackenzie River Sub-basin: Environmental Protection (Water) Policy 2009 Central Queensland Map Series, Department of Environment and Science, Queensland Government, Brisbane, available from < https://environment.des.qld.gov.au/water/policy/pdf/plans/mackenzie_plan_300811.pdf>, accessed May 2019.

Department of Environment and Heritage Protection (DEHP) (2014) Queensland Environmental Offsets Policy Significant Residual Impact Guideline, prepared by Conservation and Biodiversity Programs, Department of Environment and Science, Queensland Government, Brisbane.

Department of Environment and Science (DES) (2017) Guideline Model mining conditions, Department of Environment and Science, Queensland Government, Brisbane.

Department of Environment and Science (DES) (2018a) Fitzroy Drainage Basin – Facts and Maps. Available from: <https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/basin-fitzroy/>, accessed May 2019.

Department of Environment and Science (DES) (2018b) Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009, Department of Environment and Science, Queensland Government, Brisbane.

Department of Environment and Science (DES) (2019) Queensland Environmental Offsets Policy (Version 1.7), prepared by Conservation Policy and Planning, Department of Environment and Science, Queensland Government, Brisbane.

Department of Natural Resources and Mines (DNRM) (2001) AusRivAS Sampling and Processing Manual, Department of Natural Resources, Mines and Energy, Queensland Government, Brisbane.

Department of the Environment (DoE) (2013) Matters of National Environmental Significance, Significance impact guidelines 1.1 *Environment Protection and Biodiversity Conservation Act 1999*, Commonwealth of Australia, Canberra.

Department of the Environment and Energy (DoEE) (2018a). SPRAT EPBC Migratory Lists in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

Department of the Environment and Energy (DoEE) (2018b), Species Profile and Threats Database, Department of the Environment, Canberra. Available from:< http://www.environment.gov.au/sprat

Eyre TJ, Ferguson DJ, Hourigan CL, Smith GC, Mathieson MT, Kelly, AL, Venz MF, Hogan, LD & Rowland, J (2018), Terrestrial Vertebrate Fauna Survey Guidelines for Queensland V3.0, Queensland Herbarium, Department of Environment and Science, Queensland Government, Brisbane.

Fondriest Environmental Inc. (2014) 'Fundamentals of Environmental Measurements: Turbidity, Total Suspended Solids & Water Clarity', Available from <http://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/>, accessed May 2019.

Geoscience Australia (2018) Province and Sedimentary Basin Geology - Bowen Basin. Available from: <http://www.ga.gov.au/scientific-topics/energy/province-sedimentary-basin-geology/petroleum/onshore-australia/bowen-basin>, accessed May 2019.

Hutton AC (2009) Geological Setting of Australasian Coal Deposits, Australasian Coal Mining Practice, pp. 40-84.

Kavanagh R P and Peake P (1993) Distribution and habitats of nocturnal forest birds in south-eastern New South Wales. In 'Australian Raptor Studies' (Ed. P. Olsen.) pp.101–125 (Royal Australasian Ornithologists Union: Melbourne.)

Mutton AJ (2003) Queensland Coals - Physical and Chemical Properties, Colliery and Company Information, Department of Natural Resources and Mines, Queensland Government, Brisbane. Available from: <https://www.dnrm.qld.gov.au/?a=267497>, accessed May 2019

Nathan JW (2016) Unravelling life history of the Inland Freshwater Crab Austrothelphusa transversa in seasonal tropical river catchments, Australian Zoologist: 2016, Vol. 38, No. 2, pp. 217-222.

Neldner, VJ, Wilson, BA, Thompson, EJ & Dillewaard, HA (2017) Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland Version 4.0, Queensland Herbarium, Department of Environment and Science, Queensland Government, Brisbane.

Parsons M, Ransom G, Thoms M & Norris R (2002a) Australian River Assessment System: AusRivAS Physical and Chemical Assessment Module, Monitoring River Heath Initiative Technical Report no 23, Commonwealth of Australia and University of Canberra, Canberra.

Appendix A Database Searches

Queensland Government

Department of Environment and Science

Environmental Reports

Biodiversity and Conservation Values

Biodiversity Planning Assessments and Aquatic Conservation Assessments

For the selected area of interest
epc: 881

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or Area of Interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "Central co-ordinates" option, the resulting assessment area encompasses an area extending from 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Please direct queries about these reports to: biodiversity.planning@des.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

Table of Contents

Summary Information 4
Biodiversity Planning Assessments 6
Introduction 6
Diagnostic Criteria 6
Other Essential Criteria 8
Aquatic Conservation Assessments 13
Introduction 13
Explanation of Criteria 13
Riverine Wetlands 14
Non-riverine Wetlands 15
Threatened and Priority Species 18
Introduction 18
Threatened Species 18
BPA Priority Species 18
ACA Priority Species 19
Maps 20
Map 1 - Locality Map 20
Map 2 - Biodiversity Planning Assessment (BPA) 21
Map 3 - Corridors 22
Map 4 - Wetlands and waterways 23
Map 5 - Aquatic Conservation Assessment (ACA) - riverine 24
Map 6 - Aquatic Conservation Assessment (ACA) - non-riverine 25
References 26
Appendices 27
Appendix 1 - Source Data 27
Appendix 2 - Acronyms and Abbreviations 28

Summary Information

Tables 1 to 8 provide an overview of the AOI with respect to selected topographic and environmental values.

Table 1: Area of interest details: epc: 881

Size (ha)	7,219.57
Local Government(s)	Central Highlands Regional
Bioregion(s)	Brigalow Belt
Subregion(s)	Woorabinda
Catchment(s)	Fitzroy

The following table identifies available Biodiversity Planning Assessments (BPAs) and Aquatic Conservation Assessments (ACAs) with respect to the AOI.

Table 2: Available Biodiversity Planning and Aquatic Conservation Assessments

Assessment Type	Assessment Area and Version
Biodiversity Planning Assessment(s)	Brigalow Belt v2.1
Aquatic Conservation Assessment(s) (riverine)	Great Barrier Reef Catchments v1.3
Aquatic Conservation Assessment(s) (non-riverine)	Great Barrier Reef Catchments v1.3

Table 3: Remnant regional ecosystems within the AOI as per the Qld Herbarium's 'biodiversity status'

Biodiversity Status	Area (Ha)	% of AOI
Endangered	6.41	0.09
Of concern	236.35	3.27
No concern at present	1,816.18	25.16

The following table identifies the extent and proportion of the user specified area of interest (AOI) which is mapped as being of "State", "Regional" or "Local" significance via application of the Queensland Department of Environment and Science's *Biodiversity Assessment and Mapping Methodology* (BAMM).

Table 4: Summary table, biodiversity significance

Biodiversity significance	Area (Ha)	% of AOI
State Habitat for EVNT taxa	0.0	0.0
State	887.22	12.29
Regional	325.7	4.51
Local or Other Values	1,126.39	15.6

Table 5: Non-riverine wetlands intersecting the AOI

Non-riverine wetland types intersecting the area of interest	#
Number of Palustrine wetlands	4
Number of Lacustrine wetlands	2

Non-riverine wetland types intersecting the area of interest	#
Total number of non-riverine wetlands	6

NB. The figures presented in the table above are derived from the relevant non-riverine Aquatic Conservation Assessment(s). Later releases of wetland mapping produced via the Queensland Wetland Mapping Program may provide more recent information in regards to wetland extent.

Table 6: Named waterways intersecting the AOI

Name	Permanency
CHARLEVUE CREEK	Non-perennial
SPRINGTON CREEK	Non-perennial
STANLEY CREEK	Non-perennial

Refer to **Map 1** for general locality information.

The following two tables identify the extent and proportion of the user specified AOI which is mapped as being of "Very High", "High", "Medium", "Low", or "Very Low" aquatic conservation value for riverine and non-riverine wetlands via application of the Queensland Department of Environment and Science's *Aquatic Biodiversity Assessment and Mapping Method* (AquaBAMM).

Table 7: Summary table, aquatic conservation significance (riverine)

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
Very High	0.0	0.0
High	0.0	0.0
Medium	7,219.57	100.0
Low	0.0	0.0
Very Low	0.0	0.0

Table 8: Summary table, aquatic conservation significance (non-riverine)

Aquatic conservation significance (non-riverine wetlands)	Area (Ha)	% of AOI
Very High	0.0	0.0
High	0.0	0.0
Medium	10.88	0.15
Low	0.0	0.0
Very Low	0.0	0.0

Biodiversity Planning Assessments

Introduction

The Department of Environment and Science (DES) attributes biodiversity significance on a bioregional scale through a Biodiversity Planning Assessment (BPA). A BPA involves the integration of ecological criteria using the *Biodiversity assessment and Mapping Methodology* (BAMM) and is developed in two stages: 1) **diagnostic criteria**, and 2) **expert panel criteria**. The diagnostic criteria are based on existing data which is reliable and uniformly available across a bioregion, while the expert panel criteria allows for the refinement of the mapped information from the diagnostic output by incorporating local knowledge and expert opinion.

The BAMM methodology has application for identifying areas with various levels of significance solely for biodiversity reasons. These include threatened ecosystems or taxa, large tracts of habitat in good condition, ecosystem diversity, landscape context and connection, and buffers to wetlands or other types of habitat important for the maintenance of biodiversity or ecological processes. While natural resource values such as dryland salinity, soil erosion potential or land capability are not dealt with explicitly, they are included to some extent within the biodiversity status of regional ecosystems recognised by the DES.

Biodiversity Planning Assessments (BPAs) assign three levels of overall biodiversity significance.

- **State significance** - areas assessed as being significant for biodiversity at the bioregional or state scales. They also include areas assessed by other studies/processes as being significant at national or international scales. In addition, areas flagged as being of State significance due to the presence of endangered, vulnerable and/or near threatened taxa, are identified as "State Habitat for EVNT taxa".
- **Regional significance** - areas assessed as being significant for biodiversity at the subregional scale. These areas have lower significance for biodiversity than areas assessed as being of State significance.
- **Local significance and/or other values** - areas assessed as not being significant for biodiversity at state or regional scales. Local values are of significance at the local government scale.

For further information on released BPAs and a copy of the underlying methodology, go to:

http://www.qld.gov.au/environment/plants-animals/biodiversity/planning/

The GIS results can be downloaded from the Queensland Spatial Catalogue at:

http://qspatial.information.qld.gov.au/geoportal/

The following table identifies the extent and proportion of the user specified AOI which is mapped as being of "State", "Regional" or "Local" significance via application of the BAMM.

Table 9: Summary table, biodiversity significance

Biodiversity significance	Area (Ha)	% of AOI
State Habitat for EVNT taxa	0.0	0.0
State	887.22	12.29
Regional	325.7	4.51
Local or Other Values	1,126.39	15.6

Refer to **Map 2** for further information.

Diagnostic Criteria

Diagnostic criteria are based on existing data which is reliable and uniformly available across a bioregion. These criteria are diagnostic in that they are used to filter the available data and provide a "first-cut" or initial determination of biodiversity significance. This initial assessment is then combined through a second group of other essential criteria.

A description of the individual diagnostic criteria is provided in the following sections.

Criteria A. Habitat for EVNT taxa: Classifies areas according to their significance based on the presence of endangered, vulnerable and/or rare (EVNT) taxa. EVNT taxa are those scheduled under the *Nature Conservation Act 1992* and/or the

Environment Protection and Biodiversity Conservation Act 1999. It excludes highly mobile fauna taxa which are instead considered in Criterion H and brings together information on EVNT taxa using buffering of recorded sites or habitat suitability models (HSM) where available.

Criteria B. Ecosystem value: Classifies on the basis of biodiversity status of regional ecosystems, their extent in protected areas (presence of poorly conserved regional ecosystems), the presence of significant wetlands; and areas of national importance such as the presence of Threatened Ecological Communities, World Heritage areas and Ramsar sites. Ecosystem value is applied at a bioregional (**B1**) and regional (**B2**) scale.

Criteria C. Tract size: Measures the relative size of tracts of vegetation in the landscape. The size of any tract is a major indicator of ecological significance, and is also strongly correlated with the long-term viability of biodiversity values. Larger tracts are less susceptible to ecological edge effects and are more likely to sustain viable populations of native flora and fauna than smaller tracts.

Criteria D. Relative size of regional ecosystems: Classifies the relative size of each regional ecosystem unit within its bioregion (**D1**) and its subregion (**D2**). Remnant units are compared with all other occurrences with the same regional ecosystem. Large examples of a regional ecosystem are more significant than smaller examples of the same regional ecosystem because they are more representative of the biodiversity values particular to the regional ecosystem, are more resilient to the effects of disturbance, and constitute a significant proportion of the total area of the regional ecosystem.

Criteria F. Ecosystem diversity: Is an indicator of the number of regional ecosystems occurring within an area. An area with high ecosystem diversity will have many regional ecosystems and ecotones relative to other areas within the bioregion.

Criteria G. Context and connection: Represents the extent to which a remnant unit incorporates, borders or buffers areas such as significant wetlands, endangered ecosystems; and the degree to which it is connected to other vegetation.

A summary of the biodiversity status based upon the diagnostic criteria is provided in the following table.

Table 10: Summary of biodiversity significance based upon diagnostic criteria with respect to the AOI

Biodiversity significance	Description	Area (Ha)	% of AOI
State	Remnant contains at least 1 Vulnerable or Near Threatened species (A) & Nat. Threatened Ecol. Community (B1)	49.69	0.69
State	Remnant contains at least one Of Concern RE (B1) & Nat. Threatened Ecol. Community (B1)	170.08	2.36
Regional	Remnant contains at least 1 Vulnerable or Near Threatened species (A)	297.04	4.11
Regional	Remnant contains at least one Of Concern RE (B1)	24.52	0.34
Local or Other Values	Refer to diagnostic data for additional information	1,787.11	24.75

Assessment of diagnostic criteria with respect to the AOI

The following table reflects an assessment of the individual diagnostic criteria noted above in regards to the AOI.

Table 11: Assessment of individual diagnostic criteria with respect to the AOI

Diagnostic Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
A: Habitat for EVNT Taxa			346.7	4.8	1,451.58	20.1	530.12	7.3
B1: Ecosystem Value (Bioregion)	219.75	3.0	24.52	0.3	1,842.09	25.5		
B2: Ecosystem Value (Subregion)					2,086.36	28.9		
C: Tract Size			695.57	9.6	635.1	8.8	755.69	10.5
D1: Relative RE Size (Bioregion)							2,086.36	28.9
D2: Relative RE Size (Subregion)							2,086.36	28.9
F: Ecosystem Diversity	40.49	0.6	770.08	10.7	1,160.05	16.1	115.74	1.6
G: Context and Connection	182.92	2.5	467.75	6.5	1,377.66	19.1	58.03	0.8

Other Essential Criteria

Other essential criteria (also known as expert panel criteria) are based on non-uniform information sources and which may rely more upon expert opinion than on quantitative data. These criteria are used to provide a "second-cut" determination of biodiversity significance, which is then combined with the diagnostic criteria for an overall assessment of relative biodiversity significance. A summary of the biodiversity status based upon the other essential criteria is provided in the following table.

Table 12: Summary of biodiversity significance based upon other essential criteria with respect to the AOI

Biodiversity significance	Description	Area (Ha)	% of AOI
State	Remnant contains Special Biodiversity Values (view Expert Panel data for further information) (I)	709.9	9.83
Regional	Remnant contains Special Biodiversity Values (view Expert Panel data for further information) (I)	0.32	0.0
Regional	Remnant forms part of a bioregional corridor (J)	95.17	1.32
Local	Remnant contains Special Biodiversity Values (view Expert Panel data for further information) (I)	10.56	0.15

A description of each of the other essential criteria and associated assessment in regards to the AOI is provided in the following sections.

Criteria H. Essential and general habitat for priority taxa: Priority taxa are those which are at risk or of management concern, taxa of scientific interest as relictual (ancient or primitive), endemic taxa or locally significant populations (such as a flying fox camp or heronry), highly specialised taxa whose habitat requirements are complex and distributions are not well correlated with any particular regional ecosystem, taxa important for maintaining genetic diversity (such as complex spatial patterns of genetic variation, geographic range limits, highly disjunct populations), taxa critical for management or monitoring of biodiversity (functionally important or ecological indicators), or economic and culturally important taxa.

Criteria I. Special biodiversity values: areas with special biodiversity values are important because they contain multiple taxa in a unique ecological and often highly biodiverse environment. Areas with special biodiversity values can include the following:

- Ia - centres of endemism - areas where concentrations of taxa are endemic to a bioregion or subregion are found.
- Ib - wildlife refugia (Morton *et al*. 1995), for example, islands, mound springs, caves, wetlands, gorges, mountain ranges and topographic isolates, ecological refuges, refuges from exotic animals, and refuges from clearing. The latter may include large areas that are not suitable for clearing because of land suitability/capability.
- Ic - areas with concentrations of disjunct populations.
- Id - areas with concentrations of taxa at the limits of their geographic ranges.
- Ie - areas with high species richness.
- If - areas with concentrations of relictual populations (ancient and primitive taxa).
- Ig - areas containing REs with distinct variation in species composition associated with geomorphology and other environmental variables.
- Ih - an artificial waterbody or managed/manipulated wetland considered by the panel/s to be of ecological significance.
- Ii - areas with a high density of hollow-bearing trees that provide habitat for animals.
- Ij - breeding or roosting sites used by a significant number of individuals.
- Ik - climate change refuge.

The following table identifies the value and extent area of the Other Essential Criteria H and I within the AOI.

Table 13: Relative importance of expert panel criteria (H and I) used to access overall biodiversity significance with respect to the AOI

Expert Panel	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
H: Core Habitat Priority Taxa								
Ia: Centres of Endemism								
Ib: Wildlife Refugia	709.92	9.8	0.32		10.55	0.1		
Ic: Disjunct Populations								

Expert Panel	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
Id: Limits of Geographic Ranges								
Ie: High Species Richness								
If: Relictual Populations								
Ig: Variation in Species Composition								
Ih: Artificial Wetland								
Ii: Hollow Bearing Trees								
Ij: Breeding or Roosting Site	30.51	0.4						
Ik: Climate Refugia								

NB. Whilst biodiversity values associated with Criteria I may be present within the site (refer to tables 12 and 15), for the New England Tableland and Central Queensland Coast BPAs, area and % area figures associated with Criteria Ia through to Ij cannot be listed in the table above (due to slight variations in data formats between BPAs).

Criteria J. Corridors: areas identified under this criterion qualify either because they are existing vegetated corridors important for contiguity, or cleared areas that could serve this purpose if revegetated. Some examples of corridors include riparian habitats, transport corridors and "stepping stones".

Bioregional and subregional conservation corridors have been identified in the more developed bioregions of Queensland through the BPAs, using an intensive process involving expert panels. Map 3 displays the location of corridors as identified under the Statewide Corridor network. The Statewide Corridor network incorporates BPA derived corridors and for bioregions where no BPA has been assessed yet, corridors derived under other planning processes. *Note: as a result of updating and developing a statewide network, the alignment of corridors may differ slightly in some instances when compared to those used in individual BPAs.*

The functions of these corridors are:

- **Terrestrial** Bioregional corridors, in conjunction with large tracts of remnant vegetation, maintain ecological and evolutionary processes at a landscape scale, by:

  • Maintaining long term evolutionary/genetic processes that allow the natural change in distributions of species and connectivity between populations of species over long periods of time;

  • Maintaining landscape/ecosystems processes associated with geological, altitudinal and climatic gradients, to allow for ecological responses to climate change;

  • Maintaining large scale seasonal/migratory species processes and movement of fauna;

  • Maximising connectivity between large tracts/patches of remnant vegetation;

  • Identifying key areas for rehabilitation and offsets; and

- **Riparian** Bioregional Corridors also maintain and encourage connectivity of riparian and associated ecosystems.

The location of the corridors is determined by the following principles:

- Terrestrial

  • Complement riparian landscape corridors (i.e. minimise overlap and maximise connectivity);

  • Follow major watershed/catchment and/or coastal boundaries;

  • Incorporate major altitudinal/geological/climatic gradients;

  • Include and maximise connectivity between large tracts/patches of remnant vegetation;

• Include and maximise connectivity between remnant vegetation in good condition; and

- Riparian

• Located on the major river or creek systems within the bioregion in question.

The total extent of remnant vegetation triggered as being of "State", "Regional" or "Local" significance due to the presence of an overlying BPA derived terrestrial or riparian corridor within the AOI, is provided in the following table. For further information on how remnant vegetation is triggered due to the presence of an overlying BPA derived corridor, refer to the relevant landscape BPA expert panel report(s).

Table 14: Extent of triggered remnant vegetation due to the presence of BPA derived corridors with respect to the AOI

Biodiversity Significance	Area (Ha)	% of AOI
State	0.0	0.0
Regional	95.17	1.32
Local	0.0	0.0

NB: area figures associated with the extent of corridor triggered remnant vegetation are only available for those bioregions where a BPA has been undertaken.

Refer to **Map 3** for further information.

Threatening process/condition (Criteria K) - areas identified by experts under this criterion may be used to amend (upgrade or downgrade) biodiversity significance arising from the "first-cut" analysis. The condition of remnant vegetation is affected by threatening processes such as weeds, ferals, grazing and burning regime, selective timber harvesting/removal, salinity, soil erosion, and climate change.

Assessment of Criteria K with respect to the AOI is not currently included in the "Biodiversity and Conservation Values" report, as it has not been applied to the majority of Queensland due to data/information limitations and availability.

Special Area Decisions

Expert panel derived "Special Area Decisions" are used to assign values to Other Essential Criteria. The specific decisions which relate to the AOI in question are listed in the table below.

Table 15: Expert panel decisions for assigning levels of biodiversity significance with respect to the AOI

Decision Number	Description	Panel Recommended Significance	Criteria Values
brbn_l_62	Taunton Scientific Reserve	State	Ib (refugia): VH
brbs_l_18b	None	None	None
brbs_l_47	Regionally significant natural palustrine & lacustrine wetlands	Regional	Ib (refugia): H
brbs_l_48	Locally significant natural palustrine & lacustrine wetlands	Local	Ib (refugia): M
brbs_l_49	Gilgai Remnants	State	Ib (refugia): VH; Ij (aggregation site):VH

Expert panel decision descriptions:

brbn_l_62

Taunton National Park (Scientific) acts as a refugia within a heavily modified landscape. The park was established primarily for the purpose of protecting the endangered bridled nailtail wallaby Onychogalea fraenata. Dispersal of individuals in time to suitable habitat to the south will rely on retaining connectivity from the park, particularly along the creeks Five Mile, Duckworth, Walton, Iguana, Stanley, Charlevue, Spectacle, Lagoon and Wild Horse (not captured in the spatial implementation).

Other known conservation significant fauna which occur or have been recorded within the park are golden-tailed gecko Strophurus taenicauda, brigalow scaly-foot Paradelma orientalis, ornamental snake Denisonia maculata, speckled warbler Chthonicola sagittata, koala Phascolarctos cinereus and squatter pigeon Geophaps s. scripta. Representatives from six of the Australian snake families are also found in the reserve.

With respect to flora, 12 regional ecosystems are present including endangered brigalow communities. More than 190 species of flora have been recorded, of which at least 4 are threatened - Solanum elachophyllum, Solanum adenophorum, Dichanthium setosum and Cerbera dumicola.

brbs_l_18b

None

brbs_l_47

The panel considered that relatively natural palustrine and lacustrine wetlands and waterbodies within the Brigalow Belt bioregion act as important refugia, especially during periods of drought.

Whilst State significant wetlands are captured under Criterion B1, the panel agreed that all such natural wetland complexes with a combined area of greater than or equal to 5ha in size should be classed as being of at least Regional significance.

Refer to brbn_l_92 for the northern BRB implementation of this decision.

brbs_l_48

The panel considered that relatively natural palustrine and lacustrine wetlands and waterbodies within the Brigalow Belt bioregion act as important refugia, especially during periods of drought.

Whilst State significant wetlands are captured under Criterion B1, and regionally significant wetlands under the decision brbn_l_47, the panel agreed that all remaining relatively natural wetland complexes of less than 5ha in size be classed as being of at least local significance.

Refer to brbn_l_93 for the northern BRB implementation of this decision.

brbs_l_49

The gilgai wetland systems in the Brigalow Belt tend to be dominated by acacia and casuarina (mostly brigalow Acacia harpophylla and belah Casuarina cristata). Melaleuca, Corymbia and Eucalyptus species are also common along with Astrebla or Dichanthium spp. grassland. Gilgai systems are widespread and some are in good condition while others are largely cleared. The range of threatened wildlife present may use inundated gilgai as a water source at some stage of their life or are closely associated with the cracking clay soil habitat and wetlands.

Gilgai reptiles include the death adder Acanthophis antarcticus, De Vis' banded snake Denisonia devisi and ornamental snake D. maculata. Amphibians that use gilgai include salmon striped frog Limnodynastes salmini, scarlet-sided pobblebonk L. terraereginae and striped burrowing frog Cyclorana alboguttata. Other fauna which may use gilgai habitat at various times include bridled nailtail wallaby Onychogalea fraenata, black-striped wallaby Macropus dorsalis and the glossy black cockatoo Calyptorhynchus lathami.

Refer to brbn_l_75 for the northern BRB implementation of this decision.

Aquatic Conservation Assessments

Introduction

The Aquatic Biodiversity Assessment and Mapping Method or AquaBAMM (Clayton *et al.* 2006), was developed to assess conservation values of wetlands in queensland, and may also have application in broader geographical contexts. It is a comprehensive method that uses available data, including data resulting from expert opinion, to identify relative wetland conservation/ecological values within a specified study area (usually a catchment). The product of applying this method is an Aquatic Conservation Assessment (ACA) for the study area.

An ACA using AquaBAMM is non-social, non-economic and identifies the conservation/ecological values of wetlands at a user-defined scale. It provides a robust and objective conservation assessment using criteria, indicators and measures that are founded upon a large body of national and international literature. The criteria, each of which may have variable numbers of indicators and measures, are naturalness (aquatic), naturalness (catchment), diversity and richness, threatened species and ecosystems, priority species and ecosystems, special features, connectivity and representativeness. An ACA using AquaBAMM is a powerful decision support tool that is easily updated and simply interrogated through a geographic information system (GIS).

Where they have been conducted, ACAs can provide a source of baseline wetland conservation/ecological information to support natural resource management and planning processes. They are useful as an independent product or as an important foundation upon which a variety of additional environmental and socio-economic elements can be added and considered (i.e. an early input to broader 'triple-bottom-line' decision-making processes). An ACA can have application in:

- determining priorities for protection, regulation or rehabilitation of wetlands and other aquatic ecosystems
- on-ground investment in wetlands and other aquatic ecosystems
- contributing to impact assessment of large-scale development (e.g. dams)
- water resource and strategic regional planning prcesses

For a detailed explanation of the methodology please refer to the summary and expert panel reports relevant to the ACA utilised in this assessment. These reports can be accessed at Wetland *Info*:

http://wetlandinfo.des.qld.gov.au/wetlands/assessment/assessment-methods/aca

The GIS results can be downloaded from the Queensland Spatial Catalogue at:

http://qspatial.information.qld.gov.au/geoportal/

Explanation of Criteria

Under the AquaBAMM, eight criteria are assessed to derive an overall conservation value. Similar to the Biodiversity Assessment and Mapping Methodology, the criteria may be primarily diagnostic (quantitative) or primarily expert opinion (qualitative) in nature. The following sections provide a brief description of each of the 8 criteria.

Criteria 1. Naturalness - Aquatic: This attribute reflects the extent to which a wetland's (riverine, non-riverine, estuarine) aquatic state of naturalness is affected through relevant influencing indicators which include: presence of exotic flora and fauna; presence of aquatic communities; degree of habitat modification and degree of hydrological modification.

Criteria 2. Naturalness - Catchment: The naturalness of the terrestrial systems of a catchment can have an influence on many wetland characteristics including: natural ecological processes e.g. nutrient cycling, riparian vegetation, water chemistry, and flow. The indicators utilised to assess this criterion include: presence of exotic flora and/or fauna; riparian, catchment and flow modification.

Criteria 3. Naturalness - Diversity and Richness: This criterion is common to many ecological assessment methods and can include both physical and biological features. It includes such indicators as species richness, riparian ecosystem richness and geomorphological diversity.

Criteria 4. Threatened Species and Ecosystems: This criterion evaluates ecological rarity characteristics of a wetland. This includes both species rarity and rarity of communities / assemblages. The communities and assemblages are best represented by regional ecosystems. Species rarity is determined by NCA and EPBC status with Endangered, Vulnerable or Near-threatened species being included in the evaluation. Ecosystem rarity is determined by regional ecosystem biodiversity status i.e. Endangered, Of Concern, or Not of Concern.

Criteria 5. Priority Species and Ecosystems: Priority flora and fauna species lists are expert panel derived. These are aquatic, semi-aquatic and riparian species which exhibit at least 1 particular trait in order to be eligible for consideration. For

flora species the traits included:

- It forms significant macrophyte beds (in shallow or deep water).
- It is an important food source.
- It is important/critical habitat.
- It is implicated in spawning or reproduction for other fauna and/or flora species.
- It is at its distributional limit or is a disjunct population.
- It provides stream bank or bed stabilisation or has soil binding properties.
- It is a small population and subject to threatening processes.

Fauna species are included if they meet at least one of the following traits:

- It is endemic to the study area (>75 per cent of its distribution is in the study area/catchment).
- It has experienced, or is suspected of experiencing, a serious population decline.
- It has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area/catchment.
- It is currently a small population and threatened by loss of habitat.
- It is a significant disjunct population.
- It is a migratory species (other than birds).
- A significant proportion of the breeding population (>one per cent for waterbirds, >75 per cent other species) occurs in the waterbody (see Ramsar criterion 6 for waterbirds).
- Limit of species range.

See the individual expert panel reports for the priority species traits specific to an ACA.

Criteria 6. Special Features: Special features are areas identified by flora, fauna and ecology expert panels which exhibit characteristics beyond those identified in other criteria and which the expert panels consider to be of the highest ecological importance. Special feature traits can relate to, but are not solely restricted to geomorphic features, unique ecological processes, presence of unique or distinct habitat, presence of unique or special hydrological regimes e.g. spring-fed streams. Special features are rated on a 1 - 4 scale (4 being the highest).

Criteria 7. Connectivity: This criterion is based on the concept that appropriately connected aquatic ecosystems are healthy and resilient, with maximum potential biodiversity and delivery of ecosystem services.

Criteria 8. Representativeness: This criterion applies primarily to non-riverine assessments, evaluates the rarity and uniqueness of a wetland type in relation to specific geographic areas. Rarity is determined by the degree of wetland protection within "protected Areas" estate or within an area subject to the *Fisheries Act 1994*, *Coastal Protection and Management Act 1995*, or *Marine Parks Act 2004*. Wetland uniqueness evaluates the relative abundance and size of a wetland or wetland management group within geographic areas such as catchment and subcatchment.

Riverine Wetlands

Riverine wetlands are all wetlands and deepwater habitats within a channel. The channels are naturally or artificially created, periodically or continuously contain moving water, or connecting two bodies of standing water. AquaBAMM, when applied to riverine wetlands uses a discrete spatial unit termed subsections. A subsection can be considered as an area which encompasses discrete homogeneous stream sections in terms of their natural attributes (i.e. physical, chemical, biological and utilitarian values) and natural resources. Thus in an ACA, an aquatic conservation significance score is calculated for each subsection and applies to all streams within a subsection, rather than individual streams as such.

Please note, the area figures provided in Tables 16 and 17, are derived using the extent of riverine subsections within the AOI. Refer to **Map 5** for further information. A summary of the conservation significance of riverine wetlands within the AOI is provided in the following table.

Table 16: Overall level/s of riverine aquatic conservation significance

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
Very High	0.0	0.0

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
High	0.0	0.0
Medium	7,219.57	100.0
Low	0.0	0.0
Very Low	0.0	0.0

The individual aquatic conservation criteria ratings for riverine wetlands within the AOI are listed below.

Table 17: Level/s of riverine aquatic conservation significance based on selected criteria

Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
1. Naturalness aquatic					1,273.24	17.6	5,946.33	82.4
2. Naturalness catchment	2.53		7,217.04	100.0				
3. Diversity and richness	1,273.24	17.6	2,074.17	28.7	3,872.16	53.6		
4. Threatened species and ecosystems			7,219.57	100.0				
5. Priority species and ecosystems	7,217.04	100.0						
6. Special features								
7. Connectivity			5,946.33	82.4	1,273.24	17.6		
8. Representative-ness								

The table below lists and describes the relevant expert panel decisions used to assign conservation significance values to riverine wetlands within the AOI.

Table 18: Expert panel decisions for assigning overall levels of riverine aquatic conservation significance

Decision number	Special feature	Catchment	Criteria/Indicator/Measure	Conservation rating (1-4)
(No Records)				

4 is the highest rating/value

Expert panel decision descriptions:

(No Records)

Non-riverine Wetlands

Non-riverine wetlands include both lacustrine and palustrine wetlands, however, do not currently incorporate estuarine, marine or subterranean wetland types. A summary of the conservation significance of non-riverine wetlands within the AOI is provided in the following table. Refer to **Map 6** for further information.

Table 19: Overall level/s of non-riverine aquatic conservation significance

Aquatic conservation significance (non-riverine wetlands)	Area (Ha)	% of AOI
Very High	0.0	0.0
High	0.0	0.0
Medium	10.88	0.15
Low	0.0	0.0
Very Low	0.0	0.0

The following table provides an assessment of non-riverine wetlands within the AOI and associated aquatic conservation criteria values.

Table 20: Level/s of non-riverine aquatic conservation significance based on selected criteria

Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
1. Naturalness aquatic	4.68	0.1			6.19	0.1		
2. Naturalness catchment					10.87	0.2		
3. Diversity and richness			6.8	0.1	3.75	0.1	0.32	
4. Threatened species and ecosystems	2.43		4.37	0.1				
5. Priority species and ecosystems			10.87	0.2				
6. Special features								
7. Connectivity								
8. Representative-ness					6.8	0.1		

The table below lists and describes the relevant expert panel decisions used to assign conservation significance values to non-riverine wetlands within the AOI.

Table 21: Expert panel decisions for assigning overall levels of non-riverine aquatic conservation significance.

Decision number	Special feature	Catchment	Criteria/Indicator/Measure	Conservation rating (1-4)
ma_nr_fl_02	Regional ecosystems 8.3.4 & 11.3.27	Mackenzie	5.2.1	3

4 is the highest rating/value

Expert panel decision descriptions:

ma_nr_fl_02

These regional ecosystems contain significant habitat values that are under threat from threatening processes such as physical alteration/ destruction and invasion by **hymenachne**.

Note: This priority ecosystem decision applies to the following catchments: Calliope, Comet, Dawson, Fitzroy, Isaac, Mackenzie, Misc Other Islands, Nogoa, O'Connell, Pioneer, Plane, Proserpine, Shoalwater, Styx and Waterpark.

Threatened and Priority Species

Introduction

This chapter contains a list of threatened and priority flora and/or fauna species that have been recorded on, or within 4km of the Assessment Area.

The information presented in this chapter with respect to species presence is derived from compiled databases developed primarily for the purpose of BPAs and ACAs. Data is collated from a number of sources and is updated periodically.

It is important to note that the list of species provided in this report, may differ when compared to other reports generated from other sources such as the State government's WildNet, Herbrecs or the federal government's EPBC database for a number of reasons.

Records for threatened and priority species are filtered and checked based on a number of rules including:

- Taxonomic nomenclature - current scientific names and status,
- Location - cross-check co-ordinates with location description,
- Taxon by location - requires good knowledge of the taxon and history of the record,
- Duplicate records - identify and remove,
- Expert panels - check records and provide new records,
- Flora cultivated records excluded,
- Use precise records less than or equal to 2000m,
- Use recent records greater than or equal to 1975 animals, greater than or equal to 1950 plants.

Threatened Species

Threatened species are those species classified as "Endangered" or "Vulnerable" under the *Environment Protection and Biodiversity Conservation Act 1999* or "Endangered", "Vulnerable" or "Near threatened" under the *Nature Conservation Act 1992*.

The following threatened species have been recorded on, or within approximately 4km of the AOI.

Table 22: Threatened species recorded on, or within 4km of the AOI

Species	Common name	NCA status	EPBC status	Back on Track rank	Migratory species*	Wetland species**	Identified flora/fauna
Cerbera dumicola		NT		Low			FL
Geophaps scripta scripta	Squatter Pigeon (southern subsp.)	V	V	Medium			FA
Onychogalea fraenata	Bridled Nailtail Wallaby	E	E	Critical			FA
Solanum elachophyllum		E		Medium			FL

NB. Please note that the threatened species listed in this section are based upon the most recently compiled DES internal state-wide threatened species dataset. This dataset may contain additional records that were not originally available for inclusion in the relevant individual BPAs and ACAs.

**JAMBA - Japan-Australia Migratory Bird Agreement; CAMBA - China-Australia Migratory Bird Agreement; ROKAMBA - Republic of Korea-Australia Migratory Bird Agreement; CMS - Convention on the Conservation of Migratory Species*.

***Y - wetland indicator species*.

BPA Priority Species

A list of BPA priority species that have been recorded on, or within approximately 4km of the AOI is contained in the following table.

Table 23: Priority species recorded on, or within 4km of the AOI

(no results)

NB. Please note that the list of priority species is based on those species identified in the BPAs, however records for these species may be more recent than the originals used. furthermore, the BPA priority species databases are updated from time to time. At each update, the taxonomic details for all species are amended as necessary to reflect current taxonomic name and/or status changes.

ACA Priority Species

A list of ACA priority species used in riverine and non-riverine ACAs that have been recorded on, or within approximately 4km of the AOI are contained in the following tables.

Table 24: Priority species recorded on, or within 4 km of the AOI - riverine

Species	Common name	Back on Track rank	Identified flora/fauna
Eucalyptus camaldulensis			FL
Eucalyptus tereticornis			FL
Lomandra longifolia			FL

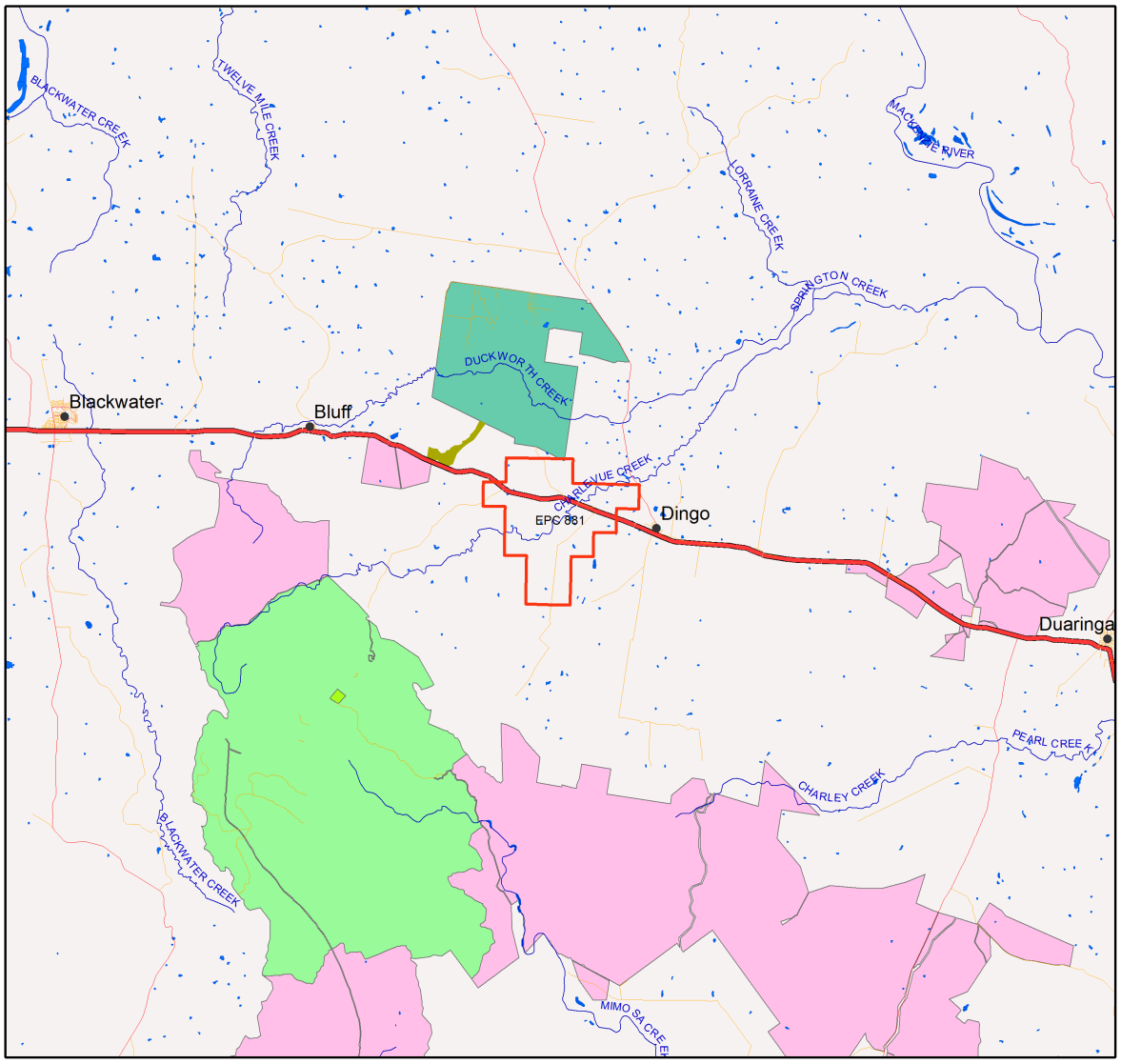
Table 25: Priority species recorded on, or within 4 km of the AOI - non-riverine

Species	Common name	Back on Track rank	Identified flora/fauna
Eucalyptus tereticornis			FL

NB. Please note that the priority species records used in the above two tables are comprised of those adopted for the released individual ACAs. The ACA riverine and non-riverine priority species databases are updated from time to time to reflect new release of ACAs. At each update, the taxonomic details for all ACAs records are amended as necessary to reflect current taxonomic name and/or status changes.

Maps

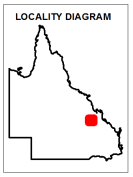
Map 1 - Locality Map



Locality Map

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Highway
- Connector
- Street/Local Road
- Reservoirs
- Lakes
- National Park (Scientific)
- National Park
- National Park (CYPAL)
- Conservation Park
- Resources Reserve
- Forest Reserve
- State Forest
- Timber Reserve
- Nature Refuges
- Coordinated Conservation Areas
- Major rivers/creeks
- Queensland



N

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

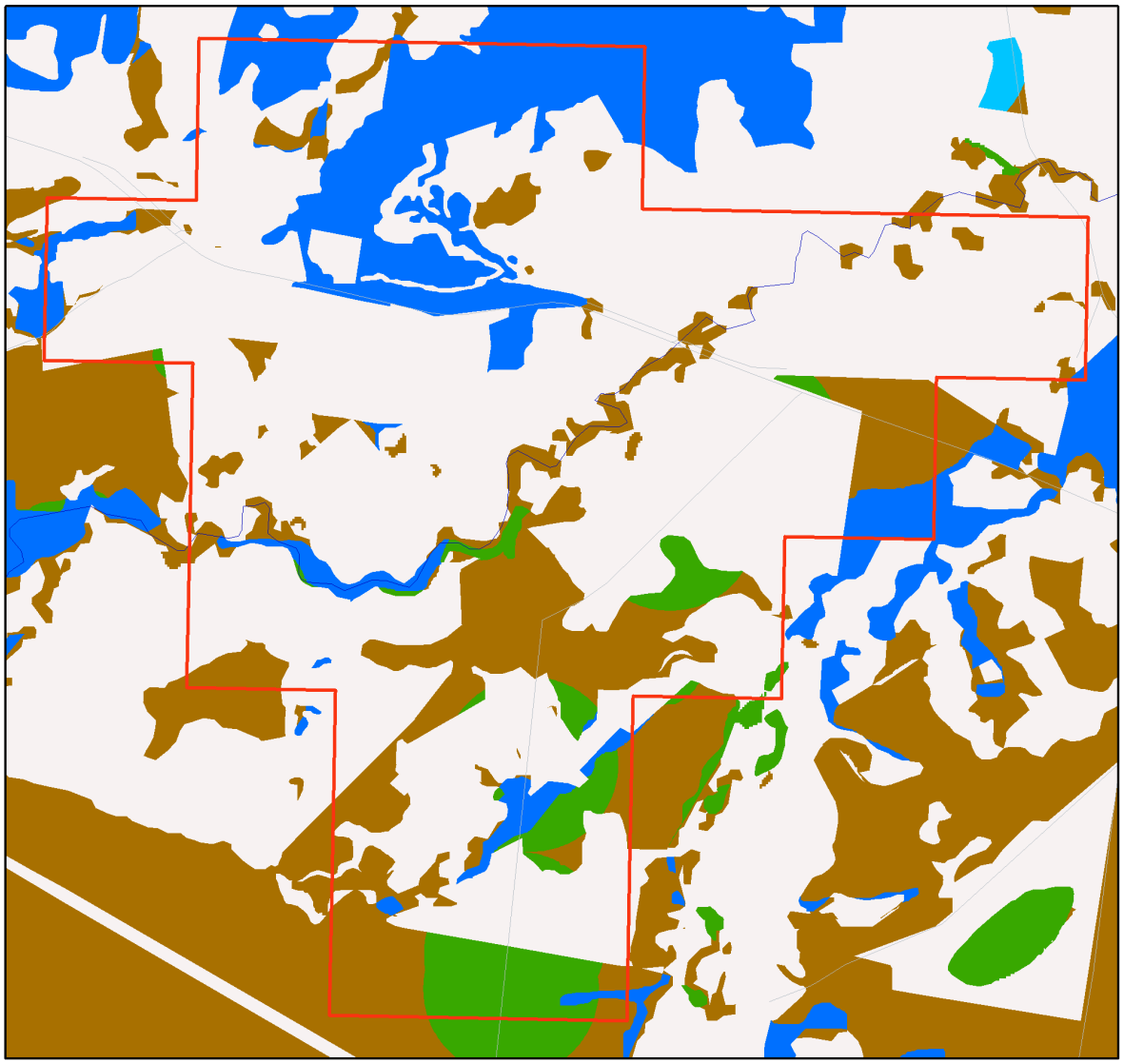
The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

0 4500 9000 13500 18000 22500 m

© The State of Queensland, 2019

This product is projected into GDA 1994 Queensland Albers

Map 2 - Biodiversity Planning Assessment (BPA)



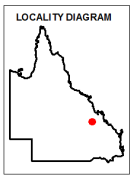
Biodiversity Planning Assessments

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Roads
- Major rivers/creeks
- Queensland

Biodiversity Planning Assessment

- State Habitat for EVNT taxa
- State
- Regional
- Local or Other Values
- Non Bioregion Ecosystem



N

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any
information contained in this product.

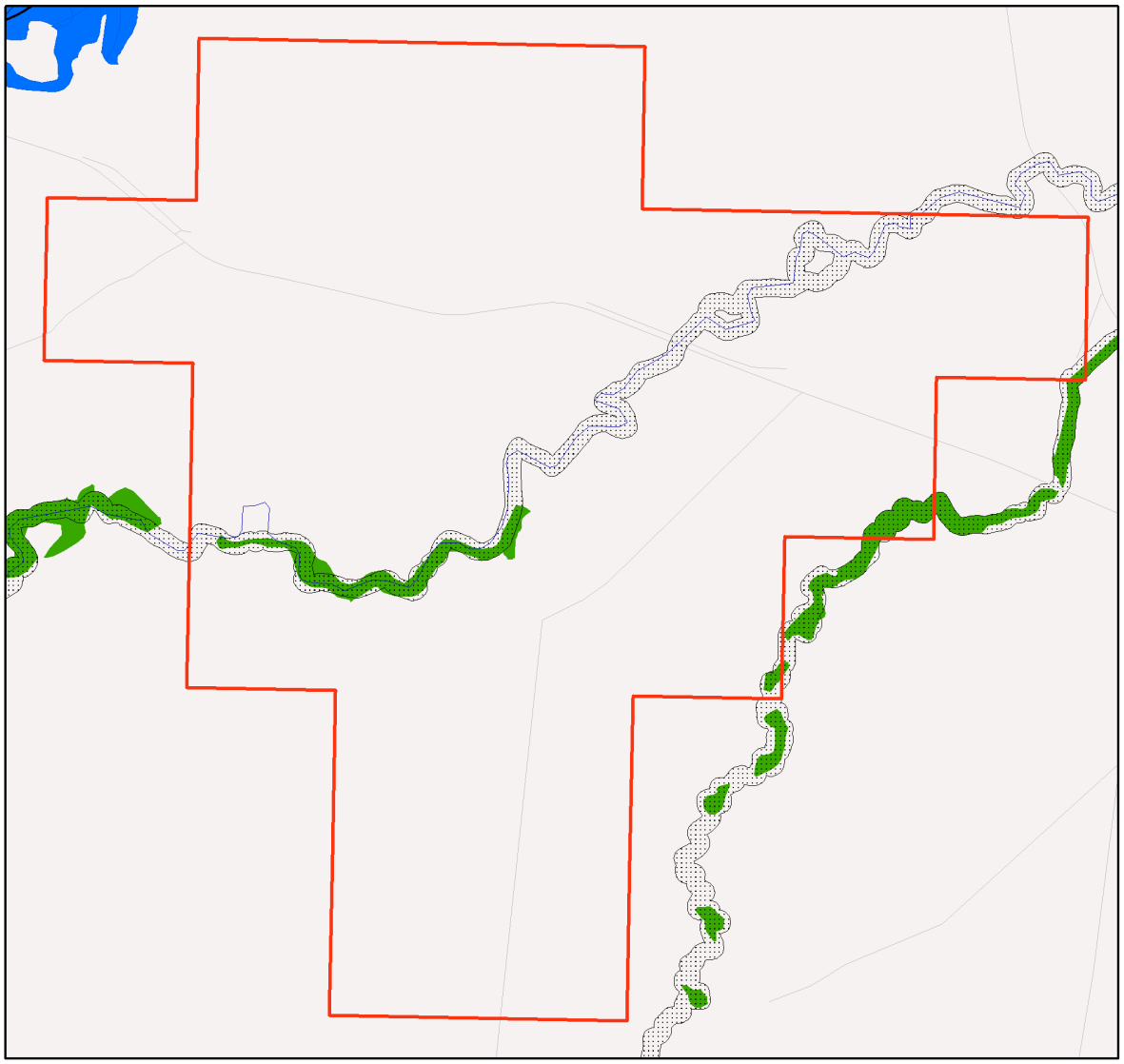
The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs
you may incur as a result of the information being inaccurate or incomplete in any wayfor any reason.

0 690 1380 2070 2760 3450 m

© The State of Queensland, 2019

This product is projected into GDA 1994 Queensland Albers

Map 3 - Corridors



Corridors

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Roads
- Major rivers/creeks
- Queensland

Corridors

- State
- Regional

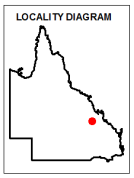
Corridor Triggered Vegetation

- State
- Regional
- Local

Core Area Vegetation

- Brigalow Belt only

LOCALITY DIAGRAM



N

0 690 1380 2070 2760 3450 m

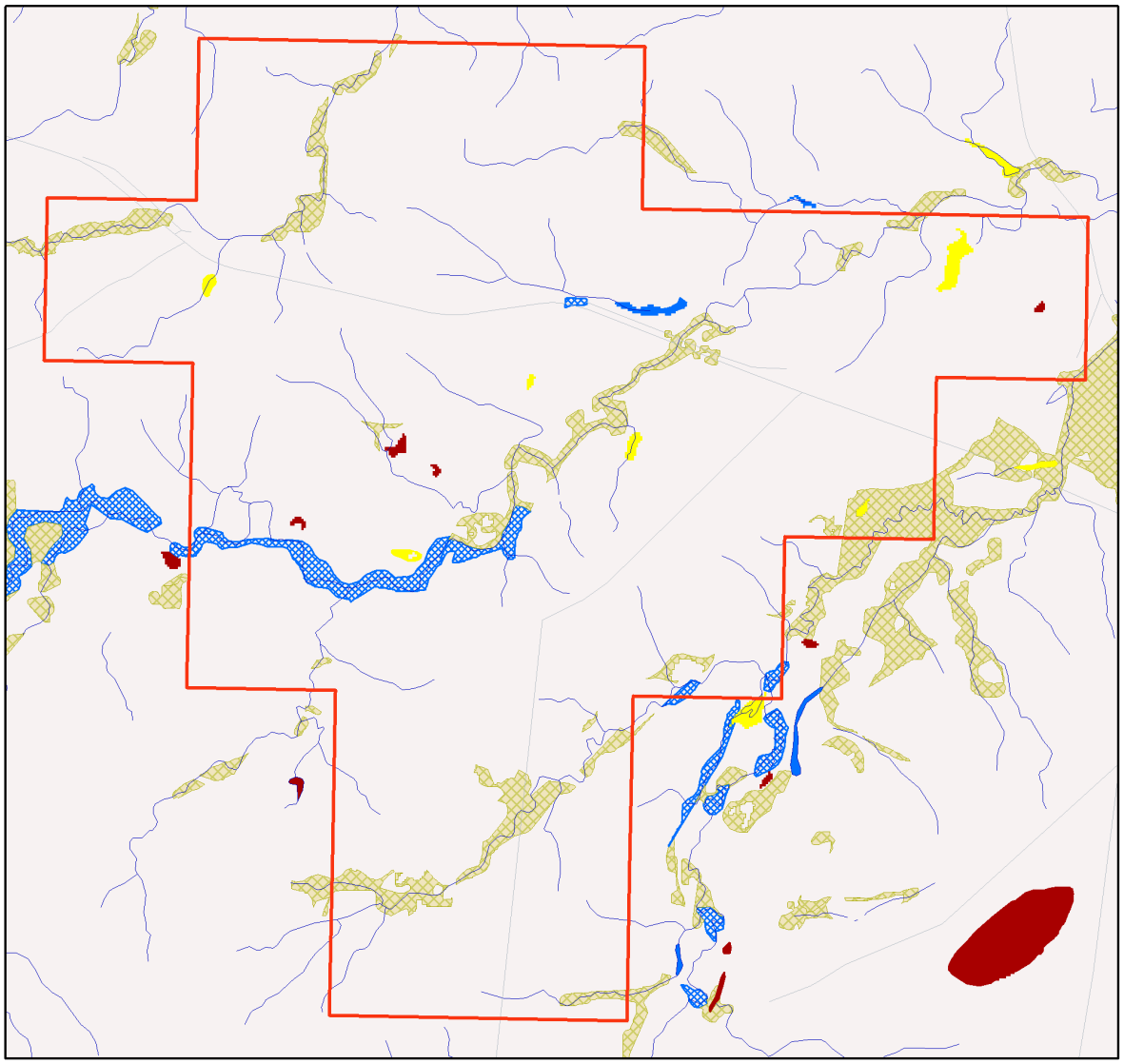
This product is projected into GDA 1994 Queensland Albers

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims allresponsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2019

Map 4 - Wetlands and waterways



Wetlands and Waterways

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Roads
- Springs
- Rivers/Creeks
- Directory of Important Wetlands
- Ramsar Sites - QLD
- Queensland

Wetland Type

- Marine Waterbodies
- Estuarine Waterbodies
- Riverine Waterbodies
- Lacustrine Waterbodies
- Palustrine Waterbodies
- Marine RE
- Estuarine RE
- Riverine RE
- Lacustrine RE
- Palustrine RE
- RE 51-80% wetland (mosaic units)
- RE 1-50% wetland (mosaic units)

LOCALITY DIAGRAM

N

0 690 1380 2070 2760 3450 m

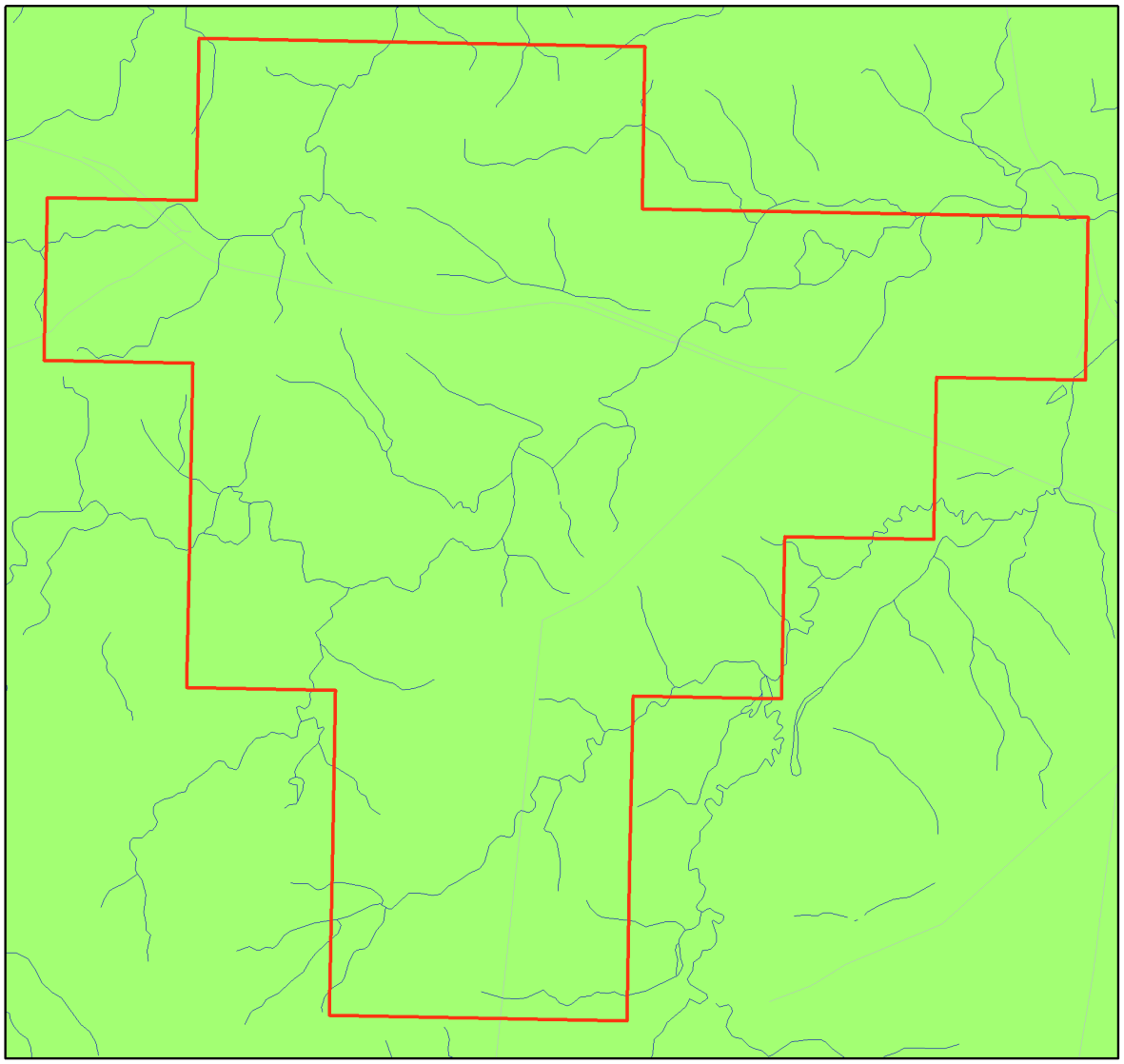
This product is projected into GDA 1994 Queensland Albers

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any
information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs
you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2019

Map 5 - Aquatic Conservation Assessment (ACA) - riverine



Aquatic Conservation Assessment (ACA) - riverine

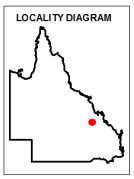
Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Roads
- Rivers/Creeks
- Queensland

ACA Riverine - Subcatchment Significance

- Very High
- High
- Medium
- Low
- Very Low

LOCALITY DIAGRAM



N

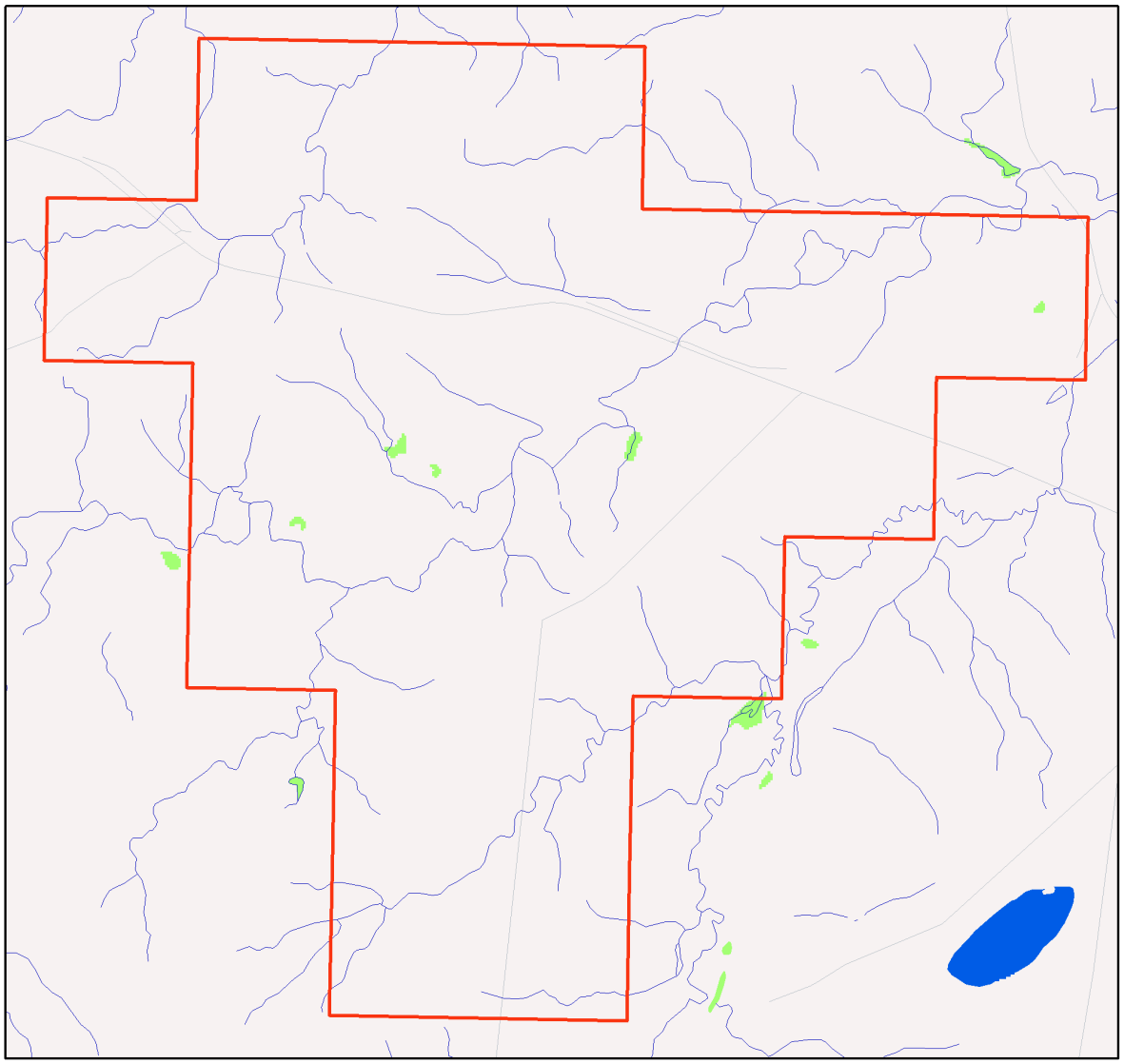
DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

This product is projected into GDA 1994 Queensland Albers

© The State of Queensland, 2019

Map 6 - Aquatic Conservation Assessment (ACA) - non-riverine



Aquatic Conservation Assessment (ACA) - nonriverine

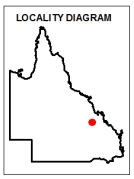
Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Roads
- Rivers/Creeks
- Queensland

ACA Non-riverine

- Very High
- High
- Medium
- Low
- Very Low

LOCALITY DIAGRAM



N

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

0 690 1380 2070 2760 3450 m

© The State of Queensland, 2019

This product is projected into GDA 1994 Queensland Albers

References

Clayton, P.D., Fielder, D.F., Howell, S. and Hill, C.J. (2006) *Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool for wetlands with trial application in the Burnett River catchment.* Published by the Environmental Protection Agency, Brisbane. ISBN 1-90928-07-3. Available at

http://wetlandinfo.des.qld.gov.au/wetlands/assessment/assessment-methods/aca/

Environmental Protection Agency (2002) *Biodiversity Assessment and Mapping Methodology. Version 2.1, July 2002.* (Environmental Protection Agency, Brisbane).

Morton, S. R., Short, J. and Barker, R. D. with an Appendix by G.F. Griffin and G. Pearce (1995). *Refugia for Biological Diversity in Arid and Semi-arid Australia. Biodiversity Series* , Paper No. 4, Biodiversity Unit, Environment Australia.

Sattler, P.S. and Williams, R.D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Brisbane.

Appendices

Appendix 1 - Source Data

Theme	Datasets
Aquatic Conservation Assessments Non-riverine*	Combination of the following datasets: Cape York Peninsula Non-riverine v1.1 Eastern Gulf of Carpentaria v1.1 Great Barrier Reef Catchment Non-riverine v1.3 Lake Eyre and Bulloo Basins v1.1 QMDB Non-riverine ACA v1.4 Southeast Queensland ACA v1.1 WBB Non-riverine ACA v1.1
Aquatic Conservation Assessments Riverine*	Combination of the following datasets: Cape York Peninsula Riverine v1.1 Eastern Gulf of Carpentaria v1.1 Great Barrier Reef Catchment Riverine v1.1 Lake Eyre and Bulloo Basins v1.1 QMDB Riverine ACA v1.4 Southeast Queensland ACA v1.1 WBB Riverine ACA v1.1
Biodiversity Planning Assessments*	Combination of the following datasets: Brigalow Belt BPA v2.1 Cape York Peninsula BPA v1.1 Central Queensland Coast BPA v1.3 Channel Country BPA v1.1 Desert Uplands BPA v1.3 Einasleigh Uplands BPA v1.1 Gulf Plains BPA v1.1 Mitchell Grass Downs BPA v1.1 Mulga Lands BPA v1.4 New England Tableland v2.3 Southeast Queensland v4.1
Statewide BPA Corridors*	Statewide corridors v1.4
Threatened Species	An internal DES database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.
BPA Priority Species	An internal DES database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.
ACA Priority Species	An internal DES database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.

***These datasets are available at:**

http://dds.information.qld.gov.au/DDS

Appendix 2 - Acronyms and Abbreviations

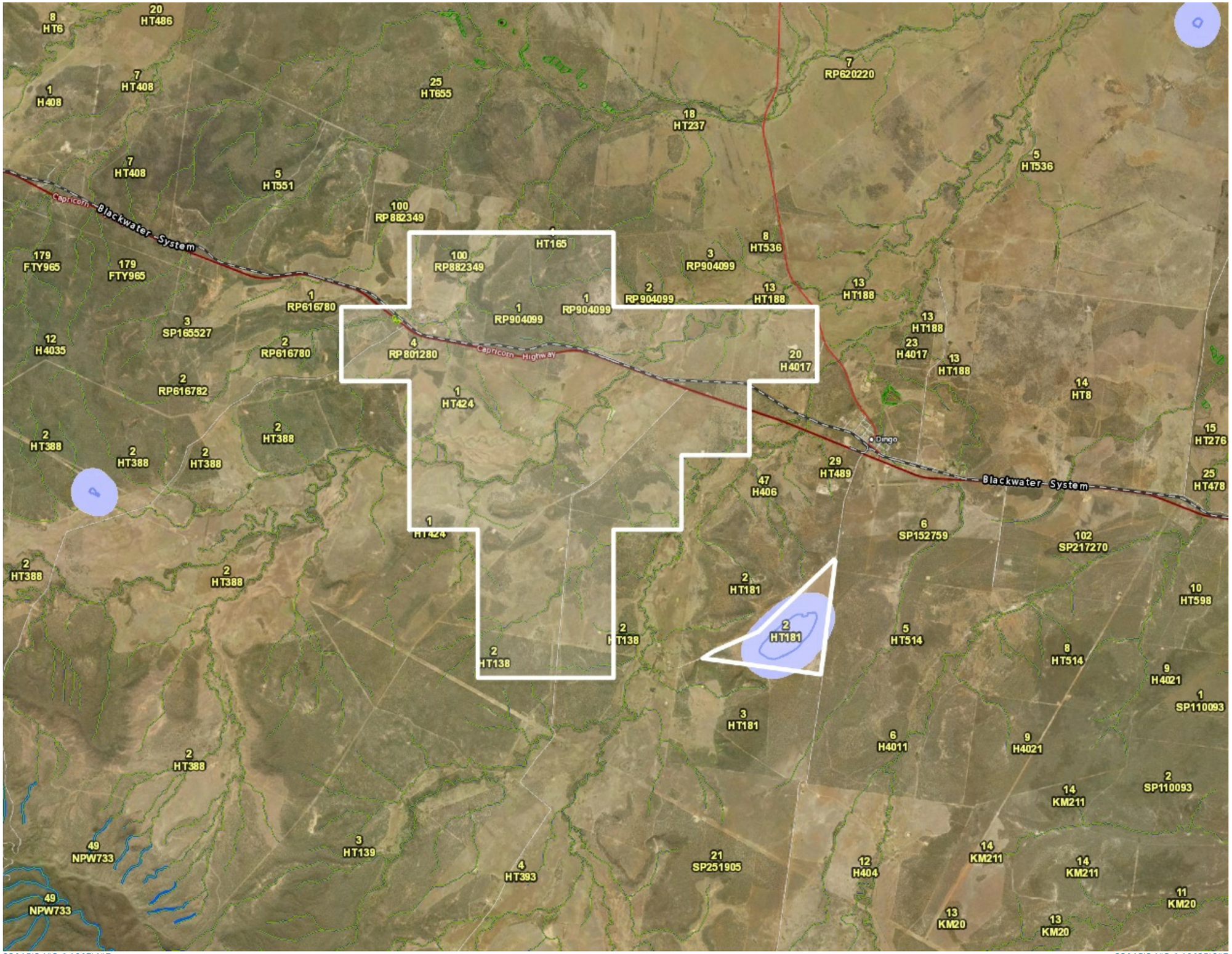
AOI	- Area of Interest
ACA	- Aquatic Conservation Assessment
AQUABAMM	- Aquatic Biodiversity Assessment and Mapping Methodology
BAMM	- Biodiversity Assessment and Mapping Methodology
BoT	- Back on Track
BPA	- Biodiversity Planning Assessment
CAMBA	- China-Australia Migratory Bird Agreement
DES	- Department of Environment and Science
EPBC	- *Environment Protection and Biodiversity Conservation Act 1999*
EVNT	- Endangered, Vulnerable, Near Threatened
GDA94	- Geocentric Datum of Australia 1994
GIS	- Geographic Information System
JAMBA	- Japan-Australia Migratory Bird Agreement
NCA	- *Nature Conservation Act 1992*
RE	- Regional Ecosystem
REDD	- Regional Ecosystem Description Database
ROKAMBA	- Republic of Korea-Australia Migratory Bird Agreement

Dingo West

Wetlands of High Ecological Significance with trigger area

23°32'48"S 149°7'4"E

23°32'48"S 149°25'6"E



23°45'34"S 149°7'4"E

23°45'34"S 149°25'6"E

A product of Queensland Globe

N

2.5 km

Print Date: 12/4/2019
Paper Size: A3

Imagery

includes material © CNES reproduced under licence from Airbus DS, all rights reserved, © 21AT © Earth-i, all rights reserved, 2019

Queensland Government

© State of Queensland 2019
You are responsible for ensuring that the map is suitable for your purposes.
The State of Queensland makes no representation or warranties in relation to the map contents and disclaims all liability.

Dingo West

Wetlands of High Ecological Significance with trigger area

Legend

Road

- Highway
- Main
- Local
- Private

Vegetation management wetlands map

- Wetlands map

VM watercourse/drainage feature - 1:100 000 and 1:250 000

Pondage area

- Aquaculture
- Salt evaporator
- Settling pond

MSES regulated vegetation [defined watercourse]

MSES declared high ecological value waters [watercourse]

MSES declared high ecological value waters [wetland]

MSES high ecological significance wetlands

MSES strategic environmental area [designated precinct]

Wetlands of high ecological significance

Trigger area

Railway

Land parcel label - gt 10 ha

Cities and Towns

Attribution

DigitalGlobe, Earthstar Geographics

Includes material © The State of Queensland, © CNES reproduced under licence from Airbus DS, all rights reserved, © 21AT © Earth-i, all rights reserved, 2017.

© State of Queensland (Department of Natural Resources, Mines and Energy), 2018

© State of Queensland (Department of Environment and Science), 2018

© State of Queensland (Department of Natural Resources, Mines and Energy) 2018

© State of Queensland (Department of Natural Resources and Mines), 2016

WetlandMaps Report

For selected area of interest

Current as at 06/06/2019

Environmental Reports - General Information

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is ot present within the Area of Interest(AOI) (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no matters of interest have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Important Note to User

Information presented in this report is based upon the mapping of water bodies and wetland regional ecosystems across Queensland. The Queensland wetland mapping was produced using existing information including water body mapping derived from Landsat satellite imagery, regional ecosystem mapping, topographic data, and a springs database. The result is a consistent wetland map for the whole of Queensland.

Ancillary data, such as higher resolution imagery (for example SPOT and aerial photographs), other vegetation and wetland mapping, geology, soil and land system mapping was also used in attributing and assessing the derived Queensland Wetlands Program wetland mapping products.

The wetland mapping was done in accordance with a detailed peer reviewed methodology which included quality assurance measures for all steps in the process. For more detailed information on how the Queensland Wetlands Program wetland mapping was produced, please see the Wetland Mapping and Classification Methodology.

Disclaimer

The State of Queensland, as represented by this department, gives no warranty in relation to the data (including without limitation, accuracy, reliability, completeness or fitness for a particular purpose) hosted on this website.

The user accepts sole responsibility and risk associated with the use and results of department data hosted on this website, irrespective of the purpose to which such use or results are applied. It is recommended that users consider independently verifying any information obtained from this website.

To the maximum extent permitted by applicable law, in no event shall the department be liable for any special, incidental, indirect, or consequential loss whatsoever (including, but not limited to, damages for loss of profits or confidential or other information, for business interruption, for personal injury, for loss of privacy, for failure to meet any duty including of good faith or of reasonable care, for negligence, for any other pecuniary or other loss whatsoever including, without limitation, legal costs on a solicitor own client basis) arising out of, or in any way related to, the use of or inability to use the data.

Summary Information

The following table provides an overview of the area of interest.

Table 1. Area of interest details

Size (ha)	133,776.49
Local Government(s)	Central Highlands Regional
Bioregion(s)	Brigalow Belt
Subregion(s)	Woorabinda, Isaac - Comet Downs
Catchment(s)	Fitzroy
Drainage sub-basin	Mackenzie River, Dawson River, Comet River

NRM Regions

The following NRM region(s) are in the area of interest:

Fitzroy Basin Association

Water Resource Plan Boundaries

The following Water Resource Plan(s) are in the area of interest:

Fitzroy Basin

Great Artesian Basin and Other Regional Aquifers

Learn more about how Wetlands are mapped in Queensland:

Queensland Wetlands Mapping Definitions

Wetlands are areas of permanent or periodic/intermittent inundation, with water that is static or flowing fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6 metres. To be a wetland the area must have one or more of the following attributes:

- at least periodically the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle, or
- the substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers, or
- the substratum is not soil and is saturated with water, or covered by water at some time.

Examples under this definition **include**:

- those areas shown as a river, stream, creek, swamp, lake, marsh, waterhole, wetland, billabong, pool or spring on the latest Sunmap 1:25,000, 1:50,000, 1:100,000 or 1:250,000 topographic map
- areas defined as wetlands on local or regional maps prepared with the aim of mapping wetlands
- wetland regional ecosystems (REs) as defined by the Queensland Herbarium (Environmental Protection Agency 2005a)
- areas containing recognised hydrophytes as provided by the Queensland Herbarium
- saturated parts of the riparian zone
- artificial wetlands such as farm dams
- water bodies not connected to rivers or flowing water such as billabongs and rock pools.

Examples under this definition **exclude**:

- areas that may be covered by water but are not wetlands according to the definition
- floodplains that are intermittently covered by flowing water but do not meet the hydrophytes and soil criteria
- riparian zone above the saturation level.

Wetland Systems

Riverine wetlands are all wetlands and deepwater habitats within a channel. The channels are naturally or artificially created, periodically or continuously contain moving water, or connecting two bodies of standing water.

Palustrine wetlands are primarily vegetated non-channel environments of less than 8 hectares. They include billabongs, swamps, bogs, springs, soaks etc, and have more than 30% emergent vegetation.

Lacustrine wetlands are large, open, water-dominated systems (for example, lakes) larger than 8ha. This definition also applies to modified systems (for example, dams), which are similar to lacustrine systems (for example, deep, standing or slow-moving waters).

Marine wetlands include the area of ocean from the coastline or estuary, extending to the jurisdictional limits of Queensland waters (3 nautical mile limit). This definition differs from that in Ramsar, as it includes waters deeper than 6m below the lowest astronomical tide.

Estuarine wetlands are those with oceanic water sometimes diluted with freshwater run-off from the land.

Subterranean wetlands are wetlands occurring below the surface of the ground and that are fed by groundwater i.e. caves and aquifers. These wetlands provide water to groundwater dependent ecosystems.

Methodology and Wetland Classification: https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/wetland-background/

Links and support

Other sites that deliver wetland related information include:

Wetland*Summary* tool: https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/

Queensland Spatial Catalogue: http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

Queensland Globe: https://qldglobe.information.qld.gov.au/

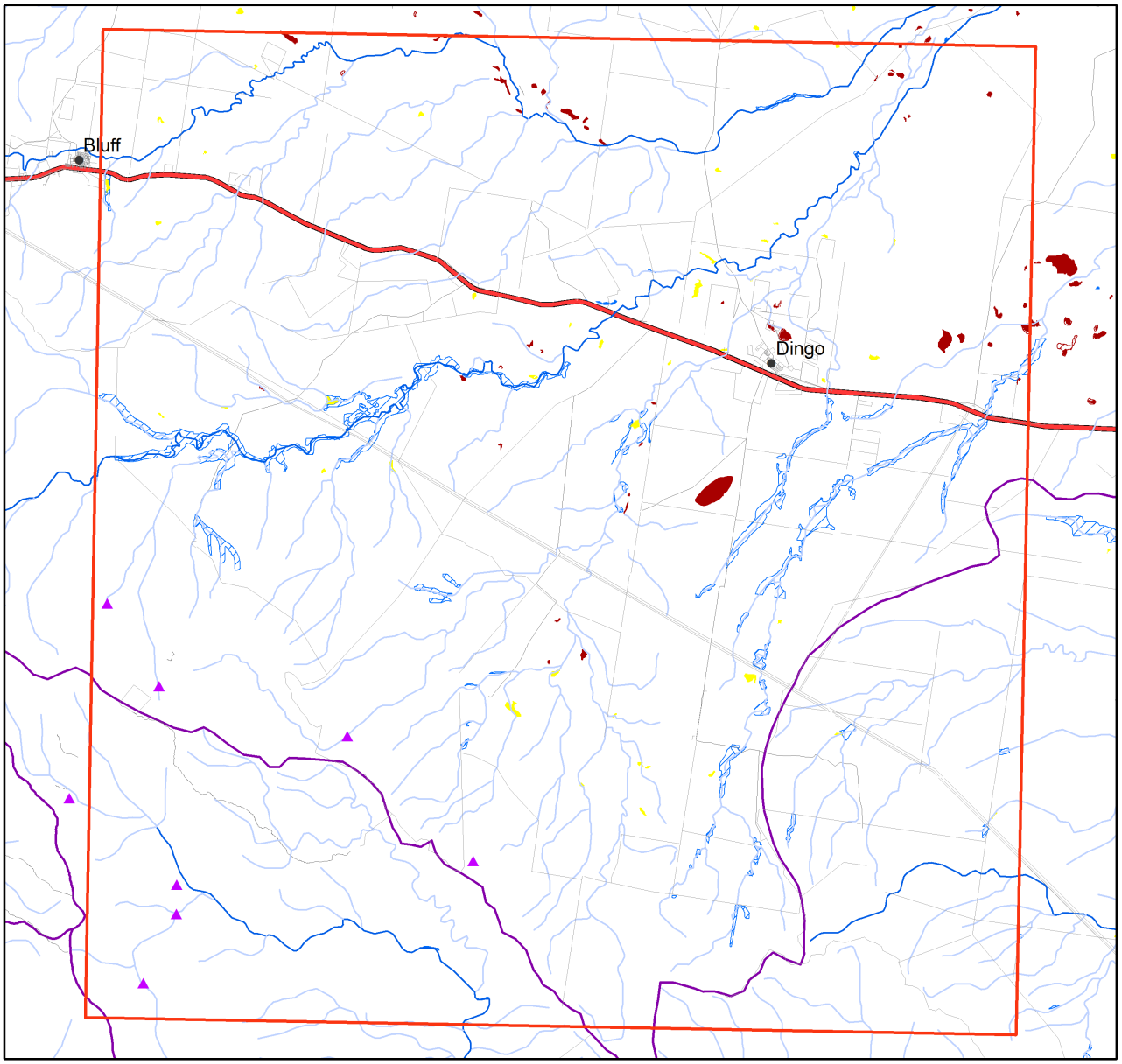
Environmental reports online: https://environment.ehp.qld.gov.au/report-request/environment/

Wetland on-line education modules: https://wetlandinfo.des.qld.gov.au/wetlands/resources/training/

Regional Ecosystem Mapping information: : https://www.qld.gov.au/environment/plants-animals/plants/herbarium/mapping-ecosystems

Aquatic Conservation Assessments: : https://wetlandinfo.des.qld.gov.au/wetlands/assessment/assessment-methods/aca/

Groundwater Dependant Ecosystems information: https://wetlandinfo.des.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/groundwater-dependent/



Queensland Wetland Map

Legend

- polygon
- Springs
- Dams and weirs
- Towns
- Highways
- Roads
- Cadastral boundaries
- Sub-basin

Wetland Mapping

Wetland System - Water Bodies

- Marine Waterbodies
- Estuarine Waterbodies
- Riverine Waterbodies
- Lacustrine Waterbodies
- Palustrine Waterbodies

Wetland System - Regional Ecosystems

- Marine RE
- Estuarine RE
- Riverine RE
- Lacustrine RE
- Palustrine RE
- RE 51_80% wetland (mosaic units)

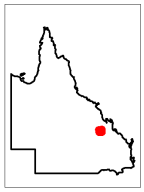
Riverine System Drainage Lines

- Major
- Minor

Queensland Government

Australian Government

Queensland Wetlands Program



N

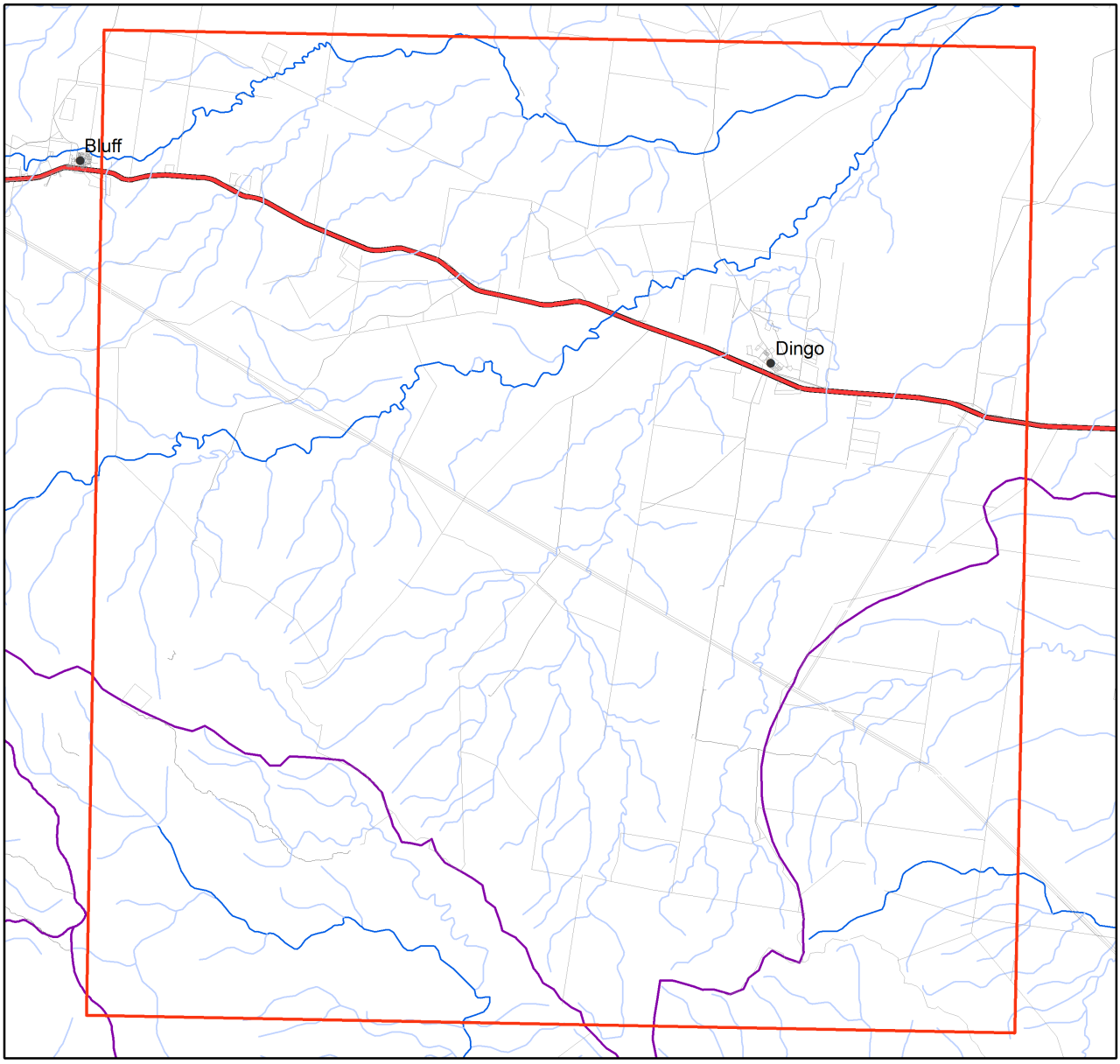
0 2250 4500 6750 9000 11250 m

Horizontal Datum: Geographic Datum of Australia 1994 (GDA94)

This map was produced by the Queensland Wetlands Program, Department of Environment and Science, June 2019.

For further information contact: wetlands@des.qld.gov.au

© The State of Queensland, 2019



Queensland Wetlands of Importance Map

Legend

- polygon
- Towns
- Cadastral boundaries
- Highways
- Roads
- Sub-basin
- Directory of Important Wetlands
- Ramsar Wetlands

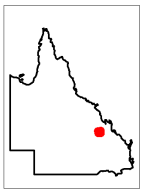
Riverine System Drainage Lines

- Major
- Minor

Queensland Government

Australian Government

Queensland Wetlands Program



N

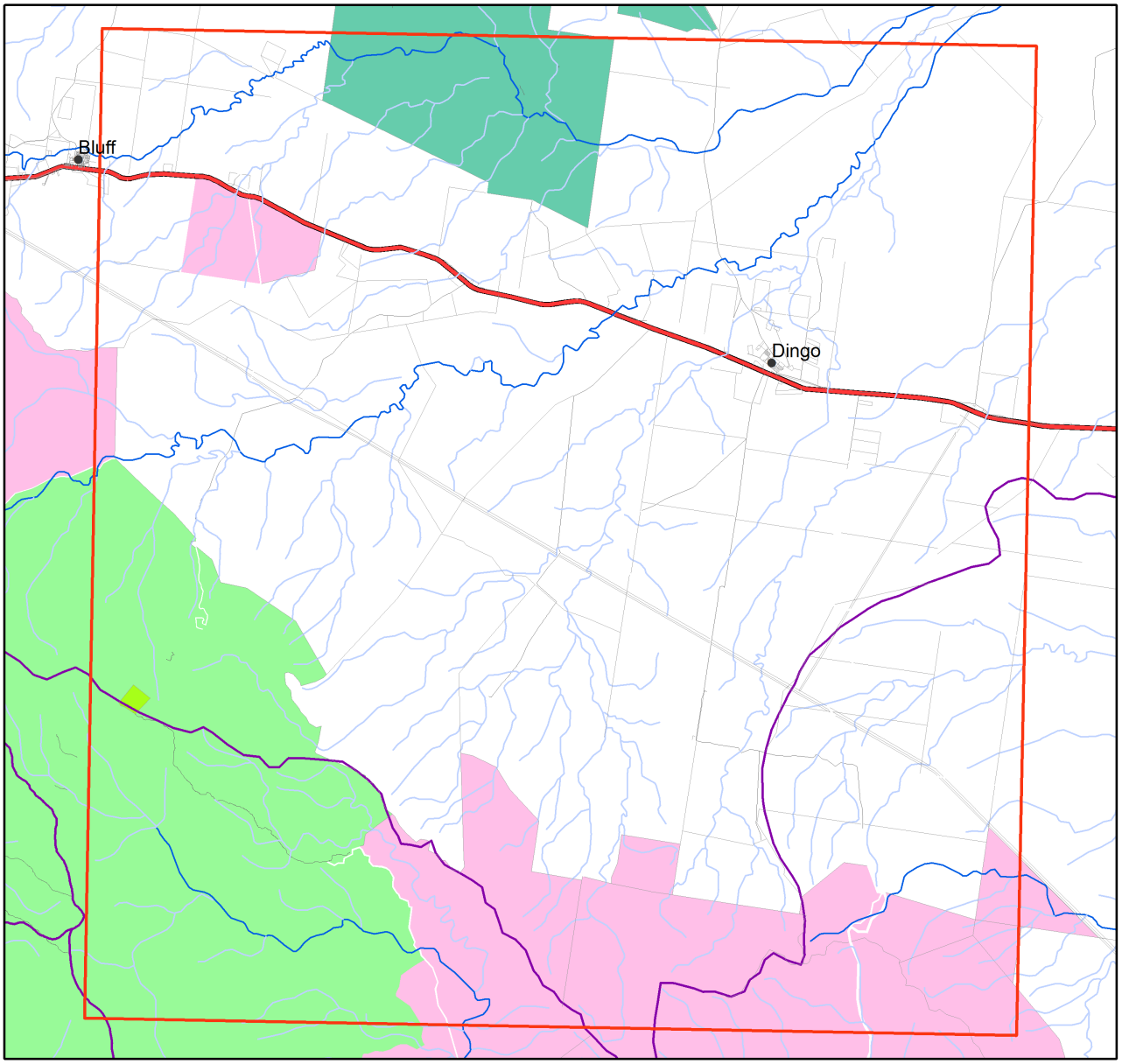
0 2300 4600 6900 9200 11500 m

Horizontal Datum: Geographic Datum of Australia 1994 (GDA94)

This map was produced by the Queensland Wetlands Program, Department of Environment and Science, June 2019.

For further information contact: wetlands@des.qld.gov.au

© The State of Queensland, 2019



Queensland Protected Area Map

Legend

- polygon
- Towns
- Cadastral boundaries
- Highways
- Roads
- Sub-basin

Riverine System Drainage Lines

- Major
- Minor

Protected Areas

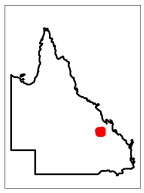
- National Park
- National Park (Scientific)
- National Park (CYPAL)
- Conservation Park
- Resources Reserve
- Forest Reserve
- State Forest
- Timber Reserve

Marine Parks

- General Use Zone
- Habitat Protection Zone
- Estuarine Conservation Zone
- Conservation Park Zone
- Buffer Zone
- Scientific Research Zone
- Marine National Park Zone
- Preservation Zone

Queensland Government
Australian Government

Queensland Wetlands Program



N

0 2250 4500 6750 9000 11250 m

Horizontal Datum: Geographic Datum of Australia 1994 (GDA94)

This map was produced by the Queensland Wetlands Program, Department of Environment and Science, June 2019.

For further information contact: wetlands@des.qld.gov.au

© The State of Queensland, 2019

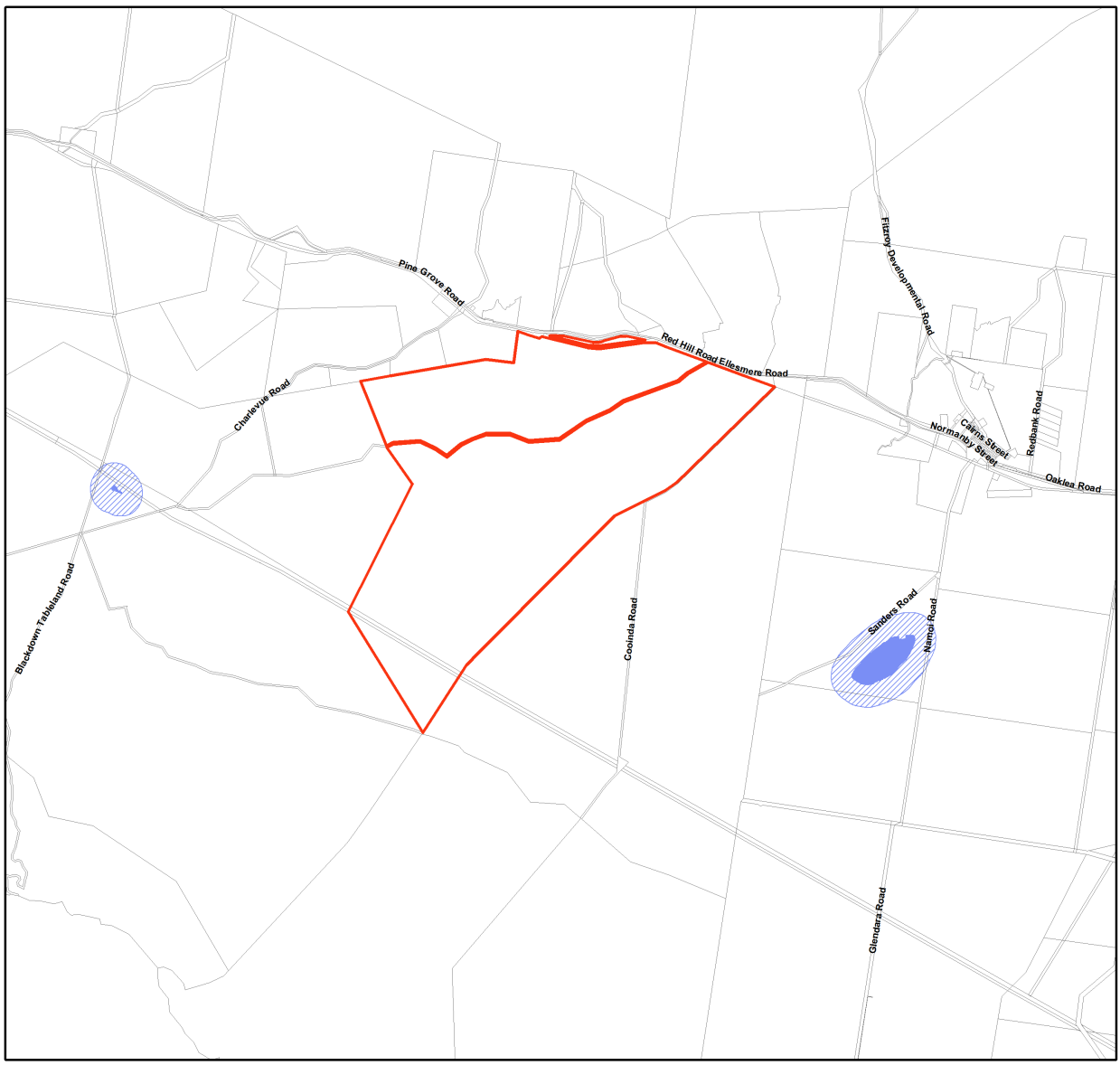
Wetland habitat types in the AOI. Total area: 11468.08ha

Wetland Class	Habitat type	Area (ha)
None	Coastal/ Sub-coastal floodplain tree swamps (Melaleuca and Eucalypt)	8578.24
Riverine	Riverine	1931.53
None	Coastal/ Sub-Coastal non-floodplain tree swamps (Melaleuca and Eucalypt)	530.79
Lacustrine	Artificial/ highly modified wetlands (dams, ring tanks, irrigation channel	149.53
Palustrine	Coastal/ Sub-coastal floodplain tree swamps (Melaleuca and Eucalypt)	121.24
Palustrine	Coastal/ Sub-Coastal non-floodplain tree swamps (Melaleuca and Eucalypt)	110.62
Palustrine	Coastal/ Sub-coastal floodplain grass, sedge and herb swamps	46.13

Queensland wetland habitat typology: Major wetland habitat types for wetland conceptual models and wetland management profiles

Wetland name	Conceptual model	Wetland profile
Mangrove Wetlands	Not developed	Mangrove Wetlands
Saltmarsh Wetlands	Not developed	Saltmarsh Wetlands
Coastal and subcoastal saline swamps of all substrates, water regimes, topographic types and vegetation communities	Coastal and subcoastal saline swamps	Coastal grass-sedge wetlands
Coastal and subcoastal non-floodplain tree swamps (Melaleuca and Eucalypt) of all substrates and water regimes	Coastal and subcoastal non-floodplain tree swamps - melaleuca and eucalypt	Coastal and subcoastal tree swamps
Coastal and subcoastal non-floodplain wet heath swamps of all substrates and water regimes	Coastal and subcoastal non-floodplain wet heath swamps	Coastal and subcoastal wet heath swamps
Coastal and subcoastal non-floodplain grass, sedge and herb swamps of all substrates and water regimes	Coastal and subcoastal non-floodplain grass, sedge and herb swamps	Coastal grass-sedge wetlands
Coastal and subcoastal spring swamps of all substrates, water types, water regimes and vegetation communities	Coastal and subcoastal spring swamps	Great Artesian Basin spring wetlands
Coastal and subcoastal floodplain tree swamps - melaleuca and eucalypt of all substrates and water regimes	Coastal and subcoastal floodplain tree swamps - melaleuca and eucalypt	Coastal and subcoastal tree swamps
Coastal and subcoastal floodplain wet heath swamps of all substrates and water regimes	Coastal and subcoastal floodplain wet heath swamps	Coastal and subcoastal wet heath swamps
Coastal and subcoastal floodplain, grass, sedge herb swamps of all substrates and water regimes	Coastal and subcoastal floodplain grass, sedge, herb swamps	Coastal grass-sedge wetlands
Coastal and subcoastal tree swamps - palm of all substrates, topographic types and water regimes	Coastal and subcoastal floodplain tree swamps - palm	Coastal Palm Swamps
Coastal and subcoastal Floodplain Lakes of all substrates, water types and water regimes	Coastal and subcoastal Floodplain Lakes	Coastal and subcoastal floodplain lakes and non-floodplain soil lakes
Coastal and subcoastal non-floodplain rock lakes of all water types and water regimes	Coastal and subcoastal non-floodplain rock lakes	Coastal and subcoastal non-floodplain rock lakes

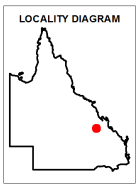
Wetland name	Conceptual model	Wetland profile
Coastal and subcoastal non-floodplain sand lakes (window) of all water types and water regimes	Coastal and subcoastal non-floodplain sand lakes - window	Coastal non-floodplain sand lakes
Coastal and subcoastal non-floodplain sand lakes (perched) of all water types and water regimes	Coastal and subcoastal non-floodplain sand lakes - perched	Coastal non-floodplain sand lakes
Coastal and subcoastal non-floodplain soil lakes of all water types and water regimes	Coastal and subcoastal non-floodplain soil lakes	Coastal and subcoastal floodplain lakes and non-floodplain soil lakes
Arid and semi-arid saline swamps of all substrates, water regimes, topographic types and vegetation communities	Arid and semi-arid saline swamps	Semi-arid swamps
Arid and semi-arid fresh tree swamps of all substrates, and water regimes and topographic types	Arid and semi-arid tree swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid lignum swamps of all substrates, and water regimes and topographic types	Arid and semi-arid lignum swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid grass, sedge, herb swamps of all substrates, water regimes and topographic types	Arid and semi-arid grass, sedge, herb swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid fresh non-floodplain tree swamps of all substrates and water regimes	Arid and semi-arid non-floodplain tree swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid fresh non-floodplain lignum swamps of all substrates and water regimes	Arid and semi-arid non-floodplain lignum swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid fresh non-floodplain grass, sedge, herb swamps of all substrates and water regimes	Arid and semi-arid non-floodplain grass, sedge, herb swamps	Arid swamps Semi-Arid swamps
Arid and semi-arid, non-floodplain swamps - springs of all substrates, water regimes and vegetation communities	Arid and semi-arid spring swamps	Great Artesian Basin spring wetlands
Arid and semi-arid, saline lakes of all substrates, topographic types and water regimes	Arid and semi-arid saline lakes	Arid and semi-arid lakes
Arid and semi-arid, floodplain lakes of all, substrates and water regimes	Arid and semi-arid floodplain lakes	Arid and semi-arid lakes
Arid and semi-arid, non-floodplain Lakes of all substrates and water regimes	Arid and semi-arid non-floodplain lakes	Arid and semi-arid lakes
Arid/ semi-arid, non-floodplain (clay pans) lakes of all substrates and water regimes	Arid and semi-arid fresh non-floodplain lakes (clay pans)	Arid and semi-arid lakes
Arid and semi-arid, Permanent Lakes permanently inundated lakes of all substrates, water types, topographic types and vegetation communities	Arid and semi-arid permanent lakes	Arid and semi-arid lakes



Map of Referable Wetlands
Wetland Protection Areas

Lot and Plan
Cadastral Boundary
Wetland Protection Areas
Wetland
Trigger Area

LOCALITY DIAGRAM



N

Note:
This map shows the location of wetland protection areas which are defined under the Environmental Protection Regulation 2008. Within wetland protection areas, certain types of development involving high impact earthworks are made assessable under Schedule 3 of the Sustainable Planning Regulation 2009.

The Department of State Development, Manufacturing, Infrastructure and Planning is the State Assessment Referral Agency (SARA) under Schedule 7 of the Sustainable Planning Regulation 2009 for assessable development involving high impact earthworks within wetland protection areas. The Department of Environment and Science is a technical agency.

The policy outcome and assessment criteria for assessing these applications are described in the State Development Assessment Provisions (SDAP) *Module 11: Wetlands and wild rivers.*

This map is produced at a scale relevant to the size of the lot on plan identified and should be printed at A4 size in portrait orientation. Consideration of the effects of mapped scale is necessary when interpreting data at a large scale.

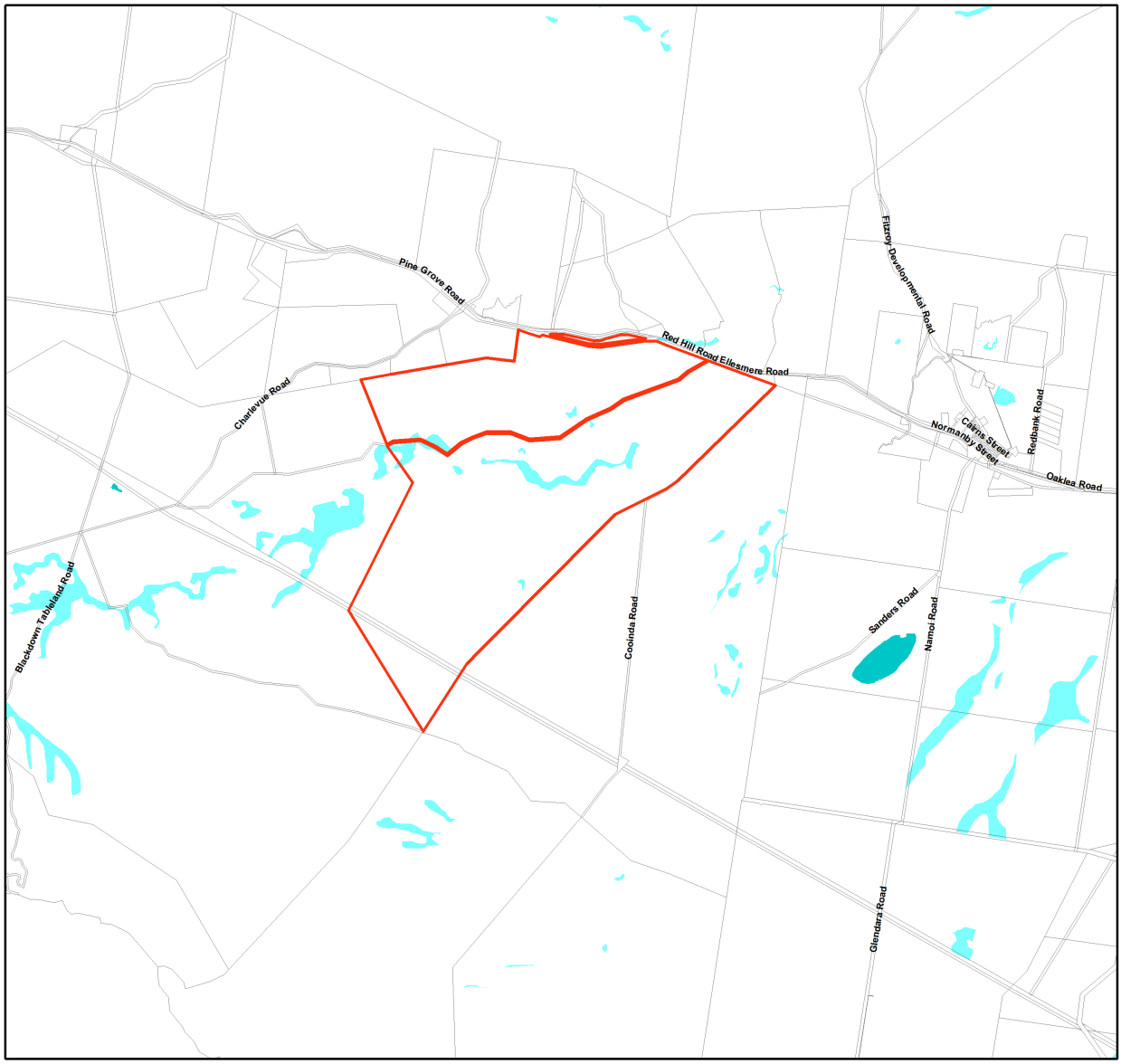
For further information or assistance with interpretation of this product, please contact the Department of Environment and Science, email planning.support@des.qld.gov.au.

0 1300 2600 3900 5200 6500 m

This product is projected into GDA 1994 MGA Zone 55

© The State of Queensland, 2018

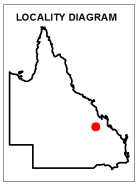
Queensland Government



Map of Referable Wetlands for the Environmental Protection Act 1994

Lot and Plan
Cadastral Boundary
HES Wetland
GES Wetland

LOCALITY DIAGRAM



N

Note:
This map shows the location of wetlands on the Map of Referable Wetlands which are defined under the Environmental Protection Regulation 2008.

Wetlands are assessed for ecological significance using the environmental values for wetlands in section 81A of the Environmental Protection Regulation 2008. Wetlands are considered either High Ecological Significance (HES) or of General Ecological Significance (GES) for the purposes of the environmental values.

This map is produced at a scale relevant to the size of the lot on plan identified and should be printed at A4 size in portrait orientation. Consideration of the effects of mapped scale is necessary when interpreting data at a large scale.

For further information or assistance with interpretation of this product, please contact the Department of Environment and Science, email planning.support@des.qld.gov.au.

0 1300 2600 3900 5200 6500 m

This product is projected into GDA 1994 MGA Zone 55

© The State of Queensland, 2018

Queensland Government

Queensland Government

Department of Environment and Science

Environmental Reports

Regional Ecosystems

Biodiversity Status

For the selected area of interest
epc: 881

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the input coordinates.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no matters of interest have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Important Note to User

Information presented in this report is based upon the Queensland Herbarium's Regional Ecosystem framework. The Biodiversity Status has been used to depict the extent of "Endangered", "Of Concern" and "No Concern at Present" regional ecosystems in all cases, rather than the classes used for the purposes of the *Vegetation Management Act 1999* (VMA). Mapping and figures presented in this document reflect the Queensland Herbarium's Remnant and Pre-clearing Regional Ecosystem Datasets, and not the certified mapping used for the purpose of the VMA.

For matters relevant to vegetation management under the VMA, please refer to the Department of Natural Resources, Mines and Energy website

https://www.dnrme.qld.gov.au/

Please direct queries about these reports to: Queensland.Herbarium@dsiti.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

Table of Contents

Summary Information 4
Regional Ecosystems 5
1. Introduction 5
2. Remnant Regional Ecosystems 6
3. Remnant Regional Ecosystems by Broad Vegetation Group 7
4. Technical and BioCondition Benchmark Descriptions 8
Maps 10
Map 1 - Location 10
Map 2 - Remnant 2015 regional ecosystems 11
Map 3 - Pre-clearing regional ecosystems 12
Map 4 - Remnant 2015 regional ecosystems by BVG (5M) 13
Map 5 - Pre-clearing regional ecosystems by BVG (5M) 14
Map 6 - Wetlands and waterways 15
Links and Other Information Sources 16
References 16
Appendices 17
Appendix 1 - Source Data 17
Appendix 2 - Acronyms and Abbreviations 18

Summary Information

The following table provides an overview of the AOI with respect to selected topographic and environmental themes. Refer to **Map 1** for locality information.

Table 1: Area of interest details: epc: 881

Size (ha)	7,219.57
Local Government(s)	Central Highlands Regional
Bioregion(s)	Brigalow Belt
Subregion(s)	Woorabinda
Catchment(s)	Fitzroy

The table below summarizes the extent of remnant vegetation classed as "Endangered", "Of concern" and "No concern at present" regional ecosystems classified by Biodiversity Status within the area of interest (AOI).

Table 2: Summary table, biodiversity status of regional ecosystems within the AOI

Biodiversity Status	Area (Ha)	% of AOI
Endangered	6.41	0.09
Of concern	237.45	3.29
No concern at present	1,842.10	25.52
Total remnant vegetation	2,085.96	28.89

Refer to **Map 2** for further information.

Regional Ecosystems

1. Introduction

Regional ecosystems are vegetation communities in a bioregion that are consistently associated with particular combinations of geology, landform and soil (Sattler and Williams 1999). Descriptions of Queensland's Regional ecosystems are available online from the Regional Ecosystem Description Database (REDD). Descriptions are compiled from a broad range of information sources including vegetation, land system and geology survey and mapping and detailed vegetation site data. The regional ecosystem classification and descriptions are reviewed as new information becomes available. A number of vegetation communities may form a single regional ecosystem and are usually distinguished by differences in dominant species, frequently in the shrub or ground layers and are denoted by a letter following the regional ecosystem code (e.g. a, b, c). Vegetation communities and regional ecosystems are amalgamated into a higher level classification of broad vegetation groups (BVGs).

A published methodology for survey and mapping of regional ecosystems across Queensland (Neldner et al 2017) provides further details on regional ecosystem concepts and terminology.

This report provides information on the type, status, and extent of vegetation communities, regional ecosystems and broad vegetation groups present within a user specified area of interest. Please note, for the purpose of this report, the Biodiversity Status is used. This report has not been developed for application of the *Vegetation Management Act 1999* (VMA). Additionally, information generated in this report has been derived from the Queensland Herbarium's Regional Ecosystem Mapping, and not the regulated mapping certified for the purposes of the VMA. If your interest/matter relates to regional ecosystems and the VMA, users should refer to the Department of Natural Resources, Mines and Energy website.

https://www.dnrme.qld.gov.au/

With respect to the Queensland Biodiversity Status,

"Endangered" regional ecosystems are described as those where:

- remnant vegetation is less than 10 per cent of its pre-clearing extent across the bioregion; or 10-30% of its pre-clearing extent remains and the remnant vegetation is less than 10,000 hectares, or
- less than 10 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss*, or
- 10-30 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss and the remnant vegetation is less than 10,000 hectares; or
- it is a rare** regional ecosystem subject to a threatening process.***

"Of concern" regional ecosystems are described as those where:

- the degradation criteria listed above for 'Endangered' regional ecosystems are not met and,
- remnant vegetation is 10-30 per cent of its pre-clearing extent across the bioregion; or more than 20 per cent of its pre-clearing extent remains and the remnant extent is less than 10,000 hectares, or
- 10-30 percent of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss.****

and "No concern at present" regional ecosystems are described as those where:

- remnant vegetation is over 30 per cent of its pre-clearing extent across the bioregion, and the remnant area is greater than 10,000 hectares, and
- the degradation criteria listed above for 'Endangered' or 'Of concern' regional ecosystems are not met.

**Severe degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 50 years even with the removal of threatening processes; or soil surface is severely degraded, for example, by loss of A horizon, surface expression of salinity; surface compaction, loss of organic matter or sheet erosion.*

***Rare regional ecosystem: pre-clearing extent (1000 ha); or patch size (100 ha and of limited total extent across its range).*

****Threatening processes are those that are reducing or will reduce the biodiversity and ecological integrity of a regional ecosystem. For example, clearing, weed invasion, fragmentation, inappropriate fire regime or grazing pressure, or infrastructure development.*

*****Moderate degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 20 years even with the removal of threatening processes; or soil surface is moderately degraded.*

2. Remnant Regional Ecosystems

The following table identifies the remnant regional ecosystems and vegetation communities mapped within the AOI and provides their short descriptions, Biodiversity Status, and remnant extent within the selected AOI. Please note, where heterogeneous vegetated patches (mixed patches of remnant vegetation mapped as containing multiple regional ecosystems) occur within the AOI, they have been split and listed as individual regional ecosystems (or vegetation communities where present) for the purposes of the table below. In such instances, associated area figures have been generated based upon the estimated proportion of each regional ecosystem (or vegetation community) predicted to be present within the larger mixed patch.

Table 3: Remnant regional ecosystems, description and status within the AOI

Regional Ecosystem	Short Description	BD Status	Area (Ha)	% of AOI
11.3.1	Acacia harpophylla and/or Casuarina cristata open forest on alluvial plains	Endangered	6.41	0.09
11.3.2	Eucalyptus populnea woodland on alluvial plains	Of concern	125.33	1.74
11.3.25	Eucalyptus tereticornis or E. camaldulensis woodland fringing drainage lines	Of concern	112.12	1.55
11.5.2	Eucalyptus crebra, Corymbia spp., with E. moluccana woodland on lower slopes of Cainozoic sand plains and/or remnant surfaces	No concern at present	1,004.51	13.91
11.5.9b	Eucalyptus crebra and other Eucalyptus spp. and Corymbia spp. woodland on Cainozoic sand plains and/or remnant surfaces	No concern at present	142.87	1.98
11.7.2	Acacia spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone	No concern at present	694.73	9.62
non-rem	None	None	5,133.61	71.11

Refer to **Map 2** for further information. **Map 3** also provides a visual estimate of the distribution of regional ecosystems present before clearing.

Table 4 provides further information in regards to the remnant regional ecosystems present within the SOI. Specifically, the extent of remnant vegetation remaining within the bioregion, the 1:1,000,000 broad vegetation group (BVG) classification, whether the regional ecosystem is identified as a wetland, and extent of representation in Queensland's Protected Area Estate. For a description of the vegetation communities within the AOI and classified according to the 1:1,000,000 BVG, refer to **Table 6**.

Table 4: Remnant regional ecosystems within the AOI, additional information

Regional Ecosystem	Remnant Extent	BVG (1 Million)	Wetland	Representation in protected estate
11.3.1	Pre-clearing 783000 ha; Remnant 2015 80000 ha	25a	None	High
11.3.2	Pre-clearing 1936000 ha; Remnant 2015 514000 ha	17a	Contains palustrine wetland (e.g. in swales).	Low
11.3.25	Pre-clearing 791000 ha; Remnant 2015 513000 ha	16a	Riverine wetland or fringing riverine wetland.	Low
11.5.2	Pre-clearing 360000 ha; Remnant 2015 190000 ha	18b	None	Low

Regional Ecosystem	Remnant Extent	BVG (1 Million)	Wetland	Representation in protected estate
11.5.9b	Pre-clearing 364000 ha; Remnant 2015 237000 ha	18b	None	Low
11.7.2	Pre-clearing 565000 ha; Remnant 2015 367000 ha	24a	None	Low
non-rem	None	None	None	None

Representation in Protected Area Estate: High greater than 10% of pre-clearing extent is represented; Medium 4 - 10% is represented; Low less than 4% is represented, No representation.

The distribution of mapped wetland systems within the area of interest is displayed in **Map 6**.

The following table lists known special values associated with a regional ecosystem type.

Table 5: Remnant regional ecosystems within the AOI, special values

Regional Ecosystem	Special Values
11.3.1	Habitat for threatened fauna species including painted honeyeater, Grantiella picta particularly in subregion 35 (Oliver et al. 2003).
11.3.2	Habitat for threatened flora species Homopholis belsonii.
11.3.25	Shown to be associated with a high fauna species richness in the Taroom area (Venz et al. 2002). Within parts of the Fitzroy catchment, this RE is known habitat for the threatened freshwater turtle Rheodytes leukops. Known to be important habitat for other riparian freshwater turtle species.
11.5.2	None
11.5.9b	None
11.7.2	Habitat for threatened plant species including Acacia wardellii.
non-rem	None

3. Remnant Regional Ecosystems by Broad Vegetation Group

BVGs are a higher-level grouping of vegetation communities. Queensland encompasses a wide variety of landscapes across temperate, wet and dry tropics and semi-arid climatic zones. BVGs provide an overview of vegetation communities across the state or a bioregion and allow comparison with other states. There are three levels of BVGs which reflect the approximate scale at which they are designed to be used: the 1:5,000,000 (national), 1:2,000,000 (state) and 1:1,000,000 (regional) scales.

A comprehensive description of BVGs is available at:

https://publications.qld.gov.au/dataset/redd/resource/

The following table provides a description of the 1:1,000,000 BVGs present and their associated extent within the AOI.

Table 6: Broad vegetation groups (1 million) within the AOI

BVG (1 Million)	Description	Area (Ha)	% of AOI
None	None	5,133.61	71.11

BVG (1 Million)	Description	Area (Ha)	% of AOI
16a	Open forest and woodlands dominated by Eucalyptus camaldulensis (river red gum) (or E. tereticornis (blue gum)) and/or E. coolabah (coolabah) (or E. microtheca (coolabah)) fringing drainage lines. Associated species may include Melaleuca spp., Corymbia tessellaris (carbeen), Angophora spp., Casuarina cunninghamiana (riveroak). Does not include alluvial areas dominated by herb and grasslands or alluvial plains that are not flooded. (land zone 3) (MGD, BRB, GUP, CHC, MUL, DEU, EIU, NWH, SEQ, [NET, WET]) (All bioregions except CYP and CQC)	112.12	1.55
17a	Woodlands dominated by Eucalyptus populnea (poplar box) (or E. brownii (Reid River box)) on alluvium, sand plains and footslopes of hills and ranges. (land zones 3, 5, 10, 9, 4, 11, 12, [8]) (BRB, MUL, DEU, MUL, EIU)	125.33	1.74
18b	Woodlands dominated Eucalyptus crebra (sens. lat.) (narrow-leaved red ironbark) frequently with Corymbia spp. or Callitris spp. on flat to undulating plains. (land zones 5, 3) (BRB, DEU, EIU, GUP, CYP)	1,147.37	15.89
24a	Low woodlands to tall shrublands dominated by Acacia spp. on residuals. Species include A. shirleyi (lancewood), A. catenulata (bendee), A. microsperma (bowyakka), A. clivicola, A. sibirica, A. rhodoxylon (rosewood) and A. leptostachya (Townsville wattle). (land zones 7, 10, 5, 12, 11, [9, 3]) (MUL, CHC, BRB, GUP, EIU, MGD, DEU, NWH, [CYP])	694.73	9.62
25a	Open forests to woodlands dominated by Acacia harpophylla (brigalow) sometimes with Casuarina cristata (belah) on heavy clay soils. Includes areas co-dominated with A. cambagei (gidgee) and/or emergent eucalypts (land zones 4, 9, 3, 11, 7, 12, [5, 8]) (BRB, MUL, MGD, DEU, [SEQ])	6.41	0.09

Refer to **Map 4** for further information. **Map 5** also provides a representation of the distribution of vegetation communities as per the 1:5,000,000 BVG believed to be present prior to European settlement.

4. Technical and BioCondition Benchmark Descriptions

Technical descriptions provide a detailed description of the full range in structure and floristic composition of regional ecosystems (e.g. 11.3.1) and their component vegetation communities (e.g. 11.3.1a, 11.3.1b). See:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

The descriptions are compiled using site survey data from the Queensland Herbarium's CORVEG database. Distribution maps, representative images (if available) and the pre-clearing and remnant extent (hectares) of each vegetation community derived from the regional ecosystem mapping data are included. The technical descriptions should be used in conjunction with the fields from the regional ecosystem description database (REDD) for a full description of the regional ecosystem.

Technical descriptions include data on canopy height, canopy cover and native plant species composition of the predominant layer, which are attributes relevant to assessment of the remnant status of vegetation under the *Vegetation Management Act 1999*. However, as technical descriptions reflect the full range in structure and floristic composition across the climatic, natural disturbance and geographic range of the regional ecosystem, local reference sites should be used for remnant assessment where possible (Neldner et al. 2012 (PDF)* section 3.3.1 of:

https://publications.qld.gov.au/dataset/redd/resource/

The technical descriptions are subject to review and are updated as additional data becomes available.

When conducting a BioCondition assessment, these technical descriptions should be used in conjunction with BioCondition benchmarks for the specific regional ecosystem, or component vegetation community.

http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

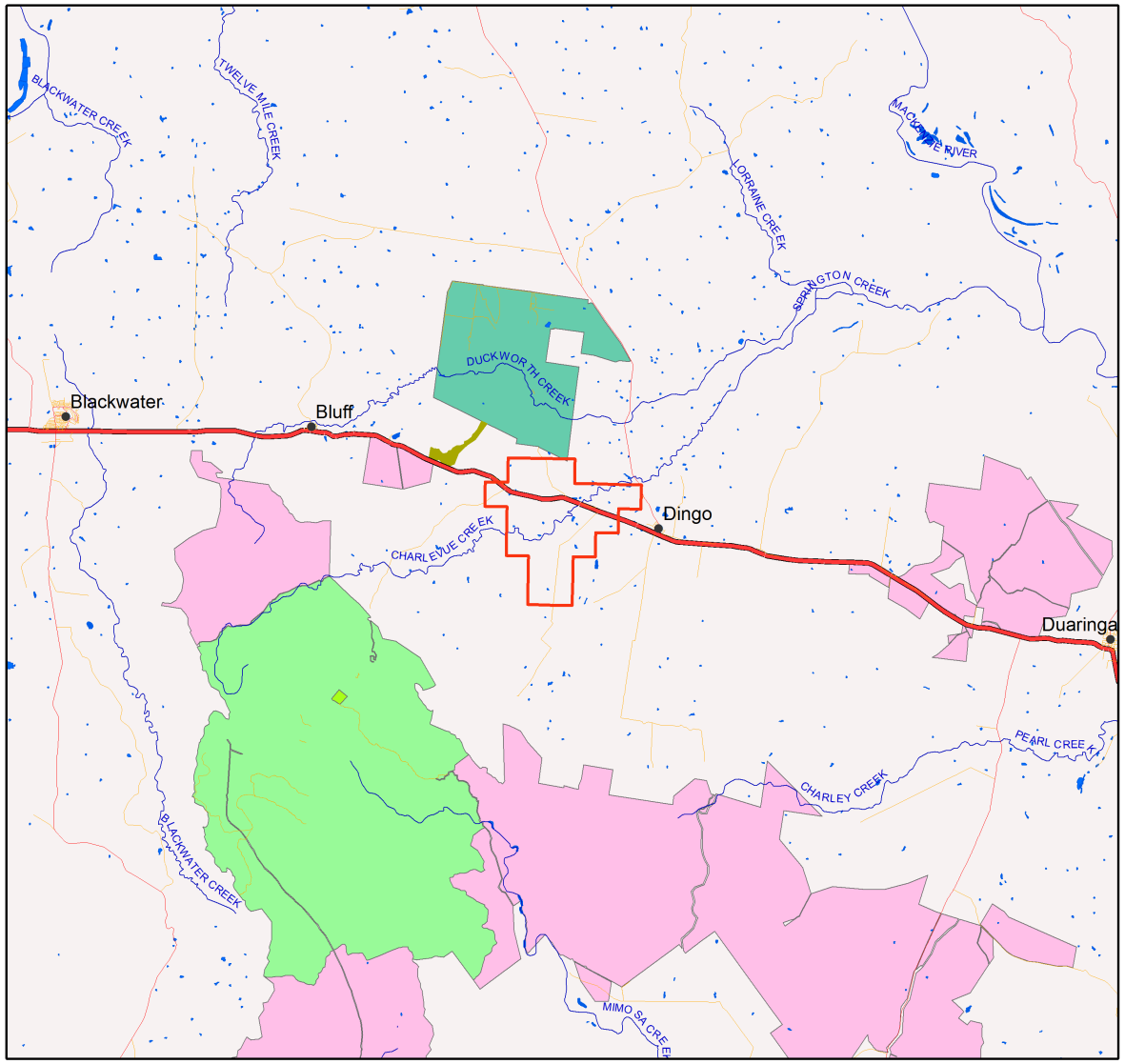
Benchmarks are based on a combination of quantitative and qualitative information and should be used as a guide only. Benchmarks are specific to one regional ecosystem vegetation community, however, the natural variability in structure and floristic composition under a range of climatic and natural disturbance regimes has been considered throughout the geographic extent of the regional ecosystem. Local reference sites should be used for this spatial and temporal (seasonal and annual) variability.

Table 7: List of remnant regional ecosystems within the AOI for which technical and biocondition benchmark descriptions are available

Regional ecosystems mapped as within the AOI	Technical Descriptions	Biocondition Benchmarks
11.3.1	Available	Available
11.3.2	Available	Available
11.3.25	Not currently available	Available
11.5.2	Not currently available	Not currently available
11.5.9b	Not currently available	Not currently available
11.7.2	Not currently available	Available
non-rem	Not currently available	Not currently available

Maps

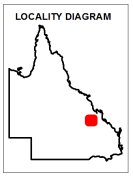
Map 1 - Location



Locality Map

Legend

- Selected Exploration Permit Coal (EPC)
- Towns
- Highway
- Connector
- Street/Local Road
- Reservoirs
- Lakes
- National Park (Scientific)
- National Park
- National Park (CYPAL)
- Conservation Park
- Resources Reserve
- Forest Reserve
- State Forest
- Timber Reserve
- Nature Refuges
- Coordinated Conservation Areas
- Major rivers/creeks
- Queensland



N

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

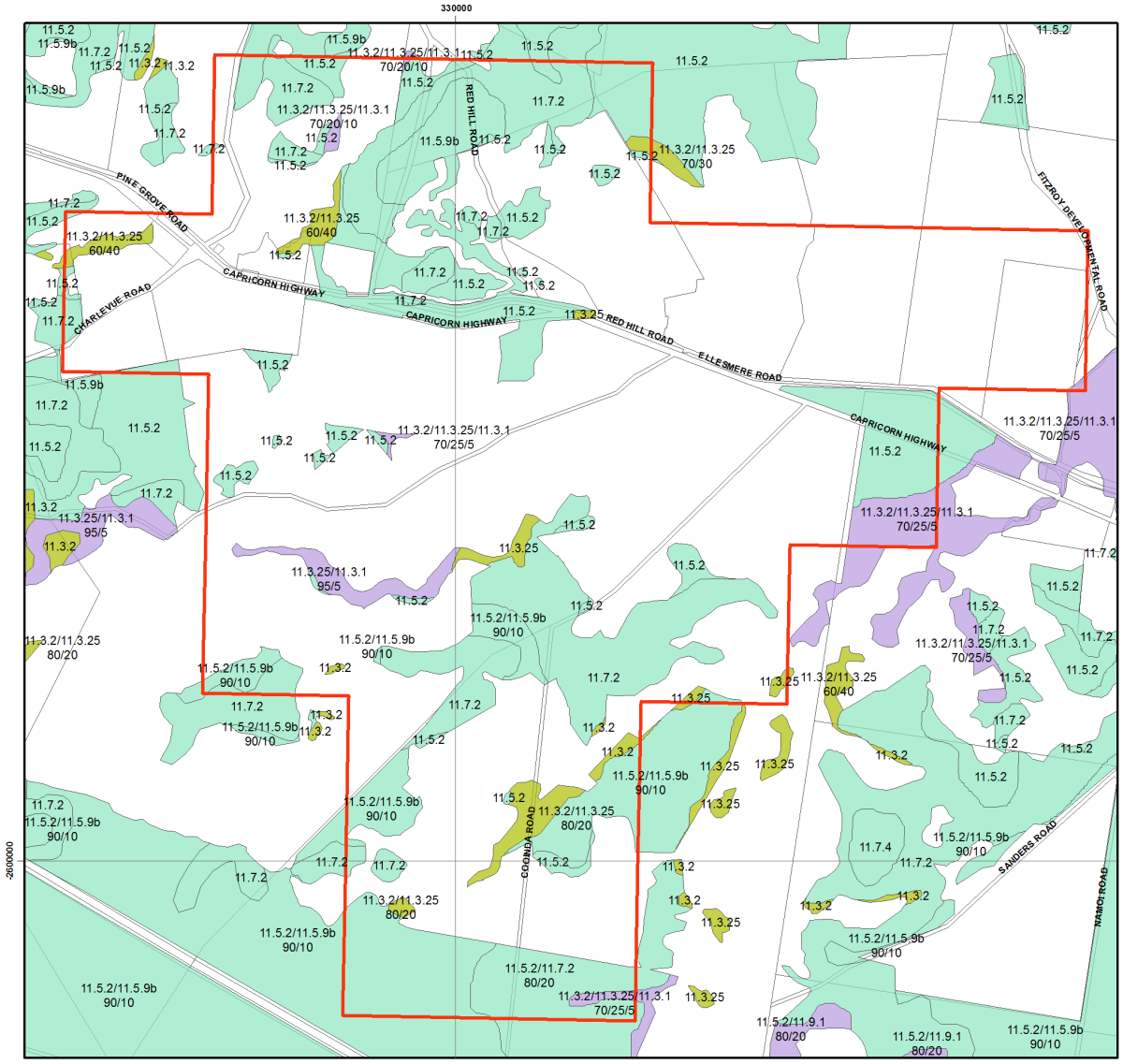
The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

0 4500 9000 13500 18000 22500 m

© The State of Queensland, 2018

This product is projected into GDA 1994 Queensland Albers

Map 2 - Remnant 2015 regional ecosystems



Remnant 2015 Regional Ecosystems

Biodiversity Status

- Selected Exploration Permit Coal (EPC)
- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Non-remnant vegetation, cultivated or built environment
- Plantation
- Water
- Cadastral Boundaries

N

0 0.75 1.5 2.25 3 km

This product is projected into GDA 1994 Queensland Albers

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.

Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".

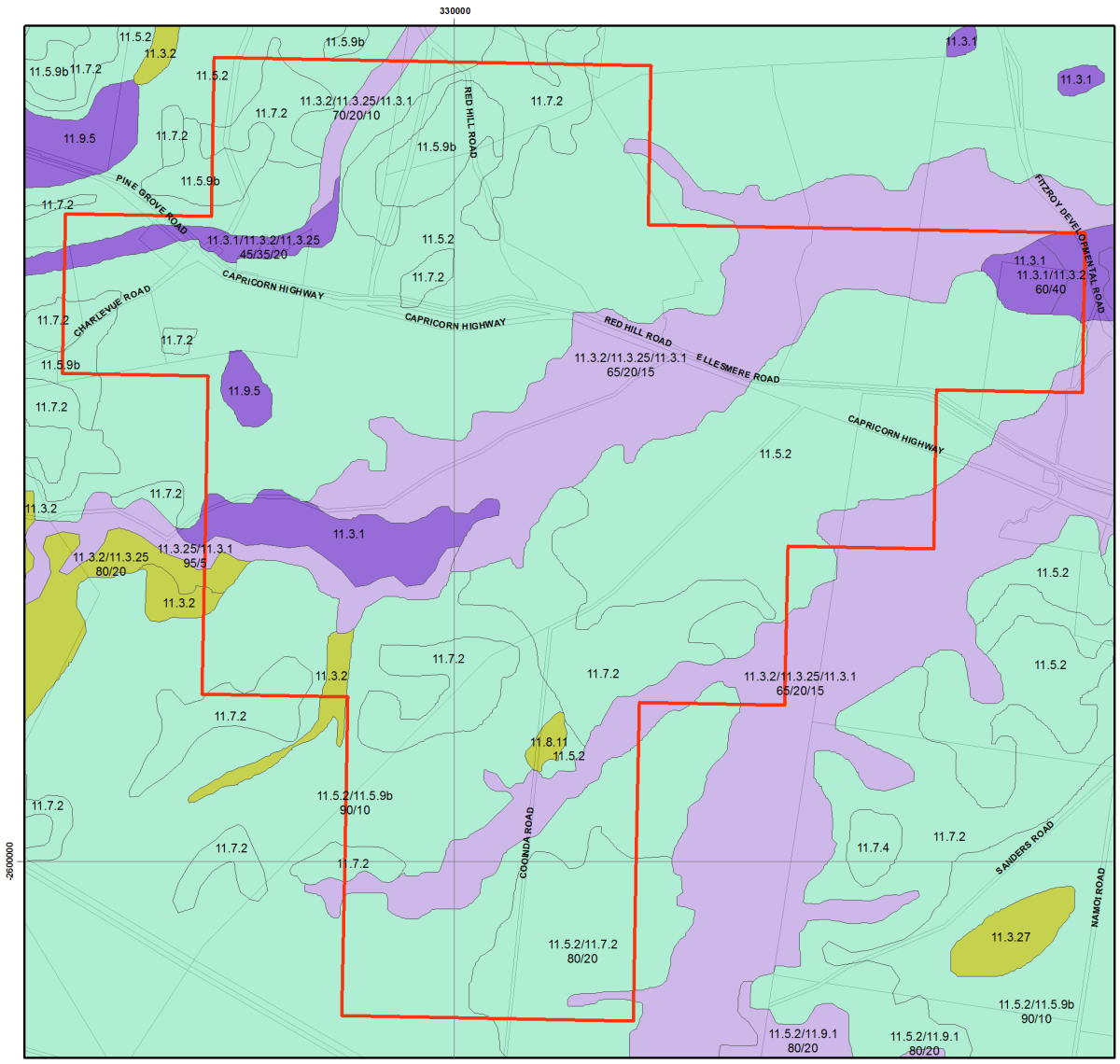
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.

Non-remnant vegetation includes regrowth and disturbed native vegetation.

© The State of Queensland, 2018

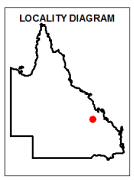
Map 3 - Pre-clearing regional ecosystems



Pre-clearing Regional Ecosystems

Biodiversity Status

- Selected Exploration Permit Coal (EPC)
- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Water
- Cadastral Boundaries



N

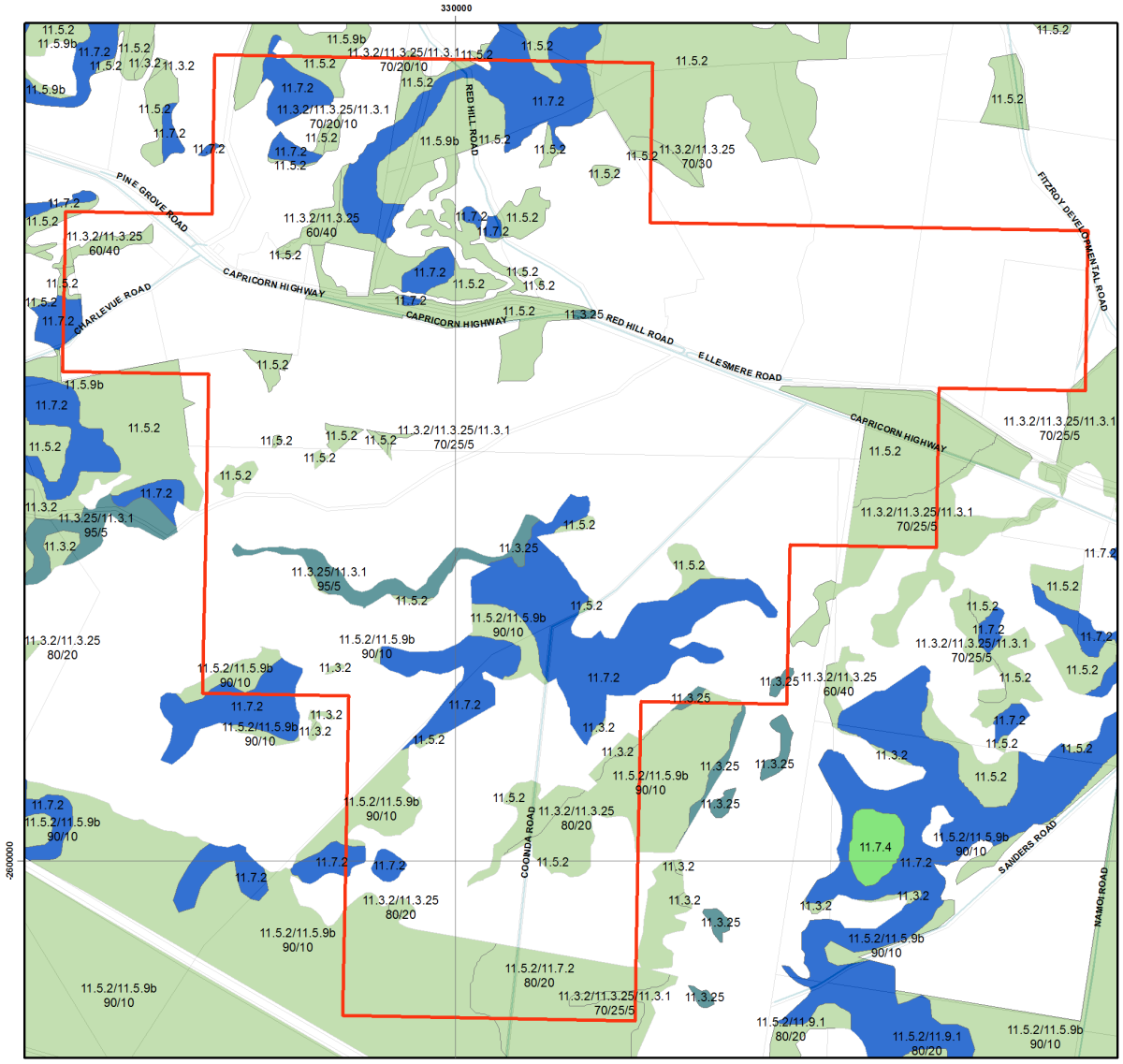
0 0.75 1.5 2.25 3 km

This product is projected into GDA 1994 Queensland Albers

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

© The State of Queensland, 2018

Map 4 - Remnant 2015 regional ecosystems by BVG (5M)



Remnant 2015 Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

- Selected Exploration Permit Coal (EPC)
- 1. Rainforests and scrubs (1-7b)
- 2. Wet eucalypt open forests (8-8b)
- 3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
- 4. Eucalypt open forests to woodlands on floodplains (16-16d)
- 5. Eucalypt dry woodlands on inland depositional plains (17-18d)
- 6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
- 7. Callitris woodland - open forests (20a)
- 8. Melaleuca open woodlands on depositional plains (21-22c)
- 9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
- 10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
- 11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
- 12. Other coastal communities or heaths (28-29b)
- 13. Tussock grasslands, forblands (30-32b)
- 14. Hummock grasslands (33-33b)
- 15. Wetlands (swamps and lakes) (34-34g)
- 16. Mangroves and saltmarshes (35-35b)
- Non-remnant vegetation, cultivated or built environment
- Water
- Cadastral Boundaries

N

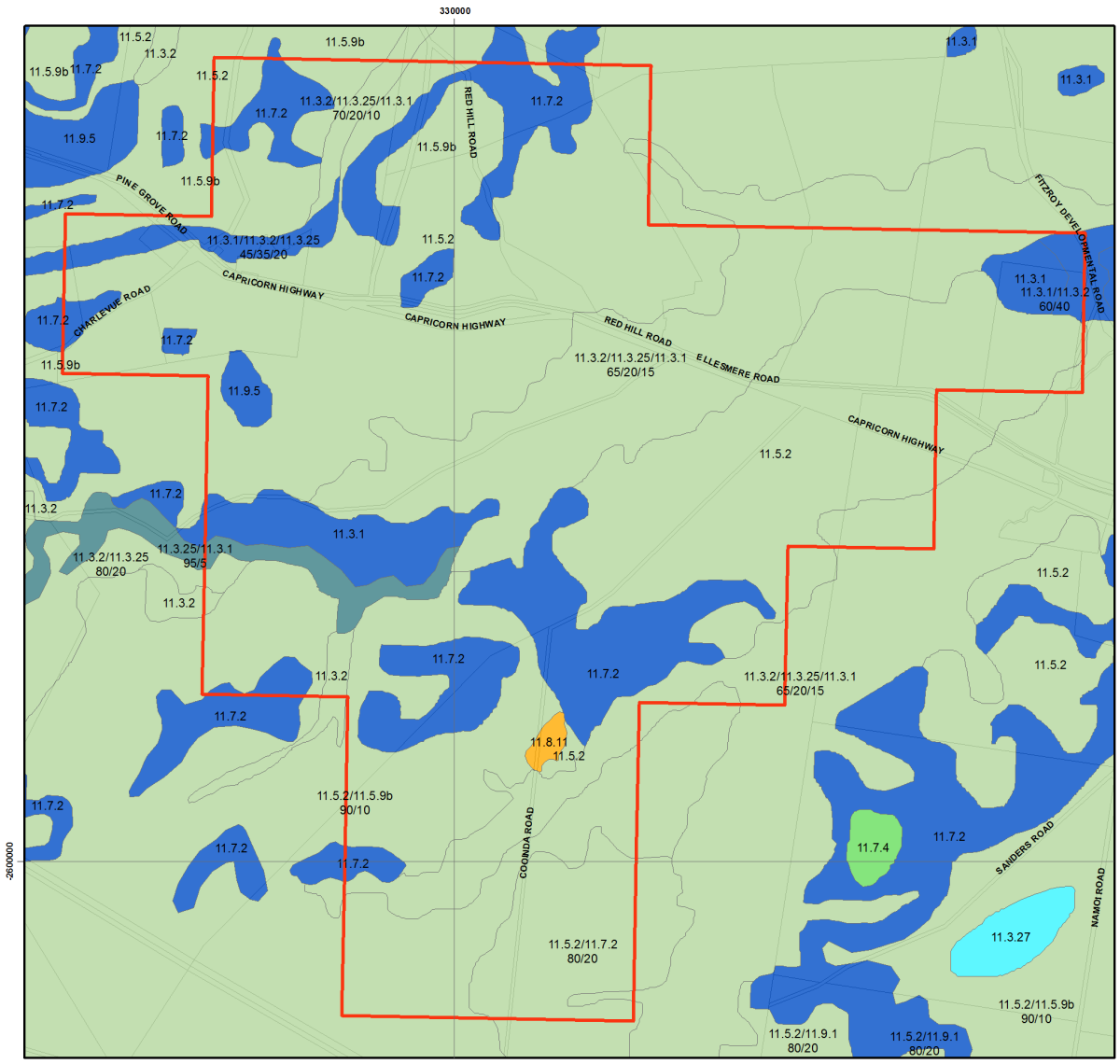
0 0.75 1.5 2.25 3 km

This product is projected into GDA 1994 Queensland Albers

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.
Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.
Non-remnant vegetation includes regrowth and disturbed native vegetation.

© The State of Queensland, 2018

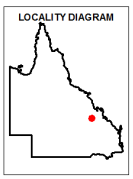
Map 5 - Pre-clearing regional ecosystems by BVG (5M)



Pre-clearing Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

- Selected Exploration Permit Coal (EPC)
- 1. Rainforests and scrubs (1-7b)
- 2. Wet eucalypt open forests (8-8b)
- 3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
- 4. Eucalypt open forests to woodlands on floodplains (16-16d)
- 5. Eucalypt dry woodlands on inland depositional plains (17-18d)
- 6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
- 7. Callitris woodland - open forests (20a)
- 8. Melaleuca open woodlands on depositional plains (21-22c)
- 9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
- 10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
- 11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
- 12. Other coastal communities or heaths (28-29b)
- 13. Tussock grasslands, forblands (30-32b)
- 14. Hummock grasslands (33-33b)
- 15. Wetlands (swamps and lakes) (34-34g)
- 16. Mangroves and saltmarshes (35-35b)
- Water
- Cadastral Boundaries



N

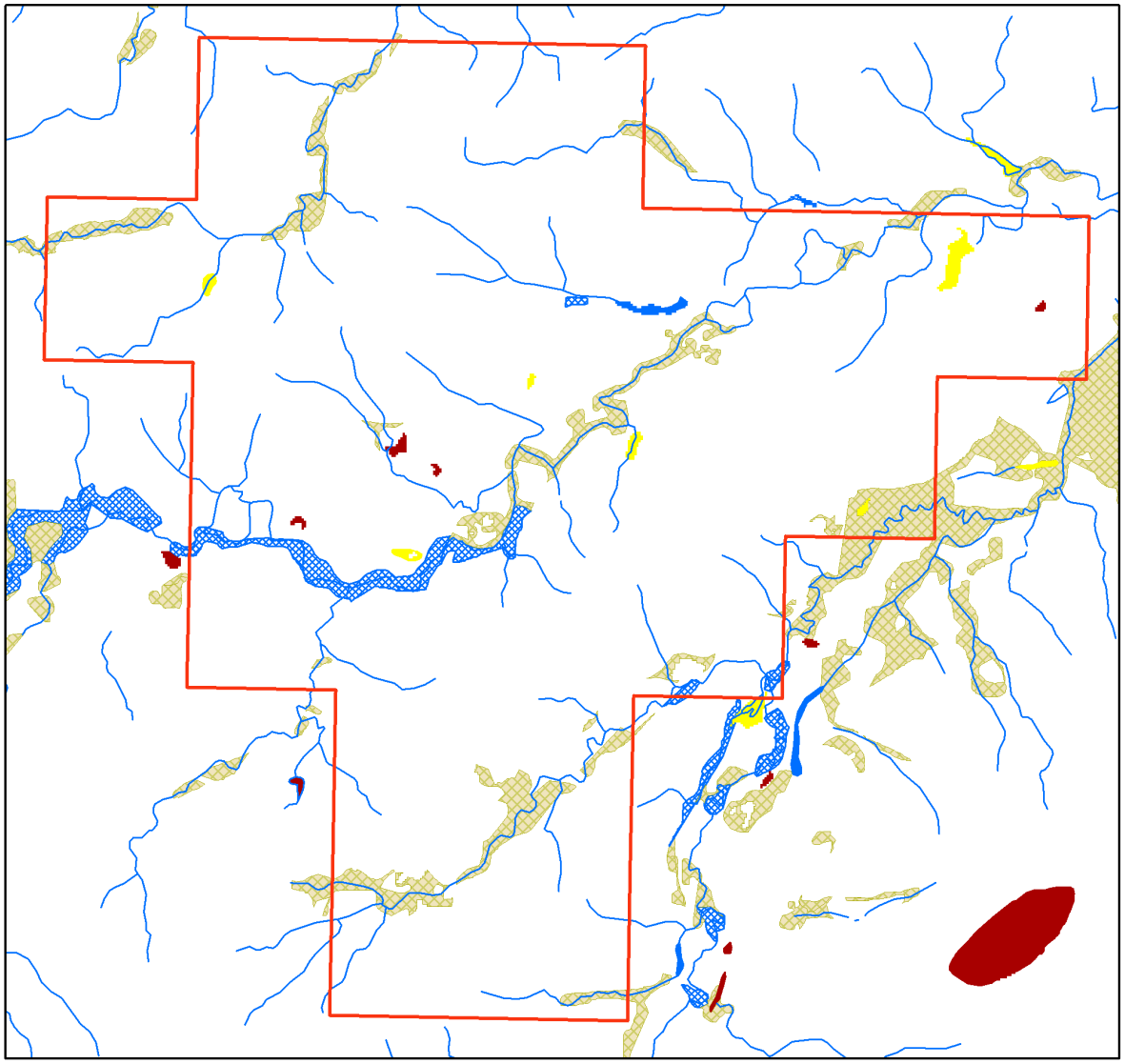
0 0.75 1.5 2.25 3 km

This product is projected into GDA 1994 Queensland Albers

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

© The State of Queensland, 2018

Map 6 - Wetlands and waterways



Queensland Wetland Data

Legend

- Selected Exploration Permit Coal (EPC)
- Towns

Queensland Wetland Data

- Riverine Drainage Lines
- Springs

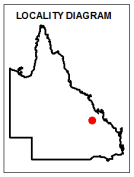
Wetland System - Water Bodies

- Marine Waterbodies
- Estuarine Waterbodies
- Riverine Waterbodies
- Lacustrine Waterbodies
- Palustrine Waterbodies

Wetland System - Regional Ecosystems

- Marine RE
- Estuarine RE
- Riverine RE
- Lacustrine RE
- Palustrine RE
- RE 51-80% wetland (mosaic units)
- RE 1-50% wetland (mosaic units)

LOCALITY DIAGRAM



N

Accuracy information: The positional accuracy of wetland data mapped at a scale of 1:100,000 is +/-100m with a minimum polygon size of 5ha or 75m wide for linear features, except for areas along the east coa st which are mapped at the 1:50,000 scale with a positional accuracy of +/-50m, with a minimum polygon size of 1ha or 35m wide for linear features. Wetlands smaller than 1ha are not delineated on the wetland data. Consideration of the effects of mapped scale is necessary when interpret ing data at a larger scale, e.g. 1:25,000. For property assessment, digital linework should be used as a guide only. The extent of wetlands depicted on this map is based on rectified 2013 Landsat ETM+ imagery supplied by Statewide Landcover and Trees Study (SLATS), Department of Environment and Science. The extent of water bodies is based on the maximum extent of inundation derived from available Landsat imagery up to and including the 2013 imagery.

0 690 1380 2070 2760 3450 m

© The State of Queensland, 2018

This product is projected into GDA 1994 Queensland Albers

Links and Other Information Sources

The Department of Environment and Science's Website -

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/

provides further information on the regional ecosystem framework, including access to links to the Regional Ecosystem Database, Broad Vegetation Group Definitions, Regional Ecosystem and Land zone descriptions.

Descriptions of the broad vegetation groups of Queensland can be downloaded from:

https://publications.qld.gov.au/dataset/redd/resource/

The methodology for mapping regional ecosystems can be downloaded from:

https://publications.qld.gov.au/dataset/redd/resource/

Technical descriptions for regional ecosystems can be obtained from:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

Benchmarks can be obtained from:

http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

For further information associated with the remnant regional ecosystem dataset used by this report, refer to the metadata associated with the Biodiversity status of pre-clearing and Remnant Regional Ecosystems of Queensland dataset (version listed in **Appendix 1**) which is available through the Queensland Government Information System portal,

http://dds.information.qld.gov.au/dds/

The Queensland Globe is a mapping and data application. As an interactive online tool, Queensland Globe allows you to view and explore Queensland maps, imagery (including up-to-date satellite images) and other spatial data, including regional ecosystem mapping. To further view and explore regional ecosystems over an area of interest, access the Biota Globe (a component of the Queensland Globe). The Queensland Globe can be accessed via the following link:

http://www.dnrm.qld.gov.au/mapping-data/queensland-globe

References

Neldner, V.J., Niehus R.E., Wilson, B.A. McDonald, W.J.F., Ford, A.J. and Accad, A. (2017) The Vegetation of Queensland. Descriptions of Broad Vegetation Groups. Version 3.0. Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts.

(https://publications.qld.gov.au/dataset/redd/resource/78209e74-c7f2-4589-90c1-c33188359086)

Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S. and Butler, D.W. (2017) *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland*. Version 4.0. Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts.

(https://publications.qld.gov.au/dataset/redd/resource/6dee78ab-c12c-4692-9842-b7257c2511e4)

Sattler, P.S. and Williams, R.D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Brisbane.

Appendices

Appendix 1 - Source Data

The dataset listed below is available for download from:

http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/download/

- Regional Ecosystem Description Database

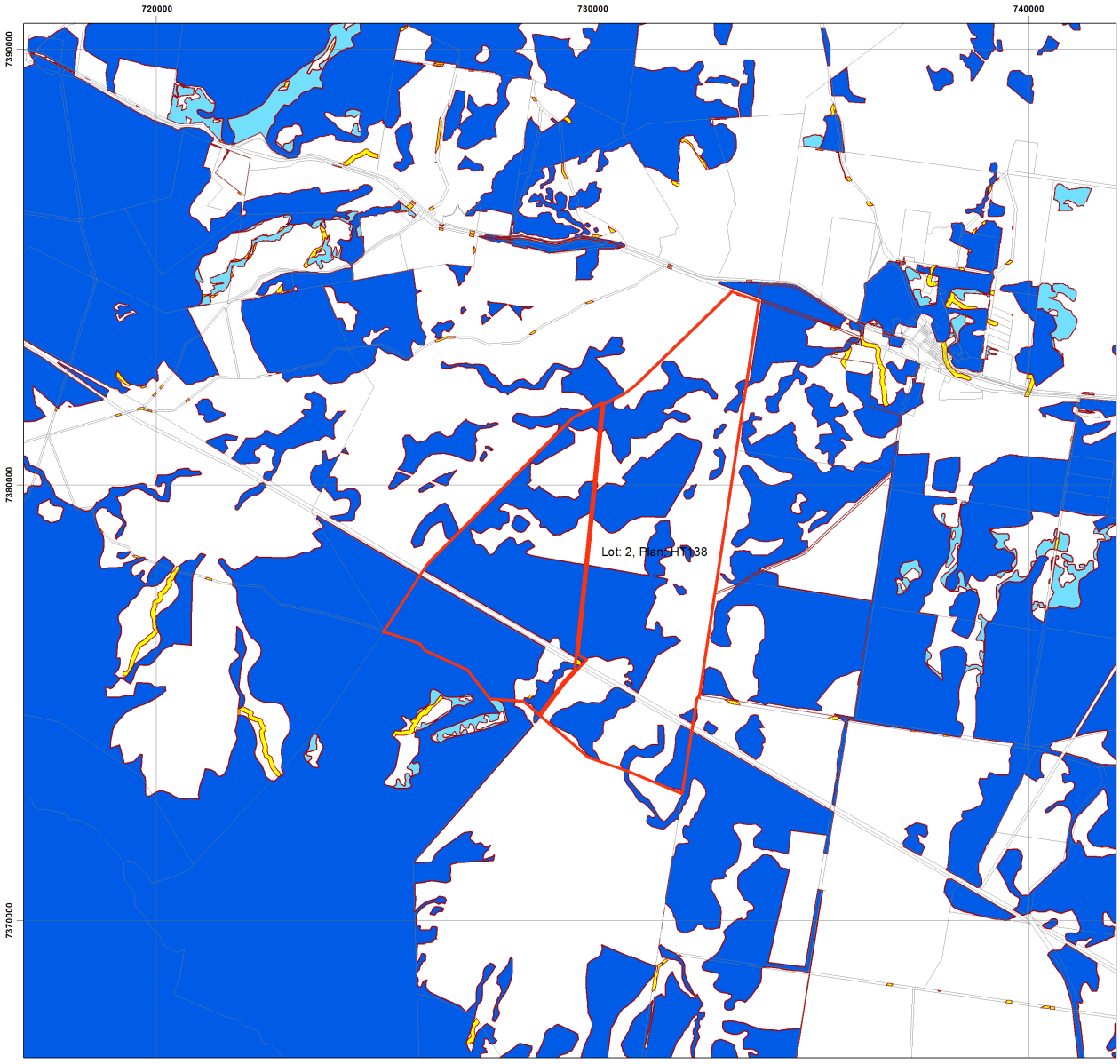
The datasets listed below are available for download from:

http://dds.information.qld.gov.au/dds/

- Biodiversity status of pre-clearing and 2015 remnant regional ecosystems of Queensland
- Pre-clearing Vegetation Communities and Regional Ecosystems of Queensland
- Queensland Wetland Data Version - Wetland lines
- Queensland Wetland Data Version - Wetland points
- Queensland Wetland Data Version - Wetland areas

Appendix 2 - Acronyms and Abbreviations

AOI	- Area of Interest
GDA94	- Geocentric Datum of Australia 1994
GIS	- Geographic Information System
RE	- Regional Ecosystem
REDD	- Regional Ecosystem Description Database
VMA	- *Vegetation Management Act 1999*

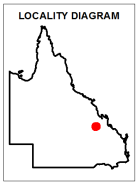


Regulated Vegetation Management Map

Legend

- Lot and Plan
- Category A area (Vegetation offsets/compliance notices/VDecs)
- Category B area (Remnant vegetation)
- Category C area (High-value regrowth vegetation)
- Category R area (Reef regrowth watercourse vegetation)
- Category X area (Exempt clearing work on Freehold, Indigenous and Leasehold land)
- Water
- Area not categorised
- Cadastral line
  Property boundaries shown are provided as a locational aid only

LOCALITY DIAGRAM



N

0 1,300 2,600 3,900 5,200 6,500 m

This product is projected into:
GDA 1994 MGA Zone 55

Disclaimer:
While every care is taken to ensure the accuracy of this product, the Department of Natural Resources, Mines and Energy makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.

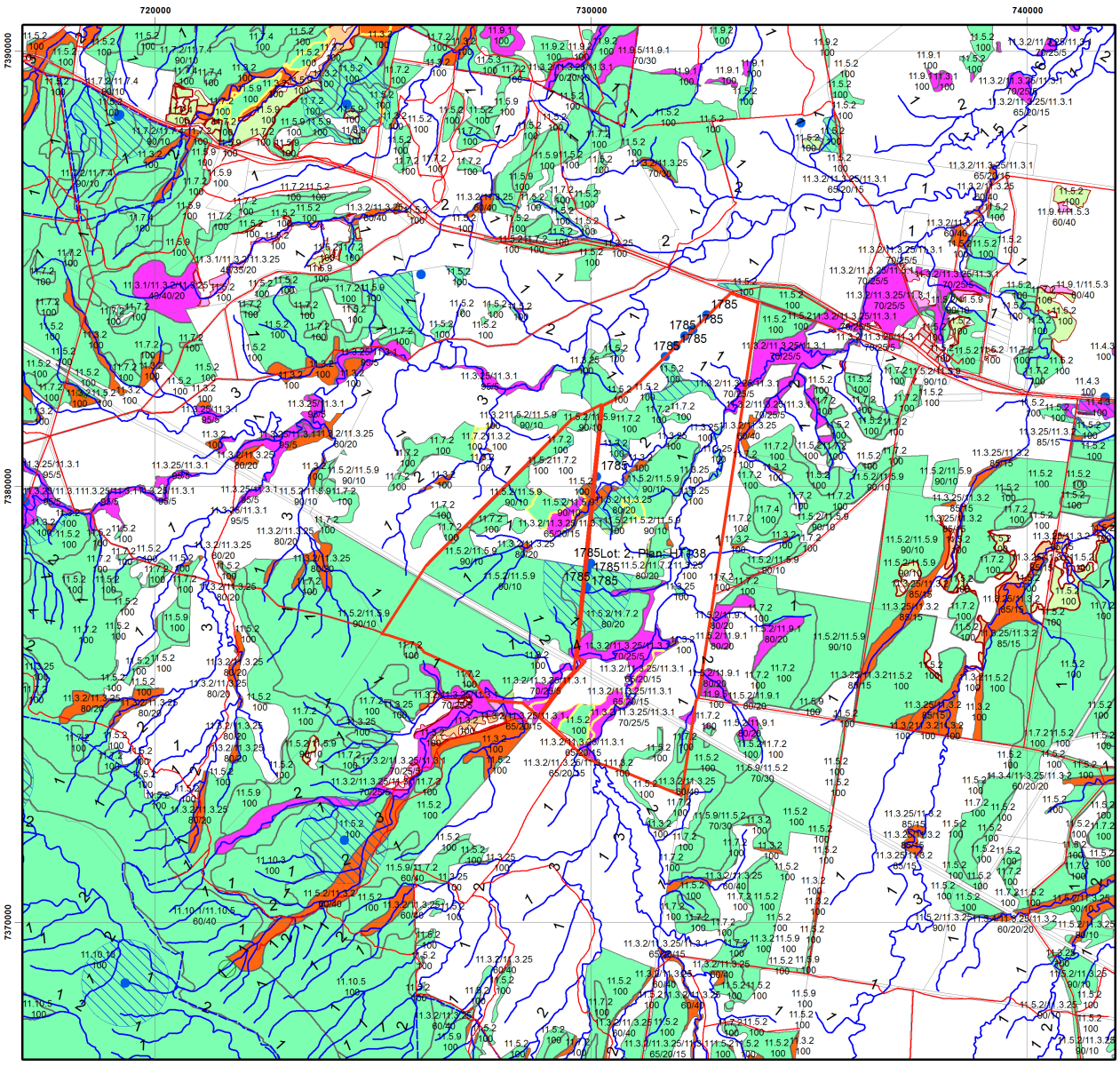
Additional information required for the assessment of vegetation values is provided in the accompanying "Vegetation Management Supporting map". For further information go to the web site: www.dnrme.qld.gov.au or contact the Department of Natural Resources, Mines and Energy.

Digital data for the regulated vegetation management map is available from the Queensland Spatial Portal at http://www.information.qld.gov.au/

This map is updated on a monthly basis to ensure new PMAVs are included as they are approved.

Queensland Government

© The State of Queensland (Department of Natural Resources, Mines and Energy), 2019



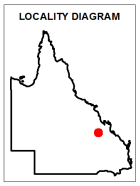
Vegetation Management Supporting Map

Legend

- Lot and Plan
- Category A or B area containing endangered regional ecosystems
- Category A or B area containing of concern regional ecosystems
- Category A or B area that is a least concern regional ecosystem
- Category A or B area under Section 20AH
  These areas are edged in yellow and filled with the remnant RE Status
- Category C area containing endangered regional ecosystems
- Category C area containing of concern regional ecosystems
- Category C area that is a least concern regional ecosystem
- Category C area under Section 20AI
  These areas are edged in purple and filled with the remnant RE Status
- Non Remnant
- Water
- Wetland on the vegetation management wetlands map
- Essential habitat on the essential habitat map
- Essential habitat species record
- Watercourses and drainage features on the vegetation management watercourse and drainage features map
  (Stream order shown as black number against stream where available)
- Roads
- National Parks, State Forest and other reserves
- Cadastral line
  Property boundaries shown are provided as a locational aid only

Queensland Government

LOCALITY DIAGRAM



N

0 975 1,950 2,925 3,900 4,875 m

This product is projected into:
GDA 1994 MGA Zone 55

Labels for Essential Habitat are centred on the area of enquiry.

Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/- 100 metres.

Disclaimer:
While every care is taken to ensure the accuracy of this product, the Department of Natural Resources, Mines and Energy makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.

Additional information may be required for the purposes of land clearing or assessment of a regional ecosystem map or PMAV applications. For further information go to the web site: www.dnrme.qld.gov.au or contact the Department of Natural Resources, Mines and Energy.

Digital data for the vegetation management watercourse and drainage feature map, vegetation management wetlands map, essential habitat map and the vegetation management remnant and regional ecosystem map are available from the Queensland Spatial Portal at http://www.information.qld.gov.au/

© The State of Queensland (Department of Natural Resources, Mines and Energy), 2019

Vegetation Management Act 1999 - Extract from the essential habitat database

Essential habitat is required for assessment under the:

- State Development Assessment Provisions - State Code 16: Native vegetation clearing which sets out the matters of interest to the state for development assessment under the *Planning Act 2016*; and
- Accepted development vegetation clearing codes made under the *Vegetation Management Act 1999*

Essential habitat for one or more of the following species is found on and within 1.1 km of the identified subject lot/s on the accompanying essential habitat map.

This report identifies essential habitat in Category A, B and Category C areas.

The numeric labels on the essential habitat map can be cross referenced with the database below to determine which essential habitat factors might exist for a particular species.

Essential habitat is compiled from a combination of species habitat models and buffered species records.

The Department of Natural Resources, Mines and Energy website (http://www.dnrme.qld.gov.au) has more information on how the layer is applied under the State Development Assessment Provisions - State Code 16: Native vegetation clearing and the *Vegetation Management Act 1999*.

Regional ecosystem is a mandatory essential habitat factor, unless otherwise stated.

Essential habitat, for protected wildlife, means a category A area, a category B area or category C area shown on the regulated vegetation management map-

1) that has at least 3 essential habitat factors for the protected wildlife that must include any essential habitat factors that are stated as mandatory for the protected wildlife in the essential habitat database; or

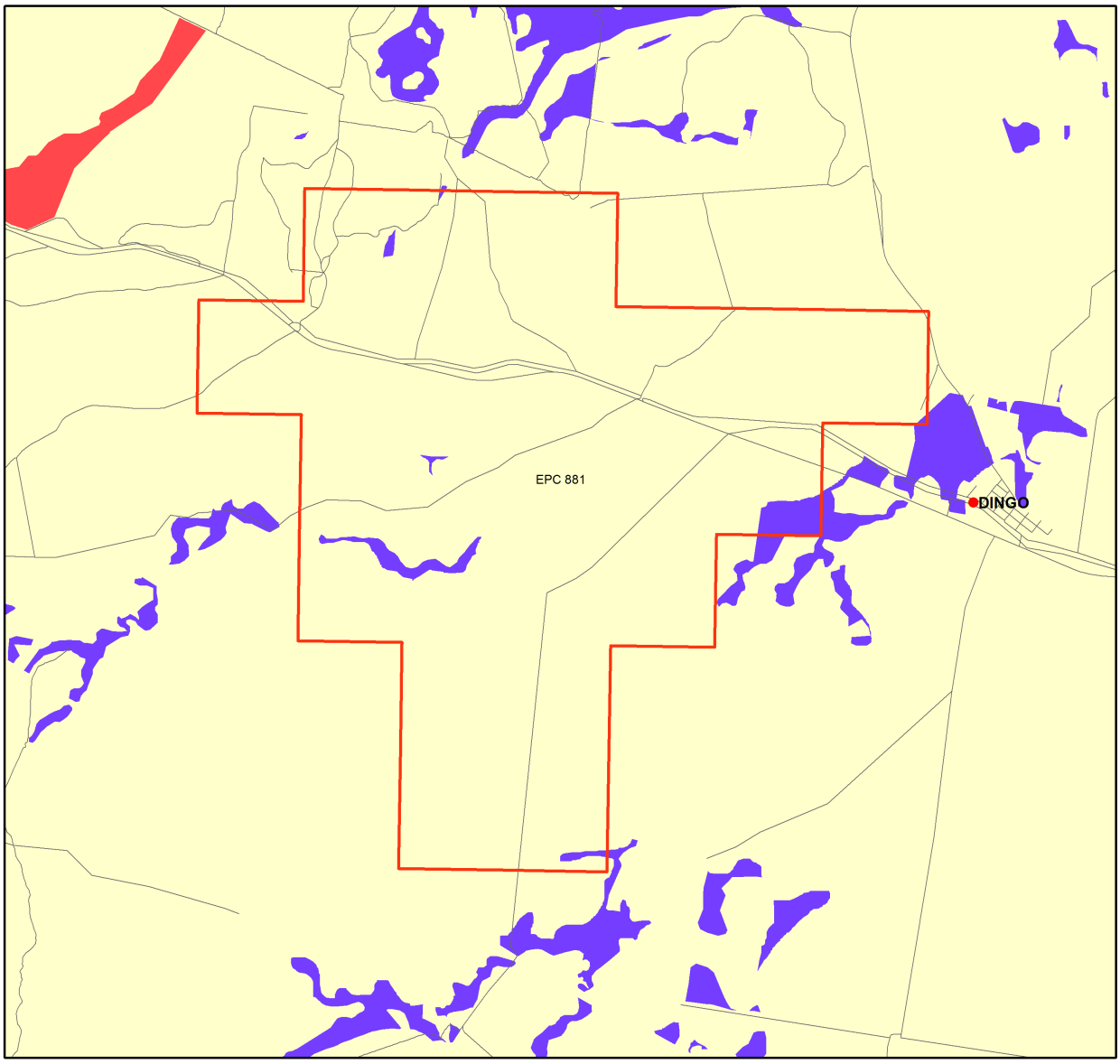
2) in which the protected wildlife, at any stage of its life cycle, is located.

Protected wildlife includes endangered, vulnerable or near-threatened native wildlife prescribed under the *Nature Conservation Act 1992*.

Essential habitat in Category A and/or Category B and/or Category C

Label	Scientific Name	Common Name	NCA Status	Vegetation Community	Altitude	Soils	Position in Landscape
1785	Geophaps scripta scripta	squatter pigeon (southern subsp.)	V	Dry eucalypt woodland (including poplar box, spotted gum, yellow box, acacia and callitris), with sparse short grass, often on sandy areas near to permanent water; grassy eucalypt woodlands. Nest on ground near or under grass tussock, log or low bush.	None	None	Gravelly ridges, traprock and river flats.

Label	Regional Ecosystem (mandatory unless otherwise specified)
1785	8.2.1, 8.2.7, 8.2.8, 8.2.12, 8.3.2, 8.3.3, 8.3.5, 8.3.6, 8.3.13, 8.5.2, 8.5.3, 8.5.5, 8.5.6, 8.9.1, 8.11.1, 8.11.3, 8.11.4, 8.11.5, 8.11.6, 8.11.8, 8.12.6, 8.12.7, 8.12.9, 8.12.12, 8.12.14, 8.12.20, 8.12.22, 8.12.23, 8.12.25, 9.3.1, 9.3.2, 9.3.3, 9.3.4, 9.3.5, 9.3.6, 9.3.7, 9.3.8, 9.3.9, 9.3.11, 9.3.13, 9.3.14, 9.3.15, 9.3.16, 9.3.17, 9.3.18, 9.3.19, 9.3.20, 9.3.21, 9.3.22, 9.3.23, 9.4.1, 9.4.2, 9.4.3, 9.5.3, 9.5.4, 9.5.5, 9.5.6, 9.5.7, 9.5.8, 9.5.9, 9.5.10, 9.5.11, 9.5.12, 9.5.16, 9.7.1, 9.7.2, 9.7.3, 9.7.5, 9.7.6, 9.8.1, 9.8.2, 9.8.4, 9.8.5, 9.8.6, 9.8.9, 9.8.10, 9.8.11, 9.10.1, 9.10.3, 9.10.6, 9.10.7, 9.10.8, 9.11.1, 9.11.2, 9.11.3, 9.11.4, 9.11.5, 9.11.7, 9.11.10, 9.11.11, 9.11.12, 9.11.13, 9.11.15, 9.11.16, 9.11.17, 9.11.18, 9.11.19, 9.11.23, 9.11.26, 9.11.28, 9.11.29, 9.11.31, 9.11.32, 9.12.1, 9.12.3, 9.12.4, 9.12.5, 9.12.6, 9.12.7, 9.12.10, 9.12.11, 9.12.12, 9.12.13, 9.12.16, 9.12.17, 9.12.18, 9.12.19, 9.12.20, 9.12.21, 9.12.22, 9.12.23, 9.12.24, 9.12.26, 9.12.28, 9.12.30, 9.12.31, 9.12.33, 9.12.35, 9.12.37, 9.12.39, 10.3.1, 10.3.2, 10.3.3, 10.3.4, 10.3.5, 10.3.6, 10.3.9, 10.3.10, 10.3.11, 10.3.12, 10.3.13, 10.3.14, 10.3.15, 10.3.19, 10.3.20, 10.3.27, 10.3.28, 10.3.30, 10.3.31, 10.4.3, 10.5.1, 10.5.2, 10.5.4, 10.5.5, 10.5.7, 10.5.9, 10.5.10, 10.5.11, 10.5.12, 10.7.2, 10.7.3, 10.7.5, 10.7.11, 10.7.12, 10.9.1, 10.9.2, 10.9.3, 10.9.5, 10.10.1, 10.10.3, 10.10.4, 10.10.5, 10.10.7, 11.2.1, 11.2.5, 11.3.1, 11.3.2, 11.3.3, 11.3.4, 11.3.6, 11.3.7, 11.3.8, 11.3.9, 11.3.10, 11.3.12, 11.3.13, 11.3.14, 11.3.15, 11.3.16, 11.3.17, 11.3.18, 11.3.19, 11.3.23, 11.3.25, 11.3.27, 11.3.28, 11.3.29, 11.3.30, 11.3.35, 11.3.36, 11.3.37, 11.3.38, 11.3.39, 11.4.2, 11.4.3, 11.4.5, 11.4.8, 11.4.10, 11.4.12, 11.4.13, 11.5.1, 11.5.2, 11.5.3, 11.5.4, 11.5.5, 11.5.8, 11.5.9, 11.5.12, 11.5.13, 11.5.14, 11.5.17, 11.5.20, 11.5.21, 11.7.1, 11.7.2, 11.7.4, 11.7.6, 11.8.2, 11.8.4, 11.8.5, 11.8.8, 11.8.9, 11.8.11, 11.8.12, 11.8.14, 11.8.15, 11.9.2, 11.9.3, 11.9.7, 11.9.9, 11.9.14, 11.10.1, 11.10.4, 11.10.6, 11.10.7, 11.10.11, 11.10.12, 11.10.13, 11.11.1, 11.11.3, 11.11.4, 11.11.6, 11.11.7, 11.11.8, 11.11.9, 11.11.10, 11.11.11, 11.11.15, 11.11.16, 11.11.19, 11.11.20, 11.12.1, 11.12.2, 11.12.3, 11.12.5, 11.12.6, 11.12.7, 11.12.8, 11.12.9, 11.12.10, 11.12.11, 11.12.12, 11.12.13, 11.12.14, 11.12.17, 11.12.20, 12.2.5, 12.2.6, 12.2.7, 12.2.10, 12.2.11, 12.3.3, 12.3.6, 12.3.10, 12.3.12, 12.3.14, 12.3.18, 12.3.19, 12.5.1, 12.5.2, 12.5.4, 12.5.5, 12.5.7, 12.5.8, 12.5.11, 12.5.12, 12.7.1, 12.7.2, 12.8.14, 12.8.16, 12.8.17, 12.8.19, 12.9-10.5, 12.9-10.7, 12.9-10.8, 12.9-10.12, 12.9-10.13, 12.9-10.25, 12.9-10.26, 12.9-10.28, 12.11.5, 12.11.7, 12.11.8, 12.11.14, 12.11.15, 12.11.20, 12.11.21, 12.11.22, 12.11.24, 12.11.25, 12.11.26, 12.11.27, 12.11.28, 12.12.7, 12.12.8, 12.12.9, 12.12.12, 12.12.14, 12.12.21, 12.12.22, 12.12.23, 12.12.24, 12.12.25, 12.12.27, 13.3.1, 13.3.4, 13.3.7, 13.11.1, 13.11.3, 13.11.4, 13.11.8, 13.12.2, 13.12.3, 13.12.5, 13.12.8, 13.12.9, 13.12.10



ENVIRONMENTALLY SENSITIVE AREAS - Mining Activities

- Selected Exploration Permit Coal (EPC)

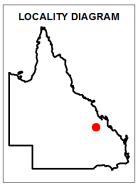
CATEGORY A
- National Parks
- Conservation Parks
- Forest Reserves
- Wet Tropics World Heritage Area
- Great Barrier Reef Marine Park Area
- Marine Parks other than General Use Zones

CATEGORY B
- World Heritage Areas
- Queensland Heritage Register Places
- Ramsar Sites
- Cultural Heritage Registered Areas and DLA's other than Stanbroke
- Special Forestry Areas
- Fish Habitat Areas
- Koala Plan
- Coordinated Conservation Areas
- Endangered Regional Ecosystems (Biodiversity Status)
- General Use Zones of Marine Parks
- Marine Plants

CATEGORY C
- Nature Refuges
- Resources Reserve
- State Forests
- Timber Reserves
- Declared Catchment Areas
- Declared Irrigation Areas
- Drainage Areas
- River Improvement Areas
- Stanbroke DLA
- Coastal Management District
- Dams and Weirs

OTHERS
- Towns
- Roads
- Repealed Wild River Nominated Waterways
- Repealed Wild River Preservation Areas
- Repealed Wild River High Preservation Areas
- Mahogany Glider Habitat
- Directory of Important Wetlands
- Queensland

LOCALITY DIAGRAM



N

0 975 1,950 2,925 3,900 4,875 m

This product is projected into GDA 1994 MGA Zone 55

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, The State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The State of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or ncomplete in any way for any reason.

External contributors (non-government parties) of the data for this product are: Great Barrier Reef Marine Park Authority

Regional ecosystem mapping (remnant biodiversity status) may incorporate amendments, resulting from property level assessments, to the release version of the mapping available on QSpatial.

NOTE TO USER: Themes presented in this map are indicative only. Field survey may be required to verify the 'true' spatial extent and value. Not all environmentally sensitive areas are presented in this map. A user should refer to the particular circumstances relevant to their situation to assess the 'completeness' of themes provided.

The user should note that some boundaries and indicated values are ambient and may change over time (e.g. regional ecosystem boundaries and conservation status, watercourse mapping etc).

The user should be aware that due to multiple overlapping themes/ layers present, some themes/layers may be obscured by others. Ordering in the Legend does not accurately reflect the order by which themes/layers are displayed.

© The State of Queensland, 2019

Queensland Government

Queensland Government

Department of Environment and Science

Environmental Reports

Matters of State Environmental Significance

For the selected area of interest
epc: 881

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Please direct queries about these reports to: Planning.Support@des.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

Table of Contents

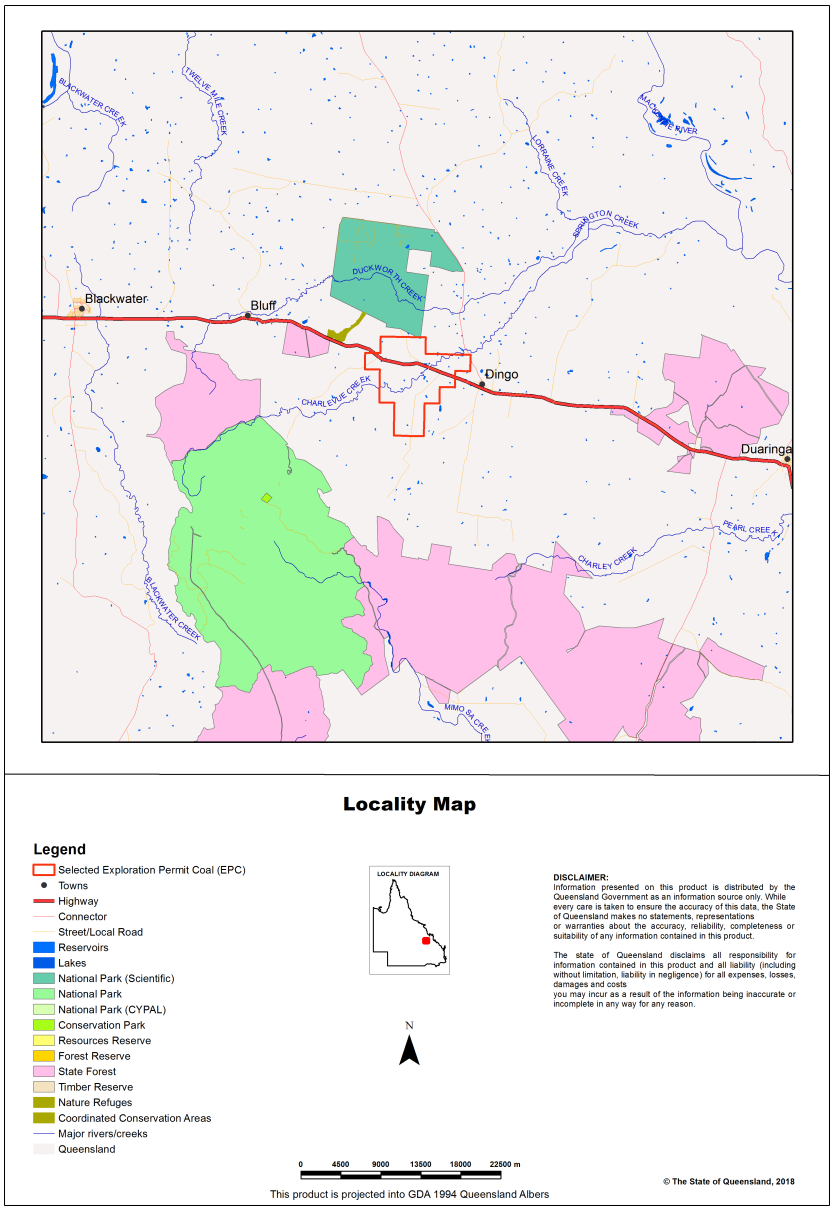
Assessment Area Details . . . 4
Matters of State Environmental Significance (MSES) . . . 5
MSES Categories . . . 5
MSES Values Present . . . 6
Additional Information with Respect to MSES Values Present . . . 7
MSES - State Conservation Areas . . . 7
MSES - Wetlands and Waterways . . . 7
MSES - Species . . . 7
MSES - Regulated Vegetation . . . 8
Map 1 - MSES - State Conservation Areas . . . 10
Map 2 - MSES - Wetlands and Waterways . . . 11
Map 3 - MSES - Species . . . 12
Map 4 - MSES - Regulated Vegetation . . . 13
Map 5 - MSES - Offset Areas . . . 14
Appendices . . . 15
Appendix 1 - Matters of State Environmental Significance (MSES) methodology . . . 15
Appendix 2 - Source Data . . . 16
Appendix 3 - Acronyms and Abbreviations . . . 17

Assessment Area Details

The following table provides an overview of the area of interest (AOI) with respect to selected topographic and environmental values.

Table 1: Summary table, details for AOI epc: 881

Size (ha)	7,219.57
Local Government(s)	Central Highlands Regional
Bioregion(s)	Brigalow Belt
Subregion(s)	Woorabinda
Catchment(s)	Fitzroy



Matters of State Environmental Significance (MSES)

MSES Categories

Queensland's State Planning Policy (SPP) includes a biodiversity State interest that states:

'The sustainable, long-term conservation of biodiversity is supported. Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset.'

The MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

The SPP defines matters of state environmental significance as:

- Protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992* ;

- Marine parks and land within a 'marine national park', 'conservation park', 'scientific research', 'preservation' or 'buffer' zone under the *Marine Parks Act 2004* ;

- Areas within declared fish habitat areas that are management A areas or management B areas under the Fisheries Regulation 2008;

- Threatened wildlife under the *Nature Conservation Act 1992* and special least concern animals under the Nature Conservation (Wildlife) Regulation 2006;

- Regulated vegetation under the *Vegetation Management Act 1999* that is:

    • Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems;

    • Category C areas on the regulated vegetation management map that are 'endangered' or 'of concern' regional ecosystems;

    • Category R areas on the regulated vegetation management map;

    • Regional ecosystems that intersect with watercourses identified on the vegetation management watercourse and drainage feature map;

    • Regional ecosystems that intersect with wetlands identified on the vegetation management wetlands map;

- Strategic Environmental Areas under the *Regional Planning Interests Act 2014* ;

- Wetlands in a wetland protection area of wetlands of high ecological significance shown on the Map of Referable Wetlands under the Environmental Protection Regulation 2008;

- Wetlands and watercourses in high ecological value waters defined in the Environmental Protection (Water) Policy 2009, schedule 2;

- Legally secured offset areas.

MSES Values Present

The MSES values that are present in the area of interest are summarised in the table below:

Table 2: Summary of MSES present within the AOI

1a Protected Areas- estates	2.94 ha	0.0%
1b Protected Areas- nature refuges	0.0 ha	0.0 %
2 State Marine Parks- highly protected zones	0.0 ha	0.0 %
3 Fish habitat areas (A and B areas)	0.0 ha	0.0 %
4 Strategic Environmental Areas (SEA)	0.0 ha	0.0 %
5 High Ecological Significance wetlands on the map of Referable Wetlands	0.0 ha	0.0 %
6a High Ecological Value (HEV) wetlands	0.0 ha	0.0 %
6b High Ecological Value (HEV) waterways **	0.0 km	Not applicable
7 Threatened species and Iconic species	0.0 ha	0.0 %
8a Regulated Vegetation - Endangered/Of concern in Category B (remnant)	248.85 ha	3.4%
8b Regulated Vegetation - Endangered/Of concern in Category C (regrowth)	3.69 ha	0.1%
8c Regulated Vegetation - Category R (GBR riverine regrowth)	19.17 ha	0.3%
8d Regulated Vegetation - Essential habitat	384.78 ha	5.3%
8e Regulated Vegetation - intersecting a watercourse **	81.4 km	Not applicable
8f Regulated Vegetation - within 100m of a Vegetation Management Wetland	0.0 ha	0.0 %
9a Legally secured offset areas- offset register areas	0.0 ha	0.0 %
9b Legally secured offset areas- vegetation offsets through a Property Map of Assessable Vegetation	0.0 ha	0.0 %

Additional Information with Respect to MSES Values Present

MSES - State Conservation Areas

1a. Protected Areas - estates

LOTPLAN	Estate name
25HT655	Taunton National Park (Scientific)

1b. Protected Areas - nature refuges

(no results)

2. State Marine Parks - highly protected zones

(no results)

3. Fish habitat areas (A and B areas)

(no results)

Refer to **Map 1 - MSES - State Conservation Areas** for an overview of the relevant MSES.

MSES - Wetlands and Waterways

4. Strategic Environmental Areas (SEA)

(no results)

5. High Ecological Significance wetlands on the Map of Referable Wetlands

(no results)

6a. High Ecological Value (HEV) waters - wetlands

(no results)

6b. High Ecological Value (HEV) waters - waterways

(no results)

Refer to **Map 2 - MSES - Wetlands and Waterways** for an overview of the relevant MSES.

MSES - Species

7. Threatened wildlife and special least concern animal

(no results)

Threatened and special least concern species records

(no results)

Note: The Threatened and Special Least Concern Animal (7) layer originates from the previous MSES version (4.1, dated at 2014). The layer does not represent all currently listed species and is subject to review.

**Nature Conservation Act 1992 (NCA) Status- Endangered (E), Vulnerable (V) or Special Least Concern Animal (SL). Environment Protection and Biodiversity Conservation Act 1999 (EPBC) status: Critically Endangered (CE) Endangered (E), Vulnerable (V)*

To request a species list for an area, or search for a species profile, access Wildlife Online at:
https://www.qld.gov.au/environment/plants-animals/species-list/

Refer to **Map 3 - MSES - Species** for an overview of the relevant MSES.

MSES - Regulated Vegetation

8a. Regulated Vegetation - Endangered/Of concern in Category B (remnant)

Regional ecosystem	Vegetation management polygon	Vegetation management status
11.3.2/11.3.25	O-dom	rem_oc
11.3.2/11.3.25/11.3.1	E-subdom	rem_end
11.3.2	O-dom	rem_oc
11.3.25/11.3.1	E-subdom	rem_end

8b. Regulated Vegetation - Endangered/Of concern in Category C (regrowth)

Regional ecosystem	Vegetation management polygon	Vegetation management status
11.3.2/11.3.25	O-dom	hvr_oc
11.3.1/11.3.2/11.3.25	E-dom	hvr_end

For further information relating to regional ecosystems in general, go to:
https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/
For a more detailed description of a particular regional ecosystem, access the regional ecosystem search page at:
https://environment.ehp.qld.gov.au/regional-ecosystems/

8c. Regulated Vegetation - Category R (GBR riverine regrowth)

Regulated vegetation map category	Map number	RVM rule
R	8750	4

8d. Regulated Vegetation - Essential habitat

Values are present

8e. Regulated Vegetation - intersecting a watercourse**

A vegetation management watercourse is mapped as present

8f. Regulated Vegetation - within 100m of a Vegetation Management wetland

Not applicable

Refer to **Map 4 - MSES - Regulated Vegetation** for an overview of the relevant MSES.

MSES - Offsets

9a. Legally secured offset areas - offset register areas

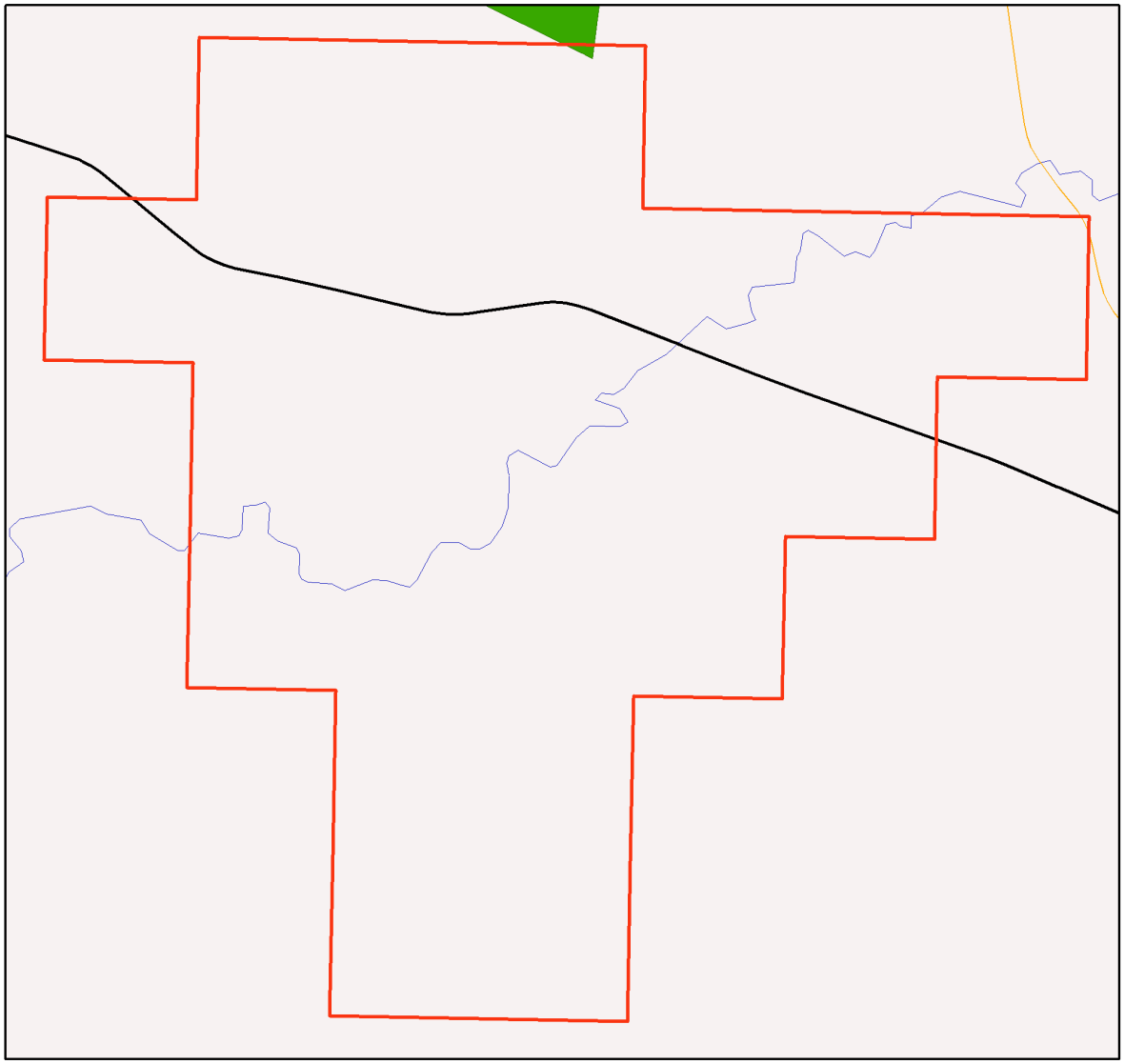
(no results)

9b. Legally secured offset areas - vegetation offsets through a Property Map of Assessable Vegetation

(no results)

Refer to **Map 5 - MSES - Offset Areas** for an overview of the relevant MSES.

Map 1 - MSES - State Conservation Areas

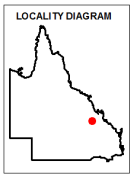


MSES - State Conservation Areas

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Protected area (estates)
- Declared fish habitat area (A and B areas)
- Marine park (highly protected)

LOCALITY DIAGRAM



Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

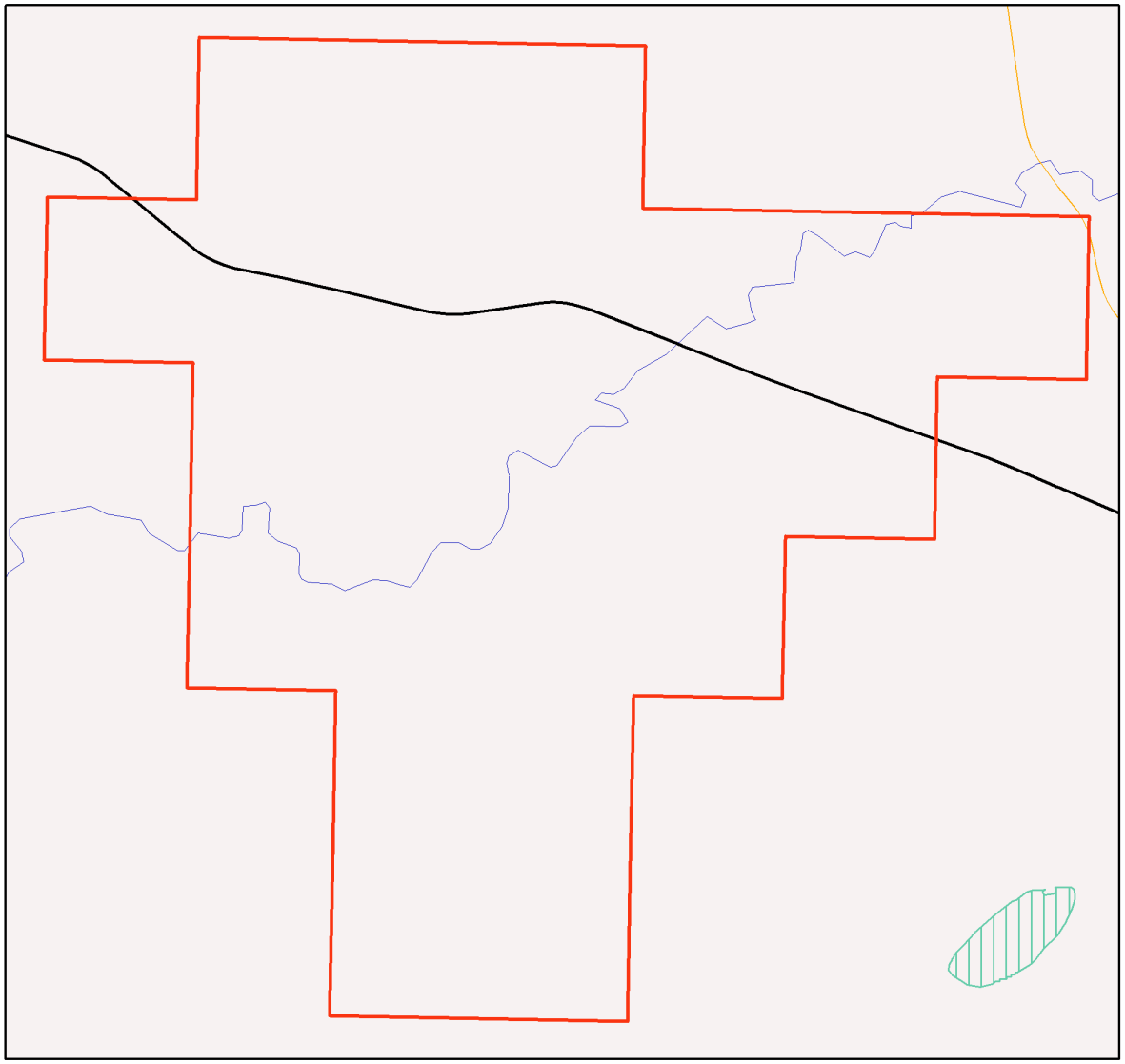
N

0 690 1380 2070 2760 3450 m

© The State of Queensland, 2018

This product is projected into GDA 1994 Queensland Albers

Map 2 - MSES - Wetlands and Waterways

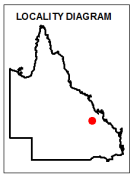


MSES - Wetlands and Waterways

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Declared high ecological value waters (watercourse)
- Strategic environmental area (designated precinct)
- Declared high ecological value waters (wetland)
- High ecological significance wetlands

LOCALITY DIAGRAM



Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the state of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

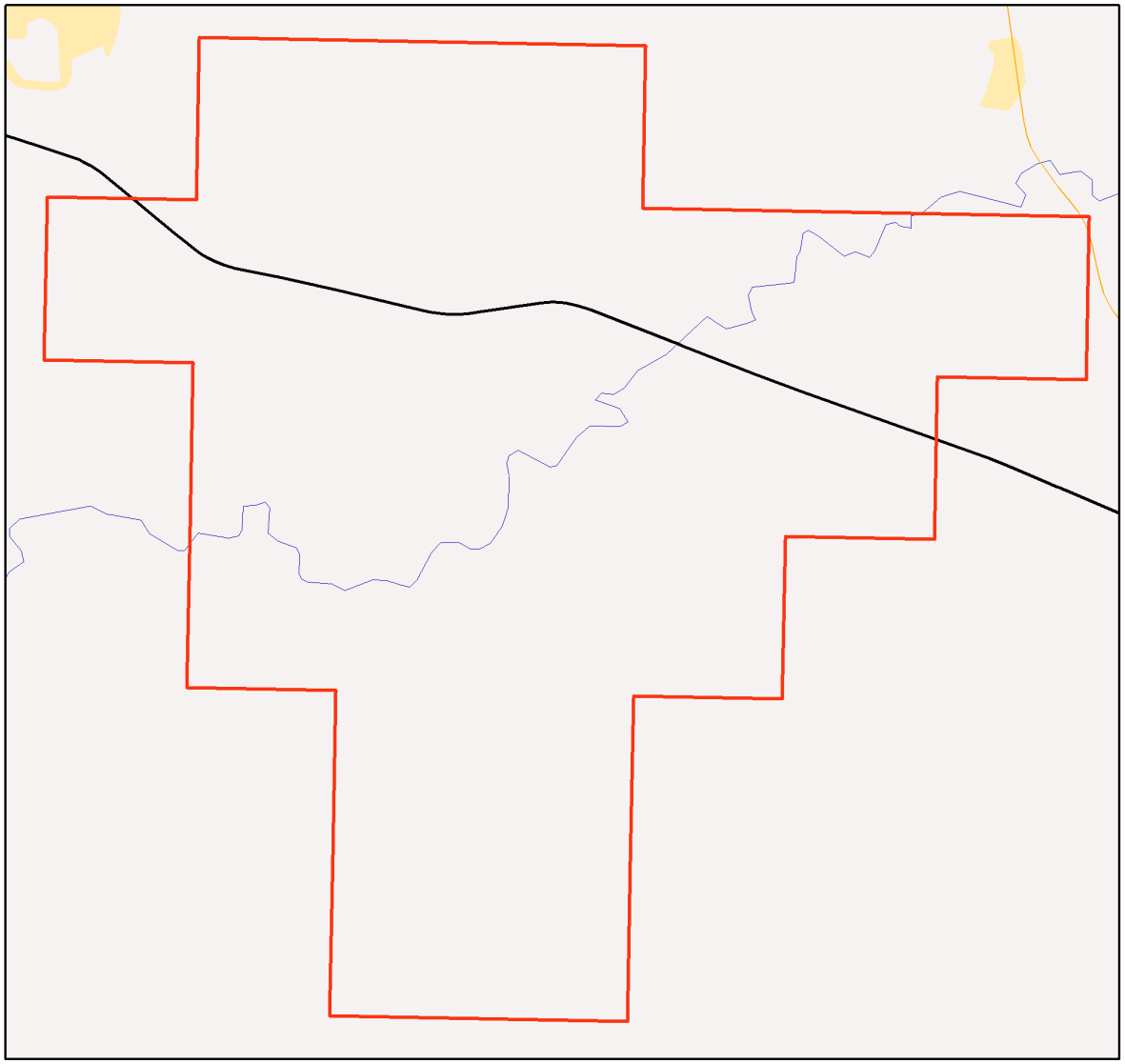
N

0 690 1380 2070 2760 3450 m

© The State of Queensland, 2018

This product is projected into GDA 1994 Queensland Albers

Map 3 - MSES - Species

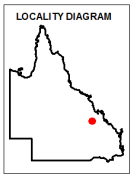


MSES - Species

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Threatened wildlife and special least concern animal

LOCALITY DIAGRAM



Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the state of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

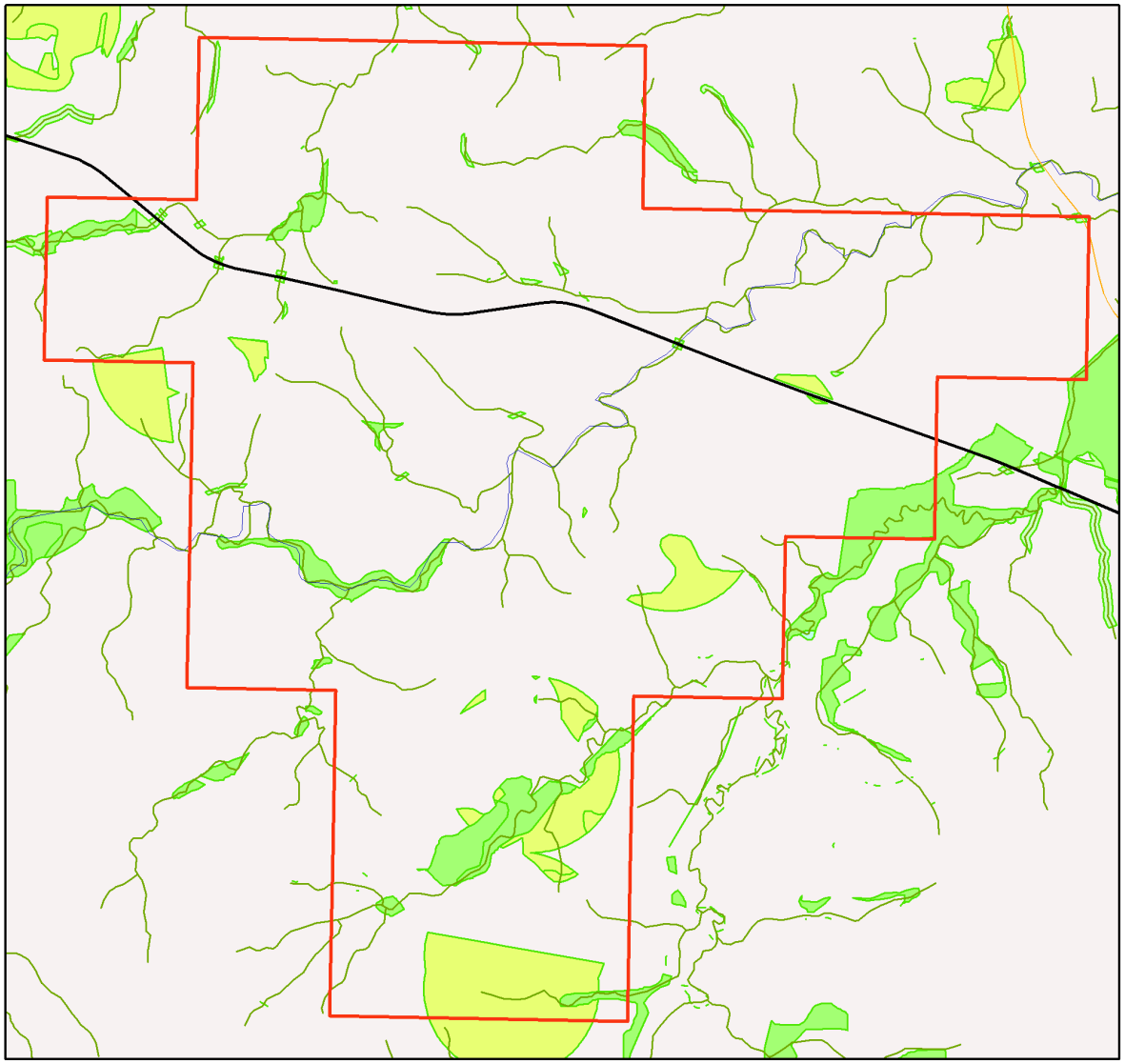
N

0 690 1380 2070 2760 3450 m

© The State of Queensland, 2018

This product is projected into GDA 1994 Queensland Albers

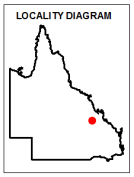
Map 4 - MSES - Regulated Vegetation



MSES - Regulated Vegetation

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Regulated vegetation (intersecting a watercourse)
- Regulated vegetation (100m from wetland)
- Regulated vegetation (category B - endangered or of concern)
- Regulated vegetation (category C - endangered or of concern)
- Regulated vegetation (category R - GBR riverine)
- Regulated vegetation (essential habitat)



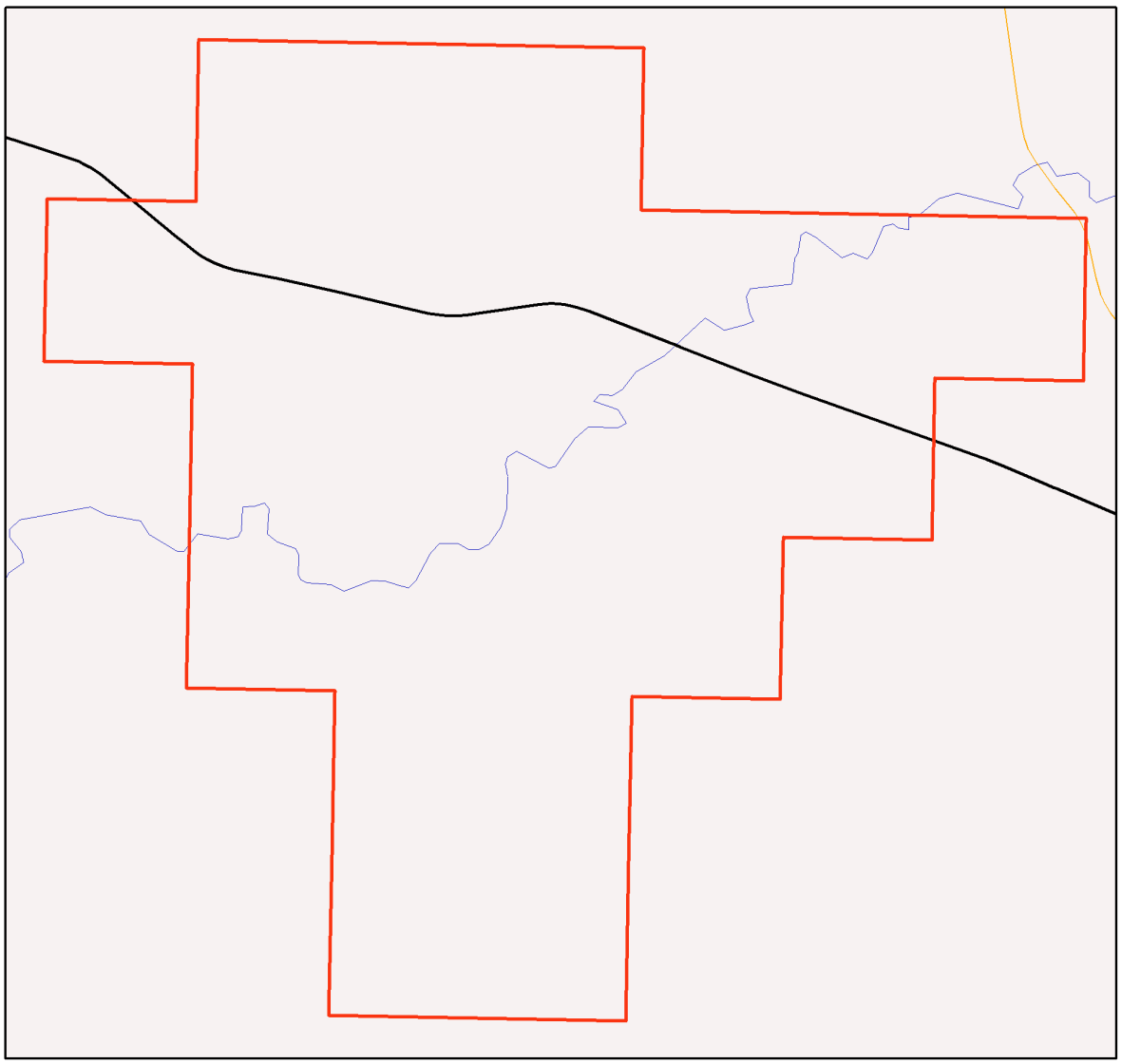
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the state of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

This product is projected into GDA 1994 Queensland Albers

© The State of Queensland, 2018

Map 5 - MSES - Offset Areas

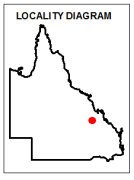


MSES - Offsets

Area of Interest

- Selected Exploration Permit Coal (EPC)
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Legally secured offset area (offset register)
- Legally secured offset area (vegetation offsets)

LOCALITY DIAGRAM



N

0 690 1380 2070 2760 3450 m

This product is projected into GDA 1994 Queensland Albers

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2018

Appendices

Appendix 1 - Matters of State Environmental Significance (MSES) methodology

MSES mapping is a regional-scale representation of the definition for MSES under the State Planning Policy (SPP). The compiled MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

The Queensland Government's "Method for mapping - matters of state environmental significance for use in land use planning and development assessment" can be downloaded from:

http://www.ehp.qld.gov.au/land/natural-resource/method-mapping-mses.html .

Appendix 2 - Source Data

The datasets listed below are available on request from:

http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

- Matters of State environmental significance

Note: MSES mapping is not based on new or unique data. The primary mapping product draws data from a number of underlying environment databases and geo-referenced information sources. MSES mapping is a versioned product that is updated generally on a twice-yearly basis to incorporate the changes to underlying data sources. Several components of MSES mapping made for the current version may differ from the current underlying data sources. To ensure accuracy, or proper representation of MSES values, it is strongly recommended that users refer to the underlying data sources and review the current definition of MSES in the State Planning Policy, before applying the MSES mapping.

Individual MSES layers can be attributed to the following source data available at QSpatial:

MSES layers	**current QSpatial data (http://qspatial.ingormation.qld.gov.au)**
Protected Areas-Estates and Nature Refuges	- Protected areas of Queensland - Nature Refuges - Queensland
Marine Park-Highly Protected Zones	Moreton Bay marine park zoning 2008
Fish Habitat Areas	Queensland fish habitat areas
Strategic Environmental Areas-designated	Regional Planning Interests Act - Strategic Environmental Areas
HES wetlands	Map of Referable Wetland - wetland layers: - Wetland management area wetlands - Wetland protection area wetlands
wetlands in HEV waters	HEV waters: - EPP Water (multiple locations) intent for waters Source Wetlands: - Queensland Wetland Mapping (Current version 4, 2015) Source Watercourses: - Vegetation management watercourse and drainage feature map (1:100000 and 1:250000) - latest version 1.4
Wildlife habitat (threatened and special least concern)	-WildNet database species records - habitat suitability models (various)
VMA regulated regional ecosystems	Vegetation management regional ecosystem and remnant map - latest version 8.0
VMA Essential Habitat	Vegetation management - essential habitat map - latest version 4.41
VMA Wetlands	Vegetation management wetlands map - latest version 2.41
Legally secured offsets	Vegetation Management Act property maps of assessable vegetation. For offset register data-contact DES
Regulated Vegetation Map	Vegetation management - regulated vegetation management map - latest version 1.41

Appendix 3 - Acronyms and Abbreviations

AOI	- Area of Interest
DES	- Department of Environment and Science
EP Act	- *Environmental Protection Act 1994*
EPP	- Environmental Protection Policy
GDA94	- Geocentric Datum of Australia 1994
GEM	- General Environmental Matters
GIS	- Geographic Information System
MSES	- Matters of State Environmental Significance
NCA	- *Nature Conservation Act 1992*
RE	- Regional Ecosystem
SPP	- State Planning Policy
VMA	- *Vegetation Management Act 1999*

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

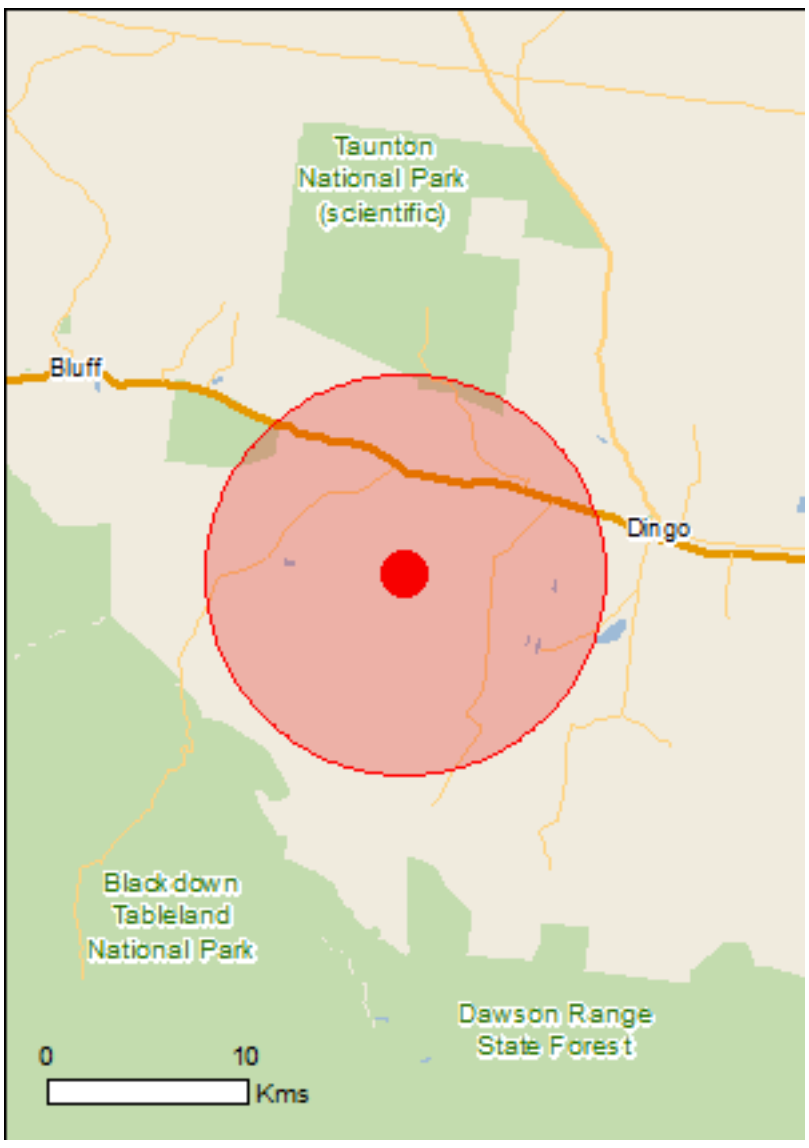
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 03/06/19 10:44:27

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

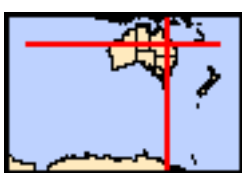
Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	25
Listed Migratory Species:	12

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	18
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	2
Regional Forest Agreements:	None
Invasive Species:	21
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area
Weeping Myall Woodlands	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat known to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species habitat may occur within area
Fish		
Maccullochella peelii Murray Cod [66633]	Vulnerable	Species or species habitat may occur within area
Mammals		

Name	Status	Type of Presence
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat likely to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Nyctophilus corbeni Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat may occur within area
Onychogalea fraenata Bridled Nail-tail Wallaby, Bridled Nailtail Wallaby [239]	Endangered	Species or species habitat known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Cadellia pentastylis Ooline [9828]	Vulnerable	Species or species habitat likely to occur within area
Dichanthium setosum bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area
Logania diffusa [24159]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat likely to occur within area
Denisonia maculata Ornamental Snake [1193]	Vulnerable	Species or species habitat may occur within area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat may occur within area
Elseya albagula Southern Snapping Turtle, White-throated Snapping Turtle [81648]	Critically Endangered	Species or species habitat likely to occur within area
Furina dunmalli Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area
Rheodytes leukops Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver [1761]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		

Name	Threatened	Type of Presence
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat likely to occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur

Name	Threatened	Type of Presence within area
[Ardea alba](#) Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
[Ardea ibis](#) Cattle Egret [59542]		Species or species habitat may occur within area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat may occur within area
[Chrysococcyx osculans](#) Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
[Gallinago hardwickii](#) Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
[Haliaeetus leucogaster](#) White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
[Merops ornatus](#) Rainbow Bee-eater [670]		Species or species habitat may occur within area
[Monarcha melanopsis](#) Black-faced Monarch [609]		Species or species habitat likely to occur within area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat may occur within area
[Myiagra cyanoleuca](#) Satin Flycatcher [612]		Species or species habitat may occur within area
[Pandion haliaetus](#) Osprey [952]		Species or species habitat likely to occur within area
[Rhipidura rufifrons](#) Rufous Fantail [592]		Species or species habitat may occur within area
[Rostratula benghalensis (sensu lato)](#) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Taunton	QLD
Wallaby Lane	QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Vachellia nilotica Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-23.66512 149.21782

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

© Commonwealth of Australia
Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

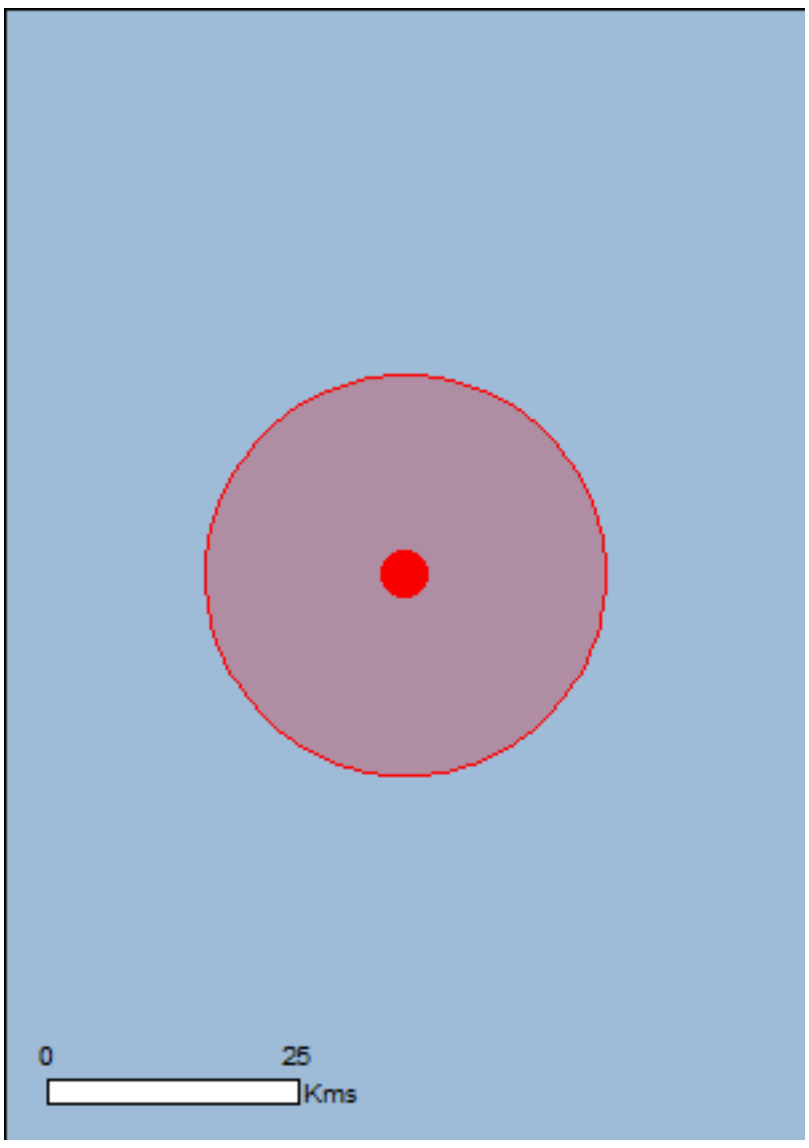
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 03/06/19 09:45:26

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

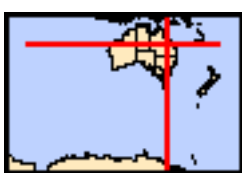
Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 20.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	4
Listed Threatened Species:	28
Listed Migratory Species:	15

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	21
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	4
Regional Forest Agreements:	None
Invasive Species:	21
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area
Natural Grasslands of the Queensland Central Highlands and northern Fitzroy Basin	Endangered	Community likely to occur within area
Weeping Myall Woodlands	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat known to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species habitat likely to occur within area
Fish		
Maccullochella peelii Murray Cod [66633]	Vulnerable	Species or species habitat may occur within

Name	Status	Type of Presence
		area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat likely to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Nyctophilus corbeni Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat may occur within area
Onychogalea fraenata Bridled Nail-tail Wallaby, Bridled Nailtail Wallaby [239]	Endangered	Species or species habitat known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Plants		
Cadellia pentastylis Ooline [9828]	Vulnerable	Species or species habitat likely to occur within area
Daviesia discolor [3567]	Vulnerable	Species or species habitat likely to occur within area
Dichanthium setosum bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area
Homoranthus decumbens a shrub [55186]	Endangered	Species or species habitat may occur within area
Logania diffusa [24159]	Vulnerable	Species or species habitat likely to occur within area
Macrozamia platyrhachis cycad [3412]	Endangered	Species or species habitat likely to occur within area
Reptiles		
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat known to occur within area
Denisonia maculata Ornamental Snake [1193]	Vulnerable	Species or species habitat known to occur within area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat known to occur within area
Elseya albagula Southern Snapping Turtle, White-throated Snapping Turtle [81648]	Critically Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Furina dunmalli		
Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area
Rheodytes leukops		
Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver [1761]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Marine Species		
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat known to occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat likely to occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Pandion haliaetus		
Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Chrysococcyx osculans		
Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat known to occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat likely to occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat likely to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Reptiles		
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Blackdown Tableland	QLD
Ghungalu	QLD
Taunton	QLD
Wallaby Lane	QLD

Invasive Species	[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus		
House Sparrow [405]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Vachellia nilotica Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-23.66512 149.21782

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

© Commonwealth of Australia
Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

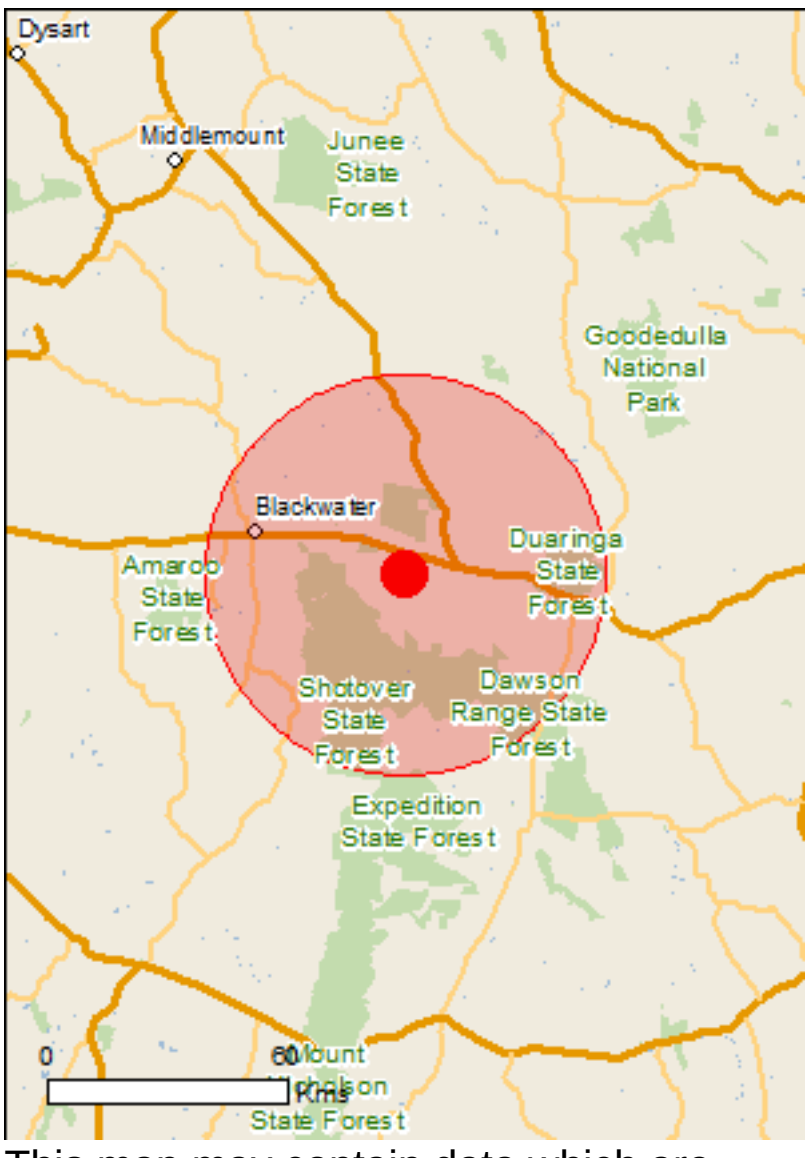
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 03/06/19 09:45:56

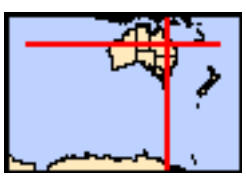
Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 50.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	39
Listed Migratory Species:	16

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	22
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	5
Regional Forest Agreements:	None
Invasive Species:	27
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area
Natural Grasslands of the Queensland Central Highlands and northern Fitzroy Basin	Endangered	Community likely to occur within area
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Endangered	Community likely to occur within area
Weeping Myall Woodlands	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat known to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Poephila cincta cincta Southern Black-throated Finch [64447]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Fish		
Maccullochella peelii		
Murray Cod [66633]	Vulnerable	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus hallucatus		
Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat likely to occur within area
Macroderma gigas		
Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Nyctophilus corbeni		
Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat may occur within area
Onychogalea fraenata		
Bridled Nail-tail Wallaby, Bridled Nailtail Wallaby [239]	Endangered	Species or species habitat known to occur within area
Petauroides volans		
Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour may occur within area
Plants		
Acacia grandifolia		
[3566]	Vulnerable	Species or species habitat known to occur within area
Aristida annua		
[17906]	Vulnerable	Species or species habitat likely to occur within area
Bertya opponens		
[13792]	Vulnerable	Species or species habitat likely to occur within area
Cadellia pentastylis		
Ooline [9828]	Vulnerable	Species or species habitat likely to occur within area
Cycas ophiolitica		
[55797]	Endangered	Species or species habitat likely to occur within area
Daviesia discolor		
[3567]	Vulnerable	Species or species habitat likely to occur within area
Dichanthium queenslandicum		
King Blue-grass [5481]	Endangered	Species or species habitat may occur within area
Dichanthium setosum		
bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Eucalyptus raveretiana Black Ironbox [16344]	Vulnerable	Species or species habitat likely to occur within area
Homoranthus decumbens a shrub [55186]	Endangered	Species or species habitat known to occur within area
Logania diffusa [24159]	Vulnerable	Species or species habitat likely to occur within area
Macrozamia platyrhachis cycad [3412]	Endangered	Species or species habitat likely to occur within area
Phaius australis Lesser Swamp-orchid [5872]	Endangered	Species or species habitat known to occur within area
Solanum dissectum [75720]	Endangered	Species or species habitat known to occur within area
Solanum johnsonianum [84820]	Endangered	Species or species habitat may occur within area
Reptiles		
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat known to occur within area
Denisonia maculata Ornamental Snake [1193]	Vulnerable	Species or species habitat known to occur within area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat known to occur within area
Elseya albagula Southern Snapping Turtle, White-throated Snapping Turtle [81648]	Critically Endangered	Species or species habitat known to occur within area
Furina dunmalli Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area
Rheodytes leukops Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver [1761]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Marine Species		
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat known to occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Species or species habitat likely to occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat likely to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii		
Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Defence - BLACKWATER TRAINING DEPOT

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		

Name	Threatened	Type of Presence
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat likely to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
[Rhipidura rufifrons](#) Rufous Fantail [592]		Species or species habitat may occur within area
[Rostratula benghalensis (sensu lato)](#) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Reptiles		
[Crocodylus porosus](#) Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Blackdown Tableland	QLD
Blackwater	QLD
Ghungalu	QLD
Taunton	QLD
Wallaby Lane	QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering		Species or species habitat likely to occur

Name	Status	Type of Presence
Cypress, Salt Cedar [16018] Vachellia nilotica		within area
Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-23.66512 149.21782

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

© Commonwealth of Australia
Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: Native
Status: Rare and threatened species
Records: All
Date: All
Latitude: -23.6651
Longitude: 149.2178
Distance: 10
Email: ceales@aarc.net.au
Date submitted: Monday 03 Jun 2019 10:43:03
Date extracted: Monday 03 Jun 2019 10:50:02

The number of records retrieved = 9

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Columbidae	*Geophaps scripta scripta*	squatter pigeon (southern subspecies)		V	V	15
animals	mammals	Macropodidae	*Onychogalea fraenata*	bridled nailtail wallaby		E	E	6
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		V	V	1
animals	mammals	Pseudocheiridae	*Petauroides volans*	greater glider		V	V	1
animals	mammals	Pseudocheiridae	*Petauroides volans volans*	southern greater glider		V	V	1
animals	reptiles	Diplodactylidae	*Strophurus taenicauda*	golden-tailed gecko		NT		2
plants	Equisetopsida	Apocynaceae	*Cerbera dumicola*			NT		2/2
plants	Equisetopsida	Orchidaceae	*Corunastylis pedersonii*			V		1/1
plants	Equisetopsida	Solanaceae	*Solanum elachophyllum*			E		1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government Wildlife Online - Extract Date 03/06/2019 at 10:50:02

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: Native
Status: Rare and threatened species
Records: All
Date: All
Latitude: -23.6651
Longitude: 149.2178
Distance: 20
Email: ceales@aarc.net.au
Date submitted: Monday 03 Jun 2019 10:01:02
Date extracted: Monday 03 Jun 2019 10:10:11

The number of records retrieved = 32

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Limnodynastidae	*Adelotus brevis*	tusked frog		V		9
animals	birds	Accipitridae	*Erythrotriorchis radiatus*	red goshawk		E	V	1
animals	birds	Cacatuidae	*Calyptorhynchus lathami*	glossy black-cockatoo		V		2
animals	birds	Cacatuidae	*Calyptorhynchus lathami erebus*	glossy black-cockatoo (northern)		V		9/1
animals	birds	Columbidae	*Geophaps scripta scripta*	squatter pigeon (southern subspecies)		V	V	23
animals	mammals	Dasyuridae	*Antechinus argentus*	silver-headed antechinus		V	E	23
animals	mammals	Macropodidae	*Onychogalea fraenata*	bridled nailtail wallaby		E	E	37
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		V	V	6
animals	mammals	Pseudocheiridae	*Petauroides volans*	greater glider		V	V	3
animals	mammals	Pseudocheiridae	*Petauroides volans volans*	southern greater glider		V	V	40
animals	reptiles	Diplodactylidae	*Strophurus taenicauda*	golden-tailed gecko		NT		10/1
animals	reptiles	Pygopodidae	*Delma torquata*	collared delma		V	V	1
plants	Equisetopsida	Apocynaceae	*Cerbera dumicola*			NT		3/3
plants	Equisetopsida	Arecaceae	*Livistona fulva*			V		9/9
plants	Equisetopsida	Asteraceae	*Rutidosis glandulosa*			NT		7/7
plants	Equisetopsida	Byttneriaceae	*Commersonia pearnii*			E		2/2
plants	Equisetopsida	Euphorbiaceae	*Bertya pedicellata*			NT		2
plants	Equisetopsida	Fabaceae	*Daviesia discolor*			V	V	3/3
plants	Equisetopsida	Fabaceae	*Daviesia quoquoversus*			V		2/2
plants	Equisetopsida	Lamiaceae	*Plectranthus blakei*			NT		9/9
plants	Equisetopsida	Loganiaceae	*Logania diffusa*			V	V	3/2
plants	Equisetopsida	Mimosaceae	*Acacia storyi*			NT		8/6
plants	Equisetopsida	Myrtaceae	*Melaleuca pearsonii*			NT		10/10
plants	Equisetopsida	Myrtaceae	*Baeckea trapeza*			V		7/7
plants	Equisetopsida	Myrtaceae	*Melaleuca groveana*			NT		5/4
plants	Equisetopsida	Orchidaceae	*Corunastylis pedersonii*			V		1/1
plants	Equisetopsida	Orchidaceae	*Gastrodia crebriflora*			V		1/1
plants	Equisetopsida	Orchidaceae	*Corunastylis valida*			V		1/1
plants	Equisetopsida	Picrodendraceae	*Pseudanthus pauciflorus subsp. arenicola*			NT		2/1
plants	Equisetopsida	Solanaceae	*Solanum adenophorum*			E		9/8
plants	Equisetopsida	Solanaceae	*Solanum elachophyllum*			E		7/5
plants	Equisetopsida	Zamiaceae	*Macrozamia platyrhachis*			E	E	19/8

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: Native
Status: Rare and threatened species
Records: All
Date: All
Latitude: -23.6651
Longitude: 149.2178
Distance: 50
Email: ceales@aarc.net.au
Date submitted: Monday 03 Jun 2019 10:00:25
Date extracted: Monday 03 Jun 2019 10:10:03

The number of records retrieved = 49

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Limnodynastidae	*Adelotus brevis*	tusked frog		V		10
animals	birds	Accipitridae	*Erythrotriorchis radiatus*	red goshawk		E	V	15
animals	birds	Cacatuidae	*Calyptorhynchus lathami*	glossy black-cockatoo		V		4
animals	birds	Cacatuidae	*Calyptorhynchus lathami erebus*	glossy black-cockatoo (northern)		V		19/2
animals	birds	Columbidae	*Geophaps scripta scripta*	squatter pigeon (southern subspecies)		V	V	44
animals	birds	Estrildidae	*Poephila cincta cincta*	black-throated finch (white-rumped subspecies)		E	E	4/1
animals	birds	Meliphagidae	*Grantiella picta*	painted honeyeater		V	V	3
animals	birds	Pedionomidae	*Pedionomus torquatus*	plains-wanderer		V	CE	1
animals	birds	Psittacidae	*Lathamus discolor*	swift parrot		E	CE	1
animals	birds	Psittacidae	*Psephotus pulcherrimus*	paradise parrot		PE	EX	9/2
animals	birds	Strigidae	*Ninox strenua*	powerful owl		V		3
animals	birds	Turnicidae	*Turnix melanogaster*	black-breasted button-quail		V	V	7
animals	insects	Lycaenidae	*Jalmenus eubulus*	pale imperial hairstreak		V		5
animals	mammals	Dasyuridae	*Antechinus argentus*	silver-headed antechinus		V	E	23
animals	mammals	Macropodidae	*Onychogalea fraenata*	bridled nailtail wallaby		E	E	41
animals	mammals	Phascolarctidae	*Phascolarctos cinereus*	koala		V	V	14
animals	mammals	Potoroidae	*Bettongia gaimardi gaimardi*	eastern bettong		PE	EX	4
animals	mammals	Pseudocheiridae	*Petauroides volans volans*	southern greater glider		V	V	71
animals	mammals	Pseudocheiridae	*Petauroides volans*	greater glider		V	V	3
animals	mammals	Vespertilionidae	*Chalinolobus dwyeri*	large-eared pied bat		V	V	2
animals	reptiles	Chelidae	*Elseya albagula*	southern snapping turtle		E	CE	2
animals	reptiles	Chelidae	*Rheodytes leukops*	Fitzroy River turtle		V	V	1
animals	reptiles	Diplodactylidae	*Strophurus taenicauda*	golden-tailed gecko		NT		10/1
animals	reptiles	Elapidae	*Denisonia maculata*	ornamental snake		V	V	2
animals	reptiles	Pygopodidae	*Delma torquata*	collared delma		V	V	1
plants	Equisetopsida	Apocynaceae	*Cerbera dumicola*			NT		6/6
plants	Equisetopsida	Arecaceae	*Livistona fulva*			V		16/12
plants	Equisetopsida	Asteraceae	*Rutidosis glandulosa*			NT		7/7
plants	Equisetopsida	Byttneriaceae	*Commersonia pearnii*			E		2/2
plants	Equisetopsida	Euphorbiaceae	*Bertya pedicellata*			NT		3
plants	Equisetopsida	Fabaceae	*Daviesia quoquoversus*			V		7/2
plants	Equisetopsida	Fabaceae	*Daviesia discolor*			V	V	8/6
plants	Equisetopsida	Lamiaceae	*Plectranthus blakei*			NT		10/10
plants	Equisetopsida	Loganiaceae	*Logania diffusa*			V	V	4/2
plants	Equisetopsida	Mimosaceae	*Acacia storyi*			NT		21/17
plants	Equisetopsida	Myrtaceae	*Melaleuca pearsonii*			NT		13/12
plants	Equisetopsida	Myrtaceae	*Baeckea trapeza*			V		7/7
plants	Equisetopsida	Myrtaceae	*Sannantha brachypoda*			V		1/1
plants	Equisetopsida	Myrtaceae	*Melaleuca groveana*			NT		6/4
plants	Equisetopsida	Orchidaceae	*Phaius australis*			E	E	5/3
plants	Equisetopsida	Orchidaceae	*Corunastylis pedersonii*			V		1/1
plants	Equisetopsida	Orchidaceae	*Gastrodia crebriflora*			V		1/1
plants	Equisetopsida	Orchidaceae	*Corunastylis valida*			V		1/1
plants	Equisetopsida	Picrodendraceae	*Pseudanthus pauciflorus subsp. arenicola*			NT		2/1
plants	Equisetopsida	Solanaceae	*Solanum dissectum*			E	E	3/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	Equisetopsida	Solanaceae	*Solanum adenophorum*			E		12/10
plants	Equisetopsida	Solanaceae	*Solanum elachophyllum*			E		17/14
plants	Equisetopsida	Surianaceae	*Cadellia pentastylis*	ooline		V	V	5/4
plants	Equisetopsida	Zamiaceae	*Macrozamia platyrhachis*			E	E	55/30

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Appendix B AARC AusRivAS Physical Assessment Results

Characteristic	DWR1				
Bank Shape	**Left Bank**		**Right Bank**		
	Concave		Concave		
Bank Slope	**Left Bank**		**Right Bank**		
	30°		35°		
Associated Watercourse	Stanley Creek				
Factors Affecting Bank Stability	High presence of weeds, low tree density				
Artificial Bank Stability Features	Highway culvert, rocks added to stream bed, fence line				
Large Woody Debris	1%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	NA	None	NA	None	NA
Water Level	Dry at time of survey				
Bare Ground	Low (1-10%)				
Exposed Tree Roots	Low (1-10%), primarily at the base of trees at fence line				
Gully Erosion	Low (1-10%)				
Bank Slumping	None				
Local Catchment Erosion	None				

Characteristic	DWR4				
Bank Shape	**Left Bank**		**Right Bank**		
	Concave		Concave		
Bank Slope	**Left Bank**		**Right Bank**		
	flat		flat		
Associated Watercourse	Charlevue Creek				
Factors Affecting Bank Stability	Bank highly stable, small depression area				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	2%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	NA	None	NA	None	NA
Water Level	Dry at time of survey				
Bare Ground	None				
Exposed Tree Roots	None				
Gully Erosion	None				
Bank Slumping	None				
Local Catchment Erosion	None				

B

Characteristic	DWR5				
Bank Shape	**Left Bank**		**Right Bank**		
	Concave		Concave		
Bank Slope	**Left Bank**		**Right Bank**		
	65°		50°		
Associated Watercourse	Charlevue Creek				
Factors Affecting Bank Stability	Low ground cover on edges, high cattle traffic, cleared area, high weed presence				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	10%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	Turbid	None	None	None	None
Water Level	0.3 m				
Bare Ground	Low (1-10%)				
Exposed Tree Roots	Low (1-10%)				
Gully Erosion	Low (1-10%)				
Bank Slumping	Some (10-50%)				
Local Catchment Erosion	Moderate (50-75%) primarily in areas of high				

Characteristic	DWR6				
Bank Shape	**Left Bank**		**Right Bank**		
	Concave		Concave		
Bank Slope	**Left Bank**		**Right Bank**		
	flat		flat		
Associated Watercourse	Springton Creek				
Factors Affecting Bank Stability	-				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	2%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	NA	None	NA	None	NA
Water Level	Dry at time of survey				
Bare Ground	Low (1-10%)				
Exposed Tree Roots	None				
Gully Erosion	Low (1-10%)				
Bank Slumping	None				
Local Catchment Erosion	Low (1-10%)				

B

Characteristic	DWI1				
Bank Shape	**Left Bank**		**Right Bank**		
	Convex		Concave		
Bank Slope	**Left Bank**		**Right Bank**		
	30°		20°		
Associated Watercourse	Stanley Creek				
Factors Affecting Bank Stability	Low ground cover on edges, high weed presence				
Artificial Bank Stability Features	Farmer dam, access tracks, fence line				
Large Woody Debris (%)	0%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	NA	None	NA	None	NA
Water Level	Dry at time of survey				
Bare Ground	Low (1-10%)				
Exposed Tree Roots	None				
Gully Erosion	None				
Bank Slumping	None				
Local Catchment Erosion	Some (10-50%)				

Characteristic	DWI3				
Bank Shape	**Left Bank**		**Right Bank**		
	Convex		Convex		
Bank Slope	**Left Bank**		**Right Bank**		
	85°		85°		
Associated Watercourse	Charlevue Creek				
Factors Affecting Bank Stability	Low ground cover on edges, steep banks, high cattle traffic, low presence of mature trees				
Artificial Bank Stability Features	Creek crossing				
Large Woody Debris (%)	5%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	NA	None	NA	None	NA
Water Level	Dry at time of survey				
Bare Ground	Low (1-10%)				
Exposed Tree Roots	Low (1-10%)				
Gully Erosion	Some (10-50%)				
Bank Slumping	Moderate (50-75%)				
Local Catchment Erosion	Moderate (50-75%)				

B

Characteristic	DWI6				
Bank Shape	**Left Bank**		**Right Bank**		
	Convex		Convex		
Bank Slope	**Left Bank**		**Right Bank**		
	80°		75°		
Associated Watercourse	Springton Creek				
Factors Affecting Bank Stability	Low ground cover on edges				
Artificial Bank Stability Features	Located at highway crossing, large bridge, concrete base in areas				
Large Woody Debris (%)	0%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	Turbid	None	None	None	None
Water Level	0.8 m				
Bare Ground	Low (1-10%)				
Exposed Tree Roots	Some (10-50%)				
Gully Erosion	Moderate (50-75%)				
Bank Slumping	Moderate (50-75%)				
Local Catchment Erosion	Some (10-50%)				

B

Characteristic	DWI8				
Bank Shape	**Left Bank**			**Right Bank**	
	Convex			Convex	
Bank Slope	**Left Bank**			**Right Bank**	
	75°			85°	
Associated Watercourse	Springton Creek				
Factors Affecting Bank Stability	Low vegetation cover on edges, steep bank edges, heavy clearing in surrounding areas, high cattle traffic				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	30%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	NA	None	NA	None	NA
Water Level	Dry at time of survey				
Bare Ground	Moderate (50-75%)				
Exposed Tree Roots	Moderate (50-75%)				
Gully Erosion	Extensive (>75%)				
Bank Slumping	Moderate (50-75%)				
Local Catchment Erosion	Some (10-50%)				

Characteristic	DWI9				
Bank Shape	**Left Bank**			**Right Bank**	
	Concave			Concave	
Bank Slope	**Left Bank**			**Right Bank**	
	35°			15°	
Associated Watercourse	Springton Creek				
Factors Affecting Bank Stability	Weed presence, low ground cover presence, signs of water logging				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	10%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	Turbid	None	None	None	None
Water Level	0.4 m				
Bare Ground	Low (1-10%)				
Exposed Tree Roots	None				
Gully Erosion	Low (1-10%)				
Bank Slumping	Low (1-10%)				
Local Catchment Erosion	Some (10-50%)				

B

Characteristic	DAR1				
Bank Shape	**Left Bank**		**Right Bank**		
	Concave		Convex		
Bank Slope	**Left Bank**		**Right Bank**		
	45°		60°		
Associated Watercourse	Charlevue Creek				
Factors Affecting Bank Stability	Low ground cover on edges, steep bank, exposed roots, signs of flooding, cattle access, high weed presence				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	20%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	Turbid	None	None	None	None
Water Level	0.4 m				
Bare Ground	Moderate (50-75%)				
Exposed Tree Roots	Low (1-10%)				
Gully Erosion	None				
Bank Slumping	Some (10-50%)				
Local Catchment Erosion	Low (1-10%)				

B

Characteristic	DAI1				
Bank Shape	**Left Bank**		**Right Bank**		
	Concave		Convex		
Bank Slope	**Left Bank**		**Right Bank**		
	55°		70°		
Associated Watercourse	Charlevue Creek				
Factors Affecting Bank Stability	Low ground cover on edges, steep banks, high weed presence				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	40%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	Turbid	None	None	None	None
Water Level	0.4 m				
Bare Ground	Moderate (50-75%)				
Exposed Tree Roots	Low (1-10%)				
Gully Erosion	Low (1-10%)				
Bank Slumping	Low (1-10%)				
Local Catchment Erosion	Extensive (>75%)				

Characteristic	DAI2				
Bank Shape	**Left Bank**		**Right Bank**		
	Concave		Concave		
Bank Slope	**Left Bank**		**Right Bank**		
	35°		25°		
Associated Watercourse	Charlevue Creek				
Factors Affecting Bank Stability	Low ground cover on edges, cattle access				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	10%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	Turbid	None	None	None	None
Water Level	0.4 m				
Bare Ground	Low (1-10%)				
Exposed Tree Roots	Moderate (50-75%)				
Gully Erosion	Some (10-50%)				
Bank Slumping	Some (10-50%)				
Local Catchment Erosion	Low (1-10%)				

B

Characteristic	DAI3				
Bank Shape	**Left Bank**		**Right Bank**		
	Convex		Concave		
Bank Slope	**Left Bank**		**Right Bank**		
	30°		70°		
Associated Watercourse	Charlevue Creek				
Factors Affecting Bank Stability	Low ground cover on edges, cattle access				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	20%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	Turbid	None	Slick	Algal	None
Water Level	0.3 m				
Bare Ground	Low (1-10%)				
Exposed Tree Roots	Some (10-50%)				
Gully Erosion	Some (10-50%)				
Bank Slumping	Moderate (50-75%)				
Local Catchment Erosion	Some (10-50%)				

Characteristic	DAI4				
Bank Shape	**Left Bank**		**Right Bank**		
	Concave		Concave		
Bank Slope	**Left Bank**		**Right Bank**		
	45°		30°		
Associated Watercourse	Charlevue Creek				
Factors Affecting Bank Stability	Low ground cover on edges, cattle access, flooding, high exposed roots, access tracks				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	10%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	Turbid	None	None	None	None
Water Level	0.4 m				
Bare Ground	Some (10-50%)				
Exposed Tree Roots	Moderate (50-75%)				
Gully Erosion	Some (10-50%)				
Bank Slumping	Moderate (50-75%)				
Local Catchment Erosion	Some (10-50%)				

B

Characteristic	DAI5				
Bank Shape	**Left Bank**			**Right Bank**	
	Concave			Concave	
Bank Slope	**Left Bank**			**Right Bank**	
	85°			85°	
Associated Watercourse	Springton Creek				
Factors Affecting Bank Stability	Steep bank edges, bank slumping				
Artificial Bank Stability Features	None				
Large Woody Debris (%)	20%				
Turbidity, Water and Sediment Oils and Odours	**Turbidity**	**Sediment Oils**	**Water Oils**	**Sediment Odours**	**Water Odours**
	Turbid	None	None	None	None
Water Level	0.6 m				
Bare Ground	Low (1-10%)				
Exposed Tree Roots	Low (1-10%)				
Gully Erosion	Some (10-50%)				
Bank Slumping	Low (1-10%)				
Local Catchment Erosion	Some (10-50%)				

B

Appendix C Macroinvertebrate Sampling Results

Class/Order	Family/Sub-family	SIGNAL 2 Value	DAI4	DAI1	DAI2	DAI3	DAI5	DAR1	DRW5	DWI9	DWI6
Cladocera	sp.	N/A	16	12	60	1	17	27	200		66
Coleoptera	Dytiscidae	2		3	3			3	4	2	1
Coleoptera	Gyrinidae	4		1							
Coleoptera	Hydraenidae	3						1	1	1	
Coleoptera	Scirtidae	6		5	2				1	6	
Coleoptera	Nanophyidae	3			1						
Copepoda	sp.	N/A	16	15	60		23	46	350	113	24
Decapoda	Atyidae	3			2						
Decapoda	Palaemonidae	4			2						
Decapoda	Parastacidae	4							1		1
Decapoda	Parathelphusidae	3		3						1	
Diptera	Chaoboridae	2	4	13	10			4		2	3
Diptera	Culicidae	1	6	8	20		2		12	22	12
Diptera	Ceratopogonidae	4				1					
Diptera	Dolichopodidae	3									1
Diptera	Tanypodinae	4			2						
Diptera	Chironominae	3			2			4			1
Ephemeroptera	Baetidae	5	1	1	2			1			
Gastropoda	Planorbidae	2			4						
Hemiptera	Veliidae	3	18	1	2			1	47	14	6
Hemiptera	Gerridae	4									2
Hemiptera	Nepidae	3			1						
Hemiptera	Notonectidae	1			1				2	1	1
Hemiptera	Micronectidae	2			3				5		2
Nematoda	sp.	3	1	1					1	25	3
Odonata	Isostictidae	3				1					
Oligochaeta	sp.	2	2		1		2	1		2	
Ostracoda	sp.	N/A						1	1		2
Turbellaria	Temnocephalidae	5								1	

C

Appendix D Riparian and Aquatic Vegetation Species List

Scientific Name	Common Name	NC Act/ Biosecurity Act Status	EPBC Act Status	DWR1	DWR4	DWR5	DWR6	DWI1	DWI3	DWI6	DWI8	DWI9	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5
Acacia cretata		LC	-	x		x	x	x		x		x						x
Acacia excelsa	Ironwood	LC	-			x			x									
Acacia salicina		LC	-			x				x	x							
Acacia tetragonophylla	Dead finish	LC	-			x												
Acalypha eremorum	Soft acalypha	LC	-												x			
Acanthospermum hispidum	Starrburr	I	-					x										
Afrohybanthus enneaspermus		LC	-								x							
Agave americana	Agave	I	-							x								
Ageratum houstonianum	Billy goat weed	LC	-					x			x							
Alectryon diversifolius	Hollybush	LC	-										x	x				
Allocasuarina leuhmanii	Bulloak	LC	-								x							
Alphitonia excelsa	Soap tree	LC	-	x			x	x	x		x	x	x					
Aristida calycina	Dark wire grass	LC	-			x			x		x							
Aristida latifolia		LC	-										x					x
Atalaya hemiglauca	Whitewood	LC	-										x	x		x	x	x
Bauhinia carronii		LC	-										x	x	x	x	x	
Bidens pilosa	Cobblers peggs	I	-										x	x	x			
Bothriochloa pertusa		I	-			x	x	x		x			x		x	x		x
Bryophyllum daigremontianum	Mother of thousands	RI	-					x										
Bryophyllum delagoense	Mother of millions	RI	-													x		
Bulbostylis barbata	Dainty sedge	LC	-			x					x		x		x	x	x	x
Capparis laisantha	Nipan	LC	-						x	x								x
Capparis mitchellii		LC	-			x												
Carissa spinarum	Currant bush	LC	-			x		x		x			x			x	x	x
Cassia brewsteri		LC	-					x						x			x	

D

Scientific Name	Common Name	NC Act/ Biosecurity Act Status	EPBC Act Status	DWR1	DWR4	DWR5	DWR6	DWI1	DWI3	DWI6	DWI8	DWI9	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5
Casuarina cunninghamiana		LC	-										x	x	x			
Cenchrus ciliaris	Buffel grass	I	-			x		x	x		x		x		x		x	
Cheilanthes sieberi subsp sieberi	Poison rock fern	LC	-						x									
Chloris gayana	Rhodes grass	I	-				x		x	x		x						
Chloris inflata		I	-				x			x								
Chrysocephalum apiculatum	Yellow button	LC	-						x		x							
Commelina diffusa	Native wandering jew	LC	-				x							x	x			x
Coreopsis lanceolata	Coreopsis	I	-					x										
Corymbia clarksoniana		LC	-				x		x		x							x
Corymbia tessellaris		LC	-	x					x				x					x
Crolataria pallida		I	-		x			x										
Crotalaria montana		LC	-							x								
Cryptostegia grandiflora	Rubber vine	RI	WoNS							x			x		x			
Cyanthillium cinereum		LC	-													x		
Cynodon dactylon	Couch grass	I	-		x													
Cyperus rotundus	Nut grass	I	-													x		
Dactyloctenium radulans	Button grass	LC	-		x													
Desmodium variance	Small leaved ebony	LC	-								x							
Diospyros humilis		LC	-														x	
Echinochloa colona	Awnless barnyard grass	I	-		x													
Enneapogon lindleyanus		LC	-						x									
Enteropogon acicularis	Curly windmill grass	LC	-					x	x	x	x	x			x	x	x	
Eragrostis elongata		LC	-		x						x							
Eragrostis trichophora		I	-							x								x
Erythrina vespertilio	Batwing coral tree	LC	-												x			

D

Scientific Name	Common Name	NC Act/ Biosecurity Act Status	EPBC Act Status	DWR1	DWR4	DWR5	DWR6	DWI1	DWI3	DWI6	DWI8	DWI9	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5
Erythroxylum australe	Cocaine bush	LC	-			x										x		
Eucalyptus camaldulensis	River red gum	LC	-	x		x	x	x	x	x		x	x	x	x	x	x	x
Eucalyptus crebra		LC	-			x	x											
Eucalyptus dallachiana		LC	-			x				x								
Euphorbia drumondii		LC	-		x													
Eustrephus latifolius	Wombat berry	LC	-										x		x	x	x	x
Everstia vaccinifolia		LC	-														x	
Evolvulus alsinoides		LC	-			x												
Ficus opposita	Sandpaper fig	LC	-										x	x		x		
Galactia tenuiflora		LC	-				x			x	x				x	x		x
Glinus lotoides	Hairy carpet weed	LC	-		x		x				x							
Glycine sp.		LC	-													x		x
Gomphrena celosioides	Gomphrena weed	I	-		x	x				x								
Grewia retusifolia	Dogs balls	LC	-						x						x	x		x
Harrisia martinii		RI	-														x	
Heteropogon contortus	Black spear grass	LC	-				x	x	x	x	x	x						
Hibiscus heterophyllus		LC	-										x					
Imperata cylindrica	Blady grass	LC	-						x	x								
Indigofera tinctoria	True indigo	I	-															x
Ipomoea plebeia	Bellvine	LC	-								x							
Lantana camara	Lantana	RI	WoNS									x						
Lobelia concolor	Poison pratia	LC	-												x			
Lomandra longifolia		LC	-	x						x			x	x	x		x	x
Lophostemon grandiflorus		LC	-							x			x	x	x	x	x	x
Ludwigia octovalvis	Willow primrose	LC	-		x													

D

Scientific Name	Common Name	NC Act/ Biosecurity Act Status	EPBC Act Status	DWR1	DWR4	DWR5	DWR6	DWI1	DWI3	DWI6	DWI8	DWI9	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5
Macroptilium atropurpureum	Siratro	I	-	x				x						x	x			x
Malvastrum americanum	Malvastrum	I	-									x	x					
Megathyrus maximus		I	-	x				x		x		x	x	x	x	x	x	x
Melaleuca nervosa		LC	-				x		x		x	x						
Melinis repens	Red natal grass	I	-								x	x						
Mimosa pigra	Mimosa	I	WoNS												x			
Mimosa pudica	Sensitive plant	I	-												x	x		
Murdannia gramenea		LC	-				x											
Opuntia tomentosa	Velvety Tree Pear	RI	WoNS	x			x									x		x
Oxalis sp		-	-								x							
Parthenium hysterophorus	Parthenium	RI	WoNS									x	x	x	x	x		
Passiflora foetida	Stinking passionflower	I	-	x									x	x	x	x		x
Perotis rara	Comet grass	LC	-						x		x							
Petalostigma pubescens	Quinine tree	LC	-						x		x							
Phyllantus virgatus		LC	-						x									
Plumbago zeylanica		LC	-												x			
Portulaca pilosa		I	-			x					x							
Rhynochosia minima	Rycho	LC	-		x								x					
Riccinis communis	Casteroil bush	I	-											x				
Rostellularia adscendacea		LC	-			x												
Santalatum lanceolatum		LC	-					x										
Scleroleana lanicuspis	Woolly copper burr	LC	-						x									x
Scoparia dulcis		I	-						x		x							
Sida acuta	Narrow leaved sida	I	-	x				x			x							
Sida cordifolia	Flannel weed	I	-	x														

D

Scientific Name	Common Name	NC Act/ Biosecurity Act Status	EPBC Act Status	DWR1	DWR4	DWR5	DWR6	DWI1	DWI3	DWI6	DWI8	DWI9	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5
Sida rhombifolia		I	-							x			x					
Sida subspicata		LC	-	x		x	x	x	x	x	x	x			x	x	x	x
Sporobolos sp			-				x	x		x			x					
Stachytarpheta cayennensis	Purple snake weed	I	-	x				x		x								
Stylosanthes scabra	Smooth stylo	I	-			x	x	x	x	x		x						
Stylosanthes viscosa	Sticky stylo	I	-	x		x	x	x		x	x	x	x			x		x
Terminalia oblongata		LC	-												x	x	x	
Themeda triandra	Kangaroo grass	LC	-				x			x		x	x					x
Urochloa mosambicensis	Sabi grass	LC	-		x	x	x			x			x	x	x	x	x	x
Verbena rigida	Veined verbana	I	-												x			
Xanthium occidentale	Noogoora burr	I	-	x				x					x	x	x			
	Orchid sp		-				x											

LC - Least Concern
I - Introduced
WoNS – Weed of National Significance
RI – Restricted Invasive Species

D

Appendix E Riparian Zone Vertebrate Fauna Species List

Family	*Scientific Name*	Common Name	NC Act/Biosecurity Act Status	EPBC Act status	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5	Total
Reptiles											
Colubridae	*Tropidonophis mairii*	Keelback snake	LC	-		1					1
Agamidae	*Diporiphora australis*	Tommy roundhead	LC	-					1		1
Gekkonidae	*Gehyra dubia*	Dubious dtella	LC	-		3	1				4
Scincidae	*Carlia rubigo*	Orange-flanked rainbow-skink	LC	-	2	3	1	2	2	1	11
Scincidae	*Morethia boulengeri*	South-eastern morethia Skink	LC	-				1			1
Scincidae	*Cryptoblepharus virgatus*	Wall skink	LC	-					1		1
Scincidae	*Menetia greyii*	Common dwarf skink	LC	-			1	2		1	4
Scincidae	*Carlia vivax*	Lively rainbow skink	LC	-		1		1			2
				LIZARDS	**2**	**7**	**3**	**6**	**4**	**2**	**24**
				SNAKES	**0**	**1**	**0**	**0**	**0**	**0**	**1**
				TOTAL REPTILES	**2**	**8**	**3**	**6**	**4**	**2**	**25**
Amphibians											
Bufonidae	*Rhinella marina*	Cane toad	I	-		3					3
Hylidae	*Litoria inermis*	Bumpy rocket frog	LC	-						1	1
				TOTAL AMPHIBIANS	**0**	**3**	**0**	**0**	**0**	**1**	**4**
Birds											
Acanthizidae	*Gerygone albogularis*	White-throated gerygone	LC	-	3						3
Acanthizidae	*Smicrornis brevirostris*	Weebill	LC	-	2		1	1			4
Accipitridae	*Aquila audax*	Wedge-tailed eagle	LC	-				1			1
Accipitridae	*Haliastur sphenurus*	Whistling kite	LC	-			3		1		4
Accipitridae	*Accipiter fasciatus*	Brown goshawk	LC	-					2		2
Alcedinidae	*Dacelo leachii*	Blue-winged kookaburra	LC	-				2			2
Artamidae	*Cracticus nigrogularis*	Pied butcherbird	LC	-		3	1		4	4	12
Artamidae	*Cracticus tibicen*	Australian magpie	LC	-	5	1	4	2	4	5	21

E

Family	*Scientific Name*	Common Name	NC Act/Biosecurity Act Status	EPBC Act status	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5	Total
Artamidae	*Strepera graculina*	Pied currawong	LC	-	5		1				6
Cacatuidae	*Cacatua galerita*	Sulphur-crested cockatoo	LC	-	2	2		1		4	9
Cacatuidae	*Calyptorhynchus banksii*	Red-tailed black-cockatoo	LC	-	1	3					4
Cacatuidae	*Eolophus roseicapilla*	Galah	LC	-	4		2	2	1	1	10
Campephagidae	*Coracina novaehollandiae*	Black-faced cuckoo-shrike	LC	-	2	2					4
Campephagidae	*Coracina papuensis*	White-bellied cuckoo-shrike	LC	-	1						1
Charadriidae	*Vanellus miles*	Masked lapwing	LC	-						2	2
Columbidae	*Geopelia humeralis*	Bar-shouldered dove	LC	-		2					2
Columbidae	*Geopelia striata placida*	Peaceful dove	LC	-	1		2		1		4
Columbidae	*Ocyphaps lophotes*	Crested pigeon	LC	-			1				1
Coraciidae	*Eurystomus orientalis*	Dollarbird	LC	-	2						2
Corcoracidae	*Struthidea cinerea*	Apostlebird	LC	-	1	9		4		4	18
Corvidae	*Corvus orru*	Torresian crow	LC	-	4		4	7	6	3	24
Dicruridae	*Dicrurus bracteatus*	Spangled drongo	LC	-	2						2
Estrildidae	*Taeniopygia bichenovii*	Double-barred finch	LC	-					3		3
Falconidae	*Falco cenchroides*	Nankeen kestrel	LC	-				1			1
Birds											
Gruidae	*Grus rubicunda*	Brolga	LC	-					2		2
Halcyonidae	*Dacelo novaeguineae*	Laughing kookaburra	LC	-	3	9		1		1	14
Maluridae	*Malurus leucopterus*	White winged fairywren	LC	-					1	2	3
Maluridae	*Malurus melanocephalus*	Red-backed fairywren	LC	-	5		1				6
Megaluridae	*Cincloramphus cruralis*	Brown songlark	LC	-			1			1	2
Meliphagidae	*Entomyzon cyanotis*	Blue-faced honeyeater	LC	-		3		1			4
Meliphagidae	*Lichenostomus virescens*	Singing honeyeater	LC	-	1				3	2	6
Meliphagidae	*Lichmera indistincta*	Brown honeyeater	LC	-				1			1

E

Family	*Scientific Name*	Common Name	NC Act/Biosecurity Act Status	EPBC Act status	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5	Total
Meliphagidae	*Manorina melanocephala*	Noisy miner	LC	-	1	13	1	2		2	19
Meliphagidae	*Melithreptus albogularis*	White-throated honeyeater	LC	-		1	2				3
Meliphagidae	*Philemon corniculatus*	Noisy friarbird	LC	-	2						2
Meliphagidae	*Philemon citreogularis*	Little friarbird	LC	-						1	1
Meropidae	***Merops ornatus***	**Rainbow bee-eater**	**LC**	**Ma**	**1**						**1**
Monarchidae	*Grallina cyanoleuca*	Magpie-lark	LC	-		2	1	2	3	4	12
Monarchidae	*Myiagra inquieta*	Restless flycatcher	LC	-				1			1
Monarchidae	*Myiagra rubecula*	Leaden flycatcher	LC	-	1				2		3
Oriolidae	*Sphecotheres vieilloti*	Australasian figbird	LC	-	3						3
Pachycephalidae	*Colluricincla harmonica*	Grey shrike-thrush	LC	-	2	1	3	1			7
Pachycephalidae	*Pachycephala pectoralis*	Golden whistler	LC	-	1						1
Pardalotidae	*Pardalotus striatus*	Striated pardalote	LC	-	2	2	2	2	2	1	11
Pomatostomidae	*Pomatostomus temporalis*	Grey-crowned babbler	LC	-	2			1			3
Psittacidae	*Aprosmictus erythropterus*	Red-winged parrot	LC	-				1		1	2
Psittacidae	*Platycercus adscitus*	Pale-headed rosella	LC	-	4	1	3	1		3	12
Psittacidae	*Trichoglossus moluccanus*	Rainbow lorikeet	LC	-	11	1				4	16
Birds											
Ptilonorhynchidae	*Chlamydera maculata*	Spotted bowerbird	LC	-			1				1
Rhipiduridae	*Rhipidura albiscapa*	Grey fantail	LC	-		1					1
Rhipiduridae	*Rhipidura leucophrys*	Willie wagtail	LC	-	1	1		4		1	7
Strigidae	*Ninox boobook*	Southern boobook	LC	-	1						1
Threskiornithidae	*Threskiornis spinicollis*	Straw-necked ibis	LC	-						1	1
Tytonidae	*Tyto alba*	Barn owl	LC	-		1					1
				TOTAL BIRDS	**76**	**58**	**34**	**39**	**35**	**47**	**289**
Mammals											

E

Family	*Scientific Name*	Common Name	NC Act/Biosecurity Act Status	EPBC Act status	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5	Total
Phalangeridae	*Trichosurus vulpecula*	Common brushtail possum	LC	-			1		1		2
Pseudocheiridae	***Petauroides volans volans***	**Greater glider**	**V**	**V**		**4**	**2**				**6**
				TOTAL MAMMALS	**0**	**4**	**3**	**0**	**1**	**0**	**8**

LC - Least Concern
V – Vulnerable
Ma - Marine
I - Introduced

E

Appendix F Fish and Crustacean Species List

Family	*Scientific Name*	Common Name	NC Act/Biosecurity Act Status	EPBC Act status	DAR1	DAI1	DAI2	DAI3	DAI4	DAI5	Total
Aquatic Life											
Atyidae	*Paratya australiensis*	Freshwater shrimp	LC	-					2		2
Parastacidae	*Cherax destructor*	Blue claw crayfish	LC	-	1	5	7		20	21	54
Parathelphusidae	*Austrothelphusa transversa*	Freshwater crab	LC	-	5	10	5			1	21
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish	LC	-					2	3	5
Terapontidae	*Leiopotherapon unicolor*	Spangled perch	LC	-			2		1		3
				CRUSTACEANS	**6**	**15**	**12**	**0**	**22**	**22**	**77**
				FISH	**0**	**0**	**2**	**0**	**3**	**3**	**8**
				TOTAL AQUATIC LIFE	**6**	**15**	**14**	**0**	**25**	**25**	**85**

LC - Least Concern

F

Appendix G Queensland Herbarium Identification Results

Queensland
Government

Department of
Environment and Science

Queensland Herbarium
Brisbane Botanic Gardens Mt Coot-tha•Toowong 4066 Queensland•Australia
Telephone +61 7 3199 7699 • Facsimile +61 7 3876 1278
e-mail Queensland.Herbarium@qld.gov.au
http://www.qld.gov.au/herbarium

Enquiries Tony Bean
Telephone 07 3896 9318
Your reference
Our reference ARB:mh 252/19

29 April 2019

Caitlin Eales
AARC Environmental Solutions
Suite 5a, 1 Swann Road
TARINGA Qld 4068

Dear Caitlin

The botanical specimens received by the Queensland Herbarium on 11 April 2019 have been identified as:

DWI 6	**Eragrostis trichophora*
DWR 4	*Ammannia multiflora*
DWR 4	*Cyperus difformis*
DA 12	*Lobelia concolor*
DWR 4	*Glinus lotoides*
DA 15	*Arundinella nepalensis*
DWR 6	*Murdannia graminea*
DAR 1	*Arundinella nepalensis*
DAI 5	**Indigofera tinctoria*

*Naturalised, non-native species

There is a charge of $228.80 (2 hrs @ $114.40 per hr incl GST) for these identifications.

You can contribute to Queensland's biodiversity information by submitting this/these plant identification(s) and associated information to the Atlas of Living Australia using the 'Report a sighting' template at (https://www.ala.org.au/)

Yours sincerely

G.P.Guymer
Director

Download a full version of Census of the Queensland Flora 2018
https://data.qld.gov.au/dataset/census-of-the-queensland-flora-2018

GEMINI PROJECT
ENVIRONMENTAL OFFSET STRATEGY

PREPARED FOR

MAGNETIC SOUTH PTY LTD

NOVEMBER 2020

BRISBANE OFFICE
Suite 5, 1 Swann Road
Taringa, QLD 4068
P +61 7 3217 8772

CAIRNS OFFICE
PO Box 4887
Cairns, QLD 4879
P +61 7 4057 9402

E info@aarc.net.au
AARC.NET.AU

ACN. 620 818 920
ABN. 71 620 818 920

AARC Environmental Solutions Pty Ltd

Document History and Status

Issue	Rev.	Issued To	Qty	Date	Reviewed	Approved
Draft	0.1	JX	1	17/11/20	GB	GB

Author: Gina Minatel
Project Manager: Heath Carney
Name of Client: Magnetic South Pty Ltd
Name of Project: Gemini Project
Title of Document: Environmental Offset Strategy
Document Version: Final

This controlled document is the property of AARC Environmental Solutions Pty Ltd and all rights are reserved in respect of it. This document may not be reproduced or disclosed in any manner whatsoever, in whole or in part, without the prior written consent of AARC Environmental Solutions Pty Ltd. AARC Environmental Solutions Pty Ltd expressly disclaims any responsibility for or liability arising from the use of this document by any third party.

Opinions and judgments expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal opinions. Information obtained from interviews and contained in the documentation has been assumed to be correct and complete. AARC Environmental Solutions Pty Ltd does not accept any liability for misrepresentation of information or for items not visible, accessible, nor able to be inspected at the sites at the time of the site visits.

GEMINI PROJECT ENVIRONMENTAL OFFSET STRATEGY

INDEX

1.0 INTRODUCTION 1

1.1 PURPOSE 1

1.2 PROJECT DESCRIPTION 1

2.0 LEGISLATION AND REGULATORY FRAMEWORK 6

2.1 ENVIRONMENTAL PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 6

2.2 QUEENSLAND ENVIRONMENTAL OFFSETS FRAMEWORK 6

2.2.1 Environmental Offsets Act 2014 and Environmental Offsets Regulation 2014 7

2.2.2 Queensland Environmental Offsets Policy 8

2.3 MLES – CENTRAL HIGHLANDS REGIONAL COUNCIL 8

3.0 PROJECT ENVIRONMENTAL OFFSET REQUIREMENTS 9

3.1 PRESCRIBED MATTERS WITHIN THE STUDY AREA 9

3.1.1 Endangered or Of Concern Regional Ecosystems 9

3.1.2 Vegetation located the within a defined distance from the defining banks of a relevant watercourse 9

3.1.3 Connectivity areas 9

4.0 OFFSET DELIVERY STRATEGY 12

4.1 OFFSET DELIVERY ASSESSMENT 12

4.1.1 Land-based offset 12

4.1.1.1 Condition Assessment of land-based offsets 12

4.1.1.2 Calculation of offset supply 13

4.1.1.3 Offset delivery steps 13

4.1.2 Financial Settlement Offset 16

4.2 POTENTIAL OFFSET SUPPLY AREAS FOR THE PROJECT 16

4.2.1 Offset target areas 16

4.2.2 Offset supply on Magnetic South land 20

5.0 CONCLUSION 22

6.0 REFERENCES 23

LIST OF FIGURES

Figure 1: Project locality 4
Figure 2: Project layout 5
Figure 3: Distribution of prescribed environmental matters within the study area 11
Figure 4: Target area for offset supply 17
Figure 5: Potential offset supply areas within 35km 19
Figure 6: Potential offset supply areas within Magnetic South properties 21

LIST OF TABLES

Table 1: MSES Offset Requirements 10
Table 2: Estimated offset supply requirement 14
Table 3: Potential offset supply area 18
Table 4: Area of potential offset land within Magnetic South properties 20

LIST OF APPENDICES

Appendix A Land Fragmentation Connectivity Tool Results 24
Appendix B Financial Settlement Offset Calculator Results 25

LIST OF ABBREVIATIONS

%	percent
$	dollar
AARC	AARC Environmental Solutions Pty Ltd
BVG	Broad Vegetation Group
DAF	Department of Agriculture and Fisheries
DES	Department of Environment and Science
DEHP	Department of Environment and Heritage Protection
DBMP	Direct Benefit Management Plan
EA	Environmental Authority
EHP	Environment and Heritage Protection
EP Regulation	Environmental Protection Regulation 2019
EO Act	Environmental Offsets Act 2014
EO Regulation	Environmental Offsets Regulation 2014
EP Act	Environmental Protection Act 1994
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999
EPC	Exploration Permit Coal
GDE	Groundwater Dependant Ecosystems
ha	hectares
HES	High Ecological Significance
km	kilometre
LGA	Local Government Area
Mtpa	million tonnes per annum
ML	Mining Lease
MLA	Mining Lease Application
MLES	Matters of Local Environmental Significance

MNES	Matters of National Environmental Significance
MSES	Matters of State Environmental Significance
NC Act	Nature Conservation Act 1992
PCI	Pulverised Coal Injection
Qld	Queensland
QEOP	Queensland Environmental Offsets Policy
ROM	Run of mine
RE	Regional Ecosystem
SOIC	Strategic Offset Investment Corridor
TEC	Threatened Ecological Community
VM Act	Vegetation Management Act 1999
the Project	Gemini Project
Magnetic South	Magnetic South Pty Ltd

1.0 INTRODUCTION

AARC Environmental Solutions Pty Ltd (AARC) was commissioned by Magnetic South Pty Ltd (Magnetic South) to prepare an Environmental Offset Strategy for the Gemini Project (the Project). The Project is located approximately 110 km east of Emerald and 125 km west of Rockhampton in the Bowen Basin of Central Queensland, and within the Central Highlands Regional Council Local Government Area (LGA) (Figure 1).

The Project lies within Mining Lease Application (MLA) 700056, which falls within Exploration Permit Coal (EPC) 881. The Project is a greenfield, open-cut metallurgical coal mine, producing Pulverised Coal Injection (PCI) coal and coking coal for export for steel production. Existing local and regional infrastructure, facilities and services are proposed to support Project activities. These include the SunWater water distribution network, the Aurizon rail network, Ergon's electricity network, the Capricorn Highway, and Gladstone export coal terminals.

The proponent is in the process of preparing an Environmental Authority (EA) under the *Environmental Protection Act 1994* (EP Act). This application was accepted on 23 October 2019 by the administering authority. This Offset Strategy has been developed in response to an Information Request (IR) received 31 January 2020. Prior to this, an *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) referral (2010/5775) was lodged in 2010 for the Project, which was declared 'Not a Controlled Action if undertaken in a Particular Manner' in July 2011.

An initial assessment of the terrestrial and aquatic ecological values was conducted within EPC 881 (herein referred to as the study area) by AARC in 2019. The *Terrestrial Ecology Assessment Report* and the *Aquatic Ecology Assessment Report* (AARC 2020a & 2020b) assessed the environmental values and potential impacts of the Project to ecological values including matters of state environmental significance (MSES). The findings of these studies have been used to inform this Environmental Offset Strategy; in particular:

- Vegetation mapping and community description;
- Likelihood of occurrence assessment for flora and fauna species of conservation significance;
- Habitat mapping for conservation significant species and communities;
- Detailed assessment of the ecological condition and value of waterways, wetlands and Groundwater Dependant Ecosystems (GDE);
- Impact assessments for MSES; and
- Offset requirements for impacted MSES.

1.1 PURPOSE

The purpose of this Environmental Offset Strategy is to outline the Project's environmental offset requirements under the applicable offset framework. The Environmental Offset Strategy includes:

- a summary of environmental offset requirements for the Project (Section 3.0); and
- proposed offset delivery mechanisms including staging (Section 4.0).

1.2 PROJECT DESCRIPTION

The Project involves the construction and operation of an open cut coal mine with a planned production rate of up to 1.9 million tonnes per annum (Mtpa) of ROM coal for export for steel production. The Project

term is anticipated to be 25 years from grant of the mining lease (ML); with this term including initial construction, mine operation and rehabilitation activities.

Mine construction activities are scheduled to commence in July 2021; subject to granting of the Project ML and EA. It is anticipated that it will take approximately six months to establish the necessary infrastructure to commence overburden removal and 18 months to commence coal production. A conceptual Project layout is provided in Figure 2, which represents the total area disturbed by mine operations only and does not equate to the disturbance footprint at any one point in time. The layout and mining sequence may vary from that shown in Figure 2 to account for localised geological features, detailed engineering design, mining economics and variations in market tonnages and quality requirements.

Open-cut mining areas will be developed and rehabilitated progressively. The total disturbance footprint for the Project is 1,953 ha which incorporates all mining and infrastructure components. the Project delivery has been split into two distinct stages based on the mine sequence. The total disturbance footprint for Stage 1 is approximately 1,267 ha, which includes Pit AB and associated infrastructure north west of Pit AB. Pit C and the haul road connecting Pit C and Pit AB will be developed in Stage 2, which is approximately 686 ha (refer Figure 2 and Figure 3).

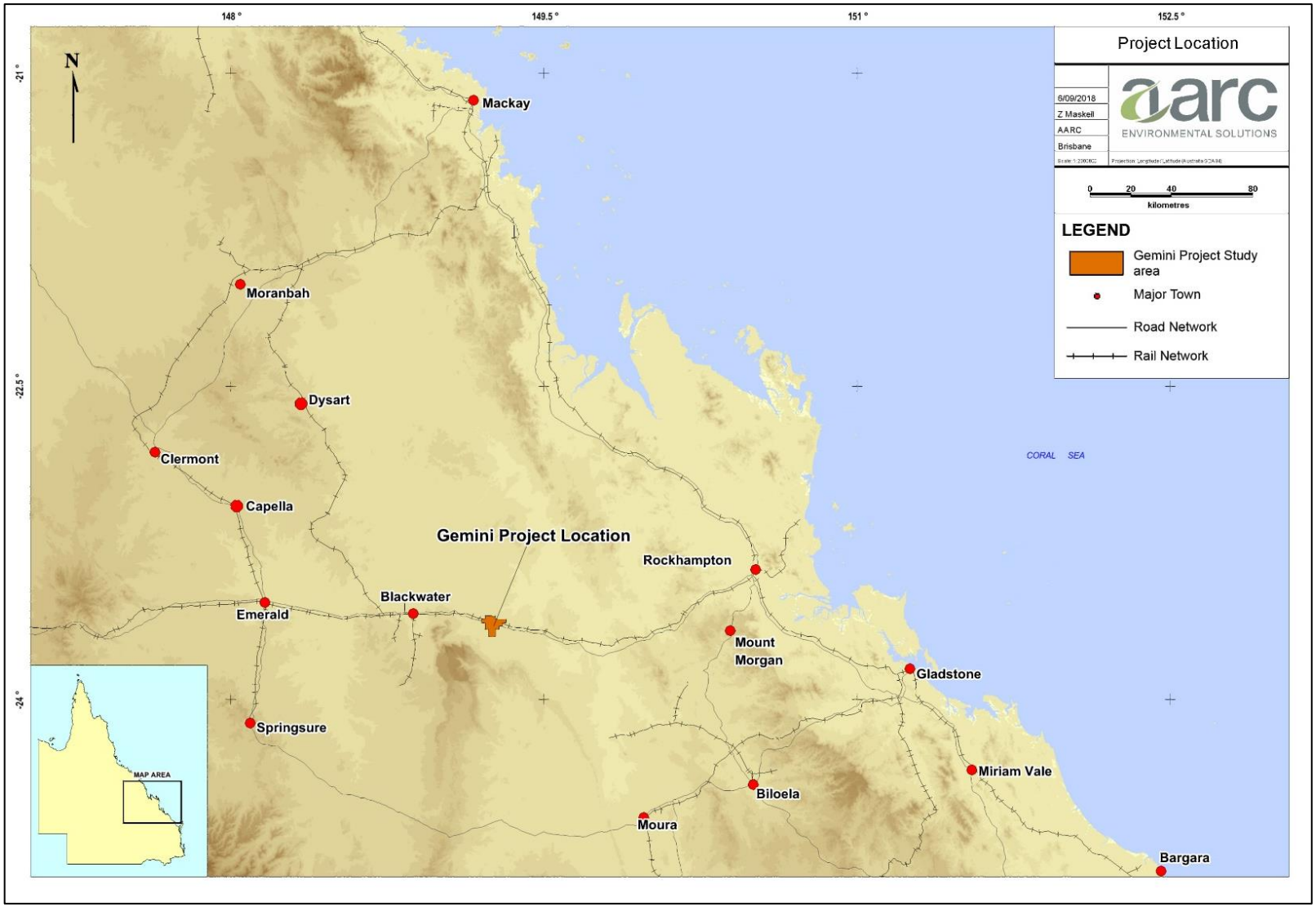


Figure 1: Project locality

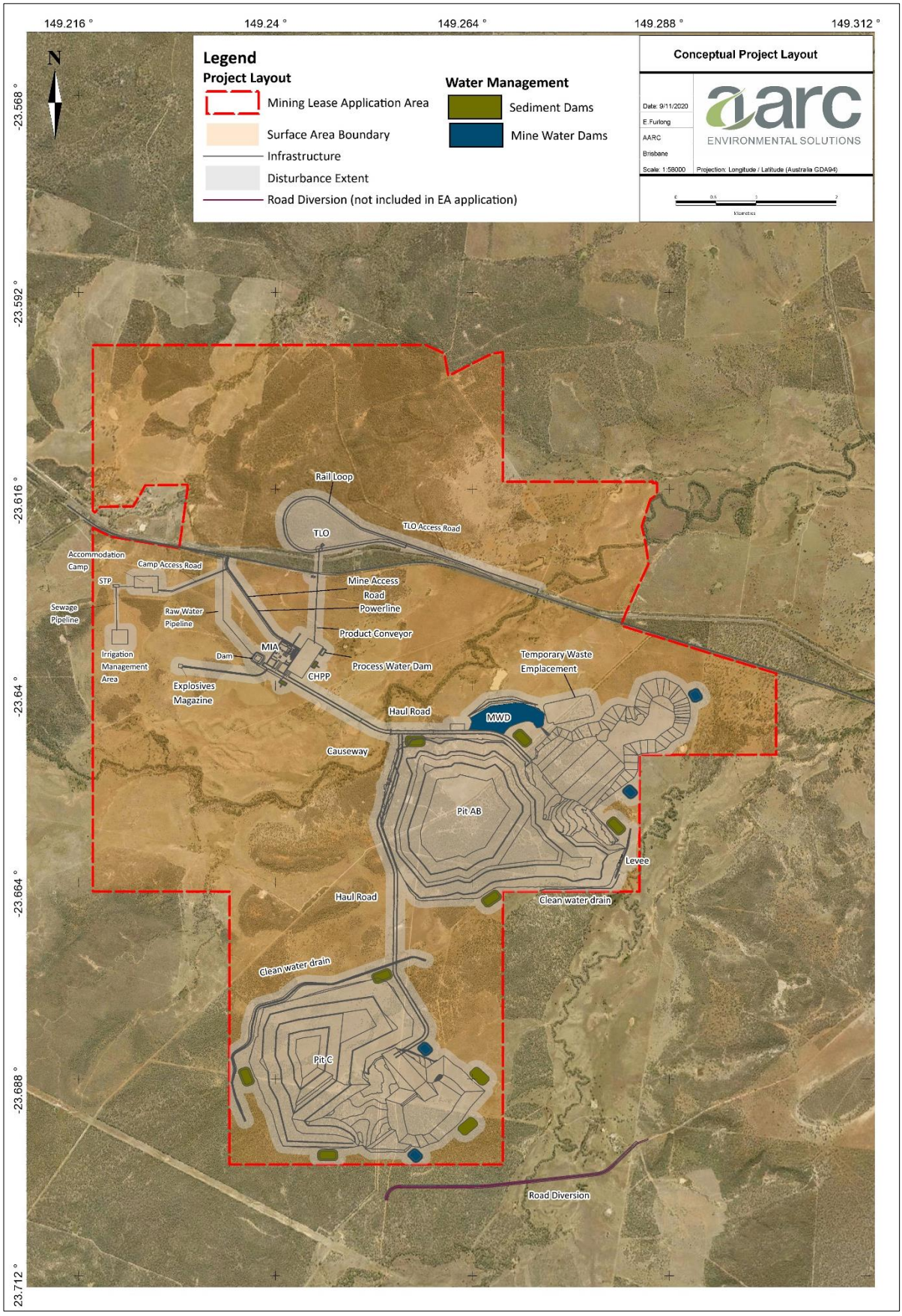


Figure 2: Project layout

2.0 LEGISLATION AND REGULATORY FRAMEWORK

Commonwealth, State and Local legislation policies and guidelines relevant to environmental offsets are discussed below.

2.1 ENVIRONMENTAL PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

Under the *Commonwealth Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), an action requires approval from the Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a matters of national environmental significance (MNES). There are nine matters of national environmental significance listed under the act, which include:

- World heritage properties;
- National heritage places;
- Wetlands of international importance;
- The Great Barrier Reef Marine Park;
- Commonwealth marine areas;
- Listed threatened ecological communities;
- Listed threatened species;
- Listed threatened migratory species; and,
- A water resource, in relation to coal seam gas development and large coal mining development.

An EPBC Referral (2010/5775) was lodged in 2010 for the Gemini Project (the Project) previously known as the Dingo West Project by Dingo West Pty Ltd. The Project was declared 'Not a Controlled Action if undertaken in a Particular Manner' in July 2011.

The Particular Manner Decision conditions (EPBC 2010/5775) are as follows:

1. *To prevent downstream impacts to the Fitzroy river turtle (Rheodytes leukops) the person taking the action must appropriately bund or locate pits in a manner that prevents surface water from entering the pit during a 1:1000 year flood event (as indicated in flood modelling).*

2. *To prevent downstream impacts to the Fitzroy river turtle (Rheodytes leukops) the person taking the action must appropriately bund or locate dams in a manner that prevents surface water from entering or damaging the dams during a during a 1:1000 year flood event (as indicated in flood modelling).*

The Project requires no further assessment or provision of offsets under the EPBC Act.

2.2 QUEENSLAND ENVIRONMENTAL OFFSETS FRAMEWORK

Under Queensland law, offsets may be required for certain activities, where there is an unavoidable impact on significant environmental values. To counterbalance this loss, offsets, which can include improvement and protection of alternative sites and/or actions that improve environmental viability, can

provide a conservation outcome that is equivalent to the environmental value being lost at the impact site (DES 2020a).

The Queensland environmental offsets framework consists of:

- *Environmental Offsets Act 2014* (EO Act);
- *Environmental Offsets Regulation 2014* (EO Regulation);
- *Queensland Environmental Offsets Policy* (QEOP) (DES 2020a); and
- *QEOP Significant Residual Impact Guideline* (EHP 2014).

The offsets framework requires environmental offsets to be delivered where the Project (prescribed activity) is likely to result in a significant residual impact on a prescribed environmental matter. *The QEOP Significant Residual Impact Guideline* (EHP 2014) was used to determine if residual impacts on prescribed environmental matters were significant for the project (AARC 2020a).

2.2.1 Environmental Offsets Act 2014 and Environmental Offsets Regulation 2014

Significant impacts to MSES require environmental offsets under the EO Act. MSES are defined below and are outlined in Schedule 2 of the EO Regulation. They comprise:

- Regulated vegetation including:
  i. REs that are listed as 'Endangered' or 'Of Concern' (under the *Vegetation Management Act 1999* (VM Act));
  ii. REs that intersect areas shown as wetlands on the 'vegetation management wetlands map' (as certified under the VM Act);
  iii. REs located within the defined distance from the defining banks of a relevant watercourse or relevant drainage feature identified on the 'regulated vegetation management watercourse and drainage feature map' (as certified under the VM Act);
  iv. REs mapped as essential habitat on the 'essential habitat map' (as certified under the VM Act) for flora and fauna listed as 'endangered' or 'vulnerable' (under the *Nature Conservation Act 1992* (NC Act)); or
  v. A prescribed regional ecosystem is a matter of State environmental significance, for a prescribed activity mentioned in schedule 1, item 7(e) [1], if the ecosystem is an area of essential habitat on the essential habitat map for an animal that is near threatened wildlife or a plant that is near threatened wildlife;
- Remnant REs that contain an area of land required for ecosystem functioning (i.e. a connectivity area);
- Mapped wetlands and watercourses including:
  i. A wetland in a 'wetland protection area'; or of 'high ecological significance' as shown on the 'map of referable wetlands' (as defined under the *Environmental Protection Regulation 2019* (EP Regulation)); or

[1] Prescribed activity mentioned in schedule 1, item 7(e): development for which an environmental offset may be required under the State code 16 (Native vegetation clearing).

ii. A wetland or watercourse in 'high ecological value waters' (as defined under the *Environmental Protection (Water and Wetland Biodiversity) Policy* 2019);

- Designated precincts in a 'strategic environmental area' (under the *Regional Planning Interests Regulation 2014*);
- Protected wildlife habitat, which includes;
  i. High risk areas on the 'flora survey trigger map' that contain 'endangered' or 'vulnerable' plants (under the NC Act);
  ii. Areas (not on the 'flora survey trigger map') that contain 'endangered' or 'vulnerable' plants (under the NC Act);
  iii. Koala habitat area (as defined in the NC Act);
  iv. Habitat for 'endangered', 'vulnerable' and 'special least concern' animals (under the NC Act);
- Protected areas (under the NC Act) and highly protected zones of State marine parks (under the Marine Parks Act 2004);
- Fish habitat areas and waterways providing for fish passage (under the Fisheries Act 1994);
- Marine plants (under the Fisheries Act 1994); and
- Legally secured offset areas.

2.2.2 Queensland Environmental Offsets Policy

The QEOP is a statutory instrument that provides a single, streamlined framework for environmental offsets in Queensland. An offset may be delivered as a:

Proponent-driven offset: A proponent-driven offset may take the form of a traditional land-based offset; be undertaken through actions under a Direct Benefit Management Plan (DBMP); or a combination of both. For a proponent-driven offset, the offset delivery liability remains with the proponent and the offset must be delivered in accordance with an Offset Delivery Plan approved by the administering agency.

Financial settlement offset: For financial settlement offsets; the payment amount must be calculated in accordance with the methodology set out in in the QEOP. A web-based 'financial settlement offset calculator' is available on the Qld Government website that can assist in this process. The State is responsible for delivering a conservation outcome from the financial settlement offset payment.

A combination of a proponent-driven offset and financial settlement offset may be utilised.

2.3 MLES – CENTRAL HIGHLANDS REGIONAL COUNCIL

The project is located within the Central Highlands Regional Council LGA, which operates under the *Central Highlands Regional Council Planning Scheme 2016* (Central Highlands Regional Council 2016). As part of this Planning Scheme, matters of local environmental significance (MLES) are identified in overlay maps.

Searches of the *Central Highlands Regional Council Planning Scheme 2016* identified no MLES within the Project area.

3.0 PROJECT ENVIRONMENTAL OFFSET REQUIREMENTS

An ecological assessment comprising desktop assessments and field studies was undertaken to identify ecology values pertaining to the Project. The *Terrestrial Ecology Assessment Report* (AARC 2020a) provides details on the methods, results and impact assessments undertaken to determine if significant residual impacts to prescribed environmental matters are likely to occur as a result of the Project.

The Total Residual Impact Area has been calculated based on the remaining impact to prescribed environmental matters once all reasonable measures to avoid and minimise impacts to each matter was determined. Section 8.0 of the *Terrestrial Ecology Assessment Report* (AARC 2020a) outlines the mitigation and management strategies recommended to minimise and mitigate impacts to ecological values. Magnetic South has designed the project layout to aim to avoid areas of high ecological value, reducing impacts to prescribed environmental matters. Additional mitigation and management strategies are also recommended in the AARC (2020a) report.

3.1 PRESCRIBED MATTERS WITHIN THE STUDY AREA

Table 1 outlines the total offset requirements to be delivered under the QEOP (DES 2020a) as well as the requirements of staged offset strategy.

3.1.1 Endangered or Of Concern Regional Ecosystems

The study area consists of six vegetation communities. The remnant RE's associated with these vegetation communities include 11.5.2, 11.7.2, 11.3.25 and 11.3.2. *Eucalyptus populnea* (poplar box) woodland on alluvial plains (RE 11.3.2) is the only RE within the study area with a VM Act status Of Concern. Only small patches of this vegetation community occur within the study area, occupying 36.52 ha (0.5%) of the total area. Overall, 2.57 ha will be impacted due to Project activities that cannot be avoided or mitigated. Of this 2.57 ha, 1.83 ha will be impacted as part of Stage 1 and 0.74 ha will be impacted as part of Stage 2 (Figure 3).

3.1.2 Vegetation located the within a defined distance from the defining banks of a relevant watercourse

Several watercourses and waterways identified under the VM Act traverse the study area. The remnant vegetation located within the defined distance from the defining banks of identified VM Act watercourses, as defined in Appendix 3 of the QEOP, constitute a prescribed matter. Overall, 58.32 ha of this vegetation associated with the REs 11.5.2, 11.7.2, 11.3.25 and 11.3.2 will be impacted. Stage 1 impacts include 35.4 ha, whereas 22.39 ha will be impacted in Stage 2, due to Project activities that cannot be avoided or mitigated within these areas (Figure 3).

3.1.3 Connectivity areas

The Landscape Fragmentation and Connectivity Tool, used to determine whether a development significantly impacts Connectivity Areas as defined in Schedule 2 (DES 2018), was applied to the proposed extent of the disturbance area. The results found that significant impacts would occur to connectivity at both the local scale and to core remnant areas (Appendix B). It should be noted that the tool was run with the current regulated vegetation layer (DNRME 2020) instead of the field verified vegetation map due to technical limitations of the tool. This minor variation is highly unlikely to influence the results of analysis, being a significant impact on connectivity.

The total 710.72 ha of ground-truthed remnant vegetation within the proposed disturbance area has therefore been proposed to be offset, due to Project activities that cannot be avoided or mitigated. Specifically, 395.55 ha will require an offset in Stage 1 and 315.17 ha in Stage 2.

Table 1: MSES Offset Requirements

MSES	Regional Ecosystem	Residual Impact (ha)	Total Residual Impact Area (ha)	Residual Impact Stage 1 (ha)	Total Residual Impact Area Stage 1 (ha)	Residual Impact Stage 2 (ha)	Total Residual Impact Area Stage 2 (ha)	Habitat Description
Of Concern Regional Ecosystem	11.3.2	2.57	2.57	1.83	1.83	0.74	0.74	This vegetation community was decribed as *Eucalyptus populnea* (poplar box) woodland on alluvial plains. It was represented in several small to moderate patches within the study area and is subject to pressures from grazing and exotic species invasion.
REs located within the defined distance from the defining banks of a VM Act watercourse.	11.5.2	31.01	58.32	11.69	35.4	19.32	22.39	Several VM Act watercourses traverse the Study area. Impacts will occur to watercourse vegetation that is associated with RE 11.3.25, 11.5.2, 11.3.2 and 11.7.2.
	11.3.2	0.59		0.59		0		
	11.7.2	17.82		17.82		0		
	11.3.25	8.9		3.82		5.08		
Connectivity area	-	710.72	710.72	-	395.55	-	315.17	The Landscape Fragmentation and Connectivity Tool determined that there is significant impact to the connectivity of the remnant vegetation within the Project. Landscape Fragmentation and Connectivity Tool is based on current government mapping.
Total			**771.61**		**432.78**		**338.3**	

** The assessment of impact on connectivity using Landscape Fragmentation and Connectivity Tool is based on current government mapping; however, the total area to be offset has been proposed based on the field verified remnant vegetation within the impact area.*

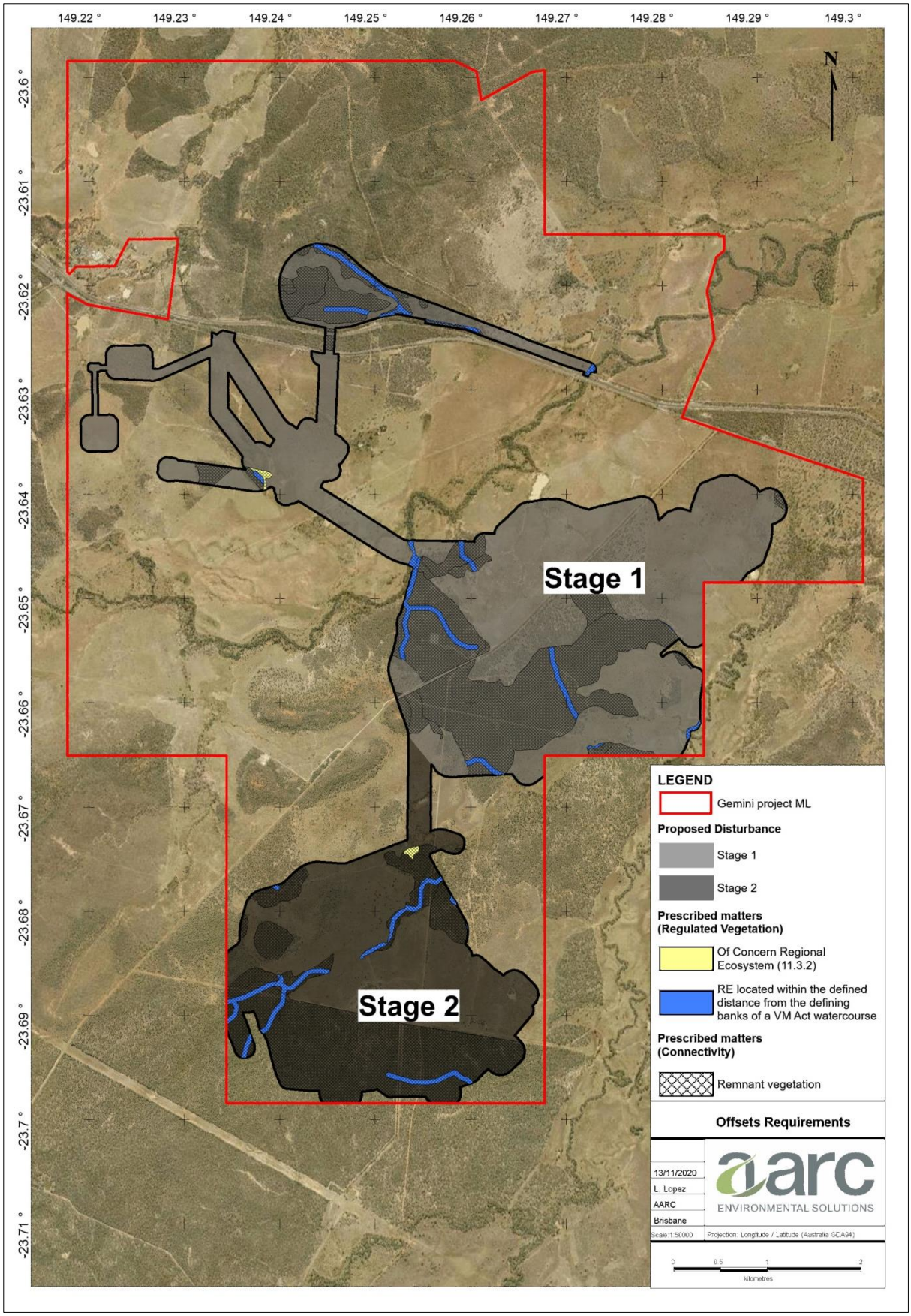


Figure 3: Distribution of prescribed environmental matters within the study area

4.0 OFFSET DELIVERY STRATEGY

The environmental offset requirements for the Project are proposed to compensate for the loss of connectivity, Regulated Vegetation (Of Concern REs), and remnant vegetation located within the defined distance from the defining banks of a VM Act watercourse, detailed in Section 3.1.2.

The Project will be developed progressively and as such, a staged offset delivery approach is proposed. This approach will enable offsets to be estimated accurately and delivered in a way that meets the obligations of the Project without over or underestimating the offset obligations. Staged offsets enable prescribed environmental matters to be accounted for as the project develops with time.

Figure 3 shows the study area and the approach to delivery of offsets.

The following sections outline the offset delivery options for the Project.

4.1 OFFSET DELIVERY ASSESSMENT

Under the QEOP there are three offset delivery options, which include:

- Proponent-driven offsets, taking the form of a land-based offset;
- Proponent-driven offsets, as part of a Direct Benefit Management Plan (DBMP) (can only be up to 10% of the offset delivery); and,
- Financial settlement offset.

A combination of offset delivery options is acceptable. However, the DBMP can only contribute up to 10% of the offset delivery.

Magnetic South is proposing to deliver a combination of Proponent-driven land-based offsets and financial settlement offsets. At this stage of Project development Magnetic South is yet to confirm exact proportions. This detail will be provided in the Offset Delivery Plan to be prepared following project approval before impact on the prescribed environmental matter occurs.

The offset delivery options described below are proposed.

4.1.1 Land-based offset

Magnetic South is likely to provide a portion of the offset delivery on suitable land they own in the vicinity of the Project or provided by a third-party offset provider.

4.1.1.1 Condition Assessment of land-based offsets

For land-based offsets, the suitability of the offset site relative to the impact site is measured by undertaking a habitat quality assessment. This assessment will be undertaken using the *Guide to Determining Terrestrial Habitat Quality* (DES 2020b) to measure a conservation outcome.

The *Guide to Determining Terrestrial Habitat Quality* (DES 2020b) outlines two processes that can be undertaken when determining habitat quality. The Rapid Assessment process can be used to approximate a habitat quality score without undertaking a Standard Assessment. This Rapid Assessment can only be used on the impact site, providing a habitat quality score of 7 out of 10. This score represents an average score of generic remnant RE's in Queensland derived from Queensland Herbarium experts.

The Standard Assessment process can also be used to determine habitat quality for impact sites and forms a requirement for offset supply sites. To determine the habitat quality score a more rigorous field evaluation is undertaken, including the measurement of ecological condition parameters from transects established within defined assessment units.

4.1.1.2 Calculation of offset supply

Once the habitat quality scores have been determined for the offset and impact sites these numbers are entered into the Land-based Offset Multiplier Calculator. This calculator uses the inputted information to determine the required size of an offset supply land for each value.

A multiplier is defined as "*a number used to calculate the size of the offset requirement given the significant residual impact area, for a given prescribed environmental matter*". The required offset area is calculated by multiplying the area of impact by the prescribed multiplier:

Offset Area = Area of Impact x Multiplier

The prescribed multiplier is set at a maximum of four (i.e. a maximum of four times the area of the residual impact), except for impacts to connectivity and waterways providing for fish passage, for which the prescribed multiplier is set to a maximum of one.

For the purposes of this Environmental Offsets Strategy, the maximum multiplier was assumed to calculate the maximum size of the offset supply. Estimated offset supply areas required for the Project are summarised in Table 2.

4.1.1.3 Offset delivery steps

The proponent will provide a notice of election including a proposed offset delivery plan, prior to impacts occurring.

Where land-based offsets are proposed, the next stage of offset delivery will include field ecology surveys of the potential offset supply sites. Surveys will aim to validate the suitability of habitats, assess ecological condition and collect information to support preparation of offset management plans. Final offset calculators will then be prepared post field validation to confirm the extent of offset supply land required.

An outline of potential offset supply areas for the Project has been described in Section 4.2, based on the land-based offset requirements mentioned below.

Table 2: Estimated offset supply requirement

MSES	Habitat Description	Regional Ecosystem	Total Residual Impact Area (ha)	Total Residual Impact Area Stage 1 (ha)	Total Residual Impact Area Stage 2 (ha)	QEOP Multiplier	Total Required Supply Area (ha)	Stage 1 Required Supply Area (ha)	Stage 2 Required Supply Area (ha)	QEOP Offset Supply Criteria
Of Concern Regional Ecosystem	This vegetation community was characterised by *Eucalyptus populnea* (poplar box) woodland on alluvial plains. It was represented in several small to moderate patches within the study area and is subject to pressures from grazing, exotic species invasion.	11.3.2	2.57	1.83	0.74	4	10.8	7.32	2.96	In relation to endangered and of concern regional ecosystems—the offset site must be: • Of the same broad vegetation group as the impacted Regional Ecosystem; • Of the same regional ecosystem status; and • Within the same bioregion
REs located within the defined distance from the defining banks of a VM Act watercourse.	Several VM Act watercourses traverse the Study area. Impacts will occur to watercourse vegetation that is associated with RE 11.3.25, 11.5.2, 11.3.2 and 11.7.2.	11.5.2	31.01	11.69	19.32	4	233.28	135.68	97.6	For vegetation intersecting a watercourse or drainage feature the offset site must be: • Of the same broad vegetation group as the impacted Regional Ecosystem; • Within the same bioregion; and • Associated with a watercourse or drainage feature
		11.3.2	0.59	0.59	0.00					
		11.7.2	17.82	17.82	0.00					
		11.3.25	8.9	3.82	5.08					
		Total	58.32	33.92	24.4					

Connectivity area	The Landscape Fragmentation and Connectivity Tool determined that there is significant impact to the connectivity of the remnant vegetation within the Project. Landscape Fragmentation and Connectivity Tool is based on current government mapping.	-	710.72	395.55	315.17	1	710.72	395.55	315.17	• Must be a non-remnant ecosystem; and • Must be in the same subregion; however, if the subregion is intact, the offset should be in the nearest fragmented subregion.
						Total	**954.8**	**538.55**	**415.73**	

4.1.2 Financial Settlement Offset

Magnetic South expect to deliver a portion of the offset supply requirement via financial settlement. This involves payment of an amount, calculated in accordance with the Financial Settlement Offset Calculation Methodology, outlined in Appendix 4 of the QEOP. The financial settlement calculation can be based off the *Queensland Government's Financial Settlement Offset Calculator* or the formula within Appendix 4 of the QEOP. It should be noted that both methods of calculation use the same components to determine the financial offset total.

The financial settlement calculation is based on the following formula:

Financial settlement = (total offset area x on-ground cost per ha) + landholder incentive payment + administrative cost

Each component within the above calculation uses different inputs and has its own specific formula, which is also outlined in Appendix 4 of the QEOP.

Calculation of the financial settlement for 100% of the offset requirement has been provided below and can be found in detail in Appendix B:

- In total $3,786,509.52 would be required to secure an offset of 954.8 ha for the entire study area;
- $2,192,600.70 would be required to secure an offset of 538.55 ha for Stage 1 only; and,
- $1,721,708.82 would be required to secure an offset of 415.73 ha for Stage 2 only.

Magnetic South will recalculate the financial offset contribution for the specific proportion of offset requirement determined. This will be defined in the Notice of Election and Offset Delivery Plan.

4.2 POTENTIAL OFFSET SUPPLY AREAS FOR THE PROJECT

Under the QEOP; to enhance the likelihood of the environmental offset being successful and achieving a conservation outcome, the offset should be in a strategic location that provides tangible benefits for the impacted prescribed environmental matter. This will be achieved through the following approach:

- Wherever possible offsets will be located within a Strategic Offset Investment Corridor (SOIC) closest to the impacted site; and
- In order of priority:
    - Offsets will be located within the same LGA; and/or
    - Offsets will be located within the same sub-region; and/or
    - Offsets will be located within the same bioregion.

4.2.1 Offset target areas

Figure 4 displays the study area in relation to the above supply location priorities. The Southern Brigalow Belt Bioregion has SOIC's defined, which occur in the same LGA and sub-bioregion as the Project. The area in Figure 5 represented by cross hatching shows the overlap of the Central Highlands Regional Council LGA, and the Woorabinda sub-bioregion (of the Southern Brigalow Belt Bioregion). This area (further accented by a pale pink background) represents the most strategic area for the Project's offset supply to be located, referred to as the Target Offset Supply Area.

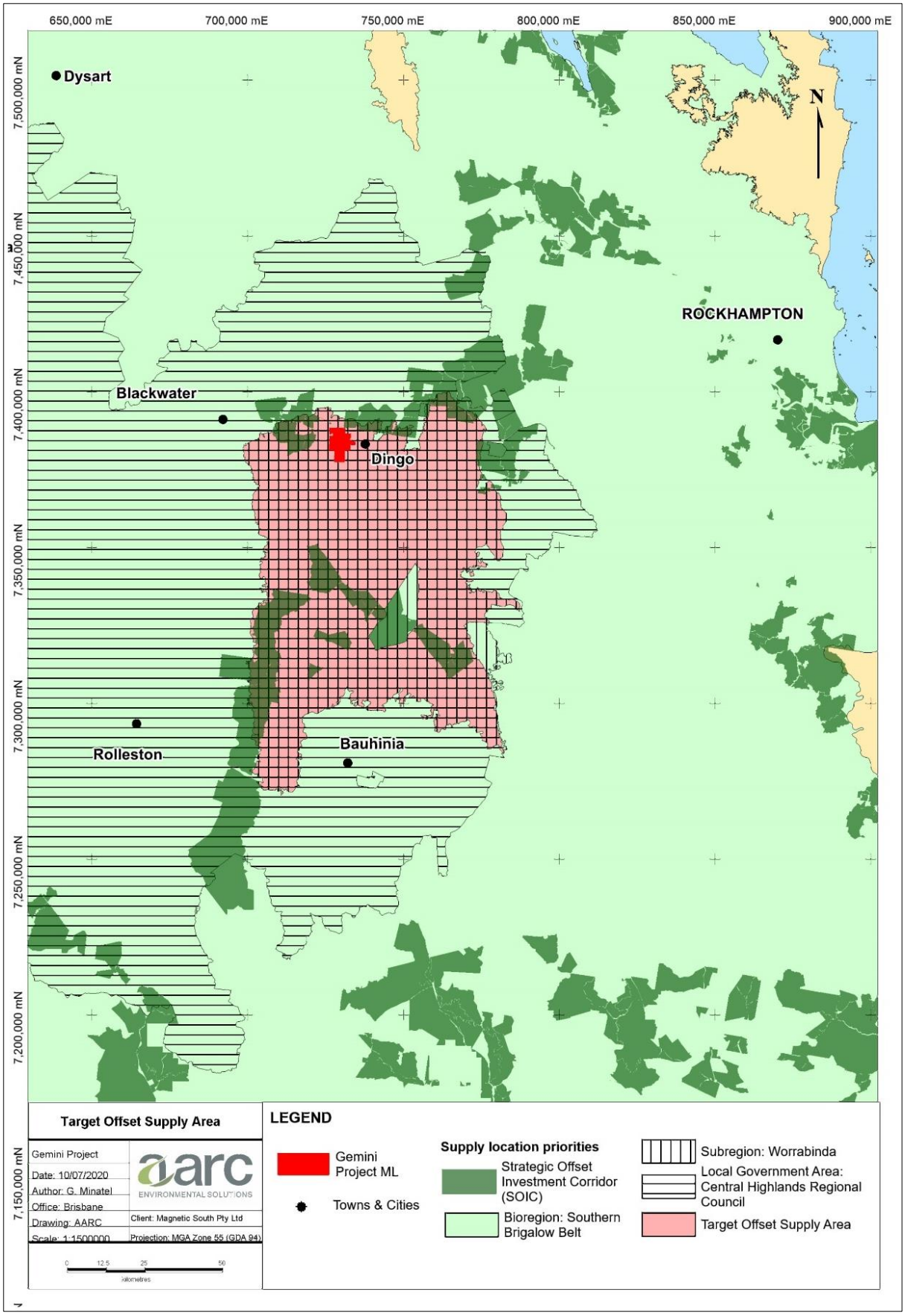


Figure 4: Target area for offset supply

Within the Target Offset Supply Area; pre-clear and remnant RE mapping was utilised to determine spatial availability of potential offset supply. Protected Areas, external Mining Leases, MSES legally secured offset areas and Category A regulated vegetation were removed from the potential offset supply areas, to give a more accurate estimation of the land that would be available for offsetting.

Table 3 outlines the potential supply area for each impacted matter, and the resulting targeted criteria for selection of potential offset supply. The available area for each impacted matter has been delineated into existing remnant vegetation, and non-remnant. Identification of suitable non-remnant sites was based on the *Vegetation management pre-clear regional ecosystem map - version 11.0* (DNRME 2019). The following calculations are based on the available area within the Target Offset Supply Area and within 35km from the study area.

Table 3: Potential offset supply area

Impacted Matter	Offset Supply Requirements	Total Supply Area Required (ha)	Stage 1 Required Supply Area (ha)	Stage 2 Required Supply Area (ha)	Supply Available: Non-remnant (ha)	Supply Available: Remnant (ha)
Of Concern Regional Ecosystem	• Of the same *broad vegetation group* as the impacted regional ecosystem; • Of the same regional ecosystem status; and • Within the same bioregion	10.8	7.32	2.96	14,137.01	2,780.61
REs located within the defined distance from the defining banks of a VM Act watercourse.	• Of the same broad vegetation group as the impacted regional ecosystem; • Within the same bioregion; and • Associated with a watercourse or drainage feature	233.28	135.68	97.6	4,454.30	2,652.00
Connectivity area	• A non-remnant ecosystem; and • In the same subregion; however, if the subregion is intact, the offset should be in the nearest fragmented subregion	710.72	395.55	315.17	157,710.89	-

Ideally, offset supply areas will be located close to the impact site. Figure 5 illustrates the potential offset supply within the Target Offset Supply Area and within 35 km of the Project. Subject to suitable land acquisition arrangements, it would be possible to satisfy 100% of required offset supply within these local areas.

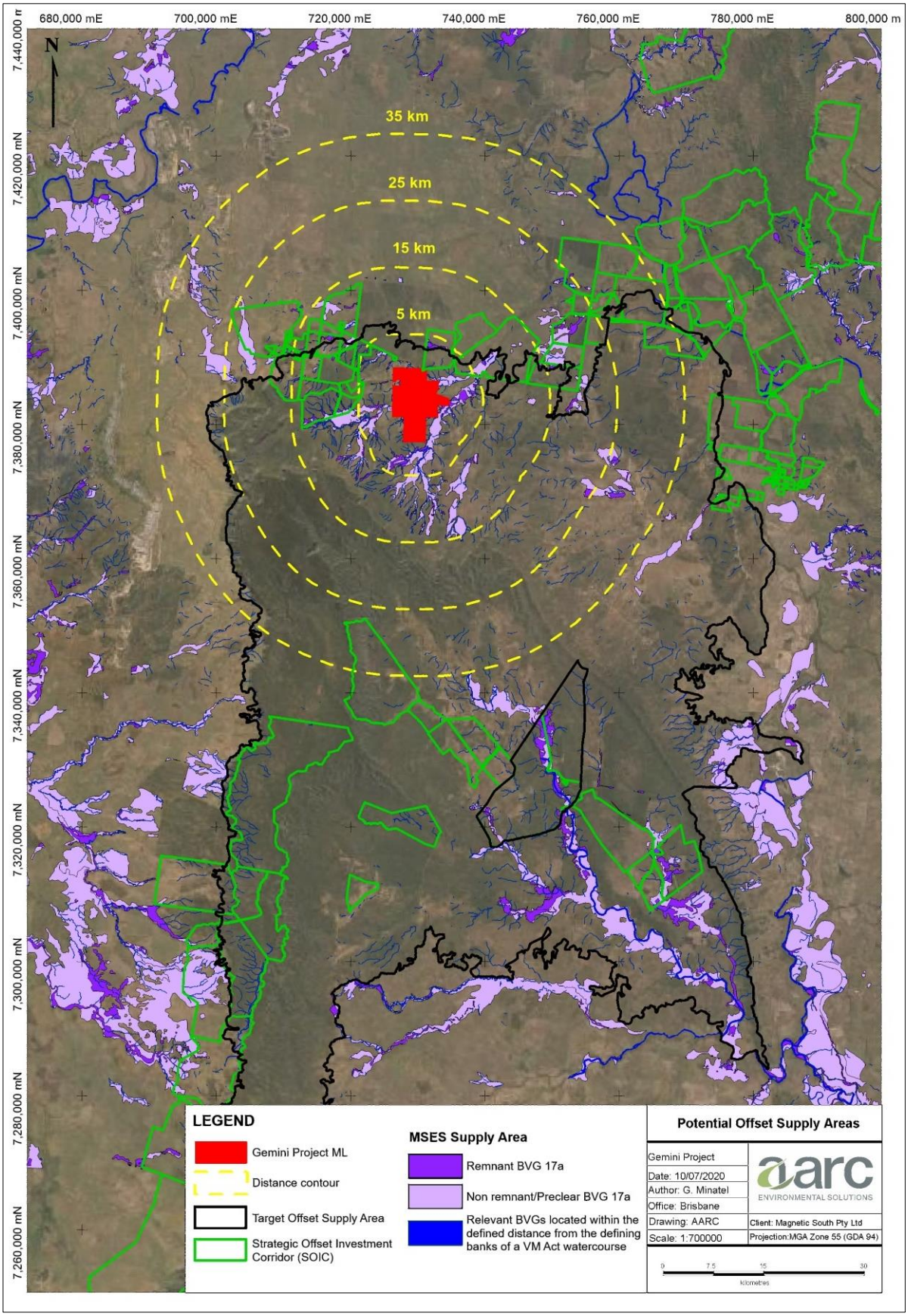


Figure 5: Potential offset supply areas within 35km

4.2.2 Offset supply on Magnetic South land

Magnetic South is the owner of land underlying the Project, along with some adjacent land parcels (Figure 6). Given the location of this land in relation to the proposed disturbance, this area is considered a suitable option for offset supply.

Although the final offset supply area will be subject to condition analysis, preliminary desktop assessment indicates the likely presence of sufficient offset supply land within Magnetic South properties to satisfy 100% of the offset requirement for the Project.

An impact area may have more than one prescribed environmental matter located on it. The Queensland Environmental Offsets Policy allows for the co-location of multiple prescribed environmental matters, except for species categorised into different functional groups.

Where possible, the offset requirements will be co-located (e.g. connectivity).

Table 4: Area of potential offset land within Magnetic South properties

Impacted Matter	Offset Supply Requirements	Total Supply Area Required (ha)	Stage 1 Required Supply Area (ha)	Stage 2 Required Supply Area (ha)	Supply Available: Non-remnant (ha)	Supply Available: Remnant (ha)
Of Concern Regional Ecosystem	• Of the same *broad vegetation group* as the impacted regional ecosystem; • Of the same regional ecosystem status; and • Within the same bioregion	10.8	7.32	2.96	1,744	426.99
REs located within the defined distance from the defining banks of a VM Act watercourse.	• Of the same broad vegetation group as the impacted regional ecosystem; • Within the same bioregion; and • Associated with a watercourse or drainage feature	233.28	135.68	97.6	355.13	355.2
Connectivity area	• A non-remnant ecosystem; and • In the same subregion; however, if the subregion is intact, the offset should be in the nearest fragmented subregion	710.72	395.55	315.17	4,763	-

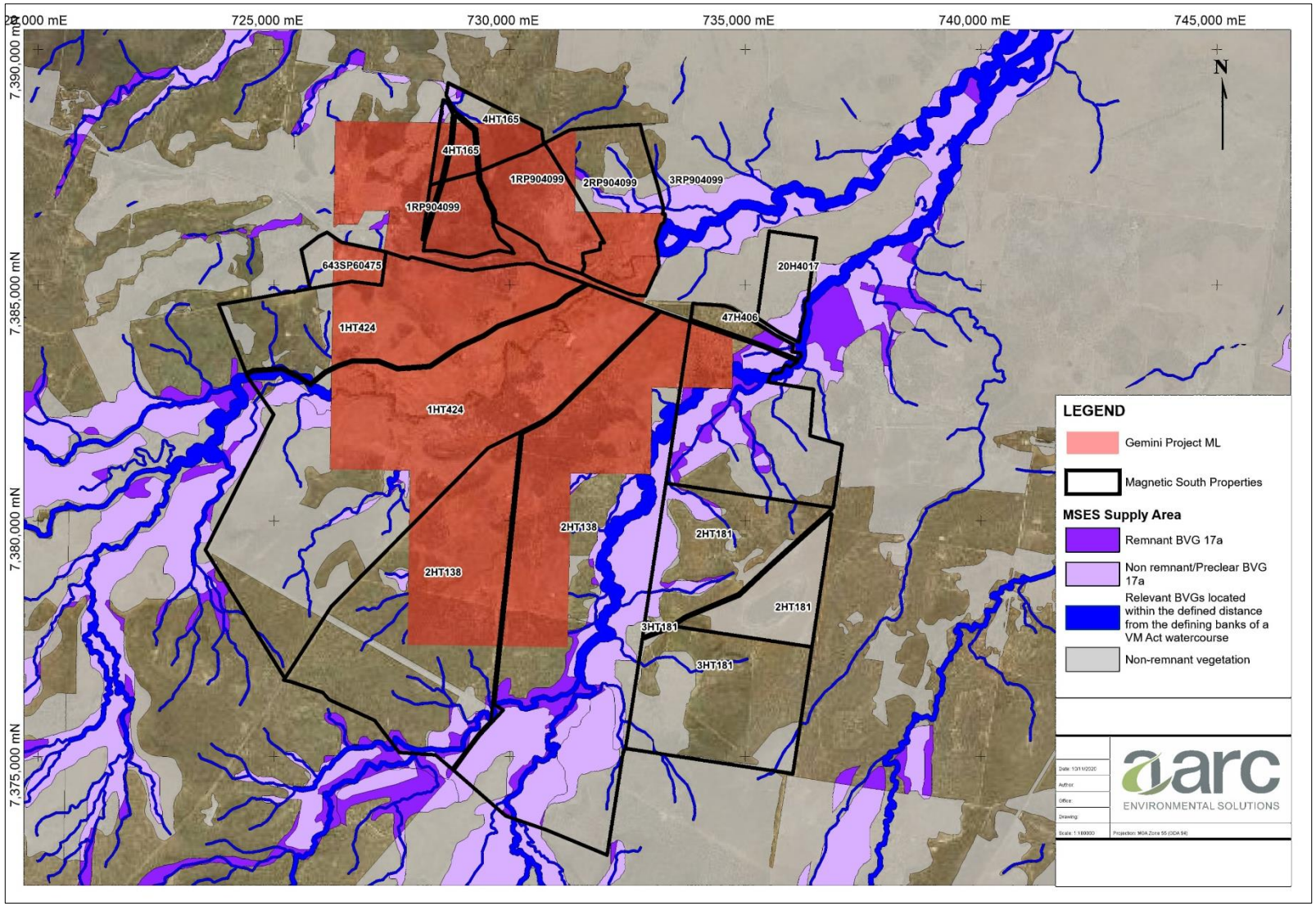


Figure 6: Potential offset supply areas within Magnetic South properties

5.0 CONCLUSION

Based on results of the significant residual impact assessment, impacts to three different MSES are proposed to be offset. Environmental offsets for the Project will include a combination of land-based offset supply and financial settlement. A two staged delivery approach is proposed.

A desktop assessment of offset supply areas was undertaken within properties owned by Magnetic South adjacent to the Project, as well as within a broader region (within 35 km of the Project). This analysis concluded that 100% of the offset requirement can likely be satisfied within the Magnetic South properties alone. However, substantial further supply opportunity exists in the surrounding landscape

Prior to project development, a condition assessment will be undertaken for both impacted land and offset supply land. A specific offset delivery plan will be prepared and submitted for approval prior to impacts occurring.

6.0 REFERENCES

AARC Environmental Solutions Pty Ltd (AARC) 2020a, Gemini Project: Terrestrial Ecology Assessment, prepared for Magnetic South Pty Ltd.

AARC Environmental Solutions Pty Ltd (AARC) 2020b, Gemini Project: Aquatic Ecology Assessment, prepared for Magnetic South Pty Ltd.

AARC Environmental Solutions Pty Ltd (AARC) 2020c, Gemini Project: Site-specific EA Application: Supporting Information, prepared for Magnetic South Pty Ltd.

Central Highlands Regional Council 2016, Central Highlands Planning Scheme 2016 (Amendment No. 4), Central Highlands Regional Council, viewed 1 July 2020 <http://www.centralhighlands.qld.gov.au/building-planning-projects/development/planning-documents/central-highlands-regional-planning-scheme/>.

Department of Environment and Heritage Protection (EHP) 2014, Queensland Environmental Offsets Policy: Significant Residual Impact Guideline, Department of Environment and Science, State of Queensland, Brisbane, viewed 2 July 2020 <https://environment.des.qld.gov.au/__data/assets/pdf_file/0017/90404/significant-residual-impact-guide.pdf >.

Department of Environment and Science (DES) 2020a, Queensland Environmental Offsets Policy (Version 1.8), Department of Environment and Science, State of Queensland, Brisbane, viewed 1 July 2020 < https://environment.des.qld.gov.au/__data/assets/pdf_file/0018/102834/offsets-policyv1-8.pdf>

Department of Environment and Science (DES) 2020b, Guide to determining terrestrial habitat quality: Methods for assessing habitat quality under the Queensland Environmental Offsets Policy (Version 1.3), Department of Environment and Science, State of Queensland, Brisbane, viewed 1 July 2020 < https://environment.des.qld.gov.au/__data/assets/pdf_file/0017/102833/habitat-quality-assessment-guide-v1-3.pdf>

Department of Natural Resources Mines and Energy (DNRME) 2019, *Vegetation management pre-clear regional ecosystem map - version 11.0*, Department of Natural Resources Mines and Energy, State of Queensland, Brisbane, viewed July to November 2020.

Appendix A Land Fragmentation Connectivity Tool Results

Department of Environment and Heritage Protection (DEHP)
Landscape Fragmentation and Connectivity (LFC) Tool version 1.4 LOGFILE
Process started at 11-11-2020 07:13:08 PM
Python version: 2.7.14 (v2.7.14:84471935ed, Sep 16 2017, 20:19:30) [MSC v.1500 32 bit (Intel)]
Arcpy version: 10.6
Username: carte

INPUT PARAMETERS
Output Workspace: W:\RACAD\AARC LFC TOOL - DINGO WEST\LFC OUTPUT
Threshold lookup table: W:\RACAD\12 - QLD DATA - LFC TOOL\LFC_data.gdb\tbl_Regional_frag_local_threshold
Remnant cover layer: W:\RACAD\AARC LFC TOOL - DINGO WEST\RVM MAPPING EXTRACT\Regulated_vegetation_management_export.shp
Remnant cover layer edited: False
Regional buffer extent: 20 kilometres
Local buffer extent: 5 kilometres
Impact layer: W:\RACAD\AARC LFC TOOL - DINGO WEST\DISTURBANCE AREAS\20201109 Infrastructure_Buffer100m AREA.shp
layer projection: GDA_1994_MGA_Zone_55
Raster cell resolution for analysis: 10 metres
Edge Width: 50 metres
(The distance from non-remnant landscapes through to the core ecosystem - the edge of remnant ecosystems)
Default projection: W:\RACAD\12 - QLD DATA - LFC TOOL\scripts\QLD Albers Equal Area Conic.prj

19:13:08 Checking out the spatial analyst tool - required for LFC

19:13:08 BEGINNING LANDSCAPE FRAGMENTATION AND CONNECTIVITY ANALYSIS

19:13:08 This tool will categorise the landscape into:
{0: 'non-rem', 1: 'patch', 2: 'edge', 3: 'perforated', 4: 'core (< 100 hectares)', 5: 'core (100-500 hectares)', 6: 'core (> 500 hectares)', 7: 'water'}

19:13:29 W:\RACAD\AARC LFC TOOL - DINGO WEST\LFC OUTPUT\lyr_file does not exist, creating it now.
19:13:29 Copying across impact site feature(s) and calculating area in hectares (AreaHA)
19:13:32 Making a local copy of the impact site
19:13:34 Preparing remnant cover layer for analysis
19:13:37 Created regional scale buffer of 20 kilometres
19:13:39 Created local scale buffer of 5 kilometres
19:13:47 Clipped the remnant cover to the regional buffer extent
19:13:49 Unioned the pre impact remnant layer with the impact site
19:13:53 Attributed the impact area as not RVM Cat B
19:13:53 Area of RVM Cat B clearing is 783.38 hectares
19:13:53 SQL selection used is "RVM_CAT" = 'B' and "Cover" = 'Not RVM Cat B' on shapefile W:\RACAD\AARC LFC TOOL - DINGO WEST\LFC OUTPUT\main_output\clip_remcover_post.shp

19:13:55 Categorised the cover attributes in clip_remcover_pre.shp ready for raster conversion
19:15:00 Converted clip_remcover_pre.shp to raster

19:15:03 Categorised the cover attributes in clip_remcover_post.shp ready for raster conversion
19:16:11 Converted clip_remcover_post.shp to raster

19:16:11 Run Landscape fragmentation analysis on the pre impact regional landscape

REGULATED VEGETATION TYPES BEING EXTRACTED FROM LAND COVER
IDENTIFICATION OF CORE, PATCH, EDGE AND PERFORATIONS
COMBINING FRAGMENTATION CLASSES

CLASSIFYING CORE FOREST PATCHES BY AREA
COMPOSING FINAL FRAGMENTATION MAP
COMPOSING FINAL FRAGMENTATION MAP
(FRAGMENTATION CALCULATION TIME WAS 21.2 MINUTES)

19:37:25 Run Landscape fragmentation analysis on the post impact regional landscape

REGULATED VEGETATION TYPES BEING EXTRACTED FROM LAND COVER
IDENTIFICATION OF CORE, PATCH, EDGE AND PERFORATIONS
COMBINING FRAGMENTATION CLASSES
CLASSIFYING CORE FOREST PATCHES BY AREA
COMPOSING FINAL FRAGMENTATION MAP
COMPOSING FINAL FRAGMENTATION MAP
(FRAGMENTATION CALCULATION TIME WAS 21.3 MINUTES)

Extracting a local subset of lfc_regional_pre_impact
Extracting a local subset of lfc_regional_post_impact

Collating pre and post impact statistics and trigger assessment
20:01:17 Summarising area statistics for: lfc_localmsk_pre_impact
20:01:19 Summarising area statistics for: lfc_localmsk_post_impact
20:01:20 Summarising area statistics for: lfc_regional_pre_impact
20:01:29 Summarising patch count for lfc_localmsk_pre_impact
20:02:43 Summarising patch count for lfc_localmsk_post_impact

Analysing impact on Connectivity Areas

SIGNIFICANCE TEST ONE

The regional total area is 182159.98
The regional extent of core remnant is 85580.99
The regional extent of core remnant is 46.98 percent
This level of regional fragmentation sets a local impact threshold of: 10.0 percent

The table below lists the local impact thresholds for categories of regional core remnant extent:

REGIONAL CORE CATEGORY	LOCAL IMPACT THRESHOLD
< 10	2.0
10 - 30	5.0
30 - 50	10.0
50 - 70	20.0
70 - 90	30.0
>90	50.0

Area of core at the local scale (pre impact): 8941.33
Area of core at the local scale (post impact): 8264.93
Percent change of core at the local scale (post impact): 7.56 percent

SIGNIFICANCE TEST TWO

The number of core remnant areas occurring on the site: 10
The number of core remnant areas remaining on the site post impact: 7
(Only core polygons greater than or equal to 1 hectare are included)

RESULT

20:04:55 This analysis has determined a SIGNIFICANT impact on connectivity areas
(A significant reduction in core remnant at the local scale is False OR a change from core to non-core remnant at the site scale is True)

(Total area of RVM Cat B clearing is 783.38 hectares)

The significance table has been written to: ..\main_output\lfc_significance_assessment.csv
The local scale summary table has been written to: ..\main_output\lfc_local_scale_summary.csv
The site scale summary table has been written to: ..\main_output\lfc_site_scale_summary.csv
GIS layer files copied into folder \lyr_file within the project folder.
View layers in ArcMAP using..\W:\RACAD\AARC LFC TOOL - DINGO WEST\LFC OUTPUT\lyr_file\lyr_file\Connectivity Area Impact Assessment.lyr

Please scrutinise the output tables and spatial layers to confirm the desktop modelling of connectivity area impact

This analysis used an unedited copy of the Regulated Vegetation layer.

20:43:31 COMPLETED LANDSCAPE FRAGMENTATION AND CONNECTIVITY ANALYSIS

Appendix B Financial Settlement Offset Calculator Results

Environmental offsets calculator results - Financial settlement offset calculator

Payment details

Non-protected area cost

On ground cost	$2,962,840.00
Landholder incentive payment	$82,959.52
Administrative cost	$740,710.00
Total non-protected area cost	$3,786,509.52

Protected area cost

Total protected area cost	$0.00

Total cost

Grand total	$3,786,509.52

Total offset area: 954.28 ha

Section 1

LGA
Central Highlands Regional Council
Bioregion
Brigalow Belt
Subregion
Woorabinda
Impact area
771.61 ha
Notional offset area
954.28 ha
Distinct matter area 1.1

Impact area: 2.57 ha
Notional offset area: 10.28 ha

Matter groups:

- 1.1.1: Regional ecosystem - 11.3.2 (Eucalyptus populnea woodland on alluvial plains)

Distinct matter area 1.2

Impact area: 31.01 ha
Notional offset area: 124.04 ha

Matter groups:

- 1.2.1: Regional ecosystem - 11.5.2 (Eucalyptus crebra, Corymbia spp., with E. moluccana woodland on lower slopes of Cainozoic sand plains and/or remnant surfaces)

Distinct matter area 1.3

Impact area: 0.59 ha
Notional offset area: 2.36 ha

Matter groups:

- 1.3.1: Regional ecosystem - 11.3.2 (Eucalyptus populnea woodland on alluvial plains)

Distinct matter area 1.4

Impact area: 17.82 ha
Notional offset area: 71.28 ha

Matter groups:

- 1.4.1: Regional ecosystem - 11.7.2 (Acacia spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone)

Distinct matter area 1.5

Impact area: 8.9 ha
Notional offset area: 35.6 ha

Matter groups:

- 1.5.1: Regional ecosystem - 11.3.25 (Eucalyptus tereticornis or E. camaldulensis woodland fringing drainage lines)

Distinct matter area 1.6

Impact area: 710.72 ha
Notional offset area: 710.72 ha

Matter groups:

- 1.6.1: Connectivity

Sections, areas and matter groups used in calculations

Section	Bioregion / Marine (and waterways) zone	Subregion / Marine bioregion	Local government area (LGA)	Distinct matter area (DMA)	DMA impact area (ha)	DMA notional offset area (ha)	Matter group
1	Brigalow Belt	Woorabinda	Central Highlands Regional Council	1.1	2.57	10.28	1.1.1 Regional ecosystem - 11.3.2 (Eucalyptus populnea woodland on alluvial plains)

Sections, areas and matter groups used in calculations

Section	Bioregion / Marine (and waterways) zone	Subregion / Marine bioregion	Local government area (LGA)	Distinct matter area (DMA)	DMA impact area (ha)	DMA notional offset area (ha)	Matter group
1	Brigalow Belt	Woorabinda	Central Highlands Regional Council	1.2	31.01	124.04	1.2.1 Regional ecosystem - 11.5.2 (Eucalyptus crebra, Corymbia spp., with E. moluccana woodland on lower slopes of Cainozoic sand plains and/or remnant surfaces)
1	Brigalow Belt	Woorabinda	Central Highlands Regional Council	1.3	0.59	2.36	1.3.1 Regional ecosystem - 11.3.2 (Eucalyptus populnea woodland on alluvial plains)
1	Brigalow Belt	Woorabinda	Central Highlands Regional Council	1.4	17.82	71.28	1.4.1 Regional ecosystem - 11.7.2 (Acacia spp. woodland on Cainozoic lateritic duricrust. Scarp retreat zone)
1	Brigalow Belt	Woorabinda	Central Highlands Regional Council	1.5	8.9	35.6	1.5.1 Regional ecosystem - 11.3.25 (Eucalyptus tereticornis or E. camaldulensis woodland fringing drainage lines)
1	Brigalow Belt	Woorabinda	Central Highlands Regional Council	1.6	710.72	710.72	1.6.1 Connectivity

GEMINI PROJECT
SOIL AND LAND SUITABILITY ASSESSMENT

PREPARED FOR
MAGNETIC SOUTH PTY LTD

JULY 2019

BRISBANE OFFICE
Suite 5, 1 Swann Road
Taringa, QLD 4068
P +61 7 3217 8772

CAIRNS OFFICE
PO Box 4887
Cairns, QLD 4879
P +61 7 4057 9402

E info@aarc.net.au
AARC.NET.AU

ACN. 620 818 920
ABN. 71 620 818 920

AARC Environmental Solutions Pty Ltd

Document History and Status

Issue	Rev.	Issued To	Qty	Date	Reviewed	Approved
1	0	MS	1	22/09/19	GB	GB

Author:	Zoe Maskell & Steven Griffiths
Project Manager:	Gareth Bramston
Name of Client:	Magnetic South Pty Ltd
Name of Project:	Gemini Project
Title of Document:	Soil and Land Suitability Assessment
Document Version:	Final

This controlled document is the property of AARC Environmental Solutions Pty Ltd and all rights are reserved in respect of it. This document may not be reproduced or disclosed in any manner whatsoever, in whole or in part, without the prior written consent of AARC Environmental Solutions Pty Ltd. AARC Environmental Solutions Pty Ltd expressly disclaims any responsibility for or liability arising from the use of this document by any third party.

Opinions and judgments expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal opinions. Information obtained from interviews and contained in the documentation has been assumed to be correct and complete. AARC Environmental Solutions Pty Ltd does not accept any liability for misrepresentation of information or for items not visible, accessible, nor able to be inspected at the sites at the time of the site visits.

GEMINI PROJECT
SOIL AND LAND SUITABILITY

INDEX

1.0 INTRODUCTION 1
1.1 SCOPE OF STUDY 1
1.2 PROJECT BACKGROUND 2
1.3 LOCAL WATERWAYS AND TOPOGRAPHY 2
1.4 CURRENT LAND USE 2
1.5 REGIONAL GEOLOGY 5
1.5.1 Solid Geology 5
1.5.2 Surface Geology 5
1.6 REGIONAL CLIMATE 8
1.7 LAND SYSTEMS 8
1.7.1 Dingo Land System 9
1.7.2 Melbadale 9
2.0 RELEVANT LEGISLATION, POLICY AND GUIDELINES 10
2.1 REGIONAL PLANNING INTERESTS ACT 2014 (QLD) 10
2.2 GUIDELINES 10
3.0 SOIL SURVEY METHODOLOGY 11
3.1 DESKTOP ANALYSIS 11
3.2 SURVEY DESIGN 11
3.3 FIELD INVESTIGATIONS 12
3.4 LABORATORY ANALYSIS 12
3.5 CHARACTERISATION OF SOIL MANAGEMENT UNITS 13
4.0 SOIL SURVEY RESULTS 14
4.1 ANDERSON SOIL MANAGEMENT UNIT 16
4.2 BARRY SOIL MANAGEMENT UNIT 19
4.3 CHARLEVUE SOIL MANAGEMENT UNIT 22
4.4 COOINDA SOIL MANAGEMENT UNIT 25
4.5 ELLESMERE SOIL MANAGEMENT UNIT 28
4.6 GEOFFREY SOIL MANAGEMENT UNIT 31
4.7 JAMES SOIL MANAGEMENT UNIT 35
4.8 KOSH SOIL MANAGEMENT UNIT 38

4.9 NAMOI SOIL MANAGEMENT UNIT 41
4.10 NIGEL SOIL MANAGEMENT UNIT 44
4.11 NORMANBY SOIL MANAGEMENT UNIT 47
4.12 WALLACE SOIL MANAGEMENT UNIT 51

5.0 LAND SUITABILITY 54
5.1 CATTLE GRAZING 55
5.1.1 Water Availability 55
5.1.2 Nutrient Deficiency 56
5.1.3 Soil Physical Factors 57
5.1.4 Salinity 58
5.1.5 Rockiness 58
5.1.6 Microrelief 59
5.1.7 pH 60
5.1.8 Exchangeable Sodium Percentage (ESP) 60
5.1.9 Wetness 61
5.1.10 Water Erosion 61
5.1.11 Flooding 62
5.1.12 Vegetation Regrowth (management limitation) 63
5.1.13 Summary of Land suitability for Cattle Grazing 64
5.2 DRYLAND CROPPING 67
5.2.1 Water Erosion 67
5.2.2 Erosion hazard, Subsoil Erodibility 68
5.2.3 Soil Water Availability 69
5.2.4 Narrow Moisture Range 69
5.2.5 Surface Condition 70
5.2.6 Rockiness 71
5.2.7 Microrelief 72
5.2.8 Wetness 72
5.2.9 Summary of Land Suitability for Dryland Cropping 74

6.0 SOIL HANDLING RECOMMENDATIONS 77
6.1 TOPSOIL SUITABILITY AND STRIPPING 77
6.2 TOPSOIL STOCKPILING 80
6.3 TOPSOIL PLACEMENT 81

7.0 POTENTIAL IMPACTS AND MANAGEMENT 83
7.1 LAND SUITABILITY 83
7.2 EROSION 84
7.3 EROSION OF REHABILITED LANDFORMS 84
7.4 SOIL DEGRADATION 85

8.0 REFERENCES 87

LIST OF FIGURES

Figure 1 Project Location 3
Figure 2 Waterways and Topography associated with the Project 4
Figure 3 Solid Geology 6
Figure 4 Surface Geology 7
Figure 5 Mean temperature and rainfall data for the region 8
Figure 6 Distribution of Soil Management Units 15
Figure 7 Cattle Grazing Land Suitability Classes 66
Figure 8 Dryland Cropping Land Suitability Classes 76

LIST OF TABLES

Table 1 Survey Site Numbers for SLSA 2018 11
Table 2 Area of Soil Management Units 14
Table 3 Anderson Soil Unit Description 16
Table 4 Chemical Properties of the Anderson SMU 17
Table 5 Surface Soil (0-10 cm) Properties of the Anderson SMU 18
Table 6 Barry Soil Unit Description 19
Table 7 Chemical Properties of the Barry SMU 20
Table 8 Surface Soil (0-10cm) Properties of the Barry SMU 21
Table 9 Charlevue Soil Unit Description 22
Table 10 Chemical Properties of the Charlevue SMU 23
Table 11 Surface Soil (0-10 cm) Properties of the Charlevue SMU 24
Table 12 Cooinda Soil Unit Description 25
Table 13 Chemical Properties of the Cooinda SMU 26
Table 14 Surface Soil (0-10cm) Properties of the Cooinda SMU 27
Table 15 Ellesmere Soil Unit Description 28
Table 16 Chemical Properties of the Ellesmere SMU 29
Table 17 Surface Soil (0-10 cm) Properties of the Ellesmere SMU 30
Table 18 Geoffrey Soil Unit Description 31
Table 19 Chemical Properties of the Geoffrey SMU 33
Table 20 Surface Soil (0-10cm) Properties of the Geoffrey SMU 33
Table 21 James Soil Unit Description 35

Table 22 Chemical Properties of the James SMU 36
Table 23 Surface Soil (0-10 cm) Properties of the James SMU 37
Table 24 Kosh Soil Unit Description 38
Table 25 Chemical Properties of the Kosh SMU 39
Table 26 Surface Soil (0-10 cm) Properties of the Kosh SMU 40
Table 27 Namoi Soil Unit Description 41
Table 28 Chemical Properties of the Namoi SMU 42
Table 29 Surface Soil (0-10 cm) Properties of the Namoi SMU 43
Table 30 Nigel Soil Unit Description 44
Table 31 Chemical Properties of the Nigel SMU 45
Table 32 Surface Soil (0-10 cm) Properties of the Nigel SMU 46
Table 33 Normanby Soil Unit Description 47
Table 34 Chemical Properties of the Normanby SMU 48
Table 35 Surface Soil (0-10 cm) Properties of the Normanby SMU 49
Table 36 Wallace Soil Unit Description 51
Table 37 Chemical Properties of the Wallace SMU 52
Table 38 Surface Soil (0-10 cm) Properties of the Wallace SMU 53
Table 39 Agricultural and Conservation Land Classes 54
Table 40 Plant Available Water Capacity 56
Table 41 Land Suitability Classes for Cattle Grazing based on Nutrient Status 57
Table 42 Land Suitability Classes for Cattle Grazing based on Soil Physical Factors 57
Table 43 Land Suitability Classes for Cattle Grazing based on Salinity 58
Table 44 Land Suitability Classes for Cattle Grazing 59
Table 45 Land Suitability Classes for Cattle Grazing based on microrelief 59
Table 46 Land Suitability Classes for Cattle Grazing based on pH 60
Table 47 Land Suitability Classes for Cattle Grazing based on ESP 60
Table 48 Land Suitability Classes for Cattle Grazing based on Wetness 61
Table 49 Land Suitability Classes for Cattle Grazing based on Water Erosion 62
Table 50 Land Suitability Classes for Cattle Grazing based on Flooding 62
Table 51 Land Suitability Classes for Cattle Grazing based on Vegetation 63
Table 52 Summary of Land Suitability Limitations for Cattle Grazing 64
Table 53 Land Suitability Classes for Dryland Cropping based on Water Erosion 67
Table 54 Land Suitability Classes for Dryland Cropping based on Erosion Hazard and Subsoil Erodibility 68
Table 55 Land Suitability Classes for Dryland Cropping based on Soil Water Availability 69
Table 56 Land Suitability Classes for Dryland Cropping based on Narrow Moisture Range 70
Table 57 Land Suitability Classes for Dryland Cropping based on Surface Condition 70
Table 58 Land Suitability Classes for Dryland Cropping based on Rockiness 71
Table 59 Land Suitability Classes for Dryland Cropping based on Microrelief 72
Table 60 Land Suitability Classed for Dryland Cropping based on Wetness 72

Table 61 Summary of Land Suitability Limitations for Dryland Cropping 74
Table 62 Maximum Topsoil Stripping Depths for all Soil Management Units.....77
Table 63 Estimated Soil Volumes.....81
Table 64 Summary of the Size and Suitability Classes for all SMUs 83

LIST OF PHOTO PLATES

Photo Plate 1 Anderson SMU Vegetation 16
Photo Plate 2 Barry SMU Vegetation 19
Photo Plate 3 Charlevue SMU Vegetation 22
Photo Plate 4 Cooinda SMU Vegetation 25
Photo Plate 5 Ellesmere SMU Vegetation.....28
Photo Plate 6 Geoffrey SMU Vegetation (showing cleared and vegetated sections).....31
Photo Plate 7 James SMU Vegetation 35
Photo Plate 8 Kosh SMU Vegetation (cleared) 38
Photo Plate 9 Namoi SMU Vegetation 41
Photo Plate 10 Nigel SMU Vegetation 44
Photo Plate 11 Normanby SMU Vegetation 47
Photo Plate 12 Wallace SMU Vegetation.....51

LIST OF APPENDICES

Appendix A Lab Results ..... A
Appendix B Soil Profile Data ..... B
Appendix C Soil Observation Data C

LIST OF ABBREVIATIONS

%	-	Percentage
<	-	less than
>	-	greater than
°C	-	Degrees Celsius
AARC	-	AARC Environmental Solutions Pty Ltd
ALS	-	Australian Laboratory Services
BoM	-	Bureau of Meteorology
Ca	-	Calcium
Ca/Mg	-	Calcium/Magnesium Ratio
CEC	-	Cation Exchange Capacity
CH4	-	Methane
cm	-	Centimetre(s)
CO2	-	Carbon Dioxide
Cu	-	Copper
DME	-	Department of Mines and Energy
DNRM	-	Department of Natural Resources and Mining
dS/m	-	deciSiemens(s) per metre
DSITI	-	Department of Science, Information Technology and Innovation
EC	-	Electrical Conductivity
EPC	-	Exploration Permit Coal
ESP	-	Exchangeable Sodium Percentage
GPS	-	Global Positioning System
ha	-	Hectare(s)
Iron	-	Fe
K	-	Potassium

km	-	Kilometre(s)
km^2	-	Kilometre(s) squared
m	-	metre(s)
m2	-	metre(s) squared
m3	-	metre(s) cubed
Magnetic South	-	Magnetic South Pty Ltd
MCA	-	Mineral Council of Australia
meq/100g	-	milliequivalent(s) per 100 grams
Mg	-	Magnesium
mg/kg	-	milligram(s) per kilogram
mm	-	Millimetre(s)
Mn	-	Manganese
N2O	-	Nitrous oxide
Na	-	Sodium
NATA	-	National Association of Testing Authorities
PAWC	-	Plant Available Water Capacity
ppm	-	Parts per million
PSA	-	Particle Size Analysis
ROM	-	Run of Mine
RPI Act	-	*Regional Planning Interests Act 2014 (Qld)*
RPI Regulation	-	Regional Planning Interests Regulation 2014
SILO	-	Scientific Information for Land Owners
SC Act	-	*Soil Conservation Act 1986 (Qld)*
SCL	-	Strategic Cropping Land
SLSA	-	Soil and Land Suitability Assessment
SMU	-	Soil Management Units
Taunton national Park	-	Taunton National Park (Scientific)
The Project	-	Gemini Project

tpa	-	tonnes per annum
V:H	-	vertical to horizontal ratio
Zn	-	Zinc

1.0 INTRODUCTION

AARC Environmental Solutions Pty Ltd (AARC) was commissioned by Magnetic South Pty Ltd (Magnetic South) to conduct a Soil and Land Suitability Assessment (SLSA) for the Gemini Project (the Project).

An assessment of the Project's soil and land suitability values was conducted within Exploration Permit Coal (EPC) 881 near Dingo in Central Queensland. This assessment forms part of the supporting studies required for the Project's Environmental Authority (EA) Application.

The Project is a greenfield, open-cut metallurgical mine approval, proposing production of Pulverised Coal Injection (PCI) coal for export to the international steel making industry.

This SLSA documents the nature and distribution of major soil types in the target area and assesses their suitability for land uses such as cattle grazing and cropping. This assessment establishes baseline environmental characteristics and values relating to land use and suitability and makes recommendations for the management of soil resources.

1.1 SCOPE OF STUDY

The objectives of the SLSA were to:

- Describe the agricultural use of the land of the Project and the surrounding area, including any crop rotations;
- Describe, map and illustrate soil types and profiles according to the *Australian Soil and Land Survey Field Handbook* (NCST 2009), *Guidelines for Surveying Soil and Land Resources* (McKenzie et. al. 2008) and *Australian Soil Classification* (Isbell 2002);
- Identify soils that would require specialised management due to wetness, erosivity, depth, acidity, salinity or other features;
- Identify soil management units from representative samples down the soil profile, based on their physical and chemical properties;
- Describe and map land suitability classes of the potentially affected area in accordance with the *Guidelines for Agricultural Land Evaluation in Queensland – Second Edition (Draft)* (DSITI & DNRM 2015), and the *Regional Land Suitability Frameworks for Queensland Guidelines for Agricultural Land Evaluation in Queensland – Second Edition (Draft)* (DSITI & DNRM 2013);
- Assess the potential impacts of the Project on the soil and land use values and provide recommended mitigation measures to minimise negative impacts; and
- Include the findings in a stand-alone report suitable for reference in the Project's EA Application.

1.2 PROJECT BACKGROUND

The Project is situated in the Bowen Basin, Central Queensland, approximately 3 kilometres (km) west of the township of Dingo, 110 km east of Emerald, and 125 km south-west of Rockhampton (Figure 1). The study area is contained within the bounds of EPC 881.

The Project is proposed to be an open-cut coal mine with an anticipated life of 25 years from grant of the mining lease (ML); with this term including initial construction, mine operation and rehabilitation activities.

1.3 LOCAL WATERWAYS AND TOPOGRAPHY

The Project lies within the Fitzroy River Basin, which encompasses an area of 142,545 square kilometres (km^2) and contains the Comet, Connors, Dawson, Don, Nogoa and Mackenzie Rivers, which make up its six sub-catchment areas (BoM 2018; DES 2018).

The Project lies within the Mackenzie River sub-catchment, which covers a total area of 12,985 km^2, and is situated in the centre of the Fitzroy River catchment. The major water body associated with the Project site is Charlevue Creek, which dissects the EPC in a north-easterly direction. This creek begins within the boundaries of Blackdown Tablelands National Park, flowing north-east before joining with Springton Creek and the Fitzroy River, eventually reaching the Pacific Ocean approximately 46 km north of Gladstone. Two significantly smaller creeks, Stanley and Springton, cross the Project boundaries in the north-west and south-east respectively. These two creeks also eventually converge with the Mackenzie River. Associated tributaries, dams and drainage features also appear across the site. Figure 2 displays the extent of the watercourses associated with the study area.

Topography of the land varies from flat to undulating hills, with elevation within the study area ranging between 120 metres (m) and 150 m above sea level. The landscape is influenced by the presence of Charlevue Creek and its associated flood plains, which have relatively lower elevations than the surrounding landscape of undulating hills. The topography of the Project is representative of the surrounding region.

1.4 CURRENT LAND USE

The land within the Project boundary is currently used for low intensity cattle grazing and resource exploration activities. There is one highway (Capricorn) and five publicly gazetted roads (Charlevue, Cooinda, Red Hill, Normanby, and Ellesmere) dissecting the area.

.

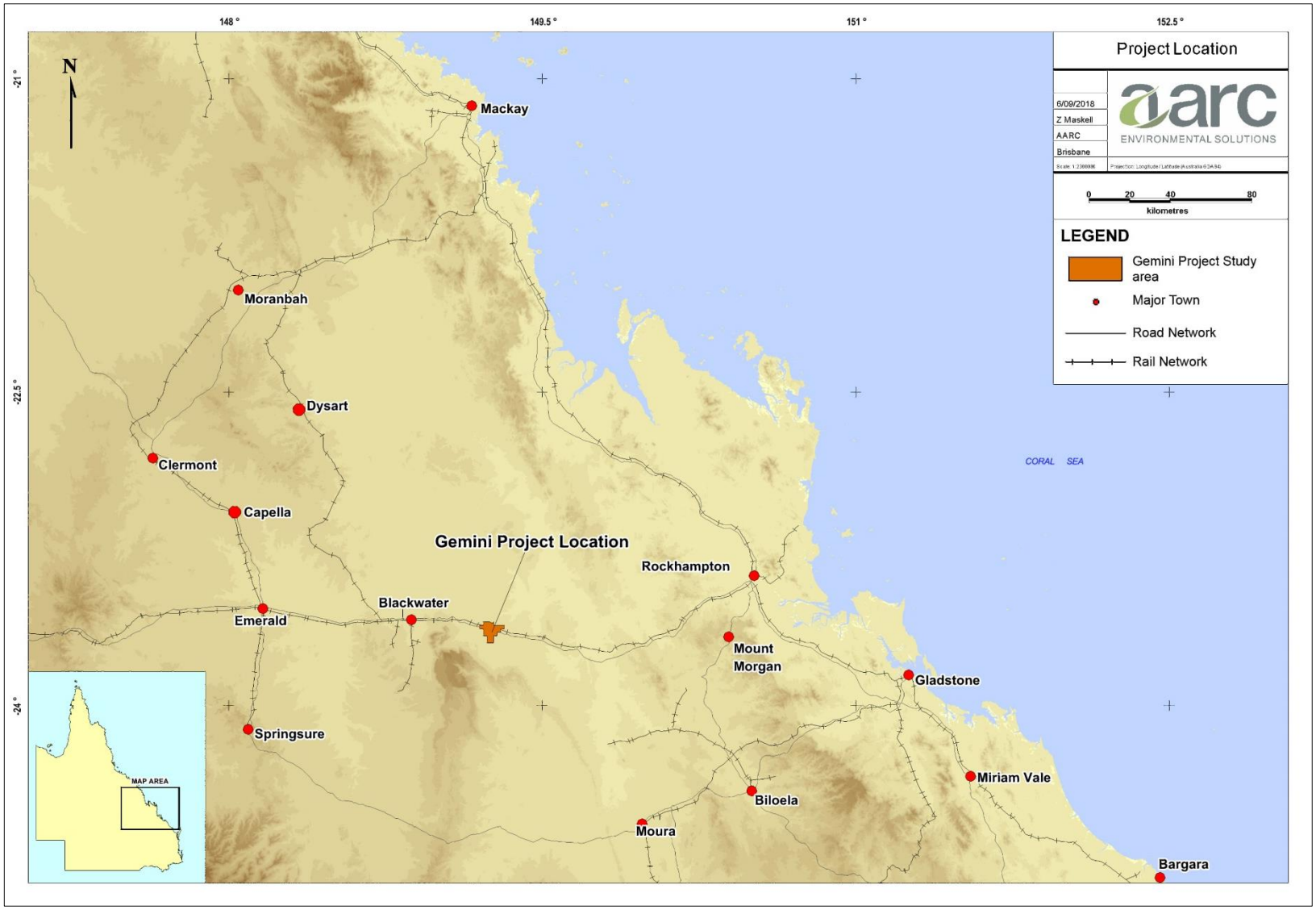


Figure 1 Project Location

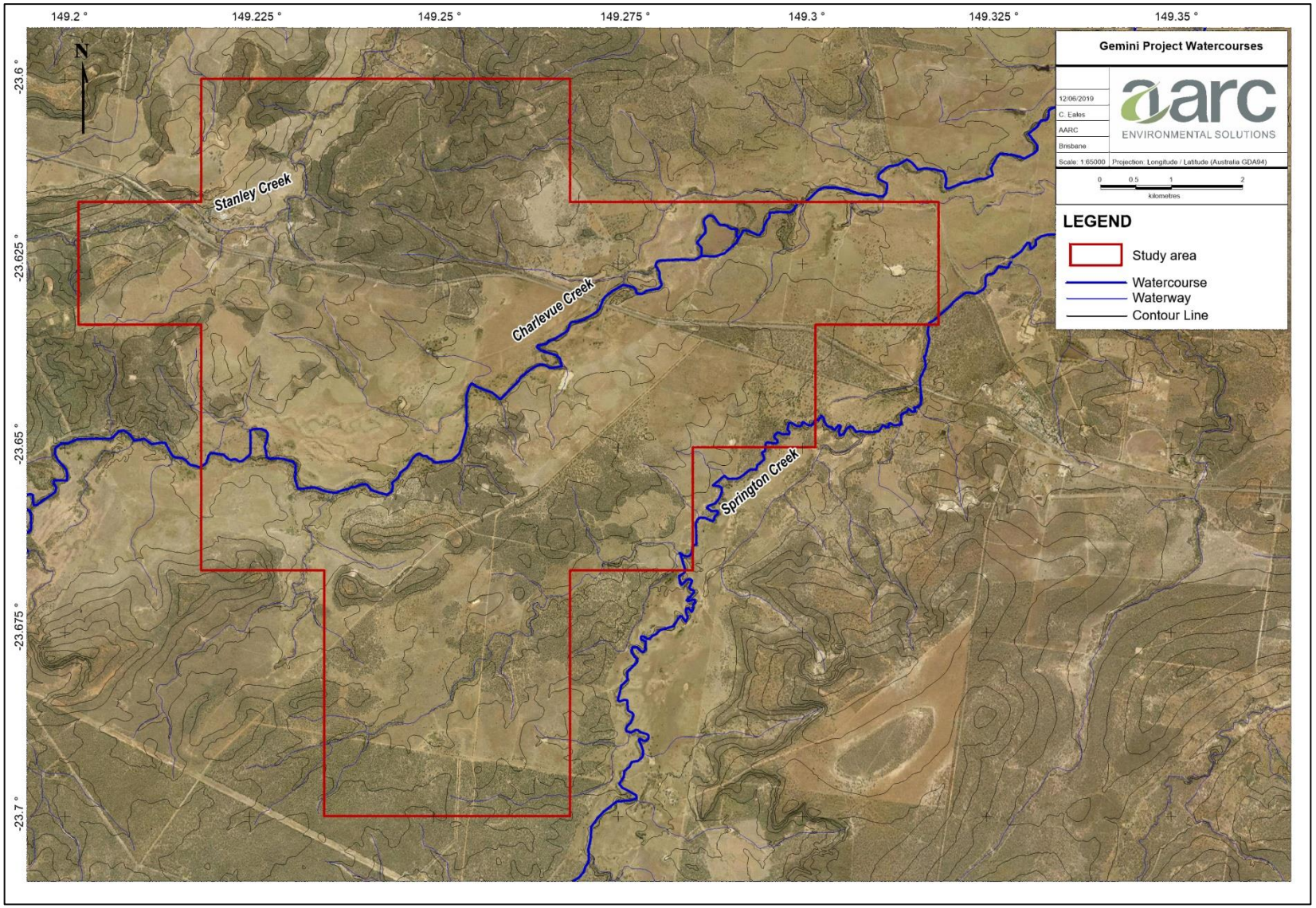


Figure 2 Waterways and Topography associated with the Project

1.5 REGIONAL GEOLOGY

The geology of the Dingo area is dominated by its position within the Bowen Basin. The Bowen Basin is one of Queensland's largest depositional zones, forming through a period of rifting and subsidence lasting from the Early Permian to Mid-Triassic. The area surrounding the Project is dominated by clastic sedimentary rocks of marine and lacustrine origin, including sandstones, conglomerates, mudstones, siltstones and coal (Geoscience Australia 2018).

The coastal and inland depositional environments which created these deposits allowed for the formation of extensive coal seams throughout the Bowen Basin, with the anoxic deposition of organic matter subsequently compacted and de-volatised through compression and increased temperatures (Brooks & Smith 1969).

Generally, coal seams found in the east-central part of the basin contain higher quality coking coal deposits, with rank falling below coking range farther south and west (Hutton 2009). The high-quality coal measures found at within the Gemini Project are of Permian age, and are generally located less than 60 m from the surface (Mutton 2003).

1.5.1 Solid Geology

The following solid geology map units were identified within the Project area.

- Rangal Coal Measures (Pwj) – Late Permian sedimentary unit comprised of sandstone, siltstone, mudstone, coal, tuff and conglomerate;
- Gyranda Subgroup (Pwy) – Late Permian sedimentary unit comprised of siltstone and shale with minor tuff and volcanilithic sandstone and rare coal (lower part - Banana Formation); calcareous sandstone, mudstone and siltstone (upper part - Wiseman Formation); and
- Rewan Group (Rr) – Early Triassic – Middle Triassic sedimentary unit comprised of lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base).

These map units are displayed below in Figure 3.

1.5.2 Surface Geology

The following surface geology map units were identified within the Project area.

- Qa-QLD (Qa) – Quaternary clay, silt, sand and gravel; flood-plain alluvium
- Td-QLD (Td) – Tertiary duricrusted palaeosols at the top of deep weathering profiles, including ferricrete and silcrete; duricrusted old land surfaces.
- Duaringa Formation (Tu) – Eocene-Oligocene mudstone, sandstone, conglomerate, siltstone, oil shale, lignite and basalt.
- Gyranda Subgroup (Pwy) – Late Permian sedimentary unit comprised of siltstone and shale with minor tuff and volcanilithic sandstone and rare coal (lower part - Banana Formation); calcareous sandstone, mudstone and siltstone (upper part - Wiseman Formation);

These map units are displayed below in Figure 4.

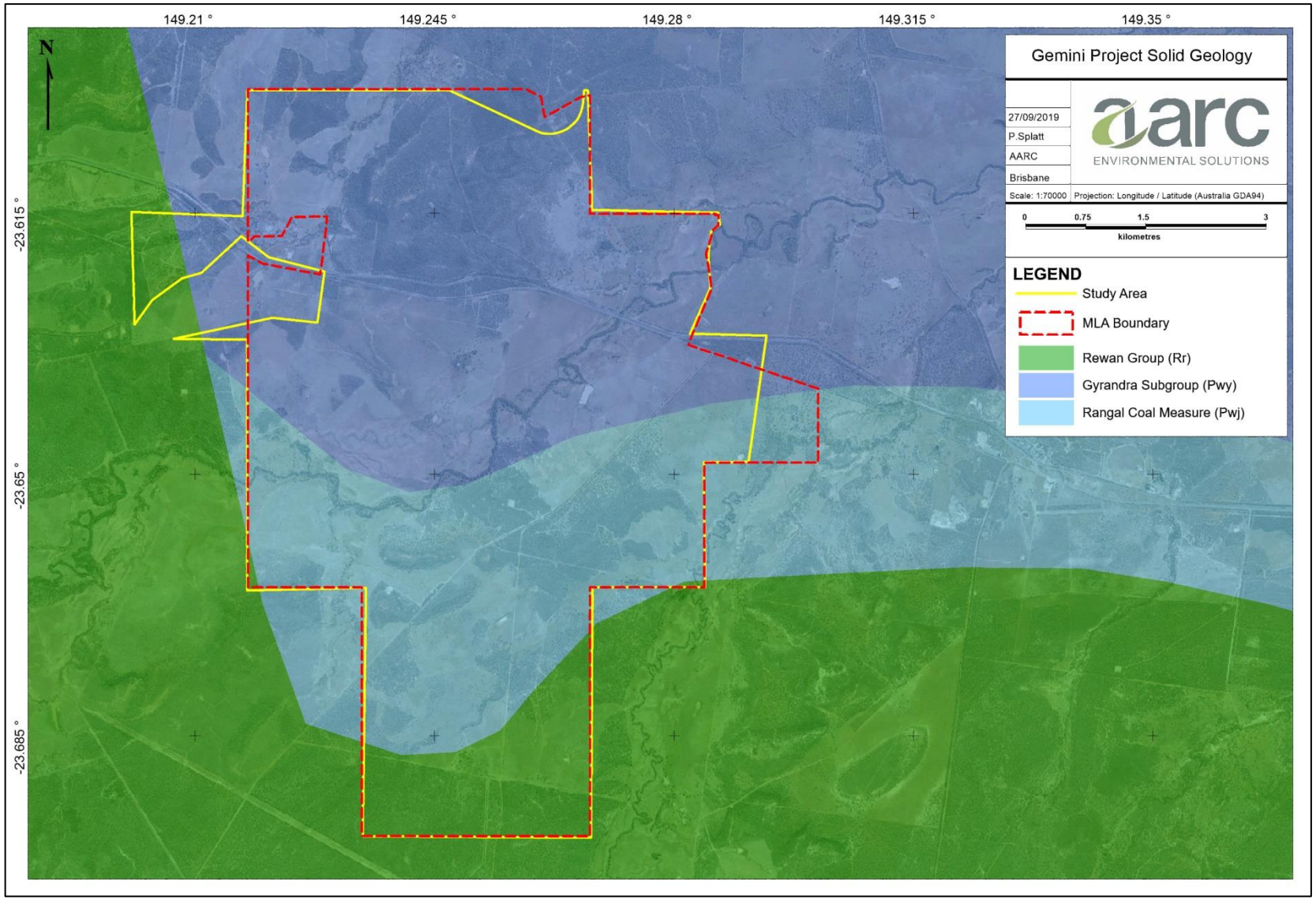


Figure 3 Solid Geology

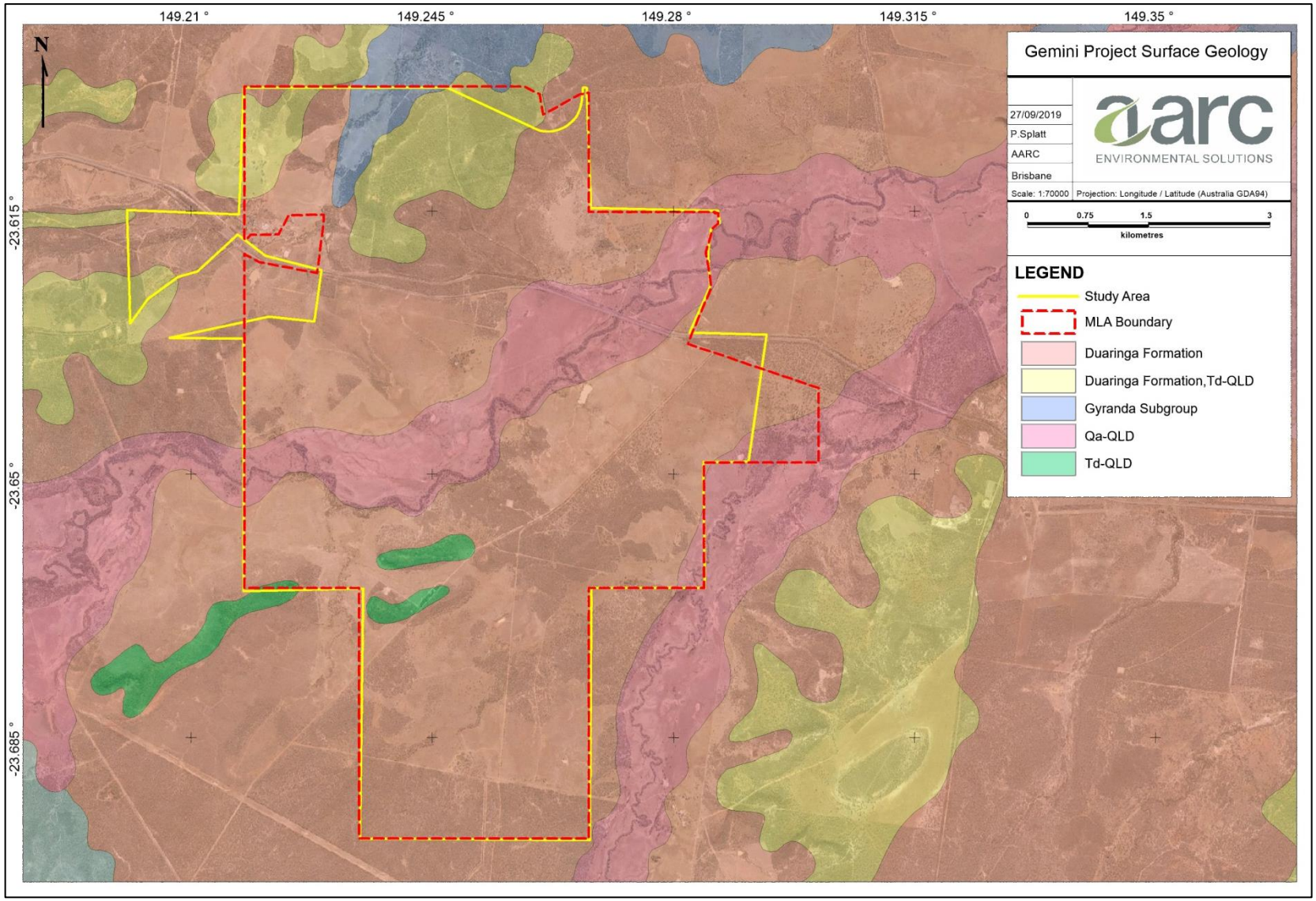


Figure 4 Surface Geology

1.6 REGIONAL CLIMATE

The regional climate is classified as semi-arid, characterised with warm dry summers and warm winters. Climate data for the Project has been sourced from Scientific Information for Land Owners (SILO) climate database (Queensland Government), which operates by interpolating data from the Commonwealth Bureau of Meteorology (BoM) into a single point data drill. SILO was selected to obtain the data, instead of weather station data from BoM, due to the significant distance between the Project and the closest weather station located in Blackwater Water Treatment Plant weather station approximately 50 km away, which only recorded weather data between 1995 and 2008.

Figure 5 shows average temperature and rainfall registered in the area from January 1999, to present. The data indicates the annual mean rainfall for the region is highest between December and March with the maximum average registering in December (111.5 millimetres (mm)).

The hottest months typically occur between October and March while the coldest months occur between May and September. The highest mean maximum temperature typically occurs in December (34.2 degrees Celsius (°C)) and the lowest mean minimum temperature in July (8.5°C). The mean annual maximum temperature for the region is 29.8°C and the mean annual minimum temperature is 16 °C.

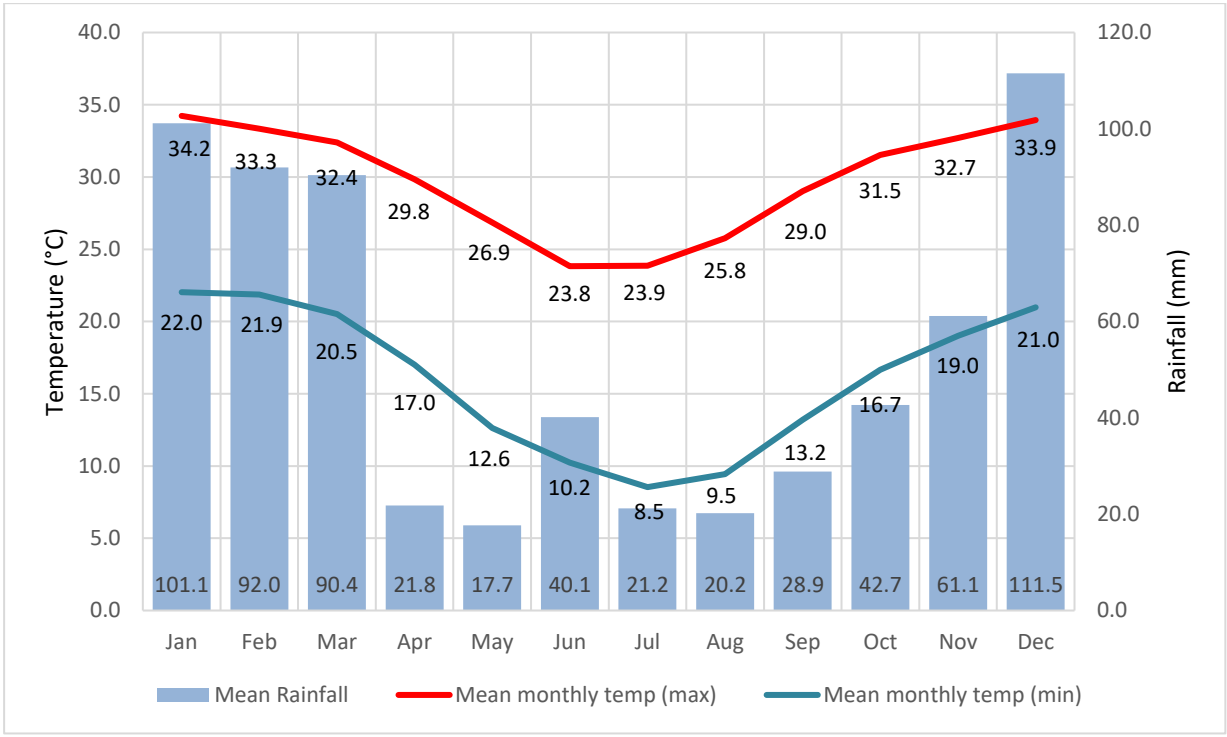


Figure 5 Mean temperature and rainfall data for the region

1.7 LAND SYSTEMS

The General Report on Lands of the Dawson-Fitzroy Area (Speck et. al. 1967) mapped at a scale of 1:80,000 indicated the study area contains the Dingo Land System and the Melbadale Land System.

1.7.1 Dingo Land System

The Dingo Land System is characterised by fluvial plains surrounding significant waterways. It is mostly composed of stable flood plains traversed by a branching pattern of drainage floors. The majority of deposits are weathered alluvium, with slopes of coarser or finer textured alluvium (depending on flow patterns). Channels can be up to 30 m wide and 3 m deep, with fringing riparian vegetation. Main drainage floors can then extend 800 m outwards, with deep texture contrast sandy loams over mottled clays, and open spaces of *Eucalyptus tereticornis* (Blue gum) and *Eucalyptus crebra* (Narrow-leaved ironbark) with sparse shrubs. Large plains surround drainage features (up to 3 km wide) which can contain either deep texture contrast soils with *Eucalyptus populnea* (Poplar box) woodlands, or deep layered soils on alluvium with woodlands of Blue gum and Narrow-leaved ironbark. Slopes within this land unit are usually the result of strongly gilgaied shrink-swell clays, forming depressions of finer soil textures with *Acacia harpophylla* (Brigalow) scrub.

Geology in this unit is comprised of weathered Quaternary alluvium.

1.7.2 Melbadale

The Melbadale Land System in characterised by the shallow dissection of weathered tertiary land surfaces, forming undulating plains dominated by complex depositional mid and lower slopes, with minor lateritic upper slopes in some places. This land system features moderately dense branching drainage patterns, with local relief usually less than 15 m. Depending on the steepness of terrain, upper slopes are often dominated by deep loamy red earths (gentle slopes) with *Eucalyptus crebra*, or shallow fine sandy loams (steep terrain) with *Acacia shirleyi* (lancewood) forests. Mid to lower slopes are often associated with deep texture contrast soils of loamy sands overlying mottled sandy clays, with grassy woodlands of open-spaced narrow-leaved ironbark and shrubs. Lower slopes are often associated with deep light to medium clays, with tall forests of narrow-leaved ironbark. Tributaries have variable soil textures depending on slope, though stratified loams and texture contrast soils are common.

Geology in this land system is comprised of Quaternary to Late Tertiary colluvial/alluvium, laterised tertiary sandstone, conglomerate, and shale.

2.0 RELEVANT LEGISLATION, POLICY AND GUIDELINES

Relevant legislation, and supporting policy and guidelines, relevant to the assessment of soil and land suitability values on the Project are discussed below.

2.1 REGIONAL PLANNING INTERESTS ACT 2014 (QLD)

The *Regional Planning Interests Act 2014 (Qld)* (RPI Act) aims to identify areas of Queensland that are of regional interests because they contribute, or are likely to contribute, to Queensland's economic, social and environmental prosperity. The RPI Act also aims to give effect to the policies about matters of State interest stated in regional plans and effectively manage impact of resource activities on the areas of regional interest and the coexistence of the two and other regulated activities such as highly productive agricultural activities.

Areas of regional interest that the RPI Act aims to protect are classified as:

- Living areas in regional communities (Priority Living Areas);
- High-quality agricultural areas from dislocation (Priority Agricultural Areas);
- Strategic cropping areas; and
- Regionally important environmental areas (Strategic Environmental Areas).

Detailed description of what constitutes each type of area of regional interest are addressed in Section 8 – 11 of the Act and the Regional Planning Interests Regulation 2014 (RPI Regulation). The RPI Act and RPI Regulation seeks to strike an appropriate balance between protecting priority land uses and delivering a diverse and prosperous economic future for our regions.

There are no areas of regional interest within the study area. Bluff is located just over 6 km to the west is mapped as a Priority Living Area and the nearest SCAs are about 5 km to the north and north-east.

2.2 GUIDELINES

Below is a summary of all relevant guidelines and resources pertaining to the assessment of soil and land suitability for the Project. These guidelines form the basis of the methodology and requirements around these assessments.

- *Australian Soil and Land Survey Field Handbook* (NCST 2009),
- *The Australian Soil Classification Revised Edition* (Isbell 2002);
- *Guidelines for Agricultural Land Evaluation in Queensland – Second Edition* (DSITI & DNRM 2015);
- *Guidelines for Surveying Soil and Land Resources* (McKenzie et al. 2008);
- *Regional Land Suitability Frameworks for Queensland Guidelines for Agricultural Land Evaluation in Queensland – Second Edition* (DSITI & DNRM 2013); and
- *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995).

3.0 SOIL SURVEY METHODOLOGY

3.1 DESKTOP ANALYSIS

Desktop analysis was conducted prior to field sampling. This analysis was comprised of background research and evaluation of available information for the study area. Resources used included:

- The Digital Atlas of Australian Soils (BRS, 1991). Australian soils were mapped at a scale of 1:2,000,000. Although this scale is broad it provided a good foundation for understanding the soils that may be present in the Project region.
- Government maps featuring regional topography, geology, contour data, and watercourse locations was used to help refine mapping boundaries, particularly where soil types were a function of gradient.
- Reference information for land systems: *Lands of the Dawson-Fitzroy Area, Queensland* (Speck et al. 1967).
- Reference Information for regional geology: *Geology of the Bowen Basin, Queensland* (Dickins & Malone 1973).
- Reference information for land management: *Understanding and Managing Soils in the Central Highlands* (DPI, 1993).

3.2 SURVEY DESIGN

Methodologies employed throughout this study followed procedures detailed in the *Australian Soil and Land Survey Field Handbook* (NCST, 2009) and the *Guidelines for Surveying Soil and Land Resources* (McKenzie et. al. 2008). The soil survey was based on a free-survey technique with soil profile and observation sites located to best represent all soil types present in the Project.

For this site, a scale between 1:25,000 to 1:100,000 was deemed most appropriate. This scale was selected based on information contained within the *Guidelines for Surveying Soil and Land Resources* (McKenzie et. al. 2008). The final mapping scale for the Project site fell within the specified range.

To achieve a mapping scale of 1:25,000 to 1:100,000, McKenzie et. al. (2008) suggest a minimum recommended sampling density of 1 site per 25 ha with data collection comprising detailed soil profile descriptions (15 to 35 percent (%) of sites), representative profile sampling for lab analysis (1 to 5%) and mapping observations sites (55 to 83%).

The number of sites surveyed for the SLSA (Table 1) exceeded these minimum requirements.

Table 1 Survey Site Numbers for SLSA 2018

Survey Site	Scale	Detailed Soil Profiles	Representative Profiles for Analysis	Mapping Observations	Total
Gemini (6,240 ha)	1:70,000	60	12	180	252

3.3 FIELD INVESTIGATIONS

Field sampling at the Project was undertaken from 20th to 29th of June 2018, consisting of both primary sampling sites (profiles) and secondary visual assessments (observations).

During the survey, sampling site locations were determined using desktop analysis, land management units, landform and vehicle access. Visual assessments were conducted continually whilst traversing the landscape to confirm major soil types and boundaries between soil units. Each site location was recorded using a Global Positioning System (GPS).

Detailed soil profiles were undertaken at 60 sites within the Project boundaries. A jack hammer operated soil corer was used to excavate cores to a maximum depth of 120 centimetres (cm). Soil samples were collected from profiles at standard depths of 0-10, 20-30, 50-60, 80-90, and 110-120 cm where possible. Samples were sealed in clean, plastic zip-lock bags and labelled with the site number, date, depth of sampling, and the initials of the sampler.

Parameters recorded included micro-relief, permeability, drainage, substrate, site disturbance, landform (slope %, relief, elevation, morphological type, landform element and landform pattern), runoff, erosion, SC fragments, rock outcrops, surface condition and dominant vegetation type. Soil profile morphology was described in the field in terms of horizon type, horizon depth, boundary, colour, mottles, texture, coarse fragments, structure, segregations, consistency, and field pH.

3.4 LABORATORY ANALYSIS

Soil profiles from 12 representative sites were selected for analysis through Australian Laboratory Services (ALS) for National Association of Testing Authorities (NATA) approved physical and chemical analyses. All standard depths at the chosen sites were utilised in chemical analysis. Samples were analysed to:

- Confirm the classification of the described soil profile;
- Assist in the description of soil characteristics;
- Assist in the determination of land suitability classes;
- Assist in the determination of topsoil and subsoil as a suitable topdressing media; and
- Assist in the identification of soils that would require specialised management.

Physical and chemical parameters analysed for all samples included:

- pH;
- Electrical Conductivity (EC);
- Moisture Content;
- Chloride (Soluble);
- Exchangeable Cations (Calcium(Ca), Magnesium (Mg), Sodium (Na), Potassium (K));
- Cation Exchange Capacity (CEC); and
- Exchangeable Sodium Percentage (ESP).

Additional physical and chemical parameters analysed for topsoil samples included:

- Organic Matter (%);
- Particle Size Analysis (PSA);
- Extractable Trace Elements/Metals (Iron (Fe), Copper (Cu), Zinc (Zn), Manganese (Mn));
- Boron ($CaCl_2$ extractable);
- N as Nitrate;
- Sulphate (water soluble S as SO_4);
- Phosphorus and Potassium (Colwell); and
- Emerson Class.

3.5 CHARACTERISATION OF SOIL MANAGEMENT UNITS

Soil classification was undertaken using the methodologies specified in *The Australian Soil Classification* (Isbell 2002). Soil Management Units (SMUs) were then described based on the soils' physical and chemical attributes, and land attributes in accordance with the *Guidelines for Surveying Soil and Land Resources* (McKenzie et. al. 2008).

Typically, each SMU was described in terms of its soil profile class, defined as a group of similar soils, having soil profile properties in common. The soils' attributes/limitations were then interpreted using the *Guidelines for Agricultural Land Evaluation in Queensland – Second Edition* (DSITI & DNRM, 2015) to determine their suitability for cattle grazing and broadacre cropping. SMUs were mapped at a scale of 1:70,000 across the Project.

4.0 SOIL SURVEY RESULTS

Within the Project, a total of 12 SMUs were described. Table 2 provides an overview of each SMU and its extent within the Project. The spatial distribution of the SMUs is depicted in Figure 6.

Ratings and categories outlined in the CSIRO publications *Interpreting Soil Test Results – Third Edition* (Hazelton & Murphy 2016) and *Soil Chemical Methods of Australasia* (Rayment & Lyons 2011) were used to assist in interpretation of the SMU physical and chemical properties.

Table 2 Area of Soil Management Units

SMU	Surface Area (ha)	Percent of Study Area (%)
Anderson	37.8	0.61
Barry	156.5	2.54
Charlevue	232.9	3.77
Cooinda	34.9	0.57
Ellesmere	14.6	0.24
Geoffrey	4,079	66.10
James	145.2	2.35
Kosh	927.6	15.03
Namoi	177.6	2.89
Nigel	286.4	4.64
Normanby	48.5	0.79
Wallace	32.0	0.52
Total Area	**6,171.3**	**100**

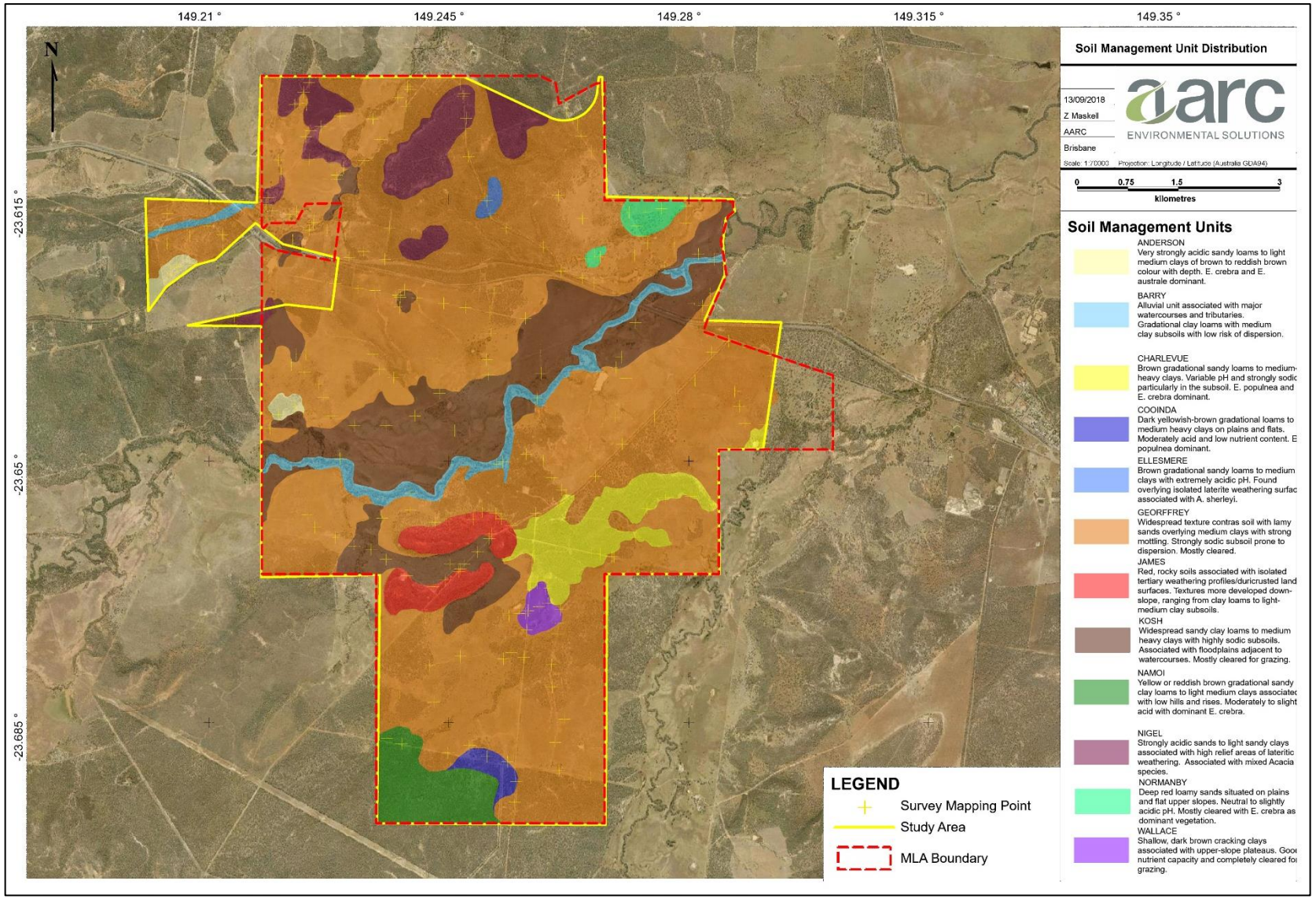


Figure 6 Distribution of Soil Management Units

4.1 ANDERSON SOIL MANAGEMENT UNIT

Soil Unit Description: Hard setting soil unit associated with isolated hills. Soil textures grade from loams at the surface, to light medium clays with depth, sometimes exhibiting red mottling. Vegetation associated with this unit includes *Eucalyptus crebra*, *Corymbia clarksoniana*, and *Acacia rhodoxylon* with *Erythroxylum australe* in the shrub layer.

Australian Soil Classification: Red Kurosol.

Photo Plate 1 Anderson SMU Vegetation

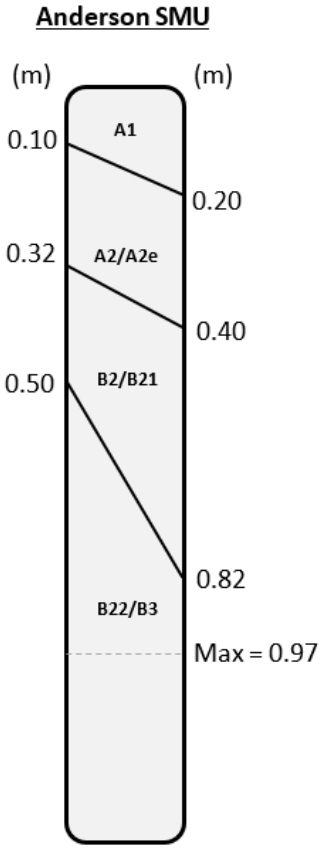
Table 3 Anderson Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP37, DP26
Observation Site Numbers	DO55, DO75
Landform	Isolated hills
Land System	Melbadale
Slope	1 to 6%
Geology	Rewan Group (Rr) – Early Triassic – Middle Triassic sedimentary unit comprised of lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base)
Vegetation	*Eucalyptus crebra, Corymbia clarksoniana,* and *Acacia rhodoxylon* with *Erythroxylon australe* in the shrub layer.
Runoff	Moderate to Rapid
Permeability	Slowly to moderately permeable
Drainage	Imperfectly to moderately well drained

Profile Description Representative Sites: DP37 and DP26.

The **surface soil** (A1) is a reddish brown to dark greyish brown (5YR4/4, 10YR3/2) sandy loam to clay loam with massive structure. It has a field pH of 4.5, demonstrating a gradual change to;

The **lower surface soil** (A2/A2e) is a reddish brown (5YR4/4) sandy loam to light medium clay with some profiles exhibiting conspicuous bleaching. It has massive to weak polyhedral structure and a field pH of 4.5 to 5.0. Sub-rounded to rounded coarse fragments make up 1 to 20% of this soil horizon. Clear or gradual change to;



The **subsoil** (B2/B21) is a brown to yellowish red (10YR5/3, 5YR4/6) light to light medium clay with weak lenticular to moderate polyhedral structure. It can exhibit red mottles, and has angular course fragments making up to 20% of the horizon. This horizon has a field pH of 5.5, with a gradual change to;

The **lower subsoil** can present as two different horizons depending on slope. B22 is a light brownish grey (10YR6/2) medium clay with strong angular blocky structure with red mottles. B3 is a yellowish red (5YR4/6) light clay with massive structure, and a small amount of 2-6 mm diameter rounded coarse fragments. The pH in these horizons ranges from 5.5 to 5.8.

Chemical and Physical Analysis

Table 4 Chemical Properties of the Anderson SMU

Representative site: DP26									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	4.6	Very strongly acid	0.064	Very low	30	3.7	Non-sodic	1	3
0.2-0.3	4.7	Very strongly acid	0.028	Very low	10	2.6	Non-sodic	4.3	4
0.5-0.6	4.8	Very strongly acid	0.02	Very low	10	4.5	Non-sodic	8.2	4

Depth (m)	**CEC**		**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**
	meq / 100g	**Rate**	**Ca**	**Mg**	**K**	**Na**	
0-0.1	2.7	Very low	0.7	0.2	0.4	<0.1	3.5
0.2-0.3	2.8	Very low	0.4	0.2	0.2	<0.1	2.0
0.5-0.6	4.2	Very low	0.2	1	<0.1	<0.1	0.2
Percentage in Topsoil			25.93%	7.41%	14.81%	3.70%	-

Key: meq/100g milliequivalent per 100 grams
dS/m deciSiemens per metre
mg/kg milligrams per kilogram

The Anderson SMU has a very strongly acidic pH throughout the profile, ranging from 4.6 in the topsoil, to 4.8 in the lower subsoil. EC and chloride results indicate that at all depths, salinity is very low, with EC ranging from 0.064 deciSiemens per metre (dS/m) in the topsoil, to 0.02 dS/m in the subsoil layer. Chloride concentrations reflected this result, decreasing with depth from 30 milligrams per kilogram (mg/kg) to 10 mg/kg, both well below toxic limits.

CEC is considered very low throughout the profile, though increases from 2.7 milliequivalent per 100 grams (meq/100g) in the topsoil, to 4.2 meq/100g in the subsoil layer. This may be attributed to the high amount of sand in this Exchangeable cation concentrations reflect the low CEC, with calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) presenting with <1.0 meq/100g) at all depths. Cation percentages are also below appropriate levels, except potassium, which presents within the appropriate range.

The Ca/Mg ratio in the topsoil is between 1 and 4 (low calcium), though this is considered appropriate for sandy soils. This ratio falls to 0.2 in the lower subsoil (Ca deficient). Due to the low clay content of this soil, the low Ca/Mg ratio seen here isn't likely to increase the risk of dispersion in this soil unit.

Table 5 Surface Soil (0-10 cm) Properties of the Anderson SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	Sand	Silt	Clay				
10	66	13	11	3	10.2	20	3.3
Extractable Nutrients (mg/kg)				Extractable Metals (mg/kg)			
P	K	B		Cu	Fe	Mn	Zn
11	<200	0.6		<1.00	296	5.46	<1.00

Key: < less than

The surface soil (A1) was dominated by sand (66%), with 10% gravel, 13% silt, and 11% clay. It lacks true structure (massive), and is non-sodic, with a Ca/Mg ratio of 3.5, and an organic matter content of 3.3%. This information paired with the topsoil's Emerson Class Number of 3, indicates that this soil has favourable chemistry, and is unlikely to suffer from dispersion. The high concentration of coarse particles (sand and gravel) may mean this SMU has the tendency to slump under pressure, as it lacks the binding capacity provided by higher clay percentages.

Nutrient levels are variable, with nitrate concentration (10.2 mg/kg) within the guideline range for supporting plant life, while phosphorous (11 mg/kg) and potassium (<200 mg/kg) are not. Boron (0.6 mg/kg) and sulphate (20 mg/kg) concentrations are acceptable, though extractable metals are generally too low (copper and zinc) or too high (iron), with only manganese within the appropriate range for plant life. Acidic pH values in the topsoil will limit the availability of these nutrients to plants, by impacting solubility and speciation. In addition to this, high iron levels can lead to plant toxicity and inefficiency in photosynthesis (Connolly & Guerinot, 2002).

4.2 BARRY SOIL MANAGEMENT UNIT

Soil Unit Description: Hard setting soil associated with rivers, drainage lines and levees. Surface soils in this unit are comprised of clay loams to medium clays, grading into light or medium clays at variable depths. Dominant vegetation includes *Eucalyptus tessellaris, Eucalyptus populnea* and *Eucalyptus tereticornis,* with *Lysiphyllum hookeri*, *Cassia spinarum* and *Cassia brewsteri* in the shrub layer.

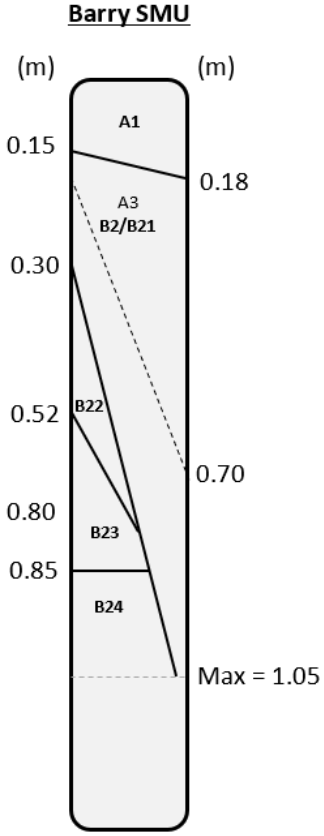
Australian Soil Classification: Brown Dermosol.

Photo Plate 2 Barry SMU Vegetation

Table 6 Barry Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP14, DP29, DP36
Observation Site Numbers	DO45, DO79, DO203
Landform	Alluvial plains and levees
Land System	Dingo
Slope	2 to 3%
Geology	Qa-QLD (Qa) – Quaternary clay, silt, sand and gravel; flood-plain alluvium
Vegetation	*Eucalyptus tessellaris, Eucalyptus populnea* and *Eucalyptus tereticornis*, with *Lysiphyllum hookeri, Cassia spinarum* and *Cassia brewsteri* in the shrub layer.
Runoff	Moderate to Rapid
Permeability	Moderately to highly permeable
Drainage	Moderately well drained

Profile Description – Representative Sites: DP14, DP29 and DP36



The **surface soil** (A/A1) is a dark reddish brown (5YR3/4, 7.5YR4/3) clay loam to medium clay with weak to moderate polyhedral or platy structure. It has a field pH of 6.0 to 6.5, with a gradual change to either A3 or B2;

The **lower surface soil** (A3) was not present at all profile sites. It is a reddish brown (5YR4/4) sandy clay loam with massive structure and a field pH of 6.5. Gradual change to;

The **upper subsoil** (B2/B21) is a dark reddish brown to brown (5YR3/3, 7.5YR4/4) sandy light medium clay to medium heavy clay, with weak to moderate structure. It has a field pH of 6.0 to 6.5, with a gradual change to;

The **subsoil** (B22) is a brown to dark brown (7.5YR4/4, 7.5YR3/2) clay loam to medium clay, which can either extend to great depths in the profile, or grade into the subsoil horizons. It has moderate polyhedral structure and a field pH of 6.0 to 6.5. Gradual change to;

The **mid-subsoil** (B23) is a brown (7.5YR4/4) light clay with moderate platy structure and a field pH of 6.5. Clear change to;

The **lower-subsoil** (B24) is a dark brown (7.5YR3/3) light medium clay with moderate polyhedral structure and a field pH of 6.5.

Chemical and Physical Analysis

Table 7 Chemical Properties of the Barry SMU

Representative site: DP14									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	6.5	Slightly acid	0.063	Very low	20	0.3	Non-sodic	2.3	3
0.2-0.3	6.8	Neutral	0.012	Very low	<10	0.5	Non-sodic	5.1	4
0.5-0.6	6.9	Neutral	0.01	Very low	<10	0.7	Non-sodic	4.3	3
0.8-0.9	7.2	Neutral	0.012	Very low	<10	1	Non-sodic	7.2	3

Depth (m)	**CEC**		**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**
	meq / 100g	**Rate**	**Ca**	**Mg**	**K**	**Na**	
0-0.1	12.5	Moderate	6.4	5.2	0.9	<0.1	1.2
0.2-0.3	11.3	Low	6.1	4.9	0.2	<0.1	1.2
0.5-0.6	10.4	Low	5.5	4.6	0.2	<0.1	1.2
0.8-0.9	18	Moderate	10	7.5	0.3	0.2	1.3

Percentage in Topsoil	51.20%	41.60%	7.20%	0.30%	-

The Barry SMU has a slightly acidic pH (6.5) which increases gradually with depth, becoming neutral at 0.2 m (6.8), and increasing to pH 7.2 with depth. EC is very low throughout the profile, ranging from 0.063 dS/m in the topsoil, to 0.012 dS/m in the lower subsoil. Chloride concentrations reflect this result, ranging from 20 mg/kg to <10 mg/kg mg/kg with depth.

CEC varies with depth from moderate in the topsoil, to low in the mid-stratum, to moderate in the lower subsoil. This result is reflected in the concentrations of exchangeable cations, which are higher in the topsoil and lower subsoil than they are in the mid-level horizons. Ca, Mg, K and Na are all within the desirable range for plant growth, at all depths. Throughout the profile, calcium dominates magnesium, with a Ca/Mg ratio of 1.2 to 1.3 at all depths. This assists in decreasing any risk of dispersion in the soil, though plants could benefit from additional calcium.

ESP is considered non-sodic at all depths, ranging from 0.3% in the topsoil layer to 1.0% in the lower subsoil. This is beneficial for plant life and ensures that the unit should remain relatively stable when wet. This conclusion is supported by the unit's Emerson Class Numbers, which vary from 3 to 4 throughout the profile, suggesting that if left undisturbed, this unit should not become dispersive.

Table 8 Surface Soil (0-10cm) Properties of the Barry SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	**Sand**	**Silt**	**Clay**				
2	42	42	14	3	1.7	<10	3.3
Extractable Nutrients (mg/kg)				**Extractable Metals (mg/kg)**			
P	**K**	**B**		**Cu**	**Fe**	**Mn**	**Zn**
64	596	0.4		<1.00	53.4	37.2	2.88

The surface soil (A/A1) is dominated by sand (42%) and silt (42%), with 14% clay and 2% gravel. It has weak to moderate structure and is hard setting. The surface soil is non-sodic, with a Ca/Mg ratio of 1.2, and a high organic matter content of 3.3%. This information paired with the topsoil's Emerson Class Number of 3 suggests that the surface soil is unlikely to suffer from dispersion when wetted. The water-holding capacity of the topsoil is relatively good, due to the organic matter content and presence of clay sized particles. This is evidenced by the increase in moisture content with depth (as seen in Table 7).

Nutrient levels are variable, with deficient nitrate (1.7 mg/kg), and adequate concentrations of phosphorous (64 mg/kg) and potassium (569 mg/kg). Boron (0.4 mg/kg) and sulphate (<10 mg/kg) are both below guideline levels for supporting plant life. Extractable metal concentrations also vary in their suitability. While zinc is at an appropriate concentration (2.88 mg/kg), manganese (37.2 mg/kg) and iron (53.4 mg/kg) are both slightly higher than desirable, while copper is below detectable concentration (<1.0 mg/kg). These variable nutrient and metals concentrations are likely to limit the types of vegetation supported by the Barry SMU.

4.3 CHARLEVUE SOIL MANAGEMENT UNIT

Soil Unit Description: Hard setting soil associated with plains and rises. Textures within this unit grade from sandy clay loams or light clays in the surface soil, to medium heavy clays in the subsoil horizons. Dominant vegetation includes *Eucalyptus populnea* and *Eucalyptus crebra,* with *Flindersia dissosperma* (sometimes dominant) and *Cassia spinarum* in the shrub layer.

Australian Soil Classification: Red or Brown Dermosol

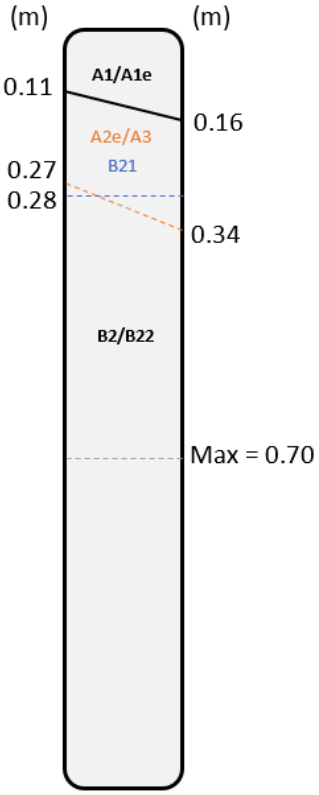
Photo Plate 3 Charlevue SMU Vegetation

Table 9 Charlevue Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP6, DP10, DP11
Observation Site Numbers	DO6, DO24, DO25, DO27, DO244
Landform	Plains and rises
Land System	Melbadale
Slope	1 to 3%
Geology	Qa-QLD (Qa) – Quaternary clay, silt, sand and gravel; flood-plain alluvium
Vegetation	*Eucalyptus populnea* and *Eucalyptus crebra*, with *Flindersia dissosperma* and *Cassia spinarum* in the shrub layer.
Runoff	Very slow to rapid
Permeability	Slowly permeable
Drainage	Poorly drained

Profile Description – Representative Sites: DP6, DP10 and DP11

Charlevue SMU



The **surface soil** (A1/A1e) is a dark brown to brown (7.5YR3/3, 7.5YR4/3, 10YR3/3) sandy clay loam to light medium clay, with weak to moderate structure. It may exhibit conspicuous bleaching, and has a field pH of 5.5 to 5.8. Clear or sharp change to;

The **lower surface soil** (A2e/A3) was not present as all profile sites. It is a light to medium clay with moderate structure, sometimes exhibiting conspicuous bleaching. Field pH is 5.5 to 6.0, with a sharp or abrupt change to;

The **upper subsoil** (B21) was only present at one profile site. It is a dark brown (7.5YR3/4) medium clay with weak lenticular structure and a field pH of 6.5. Clear change to;

The **lower subsoil** (B2/B22) is a reddish or yellowish brown (5YR4/4, 10YR4/6) medium heavy clay with weak to moderate structure. It has a field pH of 6.5 to 7.0.

Chemical and Physical Analysis

Table 10 Chemical Properties of the Charlevue SMU

Representative site: DP6									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	5.4	Strongly acid	0.28	Medium	420	19.8	Strongly sodic	9.1	4
0.2-0.3	6.4	Slightly acid	0.43	Medium	680	15.1	Strongly sodic	11.8	2
0.5-0.6	7.9	Moderately alkaline	0.46	High	630	29.4	Strongly sodic	10.7	1

Depth (m)	**CEC**		**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**
	meq / 100g	**Rate**	**Ca**	**Mg**	**K**	**Na**	
0-0.1	6.3	Low	1.7	3.1	0.1	1.2	0.5
0.2-0.3	11.4	Low	3.2	6.4	<0.1	1.7	0.5
0.5-0.6	13.1	Moderate	2.7	6.5	<0.2	3.8	0.4
Percentage in Topsoil			26.98%	49.21%	1.59%	19.80%	-

The Charlevue SMU has a variable pH, ranging from 5.4 (strongly acid) in the topsoil to 7.9 (moderately alkaline) in the lower subsoil. EC is medium in the surface soil (0.28 to 0.43 dS/m), and increases to high in the subsoil (0.46 dS/m). Chloride is considered to be high from 0.2 m depth downwards (>600 mg/kg), which can cause toxicity by interfering with plants' osmotic capacity.

CEC increases with depth, ranging from low (6.3 meq/100g) in the topsoil, to moderate (13.1 meq/100g) in the subsoil layer. This result is reflected in the concentrations of exchangeable cations, which also generally increase with depth. Potassium concentrations were lower than desirable, and though calcium and magnesium fell within the appropriate concentration ranges, necessary percentages were unbalanced throughout the profile. In the topsoil, exchangeable cations are dominated by magnesium at 49.21%, which translates to a Ca/Mg ratio of 0.5. Subsoil layers see a decrease in this ratio, with magnesium (6.5 meq/100g) dominating over calcium (2.7 meq/100g). Due to the high clay content of this soil, this is likely to increase the risk of dispersion in this soil unit.

ESP is considered strongly sodic throughout the profile, ranging from 19.8% in the topsoil layer to 29.4% in the lower subsoil. Due to the high clay content in this soil, this is likely to increase the dispersive tendencies of the unit with depth. This result is reflected in the unit's Emerson Class Numbers, which range from 4 in the surface soil (non-dispersive) to 1 in the lower subsoil (highly dispersive).

Table 11 Surface Soil (0-10 cm) Properties of the Charlevue SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	Sand	Silt	Clay				
5	54	38	3	4	0.4	20	1
Extractable Nutrients (mg/kg)				Extractable Metals (mg/kg)			
P	K		B	Cu	Fe	Mn	Zn
12	<200		0.8	<1.00	29.7	5.45	<1.00

The surface soil (A1/A1e) for the Charlevue SMU is dominated by sand (54%) and silt (38%), with 5% gravel and 3% clay. It has weak to moderate structure, and a hard setting surface condition. The topsoil is strongly sodic, with a Ca/Mg ratio of 0.5, and an organic matter content of 1.0%. This information would usually suggest that dispersion would be a considerable risk for the topsoil, though chemical results presented an Emerson Class Number of 4 (non-dispersive). This is likely due to the high sand content in the topsoil layer, which decreases with depth as clay content (and dispersive tendency) increases.

Nutrient levels in the topsoil layer are generally poor, with nitrate (0.4 mg/kg), phosphorous (12 mg/kg) and potassium (<200 mg/kg) below suitable levels. Sulphate (20 mg/kg) and boron (0.8 mg/kg) are within acceptable ranges for supporting plant life. Extractable metals vary in their suitability. Both copper and zinc are below reportable amounts, while manganese (5.45 mg/kg) and iron (29.7 mg/kg) are present in suitable concentrations.

Strongly acidic soils such as these can limit the availability of these nutrients to plants, by affecting their solubility, speciation, and toxicity.

4.4 COOINDA SOIL MANAGEMENT UNIT

Soil Unit Description: Hard setting soil associated with plains. Texture development within this unit is gradual, changing from a sandy clay loam in the topsoil, to a sandy light clay at mid-depth, and a medium heavy clay in the deeper subsoil. Dominant vegetation includes *Eucalyptus populnea* and *Flindersia dissosperma* (sometimes dominant), with *Cassia spinarum* in the shrub layer.

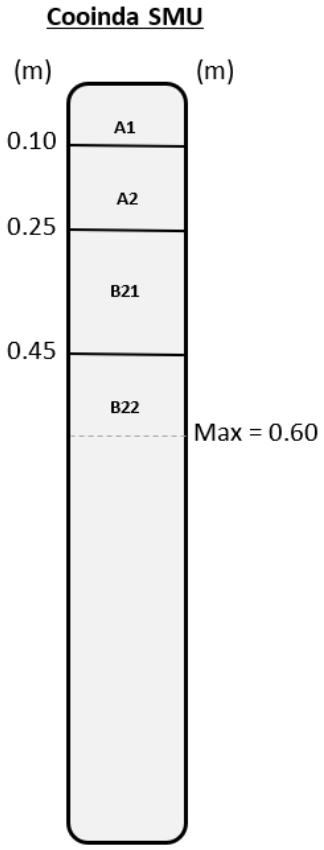
Australian Soil Classification: Brown Dermosol

Photo Plate 4 Cooinda SMU Vegetation

Table 12 Cooinda Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP2
Observation Site Numbers	N/A
Landform	Plains and flats
Land System	Melbadale
Slope	2%
Geology	Qa-QLD (Qa) – Quaternary clay, silt, sand and gravel; flood-plain alluvium
Vegetation	Eucalyptus populnea and Flindersia dissosperma (sometimes dominant), with Cassia spinarum in the shrub layer.
Runoff	Moderate
Permeability	Slowly permeable
Drainage	Imperfectly drained

Profile Description – Representative Sites: DP2



The **surface soil** (A1) is a dark yellowish brown (10YR3/6) sandy clay loam with strong play structure. It has a small percentage (<2%) of small sub-rounded coarse fragments. The field pH is 6.0. Clear change to;

The **lower surface soil** (A2) is a dark brown (7.5YR3/4) sandy light clay with moderate polyhedral structure. It also has a small percentage (<2%) of small sub-rounded coarse fragments, with a field pH of 5.5. Gradual change to;

The **upper subsoil** (B21) is a dark yellowish brown (10YR4/4) sandy light clay with moderate polyhedral structure. It has a small percentage (<2%) of small sub-rounded coarse fragments (these are consistent throughout the entire profile), with a field pH of 6.0. Sharp change to;

The **lower subsoil** (B22) is a dark yellowish brown (10YR4/6) medium heavy clay with moderate lenticular structure. It has a small percentage (<2%) of small sub-rounded coarse fragments, with a field pH of 7.0.

Chemical and Physical Analysis

Table 13 Chemical Properties of the Cooinda SMU

Representative site: DP2									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	5.6	Moderately acid	0.015	Very low	<10	0.9	Non-sodic	4.2	3
0.2-0.3	5.7	Moderately acid	0.013	Very low	10	2.1	Non-sodic	6.0	3
0.5-0.6	6.8	Neutral	0.043	Very low	40	10.9	Sodic	10.0	3

Depth (m)	**CEC**		**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**
	meq / 100g	**Rate**	**Ca**	**Mg**	**K**	**Na**	
0-0.1	4.4	Very low	1.9	2.0	0.4	<0.1	1.0
0.2-0.3	4.6	Very low	1.5	2.6	0.2	<0.1	0.6
0.5-0.6	9.8	Low	1.9	6.7	0.1	1.1	0.3
Percentage in Topsoil			43.18%	45.45%	9.09%	0.9%	-

The pH of the Cooinda SMU ranges from moderately acid (5.6) in the topsoil, to neutral (6.8) in the lower subsoil. EC is very low throughout the profile, with topsoil values of 0.015 dS/m, increasing to 0.043 dS/m in the subsoil. Chloride levels reflect EC, increasing from less than 10 mg/kg to 40 mg/kg with depth.

CEC increases down the soil profile, ranging from very low (4.4 meq/100g) in the topsoil to low (9.8 meq/100g) in the subsoil. An increase in clay content with depth likely contributes to this increase in CEC. Exchangeable cations are dominated by magnesium and calcium in the topsoil, then magnesium in the subsoil, resulting in a Ca/Mg ratio that decreases with depth from 1.0 to 0.3. Magnesium concentrations (meq/100g) are within acceptable ranges at all depths, though all other cations are either too low (calcium and potassium) or too high (sodium) to be considered appropriate for healthy plant growth.

ESP ranges from non-sodic (0.9%) in the topsoil layer, to sodic (10.9%) in the lower subsoil. Due to the moderate clay content within this soil, this ESP may impact the dispersive tendencies of the soil unit. This result is reflected in the unit's Emerson Class Numbers, which remain at the same level throughout the profile (3), suggesting that the soil unit may become dispersive if physically disturbed.

Table 14 Surface Soil (0-10cm) Properties of the Cooinda SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	Sand	Silt	Clay				
7	51	30	12	3	1.2	<10	1
Extractable Nutrients (mg/kg)				Extractable Metals (mg/kg)			
P	K	B		Cu	Fe	Mn	Zn
15	<200	0.4		<1.00	76.9	61.6	1.82

The surface soil (A1) for the Cooinda SMU is dominated by sand (51%), with 30% silt, 12% clay, and 7% gravel. It has a strong platy structure and is hard setting. The topsoil is non-sodic, with a Ca/Mg ratio of 1.0, and an organic matter content of 1.0%. This information paired with the topsoil's Emerson Class Number of 3 suggests that the soil may suffer from dispersion if physically disturbed. The mixture of particle sizes seen here will assist in stabilising the topsoil horizon, as pore spaces between sand grains may be infilled with the sand and silt fractions.

Nutrient levels are low, with nitrate (1.2 mg/kg), phosphorous (15 mg/kg) and potassium (<200 mg/kg) all below the guideline levels for plant life. Boron (0.4 mg/kg) and sulphate (<10 mg/kg) were also lower than desired. Extractable metals were found below suitable concentrations with zinc (1.82 mg/kg) the only trace element detected within the desirable range. Iron (76.9 mg/kg) and manganese (61.6 mg/kg) were both high enough to potentially impact plant health, while copper (<1.0 mg/kg) was below the desirable concentration.

4.5 ELLESMERE SOIL MANAGEMENT UNIT

Soil Unit Description: Hard setting soil associated with isolated hills of weathered tertiary surfaces (laterite). Textures within this unit grade from fine sandy loams in the surface soil to medium clays in the subsoil horizons. Dominant vegetation is *Acacia shirleyi*, with *Erythroxylon australe* in the shrub layer.

Australian Soil Classification: Red Dermosol.

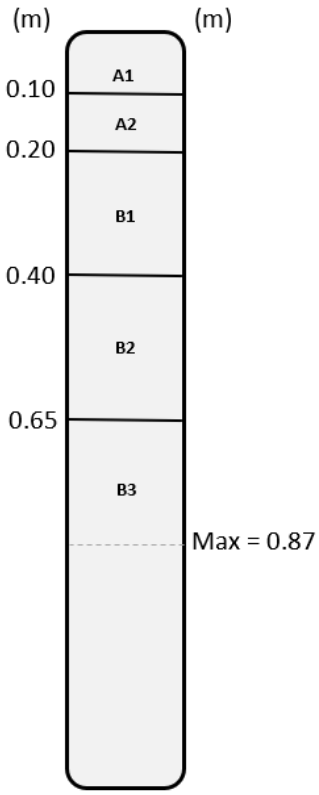
Photo Plate 5 Ellesmere SMU Vegetation

Table 15 Ellesmere Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP40
Observation Site Numbers	N/A
Landform	Isolated hills
Land System	Melbadale
Slope	3-5%
Geology	Gyranda Subgroup (Pwy) – Late Permian sedimentary unit comprised of siltstone and shale with minor tuff and volcanilithic sandstone (lower part)
Vegetation	*Acacia shirleyi*, with *Erythroxylon australe* in the shrub layer.
Runoff	Slow
Permeability	Slowly permeable
Drainage	Moderately well drained

Profile Description – Representative Sites: DP40

Ellesmere SMU



The **surface soil** (A1) is a dark brown (7.5YR3/4) fine sandy loam with moderate platy structure. It has a field pH of 5.0, with a gradual change to;

The **lower surface soil** (A2) is a dark brown (7.5YR3/4) sandy clay loam with grainy structure. It has a field pH is 4.5, with a gradual change to;

The **upper subsoil** (B1) is a brown (7.5YR4/4) light clay with grainy structure and a field pH of 4.5. Gradual change to;

The **mid-subsoil** (B2) is a yellowish red (5YR4/6) medium clay with moderate polyhedral structure. It has a field pH of 5.5, with a clear change to;

The **lower subsoil** (B3) is a light brown (7.5YR6/3) medium clay with moderate polyhedral structure. It has a field pH of 5.5.

Chemical and Physical Analysis

Table 16 Chemical Properties of the Ellesmere SMU

Representative site: DP40									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	4.6	Very strongly acid	0.02	Very low	<10	<0.1	Non-sodic	1.4	3
0.2-0.3	4.6	Very strongly acid	0.011	Very low	<10	6.4	Sodic	3.4	3
0.5-0.6	5.1	Strongly acid	0.017	Very low	<10	10.5	Sodic	11.8	4
0.8-0.9	5.5	Strongly acid	0.026	Very low	<10	13.8	Sodic	10.0	4

Depth (m)	**CEC**		**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**
	meq / 100g	**Rate**	**Ca**	**Mg**	**K**	**Na**	
0-0.1	2.3	Very low	0.4	0.2	0.2	<0.1	2
0.2-0.3	2.2	Very low	<0.1	0.2	0.1	<0.1	<0.1
0.5-0.6	5.7	Very low	<0.1	1.7	0.1	0.2	<0.1
0.8-0.9	6.9	Low	<0.1	3.4	0.1	0.6	<0.1
Percentage in Topsoil			17.39%	8.70%	8.70%	<0.1	-

The Ellesmere SMU is a highly acidic soil unit, ranging from 4.6 (very strongly acid) in the topsoil to 5.5 (strongly acid) in the lower subsoil layer. EC is very low throughout the profile, changing from 0.02 dS/m in the topsoil, to 0.026 dS/m in the lower subsoil. Chloride concentrations are very low, consistently presenting at <10 mg/kg.

CEC increases progressively with depth, ranging from very low in the topsoil (2.3 meq/100g) to low in the subsoil (6.9 meq/100g). Corresponding exchangeable cation concentrations are also low, the only values within the appropriate range being magnesium in the bottom two horizons, and potassium in the topsoil. Calcium dominated magnesium in the surface soil layer (Ca/Mg = 2.0), though this was reversed in the subsoil (Ca/Mg = <0.1), where Mg comprises 49.28% of the exchangeable cations, with Ca below reportable levels. These low levels of exchangeable cations may be limiting plant growth.

While sodium concentrations are within the commonly measured levels at all depths, ESP ranges from <0.1% (non-sodic) in the topsoil layer to 13.8% (sodic) in the lower subsoil, becoming sodic at 0.2 m depth. This unit has a moderate clay content in the subsoil layers, though has a very low/low CEC. For this reason, the impact of sodicity is less pronounced than it would be in a soil with high CEC, as sodium atoms cannot effectively separate the clay particles within the soil. This interpretation is reflected in the unit's Emerson Class Numbers, which range from 3 in the surface soil (dispersive if disturbed) to 4 in the subsoil layers (non-dispersive).

Table 17 Surface Soil (0-10 cm) Properties of the Ellesmere SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	Sand	Silt	Clay				
3	68	19	10	3	1.6	<10	5
Extractable Nutrients (mg/kg)				Extractable Metals (mg/kg)			
P	K	B		Cu	Fe	Mn	Zn
6	532	0.4		<1.00	327	3.13	<1.00

The surface soil (A1) is dominated by sand (68%), with 19% silt, 10% clay, and 3% gravel. It has a moderate, platy structure and is hard setting. The topsoil is non-sodic, with a Ca/Mg ratio of 2.0, and a high organic matter content of 5%. This information paired with the topsoil's Emerson Class Number of 3, suggests that the surface soil is unlikely to suffer from dispersion if it is not physically disturbed.

Nutrient levels for this SMU are variable. Nitrate (1.6 mg/kg) and phosphorous (6 mg/kg) were both below desirable levels, while potassium (535 mg/kg) was extremely high for both grazing and cropping land uses. Both sulphate (<10 mg/kg) and boron (0.4 mg/kg) were lower than desired. Extractable metals were generally unsuitable, with only manganese (3.13 mg/kg) within the appropriate range. Copper and zinc were both below reportable levels, while iron (327 mg/kg) concentrations were significantly elevated.

Elevated iron levels such as these can cause toxicity to plants and limit their photosynthetic efficiency. They can also limit the uptake of phosphorous, which is already below the ideal concentration. In addition to this, acidic pH values such as those seen in this SMU can limit the availability of all metals and nutrients to plants, by increasing toxicity, reducing solubility and altering elemental speciation.

4.6 GEOFFREY SOIL MANAGEMENT UNIT

Soil Unit Description: This unit consists of texture contrast soils with soft surface conditions, associated with undulating plains and rises. Textures range from loamy sands to sandy light clays, overlying sandy medium clays with conspicuous orange or red mottling. Where these soils were exposed due to insufficient groundcover, extensive washouts and large erosion gullies were observed. In these areas, overland flow had removed coarse sandy material, leaving the easily eroded clays exposed to surface runoff. The Geoffrey SMU was often cleared, though when present dominant vegetation included *Eucalyptus crebra*, *Melaleuca leucadendra*, *Casuarina cunninghamiana* and *Corymbia clarksoniana*, with *Alphitonia excelsa*, *Petalostigma pubecens*, and *Acacia rhodoxylon* in the shrub layer.

Australian Soil Classification: Brown Sodosol.

Photo Plate 6 Geoffrey SMU Vegetation (showing cleared and vegetated sections)

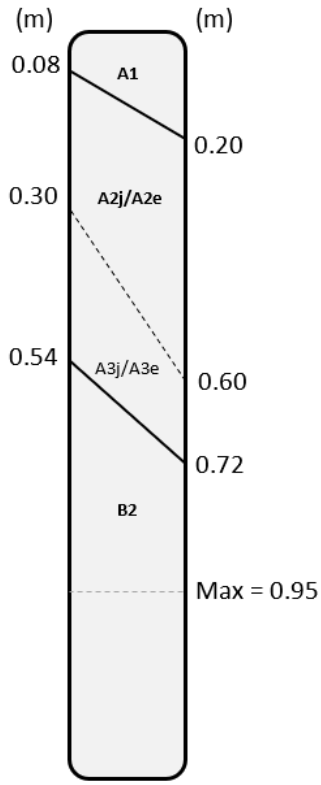
Table 18 Geoffrey Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP1, DP5, DP7, DP8, DP9, DP12, DP13, DP15, DP18, DP19, DP20, DP30, DP32, DP33, DP38, DP39, DP42, DP44, DP45, DP49, DP53, DP54, DP55, DP56, DP57, DP58
Observation Site Numbers	DO2, DO3, DO9, DO11-DO14, DO22, DO29, DO30, DO33, DO46, DO51-DO53, DO58, DO59, DO61-DO65, DO70, DO71, DO77, DO78, DO80-DO82, DO86, DO88-DO94, DO103, DO109, DO111-DO116, DO200, DO213, DO216-DO218, DO221, DO226-DO230, DO232, DO238-DO241, DO245-DO247, DO249, DO251, DO252, DO254, DO256-DO258, DO260-DO263, DO265
Landform	Undulating plains and hills
Land System	Melbadale
Slope	1 to 5%
Geology	Duaringa Formation (Tu) – Eocene-Oligocene mudstone, sandstone, conglomerate, siltstone, oil shale, lignite and basalt

Parameter	Soil Unit Description
Vegetation	*Eucalyptus crebra, Melaleuca leucadendra, Casuarina cunninghamiana* and *Corymbia clarksoniana*, with *Alphitonia excelsa*, *Petalostigma pubecens*, and Acacia rhodoxylon in the shrub layer.
Runoff	Slow to Rapid
Permeability	Very slowly permeable
Drainage	DP1, DP5, DP7, DP8, DP9, DP12, DP13, DP15, DP18, DP19, DP20, DP30, DP32, DP33, DP38, DP39, DP42, DP44, DP45, DP49, DP53, DP54, DP55, DP56, DP57, DP58

Profile Description – Representative Sites: DP1, DP5, DP7, DP30, DP32

Geoffrey SMU



The **surface soil** (A1) is a pale brown to brown (10YR6/3, 7.5YR4/4, 7.5YR4/3) sand to fine sandy loam with massive or grainy structure. This horizon has a field pH of 5.5 to 6.0, with a gradual change to;

The **mid-surface soil** (A2j/A2e) is a brown (7.5YR4/3, 7.5YR5/4, 10YR5/3) sand to fine sandy clay loam with sporadic or conspicuous bleaching. It has a massive to grainy structure and a field pH of 5.5 to 6.0. At some sites, this horizon had an abrupt change to B2, though at other sites had a gradual change to;

The **lower surface soil** (A3j/A3e) was not present at all sites. It is a sporadically or conspicuously bleached pale brown to pink (10YR6/3, 5YR7/3) sand to light sand. It has a grainy structure with a field pH of 6.0 to 6.5. Where present, this horizon has an abrupt change to;

The **subsoil** (B2) is very easy to differentiate from the overlying horizons. It is a yellowish brown to greyish brown (10YR6/4, 10YR5/2, 10YR4/6) medium clay, with moderate lenticular structure. Field pH is 6.0 to 7.5. This horizon continues to great depths, and exhibits distinct yellow, orange and red mottles.

Chemical and Physical Analysis

Table 19 Chemical Properties of the Geoffrey SMU

Representative site: DP1									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	5.8	Moderately acid	0.026	Very low	20	1.0	Non-sodic	2.7	4
0.2-0.3	5.6	Moderately acid	0.006	Very low	<10	1.8	Non-sodic	0.8	4
0.5-0.6	6.0	Moderately acid	0.004	Very low	<10	8.2	Sodic	0.8	4
0.8-0.9	8.1	Moderately alkaline	0.137	Low	110	22.1	Strongly sodic	9.0	1
Depth (m)	**CEC**			**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**	
	meq / 100g	**Rate**		**Ca**	**Mg**	**K**	**Na**		
0-0.1	1.7	Very low		0.7	0.7	0.3	<0.1	1.0	
0.2-0.3	0.8	Very low		0.2	0.2	0.2	<0.1	1.0	
0.5-0.6	0.4	Very low		0.1	0.2	<0.1	<0.1	0.5	
0.8-0.9	8.8	Low		0.9	5.9	<0.2	2.0	<0.2	
Percentage in Topsoil				41.18%	41.18%	17.65%	1.00%	-	

Due to the stark difference in textures between the topsoil and subsoil layers, pH for the Geoffrey SMU changes quite dramatically down the soil profile. Sandy, massive horizons (0.0 to 0.6 m) are moderately acid, with pH increasing with depth from 5.8 to 6.0. The clay B2 horizon has a pH value over two units higher (8.1) and is classified as 'moderately alkaline'. This is likely due to the increased CEC of the clay in the B2 horizon compared with the sand in the upper horizons (A1, A2 and A3). In addition to this, salts are held in the subsoil layers, resulting in an increase in EC, chloride, and sodicity (evidenced by the ESP) in the B2 layer.

The clay-rich subsoil present a higher CEC, due to its elevated clay content. It is likely that if exposed, the subsoil (B2) would become dispersive, while the surface soil horizons (A1, A2 and A3) would remain non-dispersive. This interpretation is supported by the unit's Emerson Class numbers, which change from 4 (non-dispersive) for the topsoil layers, to 1 (extremely dispersive) for the subsoil. The dispersive tendencies of the B2 horizon may be further exacerbated by the low Ca/Mg ratio in this layer (<0.2).

Low concentrations of exchangeable cations were observed in this unit. In the surface soil, calcium and magnesium were relatively equally represented, though concentrations of these cations were extremely limited. Increased levels of some of the major cations were observed in the subsoil, these were dominated by magnesium (67.1%) and sodium (22.1%), with calcium and potassium at similar levels to observed levels in the A horizons. These low levels of calcium in comparison to magnesium in the B2 horizon further increases the susceptibility of this layer to dispersion upon wetting.

The Geoffrey soil unit also lends itself to storage of water above the B2 horizon due to the low permeability of the clay sub-soil layers..

Table 20 Surface Soil (0-10cm) Properties of the Geoffrey SMU

Particle Size Analysis %	Emerson	Nitrate	Sulphate	Organic

Gravel	Sand	Silt	Clay	Class No.	(mg/kg)	(mg/kg)	Matter (%)
1	65	25	9	4	3	<10	1.8
Extractable Nutrients (mg/kg)				**Extractable Metals (mg/kg)**			
P	**K**	**B**		**Cu**	**Fe**	**Mn**	**Zn**
8	<200	0.2		<1.00	166	16.0	2.16

The surface soil (A1) is dominated by sand (65%) with 25% silt, 9% clay, and 1% gravel. It has grainy texture, and a soft surface condition. The topsoil is non-sodic, with a Ca/Mg ratio of 1.0, and an organic matter content of 1.8%. The soil has an Emerson Class of 4, indicating that the topsoil unit is unlikely to become dispersive when wetted. Sandy soils such as these are often less susceptible to erosion, due to the large particle size of the sand grains, and their low CEC.

Topsoil nutrients for the Geoffrey SMU are generally quite limited, with nitrate (3 mg/kg), phosphorous (8 mg/kg) and potassium (<200 mg/kg) below desirable levels. Boron (0.2 mg/kg) and sulphate (<10 mg/kg) are also lower than guideline recommendations for suitable plant growth medium. For extractable metals, manganese (16.0 mg/kg) and zinc (2.16 mg/kg) are within the desirable range, though iron (166 mg/kg) is elevated, and copper (<1.0 mg/kg) is below reportable levels. These low levels of nutrients are likely due to the low CEC and leaching capacity of sand, paired with the nutrient content of the parent material.

4.7 JAMES SOIL MANAGEMENT UNIT

Soil Unit Description: Hard setting red soils associated with hills and rises. Textures within this unit vary depending on slope, with lesser developed soils found on crests (sandy clay loams to clay loams) and more developed/deeper soils found on mid slopes (clay loams to light medium clays). Dominant vegetation includes *Acacia rhodoxylon, Eucalyptus crebra,* and *Corymbia clarksoniana.*

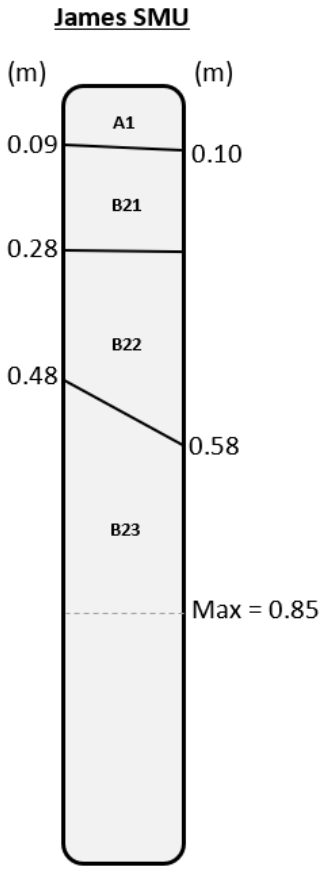
Australian Soil Classification: Red Dermosol.

Photo Plate 7 James SMU Vegetation

Table 21 James Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP17, DP16.1
Observation Site Numbers	DO39, DO40, DO42, DO253
Landform	Hills and rises
Land System	Melbadale
Slope	4 to 6%
Geology	Td-QLD (Td) – Tertiary duricrusted palaeosols at the top of deep weathering profiles, including ferricrete and silcrete; duricrusted old land surfaces.
Vegetation	*Acacia rhodoxylon, Eucalyptus crebra,* and *Corymbia clarksoniana*.
Runoff	Moderate to rapid
Permeability	Moderately permeable
Drainage	Moderately to well drained

Profile Description – Representative Sites: DP17 & DP16.1



The **surface soil** (A1) is a dark reddish brown (5YR3/4) sandy clay loam to clay loam with weak to moderate platy structure. Profiles with higher relief may have a small number of sub-rounded coarse fragments. This horizon has a pH of 6.0, with a gradual change to;

The **upper subsoil** (B21) varies in texture depending on relief within the landscape. Profiles with high relief (crests) exhibit a dark red (2.5YR3/6) clay loam, with a grainy structure and a significant amount (10-20%) of small sub-rounded coarse fragments. Lower relief profiles (slopes) are a dark reddish-brown (5YR3/4) light medium clay with weak angular blocky structure and no coarse fragments. Both variations of this horizon have a pH of 6.0, with a gradual change to;

The **mid-subsoil** (B22) is also variable in texture depending on relief. High relief (crest) examples are dark red in colour (2.5YR3/6) with a clay loam texture and a large amount (50-90%) of small sub-rounded coarse fragments. Lower relief profiles (slopes) are also dark red in colour (2.5YR3/6) with light clay texture, and no coarse fragments. Both versions of this horizon have a pH of 6.0, and moderate structure, with lower relief profiles gradually changing to;

The **lower subsoil** (B23) is only present on the lower slopes of the James SMU, where deeper clays have had the opportunity to develop. It is dark red in colour (2.5YR3/6), with a light medium clay texture, moderate lenticular structure and no coarse fragments. Field pH is 6.5.

Chemical and Physical Analysis

Table 22 Chemical Properties of the James SMU

Representative site: DP17									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	6.2	Slightly acid	0.013	Very low	<10	0.4	Non-sodic	1.5	8
0.2-0.3	6.1	Slightly acid	0.006	Very low	<10	0.7	Non-sodic	7.0	3
0.5-0.6	6.4	Slightly acid	0.015	Very low	<10	1.4	Non-sodic	10.2	4

Depth (m)	**CEC**		**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**
	meq / 100g	**Rate**	**Ca**	**Mg**	**K**	**Na**	
0-0.1	4.3	Very low	2.0	1.8	0.4	<0.1	1.1
0.2-0.3	5.9	Very low	3.1	2.4	0.3	<0.1	1.3
0.5-0.6	5.8	Very low	2.4	3.2	<0.1	<0.1	0.8
Percentage in Topsoil			46.51%	41.86%	9.30%	0.40%	-

pH in the James SMU is slightly acidic throughout the profile, with very little variation. It increases gradually with depth from 6.2 in the topsoil, to 6.4 in the lower subsoil. EC is very low at all depths, ranging from 0.013 dS/m in the topsoil to 0.015 dS/m in the subsoil. Chloride levels reflect this result, presenting at <10 mg/kg throughout the profile.

CEC remains fairly consistent with depth, ranging from 4.3 meq/100g (very low) in the topsoil to 5.8 meq/100g (very low) in the subsoil. Despite this, concentrations of available cations are within the acceptable ranges, with the exception of potassium in the lower subsoil, which is below reportable levels. In the topsoil, exchangeable cations are dominated by calcium (46.51%) and magnesium (41.86%) in roughly equal amounts (Ca/Mg = 1.1). The mid-stratum layer sees this ratio increase to 1.3, before dropping in the subsoil layer to 0.8.

ESP is considered non-sodic throughout the profile, ranging from 0.4% in the topsoil layer to 1.4% in the lower subsoil. This ESP isn't likely to impact the dispersive tendencies of the soil unit. This interpretation is confirmed by the unit's Emerson Class Numbers, which range from 8 (non-dispersive) in the surface soil, to 3 (dispersive if disturbed) in the mid-stratum, to 4 (non-dispersive) in the subsoil layer.

Table 23 Surface Soil (0-10 cm) Properties of the James SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	Sand	Silt	Clay				
6	56	21	17	8	1.1	<10	2.8
Extractable Nutrients (mg/kg)				Extractable Metals (mg/kg)			
P	K	B		Cu	Fe	Mn	Zn
14	<200	0.3		<1.00	21.4	18.7	<1.00

The surface soil (A1) is dominated by sand (56%) with 21% silt, 17% clay, and 6% gravel. It has moderate, platy structure, and a hard setting surface. The topsoil is non-sodic, with a Ca/Mg ratio of 1.1, and an organic matter content of 2.8%. This favourable chemistry combination, paired with the topsoil's Emerson Class Number of 8, suggests that the surface soil is unlikely to suffer from dispersion. The water-holding capacity of the topsoil is relatively poor, due to the lack of clay sized particles. This is evidenced by the increase in moisture content with depth (as seen in Table 22).

Nutrient availability within the James SMU is generally limited. Nitrate (1.1 mg/kg), phosphorous (14 mg/kg) and potassium (<200 mg/kg) are all well below the desirable concentrations, with sulphate (<10 mg/kg) and boron (0.3 mg/kg) also low. Extractable metals vary in concentration. While, iron (21.4 mg/kg) and manganese (18.7 mg/kg) are both within the suitable range for plant life, copper and zinc are below reportable levels.

It is noted that the soil profile examined here represents a mid-slope site on the James SMU, with profiles higher in the landscape (e.g. hill crests) typically possessing shallower subsoils, lower CECs and reduced nutrient concentrations.

4.8 KOSH SOIL MANAGEMENT UNIT

Soil Unit Description: Hard setting soil associated with alluvial plains, plains and low rises. Textures within this unit are gradational, changing from sandy clay loams and light clays in the topsoil, to medium heavy clays in the lower subsoil. Commonly, this unit was cleared for grazing, with regrowth consisting of scrub species including *Vachellia nilotica*, *Cassia spinarum, Capparis lasiantha, Cassia brewsteri*, and various Eucalyptus shrubs. When present, vegetation included *Eucalyptus tereticornis, Acacia hemiglauca, Acacia salicina, Lysiphyllum hookeri, Eucalyptus crebra* and *Eucalyptus populnea*.

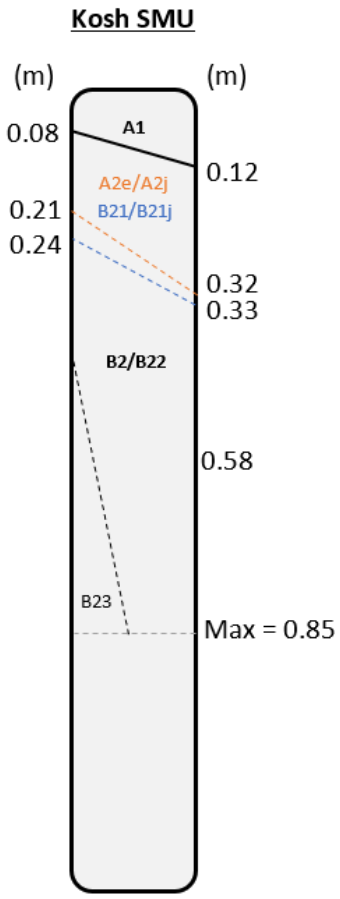
Australian Soil Classification: Brown Dermosol

Photo Plate 8 Kosh SMU Vegetation (cleared)

Table 24 Kosh Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP16.2, DP21, DP22, DP23, DP25, DP27, DP31, DP34, DP35, DP41, DP47, DP59
Observation Site Numbers	DO34, DO35, DO37, DO38, DO67, DO73, DO201, DO204, DO231, DO250, DO255
Landform	Alluvial plains, plains and rises
Land System	Dingo
Slope	1 to 4%
Geology	Qa-QLD (Qa) – Quaternary clay, silt, sand and gravel; flood-plain alluvium
Vegetation	Cleared - *Vachellia nilotica, Cassia spinarum, Capparis lasiantha, Cassia brewsteri* Vegetated - *Eucalyptus tereticornis, Acacia hemiglauca, Acacia salicina, Lysiphyllum hookeri, Eucalyptus crebra* and *Eucalyptus populnea*.
Runoff	Very slow to rapid
Permeability	Slowly permeable
Drainage	Poorly drained

Profile Description – Representative Sites: DP23, DP34, DP35, DP47



The **surface soil** (A1) is a brown to dark reddish brown (7.5YR4/3, 10YR3/3, 5YR3/3) sandy clay-loam to medium clay with weak to massive structure. Field pH of 6.0 to 6.5, with clear/gradual change to;

The **lower surface soil** (A2e/A2j) is a sporadically or conspicuously bleached horizon present at approximately half of the profile sites. It is a pale brown to brown (10YR6/3, 7.5YR4/3) sandy clay-loam to medium clay that usually has massive structure (though can be weak angular blocky), with a field pH of 6.0 to 7.0. When present, this layer has a clear or gradual change to;

The **upper subsoil** (B21/B21j) was not present at all sites. When present this horizon can exhibit sporadic bleaching. It is a brown to dark reddish brown (7.5YR4/4, 5YR3/2) medium heavy clay with weak to moderate angular blocky structure. This horizon has a field pH of 6.0 to 7.0, with a clear or gradual change to;

The **subsoil** (B2/B22) is variable in colour, presenting as a dark brown, dark reddish, or yellowish brown colour (7.5YR3/3, 5YR3/3, 10YR5/6). Soil texture is a medium heavy clay, with moderate lenticular structure. pH gradually increased with depth at all sites, ranging from 7.0 to 9.0, sometimes within the same soil profile. This layer can extend to great depths, otherwise exhibiting a gradual change to;

The l**ower subsoil** (B23) was only observed at two sites. It is a dark brown (7.5YR3/4) medium heavy clay with moderate lenticular structure, and a field pH ranging from 6.5 to 7.5 (increasing with depth).

Chemical and Physical Analysis

Table 25 Chemical Properties of the Kosh SMU

Representative site: DP34									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	6.3	Slightly acid	0.036	Very Low	<10	0.6	Non-sodic	2.8	4
0.2-0.3	7.7	Slightly alkaline	0.083	Very Low	60	13.2	Sodic	7.1	2
0.5-0.6	8.5	Strongly alkaline	0.415	Medium	490	19.5	Strongly sodic	9.0	2
Depth (m)	**CEC**			**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**	
	meq / 100g	**Rate**		**Ca**	**Mg**	**K**	**Na**		
0-0.1	6.8	Low		4.4	1.7	0.6	<0.1	2.6	
0.2-0.3	13.3	Moderate		4.4	6.9	0.2	1.8	0.6	
0.5-0.6	17.4	Moderate		4.1	9.7	<0.2	3.4	0.4	
Percentage in Topsoil				64.71%	25.00%	8.82%	0.60%	-	

The pH within the Kosh SMU is highly variable, changing from 6.3 (slightly acid) in the topsoil to 8.5 (strongly alkaline) in the lower subsoil. EC follows a similar pattern, changing from very low between 0.0 and 0.3 m depth, to medium in the subsoil. Chloride concentration also increases significantly with depth, ranging from <10 mg/kg in the topsoil, to 490 mg/kg in the subsoil layer. High chloride concentrations such as these can impact a plant's osmotic capacity, impacting its ability to access water and nutrients.

CEC increases with depth from low (6.8 meq/100g) to moderate (17.4 meq/100g), likely due to the increased clay content in the subsoil layers. Exchangeable cations within the topsoil are dominated by calcium (64.71%) and magnesium (25.00%), with potassium at 8.82%. These concentrations and ratios are considered appropriate for plant growth, though become less so with depth. While calcium remains relatively consistent throughout the profile, magnesium and sodium concentrations continue to increase, eventually contributing to 55.75% and 19.5% of the total CEC, respectively. The Ca/Mg ratio drops from 2.6 in the topsoil, to 0.4 in the lower subsoil layer. This is detrimental to the ability of the soil to maintain its integrity upon exposure, significantly increasing the subsoil's potential erodibility.

ESP for this SMU increases progressively with depth, changing from non-sodic (0.6%) in the topsoil to strongly sodic (19.5%) in the lower subsoil. Due to the high clay content in the lower horizons, the elevated ESP observed here is likely to impact the dispersive tendencies of the soil unit. This interpretation is reflected in the sample's Emerson Class Numbers, which range from 4 in the surface soil (non-dispersive) to 2 in the subsoil (moderately dispersive).

It is likely that subsoils in this unit would be considerably erosive.

Table 26 Surface Soil (0-10 cm) Properties of the Kosh SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	Sand	Silt	Clay				
4	63	24	9	4	2.5	<10	4
Extractable Nutrients (mg/kg)				**Extractable Metals (mg/kg)**			
P	K	B		Cu	Fe	Mn	Zn
13	<200	0.4		<1.00	32.4	17.5	1.20

The topsoil layer (A1) for the Kosh SMU is dominated by sand-sized particles (63%), with 24% silt, 9% clay, and 4% gravel. It has a weak structure, with a hard setting surface. The surface soil is non-sodic, with a Ca/Mg ratio of 2.6, and an organic matter content of 4%. This means the topsoil has favourable chemistry in terms of dispersion, evidenced by the unit's Emerson Class of 4 (non-dispersive). This topsoil is particularly significant for this SMU, as it protects the underlying sodic clay from erosion.

Nutrient content within this topsoil is quite poor. Nitrate (2.5 mg/kg), phosphorous (13 mg/kg) and potassium (<200 mg/kg) are all below suitable levels, as are sulphate (<10 mg/kg) and boron (0.4 mg/kg). Extractable metal concentrations are adequate, with only copper below the required concentration.

4.9 NAMOI SOIL MANAGEMENT UNIT

Soil Unit Description: Hard setting soil associated with hills and rises. Textures within this unit are gradational, changing from a sandy clay loam in the topsoil to a light medium clay in the subsoil. Dominant vegetation includes *Eucalyptus crebra,* with *Heteropogon contortus* and juvenile Acacia species.

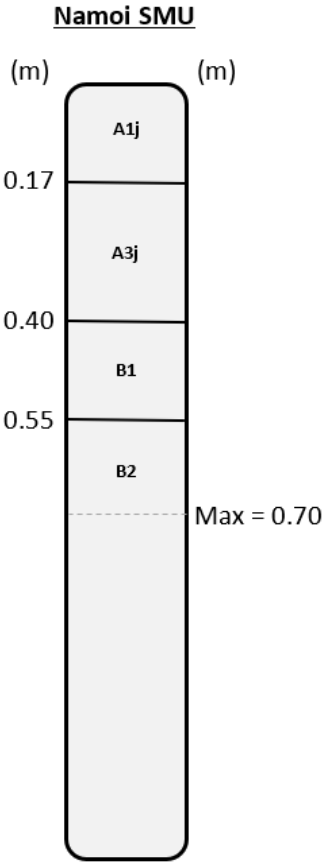
Australian Soil Classification: Red Dermosol

Photo Plate 9 Namoi SMU Vegetation

Table 27 Namoi Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP3
Observation Site Numbers	DO1
Landform	Hills and rises
Land System	Melbadale
Slope	4%
Geology	Rewan Group (Rr) – Early Triassic – Middle Triassic sedimentary unit comprised of lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base)
Vegetation	*Eucalyptus crebra*, with *Heteropogon contortus* and juvenile Acacia species.
Runoff	Rapid
Permeability	Slowly permeable
Drainage	Moderately well drained

Profile Description – Representative Sites: DP3.



The **surface soil** (A1j) is a dark brown (7.5YR3/4) sandy clay-loam with sporadic bleaching. It has a moderate lenticular structure, and a field pH of 5.0. Clear change to;

The **lower surface soil** (A3j) is a reddish brown (5YR4/4) sandy clay-loam+ with sporadic bleaching. It has a weak angular blocky structure, and a field pH of 5.5. Gradual change to;

The **upper subsoil** (B1) is a yellowish red (5YR4/6) light clay with weak angular blocky structure, and a field pH of 6.0. Gradual change to;

The **lower subsoil** (B2) is a yellowish red (5YR5/8) light medium clay with moderate polyhedral structure, and a field pH of 6.5. It may contain a small number (<2%) of subangular coarse fragments and faint red mottling.

Chemical and Physical Analysis

Table 28 Chemical Properties of the Namoi SMU

Representative site: DP3									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	5.7	Moderately acid	0.011	Very Low	<10	0.6	Non-sodic	2.8	3
0.2-0.3	5.5	Strongly acid	0.008	Very Low	<10	1.8	Non-sodic	3.2	3
0.5-0.6	6.1	Slightly acid	0.007	Very Low	<10	4.1	Non-sodic	6.6	3
Depth (m)	**CEC**			**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**	
	meq / 100g	**Rate**		**Ca**	**Mg**	**K**	**Na**		
0-0.1	2.0	Very low		1.0	0.6	0.2	<0.1	1.7	
0.2-0.3	1.9	Very low		0.8	0.8	<0.1	<0.1	1.0	
0.5-0.6	3.0	Very low		0.7	2.1	<0.1	0.1	0.3	
Percentage in Topsoil				50.00%	30.00%	10.00%	0.60%	-	

The Namoi SMU has a pH that is most acidic in the upper subsoil (5.5), with a moderately acidic topsoil (5.7), and a slightly acidic lower subsoil (6.1). EC is very low at all depths, ranging from 0.01 dS/m in the topsoil, to 0.007 dS/m in the subsoil horizon. Chloride concentration reflects this result, presenting at <10 mg/kg at all depths.

CEC is also very low throughout the profile, changing from 2.0 meq/100g in the surface horizons, to 3.0 meq/100g in the subsoil layer. Exchangeable cations were found at concentrations below desirable, with calcium at 1.0 mg/kg, and magnesium at 0.6 mg/kg. Topsoil potassium however (0.2 mg/kg), meets the required concentration. Calcium levels decrease with depth, while magnesium increases, such that the lower subsoil has a Ca/Mg ratio of 0.3. This could exacerbate soil dispersion if ESP was high, though in this case should not reduce soil cohesion. Overall, exchangeable cation concentrations do not reflect the optimal ranges expected of a healthy soil, which may be affecting plant health within this SMU.

ESP is considered non-sodic throughout the profile, ranging from 0.6 to 4.1% with depth. The entire profile has an Emerson Class of 3, meaning that the soil should remain non-dispersive unless it is physically disturbed.

Table 29 Surface Soil (0-10 cm) Properties of the Namoi SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	Sand	Silt	Clay				
3	64	21	12	3	1.7	<10	0.8
Extractable Nutrients (mg/kg)				Extractable Metals (mg/kg)			
P	K	B		Cu	Fe	Mn	Zn
7	<200	0.2		<1.00	86.3	43.7	2.09

The surface soil (A1j) has a high concentration of sand (64%), with 21% silt, 12% clay, and 3% gravel. It has moderate, lenticular structure, and is hard setting. The topsoil is non-sodic, with a Ca/Mg ratio of 1.7, and an organic matter content of 0.8%. Low organic matter levels combined with high sand percentages, means that the topsoil for Namoi is likely to have a low water holding capacity. The Emerson Class Number is 3, meaning that the surface soil horizon may become dispersive when wetted, if physically disturbed through stripping or tillage.

Nutrient levels are generally low, with nitrate (1.7 mg/kg), phosphorous (7 mg/kg) and potassium (<200 mg/kg) all below the desirable concentrations. Sulphate (<10 mg/kg) and boron (0.2 mg/kg) are also lower than expected for soils supporting plant growth. Extractable metals are generally unsuitable, with only zinc (2.09 mg/kg) within the acceptable range. Variable concentrations of nutrients and metals could limit vegetation type and plant growth within the Namoi SMU.

4.10 NIGEL SOIL MANAGEMENT UNIT

Soil Unit Description: Hard setting soil associated with isolated high relief areas of tertiary land surface. Textures within this unit are rudimentary, grading from sands to sandy light clays. Vegetation is variable between sites, but includes *Acacia shirleyi, Acacia rhodoxylon, Eucalyptus crebra, Melaleuca leucadendra, Corymbia clarksoniana,* and *Eucalyptus tessellaris.*

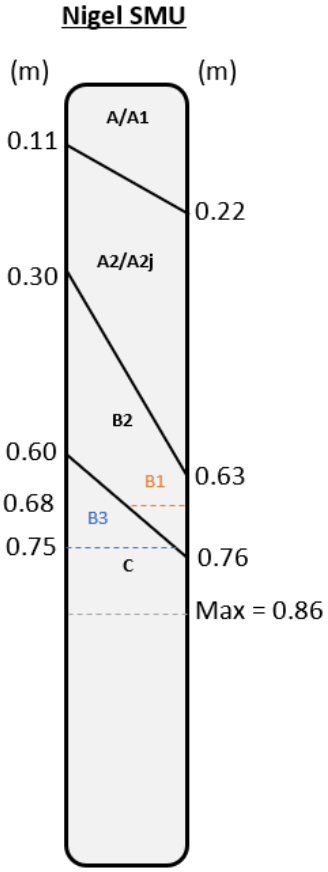
Australian Soil Classification: Brown Kandosol

Photo Plate 10 Nigel SMU Vegetation

Table 30 Nigel Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP43, DP51, DP52
Observation Site Numbers	DO83, DO101, DO107
Landform	Hills and rises
Land System	Melbadale
Slope	3 to 5%
Geology	Gyranda Subgroup (Pwy) – Late Permian sedimentary unit comprised of siltstone and shale with minor tuff and volcanilithic sandstone and rare coal (lower part - Banana Formation) (weathered to laterite)
Vegetation	*Acacia shirleyi, Acacia rhodoxylon, Eucalyptus crebra, Melaleuca leucadendra, Corymbia clarksoniana,* and *Eucalyptus tessellaris.*
Runoff	Very slow to rapid
Permeability	Slowly permeable
Drainage	Poorly drained

Profile Description – Representative Sites: DP43, DP51 & DP52



The **surface soil** (A/A1) is a dark brown to greyish brown (10YR3/3, 7.5YR3/4, 10YR4/4) sand to loamy sand with massive structure. It has a field pH of 4.8 to 5.5, with a clear or gradual change to;

The **lower surface soil** (A2/A2j) is a dark red to yellowish-red (2.5YR3/6, 5YR4/6, 5YR3/3) sand to clayey sand, which often demonstrates sporadic bleaching. It has a massive/grainy structure and a field pH ranging from 5.0 to 5.5. This horizon exhibits a clear or gradual change to;

The **upper subsoil** (B1) was only present at one profile site. It is a red (2.5YR4/6) loamy sand with grainy structure and a field pH of 5.5. When present, this horizon has a clear change to the C horizon, though when absent, A2/A2j grades gradually to;

The **subsoil** (B2) is a yellowish brown (10YR4/6, 10YR5/6) soil with a clayey sand to sandy light clay texture. Structure in this horizon is weak to massive, with field pH values of 5.5. This unit can have a clear or gradual change to the C horizon, or;

The **lower subsoil** (B3) was only present at one site. It was a dark yellowish brown (10YR4/6) clayey sand with massive structure and a field pH of 6.0. It contained a small amount (<2%) of manganiferous nodules.

The **parent material** (C) was comprised of laterite pebbles with a pH ranging from 5.5 to 6.0.

Chemical and Physical Analysis

Table 31 Chemical Properties of the Nigel SMU

Representative site: DP52									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	4.4	Extremely acid	0.038	Very Low	10	1.3	Non-sodic	7.3	4
0.2-0.3	4.6	Very strongly acid	0.01	Very Low	<10	<0.1	Non-sodic	2.3	4
0.5-0.6	4.6	Very strongly acid	0.01	Very Low	<10	<0.1	Non-sodic	2.3	4

Depth (m)	**CEC**		**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**
	meq / 100g	**Rate**	**Ca**	**Mg**	**K**	**Na**	
0-0.1	2.8	Very low	0.8	0.4	0.2	<0.1	2.0
0.2-0.3	1.7	Very low	<0.1	<0.1	0.1	<0.1	<0.1
0.5-0.6	1.6	Very low	<0.1	<0.1	<0.1	<0.1	<0.1
Percentage in Topsoil			28.57%	14.29%	7.14%	1.30%	-

The Nigel SMU has an extremely low pH throughout the profile, ranging from 4.4 (extremely acidic) in the topsoil to 4.6 (strongly acidic) in the subsoil layers. EC is very low at all depths, a result reflected in chloride results, which are consistently less than or equal to 10 mg/kg.

CEC is also very low, ranging from 2.8 mg/kg in the topsoil to 1.6 mg/kg in the subsoil. This has resulted in very low concentrations of exchangeable cations. Calcium ranges from 0.8 in the topsoil, to <0.1 in the subsoil layers. Magnesium was measured at 0.4 meq/100g in the topsoil, and 0.1 meq/100g in the lower subsoil. Optimal potassium levels should be >0.2 meq/100g, and though this level was met in the topsoil, the concentration dropped to <0.1 meq/100g in the subsoil horizons.

ESP is considered non-sodic at all depths, ranging from 1.3 % in the topsoil layer to <0.1% in the lower subsoil. Therefore, the unit is unlikely to become dispersive when wetted. This interpretation is reflected in the unit's Emerson Class Numbers, which were calculated at 4 for all horizons (non-dispersive).

In addition to this, low pH values can reduce the CEC of the soil, and affect the solubility, availability, and potential toxicity of various macro and micronutrients to plant roots. This means that even if they are present in the soil, some elements (such as calcium, magnesium, and potassium) will become less available to plant roots below a pH of 5.0 and may even become damaging to vegetation (Hazelton & Murphy, 2016).

Table 32 Surface Soil (0-10 cm) Properties of the Nigel SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	Sand	Silt	Clay				
1	76	17	6	4	11.2	<10	4.6
Extractable Nutrients (mg/kg)				Extractable Metals (mg/kg)			
P	K	B		Cu	Fe	Mn	Zn
7	<200	0.2		<1.00	331	3.21	<1.00

The surface soil (A/A1) for the Nigel SMU is dominated by sand (76%) with 17% silt, 6% clay and 1% gravel. It is hard setting and has a massive structure. The topsoil is non-sodic, with a Ca/Mg ratio of 2.0, and a relatively high organic matter content of 4.6%. This indicates that the soil is unlikely to disperse upon wetting, shown by the surface soil's Emerson Class Number of 4 (non-dispersive). Although dispersion is not likely to become an issue, this structureless topsoil indicates that the soil may slake upon wetting, losing air filled porosity and allowing it to collapse under its own weight.

Nutrient levels are generally poor, with nitrate present at optimum levels (11.2 mg/kg), while phosphorous (7 mg/kg) and potassium (<200 mg/kg) outside of the guideline levels for supporting plant life. Boron (0.2 mg/kg) and sulphate (<10 mg/kg) are also lower than desired and may be causing nutrient deficiency.

Extractable metals are quite unbalanced, with copper and zinc at <1.00 mg/kg, and iron much higher than expected in a healthy soil. At 3.21 mg/kg, manganese is the only trace element within the desirable range.

This SMU is characterised by extremely low nutrient levels, exacerbated by limited availability to plant roots caused by the extremely acidic pH throughout the profile. The physical characteristics of this soil, however, are considered suitable in terms of stability.

4.11 NORMANBY SOIL MANAGEMENT UNIT

Soil Unit Description: Deep red earth with soft surface condition, associated with plains, and the flat areas of upper slopes. Textures within this unit are relatively consistent throughout the profile, ranging from loamy sands to sandy light medium clays. Vegetation is mostly cleared, but when present includes *Eucalyptus crebra* and *Alectryon oleifolius.*

Australian Soil Classification: Red Kandosol

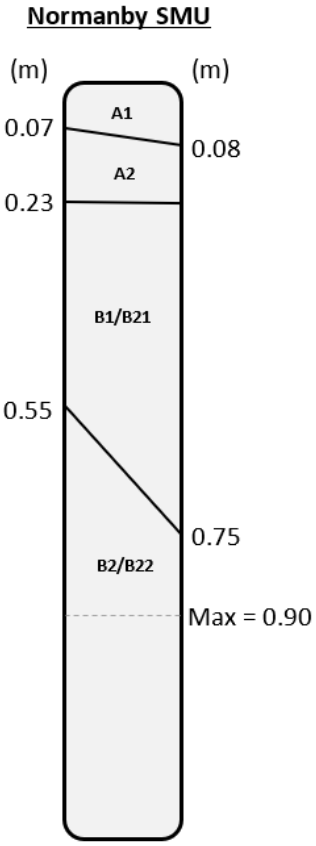
Photo Plate 11 Normanby SMU Vegetation

Table 33 Normanby Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP48, DP50
Observation Site Numbers	DO208
Landform	Plains and upper slopes
Land System	Melbadale
Slope	2 to 3%
Geology	Duaringa Formation (Tu) – Eocene-Oligocene mudstone, sandstone, conglomerate, siltstone, oil shale, lignite and basalt (iron-rich)
Vegetation	Cleared with *Eucalyptus crebra* and *Alectryon oleifolius.*
Runoff	Slow
Permeability	Moderately to highly permeable

Drainage	Moderately to well drained

Profile Description – Representative Sites: DP48 & DP50



The **surface soil** (A1) is a reddish brown (2.5YR4/4, 5YR4/3) loamy sand to sandy loam, with grainy structure. It has a field pH of 6.0 to 6.5 and a clear or gradual change to;

The **lower surface soil** (A2) is a reddish brown to dark reddish brown (2.5YR3/3, 2.5YR4/3) loamy sand to sandy loam with a grainy/massive structure. It has a field pH of 6.0 to 6.5, and a gradual change to;

The **upper subsoil** (B1/B21) is a red (10R4/6, 2.5YR4/6) loamy sand to sandy loam. It has massive/grainy structure and a pH ranging from 6.0 to 6.5. Gradual change to;

The **lower subsoil** (B2/B22) is a red to dark red (10YR4/6, 2.5YR3/6) sandy loam to sandy light medium clay. It has weak lenticular structure and a field pH ranging from 6.0 to 7.0.

Chemical and Physical Analysis

Table 34 Chemical Properties of the Normanby SMU

Representative site: DP50									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	6.7	Neutral	0.036	Very Low	<10	<0.1	Non-Sodic	6.1	4
0.2-0.3	6.6	Neutral	0.006	Very Low	<10	<0.1	Non-Sodic	1.7	4
0.5-0.6	6.1	Slightly Acid	0.003	Very Low	<10	<0.1	Non-Sodic	1.5	4

Depth (m)	**CEC**		**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**
	meq / 100g	**Rate**	**Ca**	**Mg**	**K**	**Na**	
0-0.1	2.4	Very Low	1.3	0.6	0.4	<0.1	2.2

0.2-0.3	2.1	Very Low	1.4	0.4	0.3	<0.1	3.5
0.5-0.6	1.6	Very Low	0.9	0.5	<0.1	<0.1	1.8
Percentage in Topsoil			54.17%	25.00%	16.67%	4.17%	-

The Normanby soil unit has a neutral to slightly acidic pH throughout the soil profile, decreasing with depth from 6.7 to 6.1. EC is very low throughout the profile, ranging from 0.036 dS/m in the topsoil to 0.003 dS/m in the subsoil. Chloride levels reflect this result, presenting at less than 10 mg/kg at all depths.

CEC measurements are considered very low, ranging from 2.4 meq/100g to 1.6 meq/100g with depth. Exchangeable cation concentrations reflected this result, with calcium, magnesium and potassium concentrations below the desirable level at all depths. The ratios between each cation, however, were appropriate. In addition to this, calcium dominated magnesium at all depths, the Ca/Mg ratio ranging from 2.2 in the topsoil, to 3.5 in the mid-stratum, to 1.8 in the lower subsoil, further reducing the likelihood that this SMU will suffer from dispersion

Of the exchangeable cations, very little was sodium, with ESP values consistently below reportable levels (<0.1%), indicating that the soil is likely to be non-dispersive. This interpretation is supported by the unit's Emerson Class Numbers, which are considered non-dispersive (4) at all depths.

Although this soil is non-dispersive and suitable in terms of pH and salinity, the low levels of exchangeable cations limit the soil in terms of its ability to provide a suitable medium for plant growth. In addition to this, the high sand content within this SMU puts it at risk of slumping if the slope angle is too high.

Table 35 Surface Soil (0-10 cm) Properties of the Normanby SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	Sand	Silt	Clay				
1	83	9	7	4	10.3	<10	1.1
Extractable Nutrients (mg/kg)				**Extractable Metals (mg/kg)**			
P	**K**	**B**		**Cu**	**Fe**	**Mn**	**Zn**
6	275	<0.2		<1.00	29.1	13.0	<1.00

The surface soil (A1) for the Normanby unit is dominated by sand (83%) with 9% silt, 7% clay and 1% gravel. It had a grainy structure, and a soft surface condition. The topsoil is non-sodic, with a Ca/Mg ratio of 2.2, and an organic matter content of 1.1%. This information, paired with the topsoil's Emerson Class Number of 4, suggests that the surface soil is unlikely to become dispersive when wetted. The red colour of the soil indicates that drainage and permeability are both highly active in this soil unit.

Nutrient levels within this soil are generally low. Nitrate concentration is within the acceptable bounds at 10.3 mg/kg, as is potassium at 275 mg/kg. Phosphorous, boron and sulphate, however, are all below the desirable level, potentially causing nutrient deficiency. Extractable metal concentrations vary in their suitability, with copper and zinc below reportable levels, and iron and manganese within the appropriate range for plant life.

The limited nutrient holding capacity of this soil can be attributed to its low clay content and low organic matter levels.

4.12 WALLACE SOIL MANAGEMENT UNIT

Soil Unit Description: Shallow, self-mulching, cracking clay associated with upper slope flats. Textures within this unit grade from medium heavy clays to heavy clays, with the B3/C horizon met at approximately 0.24 m depth. The Wallace SMU is extensively cleared, with the boundary of the unit corresponding to an increase in standing vegetation. The dominant grass species is likely *Aristida latifolia*, with confirmation required during the wet season when an accurate identification can be made.

Australian Soil Classification: Black Vertosol.

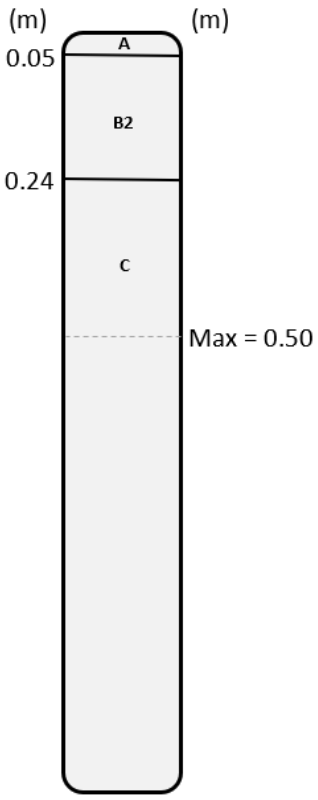
Photo Plate 12 Wallace SMU Vegetation

Table 36 Wallace Soil Unit Description

Parameter	Soil Unit Description
Profile Site Numbers	DP4
Observation Site Numbers	DO5, DO18, DO248
Landform	Flats on upper slopes
Land System	Melbadale
Slope	1%
Geology	Qa-QLD (Qa) – Quaternary clay, silt, sand and gravel; flood-plain alluvium
Vegetation	Cleared with *Aristida latifolia* (unconfirmed)
Runoff	Slow
Permeability	Moderately permeable
Drainage	Moderately well drained

Profile Description – Representative Sites: DP4

Wallace SMU



The **surface soil** (A) is a very dark brown (7.5YR2.5/2) medium heavy clay with weak lenticular structure and a pH of 6.5. Gradual change to;

The **subsoil** (B2) is a very dark brown (7.5YR2.5/2) heavy clay with moderate sub-angular blocky structure. It has a small amount (<2%) of sub-angular coarse fragments, and a field pH of 6.5. Clear change to;

The **parent material** (C) is a dark grey (7.5YR4/1) rocky material of sedimentary origin, with a field pH of 6.5.

Chemical and Physical Analysis

Table 37 Chemical Properties of the Wallace SMU

Representative site: DP4									
Depth (m)	**pH**		**EC**		**Cl**	**ESP%**		**Moisture (%)**	**Emerson Class No.**
	#	**Rate**	**dS/m**	**Rate**	**mg/kg**	**%**	**Rate**		
0-0.1	6.8	Neutral	0.09	Low	30	0.3	Non-sodic	5.4	3
0.2-0.3	7.4	Slightly alkaline	0.038	Very Low	10	0.6	Non-sodic	13.8	4
Depth (m)	**CEC**			**Exchangeable Cations (meq/100g)**				**Ca/Mg Ratio**	
	meq / 100g		**Rate**	**Ca**	**Mg**	**K**	**Na**		
0-0.1	39		High	18.7	18.3	1.8	0.1	1.0	
0.2-0.3	44		Very high	27.3	16.1	0.3	0.3	1.7	
Percentage in Topsoil				47.95%	46.92%	4.62%	0.30%	-	

The Wallace SMU is a well-rounded soil unit, which would be appropriate for an agricultural land use, but for its shallow soil depth. Soil pH ranges from 6.8 in the topsoil (neutral) to 7.4 in the subsoil (slightly alkaline). Salinity in this soil is not a concern, with EC ranging from low (0.09 dS/m) to very low (0.038 dS/m), with chloride well below toxic levels.

The high clay content and organic matter in this soil is associated with an elevated CEC, ranging from high in the topsoil (39 meq/100g) to very high in the subsoil (44 meq/100g). This has resulted in relatively high concentrations of available cations, dominated by calcium (18.7 to 27.3 meq/100g) and magnesium (18.3 to 16.1 meq/100g), with suitable levels of potassium (1.8 to 0.3 meq/100g). Calcium was present in higher quantities than magnesium at all depths, with the Ca/Mg ratio ranging from 1.0 to 1.7. This reduces the likelihood of any dispersive tendencies within the soil.

ESP is extremely low and considered non-sodic throughout the profile, ranging from 0.3% to 0.6%, meaning that this soil in unlikely to become dispersive upon wetting. Emerson Class numbers support this fact, ranging from 3 in the surface soil (dispersive if physically disturbed) to 4 in the subsoil (non-dispersive).

Water-holding capacity appears to increase with depth and clay content, as evidenced by the increase in moisture % with depth seen in Table 37.

Table 38 Surface Soil (0-10 cm) Properties of the Wallace SMU

Particle Size Analysis %				Emerson Class No.	Nitrate (mg/kg)	Sulphate (mg/kg)	Organic Matter (%)
Gravel	Sand	Silt	Clay				
4	14	52	30	3	6.6	10	4.1
Extractable Nutrients (mg/kg)				Extractable Metals (mg/kg)			
P	K	B		Cu	Fe	Mn	Zn
169	652	0.5		1.61	63.4	53.4	1.02

The surface soil (A) for the Wallace SMU is dominated by silt sized particles (52%), with 30% clay, 14% sand, and 4% gravel. It has a weak lenticular structure, and a fine, self-mulching surface. The topsoil is non-sodic, with a Ca/Mg ratio of 1.0, and an organic matter content of 4.1%. This information paired with the soil's Emerson Class Number of 3, suggests that is will remain non-dispersive unless physically disturbed. This potential dispersion is likely influenced by the relatively low Ca/Mg ratio of the topsoil unit.

Nutrient levels in this topsoil are generally good. Nitrate (6.6 mg/kg) was outside of the acceptable bounds for agriculture, though phosphorous (169 mg/kg), potassium (652 mg/kg), boron (0.5 mg/kg) and sulphate (10 mg/kg) were well within the desired concentrations. For the extractable metals, only zinc (1.02 mg/kg) was found to be at an appropriate level, with copper (1.61 mg/kg) lower than desired, and iron (63.4 mg/kg) and manganese (53.4 mg/kg) higher than necessary.

High clay content, low sodicity, and desirable nutrient concentrations make this unit one of the best growth mediums in the survey area. This fact is observable in the field as the SMU area supports a healthy sward of highly palatable grass species that are rare or absent in most other SMUs. The shallow soil depth and low nitrate concentration are both limiting factors for agricultural use of this soil, though as grazing land it is highly suitable.

5.0 LAND SUITABILITY

The aim of this land suitability assessment is to evaluate the suitability of the Project for agricultural land uses including cattle grazing and dryland cropping, prior to the development of the mine. Land suitability assessment considers environmental factors including climate, soils, geology, geomorphology, erosion, topography and the effects of past land use. The classification does not always represent the current land use. Rather, it indicates the potential of the land to be used for a range of agricultural activities.

The assessment for land suitability (cattle grazing and dryland cropping) has been carried out in accordance with the methodologies described in:

- DSITI & DNRM (2015). *Guidelines for Agricultural Land Evaluation in Queensland* (2nd edition). Queensland Government, Brisbane, Queensland; and
- DSITI & DNRM (2013). *Regional Land Suitability Frameworks for Queensland*, Chapter 10 – Suitability Framework for the Inland Fitzroy and Southern Burdekin area. Queensland Government. Brisbane, Queensland.

The five land suitability classes used for assessing the land are defined in Table 39. Land is considered less suitable as the severity of limitations for a land use increase. The land suitability class reflects the score of the most limiting attribute for a given SMU. An increase in limitations may reflect either:

- Reduced potential for production; and/or
- Increased inputs to achieve and acceptable level of production;
- Increased inputs to prepare the land for successful production; and/or
- Increased inputs required to prevent land degradation.

Table 39 Agricultural and Conservation Land Classes

Agricultural Land Class	Type	Description
Class 1	Agricultural	**Suitable land** with negligible limitations. This is highly productive land requiring only simple management practices to maintain economic production.
Class 2	Agricultural	**Suitable land** with minor limitations which either reduce production or require more than the simple management practices of class 1 land to maintain economic production.
Class 3	Agricultural	**Suitable land** with moderate limitations which either further lower production or require more than those management practices of class 2 land to maintain economic production.
Class 4	Agricultural	**Marginal land**, which is presently considered unsuitable due to severe limitations. The long-term significance of these limitations on the proposed land use is unknown or not quantified. The use of this land is dependent upon undertaking additional studies to determine whether the effect of the limitation(s) can be reduced to achieve sustained economic production.
Class 5	Agricultural	**Unsuitable land** with extreme limitations that preclude its use.

Key: green shading suitable
red shading unsuitable

5.1 CATTLE GRAZING

Limitations for the assessment of grazing land suitability on improved pastures as outlined in the *Land Suitability Assessment Technique* (DME 1995) Guidelines (Table 2.2 and 2.3) are:

- Water availability;
- Nutrient deficiency;
- Soil physical factors;
- Salinity;
- Rockiness;
- Micro relief;
- pH;
- ESP;
- Wetness;
- Topography;
- Water erosion;
- Flooding; and
- Vegetation

Numerous parameters outlined in this assessment require calculation of the 'rootzone'. The rootzone is the depth to hard or weathered rock, or the depth to a significant salt bulge within the soil profile. A depth of 0.6 m has been assumed as the rootzone for any profile in which weathered rock, and/or a salt bulge was absent as outlined in the guidelines (DME 1995).

Class 1 and **class 2** land is considered suitable for grazing improved pastures with maximum grazing productivity achieved in most seasons. **Class 3** land is considered suitable for grazing improved pastures however it is less productive than **Classes 1** and **2**. **Class 4** land is categorised as marginal for grazing improved pastures although it is largely considered suitable for grazing native pastures of variable quality. **Class 5** land is unsuitable for any form of pasture improvement and is limited to low productivity grazing of native pastures. Due to the poor soil quality **Class 5** land may require destocking in poor seasons.

5.1.1 Water Availability

Plant available water capacity (PAWC) for each soil management unit was calculated with reference to Table 2.3 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995). PAWC cut-off levels for each of the land suitability classes are as follows:

Class 1: >125 mm

Class 2: 100-125 mm

Class 3: 75-100 mm

Class 4: 50-75 mm

Class 5: <50 mm

These cut-off levels are not based on a specific species of pasture, but on pasture as a general land use. The soils are assessed on the depth to weathered rock, or other root inhibiting factor such as a salt bulge or significant sodicity. The availability of water in soils is vital for both plants and soil organisms as they require water to survive.

Table 40 Plant Available Water Capacity

Soil Management Unit	Limiting Features	PAWC (mm)	Land Suitability Class
Anderson	Gradational earth reaching 75-125 cm depth with no weathered rock/salt bulge (no rock/salt layer reached at 97cm).	100-125	2
Barry	Gradational earths reaching >125 cm depth with no weathered rock/salt layer (no rock/salt layer reached at 105 cm – alluvial units typically deep and non-sodic).	125-150	1
Charlevue	Gradational earth reaching 50-75 cm depth with no weathered rock/salt layer (EC >0.9 dS/m or Cl >900 mg/kg) (max core depth 70 cm).	75-100	3
Cooinda	Gradational earth reaching 50-75cm depth with no weathered rock/salt layer (EC >0.9 dS/m or Cl >900 mg/kg) (max core depth 60 cm).	75-100	3
Ellesmere	Gradational earth reaching 75-125cm depth with no weathered rock/salt layer (EC >0.9 dS/m or Cl >900 mg/kg) (max core depth 60 cm).	100-125	2
Geoffrey	Sands and sandy loams 45-90 cm deep	75-100	3
James	Gradational earths reaching 75-125 cm depth with no weathered rock/salt layer (EC >0.9 dS/m or Cl >900 mg/kg) (max core depth 85 cm).	100-125	2
Kosh	Non-cracking clay reaching 75-125 cm depth with no weathered rock/salt layer (EC >0.9 dS/m or Cl >900 mg/kg) (max core depth 85 cm).	100-125	2
Namoi	Non-cracking clay reaching 75-125cm depth with no weathered rock/salt layer (EC >0.9 dS/m or Cl >900 mg/kg) (max core depth 70cm).	100-125	2
Nigel	Clayey sands with 75-125 cm depth to weathered rock (parent material at 76 cm).	100-125	2
Normanby	Loamy sands >90 cm deep.	75-100	3
Wallace	Cracking clays with alkaline pH, and 20-40 cm depth to weathered or hard rock.	75-100	3

Key: > greater than

5.1.2 Nutrient Deficiency

The nutrient status of each Soil Management Unit identified has been assessed against Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995). The land suitability classes identified for each Soil Management Unit are presented in Table 41. Note that bicarbonate P was only analysed within the topsoil layer (0-10 cm). Soil nutrients are vital for plant and animal growth and metabolism.

Table 41 Land Suitability Classes for Cattle Grazing based on Nutrient Status

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	Eucalypt vegetation and downs with bicarbonate P >10 mg/kg.	2
Barry	Eucalypt vegetation and downs with bicarbonate P >10 mg/kg.	2
Charlevue	Eucalypt vegetation and downs with bicarbonate P >10 mg/kg.	2
Cooinda	Eucalypt vegetation and downs with bicarbonate P >10 mg/kg.	2
Ellesmere	Other soils with Bicarbonate P 5-10 mg/kg.	3
Geoffrey	Other soils with Bicarbonate P 5-10 mg/kg.	3
James	Eucalypt vegetation and downs with bicarbonate P >10 mg/kg.	2
Kosh	Eucalypt vegetation and downs with bicarbonate P >10 mg/kg.	2
Namoi	Other soils with Bicarbonate P 5-10 mg/kg.	3
Nigel	Soil overlying rock at shallow depth, with bicarbonate P 5-10 mg/kg.	4
Normanby	Sands and loams at least 0.75 m deep with bicarbonate P 5-10 ppm.	4
Wallace	Former scrub soils with bicarbonate P >10 mg/kg.	1

Key: ppm parts per million

5.1.3 Soil Physical Factors

Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995) has been used to assess the physical factors of each Soil Management Unit identified. Results are presented in Table 42. The physical condition of soils plays a direct role with seed germination and emergence. Adverse conditions such as hard setting or crusting of surface soils reduces plant establishment through creating a barrier, reducing seed soil contact.

Table 42 Land Suitability Classes for Cattle Grazing based on Soil Physical Factors

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	Rigid soils with a hard setting surface when dry	2
Barry	Rigid soils with a hard setting surface when dry	2
Charlevue	Rigid soils with a hard setting surface when dry	2
Cooinda	Rigid soils with a hard setting surface when dry	2
Ellesmere	Rigid soils with a hard setting surface when dry	2
Geoffrey	Rigid soils with a loose, soft or firm surface when dry.	1
James	Rigid soils with a hard setting surface when dry	2
Kosh	Rigid soils with a hard setting surface when dry	2
Namoi	Rigid soils with a hard setting surface when dry	2

Soil Management Unit	Limiting Features	Land Suitability Class
Nigel	Rigid soils with a hard setting surface when dry	2
Normanby	Rigid soils with a loose, soft or firm surface when dry.	1
Wallace	Cracking clays with coarse peds (>10 mm)	3

5.1.4 Salinity

Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995) has been used to determine the land suitability class against salinity parameters. Given salinity can inhibit plant growth; the highest EC recorded is considered the most limiting factor and dictates the rating given to each Soil Management Unit. The results are provided in Table 43. Significant levels of salinity present in the rootzone can negatively impact plant growth and production.

Table 43 Land Suitability Classes for Cattle Grazing based on Salinity

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1
Barry	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1
Charlevue	Rootzone EC 0.15-0.3 mS/cm, and rootzone Cl 300-600 mg/kg	2
Cooinda	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1
Ellesmere	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1
Geoffrey	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1
James	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1
Kosh	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1
Namoi	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1
Nigel	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1
Normanby	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1
Wallace	Rootzone EC <0.15 mS/cm, Rootzone Cl <300 ppm	1

5.1.5 Rockiness

The land suitability for each Soil Management Unit based on rockiness was assessed in regard to Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995). Results are presented in Table 44. The impacts of rockiness are more extreme for cropping than for grazing. In regard to grazing, rock outcrops reduce the area available to grow pasture, indirectly impacting the carrying capacity of the land.

Table 44 Land Suitability Classes for Cattle Grazing

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	<20% course surface gravel and rock outcrop	1
Barry	<20% course surface gravel and rock outcrop	1
Charlevue	<20% course surface gravel and rock outcrop	1
Cooinda	<20% course surface gravel and rock outcrop	1
Ellesmere	<20% course surface gravel and rock outcrop	1
Geoffrey	<20% course surface gravel and rock outcrop	1
James	20 to 50% course surface gravel and rock outcrop	2
Kosh	<20% course surface gravel and rock outcrop	1
Namoi	<20% course surface gravel and rock outcrop	1
Nigel	<20% course surface gravel and rock outcrop	1
Normanby	<20% course surface gravel and rock outcrop	1
Wallace	<20% course surface gravel and rock outcrop	1

5.1.6 Microrelief

The microrelief for each Soil Management Unit identified has been assessed against Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995), presented in Table 45. Microrelief refers to local relief (up to several metres) around the plane of the land (NCST 2009). Impacts of microrelief on the suitability of land for cattle grazing are only experienced when soil is severely melon holed. Ponding of water in the depressions can reduce pasture yield, indirectly impacting the land's carrying capacity.

Table 45 Land Suitability Classes for Cattle Grazing based on microrelief

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	Melon holes cover <20% surface area	1
Barry	Melon holes cover <20% surface area	1
Charlevue	Melon holes cover <20% surface area	1
Cooinda	Melon holes cover <20% surface area	1
Ellesmere	Melon holes cover <20% surface area	1
Geoffrey	Melon holes cover <20% surface area	1
James	Melon holes cover <20% surface area	1
Kosh	Melon holes cover <20% surface area	1
Namoi	Melon holes cover <20% surface area	1
Nigel	Melon holes cover <20% surface area	1
Normanby	Melon holes cover <20% surface area	1
Wallace	Melon holes cover <20% surface area	1

5.1.7 pH

The land suitability class for pH has been assessed against Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995), and presented in Table 46. Soil pH determines the availability of nutrients for plant intake. Where the soil material is strongly acidic, problems with aluminium and manganese toxicity may occur, limiting root growth and plant productivity. Strongly acidic soils may require input of lime or dolomite to increase soil pH. Strongly alkaline soils will restrict the availability of some elements (Fe, Cu, Zn) and may be an indicator of sodicity. Ameliorates may be added to the soil to correct pH and increase nutrient availability.

Table 46 Land Suitability Classes for Cattle Grazing based on pH

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	pH 4.5-5.0	3
Barry	pH 6.6-8.0	2
Charlevue	pH 5.6-6.6	1
Cooinda	pH 5.6-6.6	1
Ellesmere	pH 4.5-5.0	3
Geoffrey	pH 5.6-6.6	1
James	pH 5.6-6.6	1
Kosh	pH 6.6-8.0	2
Namoi	pH 5.6-6.6	1
Nigel	pH 4.5-5.0	3
Normanby	pH 5.6-6.6	1
Wallace	pH 6.6-8.0	2

5.1.8 Exchangeable Sodium Percentage (ESP)

The ESP of each Soil Management Unit identified has been assessed against Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995). ESP is used to determine the erosion potential of soils. The land suitability class identified for each Soil Management Unit based on ESP in the upper 100 mm of soil is presented in Table 47.

Table 47 Land Suitability Classes for Cattle Grazing based on ESP

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	ESP (10 cm) <5%	1
Barry	ESP (10 cm) <5%	1
Charlevue	ESP (10 cm) 15-30%	4
Cooinda	ESP (10 cm) <5%	1
Ellesmere	ESP (10 cm) <5%	1
Geoffrey	ESP (10 cm) <5%	1
James	ESP (10 cm) <5%	1

Soil Management Unit	Limiting Features	Land Suitability Class
Kosh	ESP (10 cm) <5%	1
Namoi	ESP (10 cm) <5%	1
Nigel	ESP (10 cm) <5%	1
Normanby	ESP (10 cm) <5%	1
Wallace	ESP (10 cm) <5%	1

5.1.9 Wetness

The land suitability class identified for each Soil Management Unit based on wetness has been assessed against Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995), and is presented in Table 48. The wetness limitation refers to any excess water both in or on the soil profile. The adverse effects of excess water include reducing plant growth, impeding oxygen supply to plant roots (possibly leading to denitrification) and increased risk of plant disease.

Table 48 Land Suitability Classes for Cattle Grazing based on Wetness

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	Elevated plains	1
Barry	Undulating terrain	1
Charlevue	Rigid soils with strongly sodic subsoil (ESP≥15) within 60 cm of the surface	2
Cooinda	Elevated plains	1
Ellesmere	Undulating terrain	1
Geoffrey	Undulating terrain	1
James	Undulating terrain	1
Kosh	Rigid soils with strongly sodic subsoil (ESP≥15) within 60 cm of the surface	2
Namoi	Elevated plains	1
Nigel	Elevated plains	1
Normanby	Elevated plains	1
Wallace	Elevated plains	1

5.1.10 Water Erosion

The land suitability class identified for each Soil Management Unit based on water erosion has been assessed against Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995), and presented in Table 49. Erosion of topsoil reduces the productivity of the land through the loss of key nutrients in the soil's upper horizons.

Table 49 Land Suitability Classes for Cattle Grazing based on Water Erosion

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	Slopes 3-12% on non-sodic rigid soils	2
Barry	Slopes <3% on non-sodic rigid soils	1
Charlevue	Slopes 1-3% on sodic rigid soils	2
Cooinda	Slopes <3% on non-sodic rigid soils	1
Ellesmere	Slopes 3-12% on non-sodic rigid soils	2
Geoffrey	Slopes 3-12% on non-sodic rigid soils	2
James	Slopes 3-12% on non-sodic rigid soils	2
Kosh	Slopes 3-12% on non-sodic rigid soils	2
Namoi	Slopes 3-12% on non-sodic rigid soils	2
Nigel	Slopes 3-12% on non-sodic rigid soils	2
Normanby	Slopes <3% on non-sodic rigid soils	1
Wallace	Slopes <3% on non-sodic rigid soils	1

5.1.11 Flooding

The land suitability class identified for each Soil Management Unit based on flooding risk has been assessed against Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995), and is presented in Table 50. Flooding may result in plant death or reduced growth. In severe cases were land is inundated for a prolonged period stock loss and loss of grazing production may also occur.

Table 50 Land Suitability Classes for Cattle Grazing based on Flooding

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	No flooding	1
Barry	Periodic flooding	2
Charlevue	No flooding	1
Cooinda	No flooding	1
Ellesmere	No flooding	1
Geoffrey	Periodic flooding	2
James	No flooding	1
Kosh	Periodic flooding	2
Namoi	No flooding	1
Nigel	No flooding	1
Normanby	No flooding	1
Wallace	No flooding	1

5.1.12 Vegetation Regrowth (management limitation)

The land suitability class identified for each Soil Management Unit based on vegetation regrowth has been assessed against Table 2.2 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995), and is presented in Table 51. Vegetation communities may contain poisonous species or woody weeds that will limit the productivity of grazing pastures to varying degrees and increase the need for land management. The density of tree species and presence of a woody shrub layer may also limit the carrying capacity of the land.

Table 51 Land Suitability Classes for Cattle Grazing based on Vegetation

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	Eucalypt woodlands with wattle understorey	4
Barry	Mountain coolabah and ironbark open woodlands	1
Charlevue	Box and ironbark woodlands without wattle understorey	2
Cooinda	Box woodlands without wattle understorey	2
Ellesmere	Acacia scrub without melonholes	1
Geoffrey	Bloodwood and ironbark open woodlands	1
James	Box and ironbark woodlands with wattle understorey	4
Kosh	Box and ironbark woodlands without wattle understorey (cleared)	2
Namoi	Ironbark open woodlands	1
Nigel	Acacia scrub without melonholes	1
Normanby	Ironbark open woodlands	1
Wallace	(cleared)	-

5.1.13 Summary of Land suitability for Cattle Grazing

Table 52 Summary of Land Suitability Limitations for Cattle Grazing

Limitation	Anderson	Barry	Charlevue	Cooinda	Ellesmere	Geoffrey	James	Kosh	Namoi	Nigel	Normanby	Wallace
Water availability	2	1	3	3	2	3	2	2	2	2	3	3
Nutrient deficiency	2	2	2	2	3	3	2	2	3	4	4	1
Soil physical factors	2	2	2	2	2	1	2	2	2	2	1	3
Salinity	1	1	2	1	1	1	1	1	1	1	1	1
Rockiness	1	1	1	1	1	1	2	1	1	1	1	1
Microrelief	1	1	1	1	1	1	1	1	1	1	1	1
pH	3	2	1	1	3	1	1	2	1	3	1	2
ESP (10cm) %	1	1	4	1	1	1	1	1	1	1	1	1
Wetness	1	1	2	1	1	1	1	2	1	1	1	1
Water Erosion	2	1	2	1	2	2	2	2	2	2	1	1
Flooding	1	2	1	1	1	2	1	2	1	1	1	1
Vegetation Regrowth	4	1	2	2	1	1	4	2	1	1	1	-
Overall Suitability Rating	4	2	4	3	3	3	4	2	3	4	4	3

Key: green shading suitable
red shading unsuitable

On the Project, the suitability of land for cattle grazing is most limited by nutrient deficiency, ESP, and vegetation. Low nutrient levels and high sodicity in the soils may limit livestock production through a reduction in pasture growth and nutritive value of pasture species. Vegetation regrowth species can also impact the suitability of the land if they contain woody or poisonous species. In addition to this, high density regrowth and a woody shrub layer may reduce the carrying capacity of the land, making it unsuitable for grazing.

While no Class 1 land was identified for the Project, examination of the land suitability limitations for cattle grazing (Table 52) indicate 1084.1 ha of the Project is suitable for cattle grazing with minor limitations (Class 2), while 4338 ha is suitable for cattle grazing with moderate limitations (Class 3). The remaining area (750.8 ha) was comprised of Class 4 land, with no Class 5 land identified.

SMUs Barry and Kosh are classified as Class 2 land which is suitable for cattle grazing with minor limitations. In most seasons, younger cattle on Class 2 land will perform well, with minimal inputs required (e.g. fertiliser, land preparation or maintenance) to achieve a weight grade similar to cattle raised on Class 1 land. Land graded as Class 3 (SMUs Cooinda, Ellesmere, Geoffrey, Namoi and Wallace) may require some inputs to achieve this same weight grade, with emphasis on remediating nutrient deficiency and hard setting soil surfaces.

SMUs Anderson, Charlevue, James, Nigel and Normanby are classified as Class 4 land, which is considered suitable for improved pastures (though with severe limitations). Class 4 land will generally require significant inputs in the form of fertiliser or land management, which may not be justified given the limited benefits this land can offer. Given changes to knowledge, economics or technology this land could be sustainably managed, though does not currently hold significant economic value for improved pastures. These areas may be suitable for grazing native pastures of variable quality, though would likely have a reduced output when compared with land Classes 1, 2 and 3.

Figure 7 shows the distribution of land suitability classes for cattle grazing across the Project.

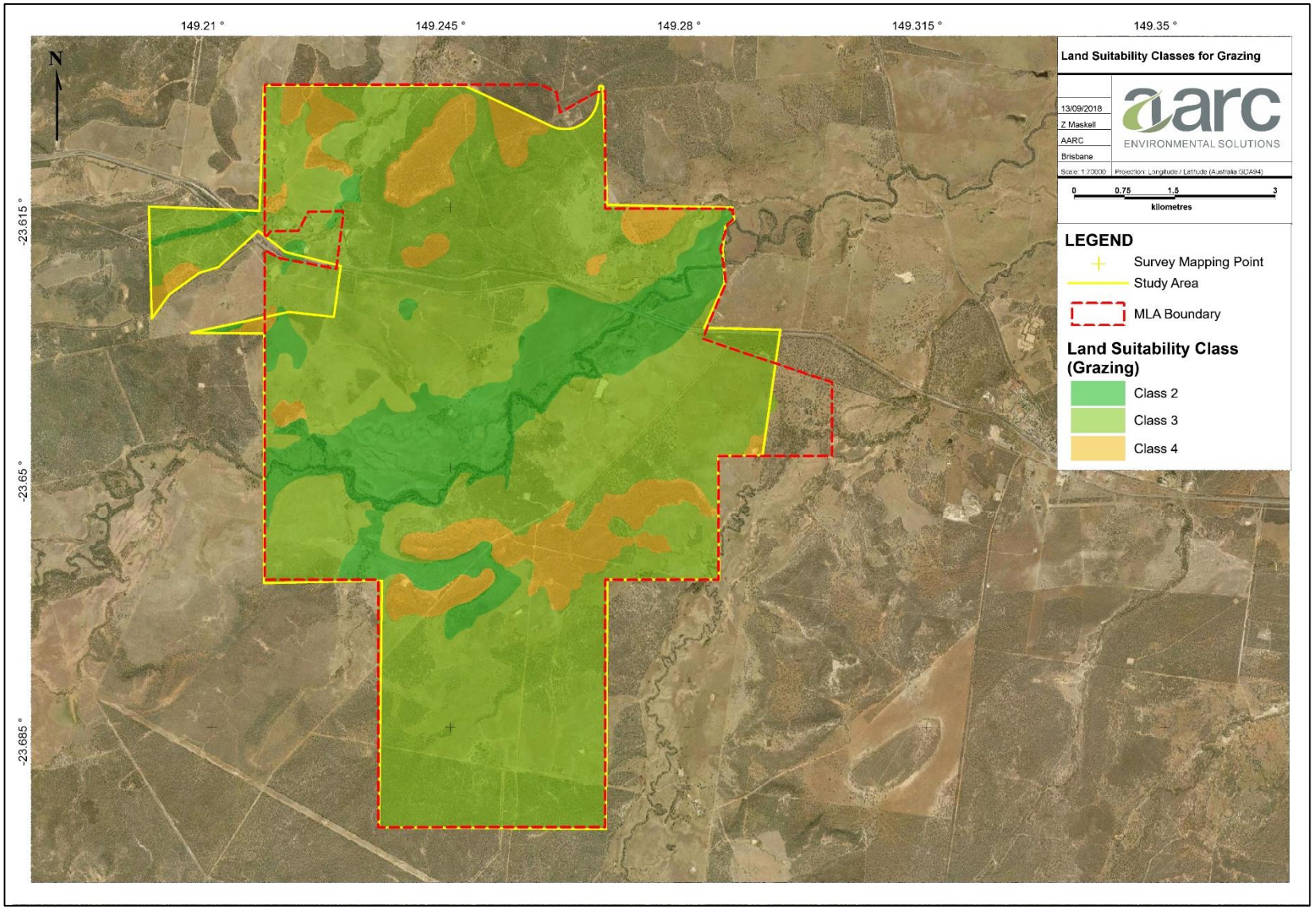


Figure 7 Cattle Grazing Land Suitability Classes

5.2 DRYLAND CROPPING

The Project lies within the Inland Fitzroy and Southern Burdekin area. Limitations for the assessment of dryland cropping suitability are specific to the Projects region and include:

- Water Erosion;
- Erosion hazard, subsoil erodibility;
- Soil water availability;
- Narrow moisture range;
- Surface conditions;
- Rockiness;
- Microrelief; and
- Wetness.

Several of these limitations contain subclasses based on the varying land management practices required for different crops. This suitability assessment will present findings based on the lowest land suitability rating returned across all of the suitability subclasses.

Assessment of the SMUs suitability for dryland cropping has been conducted in accordance with the methodology described within the *Guidelines for Agricultural Land Evaluation in Queensland* (DSITIA & DNRM 2015) and the *Regional Land Suitability Frameworks for Queensland* – Chapter 10 (DSITIA & DNRM 2013). The Suitability framework for the Inland Fitzroy and Southern Burdekin area focusses on assessing the potential for cultivating twelve specific crops including:

- Barley;
- Chickpea;
- Maize;
- Millet;
- Mungbean;
- Oats;
- Safflower;
- Sorghum;
- Soybean;
- Sunflower;
- Triticale; and
- Wheat.

Numerous parameters outlined in this assessment require calculation of the 'rootzone'. The rootzone is the depth to hard or weathered rock, or the depth to a significant salt bulge within the soil profile. A depth of 0.6 m has been assumed as the rootzone for any profile in which weathered rock, and/or a salt bulge was absent as outlined in the guidelines (DME 1995).

5.2.1 Water Erosion

The land suitability class identified for each SMU based on water erosion was determined using the *Regional Land Suitability Frameworks for Queensland* – Chapter 10, Table E, and is presented in Table 53. Dispersive properties were allocated based on Emerson Class Number and sodicity for each SMU. Erosion of topsoil reduces the productivity of the land through the loss of key nutrients in the soil's upper horizons.

Table 53 Land Suitability Classes for Dryland Cropping based on Water Erosion

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	Slopes of 5-8% with non-dispersive weakly coherent soil in the surface 200 mm	4
Barry	Slope of 1-3% with non-dispersive weakly coherent soil in the surface 200 mm	3
Charlevue	Slope of 1-3% with dispersive soil in the surface 200 mm	5
Cooinda	Slope of 1-3% with non-dispersive weakly coherent soil in the surface 200 mm	3

Soil Management Unit	Limiting Features	Land Suitability Class
Ellesmere	Slope of 3-5% with non-dispersive weakly coherent soil in the surface 200 mm	4
Geoffrey	Slopes of 3-5% with non-dispersive moderate to strongly coherent soil in the surface 200 mm	3
James	Slopes of 5-8% with non-dispersive moderate to strongly coherent soil in the surface 200 mm	3
Kosh	Slope of 1-3% with non-dispersive moderate to strongly coherent soil in the surface 200 mm	2
Namoi	Slopes of 3-5% with non-dispersive weakly coherent soil in the surface 200 mm	4
Nigel	Slopes of 3-5% with non-dispersive moderate to strongly coherent soil in the surface 200 mm	3
Normanby	1-3% with non-dispersive moderate to strongly coherent soil in the surface 200 mm	2
Wallace	Slopes of 0.5-1% with non-dispersive weakly coherent soil in the surface 200 mm	2

5.2.2 Erosion hazard, Subsoil Erodibility

The land suitability class identified for each Soil Management Unit based on erosion hazard and subsoil erodibility was determined using the *Regional Land Suitability Frameworks for Queensland* – Chapter 10, Table Es, and is presented in Table 54. Subsoil was assessed based on soils ESP, EC, CEC and Ca/Mg ratio. Soils with high ESP and low EC have a tendency to disperse (DME 1995). Low Ca/Mg ratios also indicate dispersive properties of soil. CEC is required to interpreting the ESP value as the lower the CEC value, the less significant the role of the ESP.

Table 54 Land Suitability Classes for Dryland Cropping based on Erosion Hazard and Subsoil Erodibility

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	Slopes of 5-8% with no subsoil (200-1000 mm) dispersion	3
Barry	Slope of 1-3% with low to moderate dispersive subsoil (200-1000 mm) and clay content greater than 20%	3
Charlevue	Slope of 1-3% with strongly dispersive subsoil (200-1000 mm) on 2 or more tests and clay content greater than 20%	4
Cooinda	Slope of 1-3% with low to moderate dispersive subsoil (200-1000 mm) and clay content greater than 20%	3
Ellesmere	Slope of 3-5% with strongly dispersive subsoil (200-1000 mm) on 2 or more tests and clay content greater than 20%	5
Geoffrey	Slopes of 3-5% with strongly dispersive subsoil (200-1000 mm) on 2 or more tests and clay content greater than 20%	5
James	Slopes of 5-8% with no subsoil (200-1000 mm) dispersion	3
Kosh	Slope of 1-3% with strongly dispersive subsoil (200-1000 mm) on 2 or more tests and clay content greater than 20%	4
Namoi	Slopes of 3-5% with low to moderate dispersive subsoil (200-1000 mm) and clay content greater than 20%	3
Nigel	Slopes of 3-5% with no subsoil (200-1000 mm) dispersion	3
Normanby	1-3% with no subsoil (200-1000 mm) dispersion	1
Wallace	Slopes of 0.5-1% with no subsoil (200-1000 mm) dispersion	1

5.2.3 Soil Water Availability

The land suitability class identified for each Soil Management Unit based on soil water availability was determined using the *Regional Land Suitability Frameworks for Queensland* – Chapter 10, Table M, and is presented in Table 55. PAWC values were estimated with reference to Table 2.3 of the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (DME 1995). These cut-off levels are not based on a particular cropping species, but on cropping as a general land use. The soils are assessed on the depth to weathered rock, or other root inhibiting factors such as a salt bulge or significant sodicity. PAWC cut-off levels for each of the land suitability classes are as follows:

Class 1: >125 mm

Class 2: 100-125 mm

Class 3: 75-100 mm

Class 4: 50-75 mm

Class 5: <50 mm

These values were used to delegate land suitability classes for different groups of crop species, as outlined in *Regional Land Suitability Frameworks for Queensland* - Chapter 10, Table M.

Table 55 Land Suitability Classes for Dryland Cropping based on Soil Water Availability

Soil Management Unit	PAWC (mm)	Land Suitability Class (Group A)	Land Suitability Class (Group B)	Land Suitability Class (Group C)
Anderson	100-125	3	3	4
Barry	125-150	2	2	3
Charlevue	75-100	3	4	5
Cooinda	75-100	3	4	5
Ellesmere	100-125	3	3	4
Geoffrey	75-100	3	4	5
James	100-125	3	3	4
Kosh	100-125	3	3	4
Namoi	100-125	3	3	4
Nigel	100-125	3	3	4
Normanby	100-125	3	3	4
Wallace	75-100	3	4	5

5.2.4 Narrow Moisture Range

The land suitability class identified for each SMU based on narrow moisture range was determined using the *Regional Land Suitability Frameworks for Queensland* – Chapter 10, Table Pm, and is presented in Table 56. The narrow moisture range of a soil plays a role in determining the soil's capacity for cultivation within the restraints of machinery.

Table 56 Land Suitability Classes for Dryland Cropping based on Narrow Moisture Range

Soil Management Unit	Limiting Features	Land Suitability Class
Anderson	Narrow moisture range for cultivation – imperfectly drained to moderately well drained; hard setting when dry and not 'spewy' when wet.	3
Barry	Narrow moisture range for cultivation – imperfectly drained to moderately well drained; hard setting when dry and not 'spewy' when wet. Hard setting pedal clays.	3
Charlevue	Narrow moisture range for cultivation – imperfectly drained to moderately well drained; hard setting when dry and not 'spewy' when wet. Hard setting pedal clays.	3
Cooinda	Narrow moisture range for cultivation – imperfectly drained to moderately well drained; hard setting when dry and not 'spewy' when wet. Hard setting pedal clays.	3
Ellesmere	Moderate moisture range for cultivation – moderately well drained to rapidly drained; predominantly hard setting when dry and not 'spewy' when wet. Moderately well drained hard setting loamy surfaced soils.	2
Geoffrey	Wide moisture range for cultivation – moderately well drained to rapidly drained; not hard setting when dry and not 'spewy' (i.e. boggy) when wet. Deep sands and thick sandy surfaced texture contrast soils	1
James	Moderate moisture range for cultivation – moderately well drained to rapidly drained; predominantly hard setting when dry and not 'spewy' when wet. Moderately well drained hard setting loamy surfaced soils.	2
Kosh	Narrow moisture range for cultivation – imperfectly drained to moderately well drained; hard setting when dry and not 'spewy' when wet. Hard setting pedal clays.	3
Namoi	Moderate moisture range for cultivation – moderately well drained to rapidly drained; predominantly hard setting when dry and not 'spewy' when wet. Moderately well drained hard setting loamy surfaced soils.	2
Nigel	Narrow moisture range for cultivation – imperfectly drained to moderately well drained; hard setting when dry and 'spewy' when wet. Loamy surfaced (less than 0.4 m).	3
Normanby	Moderate moisture range for cultivation – moderately well drained to rapidly drained; not hard setting when dry and not 'spewy' when wet. Well drained earths.	2
Wallace	Narrow moisture range for cultivation – imperfectly drained to moderately well drained; hard setting, firm or weakly self-mulching when dry and not 'spewy' when wet. Hard setting or weakly self-mulching, pedal clays.	3

5.2.5 Surface Condition

The land suitability class identified for each SMU based on surface condition was determined using the *Regional Land Suitability Frameworks for Queensland* – Chapter 10, Table Ps, and is presented Table 57. The physical condition of soils plays a direct role with seed germination and emergence. Adverse conditions such as hard setting or crusting of surface soils reduces plant establishment through creating a barrier, reducing seed soil contact.

Table 57 Land Suitability Classes for Dryland Cropping based on Surface Condition

Soil Management Unit	Limiting Features	Land Suitability Class

Anderson	Loamy, fine sand, silty or clayey surface soils that are hard setting, massive or crusting.	4
Barry	Clay soils with hard setting, firm pedal or weakly self-mulching surface horizons.	3
Charlevue	Clay soils with hard setting, firm pedal or weakly self-mulching surface horizons.	3
Cooinda	Clay soils with hard setting, firm pedal or weakly self-mulching surface horizons.	3
Ellesmere	Soils with soft, firm or only weakly hard setting, sandy to loamy surface horizons	2
Geoffrey	Soils with soft, firm or only weakly hard setting, sandy to sandy loam surface horizons	2
James	Clay soils with hard setting, firm pedal or weakly self-mulching surface horizons.	3
Kosh	Loamy, fine sand, silty or clayey surface soils that are hard setting, massive or crusting.	4
Namoi	Clay soils with hard setting, firm pedal or weakly self-mulching surface horizons.	3
Nigel	Loamy, fine sand, silty or clayey surface soils that are hard setting, massive or crusting.	4
Normanby	Soils with soft or loose sandy to sandy loam surface horizons	1
Wallace	Coarse self-mulching clays (peds greater than 5–10 mm); poor seed soil contact due to separation of large peds with drying	3

5.2.6 Rockiness

The land suitability class identified for each SMU based on rockiness was determined using the *Regional Land Suitability Frameworks for Queensland* – Chapter 10, Table R, and is presented in Table 58. Rocky outcrops and soils containing coarse fragments hinder cultivation of crops and may damage harvesting machinery.

Table 58 Land Suitability Classes for Dryland Cropping based on Rockiness

Soil Management Unit	Limiting Features	Land Suitability Class (Group A)	Land Suitability Class (Group B)
Anderson	Gravels less than 20 mm and abundance less than 10%	1	1
Barry	Gravels less than 20 mm and abundance less than 10%	1	1
Charlevue	Gravels less than 20 mm and abundance less than 10%	1	1
Cooinda	Gravels less than 20 mm and abundance less than 10%	1	1
Ellesmere	Gravels less than 20 mm and abundance less than 10%	1	1
Geoffrey	Gravels less than 20 mm and abundance less than 10%	1	1
James	Gravels less than 20 mm and abundance 20-50%	2	3
Kosh	Gravels less than 20 mm and abundance less than 10%	1	1
Namoi	Gravels less than 20 mm and abundance less than 10%	1	1
Nigel	Gravels less than 20 mm and abundance less than 10%	1	1

Soil Management Unit	Limiting Features	Land Suitability Class (Group A)	Land Suitability Class (Group B)
Normanby	Gravels less than 20 mm and abundance less than 10%	1	1
Wallace	Gravels less than 20 mm and abundance less than 10%	1	1

5.2.7 Microrelief

The land suitability class identified for each SMU based on microrelief was determined using the *Regional Land Suitability Frameworks for Queensland* – Chapter 10, Table Tm, and is presented in Table 59. Suitability classes for microrelief are based on the degree to which land needs to be levelled for dryland cropping.

Table 59 Land Suitability Classes for Dryland Cropping based on Microrelief

Soil Management Unit	Limiting Features	Land Suitability Class (Group A)
Anderson	No microrelief across the majority (greater than 70%) of the land surface	1
Barry	No microrelief across the majority (greater than 70%) of the land surface	1
Charlevue	No microrelief across the majority (greater than 70%) of the land surface	1
Cooinda	No microrelief across the majority (greater than 70%) of the land surface	1
Ellesmere	No microrelief across the majority (greater than 70%) of the land surface	1
Geoffrey	No microrelief across the majority (greater than 70%) of the land surface	1
James	No microrelief across the majority (greater than 70%) of the land surface	1
Kosh	No microrelief across the majority (greater than 70%) of the land surface	1
Namoi	No microrelief across the majority (greater than 70%) of the land surface	1
Nigel	No microrelief across the majority (greater than 70%) of the land surface	1
Normanby	No microrelief across the majority (greater than 70%) of the land surface	1
Wallace	No microrelief across the majority (greater than 70%) of the land surface	1

5.2.8 Wetness

The land suitability class identified for each Soil Management Unit based on wetness was determined using the *Regional Land Suitability Frameworks for Queensland* – Chapter 10, Table W, and is presented in Table 60. Soil that becomes waterlogged due to poor permeability and drainage may reduce plant growth, oxygen supply to roots and cause plants to become more susceptible to disease.

Table 60 Land Suitability Classed for Dryland Cropping based on Wetness

Soil Management	Limiting Features	Land Suitability Class (Group A)	Land Suitability Class (Group B)	Land Suitability Class (Group C)

Unit				
Anderson	Moderately well drained and moderately permeable	1	1	2
Barry	Moderately well drained and highly permeable	1	1	2
Charlevue	Poorly drained	5	5	5
Cooinda	Imperfectly drained and slowly permeable	4	4	4
Ellesmere	Moderately well drained and slowly permeable	2	2	2
Geoffrey	Imperfectly drained and slowly permeable	4	4	4
James	Moderately well drained and moderately permeable	1	1	2
Kosh	Poorly drained	5	5	5
Namoi	Moderately well drained and slowly permeable	2	2	2
Nigel	Poorly drained	5	5	5
Normanby	Moderately well drained and highly permeable	1	1	2
Wallace	Moderately well drained and moderately permeable	1	1	2

5.2.9 Summary of Land Suitability for Dryland Cropping

Table 61 Summary of Land Suitability Limitations for Dryland Cropping

Limitation		Anderson	Barry	Charlevue	Cooinda	Ellesmere	Geoffrey	James	Kosh	Namoi	Nigel	Normanby	Wallace
Water Erosion		4	3	5	3	4	3	3	2	4	3	2	2
Erosion Hazard, Subsoil Erodibility		3	3	4	3	5	5	3	4	3	3	3	1
Soil Water Availability	**A**	3	2	3	3	3	3	3	3	3	3	3	3
	B	3	2	4	4	3	4	3	3	3	3	3	4
	C	4	3	5	5	4	5	4	4	4	4	4	5
Narrow Moisture Range		3	3	3	3	2	1	2	3	2	3	2	3
Surface Condition		4	3	3	3	2	2	3	4	3	4	1	3
Rockiness	**A**	1	1	1	1	1	1	2	1	1	1	1	1
	B	1	1	1	1	1	1	3	1	1	1	1	1
Microrelief		1	1	1	1	1	1	1	1	1	1	1	1
Wetness	**A**	1	1	5	4	2	4	1	5	2	5	1	1
	B	1	1	5	4	2	4	1	5	2	5	1	1
	C	2	2	5	4	2	4	2	5	2	5	2	2
Overall Suitability Rating		4	3	5	5	5	5	4	5	4	5	4	5

Key: green shading suitable
red shading unsuitable

Land suitability for dryland cropping on the Project is most limited by soil water availability, soil wetness, erosion, and surface condition. Plants require suitable quantities of water to reach optimum production, and therefore maximum rooting depth, with the ability of the soil to take in water (wetness) playing a large part in crop survival. Topsoil and subsoil erosion also limit the ability of the soil to support crops. Soil preparation for sowing in the form of tillage may increase the risk of soil dispersion through slaking caused by the manipulation of soil aggregates by machinery. Surface condition also limits the soil classes, with hard setting soils found across most SMUs. Surface condition directly impacts seedling emergence and establishment by reducing seed-soil contact.

In Central Queensland, Class 1, 2 and 3 lands for dryland cropping are required to have the capacity to store sufficient levels of moisture to sustain a crop cycle from planting to harvesting with minimal rainfall. Class 4 lands are considered marginal for dryland cropping, requiring significant levels of rainfall for crop success. Class 5 lands are unsuitable for dryland cropping due to severe limitations.

Examination of the land suitability limitations for dryland cropping (Table 61) indicates that 156.5 ha of the Project is suitable for cropping with moderate limitations (Class 3), and 409.1 ha of land is marginally suitable for cropping (Class 4). The remaining 5607 ha of land is unsuitable (Class 5) due to land and soil limitations.

Only the Barry SMU is classified as Class 3, presenting soil characteristics suitable for cropping with moderate limitations. Although listed above as Class 3, it is not genuinely expected that this landform would be suitable for dryland cropping on the Project site. This is due to its presence being limited to a narrow corridor along associated with Charlevue Creek.

SMUs Anderson, James, Namoi, and Normanby are listed as Class 4 and therefore marginally suitable for broadacre cropping. The major limitations for these SMUs are associated with soil water availability, erosion, wetness and surface condition.

SMUs Charlevue, Cooinda, Ellesmere, Geoffrey, Kosh, Nigel, and Wallace are classified as Class 5 land which is considered unsuitable for broadacre cropping. This is due to their vulnerability to subsoil erodibility, the soil water holding capacity, and the impact these limitations would have on potential crops.

Figure 8 shows the distribution of land suitability classes for broadacre cropping across the Project.

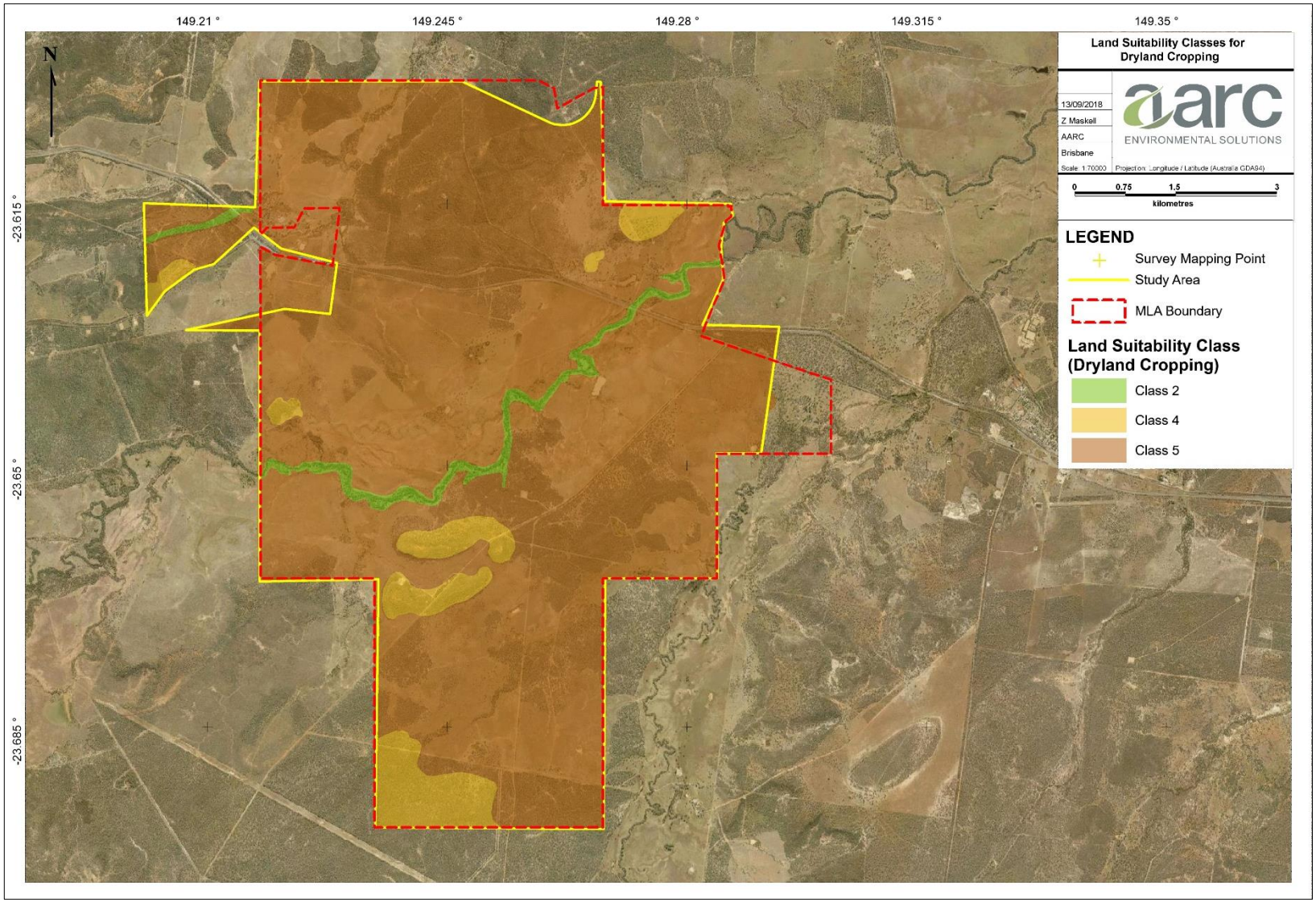


Figure 8 Dryland Cropping Land Suitability Classes

6.0 SOIL HANDLING RECOMMENDATIONS

6.1 TOPSOIL SUITABILITY AND STRIPPING

Useable soil resources are mainly confined to the surface horizons, with the upper part of the surface horizons containing seedstock, micro-organisms, and nutrients necessary for plant growth. Soil microbial activity, organic matter, and other parameters affecting soil fertility, generally decrease with depth. The following section lists a suitable topsoil stripping depth for each SMU and the maximum depth to which suitable subsoil material may be stripped for stockpiling and future rehabilitation. Stripping recommendations were determined based on SMU characteristics and the presence of inherent limitations (such as pH, salinity and sodicity).

Generally, stripping should be timed to occur in conjunction with favourable climatic conditions to reduce compaction and erosion issues. Stripping should generally occur in a single stage, however, where stripping depths exceed 0.30 m it is recommended that two-stage stripping methods are employed to reduce mixing between topsoil and subsoils. Where possible, topsoil will be directly placed in prepared rehabilitation areas and used immediately rather than stockpiled.

Table 62 summarises the maximum recommended depths to which each SMU should be stripped, a detailed discussion of each unit's stripping depth is outlined in the following sections.

Table 62 Maximum Topsoil Stripping Depths for all Soil Management Units

SMU	Topsoil Stripping Depth (m)	Maximum Subsoil Stripping Depth (m)
Anderson	0.0	0.0
Barry	0.2	0.9
Charlevue	0.0	0.0
Cooinda	0.3	0.6*
Ellesmere	0.0	0.0
Geoffrey	0.3	0.5*
James	0.3	0.6
Kosh	0.2	0.5*
Namoi	0.2	0.6*
Nigel	0.0	0.0
Normanby	0.3	0.9*
Wallace	Surface → C Horizon	-

Note: Stripping depths with as asterisk (*) may require nutrient supplements or soil ameliorants for successful use in rehabilitation.

Anderson Soil Management Unit **(Stripping Depth 0.0 m)**

The Anderson SMU is unsuitable for rehabilitation use. This soil is very strongly acid at the surface (pH 4.6) remaining so with depth, where it increases slightly to 4.8. pH values such as these would restrict plant growth and productivity, by reducing the availability of plant nutrients and causing root damage. The addition of lime would neutralise the acidic pH, though this SMU would require vast amounts to accommodate healthy plant growth. The cost of such an exercise would be high, and therefore this SMU is not recommended for use during rehabilitation.

Barry Soil Management Unit **(Stripping Depth 0.9 m)**

The Barry SMU presents no chemical limitations to stripping in the top 0.9 m of the profile. CEC is moderate to low throughout the profile, and exchangeable sodium is below critical values at all depths. The pH ranges from slightly acid to neutral, with Ca/Mg ratios >1.0 in all horizons (further reducing risk of dispersion). Although deficient in nitrate and sulphate (which could be applied as a fertiliser or foliar spray), this soil contains adequate concentrations of most macro and micronutrients. Organic matter is also above 2%. Overall, this SMU is considered a good soil resource for rehabilitation. It is however, associated with Charlevue Creek – a major waterway within the Project. Disturbance of this soil type should be avoided where possible, with the exception of required road crossings where erosion should be closely managed in the disturbed landform.

Charlevue Soil Management Unit **(Stripping Depth 0.0 m)**

The Charlevue SMU has severe chemical limitations that prevent it from becoming an adequate soil resource. pH for this unit is strongly acid in the topsoil (5.4), and though this increases to moderately alkaline with depth (7.9), mixing the horizons to make it usable would be a futile effort, due to the sodicity of the soil. The unit has strongly sodic soil at all depths, ranging from 15.1 to 29.4%. This paired with very low Ca/Mg ratios has resulted in a soil that is prone to dispersion, particularly below 0.2 m where the Emerson Class Number changes from 4, to 2, to 1. The evidence shows that the soil is in fact non-dispersive in the topsoil horizon, though this is where pH is most acidic (and therefore unusable).

The soil could be improved through the use of lime, which would increase the pH and replace some of the sodium with calcium (reducing ESP), but this would be a costly procedure. In addition to this, the unit is low in nutrients, and fertilisers would also need to be added to make it a viable soil resource. It is recommended that this soil should not be utilised in rehabilitation.

Cooinda Soil Management Unit **(Stripping Depth 0.6 m)**

The Cooinda SMU has some limitations in terms of its usability as a soil resource. The pH ranges from moderately acid in the surface soil (5.6 to 5.7) to neutral in the subsoil (6.8). Sodicity also changes from non-sodic (0.9 to 2.1%) in the topsoil, to sodic (10.9%) in the subsoil layer. The actual concentration of sodium in the subsoil layer is quite low (1.1%), though sodicity is presented as high due to the low CEC, giving an Emerson Class number of 3 (dispersive if disturbed) for all layers. Adequate mixing of the A and B horizons from 0.0 to 0.6 m could balance out these inconsistencies in pH and sodicity, creating a soil that is a better growth medium. In addition to this, nutrient levels for this SMU are particularly low. The addition of fertiliser would benefit this soil greatly. Any ameliorated soils should be tested for pH, sodicity, and nutrient content before use.

Ellesmere Soil Management Unit **(Stripping Depth 0.0 m)**

The Ellesmere SMU has severe chemical limitations in terms of pH, which ranges from very strongly acid in the surface soil (4.6) to strongly acid in the lower subsoil (5.5). pH levels such as these will

reduce the availability of some plant nutrients, and increase the toxicity of other elements to plants. This could be amended through the addition of liming agents, though the pH is so low that uneconomic quantities would be required to remediate the problem. In addition to this, nutrient levels are so low in this unit that the incorporation of fertilizers is not likely to be economically viable. This SMU should not be utilised as a soil resource in rehabilitation.

Geoffrey Soil Management Unit **(Stripping Depth 0.5 m)**

The Geoffrey SMU is the largest soil unit within the mapping area. Comprised of deep sands overlying sodic, dispersive clays (Emerson Class of 1), this soil is prone to erosion if subsoils are exposed. In addition to this, nutrient levels in the sandier horizons are somewhat limited in terms of their capacity to support plant life.

Topsoil stripping should aim to segregate the A and B horizons of this soil unit, which are easily distinguishable to trained operators. Where possible, stockpiling of the B horizon should be avoided (i.e. directly placed), or closely managed, due to the dispersive nature of the subsoil.

Due to the sandy nature of the A horizons, it is recommended that soil horizons in the natural landscape are restored during rehabilitation. The clay rich subsoils should be placed first on the rehabilitated landform, followed by the sandy A horizon over the top to recreate the A and B horizons. Placement of the subsoil layer is expected to retain soil moisture necessary for successful revegetation.

Furthermore, it is recommended that where possible this SMU is used in flatter areas of the final landform to limit potential erosion issues.

James Soil Management Unit **(Stripping Depth 0.6 m)**

This SMU presents no chemical limitations to stripping in the top 0.6 m of the profile. CEC is very low throughout the profile, and ESP is classified as non-sodic at all depths. The pH is slightly acid, though should not present a problem for plant establishment. Although the Ca/Mg ratio is >1.0 until 0.5 m, as the sodicity is so low, this should not enhance dispersion. As nutrient availability is quite limited, this SMU would benefit from the addition of fertilisers or foliar applications.

Kosh Soil Management Unit **(Stripping Depth 0.5 m)**

The Kosh SMU is one of the larger soil units in the study area, and given its size, the best unit for grazing cattle. It presents a challenge due to the ESP unit, which although non-sodic in the topsoil (0.6%), becomes strongly sodic (19.5%) and erosive in the subsoil horizon. Paired with a reduction in Ca/Mg ratios, the subsoil is likely to become highly dispersive at depth. If utilised in rehabilitation, care will need to be taken to ensure that only the top 0.5 m of soil is stripped for reuse. In addition to this, this SMU could benefit from the addition of fertilisers, particularly those containing NPK. The addition of organic matter (potentially sourced from mulched vegetation removed prior to stripping) would act in increasing the CEC and water holding capacity of the soil.

Left undisturbed, this SMU remains the best area for grazing cattle within the Project. It also presents a significant challenge in stripping, and removing soils. Where possible, it should be left undisturbed.

Namoi Soil Management Unit **(Stripping Depth 0.6 m)**

The Namoi SMU has chemical limitations related to soil pH, which fluctuates from slightly acid (6.1) to strongly acid (5.5) throughout the soil profile. However, it is non-dispersive, and therefore may benefit from mixing with other soil units and/or the addition of lime to reduce pH. Adding lime to this soil would

also assist in improving the Ca/Mg ratio of the soil, encouraging increased plant growth. Topsoil could also benefit from the addition of fertiliser.

Nigel Soil Management Unit **(Stripping Depth 0.0 m)**

The Nigel SMU is not recommended to be used in rehabilitation, due to severe limitations related to soil pH. The surface horizon is extremely acidic (4.4), becoming very strongly acidic with depth (4.6). Values such as these are likely to decrease the availability of nutrients to plants, and damage plant roots. Although pH may be amended using liming agents, the size of this unit paired with the cost of such a venture makes the use of lime unsuitable for this unit. The Nigel SMU also has low nutrient levels, and is not considered suitable for use in rehabilitation.

Normanby Soil Management Unit **(Stripping Depth 0.9 m)**

The Normanby SMU has no chemical limitations in terms of stripping and rehabilitation. pH in the surface soil is neutral, and although it becomes slightly acidic at 0.5 m depth, the subsoil is still considered within the suitable range for plant life. Salinity is not an issue in this soil, with EC and chloride values both exceedingly low. Dispersion is also not a likely risk in this SMU, which has non-sodic sandy loams extending to great depths in the profile. Nutrient content in this soil however, is generally low, and the soil may be augmented with fertilisers if used in rehabilitation. In addition to this, the high sand content in this soil means that rehabilitated surfaces should not exceed a 3% slope, to reduce the risk of slumping.

Wallace Soil Management Unit **(Stripping Depth Surface → C Horizon)**

The Wallace SMU is a high-quality soil with excellent potential as a topdressing medium. pH ranges from neutral (6.8) to slightly alkaline (7.4), salinity and sodicity are low, and exchangeable cations are within suitable limits for plant growth. Nutrient content is also quite robust, particularly the unit's NPK concentrations. The main limiting factor for this soil is the shallow depth, which was 0.2 m at the sampled location for this SMU. At this depth, the solum grades abruptly into pale grey parent material (C horizon). Identification of this demarcation is easy due to the stark contrast in colour between the black clay soil and the underlying parent material. As the depth to the C horizon may vary slightly across this unit, the stripping depth of 0.2 m may be an underestimate. Stripping depths are better defined within this SMU as the depth of media that exists above the C horizon, rather than a static depth.

The Wallace SMU would be an excellent resource to use when improving the quality of topsoil within other units, by mixing this material with others that may have limited nutrient/water holding capacity or nutrient content (such as those seen in the Geoffrey SMU).

6.2 TOPSOIL STOCKPILING

Stockpiling of topsoil for extended periods can lead to physiochemical changes in the soil and impact on the viability of the soil seed bank. Management recommendations to reduce the risk of soil degradation and improve the chances of rehabilitation success include the following:

- Where possible, topsoil should be directly placed in prepared rehabilitation areas rather than stockpiled. This will assist in maintaining a viable seedbank and will promote revegetation, thus, reducing potential for erosion;

- Topsoil should also be planted over as soon as possible after being placed in prepared rehabilitation areas. This will assist in preventing erosion of the topsoil, and making the best use of the soil's available nutrients;

- If soil is stored, stockpiles should generally be less than 2 m high and be contoured and positioned to encourage water to drain, and discourage erosion;

- If the stockpiles require grass cover, they will need to be ripped and seeded with a quick establishment pasture, to limit erosion, and maintain a viable seed bank. This should be done if the period of stockpiling is greater than one growing season or six months. Topsoil should ideally be stockpiled for the minimum time, with studies in the Hunter Valley having shown that the majority of deterioration occurs in the first year (Keipert et al. 2005). Establishment of weeds on the stockpiles will also need to be monitored and controlled;

- Where soil has been stockpiled for extended periods, soil testing is recommended. If required, fertilizers, soil ameliorants, and seeding is recommended.

Table 63 shows the estimated volumes of soil per SMU for the whole Project area, given the stripping depths outlined in section 6.1, and areas listed in section 4.0.

Table 63 Estimated Soil Volumes

SMU	Topsoil Stripping Depth (m)	Maximum Subsoil Stripping Depth (m)	SMU Area (m^2)	Potential Topsoil Volume (m^3)	Potential Subsoil Volume (m^3)
Anderson	0.0	0.0	377,800	0	0
Barry	0.2	0.9	1,565,000	313,000	1,095,500
Charlevue	0.0	0.0	2,329,000	0	0
Cooinda	0.3	0.6	349,400	104,820	104,820
Ellesmere	0.0	0.0	145,900	0	0
Geoffrey	0.3	0.5	40,790,000	12,237,000	8,158,000
James	0.3	0.6	1,452,000	435,600	435,600
Kosh	0.2	0.5	9,276,480	1,855,296	2,782,944
Namoi	0.2	0.6	1,758,000	351,600	703,200
Nigel	0.0	0.0	2,864,180	0	0
Normanby	0.3	0.9	484,960	145,488	290,976
Wallace	Minimum 0.2 (Surface → C Horizon)	-	320,400	64,080	-

Key: m^2 metres squared
M^3 metres cubed

6.3 TOPSOIL PLACEMENT

Where possible, placement of topsoil at a thickness of approximately 0.3 m is recommended across the rehabilitated area to create a growth medium of sufficient depth to hold water and support revegetation. If available, subsoils that have been identified as having a high clay content with low erosivity risk can be returned first at a depth of up to 0.5 m, prior to the addition of sandier topsoil. This may assist in providing a more suitable growth medium that holds water for long periods of time.

It is recommended that topsoil is deep ripped, into the underlying spoil surface, to encourage surface water infiltration and minimise soil loss due to erosions. On slopes of spoil dumps, ripping should be undertaken along the contour.

For the Geoffrey SMU, it is recommended that soil horizons in the natural landscape are restored during rehabilitation. The clay rich subsoils should be placed first on the rehabilitated landform, followed by the sandy A horizon over the top to recreate the A and B horizons. Placement of the subsoil layer is expected to retain soil moisture necessary for successful revegetation.

Grass and woody vegetation remaining after land clearing can be incorporated into the rehabilitation design at strategic locations to help limit runoff/erosion (by slowing down overland flow), retain active biological activity, and provide habitat for returning fauna. Additionally, mulched organic material incorporated into the soil (particularly the topsoil) will increase organic carbon levels over time, further stabilising the soil and landscape.

7.0 POTENTIAL IMPACTS AND MANAGEMENT

7.1 LAND SUITABILITY

The development of the Project will disturb land through the construction of infrastructure and operation of the mine. This disturbance will impact the land suitability of the Project throughout the life of the mine and after its closure. Pre-mining land suitability classes were outlined in Section 5.0 and are summarised below in Table 64.

Table 64 Summary of the Size and Suitability Classes for all SMUs

SMU	Land Suitability Class (Grazing)	Land Suitability Class (Cropping)	Total Area (ha)
Anderson	4	4	37.8
Barry	2	3	156.5
Charlevue	4	5	232.9
Cooinda	3	5	34.9
Ellesmere	3	5	14.6
Geoffrey	3	5	4,079
James	4	4	145.2
Kosh	2	5	927.6
Namoi	3	4	177.6
Nigel	4	5	286.4
Normanby	4	4	48.5
Wallace	3	5	32

Key: green shading suitable
red unsuitable

The majority of areas in the final landform will aim to restore a post-mining land use of grazing. The exceptions being water management features such as ponds and drains, which will be returned to a land use of native ecosystems or equivalent. This includes the final pit lake and high walls, that will be restored to achieve a fauna habitat land use. These areas are expected to be unsuitable for grazing and will achieve a reduced land suitability score of 5.

It should be noted that mining activities, including the stripping, stockpiling, handling, and compaction of soil, have the potential to impact its physical, chemical and biological properties. Therefore, the pre-mining land suitability for cattle grazing may be reduced for some rehabilitated landforms. Many of the potential impacts on soil can be mitigated through:

- Good topsoil management practices (See Section 6.0);
- The addition of fertilizers and soil ameliorants; and
- Timely seeding with suitable species.

Where the final landforms represent a relatively flat landscape (e.g. slopes less than 5%) it is envisaged that the post-mining land suitability for cattle grazing will generally reflect that of the pre-mining landscape.

Other areas, such as steeper outer slopes of spoil (e.g. slopes of greater than 10%) may be subject to erosion and as such may be less suited to cattle grazing than the pre-mining landscape. A reduced land suitability score is expected on these landforms.

Landform depressions that perennially hold surface water are expected on the rehabilitated spoil dump. These can act as dams for cattle grazing and can assist in trapping water within the surrounding growth medium. These areas typically do not support pasture species, with wetland flora usually established. As such, a reduction in land suitability for cattle grazing is also expected in these surface depressions.

7.2 EROSION

Disturbance of vegetation and the topsoil layer can lead to the mobilisation of soil through the process of erosion, particularly water erosion through heavy rainfall or overland flow. The risk of erosion at the Project will be increased by the following activities:

- Clearing of vegetation;
- Topsoil stripping and stockpiling;
- Construction of infrastructure; and
- Exposure of slopes.

Management recommendations to reduce the risk and impacts of erosion include:

- Limiting land clearing to the minimum amount of land required for safe operation of the Project;
- Diversion of overland flow/runoff around disturbed areas;
- Progressive rehabilitation of landforms and direct placement of topsoil to help preserve the seed bank and reduce erosion;
- Seeding of topsoil as soon as possible after placement onto rehabilitated areas, to ensure root masses assist in preventing erosion;
- Topsoil stockpiles should be placed away from drainage areas, roads, machinery, transport corridors, and stock grazing areas;
- Topsoil stockpiles should be seeded or covered with a water-shedding lining to prevent unnecessary erosion of soil; and
- The use of sediment control structures such as retention ponds, to minimise the release of water and suspended sediments into the receiving environment.

7.3 EROSION OF REHABILITED LANDFORMS

Erosion of rehabilitated landforms reduces the likelihood of revegetation success, and in extreme cases can compromise the structural integrity of the landform, making it unstable and unsafe. In addition, if not managed correctly, erosion can result in the release of suspended sediments and potential contaminants into the receiving environment.

SMUs within the Project have some dispersive characteristics, and will be potentially subject to erosion, particularly on artificial slopes. The rehabilitated landform design for the Project should consider implementing controls to manage surface runoff on final landform slopes. Such controls include:

- Limiting side slopes of spoil to a maximum slope of 1V:6H (vertical : horizontal) (approximately 16%) or less;
- Construction of contour banks on slopes at a recommended spacing of 80 m for slopes of 1V:6H (MCA 1998). Larger contour drains are generally more stable and longer lasting. It is recommended that drains/berms are a minimum of 5 m wide and a minimum of 500 mm in height. However, construction of larger contours is encouraged. Berms should be constructed of compacted material (IE Aust Erosion and Sediment Control Guidelines(Witheridge et al. 1996));
- Contour banks should convey water to engineered rock-lined spine drains on steep slopes. The size of the rock used should be approximately 300 to 450 mm in diameter. A competent basalt or alternative rock source is recommended. The use of geofabric in construction of rock lined spine drains is also recommended;
- To reduce the need for engineered drains, landform modelling should be centred around gentle concave slopes or terraced profiles. For some materials, designs such as these can significantly reduce runoff velocity and erosion by a magnitude of two or three times, however, the approach can be difficult to implement where space is a limiting factor;
- The incorporation of rock into the topsoil medium can also assist in reducing erodibility, as well as increasing infiltration (Alt et al. 2009); and
- Rehabilitated areas should be ripped to reduce compaction from heavy machinery, encourage infiltration of water and prevent erosion. If engineered waterways are included in the landform, areas should be ripped on a grade (e.g. 0.5%). Otherwise, areas should be ripped on the contour. Ripping depths will vary depending on the type of spoil material, depth of topsoil and equipment used for rehabilitation operations. Typical ripping depths would be 500 to1000 mm.

7.4 SOIL DEGRADATION

Stripping, stockpiling and handling of topsoil can potentially have a negative impact on the chemical and physical attributes of the soil. Specifically, the following impacts may occur as a result of mining activities:

- Exposure of saline or sodic subsoils during soil stripping;
- Loss of soil physical structure due to excavation and handling;
- Loss of the soil seedbank; and
- Impacts on soil fertility due to mixing with subsoils, or resulting from changes in chemistry when subsoils are exposed to oxygen.

Physiochemical changes to the soil may impact on the viability of the soil seed bank and reduce the likelihood of successful rehabilitation if not well managed. Management recommendations to reduce the risk of soil degradation and improve the chances of rehabilitation success include:

- Segregation of saline or sodic soils and clear demarcation of stockpiles to ensure appropriate use of the resource;

- Minimising the handling of topsoil;

- Ensuring that when required, stockpiles are generally less than 2 m high and contoured to encourage water to drain; and

- Carrying out routine testing of soil properties prior to use in rehabilitation. If required, fertilizers, soil ameliorants, and application of a seed mix is recommended to increase the likelihood of rehabilitation success.

8.0 REFERENCES

Alt S, Jenkins A & Lines-Kelly R, New South Wales Department of Primary Industries, (2009) *Saving Soil – A landholder's guide to preventing and repairing soil erosion*, Northern Rivers Catchment Management Authority.

Brooks JD & Smith JW (1969) *The diagenesis of plant lipids during the formation of coal, petroleum and natural gas—II, Coalification and the formation of oil and gas in the Gippsland Basin*, Geochimica et Cosmochimica Acta, 33(10), pp. 1183-1194.

Bureau of Meteorology (BoM) (2018) *Queensland River Basins*, Available from: http://www.bom.gov.au/qld/flood/brochures/qld/map.pdf

Bureau of Rural Science (BRS) (1991) *Digital Atlas of Australian Soils*, Department of Agriculture and Fisheries, Queensland Government, Brisbane. Available from: <http://www.asris.csiro.au/themes/Atlas.html#Atlas_Digital> accessed August 2018.

Connolly EL & Guerinot ML (2002) *Iron stress in plants*, Genome Biology, 3(8), reviews1024,1–reviews1024.4.

Department of Environment and Science (DES) (2018) *Fitzroy Drainage Basin – Facts and Maps*, Department of Environment and Science , Queensland Government, Brisbane. Available from: <https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/basin-fitzroy/ > accessed August 2018.

Department of Minerals and Energy (DME) (1995) *Technical Guidelines for Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques*, Department of Natural Resources, Mines and Energy, Queensland Government. Brisbane.

Department of Primary Industries (DPI), Thwaites RN & Maher JM (eds.) (1993) *Understanding and Managing Soils in the Central Highlands*, Department of Primary Industries Training Series, Department of Agriculture and Fisheries, Queensland Government, Brisbane.

Department of Science, Information Technology and Innovation (DSITI) & Department of Natural Resources and Mines (DNRM) (2015) *Guidelines for Agricultural Land Evaluation in Queensland* (2nd edition), Department of Science, Information Technology, Innovation and Arts & Department of Natural Resources, Mines and Energy, Queensland Government, Brisbane.

Department of Science, Information Technology and Innovation (DSITI) & Department of Natural Resources and Mines (DNRM) (2013), *Regional Land Suitability Frameworks for Queensland*. Queensland Government (Department of Science, Information Technology and Innovation and Department of Natural Resources and Mines), Brisbane Queensland. Chapter 10 – Suitability Framework for the Inland Fitzroy and Southern Burdekin area.

Dickins JM & Malone EJ (1973) *Geology of the Bowen Basin, Queensland. Bureau of Mineral Resources, Geology and Geophysics Bulletin No. 130,* Australian Government Publishing Service, Canberra.

Geoscience Australia (2018) *Province and Sedimentary Basin Geology - Bowen Basin*, Geoscience Australia. Available from: <http://www.ga.gov.au/scientific-topics/energy/province-sedimentary-basin-geology/petroleum/onshore-australia/bowen-basin> accessed August 2018.

Hazelton P & Murphy B (2016) *Interpreting Soil Test Results – What do all the Numbers Mean? Third Edition.* CSIRO Publishing, Melbourne.

Hutton AC (2009) *Geological Setting of Australasian Coal Deposits,* Australasian Coal Mining Practice (pp. 40-84).

Isbell RF (1996) (eds. 2002) *The Australian Soil Classification,* Australian Soil and Land Survey Handbook Series, CSIRO Publishing, Melbourne.

Isbell RF (1996) (eds. 2016) *The Australian Soil Classification,* Australian Soil and Land Survey Handbook Series, CSIRO Publishing, Melbourne.

Kabata-Pendias A & Pendias H (2001) *Trace Elements in Soils and Plants (3rd Edition) CRC Press*, New York.

Keipert NL (2005), *Effect of Different Stockpiling Procedures on Topsoil Characteristics in Open Cut Coal Mine Rehabilitation in the Hunter Valley, New South Wales* ,Coal Mines and Mining, University of New England.

McKenzie NJ, Grundy MJ, Webster R & Ringrose-Voase (2008) *Guidelines for Surveying Soil and Land Resources,* Australian Soil and Land Survey Handbook Series, CSIRO Publishing, Melbourne.

Minerals Council of Australia (MCA) (1998), *Back from the Brink: Reshaping Minerals Tertiary Education*, Minerals Council of Australia, Canberra.

Mutton AJ (2003) *Queensland Coals - Physical and Chemical Properties, Colliery and Company Information*, Department of Natural Resources, Mines and Energy, Queensland Government, Brisbane. Available from: <https://www.dnrm.qld.gov.au/?a=267497> accessed August 2018.

National Committee on Soil and Terrain (NCST) (2009) *Australian Soil and Land Survey Field Handbook*, Third Edition, Australian Soil and Land Survey Handbook Series, CSIRO Publishing, Melbourne.

Rayment GE & Lyons D (2011) *Soil Chemical Methods – Australasia*, Australian Soil and Land Survey Handbook Series, CSIRO Publishing, Melbourne.

Smith KA, Ball T, Conen F, Dobbie KE, Massheder A & Rey A (2018) *Exchange of greenhouse gases between soil and atmosphere: interactions of soil physical factors and biological processes*, European Journal of Soil Science, 69(1), pp. 10-20.

Speck NH, Wright RL, Sweeny FC, Perry RA, Fitzpatrick EA, Nix HA, Gunn RH & Wilson IB (1967), *Lands of the Dawson-Fitzroy Area,* Queensland. Land Research Series No 21, CSIRO, Melbourne.

Witheridge, Grant & Walker, Robert & Institution of Engineers, Australia, Queensland Division (1996), *Soil erosion and sediment control : engineering guidelines for Queensland construction sites,* Institution of Engineers, Queensland Division, Brisbane, Qld

Withnall IW & Cranfield LC (2012) *Queensland Geological framework,* Department of Natural Resources, Mines and Energy, Queensland Government, Brisbane. Available from <https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0007/197647/geology-of-queensland.pdf> accessed August 2018.

Withnall IW (1989) *Precambrian and Palaeozoic geology of the south eastern Georgetown Inlier, north Queensland*, Queensland Department of Mines, Report 2, pp. 102, Department of Natural Resources, Mines and Energy, Queensland Government, Brisbane.

Appendix A Lab Results

		DP1				DP2			DP3			DP4	
		DP1: 0-10	DP1: 20-30	DP1: 50-60	DP1: 80-90	DP2: 0-10	DP2: 20-30	DP2: 50-60	DP3: 0-10	DP3: 20-30	DP3: 50-60	DP4: 0-10	DP4: 20-30
Analyte grouping/Analyte	**Unit**												
EA002: pH 1:5 (Soils)													
pH Value	pH Unit	**5.8**	**5.6**	**6.0**	**8.1**	**5.6**	**5.7**	**6.8**	**5.7**	**5.5**	**6.1**	**6.8**	**7.4**
EA010: Conductivity													
Electrical Conductivity @ 25°C	µS/cm	**26**	**6**	**4**	**137**	**15**	**13**	**43**	**11**	**8**	**7**	**90**	**38**
EA055: Moisture Content (Dried @ 105-110°C)													
Moisture Content	%	**2.7**	**0.8**	**0.8**	**9.0**	**4.2**	**6.0**	**10.0**	**2.8**	**3.2**	**6.6**	**5.4**	**13.8**
EA058: Emerson Aggregate Test													
Color (Munsell)		**Dark Brown**	**Brown**	**Brown**	**Yellowish Brown**	**Dark Brown**	**Brown**	**Yellowish Brown**	**Dark Brown**	**Dark Brown**	**Yellowish Red**	**Very Dark Brown**	**Dark Brown**
Texture		**Loamy Sand**	**Loam**	**Sandy Clay Loam**	**Sandy Clay Loam**	**Sandy Clay Loam**	**Sandy Loam**	**Sandy Clay**	**Sandy Clay Loam**	**Sandy Clay Loam**	**Sandy Clay Loam**	**Sandy Clay Loam**	**Sandy Clay Loam**
Emerson Class Number		**4**	**4**	**4**	**1**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**4**
EA150: Soil Classification - National Committee on Soil and Terrain (2009)													
Silt (2-20 µm)	%	**9**	**----**	**----**	**----**	**20**	**----**	**----**	**11**	**----**	**----**	**39**	**----**
Fine Sand (0.02-0.2 mm)	%	**44**	**----**	**----**	**----**	**25**	**----**	**----**	**32**	**----**	**----**	**18**	**----**
Coarse Sand (0.2-2.0 mm)	%	**31**	**----**	**----**	**----**	**23**	**----**	**----**	**30**	**----**	**----**	**6**	**----**
ED006: Exchangeable Cations on Alkaline Soils													
Exchangeable Calcium	meq/100g	**0.7**	**0.2**	**0.1**	**0.9**	**1.9**	**1.5**	**1.9**	**1.0**	**0.8**	**0.7**	**18.7**	**27.3**
Exchangeable Magnesium	meq/100g	**0.7**	**0.2**	**0.2**	**5.9**	**2.0**	**2.6**	**6.7**	**0.6**	**0.8**	**2.1**	**18.3**	**16.1**
Exchangeable Potassium	meq/100g	**0.3**	**0.2**	<0.1	<0.2	**0.4**	**0.2**	**0.1**	**0.2**	<0.1	<0.1	**1.8**	**0.3**
Exchangeable Sodium	meq/100g	<0.1	<0.1	<0.1	**2.0**	<0.1	<0.1	**1.1**	<0.1	<0.1	**0.1**	**0.1**	**0.3**
Cation Exchange Capacity	meq/100g	**1.7**	**0.8**	**0.4**	**8.8**	**4.4**	**4.6**	**9.8**	**2.0**	**1.9**	**3.0**	**39.0**	**44.0**
Exchangeable Sodium Percent	%	**1.0**	**1.8**	**8.2**	**22.1**	**0.9**	**2.1**	**10.9**	**0.6**	**1.8**	**4.1**	**0.3**	**0.6**
Calcium/Magnesium Ratio		**1.0**	**1.0**	**0.5**	<0.2	**1.0**	**0.6**	**0.3**	**1.7**	**1.0**	**0.3**	**1.0**	**1.7**
Magnesium/Potassium Ratio		**1.9**	**1.4**	**----**	**----**	**5.0**	**17.0**	**52.0**	**2.8**	**----**	**----**	**9.9**	**52.8**
ED021: Bicarbonate Extractable Potassium (Colwell)													

Bicarbonate Extractable K (Colwell)	mg/kg	<200	----	----	----	<200	----	----	<200	----	----	**652**	----
ED040S : Soluble Sulfate by ICPAES													
Sulfate as SO4 2-	mg/kg	<10	----	----	----	<10	----	----	<10	----	----	**10**	----
Sulfur as S	mg/kg	<10	----	----	----	<10	----	----	<10	----	----	<10	----
Silica	mg/kg	**48**	----	----	----	**68**	----	----	**44**	----	----	**165**	----
ED045G: Chloride by Discrete Analyser													
Chloride	mg/kg	**20**	<10	<10	**110**	<10	**10**	**40**	<10	<10	<10	**30**	**10**
ED091 : Calcium Chloride Extractable Boron													
Boron	mg/kg	**0.2**	----	----	----	**0.4**	----	----	**0.2**	----	----	**0.5**	----
ED092: DTPA Extractable Metals													
Copper	mg/kg	<1.00	----	----	----	<1.00	----	----	<1.00	----	----	**1.61**	----
Iron	mg/kg	**166**	----	----	----	**76.9**	----	----	**86.3**	----	----	**63.4**	----
Manganese	mg/kg	**16.0**	----	----	----	**61.6**	----	----	**43.7**	----	----	**53.4**	----
Zinc	mg/kg	**2.16**	----	----	----	**1.82**	----	----	**2.09**	----	----	**1.02**	----
EK057G: Nitrite as N by Discrete Analyser													
Nitrite as N (Sol.)	mg/kg	<0.1	----	----	----	**0.2**	----	----	<0.1	----	----	**0.8**	----
EK058G: Nitrate as N by Discrete Analyser													
Nitrate as N (Sol.)	mg/kg	**3.0**	----	----	----	**1.2**	----	----	**1.7**	----	----	**6.6**	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser													
Nitrite + Nitrate as N (Sol.)	mg/kg	**3.0**	----	----	----	**1.4**	----	----	**1.7**	----	----	**7.4**	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)													
Bicarbonate Ext. P (Colwell)	mg/kg	**8**	**6**	**8**	**6**	**15**	**6**	**6**	**7**	**6**	**7**	**169**	**47**
EP004: Organic Matter													
Organic Matter	%	**1.8**	**2.2**	**0.8**	**0.6**	**1.0**	**1.0**	**1.0**	**0.8**	**0.6**	**0.9**	**4.1**	**1.7**
Total Organic Carbon	%	**1.0**	**1.2**	<0.5	<0.5	**0.6**	**0.6**	**0.6**	<0.5	<0.5	<0.5	**2.4**	**1.0**

		DP6			DP7			DP14				DP17		
		DP6: 0-10	DP6: 20-30	DP6: 50-60	DP7: 0-10	DP7: 20-30	DP7: 50-60	DP14: 0-10	DP14: 20-30	DP14: 50-60	DP14: 80-90	DP17: 0-10	DP17: 20-30	DP17: 50-60
Analyte grouping/Analyte	**Unit**													
EA002: pH 1:5 (Soils)														
pH Value	pH Unit	**5.4**	**6.4**	**7.9**	**5.5**	**6.0**	**7.8**	**6.5**	**6.8**	**6.9**	**7.2**	**6.2**	**6.1**	**6.4**
EA010: Conductivity														
Electrical Conductivity @ 25°C	µS/cm	**280**	**431**	**458**	**6**	**10**	**193**	**63**	**12**	**10**	**12**	**13**	**6**	**15**
EA055: Moisture Content (Dried @ 105-110°C)														
Moisture Content	%	**9.1**	**11.8**	**10.7**	**2.0**	**1.2**	**9.2**	**2.3**	**5.1**	**4.3**	**7.2**	**1.5**	**7.0**	**10.2**
EA058: Emerson Aggregate Test														
Color (Munsell)		**Yellowish Brown**	**Dark Yellowish Brown**	**Olive Brown**	**Brown**	**Brown**	**Dark Yellowish Brown**	**Dark Brown**	**Dark Brown**	**Dark Brown**	**Dark Brown**	**Dark Brown**	**Dark Reddish Brown**	**Dark Red**
Texture		**Sandy Clay Loam**	**Clay Loam**	**Sandy Clay**	**Sandy Clay Loam**	**Sandy Clay Loam**	**Sandy Clay**	**Sandy Clay**	**Sandy Clay**	**Sandy Clay**	**Sandy Clay**	**Gravelly Sand**	**Sandy Clay**	**Sandy Clay**
Emerson Class Number		**4**	**2**	**1**	**4**	**3**	**2**	**3**	**4**	**3**	**3**	**8**	**3**	**4**
EA150: Soil Classification - National Committee on Soil and Terrain (2009)														
Silt (2-20 µm)	%	**5**	**----**	**----**	**17**	**----**	**----**	**24**	**----**	**----**	**----**	**9**	**----**	**----**
Fine Sand (0.02-0.2 mm)	%	**48**	**----**	**----**	**32**	**----**	**----**	**37**	**----**	**----**	**----**	**35**	**----**	**----**
Coarse Sand (0.2-2.0 mm)	%	**23**	**----**	**----**	**28**	**----**	**----**	**20**	**----**	**----**	**----**	**24**	**----**	**----**
ED006: Exchangeable Cations on Alkaline Soils														
Exchangeable Calcium	meq/100g	**1.7**	**3.2**	**2.7**	**0.3**	<0.1	**0.8**	**6.4**	**6.1**	**5.5**	**10.0**	**2.0**	**3.1**	**2.4**
Exchangeable Magnesium	meq/100g	**3.1**	**6.4**	**6.5**	**0.4**	**0.7**	**6.8**	**5.2**	**4.9**	**4.6**	**7.5**	**1.8**	**2.4**	**3.2**
Exchangeable Potassium	meq/100g	**0.1**	<0.1	<0.2	**0.1**	<0.1	<0.2	**0.9**	**0.2**	**0.2**	**0.3**	**0.4**	**0.3**	<0.1
Exchangeable Sodium	meq/100g	**1.2**	**1.7**	**3.8**	<0.1	**0.2**	**2.9**	<0.1	<0.1	<0.1	**0.2**	<0.1	<0.1	<0.1
Cation Exchange Capacity	meq/100g	**6.3**	**15.1**	**13.1**	**1.3**	**1.2**	**10.4**	**12.5**	**11.3**	**10.4**	**18.0**	**4.3**	**5.9**	**5.8**
Exchangeable Sodium Percent	%	**19.8**	**0.5**	**29.4**	**4.3**	**21.0**	**27.5**	**0.3**	**0.5**	**0.7**	**1.0**	**0.4**	**0.7**	**1.4**
Calcium/Magnesium Ratio		**0.5**	**11.4**	**0.4**	**0.8**	<0.1	<0.2	**1.2**	**1.2**	**1.2**	**1.3**	**1.1**	**1.3**	**0.8**
Magnesium/Potassium Ratio		**27.9**	**----**	**----**	**3.4**	**----**	**----**	**5.7**	**20.4**	**25.6**	**24.8**	**5.0**	**8.2**	**----**
ED021: Bicarbonate Extractable Potassium (Colwell)														

Bicarbonate Extractable K (Colwell)	mg/kg	<200	----	----	<200	----	----	**596**	----	----	----	<200	----	----
ED040S : Soluble Sulfate by ICPAES														
Sulfate as SO4 2-	mg/kg	**20**	----	----	<10	----	----	<10	----	----	----	<10	----	----
Sulfur as S	mg/kg	<10	----	----	<10	----	----	<10	----	----	----	<10	----	----
Silica	mg/kg	**299**	----	----	**248**	----	----	**77**	----	----	----	**118**	----	----
ED045G: Chloride by Discrete Analyser														
Chloride	mg/kg	**420**	**680**	**630**	<10	**10**	**200**	**20**	<10	<10	<10	<10	<10	<10
ED091 : Calcium Chloride Extractable Boron														
Boron	mg/kg	**0.8**	----	----	<0.2	----	----	**0.4**	----	----	----	**0.3**	----	----
ED092: DTPA Extractable Metals														
Copper	mg/kg	<1.00	----	----	<1.00	----	----	<1.00	----	----	----	<1.00	----	----
Iron	mg/kg	**29.7**	----	----	**21.7**	----	----	**53.4**	----	----	----	**21.4**	----	----
Manganese	mg/kg	**5.45**	----	----	**9.15**	----	----	**37.2**	----	----	----	**18.7**	----	----
Zinc	mg/kg	<1.00	----	----	**2.23**	----	----	**2.88**	----	----	----	<1.00	----	----
EK057G: Nitrite as N by Discrete Analyser														
Nitrite as N (Sol.)	mg/kg	<0.1	----	----	<0.1	----	----	**0.4**	----	----	----	**0.1**	----	----
EK058G: Nitrate as N by Discrete Analyser														
Nitrate as N (Sol.)	mg/kg	**0.4**	----	----	**0.7**	----	----	**1.7**	----	----	----	**1.1**	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser														
Nitrite + Nitrate as N (Sol.)	mg/kg	**0.4**	----	----	**0.7**	----	----	**2.1**	----	----	----	**1.2**	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)														
Bicarbonate Ext. P (Colwell)	mg/kg	**12**	<5	**11**	**15**	**5**	**6**	**64**	**12**	**19**	**27**	**14**	**7**	**8**
EP004: Organic Matter														
Organic Matter	%	**1.0**	**1.3**	**1.1**	<0.5	**0.5**	<0.5	**3.3**	**3.0**	**2.9**	**2.8**	**2.8**	**2.2**	**2.6**
Total Organic Carbon	%	**0.6**	**0.7**	**0.6**	<0.5	<0.5	<0.5	**1.9**	**1.7**	**1.7**	**1.6**	**1.6**	**1.3**	**1.5**

		DP26			DP34			DP40				DP50		
		DP26: 0-10	DP26: 20-30	DP26: 50-60	DP34: 0-10	DP34: 20-30	DP34: 50-60	DP40: 0-10	DP40: 20-30	DP40: 50-60	DP40: 80-90	DP50: 0-10	DP50: 20-30	DP50: 50-60
Analyte grouping/Analyte	**Unit**													
EA002: pH 1:5 (Soils)														
pH Value	pH Unit	**4.6**	**4.7**	**4.8**	**6.3**	**7.7**	**8.5**	**4.6**	**4.6**	**5.1**	**5.5**	**6.7**	**6.6**	**6.1**
EA010: Conductivity														
Electrical Conductivity @ 25°C	µS/cm	**64**	**28**	**20**	**36**	**83**	**415**	**20**	**11**	**17**	**26**	**36**	**6**	**3**
EA055: Moisture Content (Dried @ 105-110°C)														
Moisture Content	%	**1.0**	**4.3**	**8.2**	**2.8**	**7.1**	**9.0**	**1.4**	**3.4**	**11.8**	**10.0**	**6.1**	**1.7**	**1.5**
EA058: Emerson Aggregate Test														
Color (Munsell)		**Very Dark Greyish Brown**	**Brown**	**Yellowish Red**	**Very Dark Greyish Brown**	**Dark Yellowish Brown**	**Dark Yellowish Brown**	**Very Dark Greyish Brown**	**Brown**	**Dark Red**	**Red**	**Dark Reddish Brown**	**Yellowish Red**	**Yellowish Red**
Texture		**Sandy Loam**	**Sandy Clay Loam**	**Sandy Clay**	**Sandy Clay Loam**	**Sandy Clay**	**Sandy Clay**	**Sandy Loam**	**Sandy Clay Loam**	**Sandy Clay**	**Sandy Clay**	**Sandy Loam**	**Loamy Sand**	**Sandy Loam**
Emerson Class Number		**3**	**4**	**4**	**4**	**2**	**2**	**3**	**3**	**4**	**4**	**4**	**4**	**4**
EA150: Soil Classification - National Committee on Soil and Terrain (2009)														
Silt (2-20 µm)	%	**7**	**----**	**----**	**16**	**----**	**----**	**9**	**----**	**----**	**----**	**3**	**----**	**----**
Fine Sand (0.02-0.2 mm)	%	**27**	**----**	**----**	**28**	**----**	**----**	**40**	**----**	**----**	**----**	**25**	**----**	**----**
Coarse Sand (0.2-2.0 mm)	%	**36**	**----**	**----**	**34**	**----**	**----**	**30**	**----**	**----**	**----**	**63**	**----**	**----**
ED006: Exchangeable Cations on Alkaline Soils														
Exchangeable Calcium	meq/100g	**0.7**	**0.4**	**0.2**	**4.4**	**4.4**	**4.1**	**0.4**	<0.1	<0.1	<0.1	**1.3**	**1.4**	**0.9**
Exchangeable Magnesium	meq/100g	**0.2**	**0.2**	**1.0**	**1.7**	**6.9**	**9.7**	**0.2**	**0.2**	**1.7**	**3.4**	**0.6**	**0.4**	**0.5**
Exchangeable Potassium	meq/100g	**0.4**	**0.2**	<0.1	**0.6**	**0.2**	<0.2	**0.2**	**0.1**	**0.1**	**0.1**	**0.4**	**0.3**	<0.1
Exchangeable Sodium	meq/100g	<0.1	<0.1	<0.1	<0.1	**1.8**	**3.4**	<0.1	<0.1	**0.2**	**0.6**	<0.1	<0.1	<0.1
Cation Exchange Capacity	meq/100g	**2.7**	**2.8**	**4.2**	**6.8**	**13.3**	**17.4**	**2.3**	**2.2**	**5.7**	**6.9**	**2.4**	**2.1**	**1.6**
Exchangeable Sodium Percent	%	**3.7**	**2.6**	**4.5**	**0.6**	**13.2**	**19.5**	<0.1	**6.4**	**10.5**	**13.8**	<0.1	<0.1	<0.1
Calcium/Magnesium Ratio		**3.5**	**2.0**	**0.2**	**2.6**	**0.6**	**0.4**	**2.0**	<0.1	<0.1	<0.1	**2.2**	**3.5**	**1.8**
Magnesium/Potassium Ratio		**0.5**	**1.4**	**----**	**2.7**	**33.5**	**----**	**0.9**	**1.7**	**12.6**	**27.5**	**1.4**	**1.4**	**----**
ED021: Bicarbonate Extractable Potassium (Colwell)														

Bicarbonate Extractable K (Colwell)	mg/kg	<200	----	----	<200	----	----	**532**	----	----	----	**275**	----	----
ED040S : Soluble Sulfate by ICPAES														
Sulfate as SO4 2-	mg/kg	**20**	----	----	<10	----	----	<10	----	----	----	<10	----	----
Sulfur as S	mg/kg	<10	----	----	<10	----	----	<10	----	----	----	<10	----	----
Silica	mg/kg	**50**	----	----	**413**	----	----	**77**	----	----	----	**66**	----	----
ED045G: Chloride by Discrete Analyser														
Chloride	mg/kg	**30**	**10**	**10**	<10	**60**	**490**	<10	<10	<10	<10	<10	<10	<10
ED091 : Calcium Chloride Extractable Boron														
Boron	mg/kg	**0.6**	----	----	**0.4**	----	----	**0.4**	----	----	----	<0.2	----	----
ED092: DTPA Extractable Metals														
Copper	mg/kg	<1.00	----	----	<1.00	----	----	<1.00	----	----	----	<1.00	----	----
Iron	mg/kg	**296**	----	----	**32.4**	----	----	**327**	----	----	----	**29.1**	----	----
Manganese	mg/kg	**5.46**	----	----	**17.5**	----	----	**3.13**	----	----	----	**13.0**	----	----
Zinc	mg/kg	<1.00	----	----	**1.20**	----	----	<1.00	----	----	----	<1.00	----	----
EK057G: Nitrite as N by Discrete Analyser														
Nitrite as N (Sol.)	mg/kg	**0.2**	----	----	**0.5**	----	----	**0.2**	----	----	----	<0.1	----	----
EK058G: Nitrate as N by Discrete Analyser														
Nitrate as N (Sol.)	mg/kg	**10.2**	----	----	**2.5**	----	----	**1.6**	----	----	----	**10.3**	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser														
Nitrite + Nitrate as N (Sol.)	mg/kg	**10.4**	----	----	**3.0**	----	----	**1.8**	----	----	----	**10.3**	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)														
Bicarbonate Ext. P (Colwell)	mg/kg	**11**	**65**	**6**	**13**	**7**	**5**	**6**	<5	**7**	**5**	**6**	<5	<5
EP004: Organic Matter														
Organic Matter	%	**3.3**	**2.3**	**2.2**	**4.0**	**1.7**	**0.8**	**5.0**	**1.5**	**1.2**	**0.9**	**1.1**	**0.7**	**0.6**
Total Organic Carbon	%	**1.9**	**1.3**	**1.2**	**2.3**	**1.0**	<0.5	**2.9**	**0.9**	**0.7**	<0.5			

		DP52		
		DP52: 0-10	DP52: 20-30	DP52: 50-60
Analyte grouping/Analyte	**Unit**			
EA002: pH 1:5 (Soils)				
pH Value	pH Unit	**4.4**	**4.6**	**4.6**
EA010: Conductivity				
Electrical Conductivity @ 25°C	µS/cm	**38**	**10**	**10**
EA055: Moisture Content (Dried @ 105-110°C)				
Moisture Content	%	**7.3**	**2.3**	**2.3**
EA058: Emerson Aggregate Test				
Color (Munsell)		**Very Dark Brown**	**Dark Brown**	**Strong Brown**
Texture		**Sandy Loam**	**Sandy Loam**	**Sandy Loam**
Emerson Class Number		**4**	**4**	**4**
EA150: Soil Classification - National Committee on Soil and Terrain (2009)				
Silt (2-20 µm)	%	**7**	**----**	**----**
Fine Sand (0.02-0.2 mm)	%	**34**	**----**	**----**
Coarse Sand (0.2-2.0 mm)	%	**42**	**----**	**----**
ED006: Exchangeable Cations on Alkaline Soils				
Exchangeable Calcium	meq/ 100g	**0.8**	<0.1	<0.1
Exchangeable Magnesium	meq/ 100g	**0.4**	<0.1	<0.1
Exchangeable Potassium	meq/ 100g	**0.2**	**0.1**	<0.1
Exchangeable Sodium	meq/ 100g	<0.1	<0.1	<0.1
Cation Exchange Capacity	meq/ 100g	**2.8**	**1.7**	**1.6**
Exchangeable Sodium Percent	%	**1.3**	<0.1	<0.1
Calcium/Magnesium Ratio		**2.0**	**----**	**----**
Magnesium/Potassium Ratio		**1.6**	<0.1	**----**
ED021: Bicarbonate Extractable Potassium (Colwell)				
Bicarbonate Extractable K (Colwell)	mg/kg	<200	**----**	**----**
ED040S : Soluble Sulfate by ICPAES				

Sulfate as SO4 2-	mg/kg	<10	**----**	**----**
Sulfur as S	mg/kg	<10	**----**	**----**
Silica	mg/kg	**61**	**----**	**----**
ED045G: Chloride by Discrete Analyser				
Chloride	mg/kg	**10**	<10	<10
ED091 : Calcium Chloride Extractable Boron				
Boron	mg/kg	**0.2**	**----**	**----**
ED092: DTPA Extractable Metals				
Copper	mg/kg	<1.00	**----**	**----**
Iron	mg/kg	**331**	**----**	**----**
Manganese	mg/kg	**3.21**	**----**	**----**
Zinc	mg/kg	<1.00	**----**	**----**
EK057G: Nitrite as N by Discrete Analyser				
Nitrite as N (Sol.)	mg/kg	<0.1	**----**	**----**
EK058G: Nitrate as N by Discrete Analyser				
Nitrate as N (Sol.)	mg/kg	**11.2**	**----**	**----**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser				
Nitrite + Nitrate as N (Sol.)	mg/kg	**11.2**	**----**	**----**
EK080: Bicarbonate Extractable Phosphorus (Colwell)				
Bicarbonate Ext. P (Colwell)	mg/kg	**7**	**6**	**6**
EP004: Organic Matter				
Organic Matter	%	**4.6**	**1.6**	**1.2**
Total Organic Carbon	%	**2.7**	**0.9**	**0.7**

Appendix B Soil Profile Data

Project Name: Dingo Soils

[Site Description]

Date:	20/06/2018		**Site:**	DP1	
Location:	Atkinson		**Coordinates:**	E 0731029	N 7377997
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	3		**Substrate:**	Sandstone/mudstone	
Erosion:	Stable		**Surface Condition:**	Firm	
Landform	Elevation:	160	**Permeability:**	1	
	Slope (%):	2	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	D	10YR6/3 (D) 10YR4/3 (W)	-	FLS	-	V	-	D2	5	6
A2E	10-60	A	10YR7/2 (D) 10YR5/3 (W)	-	FLS	-	G	-	D1	30	6
B2	60-90		10YR5/2	FO3	FSMC	-	M4LE	-	D5	60	6.5
										90	7.5

Vegetation: E. tesselaris, C. clarksoniana, E. crebra, A. rhodoxylon

Notes: Springwood/Luxoc? B2 grey matrix with orange mottles. Elevation? Refer to topo map.

Project Name: Dingo Soils

[Site Description]

Date:	21/06/2018		**Site:**	DP2	
Location:	Atkinson		**Coordinates:**	E 0729295	N 7378337
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	12SMS	
Site Disturbance:	3		**Substrate:**	Q. alluvium/colluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	139	**Permeability:**	2	
	Slope (%):	2	**Drainage:**	3	
	Relief:		**Run-off:**	3	

[Cooinda]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	10YR3/6	-	SCL	12SM	S3PL	-	D2	5	6
A2	10-25	D	7.5YR3/4	-	SLC	12SM	M3PO	-	D2	15	5.5
B21	25-45	S	10YR4/4	-	SLC	12SM	M3PO	-	D3	35	6
B22	45-60		10YR4/6	-	MHC	12SM	M4LE	-	D4	55	7

Vegetation: E. populnea, F. dissosperma

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	21/06/2018		**Site:**	DP3	
Location:	Atkinson		**Coordinates:**	E 0728011	N 7378628
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill Crest		**Rock Outcrops:**	-	
Morphological Type:	Crest		**S C Fragments:**	-	
Site Disturbance:	1		**Substrate:**	Laterite or Q. alluvium	
Erosion:	S		**Surface Condition:**	H	
Landform	Elevation:	139	**Permeability:**	2	
	Slope (%):	4	**Drainage:**	4	
	Relief:		**Run-off:**	4	

[Namoi]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1j	0-17	C	7.5YR5/4 (D) 7.5YR3/4 (W)	-	SCL	-	MLE	-	D3	5	5
A3j	17-40	D	7.5YR5/6 (D) 5YR4/4 (W)	-	SCL+	-	WAB	-	D3	25	5.5
B1	40-55	D	5YR4/6	-	LC	-	WAB	-	D4	45	6
B2	55-70		5YR5/8	2FR1	LMC	12SM	MPO	-	D4	60	6.5

Vegetation: E. crebra (D), A. rhodoxylon, H. contortus

Notes: B2 – brown orange matrix

Project Name: Dingo Soils

[Site Description]

Date:	21/06/2018		**Site:**	DP4	
Location:	Atkinson		**Coordinates:**	E 0730098	N 7380449
Landform Pattern:	Rise		**Micro Relief:**	**Small cracks (shrink swell)**	
Landform Element:	Hill slope		**Rock Outcrops:**	**-**	
Morphological Type:	Upper slope		**S C Fragments:**	**-**	
Site Disturbance:	4		**Substrate:**	**Q. alluvium**	
Erosion:	Stable		**Surface Condition:**	**M**	
Landform	Elevation:	135	**Permeability:**	**3**	
	Slope (%):	1	**Drainage:**	**4**	
	Relief:		**Run-off:**	**2**	

[Wallace]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A	0-5	D	7.5YR2.5/2	-	MHC	-	W4LE	-	D5	3	6.5
B2	5-24	C	7.5YR2.5/2	-	HC	11SMS	M5SB	-	D5	15	6.5
C	24-50		7.5YR4/1	-	-			-	D6	35	6.5

Vegetation: Cleared, one grass species (A. latifolia)

Notes: Substrate not likely rock, but tertiary sediments. Slickensides in B2. Shrink swell clay forms small cracks across surface.

Project Name: Dingo Soils

[Site Description]

Date:	21/06/2018		**Site:**	DP5	
Location:	Atkinson		**Coordinates:**	E 0728662	N 7379700
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:		**Permeability:**	2	
	Slope (%):		**Drainage:**	2	
	Relief:		**Run-off:**	1	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-12	D		-	S	-	V	-	D1	5	5.5
A2j	12-30	D		-	S	-	V	-	D1	15	5.5
A3e	30-54	A		-	S	-	G	-	D1	40	6
B2	54-65			21FYD	SMC	-	M3LE	-	T5	60	7

Vegetation: C. clarksoniana, M. leucadendra, C. cunninghamiana

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	21/06/2018		**Site:**	DP6	
Location:	Atkinson		**Coordinates:**	E 0730331	N 7381303
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Mid slope		**S C Fragments:**	21SMS	
Site Disturbance:	2		**Substrate:**	Sedimentary rock	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	153	**Permeability:**	2	
	Slope (%):		**Drainage:**	2	
	Relief:		**Run-off:**	4	

[Charlevue]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-11	C	10YR5/3 (D) 10YR3/3 (W)	-	LMC	-	W2PO	-	D4	5	5.8
A3	11-27	S	10YR4/4	-	MC	-	M2SB	-	D5	15	6
B2	27-60		10YR5/6	-	MHC	-	M3LE	-	T6	40	7

Vegetation: F. dissosperma, E. populnea

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	21/06/2018		**Site:**	DP7	
Location:	Atkinson		**Coordinates:**	E 0732069	N 7388338
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Sandstone or mudstone	
Erosion:	S		**Surface Condition:**	H	
Landform	Elevation:	155	**Permeability:**	2	
	Slope (%):		**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-20	D	10YR4/6	-	SCL	-	W2LE	-	D2	10	5.5
A2e	20-34	A	7.5YR7/3 (D) 7.5YR5/4 (W)	-	FSCL	-	G	-	D1	25	5.5
B2	34-65		10YR4/6	-	SMC	-	M3LE	-	T5	50	7

Vegetation: C. cunninghamiana, E. populnea

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	22/06/2018		**Site:**	DP8	
Location:	Atkinson		**Coordinates:**	E 0730656	N 7378873
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Upper slope		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	141	**Permeability:**	2	
	Slope (%):	6	**Drainage:**	3	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
Aj	0-32	S	7.5YR5/6 (D) 7.5YR4/3 (W)	-	SL	12SMS	G	-	D1	15	5.5
B	32-60		7.5YR4/6	M31FO	MC	-	W3LE	-	D6	50	6.5

Vegetation: Cleared

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	22/06/2018		**Site:**	**DP9**	
Location:	Atkinson		**Coordinates:**	**E 0731431**	**N 7381263**
Landform Pattern:	Rise		**Micro Relief:**	**-**	
Landform Element:	Hill slope		**Rock Outcrops:**	**- (outcrop up slope DO20)**	
Morphological Type:	Lower slope		**S C Fragments:**	**-**	
Site Disturbance:	2		**Substrate:**	**Quartzite sandstone**	
Erosion:	Stable		**Surface Condition:**	**S**	
Landform	Elevation:	117	**Permeability:**	**3**	
	Slope (%):	5	**Drainage:**	**3**	
	Relief:		**Run-off:**	**3**	

[Geoffrey – shallow phase]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-11	D	7.5YR3/2	-	SL	-	V	-	D1	5	5.5
A2	11-19	C	10YR3/3	-	SL	-	W2AB	-	D2	15	5.5
B2	19-45	C	10YR5/2	M3DOC	SLC	-	W2LE	-	D3	30	5.5
B3	45-55		10YR5/3	M3DOC	SLC	32SM	V	-	D4	50	5.5

Vegetation: A. rhodoxylon and E. crebra

Notes: Soil increases down slope. Quartzite and redder soils up hill. Looks like shallow phase Geoffrey?

Project Name: Dingo Soils

[Site Description]

Date:	22/06/2018		**Site:**	DP10	
Location:	Atkinson		**Coordinates:**	E 0732219	N 7382129
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	14UMVS	
Site Disturbance:	2		**Substrate:**	Quartzite? Q. alluvium?	
Erosion:	S		**Surface Condition:**	H	
Landform	Elevation:	117	**Permeability:**	2	
	Slope (%):	1	**Drainage:**	2	
	Relief:		**Run-off:**	1	

[Charlevue]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1e	0-16	S	7.5YR6/2 (D) 7.5YR4/3 (W)	-	SCL	-	M2LE	-	D2	10	5.5
B21	16-28	C	7.5YR3/4	-	MC	-	M2LE	-	D4	20	6
B22	28-60		10YR4/6	-	MHC	-	W3LE	-	T5	40	6.5
										50	7

Vegetation: E. populnea, F. dissosperma, C. spinarum

Notes: Texture contrast soil. Clay variant, may not be Geoffrey.

Project Name: Dingo Soils

[Site Description]

Date:	22/06/2018		**Site:**	DP11	
Location:	Atkinson		**Coordinates:**	E 0733663	N 7382923
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	108	**Permeability:**	2	
	Slope (%):	1	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Charlevue]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1e	0-12	C	7.5YR3/3 (W) 7.5YR5/3 (D)	-	LC	-	W3LE	-	D5	5	5.5
A2e	12-34	A	7.5YR4/4 (W) 7.5YR6/4 (D)	-	LC	-	V	-	D5	30	5.5
B2	34-70		5YR4/4	-		-	M3LE	-	D5	50	6.5

Vegetation: E. populnea, C. spinarum

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	22/06/2018		**Site:**	DP12	
Location:	Atkinson		**Coordinates:**	E 0733811	N 7383903
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill crest		**Rock Outcrops:**	-	
Morphological Type:	crest		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	137	**Permeability:**	2	
	Slope (%):	3	**Drainage:**	3	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-8	C	10YR4/3	-	SL	-	M3PL	-	D2	5	5
A2e	8-58	A	10YR6/3 (D) 10YR4/3 (W)	-	SL	-	G	-	D1	30	6
A3e	58-63	A	10YR7/2 (D) 10YR5/3 (W)	-	SL	-	V	-	D2	60	6.5
B2	63-70		10YR5/4	M41FOD	MC	12UMS	M3LE	-	D5	66	6.5

Vegetation: E. crebra, C. clarksoniana

Notes: This unit will have low moisture holding capacity, unless water trapped by clay layer.

Project Name: Dingo Soils

[Site Description]

Date:	22/06/18		**Site:**	DP13	
Location:	Atkinson		**Coordinates:**	E 0731176	N 7382463
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	155	**Permeability:**	1	
	Slope (%):	2	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-12	C	10YR6/3	-	SCL	-	W3PL	-	D2	5	6
A2e	12-38	C	10YR7/4 (D) 10YR5/4 (W)	-	SL	-	V	-	D1	20	5.8
A3e	38-51	A	10YR8/2 (D) 10YR6/4 (W)	-	SL	-	G	-	D1	45	5.5
B2	51-68		10YR5/4	M42DRD	MC	-	M3LE	-	T5	60	6.5

Vegetation: C. clarksoniana, E. crebra, A. rhodoxylon

Notes: Same unit as DP12

Project Name: Dingo Soils

[Site Description]

Date:	22/06/2018		**Site:**	DP14	
Location:	Matt		**Coordinates:**	E 0729800	N 7382699
Landform Pattern:	Alluvial Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	141	**Permeability:**	3	
	Slope (%):	2	**Drainage:**	4	
	Relief:		**Run-off:**	3	

[Barry]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A	0-15	D	7.5YR4/3	-	LMC	-	M3PL	-	D4	5	6.5
B21	15-31	D	7.5YR3/3	-	LMC	-	M3SB	-	D4	20	6.5
B22	31-52	D	7.5YR4/4	-	CL	-	M3PO	-	D5	40	6.5
B23	52-85	C	7.5YR4/4	-	LC	-	M3PL	-	D5	70	6.5
B24	85-105		7.5YR3/3	-	LMC	-	M3PO	-	D4	95	6.5

Vegetation: E. populnea, L. hookeri, E. tereticornis

Notes: Alluvial unit

Project Name: Dingo Soils

[Site Description]

Date:	23/06/2018		**Site:**	DP15	
Location:	Atkinson		**Coordinates:**	E 0729898	N 7377652
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill crest		**Rock Outcrops:**	-	
Morphological Type:	Crest		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	140	**Permeability:**	2	
	Slope (%):	4	**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1e	0-10	D	10YR6/3 (D) 10YR4/3 (W)	-	FSL	-	V	-	D2	5	6
A2e	10-40	C	10YR6/4 (D) 10YR5/4 (W)	-	FSL	11UM-S	V	-	D2	20	5.5
A3e	40-50	A	10YR7/3 (D) 10YR5/4 (W)	-	FSL	32UM-S	G	-	D1	45	6
B2	50-55		10YR5/6	M42DRD	MC	-	M2SB	-	D5	55	6.5

Vegetation: E. crebra, E. tesselaris, C. clarksoniana, A. excelsa

Notes: Looks same as DP13 (bleached A horizon), Lots of erosion approximately 100m south. Texture contrast soils are prone to erosion and sensitive to stripping.

Project Name: Dingo Soils

[Site Description]

Date:	23/06/2018		**Site:**	DP16.1	
Location:	Matt		**Coordinates:**	E 0729618	N 7381631
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill crest		**Rock Outcrops:**	-	
Morphological Type:	Crest		**S C Fragments:**	41UM-S	
Site Disturbance:	2		**Substrate:**	Iron-rich sedimentary	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	145	**Permeability:**	3	
	Slope (%):	6	**Drainage:**	5	
	Relief:		**Run-off:**	4	

[James]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	D	5YR3/4	-	SCL	11UM-S	W3PL	-	D4	5	6
B21	10-28	D	2.5YR3/6	-	CL	31UM-S	G	-	D3	20	6
B22	28-58		2.5YR3/6	-	CL	51SM-S	M3PO	-	D4	45	6

Vegetation: A. rhodoxylon, C. clarksoniana

Notes: Very red soil on hill. Started as topography increased. Uniform textures throughout.

Project Name: Dingo Soils

[Site Description]

Date:	23/06/2018		**Site:**	DP16.2	
Location:	Matt		**Coordinates:**	E 0729199	N 7381193
Landform Pattern:	Alluvial plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	Small 1-5mm rounded fm nodules in places	
Site Disturbance:	4		**Substrate:**	Iron-rich sedimentary	
Erosion:	S (eroded stream ~100m away)		**Surface Condition:**	H	
Landform	Elevation:	132	**Permeability:**	3	
	Slope (%):	2	**Drainage:**	3	
	Relief:		**Run-off:**	3	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A	0-9	D	7.5YR4/3	-	CL	-	M2SB	-	D2	5	6.5
B21	9-42	D	5YR3/2	-	MC	14AM	M3LE	-	D5	30	8
B22	42-76		5YR4/4	-	MC	-	M3LE	-	D4	60	8

Vegetation: Cleared, C. spinarum, V. nilotica, E. populnea

Notes: This alluvial plain appears to have formed from reddish hills in the surrounding area (vegetated). Clayey, but different from black vertosol in DP4.

Project Name: Dingo Soils

[Site Description]

Date:	23/06/2018		**Site:**	DP17	
Location:	Matt		**Coordinates:**	E 0729348	N 7381855
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Mid slope		**S C Fragments:**	21RM-S	
Site Disturbance:	2		**Substrate:**	Q. alluvium/colluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	139	**Permeability:**	3	
	Slope (%):	4	**Drainage:**	4	
	Relief:		**Run-off:**	3	

[James]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-9	D	5YR3/4	-	CL	-	M2PL	-	D2	5	6
B21	9-28	D	5YR3/4	-	LMC	-	W2AB	-	D3	20	6
B22	28-48	D	2.5YR3/6	-	LC	-	M2SB	-	D3	40	6
B23	48-85		2.5YR3/6	-	LMC	-	M3LE	-	D4	60	6.5
										70	6.5

Vegetation: A. rhodoxylon, E. crebra

Notes: Mid-slope on non-alluvial side of red hill

Project Name: Dingo Soils

[Site Description]

Date:	23/06/2018		**Site:**	**DP18**	
Location:	Matt		**Coordinates:**	**E 0728774**	**N 7381822**
Landform Pattern:	Rise		**Micro Relief:**	**-**	
Landform Element:	Hill slope		**Rock Outcrops:**	**-**	
Morphological Type:	Lower slope		**S C Fragments:**	**-**	
Site Disturbance:	2		**Substrate:**	**Sandstone or mudstone**	
Erosion:	A3		**Surface Condition:**	**H**	
Landform	Elevation:	136	**Permeability:**	**1**	
	Slope (%):	2	**Drainage:**	**3**	
	Relief:		**Run-off:**	**3**	

[Geoffrey - Creek Cutting]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
Ae	0-45	C	10YR4/3	-	LC	-	V	-	D5	20	5.5
B	45→		10YR6/6	M41DYD	HC	-	S3AB	2NN1	D5	70	7

Vegetation: E. crebra

Notes: Creek cutting site (no samples taken)

Project Name: Dingo Soils

[Site Description]

Date:	23/06/2018		**Site:**	DP19	
Location:	Matt		**Coordinates:**	E 0728412	N 7382010
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Foot slope		**Rock Outcrops:**	-	
Morphological Type:	Lower slope		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Q. alluvium/colluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	145	**Permeability:**	2	
	Slope (%):	2	**Drainage:**	3	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	5YR4/2	-	SCL	22UM-S	W2PO	-	D3	5	6.5
A2e	10-22	D	5YR7/1 (D) 5YR4/2 (W)	-	SCL	22UM-S	V	-	D3	15	6.5
A3e	22-48	D	5YR8/1 (D) 5YR6/2 (W)	-	LSC	22RM-S	G	2NN2	D1	30	6.5
B1	48-65	C	5YR6/2	M3FOD	SLMC	12AM-S	W2SB	3NN2	D4	55	6.5
B2	65-85		5YR6/2	M3FOD	MC	-	W2LE		D4	75	6

Vegetation: E. crebra, E. tesselaris, E. populnea, C. brewsteri

Notes: Beige flats/rises (Geoffrey)

Project Name: Dingo Soils

[Site Description]

Date:	23/06/.2018		**Site:**	DP20	
Location:	Matt		**Coordinates:**	E 0730151	N 7382804
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Drainage depression		**Rock Outcrops:**	-	
Morphological Type:	Depression		**S C Fragments:**	32UM-S	
Site Disturbance:	2		**Substrate:**	Sandstone or mudstone	
Erosion:	A3		**Surface Condition:**	H	
Landform	Elevation:	153	**Permeability:**	1	
	Slope (%):		**Drainage:**	2	
	Relief:		**Run-off:**	4	

[Geoffrey - Creek Cutting]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1e	0-20	C	10YR4/3	-	SL	-	V	-	D4	10	5
B2	20→		10YR6/6	M41DYD	MHC	-	M3LE	2NN1	D5	50	6.5

Vegetation: A. rhodoxylon, E. crebra

Notes: Creek cutting, same as DP18/19 (Geoffrey)

Project Name: Dingo Soils

[Site Description]

Date:	23/06/2018		**Site:**	DP21	
Location:	Matt		**Coordinates:**	E 0731807	N 7384730
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	3		**Substrate:**	Q. alluvium/colluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	143	**Permeability:**	2	
	Slope (%):	2	**Drainage:**	3	
	Relief:		**Run-off:**	2	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-8	C	7.5YR4/3	-	SL	-	W2LE	-	D2	5	6
B1	8-28	C	5YR4/3	-	LMC	-	W3LE	-	D4	20	6
B2	28-70		5YR4/4	-	MC	-	V	-	D5	50	6.5

Vegetation: V. nilotica, C. spinarum, E. tesselaris, E. tereticornis (shrubs)

Notes: Different unit – more blocky structure in top soils than powdery unit (Geoffrey).

Project Name: Dingo Soils

[Site Description]

Date:	23/06/2018		**Site:**	DP22	
Location:	Matt		**Coordinates:**	E	N
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	149	**Permeability:**	2	
	Slope (%):	1	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	5YR4/3	-	LMC	-	M2AB	-	D4	5	6
A2e	10-22	A	5YR6/2 (D) 5YR4/2 (W)	-	LC	-	V	-	D4	15	6
B2	22-85		7.5YR3/4	-	MHC	-	M4LE	-	T5	40	6
										70	7.5

Vegetation: Cleared with V. nilotica, C. lasiantha

Notes: Different unit to other texture contrast soils. Clay is dark brown not grey, and bleached horizons are very shallow. B2 is soapy.

Project Name: Dingo Soils

[Site Description]

Date:	24/06/2018		**Site:**	DP23	
Location:	Matt		**Coordinates:**	E 0730391	N 7384342
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	113	**Permeability:**	2	
	Slope (%):	1	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	5YR3/3	-	MC	-	W2SB	-	D5	5	6
B21	10-24	D	5YR3/2	-	MHC	-	M3AB	-	D4	15	6
B22	24-44	D	5YR3/3	-	MHC	-	M2LE	-	T4	30	6
B23	44-73		7.5YR3/4	-	MHC	-	M3LE	-	T4	50	6.5
										70	7.5

Vegetation: Cleared with V. nilotica

Notes: Same as DP22. Soapy B23.

Project Name: Dingo Soils

[Site Description]

Date:	24/06/18		**Site:**	DP24	
Location:	Matt		**Coordinates:**	E 0729605	N 7383991
Landform Pattern:	Plain or alluvial plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	117	**Permeability:**	3	
	Slope (%):	1	**Drainage:**	4	
	Relief:		**Run-off:**	2	

[BOUNDARY]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	10YR3/4	-	L	-	G	-	D2	5	6.5
A2e	10-23	A	10YR6/3 (D) 10YR4/3 (W)	-	SL	-	M3PL	-	D2	15	6.5
B1	23-54	D	7.5YR4/6	-	SL	-	V	-	D1	35	6.5
B2	54-85		7.5YR5/6	-	SCL	-	W2SB	2MN2	D4	60	6.5
										80	6.5

Vegetation: Cleared. Small E. populnea and C. brewsteri

Notes: Alluvial unit. Closer to river. Sandier soil than DP22/23 – no clay horizon. Potential boundary unit?

Project Name: Dingo Soils

[Site Description]

Date:	24/06/2018		**Site:**	DP25	
Location:	Matt		**Coordinates:**	E 0727595	N 7383271
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	115	**Permeability:**	2	
	Slope (%):	1	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1j	0-9	C	5YR6/3 (D) 7.5YR3/4 (W)	-	SCL	-	V	-	D2	5	6
A2e	9-23	D	7.5YR7/4 (D) 7.5YR4/4 (W)	-	SLC	-	V	-	D3	15	6
B1	23-33	C	7.5YR4/4	-	MC	-	M4LE	-	D5	30	6
B2	33-65		5YR3/4	-	MHC	-	W3LE	-	D5	40	7
										60	8

Vegetation: Cleared with V. nilotica, C. lasiantha. More alluvial units seem to have E. populnea (DP24)

Notes: Same as DP22 and DP23 – likely sodic. Soapy B2.

Project Name: Dingo Soils

[Site Description]

Date:	24/06/2018		**Site:**	DP26	
Location:	Matt		**Coordinates:**	E 0726714	N 7383558
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Upper slope		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Coarse grained sed – iron-rich	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	124	**Permeability:**	2	
	Slope (%):	6	**Drainage:**	4	
	Relief:		**Run-off:**	4	

[Anderson]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	D	10YR3/2	-	SL	-	V	-	D2	5	4.5
A2e	10-32	C	10YR6/3 (D) 5YR4/4 (W)	-	SL	33SM	V	-	D2	15	5.0
B21	32-50	D	10YR5/3	M3FR1	MC	-	M2PO	-	D5	35	5.5
B22	50-75		10YR6/2	M4DR2	MC	-	S2AB	-	D4	60	5.5
										70	5.5

Vegetation: E. crebra, A. rhodoxylon

Notes: Almost at crest of hill. Not many hills on this property.

Project Name: Dingo Soils

[Site Description]

Date:	24/06/2018		**Site:**	DP27	
Location:	Matt		**Coordinates:**	E 0725835	N 7384918
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Lower slope		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	130	**Permeability:**	2	
	Slope (%):	3	**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-9	D	7.5YR4/3	-	CL	-	W1SB	-	D4	5	6
B1	9-25	S	7.5YR4/3	-	MC	-	W2SB	-	D4	15	6
B21j	25-38	C	10YR7/4 (D) 7.5YR4/4 (W)	-	MHC	-	W2LE	-	D3	30	6
B22	38-60		10YR4/6	-	MHC	-	M2LE	-	T5	45	6.5
										60	7.5

Vegetation: E. crebra, E. populnea, C. brewsteri

Notes: Another one like DP22/23 (Kosh). Soapy B22 suggests sodic subsoil.

Project Name: Dingo Soils

[Site Description]

Date:	24/06/2018		**Site:**	DP28	
Location:	Matt		**Coordinates:**	E 0726342	N 7383254
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	122	**Permeability:**	2	
	Slope (%):	2	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[BOUNDARY]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-8	D	7.5YR4/3	-	SL	-	W2AB	-	D2	5	7.5
A2j	8-28	D	7.5YR6/4 (D) 7.5YR4/4 (W)	-	SL	-	V	-	D2	20	6.5
A3j	28-44	A	5YR6/4 (D) 5YR4/6 (W)	-	SL	-	V	-	D3	35	6
B2	44-75		5YR4/4	-	MC	-	M2LE	-	T5	50	5.5
										65	6

Vegetation: Cleared, A. salicina, E. populnea shrubs

Notes: Appears to be different unit. Deep surface soils. Red clay subsoil. Neutral surface with acidic subsurface. Could be Kosh/Anderson?

Project Name: Dingo Soils

[Site Description]

Date:	24/06/2018		**Site:**	DP29	
Location:	Matt		**Coordinates:**	E 0727377	N 7382782
Landform Pattern:	Alluvial plain		**Micro Relief:**	-	
Landform Element:	Levee		**Rock Outcrops:**	-	
Morphological Type:	Depression/flat		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	124	**Permeability:**	3	
	Slope (%):	3	**Drainage:**	4	
	Relief:		**Run-off:**	4	

[Barry]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-15	D	7.5YR3/3	-	MC	-	M3PO	-	D2	8	6
B21	15-33	D	7.5YR4/4	-	MHC	-	M3PO	-	D3	25	6
B22	33-80		7.5YR3/2	-	MC	-	M4PO	-	D3	40	6
										60	6
										80	6

Vegetation: E. tesselaris, E. populnea, L. hookeri, C. spinarum, C. brewsteri

Notes: Alluvial unit

Project Name: Dingo Soils

[Site Description]

Date:	24/06/18		**Site:**	DP30	
Location:	Matt		**Coordinates:**	E 0728190	N 7383971
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Mid slope		**S C Fragments:**	-	
Site Disturbance:	2-4 (on fence)		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	L	
Landform	Elevation:	141	**Permeability:**	1	
	Slope (%):	4	**Drainage:**	1	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-8	D	7.5YR4/2	-	SL	-	V	-	D2	5	6
A2j	8-30	D	7.5YR6/3 (D) 7.5YR4/3 (W)	-	S	-	G	-	D1	20	6
A3e	30-72	A	7.5YR7/2 (D) 10YR6/3 (W)	-	S	-	G	-	D1	50	6
B2	72-95		10YR6/4	M4DR/OS	MC	-	M2AB	-	T5	80	6
										90	6

Vegetation: A. excelsa, M. leucadendra, P. pubecens, C. clarksoniana

Notes: Same as DP18/19 (Geoffrey) from Atkinson. Pale bleached sands over grey clay with orange mottles.

Project Name: Dingo Soils

[Site Description]

Date:	24/06/2018		**Site:**	DP31	
Location:	Matt		**Coordinates:**	E 0729088	N 3783173
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	147	**Permeability:**	2	
	Slope (%):	1	**Drainage:**	4	
	Relief:		**Run-off:**	1	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-8	D	7.5YR4/4	-	CL	-	V	-	D2	5	6.5
A2e	8-25	C	7.5YR6/4 (D) 7.5YR4/4 (W)	-	CL	-	V	-	D2	20	7
B1j	25-38	D	5YR4/6 (D) 5YR4/4 (W)	-	MC	-	W3AB	-	D4	30	6.5
B2	38-80		5YR4/6	-	MC	-	M2LE	-	D5	45	6
										80	6.5

Vegetation: Cleared, C. brewsteri, E. populnea, A. harpophylla, A. salicina

Notes: No alkaline subsoil here. Too close to creek?

Project Name: Dingo Soils

[Site Description]

Date:	24/06/2018		**Site:**	DP32	
Location:	Matt		**Coordinates:**	E 0729720	N 7385206
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Simple slope		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Sandstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:		**Permeability:**	1	
	Slope (%):		**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	5YR4/2	-	LS	-	G	-	D1	5	5.5
A2e	10-60	C	5YR7/2 (D) 5YR 5/2 (W)	-	S	-	G	-	D1	35	6
A3j	60-70	A	5YR8/2 (D) 5YR7/3 (W)	-	LS	-	G	-	D1	65	6.5
B2	70-90		5YR7/2	M42DOC	MC	-	M3LE	-	D5	80	7.5

Vegetation: M. leucadendra, C. clarksoniana, C. cunninghamiana, E. tereticornis

Notes: Geoffrey

Project Name: Dingo Soils

[Site Description]

Date:	25/06/2018		**Site:**	DP33	
Location:	Matt		**Coordinates:**	E 0727686	N 7385306
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill crest		**Rock Outcrops:**	-	
Morphological Type:	Crest		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Sandstone	
Erosion:	Stable		**Surface Condition:**	F	
Landform	Elevation:	131	**Permeability:**	1	
	Slope (%):	2	**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	5YR3/3	-	LS	-	V	-	D2	5	6
A2	10-70	D	5YR4/6	-	S	-	G	-	D1	40	6
A3j	70-83	A	7.5YR6/6 (D) 7.5YR5/6 (W)	-	S	-	G	-	D2	75	6
B2	83-100		7.5YR5/3	M42PRS	MHC	-	M5LE	-	T5	90	5.5

Vegetation: Cleared. A. harpophylla saplings, nearby veg C. clarksoniana, C. cunninghamiana, M. leucadendra

Notes: Sand appears less obviously bleached at crest vs. mid-lower slopes. Water available for less time. Mottling very prominent, though only red – no orange. Less variable water table.

Project Name: Dingo Soils

[Site Description]

Date:	25/06/2018		**Site:**	DP34	
Location:	Matt		**Coordinates:**	E 0728311	N 7385163
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Foot slope		**Rock Outcrops:**	-	
Morphological Type:	Lower slope		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	117	**Permeability:**	2	
	Slope (%):	2	**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-12	D	10YR3/3	-	SCL	-	W3SB	-	D2	5	6
A2e	12-24	C	10YR7/3 (D) 10YR6/3 (W)	-	SCL	-	V	-	D3	17	6
B2	24-80		10YR5/6	-	MHC	-	M2LE	-	T5	30	6
										50	7.5
										70	8

Vegetation: Cleared with V. nilotica, C. spinarum

Notes: Kosh

Project Name: Dingo Soils

[Site Description]

Date:	25/06/2018		**Site:**	DP35	
Location:	Matt		**Coordinates:**	E 0730393	N 7384004
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	97	**Permeability:**	2	
	Slope (%):	3	**Drainage:**	4	
	Relief:		**Run-off:**	3	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-8	D	7.5YR4/3	-	LC	-	V	-	D4	5	6
A2j	8-32	C	7.5YR5/4 (D) 7.5YR3/4 (W)	-	MC	-	W3AB	-	D3	20	6
B2	32-85		7.5YR3/4	-	MHC	-	M3LE	-	T4	40	6
										60	6.5
										80	7.5

Vegetation: E. teritecornis, A. hemiglauca, A. salicina, L. hookeri

Notes: Kosh

Project Name: Dingo Soils

[Site Description]

Date:	25/06/2018		**Site:**	DP36	
Location:	Matt		**Coordinates:**	E 0730325	N 7383633
Landform Pattern:	Alluvial plain		**Micro Relief:**	-	
Landform Element:	Levee		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Q. alluvium	
Erosion:	AN		**Surface Condition:**	H	
Landform	Elevation:	99	**Permeability:**	4	
	Slope (%):	2	**Drainage:**	4	
	Relief:		**Run-off:**	3	

[Barry]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-18	D	5YR3/4	-	CL	-	W3PL	-	D4	10	6.5
A3	18-70	D	5YR4/4	-	SCL	-	V	-	D3	40	6.5
B2	70-95		5YR3/3	-	SLMC	-	W1LE	-	D4	80	6.5
										95	6.5

Vegetation: E. tesselaris, E. populnea, E. tereticornis

Notes: DP35 is not ALP but PLA, not LEV but PLA.

Project Name: Dingo Soils

[Site Description]

Date:	25/06/2018		**Site:**	DP37	
Location:	Beath		**Coordinates:**	E	N
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill Crest		**Rock Outcrops:**	-	
Morphological Type:	Crest		**S C Fragments:**	2MN2-S	
Site Disturbance:	3		**Substrate:**	Coarse iron sandstone	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:		**Permeability:**	3	
	Slope (%):		**Drainage:**	3	
	Relief:		**Run-off:**	3	

[Anderson]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-20	D	5YR4/4	-	CL	-	V	-	D3	10	4.5
A2	20-40	D	5YR4/4	-	LMC	12RM	W2PL	-	D3	30	4.5
B2	40-82	D	5YR4/6	-	LMC	32AM	W1LE	1MN1	D5	60	5.5
B3	82-97		5YR4/6	-	LC	11UM	V	-	D4	90	5.8

Vegetation: E. australe, C. clarksoniana, E. crebra, A. rhodoxylon

Notes: Red soil

Project Name: Dingo Soils

[Site Description]

Date:	25/06/2018		**Site:**	DP38	
Location:	Beath		**Coordinates:**	E 0724862	N 7386456
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Mid-slope		**S C Fragments:**	-	
Site Disturbance:	3		**Substrate:**	Sandstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	150	**Permeability:**	2	
	Slope (%):		**Drainage:**	3	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-15	C	10YR3/3	-	SLC	-	V	-	D2	5	5.5
A2j	15-55	D	10YR6/3 (D) 10YR5/3 (W)	-	SLC	-	G	-	D1	30	4.5
B1j	55-72	D	10YR7/4 (D) 10YR5/4 (W)	-	SLC	-	V	-	D2	60	4.5
B2	72-90		10YR6/4	M31FO/YD	SLC	-	W2SB	-	D4	90	5

Vegetation: M. leucadendra, Acacia sp.

Notes: This sand is much deeper than other Geoffrey units.

Project Name: Dingo Soils

[Site Description]

Date:	25/06/2018		**Site:**	DP39	
Location:	Bradbury		**Coordinates:**	E 0729901	N 7386161
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Mid-slope		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Sandstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	141	**Permeability:**	1	
	Slope (%):	3	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1j	0-8	C	10YR6/3 (D) 10YR4/4 (W)	-	LS	-	G	-	D2	5	4.8
A2e	8-36	A	10YR7/4 (D) 10YR4/6 (W)	-	LS	-	G	-	D2	20	4.8
B2	36-72		10YR6/4	M42DOD	MHC	-	M5LE	-	D6	40	6
										55	6
										70	7

Vegetation: C. clarksoniana, A. excelsa, P. pubecens, E. crebra

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	25/06/2018		**Site:**	DP40	
Location:	Bradbury		**Coordinates:**	E 0729623	N 7386575
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill crest		**Rock Outcrops:**	-	
Morphological Type:	Crest		**S C Fragments:**	-	
Site Disturbance:	-		**Substrate:**	Fine sandstone	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	142	**Permeability:**	2	
	Slope (%):	3	**Drainage:**	4	
	Relief:		**Run-off:**	2	

[Ellesmere]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	D	7.5YR3/4	-	FSL	-	M3PL	-	D2	5	5
A2	10-20	D	7.5YR3/4	-	SCL	-	G	-	D2	15	4.5
B1	20-40	D	7.5YR4/4	-	LC	-	G	-	D2	30	4.5
B2	40-65	C	5YR4/6		MC	-	M2PO	-	D4	50	5.5
B3	65-87		7.5YR6/3		MC	-	M2PO	-	T5	70	5.5

Vegetation: A. sherleyi

Notes: Similar looking to Geoffrey but with different veg and less sandy. Also highly acidic.

Project Name: Dingo Soils

[Site Description]

Date:	26/06/2018		**Site:**	DP41	
Location:	Alan		**Coordinates:**	E 0727396	N 7386922
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Sandstone	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	97	**Permeability:**	2	
	Slope (%):	1	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Kosh – pale varient]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	D	5YR4/3	-	L	-	W2SB	-	D3	5	6
A2j	10-30	S	7.5YR7/4	-	L	-	V	-	D4	20	5.5
B21j	30-42	C	7.5YR7/4	-	SMC	-	M2LE	-	D5	35	6
B22	42-82			-	MC	-	M3LE	-	D5	50	7
										80	9

Vegetation: Cleared with C. spinarum and V. nilotica

Notes: Kosh. Not sandy enough for Geoffrey, in correct location for Kosh and has alkaline subsoil.

Project Name: Dingo Soils

[Site Description]

Date:	26/06/2018		**Site:**	DP42	
Location:	Alan		**Coordinates:**	E 0728049	N 7387508
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Upper slope		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Sandstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	98	**Permeability:**	2	
	Slope (%):	5	**Drainage:**	4	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-13	D	10YR4/3	-	LS	-	V	-	D1	8	5
A2e	13-44	D	10YR7/4 (D) 10YR5/4 (W)	-	S	-	G	-	D1	30	5
A3e	44-66	C	10YR7/4 (D) 10YR5/4 (W)	-	LS	-	V	-	D2	55	5
B1j	66-97	A	10YR6/4 (D) 10YR5/6 (W)	M22FR/OD	CS	-	W2SB	-	D2	75	6
B2	97-110		10YR6/6	M42DR/OC	SLMC	-	M2LE	-	D4	90	6

Vegetation: Cleared with E. australe and C. clarksoniana shrubs

Notes: Geoffrey.

Project Name: Dingo Soils

[Site Description]

Date:	26/06/2018		**Site:**	DP43	
Location:	Alan		**Coordinates:**	E 0727017	N 7387656
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill crest		**Rock Outcrops:**	-	
Morphological Type:	Crest		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Sandstone	
Erosion:	Active sheet		**Surface Condition:**	H	
Landform	Elevation:	138	**Permeability:**	3	
	Slope (%):	3	**Drainage:**	3	
	Relief:		**Run-off:**	2	

[Nigel]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A	0-20	D	10YR3/3	-	S	-	V	-	D1	5	4.8
A2	20-63	D	2.5YR3/6	-	S	-	G	-	D1	30	5.5
B1	63-68	C	2.5YR4/6	-	LS	-	G	-	D2	50	5.5
C	68→				C (laterite pebbles)					60	5.5

Vegetation: A. sherleyi and cleared

Notes: Same as laterite unit from Joan Bradbury's property (Nigel)

Project Name: Dingo Soils

[Site Description]

Date:	26/06/2018		**Site:**	DP44	
Location:	Alan		**Coordinates:**	E 0726526	N 7387223
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	146	**Permeability:**	1	
	Slope (%):	1	**Drainage:**	4	
	Relief:		**Run-off:**	2	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-12	D	7.5YR3/4	-	LS	-	V	-	D2	8	6
A2e	12-35	C	10YR6/4 (D) 10YR4/6 (W)	-	S	-	G	-	D2	20	6
A3j	35-67	C	10YR7/4 (D) 10YR5/8 (W)	-	LS	-	W1LE	-	D2	50	6
B2	67-75		10YR5/6	Faint orange	SLMC	-	V	-	D5	70	6

Vegetation: Open clearing, pastures, near E. tesselaris, E. crebra, C. clarksoniana

Notes: Did not reach clay layer but still Geoffrey.

Project Name: Dingo Soils

[Site Description]

Date:	26/06/2018		**Site:**	DP45	
Location:	Alan		**Coordinates:**	E 0727775	N 7385854
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Upper slope		**S C Fragments:**	-	
Site Disturbance:	3		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	128	**Permeability:**	1	
	Slope (%):	3	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-12	D	7.5YR3/3	-	SL	-	V	-	D1	8	4.8
A2j	12-55	D	7.5YR7/3 (D) 7.5YR464 (W)	-	SL	-	G	-	D1	30	5
A3e	55-61	A	10YR7/4 (D) 10YR6/3 (W)	-	S	-	G	-	D1	55	6
B2	61-73		10YR6/2	42PRC	MC	-	M3LE	-	D5	70	6

Vegetation: E. crebra, C. clarksoniana, Acacia spp.

Notes: Did not sample this site.

Project Name: Dingo Soils

[Site Description]

Date:	26/06/2018		**Site:**	DP46	
Location:	Alan		**Coordinates:**	E 0727034	N 7386292
Landform Pattern:	Drainage depression		**Micro Relief:**	-	
Landform Element:	Levee		**Rock Outcrops:**	-	
Morphological Type:	Depression		**S C Fragments:**	-	
Site Disturbance:	3		**Substrate:**	Q. alluvium	
Erosion:	AW		**Surface Condition:**	H	
Landform	Elevation:	115	**Permeability:**	1	
	Slope (%):	1	**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-15	A	10YR4/4	-	LC	-	V	-	D5	10	5.8
A2	15-50	C	10YR4/6 (W) 10YR7/4 (D)	-	MC	-	S3PO	-	D5	40	6
B2	50-70		7.5YR5/6		MC	-	S3AB	2MN2	D5	60	6.5
										100	7

Vegetation: E. teritecornis, Acacia spp.

Notes: Second alluvial unit. Looks like alluvial variant of Geoffrey. Topsoil not as sandy or deep.

Project Name: Dingo Soils

[Site Description]

Date:	27/06/2018		**Site:**	DP47	
Location:	Kevin		**Coordinates:**	E 0732691	N 7384997
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Q. alluvium	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	90	**Permeability:**	2	
	Slope (%):	2	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	10YR3/3	-	CL	-	W3PL	-	D2	5	6.5
A2e	10-21	D	10YR6/3 (D) 7.5YR4/3 (W)	-	CL	-	V	-	D4	15	7
B21j	21-33	C	7.5YR6/4 (D) 7.5YR4/4 (W)	-	MHC	-	W2AB	-	D5	25	7
B22	33-70		7.5YR3/3	-	MHC	-	M3SB	-	D5	40	7
										70	8.5

Vegetation: Cleared with C. lasiantha, V. nilotica, C. spinarum

Notes: Likely Kosh

Project Name: Dingo Soils

[Site Description]

Date:	27/06/2018		**Site:**	DP48	
Location:	Kevin		**Coordinates:**	E 0732221	N 7386415
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Upper slope		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Iron-rich sandstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	95	**Permeability:**	4	
	Slope (%):	3	**Drainage:**	5	
	Relief:		**Run-off:**	2	

[Normanby]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-7	C	2.5YR4/4	-	LS	-	G	-	D1	5	6.5
A2	7-23	D	2.5YR3/3	-	LS	-	V	-	T2	15	6.5
B1	23-75	D	10R4/6	-	LS	-	V	-	T3	35	6.5
B2	75-90		10R4/6	-	SLMC	-	W1LE	-	T3	80	7

Vegetation: E. crebra, A. oleifolius, cleared

Notes: Red earth occupies upper slope in this area

Project Name: Dingo Soils

[Site Description]

Date:	27/06/2018		**Site:**	DP49	
Location:	Bradbury		**Coordinates:**	E 0730993	N 7387688
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Simple slope		**S C Fragments:**	-	
Site Disturbance:	3		**Substrate:**	Sandstone	
Erosion:	Stable		**Surface Condition:**	F	
Landform	Elevation:	107	**Permeability:**	1	
	Slope (%):	4	**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	7.5YR4/3	-	LS	-	V	-	D2	5	5.5
A2e	10-36	D	10YR4/3 (W) 10YR6/3 (D)	-	LS	-	V	-	D1	25	6
A3e	36-54	A	10YR8/2 (D) 10YR6/4 (W)	-	LS	-	G	-	D1	45	6
B2	54-80		10YR6/3	32DY	MHC	-	M3LE	-	T4	60	7
										80	7

Vegetation: C. cunninghamiana, E. teritecornis

Notes: Geoffrey

Project Name: Dingo Soils

[Site Description]

Date:	26/06/2018		**Site:**	DP50	
Location:	Bradbury		**Coordinates:**	E 0731220	N 7385733
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Iron-rich sandstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	119	**Permeability:**	3	
	Slope (%):	2	**Drainage:**	4	
	Relief:		**Run-off:**	2	

[Normanby]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-8	D	5YR4/3	-	SL	-	V/G	-	D1	5	6
A2	8-23	D	2.5YR4/3	-	SL	-	G	-	D2	15	6
B21	23-54	D	2.5YR4/6	-	SL	-	G	-	D2	35	6
B22	54-73		2.5YR3/6	-	SL	-	W1LE	-	D2	60	6

Vegetation: Cleared with E. crebra

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	27/06/2017		**Site:**	DP51	
Location:	Bradbury		**Coordinates:**	E 0729334	N 7387801
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Simple slope		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Iron rich sandstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	150	**Permeability:**	3	
	Slope (%):	3	**Drainage:**	4	
	Relief:		**Run-off:**	2	

[Nigel]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-11	C	10YR4/4	-	LS	-	V	-	D1	5	5
A2j	11-30	D	5YR3/3 (W) 7.5YR5/6 (D)	-	LS	-	G	-	D2	20	5
A3j	30-45	D	10YR5/8	-	SCL	-	G	-	D2	35	5.5
B2	45-76	C	10YR5/6	-	SLC	-	V	-	D3	60	5.5
C	76-86									80	6

Vegetation: M. leucadendra, C. clarksoniana, E. tesselaris, Acacia sp.

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	27/06/2018		**Site:**	DP52	
Location:	Bradbury		**Coordinates:**	E 0729292	N 7388122
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Crest		**S C Fragments:**	-	
Site Disturbance:	1		**Substrate:**	Laterite	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	148	**Permeability:**	3	
	Slope (%):	5	**Drainage:**	3	
	Relief:		**Run-off:**	3	

[Nigel]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-22	D	7.5YR3/4	-	LS	-	V	-	D2	10	5.5
A2j	22-40	C	5YR4/6 (W) 7.5YR5/8 (D)	-	CS	-	V	-	D1	30	5
B2	40-60	D	7.5YR4/4	-	CS	-	W2PO	-	D1	50	5.5
B3	60-75		10YR4/6	-	CS	-	V	1MN2	D2	70	6

Vegetation: A. rhodoxylon, E. crebra

Notes: Unit is rosewood laterite

Project Name: Dingo Soils

[Site Description]

Date:	27/06/2018		**Site:**	DP53	
Location:	Bradbury		**Coordinates:**	E 0728508	N 7388239
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Upper slope		**S C Fragments:**	-	
Site Disturbance:	2		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	120	**Permeability:**	1	
	Slope (%):	4	**Drainage:**	2	
	Relief:		**Run-off:**	4	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	D	7.5YR3/3	-	FSL	-	V	-	D1	5	6
A2j	10-24	D	10YR3/3 (D) 10YR6/2 (W)	-	CS	-	G	-	D1	18	6
A3e	24-42	A	10YR7/2 (D) 7.5YR5/3 (W)	-	LS	-	G	-	D1	35	5.5
B2	42-58		10YR5/2		MC	-	M3LE	-	D5	50	6

Vegetation: E. populnea, C. spinarum

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	28/06/2018		**Site:**	DP54	
Location:	Bradbury		**Coordinates:**	E 0731040	N 7386289
Landform Pattern:	Plain		**Micro Relief:**	-	
Landform Element:	Plain		**Rock Outcrops:**	-	
Morphological Type:	Flat		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	L	
Landform	Elevation:	112	**Permeability:**	1	
	Slope (%):	1	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-9	C	10YR4/4	-	LS	-	V	-	D1	5	6
A2e	9-29	C	7.5YR7/3 (D) 7.5YR5/3 (W)	-	LS	-	G	-	D2	20	6
A3e	29-38	A	10YR7/3 (D) 7.5YR6/4 (W)	-	LS	-	G	-	D2	35	6
B2	38-45		7.5YR5/3	M42FOD	MHC	-	M2LE	-	D5	45	6.5

Vegetation: Cleared

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	28/06/2018		**Site:**	DP55	
Location:	Atkinson		**Coordinates:**	E 0733270	N 7383687
Landform Pattern:	Ruse		**Micro Relief:**	M and T (biotic)	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Upper slope		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Mudstone or sandstone	
Erosion:	Stable		**Surface Condition:**	H	
Landform	Elevation:	105	**Permeability:**	1	
	Slope (%):	3	**Drainage:**	2	
	Relief:		**Run-off:**	2	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	10YR4/3	-	LS	-	V	-	D2	5	6
A2j	10-20	C	10YR6/3 (D) 10YR4/6 (W)	-	LS	-	V	-	D3	15	6
A31j	20-46	S	10YR6/4 (D) 10YR6/4 (W)	-	LS	-	G	-	D2	35	6
A32j	46-52	A	10YR8/3 (D) 7.5YR6/4 (W)	-	LS	-	G	-	D1	48	6
B2	52-62		10YR5/6	-	MHC	-	M2LE	-	T5	60	6.5

Vegetation: Cleared with gum shrubs (C. clarksoniana)

Notes: Lots of uneven ground

Project Name: Dingo Soils

[Site Description]

Date:	28/06/2018		**Site:**	DP56	
Location:	Atkinson		**Coordinates:**	E 0731652	N 7383912
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill crest		**Rock Outcrops:**	-	
Morphological Type:	Crest		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	103	**Permeability:**	1	
	Slope (%):	2	**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-10	C	10YR4/3	-	LS	-	V	-	D1	5	6
A2	10-19	C	10YR5/3	-	LS	-	M2PL	-	D2	15	6
A31e	19-47	D	10YR8/4 (D) 7.5YR6/4 (W)	-	LS	-	V	-	D1	35	6
A32e	47-53	A	10YR8/4 (D) 7.5YR5/4 (W)	-	LS	-	V	-	D2	45	6
B2	53-76		10YR6/6	M31FRD	MHC	-	M3LE	-	T5	55	7

Vegetation: Cleared.

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	28/06/2018		**Site:**	DP57	
Location:	Matt		**Coordinates:**	E 0726879	N 7381963
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Mid slope		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	F	
Landform	Elevation:	112	**Permeability:**	1	
	Slope (%):	3	**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-9	C	7.5YR4/3	-	SCL	-	V	-	D2	5	6
A2	9-23	D	7.5YR6/4	-	SCL	-	V	-	D3	30	6
A31	23-70	C	7.5YR6/6	-	SLC	-	V	-	D3	55	6
A32e	70-80	A	7.5YR5/6	-	SLC	-	G	-	D2	75	6
B2	80-100		7.5YR5/6	M42PRC	MC	-	M2LE	-	T5	100	6.5

Vegetation: Cleared with C. brewsteri

Notes: Higher in landscape = less bleaching and redder soil. (Geoffrey)

Project Name: Dingo Soils

[Site Description]

Date:	28/06/2018		**Site:**	DP58	
Location:	Matt		**Coordinates:**	E 0728775	N 7384245
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Mid slope		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Sandstone or mudstone	
Erosion:	Stable		**Surface Condition:**	S	
Landform	Elevation:	131	**Permeability:**	1	
	Slope (%):	5	**Drainage:**	2	
	Relief:		**Run-off:**	3	

[Geoffrey]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-15	C	7.5YR4/4	-	LS	-	V	-	D1	10	6
A2e	15-55	C	7.5YR7/3 (D) 7.5YR6/3 (W)	-	LS	-	V	-	D1	35	6
A3e	55-62	A	7.5YR7/3 (D) 7.5YR5/4 (W)	-	LS	-	V	-	D1	58	6.5
B2	62-66		7.5YR6/3	-	MC	-	W2LE	-	D5	64	7

Vegetation: Cleared, M. leucadendra, C. cunninghamiana, C. clarksoniana

Notes:

Project Name: Dingo Soils

[Site Description]

Date:	28/06/2018		**Site:**	DP59	
Location:	Matt		**Coordinates:**	E 0726749	N 738337
Landform Pattern:	Rise		**Micro Relief:**	-	
Landform Element:	Hill slope		**Rock Outcrops:**	-	
Morphological Type:	Lower slope		**S C Fragments:**	-	
Site Disturbance:	4		**Substrate:**	Fine sandstone	
Erosion:	Stable		**Surface Condition:**	F	
Landform	Elevation:	144	**Permeability:**	2	
	Slope (%):	4	**Drainage:**	3	
	Relief:		**Run-off:**	3	

[Kosh]

[Soil Description]

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH	
A1	0-5	C	7.5YR2.5/3	-	CL	-	W1LE	-	D2	5	6.5
B21	5-24	C	7.5YR3/2	-	CL	-	W2PO	-	D3	15	7
B22j	24-40	C	10YR4/3 (D) 10YR3/3 (W)	-	LC	-	W2AB	-	D3	30	7.5
B23	40-68		10YR3/4	-	MC	-	M3LE	-	D5	45	8
										60	8.5

Vegetation: Cleared with C. lasiantha, C. spinarum

Notes: B23 soapy. (Kosh)

Appendix C Soil Observation Data

Site Name	Date	Latitude	Longitude	Elevation	Soil Unit	Vegetation Notes
DO1	20/06/2018	-23.69	149.24	136.51	Namoi	E. crebra, E. tereticornis
DO2	21/06/2018	-23.69	149.24	136.01	Geoffrey	E. crebra, Acacia spp, C. clarksoniana
DO3	21/06/2018	-23.69	149.25	136.75	Geoffrey	E. populnea
DO4	21/06/2018	-23.67	149.25	129.08	*boundary*	W: A. rhodoxylon E: E. crebra, E. populnea
DO5	21/06/2018	-23.67	149.26	130.10	Wallace	Cleared
DO6	21/06/2018	-23.67	149.26	125.32	Charlevue	E. crebra, E. populnea
DO7	21/06/2018	-23.67	149.26	127.57	*boundary*	Cleared
DO8	21/06/2018	-23.67	149.26	139.19	*boundary*	N: Cleared S: E. crebra, E. populnea, E. tereticornis
DO9	21/06/2018	-23.68	149.25	143.03	Geoffrey	E. crebra, silver wattle, E. exerta
DO10	21/06/2018	-23.68	149.24	172.43	*boundary*	E: E. crebra, A. rhodoxylon
DO11	21/06/2018	-23.68	149.24	168.21	Geoffrey	Cleared
DO12	21/06/2018	-23.68	149.25	163.36	Geoffrey	Cleared
DO13	21/06/2018	-23.68	149.25	157.39	*boundary*	Cleared
DO14	21/06/2018	-23.68	149.26	126.09	Geoffrey	E. crebra. Silver wattle
DO15	21/06/2018	-23.67	149.26	120.15	*boundary*	
DO16	21/06/2018	-23.67	149.26	120.78	*boundary*	Cleared
DO17	21/06/2018	-23.67	149.26		*boundary*	A. rhodoxylon, E. populnea
DO18	21/06/2018	-23.67	149.26	123.08	Wallace	E. populnea, F. dissosperma
DO19	21/06/2018	-23.67	149.26	122.75	*boundary*	Silver leaf iron bark
DO20	21/06/2018	-23.66	149.27	132.22	Unsure	A. rhodoxylon, E. crebra
DO21	21/06/2018	-23.66	149.27	126.74	*boundary*	A. rhodoxylon, E. crebra
DO22	21/06/2018	-23.66	149.27	118.17	Geoffrey	A. rhodoxylon, E. crebra
DO23	22/06/2018	-23.66	149.27	116.85	*boundary*	A. rhodoxylon, E. populnea
DO24	22/06/2018	-23.66	149.27	123.34	Charlevue	E. populnea, A. rhodoxylon, F. dissosperma
DO25	22/06/2018	-23.65	149.28	115.16	Charlevue	E. populnea, A. rhodoxylon, F. dissosperma
DO26	22/06/2018	-23.66	149.28	110.70	*boundary*	E: E. crebra, E. tereticornis W: E. populnea, F. dissosperma
DO27	22/06/2018	-23.65	149.29	107.36	Charlevue	E. populnea, C. spinarum
DO28	22/06/2018	-23.65	149.29	121.09	*boundary*	N: E. crebra S: E. populnea
DO29	22/06/2018	-23.64	149.29	151.43	Geoffrey	E. crebra
DO30	22/06/2018	-23.63	149.29	148.82	Geoffrey	W: E. populnea, C. cunninghamiana E: E. crebra
DO31	22/06/2018	-23.69	149.25	141.68	*boundary*	N: C. cunninghamiana, silver wattle S: C. clarksoniana, E. crebra, E. tesselaris
DO32	22/06/2018	-23.69	149.25	137.70	*boundary*	W: E. populnea, F. dissosperma E: C. cunninghamiana, silver wattle
DO33	22/06/2018	-23.68	149.26	123.72	Geoffrey	E. crebra, E. tesselaris. C. cunninghamiana
DO34	22/06/2018	-23.66	149.25	142.72	Kosh	E. crebra, C. clarksoniana, A. rhodoxylon
DO35	22/06/2018	-23.66	149.25	134.31	Kosh	Cleared with C. spinarum, C. lasiantha, V. nilotica
DO36	22/06/2018	-23.66	149.25	133.08	*boundary*	NW: Cleared with C. spinarum SE: A. rhodoxylon, E. crebra

Site Name	Date	Latitude	Longitude	Elevation	Soil Unit	Vegetation Notes
DO37	22/06/2018	-23.66	149.25	130.55	Kosh	Cleared, C. spinarum, C. lasiantha
DO38	22/06/2018	-23.66	149.23	119.76	Kosh	Cleared, V. nilotica
DO39	22/06/2018	-23.67	149.24	131.19	James	C. clarksoniana, E. crebra Charlevue, A. rhodoxylon
DO40	23/06/2018	-23.66	149.25	136.54	James	E. crebra, A. rhodoxylon
DO41	23/06/2018	-23.66	149.25	130.72	*boundary*	N: A. rhodoxylon S: E. crebra, A. rhodoxylon, E. populnea
DO42	23/06/2018	-23.66	149.25	131.46	James	C. clarksoniana, E. crebra, A. rhodoxylon
DO43	23/06/2018	-23.66	149.24	137.23	*boundary*	W: E. crebra, C. clarksoniana, A. rhodoxylon E: E. crebra, C. clarksoniana
DO44	23/06/2018	-23.66	149.24	133.07	*boundary*	NE: E. crebra, SW: Cleared
DO45	23/06/2018	-23.65	149.24	134.12	Barry	L. hookeri, E. tereticornis, C. cunninghamiana
DO46	23/06/2018	-23.65	149.26	160.48	Geoffrey	E. crebra, A. rhodoxylon, C. brewsteri
DO47	23/06/2018	-23.65	149.26	156.06	Unsure	F. dissosperma, E. populnea
DO48	23/06/2018	-23.65	149.25	146.98	*boundary*	SW: E. crebra, A. rhodoxylon NE: L. hookeri, C. clarksoniana, E. tereticornis
DO49	23/06/2018	-23.66	149.25		*boundary*	SW: E. crebra N: A. rhodoxylon
DO50	23/06/2018	-23.66	149.25	157.90	*boundary*	S: E. crebra N: A. rhodoxylon
DO51	23/06/2018	-23.66	149.26	157.27	Geoffrey	A. rhodoxylon
DO52	23/06/2018	-23.65	149.27	159.55	Geoffrey	E. populnea, E. crebra, A. rhodoxylon
DO53	23/06/2018	-23.64	149.27	154.17	Geoffrey	
DO54	24/06/2018	-23.63	149.21	146.89	Unsure	A. salicina, E. crebra, A. rhodoxylon
DO55	24/06/2018	-23.64	149.22		Anderson	E. crebra, A. rhodoxylon, E. australe
DO56	24/06/2018	-23.64	149.22	125.28	*boundary*	SE: Cleared NW: Cleared with E. crebra, A. rhodoxylon
DO57	24/06/2018	-23.65	149.23	135.23	*boundary*	S: E. populnea, L. hookeri, C. clarksoniana N: DP22 (Kosh)
DO58	24/06/2018	-23.64	149.23	153.93	Geoffrey	M. leucadendra, C. cunninghamiana, silver wattle
DO59	24/06/2018	-23.64	149.23	155.62	Geoffrey	Cleared, silver acacia shrubs
DO60	24/06/2018	-23.63	149.26	101.34	*boundary*	W: C. cunninghamiana, M leucadendra, C. clarksoniana E: Cleared
DO61	24/06/2018	-23.63	149.25	107.73	Geoffrey	Cleared with M. leucadendra
DO62	24/06/2018	-23.63	149.25	117.22	Geoffrey	Cleared with M. leucadendra, C. cunninghamiana
DO63	24/06/2018	-23.63	149.24	121.62	Geoffrey	Cleared
DO64	24/06/2018	-23.63	149.23	120.99	Geoffrey	C. cunninghamiana, M. leucadendra, C. clarksoniana
DO65	24/06/2018	-23.63	149.23	119.36	Geoffrey	Cleared, E. populnea shrubs
DO66	24/06/2018	-23.63	149.24	112.17	*boundary*	Cleared
DO67	24/06/2018	-23.63	149.24	115.92	Kosh	
DO68	24/06/2018	-23.63	149.24	114.36	*boundary*	S: Geoffrey N: Kosh
DO69	24/06/2018	-23.63	149.24	115.14	*boundary*	S: V. nilotica N: gum shrubs
DO70	24/06/2018	-23.63	149.24	114.56	Geoffrey	M. leucadendra, C. clarksoniana
DO71	24/06/2018	-23.63	149.25	101.65	Geoffrey	C. clarksoniana

Site Name	Date	Latitude	Longitude	Elevation	Soil Unit	Vegetation Notes
DO72	24/06/2018	-23.64	149.25	99.67	*boundary*	N: C. clarksoniana, E. populnea S: V. nilotica, C. lasiantha
DO73	24/06/2018	-23.65	149.24	103.09	Kosh	V. nilotica, A. salicina
DO74	24/06/2018	-23.64	149.23	103.96	*boundary*	N: M. leucadendra, silver wattle S: V. nilotica
DO75	25/06/2018	-23.62	149.20	161.90	Anderson	E. austral, C. clarksoniana, E. crebra
DO76	25/06/2018	-23.62	149.21		*boundary*	NE: A. excelsa, M. leucadendra SW: E. australe
DO77	25/06/2018	-23.62	149.21	150.49	Geoffrey	
DO78	25/06/2018	-23.62	149.21	142.42	Geoffrey	M. leucadendra, C. clarksoniana, silver wattle
DO79	25/06/2018	-23.62	149.20	142.41	Barry	E. populnea, A. excelsa
DO80	25/06/2018	-23.62	149.20		Geoffrey	M. leucadendra
DO81	25/06/2018	-23.62	149.26	130.63	Geoffrey	M. leucadendra, C. cunninghamiana, E. australe, E. tesselaris, E. populnea, C. clarksoniana
DO82	25/06/2018	-23.61	149.25	145.47	Geoffrey	A. excelsa, E. crebra, C. clarksoniana, E. australe
DO83	25/06/2018	-23.60	149.25		Nigel	A. rhodoxylon
DO84	25/06/2018	-23.60	149.25	141.34	*boundary*	NW: E. populnea, A. excelsa, C. clarksoniana, E. australe SE: A. rhodoxylon
DO85	25/06/2018	-23.62	149.25	137.74	*boundary*	SE: C. clarksoniana, E. crebra, E. australe, A. excelsa NW: A. sherleyi
DO86	25/06/2018	-23.62	149.22	97.63	Geoffrey	E. tesselaris, E. tereticornis
DO87	25/06/2018	-23.62	149.23	97.59	*boundary*	
DO88	26/06/2018	-23.61	149.23	95.61	Geoffrey	P. pubecens, A. excelsa, E. crebra, E. tesselaris
DO89	26/06/2018	-23.60	149.24	103.38	Geoffrey	A. excelsa, C. clarksoniana, P. pubecens
DO90	26/06/2018	-23.60	149.24		Geoffrey	A. excelsa, C. clarksoniana, P. pubecens
DO91	26/06/2018	-23.60	149.24	97.07	Geoffrey	E. populnea, A. harpophylla, E. tereticornis
DO92	26/06/2018	-23.60	149.23	99.37	Geoffrey	E. populnea, C. lasiantha, C. brewsteri, C. clarksoniana
DO93	26/06/2018	-23.60	149.23	112.69	Geoffrey	Cleared with C. clarksoniana
DO94	26/06/2018	-23.60	149.23	112.07	Geoffrey	E. crebra, C. clarksoniana, A. excelsa, C. cunninghamiana, M. leucadendra
DO95	26/06/2018	-23.61	149.23	125.99	*boundary*	W: Lancewood Ellesmere E: E. crebra, C. clarksoniana, A. excelsa, C. cunninghamiana, M/ leucadendra
DO100	26/06/2018	-23.60	149.22	133.16	*boundary*	NE: Cleared SW: A. sherleyi
DO101	26/06/2018	-23.60	149.22	135.95	Nigel	Lancewood
DO102	26/06/2018	-23.60	149.22		*boundary*	SW: A. excelsa, C. clarksoniana, M. leucadendra, E. crebra NE: A. sherleyi
DO103	26/06/2018	-23.60	149.22	136.65	Geoffrey	
DO104	26/06/2018	-23.60	149.22	139.50	*boundary*	Cleared
DO105	26/06/2018	-23.61	149.22	144.54	*boundary*	
DO106	26/06/2018	-23.61	149.22	144.11	*boundary*	
DO107	26/06/2018	-23.61	149.22	138.97	Nigel	
DO108	26/06/2018	-23.62	149.22	132.74	*boundary*	

Site Name	Date	Latitude	Longitude	Elevation	Soil Unit	Vegetation Notes
DO109	26/06/2018	-23.62	149.22	122.39	Geoffrey	
DO110	26/06/2018	-23.61	149.21	133.53	*boundary*	
DO111	26/06/2018	-23.62	149.23	118.64	Geoffrey	
DO112	26/06/2018	-23.62	149.23	126.91	Geoffrey	
DO113	26/06/2018	-23.62	149.24	131.25	Geoffrey	
DO114	26/06/2018	-23.62	149.24	133.52	Geoffrey	A. excelsa, E. australe, C. clarksoniana, C. cunninghamiana, M. leucadendra
DO115	26/06/2018	-23.62	149.22	114.31	Geoffrey	Cleared with E. populnea and C. spinarum
DO116	26/06/2018	-23.62	149.22		Geoffrey	E. teritecornis
DO117	26/06/2018	-23.62	149.22	110.71	*boundary*	W: Cleared E: E. populnea, E. tereticornis, E. tesselaris
DO118	26/06/2018	-23.61	149.23	109.29	*boundary*	NW: Cleared with gum shrubs SE: Cleared with C. spinarum and C. lasiantha
DO119	26/06/2018	-23.61	149.22	127.46	*boundary*	S: Cleared N: A. rhodoxylon, A. sherleyi, E. crebra
DO200	26/06/2018	-23.61	149.23	113.78	Geoffrey	
DO201	26/06/2018	-23.62	149.22	114.21	Kosh	C. spinarum, E. populnea (shrubs)
DO202	27/06/2018	-23.63	149.28	88.31	*boundary*	E: M. leucadendra, E. crebra W: Cleared with C. spinarum, C. lasiantha and V. nilotica
DO203	27/06/2018	-23.63	149.28	88.35	Barry	E: M. leucadendra, E. crebra, A. hemiglauca W: Cleared with C. spinarum, C. lasiantha and V. nilotica
DO204	27/06/2018	-23.62	149.28		Kosh	L. hookeri, E. tereticornis, A. hemiglauca
DO205	27/06/2018	-23.62	149.28	89.52	*boundary*	Cleared with C. lasiantha
DO206	27/06/2018	-23.62	149.28	90.15	*boundary*	E: Cleared with C. lasiantha W: E populnea S: L. hookeri
DO207	27/06/2018	-23.62	149.28	87.91	*boundary*	NW: C. brewsteri, A. salicina SE: V. nilotica
DO208	27/06/2018	-23.62	149.28	88.71	Normanby	V. nilotica, C. lasiantha
DO209	27/06/2018	-23.62	149.28	96.42	Unsure	
DO210	27/06/2018	-23.62	149.27	98.61	*boundary*	W: E. populnea, A. hemiglauca, E. crebra E: Cleared
DO211	27/06/2018	-23.62	149.27	100.35	*boundary*	
DO212	27/06/2018	-23.62	149.27	99.42	*boundary*	
DO213	27/06/2018	-23.61	149.27	104.48	Geoffrey	M. leucadendra, E. tereticornis, A. excelsa, C. cunninghamiana
DO214	27/06/2018	-23.60	149.26	118.34	*boundary*	S: M. leucadendra, C. cunninghamiana N: A. rhodoxylon
DO215	27/06/2018	-23.60	149.26	118.67	*boundary*	
DO216	27/06/2018	-23.63	149.27	112.48	Geoffrey	N: A. excelsa, P. pubecens, C. clarksoniana, E. crebra S: A. rhodoxylon
DO217	27/06/2018	-23.62	149.26	113.31	Geoffrey	
DO218	27/06/2018	-23.62	149.27	114.90	Geoffrey	E. crebra. C. clarksoniana
DO219	27/06/2018	-23.62	149.27	113.93	*boundary*	SE: C. clarksoniana NW: E. crebra

Site Name	Date	Latitude	Longitude	Elevation	Soil Unit	Vegetation Notes
DO220	27/06/2018	-23.62	149.27	119.20	*boundary*	
DO221	27/06/2018	-23.62	149.27	115.32	Geoffrey	
DO222	27/06/2018	-23.62	149.27	118.86	*boundary*	
DO223	27/06/2018	-23.62	149.26	118.08	*boundary*	W: M. leucadendra, E. tereticornis E: Cleared with E. crebra
DO224	27/06/2018	-23.61	149.25	134.53	*boundary*	N: M. leucadendra, E. tereticornis, A. excelsa, C. cunninghamiana S: A. sherleyi
DO225	27/06/2018	-23.61	149.25	147.83	*boundary*	S: M. leucadendra, E. tereticornis, A. excelsa, C. cunninghamiana N: A. rhodoxylon
DO226	27/06/2018	-23.61	149.26	115.50	Geoffrey	E. tereticornis
DO227	27/06/2018	-23.63	149.26	97.94	Geoffrey	A. rhodoxylon, E. populnea, A. hemiglauca
DO228	27/06/2018	-23.63	149.27	97.28	Geoffrey	
DO229	27/06/2018	-23.63	149.29	107.20	Geoffrey	
DO230	27/06/2018	-23.64	149.29	96.27	Geoffrey	
DO231	27/06/2018	-23.66	149.23	104.96	Kosh	V. nilotica, C. lasiantha, C. spinarum
DO232	28/06/2018	-23.66	149.23	107.90	Geoffrey	
DO233	28/06/2018	-23.67	149.26	109.30	*boundary*	
DO234	28/06/2018	-23.67	149.25	117.29	Unsure	A. rhodoxylon
DO235	28/06/2018	-23.67	149.26	113.80	*boundary*	
DO236	28/06/2018	-23.66	149.26	136.84	*boundary*	N: C. clarksoniana, C. cunninghamiana, M. leucadendra S: A. rhodoxylon
DO237	28/06/2018	-23.64	149.24	128.20	*boundary*	N: Low lying grasses S: longer grasses on rise
DO238	28/06/2018	-23.64	149.22	147.20	Geoffrey	C. brewsteri, E. populnea
DO239	28/06/2018	-23.64	149.22	147.21	Geoffrey	E. populnea, silver wattle, C. clarksoniana
DO240	28/06/2018	-23.64	149.22	142.71	Geoffrey	C. brewsteri, silver wattle
DO241	28/06/2018	-23.64	149.23	148.84	Geoffrey	C. brewsteri, silver wattle
DO243	28/06/2018	-23.65	149.26	150.16	*boundary*	A. rhodoxylon
DO244	28/06/2018	-23.66	149.26	143.69	Charlevue	A. rhodoxylon
DO245	28/06/2018	-23.64	149.23	138.43	Geoffrey	C. brewsteri, silver wattle
DO246	28/06/2018	-23.69	149.26	140.80	Geoffrey	Cleared
DO247	28/06/2018	-23.69	149.26	142.68	Geoffrey	Cleared
DO248	28/06/2018	-23.67	149.26	132.57	Wallace	Cleared
DO249	28/06/2018	-23.64	149.29	124.77	Geoffrey	Cleared
DO250	28/06/2018	-23.64	149.27	119.88	Kosh	Cleared with V. nilotica, C. lasiantha, C. spinarum
DO251	28/06/2018	-23.62	149.28	113.38	Geoffrey	Cleared
DO252	28/06/2018	-23.64	149.28	126.57	Geoffrey	Cleared
DO253	28/06/2018	-23.67	149.24	136.26	James	E. crebra, A. rhodoxylon
DO254	28/06/2018	-23.66	149.23	133.32	Geoffrey	Cleared
DO255	28/06/2018	-23.66	149.24	128.72	Kosh	Cleared with V. nilotica, C. lasiantha, C. spinarum
DO256	28/06/2018	-23.67	149.24	136.77	Geoffrey	Cleared
DO257	28/06/2018	-23.65	149.26	134.96	Geoffrey	
DO258	28/06/2018	-23.68	149.26	134.77	Geoffrey	
DO260	28/06/2018	-23.61	149.26	128.32	Geoffrey	

Site Name	Date	Latitude	Longitude	Elevation	Soil Unit	Vegetation Notes
DO261	28/06/2018	-23.61	149.23	126.20	Geoffrey	
DO262	28/06/2018	-23.62	149.21	143.30	Geoffrey	
DO263	28/06/2018	-23.62	149.21	140.69	Geoffrey	
DO264	28/06/2018	-23.64	149.27	107.58	*boundary*	SE: Cleared NW: Cleared with V. nilotica and C. lasiantha
DO265	28/06/2018	-23.64	149.28		Geoffrey	Cleared with E. populnea
Heavy clay intergrade	28/06/2018	-23.67	149.25	113.92	*boundary*	

GEMINI PROJECT
Site-specific EA Application: Revised Supporting Information

PREPARED FOR
MAGNETIC SOUTH PTY LTD

DECEMBER 2020

BRISBANE OFFICE
Suite 5, 1 Swann Road
Taringa, QLD 4068
P +61 7 3217 8772

CAIRNS OFFICE
PO Box 4887
Cairns, QLD 4879
P +61 7 4057 9402

E info@aarc.net.au
AARC.NET.AU

ACN. 620 818 920
ABN. 71 620 818 920

AARC Environmental Solutions Pty Ltd

Document History and Status

Issue	Rev.	Issued To	Qty	Date	Reviewed	Approved
1	0	Internal	1	10/10/19	GB	GB
1	0	MS	1	10/10/19	PI	PI
2	1	Internal	1	17/10/19	GB	GB
2	1	MS	1	17/10/19	PI	PI
3	0	MS	1	15/12/20	JX	JX
3	1	Internal	1	21/12/20	HC	HC

Project Manager:	Gareth Bramston
Name of Client:	Magnetic South Pty Ltd
Name of Project:	Gemini Project
Title of Document:	Site-specific EA Application: Revised Supporting Information
Document Version:	Final

This controlled document is the property of AARC Environmental Solutions Pty Ltd, and all rights are reserved in respect of it. This document may not be reproduced or disclosed in any manner whatsoever, in whole or in part, without the prior written consent of AARC Environmental Solutions Pty Ltd. AARC Environmental Solutions Pty Ltd expressly disclaims any responsibility for or liability arising from the use of this document by any third party.

Opinions and judgments expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal opinions. Information obtained from interviews and contained in the documentation has been assumed to be correct and complete. AARC Environmental Solutions Pty Ltd does not accept any liability for misrepresentation of information or for items not visible, accessible, nor able to be inspected at the sites at the time of the site visits.

GEMINI PROJECT
EA APPLICATION

INDEX

1.0 INTRODUCTION 1

1.1 THE PROPONENT 1

1.2 ENVIRONMENTAL IMPACT STATEMENT TRIGGERS 1

1.3 CONTENT OF SUPPORTING INFORMATION 1

1.4 ENVIRONMENTALLY RELEVANT ACTIVITIES 1

1.5 NOTIFIABLE ACTIVITIES 1

2.0 PROJECT LOCATION, SETTING AND TENURE 6

2.1 LOCATION AND SETTING 6

2.2 LOCAL METEOROLOGICAL CONDITIONS 9

2.3 TENURE AND LAND OWNERSHIP 10

2.3.1 Tenure 10

2.3.2 Land Ownership 13

3.0 PROJECT DESCRIPTION 15

3.1 PROJECT OVERVIEW 15

3.2 PROJECT DISTURBANCE AREA 18

3.3 CONSTRUCTION 18

3.3.1 Mine Access Road 19

3.3.2 Explosives Storage 23

3.3.3 CHPP, Stockpiles and Overland Conveyor 23

3.3.4 Train Load Out Facility and Access Road 23

3.3.5 Haul Roads 23

3.4 SITE WATER MANAGEMENT 28

3.4.1 Water Management Principles 28

3.4.2 Site Water Management System 28

3.4.3 Water Management Infrastructure 31

3.4.3.1 Temporary Flood Protection Levee 31

3.4.3.2 Clean Water Drains 31

3.4.3.3 Water Storages 40

3.4.4 Preliminary Consequence Category Assessment 41

3.4.4.1 Consequence Assessment – Dams 41

3.4.4.2 Consequence Assessment – Levee 42

3.4.5 Site Water Balance Model 42

3.5 SUPPORTING INFRASTRUCTURE 45
3.5.1 Power Supply 45
3.5.2 Water Supply 45
3.5.3 Sewage 46
3.5.3.1 Irrigation Management Area 46
3.5.3.2 Irrigation Regime 47
3.5.4 Telecommunications 50
3.5.5 Fuel Supply 50
3.6 MINING OPERATIONS 50
3.6.1 Open-cut Mining Method and Activities 50
3.6.2 Mine Schedule 51
3.6.3 ROM Coal Processing 63
3.6.4 Rail Transport and Port Operations 63
3.7 EQUIPMENT FLEET 65
3.8 ROAD TRANSPORT 65
3.9 WORKFORCE 66
3.10 WORKFORCE ACCOMMODATION 66
4.0 REHABILITATION AND CLOSURE 67
4.1 LEGISLATIVE FRAMEWORK 67
4.1.1 Environmental Protection Act 1994 67
4.1.2 Mineral and Energy Resources (Financial Provisioning) Act 2018 67
4.1.3 Policies, Subordinate Legislation and Guidelines 68
4.2 KEY INFLUENCING ECOSYSTEM PROCESSES AND FUNCTIONS 68
4.2.1 Climate 68
4.2.2 Landscape, Landform and Hydrology 68
4.2.3 Spoil Geochemistry 69
4.2.4 Topsoil Resources 70
4.2.5 Terrestrial Ecology 71
4.2.6 Current Land Use and Land Suitability 72
4.3 REHABILITATION OBJECTIVES 72
4.3.1 Rehabilitation Areas 73
4.3.2 Post-mining Land Use 75
4.3.2.1 Alternative Post-Mine Closure Options Analysed 77
4.4 REHABILITATION METHODS AND CONTROLS 80
4.4.1 Reshaping/Landform Development 80
4.4.2 Topsoil Management 80
4.4.2.1 Identification of Topsoil Resources 81
4.4.2.2 Topsoil Stripping 81
4.4.2.3 Topsoil Stockpiling 81
4.4.2.4 Topsoil Application 82

4.4.2.5 Topsoil Inventory 83
4.4.3 Revegetation Program 83
4.4.4 Rehabilitation Maintenance and Repair 83
4.4.5 Rehabilitation Trials 84
4.4.6 Waste Rock Landform Development and Rehabilitation 84
4.4.7 Rejects Placement 86
4.4.7.1 Final Voids 87
4.4.8 Mine Infrastructure Areas 90
4.4.9 Water Management Infrastructure 90
4.5 REHABILITATION MILESTONES 91
4.5.1 Schedule of Land Available for Rehabilitation 91
4.5.1.1 Milestone 1: Infrastructure Decommissioning and Removal 91
4.5.1.2 Milestone 2: Remediation of Contaminated Land 91
4.5.1.3 Milestone 3: Landform Development and Reshaping / Profiling 92
4.5.1.4 Milestone 4: Surface Preparation 92
4.5.1.5 Milestone 5: Revegetation 92
4.5.1.6 Milestone 6: Establishment of Target Vegetation 92
4.5.1.7 Milestone 7: Residual Void Lake 93
4.5.1.8 Milestone 8: Achievement of Stable PMLU 93
4.5.2 Rehabilitation Indicators and Completion Criteria 93
4.6 PRELIMINARY REHABILITATION MILESTONE SCHEDULE 96
4.7 LAND DISTURBANCE MANAGEMENT AND CONTROLS 113
4.7.1 Land Disturbance Permit System 113
4.7.2 Erosion and Sediment Control 114
4.7.3 Contaminated Land 115
4.7.4 Weed and Pest Management Plan 116
4.7.5 Grazing and Agriculture Management 117
4.8 REHABILITATION MONITORING AND MEASUREMENT 118
4.8.1 Monitoring Methodology 118
4.8.2 Review of Rehabilitation Monitoring Data 119
4.9 CLOSURE AND RELINQUISHMENT 120
4.9.1 Closure Planning 120
4.9.2 Final Rehabilitation Report and EA Surrender 120
5.0 LAND 121
5.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES 121
5.2 DESCRIPTION OF ENVIRONMENTAL VALUES 121
5.2.1 Landform and Visual Amenity 121
5.2.2 Native Title and Cultural Heritage 123
5.2.3 Geology 123
5.2.4 Land Systems 127

5.2.5 Soils 127
5.2.6 Land Suitability 133
5.2.7 Land Use 136
5.2.8 Areas of Regional Interest 136
5.3 POTENTIAL IMPACTS 138
5.3.1 Landform 138
5.3.2 Visual Amenity 138
5.3.3 Soils 139
5.3.3.1 Sodic Soils 139
5.3.4 Land Suitability and Land Use 140
5.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING 140
5.4.1 Landform 140
5.4.2 Visual Amenity 141
5.4.3 Land Contamination 141
5.4.3.1 Emergency Response and Spill Management Plan 141
5.4.3.2 Fuel and Hazardous Storage Management Plan 143
5.4.4 Soils 145
5.4.5 Erosion Protection Measures 146
5.4.6 Topsoil Handling Procedures 146
5.4.7 Land Suitability and Land Use 147
5.4.8 Cultural Heritage Management Plan 147
5.4.8.1 Aboriginal Object Find 148
5.4.8.2 Human Skeletal Remains Find 148
6.0 FLORA AND FAUNA 150
6.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES 150
6.2 DESCRIPTION OF ENVIRONMENTAL VALUES 151
6.2.1 Regional and Local Setting 151
6.2.2 Terrestrial Flora 152
6.2.3 Terrestrial Fauna 157
6.2.4 Aquatic Ecology 158
6.3 POTENTIAL IMPACTS 162
6.3.1 Terrestrial Flora 162
6.3.2 Terrestrial Fauna 163
6.3.3 Aquatic Ecology 165
6.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING 166
6.4.1 Terrestrial Flora 166
6.4.2 Terrestrial Fauna 167
6.4.3 Aquatic Ecology 168
6.5 ENVIRONMENTAL OFFSETS 169

7.0 SURFACE WATER 172
7.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES 172
7.2 DESCRIPTION OF ENVIRONMENTAL VALUES 172
7.2.1 Drainage Network 173
7.2.2 Wetlands 177
7.2.3 Surface Water Quality 177
7.2.4 Stream Sediment Quality 184
7.2.4.1 Stream Sediment Characteristics 184
7.2.5 Existing Flood Conditions 185
7.3 POTENTIAL IMPACTS 186
7.3.1 Project Water Availability 186
7.3.2 Loss of Catchment Area 189
7.3.3 Impacts on Surface Water Quality 190
7.3.4 Mine Affected Water Releases 190
7.3.5 Post-mining Final Void Lakes 191
7.3.6 Impacts on Flooding 191
7.3.7 Cumulative Impacts 195
7.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING 195
7.4.1 Site Water Management Plan 195
7.4.2 Mine Affected Water Release 198
7.4.3 Flood Mitigation 198
7.4.4 Receiving Water Monitoring 198
7.4.4.1 Receiving Environment Monitoring Program 198
7.4.5 Site Water Management System Monitoring 200
8.0 GROUNDWATER 201
8.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES 201
8.2 DESCRIPTION OF ENVIRONMENTAL VALUES 201
8.2.1 Geology and Hydrogeology 202
8.2.2 Groundwater Quality 206
8.2.3 Hydraulic Conductivity 207
8.2.4 Groundwater Level 208
8.3 POTENTIAL IMPACTS 213
8.3.1 Groundwater Model 214
8.3.2 Assessment Criteria 214
8.3.3 Modelling Results 215
8.3.4 Impacts on Existing Groundwater Users 218
8.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING 219
9.0 AIR QUALITY 225
9.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES 225

9.2 DESCRIPTION OF ENVIRONMENTAL VALUES 225
9.2.1 Land Use 226
9.2.2 Climate and Wind Characteristics 226
9.2.3 Existing Air Quality 226
9.2.3.1 Existing Sources of Emissions 226
9.2.3.2 Ambient Air Quality 226
9.2.4 Sensitive Receptors 229
9.3 POTENTIAL IMPACTS 231
9.3.1 Air Quality Objectives and Criteria 232
9.3.2 Emissions 232
9.3.3 Modelling Results 233
9.3.3.1 Suspended Particulate Matter (TSP) 234
9.3.3.2 Suspended Particulate Matter (PM_{10}) 234
9.3.3.3 Suspended Particulate Matter ($PM_{2.5}$) 235
9.3.3.4 Dust Deposition 235
9.3.4 Impacts and Risks 235
9.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING 236
9.4.1 Air Quality Management Plan 237

10.0 GREENHOUSE GAS 239
10.1 REGULATORY FRAMEWORK FOR GREENHOUSE GAS EMISSIONS 239
10.2 EMISSIONS SOURCES 240
10.2.1 Land Clearing 240
10.3 EMISSIONS ESTIMATION 241
10.3.1 Scope 1 and Scope 2 241
10.3.2 Scope 3 242
10.3.3 Reportable Emissions 242
10.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING 243

11.0 NOISE AND VIBRATION 244
11.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES 244
11.2 DESCRIPTION OF ENVIRONMENTAL VALUES 244
11.2.1 Land Use 244
11.2.2 Sensitive Receptors 244
11.2.3 Climate and Wind Characteristics 245
11.2.4 Background Noise Levels 245
11.3 POTENTIAL IMPACTS 246
11.3.1 Noise Quality Objectives and Criteria 246
11.3.2 Noise Prediction Model 247
11.3.3 Noise Modelling Results 248
11.3.4 Background Creep 258

11.3.5 Vibration Assessment 258
11.3.6 Impact Summary 260
11.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING 261
11.4.1 Noise Monitoring 261
11.4.2 Noise Mitigation Management and Scenarios 262
12.0 WASTE GENERATION 264
12.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES 264
12.2 DEFINITION OF WASTE 264
12.3 IDENTIFIED WASTE TYPES 266
12.4 REGIONAL WASTE MANAGEMENT FACILITIES 273
12.5 WASTE MANAGEMENT 273
12.6 CLEANER PRODUCTION 276
12.7 REGULATED WASTE MANAGEMENT 277
12.7.1 Regulated Waste Treatment and Disposal 277
12.7.1.1 Sewage Waste Treatment 278
12.7.1.2 Sludge Treatment 279
12.7.2 Regulated Waste Transport 279
12.8 WASTE AUDITING, MONITORING AND REPORTING 280
12.8.1 Non-Mineral Waste Management Plan 280
13.0 WASTE ROCK AND COAL REJECT GEOCHEMISTRY 282
13.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES 282
13.2 DESCRIPTION OF ENVIRONMENTAL VALUES 283
13.2.1 Surface Water and Groundwater Resources 283
13.3 POTENTIAL IMPACTS 284
13.3.1 Coal Reject Geochemistry 284
13.3.2 Waste Rock Geochemistry 285
13.3.3 Potential Impacts on Surface and Groundwater Resources 286
13.3.4 Spontaneous Coal Combustion Potential 287
13.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING 288
13.4.1 Coal Reject Materials 288
13.4.2 Mining Waste Materials 288
13.4.3 Spontaneous Combustion 289
13.4.4 Waste Rock Emplacement Rehabilitation 289
13.4.5 Erosion and Sediment Run-Off 291
13.4.6 Monitoring Program 291
14.0 RISK ASESSMENT 293
14.1 RISK ASSESSMENT REQUIREMENTS 293
14.2 RISK IDENTIFICATION 293
14.3 RISK ASSESSMENT PROCESS 294

14.3.1 Risk Assessment Scheme 295
14.4 RISK ASSESSMENT OUTCOMES 297
14.5 RISK MITIGATION 298
15.0 DRAFT EA CONDITIONS 304
15.1 ENVIRONMENTALLY RELEVANT ACTIVITIES 304
15.2 PROPOSED CONDITIONS 306
16.0 REFERENCES 333

LIST OF APPENDICES

Appendix A Traffic Impact Assessment ..... A
Appendix B Surface Water Assessment ..... B
Appendix C Groundwater Impact Assessment C
Appendix D Groundwater Monitoring Data ..... D
Appendix E Groundwater Monitoring and Management Plan ..... E
Appendix F Groundwater Dependent Ecosystem Assessment ..... F
Appendix G Geochemical Assessment of Mining Waste Materials ..... G
Appendix H Geochemical Assessment of Coal Reject Material ..... H
Appendix I Soil and Land Suitability Assessment I
Appendix J Terrestrial Ecology Assessment ..... J
Appendix K Aquatic Ecology Assessment ..... K
Appendix L Air Quality and Greenhouse Gas Assessment L
Appendix M Noise Impact Assessment ..... M
Appendix N Land-Based Effluent Disposal Assessment ..... N
Appendix O Visual Amenity Assessment ..... O
Appendix P Erosion and Sediment Control Plan ..... P
Appendix Q Receiving Environment Monitoring Program Design Document ..... Q
Appendix R Environmental Offsets Strategy ..... R

LIST OF FIGURES

Figure 1 Regional Location 7
Figure 2 Project Location 8
Figure 3 Climatograph 9
Figure 4 Resource Tenements – Coal 11
Figure 5 Resource Tenements – Petroleum 12

Figure 6 Land Ownership 14
Figure 7 Conceptual Layout - Gemini Project 17
Figure 8 Conceptual Design - Mine Access Road 20
Figure 9 Conceptual Design - Mine Access Road Intersection 21
Figure 10 Conceptual Layout - MIA 22
Figure 11 Conceptual Layout - MIA and Associated Infrastructure 24
25
Figure 12 Conceptual Layout - Product Coal Overland Conveyor 25
Figure 13 Conceptual Design - Conveyor Crossing (Capricorn Highway) 26
Figure 14 Conceptual Design - Conveyor Crossing (Blackwater Railway) 27
Figure 15 Proposed Integrated SWMS Schematic 30
Figure 16 Flood Protection Levee Plan and Longitudinal Section 34
Figure 17 Pit AB Clean Water Drain Conceptual Design 35
Figure 18 Pit C Clean Water Drain Conceptual Design 36
Figure 19 Pit C Clean Water Drain Conceptual Design 37
Figure 20 Pit C Clean Water Drain Conceptual Design 38
Figure 21 Levees and Drains - Typical Sections and Details 39
Figure 22 Conceptual Layout - Raw Water Supply Pipeline 49
Figure 23 Mine Stage Plan - Year 02 53
Figure 24 Mine Stage Plan - Year 04 54
Figure 25 Mine Stage Plan - Year 06 55
Figure 26 Mine Stage Plan - Year 08 56
Figure 27 Mine Stage Plan - Year 10 57
Figure 28 Mine Stage Plan - Year 12 58
Figure 29 Mine Stage Plan - Year 13 59
Figure 30 Mine Stage Plan - Year 15 60
Figure 31 Mine Stage Plan - Year 17 61
Figure 32 Mine Stage Plan – Final Landform 62
Figure 33 Conceptual Materials Handling Flowchart 64
Figure 34 Percentile Ranking of Water Years 69
Figure 35 Rehabilitation Areas 74
Figure 36 Post Mining Land Uses 76
Figure 37 Conceptual Layout of Pit AB Groundwater Levels 79
Figure 38 Milestone Completion Areas Year 4 104
Figure 39 Milestone Completion Areas Year 8 105
Figure 40 Milestone Completion Areas Year 12 106
Figure 41 Milestone Completion Areas Year 17 107
Figure 42 Milestone Completion Areas Year 21 108
Figure 43 Milestone Completion Areas Year 25 109
Figure 44 Milestone Completion Areas Year 29 110

Figure 45 Milestone Completion Areas Year 33 111
Figure 46 Milestone Completion Areas Year 37 112
Figure 47 Surface Geology 125
Figure 48 Solid Geology 126
Figure 49 Distribution of SMUs 132
Figure 50 Land Suitability Classes - Cattle Grazing 135
Figure 51 Land Suitability Classes - Dryland Cropping 137
Figure 52 Vegetation Communities 154
Figure 53 *Cerbera dumicola* Locations and Known Habitat 155
Figure 54 Locations of Fauna Species of Conservation Significance 161
Figure 55 Fitzroy River Basin 174
Figure 56 Local Catchments 175
Figure 57 Regional Receiving Environment 176
Figure 58 Water Quality Monitoring Dates on Flow Frequency Curve 180
Figure 59 Surface Water Sampling Locations 181
Figure 60 Stream Sediment Particle Size Analysis 185
Figure 61 Predicted Flood Extent and Depth For Existing Conditions (1% AEP) 187
Figure 62 Predicted Flood Velocity for Existing Conditions (1% AEP) 188
Figure 63 Raw Water Pipeline Usage 189
Figure 64 Predicted Flood Extent and Depth for Developed Conditions (1% AEP) 193
Figure 65 Change in Peak Flood Level from the Project (1% AEP) 194
Figure 66 Project Location and Bowen Basin Solid Geology 203
Figure 67 DNRME Groundwater Database - Aquifer and EC data 204
Figure 68 Groundwater Monitoring Bore Network 205
Figure 69 Relationship Between Hydraulic Conductivity and Depth 208
Figure 70 Water Level Data (Tertiary Groundwater Units) 210
Figure 71 Water Level Data (Permian Coal Seam Groundwater Units) 211
Figure 72 Water Level Data (Quaternary Alluvium - Bore DW7076W) 212
Figure 73 Water Level Data (Quaternary Alluvium - Bore DW7292W1) 212
Figure 74 Water Level Drawdown Contours (2m and 5m) - End Of Mining 216
Figure 75 Water Level Drawdown Contours (2m and 5m) - Post-Mining Equilibrium 217
Figure 76 Local Terrain 228
Figure 77 Sensitive Receptors Within 5 km of the Project 230
Figure 78 Total Greenhouse Gas Emissions by Scope 242
Figure 79 Year 2 - Night ‘Adverse’ Scenario (Mine and Rail Loadout) 252
Figure 80 Year 2 - Day ‘Adverse’ Scenario (Mine and Rail Loadout) 253
Figure 81 Year 8 - Night ‘Adverse’ Scenario (Mine and Rail Loadout) 254
Figure 82 Year 8 - Day ‘Adverse’ Scenario (Mine and Rail Loadout) 255
Figure 83 Year 15 - Night ‘Adverse’ Scenario (Mine and Rail Loadout) 256
Figure 84 Year 15 - Day ‘Adverse’ Scenario (Mine and Rail Loadout) 257

Figure 85 Current CHRC Waste Infrastructure Plan 274
Figure 86 Risk Profile 297
Figure 87 Risk Profile by Consequence Area 297

LIST OF TABLES

Table 1 EIS Trigger Criteria 2
Table 2 EP Act Requirements for Supporting Information 3
Table 3 Applicable ERAs for the Project 4
Table 4 Notifiable Activities For the Project 5
Table 5 Average Monthly Rainfall and Evaporation 10
Table 6 Land Ownership 13
Table 7 Total Disturbance Area 18
Table 8 Site Water Types 29
Table 9 Gemini Project Sediment Dam Design 41
Table 10 Summary of Consequence Assessment - Dams 42
Table 11 Overall Consequence Categories 42
Table 12 Summary of Site Water Demands and Expected Groundwater Inflows 44
Table 13 Average Annual Site Water Balance 45
Table 14 Indicative Mine Schedule 52
Table 15 Estimated Topsoil Volumes Available for Rehabilitation 71
Table 16 Land Suitability Assessment 72
Table 17 Nominated PMLUs 75
Table 18 Waste Rock Emplacement Parameters 86
Table 19 Final Void Physical Characteristics 87
Table 20 Preliminary Schedule of Land Available for Rehabilitation 91
Table 21 Rehabilitation Milestone Completion Criteria 94
Table 22 Milestone Schedule Rehabilitation Area 1 97
Table 23 Milestone Schedule Rehabilitation Area 2 98
Table 24 Milestone Schedule Rehabilitation Area 3 99
Table 25 Milestone Schedule Rehabilitation Area 4 100
Table 26 Milestone Schedule Rehabilitation Area 5 101
Table 27 Milestone Schedule Rehabilitation Area 6 102
Table 28 Milestone Schedule Rehabilitation Area 7 103
Table 29 Visual Amenity Vantage Points 123
Table 30 SMUs Within The Study Area 128
Table 31 Agricultural and Conservation Land Classes 133
Table 32 Land Suitability Classes for SMUs 134

Table 33 Summary of Vegetation Communities 153
Table 34 Weed Species of Management Concern 156
Table 35 Introduced Fauna Species 158
Table 36 Summary of Project MSES and Likelihood of Significant Residual Impact 170
Table 37 Summary of MSES Impact Assessment and Gemini Project Offset Requirements 171
Table 38 WQO Guideline Values 178
Table 39 Physico-chemical Parameters (Charlevue Creek) 182
Table 40 Physico-chemical Parameters (Stanley Creek and Springton Creek) 183
Table 41 SQG Objective Values 184
Table 42 Catchment Intercepted by SWMS at Year 18 189
Table 43 Catchment Intercepted by Final Void at Mine Closure 190
Table 44 Final Void Surface Water Model 191
Table 45 Receiving Water Monitoring Locations 199
Table 46 Summary of Groundwater Quality Results from Monitored Bores 207
Table 47 Hydraulic Conductivity and Air-Lift Yield Data Per Groundwater Unit 208
Table 48 Estimated Take of Associated Water 213
Table 49 Bores from DNRME Groundwater Database Within 2 M Drawdown Zone 219
Table 50 Groundwater Monitoring Bores 221
Table 51 Proposed Groundwater Quality Trigger Levels 223
Table 52 Ambient Background Concentrations Used To Assess Cumulative Impacts 229
Table 53 Sensitive Receptors Within 10 km of the Project 231
Table 54 EPP (Air) Relevant Air Quality Objectives 232
Table 55 Dust Control Measures and Relative Reduction in Emissions 233
Table 56 Reporting Thresholds for Greenhouse Gas Emissions and Energy Use 240
Table 57 Summary of Scope 1 and Scope 2 GHG Emissions 241
Table 58 Meteorological Scenarios 245
Table 59 Background Noise Level 246
Table 60 Proposed Noise Limits 247
Table 61 Proposed Blasting Vibration and Air-blast Criteria 247
Table 62 Predicted Noise Levels - Year 2 249
Table 63 Predicted Noise Levels – Year 8 250
Table 64 Predicted Noise Levels – Year 15 251
Table 65 Ground Vibration Levels at Various Distances from The Blast 259
Table 66 Airblast Noise Levels At Various Distances From The Blast 260
Table 67 Example Mitigation Scenarios 263
Table 68 Anticipated Waste Generation From The Construction and Operation of the Project 267
Table 69 Wastewater Quality Limits 278
Table 70 Likelihood of Exposure 295
Table 71 Severity and Consequence Classification 296

Table 72 Risk Level Matrix 296
Table 73 Risk Level Actions 296
Table 74 Summary of Identified Risks and Mitigation Measures 299
Table 75 Environmentally Relevant Activities 305

ABBREVIATIONS, ACRONYMS, AND GLOSSARY OF TERMS

<	less than
>	more than
AARC	AARC Environmental Solutions Pty Ltd
AEP	annual exceedance probability
AMD	acid mine drainage
ANFO	ammonium nitrate fuel oil
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ANZMEC	Australian and New Zealand Minerals and Energy Council
AQMP	*Air Quality Management Plan*
AS	Australian Standard
ASK	Trinity Consultants Australia Pty Ltd trading as ASK Consulting Engineers
ATP	authority to prospect
AusRivAS	Australian River Assessment System
AVH	The Australasian Virtual Herbarium
Biosecurity Act	*Biosecurity Act 2014* (Qld)
BoM	Bureau of Meteorology
BOYD	John T. Boyd Company
Cardno	Cardno (Qld) Pty Ltd
CEC	cation exchange capacity
CH_4	methane
CHPP	coal handling and preparation plant
CHRC	Central Highlands Regional Council
CMSH Act	*Coal Mining Safety and Health Act 1999*
CMSH Regulation	Coal Mining Safety and Health Regulation 2017
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
CSIRO	Commonwealth Scientific and Industrial Research Organisation

DA	former Department of Agriculture (WA)
DAF	Department of Agriculture and Fisheries (Qld)
DATSIP	Department of Aboriginal and Torres Strait Islander Partnerships (Qld)
DES	Department of Environment and Science (Qld)
DEWHA	former Department of the Environment, Water, Heritage and the Arts (Cth)
DFAT	Department of Foreign Affairs and Trade (Cth)
DME	former Department of Minerals and Energy (Qld)
DNRM	former Department of Natural Resources and Mines (Qld)
DNRME	Department of Natural Resources, Mines and Energy (Qld)
DoEE	Department of the Environment and Energy (Cth)
DSA	design storage allowance
DSITI	former Department of Science, Information Technology and Innovation (Qld)
E	east
e.g.	'*for example'*
EA Application	'*Site-specific application for a new environmental authority for a resource activity'*
EA	environmental authority
EC	electrical conductivity
EHP	former Department of Environment and Heritage Protection (Qld)
EIS	Environmental Impact Statement
EP Act	*Environmental Protection Act 1994* (Qld)
EP Regulation	*Environmental Protection Regulation 2019* (Qld)
EP	equivalent person
EPA Victoria	Environmental Protection Agency Victoria (Vic)
EPA	Environmental Protection Agency (US)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPC	exploration permit for coal
EPP (Air)	*Environmental Protection (Air) Policy 2019* (Qld)
EPP (Noise)	*Environmental Protection (Noise) Policy 2019* (Qld)
EPP (WWB)	*Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (Qld)
ERA	environmentally relevant activity
ERC	estimated rehabilitation cost
ESCP	*Erosion and Sediment Control Plan*
ESP	exchangeable sodium percentage
etc.	*'and other similar things'*

EV	environmental value
GDE	groundwater dependent ecosystem
GHG	greenhouse gas
HES	high ecological significance
i.e.	*'in other words'*
ICPMS	inductively coupled plasma mass spectrometry
IECA	International Erosion Control Association
INAP	International Network on Acid Prevention
JBT	JBT Consulting Pty Ltd
K	site and rock constant
Katestone	Katestone Environmental Pty Ltd
KLC	kinetic leach column
L_{90}	'A' weighted sound pressure level equalled or exceeded 90% of the time
$L_{Aeq,adj,T}$	the L_{eq} adjusted for tonal or impulsive noise characteristics and with a measurement interval of 'T' duration (e.g., 15 minutes, 1 hour).
LC	least concern
L_{eq}	equivalent continuous sound level
LGA	local government area
LOR	limit of reporting
Magnetic South	Magnetic South Pty Ltd (the Proponent)
MAW	mine affected water
MDL	mineral development licence
MERFP Act	*Mineral and Energy Resources (Financial Provisioning) Act 2018* (Qld)
MGA	Map Grid of Australia
MIA	mine infrastructure area
ML	mining lease
MLA	mining lease application
MRL	mandatory reporting level
MSES	Matter(s) of State Environmental Significance
N	north
n/a	not applicable
N_2O	nitrous oxide
NAF	non-acid forming

NATA	National Association of Testing Authorities
NC Act	*Nature Conservation Act 1992* (Qld)
NC	no concern at present
NE	northeast
NGER Act	*National Greenhouse and Energy Reporting Act 2007* (Cth)
NGER Determination	*National Greenhouse and Energy Reporting (Measurement) Determination 2008* (Cth)
NGER Guidelines	*National Greenhouse and Energy Reporting Guidelines*
NGER Scheme	*National Greenhouse and Energy Reporting Scheme*
No.	number
NPI	National Pollution Inventory
NPV	net present value
NT	near threatened
NUMA	non-use management area
OC	of concern
PAF	potentially acid forming
PCA	potential commercial area
PCI	pulverised coal injection
PET	Plecoptera, Ephemeroptera, Trichoptera
pH	'*scale used to specify how acidic or basic a water-based solution is*'
PM_{10}	particulate matter with equivalent aerodynamic diameters of 10 µm or less
$PM_{2.5}$	particulate matter with equivalent aerodynamic diameters of 2.5 µm or less
PMF	probable maximum flood
PMLU	post-mining land use
PPE	personal protective equipment
PPV	peak particle velocity
PRCP	*Progressive Rehabilitation and Closure Plan*
QGC	Queensland Gas Company
RE	regional ecosystem
REMP	*Receiving Environment Monitoring Program*
RGS	RGS Environmental Pty Ltd
RIS	restricted invasive species
RN	registration number

ROM	run-of-mine
SE	southeast
SILO	Scientific Information for Land Owners
SLC	special least concern
SMD	slightly to moderately disturbed
SMU	soil management unit
SQG	sediment quality guideline
STP	sewage treatment plant
SWL	surface water level
SWMS	Site Water Management System
TBA	'*to be assigned*'
TDS	total dissolved solids
TEC	threatened ecological community
the Project	Gemini Project
TLO	train load out
TSP	total suspended particulate matter
TSSC	Threatened Species Scientific Committee
V	vulnerable
V:H	vertical to horizontal ratio
VC	vegetation community
VM Act	*Vegetation Management Act 1999* (Qld)
W	west
Water Act	*Water Act 2000* (Qld)
WoNS	weed(s) of national significance
WQO	water quality objective
WRM	WRM Water and Environment Pty Ltd

UNITS OF MEASUREMENT

%	percent
°	degree(s)
°C	degree(s) Celsius
cm	centimetre(s)

dB	decibel(s)
dBA	'A' weighted decibel
dBZ	decibel relative to 'Z'
dS/m	deciSiemens per metre
ha	hectare(s)
Hz	Hertz
kg/ha	kilogram(s) per hectare
kL	kilolitre(s)
km	kilometre(s)
km^2	square kilometre(s)
kt CO_2-e	kilotonne(s) of carbon dioxide equivalent
kt	kilotonne(s)
kV	kilovolt(s)
L	litre(s)
L/s	litre(s) per second
m	metre(s)
m/day	metre(s) per day
m/s	metre(s) per second
m^2	square metre(s)
m^3	cubic metre(s)
m^3/day	cubic metre(s) per day
mAHD	metre(s) in Australian Height Datum
Mbcm	million bank cubic metre(s)
mbgl	metre(s) below ground level
meq/100g	milliequivalent per 100 grams
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per litre
mg/m^2/day	milligram(s) per square metre per day
Ml	megalitre(s)
ml	millilitre(s)
Ml/a	megalitre(s) per annum
mm	millimetre(s)
mm/s	millimetre(s) per second

Mt	million tonne(s)
Mtpa	million tonne(s) per annum
NTU	Nephelometric Turbidity Unit
t	tonne(s)
t/a	tonne(s) per annum
TJ	terajoule(s)
µg/L	microgram(s) per litre
µg/m^3	microgram(s) per cubic metre
µm	micrometre(s)
µS/cm	microSiemens per centimetre

1.0 INTRODUCTION

AARC Environmental Solutions (AARC) was commissioned by Magnetic South Pty Ltd (Magnetic South; the Proponent) to prepare an environmental authority (EA) application for the Gemini Project (the Project). This report provides the supporting information to be considered as part of the EA Application to the Department of Environment and Science (DES) in consideration of Sections 125 and 126A of the *Environmental Protection Act 1994* (EP Act).

This document provides a description of the Project, environmentally relevant activities (ERAs), environmental values (EVs), potential impacts of the ERAs on the identified EVs, and mitigation measures and management commitments.

1.1 THE PROPONENT

The Proponent for the Gemini Project is:

Magnetic South Pty Ltd

Suite 302, Level 3, 102 Adelaide Street, Brisbane, Queensland, 4000

ABN: 95 122 465 749

ACN: 122 465 749

Magnetic South is a private Australian based company which was founded in 2006. The executive team of Magnetic South has some 60 years' experience in the development and operation of metallurgical coal assets and agribusiness in central Queensland.

Magnetic South is the registered entity proposing to carry out the Project, and all permits and licences are held and will be issued to that entity.

1.2 ENVIRONMENTAL IMPACT STATEMENT TRIGGERS

The proposed EA Application does not trigger the requirement for an Environmental Impact Statement (EIS) under the EP Act. The Project does not propose any petroleum or coal seam gas activities. EIS triggers for a new application for mining activities are summarised below in Table 1.

1.3 CONTENT OF SUPPORTING INFORMATION

In accordance with Section 125 and 126A of the EP Act, this document includes the information described in Table 2.

1.4 ENVIRONMENTALLY RELEVANT ACTIVITIES

ERAs include resource activities or specific agricultural activities or other activities as defined by the EP Act. Current prescribed ERAs and resource activities are specified in Schedules 2 and 3, respectively, of the *Environmental Protection Regulation 2019* (EP Regulation). The Project will include the resource activity of "mining black coal" as well as the ancillary activities outlined in Table 3 which require approval as part of the EA Application.

1.5 NOTIFIABLE ACTIVITIES

Notifiable activities are activities that have the potential to cause land contamination. The notifiable activities listed under Schedule 3 of the EP Act relevant to the Project are provided in Table 4.

Table 1 EIS Trigger Criteria

EIS Trigger	Yes / No
For greenfield (new) mine proposals	
Would the application involve the removal of two million tonnes per year or more of run-of-mine (ROM) ore or coal?	**No.** The Gemini Project is proposing the removal of up to 1.9 Mtpa of ROM coal, averaging 1.8 Mtpa over the production life of the Project.
Would the application involve the removal of one million tonnes per year or more of ROM ore or coal on or under a floodplain or in a coastal hazard area?	**No.** The Gemini Project is not proposing the removal of 1 Mtpa or more of ROM coal under a floodplain as defined by the *Water Act 2000*.The Gemini Project is not located in a coastal hazard area.
Would the application involve the introduction of a novel or unproven resource extraction process, technology or activity?	**No.** The Gemini Project is proposing a traditional truck and shovel operation, and proven processing approach.

Table 2 EP Act Requirements for Supporting Information

Component	Relevant Section
Section 125 – Requirements for applications generally	
Description of all environmentally relevant activities for the application.	Section 1.4 and Table 3
Description of any development permit under the Planning Act, or State Development Area approval under the State Development Act required for carrying out the environmentally relevant activities for the application.	No approvals are required under the *Planning Act 2016* or *State Development and Public Works Organisation Act 1971*.
Description of the land on which each activity will be carried out.	Section 5.0
Assessment of the likely impact of each relevant activity on environmental values, including: • a description of the environmental values likely to be affected by each relevant activity; • details of any emissions or releases likely to be generated by each relevant activity; • a description of the risk and likely magnitude of impacts on the environmental values; • details of the management practices proposed to be implemented to prevent or minimise adverse impacts; and • details of how the land, the subject of the application will be rehabilitated after each relevant activity ceases.	EVs, emissions or releases, risk and magnitude of impacts, and proposed management practices are detailed within each 'environmental' section. This constitutes Section 5.0 through to Section 13.0. Section 4.0
Description of the proposed measures for minimising and managing waste generated by each relevant activity.	Section 12.5 and Section 12.7
Details of any site management plan that relates to the application.	Details of relevant management plans are covered in the *Mitigation Measures, Management and Monitoring* subsection of each 'environmental' section (Section 5.0 through to Section 13.0).
Section 126A – Requirements for site-specific applications – particular resource projects and resource activities	
Any proposed exercise of underground water rights during the period in which resource activities will be carried out under the relevant tenure.	Section 8.3
The areas in which underground water rights are proposed to be exercised.	Pit AB and Pit C mining areas as specified in the conceptual layout (Figure 7) and mine stage plans (Figure 23 through to Figure 32).
For each aquifer affected, or likely to be affected, by the exercise of underground water rights: • a description of the aquifer; • an analysis of the movement of underground water to and from the aquifer, including how the aquifer interacts with other aquifers and surface water; • a description of the area of the aquifer where the water level is predicted to decline because of the exercise of underground water rights; and • the predicted quantities of water to be taken or interfered with because of the exercise of underground water rights during the period in which resource activities are carried out.	Section 8.2.1 Section 8.2.4 and Figure 71 Section 6.3.1 and Section 6.4.1 Section 8.3.3, Figure 74 and Figure 75 Table 12 and Table 13.
The environmental values that will, or may, be affected by the exercise of underground water rights and the nature and extent of the impacts on the environmental values.	Section 8.2 Section 8.3.3 and Section 8.3.4
Any impacts on the quality of groundwater that will, or may, happen because of the exercise of underground water rights during or after the period in which resource activities are carried out.	Section 8.3.3
Strategies for avoiding, mitigating or managing the predicted impacts on the environmental values or the impacts on the quality of groundwater.	Section 8.4

Table 3 Applicable ERAs for the Project

Environmentally Relevant Activity	Description
Schedule 2 (Prescribed ERAs)	
8 (1) (c) Chemical storage	Chemical storage (the relevant activity) consists of storing more than 500 m^3 of class C1 or C2 combustible liquids under AS1940 or dangerous goods class 3. Threshold 3) Storing more than 500 m^3 of chemicals of class C1 or C2 combustible liquids under AS1940 or dangerous goods class 3 under subsection (1)(c). *Aggregate Environmental Score: 85*
31 (1) Mineral processing	Mineral processing (the relevant activity) consists of processing, in a year, a total of 1,000t or more of coke or mineral products. Threshold 2) Processing, in a year, the following quantities of mineral products, other than coke (b) more than 100,000 t. *Aggregate Environmental Score: 280*
33 (1) Crushing, milling, grinding or screening	Crushing, milling, grinding or screening (the relevant activity) consists of crushing, grinding, milling or screening more than 5,000 t of material in a year. Threshold Crushing, grinding, milling or screening more than 5,000 t of material in a year. *Aggregate Environmental Score: no score*
60 (1)(ii)(A) Waste disposal	Waste disposal (the relevant activity) consists of operating a facility for disposing of general waste and a quantity of limited regulated waste that is no more than 10% of the total amount of waste received at the facility in a year. Threshold 2) Operating a facility for disposing of, in a year, (h) more than 200,000 t. *Aggregate Environmental Score: 107*
63 (1)(b)(i) Sewage treatment	Sewage treatment (the relevant activity) consists of operating 1 or more sewage treatment works at a site that have a total daily peak design capacity of at least 21EP. Threshold 1) Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (b) more than 100 but not more than 1500 EP (i) if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme. *Aggregate Environmental Score: 27*
Schedule 3 (Resource Activity)	
13 Mining black coal	*Aggregate Environmental Score: 128*

Table 4 Notifiable Activities For the Project

Notifiable Activities	Description
Schedule 3	
1 Abrasive Blasting	Carrying out abrasive blast cleaning (other than cleaning carried out in fully enclosed booths) or disposing of abrasive blasting material.
7 Chemical Storage	Storing more than 10 t of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code.
15 Explosives production or storage	Operating an explosives factory under the *Explosives Act 1999.*
24 Mine Wastes	a) storing hazardous mine or exploration wastes, including, for example, tailing dams, overburden or waste rock dumps containing hazardous contaminants; or b) exploring for, or mining or process, minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants.
29 Petroleum Product or Oil Storage	Storing petroleum products or oil: a) in underground tanks with more than 200 litre (L) capacity; or b) in above ground tanks with: I. for petroleum products or oil in class 3 in packaging groups 1 and 2 of the dangerous goods code – more than 2,500 L capacity; or II. for petroleum products or oil in class 3 in packaging groups 3 of the dangerous goods code – more than 5,000 L capacity; or III. for petroleum products that are combustible liquids in class C1 or C2 in *Australian Standard AS1940 The storage and handling of flammable and combustible liquids* published by Standards Australia – more than 25,000 L capacity.
37 Waste Storage, treatment of disposal	Storing, treating, reprocessing or disposing of waste prescribed under a regulation to be regulated waste for this item (other than at the place it is generated), including operating a nightsoil disposal site or sewage treatment plant where the site or plant has a design capacity that is more than the equivalent of 50,000 persons having sludge drying beds or on-site disposal facilities.

2.0 PROJECT LOCATION, SETTING AND TENURE

2.1 LOCATION AND SETTING

The Project is situated within the Bowen Basin, approximately 110 km east of Emerald and 125 km southwest of Rockhampton, in central Queensland (Figure 1). Blackwater, a larger town serving mines in the region, is located approximately 34 km to the west (Figure 1). The small rural townships of Bluff and Dingo are located approximately 15 km west and 3 km east of the Project, respectively (Figure 1).

The Project is located within the Central Highlands Regional Council (CHRC) local government area (LGA), which covers approximately 60,000 km^2 and supports a population of more than 30,000 residents living in Arcadia Valley, Bauhinia, Blackwater, Bluff, Capella, Comet, Dingo, Duaringa, Emerald, Rolleston, Sapphire Gemfields, Springsure and Tieri.

Nearby mining operations include Bluff PCI Project (approximately 12 km to the west), Yarrabee Coal Mine (approximately 34 km to the northwest), Jellinbah Mine (approximately 32 km to the northwest), Curragh Coal Mine (approximately 33 km to the northwest), and the Blackwater Mine (approximately 36 km to the southwest) (Figure 2). It is noted the Bluff Mine is currently in care and maintenance with no certainty of return to operations.

Taunton National Park is situated to the north of the Project's mining lease application (MLA) area, whilst Walton State Forest is approximately 6 km to the west and Blackdown Tablelands National Park is located approximately 9 km to the southwest of the MLA (Figure 2).

The Capricorn Highway, which is a state-controlled road, links Rockhampton with western Queensland (Figure 1). Capricorn Highway traverses the MLA and links the townships of Bluff and Dingo (Figure 2). The Aurizon Blackwater Rail System (Blackwater Railway) tracks along the northern side of the Capricorn Highway (Figure 1 and Figure 2). A stock route (ID: 413CENT) tracks alongside the Capricorn Highway and is currently open but classified as minor and unused.

Publicly gazetted roads including Sanders, Namoi, Charlevue, Cooinda, Red Hill, Normanby and Ellesmere roads provide local access (Figure 2).

The topography of the MLA varies from flat to gently undulating, with elevations ranging between approximately 120-150 metres in Australian Height Datum (mAHD). The MLA and surrounds are currently used for low intensity cattle grazing and resource exploration activities. Land ownership in the vicinity of the Project is described in Section 2.3.2. It is Magnetic South's intention that the land continue to be used for agricultural purposes until such time that it is required for Project construction and/or operation. Land not required for mining activities will continue to be utilised for agricultural purposes throughout the life of the Project.

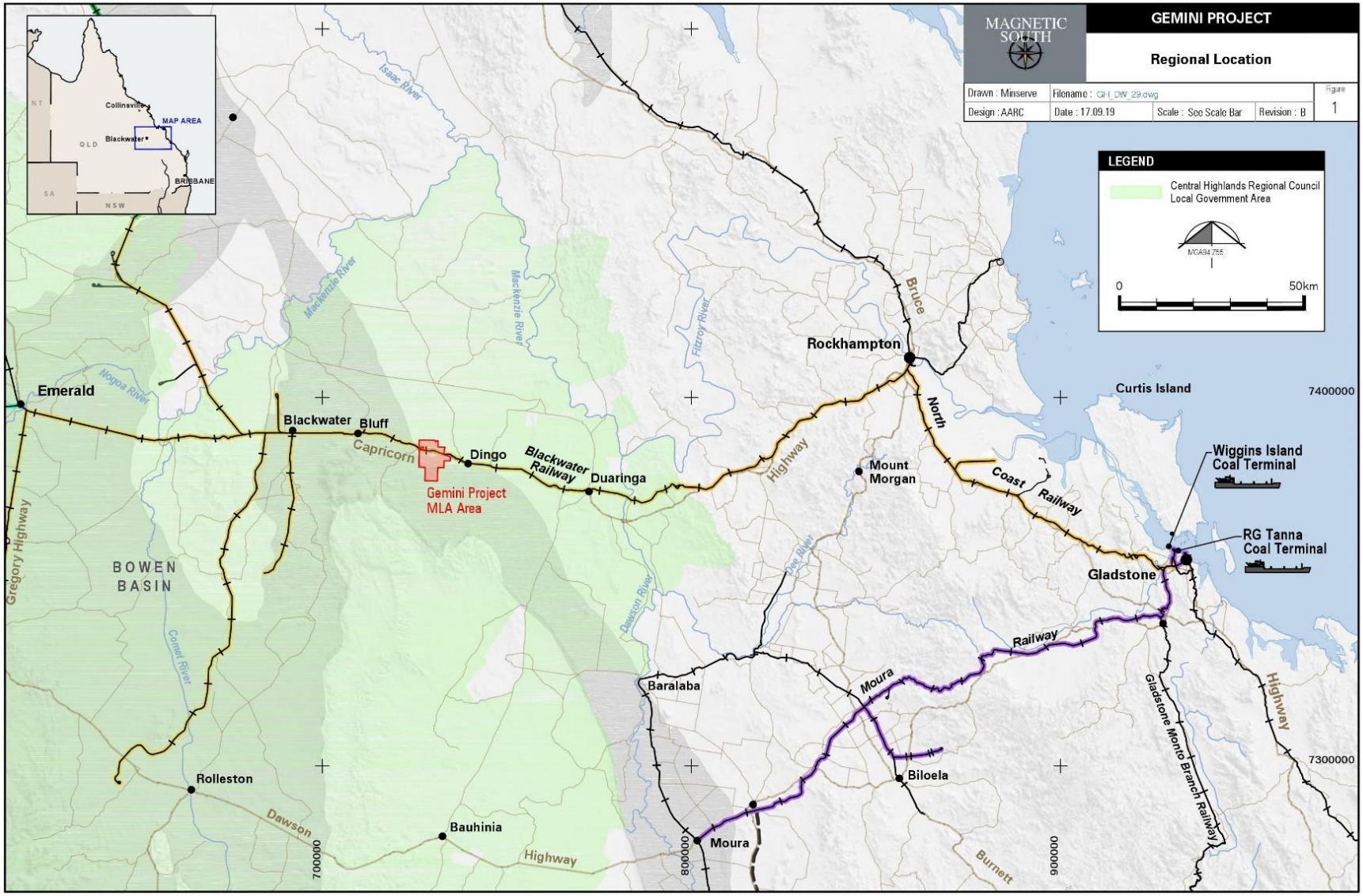


Figure 1 Regional Location

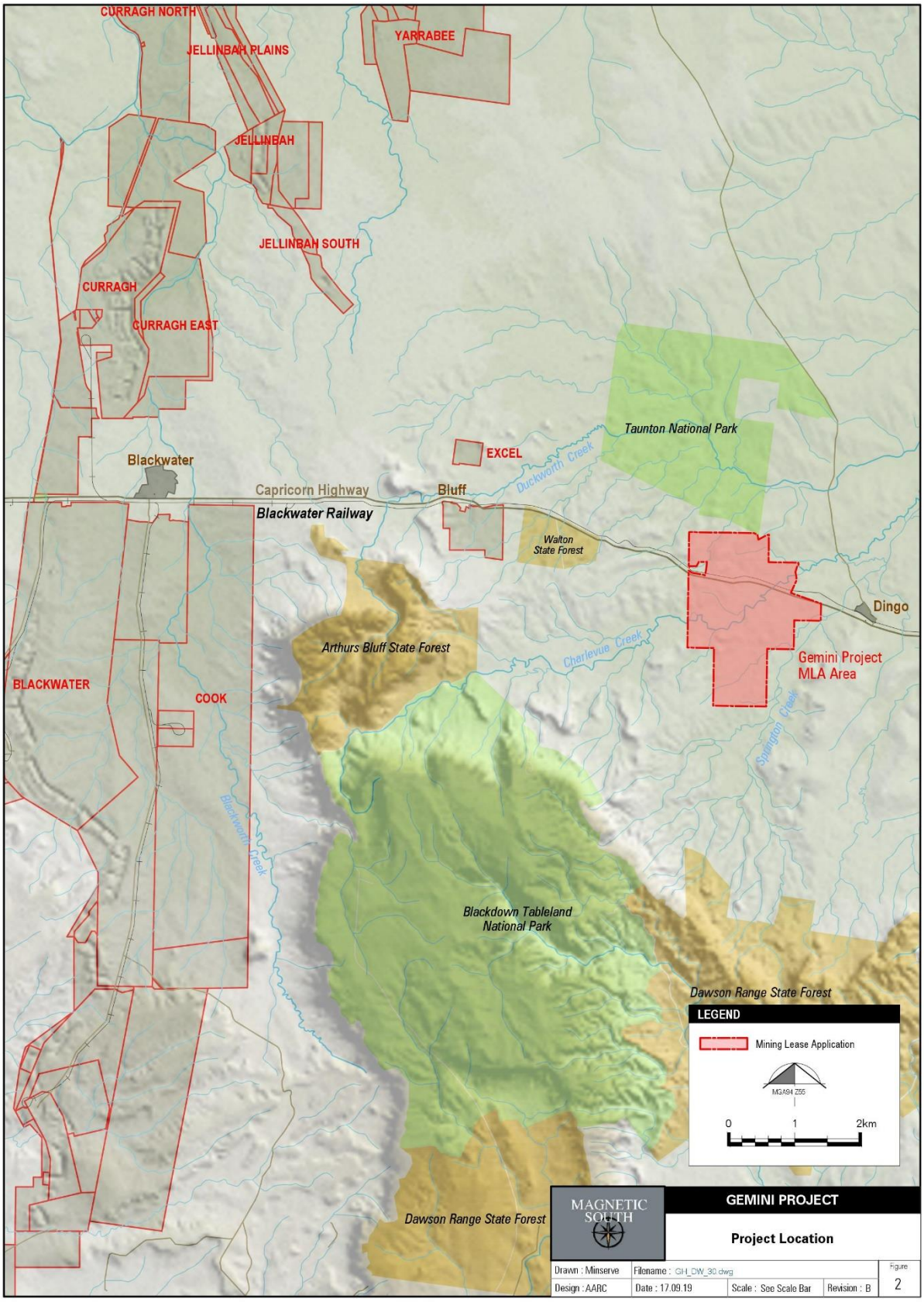


Figure 2 Project Location

2.2 LOCAL METEOROLOGICAL CONDITIONS

The Project area has a climate classification of 'subtropical' (moderately dry winter) using the Bureau of Meteorology's (BoM) modified Köppen climate classification system. The local region experiences a subtropical climate characterised by high variability seasonal rainfall subject to cyclic wet summer and dry winter seasons, with variable temperature and evaporation. Predominantly wind blows from the southeast and east in the region.

Local meteorological conditions have been compiled using data from the Scientific Information for Land Owners (SILO) Data Drill. The Data Drill accesses grids of climate data available from surrounding BoM point observations and then creates interpolated climate values for the requested location. The SILO climate data was obtained for coordinates that correspond to the approximate centre of the Project MLA. The data has been utilised to produce a climatograph for the Project (Figure 3).

The mean annual rainfall for the Project region is approximately 655 mm with average annual (pan) evaporation of 2,024 mm which exceeds rainfall for every month of the year (Table 5). Rainfall is highly seasonal, with November to March generally accepted as the 'wet season' and rainfall during this time accounting for approximately 68% of the region's total yearly rainfall. The 'dry season' usually occurs from April through to October with monthly rainfall totals below 45 mm consistently throughout this period. The rainfall data for this region is consistent with the Köppen classification of 'subtropical' (moderately dry winter).

The hottest months typically occur between October and March while the coolest months occur between May and September. The highest mean maximum temperature typically occurs in January (33.8°C) and the lowest mean minimum temperature in July (7.7°C).

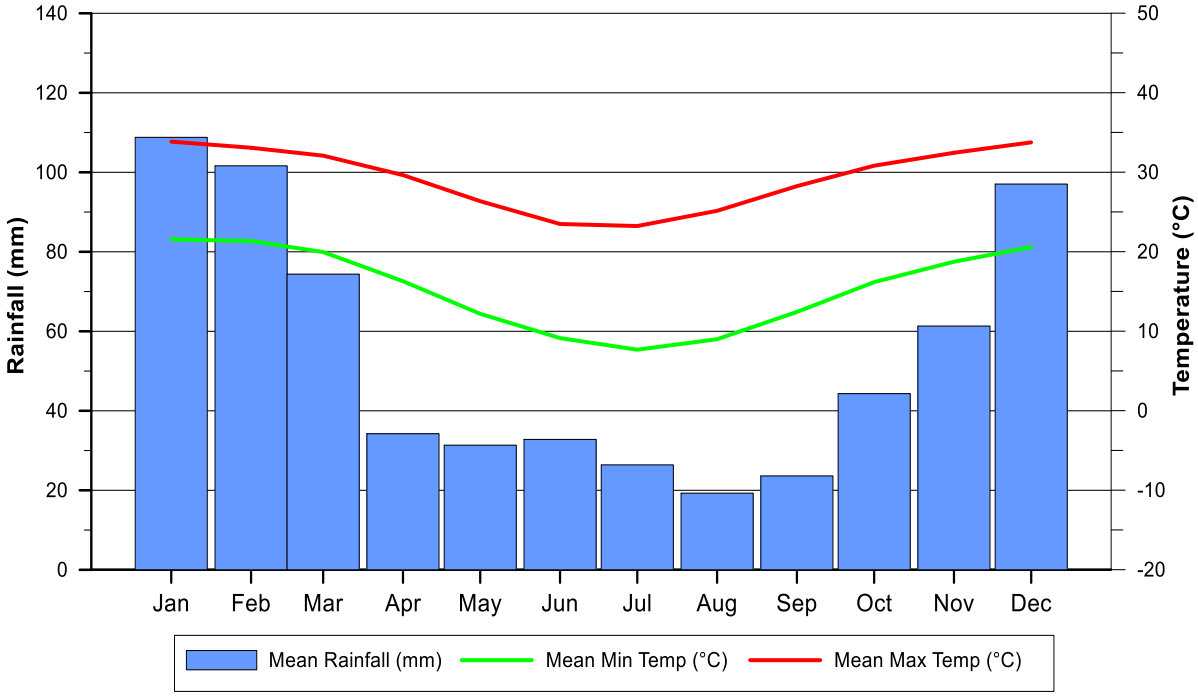


Figure 3 Climatograph

Table 5 Average Monthly Rainfall and Evaporation

Month	Average Rainfall (mm)	Average Evaporation (mm)
January	108.8	229.6
February	101.6	186.4
March	74.4	185.1
April	34.2	150.8
May	31.3	117.7
June	32.8	93.5
July	26.4	101.2
August	19.3	129.9
September	23.6	164.2
October	44.3	207.6
November	61.3	220.2
December	97	237.8
Total	**655.2**	**2,024.1**

2.3 TENURE AND LAND OWNERSHIP

2.3.1 Tenure

The Project is located entirely within the MLA, which is within exploration permit for coal (EPC) 881 held by Magnetic South (Figure 4). The surface rights held by Magnetic South within the MLA are also shown on Figure 4.

Petroleum tenements overlapping the MLA and surrounds include authority to prospect (ATP) 758, ATP 806 and potential commercial area (PCA) 163, PCA 165, and PCA 166 (Figure 5). All of the petroleum tenements are held by OME Resources Australia Pty Ltd, a subsidiary of Queensland Gas Company (QGC). Magnetic South and OME Resources Australia Pty Ltd are parties to a co-development agreement.

Other tenements proximal to the MLA include EPC 960 and mineral development licence (MDL) 505 held by Walton Coal Pty Ltd, EPC 769 held by Peabody Capricorn Pty Ltd, and EPC 1859 held by Area Coal Pty Ltd (Figure 4).

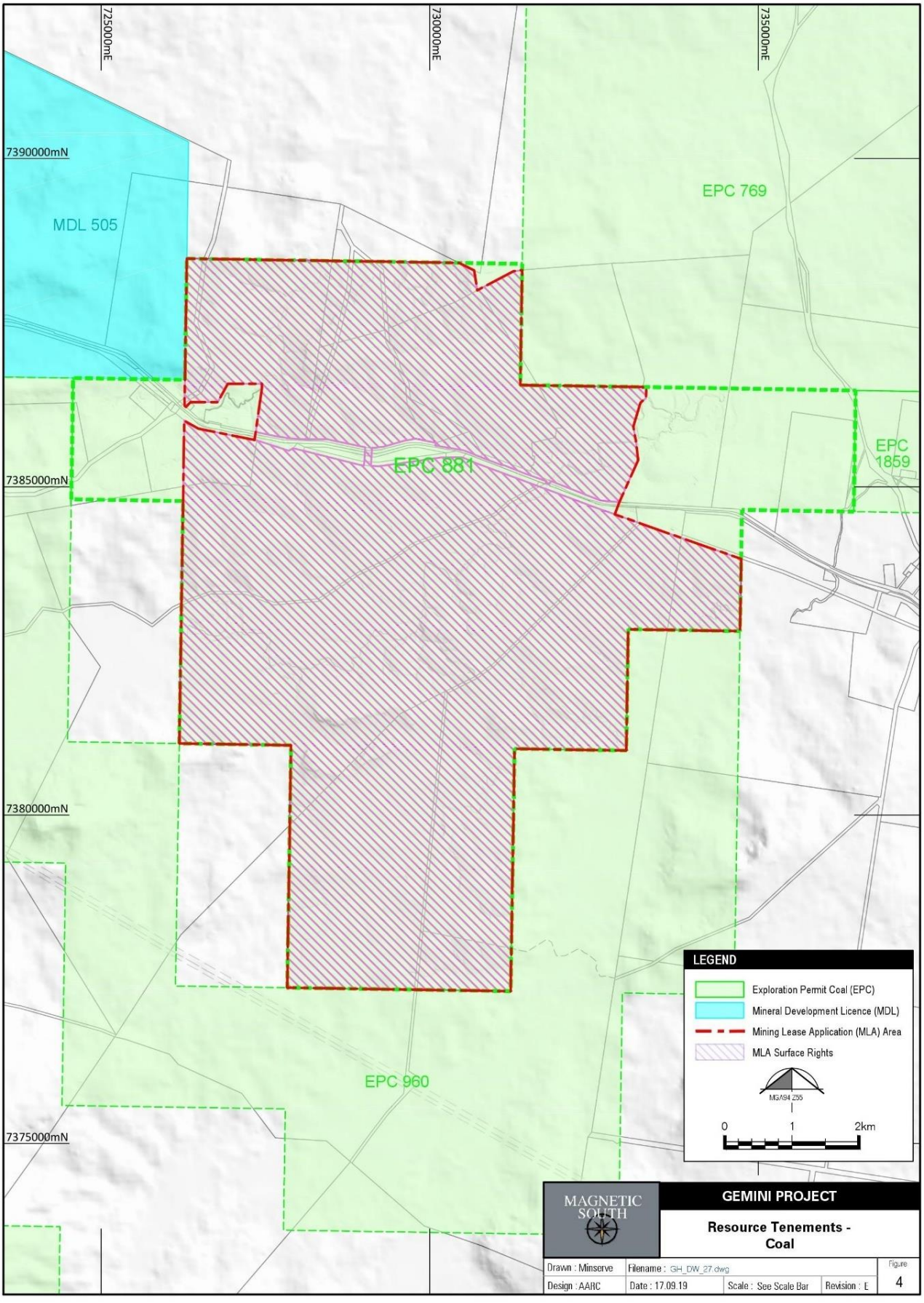


Figure 4 Resource Tenements – Coal

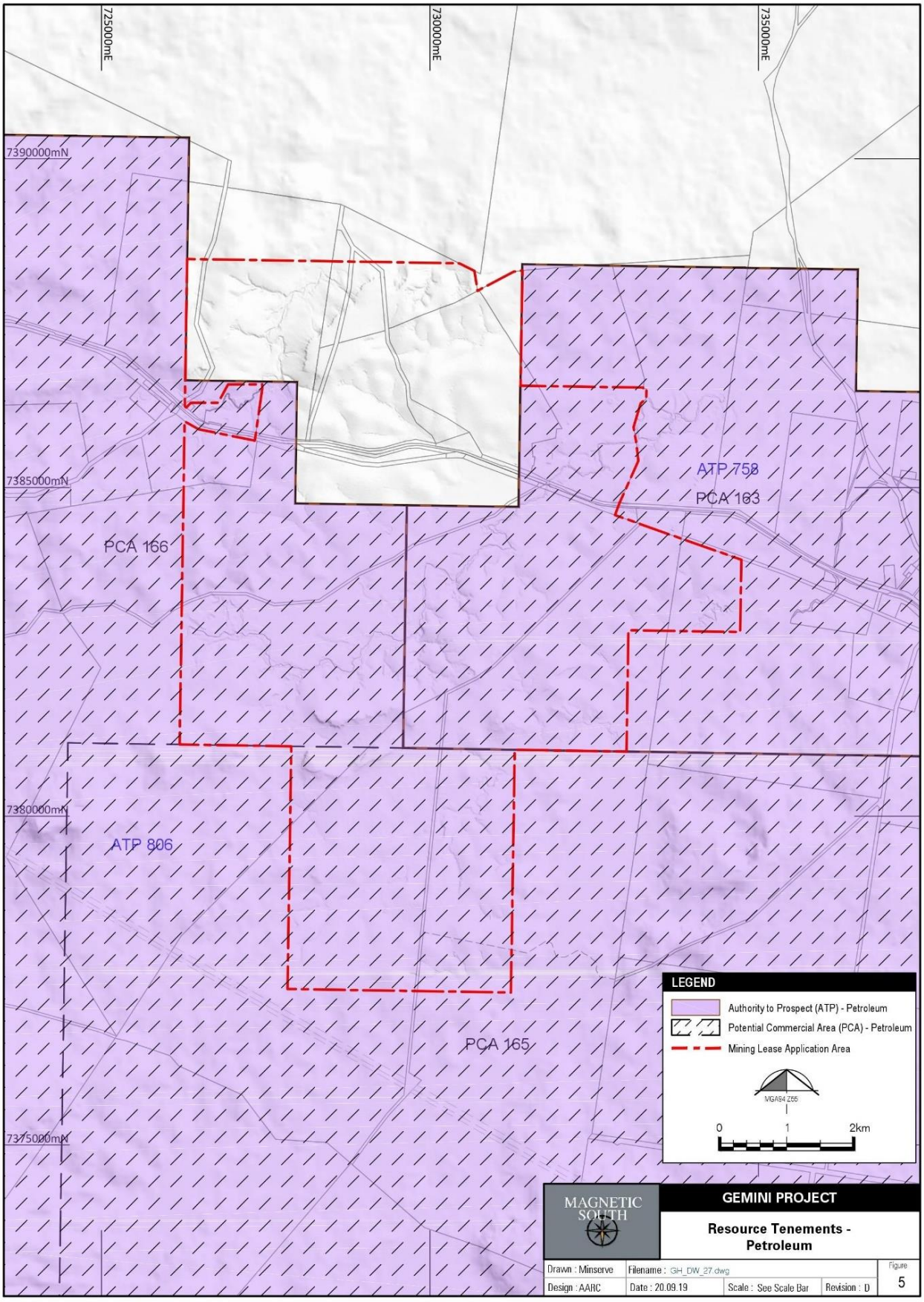


Figure 5 Resource Tenements – Petroleum

2.3.2 Land Ownership

The subject land within the MLA is held as freehold, leasehold or road reserve. Land ownership within the MLA is outlined in Table 6 and shown in Figure 6.

The Project's infrastructure is located on Lot 1 on Plan HT424 (freehold), Lot 2 on Plan HT138 (leasehold), Lot 100 on Plan RP882349 (freehold), and Lot 1 on Plan RP904099.

A number of publicly gazetted road reserves occur within the MLA; including the Capricorn Highway. The Blackwater Railway occurs within leasehold land along the northern side of the Capricorn Highway.

Consultation with private landholders within the MLA has been conducted by Magnetic South and discussions continue in relation to consent.

Table 6 Land Ownership

Registered Owner/s	Lot / Plan	Tenure	Property Name
AW, HJ, & LWG Vaughan	100 / RP882349	Freehold	Redrock Park
Magnetic South Pty Ltd	47 / H406	Freehold	Rubina
	2 / HT181	Freehold	Rubina
	3 / HT181	Freehold	Rubina
	2 / HT138	Lands Lease	-
	1 / HT424	Freehold	Yarrawonga / Longdale / St Helen's
	4 / RP801280	Freehold	-
	1 / RP904099	Freehold	Gum Flat
	4 / HT165	Freehold	
	2 / RP904099	Freehold	Ellesmere
The State of Queensland (Department of Transport and Main Roads)	643 / SP260475	Lands Lease	Rail corridor
	624 / SP260477	Lands Lease	
	25 / HT655	Lands Lease	-

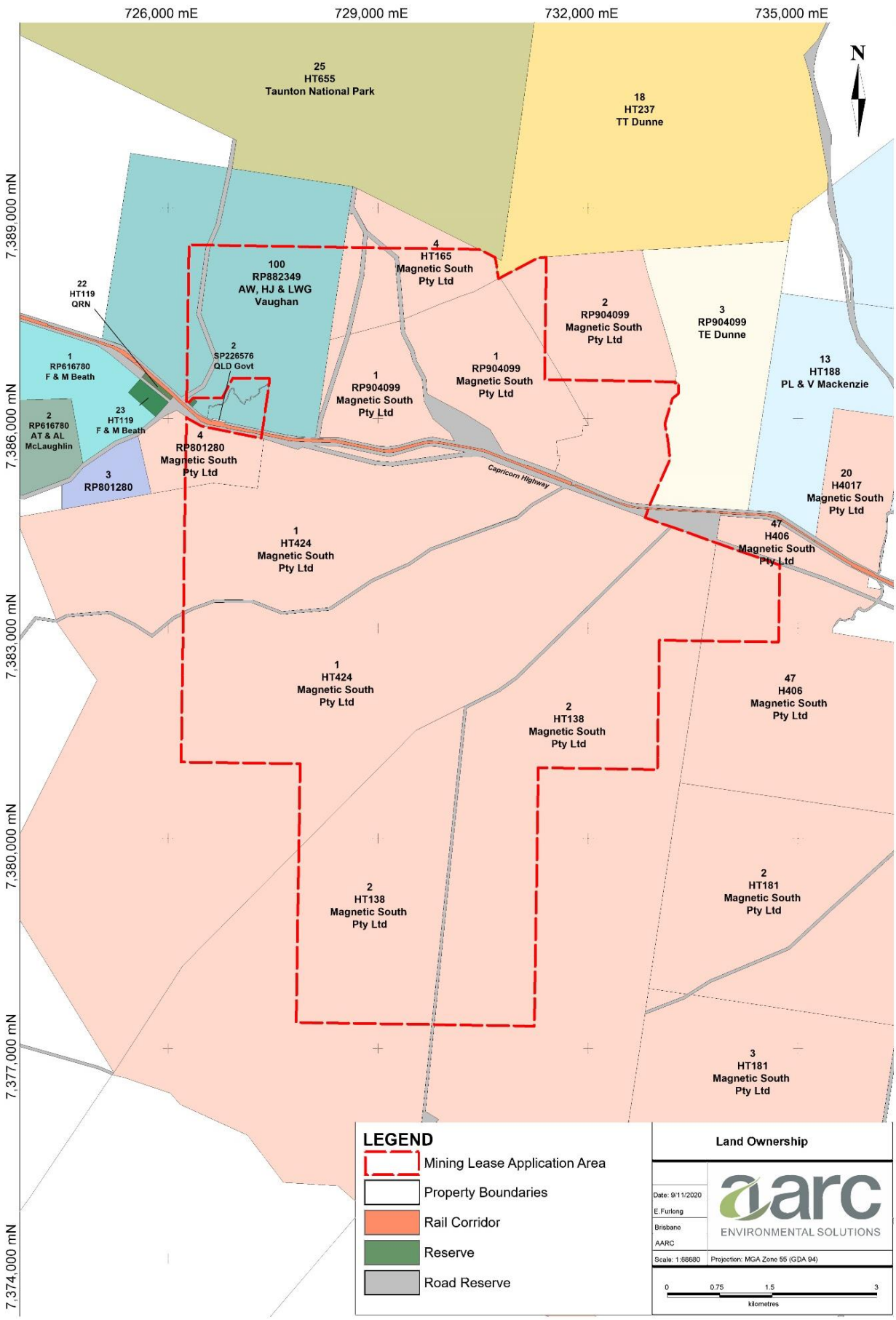


Figure 6 Land Ownership

3.0 PROJECT DESCRIPTION

3.1 PROJECT OVERVIEW

The Gemini Project is a greenfield, open-cut metallurgical coal mine producing pulverised coal injection (PCI) coal and coking coal for export to the international steel making industry.

The Project is located in the Bowen Basin, a well-established coal mining area with existing transport infrastructure. The Project will bring benefits to the local community, region, Queensland and the Commonwealth through direct employment opportunities, royalties and taxes. The Project will also utilise the services of regional suppliers of rail, power, water, communications, contractors, service providers and local businesses, which will have a positive economic impact beyond direct employment.

The Project term is anticipated to be 37 years from grant of the mining lease (ML); with this term including initial construction, mine operation and rehabilitation activities.

Mine construction activities are scheduled to commence in July 2021; subject to granting of the Project ML and EA. It is anticipated that it will take approximately six months to establish the necessary infrastructure to commence overburden removal and 18 months to commence coal production.

The main activities associated with the Project include:

- exploration activities continuing in order to support mine planning;
- development of a mine infrastructure area (MIA) including mine offices, bathhouse, crib rooms, warehouse/stores, workshop, fuel storage, refuelling facilities, wash bay, laydown area, sewage, effluent and liquid waste storage, and a helipad;
- construction and operation of a coal handling and preparation plant (CHPP) and coal handling facilities adjacent to the MIA, including run-of-mine (ROM) coal and product coal stockpiles and rejects bin/overflow (coarse and fine rejects);
- construction and operation of a surface conveyor from the product stockpiles to a train load out (TLO) facility and rail loop connecting to the Blackwater Railway to transport product coal to coal terminals at Gladstone for export.
- construction of an accommodation facility, sewage treatment plant and effluent irrigation area within the northwest bounds of the MLA;
- construction of access roads from the Capricorn Highway to the MIA, and from the Capricorn Highway to the TLO facility;
- installation of a raw water supply pipeline to connect to the Blackwater Pipeline network;
- construction of a 66 kV transmission line and switching/substation to connect to the existing regional network;
- other associated minor infrastructure, plant, equipment and activities;
- development of mine areas (open-cut pits) and out-of-pit waste rock emplacements;
- drilling and blasting of competent waste material;

- mine operations using conventional surface mining equipment (excavators, front end loaders, rear dump trucks, dozers);
- mining up to 1.9 Mtpa ROM coal (average of 1.8 Mtpa) for a construction/production period of approximately 20 years;
- progressive placement of waste rock in:
    - emplacements, adjacent to and near the open-cut voids; and
    - mine voids, behind the advancing open-cut mining operations;
- progressive rehabilitation of waste rock emplacement areas and mined voids;
- progressive establishment of soil stockpiles, laydown area and borrow pits (for road base and civil works; material will be sourced from local quarries where required);
- disposal of CHPP rejects (coarse and fine rejects) in out-of-pit spoil dumps, and in-pit behind the mining void;
- progressive development of internal roads and haul roads including a causeway over Charlevue Creek to enable coal haulage and pit access;
- development of water storage dams and sediment dams, and the installation of pumps, pipelines, and other water management equipment and structures including temporary levees, diversions and drains.

Existing local and regional infrastructure, facilities and services would be used to support Project activities. These include the SunWater water distribution network, the Aurizon rail network, Ergon's electricity network, the Capricorn Highway, and Gladstone export coal terminals.

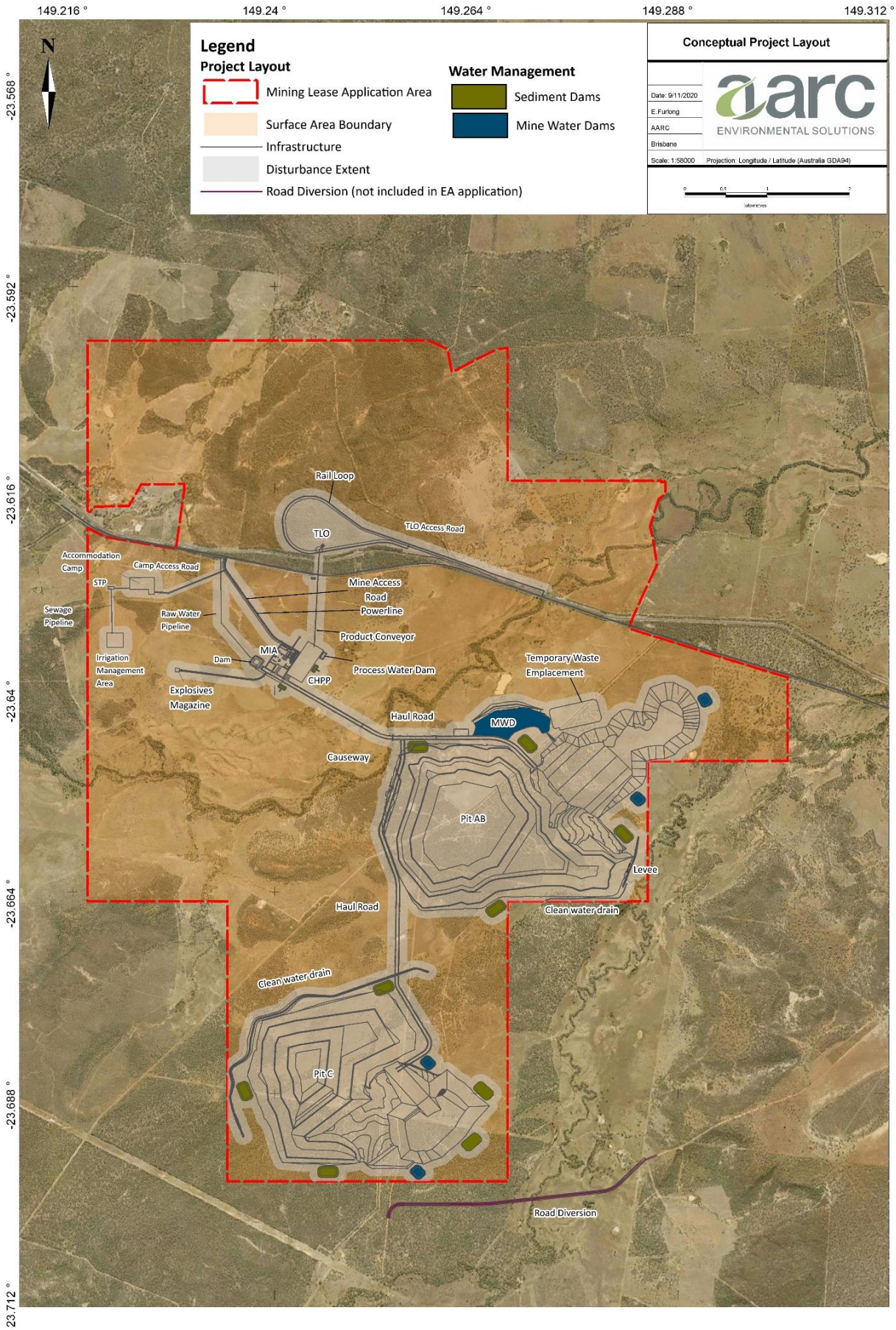


Figure 7 **Conceptual Layout - Gemini Project**

3.2 PROJECT DISTURBANCE AREA

A conceptual Project layout is provided in Figure 7 which represents the total area disturbed by mine operations only and does not equate to the disturbance footprint at any one point in time. Open-cut mining areas will be developed and rehabilitated progressively. The total disturbance footprint for the Project is 1,953.50 ha which incorporates all mining and infrastructure components as described in Table 7.

Table 7 Total Disturbance Area

Proposed Disturbance	Approximate Area (ha)
In-pit and out-of-pit waste emplacements, including dry rejects disposal areas	722.4
Temporary waste emplacements	17.5
Residual void lakes	76.5
Residual void high walls	133.1
Residual void low walls	187.2
Water management infrastructure1	85
Mine infrastructure areas	731.8
Total	**1,953.5**

* Infrastructure disturbance area includes a 100 m buffer around the perimeter of the disturbance footprint.

3.3 CONSTRUCTION

Proposed infrastructure and other development activities for the Project during the construction phase will include:

- mine access road from the Capricorn Highway to the MIA, associated Capricorn Highway intersection, site access security infrastructure and car parking at the MIA;
- MIA;
- explosives magazine;
- CHPP and associated coal handling infrastructure;
- TLO facility and access road;
- haul road to Pit AB including a low-level causeway across Charlevue Creek;
- construction of the haul road to Pit C (anticipated to commence in Year 11 of the Project); and
- accommodation facility and camp access road adjoining the mine access road.

These infrastructure components are described in Section 3.3.1 through to Section 3.3.5.

Water management infrastructure for the Project will include a temporary flood protection levee, clean water diversions for drainage features, mine water dams, sediment dams, raw water dam and process water dam. The water management components are described in Section 3.4.3.

Supporting infrastructure required for the Project includes an electrical power transmission line (refer Section 3.5.1) and raw water supply pipeline (refer Section 3.5.2).

Site preparation will include the clearance of vegetation, topsoil removal and stockpiling, bulk earthworks and temporary drainage works. Initial site preparation works will be focused on the rail infrastructure, mine access road, MIA, CHPP, accommodation facilities and haul road. Site clearance will be staged throughout the construction phases on an "as needs" basis to coincide with infrastructure installation and development to minimise the extent and duration of disturbance.

Quarry materials will be sourced from onsite deposits, where available, for use as road base, select fill, rail ballast, rock protection, and other construction materials. It is expected that waste rock from pit excavation will provide the majority of construction and bulk fill materials, however, some material may also be sourced from the onsite Project disturbance footprint or from quarries in the region.

The majority of infrastructure components (e.g., CHPP, buildings, pipelines, etc.) will be manufactured offsite and transported to site for assembly and installation.

3.3.1 Mine Access Road

Vehicle access for mine personnel, contractors, suppliers and deliveries to the Project will be via a new mine access road from the Capricorn Highway. The concept design of the mine access road is shown in Figure 8. The proposed mine access road intersection will be located approximately 2.7 km east of the Capricorn Highway/Charlevue Road intersection. The concept design of the proposed intersection is shown in Figure 9. The design includes an auxiliary left turn treatment – short turn lane and a channelised right turn treatment with reduced length of right turn slots, which has been designed in accordance with the *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections* (Austroads Ltd 2017).

The mine access road intersection will be sealed, while the remainder of the mine access road to the MIA will be unsealed. Just beyond the mine access road intersection, access to the accommodation facilities will occur via an adjoining camp access road to the west of the MIA. A *Traffic Impact Assessment* (Cardno 2019) has been prepared for the Project and is included as Appendix A.

A MIA will be constructed in the northwest of the MLA (Figure 7). An indicative layout of the MIA is shown in Figure 10. A security gate will be established at the entrance to the mine on the mine access road (Figure 10) to prevent inadvertent access to the mine site operations. The security gate will be positioned to direct visitors to the MIA and associated car park (Figure 10).

The MIA will include the mine offices, bathhouse, crib rooms, warehouses and storage areas, workshops, potable water storage, fuel storage and refuelling facilities, sewage, effluent and liquid waste storage, tyre bay, laydown area, Go-line, wash bay, and other associated amenities (Figure 10).

Personnel, visitors and deliveries will access the MIA and associated mine offices via the mine access road. Access from the MIA to the mining operations is via internal light vehicle access roads and the mine haul roads.

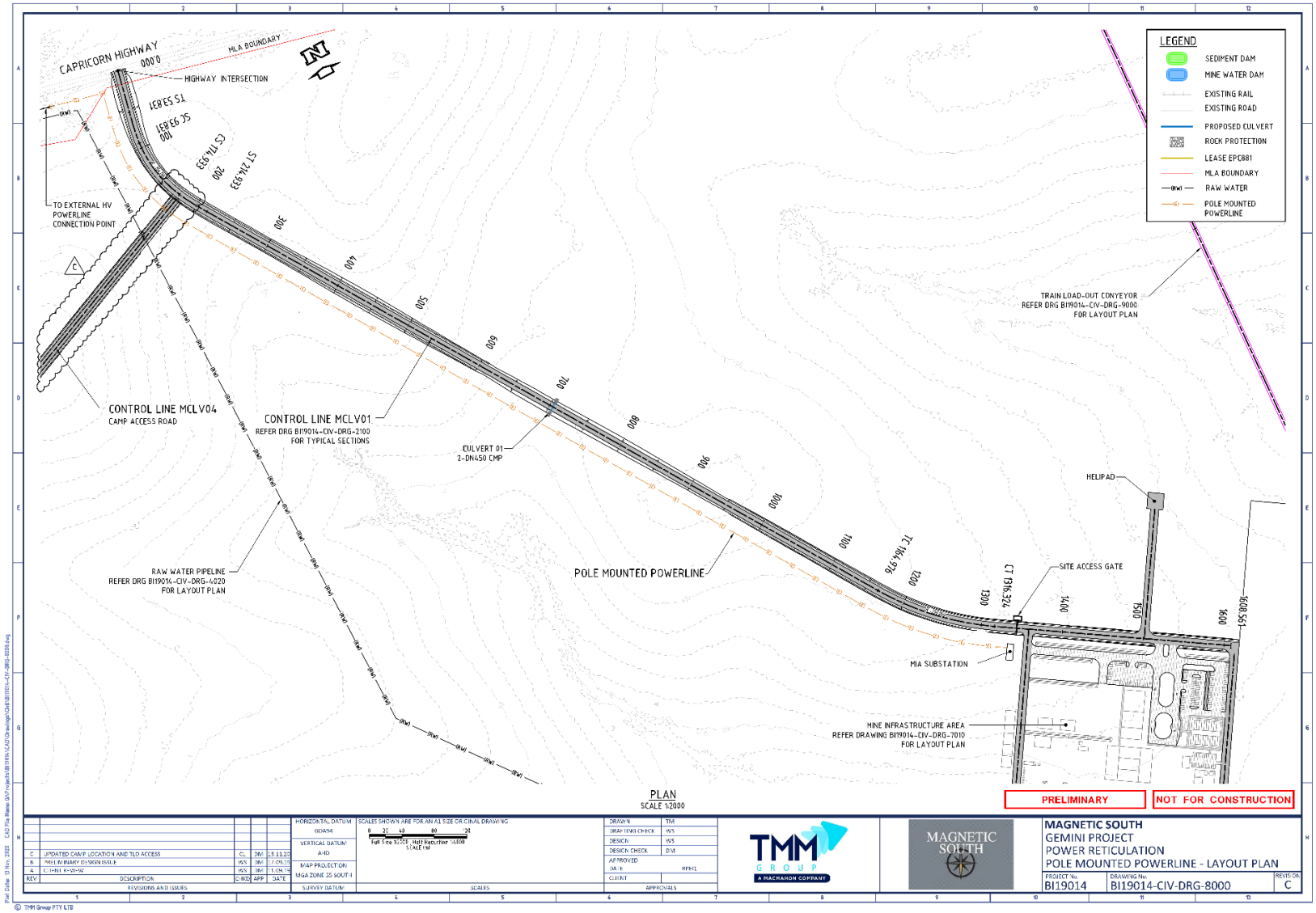
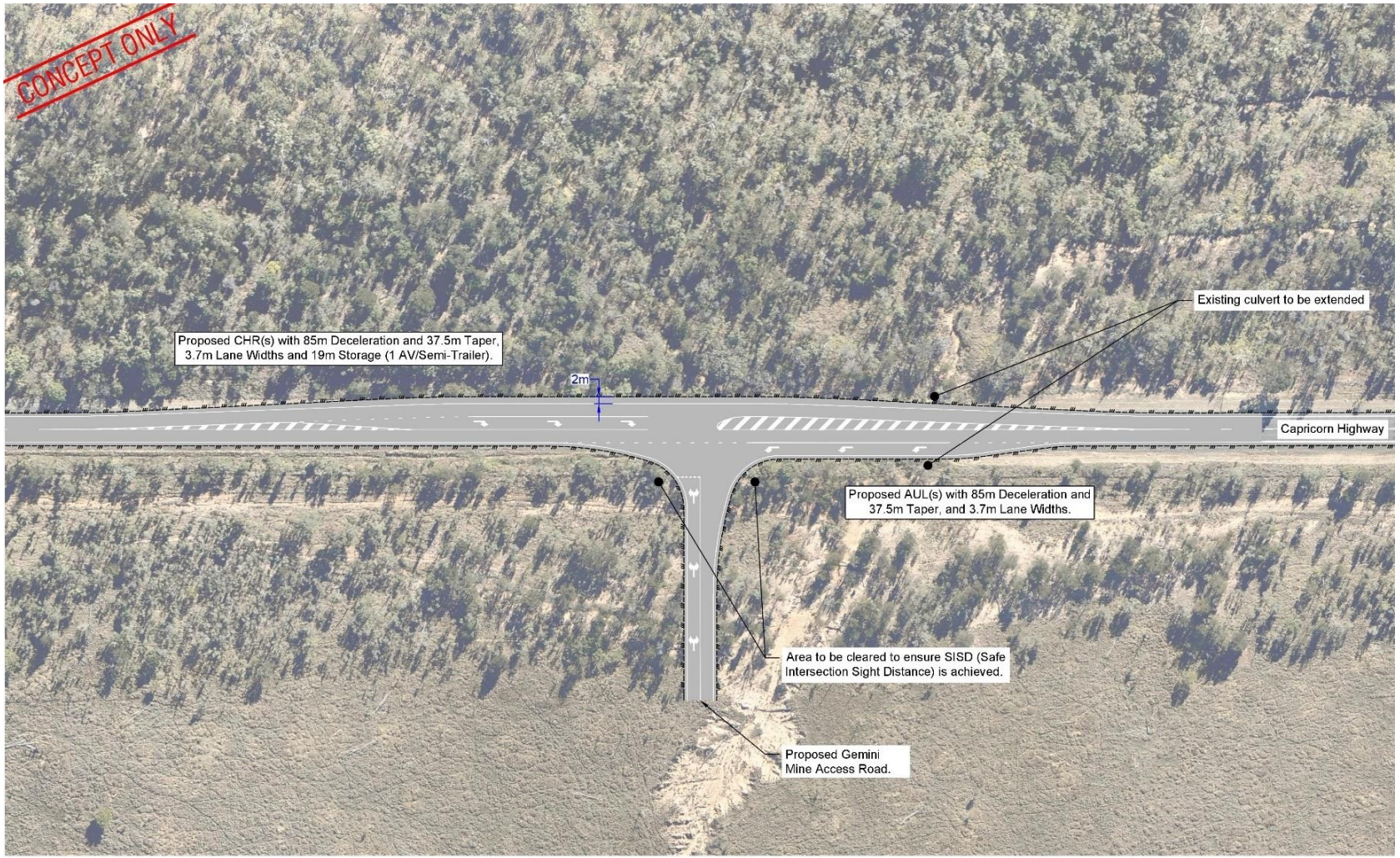


Figure 8 Conceptual Design - Mine Access Road



Safe Intersection Sight Distance (SISD)			
Westbound		Eastbound	
Required	Achieved	Required	Achieved
285m	350m+	285m	350m+

Figure 9 Conceptual Design - Mine Access Road Intersection

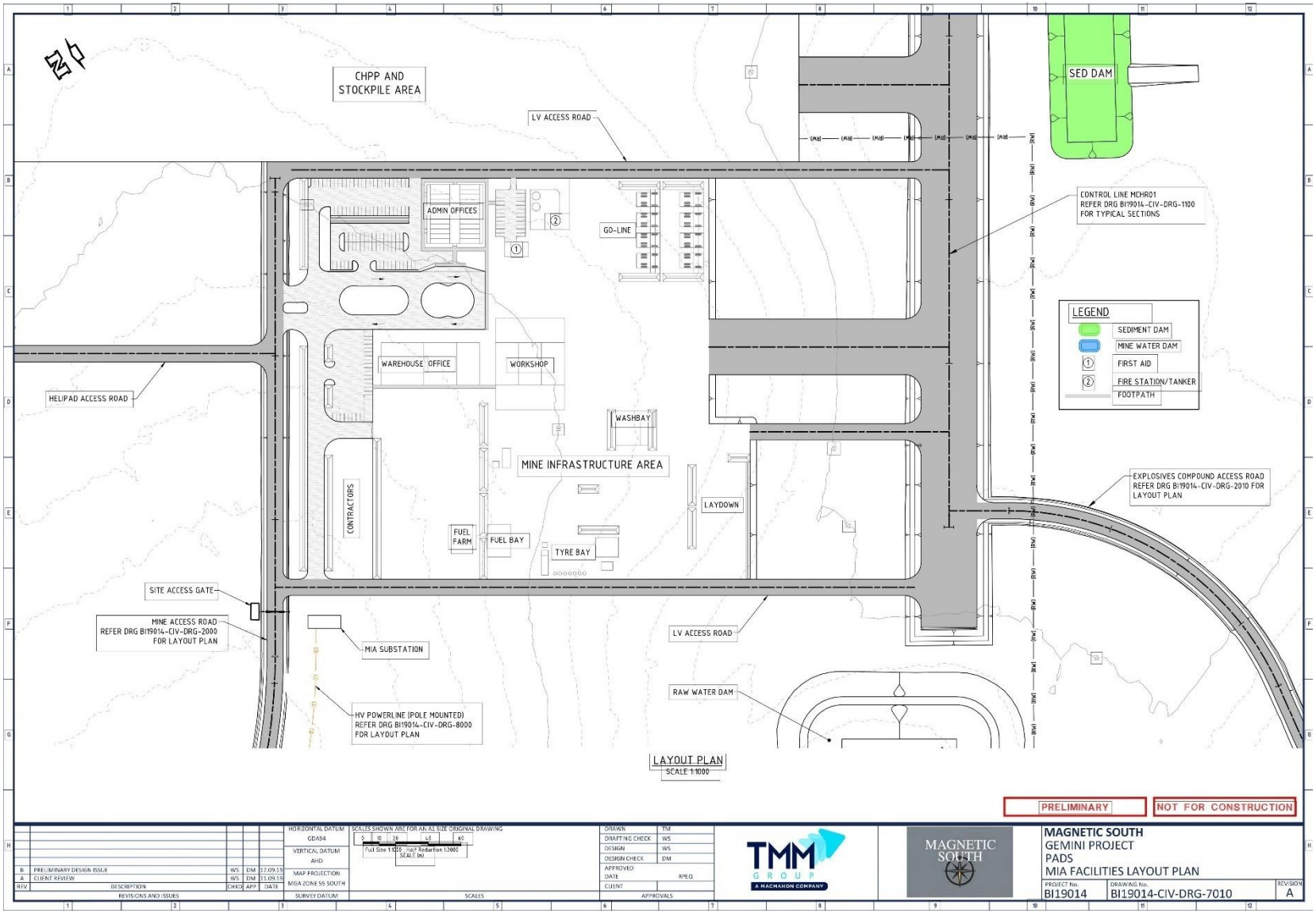


Figure 10 Conceptual Layout - MIA

3.3.2 Explosives Storage

An explosives compound will be established to the west of the MIA (Figure 7 and Figure 11). Explosives magazines will be fenced, signed and maintained in accordance with *AS2187.2-2006: Explosives – Storage and use (Part 2: Use of explosives).*

3.3.3 CHPP, Stockpiles and Overland Conveyor

A CHPP and associated coal handling facilities will be constructed adjacent to the MIA (Figure 7 and Figure 11) and will include:

- CHPP;
- ROM coal stockpile;
- product stockpile;
- rejects bin and overflow (coarse and fine rejects); and
- coal handling facilities including an overland conveyor to transport product coal to the TLO.

It is anticipated that construction of the CHPP and associated coal handling facilities will take approximately 18 months. The CHPP will operate 24 hours per day, 7 days a week.

Product coal will be direct fed to the train loading bin by conveyor from the product coal stockpile adjacent to the CHPP. The conveyor will be constructed to pass over both the Capricorn Highway and the Blackwater Railway (Figure 12). Concept design of the Capricorn Highway conveyor crossing is shown in Figure 13, and the Blackwater Railway conveyor crossing in Figure 14.

3.3.4 Train Load Out Facility and Access Road

A TLO facility comprising a rail spur, rail loop and train loading bin will be constructed adjacent to the Blackwater Railway (Figure 7). The rail spur and loop will be approximately 6 km in length and will connect to the Blackwater Railway west of the existing Charlevue Creek rail bridge.

Access to the TLO facility will utilise an existing access road off the Capricorn Highway via Red Hill Road at Lot 2 on Plan RP904099 (Figure 7). The TLO access road is unsealed and runs beneath the rail bridge proximal to Charlevue Creek and will continue around the perimeter of the TLO rail loop. This access road will be used for TLO construction activities and for operations.

3.3.5 Haul Roads

The alignment of the haul roads from the MIA to Pit AB and Pit C is shown in Figure 7. Construction of the haul road to Pit C is anticipated to commence in Year 11 of the Project.

The haul road to Pit AB will include a causeway to cross Charlevue Creek. The causeway will be designed for a 1 in 2-year rainfall event, with the capacity to carry a 540 t class excavator on a float.

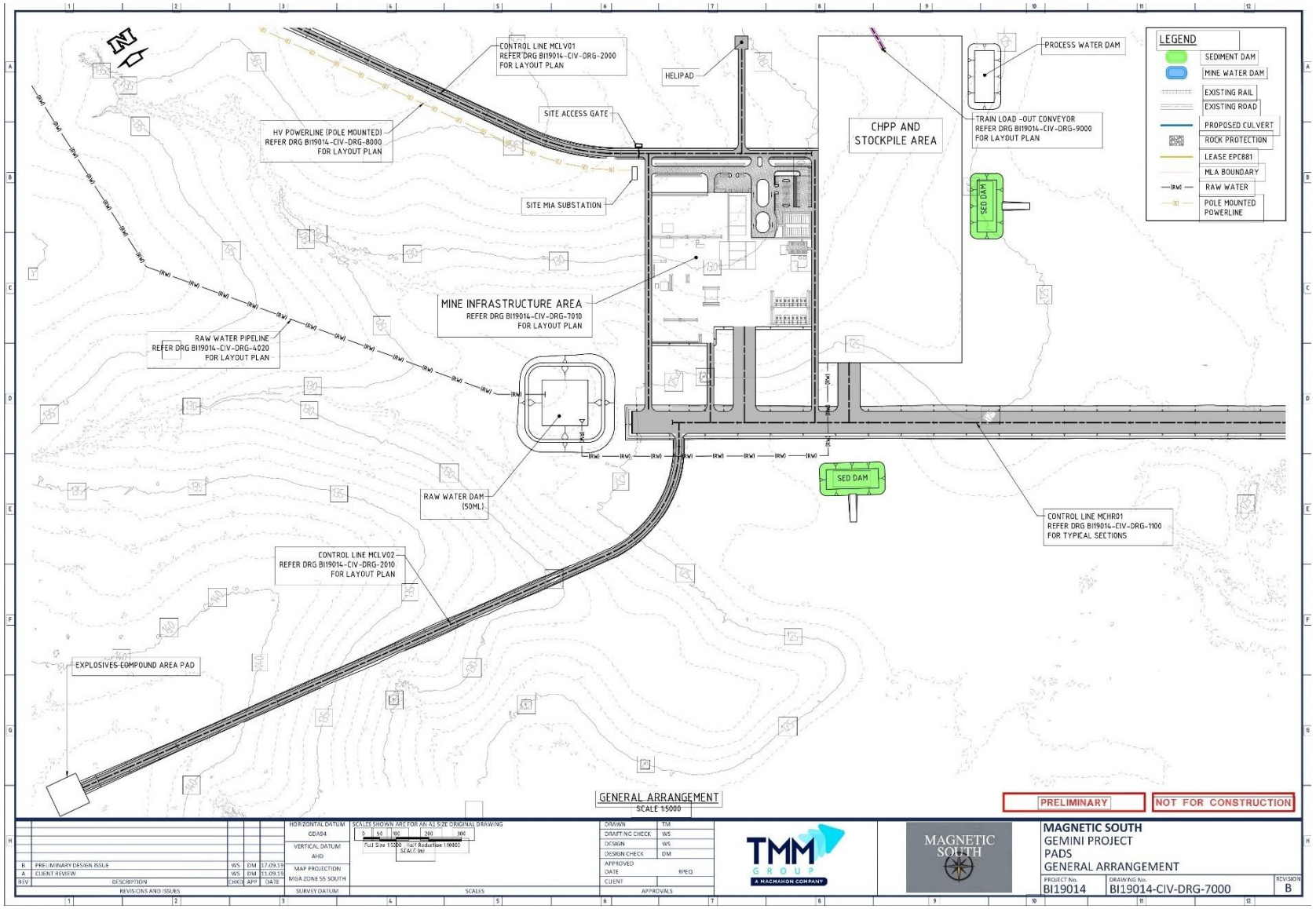


Figure 11 Conceptual Layout - MIA and Associated Infrastructure

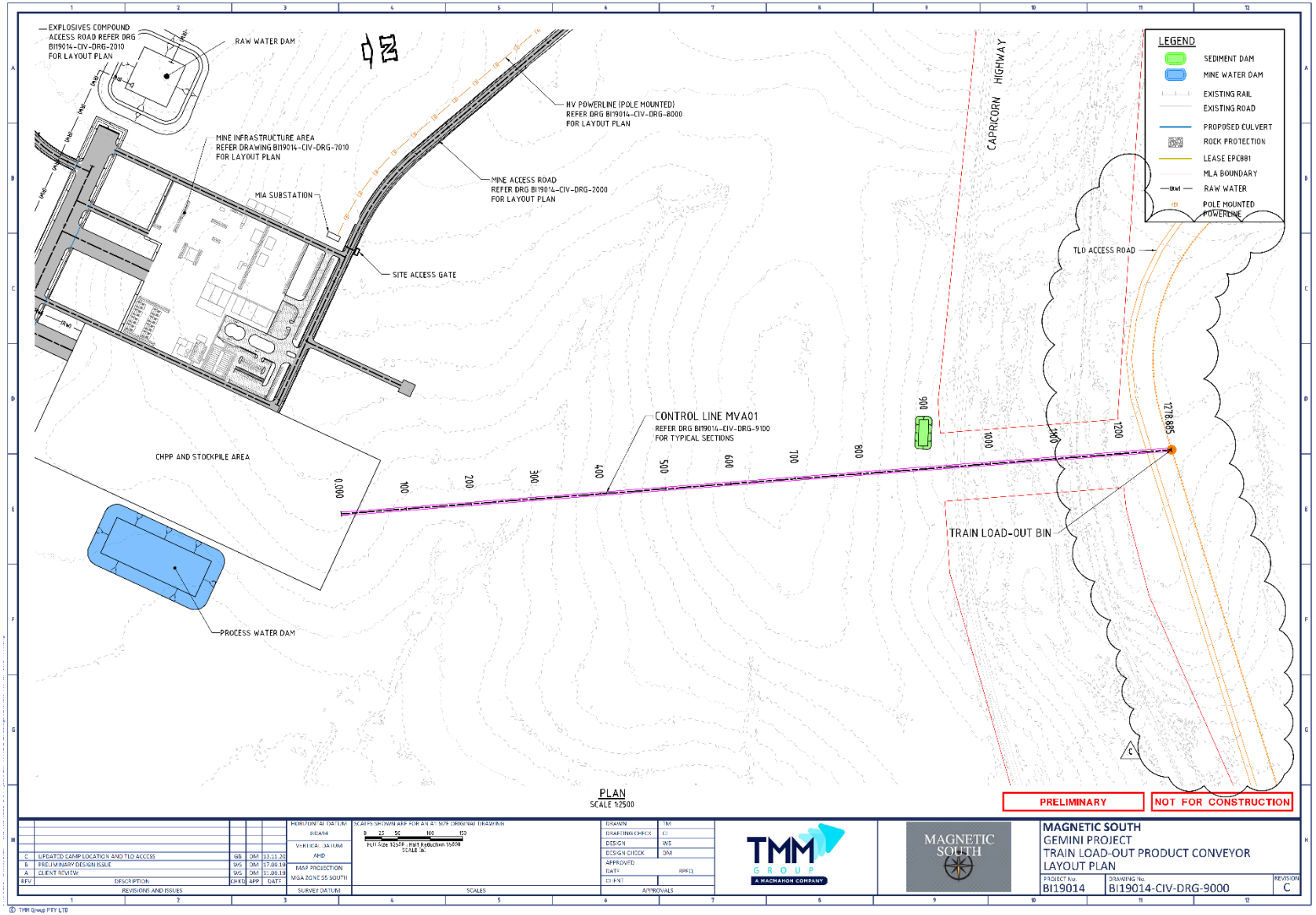


Figure 12 Conceptual Layout - Product Coal Overland Conveyor

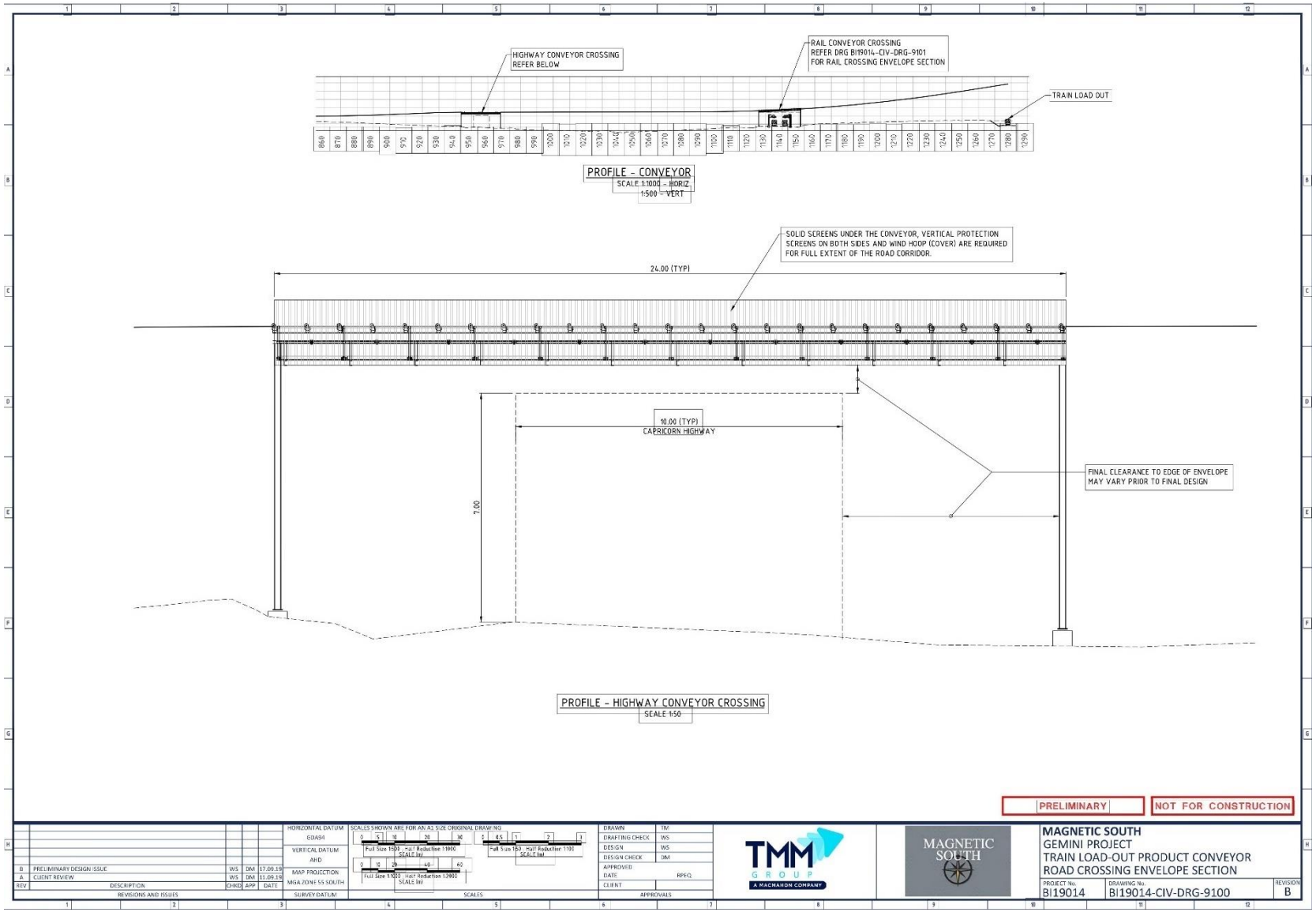


Figure 13 Conceptual Design - Conveyor Crossing (Capricorn Highway)

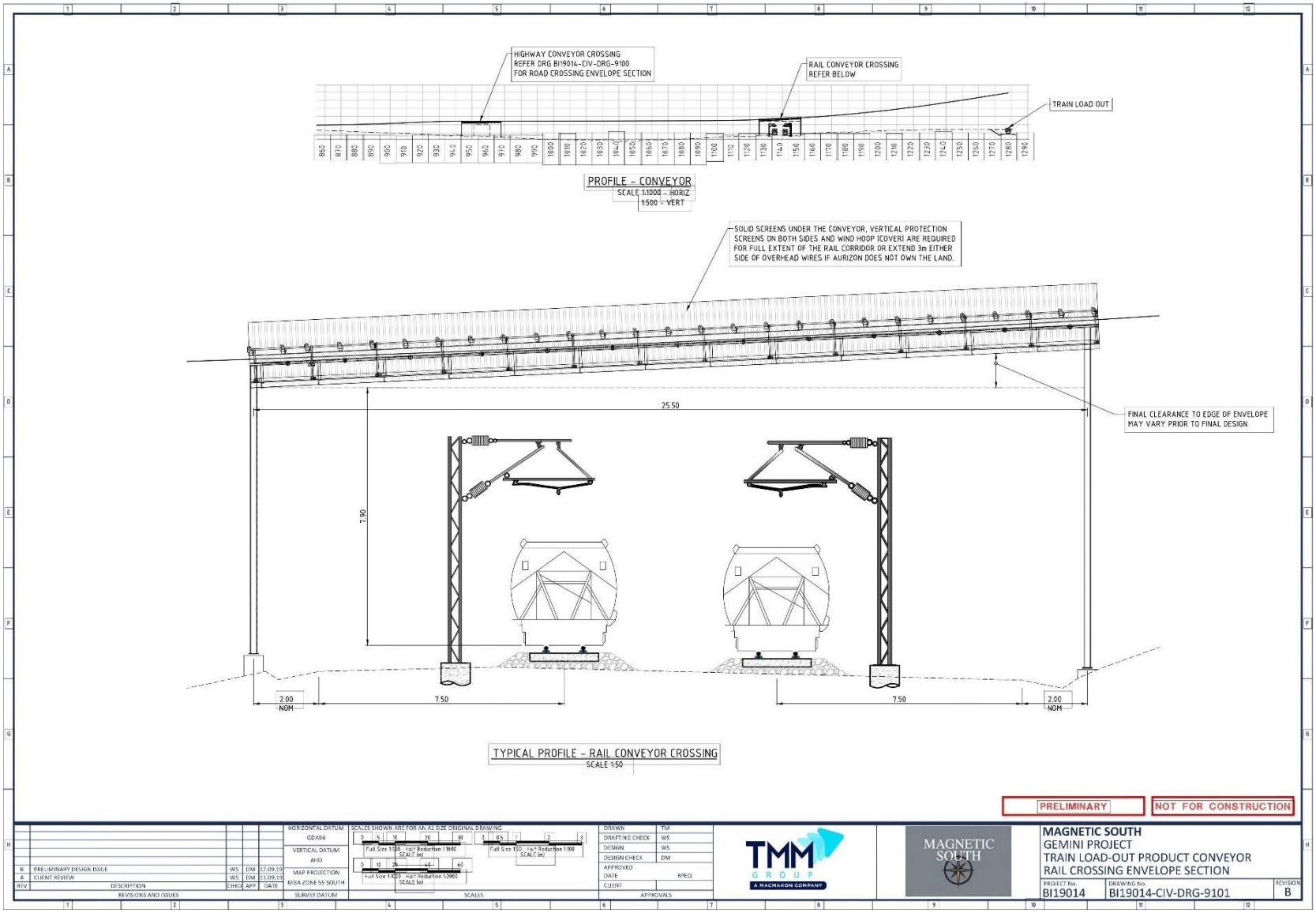


Figure 14 Conceptual Design - Conveyor Crossing (Blackwater Railway)

3.4 SITE WATER MANAGEMENT

3.4.1 Water Management Principles

The 'Site Water Management System' (SWMS) for the Gemini Project is based on the following key principles:

- divert clean catchment water around mining works to the extent practicable;
- use/recycle lesser quality water in preference to higher quality water;
- use potentially contaminated water in preference to imported raw water or uncontaminated water;
- release water from site only in accordance with the conditions of the EA, such that the released water will not significantly impact on the values of the receiving waters or downstream properties;
- manage water storages and transfers within the site in order to:
    - maximise onsite storage to meet reasonably anticipated periods of wet and dry weather; and
    - minimise disruption to mining operations.

3.4.2 Site Water Management System

For the purpose of site water management, site water has been classified into the types shown in Table 8 on the basis of the likely water quality characteristics.

The proposed strategy for the management of surface water at the Project is based on the separation of water from different sources based on anticipated water quality.

A conceptual SWMS was developed for the Project by WRM Water and Environment Pty Ltd (WRM) as a part of the *Surface Water Assessment* (WRM 2020b) (Appendix B). On the basis of the expected runoff and groundwater inflow quality, the SWMS separates water into two segregated management systems:

1. **Mine affected water (MAW) system:** will manage runoff and seepage from the mine pits, CHPP, coal stockpiles, and MIA. This is a closed system designed to prevent releases of MAW to the environment.
2. **Sediment water system:** runoff from overburden dumps will be managed under an *Erosion and Sediment Control Plan* (ESCP) which is to be implemented throughout the Project, such that sediment generated and transported by runoff will be settled in a sediment dam. As overburden runoff quality is expected to be relatively benign (refer Section 13.0), the sediment dams will potentially discharge directly into the environment (after the settlement of suspended sediment), and as such, will not affect the mine water balance. However, the water balance assessment has assumed sediment dams will be pumped back to the CHPP for reuse.

Clean water flows from undisturbed areas are generally diverted around the areas of disturbance. A raw water supply pipeline is proposed to supply all site water requirements prior to dam construction, and supplement site water supplies throughout the life of the Project. Raw water will be delivered to a

dedicated raw water dam (located adjacent to the MIA), which will also intercept clean water from its local upstream catchment.

A site water balance model has been developed by WRM (2020b) to determine the most appropriate design of the SWMS. The site water balance forms the basis of impact assessment and infrastructure design for the site. Details of the site water balance are provided in Section 3.4.5.

A schematic of the integrated SWMS configuration for the Project is shown in Figure 15.

Table 8 Site Water Types

Water Type	Definition
Mine affected water	In accordance with the *Model mining conditions* (DES 2017e), MAW means the following types of water: i) pit water, tailings dam water, processing plant water; ii) water contaminated by a mining activity which would have been an ERA under Schedule 2 of the EP Regulation if it had not formed part of the mining activity; iii) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an ESCP to manage such runoff, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water; iv) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated; v) groundwater from the mine dewatering activities; vi) a mix of MAW (under any of paragraphs i to v) and other water.
Sediment water	Surface water runoff from areas that are disturbed by mining operations (including out-of-pit waste rock emplacements). This runoff does not come into contact with coal or other carbonaceous material and may contain high sediment loads but does not contain elevated level of other water quality parameters (e.g., electrical conductivity (EC), pH, metals, metalloids, non-metals). This runoff must be managed to ensure adequate sediment removal prior to release to receiving waters.
Clean catchment water	Surface runoff from areas unaffected by mining operations. Clean catchment water includes runoff from undisturbed areas and fully rehabilitated areas.
Raw water	Untreated water, generally from an external water supply, that has not been contaminated by mining activities.
Potable water	Treated water suitable for human consumption.

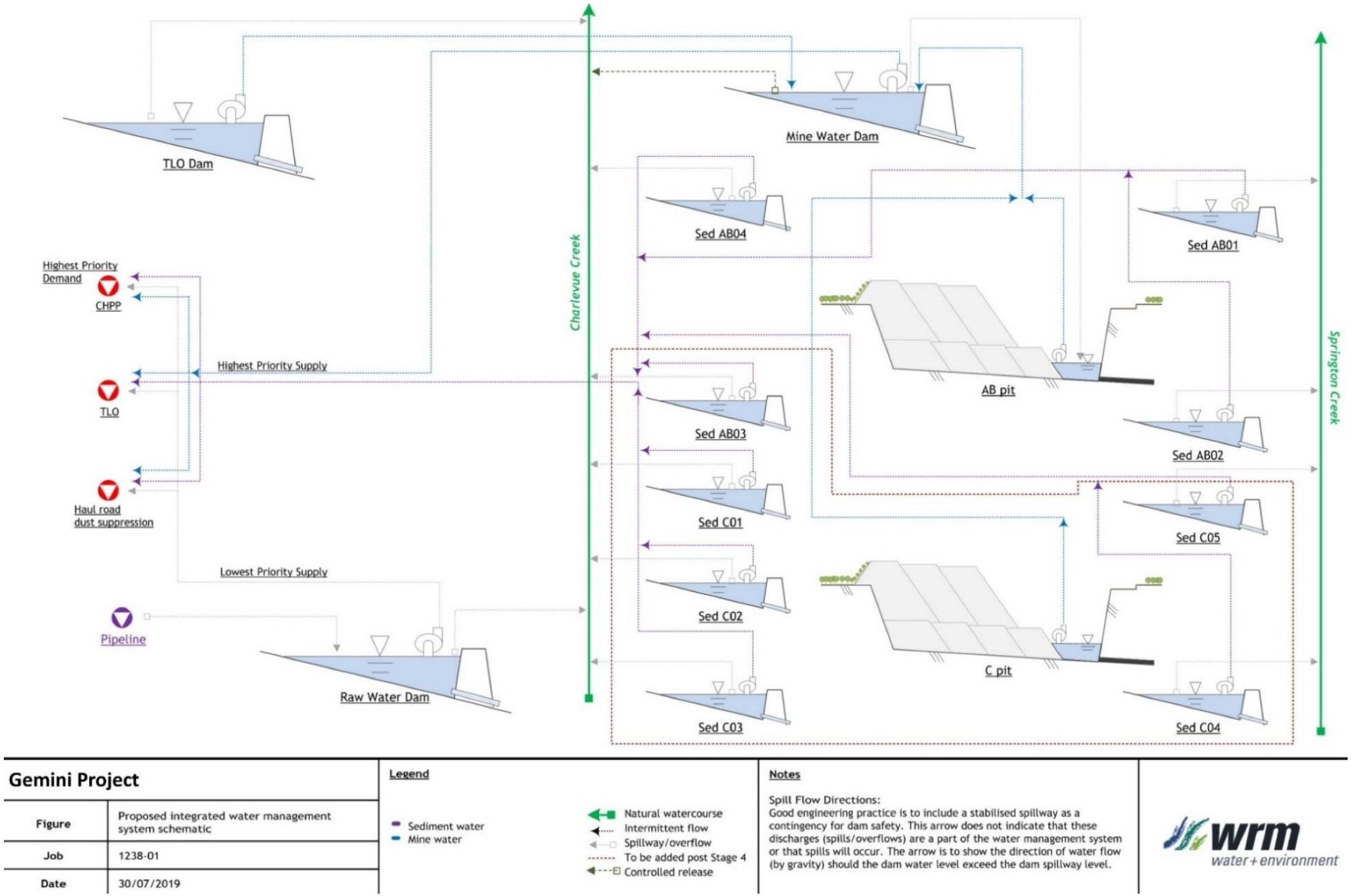


Figure 15 Proposed Integrated SWMS Schematic

3.4.3 Water Management Infrastructure

The SWMS consists of infrastructure to provide catchment separation and manage water quality and quantity onsite. Infrastructure for the Project's SWMS includes:

- temporary flood protection levee to protect Pit AB from potential flood waters;
- clean water drains to divert runoff from undisturbed catchments around areas disturbed by mining activities;
- sediment water drains to divert water from waste rock emplacements, and areas yet to be rehabilitated;
- sediment water dams to store water from waste rock emplacements and allow settlement of sediment loads before discharging treated water or recycling back to the CHPP;
- mine water drains to divert water from MIA, CHPP and coal stockpile areas into the MAW system; and
- mine water dams to store water pumped out of the pit, and collect water from the MIA, CHPP and coal stockpile areas.

Figure 7 provides a schematic layout of proposed water management infrastructure for the Project.

3.4.3.1 Temporary Flood Protection Levee

A temporary flood levee designed to provide protection from a 0.1% annual exceedance probability (AEP) flood event will be constructed adjacent to Pit AB (Figure 7). The levee will be required to reduce the risk of ingress of clean floodwaters into operational areas where they may become contaminated with possible adverse impact on water management operations and containment performance. The levee will be constructed prior to the commencement of waste stripping within Pit AB.

The levee will be a 'regulated structure' and will be designed, constructed and decommissioned in accordance with the '*Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)*' and *'Structures which are dams or levees constructed as part of environmentally relevant activities (ESR/2016/1934)*'. The design height of the levee ranges from 1.21 m to 2.37 m, determined by the modelled flood height, plus 0.5 m freeboard. A plan and longitudinal section of the levee is provided in Figure 16, with a typical cross-section provided in Figure 21. The levee will be reinforced by in-pit rock dumps as mining progresses.

These levee structures would be temporary, required only until the final overburden profile is achieved and the associated permanent drainage systems commissioned. The final voids are located and designed such that they are not inundated by flooding in the probable maximum flood. Accordingly, no flood levee will be required to prevent inundation of the final void. The levee constructed to protect the operational pit would not be required post-mining and therefore has been designed to form part of the rehabilitated dump.

3.4.3.2 Clean Water Drains

The Project will require two sections of a 'drainage feature' (as determined under the *Water Act 2000* (Water Act) to be diverted around surface disturbance areas associated with Pit AB and Pit C (Figure 7). This will allow the runoff from undisturbed upslope catchments to flow around the operations, minimising the impact on the downstream environment, while also minimising the potential volume of

water captured into the MAW system. The drainage feature is a tributary of Springton Creek and is not considered to be a 'watercourse' as defined by the Water Act.

The engineered drainage features will be required throughout operations at each mine pit and will become permanent features at mine closure.

Runoff and seepage from the mine pits will be contained within the MAW system. The mine pits and MAW dams are located such that it would not be possible for this MAW water to enter the engineered drainage features.

The overburden dumps will be initially placed within the levees, and (in accordance with the erosion and sediment control plan) sediment-laden runoff would be directed to sediment dams via drains designed to prevent overflow into the engineered drainage features.

As the final overburden dump profile is developed, a series of contour drains would direct runoff away from the engineered drainage structures and to sediment dams. Overflows to "engineered 'drainage features'" would only occur after treatment in a sediment dam.

The preliminary channel designs included in the assessment have the following design features:

- Pit AB:
    - compound trapezoidal channel shape:
        - 1m deep low flow channel with 5 m base width;
        - Base width of high flow channel 15 m;
        - side slopes 1V in 3H;
    - longitudinal slope: 0.4% (the existing channel has a slope of approximately 0.3%);
    - design 1 in 50 AEP depths are up to 3.7 m, and peak velocities range up to 2.5 m/s;
- Pit C:
    - compound trapezoidal channel shape:
        - 1m deep low flow channel with 4 m base width;
        - width of high flow channel 15 m;
        - side slopes 1V in 3H;
    - longitudinal slope varies between 0.25% and 0.4%; and
    - design 1 in 50 AEP depths are up to 1.3 m, and peak velocities range between 1.0 m/s and 2.0 m/s.

A plan and longitudinal section of the channels is provided in Figure 17 (Pit AB) and Figure 18 to Figure 20 (Pit C), with a typical cross-section provided in Figure 21.

While the engineered drainage channels themselves would not be regulated structures, they are designed to ensure they do not interfere with the functioning of the levees in the design flood event (for example by inducing scour which could affect the integrity of the levee).

Based on the flood model results, flow velocities in the Pit AB drainage feature would generally be non-erosive, however, there may be a requirement for scour protection near the channel outlet where velocities are highest.

The permanent channels will be designed to be self-sustaining features of the local surface water environment. It is therefore proposed that the design of the drains will take into account key design principles and requirements for the functionality of permanent diversions, including for operations, maintenance, monitoring and revegetation.

Magnetic South will investigate the potential to realign the proposed diversion further south at mine closure to improve the geomorphological characteristics and reduce the need for erosion protection.

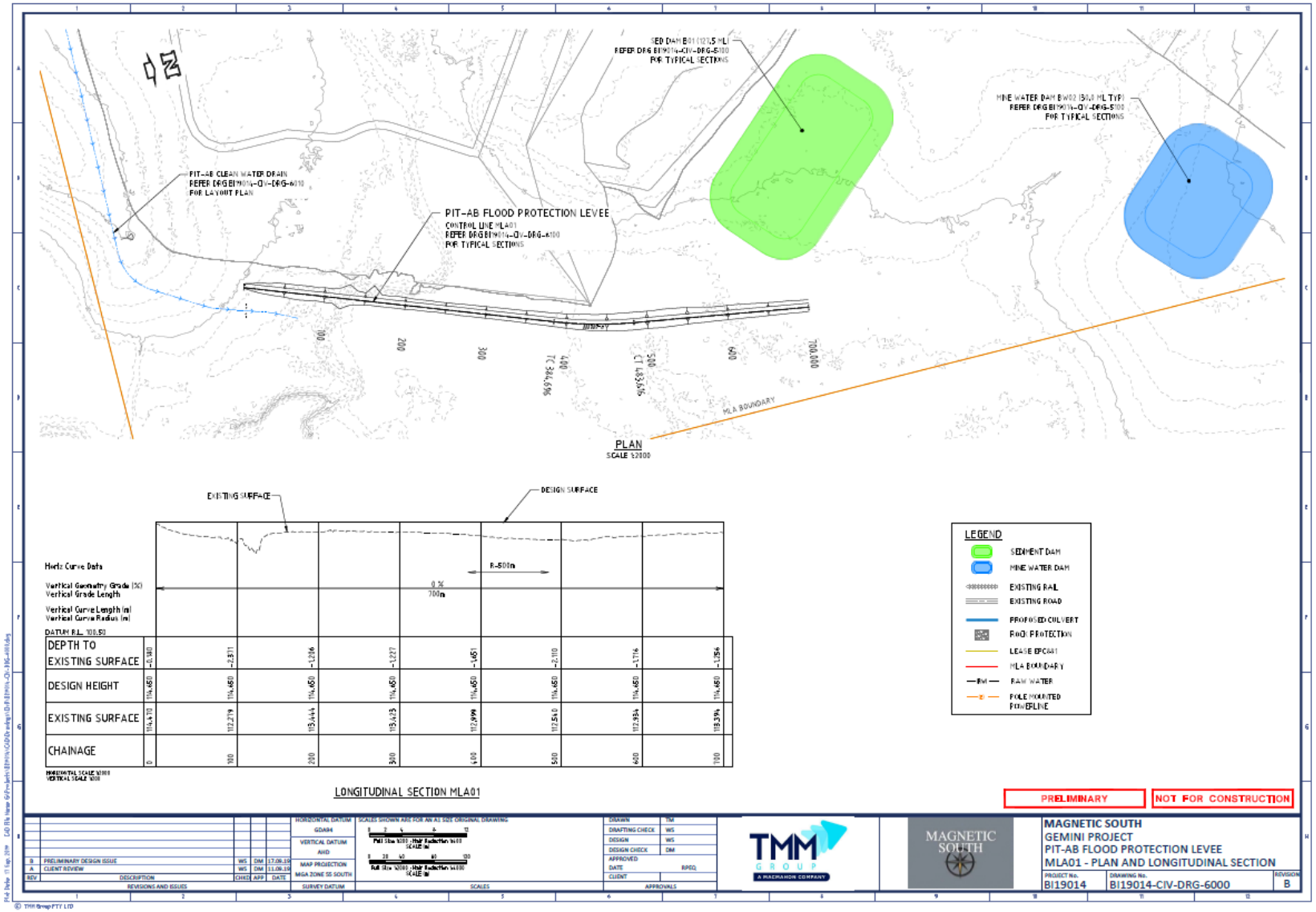


Figure 16 **Flood Protection Levee Plan and Longitudinal Section**

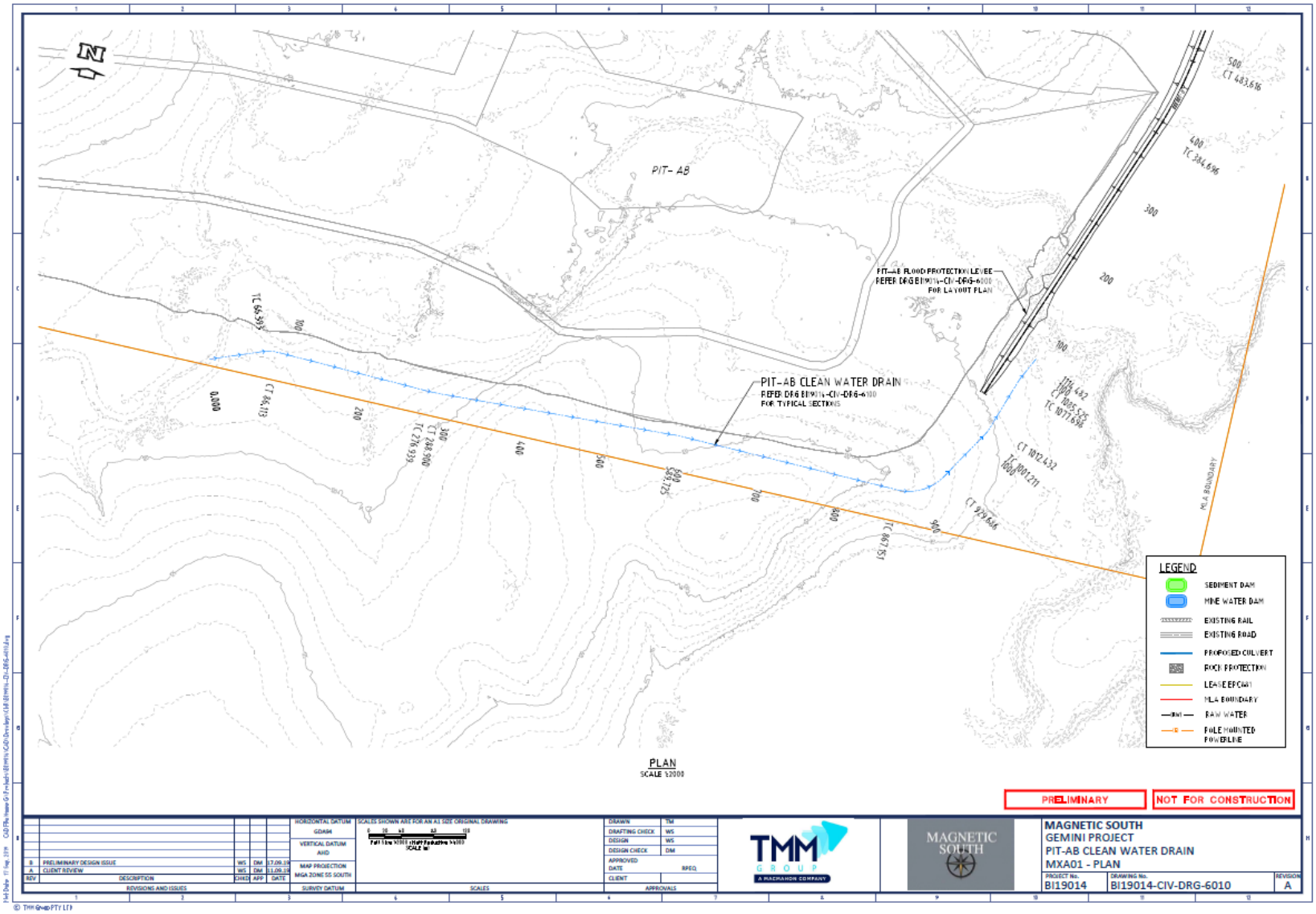


Figure 17 Pit AB Clean Water Drain Conceptual Design

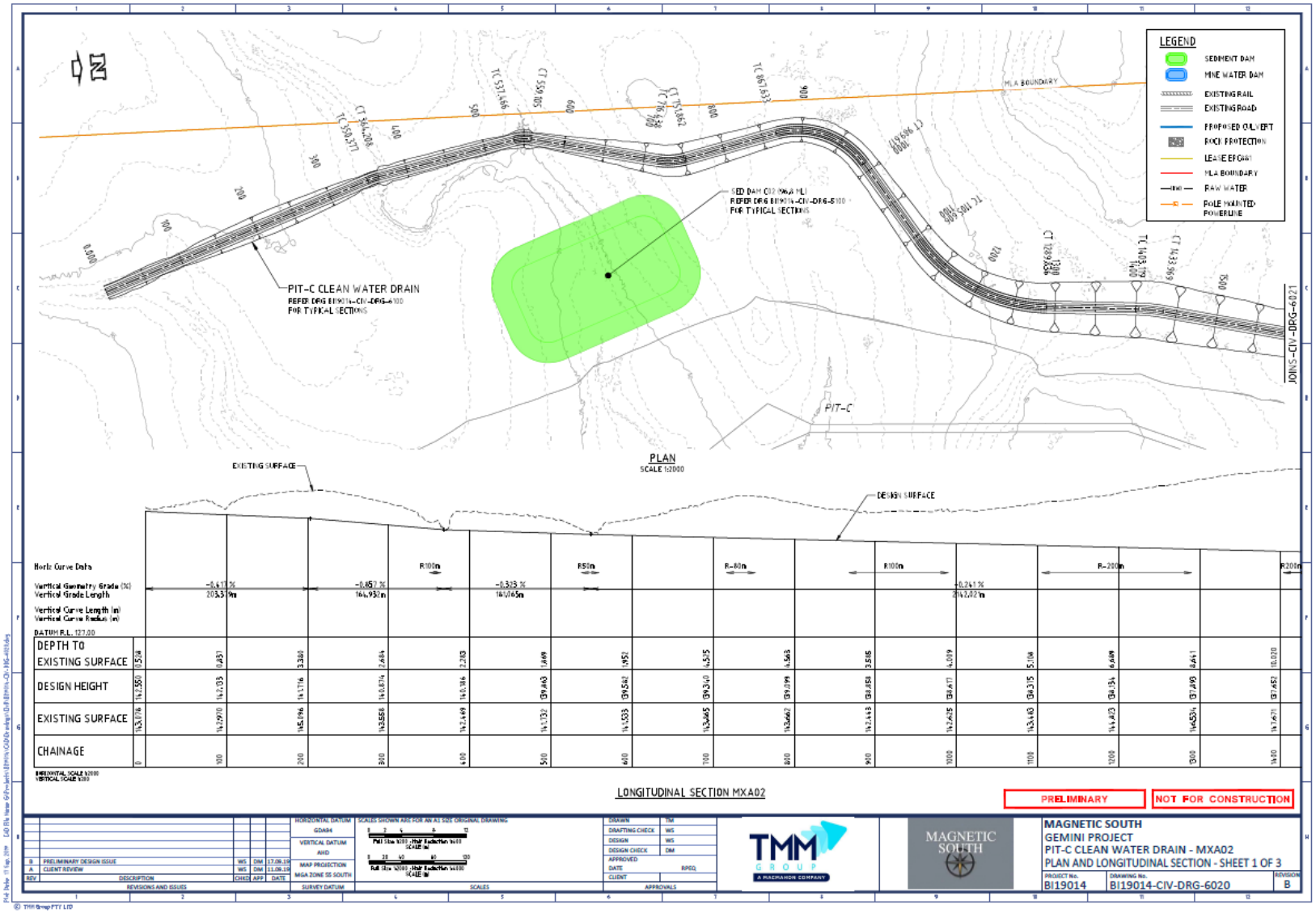


Figure 18 Pit C Clean Water Drain Conceptual Design

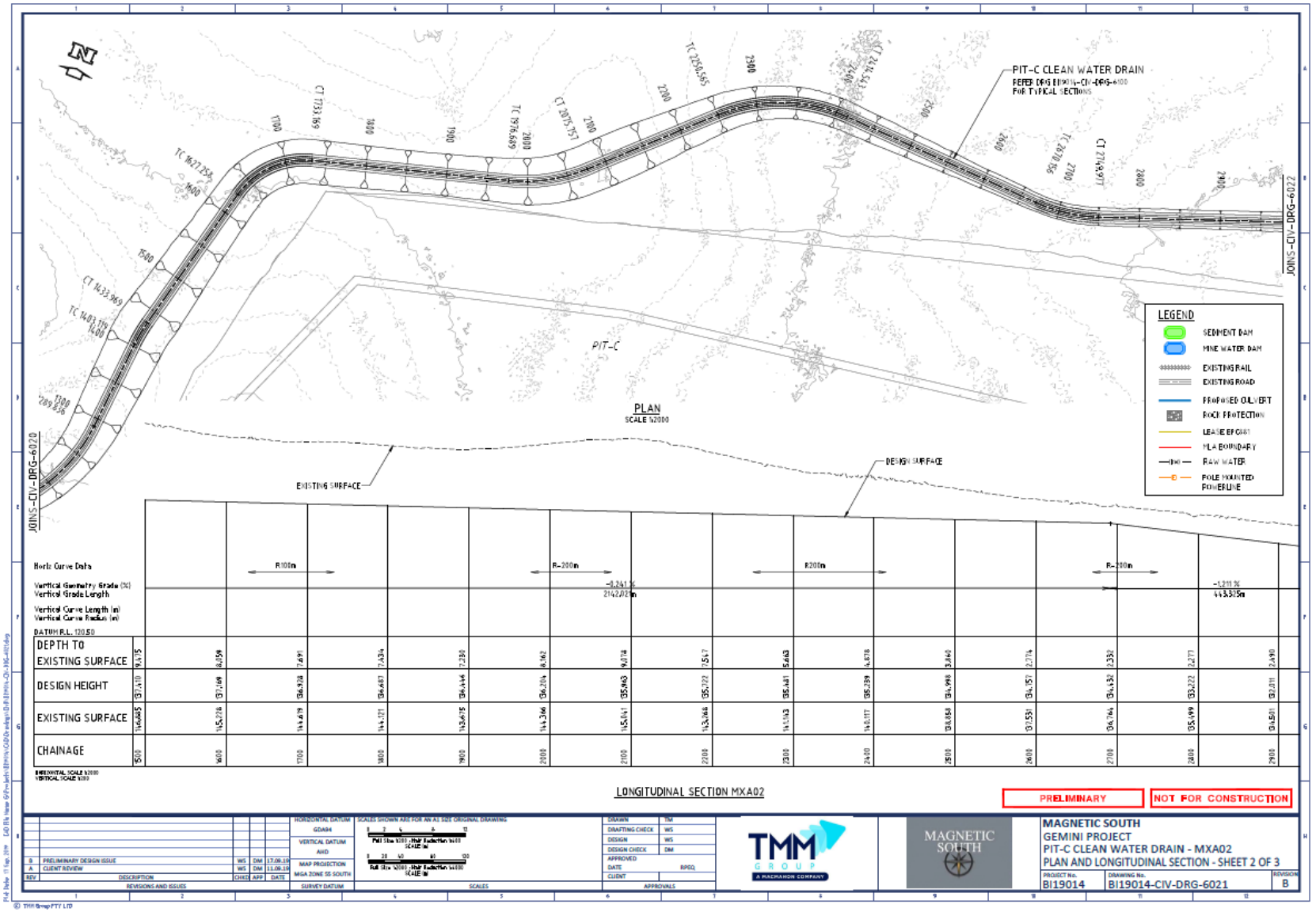


Figure 19 Pit C Clean Water Drain Conceptual Design

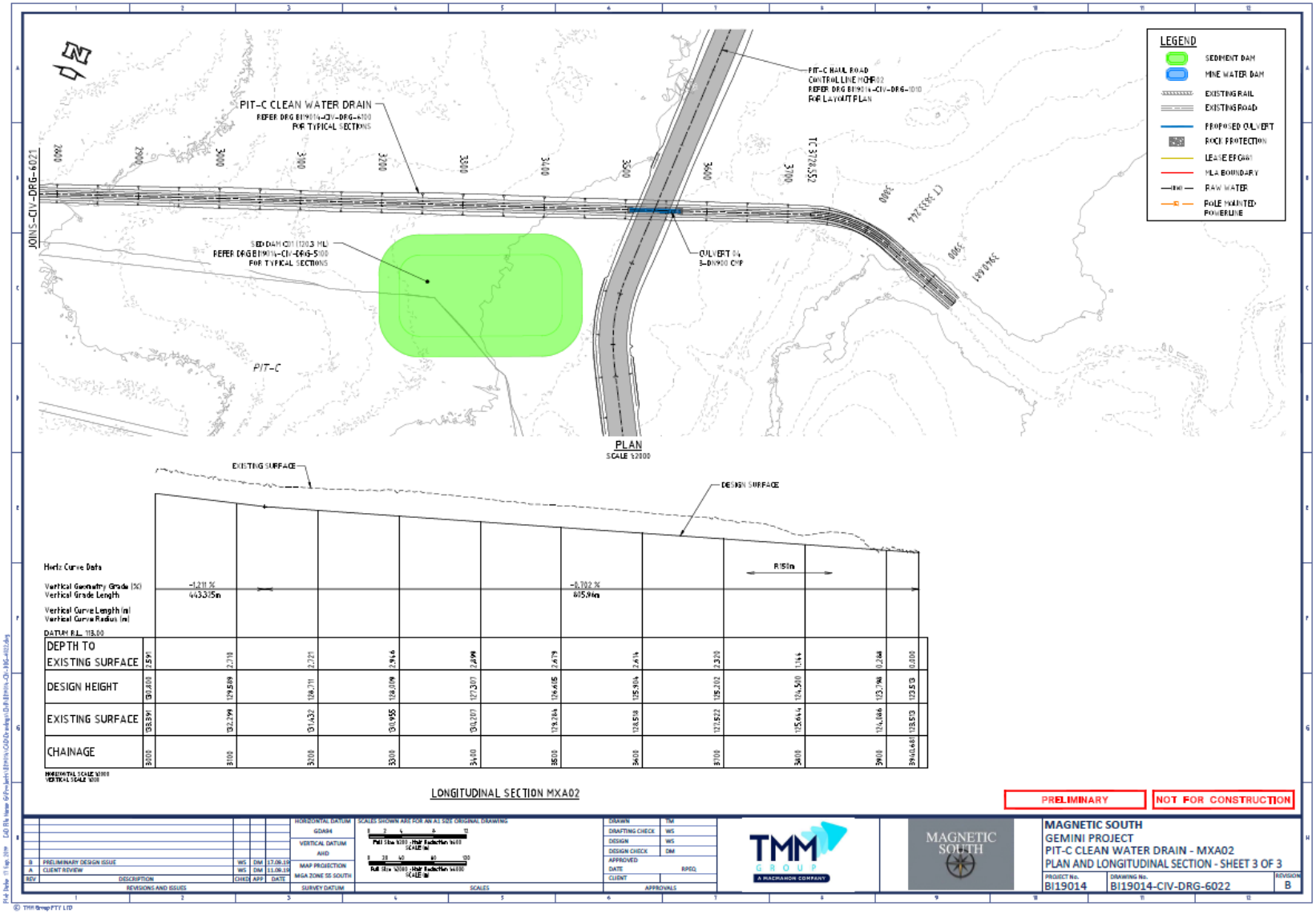


Figure 20 Pit C Clean Water Drain Conceptual Design

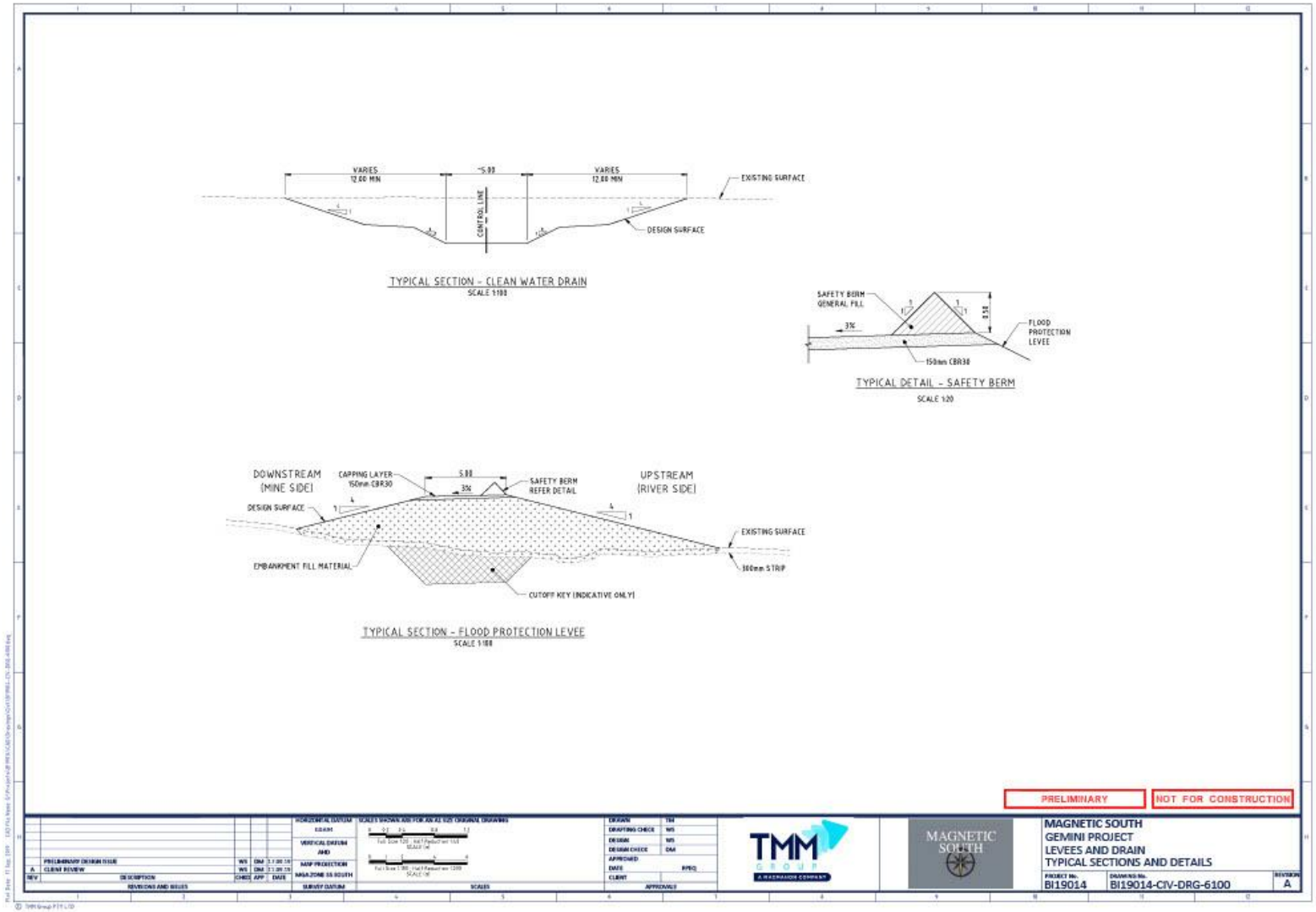


Figure 21 **Levees and Drains - Typical Sections and Details**

3.4.3.3 Water Storages

Water storages will include mine water dams, sediment dams, raw water dam, and process water dam. All storages will be located such that they are above the 0.1% AEP flood level.

All water storage dams, structures and facilities will be designed, constructed and managed in accordance with the *Manual for assessing consequence categories and hydraulic performance of structures [ESR/2016/1933]* (DES 2016).

Water collected in sediment dams will be captured and retained for reuse on-site and/or controlled release off-site to the receiving environment in accordance with *Model water conditions for coal mines in the Fitzroy basin [ESR/2015/1561]* (EHP 2013a).

Process Water Dam

Water is used in the CHPP for the sizing and removal of waste material. Water recovered from the CHPP during processing will be recycled through a closed loop circuit whereby any wastewater from the CHPP is temporarily stored in the process water dam and reused in the CHPP.

Mine Water Dams

Water that accumulates in the pits will be transferred to contained water storages (i.e., mine water dams) for beneficial use (i.e., dust suppression and/or CHPP water supply). Pit AB will be used as a supplementary mine water storage after commencement of mining in Pit C. A number of small staging dams may be used to collect water pumped from the mine pits before transferring to the mine water dam. These ancillary dams are designed to overtop back into the pits. The main mine water dam is located to the north of Pit AB and offsite discharge of mine water will be avoided by operating below a maximum operating level and directing emergency overflows from the mine water dam via a spillway to the Pit AB.

MIA dams will capture and contain runoff from the MIA and coal stockpiles. Oil/water separators are proposed for vehicle wash and workshop areas to treat hydrocarbon contaminated runoff prior to capture. These dams will be sized to ensure full containment of MIA and coal stockpile runoff.

A series of sediment traps and small drainage dams will be used to capture washdown and overflow from trains and sumps before it is directed to the TLO dam. Water collected in this small dam will be pumped to the mine water dam.

Haul Road Dams

Two small dams will be used to manage runoff from disturbed catchments. One dam (between Pit AB and Pit C) will be used to contain runoff from the Pit C haul road, while the other dam will be used to collect runoff from the haul road on the western side of Charlevue Creek.

Raw Water Dam

A raw water dam will be located adjacent to the MIA (Figure 7 and Figure 11) and will be sized to hold approximately 50 megalitres (Ml). The raw water dam will store water transported to site via the raw water pipeline from Blackwater, described in Section 3.5.2.

Sediment Dams

Sediment dams will be constructed to contain runoff from the waste rock emplacements and haul roads. The sediment dams allow for gravity settling of sediment prior to re-use of the water onsite or release

offsite. The sediment dams will be designed and operated in accordance with *Best Practice Erosion and Sediment Control* (IECA Australasia 2008) and the Department of Environment and Heritage Protection guideline for *Stormwater and environmentally relevant activities [ESR/2015/1653]* (DES 2017f). A consequence category assessment will be undertaken by a suitably qualified person during the final design process. However, sediment dams are unlikely to have a significant consequence category due to their locality from the floodplain, climate modelling and the preliminary design parameters.

The sediment dams have been sized as follows:

- water storage capacity 0.1% AEP 24-hour storm event with an adopted volumetric event runoff coefficient for disturbed catchments of 0.5;
- *total sediment basin volume = settling zone capacity + sediment storage volume.*
  The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted; and
- *solids storage volume = 25% of water storage volume.*

If required, water captured in sediment dams will be pumped back into the MAW system.

Table 9 summarises the sediment dam design criteria in accordance with the abovementioned guidelines.

The sediment dams will be maintained until the vegetation within the catchment area of the sediment dams is successfully established; and whereby surface water runoff achieves similar water quality characteristics to background sites of areas undisturbed by mining activities. Sediment dams may be maintained during rehabilitation to augment site water requirements.

Table 9 Gemini Project Sediment Dam Design

Storage	Catchment Areas (ha)	10-year 24-hour Water Storage capacity (ML)	Solids Storage Volume (ML)	Total Storage Capacity (ML)
AB01	146.1	105.9	26.5	132
AB02	155.5	112.7	28.2	141
AB03	121.8	88.3	22.1	110
AB04	114.9	83.3	20.8	104
C01	132.7	96.2	24.1	120
C02	106.8	77.4	19.4	97
C03	32.4	23.5	5.9	29
C04	76.0	55.1	13.8	69
C05	64.8	47	11.7	59

Source: Appendix B - Surface Water Assessment

3.4.4 Preliminary Consequence Category Assessment

3.4.4.1 Consequence Assessment – Dams

A consequence assessment has been completed for the dams making up the proposed water management system, in accordance with the *Manual for assessing consequence categories and hydraulic performance of structures* (DES 2016) (the Manual). Details of the assessment protocols and criteria are provided in the *Surface Water Assessment* (WRM 2020b), with results of the assessment summarised in Table 10.

Table 10 Summary of Consequence Assessment - Dams

	Main Water Dam	CHPP and MIA Dams	Raw Water Dam	Sediment Dams
Failure to contain - seepage				
Harm to humans	L	L	L	L
General environmental harm	S	L	L	L
General economic loss/damages	L	L	L	L
Failure to contain - overtopping				
Harm to humans	L	L	L	L
General environmental harm	S	L	L	L
General economic loss/damages	L	L	L	L
Dam break				
Harm to humans	L	L	L	L
General environmental harm	L	L	L	L
General economic loss/damages	S	L	L	L
OVERALL CCA RATING	**S**	**L**	**L**	**L**
Requires DSA/MRL	Y*	N	N	L
Requires engineered spillway	Y	Y	Y	Y
Requires lining (unless detailed groundwater investigation indicates risks are low)	Y	Y	N	N

L = Low consequence
S = Significant consequence
*DSA for Mine Water Dam – no DSA required if spills are directed to the Mine Pit via an appropriately robust overflow system (the Mine Pit provides the DSA)

3.4.4.2 Consequence Assessment – Levee

A consequence assessment has also been completed for the proposed levee protecting the mine pit from flood inundation. The Manual includes specific considerations for the assessment of levee. Details of the assessment protocols and criteria are provided in the *Surface Water Assessment* (WRM 2020b), with results of the assessment summarised in Table 11.

Table 11 Overall Consequence Categories

Criteria	Consequence Category
Harm to humans	L
General environmental harm	S
General economic loss/damages	L
OVERALL CCA RATING	**S**

3.4.5 Site Water Balance Model

The operating life mine stage plans were used to determine progressive catchment areas and land use types for each mine water storage. These 'snapshots' of mine operations were adopted for the site water balance modelling. OPSIM, a computer-based operational simulation model was used to assess the dynamics of the mine water balance under conditions of varying rainfall and catchment conditions throughout the development of the Project, based on the SWMS described in Section 3.4.2. The model

was configured to simulate the operations of all major components of the water management system. Detailed water balance modelling methodology is provided in Appendix B.

Water Demand

Water demands calculated for the operational life include CHPP coal washing and conveyor dust suppression, haul road dust suppression, and TLO dust suppression demands. The estimated annual demands (WRM 2020b) (Appendix B) considered the Project from the basis of full production levels (Project Year 2). Year 1 demands are estimated based on construction activities only; including infrastructure establishment and early works on Pit AB excavation. The CHPP and TLO will not be processing coal to contribute to water demand, with the only Project water demand during Year 1 would be dust suppression for construction activities. Site water demands are summarised in Table 12.

Groundwater Inflows

As indicated, there will be small 'pumpable' inflows of groundwater to mining pits at the end of operations. Current active pits do not indicate any groundwater inflows. Groundwater inflows to the pits have been assumed to increase in a linear manner over time.

Groundwater inflows were estimated in the *Groundwater Impact Assessment* (JBT 2019), which is discussed further in Section 8.0 and attached as Appendix C. The estimates provided by JBT (2019) are based on net inflows to the pit after evaporation losses from the pit faces and the entrained moisture losses due to mining.

Groundwater inflows are expected to increase over time and eventually the net inflow would exceed the total site water demand. Water is therefore expected to accumulate in the mine water dam over the long term. The relatively large capacity of the mine water dam has been provided specifically for this purpose.

The net inflow rates adopted for the site waster balance model are provided in Table 12.

Overall Water Balance

The overall average annual site water balance is summarised in Table 13. The results demonstrate the adaptive capacity of the SWMS to changing mine stages and climatic variability.

Over the life of the Project, the results of the site water balance indicate that small volumes of external water supply will be required at each stage of the Project, with the exception of Stage 1 (first four years of Project). Haul road dust suppression forms the greatest demand for water on the site, while the greatest loss of water is caused by evaporation.

Total average inflows increase steadily during the first three stages (13 years) of the Project from approximately 1,000 Ml/a to approximately 1,500 Ml/a. A larger increase is evident in Stages 4 and 5, with the commencement of Pit C adding a greater runoff catchment area which increases total average inflows to around 2,300 Ml/a over the final five years of the Project.

Total average outflows, steadily increase over the operational life of the Project from approximately 1,000 Ml/a to approximately 2,000 Ml/a.

The model of the SWMS has been configured to ensure MAW is contained within the system. Hence, the modelled results show no spills of MAW from the mine water dams (not including sediment dams).

When the sediment dams exceed their maximum operating volumes, sediment dams are allowed to discharge offsite. Note that sizing of the proposed sediment dams is in accordance with *Best Practice Erosion and Sediment Control* (IECA Australasia 2008).

Table 12 Summary of Site Water Demands and Expected Groundwater Inflows

Year	Demand (Ml/a)				Net Groundwater Inflow (Ml/a)
	CHPP	Haul Road	TLO	Total	
1	0.0	250.0	0.0	250.0	0.0
2	162.0	314.6	0.72	477.3	31.5
3	162.0	314.6	0.73	477.3	31.5
4	162.0	314.6	0.73	477.3	31.5
5	162.0	314.6	0.73	477.3	31.5
6	162.0	333.4	0.73	496.1	31.5
7	162.0	333.4	0.72	496.1	31.5
8	162.0	333.4	0.72	496.1	31.5
9	162.0	333.4	0.71	496.1	31.5
10	162.0	333.4	0.72	496.1	31.5
11	162.0	333.4	0.72	496.1	31.5
12	162.0	401.5	0.70	564.2	220.8
13	162.0	401.5	0.74	564.2	220.8
14	162.0	401.5	0.74	564.2	189.2
15	162.0	464.9	0.74	627.6	205.0
16	162.0	464.9	0.74	627.6	31.6
17	162.0	511.8	0.72	674.5	31.6
18	162.0	511.8	0.74	674.5	31.6
19	143.4	511.8	0.65	655.9	47.3
Total	**2,897.4**	**7,178.5**	**13.00**	**10,088.9**	**1,292.6**

External Water Supply

Site water requirements are preferentially sourced from the MAW system and supplemented as required by the sediment water system. However, in the event that both systems are not sufficient to meet operational water requirements, external raw water will be supplied by a spur pipeline from the Blackwater Pipeline (refer Section 3.5.2) and transferred to the raw water dam.

'External supply pipeline' refers to the quantity of raw water imported from external sources (i.e., SunWater) which is then transferred to the raw water dam.

Potential imported water requirements have been assessed using forecast simulation. The results show that:

1. imported water requirements from the external pipeline are highest in the early Project stages;
2. under very dry conditions, the demand could reach 500 Ml/a, but median Year 1 demand is less than 100 Ml/a; and
3. during later years, accumulated stored water in the MAW system and sediment water system is sufficient to supply demands in all but the driest years.

The external raw water supply contract will be sufficient to ensure continued operation even in the driest of years.

Table 13 Average Annual Site Water Balance

Process	Stage 1 Y1-Y4	Stage 2 Y5-Y10	Stage 3 Y11-Y13	Stage 4 Y14-Y15	Stage 5 Y16-Y18	Total
Inflows (Ml/a)						
Rainfall and runoff	973	1,052	1,215	2,148	2,214	7,602
Net groundwater inflow	32	32	210	118	37	428
External supply pipeline	89	51	29	17	11	196
Total Inflows	**1,093**	**1,135**	**1,454**	**2,283**	**2,261**	**8,226**
Outflows (Ml/a)						
Evaporation	250	317	386	629	762	2,344
Haul road dust suppression	315	336	405	469	515	2,040
CHPP usage	162	162	162	162	162	810
Spill from raw water dam	37	41	41	43	44	206
Spill from sediment dams	223	245	398	669	652	2,187
Spill from mine water dams	0	0	0	0	0	0
Total Outflows	**988**	**1,102**	**1,392**	**1,972**	**2,135**	**7,587**
Change in Site Water Inventory (Ml/a)	**102**	**29**	**59**	**308**	**122**	**619**

3.5 SUPPORTING INFRASTRUCTURE

3.5.1 Power Supply

Electricity supply to the region is provided by a Powerlink 275 kV/132 kV substation at Blackwater (Rangal Substation). Electricity is currently supplied to properties within the local area from a 132 kV/66 kV substation at Blackwater, as well as Ergon substations at Dingo and Bluff. Ergon Energy distributes electricity from these substations to local customers.

Power to the mine and all mining infrastructure (i.e., accommodation facilities, CHPP and MIA) will be supplied by the construction of a 66 kV transmission line and an onsite switching/substation located adjacent to the MIA. The transmission line will be connected to the regional network and be installed along the alignment of the mine access road to the MIA (Figure 8). Diesel power generation will be used for construction activities and until the transmission line is completed.

3.5.2 Water Supply

SunWater operates the Blackwater Pipeline network, which supplies water from the Bedford Weir (part of the Nogoa-Mackenzie River pipeline network) to the town of Blackwater and a number of nearby coal mines.

A spur pipeline from the Blackwater Pipeline will be constructed for the Project by SunWater with the take-off point located near the Blackwater Treatment Plant. SunWater has advised there is sufficient availability of water within the Mackenzie Nogoa River network to provide the Project's estimated water requirements, including in the driest of years. Within the MLA the water supply pipeline will be installed proximal to the mine access road corridor and connect to the raw water dam near the MIA (Figure 22).

During construction water will be required for dust suppression and civil works, as well as potable water for drinking. Water will be sourced from regional suppliers and transported to site by tanker and stored

at the MIA until the permanent supply is established. Potable water may also be supplied by truck from Blackwater.

3.5.3 Sewage

A *Land-Based Disposal Effluent Disposal Assessment* (Cardno 2020) for the Project's effluent disposal is attached as Appendix N. During both construction and operation phases, workers will generate domestic wastewater from accommodation, offices, and facilities. The wastewater will include material which is generated from the following:

- toilets (often classed as black water); and
- showers, kitchen facilities and laundry (often classed as grey water).

In accordance with the EP Regulation, wastewater has been estimated using each worker as an equivalent person (EP) with each EP generating 200 L/day. During construction, a total of 280 workers will be onsite and generate their total maximum volume of 56,000 L/day. During operations, only 140 workers will be present onsite and will generate their total maximum volume of 28,000 L/day.

All domestic wastewater will be channelled to a single sewage treatment plant (STP) located at the accommodation facilities towards the northwest of the MLA, as shown in Figure 7. The STP has been designed for a 280 EP maximum capacity (56,000 L/day). A closed wet weather storage tank will be located at the STP and designed in accordance with the *QLD Government Technical Guideline for Disposal of Effluent via Irrigation*. The closed wet weather storage tank will have a 3-day capacity of 168m^3 suitable for both construction and operations to account for times when the ground is showing signs of saturation (such as surface water pooling) during substantial rain events. The tank will have a length of 19.48m, width of 19.48m, and an overflow outlet depth of 3m.

A membrane bioreactor will be operated at the STP with an appropriately sized pump station to minimise the retention of raw sewage to less than eight hours and reduce the potential for odour and volatile organic compounds.

The treated effluent from the STP will be irrigated in a suitable irrigation management area, while the remaining sewage sludge will be removed by a licensed regulated waste contractor for offsite disposal. During the initial site preparation phase, prior to installation of the STP, all sewage will be contained at the MIA and transferred by a certified third-party contractor to an appropriately licensed regional waste disposal facility.

3.5.3.1 Irrigation Management Area

The proposed irrigation management area is located south of the Capricorn Highway towards the northwest of the MLA and is shown in Figure 7. It is located within reasonable proximity to the primary source of wastewater (accommodation facilities) and is accessible from the proposed camp access road.

The reasonably flat nature of the designated area and distance from significant watercourses is ideal for irrigation. The topography falls in a north to south direction. The irrigation area lacks any significant drainage lines / watercourses and sits on the divide between the catchment of Stanley Creek towards the north and the catchment of Charlevue Creek to the south. Two minor drainage lines off Charlevue Creek are present to the east and west of the irrigation management area. Stanley Creek and Charlevue Creek are highly ephemeral flowing only after substantial rainfall events. The management area has already been cleared and therefore contains limited ecological value.

The irrigation management area (approximately 195m x 195m, 3.8 ha) will maintain sufficient buffers from sensitive receivers such as waterways, ecosystems, and the residents/mining camp (refer to Figure 12-1 of Appendix N). The following buffer zones for the irrigation management area will be adopted in accordance with the *QLD Government Technical Guideline For Disposal of Effluent via Irrigation* to ensure environmental care and exposure to all sensitive receptors is negligible:

- natural waterways >100 m;
- residential facility or public amenities >50 m;
- domestic water bore > 250 m;
- drinking water catchment and aquatic ecosystems with high ecological value > 250 m;
- town water supply bore > 1000 m;
- groundwater bore used for potable water supply >250 m; and
- groundwater table at a depth >3 m.

A review of the Central Highlands Regional Council Flood Hazard Overlay indicates that the irrigation management area and the greater proposed mine are located a substantial distance away from Q100 floodplain based on the 1% AEP + climate change allowance. Therefore, inundation within the irrigation area is not considered to be high-risk.

Site specific soil data was unavailable from the selected irrigation management area and therefore soil characteristics have been interpolated from the Soil and *Land Suitability Assessment* (AARC 2019) (Appendix I). As a result, the irrigation management area has been characterised by the Soil Management Unit (SMU) Geoffrey which covers approximately two thirds of the mining lease (refer to Section 5.2.5). The Geoffrey SMU consists of texture contrast soils (loamy sands to sandy light clays) with soft surface conditions, associated with undulating plains and rises. The chemical and physical properties of the soil profile pH are described as moderately acidic in the upper loamy profile (5.8-6), with a sudden shift to weakly alkaline in the underlying clay profile (8.1). An increased cation exchange capacity (CEC) was observed at greater depths (0.4 – 8.8 meq / 100g) and also a general increase in salts, as is evident in the higher EC (0.004 – 0.137), chloride and sodicity in the bottom clay layer. Exchange sodium percentage (ESP) ranges from non-sodic in the upper profile (1 – 1.8%) to strongly sodic in the lower profile (22.1%).

Topsoil nutrients are generally quite limited with nitrate (3 mg/kg), phosphorous (8 mg/kg) and potassium (<200 mg/kg) below desirable levels. Boron (0.2 mg/kg) and sulphate (<10 mg/kg) are also lower than guideline recommendations for suitable plant growth medium. For extractable metals, manganese (16.0 mg/kg) and zinc (2.16 mg/kg) are within the desirable range, though iron (166 mg/kg) is elevated, and copper (<1.0 mg/kg) is below reportable levels. The nature of the soil is generally supportive of spray irrigation, though the sodicity in the lower soil profile will need to be managed to ensure the soil does not become dispersive.

3.5.3.2 Irrigation Regime

The irrigation regime will be undertaken in accordance with *AS/NZS 1547:2012 On-Site Domestic Wastewater Management.* The infrastructure required will include a STP, wet weather storage tank, closed pond, pump system, pump chamber, pipeline, flush and release valve, supply header and secondary treatment unit. The irrigation layout is illustrated in Appendix N. The pump system and pipeline will contain a separate effluent chamber with storage volume to match the electrical starting

requirements of the irrigation pump motor. The irrigation system will have a discharge capability of at least 50% more than the maximum 30-minute flow rate and capacity to withstand at least 150% of the shut-off head of the pump. The selected spray-irrigation system will evenly distribute effluent and control the droplet size, throw, and plume through the use of coarse spray heads suitable for effluent application.

Given the designated irrigation site is isolated and significant in size, management would only warrant a secondary treatment quality to contain negligible risk of human exposure, aerosol drift and odour nuisance to offsite locations. The following management measures will be implemented to ensure the limits identified in the *National Guidelines for Water Recycling* (Table 9-1, Appendix N) are achieved:

- no access during and after irrigation, until dry (1-4 hours);
- spray drift control (low-throw sprinklers - 180º inward throw);
- restricted irrigation when wind direction is not favourable, or temperature inversions present; and
- irrigation timing during the day when residents are not localised.

Magnetic South will also operate and manage an onsite septic system, which will be located at the MIA to service the office area. Waste from the septic system will be regularly pumped out and removed by a regulated waste contractor for disposal as required. Servicing or maintenance of the system will be contracted to a licensed plumber to undertake the works, as required.

Specific details and requirements regarding the sewage management system will be addressed in a *Non-Mineral Waste Management Plan* for the Project (Section 12.8.1).

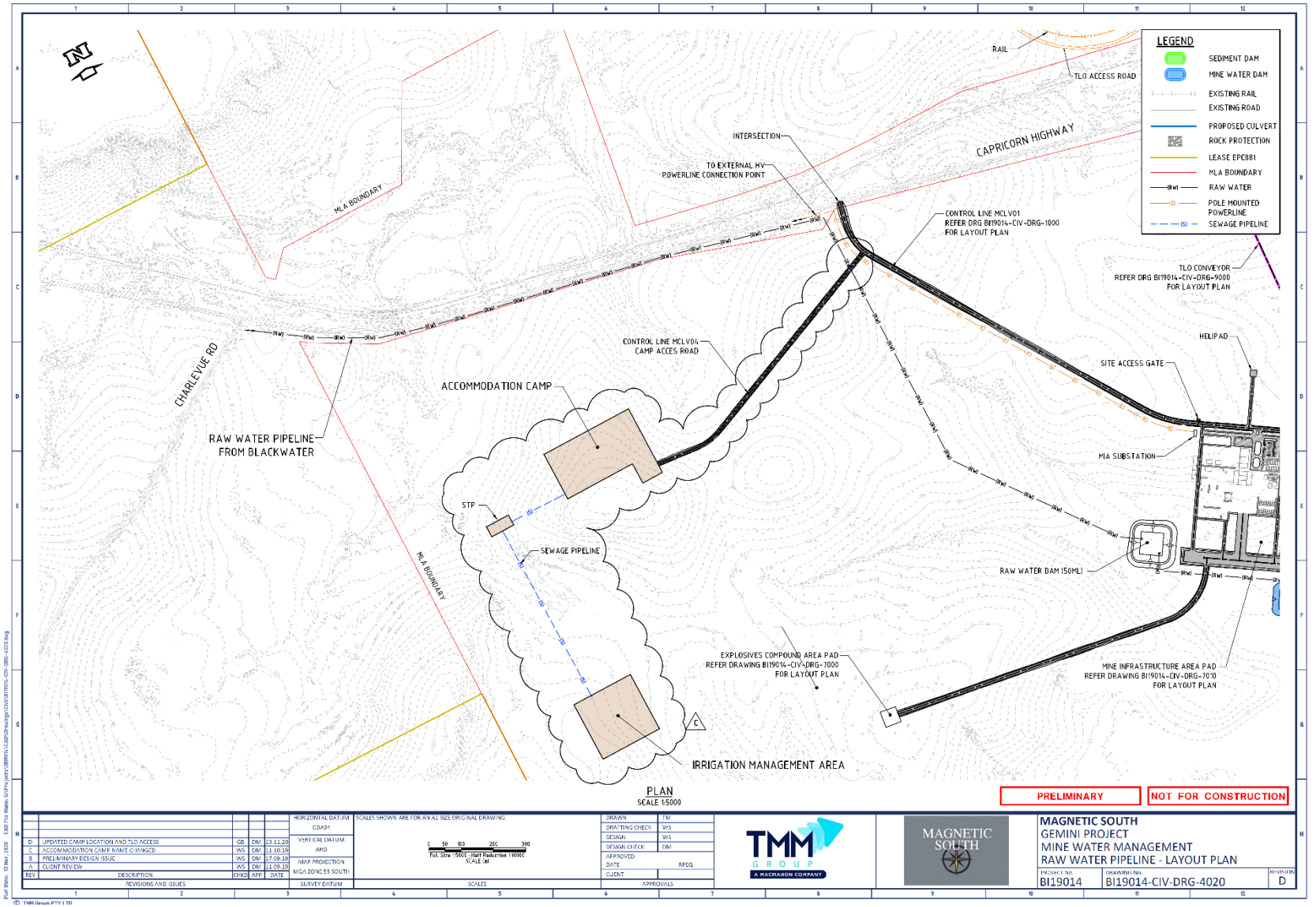


Figure 22 Conceptual Layout - Raw Water Supply Pipeline

3.5.4 Telecommunications

High speed telecommunication services are available in the region via an existing fibre optic network. Connection to this network will be undertaken utilising either microwave or fibre optic cable. A cable connection will be established in the mine access road and power supply corridor.

3.5.5 Fuel Supply

Fuels will be stored within the MIA, with additional self-bunded tanks located as required in the mining area, depending the current location of the main fleet and advancing mine face.

Fuels (including diesel) will be delivered to the Project by contractors. The transport, storage and handling of fuels (including diesel) will be undertaken in accordance with relevant legislation and guidelines.

All equipment and vehicle operators will be trained in the safe operation of the equipment (including operating procedures for the refilling and maintenance of fuel storage tanks and mine vehicles) and the relevant emergency response and spill management procedures in the event of an incident.

Regular inspection programs will be undertaken to monitor the structural integrity of fuel tanks and bunds.

3.6 MINING OPERATIONS

3.6.1 Open-cut Mining Method and Activities

The Project includes two mining areas referred to as Pit AB and Pit C. The open-cut mining areas will be mined using a conventional truck and shovel mining method with excavators and haul trucks.

Mining of Pit AB will be undertaken over a period of approximately 12 years. Out-of-pit waste rock emplacements are required until mine operations advance sufficiently to allow backfilling of the mine void. Out-of-pit waste rock emplacement for Pit AB will be conducted over a period of approximately eight years. In-pit waste rock emplacement will occur from Year 5. Following the completion of coal extraction from Pit AB, final backfilling of the Pit AB void will occur through the rehandling of out-of-pit waste rock emplacements from Year 12.

The development of Pit C is scheduled to commence in Year 12 (one year prior to the completion of mining in Pit AB) and mining will be undertaken over a period of approximately seven years. Out-of-pit waste rock emplacement will be undertaken for Pit C over a period of approximately four years. Once operations have advanced sufficiently, backfilling of the mine void will commence and continue as the mining face advances. Following the completion of coal extraction from Pit C in Year 19, final backfilling of the Pit C void will occur through the rehandling of the out-of-pit waste rock emplacement.

A summary of the open-cut mining activities is provided below.

Vegetation Clearing and Topsoil Stripping and Handling

Vegetation will be progressively cleared over the life of the Project ahead of the active mining and waste rock emplacement areas. Specific vegetation clearance procedures will be developed for the Project as described in Section 5.0.

Topsoil from disturbed areas will be stripped and stockpiled for use in rehabilitation of the final landform. Where stripped topsoils cannot be used directly for progressive rehabilitation, the topsoil will be

stockpiled separately. Specific soil management, stockpiling and re-application procedures will be developed for the Project as described in Section 4.0.

Waste Rock Management

Some weathered or friable overburden (e.g., clays and alluvium) will be pre-stripped using excavators and haul trucks, with supporting dozers.

Drilling and blasting of competent overburden and interburden material (waste rock) will be undertaken within the open-cut pit areas. Standard commercial products will be used, with the principal blasting agent being ammonium nitrate fuel oil (ANFO).

The removal of waste rock will be undertaken by excavator and haul truck, with supporting dozers to expose the underlying coal seams. The waste rock will be placed in out-of-pit waste rock emplacements, or as infill in the mine void, behind the advancing mining operations.

The permanent waste rock emplacements are located to the west of Pit AB and Pit C. The waste rock emplacements will be developed progressively during the operational life of each pit and will have a maximum elevation of approximately 190 mAHD high. As mining advances, sufficient void space will be created within the mined-out areas to enable waste rock to be placed in the in-pit waste rock emplacements.

A small temporary waste rock emplacement will also be established to the north of Pit AB. Waste material will be re-handled from each waste rock emplacement and from the temporary waste rock emplacement to backfill the final voids of each of the respective pits following the completion of coal mining activities.

ROM Coal Handling

Excavators will load the ROM coal into haul trucks for haulage to the ROM stockpile area located at the MIA. Haulage of ROM coal from Pit AB and Pit C will be conducted during day and evening hours (i.e., 7 am to 10 pm), to minimise air quality and noise impacts at sensitive receptors during the night. Noise and dust levels would be monitored for compliance management. To achieve increased Project production rate efficiencies; ROM coal haulage during night hours (i.e., 10 pm to 7 am) would be considered, providing monitoring shows that compliance can be achieved at sensitive receptors.

Landform Profiling and Rehabilitation

Re-shaping of the waste rock emplacements, re-application of topsoil and revegetation of the final landform surfaces will be undertaken progressively over the life of the Project. The rehabilitation strategy for the Project is described in Section 4.0.

3.6.2 Mine Schedule

The total quantity of coal to be mined is approximately 32 Mt ROM. The indicative mine schedule is provided in Table 14. The life of mine waste rock material handled is estimated to be approximately 475 Mbcm for the Project. The annual volumes of waste rock handled during the various mining stages of the Project are provided in Table 14.

Subject to granting of the Project ML and EA, mine construction activities are scheduled to commence in July 2021. It is anticipated that it will take approximately six months to establish the necessary infrastructure to commence overburden removal and 18 months to commence coal production.

Indicative general arrangements for various stages of the Project are shown in Figure 23 to Figure 32. The stage plans show the mine's progression over time and are based on the present schedules and production plans. The layout and mining sequence may vary from that shown to account for localised geological features, detailed engineering design, mining economics and variations in market tonnages and quality requirements.

Table 14 Indicative Mine Schedule

Year	Waste Rock (Mbcm)	ROM Coal Mined (Mtpa)	Coal Rejects (Mtpa)	Product Coal (Mtpa)[1]
Y1	13.0	0	0	0
Y2	26.1	0.9	0.83	0.07
Y3	22.1	1.9	0.54	1.36
Y4	24.4	1.9	0.53	1.37
Y5	27.8	1.9	0.54	1.36
Y6	22.5	1.9	0.54	1.36
Y7	26.8	1.9	0.56	1.34
Y8	29.9	1.9	0.55	1.35
Y9	24.0	1.9	0.57	1.33
Y10	24.2	1.9	0.55	1.35
Y11	23.4	1.9	0.56	1.34
Y12	26.2	1.9	0.60	1.30
Y13	27.5	1.8	0.41	1.39
Y14	28.2	1.8	0.41	1.39
Y15	28.7	1.8	0.42	1.38
Y16	28.1	1.8	0.41	1.39
Y17	27.4	1.8	0.45	1.35
Y18	28.9	1.8	0.42	1.38
Y19	14.3	1.6	0.38	1.22
Total	473.4 Mbcm	32.3 Mt	9.27 Mt	23.03 Mt

Notes: Mbcm million bank cubic metres

1 values represent the air-dried tonnage

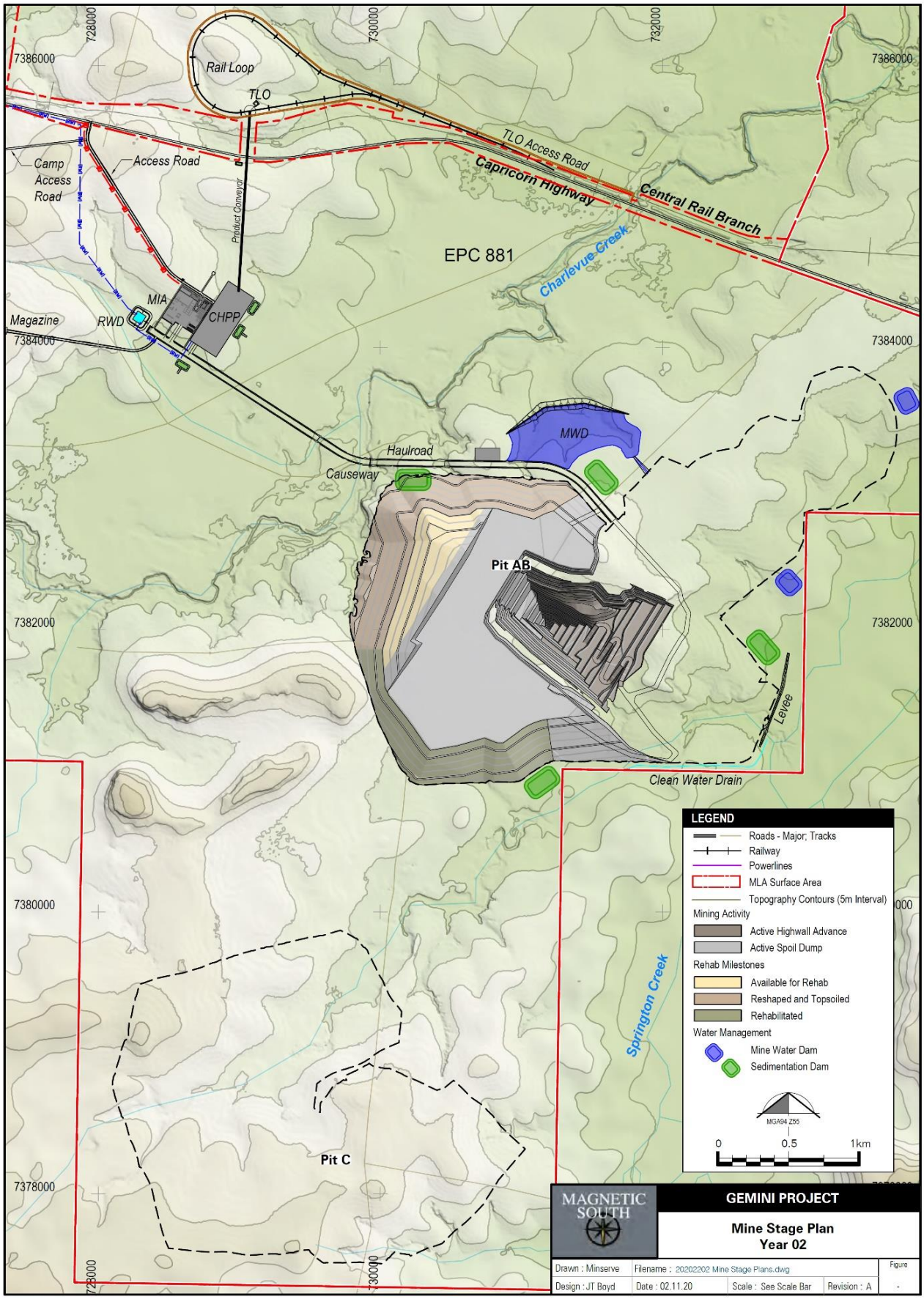


Figure 23 Mine Stage Plan - Year 02

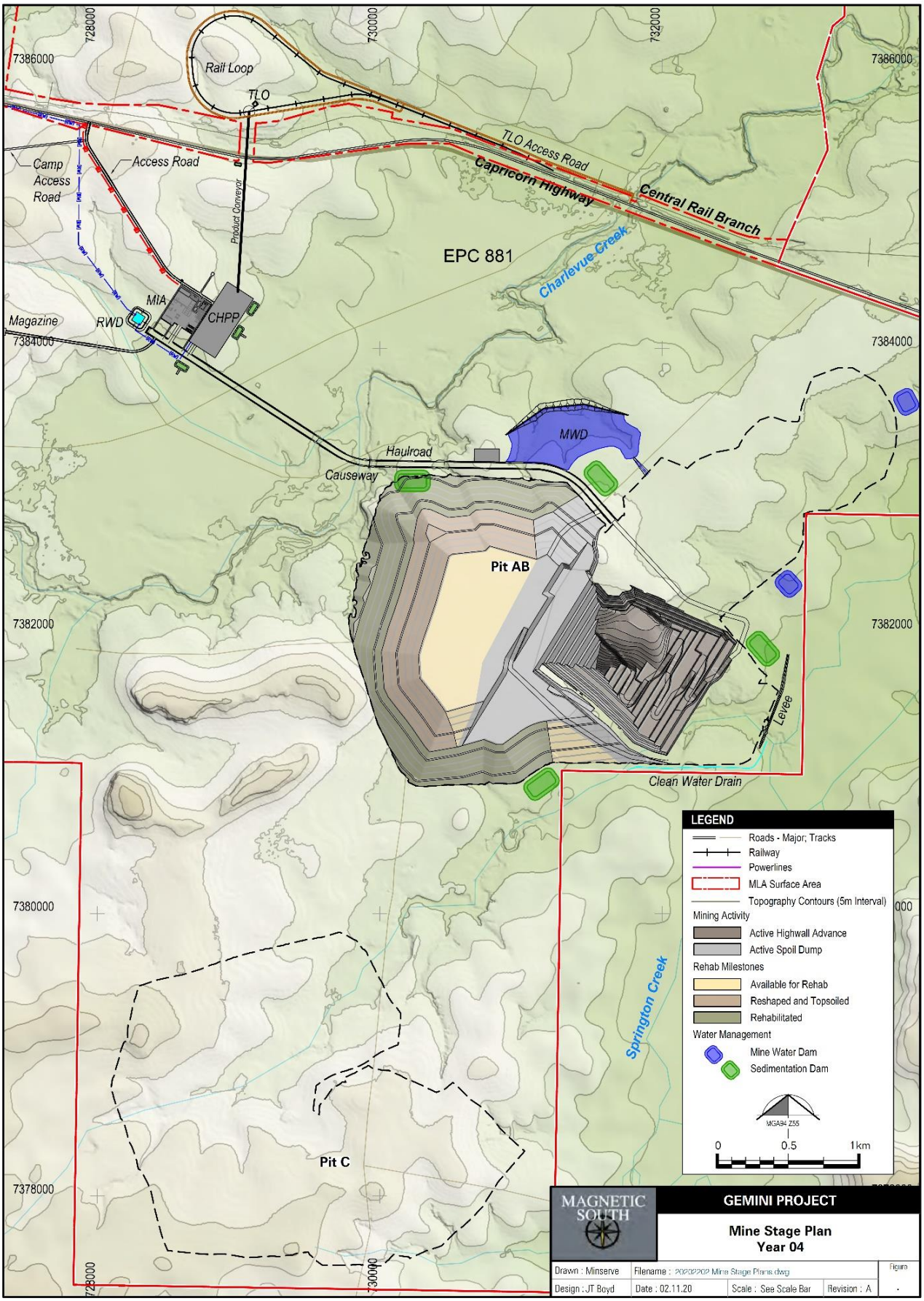


Figure 24 Mine Stage Plan - Year 04

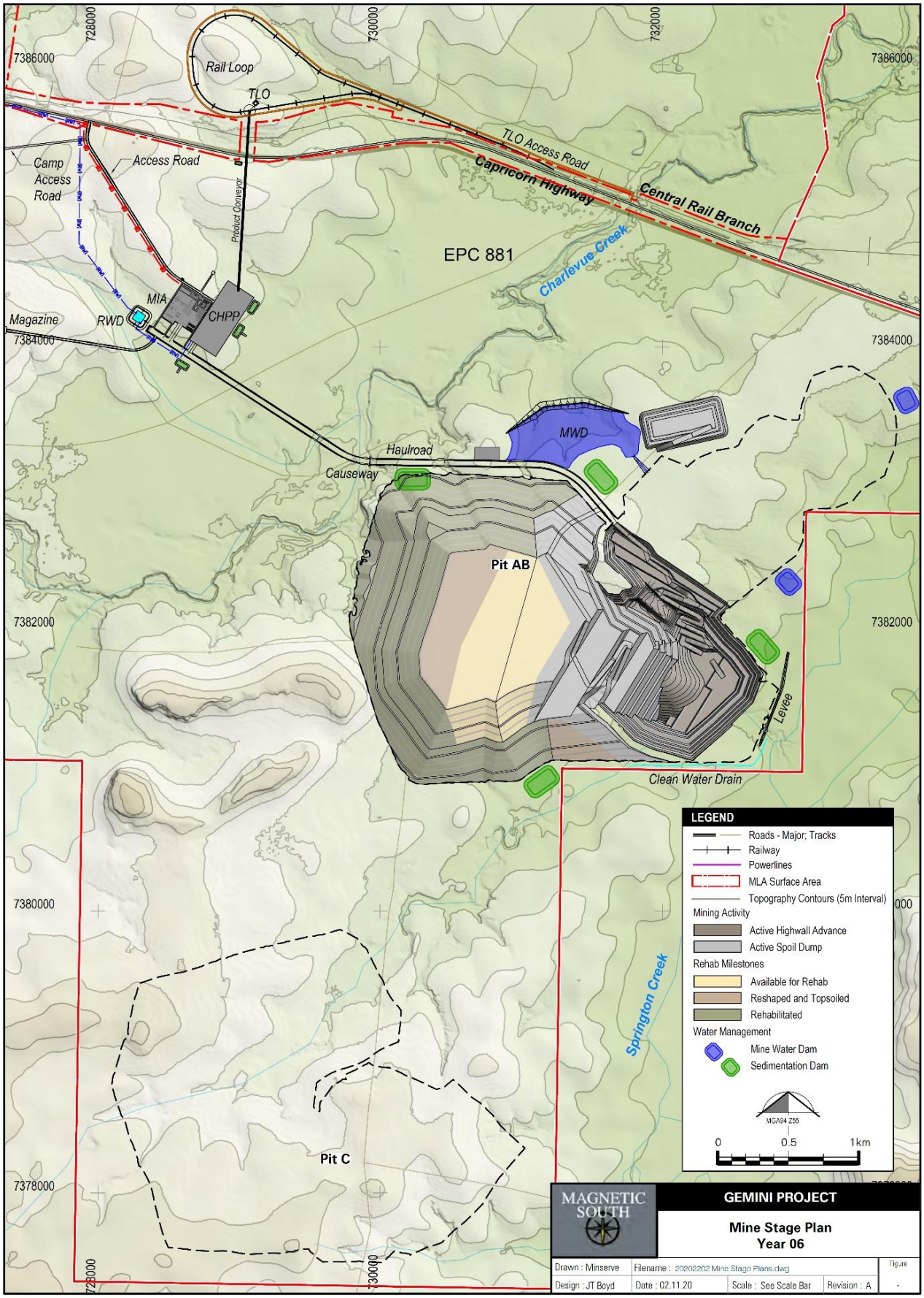


Figure 25 Mine Stage Plan - Year 06

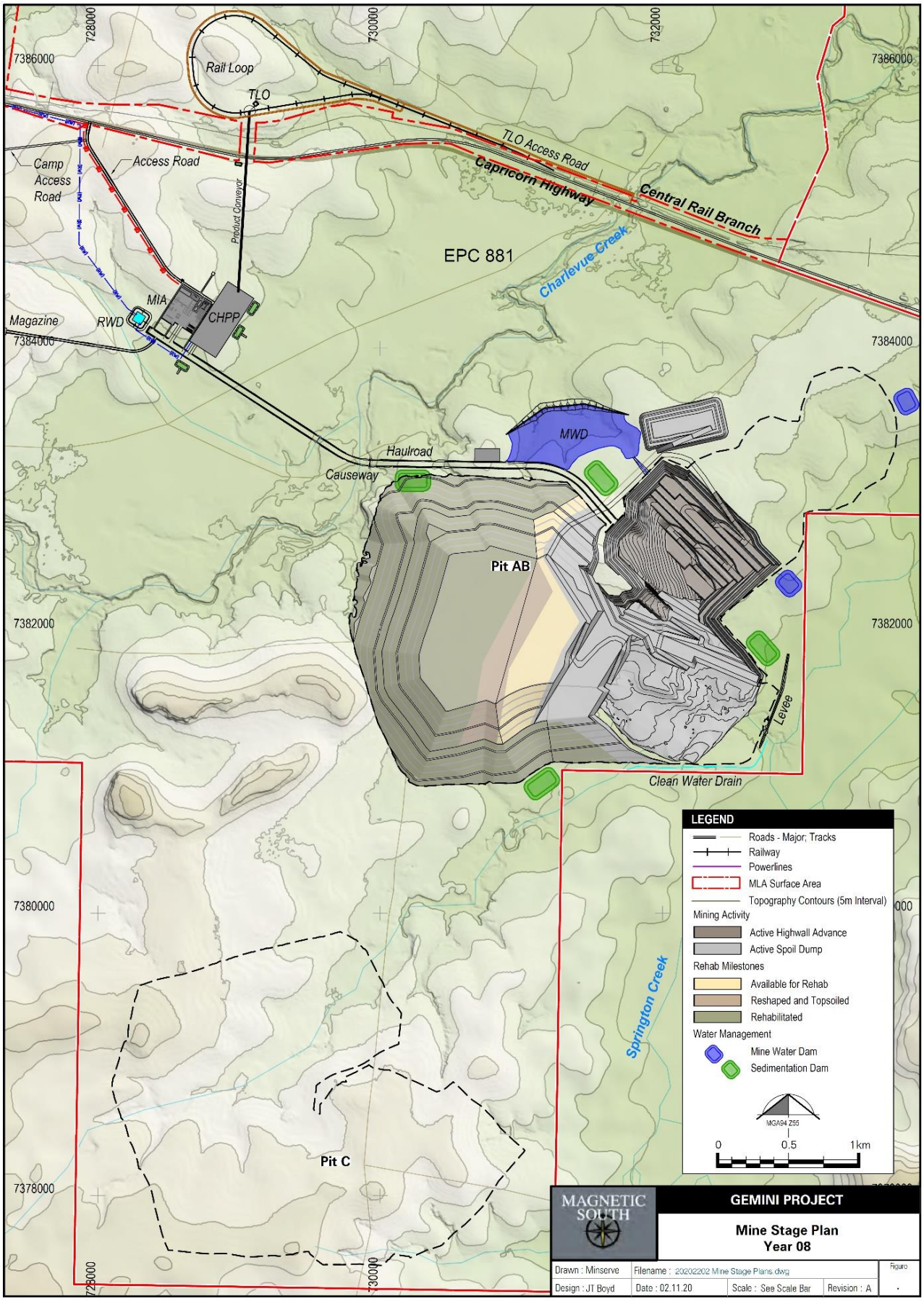


Figure 26 Mine Stage Plan - Year 08

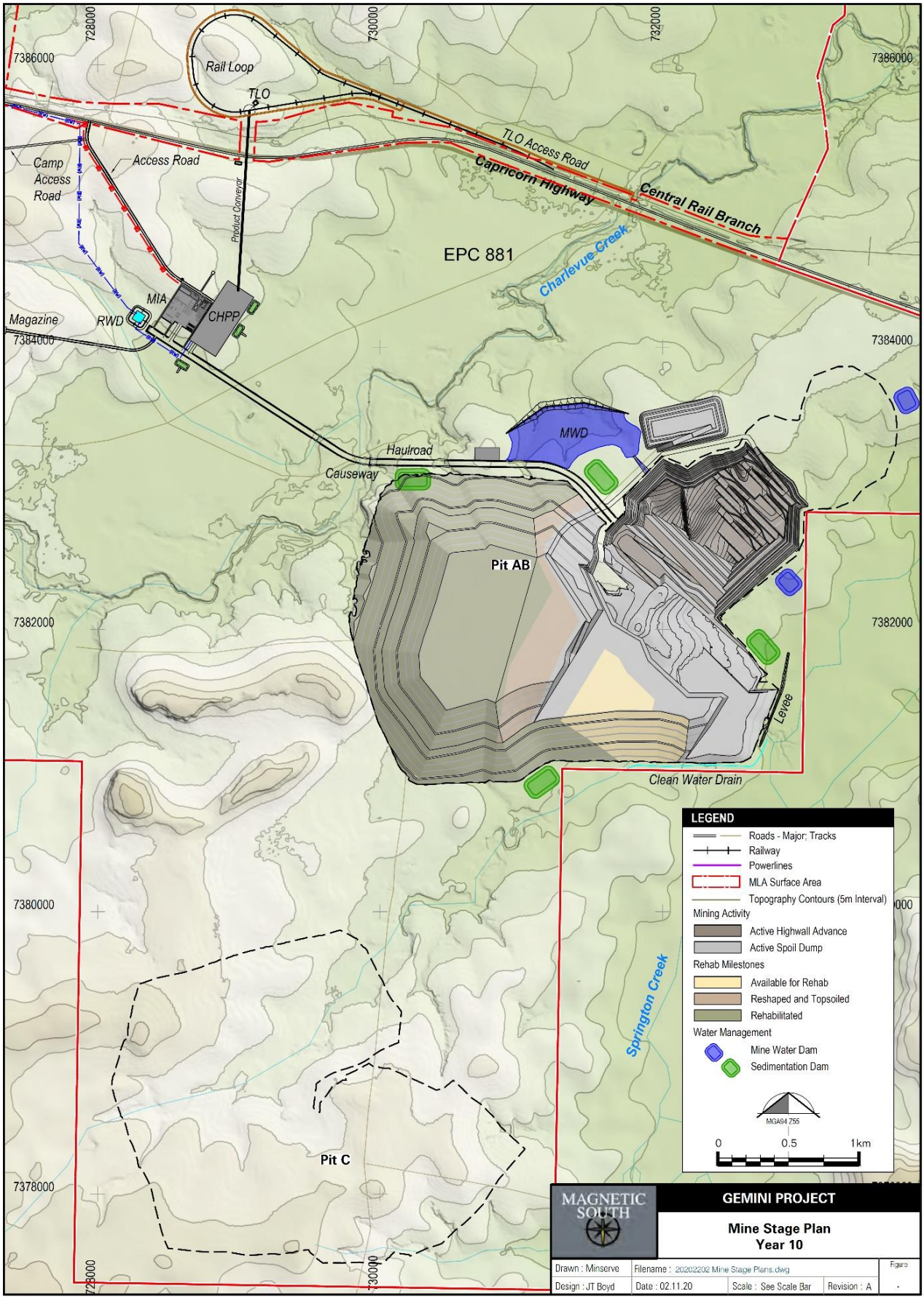


Figure 27 Mine Stage Plan - Year 10

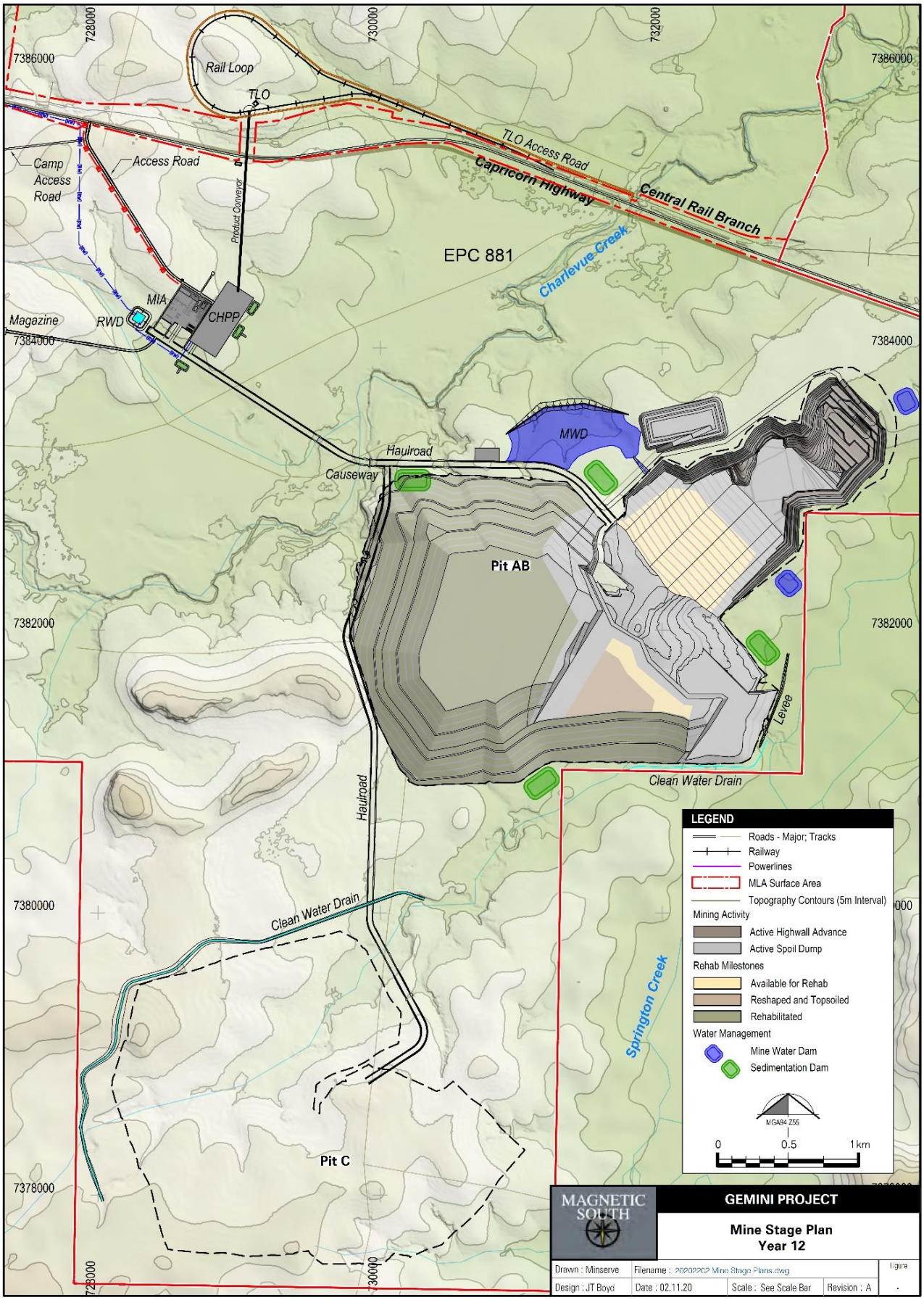


Figure 28 Mine Stage Plan - Year 12

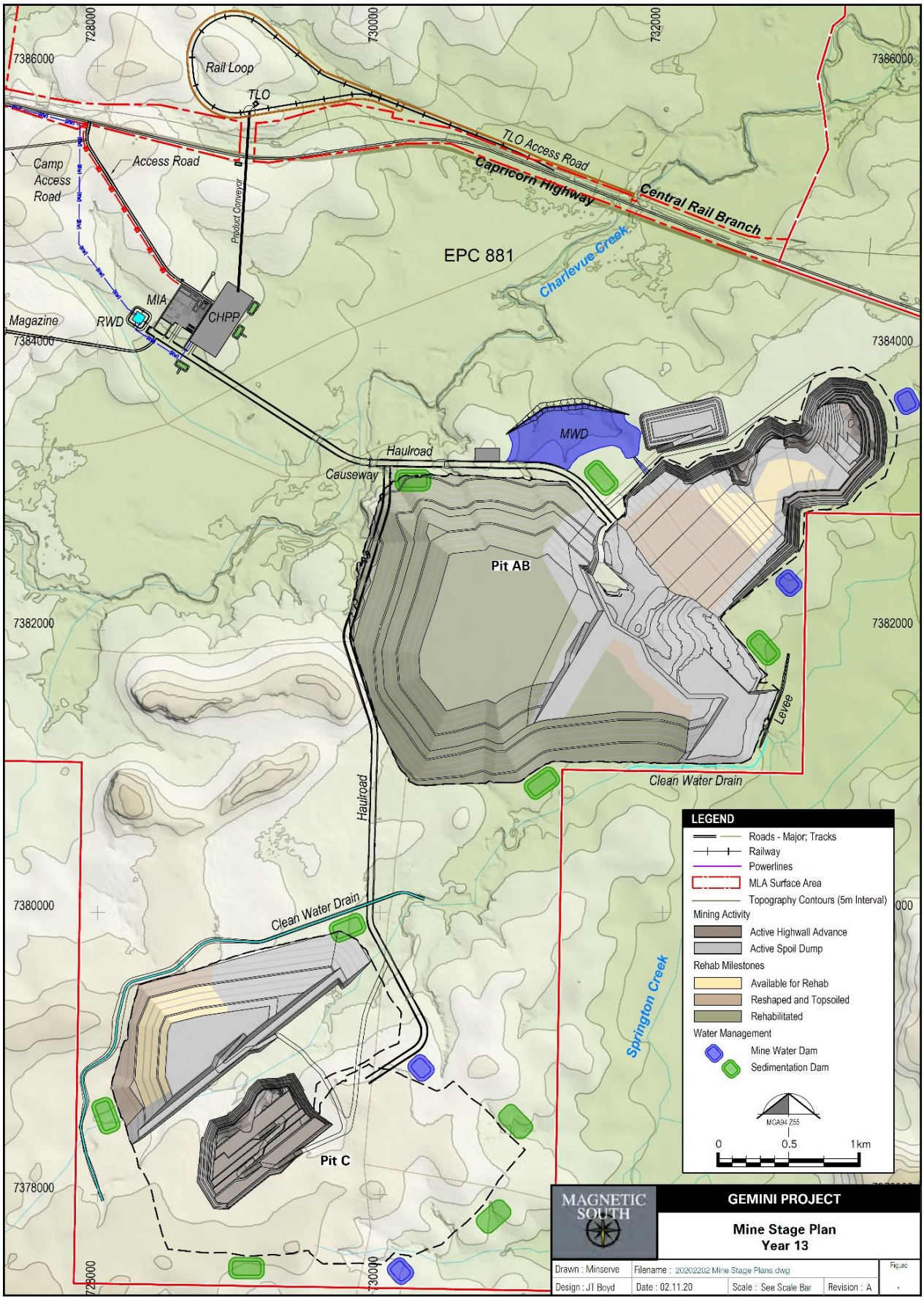


Figure 29 Mine Stage Plan - Year 13

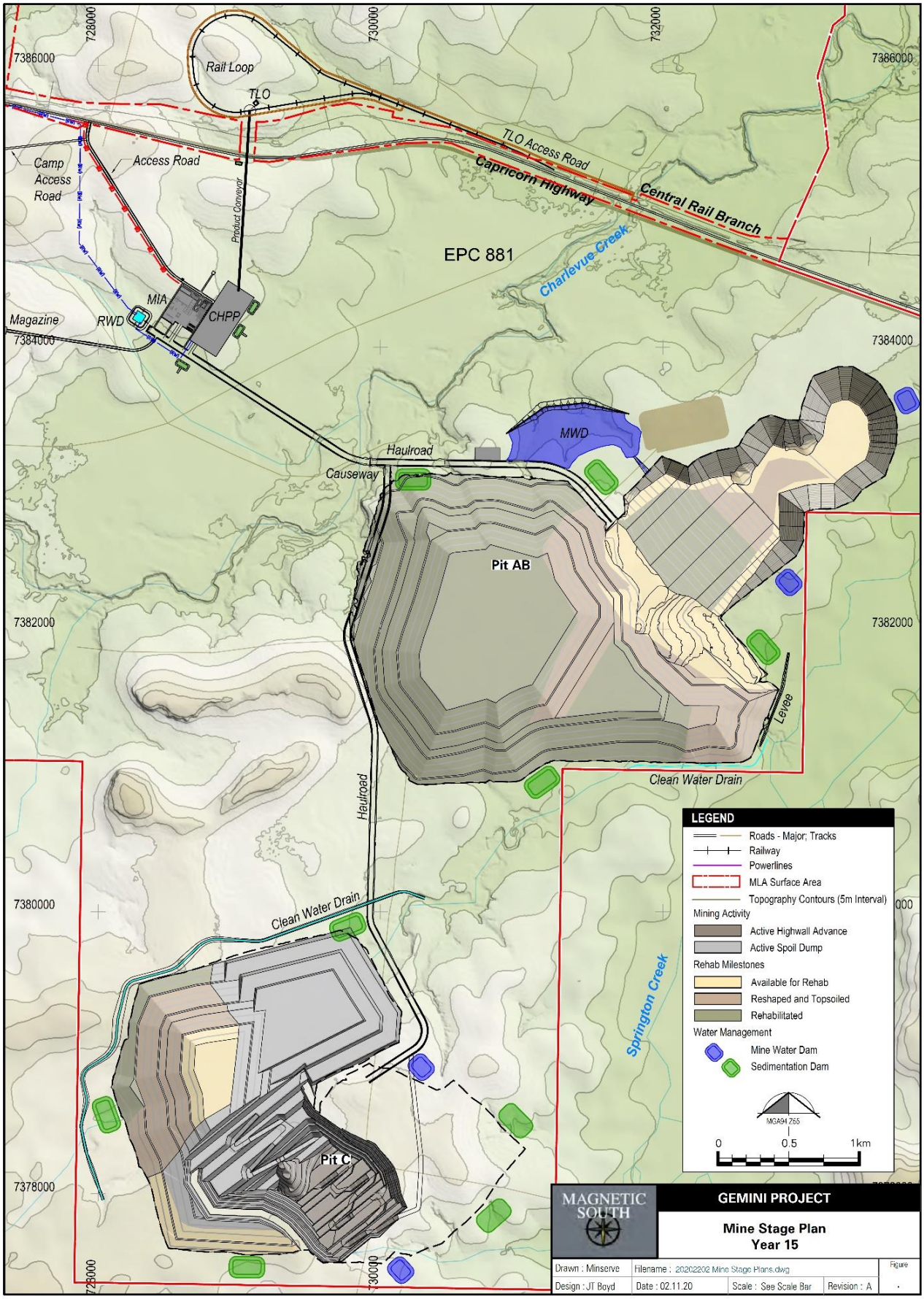


Figure 30 **Mine Stage Plan - Year 15**

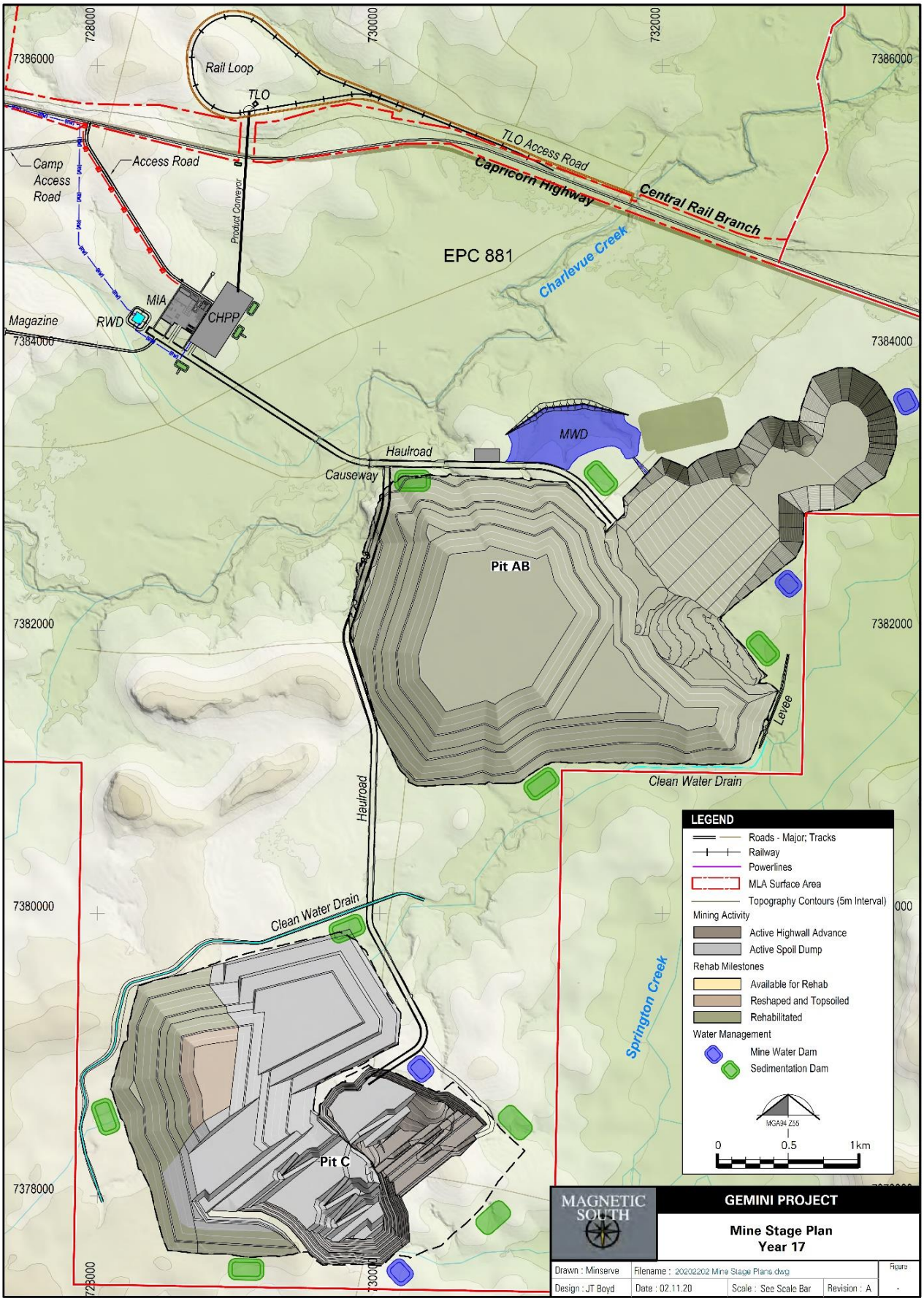


Figure 31 Mine Stage Plan - Year 17

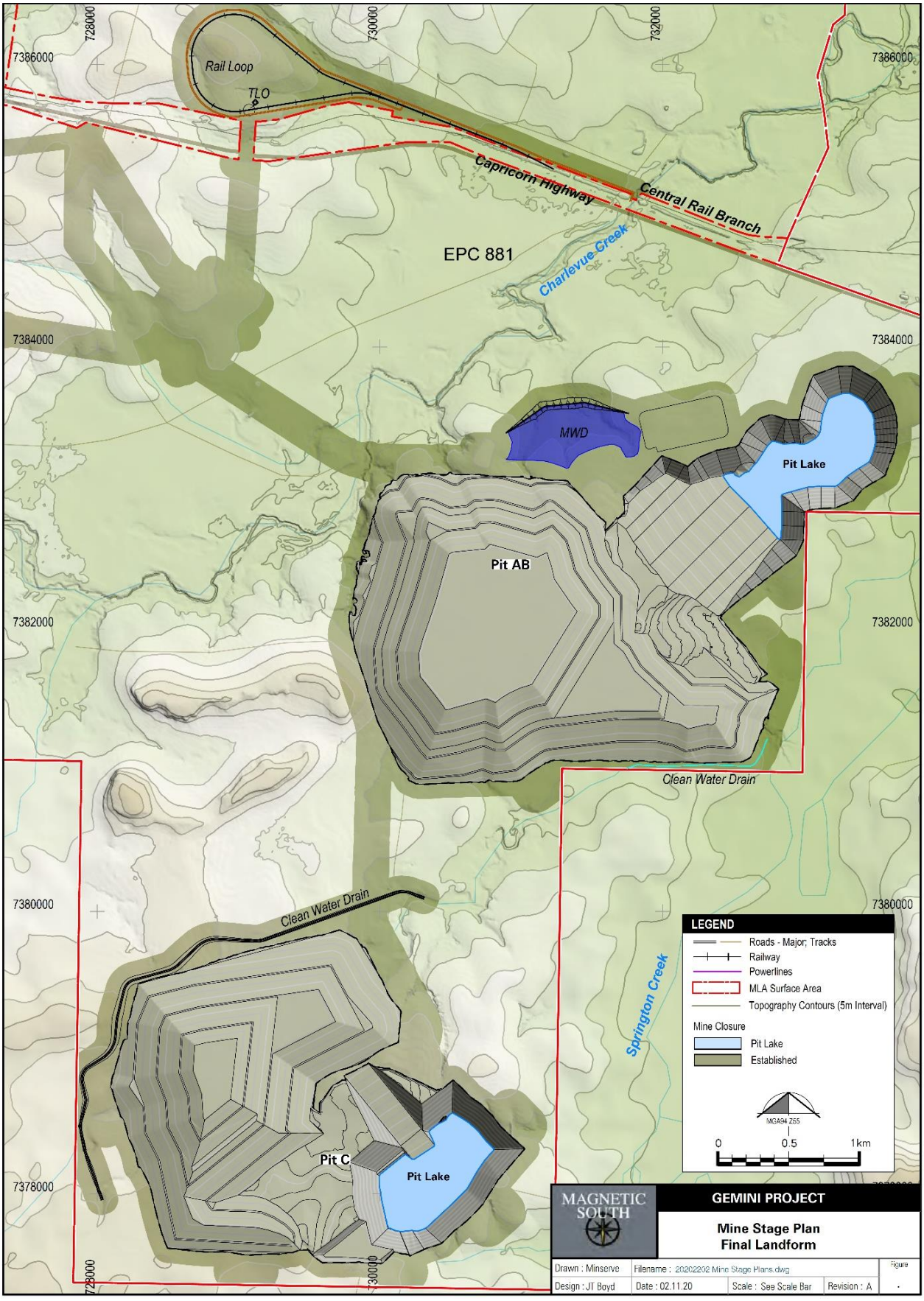


Figure 32 Mine Stage Plan – Final Landform

3.6.3 ROM Coal Processing

ROM coal from the ROM stockpile area will be crushed and screened and conveyed to the CHPP for beneficiation. A portion of mined coal may be screened and crushed and bypass the CHPP, direct to the product stockpiles.

Primary sizing will break the coal down to a maximum of 250 mm diameter. Secondary and tertiary sizing will then reduce the top size coal below 50 mm diameter.

The coarse coal circuit will comprise dense medium cyclones and centrifuges to separate the coarse rejects from the washed product coal. The fine coal circuit will comprise cyclones and sieve bends, flotation cells and thickeners, and reflux classifier and screens. Product coal will be conveyed to the product stockpiles for blending to meet customer specifications. The product coal will be conveyed to the TLO facility to be loaded onto trains.

Coarse rejects will be conveyed to the rejects bin. Fine rejects and slimes will be dewatered and conveyed to the rejects bin to be combined with the coarse reject material. The combined rejects will be loaded onto trucks for placement in out of pit spoil dumps, or in-pit behind the mining void.

The conceptual materials handling flowsheet is shown in Figure 33.

3.6.4 Rail Transport and Port Operations

The PCI coal or coking coal from the Project will be transported via the Blackwater Railway to the RG Tanna Coal Terminal or Wiggins Island Export Coal in Gladstone (Figure 1) for export to the international steel making market. Both of these terminals form part of the existing Port of Gladstone.

There will be approximately four train movements per week on average, subject to train and shipping schedules.

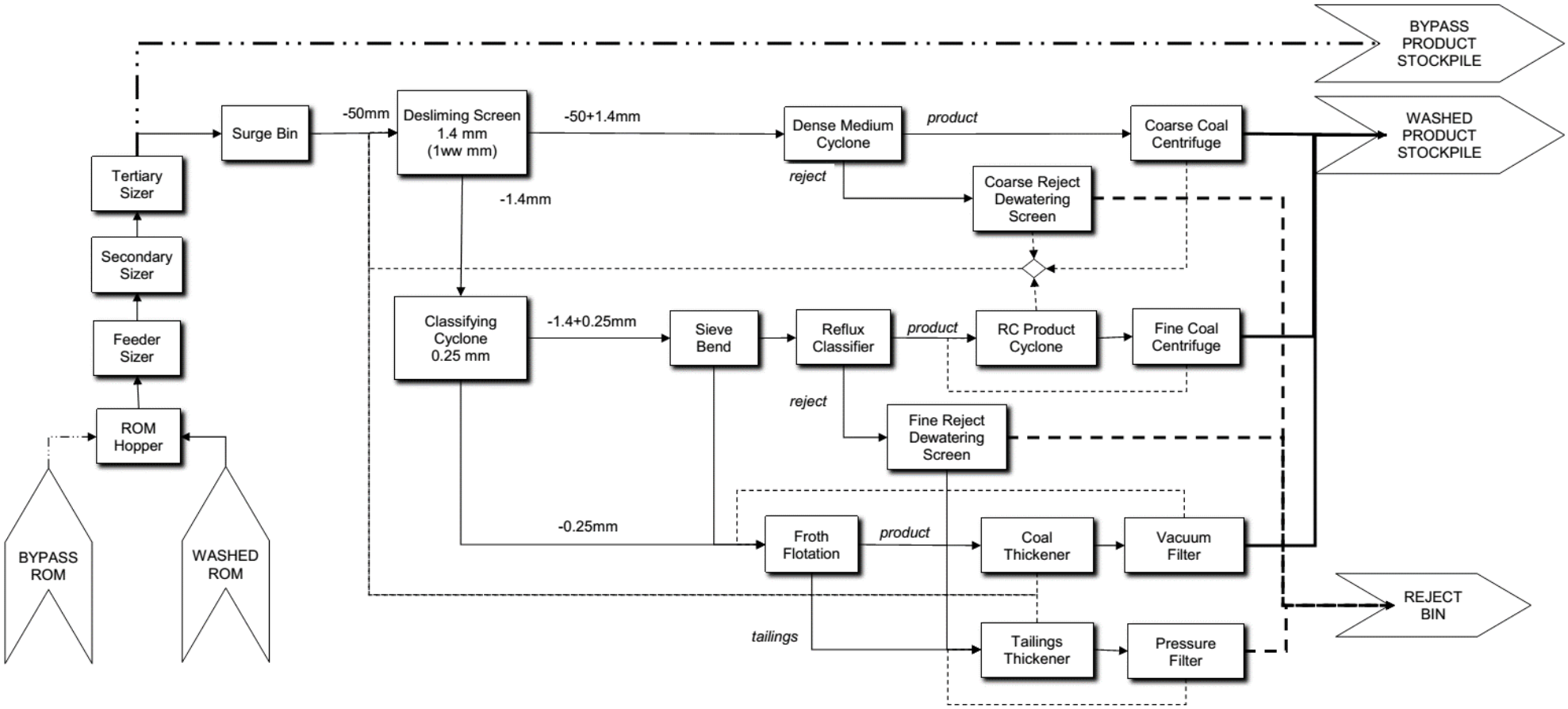


Figure 33 Conceptual Materials Handling Flowchart

3.7 EQUIPMENT FLEET

Equipment used to construct the Project will include excavators, haul trucks, dozers, drills, graders, front end loaders, cranes and water trucks. The mine fleet for the Project is forecast to vary according to the production rates and equipment requirements associated with the open-cut mining operations.

The mining equipment required for the Project includes large (540 t class) hydraulic excavators to remove the bulk of the waste rock material, supplemented by smaller 350 t and 200 t class hydraulic excavators and front-end loaders to remove interburden and partings, and to mine coal. Haul trucks will transport coal (100 t class) and waste rock (240 t class).

A fleet of ancillary equipment will be used to support the mining equipment, including dozers, graders and water trucks. Rotary drills will also be used to drill the waste rock material and coal as required.

The forecast equipment list at full development will include:

- up to four excavators;
- up to 20 haul trucks;
- up to nine dozers;
- up to two graders;
- up to four front end loaders; and
- up to two water trucks.

A small fleet of ancillary equipment will be used to service and maintain mine equipment and infrastructure and CHPP, ROM and product coal stockpiles and manage warehouse storage. This will include fuel trucks, service trucks tyre changer, forklift, mobile cranes, light trucks, loaders and light vehicles.

3.8 ROAD TRANSPORT

The Capricorn Highway traverses the MLA, providing a convenient regional link to Blackwater, Emerald and Rockhampton. As described in Section 3.3.1, an intersection with the Capricorn Highway will be constructed for the mine access road.

A number of local Council roads traverse the MLA and are located to the north and south of the Capricorn Highway. Local roads to the north of the Capricorn Highway within the MLA include Red Hill Road and Ellesmere Road.

Local roads within the MLA to the south of the Capricorn Highway include Cooinda Road and an un-named road. Cooinda Road traverses the MLA from the south and connects to the Capricorn Highway. The un-named road traverses the centre of the MLA through Lot 1 on Plan HT424 (Figure 6) and connects to the Capricorn Highway. To the east of the MLA, Sanders Road originates from Namoi Road and extends to the property boundary of Lot 2 on Plan HT138. From the property boundary, Sanders Road becomes an access track within the property and connects to Cooinda Road within the MLA. These local roads and tracks will be temporarily closed to the public for the Project.

To maintain the connection of Cooinda Road to the Capricorn Highway (via Sanders Road and Namoi Road), the access track extending from Sanders Road is proposed to be diverted. The diversion will be approximately 2 km in length and will connect onto Cooinda Road approximately 1.0-1.2 km south of its

current connection. The diversion works are located outside of the MLA and will be subject to a separate approval from the CHRC (i.e., approval is not being sought by this EA application). Notwithstanding, the approximate location of the proposed diversion is shown on Figure 7.

A *Traffic Impact Assessment* (Cardno 2019) for the Project's roads and intersections is attached as Appendix A. This assessment concluded that all proposed intersections, including the mine access intersection, successfully meet the safe intersection sight distance requirements. Modelling and analysis of the mine access intersection was conducted for a three-way priority-controlled arrangement showing that these intersections can accommodate the anticipated traffic network.

A link capacity assessment was developed for the worst-case traffic scenario anticipated in 2040. This assessment concluded that the Project's road network operates at the highest level of service under baseline traffic conditions. The status of the traffic environment with additional Project related traffic is described as "*stable flow where drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream*".

The overall impacts to the existing traffic network are not expected to be significant based on an increase in mobilisation of Project vehicles on local and State roads.

3.9 WORKFORCE

Employment opportunities that will be generated by the Project include:

- peak construction workforce of up to 260 personnel; including approximately 230 persons servicing the mine development and 30 persons servicing the rail development; and
- peak operations workforce of up to 330 personnel.

The construction workforce roster will typically be 12-hour day shifts, on a 10 days on and four days off rotation. The majority of work will be conducted during the day; however, some construction activities may require night work. For these activities continuous 24-hour activities may be undertaken, scheduled over two 12-hour shifts in a 24-hour cycle.

The operational workforce roster will be 12-hour day/night shifts, on a seven days on and seven days off rotation. The senior management and technical staff roster will be 10-hour day shifts, on a five days on and two days off rotation.

3.10 WORKFORCE ACCOMMODATION

During site preparation and construction, temporary accommodation would be available for non-resident workers within the local region in towns such as Blackwater, Dingo and Bluff and in the accommodation facility, once constructed. The accommodation facility will be constructed towards the northwest of the MLA and will have capacity to accommodate up to 280 persons, but under normal conditions will only be occupied by up to 140 persons. Access to the accommodation facility will occur off the mine access road just beyond the intersection off the Capricorn Highway.

It is anticipated that 80% of the operational workforce will be drive-in-drive-out from the surrounding region, staying at the accommodation facility and bussed to site daily. The remaining 20% of the workforce would reside locally in Dingo, Bluff or Blackwater, with daily light vehicle travel to site and carpooling where practicable.

4.0 REHABILITATION AND CLOSURE

4.1 LEGISLATIVE FRAMEWORK

4.1.1 Environmental Protection Act 1994

In Queensland, mine rehabilitation is required under the EP Act. Amendments to the EP Act in late 2018 implemented key elements of the State Government's *Mined Land Rehabilitation Policy* (State of Queensland 2018) which intends to ensure that land disturbed by mining activities is rehabilitated to a safe and stable landform that does not cause environmental harm and is able to sustain an approved post-mining land use (PMLU).

A key component of the amended Act is the requirement (clause 125 (1)(n)) for a site-specific application for a mining activity related to a ML to be accompanied by a proposed *Progressive Rehabilitation and Closure Plan* (PRCP) complying with Division 3 of Part 2 of Chapter 5. Under this Division, a PRCP must include a PRCP schedule providing rehabilitation milestones for each proposed PMLU, and management milestones for each non-use management area (NUMA) proposed; as well as stating when each milestone is to be achieved. In accordance with the *Environmental Protection (Rehabilitation Reform) Amendment Regulation 2019*, the PRCP start date is 1 November 2019.

The timing of the EA application for the Gemini Project means that it is a transitional project under the amended EP Act. If the EA application is approved, a transition notice from the regulator will be issued to the holder, requiring transition into the PRCP framework. Where practical this rehabilitation and closure section has been prepared to provide information that will ultimately be required in the PRCP.

4.1.2 Mineral and Energy Resources (Financial Provisioning) Act 2018

The *Mineral and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act) was assented to on 30th November 2018 and, apart from amending the EP Act to implement key elements of the *Mined Land Rehabilitation Policy* (State of Queensland 2018), introduces a new financial provisioning scheme, and changes the method for estimating the rehabilitation cost for a resource activity. The new financial provisioning scheme:

- provides for holders of an EA for a resource activity, to pay financial provision contributions to a scheme fund, or provide a surety;
- provides a way to manage the financial risk to the State, as well as the State's costs and expenses, where a resource activity EA holder does not comply with their obligations in relation to rehabilitation; and
- provides a source of funds to the State, for the rehabilitation and/or remediation of lands impacted by abandoned mines, as well as for research contributing to the rehabilitation of land on which resource activities have been carried out.

In accordance with Section 297 of the EP Act, it will be a condition of a resource activity EA that the holder must not carry out a resource activity unless an estimated rehabilitation cost (ERC) decision is in effect and the holder has made the relevant contribution to the scheme fund. Given this, it is anticipated that at the time of issue of an EA for the Project, the proponent will determine the ERC and apply to DES for an ERC decision for the resource activity in accordance with Section 298 of the EP Act.

4.1.3 Policies, Subordinate Legislation and Guidelines

As outlined in Section 4.1.1, the *Mined Land Rehabilitation Policy* (State of Queensland 2018) is the principal and current policy relevant to mine land rehabilitation.

At the time of writing, the following relevant subordinate legislation and guidelines were available:

- *Guideline (Resource Activities): Rehabilitation requirements for mining resource activities [ESR/2016/1875]* (DES 2014a).

The EP Act is supported by the EP Regulation.

4.2 KEY INFLUENCING ECOSYSTEM PROCESSES AND FUNCTIONS

4.2.1 Climate

Rehabilitation methods, particularly surface preparation activities, revegetation species selection, and revegetation timing need to consider the climatic aspects of the region.

The climate of the Project area is characterised as semi-arid with hot humid summers and dry mild winters. Temperatures range between 15°C and 30°C, with mean daily maximum temperatures ranging between 24°C in June and 34°C in January; and mean minimum temperatures ranging between 8°C in July and 22°C in January. The average annual rainfall is 655 mm and evaporation typically exceeds 2,040 mm per annum.

The climatic aspects of the Project site of most relevance to rehabilitation outcomes and erosional impacts can be summarised as:

- **Rainfall:** records depict a typical wet season between November and March of each year, approximately coinciding with the hotter summer months. Figure 34 highlights the significant variation of wet year average rainfall that exists in the region.

- **Evaporation:** average evaporation rates are typically three times greater than the average annual rainfall which, with the variation in annual rainfall commonly experienced is indicative that significant moisture stress can regularly occur, with a consequent potential impact on revegetation success rates and/or failure events.

- **Rainfall intensity:** the central Queensland area can experience high intensity rainfall events. Analysis of BoM 2016 Design Rainfall Data System indicates that short (less than five-minute) duration, high intensity storms of greater than 100 mm per hour would be expected in the Bluff area of central Queensland typically once or twice each year (BoM 2019a).

4.2.2 Landscape, Landform and Hydrology

The Project area is described as gently undulating with elevations ranging between 120-150 mAHD. The physiography of the area is characterised by a dissected tableland having a general relief variation of about 80 m with slopes within the MLA area well less than 5°. The topography of the Project is representative of the surrounding region. The viewscape, some 15-18 km distant to the southwest and west respectively is to the elevated Blackdown Tableland National Park and Arthurs Bluff State Forest which rise approximately 450 m above the elevation of the Project site. There is little relief to the north and east with the land falling gently toward the Mackenzie River valley.

The landscape is influenced by the presence of Charlevue Creek which bisects the MLA from west to east and Springton Creek which flows alongside the southeast boundary of the MLA. The associated

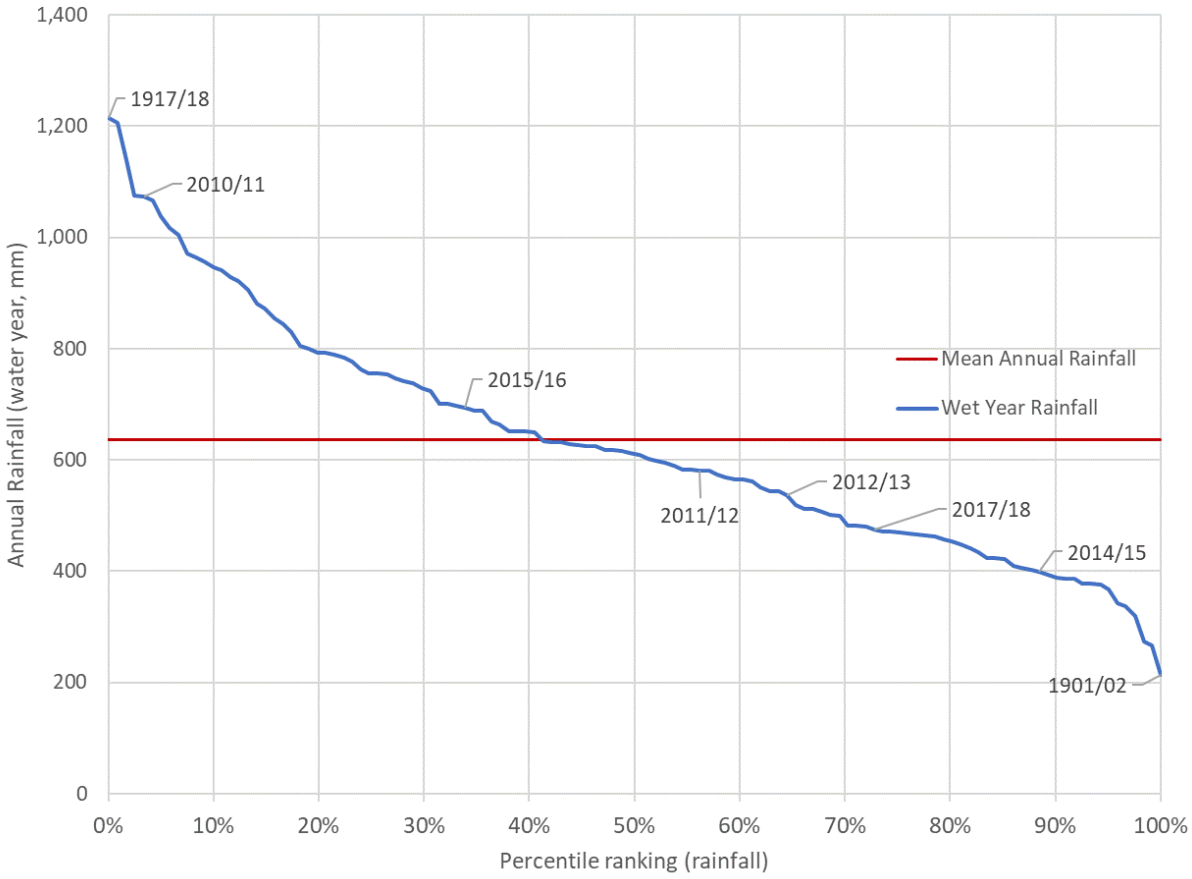


Figure 34 Percentile Ranking of Water Years

floodplains of these two watercourses result in localised lower elevations within the surrounding landscape.

The Project lies within the Mackenzie River sub-catchment, which covers a total area of 12,985 km^2, and is situated in the centre of the Fitzroy River catchment. The major water body associated with the Project site is Charlevue Creek. This creek begins within the boundaries of Blackdown Tablelands National Park, flowing to the northeast before joining Springton Creek. Springton Creek flows to the Fitzroy River eventually reaching the Pacific Ocean approximately 46 km north of Gladstone. A significantly smaller tributary, Stanley Creek crosses the northwest corner of the MLA boundary eventually converging with Springton Creek downstream of the MLA. Minor associated tributaries, dams and drainage features also exist across the site.

4.2.3 Spoil Geochemistry

A detailed *Geochemical Assessment of Mining Waste Materials* associated with the Project was undertaken by RGS Environmental Pty Ltd (RGS 2019) (Appendix G). Geochemical test work undertaken was based on industry recognised procedures for the geochemical characterisation and assessment of mine materials. Seventy samples representative of the main overburden, inter-burden and potential coal reject materials likely to be encountered during development of the Project were assessed.

Samples were subjected to a range of static and kinetic geochemical tests to assess the presence and degree of environmental risk from the oxidation of reactive sulphides, the potential for acid generation, and leaching of soluble metals/metalloids and salts. While these geochemical risks were determined to

be low, the assessment recommended the placement of any carbonaceous mining waste material in locations not near the surface or outer batters of waste rock emplacements.

The assessment identified that while most mining materials would be amenable to revegetation, they are likely to be susceptible to dispersion and erosion and may require amelioration for example, through the addition of gypsum and fertiliser. The assessment recommended additional testing of materials and field trials to assist in determining the most appropriate management options to ensure effective rehabilitation.

Geochemistry is discussed in further detail in Section 13.0.

4.2.4 Topsoil Resources

SMUs are detailed within Section 5.2.5. In general, the surface soils to be reclaimed for use in rehabilitation topsoiling activities are of variable pH (between 4.6 and 8), very low to medium salinity, non-sodic (with the exception of the Charlevue SMU), and of very low to high fertility (based on CEC analysis results). The majority of topsoil reclaimed will originate from the Geoffrey SMU which, while not dispersive in the A horizon, has a sandy texture and low nutrient status and may require amelioration to ensure successful revegetation.

A practical topsoil stripping depth of 30 cm has been adopted to capture the entire seed bank, although shallower topsoil stripping depths are recommended where soil chemistry changes occur at less than 30 cm below surface. Subsoil stripping depths are also provided to demarcate the subsoils of a suitable chemical nature for reuse in rehabilitation where desirable (Table 15).

The volume of topsoil and subsoil that can be reclaimed across the disturbance footprint has been calculated using the disturbance area and recommended stripping depth for topsoils and subsoils (refer Table 15). The assessment of soil and land suitability concluded that the topsoils within the disturbance area from Charlevue and Nigel are not suitable for use in rehabilitation activities due to soil limiting properties and have been excluded from the calculation of topsoil reserves (Appendix I).

The volume of topsoil able to be reclaimed across the disturbance footprint of the Project site is 4,953,748 m^3. In addition, 3,832,237 m^3 of subsoil material may also be reclaimed to supplement the topsoil resource. Based on a recommended minimum topsoil respreading depth of 0.3 m, approximately 5,231,820 m^3 of soil will be required for rehabilitation efforts over the life of the Project.

Generally, only topsoil from the A horizon/shallow B horizon will be stripped. Where subsoils are required to supplement topsoil resources, subsoils with high clay content and low erosivity risk will be preferentially selected. A review of the available SMUs has identified James and Barry as having preferred subsoils.

Delineation of topsoils and subsoils during stripping and stockpiling is proposed to prevent dilution of the seedbank. It is recommended that subsoils are placed below topsoil during rehabilitation to increase germination, provide a suitable medium for root development and to aid in water storage within the soil profile. Mixing of topsoils and subsoils is also possible at a recommended ratio of 2:1 but may lead to additional nutrient and seed input requirements to successfully establish vegetation.

Topsoil and subsoil volumes available for use in rehabilitation activities will be maintained in a topsoil inventory in accordance with a *Topsoil Management Plan* to be developed upon approval of the EA conditions and prior to the commencement of construction activities (refer to Section 4.4.2).

Soils are discussed in further detail in Section 5.0.

Table 15 Estimated Topsoil Volumes Available for Rehabilitation

Soil Management Unit	Surface Area to be Disturbed (m^2)	Topsoil Stripping Depth (m)	Maximum Subsoil Stripping Depth (m)	Estimated Volume of Recoverable Topsoil (m^3)	Estimated Volume of Recoverable Subsoil (m^3)
Anderson*	0.0	0.0	0.00	0	0
Barry	78,510.0	0.2	0.90	15702	54957
Charlevue*	2,183,000.0	0.0	0.00	0	0
Cooinda	349,400.0	0.3	0.60	104820	104820
Ellesmere*	0.0	0.0	0.00	0	0
Geoffrey	14,707,000.0	0.3	0.50	4412100	2941400
James	117,200.0	0.3	0.60	35160	35160
Kosh	549,000.0	0.2	0.50	109800	164700
Namoi	1,328,000.0	0.2	0.60	265600	531200
Nigel*	165,300.0	0.0	0.00	0	0
Normanby	0.0	0.3	0.90	0	0
Wallace	52,830.0	0.2	-	10566	0
Total	**19,530,240.0**	**-**	**-**	**4,953,748**	**3,832,237**

Note: - denotes areas outside the disturbance footprint that will not be used as a topsoil resource for rehabilitation
* soil properties limit plant growth and are unsuitable for use in revegetation activities

4.2.5 Terrestrial Ecology

The Project area falls within the Brigalow Belt bioregion, characterised by brigalow (*Acacia harpophylla*) woodland but presenting other vegetation such as semi evergreen vine thickets, dry eucalypt woodlands and native Bluegrass (*Dichanthium sp.*) grasslands. Due to the size of Brigalow Belt bioregion, it covers a broad climatic gradient as well as a diversity of soils and topography. As a result of agricultural and development activities, most of the relatively undisturbed areas are confined to the rugged parts of the landscape.

Consistent with the surrounding country, the MLA is predominantly non-remnant and subject to low intensity cattle grazing. Remnant vegetation includes patches of eucalypt woodland within riparian areas and on flat plains. These communities are mapped as riverine wetlands where they are associated with a major watercourse or floodplain. *Acacia sp.* closed woodlands are present on higher ground. The Project proposes clearing of 720 ha of remnant vegetation over the life of the Project.

Five weeds of national significance (WoNS) and/or restricted invasive species (RIS) under the *Biosecurity Act 2014* (Biosecurity Act) (DAF 2018a) were identified on the MLA. The near threatened plant species *Cerbera dumicola* was identified in two rocky areas to the central west of the MLA. Impacts to these populations were avoided in the Project design.

Four fauna species of conservation significance; the southern squatter pigeon (*Geophaps scripta scripta*), the greater glider (*Petauroides volans*) and the short-beaked echidna (*Tachyglossus aculeatus*) and the rufous fantail (*Rhipidura rufifrons*) were identified on the Project. The rufous fantail (*Rhipidura rufifrons*) is a listed migratory bird species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). All fauna species are regionally abundant, having been recorded

outside of the study area on numerous occasions. Ample equivalent or improved habitat is available for these species in the surrounding area. The Project proposes no significant impact to the species.

Flora, fauna and aquatic ecological systems are discussed in further detail in Section 6.0.

4.2.6 Current Land Use and Land Suitability

Under the CHRC 2016 planning scheme, the land within the Project boundary is mapped as 'rural'. This zone provides for various rural uses, opportunities for non-rural uses compatible with agriculture and the environmental features and landscape of the areas, and the protection and/or management of significant natural resources and processes related to primary production. The current use is best described as low intensity cattle grazing and resource exploration activities.

SMUs are detailed at Section 5.2.5 along with a determination of land suitability for cattle grazing (refer Section 5.2.6). The land suitability assessment identified grazing land suitability within the Project area as being of Classes 2, 3 and 4 as detailed in Table 16.

Table 16 Land Suitability Assessment

Land Suitability Class	Area Occupied	Description
Class 2	1,080.5 ha (17.49%)	Suitable land with minor limitations which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production.
Class 3	4,338 ha (70.20%)	Suitable land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production.
Class 4	750.84 ha (12.31%)	Marginal land, which is presently considered unsuitable due to severe limitations. The long-term significance of these limitations on the proposed land use is unknown or not quantified. The use of this land is dependent upon undertaking additional studies to determine whether the effect of the limitations can be reduced to achieve sustained economic production.

4.3 REHABILITATION OBJECTIVES

The overarching objective of mined land rehabilitation for the Gemini Project is to conform to the State government policy of returning disturbed lands to a safe and stable landform that does not cause environmental harm and is able to sustain an approved PMLU.

PMLUs for the mine were developed based on pre-mining land suitability, landholder/stakeholder preferences, technical studies and the existing land use and environmental values of the surrounding landscape. Magnetic South is an active member in the local community and is responsible for managing an extensive area of local cattle grazing land. Community consultation has been undertaken by Magnetic South over the past two years and has covered all relevant aspects of mine operations and closure. This Consultation included, but was not limited to:

- underlying landholders;
- surrounding community members with an interest in the Project;
- the Gaangalu Nation People;

- local council representatives; and
- state government representatives.

A meeting was held with members of the Central Highlands Regional Council on the 26 November 2019. Options for rehabilitation and final land uses were specifically addressed in this discussion. The continuation of grazing interests was a key outcome of the consultation, incorporated into the development of PMLUs.

Further consultation will be undertaken as part of the ongoing consultation strategy for the Project, including in the development phase of the PRCP. Local knowledge of graziers is highly valued by Magnetic South in all aspects of land management and is seen as essential for ensuring successful and sustainable rehabilitation of the Gemini Project.

4.3.1 Rehabilitation Areas

The disturbance areas identified in the final site design have been divided into rehabilitation areas, which have a common PMLU and rehabilitation methodology, these include:

- RA1: in-pit and out-of-pit waste emplacements, including dry rejects disposal areas;
- RA2: temporary waste emplacements;
- RA3: residual void lakes;
- RA4: residual void high walls;
- RA5: residual void low walls;
- RA6: water management infrastructure; and
- RA7: mine infrastructure areas.

These rehabilitation areas are shown below in Figure 35.

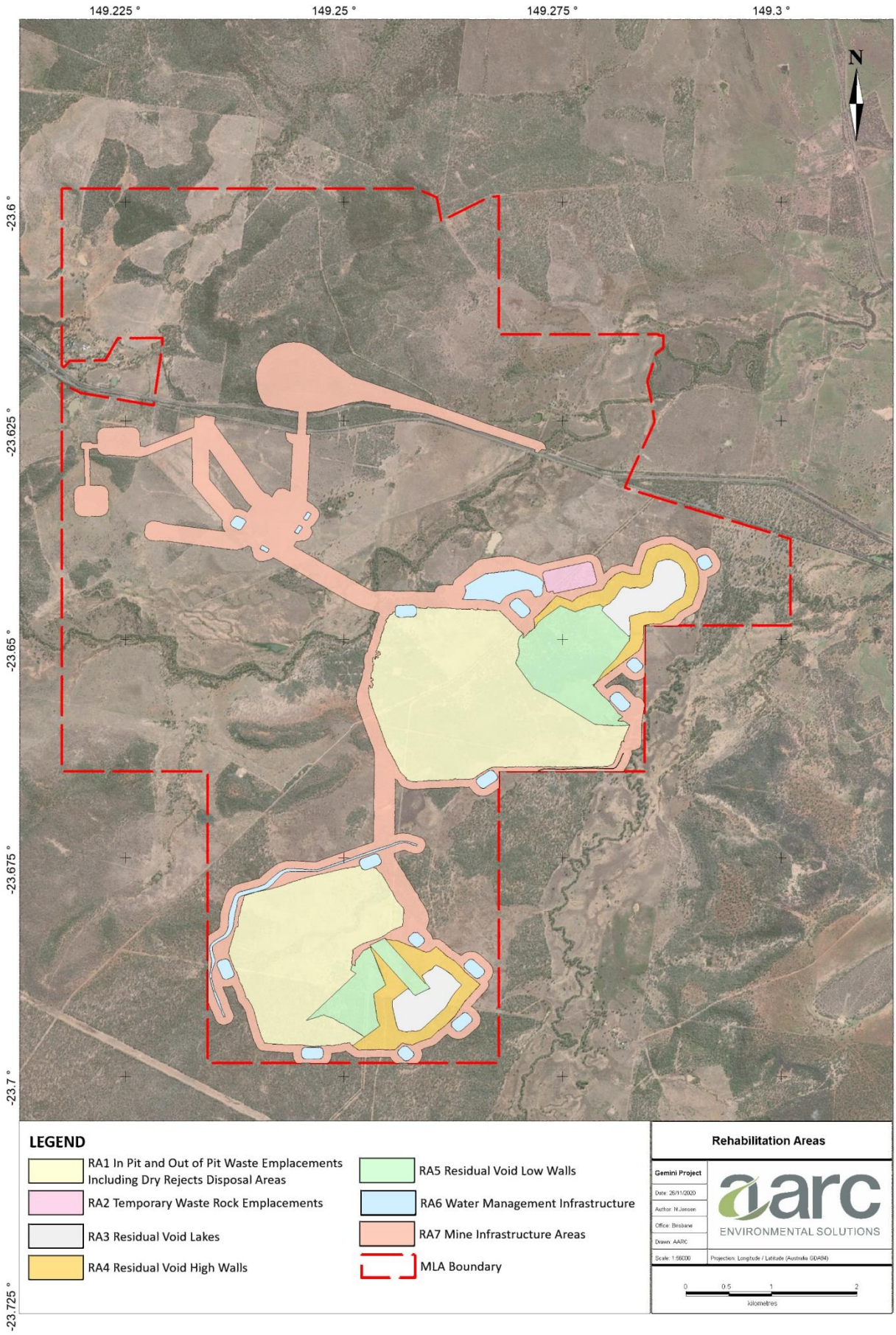


Figure 35 **Rehabilitation Areas**

4.3.2 Post-mining Land Use

In the short term, Project activities will disturb and alter the current land use of low intensity cattle grazing. The overarching objective is to return the majority of disturbed land to future landowners with a land use capacity conforming to existing local government planning instruments, and that enables a sustainable future value to be derived. Areas disturbed by mining activities will largely be returned to a grazing landscape, with the introduction of some areas of native ecosystem habitat suitable for native flora and fauna. These PMLUs have been determined based on pre-mining land suitability, landholder/stakeholder preferences, and the existing land use and environmental values of the surrounding landscape.

The development of the rehabilitation strategy for the Project has been informed by the rehabilitation hierarchy. Minimisation of disturbance has been a focus of design phase mine planning work, and a key land use objective being reinstatement of a land use at least equivalent or compatible to that existing previously. Given the existing land use of the area, reinstatement of grazing as a PMLU will be adopted for all areas apart from the proposed residual voids and any retained water management or other infrastructure where the latter supports accepted PMLUs and/or adds to the economic value of the land to be relinquished. With appropriate management of the higher sodicity topsoils identified, it is anticipated that rehabilitated landforms will be capable of sustaining improved and native pastures equivalent to those currently existing.

Two residual voids will remain post-mining and are anticipated to accumulate water over time to an equilibrium water level. The pit lakes and surrounding highwalls are proposed to support a PMLU of fauna habitat comprised of the water body itself and its surrounding inwardly draining slopes which will be rehabilitated to sustain a native ecosystem able to support native fauna. The air/waterbody interface is expected to support a range of waterborne and flying insects, as well as avifauna and various bat and microbat species. The waterbody itself is expected to support a range of freshwater aquatic plants and invertebrates in shallower edge areas and over time transition to brackish water species as water quality changes. Rehabilitated low wall slopes will be capable of supporting a grazing land use and native flora and fauna. The proposed PMLU for each of the rehabilitation areas is summarised below in Table 17 and shown in Figure 36.

Table 17 Nominated PMLUs

Rehabilitation Area	Post-mining Land Use	Approximate Footprint Area (ha)	Approximate Proportion of Total Disturbance
RA1: In-pit and out-of-pit waste emplacements, including dry rejects disposal areas	Grazing	722.4	37%
RA2: Temporary waste emplacements	Grazing	17.5	1%
RA3: Residual void lakes	Fauna habitat	76.5	4%
RA4: Residual void high walls	Native vegetation supporting fauna habitat	133.1	7%
RA5: Residual void low walls	Grazing	187.2	9%
RA6: Water management infrastructure[1]	Grazing/native vegetation	85	4%
RA7: Mine infrastructure areas[1]	Grazing	731.8	38%

Notes: 1 Where not retained under a landholder agreement allocating infrastructure responsibility.

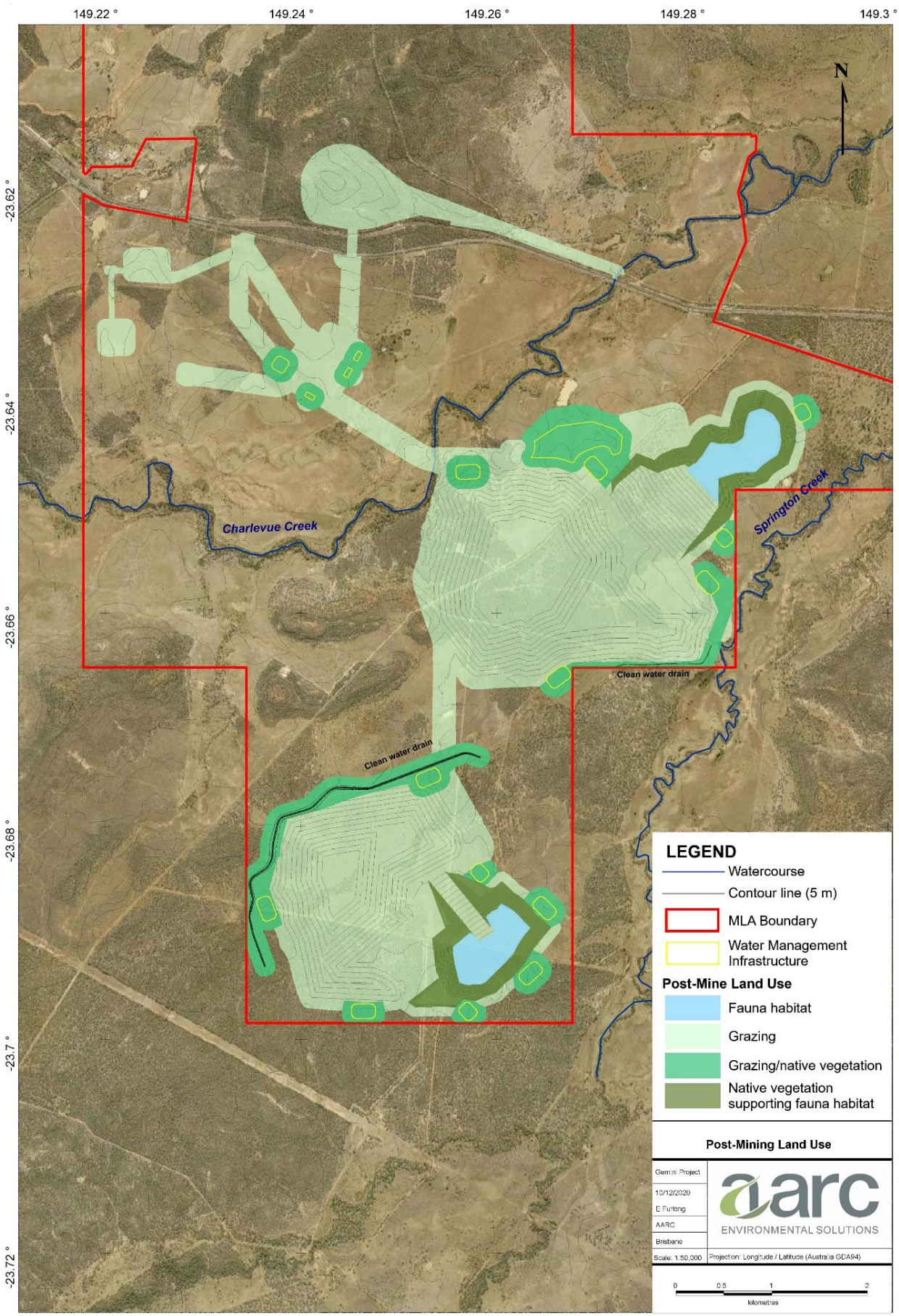


Figure 36 **Post Mining Land Uses**

The following subsections describe how progressive rehabilitation will be undertaken to achieve PMLUs for each rehabilitation functional area.

4.3.2.1 Alternative Post-Mine Closure Options Analysed

Mine planning assessed a number of options to manage and reduce final landform residual risk including backfilling the pits to a modified pre-mining topography, backfill of pits to about 80 m below the pre-mining topography and no backfilling of pits. All options required the rehandle of spoil material, the reduction of remnant highwall angles by dozer push, the reshaping of waste rock emplacements, and normal rehabilitation techniques related to topsoiling, surface preparation and revegetation. Options were evaluated on the relative basis of cost, overall project value and relative reduction in environmental risk.

The modified pre-mining topography option was based on backfilling voids to a level slightly higher than the original topography to allow for settlement over time. Once a sufficient period has been allowed for settlement, the area would be shaped and drained to manage erosion and then topsoiled and revegetated. Advantages with this option include negation of the need to stabilise highwall slopes or make safe the final void itself. The primary disadvantages with this option are:

- the significant cost of rehandling extremely large volumes of spoil at the end of mine production;
- the significant limitation on being able to undertake progressive rehabilitation given the need to rehandle a majority of waste rock material at the end of mine life; and
- the ongoing settlement of the final landform surface potentially resulting in long term stability issues.

The modified pre-mining topography option resulted in the net present value (NPV) of the project being so low that the Project could not proceed. In consideration of the margins of error within the financial model assumptions, the risk of a negative return was far too high for development. This option was therefore not considered further.

The preferred option (proposed in this application) is to backfill to 80 m below topography, based on the findings of the *Groundwater Impact Assessment* (JBT 2019) (Appendix C). This study indicated that, with controls to limit surface water draining to the pits, saline inflows would be significantly reduced if the pit was backfilled to 80 mbgl. For this option, in-pit backfill would be reshaped to 6° in line with other slopes with a corresponding grazing land use. Highwall slope management requirements would be reduced, and additional areas would be available for grazing. Only minor restrictions on progressive rehabilitation arise. While still resulting in a partially backfilled void at completion of mining, a key advantage is that water quality within the pit lakes will increase in salinity at a lower rate than otherwise.

The residual voids will comprise three principal ‘rehabilitation areas’ having differing landforms and characteristics and, as a result, differing PMLUs. These areas are described as:

- Regraded, topsoiled and revegetated low wall slopes draining to the pit water lakes and able to support a grazing PMLU.
- Two water bodies with a surface level which has been modelled to gradually increase to an equilibrium level of between 70-80 mAHD; acting as a groundwater sink and having a gradually increasing salinity. A key rehabilitation objective for this rehabilitation area is to reduce the rate of predicted water salinity present in the void primarily to allow the ecology of the residual void waterbody sufficient time to adapt to salinity changes. Backfilling the voids to 42 mAHD for Pit AB and 65 mAHD for Pit C reduces saline groundwater inflows and surface water drainage,

resulting in a significant reduction in the rate of salinity development within the pit water body. This is due to the water level adjacent the final void equal to the groundwater level within the spoil as illustrated in Figure 37.

Final void modelling suggests that during the first 200 years after closure, lake salinities will be less than 10,000 mg/L. After 500 years, salinity is conservatively modelled to increase to 30,000 mg/L. It should be noted that modelling inherently overestimates the rate of salinity increase in residual void water bodies by assuming that the source of mobile salts in overburden is infinite. Recent research is challenging this assumption, but there is little currently available data on the long-term behaviour of water bodies resident in Bowen Basin coal mine overburdens, particularly the rate of approaching a long-term equilibrium salinity level. The backfilling option adopted is intended to seal the poorer quality remnant coal seam aquifers and limit salt inputs to the pit lake from groundwater.

- Residual void high walls will be regraded to moderate slopes of approximately 22°, made safe and rehabilitated to a native ecosystem able to support native fauna as a PMLU.

Figure 37 provides progressive cross-sections depicting the proposed backfilling of spoil within AB Pit.

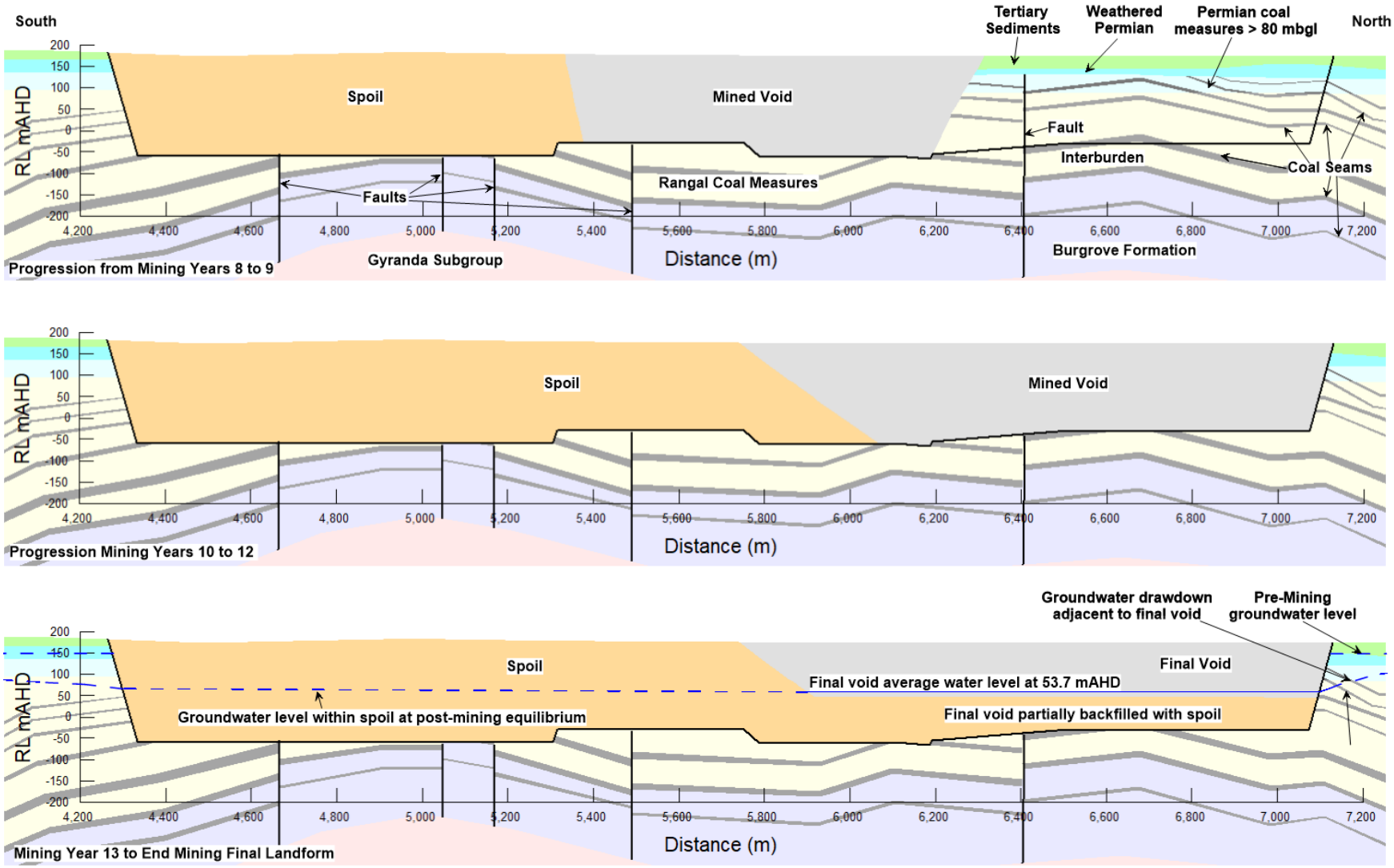


Figure 37 **Conceptual Layout of Pit AB Groundwater Levels**

4.4 REHABILITATION METHODS AND CONTROLS

Rehabilitation activities will be carried out in accordance with the following subsections. Rehabilitation activities will be subject to adaptive management where the rehabilitation methods and controls are continually improved and updated based on the results of site-specific rehabilitation trials, further land assessment (where applicable) and revisions of legislative requirements.

4.4.1 Reshaping/Landform Development

As a general guide, waste rock emplacements are constructed as benches with external faces formed from upper benches set back sufficiently from the prior bench to facilitate regrading to the design final rehabilitation slope.

Overburden placement will be undertaken using rear dump trucks in accordance with mine planning schedules and as per dump designs informed by geotechnical assessments. Standard mine survey controls will be utilised to ensure that disturbance footprints are not exceeded and that design slopes will be attained. Regrading to final landform will be undertaken using bulldozers to push to grade utilising standard survey controls.

Landform design will utilise concave slopes and terraced profiles to reduce the requirement for engineered drains. Where proposed to be utilised, and in conformance with a proposed *Master Waste Rock Emplacement Surface Drainage Plan* (discussed further in Section 4.4.6), graded banks and rock-protected spine drains will be installed to allow drainage from long rehabilitated slopes to be conveyed to natural ground level. All surface runoff from newly rehabilitated slopes will be directed into sediment dams until revegetation uptake is stable and adequate to control soil erosion. Further discussion on sediment design details and parameters is detailed in Section 3.4.3.3.

Final trimming of reshaped areas will be undertaken as required to remove excess rock and ensure correct graded bank slopes.

Topsoil spreading will then be undertaken to achieve the designated topsoil depth followed by surface preparation including at a minimum contour ripping to retain moisture and control erosion.

4.4.2 Topsoil Management

A *Topsoil Management Plan* will be developed for the Project. The overarching principle of the *Topsoil Management Plan* will be to reduce the risk of topsoil degradation and improve the chances of rehabilitation success. The objectives of the Project's *Topsoil Management Plan* are to:

- maintain a soil balance that will achieve the rehabilitation requirements throughout the life of the mine;
- maintain topsoil viability through the utilisation of best practices in soil stripping, stockpiling and application activities; and
- provide a standard practice for the Project's storage and handling of topsoil resources.

The *Topsoil Management Plan* will include the following components:

- identification and delineation of topsoil and subsoil resources including amelioration requirements;
- standard practices for topsoil and subsoil stripping;

- a topsoil and subsoil stockpiling strategy which outlines the methodologies and standard practices for the stockpiling of topsoil resources;
- procedures and methodologies used for the application of topsoil and subsoil resources;
- a topsoil and subsoil inventory which is maintained for the life of the Project;
- details of erosion and sediment controls for practices relating to topsoiling activities such as the use of sediment dams to minimise the release of water and suspended sediments into the receiving environment; and
- roles and responsibilities for the supervision of soil management.

The *Topsoil Management Plan* will reduce the risk of topsoil degradation and improve the chances of rehabilitation success through a series of management measures customised for each topsoil activity, these are described in further detail below.

4.4.2.1 Identification of Topsoil Resources

The identification and delineation of topsoil and subsoil resources will be undertaken based on the soil assessments already undertaken (AARC 2019) (Appendix I) including indicative stripping depths and topsoil qualities as summarised in Table 15.

The *Topsoil Management Plan* will detail the methods used for the further assessments of topsoil resources, where required, to confirm the topsoil stripping depth and dispersion characteristics of soils. Deficiencies in soil requirements will be identified and procedures for the amelioration of topsoils will be provided. Topsoil resources will be mapped, and GIS shapefiles will be retained for reporting purposes.

4.4.2.2 Topsoil Stripping

The *Topsoil Management Plan* will include standard methodologies for topsoil and subsoil stripping which will consider the equipment used, soil and climatic conditions under which topsoil stripping should occur, the removal of vegetation and the treatment of machinery for weeds.

4.4.2.3 Topsoil Stockpiling

A topsoil and subsoil stockpiling strategy will be developed with consideration to the management recommendations provided in the *Soil and Land Suitability Assessment* (Appendix I). To assist in maintaining a viable seedbank and promote vegetation growth, where possible, topsoil will be directly placed in prepared rehabilitation areas rather than stockpiled. Topsoil will also be planted over as soon as possible after being placed in prepared rehabilitation areas. This will assist in preventing erosion of the topsoil and making the best use of the soil's available nutrients.

Delineation of topsoils and subsoils during stripping and stockpiling is proposed to prevent dilution of the seedbank. It is recommended that subsoils are placed below topsoil during rehabilitation to increase germination, provide a suitable medium for root development and to aid in water storage within the soil profile. Mixing of topsoils and subsoils is also possible at a recommended ratio of 2:1, but may lead to additional nutrient and seed inputs to successfully establish vegetation

The topsoil and subsoil stockpiling strategy will:

- optimise the placement of topsoil stockpiles as much as practicable to:
    - exclude grazing and vehicle access;

  - minimise topsoil and subsoil handling;
  - consider climatic conditions, surface water flow and erosion controls such as the diversion of overland flow/runoff around disturbed areas;

- set stockpile design parameters including height (typically up to 3 m), shape and batter angles (no greater than 1:3) and limiting side slopes to a maximum slope of 1V:6H to reduce erosion and sediment run-off;
- describe the applicable construction equipment and practices;
- describe standard practices for the long-term storage of soil stockpiles including recommendations for soil testing and the application of fertilisers, soil ameliorants and seeding application relevant to long term stockpiling of topsoil resources;
- describe the sterile seeding for the long-term storage of stockpiles. Briefly, if the stockpiles require grass cover, they will be ripped and seeded with a quick establishment pasture, to limit erosion and maintain a viable seed bank. This will be done if the period of stockpiling is greater than one growing season or six months. In accordance with the findings of research undertaken in the Hunter Valley (Keipert et al 2005), and in order to avoid the significant deterioration that commonly occurs in the first year, topsoil will ideally be stockpiled for as short a period as possible; and
- establishment of a stockpile monitoring frequency for the control of weeds on stockpiles.

4.4.2.4 Topsoil Application

Where possible, placement of topsoil at a thickness of approximately 0.3 m is recommended across the rehabilitated area to create a growth medium of sufficient depth to hold water and support revegetation. If available, subsoils that have been identified as having a high clay content with low erosivity risk can be returned first at a depth of up to 0.5 m, prior to the addition of sandier topsoil. This may assist in providing a more suitable growth medium that holds water for long periods of time.

For the Geoffrey SMU, it is recommended that soil horizons in the natural landscape are restored during rehabilitation. The clay rich subsoils should be placed first on the rehabilitated landform, followed by the sandy A horizon over the top to recreate the A and B horizons. Placement of the subsoil layer is expected to retain soil moisture necessary for successful revegetation.

Stripping depths have accounted for the dispersive nature of the SMUs sodic subsoils. Topsoil estimates exclude any sodic subsoil material from the topsoil resource, therefore the topsoil resource is not considered sodic and dispersive. The rehabilitated landform is thus at low risk of the dispersive impacts associated with sodic soils and mitigation measures that target sodic and dispersive soils are not considered necessary.

Topsoiled areas will be ripped into the underlying spoil surface to reduce compaction from heavy machinery and to encourage surface water infiltration and minimise soil loss due to erosion. On the slopes of spoil dumps, ripping will be undertaken along the contour.

Grass and woody vegetation remaining after land clearing can be incorporated into the rehabilitation design at strategic locations to help limit runoff and erosion (by slowing down overland flow), retain active biological activity, and provide habitat for returning fauna. Additionally, mulched organic material incorporated into the soil (particularly the topsoil) will increase organic carbon levels over time, further stabilising the soil and landscape.

4.4.2.5 Topsoil Inventory

A topsoil and subsoil inventory will be maintained during the life of the Project, which accounts for the volumes and locations of topsoil as it is progressively stripped, stockpiled, and reapplied. The inventory will also address the delineation of stockpiled topsoil, protection from unplanned use or disruption and prioritisation of re-use. The soil inventory will allow early identification of potential issues such as soil balance deficits or poorer quality soils; enabling remedial actions to be planned in advance of mining operations.

4.4.3 Revegetation Program

Vegetation is generally established in rehabilitated areas through topsoil application, by direct seeding or by planting using nursery-raised tube-stock of target species. Revegetation efforts will be directed towards creating a stable and self-sustaining system, in accordance with the defined land use; that is for each defined land use the system can support the survival and reproduction of all organisms living within it, without outside intervention. Data collected from baseline assessments and relevant analogue sites will be used in a comparative analysis to determine if revegetation has achieved a self-sustaining and stable ecosystem. Species selected for rehabilitation efforts to support a self-sustaining ecosystem will provide microhabitat and cover for fauna, a natural mulch system and nutrient input from the breakdown of plant waste, stabilise soils through provision of vegetative cover and soil binding root systems to prevent erosion and promote soil aeration.

Areas identified as returning to a grazing PMLU including waste rock emplacements, mine infrastructure areas and water management areas will likely utilise grass seed mixes for the Project area that include Rhodes grass (*Chloris gayana*), Creeping bluegrass (*Bothriochloa insculpta*), Desmanthus (*Desmanthus virgatus*), Forest bluegrass (*Bothriochloa decipiens*), Queensland bluegrass (*Dichanthium sericeum*), Barbed wire grass (*Cymbopogon refractus*), Black speargrass (*Heteropogon contortus)* and Curly windmill grass (*Enteropogon acicularis*) as well as other species native to the area. Application rates are anticipated to range between 6-10 kg/ha.

For areas to be restored to native vegetation including pit low walls, species will be based on the rehabilitation objectives and will generally target species relevant to nearby remnant vegetation associations, soil types, and site conditions. Revegetation of native woodland areas for example, will include the planting of endemic species which are characteristic of pre-mining conditions, as identified through flora assessments undertaken for the Project.

Seeding will typically be scheduled to occur prior to the wet season to maximise the benefits of subsequent rainfall.

Topsoil stockpiles will be revegetated to assist in stabilisation and erosion control. Similarly, drainage lines, berms and other erosion control and stabilisation works will require revegetation with an appropriate seed mix. Application rates will vary depending on the circumstance as well as the rehabilitation species sensitivity, the growth media and the PMLU.

4.4.4 Rehabilitation Maintenance and Repair

Significant rainfall events, floods, fire, drought, pest species outbreaks or other factors may also result in a requirement to undertake additional maintenance on rehabilitated areas. Maintenance of rehabilitated areas or reparation may also be required where visual observations of rehabilitation and or rehabilitation monitoring results (refer Section 4.8) indicate that the expected trajectory towards achieving successful rehabilitation is not being met. Depending on the underlying cause of failed rehabilitation, rectification activities may include:

- earthworks repair of erosion areas;
- re-seeding / replanting failed or unsatisfactory areas;
- supplementary planting of tube-stock;
- pest and weed control;
- irrigation of plants;
- additional fertiliser or other ameliorant application to control pH and improve soil structure; and
- repair or alteration of drainage structures.

In the event that maintenance is required, a maintenance plan will be developed that properly assesses the risks of re-entering a rehabilitated area with earthmoving equipment, the sourcing of soils and topsoil, impacts on planned drainage of the site, erosion controls and revegetation methods.

4.4.5 Rehabilitation Trials

Revegetation techniques will continually be developed and refined over the life of the Project through a continual process of research, trialling, monitoring and improvement. It is common practice within mine sites to undertake site–specific rehabilitation trials to inform rehabilitation efforts and practices. Rehabilitation trials may involve refining soil preparation procedures, seed mix type, rate and application, surface cover treatment, irrigation requirements and repair methods. As such, rehabilitation trials will be used as part of adaptive management of rehabilitation and will commence as identified during mining operations.

The performance of rehabilitation trials will be assessed against the methodology outlined in Section 4.8 and dependent on the underlying principle of the trial further performance indicators may be identified on a case-by-case basis.

Subject to onsite resource capacity and availability of external research opportunities, Magnetic South may engage with external research programs such as those undertaken by ACARP and research institutions.

4.4.6 Waste Rock Landform Development and Rehabilitation

The commencement of mining necessarily sees overburden being initially placed out-of-pit to provide sufficient working space for operations to proceed. A single out-of-pit waste rock emplacement is associated with each of Pit AB and Pit C. In-pit placement of overburden will occur in Year 2 for Pit AB and about Year 15 for Pit C.

The out-of-pit waste rock emplacement for Pit AB is located to the west and south of the pit with construction coinciding with the commencement of mining. By Year 4, the full footprint of out-of-pit dumping will be reached with waste rock being placed both in-pit and within the extents of the out-of-pit waste rock emplacement. In Year 6, a small temporary out-of-pit waste rock emplacement will be constructed to the north of the pit for the purpose of providing additional pit backfilling later in the mine life.

Beyond Year 6, the majority of waste rock is placed in-pit, progressively refiling the pit from south to north as the pit progresses in the same direction. By about Year 12/13 the maximum extents of Pit AB are reached and the development of infrastructure to support Pit C commences.

Mining of Pit C commences in Year 12, again with waste rock being placed in an out-of-pit waste rock emplacement located to the west of the pit. By Year 15, waste rock from Pit C is being placed both in-pit and out-of-pit and the full disturbance footprint of the out-of-pit waste rock emplacement has been reached. Pit AB is continuing to be progressively rehabilitated, including the rehandling of spoil from the temporary out-of-pit waste rock emplacement back in-pit and all areas having been reshaped including the highwalls of Pit AB.

By Year 19, the rehabilitation of Pit AB has been completed and mining is at or near completion at Pit C, with progressive rehabilitation of the Pit C waste rock emplacements ongoing.

Figure 23 through to Figure 32 conceptually visualise the progression of the mine, including location and extent of waste rock emplacements and rehabilitation. A preliminary schedule of progressive rehabilitation milestones per rehabilitation area is provided in Section 4.6.

Minor drainage works and a pit levee are required to the southeast of Pit AB during operations to ensure high flows from an unnamed second order tributary of Springton Creek do not access the pit. In addition, a permanent drain is required to divert clean runoff from the upper reaches of an unnamed second order tributary of Springton Creek around the out-of-pit waste rock emplacement associated with Pit C. Neither of these tributaries are defined as watercourses under the Water Act.

The *Geochemical Assessment of Mining Waste Materials* (RGS 2019) (Appendix G) and *Geochemical Assessment of Coal Reject Material* (RGS 2020) (Appendix H) for the Project identified that waste rock materials have a low risk of acid generation and a high factor of safety with respect to potential for acid mine drainage (AMD).

Validation test work will be undertaken on potential spoil materials as the Project develops to enable appropriate spoil management measures to be planned and implemented as required. Where highly sodic and/or dispersive spoil is identified, this material would not be placed in final landform surfaces and would not be used in construction activities. Regardless of the spoil type, especially where engineering or geotechnical stability is required, testing would be undertaken during construction to determine the propensity of such materials to erode. Surface runoff and seepage from spoil piles, including any rehabilitated areas, would be monitored for 'standard' water quality parameters including, but not limited to, pH, EC, major anions (sulphate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), total dissolved solids (TDS) and a broad suite of soluble metals/metalloids.

Landform reshaping will occur progressively, as land is deemed available for rehabilitation, resources are available, and the mining activities do not prohibit the rehabilitation activities. As indicated in Table 18, waste rock emplacements have been designed to have externally draining slopes of a 1V:10H ratio and a maximum height of 190 mAHD (where maximum slopes adhere to 6°) constructed from rear dump truck-tipped dumps. While detailed geotechnical assessments are yet to be undertaken, the slopes proposed are at the lower end of typical design practice for waste rock emplacements in the Bowen Basin. The locations of waste rock emplacements showing proposed PMLUs are illustrated at Figure 36.

The top surfaces of both waste rock emplacements are limited in area and, given the relatively low geochemical risk currently identified, it is considered preferable to internally drain the upper surfaces of waste rock emplacements rather than increase flows down rehabilitated slopes. The practice of surface water drainage on waste rock emplacements via internal drainage is favourable on soils that have self-sealing properties, which have been recorded on site and has a low risk of failure. Internal drainage involves natural depressions or graded banks constructed with a relatively minimal slope cross section with vegetative cover which will blend into the landscape over time. Natural depressions promote internal drainage on the waste rock top surfaces without creating permanent ponding during normal and

heavy rainfall events. Further, vegetative cover will aid in the absorption of surface water and will support a cattle grazing PMLU.

Geochemical assessments indicated that there will be no detrimental impacts on water quality and therefore, if used for stock watering, water ponding on waste rock emplacements does not pose a risk to cattle (RGS 2019 and RGS 2020). If deemed necessary from the results of rehabilitation monitoring (i.e., erosion rates, habitat structure), reshaping on the top surfaces of waste rock emplacements will be conducted and land prepared for vegetative surface cover with plans developed upon consultation with a suitably qualified person.

Additionally, rehabilitated slopes will be constructed to a relatively low slope (6°) to reduce the risk of erosional instability. Given these mitigation measures, drainage from regraded rehabilitation slopes is intended to be managed with limited use of graded banks; principally by targeting sufficient surface roughness through contour cultivation and appropriate revegetation rates. However, this approach will ultimately depend on the results of further topsoil testing and the performance of early rehabilitation works. If erosion is observed in early rehabilitation efforts, graded banks and spine drains will be incorporated into the rehabilitation design, as a temporary erosion control measure.

The surface of waste rock emplacements will be progressively revegetated with a pasture crop cover mix, consistent with the proposed revegetation program.

A master *Waste Rock Emplacement Surface Drainage Plan* is proposed to be developed to detail the design and methodologies for the development of natural surface drainage depressions on waste rock emplacements and to prevent erosion on the waste rock slopes. If required, graded banks will be designed in accordance with industry recommendations (Witheridge et al. 1996), they should achieve a minimum width of 5 m and height of 500mm high (Appendix I). Larger contour drains are generally more stable and longer lasting. Rock-lined spine drains will utilise rock of between 300 – 450 mm in diameter where required. Graded banks and rock-protected spine drains are designed to blend into the landscape over time, with a relative minimal cross section to minimise the risk of failure. If necessary, these structures will be removed, and remediation activities will be undertaken. Given the overburden and topsoil materials available, the rehabilitation design parameters to be observed, and the mitigation measures and actions nominated, no significant risks associated with the rehabilitation of waste rock emplacements have been identified.

Table 18 Waste Rock Emplacement Parameters

Emplacement	PMLU	Max. Elevation (mAHD)	Typical/ Max Slope	Approx. Max. Slope Length (m)
Pit AB waste rock emplacement (in-pit and out-of-pit)	Grazing	175	6°	540
Pit AB temporary (out-of-pit)	Grazing	n/a	n/a	n/a
Pit C waste rock emplacement (in-pit and out-of-pit)	Grazing	190	6°	530

4.4.7 Rejects Placement

Coal processing is described in Section 3.6.3. Coarse rejects will be conveyed to the rejects bin. Fine rejects and slimes will be dewatered and conveyed to the rejects bin to be combined with the coarse reject material. The combined rejects will be loaded onto trucks for placement in out-of-pit spoil dumps, or in-pit behind the mining void.

Over the life of the mine, just over 9 Mt of rejects is estimated to be generated for disposal. Most coal reject materials have a relatively low risk of acid generation. While the risk of environmental harm arising

from the geochemical characteristics of materials to be handled is low, it is proposed that coal reject materials are selectively handled and encapsulated within waste rock emplacements and well away from the outside surface of rehabilitated landforms.

As such, no separate rejects facility is proposed for the Project. Representative samples of coal reject materials will be further assessed at the operational stage to ensure that the findings of the geochemical assessment (RGS 2020) (Appendix H) remain applicable.

4.4.7.1 Final Voids

Mine planning for the Project results in the northeast end of Pit AB and the east end of Pit C remaining as residual voids. Both voids will be partially backfilled with waste rock to elevate the void floor above the level of significant groundwater inflows, and to limit the potential for pit water to recharge any aquifers.

The void low wall will be rehabilitated to a gradual slope, safe for access and grazing by cattle. Small pit lakes will form on the pit floor reaching a steady state level where water losses through evaporation are equal to water inputs from rainfall, runoff and groundwater inflows. While water levels in the voids will vary over time dependent on the prevailing climatic conditions, the results of modelling indicate that an equilibrium level of approximately 70 mAHD in C Pit and 53 m AHD in AB Pit will be reached after 200 years. The steady state water level is well below the base of Tertiary aquifers negating any risk of contamination.

Perimeter drainage will be provided to limit the volume of surface water runoff, including modelled 1:1,000 storm event flows, from entering the void. The *Surface Water Assessment* (WRM 2020b) (Appendix B) confirms that pit lake water levels will not exceed 50 mbgl and that there is therefore no risk of overflow to surface waters.

Physical void characteristics are summarised in Table 19.

Table 19 Final Void Physical Characteristics

Mining Area	Approx. Pit Lake Area (ha)	Low Wall Slope	High Wall Slope
Pit AB	43	<6°	<22°
Pit C	37	<6°	<22°

Areas of the low wall capable of supporting pasture crop will be utilised as cattle grazing PMLU. The low walls may be subject to further assessment of low wall soil characteristics, stability, rehabilitation trials and stakeholder consultation to determine the final designation of land. Pit highwalls will be throw blasted and/or shaped to achieve a stable slope of 22°. Inward draining highwalls will support native vegetation post mining land use, consistent with pit lakes.

Two pit lakes with a total footprint area of approximately 81 ha will be formed as part of the final Project landform. Pit lakes have demonstrated capacity for the development of ecosystems able to behave similarly to natural wetlands (Lund and Blanchette, 2014). The underlying biophysical processes facilitating primary production are critical in allowing pit lakes to evolve into valuable ecosystems (Luek and Rasmussen, 2017; Marszelewski *et al.*, 2017; Lund and Blanchette 2014). Variables that influence primary production include bankside vegetation, nutrient concentrations in the water column (nitrogen, phosphorus and carbon), hydrology and bathymetry (Lund and Blanchette 2014).

Miguell-Chinchilla *et al.* (2014) studied the succession of macroinvertebrates in 19 pit lakes of approximately 22 years of age, that were formed as part of the reclamation process of an open cut coal

mine in Spain. Miguell-Chinchilla *et al* (2014) recorded that macroinvertebrates inhabited pit lakes along a primary succession gradient whereby the environmental conditions, including nutrient and habitat resources, determined the community structure.

The salinity of water can be classified by the level of TDS, and the following classification was used for the purpose of this EA application (DSEWPAC 2012b and Environmental Protection Agency 2020):

- freshwater up to 3,000 mg/L;
- brackish 3,000 mg/L – 5,000 mg/L;
- saline 5,000 mg/L – 35,000 mg/L; and
- hypersaline > 35,000 mg/L.

Typically, pit lakes are modelled to become increasingly saline over time (i.e., waters having a TDS greater than 5,000 mg/L). This modelling is inherently conservative as it assumes an eternal, constant, source of salinity to the void lake from spoil seepage. Water quality modelling for the Project by WRM (2019) indicates salinity of both pit voids will gradually increase over time. Salinity is predicted to remain below 5,000 mg/L in the first 100 years following mining and will remain below 10,000 mg/L for the first 200 years. The pit lake will, therefore, be classified as brackish for approximately the first 100 years and is not predicted to reach hypersaline conditions until after approximately 500 years following mining (WRM 2020b). Biodiversity generally decreases as salinity increases, however, salinity of up to 10,000 µs/cm (~6,410 mg/L) can support noteworthy ecological systems and provide a valuable refuge for species (pers comms. M.Lund December 2019).

Research indicates that pit lakes with a TDS up to ~4,500 mg/L can provide ecological value for regional species in Central Queensland (Proctor and Grigg 2006). Further, pit lakes may act as a water refuge during periods of low rainfall for mobile species such as the Grey Teal Duck (Hart 1991) has previously been recorded within the Project surrounds (AARC 2020b). Species of ducks and swans have been observed in saline pit lakes of open cut coal mines in central Queensland (pers comms. C.Cote March 2020).

Macroinvertebrates are well-adapted to brackish and brackish-saline conditions; however, species diversity typically decreases with increasing salinity. A study of pit lakes aged from 1-22 years and ranging from 330 µs/cm – 4,416 µs/cm, associated with a nearby open cut coal mine in Moura, indicated that the diversity of aquatic invertebrates was similar to nearby natural waterbodies (Proctor and Grigg 2006). The pit lakes studied by Proctor and Grigg (2006) were reported to support orders of macroinvertebrates that were also recorded on the Project site, including Diptera, Hemiptera, Odonata and Coleoptera (AARC 2020a).

In an open-cut coal mine located within the Fitzroy Basin, native fish including the Spangled Perch (a species recorded on site) have been documented to have pioneered pit lakes with TDS of up to 7,600 µs/cm region (AARC 2020a).

Proctor and Grigg (2006) concluded that in Central Queensland, final void waterbodies have the potential to provide habitat for many invertebrate taxa typical of still inland water bodies. The ability for macroinvertebrates in freshwater systems to adapt to changes in salinity is dependent on the period of acclimation where the ability to adapt to new conditions improves when changes are incremental over time (Hart 1991).

The high walls associated with pit lakes can also provide suitable refuge and brooding habitat for several mobile fauna species. In periods of low rainfall, birds, including the Grey Teal, have been recorded using

saline waters as refuges over both short- and long-term periods by drinking freshwater elsewhere (Lavery 1972). Several species of birds prefer to breed in saline conditions (Goodsell 1990). For example, the Grey Teal, Pacific Black Duck, White Faced Heron, Little Black Cormorant and Little Pied Cormorant were found by Goodsell (1990) to breed in saline conditions with TDS of up to between 14,600 mg/L (Pacific Black Duck) and 37,600 mg/L (Grey Teal). All of these species have been recorded either within the Project site or surrounds (AARC 2020b). Further, the Black Swan, a species known to inhabit the wider Project surrounds, was reported by Goodsell (1990) to breed in saline water with a TDS of up to 43,500 mg/L.

The residual high wall offers potential to provide steeper slope habitat that can be used by native nesting birds. For example, a resident Peregrine Falcon pair has been recorded successfully breeding in nests created in the high walls of an open cut mining pit in the Northern Territory (Potts and Donato 2008). Additional individual Peregrine Falcons were observed utilising the various open pit high walls for roosting. Birds documented to nest on inland, flat land or slopes may utilise the high-wall pit slopes as nesting habitat (O'Donnell and Debus 2012). Anecdotally, birds of prey have been reported to utilise the high wall as refuges in an open cut coal mine located in central Queensland (pers comms. J. Fittler March 2020); the Wedgetail Eagle, a species that has been recorded on the Project site is one example such species of bird of prey.

Insectivorous bats have been documented feeding on insects in the airspace above pit lakes in both Western Australia and central New South Wales (Griffiths *et a*l. 2014a; Griffiths *et al*. 2014b). A number of insectivorous bats have been identified on the Project Site by ANABAT surveys including the Chocolate Wattled Bat, Eastern Bent-winged Bat, Eastern Cave Bat, Goulds Wattled Bat, Inland Forest Bat, Little Pied Bat, Northern Free-tailed Bat, Troughton's Sheathtail Bat, White-striped Free-tailed Bat and the Yellow-bellied Sheath-tailed Bat (AARC 2020b).

The rock fissures and crevices present in the high-wall pit slopes provide potential refuge habitat for various cave-dwelling microbats identified within the Project Site. For example, the Little Broad-nosed Bat which roosts in hollows but which has been found in fence posts and under the metal caps of telegraph poles (Churchill 2009), Gould's Wattled Bat which has been found roosting in stumps, hollow trees and urban settings such as ceilings (ALA 2020) and the Troughton's Sheathtail Bat which has been recorded in cracks and crevices in rocky escarpments (DES 2011)), as well as species previously recorded within the Project region (e.g. the Eastern Horseshoe Bat which is known to roost in caves but also in holes and cracks in rocks (Australian Museum 2020).

Native vegetation proposed to rehabilitate the high-wall slopes will provide additional refuge for ground-dwelling fauna, including small mammals and reptiles. For example, the Delicate Mouse (*Pseudomys delicatulus*) feeds on native grass seeds and uses grass tussocks as refuges (Diete *et al*. 2015). Similarly, grass tussocks provide nature refuges for a number of mammals and reptile species found on the Project site during the fauna survey, including the Delicate Mouse, Short Beaked Echidna, Rakalie Bynoes Gecko, Elegant Snake-Eyed Skink, Prickly Knob-tailed Gecko, Eastern Stone Gecko and Box-patterned Gecko (AARC 2020b). The use of high-wall vegetation by goats, cattle, small mammals and reptiles has been observed in open-cut mines of Queensland (pers comms. C.Cote March 2020).

The ecological value of pit lakes and adjacent high-wall features can be facilitated through effective rehabilitation of the pit walls. For example, a review of the ecological processes associated with nutrient webs of natural lakes, wetlands and pit lakes, van Etten (2011) concluded that rehabilitating vegetation along the low walls can assist with improving water quality, primary production and provide suitable habitat for aquatic and terrestrial fauna. Aquatic plants along the littoral fringe have been reported to inhabit areas with consistent water levels in pit lakes with salinity less than 10,000 µs/cm, in Queensland (pers comms. J. Fittler March 2020). Further, habitat complexity including the development of

microclimates (van Etten 2011) and additional habitat could be created through the addition of cleared vegetation (i.e., tree trunks) to both the low walls and the waterbody (Luek and Rassmussen 2017).

Given that salinity is predicted to remain below 5,000 mg/L during the first 100 years of post-mining operations, the pit lake and surrounding high-wall features is predicted to provide suitable habitat for a range of native fauna, including a number of species recorded within the Project site and surrounds.

4.4.8 Mine Infrastructure Areas

Mine infrastructure areas will not be rehabilitated until mining operations have ceased. These areas will have all infrastructure removed and be regraded to their approximate original contour to ensure they are stable and sound. Footings will be either completely removed or removed to at least a depth of 1 m below surface level. Where possible infrastructure will be on-sold or sold for scrap. Clean construction and demolition waste will either be removed from site or placed within one of the final waste rock emplacements and covered. Any land identified to be subject to contamination will be subject to notification and a site investigation and either excavated and contaminated material removed to a licensed facility or, or risk assessed and listed on the Environmental Management Register.

Once reshaped, mine infrastructure areas will be subjected to rehabilitation practices including topsoiling and revegetation as described in Section 4.4.2 and Section 4.4.3. The land disturbance and other controls detailed at Section 4.7 will be implemented as appropriate. In addition, controls to address specific demolition and closure risks will be implemented.

If consultation with neighbours or other potential post-mining land users identifies any infrastructure of value to the PMLU, a written agreement will be established that transfers liability in the structure and its use to the new owner.

Haul roads will be constructed utilising spoil material sourced from initial mining operations. At closure, haul roads will have road base materials removed and be reshaped to create a stable landform that blends in with the surroundings. Minor site access roads and tracks will be rehabilitated where they are no longer required.

4.4.9 Water Management Infrastructure

Unless water storage facilities are identified by the post-mining landholder as of value to their future use of the land, and an agreement is entered into, all water storages will be drained and de-silted, and re-profiled to ensure the area is free-draining and blends in with the surrounding landscape. Disturbed areas will be seeded with a seed mix suitable for grazing / native ecosystems. Raw water dams, once no longer required, will be emptied by pumping to the final void. Dam liners will be removed and appropriately disposed of.

The temporary levee for Pit AB would be incorporated into the final landform profile on closure.

The installed clean water drains will remain post-mining. The revegetation of permanent drainage structures will incorporate geomorphic and riparian vegetation features that are consistent with the pre-mining environment. A key objective of the revegetation of permanent drainage structures will be to ensure that self-sustaining vegetation communities are achieved. Additionally, revegetation along permanent drainage structures will aim to restore habitat connectivity within the remaining portions of Springton Creek.

4.5 REHABILITATION MILESTONES

4.5.1 Schedule of Land Available for Rehabilitation

Land will become progressively available for rehabilitation throughout the life of the Project. Land is considered available for rehabilitation when:

- the land is no longer required for operating infrastructure or machinery for mining, including, for example, a dam or water storage facility;
- the land is no longer being mined and there is no plan to return to mining within 10 years after the land would otherwise have become available for rehabilitation (assuming a probable or proven ore reserve remains); and
- the land does not contain permanent infrastructure remaining on the land for a PMLU.

A preliminary schedule of when land will become available for rehabilitation is provided below in Table 20.

Table 20 Preliminary Schedule of Land Available for Rehabilitation

Rehabilitation Area	Land Available (ha)				
	Year 4	Year 8	Year 12	Year 17	Year 21
RA1: In-pit and out-of-pit waste emplacements, including dry rejects disposal areas	231.0	59.5	97.0	148.2	186.7
RA2: Temporary waste emplacements				17.5	0
RA3: Residual void lakes				40.6	35.9
RA4: Residual void high walls				64.0	69.1
RA5: Residual void low walls				127.1	60.4
RA6: Water management infrastructure					85.0
RA7: Mine infrastructure areas					731.8

4.5.1.1 Milestone 1: Infrastructure Decommissioning and Removal

Infrastructure decommissioning and removal will involve the following processes:

- disconnection and removal (or sale and removal if appropriate) of all infrastructure including pipelines, fences not a part of the PMLU, buildings, machinery, equipment, road base, water management structures;
- all wastes and temporary stockpiles will be removed.

Rehabilitation milestone 1 is applicable to all rehabilitation areas.

4.5.1.2 Milestone 2: Remediation of Contaminated Land

A contaminated land investigation of the Project site will be undertaken by a suitably qualified person. The contaminated land investigation will determine the presence of contaminated land. Remediation

activities will be undertaken and where required, consultation on appropriate remediation activities of contaminated land will be sought.

A validation report will detail the remediation of contaminated land and a site suitability statement prepared by a suitably qualified person which states that the land is suitable for the PMLU.

Rehabilitation areas for which milestone 2 is applicable include: RA6 and RA7.

4.5.1.3 Milestone 3: Landform Development and Reshaping / Profiling

On completion of construction and reprofiling of the final landform, inspection and reporting will be undertaken to provide assurance that landform development and reshaping has been undertaken in accordance with the accepted final landform design criteria.

Residual voids backfilled to 80 mbgl, necessary to support a native ecosystem land use for the final pit lake.

The geotechnical stability of landforms, including pit walls and spoil dumps, will be assessed by a suitably qualified person.

Rehabilitation areas for which milestone 3 is applicable include: RA1, RA2, RA4, RA5, RA6, RA7.

4.5.1.4 Milestone 4: Surface Preparation

Completion of earthworks associated with placement of the topsoil material on final landforms. A minimum of 0.3 m of topsoil is required on areas of land to be returned to a grazing PMLU. Deep ripping of the surfaces has been undertaken. Surface drainage features have been installed. If required, soil ameliorants have been applied. Topsoil spreading or select placement

An assessment of soil health will be completed by a suitably qualified person to verify the growth medium is suitable for achieving the intended PMLU.

Rehabilitation areas for which milestone 4 is applicable include: RA1, RA2 RA4, RA5, RA6 and RA7.

4.5.1.5 Milestone 5: Revegetation

Completed seeding of areas that have achieved milestone 4. Records of revegetation activities will be maintained, documentation of the below details will indicate completion of the milestone:

- GIS files of the areas where seeding and planting have occurred, where areas with different SMUs, seed mixes or dates of planting are mapped separately;
- date the seed mix was applied, or planting of tube stock was carried out;
- if seeding, the seed mix and rate of seeding applied;
- if planting, the number of tube stock planted;

Rehabilitation areas for which milestone 5 is applicable include: RA1, RA2, RA4, RA5, RA6 and RA7.

4.5.1.6 Milestone 6: Establishment of Target Vegetation

A minimum of 5 years of rehabilitation monitoring data will confirm that rehabilitated areas have, or are on a trajectory to, achieve a self-sustaining ecosystem. Rehabilitated areas will be assessed against target criteria and compared to analogue sites of similar characteristics and land use.

Rehabilitation areas for which milestone 6 is applicable include: RA1, RA2, RA4, RA5, RA6 and RA7.

4.5.1.7 Milestone 7: Residual Void Lake

Water level in the final void is less than 74 mAHD for C Pit and 58 mAHD for AB Pit. Water in void lakes will have a TDS of less than 10,000 mg/L when measured at the surface.

Rehabilitation areas for which milestone 7 is applicable include: RA3.

4.5.1.8 Milestone 8: Achievement of Stable PMLU

Monitoring determines that that the land is safe, structurally stable, does not cause environmental harm and is able to sustain the PMLU.

Rehabilitation areas for which milestone 8 is applicable include: RA1, RA2, RA3, RA4, RA5, RA6 and RA7.

4.5.2 Rehabilitation Indicators and Completion Criteria

The *Guideline (Resource Activities): Rehabilitation requirements for mining resource activities [ESR/2016/1875]* (DES 2014a) requires the nomination of rehabilitation performance indicators for mining resource activities. Rehabilitation performance indicators are intended to provide defensible measurements of progress towards rehabilitation targets – referred to as completion criteria.

Principles for the development of rehabilitation performance indicators are preferably specific, measurable, achievable, realistic and timely. They should be outcome-based (linked to the end land use); flexible to adapt to changing circumstances; able to evolve as the mine life progresses; subject to periodic review; and include a measurement approach that details how the criterion will have been met (DFAT 2016b; ANZMEC and MCA 2000). Baseline data described in this application has been used to inform the development of site-specific performance indicators to protect the environmental values of the Project area.

Completion criteria are the threshold values, which when met, are deemed to demonstrate that a given indicator requirement has been achieved. Completion criteria may be established through technical or engineering studies or by assessing analogue or comparative sites that are considered to represent the desired rehabilitation outcome. In many cases, completion criteria need to be developed on the basis of ongoing monitoring of analogue sites to determine seasonal behaviours or variation over time.

Milestone completion criteria relevant to each designated rehabilitation area are listed in Table 21.

Table 21 Rehabilitation Milestone Completion Criteria

Code	Milestone	Indicators	Criteria	Applicable Rehabilitation Areas
RM1	Milestone 1: Infrastructure Decommissioning and Removal	• presence of mine infrastructure equipment and materials.	• all unrequired services disconnected and removed; • all concrete, bitumen and gravel removed; • all pipelines drained and removed; • all fencing that is not part of the PMLU removed; • all buildings demolished and/or removed; • all machinery and equipment removed; • all surface water drainage infrastructure that is not retained in the final landform removed; and • all rubbish removed.	RA1, RA2, RA3, RA4, RA5, RA6, RA7
RM2	Milestone 2: Remediation of Contaminated Land	• presence of contaminated materials; and • contaminated land assessment.	• all contamination is remediated or removed; and • site investigation report prepared by a suitable qualified person which states that the site is safe for its intended use.	RA6, RA7
RM3	Milestone 3: Landform Development and Reshaping/Profiling	• landform maximum slope of spoil and voids; • void backfill depth; and • geotechnical study completed by a suitably qualified person assessing the factor of safety for all final landforms.	• all landform earthworks (excluding topsoil cover) completed; • slopes of spoil dumps conform to maximum angle of 6°; • backfilling of voids to a minimum of 80 mbgl; • highwalls of voids shaped to achieve a maximum angle of 22°; and • landform (pits and spoil dumps) assessed to be geotechnically stable by a suitably qualified person, modelled to achieve a factor of safety of ≥ 1.5.	RA1, RA2, RA4, RA5, RA6, RA7
RM4	Milestone 4: Surface Preparation	• evidence of landform surface treatment; and • soil health assessment.	• all surface drainage features installed; • topsoil placed over all reshaped surfaces to a depth of 0.3 m and deep ripped; and • soil health assessment confirms soil is suitable for target vegetation establishment. If required ameliorants have been applied.	RA1, RA2, RA4, RA5, RA6, RA7
RM5	Milestone 5: Revegetation	• rehabilitation monitoring by a suitably qualified person.	• complete seeding of all topsoiled surfaces using recommended seed mix; and • evidence of successful seed germination in rehabilitation monitoring report.	RA1, RA2, RA4, RA5, RA6, RA7
RM6	Milestone 6: Establishment of Target Vegetation	• rehabilitation monitoring by a suitably qualified person.	• average vegetation ground cover is within 2 standard deviations of equivalent analogue sites; • species richness is within 2 standard deviations of equivalent analogue sites; • weed abundance is consistent with equivalent analogue sites;	RA1, RA2, RA4, RA5, RA6, RA7

Code	Milestone	Indicators	Criteria	Applicable Rehabilitation Areas
			• for grazing areas, pasture mass, the standard unit of measuring pasture productivity (Cayley and Bird 1996) is within 2 standard deviations of analogue sites for pasture on the same SMU; and • validation by a suitably qualified person that the target PMLU is achieved.	
RM7	Residual Void Lake	• water level monitoring; • water quality monitoring; and • fauna monitoring.	• water level in the final void has achieved an RI of less than 74 mAHD for C Pit and 58 mAHD for AB Pit. Water in void lakes will have a TDS of less than 10,000 mg/L when measured at the surface.	RA3
RM8	Milestone 8: Achievement of Stable PMLU	• rehabilitation monitoring; • geotechnical study; completed by a suitably qualified person assessing the factor of safety for all final landforms; • erosion analysis completed by a suitably qualified person; • fauna surveys including camera trapping, echolocation detection, scat analysis, aquatic and terrestrial trapping and target species surveys; • surface water quality monitoring; and • groundwater quality monitoring.	• report prepared by a suitably qualified person confirming the target PMLU has been achieved and the ecosystem is self-sustaining (with required land management inputs not significantly greater than the surrounding equivalent land use); • landform (pits and spoil dumps) assessed to be geotechnically stable by a suitably qualified person, modelled to achieve a factor of safety of ≥ 1.5; • predictive analysis of erosion confirming that soil loss rates are acceptable and require land management inputs not significantly greater than the surrounding equivalent land use; • fauna survey report provides evidence of native species inhabiting or utilising pit lake / highwall ecosystems including macroinvertebrates, aquatic vertebrates, avian species, bats, and other mammals; • surface water on the site and in the receiving environment is not significantly poorer in any parameter than equivalent reference sites and the baseline quality data for the Project; • groundwater on the site and in the receiving environment is not significantly poorer in any parameter than reference sites and the baseline quality data for the Project; and • predictive modelling undertaken by a suitably qualified person, confirming that the void lake will remain a groundwater sink and that there is no risk of contamination post mining.	RA1, RA2, RA3, RA4, RA5, RA6, RA7

4.6 PRELIMINARY REHABILITATION MILESTONE SCHEDULE

A preliminary rehabilitation milestone schedule has been developed on the basis of the mine schedule described in Section 3.6.2.

Cumulative areas of rehabilitation have been calculated using geospatial data of the mining stage plans which identify the conceptual sequence of mining and rehabilitation activities particularly with respect to the functional operational steps of waste rock emplacement construction, the point at which disturbed areas become available for rehabilitation, and then completion of the activities of reshaping/topsoiling and revegetation (refer to Figure 23 - Figure 32). Variations to the mining rate will likely result in discrepancies with the predicted timing of rehabilitation activities.

A summary of the milestone schedule for each rehabilitation area is provided below (Table 22 - Table 28), and illustrated in Figure 38 to Figure 46.

Table 22 Milestone Schedule Rehabilitation Area 1

Post-Mining Land Uses (PMLU)									
Rehabilitation Area:	RA1								
Relevant Activities:	In pit and out of pit waste emplacements (including dry rejects disposal)								
Total Rehabilitation Area Size (ha):	722.4								
Commencement of First Milestone: (RM1)	Year 2								
PMLU:	Grazing								
Project Year:	**Year 4**	**Year 8**	**Year 12**	**Year 17**	**Year 21**	**Year 25**	**Year 29**	**Year 33**	**Year 37**
Cumulative Area Available (Ha):	231.0	290.5	387.5	535.7	722.4	722.4	722.4	722.4	722.4
Milestone Completed By:	10 Dec Year 4	10 Dec Year 8	10 Dec Year 12	10 Dec Year 17	10 Dec Year 21	10 Dec Year 25	10 Dec Year 29	10 Dec Year 33	10 Dec Year 37
Milestone Reference	**Cumulative area achieved (ha)**								
RM1	231.0	290.5	387.5	535.7	722.4				
RM3	231.0	290.5	387.5	535.7	722.4				
RM4	231.0	257.8	330.3	535.7	722.4				
RM5	231.0	231.0	314.6	513.5	722.4	722.4			
RM6			165.7	206.0	330.6	493.0	722.4	722.4	
RM8							425.7	425.7	722.4

Table 23 Milestone Schedule Rehabilitation Area 2

Post-Mining Land Uses (PMLU)									
Rehabilitation Area:	RA2								
Relevant Activities:	Temporary Waste Rock Emplacement								
Total Rehabilitation Area Size (ha):	17.5								
Commencement of First Milestone: (RM1)	Year 15								
PMLU:	Grazing								
Project Year:	**Year 4**	**Year 8**	**Year 12**	**Year 17**	**Year 21**	**Year 25**	**Year 29**	**Year 33**	**Year 37**
Cumulative Area Available (Ha):				17.5	17.5	17.5	17.5		
Milestone Completed By:				10 Dec Year 17	10 Dec Year 21	10 Dec Year 25	10 Dec Year 29		
Milestone Reference	**Cumulative area achieved (ha)**								
RM1				17.5					
RM3				17.5					
RM4				17.5					
RM5				17.5					
RM6					17.5	17.5			
RM8							17.5		

Table 24 Milestone Schedule Rehabilitation Area 3

Post-Mining Land Uses (PMLU)									
Rehabilitation Area:	RA3								
Relevant Activities:	Residual Void Lakes								
Total Rehabilitation Area Size (ha):	76.5								
Commencement of First Milestone: (RM1)	Year 15								
PMLU:	Fauna Habitat								
Project Year:	**Year 4**	**Year 8**	**Year 12**	**Year 17**	**Year 21**	**Year 25**	**Year 29**	**Year 33**	**Year 37**
Cumulative Area Available (Ha):				40.6	76.5	76.5	76.5	76.5	76.5
Milestone Completed By:				10 Dec Year 17	10 Dec Year 21	10 Dec Year 25	10 Dec Year 29	10 Dec Year 33	10 Dec Year 37
Milestone Reference	**Cumulative area achieved (ha)**								
RM1				40.6	76.5	76.5			
RM7						40.6	76.5	76.5	
RM8								40.6	76.5

Table 25 Milestone Schedule Rehabilitation Area 4

Post-Mining Land Uses (PMLU)									
Rehabilitation Area:	RA4								
Relevant Activities:	Residual Void High Walls								
Total Rehabilitation Area Size (ha):	133.1								
Commencement of First Milestone: (RM1)	Year 13								
PMLU:	Native Vegetation Supporting Fauna Habitat								
Project Year:	**Year 4**	**Year 8**	**Year 12**	**Year 17**	**Year 21**	**Year 25**	**Year 29**	**Year 33**	**Year 37**
Cumulative Area Available (Ha):				64.0	133.1	133.1	133.1	133.1	133.1
Milestone Completed By:				10 Dec Year 17	10 Dec Year 21	10 Dec Year 25	10 Dec Year 29	10 Dec Year 33	10 Dec Year 37
Milestone Reference	**Cumulative area achieved (ha)**								
RM1				64.0	133.1				
RM3				64.0	133.1				
RM4				64.0	133.1				
RM5				64.0	133.1	133.1			
RM6						64.0	133.1	133.1	
RM8							64.0	64.0	133.1

Table 26 Milestone Schedule Rehabilitation Area 5

Post-Mining Land Uses (PMLU)									
Rehabilitation Area:	RA5								
Relevant Activities:	Residual Void Low Walls								
Total Rehabilitation Area Size (ha):	187.2								
Commencement of First Milestone: (RM1)	Year 12								
PMLU:	Grazing								
Project Year:	Year 4	Year 8	Year 12	Year 17	Year 21	Year 25	Year 29	Year 33	Year 37
Cumulative Area Available (Ha):				127.1	187.2	187.2	187.2	187.2	187.2
Milestone Completed By:				10 Dec Year 17	10 Dec Year 21	10 Dec Year 25	10 Dec Year 29	10 Dec Year 33	10 Dec Year 37
Milestone Reference	Cumulative area achieved (ha)								
RM1				127.1	187.2				
RM3				127.1	187.2				
RM4				127.1	187.2				
RM5				127.1	187.2	187.2			
RM6						127.1	187.2	187.2	
RM8							127.1	127.1	187.2

Table 27 Milestone Schedule Rehabilitation Area 6

Post-Mining Land Uses (PMLU)									
Rehabilitation Area:	RA6								
Relevant Activities:	Water Management Infrastructure								
Total Rehabilitation Area Size (ha):	85.0								
Commencement of First Milestone: (RM1)	Year 20								
PMLU:	Grazing								
Project Year:	Year 4	Year 8	Year 12	Year 17	Year 21	Year 25	Year 29	Year 33	Year 37
Cumulative Area Available (Ha):					85.0	85.0	85.0	85.0	85.0
Milestone Completed By:					10 Dec Year 21	10 Dec Year 25	10 Dec Year 29	10 Dec Year 33	10 Dec Year 37
Milestone Reference	Cumulative area achieved (ha)								
RM1					85.0				
RM2					85.0				
RM3					85.0				
RM4						85.0			
RM5						85.0			
RM6							85.0	85.0	
RM8									85.0

Table 28 Milestone Schedule Rehabilitation Area 7

Post-Mining Land Uses (PMLU)									
Rehabilitation Area:	RA7								
Relevant Activities:	Mine Infrastructure Area								
Total Rehabilitation Area Size (ha):	731.8								
Commencement of First Milestone: (RM1)	Year 20								
PMLU:	Grazing								
Project Year:	Year 4	Year 8	Year 12	Year 17	Year 21	Year 25	Year 29	Year 33	Year 37
Cumulative Area Available (Ha):					731.8	731.8	731.8	731.8	731.8
Milestone Completed By:					10 Dec Year 21	10 Dec Year 25	10 Dec Year 29	10 Dec Year 33	10 Dec Year 37
Milestone Reference	Cumulative area achieved (ha)								
RM1					731.8				
RM2					731.8				
RM3					731.8				
RM4						731.8			
RM5						731.8			
RM6							731.8	731.8	
RM8									731.8

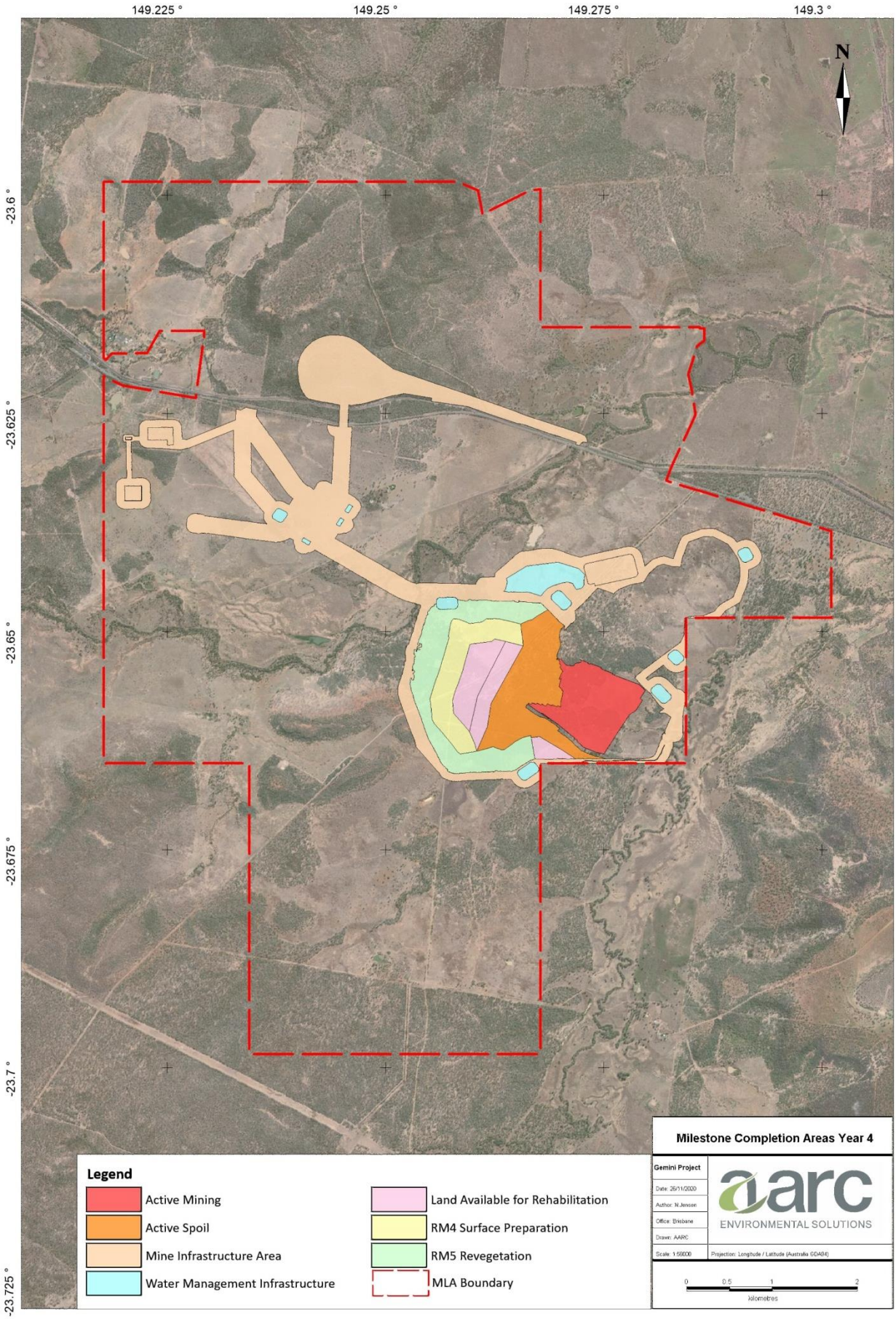


Figure 38 Milestone Completion Areas Year 4

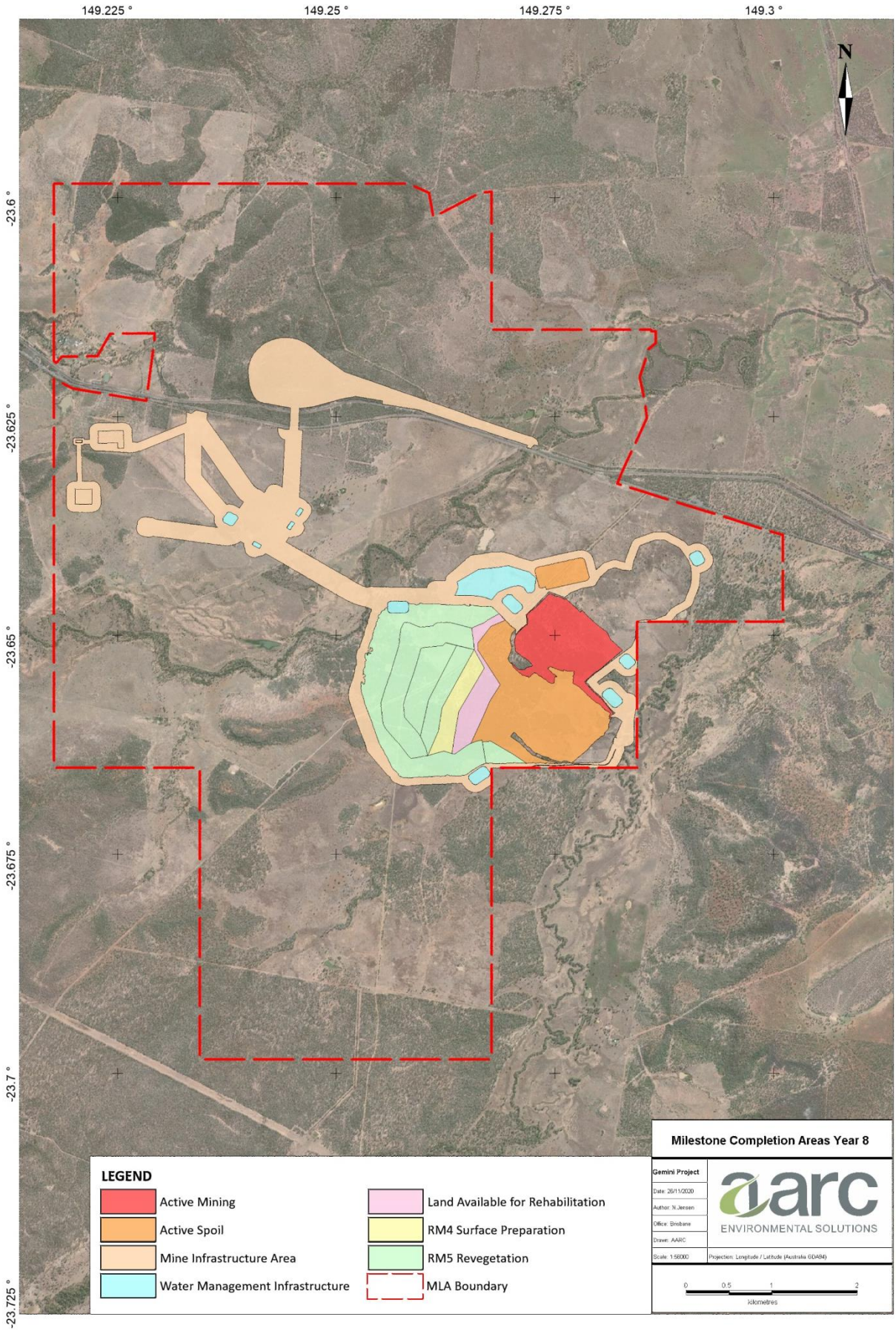


Figure 39 **Milestone Completion Areas Year 8**

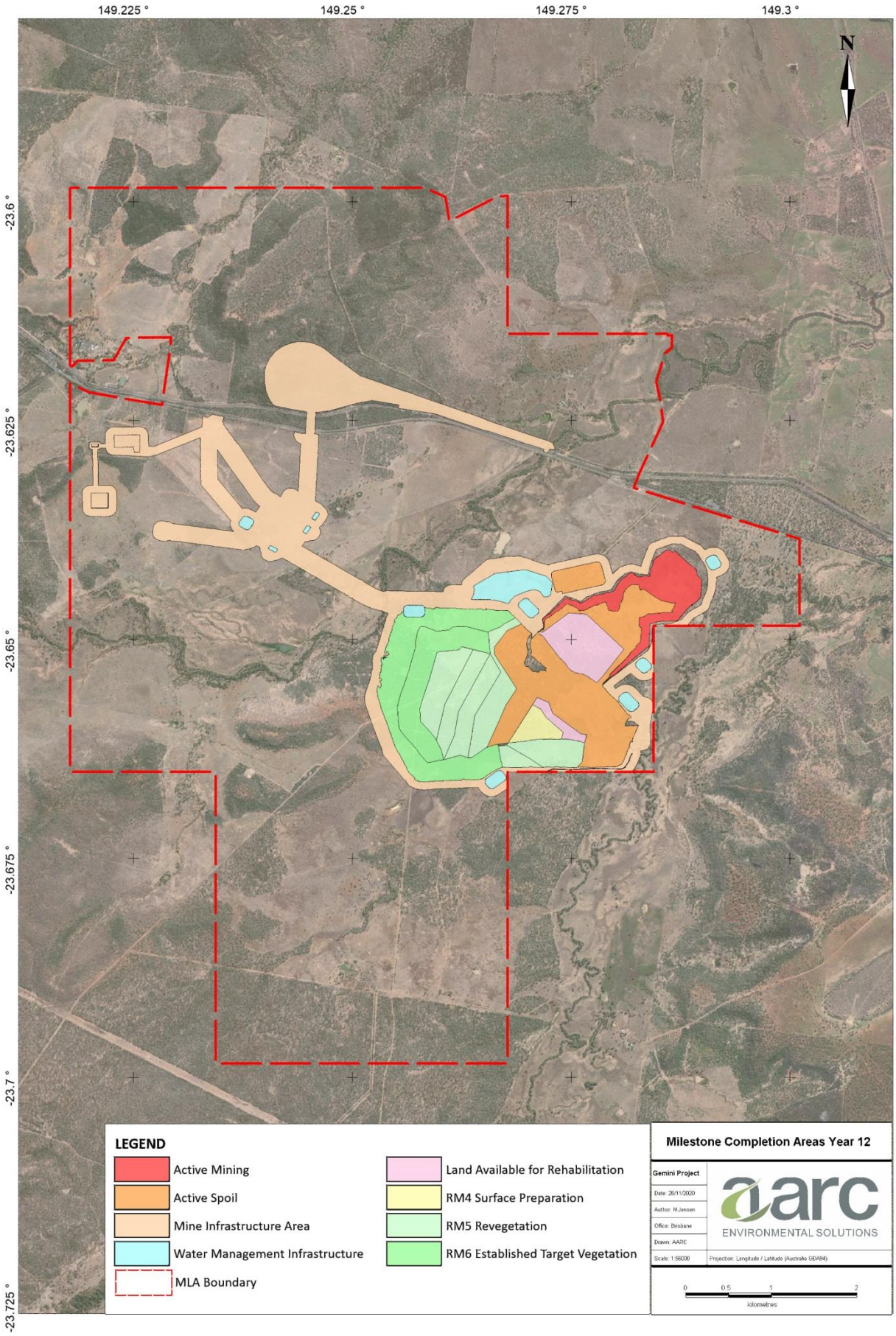


Figure 40 **Milestone Completion Areas Year 12**

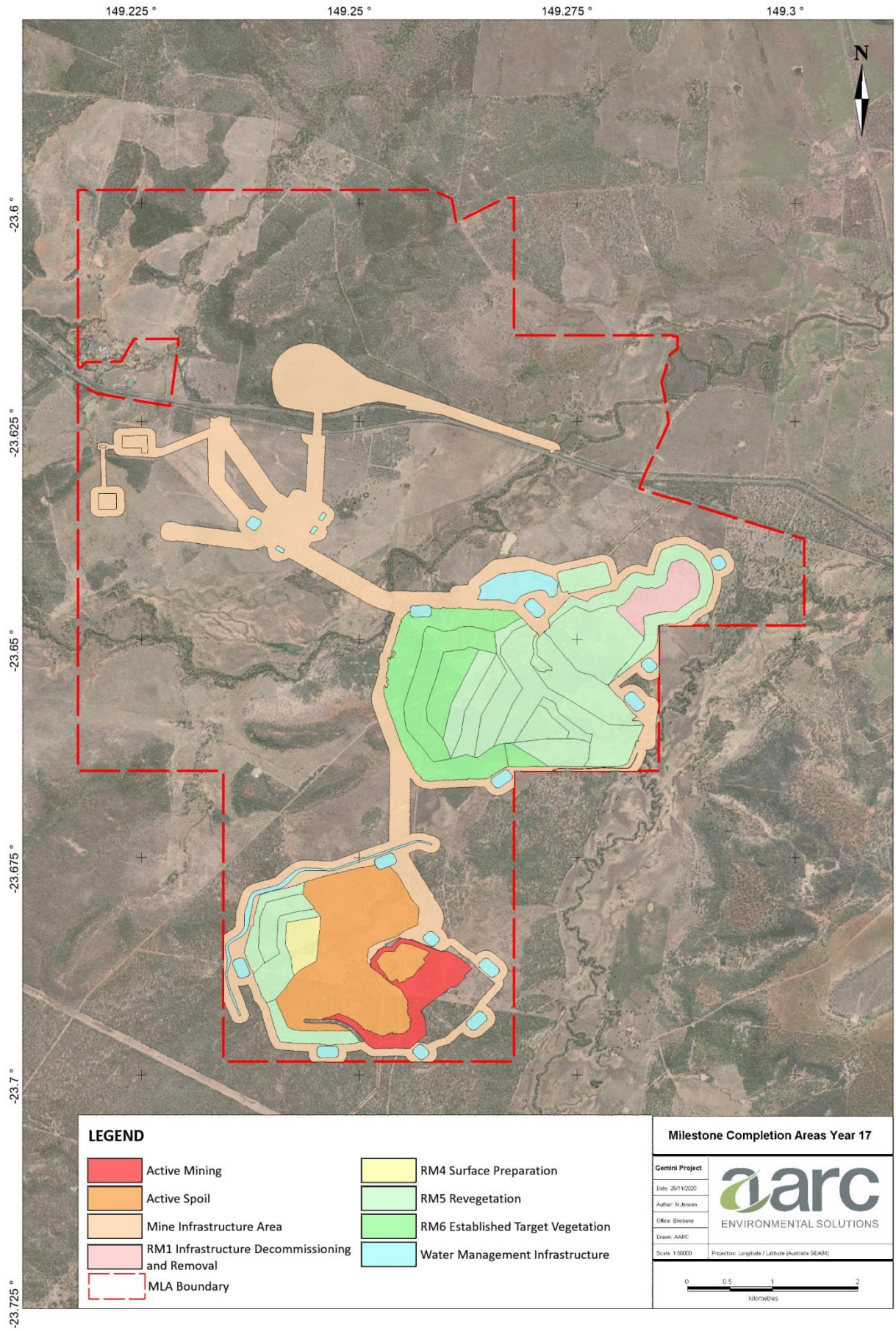


Figure 41 **Milestone Completion Areas Year 17**

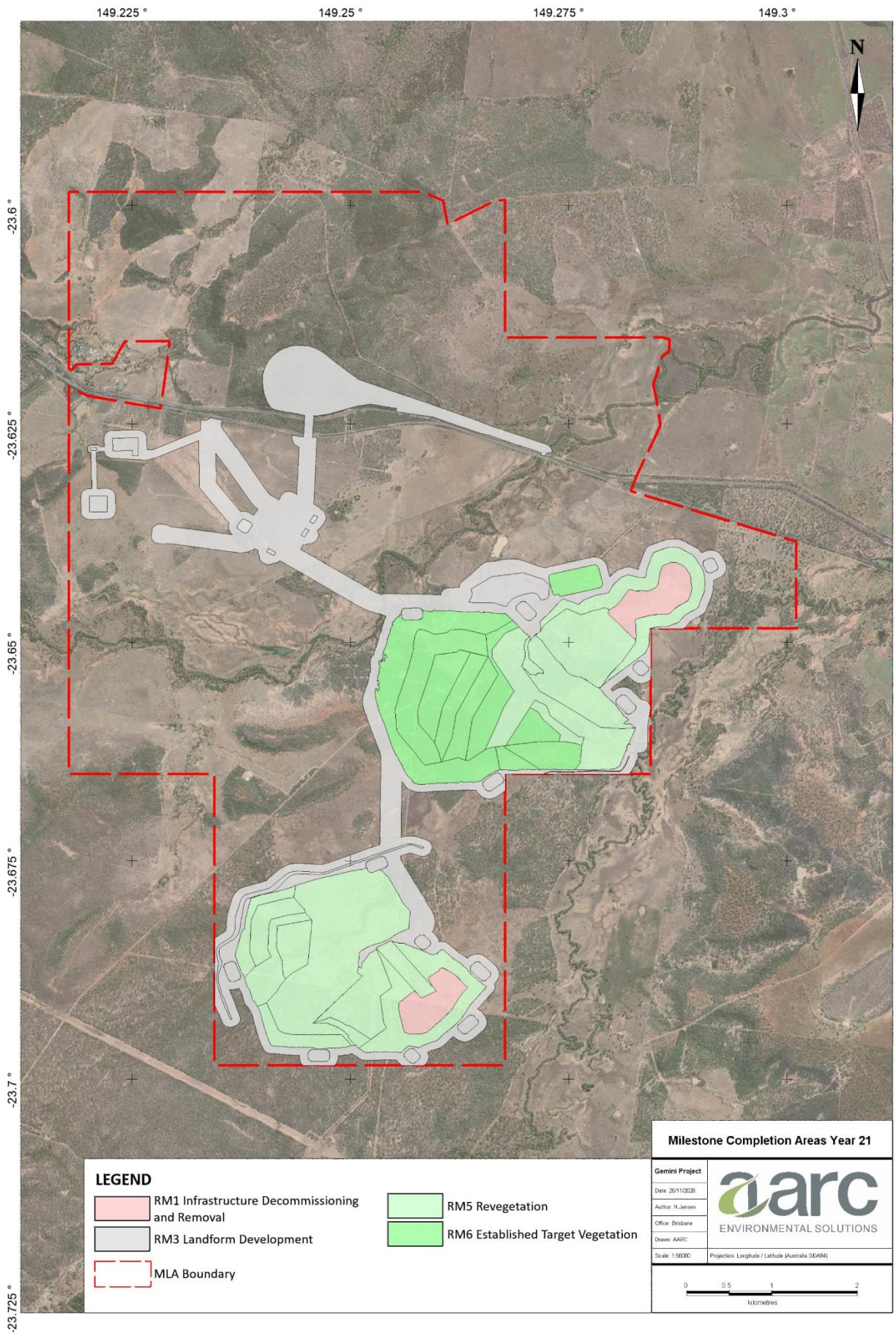


Figure 42 **Milestone Completion Areas Year 21**

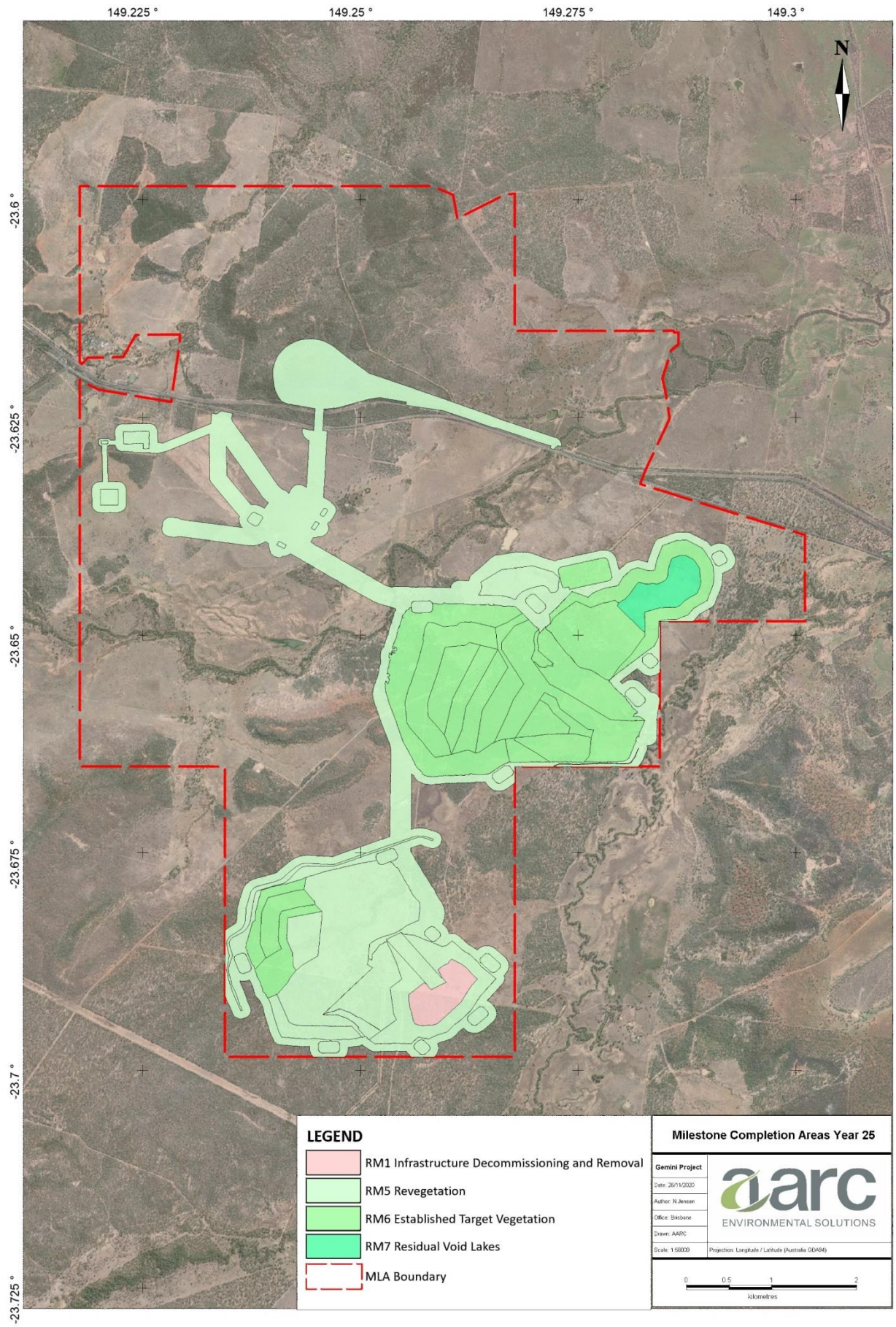


Figure 43 **Milestone Completion Areas Year 25**

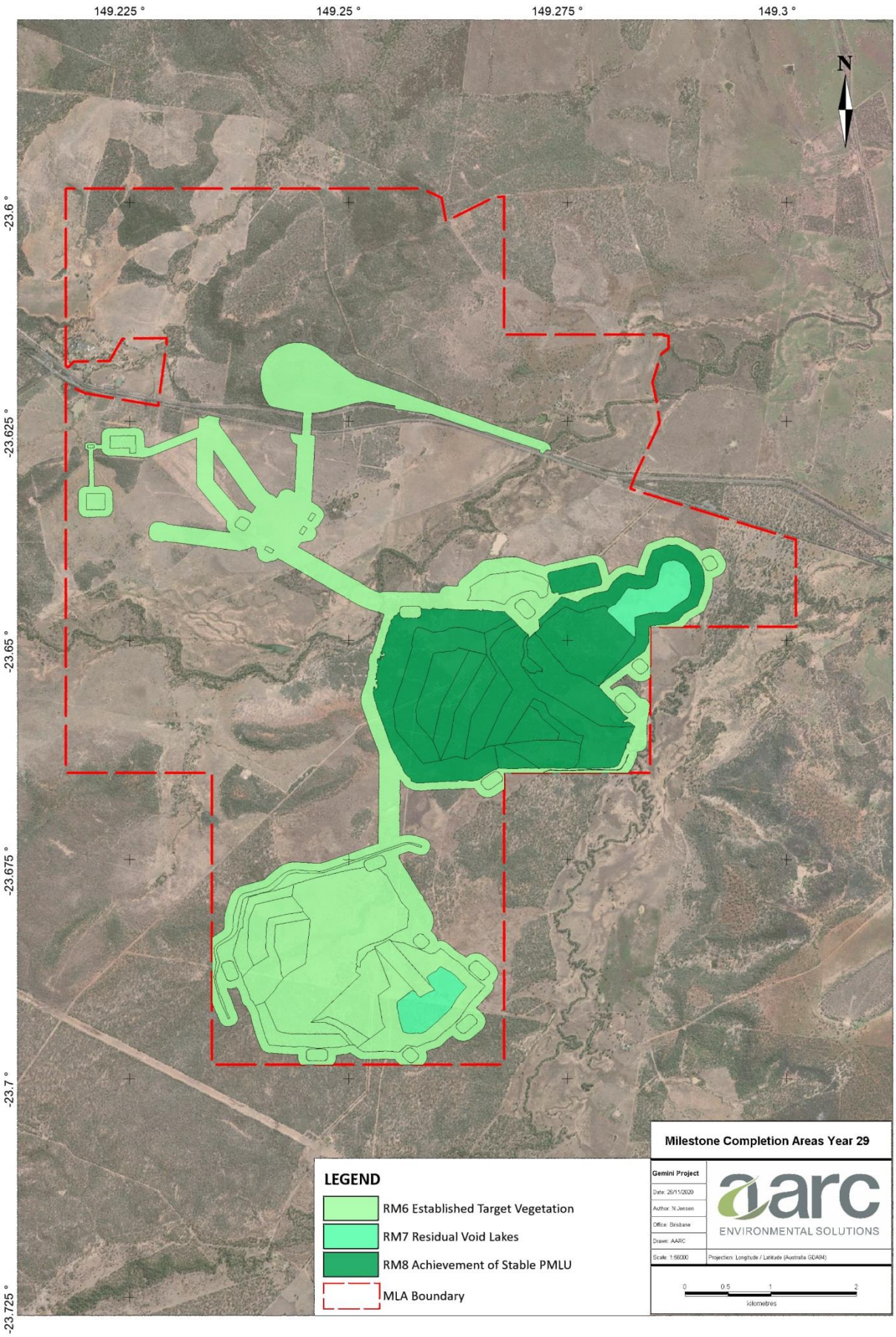


Figure 44 **Milestone Completion Areas Year 29**

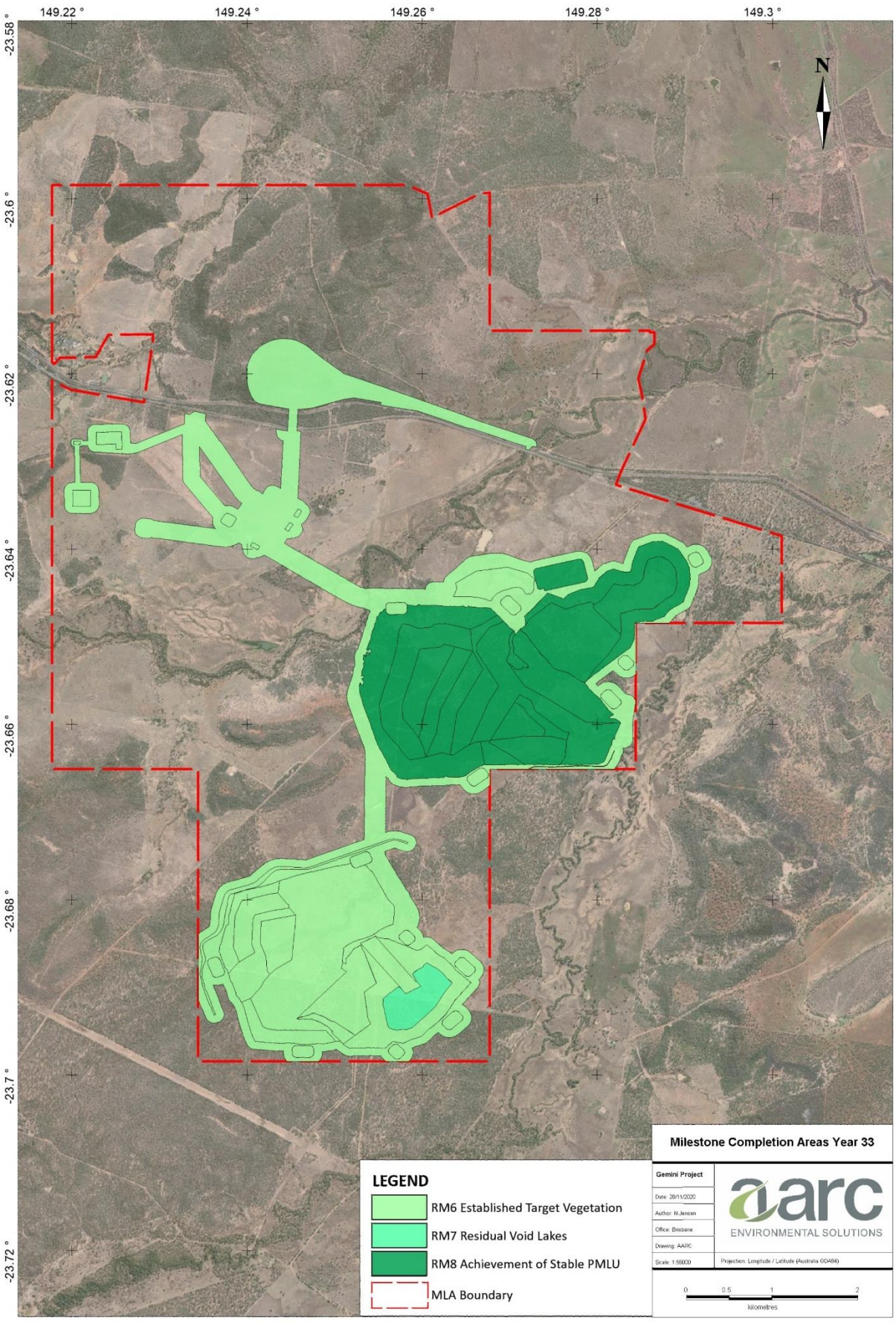


Figure 45 **Milestone Completion Areas Year 33**

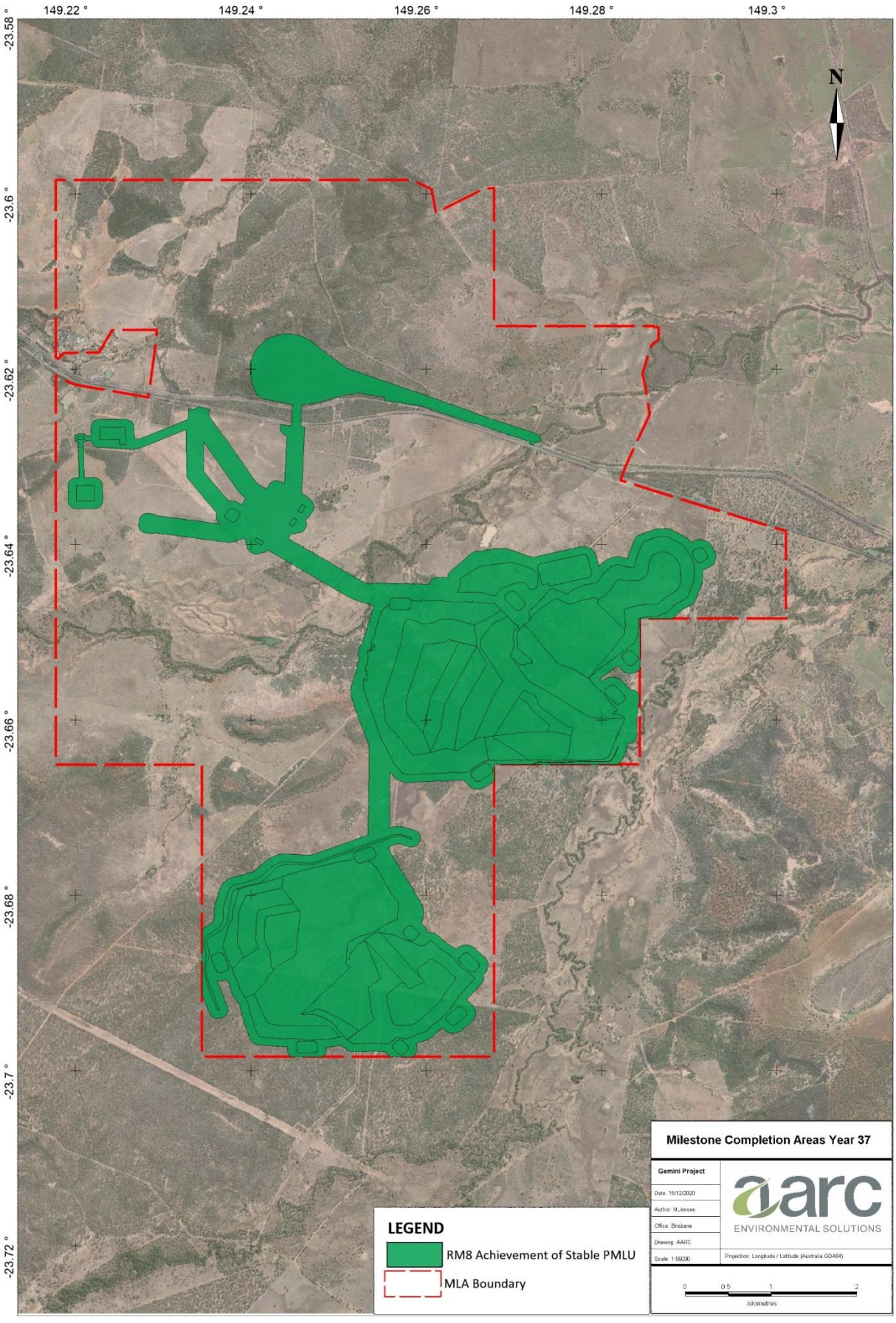


Figure 46 **Milestone Completion Areas Year 37**

4.7 LAND DISTURBANCE MANAGEMENT AND CONTROLS

4.7.1 Land Disturbance Permit System

A *Land Disturbance Permit System* will be implemented for all land disturbance works within the Project approvals boundary including:

- the disturbance of vegetation (grasses, shrubs, or trees) by machinery or other means (clearing or slashing); and
- the disturbance of soils (topsoils, subsoil, or surface rock layer) by machinery or by soil stripping, the placement of any material or infrastructure on unstripped ground, geotechnical drills, and the development of access roads/tracks.

Prior to any land disturbance, a *Land Disturbance Permit* is to be completed. The *Land Disturbance Permit System* will focus on the minimisation of impacts of land disturbance on the environmental values of the Project and surrounds.

The objective of the *Land Disturbance Permit System* is to ensure all disturbance works are undertaken in accordance with the Project's EA conditions and in an environmentally responsible manner, minimising the impact on the environmental values of the Project site and surrounding region.

The land disturbance procedure will detail the Standard Operating Procedure for the application of land disturbance including procedures for notification periods for relevant personnel, the application process and requirements, roles and responsibilities of personnel, environmental management required for land disturbance, clearing, topsoil removing a stockpiling activities and archaeological finds.

The *Land Disturbance Permit System* will require the following components be completed prior to submission and approval of land disturbance works:

- application details (personal applicant details, a description of the works, size of the disturbance and GPS coordinates);
- map of the disturbance area;
- relevant environmental management controls including a risk assessment, emergency response, erosion and sediment controls, requirements for ecological clearance, heritage clearance;
- legislative approvals, notifications and agreements where required;
- ecological, heritage, community, or land use survey requirements/approvals/notification requirements;
- possible environmental issues identified;
- rehabilitation requirements, where applicable;
- list of contractors and contact details required for any activities associated with land disturbance activities;
- visual inspections of facilities and services; and
- appropriate internal communications established.

4.7.2 Erosion and Sediment Control

A ESCP for the Project has been developed to address the construction, operational and rehabilitation/closure phases of the Project, to the comply with Schedule F31 and F32 of the Project's EA. The ESCP is provided in Appendix P and been designed using a three-tier approach beginning with management, control and treatment; which aims to minimise soil erosion and generation of sediment during disturbance activities and minimise the potential impact of the Project on the water quality of the receiving waters. The ESCP details the following:

- activities with the potential to result in soil erosion or sediment generation, including:
    - land clearing, construction activities and maintenance of haul and access routes;
    - movement of equipment; and
    - surface water run-off from waste rock material, coal, and topsoil stockpiles.
- the description, location and design of erosion and sediment control structures including the sediment dams associated with Pit AB and Pit C (Figures 8 - 12 of Appendix P);
- mitigation measures to reduce soil erosion and sediment migration into receiving waters, these measures include but are not limited to:
    - silt fences, coir logs, hay bales or other flow reduction and sediment entrapment devices;
    - traffic control measures and haul route bunding;
    - pit protection levees;
    - diversion channels;
    - cleaning of vehicles and equipment within designated cleaning areas;
    - sediment traps and dams;
    - cleaning protocols of sediment drains and entrapment devices;
    - waste rock stockpiles designed to slope of 1V:10H (adhering to a slope of 6°) to prevent landform instability and dispersal; and
    - rapid revegetation of disturbed areas and hydromulching of areas subject to short term exposure;
- sediment quality monitoring will be undertaken in accordance with a *Receiving Environment Monitoring Program* (REMP) to ensure the effectiveness of employed control measures, including the enforcement of sediment quality trigger values (further details of the REMP are provided in Section 7.4.4.1, and the REMP Design Document is included as Appendix Q);
- routine inspection and audits of the site, including periodic inspections of site drainage will be undertaken and used to inform the requirement of correction actions;
- any incidents of soil instability and erosion will be reported to the designated environmental representative on-site to facilitate management measures;

- decommissioning processes and requirements; and
- annual review requirements and responsibilities.

Erosion and sediment control structures will be designed and installed in accordance with *Best Practice Erosion and Sediment Control* (IECA Australasia 2008) and *Soil Erosion and Sediment Control: Engineering Guidelines for Queensland Construction Sites* (Witheridge & Walker 1996), as appropriate.

Four sediment dams associated with Pit AB will be installed in mining year 1 and five sediment dams associated with Pit C will be installed in mining year 13. Sediment dam design is discussed in further detail in Section 3.4.3. Temporary erosion and sediment control structures including sediment dams will be retained until re-vegetation within the sediment dam catchment has been established; and surface water run-off meets the water quality trigger values of the receiving water ways as detailed in Schedule F of the Project's EA. The time period of sediment dam retention is likely to be dictated by the germination of seeds which occurs on average within a year from planting. The sediment dam and associated drainage infrastructure would then be decommissioned and contour profiles consistent with the surrounding landscape to allow surface runoff to shed directly into the receiving environment.

The ESCP has been developed as a supporting document for the *Land Disturbance Permit System* (refer Section 4.7.1) and mine water management system (refer Section 3.4.3). Erosion and sediment controls will be routinely inspected and maintained for capacity and structural integrity including inspections following significant rainfall events.

4.7.3 Contaminated Land

The risk of land contamination will be similar to existing mining operations and is likely to be confined to accidental spills such as small diesel spills, and/or spills of chemicals likely to be onsite. Contaminated land management involves preventative management of incidental land contamination by 'Notifiable Activities' listed in Schedule 3 of the EP Act which include:

- item 7: Chemical storage (other than petroleum products or oil under item 29);
- item 15: Explosives production or storage;
- item 29: Petroleum product or oil storage; and
- item 37: Waste storage, treatment or disposal. Risk of contaminated land is associated with inappropriate storage and handling of chemicals, explosives, and waste.

The risk of contamination to land within the Project areas will be minimised through the following measures:

- sediment dams or stormwater dams will be installed and adhere to the design parameters of the '*Manual for assessing consequence categories and hydraulic performance of structures*' (DES 2016) to ensure all catchment areas downstream of the mine infrastructure area will contain any spills or contaminated stormwater run-off;
- explosives storage will be managed in accordance with AS 2187:2006 *'Explosives—Storage, transport and use*' (Standards Australia 2006);
- waste products including oil and other chemicals will be stored and disposed of according to the relevant material data safety sheets to minimise contamination risk;

- all unexpected contamination will be remediated and validated under supervision of a suitably qualified person in accordance with an *Emergency Response Plan* predefined for all hazardous materials stored on-site (the administering authority will be notified within 24 hours of detection being known);

- a contaminated land register and map will be maintained on-site detailing any contamination events, subsequent location and remediation protocols issued;

- chemical and hydrocarbon storage areas will be designed and bunded in accordance with '*AS 1940:2017, The storage and handling of flammable and combustible liquids*' (Standards Australia 2017);

- provision of training to staff on the prevention of spills and the use of spill kits; and

- a register of spill kits will be maintained, and all kits will be inspected for completeness at least quarterly.

With the implementation of the above standard operating procedures, the Project is not predicted to have an impact on the environmental values of land and water resources.

4.7.4 Weed and Pest Management Plan

A *Weed and Pest Management Plan* will be developed in accordance with the Biosecurity Act and the Central Highlands Regional Council *Pest Management Plan 2015-2020.* The objective of the Project's *Weed and Pest Management Plan* is to maintain the environmental values associated with the Project site and surrounding region and to support the local council weed and pest management objectives. The *Weed and Pest Management Plan* will be developed and implement prior to the construction of the Project.

The *Weed and Pest Management Plan* will focus on minimising the occurrence and spread of weeds through the implementation of:

- preventative measures to reduce the risk of weeds and pests on site and the spread of weeds and pests outside the Project boundaries and include;
    - wash down facilities for vehicles identified as a risk of spreading weeds;
    - the inclusion of weed and pest identification and reporting procedures for the Project in induction and training materials distributed to all employees;
    - seeding of fast-growing grass cover to topsoil stockpiles requiring long term storage and rehabilitated areas;
    - inclusion of weed and pest monitoring;
    - weed disposal procedures;
- control measures to minimise the impacts of weeds and pests on environmental values and to prevent the spread of weeds and pests outside the Project boundaries which may include:
    - the manual removal of weeds in instances of isolated weed presence;
    - herbicide application treatments; and

- liaison with local council and surrounding landholders, where required on the control of pests.

The *Weed and Pest Management Plan* will include the following components:

- a description of weed and pest animal species listed under the Biosecurity Act and known to occur on the Project site;
- identification of and commitment to appropriate management strategies to control the occurrence of pest fauna and weed species on the Project site;
- a system for early detection and eradication of new weed and pest fauna species;
- management strategies to prevent the introduction of new pest species onto the Project site;
- delineation of the roles and responsibilities of Project personnel in relation to pest and weed management on the Project site.

The *Weed and Pest Management Plan* will address weeds and pests across the Project as well as in rehabilitation areas. The first few years following planting are the most important for controlling the spread of invasive species. As pioneer species, weeds tend to out-compete native species on disturbed soils before desirable species have had time to set roots and adequately cover a rehabilitated area. During the first three growing seasons, botanical surveys and hand removal of weeds or targeted herbicide applications will be pursued as appropriate. Weed cover should be comparable to analogue sites. Regular monitoring will be undertaken specifically targeted at identified pest and weed species, and management plans implemented as appropriate to the findings of monitoring results.

4.7.5 Grazing and Agriculture Management

A *Grazing and Agriculture Management Plan* will be developed by a suitably qualified person in consultation with the landowner / leaseholder.

Grazing by cattle on rehabilitated areas will only commence once the completion criteria for the area has been met. Fencing around grazing areas / native ecosystems will be undertaken in a manner to enable standard grazing management practices. A suitable stocking rate will be determined subject to the performance of grazing trials and revegetation following the closure of the mine.

In Queensland, the underlying principle to the standard management practices of grazing and agricultural management is to utilise land in a sustainable manner while protecting the environmental value of land. Standard Management practices include the following (DERM 2011):

- managing erosion management through stock fencing (including exclusion zones of riparian corridors and watering points), vegetative cover and stocking rates;
- paddock planning layout management to manage grazing pressure and conserving the biodiversity values of land in accordance with the EPBC Act and *Vegetation Management Act 1999* (VM Act);
- weed and pest management;
- soil management; and
- fire management.

4.8 REHABILITATION MONITORING AND MEASUREMENT

Rehabilitation monitoring for the Project has the goal of assessing compliance with the rehabilitation objectives and agreed completion criteria.

Rehabilitation monitoring will be used to track the progress of revegetated areas and determine requirements for intervention, such as weed control or supplementary planting. Additionally, rehabilitation monitoring will also:

- evaluate coverage and application of topsoil prior to seeding;
- monitor drains and assess water quality to determine whether substantial silting of inverts and/or any localised failure of drain embankments has occurred;
- evaluate topsoiled areas following rainfall events (particularly on slopes) to assess whether significant rill development or loss of topsoil has occurred;
- evaluate the behaviour of placed topsoil over time (erosion or dispersion, compaction, salting or hard setting);
- assess the germination success in revegetated areas (including recording of diversity and abundance);
- monitor revegetation success over time (e.g., survival rate, plant growth, species diversity, weed content, fauna usage);
- evaluate potential threats to rehabilitated areas (e.g., weed invasion, pest species, dispersive soils or potentially acid forming (PAF) low-capacity materials, erosion); and
- record key rehabilitation information (e.g., photographic records, surveys, file notations).

To monitor the success of progressive rehabilitation, permanently marked transects will be established. These transects will generally be monitored for a minimum of five years or longer until criteria area achieved. The results will then be used to continually inform and assess the effectiveness of rehabilitation strategies and methodologies, as well as enabling movement towards progressive certification. Where new monitoring techniques and technologies are identified, these will be adopted as appropriate.

4.8.1 Monitoring Methodology

A transect based approach (consistent with the BioCondition methodology) will be utilised for rehabilitation monitoring. This approach aims to provide a measure of the capacity of a terrestrial ecosystem to maintain biodiversity values at a local or property scale and allows a comparative assessment of pre- and post-mining ecosystems.

BioCondition monitoring assesses a suite of parameters at different landscape positions on each site, namely on flats, slopes and in troughs. Repeated edaphic (soil properties) and biological measurements are taken over time for various parameters that indicate changes in ecosystem function as rehabilitation proceeds. In general, the method involves monitoring two groups of sites:

- **analogue / reference sites:** selected to best reflect the pre-mining land use (i.e., cleared pasture for cattle grazing) to obtain relevant and realistic rehabilitation criteria for the matching

PMLU. Analogue sites will be chosen as close as possible to the rehabilitated area so that the same climatic and environmental conditions existed at both sites to the extent possible; and

- **rehabilitated sites:** monitored for rehabilitation performance, successful or otherwise.

Multiple analogue/reference sites will be established on and around the Project that best represent pre-mining ecosystems. For this Project, reference sites representative of the proposed PMLU of low intensity grazing on native and improved pastures will be established prior to the commencement of the Project.

Structured, periodic monitoring of reference sites will provide an understanding of the pre-mining landscape, assisting in the future planning and refinement of rehabilitation strategies, as well as providing data for determination of completion criteria when assessing rehabilitation success.

Rehabilitation transect sites will also be established within rehabilitated landforms post mining. At each site, the following parameters will be monitored annually:

- aspect and slope;
- tree density (trees/ha);
- shrub density (shrubs/ha);
- herb/grass density (grasses/ha);
- groundcover (%);
- species composition;
- chemical and physical indicators of soil;
- erosion indicators (depth of rills or erosion lines, surface crusting, slopes); and
- photographic records of the site.

In addition to rehabilitation transect monitoring, other related site environmental monitoring will continue throughout and following the life of the mine (e.g., surface water monitoring). These data sets will also work to further inform rehabilitation success.

In accordance with current standards, rehabilitation monitoring will ultimately aim to demonstrate that domain specific completion criteria have been continuously met for a period of three years or greater.

4.8.2 Review of Rehabilitation Monitoring Data

Rehabilitation monitoring data will be used to review rehabilitation success. This will occur through:

- tracking revegetation and/or regeneration progress against performance indicators and completion criteria;
- assessing the performance of landform designs and rehabilitation concept methods;
- evaluating the effectiveness of environmental management measures/controls; and
- identifying the requirement for intervention strategies or ameliorative/contingency measures.

The results of any industry rehabilitation trials and investigations will also continue to be used to inform and refine future rehabilitation concepts, practices and measures.

4.9 CLOSURE AND RELINQUISHMENT

4.9.1 Closure Planning

A *Closure Plan* will be developed for the Project during the first five years of the Project life. The C*losure Plan* will extend the preliminary rehabilitation requirements described in Table 21 and develop detailed planning for the post-mining closure phase of the Project.

The *Closure Plan* will update and refine landform design criteria, particularly residual void slope highwall and low wall slope design and completion criteria on the basis of experience gained during mining operations. Any agreements in relation to retained infrastructure will also be addressed.

The *Closure Plan* will also refine rehabilitation maintenance requirements and provide an update on findings from rehabilitation monitoring undertaken.

4.9.2 Final Rehabilitation Report and EA Surrender

At the point in time that rehabilitation monitoring indicates that completion criteria are being achieved for all or part of the rehabilitation undertaken for the Project, either a final or progressive rehabilitation report will be compiled and submitted to the administering authority for consideration in accordance with Section 264 or Section 318ZF of the EP Act.

The final or progressive rehabilitation report will contain an environmental risk assessment which will identify any residual risks and costs. However, achievement of the completion criteria is anticipated to result in minimal residual risk due to the low risk of acid mine drainage, slope design of the waste rock emplacements is consistent with standard design practices in the Bowen Basin, the exclusion of dispersive/sodic soils from the final landform surfaces and overall landform design consistency with the surrounding environment. Residual risk is predicted to be limited to maintenance of fencing and signage around the residual void and fencing requirements and land management associated with standard cattle grazing management.

Where relinquishment requires the transfer of ownership or management of infrastructure and/or land to other parties, evidence that these parties have been involved in the process and understand the liability and responsibilities associated with the transfer will be provided. Written legal agreement with the subsequent party owners will be sought to identify acceptance of the mining legacy and any outstanding costs of remediation, monitoring and reporting. Legal agreements will be undertaken in accordance with the relevant legislative requirements at the time of relinquishment.

5.0 LAND

This section provides a description of the existing land values within and surrounding the Project. It aims to identify the Project's potential impacts on the existing values and propose mitigation measures and management strategies to prevent or minimise adverse environmental effects.

This section is informed by the *Soil and Land Suitability Assessment* (AARC 2019) presented as Appendix I.

5.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES

The environmental objective relevant to potential impacts to land as described in the EA guideline for *Application requirements for activities with impacts to land [ESR/2015/1839]* (DES 2017b) is:

The activity is operated in a way that protects the environmental values of land including soils, subsoils, landforms and associated flora and fauna.

The Project would achieve all of the following performance outcomes identified in Schedule 8, Part 3, Division 1 of the EP Regulation:

(a) activities that disturb land, soils, subsoils, landforms and associated flora and fauna will be managed in a way that prevents or minimises adverse effects on the environmental values of land;

(b) areas disturbed will be rehabilitated or restored to achieve sites that are:

(i) safe to humans and wildlife;

(ii) non-polluting;

(iii) stable; and

(iv) able to sustain an appropriate land use after rehabilitation or restoration;

(c) the activity will be managed to prevent or minimise adverse effects on the environmental values of land due to unplanned releases or discharges, including spills and leaks of contaminants; and

(d) the application of water or waste to the land is sustainable and is managed to prevent or minimise adverse effects on the composition or structure of soils and subsoils.

5.2 DESCRIPTION OF ENVIRONMENTAL VALUES

5.2.1 Landform and Visual Amenity

Landform

The topography of the Project area varies from flat to undulating hills, with elevation ranging between 120-150 mAHD. The landscape is strongly influenced by the presence of Charlevue Creek and its associated floodplains, which have relatively lower elevations than the surrounding landscape of undulating hills. An elevated ridgeline is located 2-5 km east of the Project at an elevation of 170 mAHD.

The major water body associated with the Project is Charlevue Creek, which dissects the MLA, flowing in a northeast direction. This creek begins within the boundaries of Blackdown Tablelands National Park,

flowing northeast before joining with Springton Creek and the Fitzroy River, eventually reaching the Pacific Ocean approximately 46 km north of Gladstone. Two significantly smaller creeks, Stanley and Springton, cross the Project boundaries in the northwest and southeast respectively. These two creeks eventually converge with the Mackenzie River. Associated tributaries, agricultural dams and unnamed drainage features also appear across the site.

Visual Amenity

Visual amenity refers to the quality and appreciation of a geographical location in the context of valued features, characteristics and attributes. The existing visual environment of the Project and surrounding area is typical of the Bowen Basin; with a predominant rural landscape character comprised primarily of grazing land and areas of bush reserve. To the west, views of the Arthurs Bluff State Forest can be seen from the eastern MLA boundary.

The landscape amenity is dissected by major transport infrastructure including the Capricorn Highway and the Blackwater Railway. A number of small towns and rest stops are located along the Capricorn Highway serving the local residents and mining communities. Along the transport route heading west of the Project, coal mines and associated infrastructure can occasionally be observed from public transport corridors.

The mining infrastructure relevant to potential visual exposure, includes:

- The out-of-pit waste rock emplacement of Pit AB (beginning at the commencement of mining activities) will be located approximately 2 km south of the Capricorn Highway. The topography surrounding the waste rock emplacement is relatively flat with minimal obstruction by natural features. The Pit AB waste rock emplacement will have a maximum height of 175 mAHD and be progressively rehabilitated throughout the life of mine to resemble the surrounding landscape of gently undulating hills. Whilst the Pit AB void is a depression below natural ground surface and not expected to be visible from public or private sensitive locations.

- The out-of-pit waste rock emplacement of Pit C (beginning Year 12) will be located approximately 500 m north of the Cooinda Road diversion. The Pit C waste rock emplacement will have a maximum height of 190 mAHD and also rehabilitated throughout the life of mine.

- All haul roads are internal to the MLA and are located 1 km, or more, away from the closest residential dwelling.

- The TLO will be located approximately 300 m north of the Capricorn Highway connecting to the existing Blackwater Railway. The Blackwater Railway services coal export from the Bowen Basin and is a dominant visual feature along the length of the Capricorn Highway with rail infrastructure and trains frequently visible. The proposed TLO will contain a rail spur, rail loop and train loading bin.

- An overland conveyor will transport export material from the CHPP to the TLO, crossing over the Capricorn Highway (conceptual design provisions are shown in Figure 12 to Figure 14). The proposed overhead conveyor will cross the transport route at a minimum height elevation of 7m and 10m in length, similar to that of the existing conveyor across the Capricorn Highway at Boonal, approximately 28 km west.

A *Visual Amenity Assessment* was undertaken by AARC (Appendix O). A total of five photographic vantage points were selected as representative points to reflect the visual landscape at major sensitive receptor locations and also relatively high traffic areas within the local region (refer to Table 29 for detailed vantage point descriptions). A number of visual simulations were produced at each vantage

point to identify the risk of any visual modification to the surrounding landscape, potential impacts on visual amenity are summarised below in Section 5.3.2.

Table 29 Visual Amenity Vantage Points

Vantage Point	Location Description	Coordinates (Lat/Long)	Approximate Distance from MLA
VA1	Southern side of Capricorn Highway facing south west towards Pit AB between the pit and the residence of the Rubina property. This property is owned by the proponent and as the residence will be vacated prior to the commencement of operations, it is not considered to be a sensitive receptor.	-23.641, 149.292	Within MLA
VA2	Southern side of Sanders Road facing west towards Pit C at the entrance to the residence on the Namoi Hills property along the eastern boundary. This property is owned by the proponent and as the residence will be vacated prior to the commencement of operations, it is not considered to be a sensitive receptor.	-23.696, 149.281	1.3 km
VA3	Northern side of Sanders Road facing north towards Pit AB at the entrance to the residence on the Namoi Hills property along the eastern boundary. This property is owned by the proponent and as the residence will be vacated prior to the commencement of operations, it is not considered to be a sensitive receptor.	-23.694, 149.280	1.2 km
VA4	Southern side of Capricorn Highway facing south towards Pit AB. This location is closest to the northern boundary of the Namoi Hills property.	-23.629, 149.272	Within MLA
VA5	Western side of Cooinda Road facing north towards Pit C at the entrance to the residence on the Glenwood property.	-23.720, 149.246	2.4 km

5.2.2 Native Title and Cultural Heritage

Native title determination areas described by the National Native Title Tribunal is extinguished within the boundary of the ML. As such, a native title process is not required to be undertaken as part of the MLA process.

The Proponent will comply with the *Aboriginal Cultural Heritage Act 2003* and the supporting *Duty of Care Guidelines* (DATSIP 2004) when undertaking activities within the area of EPC 881 and the proposed ML.

A *Cultural Heritage Management Plan* has been developed for the Project and signed in accordance with the *Aboriginal Cultural Heritage Act 2003*.

5.2.3 Geology

Regional Geology

The Gemini Project coal deposit is hosted within the Permian Rangal Coal Measures and the Yarrabee Structural Zone. Seven seams or seam groups have been identified at site, which belong to either the Rangal Coal Measures or the underlying Burngrove Formation (BOYD 2019). In descending stratigraphic order, the seams include the Aries, Castor, Pollux, Orion, Pisces, Virgo and Leo seams. The seams contain several individual plies that have identified for mining at the site.

The site surface geology is shown in Figure 47. It predominantly comprises sediments of the Tertiary Duaringa Formation and Quaternary alluvium associated with ephemeral creeks including Charlevue Creek and Springton Creek.

Figure 48 shows the project location in relation to the underlying Bowen Basin solid geology (i.e., the surficial unconsolidated Quaternary and Tertiary units have been removed, revealing the relationship between the underlying Triassic and Permian sediments, as well as the prevalence of regional-scale faults). The two mining areas (Pit AB and Pit C) are in areas where folding has brought the coal seams close to surface at depths that can be economically mined.

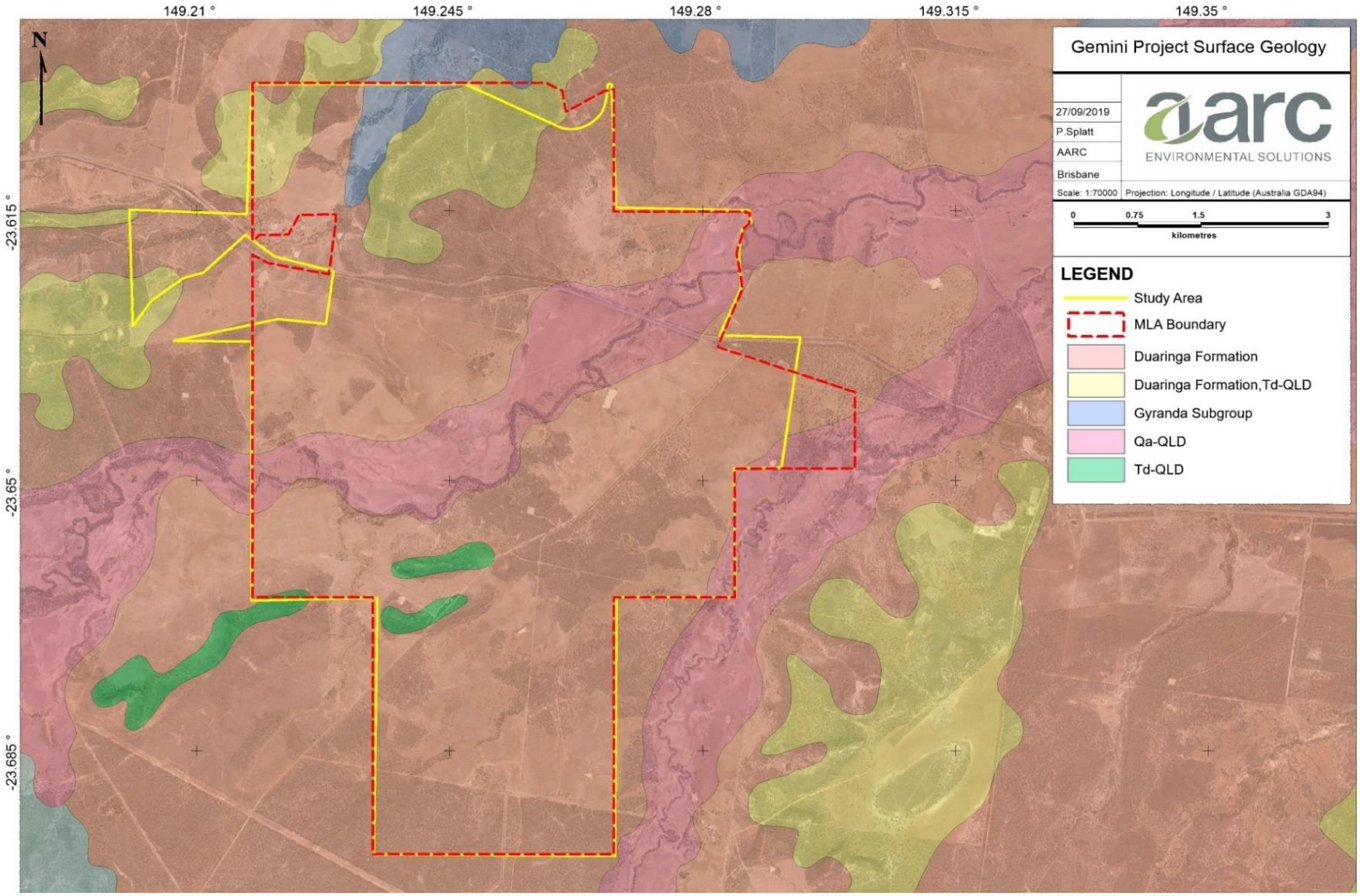


Figure 47 Surface Geology

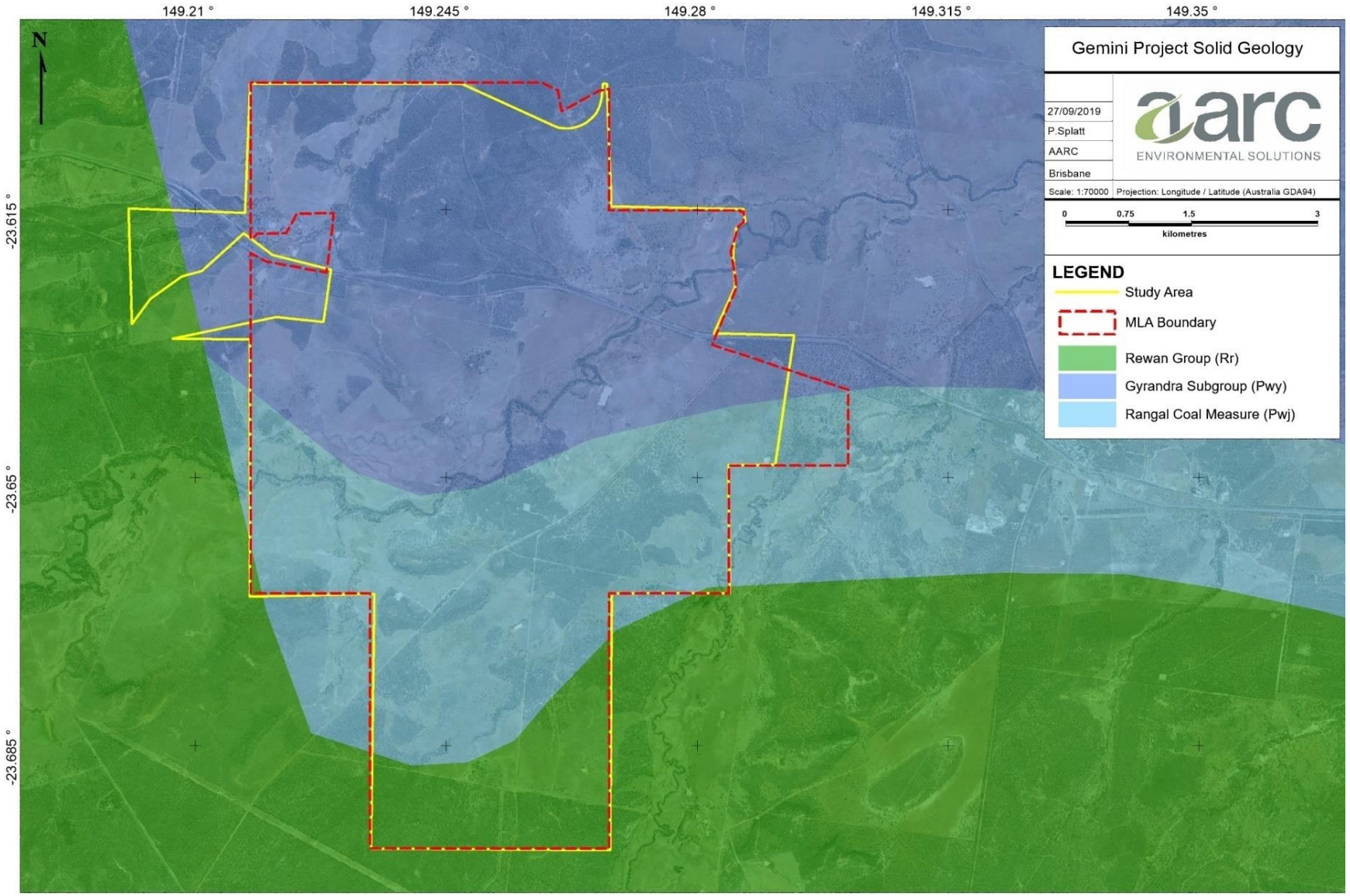


Figure 48 Solid Geology

5.2.4 Land Systems

Two land systems are mapped within the Project area and are described as follows.

Dingo Land System

The Dingo land system is characterised by fluvial plains surrounding significant waterways. It is mostly composed of stable flood plains traversed by a branching pattern of drainage floors. The majority of deposits are weathered alluvium, with slopes of coarser or finer textured alluvium (depending on flow patterns). Channels can be up to 30 m wide and 3 m deep, with fringing riparian vegetation. Main drainage floors can then extend 800 m outwards, with deep texture contrast sandy loams over mottled clays, and open spaces of *Eucalyptus tereticornis* (blue gum) and *Eucalyptus crebra* (narrow-leaved ironbark) with sparse shrubs. Large plains surround drainage features (up to 3 km wide) which can contain either deep texture contrast soils with *Eucalyptus populnea* (poplar box) woodlands, or deep layered soils on alluvium with woodlands of blue gum and narrow-leaved ironbark. Slopes within this land unit are usually the result of strongly Gilgai shrink-swell clays, forming depressions of finer soil textures with *Acacia harpophylla* (brigalow) scrub.

Geology in this unit is comprised of weathered Quaternary alluvium.

Melbadale Land System

The Melbadale land system is characterised by the shallow dissection of weathered tertiary land surfaces, forming undulating plains dominated by complex depositional mid and lower slopes, with minor lateritic upper slopes in some places. This land system features moderately dense branching drainage patterns, with local relief usually less than 15 m. Depending on the steepness of terrain, upper slopes are often dominated by deep loamy red earths (gentle slopes) with narrow-leaved ironbark, or shallow fine sandy loams (steep terrain) with *Acacia shirleyi* (lancewood) forests. Mid to lower slopes are often associated with deep texture contrast soils of loamy sands overlying mottled sandy clays, with grassy woodlands of open-spaced narrow-leaved ironbark and shrubs. Lower slopes are often associated with deep light to medium clays, with tall forests of narrow-leaved ironbark. Tributaries have variable soil textures depending on slope, though stratified loams and texture contrast soils are common.

Geology in this land system is comprised of Quaternary to late Tertiary colluvial/alluvium, laterised tertiary sandstone, conglomerate, and shale.

5.2.5 Soils

A *Soil and Land Suitability Assessment* was undertaken within the MLA by AARC (2019) and attached as Appendix I.

Methodologies employed throughout this study are detailed in Appendix I and followed procedures in the *Australian Soil and Land Survey Field Handbook* (NCST 2009) and the *Guidelines for Surveying Soil and Land Resources* (McKenzie et al 2008). The soil survey was based on a free-survey technique with soil profile and observation sites located to best represent all soil types present in the Project. At the time of the survey, the Project MLA was subject to frequent changes, therefore, the study area was based of the EPC 881 boundary, land owner access, and a 5 km buffer around the boundary of the Walton State Forest.

Within the Project, a total of 12 SMUs were described. Table 30 provides an overview of each SMU and its extent within the MLA. The spatial distribution of the SMUs has been mapped at a scale of 1:70,000 and is depicted in Figure 49.

No acid sulphate soils have been identified within the Project area.

Table 30 SMUs Within The Study Area

SMU	Surface Area (ha)	Percent of Study Area (%)	General Description
Anderson	37.80	0.61	Hard setting soil unit associated with isolated hills. Soil textures grade from loams at the surface, to light medium clays with depth, sometimes exhibiting red mottling. Vegetation associated with this unit includes *Eucalyptus crebra*, *Corymbia clarksoniana*, and *Acacia rhodoxylon* with *Erythroxylon australe* in the shrub layer. The Anderson SMU has a very strongly acidic pH throughout the profile, ranging from 4.6 in the topsoil, to 4.8 in the lower subsoil. EC and chloride results indicate that at all depths, salinity is very low, with EC ranging from 0.064 deciSiemens per metre (dS/m) in the topsoil, to 0.02 dS/m in the subsoil layer. Chloride concentrations reflected this result, decreasing with depth from 30 mg/kg to 10 mg/kg, both well below toxic limits.
Barry	156.50	2.54	Hard setting soil associated with rivers, drainage lines and levees. Surface soils in this unit are comprised of clay loams to medium clays, grading into light or medium clays at variable depths. Dominant vegetation includes *Eucalyptus tessellaris*, *Eucalyptus populnea* and *Eucalyptus tereticornis*, with *Bauhinia hookeri, Carissa spinarum* and *Cassia brewsteri* in the shrub layer. The Barry SMU has a slightly acidic pH (6.5) which increases gradually with depth, becoming neutral at 0.2 m (6.8), and increasing to pH 7.2 with depth. EC is very low throughout the profile, ranging from 0.063 dS/m in the topsoil, to 0.012 dS/m in the lower subsoil. Chloride concentrations reflect this result, ranging from 20 mg/kg to <10 mg/kg with depth.
Charlevue	232.90	3.77	Hard setting soil associated with plains and rises. Textures within this unit grade from sandy clay loams or light clays in the surface soil, to medium heavy clays in the subsoil horizons. Dominant vegetation includes *Eucalyptus populnea* and *Eucalyptus crebra,* with *Flindersia dissosperma* (sometimes dominant) and *Carissa spinarum* in the shrub layer. The Charlevue SMU has a variable pH, ranging from 5.4 (strongly acid) in the topsoil to 7.9 (moderately alkaline) in the lower subsoil. EC is medium in the surface soil (0.28-0.43 dS/m) and increases to high in the subsoil (0.46 dS/m). Chloride is considered to be high from 0.2 m depth downwards (>600 mg/kg), which can cause toxicity by interfering with plants' osmotic capacity.
Cooinda	34.90	0.57	Hard setting soil associated with plains. Texture development within this unit is gradual, changing from a sandy clay loam in the topsoil, to a sandy light clay at mid-depth, and a medium heavy clay in the deeper subsoil. Dominant vegetation includes *Eucalyptus populnea* and *Flindersia dissosperma* (sometimes dominant), with *Carissa spinarum* in the shrub layer. The pH of the Cooinda SMU ranges from moderately acid (5.6) in the topsoil, to neutral (6.8) in the lower subsoil. EC is very low throughout the profile, with topsoil values of 0.015 dS/m, increasing to 0.043 dS/m in the subsoil. Chloride levels reflect EC, increasing from <10 mg/kg to 40 mg/kg with depth.

SMU	Surface Area (ha)	Percent of Study Area (%)	General Description
Ellesmere	14.60	0.24	Hard setting soil associated with isolated hills of weathered tertiary surfaces (laterite). Textures within this unit grade from fine sandy loams in the surface soil to medium clays in the subsoil horizons. Dominant vegetation is *Acacia shirleyi*, with *Erythroxylon australe* in the shrub layer. The Ellesmere SMU is a highly acidic soil unit, ranging from 4.6 (very strongly acid) in the topsoil to 5.5 (strongly acid) in the lower subsoil layer. EC is very low throughout the profile, changing from 0.02 dS/m in the topsoil, to 0.026 dS/m in the lower subsoil. Chloride concentrations are very low, consistently presenting at <10 mg/kg.
Geoffrey	4,079.00	66.10	This unit consists of texture contrast soils with soft surface conditions, associated with undulating plains and rises. Textures range from loamy sands to sandy light clays, overlying sandy medium clays with conspicuous orange or red mottling. Where these soils were exposed due to insufficient groundcover, extensive washouts and large erosion gullies were observed. In these areas, overland flow had removed coarse sandy material, leaving the easily eroded clays exposed to surface runoff. The Geoffrey SMU was often cleared, though when present dominant vegetation included *Eucalyptus crebra*, *Melaleuca leucadendra*, *Casuarina cunninghamiana* and *Corymbia clarksoniana*, with *Alphitonia excelsa*, *Petalostigma pubescens*, and *Acacia rhodoxylon* in the shrub layer. Due to the stark difference in textures between the topsoil and subsoil layers, pH for the Geoffrey SMU changes quite dramatically down the soil profile. Sandy, massive horizons (0.0-0.6 m) are moderately acidic, with pH gradually increasing with depth from 5.8 to 6.0. The clay B2 horizon has a pH value over two units higher (8.1) and is classified as 'moderately alkaline'. This is likely due to the increased CEC of the clay in the B2 horizon compared with the sand in the upper horizons.
James	145.20	2.35	Hard setting red soils associated with hills and rises. Textures within this unit vary depending on slope, with lesser developed soils found on crests (sandy clay loams to clay loams) and more developed/deeper soils found on mid slopes (clay loams to light medium clays). Dominant vegetation includes *Acacia rhodoxylon, Eucalyptus crebra,* and *Corymbia clarksoniana.* The pH in the James SMU is slightly acidic throughout the profile, with very little variation. It increases gradually with depth from 6.2 in the topsoil, to 6.4 in the lower subsoil. EC is very low at all depths, ranging from 0.013 dS/m in the topsoil to 0.015 dS/m in the subsoil. Chloride levels reflect this result, presenting at <10 mg/kg throughout the profile.

SMU	Surface Area (ha)	Percent of Study Area (%)	General Description
Kosh	927.60	15.03	Hard setting soil associated with alluvial plains, plains and low rises. Textures within this unit are gradational, changing from sandy clay loams and light clays in the topsoil, to medium heavy clays in the lower subsoil. Commonly, this unit was cleared for grazing, with regrowth consisting of scrub species including *Vachellia nilotica*, *Carissa spinarum, Capparis lasiantha, Cassia brewsteri*, and *Eucalyptus spp.* shrubs. When present, vegetation included *Eucalyptus tereticornis, Acacia hemiglauca, Acacia salicina, Bauhinia hookeri, Eucalyptus crebra* and *Eucalyptus populnea*. Due to the stark difference in textures between the topsoil and subsoil layers, pH for the Kosh SMU changes quite dramatically down the soil profile. Sandy, massive horizons (0.0 to 0.6 m) are moderately acid, with pH gradually increasing with depth from 5.8 to 6.0. The low CEC calculated for this unit resulted in extremely low concentrations of exchangeable cations. In the surface soil, calcium and magnesium were relatively equally represented, though concentrations of these cations were extremely limited.
Namoi	177.60	2.89	Hard setting soil associated with hills and rises. Textures within this unit are gradational, changing from a sandy clay loam in the topsoil to a light medium clay in the subsoil. Dominant vegetation includes *Eucalyptus crebra,* with *Heteropogon contortus* and juvenile *Acacia spp.* The pH in the Namoi SMU is slightly acidic throughout the profile, with very little variation. It increases gradually with depth from 6.2 in the topsoil, to 6.4 in the lower subsoil. EC is very low at all depths, ranging from 0.013 dS/m in the topsoil to 0.015 dS/m in the subsoil. Chloride levels reflect this result, presenting at <10 mg/kg throughout the profile. CEC remains fairly consistent with depth, ranging from 4.3 milliequivalent per 100 grams (meq/100g) (very low) in the topsoil to 5.8 meq/100g (very low) in the subsoil.
Nigel	286.40	4.64	Hard setting soil associated with isolated high relief areas of tertiary land surface. Textures within this unit are rudimentary, grading from sands to sandy light clays. Vegetation is variable between sites, but includes *Acacia shirleyi, Acacia rhodoxylon, Eucalyptus crebra, Melaleuca leucadendra, Corymbia clarksoniana,* and *Eucalyptus tessellaris.* The pH within the Nigel SMU is highly variable, changing from 6.3 (slightly acid) in the topsoil to 8.5 (strongly alkaline) in the lower subsoil. EC follows a similar pattern, changing from very low between 0.0-0.3 m depth, to medium in the subsoil. CEC increases with depth from low (6.8 meq/100g) to moderate (17.4 meq/100g), likely due to the increased clay content in the subsoil layers.

SMU	Surface Area (ha)	Percent of Study Area (%)	General Description
Normanby	48.50	0.79	Deep red earth with soft surface condition, associated with plains, and the flat areas of upper slopes. Textures within this unit are relatively consistent throughout the profile, ranging from loamy sands to sandy light medium clays. Vegetation is mostly cleared, but when present includes *Eucalyptus crebra* and *Alectryon oleifolius*. The Normanby soil unit has a neutral to slightly acidic pH throughout the soil profile, decreasing with depth from 6.7 to 6.1. EC is very low throughout the profile, ranging from 0.036 dS/m in the topsoil to 0.003 dS/m in the subsoil. Chloride levels reflect this result, presenting at less than 10 mg/kg at all depths. CEC measurements are considered very low, ranging from 2.4 meq/100g to 1.6 meq/100g with depth. The Normanby soil unit has limited nutrient holding capacity of this soil can be attributed to its low clay content and low organic matter levels.
Wallace	32.00	0.52	Shallow, self-mulching, cracking clay associated with upper slope flats. Textures within this unit grade from medium heavy clays to heavy clays, with the B3/C horizon met at approximately 0.24 m depth. The Wallace SMU is extensively cleared, with the boundary of the unit corresponding to an increase in standing vegetation. The dominant grass species is likely *Aristida latifolia*, with confirmation required during the wet season when an accurate identification can be made. The pH within the Wallace SMU is variable changing from 6.8 (neutral) in the topsoil to 7.4 (slightly alkaline) in the lower subsoil. EC changes from low in the topsoil to very low in the lower subsoils (0.09 - 0.038). CEC increases with depth from high (39 meq/100g) to very high (44 meq/100g), likely due to the increased clay content in the subsoil layers. High clay content, low sodicity, and desirable nutrient concentrations make this unit one of the best growth mediums in the survey area.

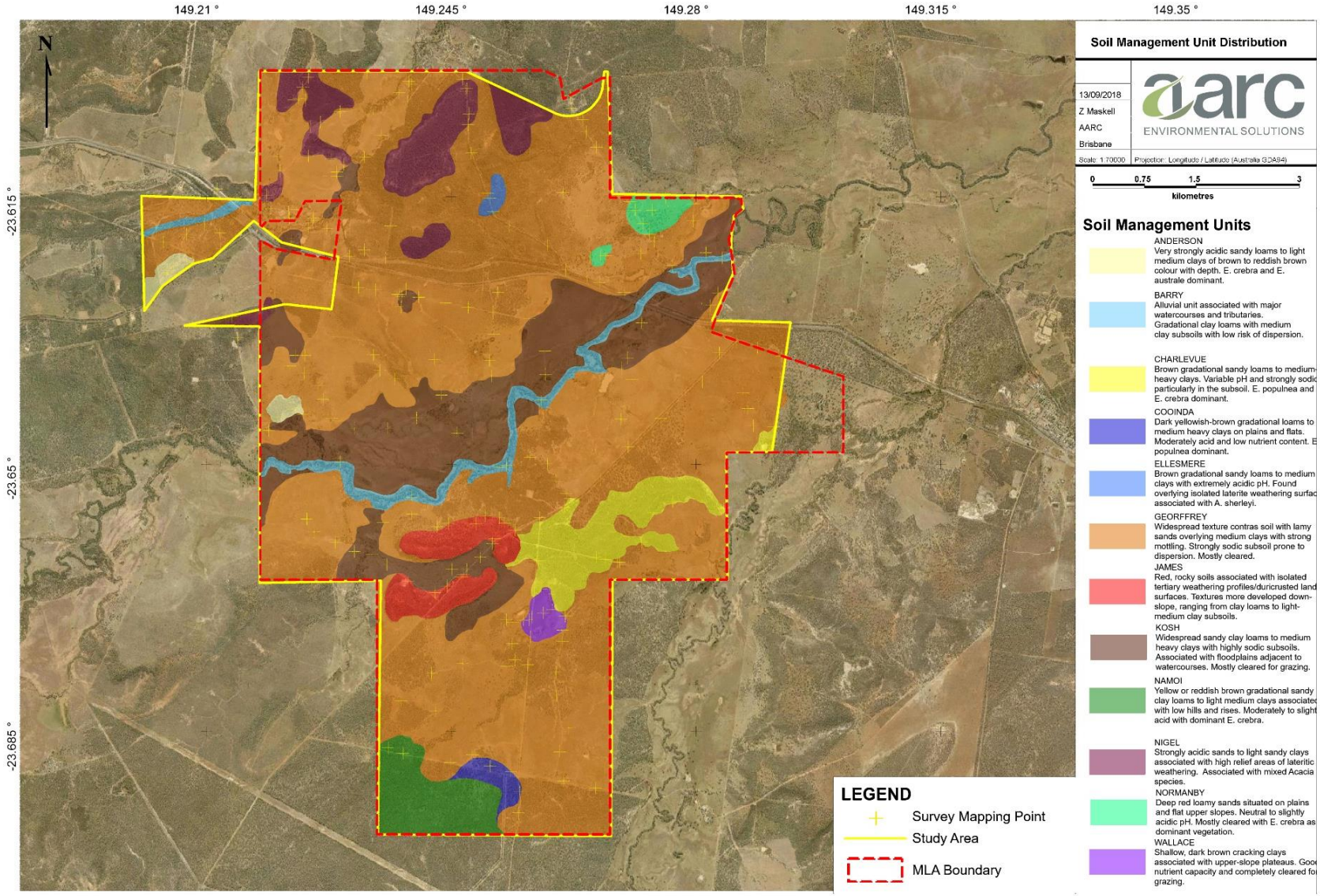


Figure 49 **Distribution of SMUs**

5.2.6 Land Suitability

The *Soil and Land Suitability Assessment* (AARC 2019) (Appendix I) considers environmental factors including climate, soils, geology, geomorphology, erosion, topography and the effects of pre-mine land use. The classification indicates the potential of the land to be used for a range of agricultural activities.

The assessment for land suitability (cattle grazing and dryland cropping) was carried out in accordance with the methodologies described in:

- *Guidelines for Agricultural Land Evaluation in Queensland* (DSITI & DNRM 2015); and
- Chapter 10 (Suitability framework for the inland Fitzroy and southern Burdekin area) of the *Regional Land Suitability Frameworks for Queensland* (DNRM & DSITI 2013).

An interpretation of the data collected on the physical, chemical and nutritional characteristics of the soil was made to rank the land according to the five-class land suitability system provided in the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME 1995). The five land suitability classes used for assessing the land are defined in Table 31.

Table 31 Agricultural and Conservation Land Classes

Agricultural Land Class	Type	Description
Class 1	Agricultural	Suitable land with negligible limitations. This is highly productive land requiring only simple management practices to maintain economic production.
Class 2	Agricultural	Suitable land with minor limitations which either reduce production or require more than the simple management practices of class 1 land to maintain economic production.
Class 3	Agricultural	Suitable land with moderate limitations which either further lower production or require more than those management practices of class 2 land to maintain economic production.
Class 4	Agricultural	Marginal land, which is presently considered unsuitable due to severe limitations. The long-term significance of these limitations on the proposed land use is unknown or not quantified. The use of this land is dependent upon undertaking additional studies to determine whether the effect of the limitation(s) can be reduced to achieve sustained economic production.
Class 5	Agricultural	Unsuitable land with extreme limitations that preclude its use.

Notes: green shading suitable
orange shading unsuitable

The land use of the Project area is more suitable for cattle grazing than dryland cropping based on the average land suitability class across the identified SMUs of the Project.

A summary of the land suitability classes for both dryland cropping and cattle grazing for each SMU identified within the study area is provided in Table 32.

Table 32 Land Suitability Classes for SMUs

SMU	Land Suitability Class (Grazing)	Land Suitability Class (Cropping)
Anderson	4	4
Barry	2	3
Charlevue	4	5
Cooinda	3	5
Ellesmere	3	5
Geoffrey	3	5
James	4	4
Kosh	2	5
Namoi	3	4
Nigel	4	5
Normanby	4	4
Wallace	3	5

Notes: green shading suitable
orange shading unsuitable

Cattle Grazing Suitability

Within the study area, the suitability of land for cattle grazing is most limited by nutrient deficiency, ESP, and vegetation. Low nutrient levels and high sodicity in the soils may limit livestock production through a reduction in pasture growth and nutritive value of pasture species. Vegetation regrowth species can also impact the suitability of the land if they contain woody or poisonous species. In addition to this, high density regrowth and a woody shrub layer may reduce the carrying capacity of the land, making it unsuitable for grazing.

While no Class 1 land was identified within the study area, examination of the land suitability limitations for cattle grazing (Figure 50) indicate 1,080.5 ha of the study area is suitable for cattle grazing with minor limitations (Class 2), while 4,338 ha is suitable for cattle grazing with moderate limitations (Class 3). The remaining area (750.84 ha) was comprised of Class 4 land, with no Class 5 land identified.

Figure 50 shows the distribution of land suitability classes for cattle grazing across the Project.

Dryland Cropping

Land suitability for dryland cropping on the study area is most limited by soil water availability, soil wetness, erosion, and surface condition. Plants require suitable quantities of water to reach optimum production, and therefore maximum rooting depth, with the ability of the soil to take in water (wetness) playing a large part in crop survival. Topsoil and subsoil erosion also limit the ability of the soil to support crops. Soil preparation for sowing in the form of tillage may increase the risk of soil dispersion through slaking caused by the manipulation of soil aggregates by machinery. Surface condition also limits the soil classes, with hard setting soils found across most SMUs. Surface condition directly impacts seedling emergence and establishment by reducing seed-soil contact.

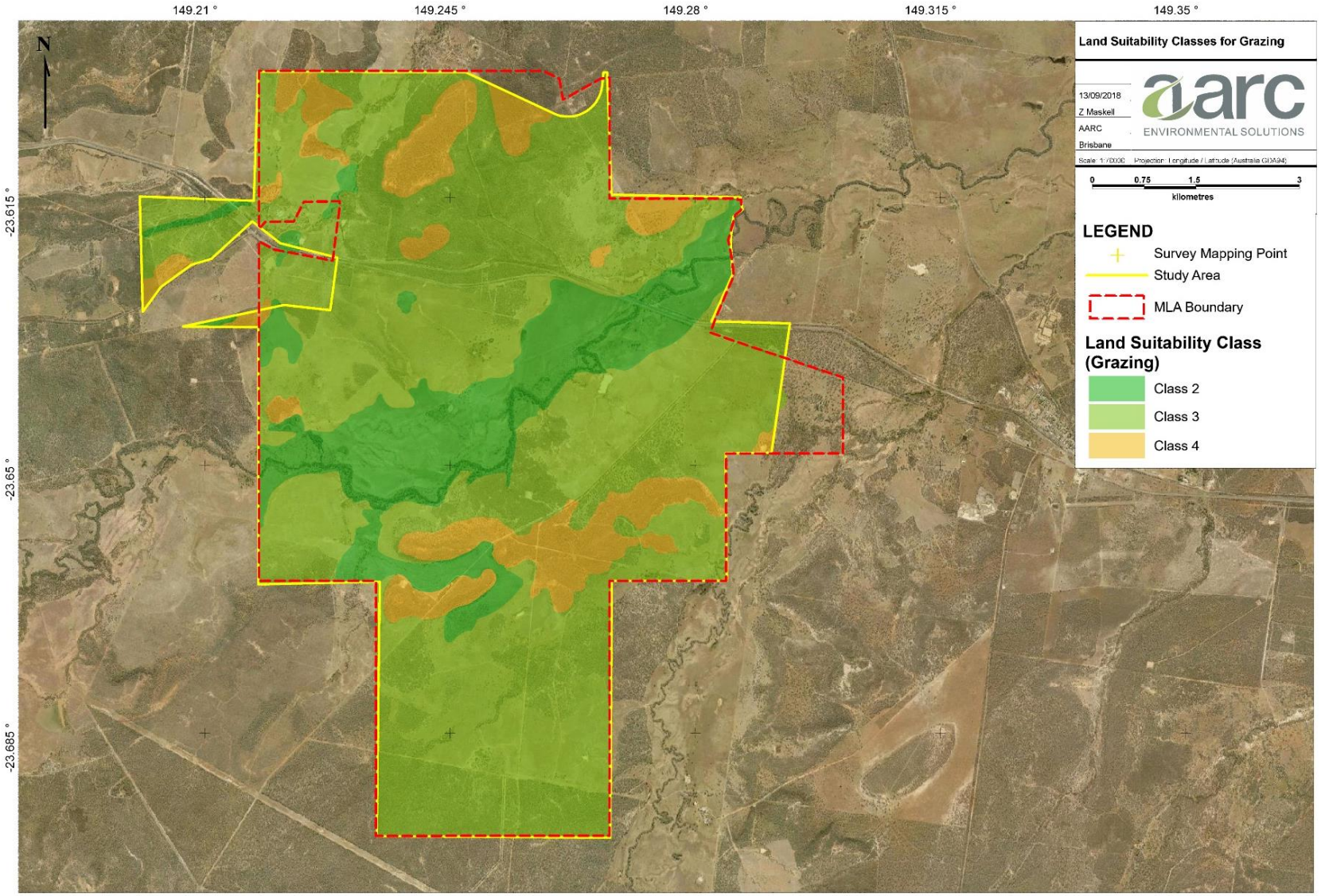


Figure 50 Land Suitability Classes - Cattle Grazing

In central Queensland, Class 1, 2 and 3 lands for dryland cropping are required to have the capacity to store sufficient levels of moisture to sustain a crop cycle from planting to harvesting with minimal rainfall. Class 4 lands are considered marginal for dryland cropping, requiring significant levels of rainfall for crop success. Class 5 lands are unsuitable for dryland cropping due to severe limitations.

Examination of the land suitability limitations for dryland cropping (Figure 51) indicates that 156.5 ha of the study area is suitable for cropping with moderate limitations (Class 3), and 409.1 ha of land is marginally suitable for cropping (Class 4). The remaining 5,607 ha of land is unsuitable (Class 5) due to land and soil limitations. Figure 51 shows the distribution of land suitability classes for broadacre cropping across the Project.

5.2.7 Land Use

The Project is located within the 'Central Queensland Regional Plan' area. Queensland land use mapping classifies the Project area as 'grazing modified pastures'. Other minor land use classifications over the site include 'residential', 'reservoir/dam', 'marsh/wetland', and primarily in association with the Capricorn Highway; 'transport and communication', 'utilities', 'services', and 'other minimal use'.

Dominant land uses within the local region are:

- grazing modified pastures;
- mining;
- other minimal use;
- managed resource protection; and
- production forestry.

The land within the Project boundary is currently used for low intensity cattle grazing and resource exploration activities. Cattle grazing being the major land use within the Project reflects the land suitability assessment which describes the site as mostly Class 2 and 3, suitable for grazing with minor to moderate limitations. The majority of the area has been cleared for cattle grazing; however, some patches of remnant vegetation remain, including riparian vegetation associated to Charlevue Creek.

The land in and around the Project is also used for purposes other than cattle grazing; including road transport, stock routes, protected areas, and coal mining. These land uses are discussed in Section 2.1.

5.2.8 Areas of Regional Interest

The Project activities are not in areas located within mapped areas of regional interest; however, a strategic cropping land trigger area exists northeast of the Project. The Project does not intersect any areas mapped as priority living areas, priority agricultural areas, strategic cropping land or strategic environmental areas.

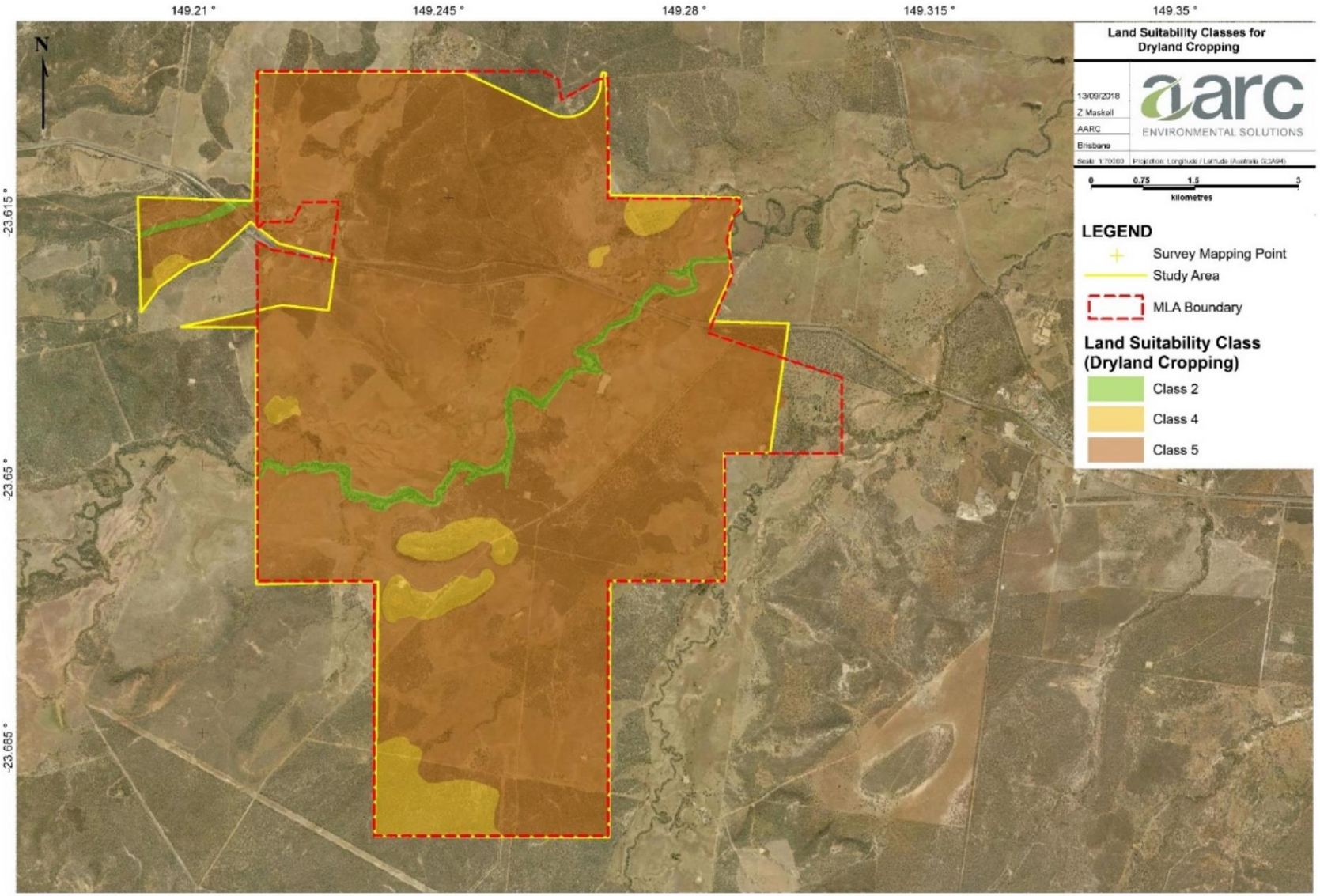


Figure 51 **Land Suitability Classes - Dryland Cropping**

5.3 POTENTIAL IMPACTS

5.3.1 Landform

Project activities involved in the construction of elevated landforms, open-cut pits and voids may impact land values by modifying the pre-mine topography. Some changes to the local topography will be temporary, such as the development of bunds and drains.

Waste rock emplacements associated with Pit AB and Pit C will be developed during operation. Where possible, spoil will be hauled and placed in-pit, behind the mining void. However, rehabilitated out-of-pit waste rock emplacement areas will remain as permanent features in the post-mining landform facilitating a slope of 1:10 vertical to horizontal ratio (V:H) and a maximum height of 190 m. Rehabilitated final void lakes are also proposed in the final landform, below the pre-mining topography.

Impacts from mining activities on the landform values of the Project may result in alteration to hydrological regimes within drainage features and an increase in Project landform exposure to erosion and instability.

Disturbance of vegetation and the topsoil layer can lead to the mobilisation of soil through the process of erosion, particularly water erosion through heavy rainfall or overland flow. The risk of erosion at the Project will be increased by the following activities:

- clearing of vegetation;
- topsoil stripping and stockpiling;
- construction of infrastructure; and
- exposure of slopes.

Erosion of rehabilitated landforms reduces the likelihood of revegetation success, and in extreme cases can compromise the structural integrity of the landform, making it unstable and unsafe. In addition, if not managed correctly, erosion can result in the release of suspended sediments and potential contaminants into the receiving environment. Soils and spoil within the Project have some dispersive characteristics within their subsoils, and will be potentially subject to erosion, particularly on artificial slopes.

5.3.2 Visual Amenity

Based on the findings of the *Visual Amenity Assessment* (AARC 2020c), the visual impacts arising from the Project are predominantly considered low. In terms of the significance of visual impacts for surrounding sensitive receptors, the following key points were identified:

- Magnetic South have purchased properties all vantage points which include a residence. The dwelling vacancy and lack of visual exposure at these vantage points means the visual sensitivity is significantly reduced and the subsequent visual impacts are minimised in the immediate surrounds of the Project
- Low impacts for visual amenity were predominantly identified across all assessed vantage points, except for vantage point VA1 observing a moderate impact and visual exposure to the final landform of the waste rock emplacement to Pit AB. The property of vantage point VA1 is owned by the proponent and will be vacated prior to the commencement of mining activities.

- The overhead conveyor is not expected to be visible from any nearby local residences, or sensitive receptors (2.9 km east on the Ellesmere property owned by the proponent and 2.9 km west at the Redrock Park property). Local topography, and the retention of existing vegetation outside of the disturbance footprint, would provide natural screening to obscure any visual modification that the conveyor might impose in either direction.

- Residual short-term and intermittent moderate visual impacts will be unavoidable for road users exposed to the overhead conveyor across the Capricorn Highway when using the main transport route; however, all mining infrastructure areas, including the overhead conveyor will be subject to decommissioning and rehabilitation. Therefore, the identified moderate impacts of the conveyor will be limited to the operational phases of the Project.

In summary, the exposure of mining infrastructure is limited to the spoil crest of Pit AB and the overhead conveyor across the Capricorn Highway connecting the TLO facility. Visual elements of the Project are not anticipated to have a significant impact for those residing in nearby properties and therefore impacts are predominantly limited to intermittent exposure when using nearby roads. In-depth descriptions of each visual simulation at the five vantage points are provided in Appendix O.

5.3.3 Soils

Mining activities, including the stripping, stockpiling, handling, and compaction of soil, have the potential to impact its physical, chemical and biological properties. Potential impacts from mining activities on the existing soils within the Project area may include:

- potential soil and land contamination through:
    - spills from mine-affected water storages or pipelines;
    - spillage of chemicals or fuel; and
    - effluent irrigation from the STP;
- loss of soil physical structure due to excavation and handling;
- loss of the soil seedbank; and
- impacts on soil fertility due to mixing with subsoils or resulting from changes in chemistry when subsoils are exposed to oxygen.

5.3.3.1 Sodic Soils

As shown in Table 30, the Project Area is dominated by the Geoffrey and Kosh SMU. These SMUs are, therefore, reflective of the predominant soil characteristics of the Project area. The subsoils of the Geoffrey and Kosh SMUs are considered strongly sodic (ESP > 14%). This indicates that subsoil may become dispersive if exposed to surface water run-off for prolonged periods of time post topsoil striping.

This dispersion can initiate the processes of sheet of gully erosion which can contribute to a loss of ground cover, surface crusting and subsequent reduction in seedling emergence as well as sedimentation of downstream water bodies. Additionally, dispersion can cause the collapse of soil structure. Collapse of soil structure reduces the porosity of soil, which subsequently increases the risk of waterlogging and reduces soil aeration and thus microbial activity.

While these SMUs have sodic subsoils, topsoil layers are not considered sodic. Stripping depths have accounted for this and have been determined to exclude any sodic subsoil material from the topsoil

resource. This topsoil resource used for rehabilitation is therefore not considered sodic and dispersive. Specialised segregation and demarcation of topsoil is therefore not considered necessary for any topsoil stockpiling within the Project area. Rehabilitated landforms are thus at low risk of the beforementioned impacts associated with sodic soils. Mitigation measures that target sodic and dispersive soils is not considered necessary. Although, it is recommended that stockpiles should be monitored monthly for evidence of erosion/structural instability.

5.3.4 Land Suitability and Land Use

Project activities will disturb and alter the current land use of low intensity cattle grazing in the short term. Cattle grazing within the Project area is categorised predominantly as land suitability class 3; suitable for cattle grazing with moderate limitations. A total area of 4, 338 ha of class 3 land exists within the Project's disturbance footprint occupying 70.20% of this extent. The remaining disturbance footprint of the Project is categorised as class 2 (17.49%) and class 4 (12.31%).

The Project aims to achieve a PMLU for all areas of rehabilitation, with no proposed NUMAs. Primarily, the land will be returned to cattle grazing land use across flat and gentle slopes. Secondly, the proposed post-mining beneficial land use will allow for the establishment and support of native ecosystems on areas of steeper slopes (i.e., treated high walls). Establishment of native ecosystems is defined as the establishment of vegetation that allows colonisation by surrounding non-weed species such that vegetation will progress towards native bushland with no designated agricultural or grazing use.

The rehabilitated final voids will remain in the post mining landform in a safe, geotechnically stable and non-polluting condition. As described in Section 4.4.7.1, the void will contain a fresh to brackish pit lake that is expected to provide suitable habitat for fauna species, particularly migratory and marine bird species. The final voids will provide a reduced land suitability of class 5.

5.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING

The Project will be managed to minimise the extent and severity of land disturbance.

5.4.1 Landform

Management practices to minimise impacts to landform values are provided below:

- land clearing will be limited to the minimum area required for safe operation of the Project. An internal *Land Disturbance Permit System* is proposed to prevent unnecessary or unauthorised impacts to land values during construction and operation;
- erosion and sediment control structures will be developed and implemented during operation in accordance with *Best Practice Erosion and Sediment Control* (IECA Australasia 2008);
- waste rock emplacements will be constructed to a slope of 1V:10H (adhering to a maximum slope of 6°) and a maximum height of 190 mAHD;
- construction of contour banks on slopes is proposed at a spacing of 80 m for slopes of 1V:10H to manage runoff and prevent erosion and associated landform instability;
- highwalls within Pit AB and Pit C will be pushed back after mining to form a slope angle of approximately 22° to ensure stability of the final landform. Treated upper slopes will be rehabilitated to achieve a PMLU suitable for native ecosystems; and

- erosion monitoring and maintenance is proposed throughout the mine life and during mine closure, until it can be demonstrated that final landforms are stable.

5.4.2 Visual Amenity

A series of management actions and measures can be employed to reduce unfavourable conditions at the selected vantage points, or sensitive receptors to minimise potential impacts on visual amenity. These measures, include:

- the use of neutral tones for infrastructure cladding to reduce any stark colour contrast between the visual modification and surrounding visual landscape and environment;
- placement of infrastructure where practical at greater distances from sensitive places (residences and transport corridors);
- placement, configuration and direction of lighting to reduce light emissions during the operational phase of the Project, in accordance with AS 4282:1997 '*Control of the obtrusive effects of outdoor lighting*' (Standards Australia 1997);
- establishment of important visual buffer zones (i.e., vegetation screening) between points of high visual impact and vulnerable sensitive receptors;
- as soon as land becomes available, out-of-pit overburden dumps be rehabilitated to reduce contrast between altered landforms and the unaffected surrounding landscape;
- overburden dumps designed to have a final landform that does not contrast significantly with the existing topography; and
- decommissioning of infrastructure in accordance with a *Closure Plan* to ensure the post-mine visual amenity resembles the previous landscape character as much as possible.

These mitigation and management strategies would support the retention of visual amenity during both construction, operation, and decommissioning of the proposed Project.

5.4.3 Land Contamination

5.4.3.1 Emergency Response and Spill Management Plan

An *Emergency Response and Spill Management Plan* will be developed to inform staff and contractors of the procedure for responding to a spill or potentially hazardous release. The objective of the *Emergency Response and Spill Management Plan* is minimising the risk of harm to persons and the environment.

The *Emergency Response and Spill Management Plan* will include the following components:

- identification of potential hazards and spill types;
- a register of hazardous chemicals and dangerous goods including the storage location and quantity;
- requirements for a risk assessment to be undertaken prior to the commencement of mining and ancillary activities;
- resource requirements for responding to spills;

- storage and handling requirements for all chemicals and hydrocarbons stored onsite including appropriate bunding, standard operating procedures and access to spill kits;
- a detailed response procedure including and emergency response plan for spills requiring evacuation; and
- reporting, investigation and review requirements following a spill or potentially hazardous release in accordance with the *Coal Mining Safety and Health Act 1999* (CMSH Act) and Coal Mining Safety and Health Regulation 2017 (CMSH Regulation) which will also be included in induction and training manuals.

Management measures to reduce the risk of spills and the consequent impact on the environmental values of land and water resources will be targeted at avoiding spills, minimising the risk of spills and the impacts on persons and the environment and the management of spill events. These will be used as key principles in the development of the *Emergency Response and Spill Management Plan.*

Avoid

Hazardous chemicals and dangerous goods will be stored in accordance with relevant Australian Standards, in bunded containment and inspections of the areas are regularly undertaken. Hazardous chemicals and dangerous goods will be handled strictly in accordance with the Material Safety Data Sheets

In the response to handling spills, safety is paramount. Spill containment or clean up should only be undertaken by trained personnel and when considered safe to do so.

Minimise

The risk of spills on human health and the environment will be minimised through the following mitigation measures:

- a detailed spills response procedure which will outline the following:
    - identification of the spill type, size and location i.e., sediment dam, topsoil stockpile, coal stockpiles etc;
    - control processes to isolate the sources and elimination of possible sources of ignition;
    - containment measures for the spill area to prevent the spill spreading into the surrounding environment and the exclusion of personnel or machinery from the spill area;
    - clean up procedures to be implemented including methodologies and application for the use of each spill kit item and disposal requirements for waste;
    - notification requirements for surrounding sensitive receivers;
- resource requirements for responding to spills in a timely manner including:
    - trained personnel in spill response procedures and training materials to ensure all staff onsite are aware of the hazards and risks associated with the hazardous chemicals and dangerous goods stored onsite;

  - spill kits with stocked with appropriate response requirements for hazardous chemicals and dangerous goods stored on site;
  - spill kits appropriately located onsite for quick response handing;
  - signage in work areas indicating the location of the nearest spill kit;

- the development of Standard Operating Procedures for the spill management for all hazardous chemicals and dangerous goods in accordance with the CMSH Regulation and Australian Dangerous Goods Code*;*
- management of site water system to operate below maximum operating level and the implementation of a spillway to direct mine water dam overflows to the mine pit; and
- requirements for risk assessments for activities involving the storage or handling of hazardous chemicals or dangerous goods to identify and reduce the risks associated with each activity/hazardous chemical or dangerous good.

Manage

The hazards associated with spills onsite will be managed through the following:

- A standardised framework for reporting requirements following a spill or potentially hazardous release including the requirement for the investigation and notification of any contamination to land resulting from a spill or release event to the DES in accordance with the Project's EA.
- An annual review of the *Emergency Response and Spill Management Plan* will be undertaken and may be revised due to the following;
  - updates to relevant legislation or policy or industry best practices;
  - procedures based on post-incident evaluation; and
  - new hazardous materials brought onto site.

5.4.3.2 Fuel and Hazardous Storage Management Plan

A *Fuel and Hazardous Liquids Storage Management Plan* will be developed. The *Fuel and Hazardous Liquids Storage Management Plan* will minimise the risk of harm to the environment and human health and address the regulatory requirements for the storage and handling of hazardous chemicals and dangerous goods as detailed in the:

- CMSH Act and CMSH Regulation;
- Australian Dangerous Goods Code;
- RS 17 Recognises Standards for Hazardous Chemicals (2019); and
- Relevant Australian Standards.

The *Fuel and Hazardous Liquids Storage Management Plan* will consist of the following components:

- a register of hazardous chemicals and dangerous goods;
- a system for the recording of material safety data sheet;
- labelling requirements for all hazardous chemicals and dangerous goods;
- standard operating procedures for the storage, handling, use and disposal of each hazardous chemical and dangerous good;
- placard requirements for the storage of hazardous chemical and dangerous goods;
- a framework for performing risk assessments for the storage, handling, use and disposal of each hazardous chemical and dangerous goods;
- a monitoring program to assess the performance of storage and handling practices and to ensure the integrity of materials prior to use;
- training requirements for relevant personnel; and
- reporting, investigation, and review procedures following incidents regarding hazardous chemicals and dangerous goods.

The management of *Fuel and Hazardous Liquids Storage Management Plan* focuses on mitigation measures that improve employee awareness of the hazards associated with hazardous materials and that minimise the risk of adverse impacts to human health and the environment. A brief summary some of the *Fuel and Hazardous Liquids Storage Management Plan* components are provided below.

Storage

Fuels will be stored within the MIA, with additional self-bunded tanks located as required in the mining area, depending the current location of the main fleet and advancing mine face.

Fuels (including diesel) will be delivered to the Project by contractors. The transport, storage and handling of fuels (including diesel) will be undertaken in accordance with relevant legislation and guidelines.

Storage and handling practices will ensure that the chemical and goods are:

- protected against damage and deterioration;
- secure to prevent loss, misuse and theft; and
- liquids are bunded to contain spillage.

Register

An up-to-date register of hazardous chemicals and dangerous goods will be maintained in accordance with the CMSH Regulation and will record:

- any hazardous chemical or dangerous good used, handled, stored or produced at the mine;
- current safety data sheet for all hazardous chemicals and dangerous goods;
- the storage location; and

- storage incompatibilities.

The register must be readily accessible by each worker required to use, handle, store or produce a hazardous chemical or dangerous good at the mine.

Labelling

The labelling requirements for all incoming hazardous materials are to be inspected upon receiving the hazardous material onsite and is the responsibility of the site senior executive. Labelling must meet the requirements set out in Part 7, Division 2 of the CMSH Regulation including:

- a warning of the presence of chemical or good;
- identification of chemical or good;
- to the extent necessary for managing risk, provides basic information about using, handling, storing, producing, or transporting the chemical or goods;
- if it is not practicable to mark or label a hazardous chemical or dangerous good, the site senior executive must ensure a notice that gives the warning, identification and basic information of the hazardous material is place in a conspicuous place as near as practicable to the chemical or good; and
- labelling must meet the requirements stated in the Globally Harmonised System, a recognised standard, the Australian Dangerous Goods Code or AS 1345.

Standard Operating Procedures

In accordance with the CMHS Regulation, Standard Operating Procedures are required for using, handling or storing of a hazardous chemical or dangerous good. In developing a standard operating procedure, the site senior executive must ensure regard is had to the material safety data sheet for the chemical or good.

Risk Assessments

Risks to be managed with regard to the conditions outlined in Part 7, Division 2, section 56F of the CMHS Regulation and consideration given to the hazardous properties of the chemical or goods

Monitoring Program

Regular monitoring to confirm the location and quantity of chemical or goods onsite, deterioration of the chemical or goods or any packaging, ensure the chemical are fit for intended use, detect leaks spills and unintended emissions, detect misuse, theft, disposed is monitoring shows deterioration or unfit.

Training

All equipment and vehicle operators will be trained in the safe operation of the equipment (including operating procedures for the refilling and maintenance of fuel storage tanks and mine vehicles) and the relevant emergency response and spill management procedures in the event of an incident.

5.4.4 Soils

Impacts to soil will be mitigated to reduce the risk of soil degradation and improve the chances of rehabilitation success. Mitigation strategies for soil include:

- Topsoil across the disturbance area will be stripped to a depth that excludes any constraining layer/properties (i.e., above a sodic/highly saline soil horizon) to ensure the topsoil resource is of good quality.

- Progressive rehabilitation of landforms and direct placement of topsoil will be carried out to help preserve the seed bank and reduce erosion.

- If topsoil resources are to be stockpiled for a period in excess of six months, testing of soil properties (including physiochemical analysis) will occur prior to use in rehabilitation. This monitoring information is only required prior to topsoil application to assess changes in topsoil quality (changes to soil chemistry and biological activity as a result of being stockpiled). Key parameters would include pH, ESP%, CEC (major cations), organic matter content and other essential nutrients such as nitrate, phosphorous and sulphate.

- If topsoil degradation has occurred, the subsequent action will be to apply fertilizers, soil ameliorants, and the application of a seed mix (refer to Section 4.4.3) to increase the likelihood of rehabilitation success. The most significant risk to topsoil is deterioration as a result of stockpiling for extended periods of time, however, topsoil is not anticipated to deteriorate to the point of becoming unsuitable for use in rehabilitation works (AARC 2019).

5.4.5 Erosion Protection Measures

Erosion protection measures developed to reduce the risk and impacts of erosion include:

- topsoiled areas will be deep ripped to reduce compaction from heavy machinery, encourage infiltration of water and prevent erosion. Areas will be ripped along the contour to reduce the velocity of runoff water down the slope. Ripping depths will vary depending on the type of spoil material, depth of topsoil and equipment used for rehabilitation operations;

- ensuring that when required, stockpiles are generally less than 2 m high and contoured to encourage water to drain;

- where required, seeding of topsoil as soon as possible after placement onto rehabilitated areas, to ensure root masses assist in preventing erosion;

- topsoil stockpiles will be placed away from drainage areas, roads, machinery, transport corridors, and stock grazing areas;

- topsoil stockpiles will be seeded or covered with a water-shedding lining to prevent unnecessary erosion of soil; and

- seeding of topsoil as soon as possible after placement onto rehabilitated areas, to ensure root masses assist in preventing erosion.

5.4.6 Topsoil Handling Procedures

A *Topsoil Management Plan* will be developed for the Project. The overarching principle of the *Topsoil Management Plan* will be to reduce the risk of topsoil degradation and improve the chances of rehabilitation success. The objectives of the Project's *Topsoil Management Plan* are to:

- maintain a soil balance that will achieve the rehabilitation requirements throughout the life of the mine;

- maintain topsoil viability through the utilisation of best practices in soil stripping, stockpiling and application activities; and
- provide a standard practice for the Project's storage and handling of topsoil resources.

Section 4.4.2 provides further details on topsoil handling for the Project.

5.4.7 Land Suitability and Land Use

Potential impacts on soil can be mitigated through:

- determining PMLUs that align with pre-mining land use and the surrounding properties;
- a final landform design that aims to maximise PMLU areas;
- progressive rehabilitation to return the land to a productive land use as soon as practicable; and
- ongoing monitoring, maintenance and rehabilitation trials to ensure a safe, stable and non-polluting landform.

The majority of areas in the final landform will be restored to a PMLU of cattle grazing. The exceptions being water management features such as ponds and drains, which will be returned to a PMLU of native ecosystems or equivalent. This includes the final pit lake and high walls, that will be restored to achieve a fauna habitat land use. These areas are expected to be unsuitable for grazing and will achieve a reduced land suitability score of 5.

5.4.8 Cultural Heritage Management Plan

A *Cultural Heritage Management Plan* has been developed in accordance with the *Aboriginal Cultural Heritage Act 2003* and the supporting *Duty of Care Guidelines* (DATSIP 2004). The Cultural Heritage Management Plan has been developed in consultation with Traditional Owner groups and any other relevant representatives. The *Cultural Heritage Management Plan* has been developed upon formal assessment of cultural heritage by a suitable qualified person and the outcomes of the assessment will be utilised to inform the Cultural Heritage Management Plan.

The objective of the *Cultural Heritage Management Plan* is to minimise the potential impacts of the Project's activities on the cultural heritage of the site through a knowledge of the site's cultural heritage and an effective monitoring and reporting framework for the management of cultural heritage and responsibilities within the Project in compliance with all Aboriginal cultural heritage management requirements under legislation, guidelines, and existing consents.

The *Cultural Heritage Management Plan* includes the following components to at minimum:

- establish the roles and responsibilities of personal relating to the coordination, implementation, management, and future conduct of matters arising in relation the *Cultural Heritage Management Plan*;
- provide a summary of the potential impacts to the cultural heritage of the Project site;
- provide procedures for the management of known and unexpected finds, where;
    - options to avoid, minimise or mitigate these impacts in a culturally appropriate fashion are developed;

  - outline details for an aboriginal find procedure (described further below);
  - detail the process to follow for the findings of human skeletal remains (described further below);
- provide procedures for consultation with relevant parties;
- include cultural heritage assessment requirements in the *Land Disturbance Permit* for Project activities involving any ground disturbance, where;
  - information regarding cultural heritage will be identified, collated and documented;
- provide a standard procedure for the reporting of the discovery of any Aboriginal cultural heritage in the Project area, where reporting is undertaken as soon as reasonably practical to the designated personnel and also as required by law; and
- distribute Indigenous cultural heritage awareness information and legal obligations in employee/contractor induction programs.

5.4.8.1 Aboriginal Object Find

At any time throughout the life of the Project, if suspected Aboriginal material has been uncovered due to the Project's activities, work in the surrounding area is to stop immediately and the following procedure followed:

- a temporary fence or barrier with a buffer zone of at least 10 m around the known edge of the site is to be erected around the site and no unauthorised entry or earth disturbance is to be carried out until the area has been assessed;
- an appropriately qualified archaeological consultant is to be engaged to identify the material and prepare an assessment report including recommended mitigation measures; and
- if the object is confirmed to be of cultural heritage significance, the relevant traditional owner groups and government personnel will be notified.

The process for handling of objects of cultural heritage significance is defined and provided in the *Cultural Heritage Management Plan* following consultation with the relevant Traditional Owner groups and government bodies.

5.4.8.2 Human Skeletal Remains Find

If suspected human skeletal remains (that are or may be those of an Aboriginal person) are uncovered due to the Project's activities it is important that all personnel adhere to provisions of the *Aboriginal Cultural Heritage Act 2003*, *Coroner's Act 2003* and the *Criminal Code Act 1899* section 236(2). The following actions should be followed:

- work in the vicinity of the find is to stop immediately, until works are authorised to resume;
- the site should be cordoned off with a buffer zone of at least 10 m around the known edge of the site and the remains left untouched. No unauthorised entry or earth disturbance is to be carried out until the area has been assessed;
- the discovery should be reported to the nearest Police Station as soon as possible; and

- a process for the reporting and handling of remains that are confirmed to be of Aboriginal origin, where the remains have not been removed by the coroner, have been developed during consultation in the development of the *Cultural Heritage and Management Plan* with the relevant Traditional Owner groups and the Department of Aboriginal and Torres Strait Islander Partnerships.

6.0 FLORA AND FAUNA

This section provides a description of the existing flora and fauna values within the Project. It aims to identify the Project's potential impacts on the existing values and propose mitigation measures and management strategies to prevent or minimise adverse environmental effects.

This section also discusses potential impacts to wetland values and groundwater dependent ecosystems (GDEs), however all other water values are discussed in Section 7.0 and Section 8.0.

This section is informed by:

- *Terrestrial Ecology Assessment* (AARC 2020b) (Appendix J);
- *Aquatic Ecology Assessment* (AARC 2020a) (Appendix K);
- *Groundwater Dependent Ecosystem Assessment* (3D Environmental 2020) (Appendix F);
- *Surface Water Assessment* (WRM 2020b) (Appendix B); and
- *Groundwater Impact Assessment* (JBT 2019) (Appendix C).

6.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES

The environmental objective relevant to potential impacts to flora and fauna as described in the EA guideline for *Application requirements for activities with impacts to land [ESR/2015/1839]* (DES 2017b) is:

The activity is operated in a way that protects the environmental values of land including soils, subsoils, landforms and associated flora and fauna.

The Project would achieve all of the following performance outcomes identified in Schedule 8, Part 3, Division 1 of the EP Regulation:

(a) activities that disturb land, soils, subsoils, landforms and associated flora and fauna will be managed in a way that prevents or minimises adverse effects on the environmental values of land;

(b) areas disturbed will be rehabilitated or restored to achieve sites that are:

(i) safe to humans and wildlife;

(ii) non-polluting;

(iii) stable; and

(iv) able to sustain an appropriate land use after rehabilitation or restoration;

(c) the activity will be managed to prevent or minimise adverse effects on the environmental values of land due to unplanned releases or discharges, including spills and leaks of contaminants; and

The environmental objective relevant to potential impacts to wetlands as described in the EA guideline for *Application requirements for activities with impacts to water* (DES 2017c) is:

The activity will be operated in a way that protects the environmental values of wetlands.

The Project would achieve the following performance outcomes identified in Schedule 8, Part 3, Division 1 of the EP Regulation:

a) *there will be no potential or actual adverse effect on a wetland as part of carrying out the activity; and*

b) *the activity will be managed in a way that prevents or minimises adverse effects on wetlands.*

The environmental objective relevant to potential impacts to surface ecological systems (i.e., GDEs) as described in the EA guideline for *Application requirements for activities with impacts to water* (DES 2017c) is:

The activity will be operated in a way that protects the environmental values of groundwater and any associated surface ecological systems.

The Project would achieve the following performance outcomes identified in Schedule 8, Part 3, Division 1 of the EP Regulation:

(a) there will be no direct or indirect release of contaminants to groundwater from the operation of the activity; and

(b) *there will be no actual or potential adverse effect on groundwater from the operation of the activity.*

Or, the activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.

6.2 DESCRIPTION OF ENVIRONMENTAL VALUES

6.2.1 Regional and Local Setting

The Project is located within the Brigalow Belt bioregion. This bioregion occupies over a fifth of Queensland; from Townsville in the north to near the border of New South Wales in the south. The Brigalow Belt bioregion is characterised by brigalow (*Acacia harpophylla*) woodland but presents other vegetation such as semi evergreen vine thickets, dry eucalypt woodlands and native bluegrass (*Dichanthium sp.*) grasslands. Due to the size of Brigalow Belt bioregion, it covers a broad climatic gradient as well as a diversity of soils and topography, the Brigalow Belt hosts a high diversity flora and fauna (DES 2018a).

As a result of agricultural and development activities, most of the relatively undisturbed areas are confined to the rugged parts of the landscape with less development value (DES 2018a), parks and reserve areas. At a local level, the Project is positioned in a relatively flat landscape, dissected by Charlevue Creek, which has a lower elevation than the surrounding land. The Project is also crossed by Stanley Creek and Springton Creek, as well as small tributaries associated with the main waterways.

Several protected areas and state forest surround the study area. State Forests in Queensland have been traditionally used as a source of supplies such as timber; however, the presence of large areas of remnant vegetation now act as ecological corridors that connect isolated habitats. The Project is situated south of Taunton National Park (Scientific), (Taunton Nation Park), a scientific reserve under the *Land Act 1994 (Queensland)*, established to protect a population of Bridled nail-tail wallabies. Taunton National Park connects to the Walton State Forest via Wallaby Late Nature Refuge, which contains suitable remnant and regrowth remnant areas used by the bridle nail-tail wallaby for feeding and shelter.

Walton State Forest connects to the sandstone ridges and plateau located at the west and south of the Project on which is located Arthur's Bluff State Forest, Blackdown Tableland National Park and Dawson Range State Forest. Dawson Range Forest is connected via remnant vegetation, to Duaringa State Forest, which, like Walton State Forest, is not located in the sandstone plateau. State mapped ecological corridors connect all the protected areas mentioned above.

Importantly, none of the described protected areas and state forests are directly connected to the study area, which is comprised of predominately pastureland and fragmented remnant vegetation. This fragmentation is the result of farming activities, including historical vegetation clearing to facilitate grazing and selective logging (e.g., Rosewood (*Acacia rhodoxylon*).

6.2.2 Terrestrial Flora

An assessment of terrestrial flora ecological values was conducted within EPC 881 (herein referred to within Section 6.0 as the study area) (Appendix J). Six field surveys were undertaken between 2017 and 2019 covering a range of seasonal and climatic conditions to ensure temporal and seasonal survey requirements for the Brigalow Belt bioregion were met. The dates of these surveys were:

1) 4th - 12th May 2017;
2) 18th - 30th September 2017;
3) 16th - 23rd February 2018;
4) 22nd - 29th March 2018;
5) 1st - 2nd August 2019; and
6) 19th August 2019.

The surveys were conducted in accordance with the following guidelines:

- *Site examination for threatened and endangered plant species* (Goff, Dawson & Rochow 1982);
- *Management of endangered plants* (Cropper 1993); and
- *Methodology for surveying and mapping regional ecosystems and vegetation communities in Queensland (V5.0)* (Neldner *et al.* 2019).

Threatened Ecological Communities

Desktop assessments identified four threatened ecological communities (TECs) that could potentially occur within 10 km of the study area:

- Brigalow (*Acacia harpophylla* dominant and co-dominant);
- Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions;
- Weeping Myall Woodlands; and
- Poplar Box Grassy Woodland on Alluvial Plains.

Vegetation surveys over the Project determined that communities recorded within the study area do not meet the condition thresholds to constitute a TEC (Appendix J).

Regional Ecosystems

Flora surveys confirmed the presence of six vegetation communities classed as remnant vegetation within the study area. Table 33 outlines the regional ecosystems (REs) characteristic of each vegetation community, where applicable, as well as a short description of the vegetation present. Figure 52 displays the distribution of vegetation communities on the study area.

Table 33 Summary of Vegetation Communities

Vegetation Community	Regional Ecosystem	VM Act Status	Biodiversity Status	Community Description
VC1	11.5.2	LC	NC	Narrow-leaved ironbark (*Eucalyptus crebra*) and Clarkson's bloodwood (*Corymbia clarksoniana*) woodland with a sparse shrub layer on sand plains.
VC2	11.7.2	LC	OC	Lancewood (*Acacia shirleyi*) and/or rosewood (*Acacia rhodoxylon*) woodland on lateritic duricrust.
VC3	11.3.25	LC	OC	Blue gum (*Eucalyptus tereticornis*) or River gum (*Eucalyptus camaldulensis*) with *Bauhinia spp.* and *Casuarina cunninghamiana* fringing woodland on drainage features.
VC4	11.3.2	OC	OC	Poplar box (*Eucalyptus populnea*) woodland on alluvial plains.
VC5	11.5.2 / 11.3.25	LC	NC / OC	Mixed polygon where the dominant vegetation community was VC1 (*Eucalyptus crebra* and *Corymbia clarksoniana* woodland) but along ephemeral creeks and with an important presence of blue gums (*Eucalyptus tereticornis*).
VC6	11.3.25 / 11.3.2 / 11.5.2	LC / OC / LC	OC / OC / NC	Mixed polygon as a result of combination of VC3 with elements of VC4 and some elements of VC1 due to edge effect.

Notes: VM Act *Vegetation Management Act 1992*
LC least concern
OC of concern
NC no concern at present

Flora Species of Conservation Significance

Field surveys included targeted searches for flora species of conservation significance. Surveys covered all potential habitat within the study area based on database searches and field observations. Targeted searches across the study area detected the presence of one flora species of conservation significance; *Cerbera dumicola,* listed as near threatened under the *Nature Conservation Act 1992* (NC Act).

Cerbera dumicola is a shrub or small tree growing to 4 m high (DES 2018d). The species occurs across a range of habitats in central and southern Queensland and is associated with a range of vegetation communities. The species is regionally abundant, having been recorded outside of the study area on multiple occasions (AVH 2019). *Cerbera dumicola* was identified during the vegetation surveys in two very localised rocky areas associated with vegetation community (VC) 2 and VC1 (on an ecotone with VC2) (Figure 53). This species was not identified within similar habitat types elsewhere in the study area during targeted searches.

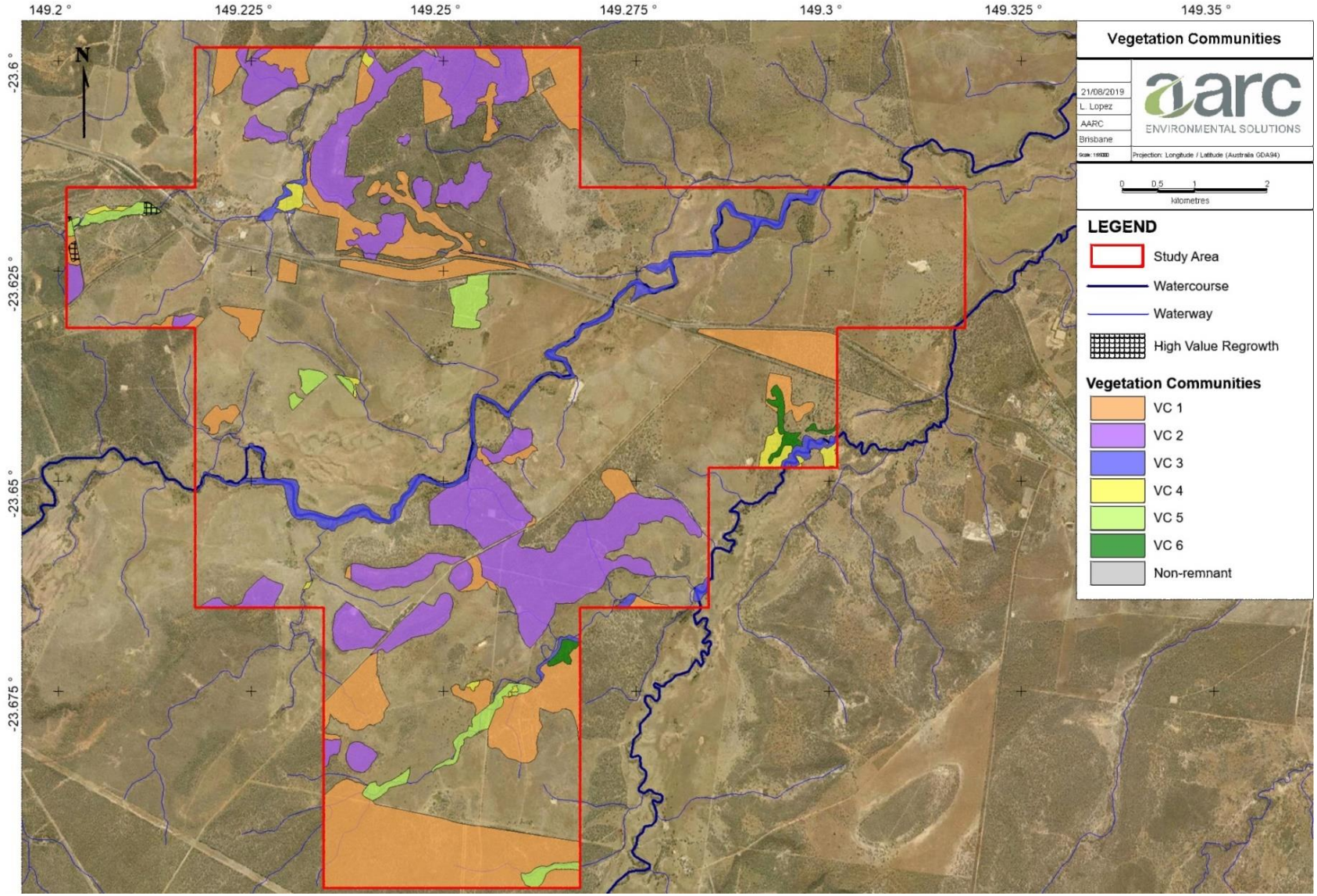


Figure 52 Vegetation Communities

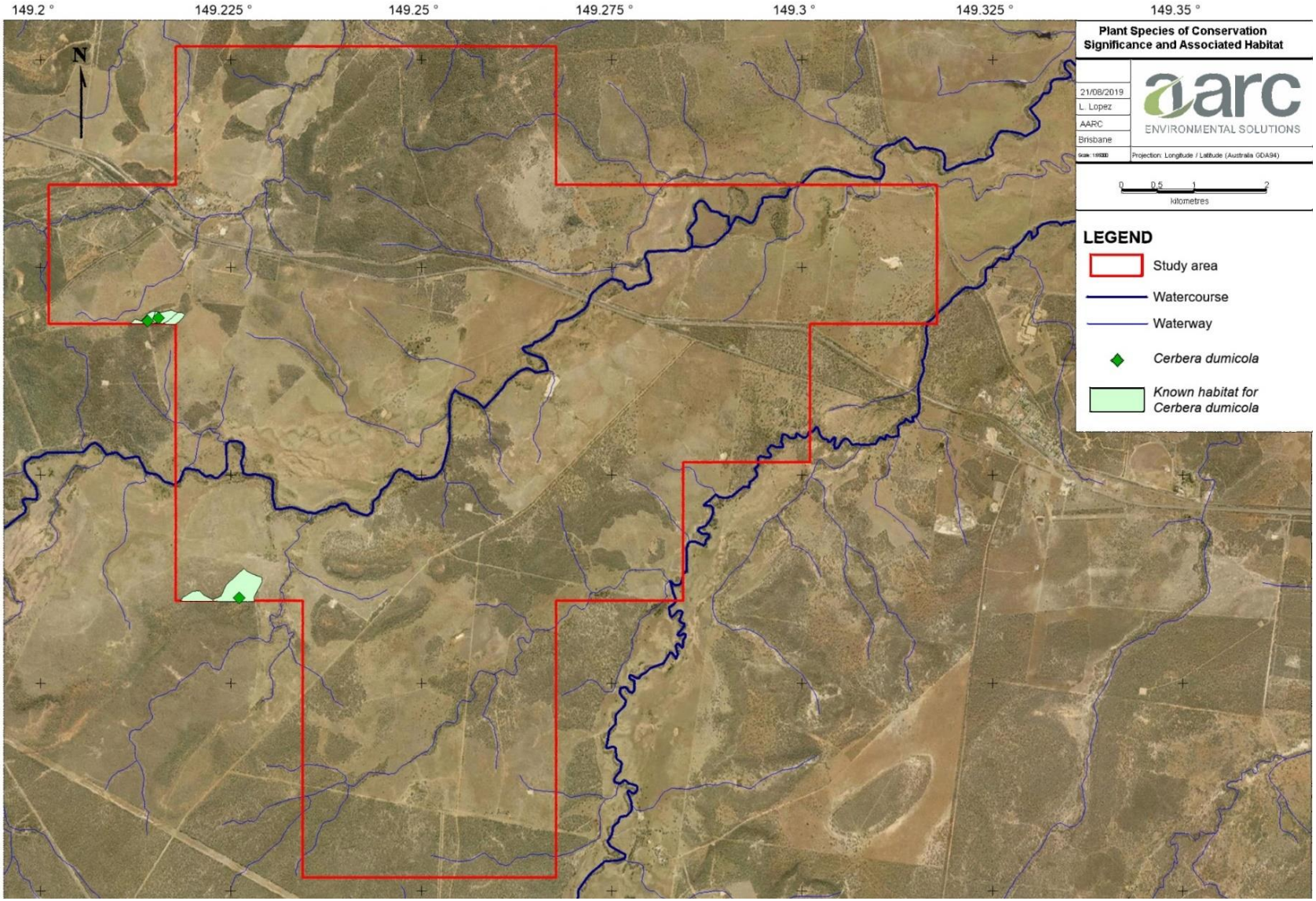


Figure 53 ***Cerbera dumicola*** **Locations and Known Habitat**

Weed Species

A total of 33 introduced flora species were recorded on the study area. Five of which are classed as WoNS and/or as RIS under the Biosecurity Act (DAF 2018a). Introduced plant species are classified as WoNS if they present a serious threat to industry, water supply, human health/safety, plant communities and/or cultural values.

Weeds of management concern (i.e., WoNS or Biosecurity Act RIS) identified within the study area are listed in Table 34. A full list of all introduced species can be found in Appendix J.

Table 34 Weed Species of Management Concern

Scientific Name	Common Name	WoNS	Biosecurity Act RIS (Category 3)
Harrisia martinii	Harrisia cactus	-	x
Cryptostegia grandiflora	Rubber vine	Yes	x
Opuntia tomentosa	Velvety tree pear	Yes	x
Parthenium hysterophorus	Parthenium	Yes	x
Bryophyllum sp.	Mother of millions	-	x
*Vachellia farnesiana**	Mimosa bush	-	-

Notes: * Considered a noxious weed of management concern.
Category 3: A person must not distribute the invasive plant either by sale or gift, release it into the environment.

Wetlands

Field surveys concluded that all the potential lacustrine and palustrine wetlands identified within the study area from desktop searches (Appendix J) were either not present or were identified as artificial (farm) dams. The only natural wetlands within the study area are riverine wetlands associated with riparian and vegetation along Charlevue Creek, Springton Creek and some larger tributaries. These have been mapped as VC3, VC5 and VC6 (Figure 52).

Outside the study area, there is a large palustrine wetland (approximately 82 ha) located approximately 4 km east of the MLA boundary. This wetland, identified as of high ecological significance (HES) under the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP (WWB)), is not connected to the study area through any waterbodies or watercourses. Current government mapping and field inspections of the mapped wetlands identified the vegetation as non-remnant. Field assessment identified the presence of flora species known to inhabit wetland environments. No water was observed during the site inspection (Appendix K).

Groundwater Dependent Ecosystems

The above-mentioned wetlands have the potential to be partially dependent on groundwater (BoM 2019b). Within the study area high potential terrestrial GDEs and moderate potential aquatic GDEs were identified by database searches in association with Charlevue Creek and Springton Creek. Moderate potential terrestrial GDEs were also mapped in association with some of the smaller waterways.

The HES wetland located 4 km to the east of the study area was also identified as potentially groundwater dependant during the database searches.

The *Groundwater Dependent Ecosystem Assessment* (Appendix K) identified two areas within the study area containing terrestrial GDEs, both dependent on alluvial perched groundwater systems that recharge from surface flow. One of these GDEs is located within Charlevue Creek while the other one is situated within a tributary of the Springton Creek. This study also determined that the HES does not constitute a GDE and therefore, is not discussed further.

Based on the location of the aquifer, salinity data and stable isotope comparisons between water sampled from the trees and groundwater, it is concluded that both perched aquifers are hydraulically disconnected from the regional groundwater table. Furthermore, the results indicate that the trees sampled are not utilising groundwater from the regional Tertiary, alluvial or Permial coal seam aquifers to any significant degree.

Assessment of impact to potential GDEs within the Project has been addressed in Section 6.3.1 and Appendix F.

6.2.3 Terrestrial Fauna

An assessment of terrestrial fauna ecological values was conducted within the study area by AARC (2020b) (Appendix J). Four field surveys were undertaken between 2017 and 2018 covering a range of seasonal and climatic conditions to ensure temporal and seasonal survey requirements for the Brigalow Belt bioregion were met. The dates of these surveys were:

1) 4-12 May 2017;
2) 18-30 September 2017;
3) 16-23 February 2018; and
4) 22-29 March 2018.

The surveys were conducted in accordance with the guidelines:

- *Survey guidelines for Australia's threatened bats* (DEWHA 2010a);
- *Survey guidelines for Australia's threatened birds* (DEWHA 2010b);
- *Survey guidelines for Australia's threatened mammals* (DEWHA 2011a);
- *Survey guidelines for Australia's threatened reptiles* (DEWHA 2011b); and
- *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (V 3.0)* (Eyre *et al.* 2018).

Fauna Species of Conservation Significance

Field surveys across the study area detected the presence of four fauna species of conservation significance, the southern Squatter pigeon (*Geophaps scripta scripta*), the Greater glider (*Petauroides volans*), the Short-beaked echidna (*Tachyglossus aculeatus*) and the Rufous fantail (*Rhipidura rufifrons)*.

The southern squatter pigeon and the greater glider are listed as vulnerable under the EPBC Act and the NC Act. The short-beaked echidna, listed as special least concern under the NC Act, was recorded across several sites over the survey seasons. The Rufous fantail is listed as a migratory species under the EPBC Act, but it is not listed under the NC Act.

The observed locations of these species within the study across the field surveys are displayed in Figure 54.

Pest Species

Four introduced and/or pest fauna species listed as RIS under the Biosecurity Act were identified within the study area (Table 35). A further two species; the cane toad (*Rhinella marina*) and the house mouse (*Mus musculus*), are not invasive species declared under the Biosecurity Act, but are recognised as invasive pests in Queensland.

Table 35 Introduced Fauna Species

Scientific Name	Common Name	Biosecurity Act RIS			
		Category 3	Category 4	Category 5	Category 6
Canis familiaris/ Canis lupus dingo	Wild dog/dingo	x	x	x	x
Oryctolagus cuniculus	Rabbit	x	x	x	x
Felis catus	Feral cat	x	x	-	x
Sus scrofa	Feral pig	x	x	-	x

Notes: Category 3: the invasive animal must not be distributed either by sale or gift or released into the environment.
Category 4: the invasive animal must not be moved.
Category 5: the invasive animal must not be kept.
Category 6: the invasive animal must not be fed.

6.2.4 Aquatic Ecology

To describe the aquatic ecology values of the Project, an assessment of aquatic ecological values was conducted within the study area by AARC (2020a) (Appendix K).

Four field surveys were undertaken between 2018 and 2020 covering a range of seasonal and climatic conditions to ensure temporal and seasonal variation. The dates of these surveys were:

1) 23rd -24th February 2018;
2) 3rd - 9th April 2019;
3) 1st - 2nd August 2019; and
4) 17th - 23rd March 2020.

Field surveys employed standard methodologies derived from:

- *Australian River Assessment System (AusRivAS) Physical Assessment Protocol* (Parsons *et al.* 2002);
- *Queensland AusRivAS Sampling and Processing Manual* (DNRM 2001);
- *Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009* (DES 2018c).
- *Survey guidelines for Australia's threatened birds* (DEWHA 2010b);
- *Survey guidelines for Australia's threatened reptiles* (DEWHA 2011b); and

- *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (V 3.0)* (Eyre et al. 2018).

Aquatic ecology values pertaining to flora, fauna, wetlands and GDEs are discussed within this section. Refer to Section 7.0 for discussion of values pertaining to water quality and hydrology.

Aquatic Ecosystems

The waterways of the study area are ephemeral, experiencing periodic flows. The aquatic setting of the Project is described in Section 5.2.1.

Charlevue Creek and Springton Creek are the major determined watercourses under the Water Act, all other waterways crossing the Project are determined drainage features. Extensive clearing for agricultural purposes has been undertaken across much of the study area including the removal of riparian vegetation. The removal of riparian vegetation and direct stock access to the waterways has resulted in bank instability, erosion and occurrence of weeds.

Priority was given to aquatic fauna sampling along the major watercourses; specifically, Charlevue Creek and Springton Creek. Charlevue Creek and Springton Creek were identified to be of higher ecological value than the other surrounding waterways. In this regard, additional fauna survey methods were completed at the chosen sites along Charlevue Creek and Springton Creek in order to identify any riparian fauna species that are reliant on the existing aquatic values within the study area.

Site scoping identified the potential for aquatic trapping to be undertaken along Stanley Creek, however the ephemeral nature of this waterway combined with its low stream order Stanley Creek resulted in not enough water to have aquatic fauna trapping undertaken or to allow for macroinvertebrate sampling to occur.

Water Quality

Surface water quality was found to be generally poor. Results for physico-chemical parameters were outside of the water quality objective (WQO) guideline values for the protection of aquatic ecosystems at many sites. Exceedances included, pH, suspended solids, dissolved oxygen, turbidity, ammonia, nitrogen, phosphorus and sulphate. Petroleum hydrocarbons were also found to exceed WQO guideline values at several sites, considered likely due to the highway and agricultural practices. However, no exceedances of the WQOs for dissolved metals were detected at any site, across all sampling periods during 2020. Water quality is discussed in detail in Section 7.0 (Surface Water).

Stream Sediment Quality

Stream sediment quality was found to contain a high proportion of sand particles with some sites containing a mixture of silt, clay and gravel. No particles were large enough to be classified as cobbles (>6 cm).

Metal concentrations in stream sediment were generally low, except for one exceedance of the Sediment Quality Guideline (SQG) for nickel levels along a tributary of Springton Creek. The 2018 sample was the highest (28.1 mg/kg), with a continued reduction in nickel levels present over the following two surveys to levels barely exceeding the low trigger value (21.9 mg/kg in 2019 and 21.3 mg/kg in 2020). Stream sediment quality is discussed in detail in Section 7.0.

Biological Indicators

Macroinvertebrate diversity, abundance and Plecoptera, Ephemeroptera and Trichoptera (PET) taxa richness were generally low with a high percent tolerant taxa. SIGNAL scores were correspondingly low and consistent with the expected results for ephemeral streams in an agricultural setting. The AusRivAS

predictive modelling found the aquatic environments to be significantly impaired through to highly degraded. Ephemeral creeks are commonly known to have impaired habitats as a result of limited water availability and separation of micro-habitats. Based on the extent and severity of this impairment, the assessment indicates poor water quality and low availability of macroinvertebrate habitat was present.

Aquatic Habitat Condition

The habitat bioassessment identified most sampling sites as having moderate biological health with evidence of bank erosion, and sparse vegetative cover; whilst the remainder were either poor or good, with none as excellent. This assessment indicates a primarily low to moderate quality of habitat available and correlates with the general low diversity and abundance of aquatic fauna present.

The condition assessment revealed most sites had a moderate to major impact from localised influences such as clearing practices disturbing or removing the riparian zone, erosion from cattle access and increased run-off (due to clearing practices), and ephemeral waterways being vulnerable to frequent instream and geomorphological changes. All sites had an indiscernible or minor influence from local or regional upstream major industries (i.e., mining, agriculture, water extraction etc) or urbanisation, with the exception of few sites with farmer dams slightly upstream.

Species of Conservation Significance

Database searches identified four fauna species of conservation significance with potential to occur within 50 km of the study area. No aquatic flora of conservation significant were identified by the desktop searches.

The *Aquatic Ecology Assessment* (AARC 2020a) (Appendix K) confirmed the absence of threatened aquatic fauna or flora within the study area. This is consistent with the highly ephemeral nature of watercourses and the disturbed condition occurring as a result of past clearing and agricultural land use.

The *Rheodytes leukops* (Fitzroy River turtle) was previously identified as potentially impacted by the 'Dingo West Project', subject to the particular manner in which the Project is undertaken (EPBC Referral Decision (2010/5775)). This was based on the likely habitat for the turtle occurring approximately 54 km downstream of the Project. The *Aquatic Ecology Assessment* (AARC 2020a) (Appendix K) confirmed that the species did not inhabit watercourses within or immediately downstream of the Project and concluded that suitable habitat for the species was not present. From this survey, the *QEOP: Significant Residual Impact Guideline* (EHP 2014) was used to determine whether or not the impacts of the Project will, or is likely, to have a significant residual impact on the Fitzroy River turtle. The assessment found the Project is considered unlikely to result in a significant residual impact.

Fish Passage

The *Queensland Waterways for Waterway Barrier Works* (DAF 2013) identifies watercourses within the Project as providing value for fish passage mapped as moderate to major risk to proposed infrastructure. Despite watercourses within the study area only containing water for very short periods of the year (post rainfall), during a flow event Charlevue Creek and Springton Creek would be utilised by fish species.

Fish passage was assessment using the *QEOP: Significant Residual Impact Guideline* (EHP 2014) to determine whether or not the impacts of the Project will, or are likely to, have a significant residual impact. The assessment identified that the Project is unlikely to result in a significant residual impact on waterways providing for fish passage. Additionally, there are no known migratory aquatic species likely to rely on the watercourses for regular movement or as access to known breeding locations.

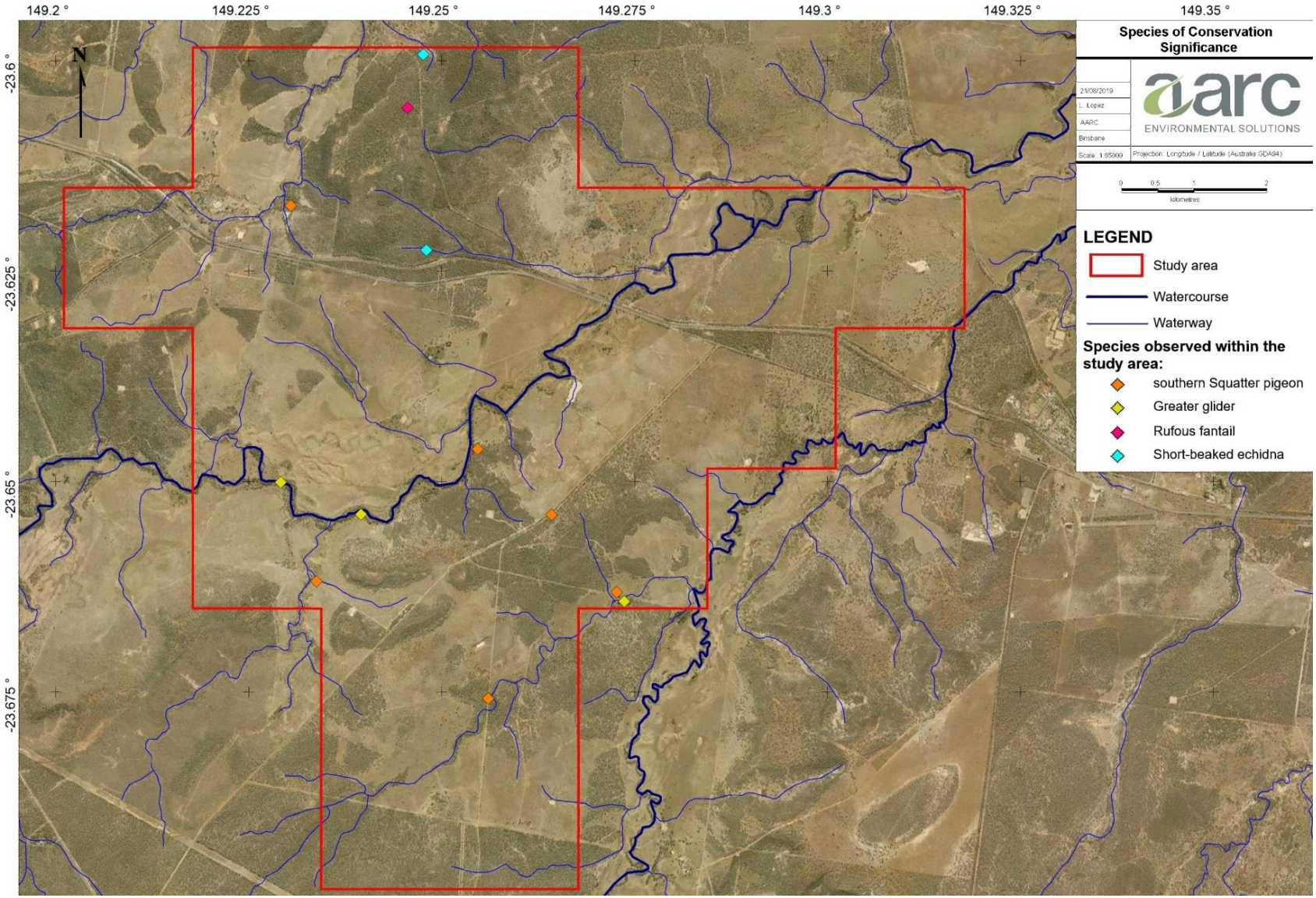


Figure 54 Locations of Fauna Species of Conservation Significance

6.3 POTENTIAL IMPACTS

6.3.1 Terrestrial Flora

Vegetation Communities

The Project will include vegetation clearance and land disturbance during the construction and operation of the mine. The extent of land disturbance would be approximately 1953 ha, of which, approximately 711 ha of remnant vegetation clearing is required over the life of the Project.

Other potential impacts to vegetation communities include:

- removal of habitat for terrestrial flora and fauna;
- further habitat fragmentation and loss of connectivity. It is noted that existing vegetation clearing due to agricultural land use has already limited habitat connectivity due to the highly fragmented remnant vegetation remaining on site; and
- potential for reduced condition of neighbouring vegetation communities due to the introduction of weeds or the release of contaminants associated with mine operations.

Flora Species of Conservation Significance and Habitat

Cerbera dumicola has been identified during the vegetation surveys in two very localised rocky areas associated with VC2 and VC1 (Figure 53). This species was not identified elsewhere in the study area.

The proposed mining activity proposes no impacts to populations of *Cerbera dumicola*.

Weed Species

Project development has the potential to create or enhance conditions for invasive weed species, which may spread and out-compete native and pasture species. Weed species may be introduced via the spread of seed on persons, vehicles and equipment, and may quickly colonise disturbed areas if left untreated.

The introduction of weed species can reduce native species abundance and diversity through competition. This can lead to the reduced condition of vegetation and native fauna habitat.

Wetlands

The Project has potential to impact on wetlands via:

- direct clearing;
- changes in hydrology;
- erosion and sedimentation; and
- contaminant release.

Groundwater Dependent Ecosystems

Where wetlands exhibit a degree of dependence on groundwater for survival, drawdown from the mine can result in a reduced ecosystem condition, changes to vegetation composition or die back.

Water quality data, groundwater level and groundwater drawdown estimation (JBT 2019) (Appendix C) were to assess GDEs and the associated impact of drawdown (AARC 2020b) (Appendix J).

Data from the *Groundwater Dependent Ecosystem Assessment* (Appendix F) together with the data obtained over several studies by JBT Consulting (Appendix C) were used in the assessment of the GDEs and the associated impact of drawdown.

Potential Impacts on GDEs within the study area

The GDEs identified within the study area are riverine type wetlands, including riparian vegetation on watercourses and floodplains.

The impacts identified to the GDEs within the study have been assessed within the GDE study (Appendix F) and summarised below:

- Direct clearing: the GDE located within the tributary of Springton Creek falls within the footprint of the mine and therefore subject to unavoidable vegetation clearing. Direct impacts on riparian vegetation (vegetation clearing) have been addressed above in this section. Impact mitigation as well as offsets requirements have been addressed in Sections 8.1.1.1 and 9.1.1 respectively of Appendix J.

- Groundwater drawdown: groundwater modelling estimated that the Project has the potential to cause a maximum drawdown of 5 m (steady-state post-mining drawdown) at some locations below the Charlevue and Springton Creeks (Appendix C), on the Tertiary and alluvial sediments (regional groundwater table). This drawdown will not have an impact on the riparian habitat identified as GDE within Charlevue Creek based on the limited hydraulic connectivity between the regional groundwater table and the perched aquifer that supports the GDE (Appendix F). Further, considering that the Project's is situated downstream of the Charlevue Creek's GDE and there will be no loss of catchment area, it is unlikely the Project will reduce the surface flows that replenish the associated perched aquifer (Appendix F).

6.3.2 Terrestrial Fauna

Fauna Species of Conservation Significance and Habitat

Field surveys across the study area detected the presence of four fauna species of conservation significance. Three of these species are listed under the NC Act, the southern Squatter pigeon (*Geophaps scripta scripta*), the Greater glider (*Petauroides volans*) and the Short-beaked echidna (*Tachyglossus aculeatus*) whilst the Rufous fantail (*Rhipidura rufifrons*) is listed as Migratory species under the EPBC Act).

Potential impacts of the Project to threatened fauna species include:

- direct clearing of habitat within the Project defined impact areas;

- further habitat fragmentation and loss of connectivity, particularly along Charlevue Creek which provides partial connectivity to larger downstream riparian communities. It is noted that existing vegetation clearing due to agricultural land use has already limited connectivity within this community;

- potential for fauna mortality through interactions with vehicles on roads and/or heavy machinery used for land clearing;

- potential for habitat degradation through increased risk of release of contaminants or sediments into receiving environments within and downstream of the Project; and

- potential for increased invasive flora and fauna.

Southern squatter pigeon (Geophaps scripta scripta)

Suitable habitat for the southern Squatter pigeon exists in open grassy woodland throughout the study area. Within this suitable habitat, fifteen birds were observed during the ecological surveys; the majority during spring 2017. The species is regionally abundant, having been observed outside of the study area on multiple occasions, with the species observed multiple times on local roads and elsewhere in the local area. No breeding activity was observed within the study area.

It is unlikely that the proposed Project will have a significant impact on the southern squatter pigeon; either the local population or the population in its entirety due to:

- the species being highly mobile;

- the abundance of equivalent and more suitable habitat outside of the study area in adjacent areas;

- the observed high local abundance of the southern squatter pigeon within and surrounding the study area; and

- the likely suitable habitat to be provided by rehabilitated land, post mining.

Greater glider (Petauroides volans)

The preferred habitat of the greater glider consists of tall, montane, moist eucalypt forests with relatively old trees and abundant hollows. It favours forests with a diversity of eucalypt species, due to seasonal variation in its preferred tree species. Critical microhabitat is an abundance of large hollows in large, old trees for daily denning shelters and breeding purposes. The species is absent from cleared areas and has little ability to disperse between fragments across cleared areas, with habitat connectivity critical to species survival (TSSC 2016).

Suitable habitat for the great glider within the study area is confined to the Eucalypt riparian woodlands such as along the Charlevue Creek; that features tall open woodland containing hollows and a sparse shrub layer.

It is unlikely that the proposed Project will have a significant impact on the greater glider; either the local population or the population in its entirety due to:

- no significant impact proposed to habitat within the study area, specifically Charlevue Creek. Proposed disturbance within this habitat is limited to the development of a small culvert crossing;

- the observed abundance of greater gliders within the study area and within the broader central Queensland region; and

- the abundance of equivalent and more suitable habitat outside of the study area in adjacent areas.

Short-beaked echidna (Tachyglossus aculeatus)

The Short-beaked echidna is found in a variety of habitat types including open forests, grasslands and heavily vegetated woodlands. Suitable habitat for the species exists across the study area.

It is unlikely that the proposed Project will have a significant impact on the short-beaked echidna, either the local population or the population in its entirety due to:

- the known abundance and wide-ranging distribution of the species;
- the presence of ample equivalent or better suited habitat surrounding the Project;
- the relatively small extent of impact proposed by the Project; and
- the likely suitable habitat to be provided by rehabilitated land, post mining.

Rufous fantail (Rhipidura rufifrons)

The Rufous fantail is generally found in rainforest, dense wet forests, swamp woodlands and mangroves, preferring deep shade, and is often seen close to the ground. During migration, it may be found in more open habitats, such as those within the study area.

It is unlikely that the proposed Project will have a significant impact on the rufous fantail, either the local population or the population in its entirety due to:

- the rufous fantail is a common and secure species (Blakers, Davies & Rielly 1984);
- the study area does not contain the preferred habitat type for the species;
- the species is highly mobile and likely only passing through the Project on its migratory path;
- no known breeding sites or nesting habitat was identified on the study area; and
- ample equivalent or higher quality habitat exists surrounding the study area.

It should be noted that the Rufous fantail is listed migratory under the EPBC Act and is not listed under the NC Act. For the purpose of this assessment, only listed species under the NC Act are further assessed, and therefore the Rufous fantail has not been discussed further.

Pest Species

Pest species compete with, and prey on native fauna. Construction and operation of the Project increases the risk of pest species on the study area through:

- generation of food and other waste that may attract pests; and
- creation of artificial ponding areas providing habitat for pest species such as cane toads.

6.3.3 Aquatic Ecology

The aquatic ecology values within the study area are limited to riverine ecosystems including Charlevue Creek, Springton Creek, and some tributaries. The creeks are highly ephemeral, experiencing periodic flows only following heavy or repeat rainfall events. Past clearing for agricultural purposes has been undertaken across much of the study area including the removal of riparian vegetation. The removal of

riparian vegetation and direct stock access to the waterways has resulted in bank instability, erosion and occurrence of weeds.

The Project has potential to impact on aquatic ecology values through:

- the release of MAW to the receiving waterways and associated impacts to ecosystem health;
- potential for spills and leaks from the mining operation to cause contamination in the receiving waterways;
- direct impacts to riverine ecosystems via land disturbance for vehicle crossings or diversion of drainage features;
- risk of increased erosion from cleared lands or mine infrastructure such as spoil dumps, resulting in increased sediment loads entering the aquatic ecosystems; and
- impediments to fish or other aquatic fauna movements due to the construction of crossings or other infrastructure.

6.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING

6.4.1 Terrestrial Flora

Vegetation Communities

To minimise and mitigate impacts to vegetation communities on the Project the following management strategies will be implemented:

- clearing of land and vegetation will be limited to areas defined in the Project approval and required for safe operation; and managed through:
    - an internal *Land Disturbance Permit System* will be implemented to minimise the chances of unauthorised clearing; and
    - areas to be cleared will be clearly defined and demarked to equipment operators;
- inductions and training materials provided to employees will identify the EVs of the site as well as the company procedures for managing impacts within its authority;
- rehabilitation will be undertaken progressively and will aim to return the land to the pre-mining land use where possible; and
- where impact to Matters of State Environmental Significance (MSES) cannot be avoided and are authorised by the Project approval, environmental offsets will be provided.

Flora Species of Conservation Significance

Suitable habitat for the *Cerbera dumicola* exists to the west of the Project, within the MLA. The proposed mine construction and development will not impact on the populations. To ensure no inadvertent impacts to *Cerbera dumicola* the following management strategies will be implemented:

- an internal *Land Disturbance Permit System* will be implemented to minimise the chances of unauthorised clearing and impacts to the populations within the MLA;

- inductions and training materials provided to employees will identify the EVs of the site as well as the company procedures for managing impacts within its authority; and

- existing populations will be monitored for abundance, distribution and health over the mine life.

It should be noted that the Rufous fantail is listed migratory under the EPBC Act and is not listed under the NC Act. For the purpose of this assessment, only listed species under the NC Act are further assessed, and therefore the Rufous fantail has not been discussed further.

Weed Species

To control the abundance and spread of weed species the following management strategies will be implemented:

- a *Weed and Pest Management Plan* will be prepared and implemented prior to construction (refer to section 4.7.4 for full description);

- as required, weeds within the MLA will be controlled using herbicides and other recommended methods;

- inductions and training materials provided to employees will assist the identification of common weeds and will include procedures for reporting; and

- access to vehicle wash down facilities will be provided for vehicles at risk of spreading weeds.

Wetlands/GDEs

Wetlands/GDEs include riverine vegetation on the MLA, particularly riparian vegetation associated with Charlevue and Springton creeks. In addition, a HES wetland is located to the southeast of the Project. To manage potential impacts on wetlands, the following will be undertaken:

- sediment and erosion control structures will be installed and maintained near all at risk areas to prevent sediment release to wetlands;

- a REMP has been developed for the project (Appendix Q), and will be implemented including monitoring of water, sediments, riparian/riverine vegetation health and biological indicators in aquatic environments;

- the release of MAW will be in accordance with the quality controls provided in the *Model Mining Conditions* (DES 2017e) and the Project's EA conditions;

- the development of a SWMS and associated ESCP; and

- groundwater bores adjacent to Charlevue Creek (DW7076W) and Springton Creek (DW7292W1), have been fitted with dataloggers. This data will allow the assessment of the range of water levels within the alluvium and the response of groundwater levels within the alluvium to rainfall recharge, stream flow events and mining activities.

6.4.2 Terrestrial Fauna

Fauna Species of Conservation Significance

Fauna species of conservation significance identified on the Project include; the southern Squatter pigeon (*Geophaps scripta scripta*), the Greater glider (*Petauroides volans*), the short-beaked echidna

(*Tachyglossus aculeatus*) and the Rufous fantail (*Rhipidura rufifrons*) (migratory). The proposed mine construction and development will not have a significant impact on these Species. To ensure no inadvertent impacts occur the following management strategies will be implemented:

- an internal *Land Disturbance Permit System* will be implemented to minimise the chances of unauthorised clearing and impacts to the threatened fauna within the MLA;
- inductions and training materials provided to employees will identify the EVs of the site as well as the company procedures for managing impacts within its authority;
- vehicles speeds will be limited within the MLA, to minimise the risk of collision;
- vegetation clearing will be done in a staged manner, allowing time for fauna to leave the area; and
- pre-clearing inspections will be undertaken by qualified staff to minimise the risk of fauna mortality.

Pest Species

To prevent the introduction of pest species and to control their spread, the following management strategies will be implemented for the Project:

- a *Weed and Pest Management Plan* will be prepared and implemented prior to construction (refer to section 4.7.4 for full description);
- rubbish and food scraps will be managed so as not to encourage pest species;
- inductions and training materials provided to employees will assist the identification of common pests and will include procedures for reporting; and
- control of feral cats and other animals will be undertaken within the MLA.

6.4.3 Aquatic Ecology

Aquatic ecology values are primarily attributed to Charlevue Creek and Springton Creek within the MLA. The following mitigation measures will be implemented to protect existing values:

- sediment and erosion control structures will be installed and maintained near all at risk areas to prevent sediment release to wetlands;
- fish passage will be managed during all phases, such that:
    - crossing design should provide for the fish passage during low and high flow events:
    - crossing design will be developed upon finalisation of the Mine Design Plans. Crossing designs for fish passage will be designed in accordance with the management measures in the *Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works* (DAF 2018b) (i.e., using box culverts to permit crossing during low flow events, enabling fish passage to be maintained within / through the Project area) and the performance outcomes detailed in State Code 18: Constructing or raising waterway barrier works in fish habitats (DILGP 2020)

  - upon finalisation of crossing design plans by a suitably qualified person development approval will be sought in accordance with the *Planning Act 2016*.

- the release of MAW, will be in accordance with the quality controls provided by the *Model Mining Conditions* (DES 2017e);

- fuel and hazardous liquids will be stored in a bunded facility, in accordance with relevant Australian Standards;

- an *Emergency Response and Spill Management Plan* will be implemented during construction and operation to minimise the risk of contaminant release to aquatic ecosystems;

- open-cut pits will be appropriately bunded or located in a manner that prevents surface water from entering the voids during a 1:1000-year flood event and dams will be appropriately bunded or located in a manner that prevents surface water from entering or damaging the dams during a 1:1000-year flood event. *This is consistent with the EPBC Referral Decision: not a controlled action if undertaken in a particular manner;* and

- a REMP will be implemented and will include monitoring of water, sediments, riparian/riverine vegetation health and biological indicators in aquatic environments.

6.5 ENVIRONMENTAL OFFSETS

The offsets framework requires environmental offsets to be delivered where an activity is likely to result in a significant residual impact on a prescribed environmental matter. The *Queensland Environmental Offset Policy Significant Residual Impact Guideline* (EHP 2014) was used to determine whether Project impacts are considered to be significant. This guideline outlines the criteria for identifying when an impact on a prescribed environmental matter (i.e., MSES) may be significant. The significant impact criteria provide a trigger for consideration of offsets (EHP 2014).

As part of the ecological assessments (AARC 2020a; AARC 2020b), significant impact assessments were conducted for all prescribed environmental matters identified in the study area. A summary of results from the assessment is provided in Table 36, and the full assessments can be found in Appendix J and Appendix K.

Of the prescribed matters that will be significantly impacted by the proposed disturbance further details of the impact assessment and offset requirements are summarised in Table 37.

Magnetic South is committed to delivering environmental offset requirements for matters with a significant residual impact as a result of the Project. Offsets will be delivered as either a financial settlement or proponent-driven offset (i.e., a land-based offset or *Direct Benefit Management Plan*), or a combination of both.

Table 36 Summary of Project MSES and Likelihood of Significant Residual Impact

Protected Matter		NC Act Status	VM Act Status	Likelihood of Occurrence Within Study Area	Likelihood of Significant Impact
Of concern RE 11.3.2		n/a	OC	Present	Yes
REs located within the defined distance from the defining banks of a VM Act watercourse		n/a	n/a	Present	Yes
Connectivity area		n/a	n/a	Present	Yes
Wildlife Habitat and Essential Habitat	Southern squatter pigeon	V	n/a	Present	No
	Greater glider	V	n/a	Present	No
	Short-beaked echidna	SLC	n/a	Present	No
Waterways providing for Fish Passage		n/a	n/a	Present	No
HES Wetlands		n/a	n/a	Not present	No

Notes:
n/a not applicable
OC of concern
NT near threatened
V vulnerable
SLC special least concern

Table 37 Summary of MSES Impact Assessment and Gemini Project Offset Requirements

MSES	Total Impact Area (ha)	Impact Assessment	Offset Requirement	Habitat Description
Of concern RE11.3.2	2.57	Clearing is non-linear and exceeds the clearing threshold.	Offset Required	This vegetation community was characterised by *Eucalyptus populnea* (poplar box) woodland on alluvial plains. It was represented in several small to moderate patches within the study area and is subject to pressures from grazing, exotic species invasion.
REs located within the defined distance from the defining banks of a VM Act watercourse	58.32	Clearing of watercourse vegetation is required. The clearing widths and areas exceed significant impact guidelines. REs supporting watercourse vegetation includes RE 11.3.25, RE 11.5.2, RE 11.3.2 and RE 11.7.2.	Offset Required	A number of VM Act watercourses traverse the MLA. Impacts will occur to watercourse vegetation that is associated with RE 11.3.25, RE 11.5.2, RE 11.3.2 and RE 11.7.2.
Connectivity area*	710.72	The *Landscape Fragmentation and Connectivity Tool** was applied to the proposed extent of disturbance area. The results found that significant impact would occur to connectivity at both local scale and to core remnant areas.	Offset Required	The *Landscape Fragmentation and Connectivity Tool* determined that there is significant impact to the connectivity of the remnant vegetation within the Project.

Notes: * *Landscape Fragmentation and Connectivity Tool* is based on current government mapping.

7.0 SURFACE WATER

This section provides a description of the existing surface water values within and surrounding the Project. It aims to identify the Project's potential impacts on the existing values and propose mitigation measures and management strategies to prevent or minimise adverse environmental effects.

This section is informed by the *Surface Water Assessment* (WRM 2020b) presented in Appendix B. A *Flood Impact Assessment* (WRM 2020a) was also conducted to inform the *Surface Water Assessment* (WRM 2020b).

Surface water values pertaining to flora, fauna and wetlands are addressed in Section 6.0.

7.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES

The environmental objective relevant to potential impacts to surface water as described in the EA guideline for *Application requirements for activities with impacts to water [ESR/2015/1837]* (DES 2017c) is:

The activity will be operated in a way that protects the environmental values of waters.

The Project would achieve all of the following performance outcomes identified in Schedule 8, Part 3, Division 1 of the EP Regulation:

a) *the storage and handling of contaminants will include effective means of secondary containment to prevent or minimise releases to the environment from spillage or leaks;*

b) *contingency measures will prevent or minimise adverse effects on the environment due to unplanned releases or discharges of contaminants to water;*

c) *the activity will be managed so that stormwater contaminated by the activity that may cause an adverse effect on an environmental value will not leave the site without prior treatment;*

d) *the disturbance of any acid sulphate soil, or potential acid sulphate soil, will be managed to prevent or minimise adverse effects on environmental values;*

e) *acid producing rock will be managed to ensure that the production and release of acidic waste is prevented or minimised, including impacts during operation and after the environmental authority has been surrendered;*

f) *any discharge to water or a watercourse or wetland will be managed so that there will be no adverse effects due to the altering of existing flow regimes for water or a watercourse or wetland; and*

g) *the activity will be managed so that adverse effects on environmental values are prevented or minimised.*

Of the performance outcomes described above, (d) assessment of acid sulphate soils is addressed in Section 5.0, (e) assessment of acid producing rock is addressed in Section 13.0 and (f) assessment of impacts to wetlands are addressed in Section 6.0.

7.2 DESCRIPTION OF ENVIRONMENTAL VALUES

The following documents were consulted to assist in identification of the surface water EVs for the Project:

- *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*;
- *Environmental Protection (Water) Policy 2009 Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin* (EHP 2011a); and
- *Water Resource (Fitzroy Basin) Plan 2011*.

The EPP (WWB) is the primary instrument for surface water management under the EP Act; it governs discharge to land, surface water and groundwater, aims to protect EVs and sets water quality guidelines and objectives.

Schedule 1 of the EPP (WWB) outlines the *Environmental Protection (Water) Policy 2009 Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin* (EHP 2011a) as the relevant document for defining EVs and WQOs for the Project region, as described in Section 7.2.3.

The *Water Resource (Fitzroy Basin) Plan 2011* sets out the allocation and sustainable management of water resources in the Fitzroy Basin. The plan also identifies outcomes for sustainable management of water, the water plan area, general and specific surface water and groundwater outcomes, as well as general and specific ecological outcomes.

7.2.1 Drainage Network

The Project area lies within the Fitzroy River Basin, which encompasses an area of 142,545 km^2 and contains the Comet, Connors, Dawson, Don, Nogoa and Mackenzie Rivers, which make up its six sub-catchment areas (BoM 2018; DES 2018b). The study area lies within the Mackenzie River catchment, which covers a total area of 12,985 km^2, and is situated in the centre of the Fitzroy River Basin (Figure 55).

The Project area also lies within the local site catchments of Springton Creek and Charlevue Creek (Figure 56). Charlevue Creek flows through the Project area in a northeast direction. This watercourse begins within the boundaries of Blackdown Tablelands National Park, flowing northeast before joining with Springton Creek and the Fitzroy River, and eventually flows into the Pacific Ocean approximately 46 km north of Gladstone. Springton Creek flows though the Project area in a north-northeast direction. These two creeks eventually converge with the Mackenzie River. First and second order streams associated with Charlevue Creek and Springton Creek also occur in the study area.

Stanley Creek traverses the northwest corner of the Project area and flows in a northeast direction to join with Duckworth Creek (offsite), which then joins with Springton Creek further downstream of the Charlevue - Springton Creek confluence (Figure 57).

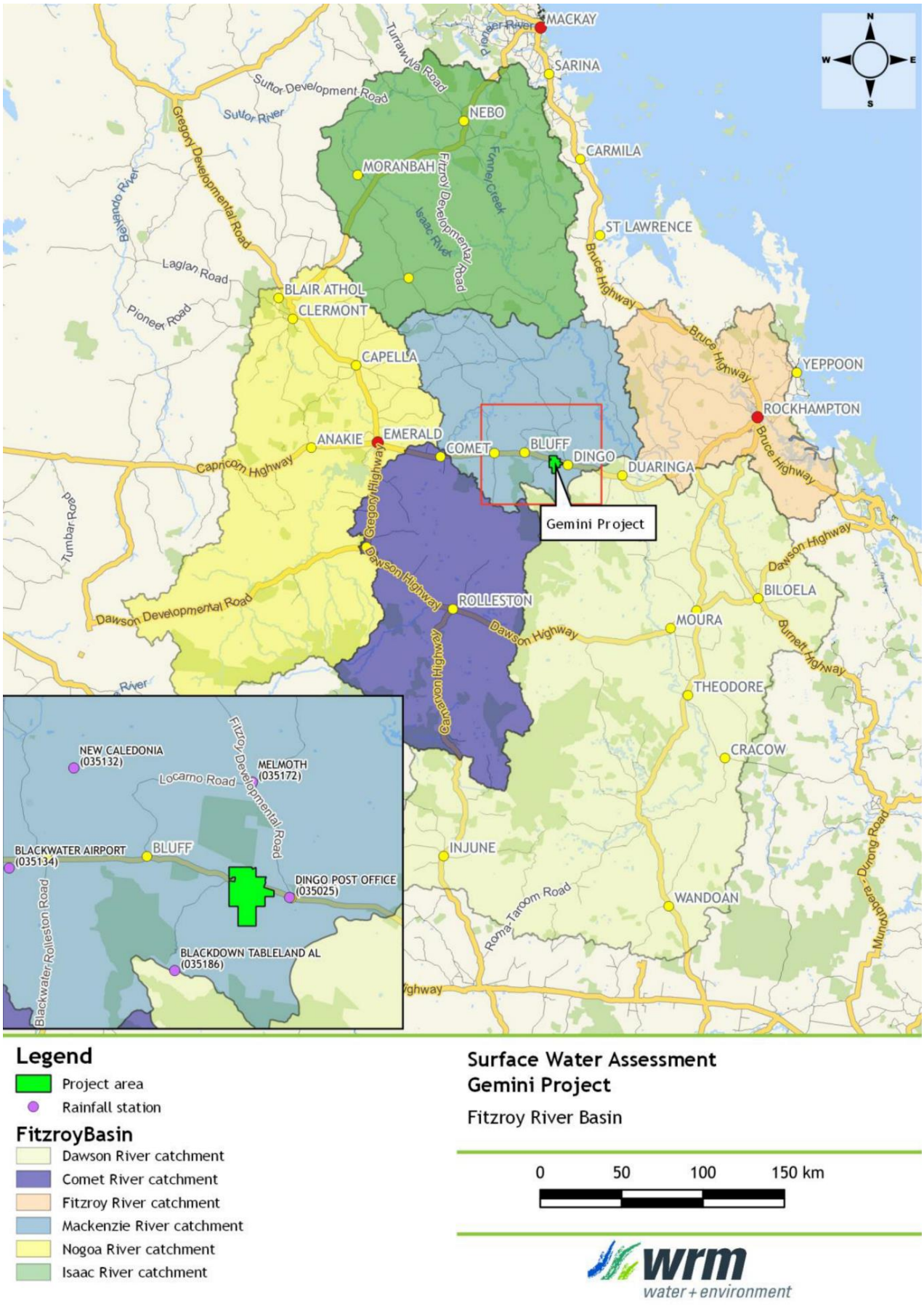


Figure 55 Fitzroy River Basin

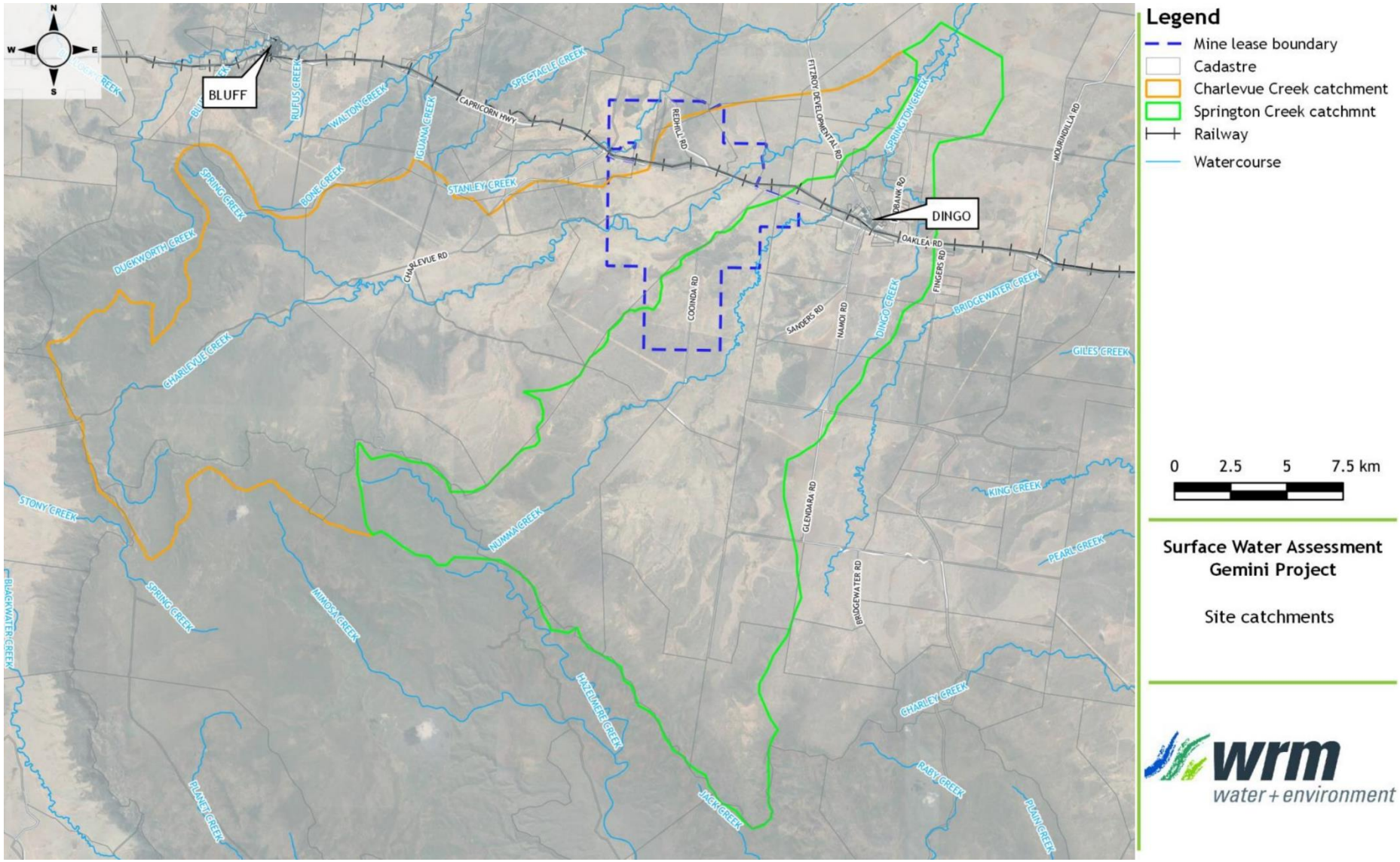


Figure 56 Local Catchments

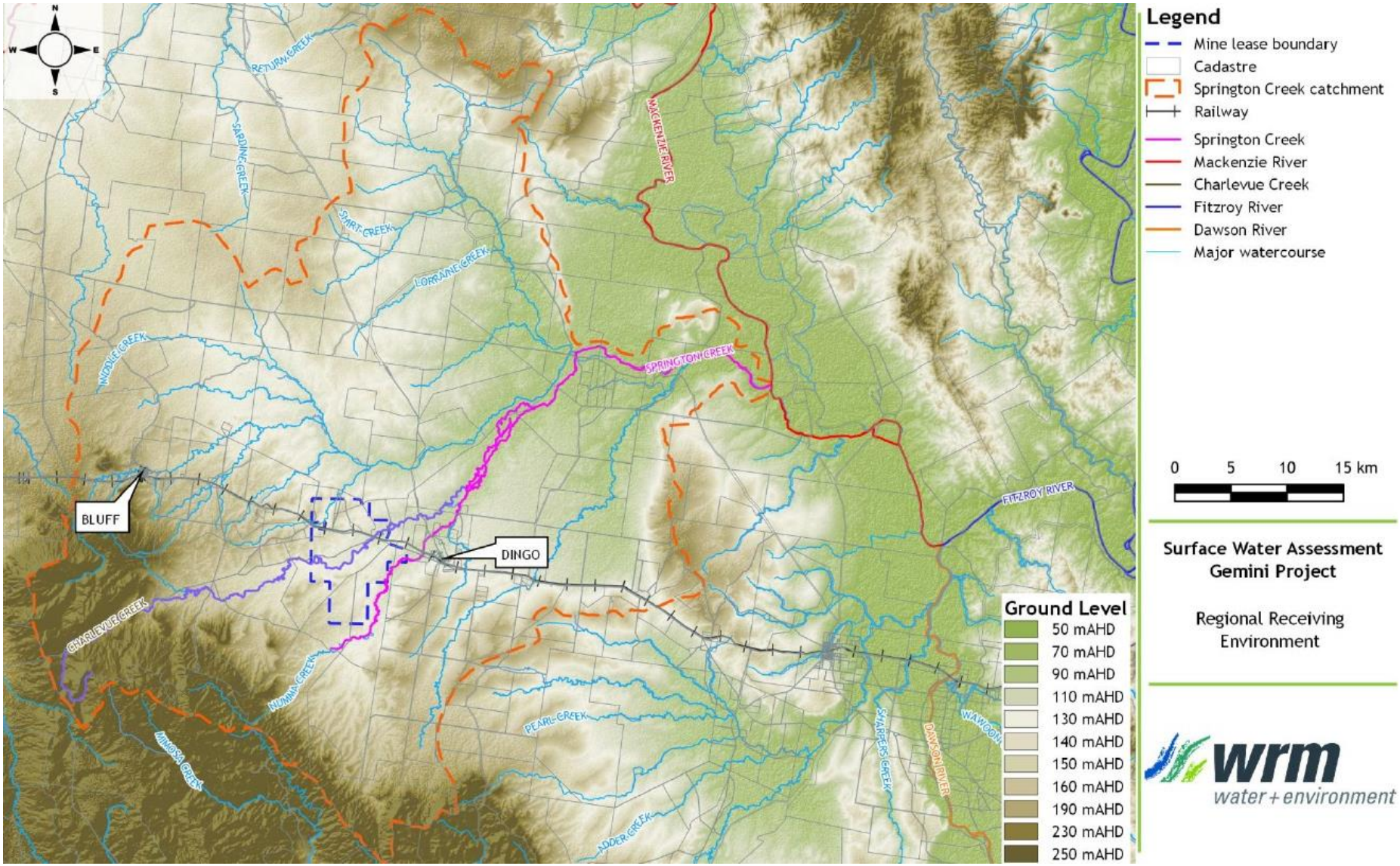


Figure 57 Regional Receiving Environment

Local Stream Morphology

All local waterways are ephemeral, with streamflow mostly occurring shortly after rainfall between September and April. Stream flows are highly variable, with most channels remaining dry during winter to early spring when rainfall and runoff is low, although some pools hold water for extended periods. Typical depth of channels reaches up to 0.8 m and a channel widths range between 1.2 and 3.5 m.

Within the Project, Springton Creek and Charlevue Creek cross alluvial floodplains. The reaches of Springton Creek and Charlevue Creek in the proposed mining area have well-defined channels, typically characterised of predominant sandy beds with a mixture of silt and clay at varying proportions, and well-established riparian vegetation.

The riparian vegetation constituted a mixture of low to moderate disturbance and were located within remnant and non-remnant environs. Disturbance of clearing for agricultural purposes and direct stock access to waterways have contributed to bank instability, erosion and occurrence of weeds. Further details are addressed in Section 6.0.

Topography of the surrounding land varies from flat to undulating, with elevation within the Project ranging from 120-150 mAHD. The landscape is influenced by Charlevue Creek, which has a lower elevation than the surrounding landscape.

7.2.2 Wetlands

The assessment of wetlands within and outside of the Project area is provided in Section 6.0, along with the description of potential impacts and mitigation measures proposed. To avoid duplication, no further discussion of wetlands is included in this section.

7.2.3 Surface Water Quality

Regional Water Quality Objectives

The document *Environmental Protection (Water) Policy 2009 for the Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin* (EHP 2011a) provides WQOs to support and protect the different EVs identified for waters within the Mackenzie River southern tributaries of the Mackenzie River sub-basin. Ten EVs are nominated broadly to the mapped areas of this zone, of which the following are relevant to the Project and its receiving waters:

- aquatic ecosystems (slightly to moderately disturbed (SMD)); and
- water suitable for stock watering.

The guideline WQOs for the protection of aquatic ecosystems and for stock watering are provided in Table 38. Collected water samples in February 2018 and April 2019 have been compared to these WQO values to characterise the existing water quality of the site-specific waterways and drainage features.

Table 38 WQO Guideline Values

Mackenzie River Sub-basin EVs and WQO Basin No. 130 (part)		
Management Intent (Level of Protection)	**WQOs to Protect EV**	
	Parameter	**Water Quality Objective**
Aquatic ecosystem *(moderately disturbed)*	**Water**	
	Ammonia N	<20 µg/L
	Oxidised N	<60 µg/L
	Organic N	<420 µg/L
	Total nitrogen	<7 µg/L
	Filterable reactive phosphorus	<20 µg/L
	Total phosphorus	<160 µg/L
	Chlorophyll a	<5.0 µg/L
	DO	85-110% saturation
	Turbidity	<50 NTU
	Suspended solids	<110 mg/L
	pH	6.5-8.5
	Conductivity (EC) baseflow	<310 µS/cm
	Conductivity (EC) high flow	<210 µS/cm
	Sulphate	<10 mg/L
	Macroinvertebrates	
	Taxa richness (composite)	12-21
	Taxa richness (edge habitat)	23-33
	PET taxa richness (composite)	2-5
	PET taxa richness (edge habitat)	2-5
	SIGNAL index (composite)	3.33-3.85
	SIGNAL index (edge habitat)	3.31-4.20
	% tolerant taxa (composite)	25-50%
	% tolerant taxa (edge habitat)	44-56%
Stock watering	**Water**	
	Total dissolved solids	3000 mg/L
	Aluminium	5 mg/L
	Arsenic	0.5 (up to 5) mg/L
	Beryllium	*not determined**
	Boron	5 mg/L
	Cadmium	0.01 mg/L
	Chromium	1 mg/L
	Cobalt	1 mg/L
Stock watering (cont.)	Copper	0.4 mg/L (sheep) 1 mg/L (cattle) 5 mg/L (pigs) 5 mg/L (poultry)
	Fluoride	2 mg/L

Mackenzie River Sub-basin EVs and WQO Basin No. 130 (part)		
Management Intent (Level of Protection)	**WQOs to Protect EV**	
	Iron	*not sufficiently toxic*
	Lead	0.1 mg/L
	Manganese	*not sufficiently toxic*
	Mercury	0.002 mg/L
	Molybdenum	0.15 mg/L
	Nickel	1 mg/L
	Selenium	0.02 mg/L
	Uranium	0.2 mg/L
	Vanadium	*not determined**
	Zinc	20 mg/L

Notes: N nitrogen
NTU Nephelometric Turbidity Units
* insufficient background data to calculate

Local Surface Water Quality Assessment

As part of an ongoing surface water monitoring program implemented at the site in 2018, water quality sampling across Charlevue Creek, Springton Creek and Stanley Creek included field readings of pH, EC and temperature and has occurred following two flow events to date. Surface water samples were also collected at each waterway that contained standing or flowing water. Location of the survey sites are displayed in Figure 59.

Flow data is unavailable for the period preceding the sampling events, however, results of the site water balance model have been used to estimate the relative magnitude of the flow events occurring in the days prior to the samples being taken.

As runoff was observed to have essentially ceased at the time of sampling, the modelled runoff for the 'undisturbed' catchment type over the 7 days prior to the sampling events on 23 February 2018 and 8 April 2019 was compared to the range of modelled weekly totals estimated over the period of climate record from 1889. The results are plotted in Figure 58 below, which shows that during both periods the modelled runoff would have been exceeded in the wettest 3% to 4% of weeks in the climate record (noting that runoff greater than 1 mm/week would only occur about 6% of the time).

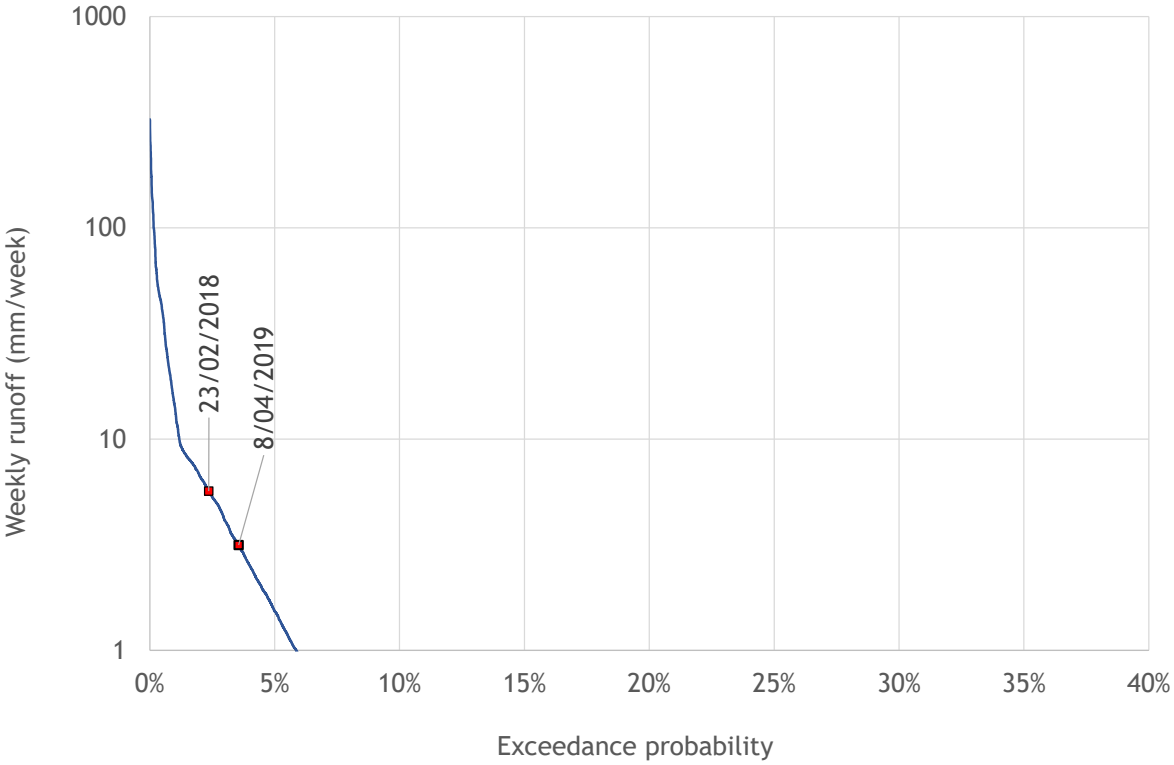


Figure 58 **Water Quality Monitoring Dates on Flow Frequency Curve**

Samples were analysed at a National Association of Testing Authorities (NATA) accredited laboratory for various physico-chemical parameters, metals, nutrients, hydrocarbons and pesticides and assessed against WQOs. Exceedances of WQOs are highlighted orange in Table 39 and Table 40.

Exceedances of WQOs for turbidity across all sites and years were observed, which can be attributable to soil erosion, runoff, pollution and algal blooms; however, some waterways can have naturally high levels of suspended solids and turbidity (Fondriest Environmental Inc. 2014).

Low levels of dissolved oxygen were observed across most sampling sites in 2018 and 2019. The low levels of dissolved oxygen were recorded in stagnant pools along ephemeral waterways, which naturally experiences dissolved oxygen values below 50% saturation (EHP 2011a). Therefore, these exceedances are not a reliable indicator of the long-term health of the system.

Petroleum hydrocarbons across sampling sites at the three waterways exceeded WQO values during the 2018 survey. Site DWR5, which is located upstream of Charlevue Creek, recorded the highest exceedance of petroleum hydrocarbons, which is mostly likely attributable to the agricultural and pastoral land uses close to or at this site. Although there were no recorded exceedances during the 2019 survey, it will continue to be closely monitored due to the existing and consistent local source of petroleum hydrocarbons.

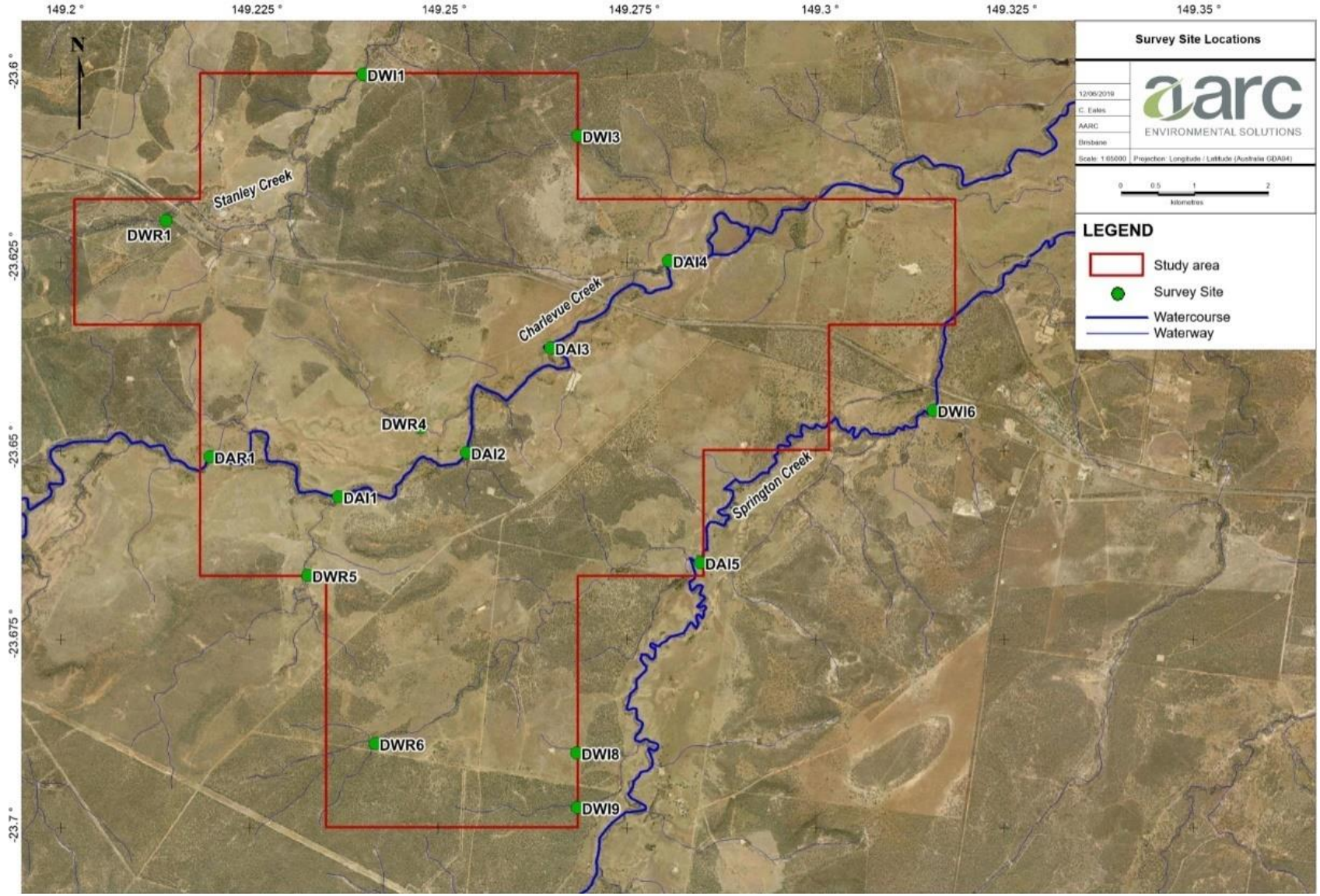


Figure 59 Surface Water Sampling Locations

Table 39 Physico-chemical Parameters (Charlevue Creek)

Parameter	Units	WQO	Charlevue Creek																			
			DAR1			DWR5			DAI1			DAI2			DWR4	DAI3			DAI4			DAI7
			2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	2020	2018	2019	2020	2018	2019	2020	2020
Temperature	°C	n/a	27.1	20.5	23.5	29.5	21.2	23.9	30.8	20.7	24.8	26	21	21.6	28.5	26.8	20.1	22.5	26.3	21.2	22.8	23.7
pH	pH unit	6.5 - 8.5[a]	7.27	7.12	7.36	7.28	6.27	7.26	6.63	6.24	7.57	6.91	6.37	7.12	7.04	6.92	6.78	7.55	6.87	6.58	7.38	7.20
EC (baseflow)	µS/cm	<310[a]	73.1	120.6	205.7	209.5	211.2	195.2	74.1	113.9	203.4	67	128.1	197.8	98.5	83.6	124.4	181.3	70.3	105.4	181.8	164.1
DO	%	85-110[a]	87	28	85.7	88	61	25.8	67	58	65.0	80	15	19.2	80.7	80	46	40.0	81	56	33.4	15.7
ORP	mV	n/a	140.5	179.8	124.5	205.4	203.8	151.3	228.7	197.8	134.5	269.3	160.6	101.4	43.5	198.3	184	119.6	137.4	210.8	106.8	130.7
SS	mg/L	<110[a]	58	172	36.0	8660	43	28	2080	131	18.0	880	228	22.0	166	6170	103	31.0	168	152	50.0	31.0
TDS	mg/L	3000[b]	45.6	85.8	122.0	125.3	147.9	114	43.5	80.6	120.0	42.8	90.1	125.0	55	51.9	89.3	111.0	44.6	73.8	110.0	98.0
Turbidity	NTU	<50[a]	387	12154.4	112	1231.6	23199	657	2050.3	13046.2	450	831.2	13896.6	128	330	2582.6	16031.5	184	506.3	13455.6	130	247
Ammonia	mg/L	<0.02[a]	0.02	0.1	0.04	0.28	0.43	1.35	0.04	0.23	0.02	0.09	0.07	<0.01	0.02	0.08	0.14	0.03	0.14	0.13	0.02	0.07
N (total)	mg/L	<0.007[a]	1.3	1.5	1.1	9.5	4.5	3.2	5.8	1.8	1.2	2.3	2.1	1.6	2.3	8.2	2	1.4	2.3	1.8	1.5	2
P (total)	mg/L	0.16[a]	0.31	0.6	0.18	3.94	0.72	0.16	1.91	0.66	0.17	0.87	0.84	0.3	0.79	2.92	0.84	0.27	0.4	0.75	0.22	0.25
P (reactive)	mg/L	<0.02[a]	0.07	0.03	<0.01	<0.01	0.03	<0.01	0.11	0.07	<0.01	0.06	0.04	0.02	0.03	0.01	0.04	0.01	0.05	0.06	<0.01	<0.01
Fluoride	mg/L	2[a]	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.3	0.2	0.1	0.3	0.2	<0.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2
SO^{4-}	mg/L	<10[a]	2	<1	<1	5	15	3	2	<1	<1	<1	<1	<1	<1	2	<1	<1	<1	1	<1	<1

Notes: a aquatic ecosystem WQO
b livestock drinking WQO
Orange cells denote an exceedance of the WQO

Table 40 Physico-chemical Parameters (Stanley Creek and Springton Creek)

Parameter	Units	WQO	Stanley & Duckworth Creek			Springton Creek							
			DWR1 (S)	DWR1 (N)	DAI8	DAR2	DWI9	DAI5			DWI6		
			2018	2018	2020	2020	2019	2018	2019	2020	2018	2019	2020
Temperature	°C	n/a	28.1	31.4	23.9	25.6	22.9	27.8	21	26.2	24.6	23.2	23.5
pH	pH unit	6.5 - 8.5[a]	6.61	7.61	7.30	7.00	6.11	6.84	6.28	7.07	7.34	5.95	7.35
EC (baseflow)	µS/cm	<310[a]	113.8	0.4	212.3	246.6	140.7	121.2	137.2	259.1	0.3	65	201.9
DO	%	85-110[a]	4	98	38.9	17.9	17.1	53	46	29	95.0	50	21.3
ORP	mV	n/a	98.2	147.1	138.9	146.8	116.5	242.5	220.9	97.4	158.6	222.8	80.2
SS	mg/L	<110[a]	106	145	65.0	22	238	852	68	40	215.0	86	41
TDS	mg/L	3000[b]	69.9	0.25	127.0	139	95.4	74.8	96.6	144	0.2	43.8	122
Turbidity	NTU	<50[a]	155.3	4.1	537	146	44098.4	3734.08	30580.5	311	21	10730.4	392
Ammonia	mg/L	<0.02[a]	0.12	0.13	0.008	0.04	0.9	<0.01	0.2	0.14	0.02	0.12	0.06
N (total)	mg/L	<0.007	1.4	2.2	1.3	1.1	4.9	3.5	4.1	1.8	1.4	1.6	1.6
P (total)	mg/L	0.16	0.32	0.43	0.28	0.14	1.11	1.5	2.15	0.25	0.27	0.47	0.24
P (reactive)	mg/L	<0.02	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Fluoride	mg/L	2[a]	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2
SO^{4-}	mg/L	<10[a]	10	2	3	<1	4	7	4	<1	<1	2	<1

Notes: a aquatic ecosystem WQO
b livestock drinking WQO
Orange cells denote an exceedance of the WQO

Given the higher carbon chain fractions being reported, possible sources include; crude oil, heavy fuel oils, lubricating oils, asphalts and pitch and even waxes and other related products. Sites DWR1 (Stanley Creek) and DWI6 (Springton Creek) occur along the Capricorn Highway, which is a possible point source for the petroleum hydrocarbons observed at these locations.

Macroinvertebrate diversity, abundance and PET richness were generally low, which is reflective of the system's low waterway health at time of sampling.

All laboratory analysis results for dissolved metals, total metals, and petroleum hydrocarbons are presented in Appendix K.

7.2.4 Stream Sediment Quality

Stream Sediment Quality Objectives

Baseline levels of metals in stream sediments provide an additional indication of waterway health. Stream sediment quality sampling was carried out at all sites in 2018 and 2019. Samples were tested for various contaminants and results were compared to the SQG values listed in *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG 2018) (Table 41).

Table 41 SQG Objective Values

Contaminant	Sediment Quality Guideline Value (mg/kg)	
	Low Value	High Value
Arsenic	20	70
Cadmium	1.5	10
Chromium	80	370
Copper	65	270
Lead	50	220
Nickel	21	52
Mercury	0.15	1
Zinc	200	410

7.2.4.1 Stream Sediment Characteristics

Stream sediment quality was well below the relevant SQG low and high trigger values for all parameters except nickel, which exceeded the SQG low trigger value at DWR6 during both years. This site is located along an unnamed waterway which feeds into Springton Creek at DAI5.

Particle size analysis and particle size classification demonstrated that Stanley Creek (DWR1) the stream sediment is predominantly sand with small amounts of clay and silt. However, further downstream along Stanley Creek (DWI1), sediment is characterised as sand (92-96%) with negligible presence of gravel, silt or clay.

Charlevue Creek stream sediment is characterised by high percentages of sand (56-94%) at the majority of sites with variable levels of clay (1-24%) and silt (1-17%). Though minor, the presence of gravel was recorded across the sites along Charlevue Creek. Sites DWR4, DAI2, and DAI5 presented lower levels of sand (9-45%), and higher percentages of clay (25-41%) and silt (17-66%). Of these sites only DWR4 had higher levels of fine particles during both the 2018 and 2019 sampling periods. This site was located along a natural depression which flows into Charlevue Creek.

Along Springton Creek stream sediment levels vary between sites but remain consistent across sample years. Springton Creek itself is characterised by predominantly sand, with consistent levels of clay and silt.

Particle size analysis is presented graphically in Figure 60 and all stream sediment laboratory analyses are provided in Appendix K.

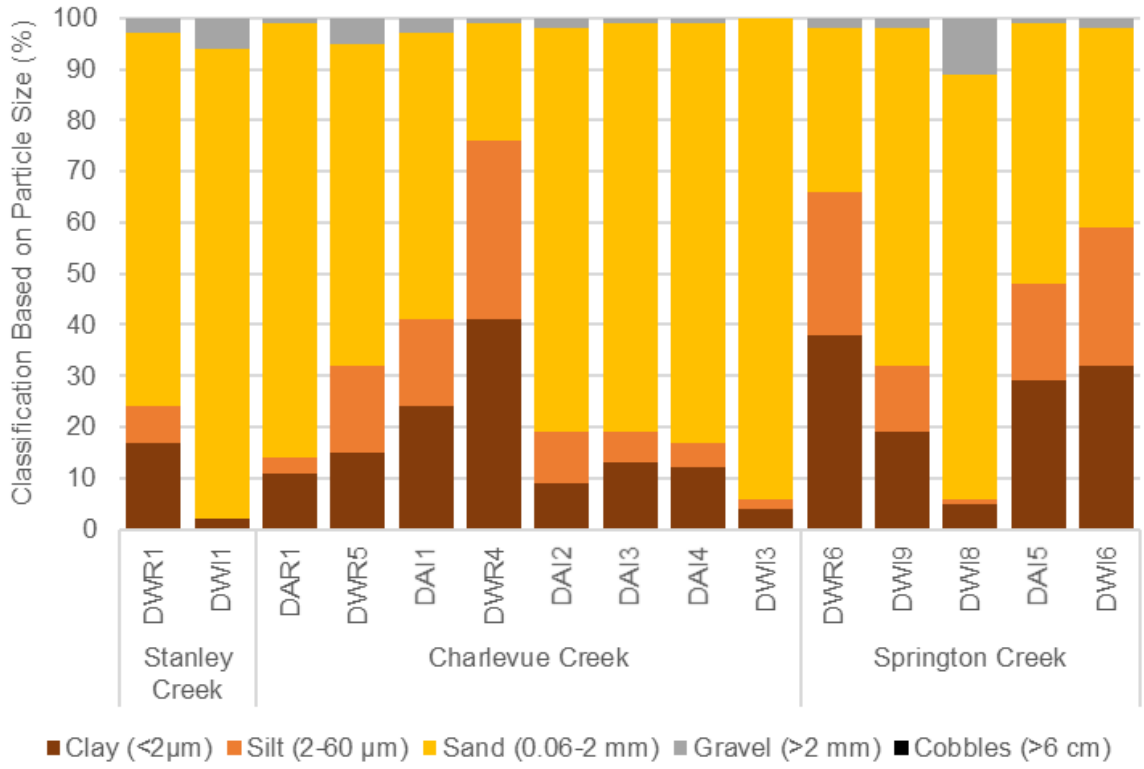


Figure 60 Stream Sediment Particle Size Analysis

7.2.5 Existing Flood Conditions

The *Flood Impact Assessment* (WRM 2020a) attached to Appendix B; defines existing flood conditions across the Project area for a range of design events, in terms of peak water level, peak velocity and water depth.

The XP-RAFTS flood model was used to estimate design discharges for the 50%, 10%, 2%, 1% and 0.1% AEP as well as the probable maximum flood (PMF) design discharge using an ensemble of design temporal patterns. In absence of gauged streamflow data, the resulting peak discharges were validated against the rational method and regional flood frequency estimation estimates (refer to Appendix B).

The XP-RAFTS modelling was then adopted as inflows to the TUFLOW hydraulic model to estimate flood extents and depths along the channel and floodplain of Charlevue Creek and Springton Creek for the nominated design events.

Under existing conditions, all flow generally remains contained within the Charlevue Creek and Springton Creek floodplain channels during a 50% AEP flood event with water depth of <1.5 m. The extent of flooding is more widespread during a 10% AEP event along the drainage features, with small areas of localised inundation with depth of up to 2.5 m along Charlevue Creek floodplains. This flood extent is generally consistent for the 2%, 1% and 0.1% AEP and PMF events, however, flood depth can increase up to 4 m in some areas along the floodplains and reaches up to more than 5 m in the main

channels. This predicted flooding regime is mainly attributable to the flat and undulating topography of the area.

Flood extent along the unnamed tributary of Springton Creek throughout all modelled AEP events are not widespread and are contained within close proximity to the main channel with shallow depths of up to 1.5 m. Peak flood depth reaches up to 2.5 m during the PMF event.

The general flooding patterns along the two drainage features indicate that flood velocity increases (up to 3.0 m/s) respective to decreasing AEP. Flood modelling also indicate lower flood velocity (less than 1.0 m/s) with further distance from the main creek channels.

Flood velocity during PMF event can reach a maximum of 4.0 m/s across most of the predicted flooding areas.

Figure 61 and Figure 62 illustrate the flooding extents, depths and velocity for 1% AEP event.

Graphical representation of all modelled existing flood conditions, showing extent, depth and velocity are provided in Appendix B.

7.3 POTENTIAL IMPACTS

The potential impacts of the Project on the surface water EVs include:

- impacts on regional water availability due to the potential need to obtain water from external sources to meet operational water requirements of mining operations;
- short-term and/or long-term loss of catchment area draining to local drainage paths due to capture of runoff within the SWMS and the open-cut pits;
- adverse impacts on the quality of surface runoff draining from the disturbed areas to the various receiving waters surrounding the Project;
- adverse impacts associated with the release of contaminants in MAW;
- impacts on flood levels at the Capricorn Highway and the Blackwater Railway upstream of the proposed rail loop and TLO facility; and
- potential impacts of the Project on flood levels and flood velocities of Charlevue Creek and Springton Creek.

7.3.1 Project Water Availability

Raw water for the Project will be sourced from the Bedford Weir, which is part of the Nogoa-Mackenzie River pipeline network, via a spur pipeline from the Blackwater Pipeline (see Section 3.5.2). The site water balance model indicates that due to the relatively low water requirements of the CHPP, the mine site water requirements of the Project can largely be sourced from water collected within the SWMS under average rainfall conditions. During low rainfall periods, the reliance of water supply from the external pipeline is expected to increase.

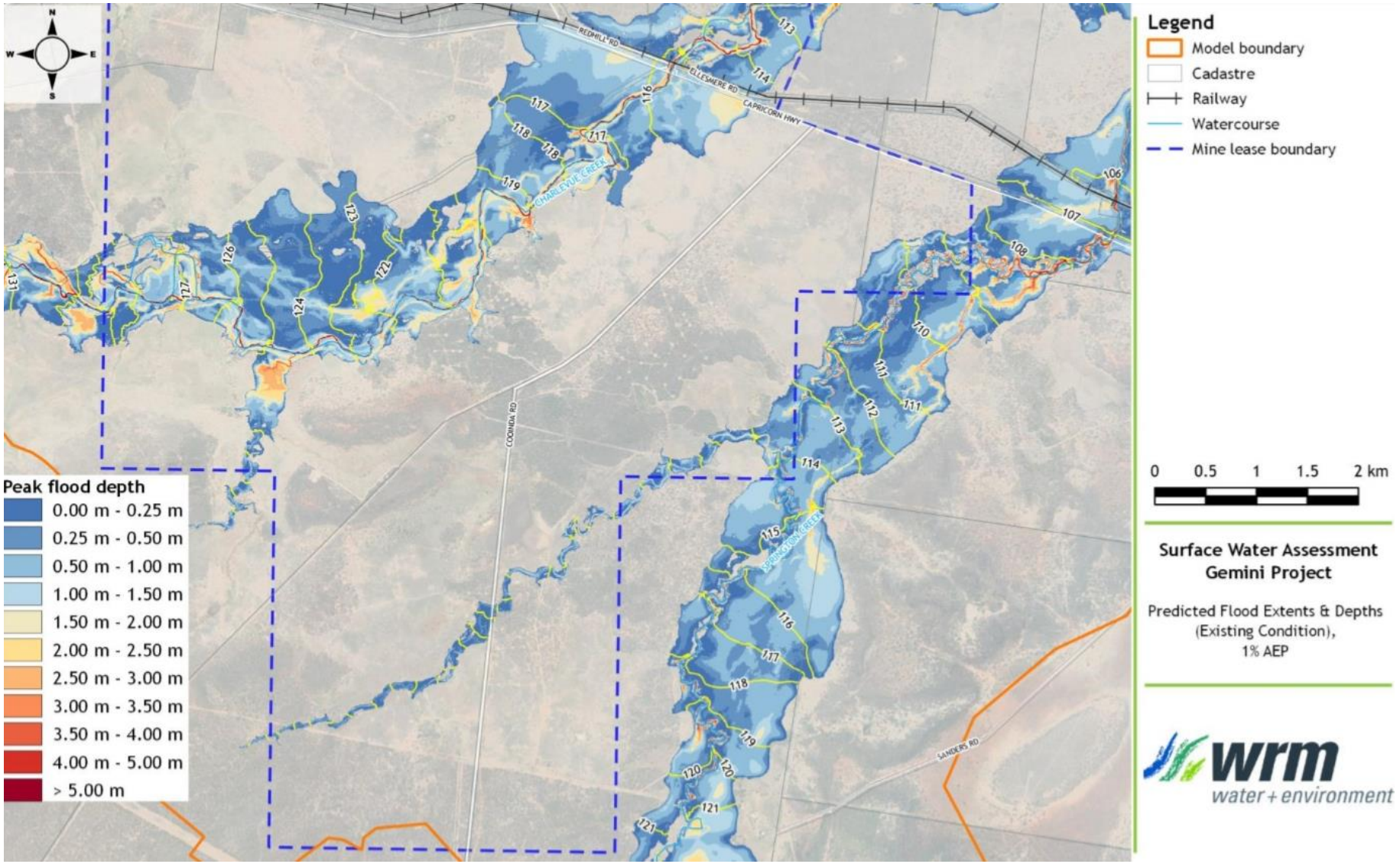


Figure 61 Predicted Flood Extent and Depth For Existing Conditions (1% AEP)

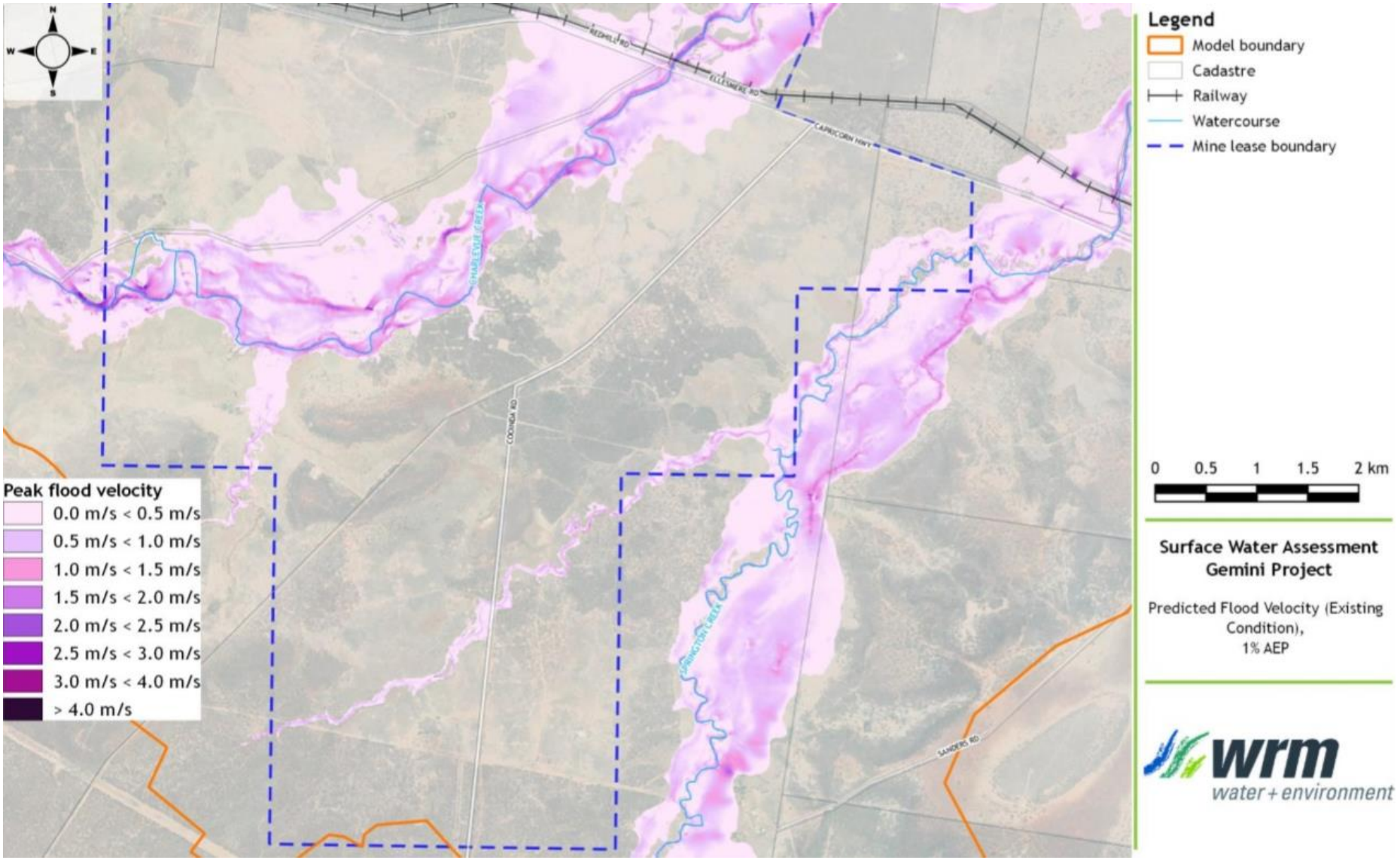


Figure 62 Predicted Flood Velocity for Existing Conditions (1% AEP)

Figure 63 demonstrates the raw water requirements from the pipeline based on the median model performance. Water requirements from the external pipeline are highest in the early Project stages. Under very dry conditions, the demand could reach 500 Ml/a, however, median demand for Year 1 is less than 100 Ml/a. During later years, accumulated stored pit and sediment dam water is sufficient to supply demands in all but the driest years.

The raw water supply contract will be sufficient to ensure continued operation even in the driest of years.

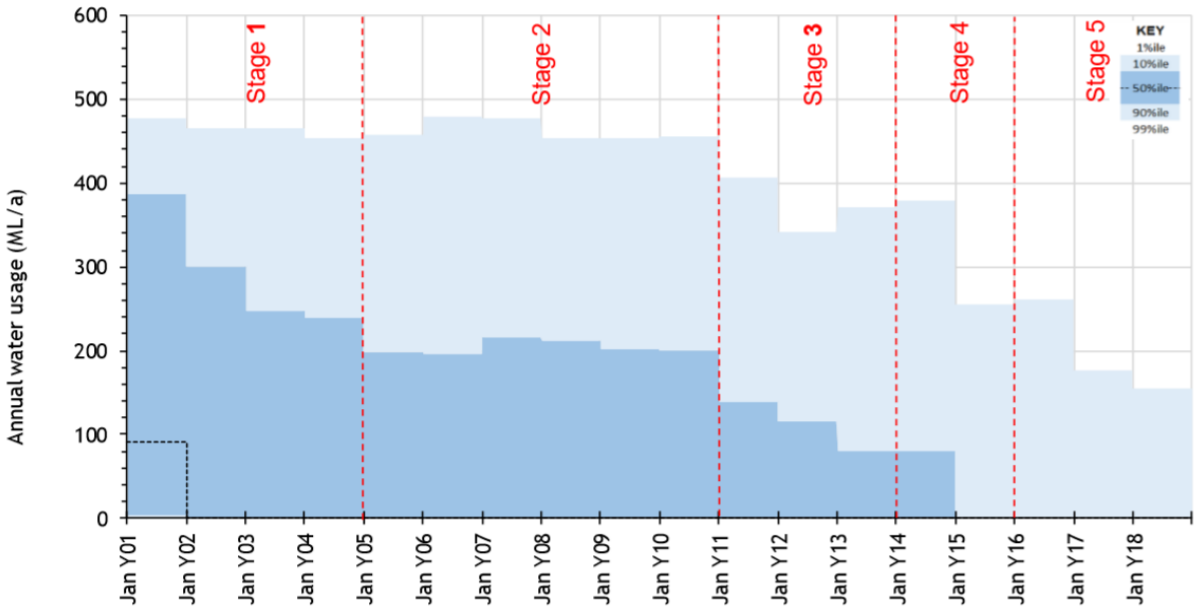


Figure 63 Raw Water Pipeline Usage

7.3.2 Loss of Catchment Area

During operations, the Project will intercept runoff from disturbed areas of the mine site. The SWMS will capture runoff from areas that previously would have flowed to receiving waters of Springton Creek and Charlevue Creek, and therefore, the catchment areas will change with the development of the Project (Table 42). The maximum captured catchment areas at Year 18 represent:

- 1.0% of Charlevue Creek catchment upstream of the confluence with Springton Creek;
- 3.6% of Springton Creek catchment upstream of the Charlevue Creek confluence; and
- 2.3% of the total combined Springton Creek catchment area, downstream of the confluence with Charlevue Creek.

Table 42 Catchment Intercepted by SWMS at Year 18

	Charlevue Creek Catchment	Springton Creek Catchment	Total Combined Catchment
	Upstream of Confluence		*Downstream of Confluence*
Total Area Intercepted by SWMS	336.9 ha	1,174.9 ha	1,511.8 ha
Total Catchment Area	32,243 ha	32,497 ha	64,740 ha
Proportion of Catchment Area Intercepted by SWMS	1%	3.6%	2.3%

After mine closure, the SWMS will be decommissioned with some residual impact on streamflow due to surface water runoff to the final voids from some areas (Table 43). The maximum captured catchment area at mine closure consists of approximately:

- 0.03% of Charlevue Creek catchment upstream of the confluence with Springton Creek;
- 1.1% of Springton Creek catchment upstream of the confluence Charlevue Creek; and
- 0.6% of the total combined Springton Creek catchment area, downstream of the confluence with Charlevue Creek.

Table 43 Catchment Intercepted by Final Void at Mine Closure

	Charlevue Creek Catchment	Springton Creek Catchment	Total Combined Catchment
	Upstream of Confluence		*Downstream of Confluence*
Total Area Intercepted by Final Void	10.0 ha	345.0 ha	355.0 ha
Total Catchment Area	32,243 ha	32,497 ha	64,740 ha
Proportion of Catchment Area Intercepted by Final Void	0.03%	1.1%	0.6%

The impact on environmental values as a result of this catchment loss is expected to be negligible, based on an estimate of the impact of catchment loss on the frequency of low flows, as illustrated in Figure 10.1 of Appendix B.

7.3.3 Impacts on Surface Water Quality

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff by increasing sediment loads and transporting contaminants from spoil and coal seams. However, with implementation of the SWMS, environmental risks resulting from disturbed area runoff are expected to be low.

MAW includes runoff from processing and coal stockpile areas, groundwater, and wastewater from the CHPP. This water will be contained in designated mine water dams onsite and will only be released in accordance with EA conditions.

Other runoff from disturbed areas, such spoil dumps, will be intercepted by sediment dams designed in accordance with the SWMS. Discharge from sediment dams directly into the receiving environment (after settlement of suspended sediments) would only occur during rainfall events. The discharge is expected to have insignificant impacts on water quality, as overburden runoff quality is expected to be relatively benign.

7.3.4 Mine Affected Water Releases

The results of the water balance modelling show no uncontrolled spills from the MAW system to receiving waters; as any unplanned overflows from mine water dams would overtop back into the pit. Additionally, the model results also show that the maximum modelled water level for both voids is well below the surface overflow level.

The release of MAW from the Project will occur in accordance with the *Model Mining Conditions* (DES 2017e) only; as set out in the EA. Relatively small volumes of water are expected to be released to Charlevue Creek, primarily due to the relatively low and infrequent flows in this waterway. Such release events would likely only occur post significant rainfall and flow within local catchments. Such conditions present opportunity for release without environmental harm, while reducing the risk of accumulating legacy water in the void. The proposed EA conditions for water release are provided in Section 15.0.

7.3.5 Post-mining Final Void Lakes

Pit AB and Pit C is proposed to be backfilled progressively during mining, with two final voids at the end of mining which will meet the rehabilitation objectives addressed in Section 4.3. Key water inputs in the voids include rainfall on pit lake water surfaces, runoff from pit faces and rehabilitated upstream catchment areas and groundwater interception. Further information regarding the final void configuration has been addressed in Section 4.4.7.1 and Table 21.

The voids are intended to be partially backfilled to a level that prevents the interchange of water between the coal seams and the lakes, resulting in lower water levels and salinities than would otherwise be the case. Backfilling with waste rock material will elevate the void floor above the level of groundwater flows to prevent pit water transiting into any aquifers.

The final pit floor of Pit AB will be at an elevation of approximately 40 mAHD, which is 72 m below the natural surface elevation. Pit C final pit floor will be at an elevation of approximately 60 mAHD or approximately 60 m below the natural surface elevation. Final void modelling suggests that during the first 200 years after closure, lake salinities will be less than 10,000 mg/L. After 500 years salinity is conservatively modelled to increase to 30,000 mg/L, however, modelling is based on an assumption that salt levels in spoil leachate do not decline over time.

Final voids were modelled to remain as a groundwater sink and do not present a risk of overtopping. The maximum modelled water level for Pit AB is 57.6 mAHD, which is approximately 54 m below the void overflow level/natural surface elevation (112 mAHD). Similarly, the maximum modelled water level for Pit C is around 73.5 mAHD, which is 54.4 m below the void surface overflow level/natural surface elevation of approximately 128 mAHD. Modelled water levels in the voids are presented in Table 44.

Table 44 Final Void Surface Water Model

Water Level	Pit AB (mAHD)	Pit C (mAHD)
Long term equilibrium water levels	52.9	70.3
Maximum long-term water levels	57.6	73.5
Minimum long-term water levels	47.4	66.0
Overflow level at natural surface	112.0	128.0

7.3.6 Impacts on Flooding

As part of the *Flood Impact Assessment* (WRM 2020a), modelling was undertaken to determine the change in flood behaviour in Charlevue Creek, Springton Creek and its unnamed tributary during developed conditions. The results are as follows:

- the Project will temporarily increase Charlevue Creek flood levels immediately upstream of the proposed haul road crossing. In a 1% AEP flood event, these impacts are contained within the MLA (Figure 64);

- the works at Pit AB will increase flood levels in Springton Creek by up to 0.22 m in a 1% AEP flood (Figure 65). These impacts would extend off-lease onto land owned by Magnetic South, and reduce with distance downstream of the boundary;

- there will be localised off-lease impacts on flood levels in the unnamed tributary of Springton Creek immediately upstream of Pit AB and Pit C;

- the proposed rail loop will not have an impact on Charlevue Creek or Springton Creek flooding;

- there will be no impact on flood levels at these waterways at Capricorn Highway, Blackwater Railway, or downstream of the Project;

- there are four locations where (based on the flood model results) floodwaters could potentially come into contact with the overburden dumps:

    - north-eastern end of Pit C – due to flow backing up to the west of the haul road crossing of the engineered drainage feature. Modelled flow velocities in this area are less than 0.4 m/s in the 0.1% AEP design flood, and would therefore not cause the migration of sediment from the final landform;

    - western side of Pit AB – due to water backing up a minor tributary of Charlevue Creek. Flow velocities in this area are expected to be less than 0.2 m/s, and therefore the likelihood of migration of sediment from these dumps is minimal;

    - eastern side of Pit AB – due to flow on the left (western) floodplain of Springton Creek. Flow velocities against the final landform are modelled to be less than 1.2 m/s in the 0.1% AEP flood, and therefore the likelihood of erosion of the dump toe is minimal; and

    - southern side of Pit AB – due to water overflowing from the unnamed tributary of Springton Creek upstream of the inlet to the engineered drainage feature. During operations, this section of the dump would be protected by a temporary levee, which would be incorporated into the final landform profile on closure. In events up to the 0.1% AEP design flood, modelled flow velocities are less than 1 m/s along most of the length of the proposed levee. Such flows would be non-erosive – and especially given the relatively short flow durations in this small catchment, the risk of migration of sediment in floodwaters would be minimal. During detailed design of the engineered drainage feature, provision will be made to ensure that flows will be non-erosive along the final landform post-closure.

Graphical representation of all modelled developed flood conditions, showing extent, depth and velocity are provided in Appendix B.

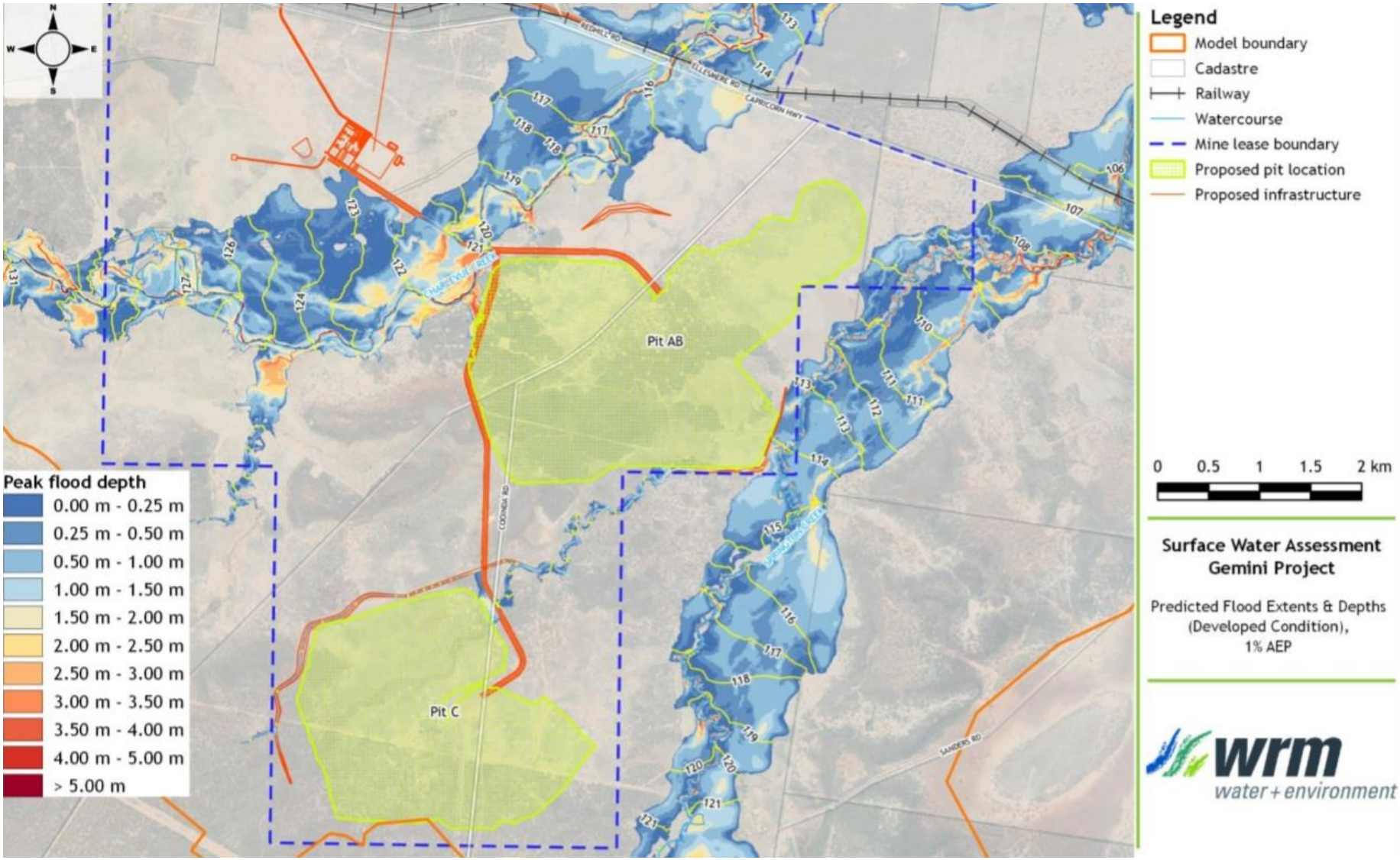


Figure 64 Predicted Flood Extent and Depth for Developed Conditions (1% AEP)

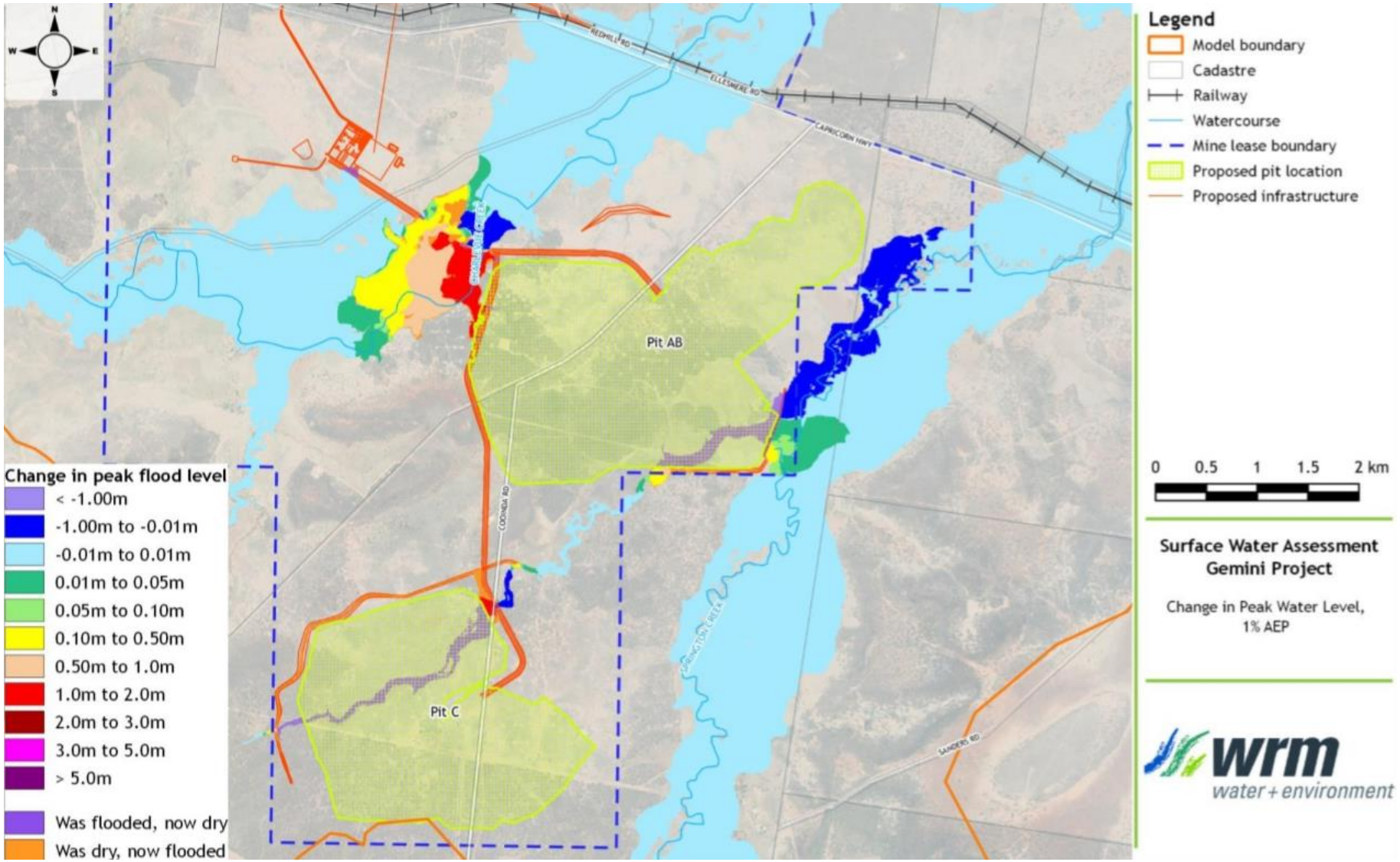


Figure 65 Change in Peak Flood Level from the Project (1% AEP)

7.3.7 Cumulative Impacts

Bluff PCI Project, located approximately 12 km west of the Project, is the nearest operation to the Gemini Project, and also contributes to the Springton Creek catchment, downstream of both Projects (Figure 57). The Walton Coal Project is proposed within the same catchment. The Bluff PCI Project and Walton Coal Project are of relatively small scale and short mine life.

Water supply for the Bluff PCI Project and Walton Coal Project are to be partially sourced from the Jellinbah Mine. Therefore, the potential cumulative impacts of these projects on flows in Springton Creek will be minimal.

Waterways that traverse the Gemini Project eventually flow into the Mackenzie River, which is a major tributary within the Fitzroy River basin. The Fitzroy River basin is the largest catchment in Queensland; draining into the Pacific Ocean and also the largest catchment draining into the Great Barrier Reef. However, it does not contribute significant freshwater flows to the coastal environment when compared to river systems further north.

Potential impacts (increased sediment load and salinity) on the water quality of the Fitzroy River basin and the connecting tributaries in the catchment will be mitigated through the use of the SWMS, including sediment basins, progressive rehabilitation, spill controls, release controls and water quality monitoring.

Provided that uncontrolled and controlled releases from the three Projects are managed in accordance with respective EA conditions, the proposed management approach for mine water from the Gemini Project is expected to have negligible cumulative impact on surface water quality and associated EVs.

Given the scale and nature of the three projects, cumulative impacts on flooding are not expected to lead to any adverse impacts on human populations, property or other environmental or social values.

7.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING

7.4.1 Site Water Management Plan

The *Site Water Management Plan* will be developed in accordance with the Project's proposed EA conditions and will be informed by the *Surface Water Assessment* (Appendix B). The overarching objectives for the *Site Water Management Plan* is to minimise the impact of the Project's activities on the environmental values of the Project site and surrounding environment. The *Site Water Management Plan* will:

- minimise the use of clean water on site;
- minimise the requirement to source water from external supplies;
- minimise impacts on the receiving environment;
- minimise the impacts of flooding on mining operations; and
- minimise cumulative impacts with other mines in the region.

The Project's *Site Water Management Plan* will include the following components:

- an overview of the water management strategy and a description of the site water balance;
- design details of water management infrastructure;

- a description of baseline environmental values and water quality trigger values;
- reference to *a REMP* and *Groundwater Monitoring Program*;
- a description of the monitoring locations, methods, and reporting procedures for a *Site Water Management Monitoring Program*;
- a risk assessment to determine the risk of contaminates on the receiving environment;
- a response procedure for the reporting of unexpected exceedances of water quality trigger values;
- the reporting requirements and annual review process applicable to the Project's *Site Water Management Plan;* and

The *Site Water Management Plan* will focus on minimising impacts to surface water and groundwater quality and resources in accordance with the management hierarchy. The management hierarchy for surface water and groundwater as set out in the EPP (WWB) requires that, to the extent that it is reasonable to do so, surface water and groundwater impacts must be dealt with in the following order of preference:

- reduce the production of wastewater or contaminants by reducing the use of water:
- prevent waste and implement appropriate waste prevention measures;
- evaluate treatment and recycling options and implement appropriate treatment and recycling;
- evaluate the options for wastewater or contaminants in the following order of preference:
    - appropriate treatment and release to a waste facility or sewer;
    - appropriate treatment and release to land; and
    - appropriate treatment and release to surface waters or groundwaters.

Reduce the production of wastewater or contaminants by reducing the use of water

The production of wastewater or contaminants by reducing the use of water will managed through the following;

- defined operating rules for water related activities (refer Table 6.7, *Surface Water Impact Assessment,* Appendix B); and
- through the use of water efficient infrastructure including the use of belt press filters in the CHPP.

Prevent wastewater and implement appropriate waste prevention measures

The mine affected water system is a closed system designed to prevent the releases of mine affected water to the environment. Overflows of the Mine Water Dam have been designed to be directed via a diversion drain to the mine pit. The mine affected water system will manage runoff and seepage form the mine pits, CHPP, coal stockpiles and MIA. There is some potential for seepage of water from the Mine Water Dam to Charlevue Creek. This dam will be designed with a floor and sides of material that will limit seepage to avoid environmental harm.

The sediment water system is designed to capture sediments transported from runoff from overburden dumps. Overburden runoff quality is expected to be relatively benign and will potentially discharge to the receiving environment. The sediment water system will be managed under an *Erosion and Sediment Control Plan.*

Clean water from undisturbed areas is generally diverted around the areas of disturbance.

The *Site Water Management Plan* will manage water storages and transfers within the site in order to maximise onsite storage to meet reasonably anticipated periods of wet and dry weather.

Evaluate treatment and recycling options and implement appropriate treatment and recycling

The *Site Water Management Strategy* has been designed to promote the use/recycle lesser quality water in preference to higher quality water and to use potentially contaminated water in preference to imported raw water or uncontaminated water through the transfer of water onsite where:

- The Mine Water Dam receives pumped groundwater and surface runoff dewatered from Pit AB and Pit C. Water will be transferred from the Mine Water Dam for reuse at the CHPP, to meet the TLO water demands and for other uses as required.

- The TLO Dam comprises a series of sediment traps and small drainage dams that will be used to capture washdown and overflow from trains and sumps before it is directed to the TLO Dam. Water collected in this small dam will pumped to the Mine Water Dam.

Evaluate the options for wastewater or contaminants

To avoid significant downstream impacts, the system has been designed to achieve a high level of containment without the need for controlled releases. However, should water quality allow, the release water from site only in accordance with the conditions of the EA, such that the released water will not significantly impact on the values of the receiving waters or downstream properties;

Any unplanned overflows from the Mine Water Dam, would overflow to the mine pit. The only potential mine water release points are the MIA Dam spillways. However, these dams will be operated in such a way that the risk of release is small. Runoff from overburden dumps will be managed under an erosion and sediment control plan to reduce sediment loads to background levels before release. Water would be discharged either via sediment dam spillways or perforated riser pipes.

The potential impacts on receiving water quality and downstream flow are to be managed by the SWMS, which are discussed in Section 3.4. This includes:

- clean water drains to divert two sections of the unnamed tributary of Springton Creek around disturbed areas;

- sediment water drains to divert water from waste rock emplacement areas, and areas yet to be rehabilitated;

- sediment water dams to store water from waste rock emplacement areas and allow settlement of sediment loads before discharging treated water or recycling back to the CHPP;

- mine water drains to divert water from MIA, CHPP and coal stockpile areas into the MAW system; and

- mine water dams to store water pumped out of the pit, and capture water from the MIA, CHPP and coal stockpile areas.

7.4.2 Mine Affected Water Release

If any controlled releases are to occur, it would be in accordance with the EA conditions; consistent with the *Model water conditions for coal mines in the Fitzroy basin [ESR/2015/1561]* (DES 2013). The model conditions provided in this document are used as a basis for proposing specific water related protection commitments of EVs in the application documentation. The conditions include minimum flow and quality criteria and include commitments for monitoring during release events.

Section 6.9 of the *Surface Water Assessment* (WRM 2020b) outlines the potential for accumulation of water in the mine water dam and the mine pits. The mine water dam would overflow to Pit AB. The results show that the risk of discharge from the Pits is negligible, and that mining operations could be sustained in the long-term by transferring excess water to Pit AB once mining there was complete. The likelihood of discharging mine affected water from the pit MAW system is minimal. As mentioned previously, at the MIA and CHPP, the MAW system has been sized to ensure the likelihood of discharge is small.

Water would only be discharged from the system when there are significant flows in the receiving waters in accordance with the EA conditions.

7.4.3 Flood Mitigation

The proposed mine operations and associated infrastructure are largely located outside of Charlevue Creek and Springton Creek flood inundation areas, as illustrated in Figure 64.

Flood management controls for the Project include construction of a temporary flood protection levee for Pit AB. The flood levee design will ensure that the mine void is outside the 0.1% AEP flood event as well as the PMF event during operations and at final landform. Design of the flood level is provided in Section 3.4.3.1.

Clean water drains are also designed to divert clean water from the unnamed tributary of Springton Creek around disturbed areas; largely Pit AB and Pit C. It is therefore proposed that the design of the drains will take into account key design principles and requirements for the functionality of permanent diversions, including for operations, maintenance, monitoring and revegetation.

7.4.4 Receiving Water Monitoring

The *Aquatic Ecology Assessment* (AARC 2020a) (Appendix K) identified exceedances of regional WQOs, including high turbidity and suspended solids in the existing receiving waters. In this instance, the regional WQOs have not been considered a reliable indicator of the local system's long-term health. Site-specific reference/baseline values will be developed after a period of monitoring to assess future local water quality data. As a result, water quality in surrounding the Project will be monitored in accordance with a REMP that has been detailed below.

7.4.4.1 Receiving Environment Monitoring Program

A REMP Design Document has been developed for the Project in accordance with the *Model Mining Conditions* (DES 2017e) to demonstrate compliance with the EA release conditions. The REMP Design Document has detailed:

- release characteristics (quality and quantity);
- environmental values of the receiving environment that may be affected by a release and need to be enhanced and protected under the EPP (WWB);

- spatial extent of suitable test sites (including the location of monitoring sites and a controlled background reference);
- temporal context (including timing and frequency of sampling);
- monitoring indicators (including physical, chemical and biological);
- water quality objectives to measure chosen indicators;
- methodologies; and
- all implemented quality control and assurance procedures.

The REMP Design Document speculates that monitoring measures will be undertaken in line with Queensland's *Monitoring and Sampling Manual 2009* (DES 2018c) during periods of stream flow, ideally towards the end of the wet season, when safe access is available, and will include the following measures:

- monitoring of water quality parameters, including but not limited to; pH, EC, major anions (sulphate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS, and a broad suite of soluble metals/metalloids;
- sediment and macroinvertebrate sampling;
- visual records of vegetation;
- stream morphology; and
- stream flow (level and velocity).

Data collection during the REMP will be undertaken annually at the two downstream sites and two upstream sites of the Project (Table 45) to compare background data and ensure any impacts to the local receiving environment are accurately reflected in the results of the REMP report.

Table 45 Receiving Water Monitoring Locations

Description	Location in Relation to the Project	Latitude	Longitude
Springton Creek US	Upstream	-23.6976	149.2738
Springton Creek DS	Downstream	-23.6434	149.3145
Charlevue Creek US	Upstream	-23.6305	149.2715
Charlevue Creek DS	Downstream	-23.6469	149.2104

Notes: Coordinates relevant to GDA94.

Monitoring will also occur at these locations during any controlled release of mine affected water. The receiving water thresholds that govern release opportunities are, pH (6.5 - 8.5), EC 310 µS/cm and sulphate 10 mg/L with streamflow parameters yet to be determined until a streamflow gauge is installed along Charlevue Creek. Under these provisions, the release of mine affected water into Charlevue Creek will only occur during periods of natural stream flow; and when receiving conditions are able meet the thresholds required to maintain relevant site-specific baseline water quality values.

Further details on the management of the receiving environment are provided in the REMP Design Document (Appendix Q).

7.4.5 Site Water Management System Monitoring

Onsite SWMS monitoring will be implemented to validate the SWMS performance against the design assumptions regarding water quality and water quantity. Monitoring will be specifically undertaken at the mine water dams and sediment dams. If required, adaptive management decisions will be undertaken where necessary to ensure protection of the surface water environment.

Mine Water Dam Monitoring

Any surface runoff and seepage water collected in mine water dams and the process water dam will be monitored for 'standard' water quality parameters including, but not limited to; pH, EC, major anions (sulphate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS and a broad suite of soluble metals/metalloids.

Sediment Dam Monitoring

Monitoring of sediment dams will be used to validate the anticipated runoff quality reporting to sediment dams and haul road runoff dams. Initial monitoring will occur on a regular (e.g., monthly) basis to demonstrate the water quality of stored waters is consistent with the relevant operating parameters to allow releases from sediment dams to occur when required. Subject to demonstrating water quality is in accordance with the WQOs, the frequency of monitoring and suite of parameters for the sediment dam monitoring will be reviewed and updated accordingly when a release occurs.

8.0 GROUNDWATER

This section provides a description of the existing groundwater values within and surrounding the Project. It aims to identify the Project's potential impacts on the existing values and propose mitigation measures and management strategies to prevent or minimise adverse environmental effects.

This section is informed by the *Groundwater Impact Assessment* (JBT 2019) presented as Appendix C.

Surface water values have been discussed in Section 7.0, and GDEs within Section 6.0, and groundwater inflows are discussed in Section 3.4.5 and Section 4.0.

8.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES

The environmental objective relevant to potential impacts to groundwater as described in the EA guideline for *Application requirements for activities with impacts to water [ESR/2015/1837]* (DES 2017c) is:

The activity will be operated in a way that protects the environmental values of groundwater and any associated surface ecological systems.

The Project would achieve one of the following performance outcomes identified in Schedule 8, Part 3, Division 1 of the EP Regulation whereby:

1. *both of the following apply:*

    (a) *there will be no direct or indirect release of contaminants to groundwater from the operation of the activity; and*

    (b) *there will be no actual or potential adverse effect on groundwater from the operation of the activity; or*

2. *the activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.*

8.2 DESCRIPTION OF ENVIRONMENTAL VALUES

The EPP (WWB) describes EVs to be protected or enhanced in Queensland. The Project is located within the 'Mackenzie Groundwaters' region within the broader Fitzroy Basin. The EVs identified on the *WQ1310 – Fitzroy Basin Groundwater Zones map* (EHP 2011b) for this region and their relevance to the Project are:

- **aquatic ecosystems:** values that are potentially associated with groundwater include those that support GDEs and are discussed in Section 6.0;
- **cultural & spiritual:** the groundwater that may be impacted by the Project is not known to have any cultural and spiritual value;
- **industrial use:** the groundwater that may be impacted by the Project may be suitable for industrial purposes, however, other than coal mining, there is no known industrial users of groundwater;
- **agricultural purposes:** groundwater use for agricultural purposes is limited to livestock and is discussed in Section 8.2.2; and

- **drinking water:** the groundwater that may be impacted by the Project is not known to be used as a drinking water supply due to its poor quality, as discussed in Section 8.2.2.

The values relevant to the MLA and surrounding area include:

- agricultural uses, where groundwater is extracted from surrounding agricultural bores; and
- aquatic ecosystems, where shallow groundwater may support GDEs in some capacity.

The *Groundwater Impact Assessment* (JBT 2019) (Appendix C) describes site-specific EVs in detail. The following sections provide a summary.

8.2.1 Geology and Hydrogeology

The surface geology of the Project predominantly comprises sediments of the Tertiary Duaringa Formation and Quaternary alluvium associated with ephemeral creeks. The underlying Bowen Basin solid geology is illustrated in Figure 66, showing the Project location in relation to the underlying Triassic and Permian sediments, as well as the prevalence of regional-scale faults. The target mining areas are located where folding has brought the coal seams closer to the surface at economically mineable depths.

There are 48 registered bores (listed as 'existing' or 'abandoned but useable') within 10 km of the MLA, with the majority of bores screened within Tertiary units (26 bores) or the Permian coal measures (15 bores). Aquifer data and groundwater EC data from the Department of Natural Resources, Mines and Energy (DNRME) groundwater database is displayed in Figure 67, and detailed in Table 4-5 of Appendix C.

The Project comprises a groundwater monitoring bore network of 38 bores at 17 sites (Figure 68), with locations detailed in Table 4-1 of Appendix C.

Analysis of available monitoring data from these regional and local bore networks concludes that groundwater occurs within three main groundwater units at site, including:

- Quaternary alluvium associated with Charlevue Creek and Springton Creek;
- Tertiary sediments of the Duaringa Formation; and
- Permian Rangal Coal Measures, where groundwater occurs preferentially within the coal seams.

A minor occurrence of Tertiary basalt has been identified from geological drilling to the north of Pit C. The area of basalt is approximately 600 m long, 200 m wide and 20 m thick and has been interpreted as a localised basalt paleochannel (JBT 2019). One groundwater monitoring bore has been located within the basalt (bore DW7105W1); the bore is 23 m deep and the basalt is dry at the bore location. The basalt flow is interpreted to be dry (as it is above the regional groundwater level) and of limited extent and is therefore not an important groundwater feature within the project area. Extensive geological drilling across the project area has shown no other evidence of basaltic flows or intrusions (JBT 2019).

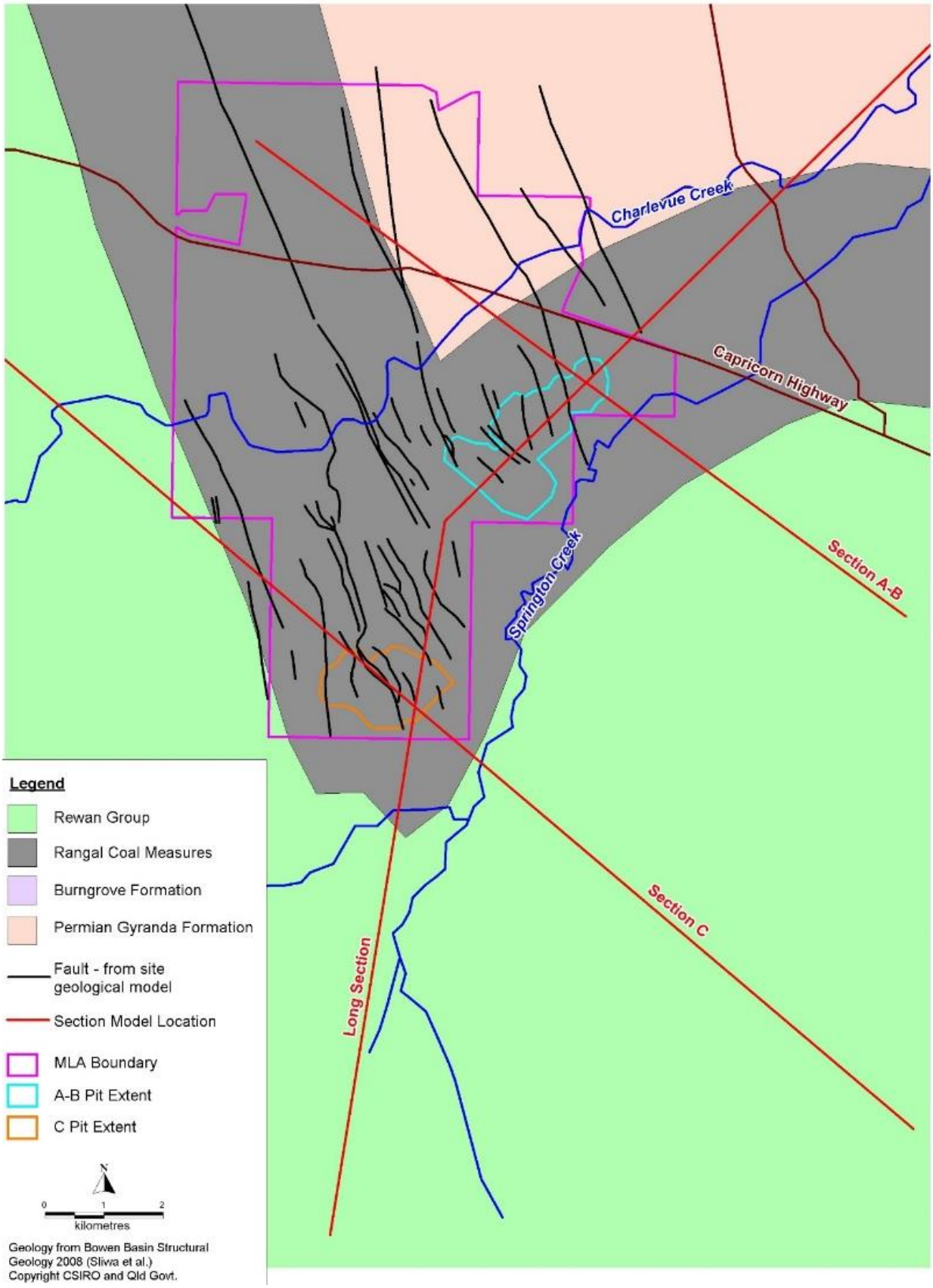


Figure 66 Project Location and Bowen Basin Solid Geology

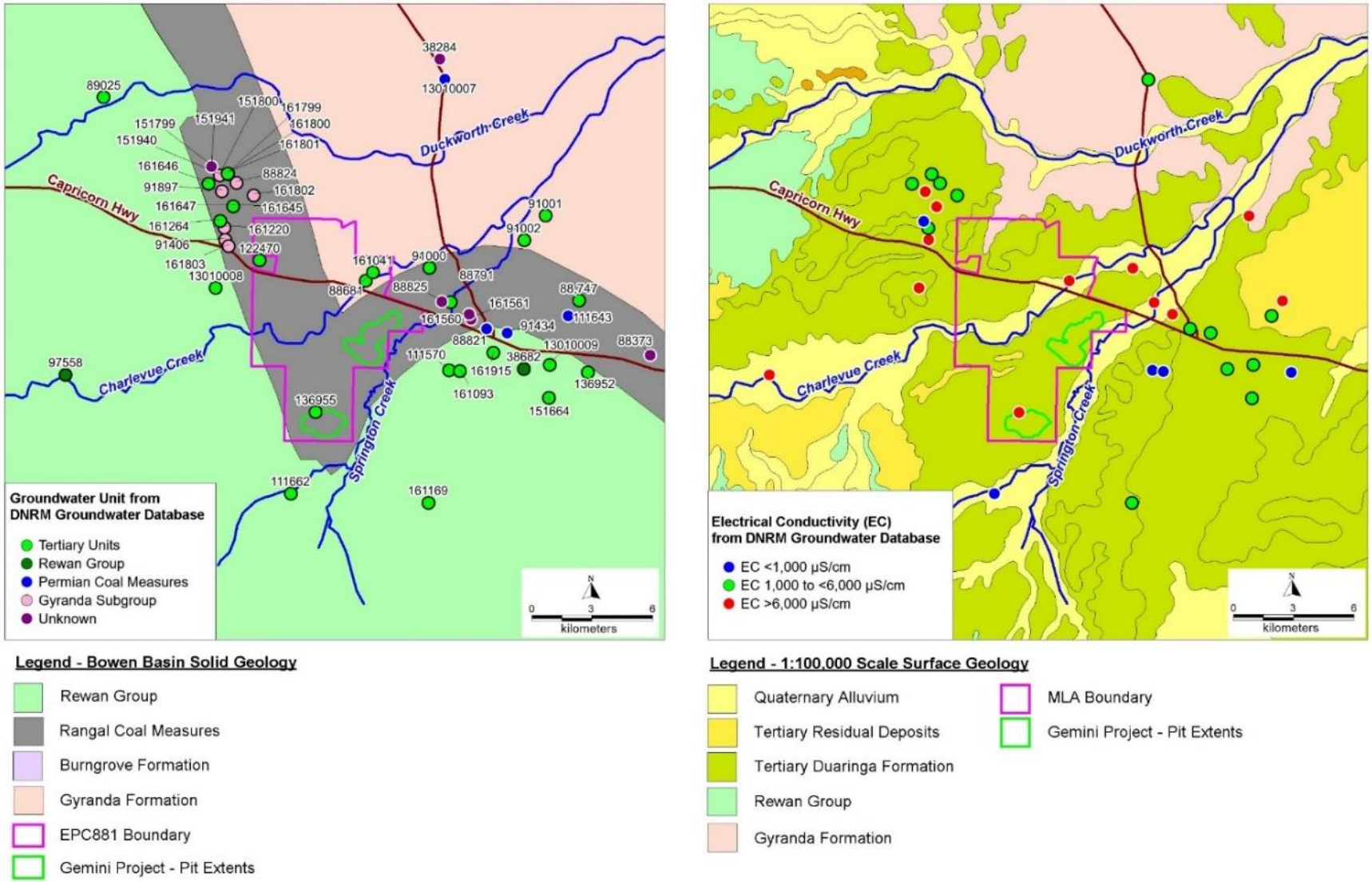


Figure 67 DNRME Groundwater Database - Aquifer and EC data

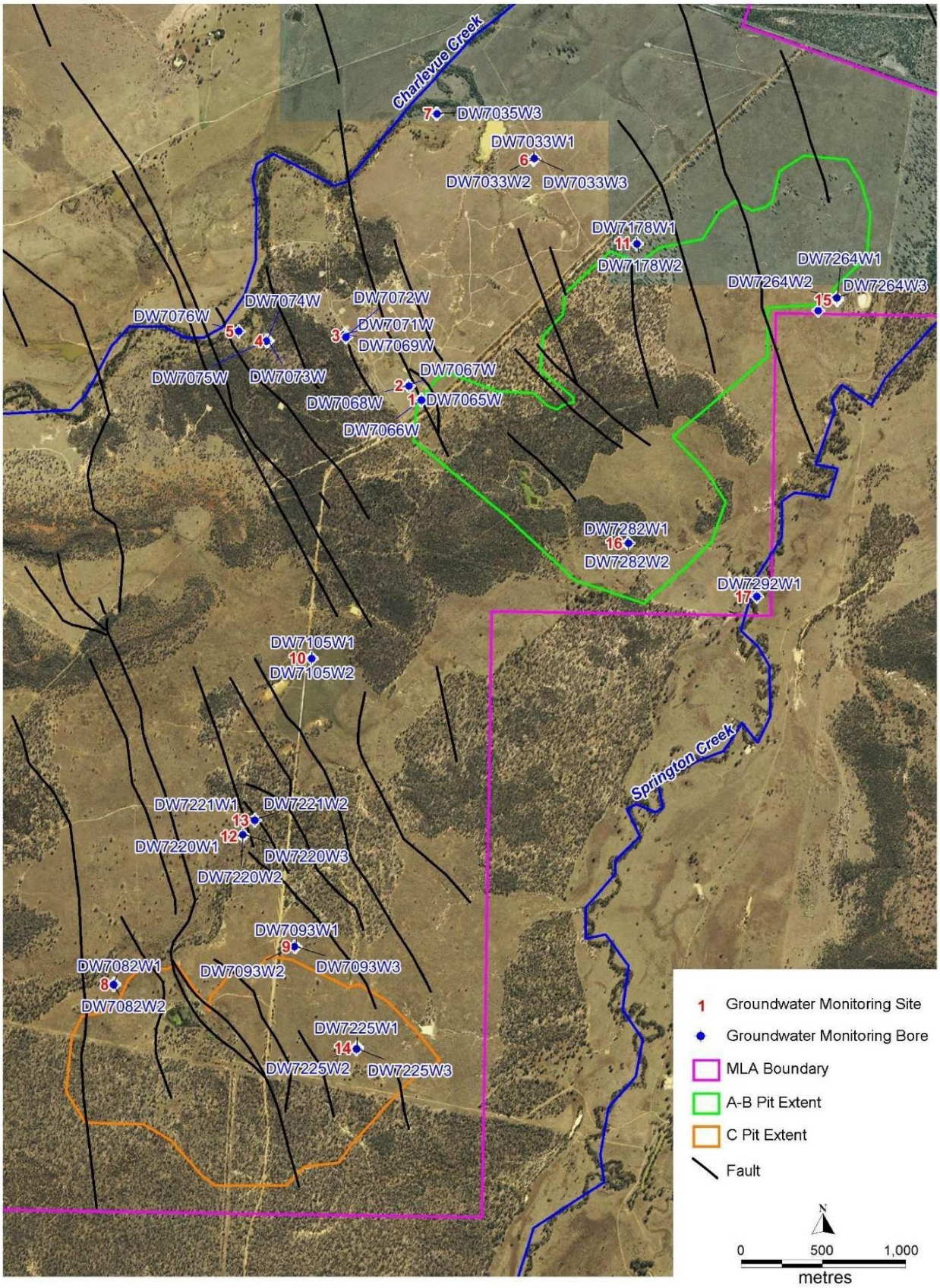


Figure 68 Groundwater Monitoring Bore Network

Detailed discussion of the installation and monitoring of the Project groundwater monitoring network can be found within Section 4.0 of Appendix C. Utilising data from the local and regional bore networks, an overview of the site-specific groundwater aquifers as described as follows. Characteristics of the aquifers are discussed in further detail in Section 8.2.2 Section 8.2.3 and Section 8.2.4.

Quaternary Alluvium

The Project has two monitoring bores within the Quaternary alluvium which is present within ephemeral waterways to the east and west of the mining areas (Springton Creek and Charlevue Creek, respectively). Recharge to alluvium is via direct rainfall recharge and occurs at a low rate. This is consistent with the observation of elevated salinity in the shallow sediments, likely due to the low rate of recharge, as well as high residence times for groundwater.

Tertiary Sediments

There are 26 registered bores in the region screened within Tertiary units and ten Project monitoring bores (one within Tertiary basalt); five of which are dry (including the Tertiary basalt bore). The presence of dry bores within the Tertiary, as well as a variation in water level between the topographically elevated base of Tertiary and topographically lower base of Tertiary, suggest that a continuous water surface does not exist in the Tertiary sediments and that the elevation of the base of Tertiary will be a control on the presence of groundwater within the sediments. From review of available data, it is assessed that it is probable that the Tertiary sediments are dry above 120 mAHD and likely dry above 110 mAHD. The Tertiary sediments exhibit similar recharge and salinity characteristics to the Quaternary alluvium.

Permian Rangal Coal Measures

There are 15 registered bores in the region screened within Permian coal seams and 26 Project monitoring bores (including three within the overburden/interburden sediments); only one of which is dry (Aries seam). Within the Permian coal measures the coal seams are the primary conduits for groundwater flow with no significant trend for upward or downward movement of groundwater between the coal seams. However, a trend occurs for groundwater movement through the coal seams from the southwest to the northeast, and also from the northwest to the southeast, towards a depression that is centred on the area where Pit AB is proposed to be developed. The coal seams are recharged in subcrop areas where the coal seams directly underlay Tertiary and/or Quaternary sediments. The extremely high salinity of groundwater within the coal measures supports an interpretation of a low rate of recharge to these units.

8.2.2 Groundwater Quality

Regional Groundwater Quality

ANZG (2018) outline a livestock drinking limit for salinity for beef cattle of 4,000 mg/L (equates to an approximate EC of 6,000 µS/cm). Bores that recorded a salinity in excess of this were assessed to be of limited or no use for stock watering.

The majority of bores within or close to the MLA recorded EC in excess of 6,000 µS/cm (refer to Table 4-5 in Appendix C). JBT (2019) noted that the EC of groundwater within the Tertiary sediments was often in excess of 10,000 µS/cm and at some sites in excess of 20,000 µS/cm (highly saline); which was consistent with groundwater quality data from the Project bore network. The majority of Tertiary bores outside the tenement area recorded an EC of <6,000 µS/cm, with four bores in Tertiary sediments to the east or south of the project area recording an EC <1000 µS/cm (mostly fresh). There is potential these bores may be used for stock-watering purposes.

Local Groundwater Quality

Groundwater quality data is available from samples taken between December 2018 and October 2020. Results are presented in Appendix D and have been summarised in Table 46.

Table 46 Summary of Groundwater Quality Results from Monitored Bores

Groundwater Unit		Field pH	EC (µS/cm)	Sulphate (mg/L)	Boron (mg/L)	Copper (mg/L)	Zinc (mg/L)
Quaternary Alluvium	Range	5.53-7.49	1,560-16,600	10-249	0.16-4.71	0.002-0.452	0.009-0.570
	Mean	6.77	10,221	140	2.83	0.129	0.142
	Median	7.21	14,300	184	3.89	0.096	0.053
Tertiary Sediments	Range	5.77-7.47	1,400-22,600	25-635	0.12-1.6	0.001-0.160	0.008-0.426
	Mean	6.5	12,413	170	0.85	0.014	0.079
	Median	6.75	9,880	146	0.78	0.007	0.058
Coal Seams	Range	5.56-8.5	959-32,800	2-841	0.1-2.1	0.001-1.470	0.007-0.420
	Mean	6.66	18,173	384	0.872	0.022	0.069
	Median	6.55	19,900	348	0.88	0.007	0.055

All groundwater units (Quaternary alluvium, Tertiary sediments and Permian coal measures) recorded very high EC above the ANZG (2018) livestock drinking limit for beef cattle of approximately 6,000 µS/cm. Salinity increases with aquifer depth, and it is unlikely that groundwater units within the Project are used for stock watering. Due to the high salinity of the groundwater, samples were also relatively high in sulphate, especially for the coal seams.

Groundwater quality was typically above the ANZG (2018) freshwater ecosystem protection trigger value (95% species protection) for boron (all samples), copper and zinc (majority of samples) as well as aluminium, arsenic, lead and nickel (a number of samples for each analyte).

The pH (field testing) of groundwater within the Project area was mostly neutral, with the Quaternary alluvium ranging from 5.53 to 7.49; the Tertiary sediments ranging from 5.77 to 7.47; and the Permian coal seams ranging from 5.56 to 8.5.

8.2.3 Hydraulic Conductivity

Falling head tests were undertaken on 25 bores from the Project bore network to obtain site-specific hydraulic conductivity data from all Project groundwater units. Hydraulic conductivity and air-lift yield data for each monitoring bore is in Table 4-2 of Appendix C (JBT 2019) and summarised for each groundwater unit in Table 47.

A total of 17 slug tests were performed on bores that are screened within the coal seams. The hydraulic conductivity decreased with depth with the difference evident when comparing coal seam bores screened at a depth of less than 80 mbgl to bores screened at a depth greater than 80 mbgl.

Table 47 Hydraulic Conductivity and Air-Lift Yield Data Per Groundwater Unit

Groundwater Unit	No. of Tests	Hydraulic Conductivity (metres per day)			Average Air-lift Yield (L/s)
		Min	Max	Geometric Mean	
Quaternary Alluvium	1	0.097	-	-	-
Tertiary	5	0.027	3.805	0.27	0.548
Permian Coal Seams	17	0.002	5.387	0.13	1.185
Coal Seams <80 mbgl	11	0.012	5.387	0.37	1.578
Coal Seams >80 mbgl	6	0.002	0.245	0.02	0.320
Permian Interburden	2	0.001	0.002	-	-

The relationship between hydraulic conductivity and depth is shown graphically in Figure 69. Of particular interest is the data for the coal seam bores, where the trend for lower hydraulic conductivity with increasing depth is illustrated via the trend line and the 95% confidence interval that has been applied to the data.

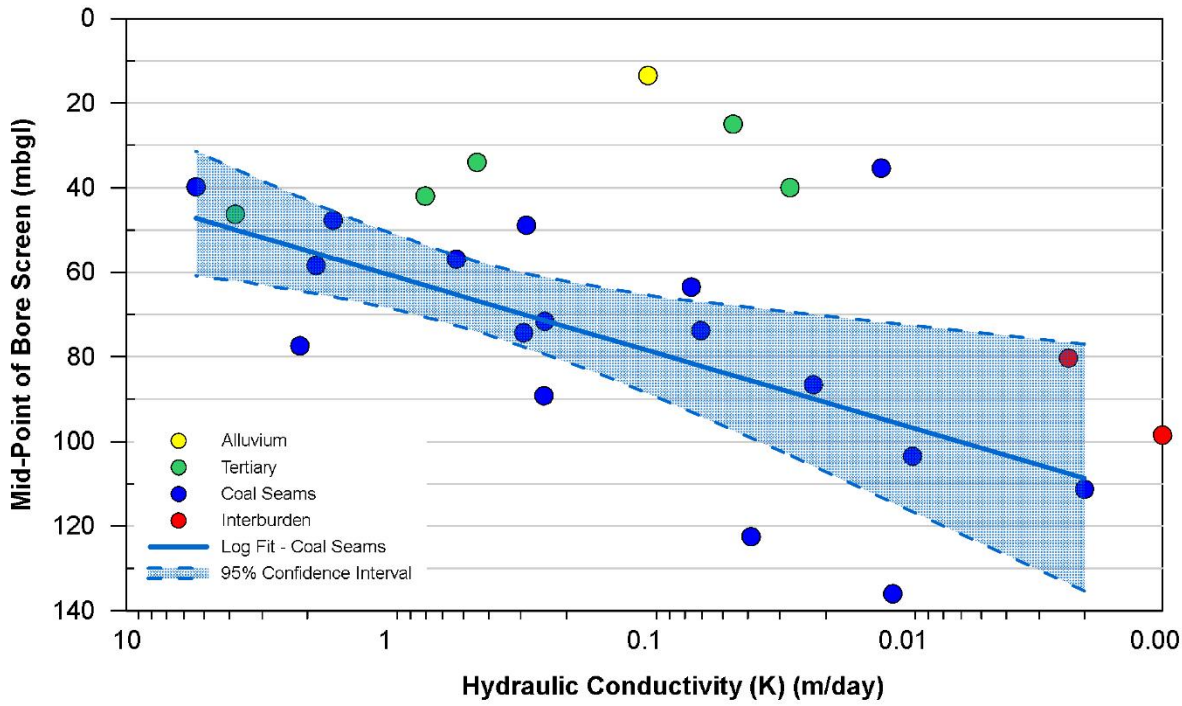


Figure 69 Relationship Between Hydraulic Conductivity and Depth

8.2.4 Groundwater Level

The most recent groundwater level data for the Project monitoring network bores is detailed in Appendix D. Figure 70 and Figure 71 illustrate water level data for Tertiary and coal seam groundwater units, respectively.

Six of the monitoring bores were dry; five within Tertiary sediments (depth: 14 m to 23 m) and one within the Aries seam (depth: 31.6 m).

Of the five dry sites; two were drilled to base of Tertiary, indicating that the Tertiary is dry at these locations, whilst the other three were not constructed to the full depth of Tertiary sediments. There was a significant reduction in depth to base of Tertiary to the west and northwest of Pit AB, where the base of Tertiary lowers from approximately 100 mAHD to 70-80 mAHD. The bores within the lower elevation area of base of Tertiary tended to record water levels in the order of 90 to 95 mAHD, whereas the bores in the higher elevation area tended to range between 105 to 113 mAHD.

The data for bores within the coal seams suggest that the coal measures are continuously saturated and that there is no significant trend for upward or downward movement of groundwater between the coal seams. Figure 71 shows the pre-mining groundwater level contours for the coal measures; indicating a trend for groundwater movement within the coal seams from the southwest to the northeast, and also from the northwest to the southeast, towards a depression that is centred on the area where Pit AB is proposed to be developed.

Bore DW7076W is located adjacent to Charlevue Creek (refer Figure 68) and screened in the Quaternary alluvium. The bore has been fitted with a data logger that records water level at 3-hourly intervals which will allow the relationship between creek flow and water level to be established over time. To date, the water level has been relatively stable, displaying a slight downward water level trend between 9-10 mbgl. A downward spike in water level following sampling is evident in the bore hydrograph (Figure 72), indicating that sampling events may have some influence on water level. An increase in water level after February 2020 suggests some correlation between rainfall events and associated streamflow, and water level. Further data will continue to be collected to establish the long-term water level trend.

Bore DW7292W1 is screened in the Quaternary alluvium adjacent to Springton Creek. The bore was initially fitted with a data logger in April 2020. However, the logger was found to be faulty and was replaced in July 2020, and records water level at 6-hourly intervals which will allow the relationship between creek flow and water level to be established over time. To date, the water level has been relatively stable, displaying a slight downward water level trend between 10-11 mbgl. A downward spike in water level following sampling is evident in the bore hydrograph (Figure 73), indicating that sampling events may have some influence on water level.

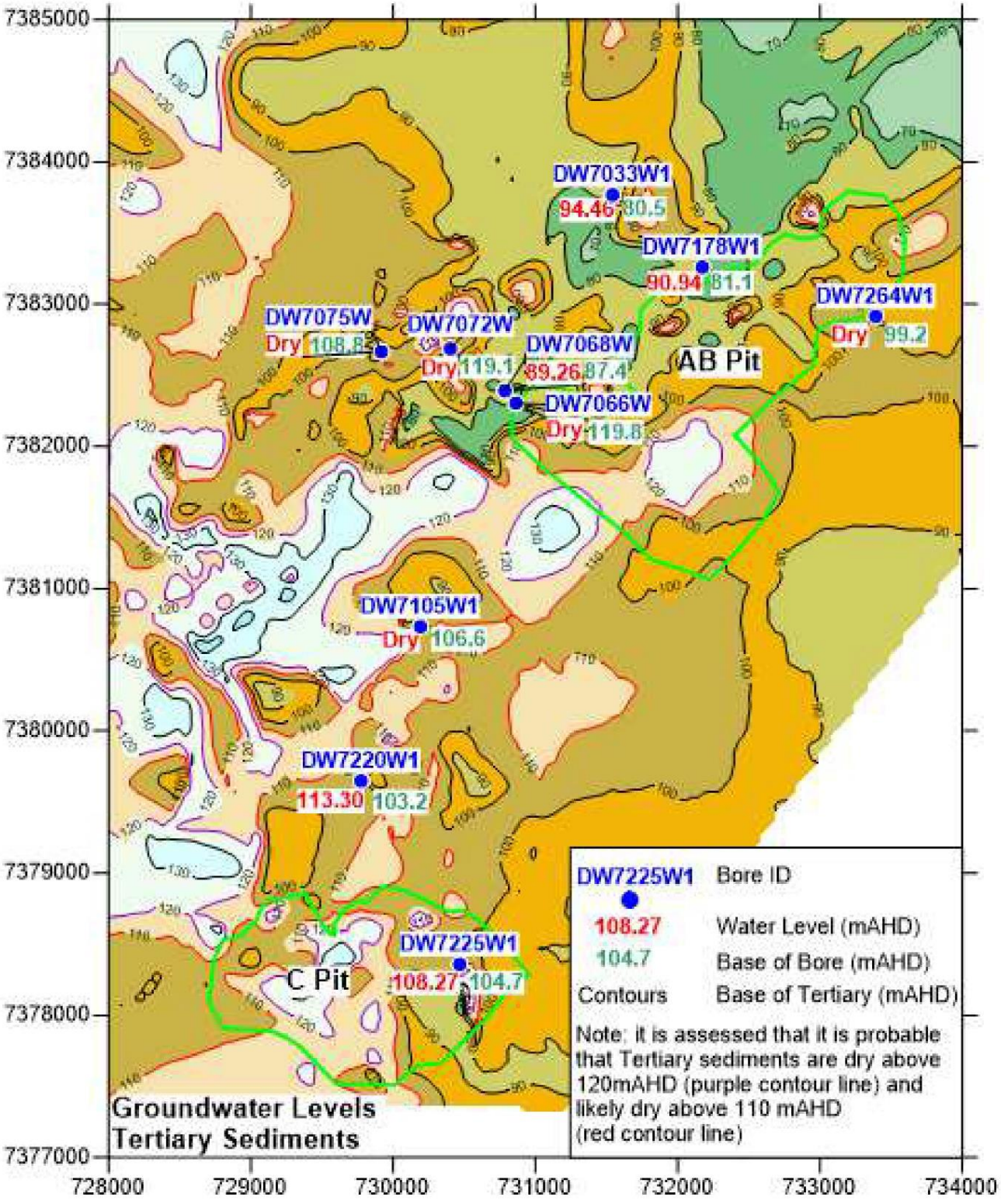


Figure 70 Water Level Data (Tertiary Groundwater Units)

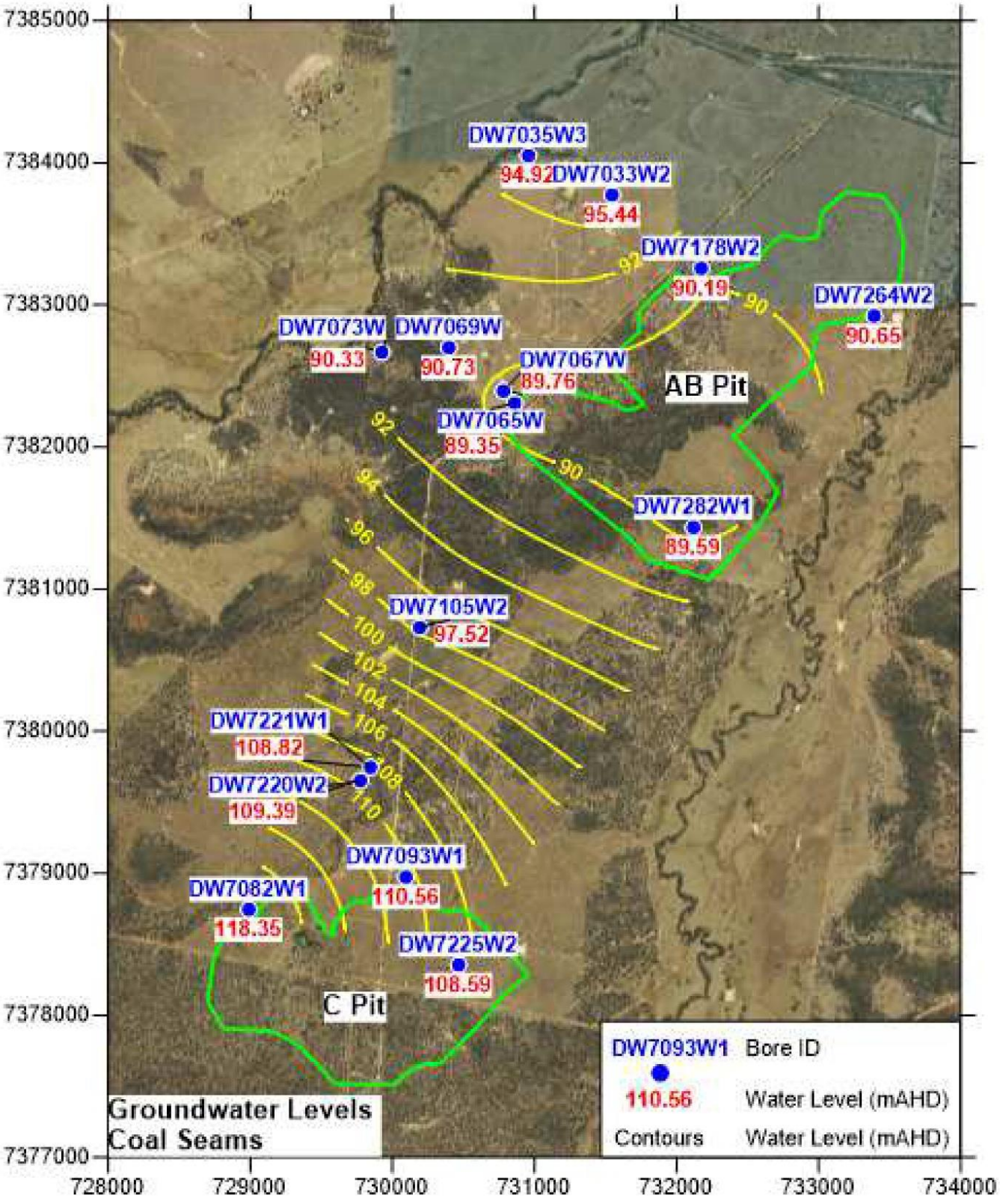


Figure 71 Water Level Data (Permian Coal Seam Groundwater Units)

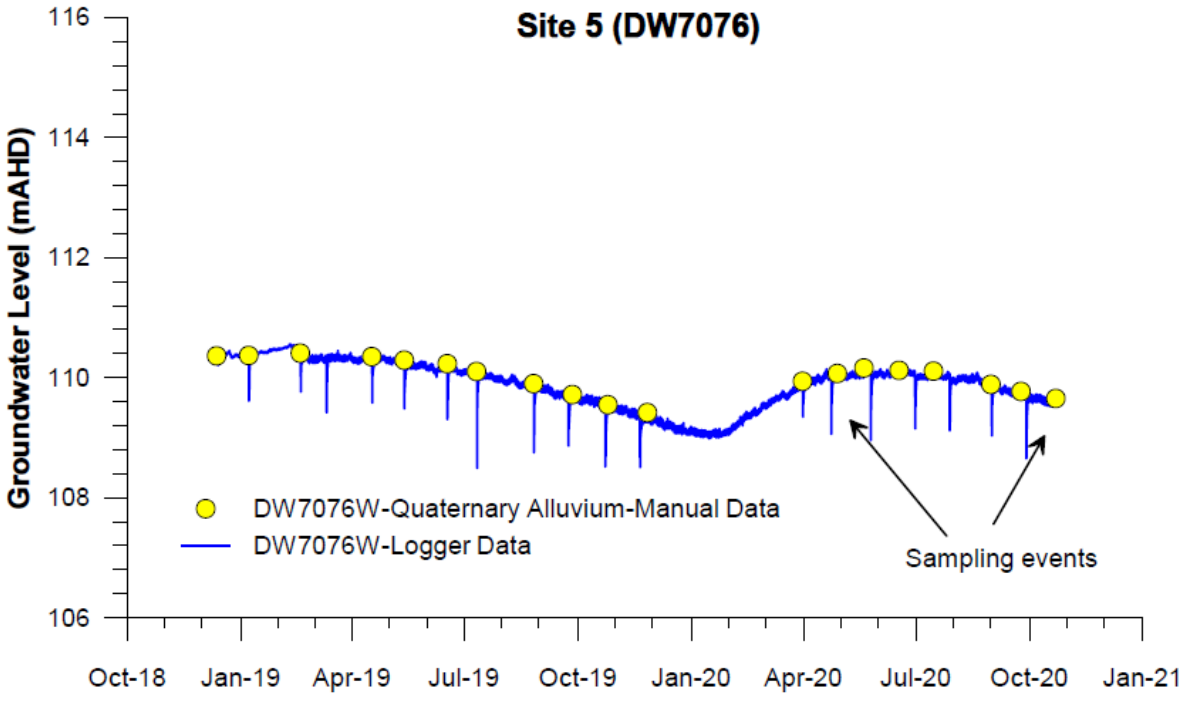


Figure 72 Water Level Data (Quaternary Alluvium - Bore DW7076W)

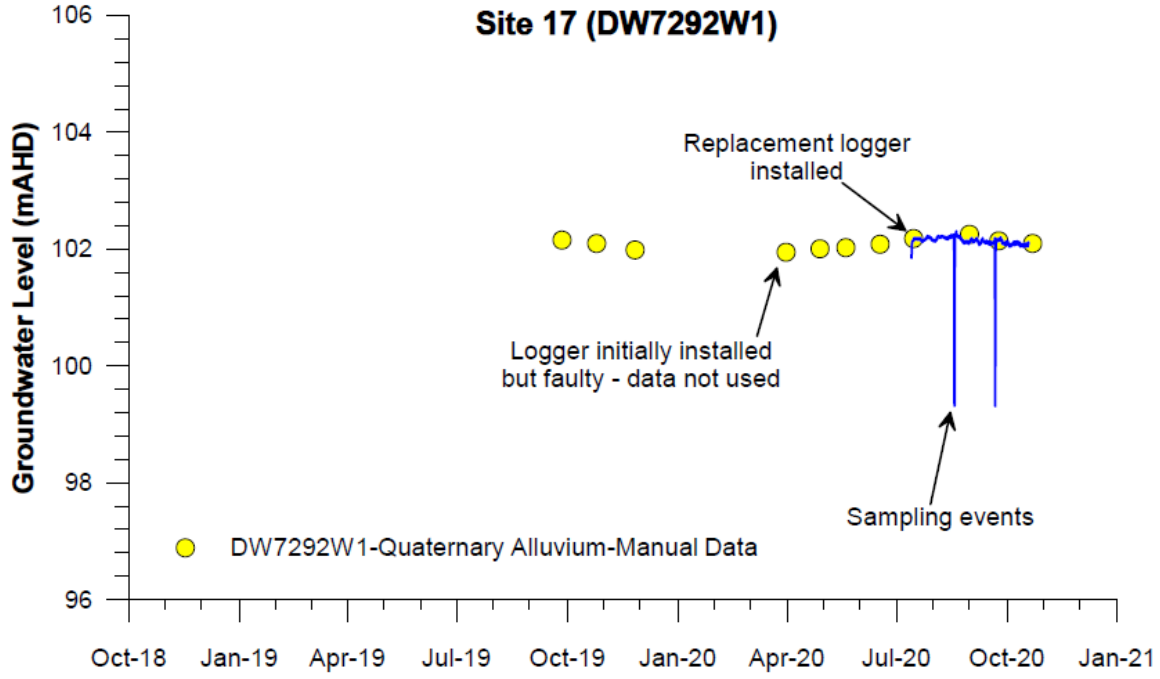


Figure 73 Water Level Data (Quaternary Alluvium - Bore DW7292W1)

8.3 POTENTIAL IMPACTS

The proposed mining activity has potential to impact groundwater values of the Project via:

- A drop in surrounding groundwater level occurring as a result of drawdown from the mining activity. The change in water level has potential to reduce the availability of water in existing groundwater bores. In addition, the drop in groundwater level may also reduce available supply for potential GDEs, where they exist within the zone of influence.

- An increased risk of groundwater contamination either via spills or leaks that might occur during the operation and have potential to seep to shallow aquifers, or in the post mining landform, subject to the final void equilibrium level and the associated risk of water in the void seeping in surrounding aquifers.

It is noted that the risk of groundwater drawdown from the project is limited to the take of Associated Water only. Groundwater is not proposed to be extracted as a source of water for any other related activity. The total predicted take of associated water is detailed in Table 48 (JBT 2019; JBT 2019, pers. comm., 8 October). For the purpose of future associated water reporting, JBT (2019) concluded that it would be more reasonable to assume the rate of inflow prior to development of the spoil aquifer, (approximately ~500 m^3/day) as the water that is developed from the spoil is derived mainly from rainfall recharge to the spoil and does not represent water from the natural formation. It is estimated that annual take of associated water will range from 150 Ml/a to 345 Ml/a.

Table 48 Estimated Take of Associated Water

Year	Pit AB		Pit C		Total
	m^3/day	Ml/a	m^3/day	Ml/a	Ml/a
1	626	228	0	0	228
2	626	228	0	0	228
3	433	158	0	0	158
4	433	158	0	0	158
5	508	185	0	0	185
6	508	185	0	0	185
7	946	345	0	0	345
8	946	345	0	0	345
9	493	180	0	0	180
10	493	180	0	0	180
11	493	180	0	0	180
12	493	180	121	44	224
13	493	180	121	44	224
14	493	180	241	88	268
15	453	165	241	88	253
16	453	165	239	87	253
17	248	91	239	87	178
18	248	91	163	59	150

The *Groundwater Impact Assessment* (JBT 2019) (Appendix C) was undertaken to assess the impacts of the Project. The following sections provide a summary of impacts relating to groundwater drawdown and the risk of contamination.

The potential for impacts of the Project on GDEs is described within Section 6.0. The potential impacts associated with final void water levels are described in more detail within Section 4.0.

Additional impacts from groundwater leaching have been identified in the *Land-Based Effluent Disposal Assessment* (Appendix N). According to the Model for Effluent Disposal through Land Irrigation (MEDLI) model scenario, elevated levels of nitrogen can be leached into the groundwater table when more nitrogen is added than removed to the soil (i.e., heavy rain periods). A construction and operational average of nitrate is predicted to leach 0.17 kg/ha/year via deep drainage during extremely impermeable conditions and during extremely permeable conditions, an average of 1.29 kg/ha/year. These conditions are still well within the accepted limit of 5 kg/ha/year. The irrigation scheme will still need to be managed via use of an appropriate irrigation rate and set back distances to minimise any impact on groundwater and any potential GDEs. The management measures of sewage effluent are discussed in Section 12.7.1.1.

8.3.1 Groundwater Model

To estimate the extent of water level impact from the proposed project, the *Groundwater Impact Assessment* (JBT 2019) (Appendix C) utilised 2-dimensional seepage modelling using the program Seep/W.

Section 5.0 of Appendix C details the essential elements of the conceptual model used to inform the Seep/W numerical model. The choice of the numerical model code was based on an assessment of the model platform and appropriate to the study requirements (assessment details in Section 6.1 of Appendix C). Sections 6.2 through to 6.5 (of Appendix C) present technical details of model inputs, whilst Section 6.7 details the uncertainty analysis.

8.3.2 Assessment Criteria

Criteria against which groundwater drawdown was assessed is based on the 'bore trigger thresholds' for the Water Act. A 'bore trigger threshold' as defined under section 362 of the Act; is a decline in the water level in the aquifer that is:

(a) the prescribed threshold for the area (if a regulation prescribes the bore trigger threshold for an area in which the aquifer is situated); or

(b) otherwise:

(i) for a consolidated aquifer – 5 m; or

(ii) for an unconsolidated aquifer – 2 m.

The potential for impact on existing groundwater users is discussed in Section 8.3.4, whilst the potential for water level impact on GDEs is discussed in Section 6.0.

8.3.3 Modelling Results

Water Quality

Modelling predicted that a permanent cone of depression will develop, directing groundwater flow towards the final voids. Therefore, the risk of the Project impacting on water quality (via outflow to the groundwater system) was assessed to be low.

It was, however, assessed that the Project could impact groundwater quality if the water within the final void were able to exit the void via unconsolidated sediments (i.e., the base of Tertiary) and flow via the groundwater system towards sensitive environmental receptors such as Springton Creek. For this reason, an assessment of the potential for water within the final voids to exit the void via the base of Tertiary sediments was undertaken. This assessment concluded that there is no outlet via the base of Tertiary for water within the final void of either Pit AB or Pit C, for either the maximum 'base case' water level or the maximum 'high inflow case' water level. It is concluded that there is a low risk of the Project impacting on groundwater quality.

Groundwater Level

The modelled drawdown extent at the end of mining is shown in Figure 74, and at post-mining equilibrium (i.e., steady-state post-mining drawdown) in Figure 75. The contours are shown as drawdown extent based on extrapolation of data points from each of the cross-section models (as depicted on Figure 74 and Figure 75).

At the end of mining, the 5 m drawdown extent is approximately 2 km from Pit AB and 1.8 km from Pit C, on the western side of the mining areas. On the eastern side, the 5 m extent is approximately 2 km from both Pit AB and Pit C. The 5 m extent of drawdown is approximately 1 km from Pit C at the southern end of the mining area, and approximately 2 km from Pit AB at the northern end. The 2 m drawdown contour extends approximately a further 1 km, than the 5 m drawdown extent.

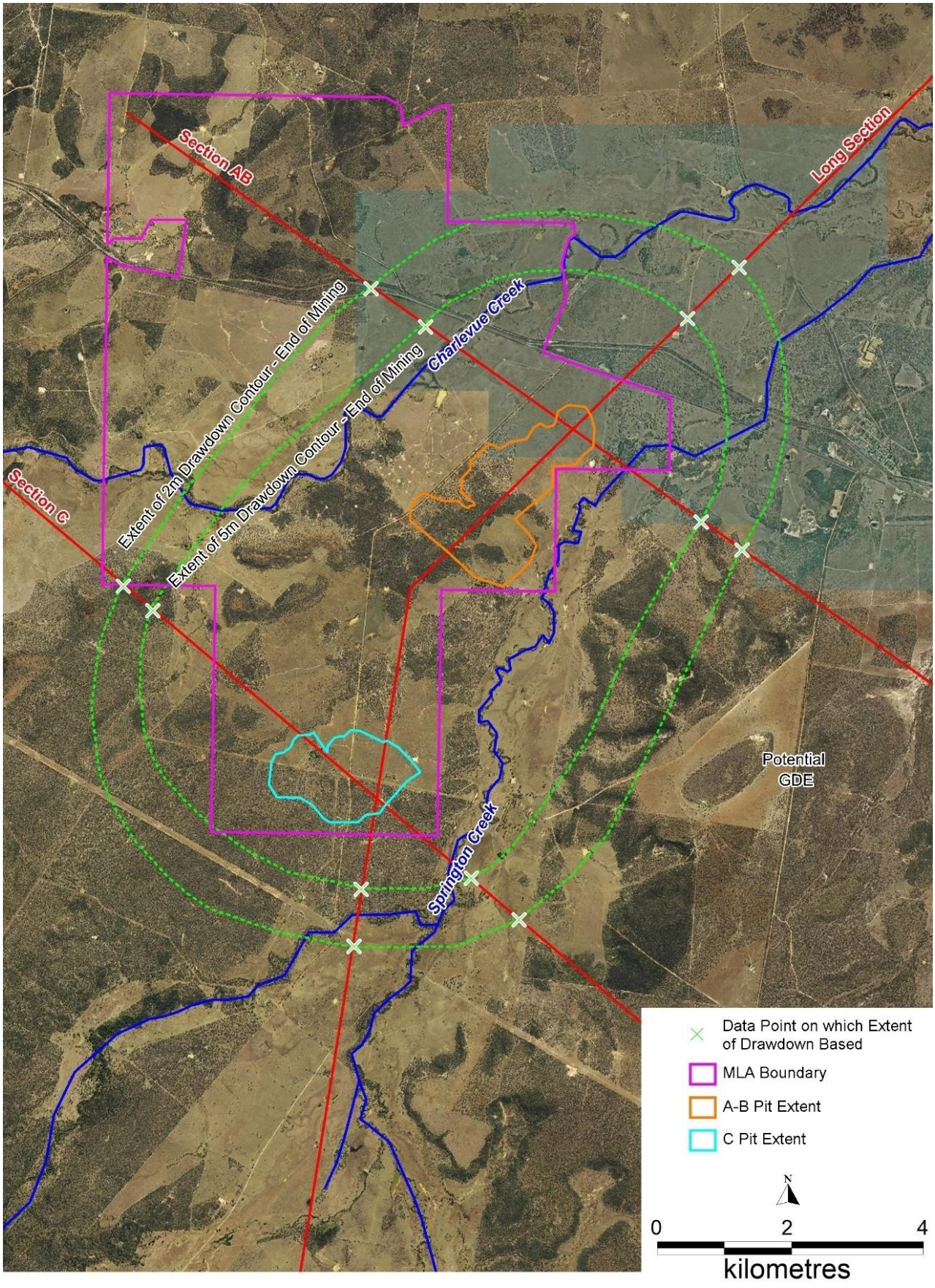


Figure 74 Water Level Drawdown Contours (2m and 5m) - End Of Mining

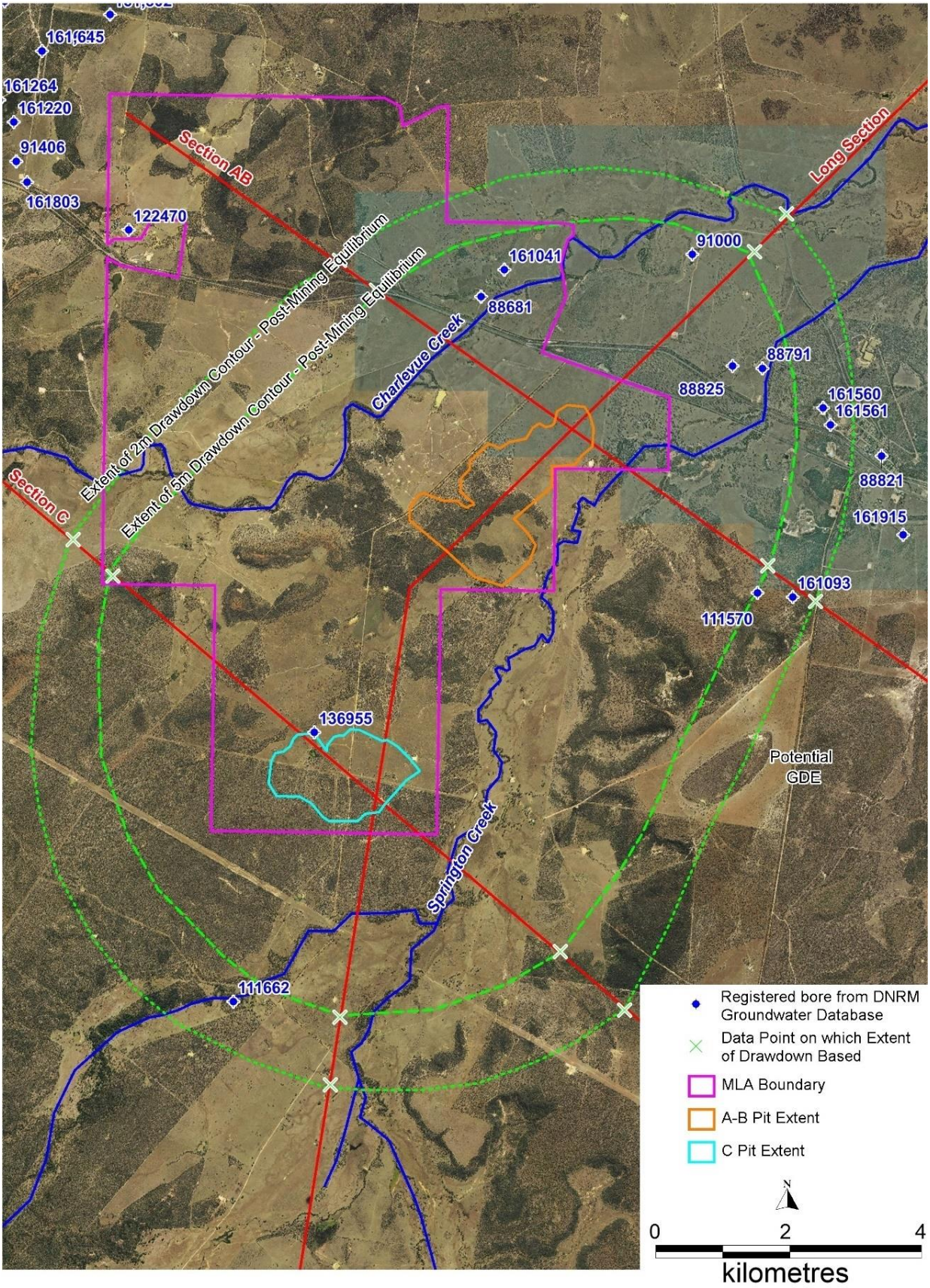


Figure 75 Water Level Drawdown Contours (2m and 5m) - Post-Mining Equilibrium

At post-mining equilibrium, the 5 m drawdown extent is approximately 2 km further from Pit C at the southern side and 2 km further from Pit AB at the northern end of the mining area, than at end of mining. The drawdown contours also extend further to the east and west another approximately 2.5 km. There are no mining operations within the zone of predicted drawdown from mining at the Gemini Project; therefore, there are no cumulative impacts to assess.

8.3.4 Impacts on Existing Groundwater Users

Groundwater Level

Figure 74 (end of mining) and Figure 75 (post-mining equilibrium) show 11 registered groundwater bores (from the DNRME groundwater database) within the 2 m drawdown zone. Summary data for the bores within this zone are shown in Table 49 and summarised as follows:

- seven bores (111662, 136955, 111570, 161093, 88973, 161041 and 88681) are located on land that is owned by Magnetic South;
- two bores (161560 and 161561) appear to be monitoring bores for the Dingo Landfill;
- three bores record groundwater that is highly saline and assessed to be of no beneficial use (in excess of the upper limit of salinity tolerance for beef cattle, sheep, horses and pigs with no loss of production, with a decline in animal health at progressively higher salinity values (ANZG 2018). These bores recorded EC values of 10,000 µS/cm (88681), 19,200 µS/cm (88791) and 14,660 µS/cm (91000);
- two bores (88825 and 161041) are sites with relatively little available data, but which are located within the zone of potential impact to the northeast and west-northwest of Pit AB respectively; and
- two bores (111570 and 161093) recorded relatively fresh groundwater (<1,000 µS/cm) at shallow depth. While these bores are located within the extent of 2 m drawdown, they were assessed to be isolated from the regional groundwater system as discussed in detail with relation to GDEs in Section 7.2.1 of Appendix C. At these sites it is noted that they are not located within the zone of potential impact at end of mining but are within the zone of potential impact at post-mining equilibrium.

Based on the assessment of bores within the zone of influence, it is unlikely that the Project will significantly impact on the availability of groundwater for agricultural land use.

Where there is remaining uncertainty over the presence, or the productive use of bores within the zone of influence, further assessment in the form of a bore plan and assessment will be undertaken prior to development. It is further noted that make-good agreements will be put in place where it is determined that drawdown affects the utility of the bore.

Water Quality

Considering the mining activity is predicted to result in a permanent cone of depression, and the lack of an outlet via the base of Tertiary for water within the final void of either Pit AB or Pit C, it was concluded that the risk of significant groundwater contamination was very low.

The risk of spills or leaks causing contamination is assessed to be manageable and unlikely to result in environmental harm.

Table 49 Bores from DNRME Groundwater Database Within 2 M Drawdown Zone

RN	Aquifer	EC (µS/cm)	SWL (mbgl)	Original Bore Name	Comment
88681	Duaringa Formation	10,000	-	-	Extremely saline - no beneficial use based on water quality.
88791	Duaringa Formation	19,200	-20	New Bore	Extremely saline - no beneficial use based on water quality.
88825	Unknown	-	-	Windmill	-
91000	Duaringa Formation	14,660	-20	Mackenzie OLO	Extremely saline - no beneficial use based on water quality.
111570	Tertiary-Undefined	240	-16	Ward	Refer to Appendix C (Section 7.2.1) for discussion.
111662	Tertiary-Undefined	750	-17	Smith	Located on land owned by Magnetic South.
136955	Tertiary-Undefined	10,300	-21	-	Located within MLA on land owned by Magnetic South.
161041	Duaringa Formation	-	-29	-	-
161093	Tertiary Mafic Volcanics	710	-19.5	-	Refer to Appendix C (Section 7.2.1) for discussion.
161560	Unknown	28,102	-	Dingo Landfill MW2	Assumed to be a monitoring bore at Dingo Landfill.
161561	Unknown	-	-	Dingo Landfill MW1	Assumed to be a monitoring bore at Dingo Landfill.

Notes: RN registration number
SWL surface water level

8.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING

Overall, the *Groundwater Impact Assessment* (JBT 2019) (Appendix C) concluded that there is a low risk the Project would impact on groundwater quality, groundwater level or potential GDEs. The management and monitoring strategies will ensure groundwater resources are managed and risk remains low. Magnetic South is committed to implementing procedures for monitoring and complaints resolution to control magnitude of risk.

Impacts and mitigation measures for protection of potential GDEs is discussed in detail within Section 6.0.

Associated Water Take

Monitoring and annual reporting of associated water take will be in accordance with the requirements of the *Mineral Resources Act 1989*.

Landholder Bores

Magnetic South will prepare an *Underground Water Impact Report* for submission and approval in accordance with the Water Act. The report will identify aquifers that are predicted to be impacted by the exercise of underground water rights; establish obligations to monitor impacts on aquifers and springs;

impose a strategy to mitigate impacts on any spring of interest; assist with management of impacts of the exercise of water rights by resource tenure holders; and establish underground water obligations (make good obligations of the resource tenure holder for private water bores.

Where it has been determined that an impact on landholder bores exists, a *Baseline Assessment Plan* will be prepared (as required by the Water Act) identifying water bores located on a holder's tenure and setting out a timetable for undertaking baseline assessments of those bores.

If required, bore assessments and 'make good agreements' will be established (in accordance with the Water Act) with any relevant stakeholders.

Groundwater Monitoring and Evaluation Program

The Project groundwater monitoring bore network established for the baseline studies will continue to be monitored throughout operation and decommissioning. A copy of the *Groundwater Monitoring and Management Plan* for the Project is included as Appendix E, with the main elements summarised below.

The monitoring program will record groundwater levels and water quality from existing monitoring bores to provide long term groundwater level data from the Project area, and to detect and quantify potential drawdown occurring during and post mining.

The groundwater monitoring bore network was designed based on the following considerations:

- bores are located within all groundwater units present at site (Quaternary alluvium of Charlevue Creek and Springton Creek, Tertiary sediments, Permian coal seams and interburden units);
- the majority of bores were located in the area of the AB pit, as this pit is planned to be developed first;
- the bores are broadly aligned in two transects to provide drawdown data within the mined area, immediately adjacent to the mined area, and at distance towards Charlevue Creek and Springton Creek;
- bores are located within all groundwater units that exist between the AB Pit and the C Pit, to provide information on the extent of drawdown between the pits and as a way of providing drawdown data to validate the groundwater model;
- additional bores are located within and immediately adjacent to the C Pit, within all groundwater units encountered in that area (to base of mining) to provide both water level and water quality data in that area;
- the spatial and vertical layout of the bore monitoring network (which includes 38 bores at 17 sites) will allow:
    - assessment of the variability of water quality across the site and within vertically separated groundwater units at the same location (e.g., coal measures and overlying Tertiary sediments);
    - assessment of the potential for upward vs downward groundwater movement at a single location;
    - assessment of groundwater flow direction within the distinct groundwater units; and

- assessment of recharge potential of the various groundwater units, particularly the Quaternary alluvium where water level loggers have been fitted to bores DW7076W and DW7292W.

Compliance and reference bores have been selected as follows:

- The compliance bores provide a spatial coverage within all groundwater units identified at site and where possible are located close to mining areas (within the zone of predicted impact) but not within the disturbance footprint of mining (i.e., within the proposed pit area).

- Reference bores have been selected to be located within the same groundwater units but at locations that are distant from the area where mining is first proposed to commence (the AB Pit Area). As mining progresses towards the C Pit area, the existing reference bores are likely to become the compliance bores for that area.

Because a large number of Tertiary monitoring bores are dry, the proposed compliance bore network for Tertiary bores is limited to the bores that contain water. One bore (DW7225W1) is located within the mining footprint of the C Pit, though mining of the AB Pit will occur in advance of mining in this area. The bore is included to provide spatial coverage of the Tertiary sediments but will require replacement once mining in the C Pit area commences.

Bores within the alluvium are targeted for monitoring via water level dataloggers to allow assessment of the range of seasonal water level variation at these sites, with data loggers fitted to bores DW7292W1 (Springton Creek alluvium) and DW7076W (Charlevue Creek alluvium).

A summary of the Project groundwater monitoring bore network is provided in Table 50.

Table 50 Groundwater Monitoring Bores

Site	Bore ID	Unit Monitored	Easting (GDA94)	Northing (GDA94)	Collar RL (mAHD)	Monitoring Frequency
Control Bores						
2	DW7068W	Tertiary	730785	7382391	134	2-Monthly
3	DW7069W	Permian	730397	7382699	132.57	2-Monthly
	DW7071W	Permian	730394	7382703	132.4	2-Monthly
4	DW7073W	Permian	729926	7382666	122.09	2-Monthly
	DW7074W	Permian	729922	7382666	122.04	2-Monthly
	DW7075W	Tertiary	729918	7382666	121.83	2-Monthly
5	DW7076W	Quaternary Alluvium	729750	7382723	119.81	2-Monthly
6	DW7033W1	Tertiary	731543	7383768	124.4	2-Monthly
	DW7033W2	Permian	731546	7383773	124.45	2-Monthly
	DW7033W3	Permian	731548	7383777	124.43	2-Monthly
7	DW7035W3	Permian	730957	7384050	116.67	2-Monthly
11	DW7178W1	Tertiary	732174	7383260	128.65	2-Monthly
15	DW7264W2	Permian	733391	7382921	112.24	2-Monthly
	DW7264W3	Permian	733391	7382925	112.24	2-Monthly
17	DW7292W1	Quaternary Alluvium	732905	7381108	113.58	2-Monthly
Reference Bores						

Site	Bore ID	Unit Monitored	Easting (GDA94)	Northing (GDA94)	Collar RL (mAHD)	Monitoring Frequency
8	DW7082W1	Permian	728989	7378746	135.26	2-Monthly
	DW7082W2	Permian	728986	7378742	135.33	2-Monthly
9	DW7093W1	Permian	730096	7378974	139	2-Monthly
	DW7093W2	Permian	730092	7378973	139.05	2-Monthly
	DW7093W3	Permian	730088	7378974	139.12	2-Monthly
10	DW7105W2	Permian	730193	7380729	128.7	2-Monthly
12	DW7220W1	Tertiary	729775	7379648	128.68	2-Monthly
	DW7220W2	Permian	729775	7379651	128.64	2-Monthly
	DW7220W3	Permian	729774	7379655	128.68	2-Monthly
13	DW7221W1	Permian	729846	7379745	129.32	2-Monthly
	DW7221W2	Permian	729845	7379742	129.25	2-Monthly
14	DW7225W1	Tertiary	730467	7378359	140.64	2-Monthly
	DW7225W2	Aries 3 Seam	730466	7378355	140.69	2-Monthly
	DW7225W3	Castor Seam	730465	7378351	140.7	2-Monthly

Groundwater Trigger Values

Based on the baseline monitoring data collected to date, trigger levels have been proposed for the compliance monitoring bores within the groundwater monitoring network. The trigger levels are proposed as interim trigger levels and it is proposed that the levels are further reviewed after collection of an additional 2 years of data. Trigger levels are provided in Table 51, and have been proposed based on the following rationale:

- for EC and sulphate the trigger level is based on the 95th percentile of the data for each groundwater unit;
- for pH, the proposed trigger level range is based on the range of site data;
- for metals/metalloids where the data is generally below the ANZG (2018) aquatic ecosystem protection limit for moderately disturbed system (95% protection), the proposed trigger level is based on the ANZG (2018) limits;
- for mercury, the proposed trigger is based on the limit of reporting (LOR) of the analytical method FIMS; and
- for metals/metalloids where the site background data is generally above the ANZG (2018) freshwater protection limit, the proposed trigger level is based on the 95th percentile of the data for each groundwater unit.

Data for each of the proposed compliance bores compared to the proposed trigger levels are shown graphically in Appendix D.

Table 51 Proposed Groundwater Quality Trigger Levels

Parameter	Groundwater Unit			Figure No (6)
	Quaternary Alluvium	Tertiary	Permian	
pH (pH units)	5.5 – 8.5 (1)	5.5 – 8.5 (1)	5.5 – 8.5 (1)	25
Electrical conductivity (µS/cm)	16209 (2)	22362 (2)	28692 (2)	23
Metals/metalloids (dissolved – mg/L) (5)				
Aluminium	0.09 (2)	0.13 (3)	0.13 (3)	26
Arsenic	0.013 (3)	0.013 (3)	0.019 (2)	27
Boron	4.66 (3)	1.46 (3)	1.42 (3)	28
Cadmium	0.0002 (2)	0.0002 (2)	0.0002 (2)	29
Cobalt	0.004 (3)	0.004 (3)	0.019 (2)	30
Chromium	0.001 (3)	0.001 (3)	0.001 (3)	31
Copper	0.069 (2)	0.065 (2)	0.083 (2)	32
Mercury	0.0001 (4)	0.0001 (4)	0.0001 (4)	33
Manganese	0.227 (2)	0.19 (2)	0.468 (2)	34
Molybdenum	0.004 (2)	0.017 (2)	0.081 (2)	35
Nickel	0.056 (2)	0.02 (2)	0.002 (2)	36
Lead	0.034 (3)	0.034 (3)	0.034 (3)	37
Selenium	0.005 (3)	0.005 (3)	0.005 (3)	38
Uranium	0.058 (2)	0.01 (2)	0.018 (2)	39
Vanadium	0.026 (2)	0.006 (3)	0.006 (3)	40
Zinc	0.46 (2)	0.17 (2)	0.015 (2)	41
Major Ions (mg/L)				
Sulphate	226 (2)	346 (2)	766 (2)	24
Calcium, chloride, potassium, magnesium, sodium, alkalinity	For interpretation purposes only			

(1) Range of site data
(2) 95th Percentile of data for each groundwater unit
(3) ANZG (2018) Aquatic ecosystem protection for moderately disturbed system (95% protection)
(4) LOR of FIMS analytical method
(5) All metals and metalloids to be measured as total (unfiltered) and dissolved (filtered).
(6) Figures provided in Appendix D

Proposed groundwater level triggers are based on the bore trigger thresholds in the *Water Act 2000* as shown in the excerpt below:

> ***bore trigger threshold**, for an aquifer, means a decline in the water level in the aquifer that is—*
>
> *(a) if a regulation prescribes the bore trigger threshold for an area in which the aquifer is situated — the prescribed threshold for the area; or*
>
> *(b) otherwise—*
>
> *(i) for a consolidated aquifer—5m; or*

(ii) for an unconsolidated aquifer—2m.

Proposed water level triggers are therefore:

- consolidated aquifers (Permian Sediments/ Rewan Group) – 5 m/year; and
- unconsolidated aquifers (Quaternary Alluvium, Tertiary sediments) – 2 m/year

The assessment of water quality data will be undertaken as follows:

- two consecutive exceedances of a trigger value as defined in Table 4-1 will constitute a trigger level exceedance; and
- four consecutive exceedances of a trigger value as defined in Table 4-1 will constitute a limit exceedance.

9.0 AIR QUALITY

This section provides a description of existing air quality within and surrounding the Gemini Project. It aims to predict any changes in air quality as a result of the Project and propose mitigation measures and management strategies.

The *Air Quality and Greenhouse Gas Assessment* (Katestone 2020) provided in Appendix L has been conducted to determine the likely impacts of the Project on airborne concentrations and dust deposition rates. Particulates considered in this assessment are:

- total suspended particulate matter (TSP);
- particulate matter with equivalent aerodynamic diameters of 10 µm or less (PM_{10}); and
- particulate matter with equivalent aerodynamic diameters of 2.5 µm or less ($PM_{2.5}$).

9.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES

The environmental objective relevant to potential impacts to air, as described in the EA guideline for *Application requirements for activities with impacts to air [ESR/2015/1840]* (DES 2017a) is:

The activity will be operated in a way that protects the environmental values of air.

The Project would achieve all of the following performance outcomes identified in Schedule 8, Part 3, Division 1 of the EP Regulation:

(a) fugitive emissions of contaminants from storage, handling and processing of materials and transporting materials within the site are prevented or minimised;

(b) contingency measures will prevent or minimise adverse effects on the environment from unplanned emissions and shut down and start up emissions of contaminants to air; and

(c) releases of contaminants to the atmosphere for dispersion will be managed to prevent or minimise adverse effects on environmental values.

9.2 DESCRIPTION OF ENVIRONMENTAL VALUES

In accordance with the *Environmental Protection (Air) Policy 2019* (EPP (Air)) the EVs pursuant to air quality to be enhanced or protected include the qualities of the air environment that are conducive to protecting:

- the health and biodiversity of ecosystems;
- human health and wellbeing;
- the aesthetics of the environment, including the appearance of buildings, structures and other property; and
- agricultural use of the environment.

9.2.1 Land Use

The Project and surrounding area is currently used predominately for cattle grazing with most of the area cleared of remnant vegetation for agricultural purposes.

To the east of the Project lies Dingo, a small town of approximately 450 people, and includes residences, sporting facilities (sports oval, tennis courts), a primary school, and local businesses (post office, hotel, shops, etc).

The study area covers approximately 400 km^2 and extends beyond the borders of the MLA in order to assess the potential impact of the Project on the air quality of the wider community. The context of the land considered in the air quality assessment of the Project is shown below in Figure 76 through topographical contours expressed in mAHD.

9.2.2 Climate and Wind Characteristics

Meteorological modelling was used to generate wind speed and direction inputs for the impact assessment as described in Appendix A of the *Air Quality and Greenhouse Gas Assessment* (Katestone 2020) (refer Appendix L). The local meteorological conditions relating to the Project have been described in Section 2.2 of this document.

9.2.3 Existing Air Quality

9.2.3.1 Existing Sources of Emissions

Ambient dust levels across the area will be influenced by natural sources of dust such as wind erosion and fires, as well as dust emissions from existing anthropogenic sources in the area, possibly including local agriculture or horticulture, and existing mines.

The National Pollution Inventory (NPI) is a public database of annual emissions of 93 substances reported by industries across Australia. The closest facility currently reporting to the NPI program is more than 10km away from the Project and unlikely to contribute to existing levels of dust within the study domain. There are seven NPI reporting facilities within a 50 km radius of the Project including six mines and one quarry. Potential contributions from the surrounding facilities, including the Bluff Coal Mine, on sensitive receptors are expected to be adequately accounted for in the Blackwater monitoring data used to determine background particulate concentrations utilised in the cumulative assessment of the Gemini Project. Further, the closest reporting facility the Bluff Mine is currently in care and maintenance with no certainty of return to operations.

These existing seven facilities are listed in Appendix L and are considered far enough away from the Gemini Project to have a minimal impact on the local dust levels near the Project or will be adequately accounted for in the ambient background monitoring data.

9.2.3.2 Ambient Air Quality

The *Air Quality and Greenhouse Gas Assessment* (Katestone 2020) (Appendix L) has estimated the expected background concentrations of relevant air contaminants (Table 52). A total of 12-months of data (April 2019 to April 2020) from the DES monitoring station at Blackwater, approximately 35 km west of the Project, was relied upon to characterise the existing environment. It is noted that DES does not conduct monitoring for TSP and dust deposition, therefore either alternative data sources have been utilised or calculated using the existing DES monitoring data (each parameter data source has been listed in Table 52). For the purposes of the cumulative impact assessment, the ambient background concentrations of PM_{10} and $PM_{2.5}$ were taken as the 70th percentile 24-hour average from the Blackwater

monitoring site. Use of the 70th percentile value was based on the methodology published by EPA Victoria (EPA Victoria 2007) and is accepted in Queensland.

On the occasions where the 24-hour background concentrations of PM_{10} and $PM_{2.5}$ exceeded the EPP (Air) objectives at the Blackwater monitoring site; a discussion on temporal and meteorological variation has been included in Table 4 of Appendix L to explain existing exceedances.

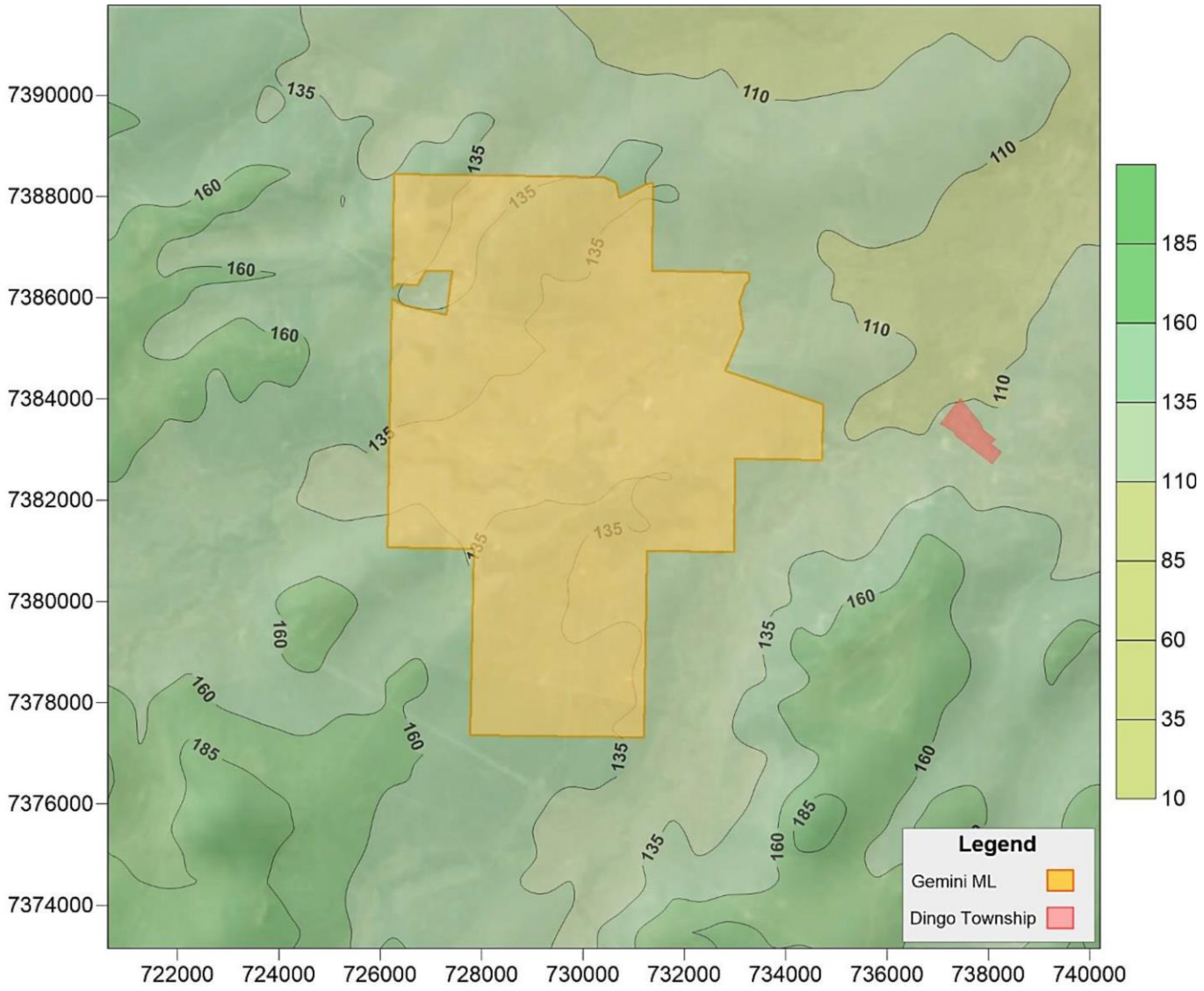


Figure 76 Local Terrain

Table 52 Ambient Background Concentrations Used To Assess Cumulative Impacts

Pollutant	Averaging Period	Concentration	Source
TSP	Annual	45.8 µg/m^3	Calculated from the average PM_{10} data measured at Blackwater using PM_{10}/TSP ratio of 0.5.
PM_{10}	24-hour	23.8 µg/m^3	70th percentile of monitoring data at Blackwater.
	Annual	22.9 µg/m^3	Average of monitoring data at Blackwater.
$PM_{2.5}$	24-hour	7.4 µg/m^3	70th percentile of monitoring data at Blackwater.
	Annual	6.8 µg/m^3	Average of monitoring data at Blackwater.
Dust Deposition	Monthly	50 mg/m²/day	Typical value for rural areas.

9.2.4 Sensitive Receptors

A desktop assessment identified a total of 25 sensitive receptors within 5 km of the Project based on the definition from the EPP (Air). Sensitive receptors considered in the assessment are presented in Figure 77 and Table 53, encompassing residences, businesses, and recreational areas.

At the time of reporting the following sensitive receptors are owned or pending purchase by Magnetic South and have not been considered further in this assessment: SR09, SR14, SR15, SR18, SR19, SR20, SR21, SR23 and SR24.

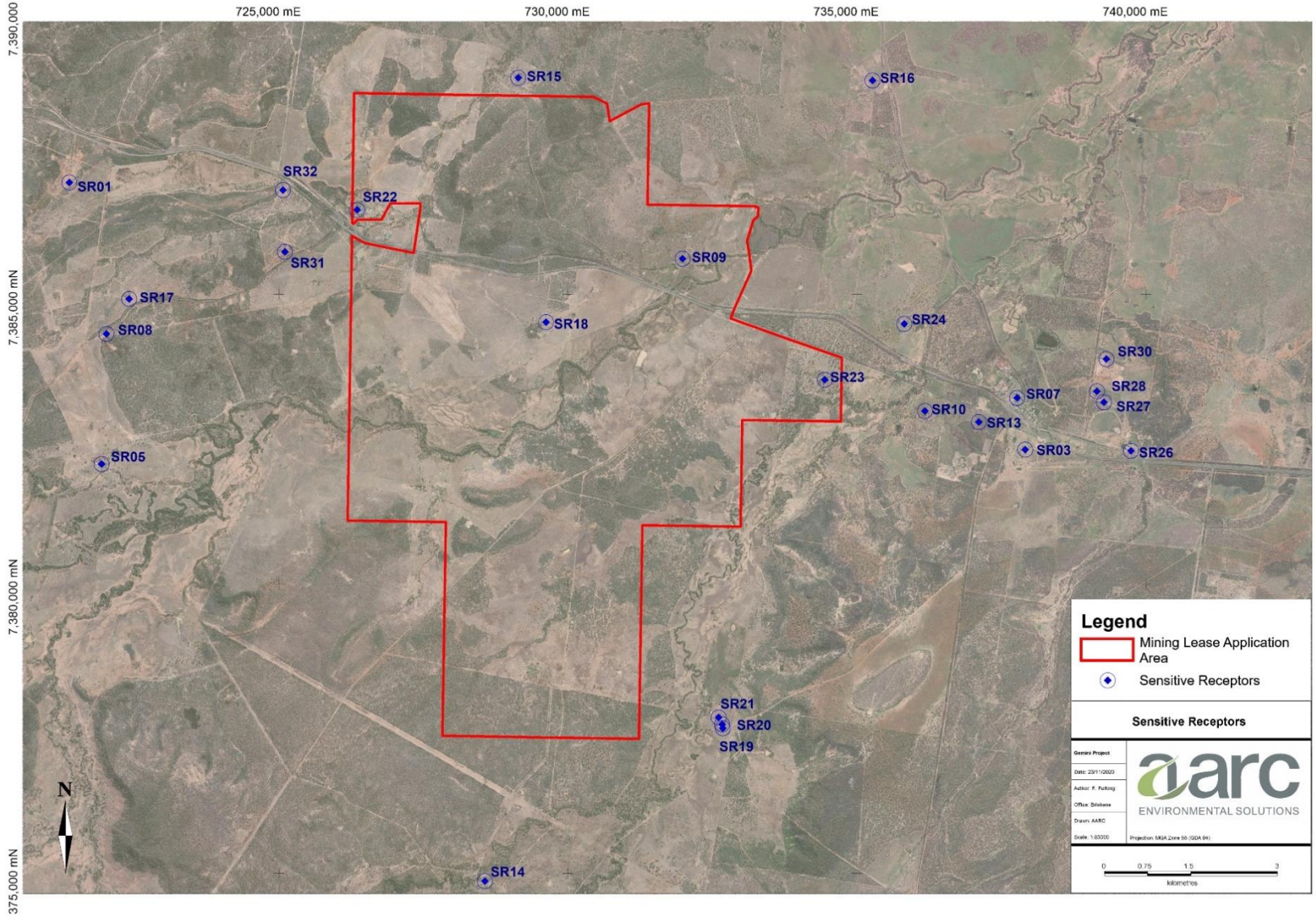


Figure 77 Sensitive Receptors Within 5 km of the Project

Table 53 Sensitive Receptors Within 10 km of the Project

Receptor ID	Receptor Type	Property Name	Easting	Northing	Location
SR01	Residential	3SP165527	721380	7386940	4.8 km W
SR03	Residential	6SP152759	737915	7382328	3.2 km E
SR05	Residential	Charlevue	721937	7382077	4.2 km W
SR07	Dingo Township (*residential, businesses & facilities*)	Dingo Township	737777 (town centre)	7383220 (town centre)	2.3 km E
SR08	Residential	Dunkerinn	722022	7384327	4.2 km W
SR09	Residential	2RP904099	2RP904099	731988	Within MLA
SR10	Residential	Fairview Park	736181	7382995	1.4 km E
SR13	Residential	Fairview Park	737113	7382802	2.3 km E
SR14	Residential	Glenwood	728569	7374873	2.5 km S
SR15	Residential	4HT165	729144	7388750	0.3 km N
SR16	Residential	Lanlea	735273	7388705	3 km NE
SR17	Residential	Myimbarr	722415	7384928	3.9 km W
SR18	Residential	1HT424	729626	7384531	Within MLA
SR19	Residential	2HT138	732684	7377515	1.4 km SE
SR20	Residential	2HT138	732671	7377581	1.4 km SE
SR21	Residential	2HT138	732614	7377700	1.4 km SE
SR22	Residential and Accommodation	Redrock Park	726358	7386469	Within MLA
SR23	Residential	47H406	734446	7383534	Within MLA
SR24	Residential	20H4017	735824	7384500	1.2 km NE
SR26	Residential	The Lazy H and Hopevale	739747	7382306	5 km E
SR27	Residential	The Lazy H and Hopevale	739278	7383145	4.5 km E
SR28	Residential	The Lazy H and Hopevale	739157	7383337	4.4 km E
SR30	Residential	The Lazy H and Hopevale	739319	7383894	4.6 km E
SR31	Residential	Unknown	725109	7385743	1.1 km NW
SR32	Residential	Unknown	725075	7386813	1.2 km NW

Notes: Datum: Map Grid of Australia (MGA) Zone 55.
Green owned or pending purchase by Magnetic South.

9.3 POTENTIAL IMPACTS

Katestone (2020) used standard industry dispersion models suitable for use in Australia and regulatory approved assessment techniques to predict ground-level concentrations of air pollutants in the areas surrounding the Project. Technical details of the methodology and models are provided in Appendix A of the *Air Quality and Greenhouse Gas Assessment* (Katestone 2020) (Appendix L).

9.3.1 Air Quality Objectives and Criteria

The EP Act provides for the management of the air environment in Queensland. The EPP (Air) was made under the EP Act with the objective "*to identify the environmental values of the air environment to be enhanced or protected and to achieve the objective of the EP Act (i.e., ecologically sustainable development)*". The EPP (Air) air quality objectives relevant to key air pollutants that may be generated from the Project are presented in Table 54.

Table 54 EPP (Air) Relevant Air Quality Objectives

Pollutant	Environmental Value	Averaging Period	Air Quality Objective	Number Exceedances Allowed Per Year
TSP	Health and Wellbeing	1 year	90 µg/m^3	None
PM_{10}		24 hours	50 µg/m^3	None
		1 year	25 µg/m^3	None
$PM_{2.5}$		24 hours	25 µg/m^3	None
		1 year	8 µg/m^3	None
Dust Deposition	Amenity	1 month	120 mg/m²/day	None

Notes: Dust deposition value is a DES recommended design objective rather than EPP (Air) objective and applies to total insoluble solids.

9.3.2 Emissions

Dust emissions will be generated over the life of the Project as a result of material extraction, handling, haulage and wind erosion of exposed mine areas. Emissions of oxides of nitrogen, sulphur dioxide and carbon dioxide (CO_2) would also occur due to blasting activities and combustion of fuels onsite. However, these emissions are transient (contained within the haul road corridor and open-cut pits) and low in magnitude compared with dust emissions. For these reasons, dust is the sole pollutant of interest for this assessment. Key dust-generating activities associated with the Project include:

- drilling and blasting;
- material extraction and handling (overburden and ROM coal);
- bulldozer activity;
- material haulage (overburden and ROM coal);
- road grading; and
- wind erosion of exposed mine areas.

Three operational modelling scenarios were used within the assessment as being the worst-case potential for dust emissions over the life of the Project based upon volumes of material extracted, proposed mining schedule and proximity of sensitive receptors. These assessed years include:

- year 2;
- year 8; and
- year 15.

The emissions estimation techniques applied in this assessment were based on standard methods that are applied throughout Australia and in the United States. These methods are consistent with those adopted for other air quality assessments conducted for other coal mines in Australia. Emissions of TSP, PM_{10} and $PM_{2.5}$ from mining activities were estimated using an approximation of emission rates from NPI emissions estimation technique handbook (DSEWPAC 2012a) and the United States Environmental Protection Agency AP42 emission handbooks (EPA 1998; EPA 2006).

Dust emissions from individual mining activities for the modelling scenarios were accounted for and have been explicitly modelled using Project specific activity information. The size distribution of dust particles was derived from the emission rates estimated for TSP, PM_{10} and $PM_{2.5}$.

Emissions have been presented inclusive of standard mitigation control factors to minimise dust emissions from mining activities. Deviation away from the NPI emissions estimation technique handbook has occurred under confidence that standard efficiency factors can be achieved. Standard efficiency factors for these control measures are presented in Table 55. Schematics and a breakdown of dust emission rates estimated for the three assessment scenarios is presented in Table 6, and Figures 7 to 9 of Appendix L.

9.3.3 Modelling Results

The dispersion modelling assessment has erred on the side of caution and selected conservative inputs; therefore, the predicted concentrations of dust are conservative estimates. Results have been presented as ground-level concentrations or deposition rates at the sensitive receptors as well as contours across the modelling domain. Results provided are subject to the standard mitigation measures outlined in Table 55.

Background dust levels have been added to the incremental model predictions in order to estimate the potential cumulative impacts of the Project with existing sources of dust in the region. Results have been assessed by comparing the cumulative concentrations and dust deposition rates with the air quality objectives described in Table 54.

Table 55 Dust Control Measures and Relative Reduction in Emissions

Activity	Control Measure	Reduction Factor
ROM coal haulage	Watering and/or suppressants/vehicle speed reduction	85%
Overburden haulage	Watering and/or suppressants/vehicle speed reduction	85%
Drilling	Drill dust suppression sprays	70%
ROM unloading at CHPP	Water sprays	70%
Crushing	Enclosure	70%
Product stockpile	Wet from CHPP	50%
Train loading	Telescopic chute with water spray	85%
Conveyor	Enclosure	70%
Conveyor	Uncovered	0%

Note: Reduction factors for coal haulage are calculated using '*NSW Coal Mining Benchmarking Study*' (Katestone, 2011) and ACARP report '*Mobile Sampling of Dust Emissions from Unsealed Roads*' (ACARP 2015). A review of both indicates that an 85% control of haul road dust emissions is achievable through a combination of watering level 2 (75% control), use of chemical suppressants (84% control) and reduction of vehicle speeds to 30 km/hr (85% control).

When interpreting the results, it is important to note that the predictions are not contemporaneous. The values presented are the maximum concentration predicted independently at each sensitive receptor or

grid point for the entire modelling period and thus constitute a worst-case or near worst-case result. These values do not necessarily occur at the same time or under the same meteorological conditions.

9.3.3.1 Suspended Particulate Matter (TSP)

Annual average TSP modelling results, inclusive of the estimated annual average background level, show concentrations of TSP comply with the relevant air quality objective at all sensitive receptors in isolation and cumulatively using the standard mitigation measures for all assessed years.

The maximum cumulative annual average TSP concentration predicted at any sensitive receptor over the three scenarios modelled is 58.3 µg/m^3, at SR22 in Year 2. This equates to 64.77% of the relevant objective value of 90 µg/m^3.

Modelled scenarios for TSP concentrations, with standard mitigation measures, have been provided as contour plots for all modelled runs alongside detailed results (Appendix L).

9.3.3.2 Suspended Particulate Matter (PM_{10})

Modelling results for PM_{10} predicted concentrations when using standard mitigation measures exceeded the 24-hour average and annual objective value of 50 µg/m^3 and 25 µg/m^3 respectively for each of the assessed mining years, these exceedances are summarised below:

- year 2:
    - 24-hour average (SR03, SR13, SR22, SR27, SR28, SR31 and SR32); and
    - annual average (SR22, SR31, and SR32).
- year 8:
    - 24-hour average (SR03, SR07, SR10, SR13, SR16, SR22, SR26, SR27, SR28, SR31 and SR32); and
    - annual average (SR22, SR31, and SR32).
- year 15:
    - 24-hour average (SR17, SR22, SR31 and SR32); and
    - annual average (SR17, SR22, SR31, and SR32).
- Further analysis of 24-hour average PM_{10} concentrations identified a time length for exceedances of at most one to three days (year 2), one to five days (year 8) and fifty days (year 15).

Modelling has shown that using standard and, when necessary, additional mitigation measures, predicted 24-hour average concentrations of PM_{10} comply with the relevant air quality objective at all sensitive receptors. Additional mitigation measures used to achieve this compliance may include but are not limited to the modification of activity rate or ceasing of certain operations. Detailed mitigation measures that will be employed are discussed in Section 9.4.

Modelled scenarios for 24-hour average and annual average PM_{10} concentrations with standard mitigation measures and additional measures, when necessary, have been provided as contour plots for all modelled runs alongside detailed results (Appendix L).

9.3.3.3 Suspended Particulate Matter ($PM_{2.5}$)

Modelling results for 24-hour average $PM_{2.5}$ concentrations, inclusive of the estimated background levels, show levels of $PM_{2.5}$ comply with the relevant air quality objective at all sensitive receptors using the standard mitigation measures for years 2, 8 and 15.

Modelling results for annual averages of $PM_{2.5}$ concentrations, inclusive of the estimated background levels, show levels of $PM_{2.5}$ comply with the relevant air quality objective at all sensitive receptors using the standard mitigation measures for years 2 and 8. However, the annual average $PM_{2.5}$ objective of 8 $\mu g/m^3$ was exceeded at SR22, SR31 and SR32 during year 15.

Modelled scenarios for $PM_{2.5}$ concentrations, with standard mitigation measures and additional measures, when necessary, have been provided as contour plots for all modelled runs alongside detailed results (Appendix L).

9.3.3.4 Dust Deposition

Monthly dust deposition modelling results, inclusive of the estimated background level, show dust deposition rates comply with the relevant air quality objective at all sensitive receptors using the standard mitigation measures for all years.

The maximum cumulative monthly dust deposition rates predicted at any sensitive receptor over the three scenarios modelled is 62.5 $mg/m^2/day$, at SR22 in Year 15. This equates to 52.08% of the relevant objective value of 120 $mg/m^2/day$.

Modelled scenarios for dust deposition concentrations, with standard mitigation measures have been provided as contour plots for all modelled runs alongside detailed results (Appendix L).

9.3.4 Impacts and Risks

Modelling shows that with the inclusion of standard and additional mitigation measures, where necessary, the Project can be operated in accordance with the EPP (Air) objectives at all sensitive places. Under these provisions, the Project is unlikely to result in impacts to air quality that could adversely affect:

- human health and wellbeing;
- health and biodiversity of ecosystems including Taunton National Park;
- aesthetics of the environment including odour, dust, visibility reducing particles or light; or
- agriculture activities including crop production.

Additional mitigation measures will be employed on an as required basis during operations to avoid any anticipated exceedances. There is a low risk that the Project would exceed the modelled scenarios with addition measures in place as the modelling has assessed potential worst-case conditions with conservative assumptions.

The management strategies discussed in Section 9.4 demonstrate the feasibility to ensure risk remains low throughout the life of the Project and provides for implementing procedures for monitoring and complaints resolution to control magnitude of risk. Appendix B (*Surface Water Assessment*) demonstrates through the water balance model that adequate amounts of water will be available to meet the water demand for the proposed dust suppression. A water supply pipeline is also proposed to provide make up water during dry periods, if required.

9.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING

The management hierarchy for air emissions as set out in the EPP (Air) requires that, to the extent that it is reasonable to do so, air emissions must be dealt with in the following order of preference:

1. avoid (e.g., using technology that avoids air emissions);
2. recycle (e.g., re-using air emissions in another industrial process);
3. minimise (e.g., treating air emissions before release); and
4. manage.

Dust management and mitigation measures will be implemented for the Project. Magnetic South is committed to implementing the following measures:

- Develop and implement a dust and particulate matter monitoring program for three sites representative of surrounding sensitive receptors for early detection of elevated PM_{10} concentrations, refer to Appendix L for approximate monitoring locations. At minimum, monitoring of air quality at these locations will include:
    - continuous monitoring of PM_{10} at one primary location;
    - continuous monitoring of $PM_{2.5}$ at one primary location;
    - dust deposition monitoring at one primary location; and
    - meteorological monitoring (including temperature, wind speed and direction) at a single location representative of the Project.
- Monitoring equipment will be installed in accordance with relevant standards (i.e., dust deposition - *AS/NZS 3580.10.1:2003*, wind speed and direction - *AS/NZS 3580.14:2014*, PM_{10} - *AS3580.9.6* and $PM_{2.5}$ - *AS3580.9.10*) or otherwise approved by the administering authority.
- Ensure mitigation measures are put in place where the dust monitoring indicates a potential exceedance. This may include, increased watering of haul roads and other dust sources, and if required, timing blasts or other high-risk activities to occur outside of high-risk weather conditions.
- Develop an *Air Quality Management Plan* that will include a range of available measures to be implemented as necessary, including the implementation of a *Trigger Action Response Plan* to ensure compliance with approval conditions (refer to section 9.4.1).
- Enter into discussions and, as appropriate, commercial arrangements with affected surrounding landholders which could include:
    a. measures (e.g., purchase or relocation) which result in homesteads no longer being considered a sensitive receptor; or
    b. installation of receptor-side mitigation (e.g., air conditioners / purifiers in affected residences).

9.4.1 Air Quality Management Plan

An example *Air Quality Management Plan* has been developed to assist in the implementation of the monitoring and reporting requirements of the proposed EA and has been provided in Appendix L. The objective of the *Air Quality Management Plan* is to ensure the integrity of the environmental values of the Project site and surrounds to minimise potential impacts to air quality.

The *Air Quality Management Plan* will include the following components:

- a summary of the baseline environment and the potential impacts of the Project on air quality;
- identification of sensitive receivers surrounding the Project;
- use of real-time measurement of dust levels and meteorological conditions;
- details of mitigation measures implemented for mining and ancillary activities;
- implementation of a *Trigger Action Response Plan* as a dust management procedure that aims to investigate and respond to unexpected dust exceedances by:
    - trigger: nomination of air quality trigger values based on complaints and/or real-time dust and meteorological measurement and a range of additional measures which will be implemented, as necessary;
    - alert: an alert occurs as a result of the conditions of a trigger being met. Each alert requires one or more responses;
    - response: a response is a dust management action that may be implemented as a result of an alert being issued; and
    - action: an action is a specific activity that is condition as part of a response.
- an air quality monitoring program detailing the monitoring network, equipment requirements and monitoring, reporting and review procedures;
- a complaints and handling response procedure; and
- details of the roles and responsibilities of personnel.

The *Air Quality Management Plan* will focus on minimising air emissions in accordance with the management hierarchy set out in the EPP (Air) in the order of avoid, recycle, minimise and manage air emissions.

Due to the nature of air emissions associated with the Project, the *Air Quality Management Plan* will implement adaptive management that includes avoidance, minimisation, and management of air quality emissions.

Avoid

Air emission avoidance is defined as the prevention of air emissions. Air emissions will be avoided by:

- the adjustments to activity rates of ceasing of certain operations under adverse meteorological conditions in accordance with a meteorological forecast system and a dust risk forecast system;

- the unauthorised clearing of land and early identification of mitigation requirements through the *Land Disturbance Permit*;
- the seeding of long-term storage topsoil stockpiles; and
- progressive rehabilitation where vegetative cover will be established as soon as possible.

Minimise

A series of mitigation measures will be implemented to minimise air emissions to the receiving environment. Air emissions generated by the Project will be minimised by:

- ensuring mitigation measures are put in place where the dust monitoring or modelling indicates a potential exceedance. This may include increased watering of haul roads and other dust sources;
- the implementation of additional remedial actions for air emissions control in the event of complaints being received, exceedances of criteria being recorded, or other trigger levels in accordance with the *Trigger Action Response Plan* being breached; for example:
    - applying additional at-source and/or at-receptor dust controls under median and high-risk trigger scenarios;
    - increasing the intensity of dust controls under median and high-risk trigger scenarios; and/or
    - modifying certain operations under high-risk trigger scenarios;
- the implementation of a dust and particulate matter monitoring program at sites representative of surrounding sensitive receptors for early detection of elevated PM_{10} concentrations.

Manage

Air emissions produced by the Project will be managed through the following measures;

- entering into discussions and, as appropriate, commercial arrangements with affected surrounding landholders which could include:
    - measures (e.g., purchase or relocation) which result in homesteads no longer being considered a sensitive receptor; and
    - installation of receptor-side mitigation (e.g., air conditioners / purifiers in affected residences).
- a response plan for complaints handling; and
- an annual review program where the performance of air quality mitigation measures is assessed and where necessary, refined.

10.0 GREENHOUSE GAS

Climate change refers to long-term fluctuations in temperature, precipitation, wind, and other elements of the Earth's climate system. The Earth naturally absorbs and reflects incoming solar radiation and emits longer wavelength terrestrial (thermal) radiation back into space. A portion of this terrestrial radiation is absorbed by gases, known as greenhouse gasses (GHGs) in the atmosphere. Changes in the atmospheric concentrations of these GHGs can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. The major GHGs which make the largest contribution to global warming are CO_2, methane (CH_4) and nitrous oxide (N_2O).

The main GHG associated with the Project is CO_2, with smaller contributions from CH_4 and N_2O. These gases vary in effect and longevity in the atmosphere, however identifying the global warming potential of each gas allows them to be described in terms of CO_2 (the most prevalent GHG); called carbon dioxide equivalent (CO_2-e). A unit of one tonne of CO_2-e is the basic unit used in carbon accounting.

The *Air Quality and Greenhouse Gas Assessment* (Katestone 2020) (Appendix L) identifies the potential sources of GHG emissions associated with the Project and quantifies the emissions from each source over the life of the Project. The estimated emissions have then been compared to State and National GHG emission inventory totals to provide an assessment of the potential significance of the Project in relation to Australia's GHG emission inventory.

10.1 REGULATORY FRAMEWORK FOR GREENHOUSE GAS EMISSIONS

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) establishes a mandatory scheme, the *National Greenhouse and Energy Reporting Scheme* (NGER Scheme) for the reporting of company GHG emissions and energy production and consumption.

The supporting *National Greenhouse and Energy Reporting Technical Guidelines* (NGER Guidelines) (DoEE 2017) are applicable across all industry sectors and cover important concepts under the NGER Act and supporting regulations, including scheme participation, and the determination of corporate, facility and operational control, and registration and reporting obligations. The *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (NGER Determination) provides methods and criteria for calculating GHG emissions and energy data under the NGER Act.

The range of emission sources covered in the NGER Determination includes:

- the combustion of fuels for energy;
- fugitive emissions from the extraction of coal;
- oil and gas;
- industrial processes (such as producing cement and steel); and
- waste management.

Registration and reporting is mandatory for corporations that have an energy consumption or GHG emissions, including Scope 1 and Scope 2, that exceed the thresholds summarised in Table 56.

Scope 1 emissions in relation to a facility refers to the release of GHG into the atmosphere as a direct result of an activity or series of activities (including ancillary activities) that constitute the facility. Scope 2 emissions refers to the release of GHG into the atmosphere as a direct result of one or more activities

that generate electricity, heating, cooling or steam that is consumed by the facility but that do not form part of the facility.

A third classification of emissions, Scope 3, is defined as indirect greenhouse gas emissions other than Scope 2 emissions that are generated in the wider economy. They occur as a consequence of the activities of a company, but from sources not owned or controlled by that company. To limit the potential of double counting of GHG emissions on a national scale, Scope 3 are not included in NGER reporting however for information purposes will be included below (Section 10.3.2).

In addition, GHG emissions associated with land clearing are not covered by the NGER scheme but for information purposes are also detailed below (Section 10.2.1 and Section 10.3.1).

Table 56 Reporting Thresholds for Greenhouse Gas Emissions and Energy Use

Threshold Level	Threshold Type	
	GHG Emissions (kt CO_2-e per year)	Energy Consumption (TJ per year)
Facility	25	100
Corporate	50	200

10.2 EMISSIONS SOURCES

For the purposes of this assessment, Scope 1, 2 and 3 GHG emissions, including land clearing estimates, were calculated on an annual basis for the Project. This includes emissions from:

Scope 1: diesel combustion from heavy machinery and equipment and haulage vehicles, fugitive emissions of CH_4 from mining of coal deposits (i.e., waste mine gas), land clearing and use of explosives;

Scope 2: electricity usage for conveyors, CHPP and other amenities; and

Scope 3: transport of coal, rail transport to coal terminal and use of coal (coking applications).

A complete summary of emission sources associated with Project is documented in Table 15 of Appendix L.

10.2.1 Land Clearing

The GHG emissions associated with land clearing have been estimated and included below (Table 57). Land clearing is considered Scope 1 and emissions were estimated based on the Full Carbon Accounting Model developed by the Australian Government to support the estimation of carbon stock change on forest systems.

Land clearing required for the Project is made up of:

- Eucalyptus woodland – 407.17 ha;
- Acacia woodland – 313.57 ha; and
- Grazing land (previously cleared) – 1,240 ha.

To account for the prolonged nature of emissions from land clearing, total GHG emissions associated with land clearing for the life of the Project have been averaged across each year of the Project. Carbon sequestration associated with land rehabilitation was not included in the assessment due to its delayed impact in the years following the conclusion of the Project.

10.3 EMISSIONS ESTIMATION

10.3.1 Scope 1 and Scope 2

Predicted GHG emissions, exclusive of land clearing, is summarised as reportable emissions (Section 10.3.3). Estimated GHG emissions (Scope 1 and Scope 2) associated with the Project are detailed in Table 57. A complete breakdown of emissions is provided in Appendix L.

The following emissions (Scope 1 and Scope 2), inclusive of land clearing, are predicted:

- total predicted emissions are expected to average 145 kt CO_2-e per year; and
- total predicted emissions range between 12 - 217 kt CO_2-e (peaking at Year 16).

For total Project GHG emissions, the percentage of relative GHG emissions sources is shown below in Figure 78. The most significant source of GHG emissions is attributed to diesel consumption for heavy machinery, mining equipment, haulage and other onsite vehicles. Similarly, fugitive methane emission and electricity usage were also identified as significant sources of GHG emissions. These emission-source trends were frequently observed for most individual years.

Table 57 Summary of Scope 1 and Scope 2 GHG Emissions

Year	GHG Emissions (kt CO_2-e/yr)		Total Scope 1 and 2	
	Scope 1	Scope 2	Incl Land Clearing	Excl Land Clearing
Year 1	22.83	1.62	24.45	18.47
Year 2	184.71	18.25	202.96	196.98
Year 3	153.58	18.25	171.83	165.85
Year 4	163.17	18.25	181.42	175.44
Year 5	175.49	18.25	193.74	187.76
Year 6	155.29	18.25	173.54	167.56
Year 7	184.55	18.25	202.80	196.82
Year 8	191.15	18.25	209.40	203.42
Year 9	157.30	18.25	175.54	169.56
Year 10	155.12	18.25	173.37	167.39
Year 11	152.13	18.25	170.37	164.39
Year 12	161.03	18.25	179.28	173.30
Year 13	168.29	18.25	186.54	180.56
Year 14	175.41	18.25	193.66	187.68
Year 15	172.91	18.25	191.15	185.17
Year 16	198.66	18.25	216.91	210.93
Year 17	171.35	18.25	189.59	183.61
Year 18	198.53	18.25	216.78	210.80
Year 19	114.33	18.25	132.58	126.59
Year 20	28.65	3.98	32.62	32.62
Year 21	29.06	2.65	31.71	31.71

Year	GHG Emissions (kt CO_2-e/yr)		Total Scope 1 and 2	
	Scope 1	Scope 2	Incl Land Clearing	Excl Land Clearing
Year 22	11.26	2.65	13.91	13.91
Year 23	11.06	2.65	13.71	13.71
Year 24	11.06	1.33	12.38	12.38
Total (kt CO_2-e)	**3146.90**	**343.34**	**3490.23**	**3376.59**

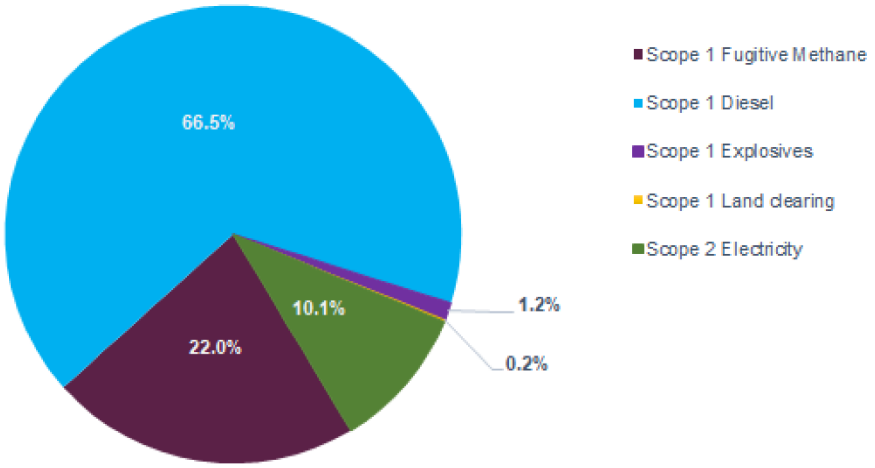


Figure 78 Total Greenhouse Gas Emissions by Scope

For comparative purposes; the latest GHG inventory estimates (excluding emissions from land use, land use change and forestry) is 538 Mt CO_2-e per year for Australia and 162 Mt CO_2-e per year for Queensland (DoEE 2019a; DoEE 2019b). Accounting for the estimated maximum year of annual GHG emissions of 217 kt CO_2-e (Year 16), the Project could contribute up to 0.04% of Australia's emissions and 0.13% of Queensland's emissions.

10.3.2 Scope 3

Total estimated annual scope 3 emissions ranged between 1905 - 3943 kt CO_2-e per year (refer to Appendix L for detailed annual summary).

10.3.3 Reportable Emissions

In accordance with the NGER scheme, the approximate reportable annual GHG emissions of the Project (excluding land clearing), range from:

Scope 1: 11 - 193 kt CO_2-e per year

Scope 2: 2 -18 kt CO_2-e per year

Total: 12 - 211 kt CO_2-e per year

Based on the NGER Act reporting thresholds detailed in Table 56, the Gemini Project will have ongoing reporting obligations including an annual assessment of GHG emissions as set out by the NGER Act and the NGER Determination.

10.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING

The following management measures are proposed to minimise GHG emissions and energy use from the Project during operation:

- where practicable, energy efficiency design aspects will be investigated as part of the detailed design process in order to reduce energy and fuel consumption;
- fuel efficiency of the construction plant/equipment will inform equipment selection, and where possible, equipment with the highest fuel efficiency and lower GHG intensive fuel (e.g., biodiesel) requirements will be used;
- minimise vegetation clearing at the Project to the authorised areas required for Project development;
- consideration of renewable energy options for initial design or future improvements, such as solar powered lighting for the MIA, CHPP and accommodation facilities;
- logistical planning to improve efficiency and minimise energy use, including route and load optimisation of mining equipment and production scheduling to reduce idle time;
- maintenance of mining equipment in accordance with manufacturer and supplier guidelines to maximise fuel efficiency;
- on-site power factor correction optimised to minimise the usage of grid electricity;
- where practical, adjust peak electricity demand through production scheduling to allow for optimal and well utilised diesel power generation capacity;
- spontaneous combustion of coal will be managed to avoid unexpected emission through the burial of reactive materials, spoil dump design, temperature monitoring and spoil dump ventilation;
- using appropriately sized equipment; and
- ongoing monitoring and reporting of GHG emissions including an annual review of energy use to identify potential energy efficiency opportunities on a regular and ongoing basis.

11.0 NOISE AND VIBRATION

This section describes the assessment of potential noise, vibration and blasting impacts from the construction, operation, and closure of the Gemini Project.

This section is informed by the *Noise Impact Assessment* (ASK 2020) provided as Appendix M.

11.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES

The environmental objectives relevant to potential noise impacts have been developed in accordance with the *Application requirements for activities with noise impacts [ESR/2015/1838]* (DES 2017d) to ensure:

The activity will be operated in a way that protects the environmental values of the acoustic environment.

The Project would achieve either one of the following performance outcomes identified in Schedule 8, Part 3, Division 1 of the EP Regulation:

1 *sound from the activity is not audible at a sensitive receptor; and*

2 *the release of sound to the environment from the activity is managed so that adverse effects on environmental values including health and wellbeing and sensitive ecosystems are prevented or minimised.*

11.2 DESCRIPTION OF ENVIRONMENTAL VALUES

11.2.1 Land Use

The Project site and surrounding area is currently used predominately for cattle grazing with most of the area cleared for agricultural purposes. To the east of the Project lies Dingo, a small town of approximately 450 people, and includes residences, sporting facilities (sports oval, tennis courts), a primary school, and local businesses (Post Office, hotel, shops, etc).

11.2.2 Sensitive Receptors

A total of 25 sensitive receptors were identified within 5 km of the Project in parallel with the *Air Quality and Greenhouse Gas Assessment* (Katestone 2020) (Appendix L) based on the definition from the *Environmental Protection (Noise) Policy 2019* (EPP (Noise)). A number of the identified sensitive receptors are located within 1 km of the Capricorn Highway and Blackwater Railway that extends through the northern section of the MLA. Eight sensitive receptors (SR09, SR14, SR15, SR19, SR20, SR21, SR23 and SR24) are located on land owned or under purchase by Magnetic South. Any dwellings situated on these properties will be vacant prior to the commencement of mining activities and therefore have been excluded from the noise assessment.

The same suite of receptors encompassing multiple dwellings and residences, facilities, businesses, and recreational areas, including the Dingo township, was used for both the air quality and noise assessments (refer to Figure 77 and Table 53).

The nearest mining operation to the Gemini Project is Bluff PCI Project, located approximately 12 km west of the Gemini Project's proposed ROM pad. At the time of submission, this mine is in care and maintenance, with no certainty of returning to operations during the life of the Gemini Project.

11.2.3 Climate and Wind Characteristics

The propagation of noise in the outdoor environment can be influenced by the local meteorological conditions. Air temperature, humidity, wind speed, wind direction and stability of the atmosphere can all influence noise either in isolation or as combined weather conditions.

Computer modelling was used to input specific meteorological conditions to predict noise levels under unfavourable 'adverse' day and night meteorological conditions using wind conditions from the southeast and west directions. The meteorological scenarios used in these modelled calculations are provided in further detail below (Table 58).

Table 58 Meteorological Scenarios

Parameter	Day Meteorological Scenarios			Night Meteorological Scenarios		
	Scenario D1	Scenario D2	Scenario D3	Scenario N1	Scenario N2	Scenario N3
Pasquill Stability Class	D	D	D	F	F	F
Temperature (°C)	25	25	25	10	10	10
Wind Speed (m/s)	2	2	2	2	2	2
Wind direction	Towards receivers	SE	W	Towards receivers	SE	W
Relative humidity (%)	40	40	40	70	70	70

11.2.4 Background Noise Levels

The Project is located in a rural area with influences from transport and the agricultural industry. Specifically, the existing acoustic environment is affected by:

- traffic on the Capricorn Highway and other local roads;
- coal trains;
- native birdlife;
- insect noise;
- agricultural equipment; and
- cattle.

A baseline noise monitoring study was conducted to determine baseline background noise prior to the commencement of the Project (Appendix M). Monitoring was undertaken in general accordance with *Australian Standard AS1055: Acoustics – Description and measurement of environmental noise* and the *Noise Measurement Manual* (EHP 2013b).

Noise levels were continuously monitored with noise loggers for up to 13 consecutive days in June 2019, and attended logging was undertaken for two nights for separate 15-minute periods. Noise logging was undertaken at three locations to produce representative modelling outcomes:

Location A: Accommodation facility (the same location as SR22). Located in an open-field, approximately 360 m northeast of the railway line and 440 m northeast of the Capricorn Highway.

Location B: Dingo Roadhouse (approximately the same location as SR03). Located in an open-field location, approximately 220 m southwest of the Capricorn Highway.

Location C: Rural residence (approximately the same location as SR19, SR20 and SR21). Located in an open-field position, approximately 200 m northeast of the homestead.

The existing background noise levels were influenced by a variety of natural sources (insects, birdsong, windblown vegetation, cattle) at all locations. In particular, locations A and B were influenced by transport related sources of background noise including the Capricorn Highway and Blackwater Railway, and locations A and C were influenced by levels of high insect noise. As insect noise is a seasonal influence, the noise level data was filtered to remove the insect noise from Locations A and C. The background noise level results were calculated using the lowest 10th percentile method and have been provided in Table 59.

Table 59 Background Noise Level

Period	Background Noise Level (L_{90} dBA)		
	Location A	Location B	Location C
Day (7am to 6pm)	33	35	25
Evening (6pm to 10pm)	23	37	29
Night (10pm to 7am)	20	27	22

Notes: dBA 'A' weighted decibel.
L_{90} 'A' weighted sound pressure level equalled or exceeded 90% of the time.

11.3 POTENTIAL IMPACTS

To assess impacts and risks of the Project to the existing noise environment, ASK (2020) undertook a noise and vibration assessment. A summary of the impact assessment and modelled results are detailed below.

11.3.1 Noise Quality Objectives and Criteria

ASK (2020) consulted several sources of information in order to propose relevant noise and vibration objectives for the Project:

- EP Act;
- EPP (Noise);
- *Guideline (Noise): Planning for noise control* (EHP 2004);
- *Guideline (Noise): Noise and vibration from blasting [EM2402]* (EHP 2016); and
- *Guideline (Mining): Model mining conditions [ESR/2016/1936]* (DES 2017e).

In accordance with *Model Mining Conditions* (DES 2017e), the EPP (Noise) and the *Planning For Noise Control* guideline (EHP 2004), the following noise criteria provided in Table 60 has been adopted.

Table 60 Proposed Noise Limits

Period	Noise Limit ($L_{Aeq,adj,1hr}$ dBA)
Day (7am to 6pm)	40
Evening (6pm to 10pm)	40
Night (10pm to 7am)	35

Notes: $L_{Aeq,adj,1hr}$ means an 'A' weighted sound pressure level of a continuous steady sound, adjusted for tonal character, that within a 1-hour period has the same mean square sound pressure of a sound that varies with time.

It is noted by the *Planning For Noise Control* (EHP 2004) that the noise reduction provided by a typical residential building façade is 7 dBA with windows open. Based on a façade reduction of 7 dBA (i.e., 7 dBA reduction in noise levels from outside a house to inside a house when windows are fully open), the EPP (Noise) indoor noise objectives could be converted to the proposed noise limits (with windows open) presented in Table 60.

The *Noise and vibration from blasting* and the *Model Mining Conditions* (DES 2017e) contain the same criteria for blasting. ASK (2020) propose that these criteria are adopted for the Project, as outlined in Table 61.

Table 61 Proposed Blasting Vibration and Air-blast Criteria

Issue	Criteria
Airblast overpressure	115 dB (linear) peak for nine out of ten consecutive blasts initiated and not greater than 120 dB (linear) peak at any time.
Ground vibration peak particle velocity	5 mm/s PPV for nine out of ten consecutive blasts and not greater than 10 mm/s PPV at any time.

PPV peak particle velocity

11.3.2 Noise Prediction Model

Mining noise emissions from the Project have been predicted for the three mine year scenarios; Year 2, Year 8, and Year 15. These years were selected to give a representation of mine noise levels near the beginning, middle and end of the project. Modelling of the scenarios has incorporated mine ground elevations, and type, number and location of equipment for each mine year. Mining noise levels at residential receptors can vary significantly depending upon the meteorology and the mine activities. Meteorology has significant effects on noise levels, predominantly due to wind speed and direction, and vertical temperature gradients, including temperature inversions. Detailed information regarding model inputs including noise source emissions, noise source locations, mobile equipment numbers and total scenario power levels is provided in Appendix M.

A SoundPLAN (Version 8.2) computer noise model was used to predict noise levels at sensitive receptors. The computer model calculated the noise levels at sensitive receptors, accounting for noise propagation variables such as distance attenuation, ground absorption, air absorption and shielding attenuation from topography, buildings or barriers.

The CONCAWE industrial noise prediction methodology was utilised within SoundPLAN, which is specially designed for large facilities and incorporates the influence of wind effects and stability of the atmosphere.

11.3.3 Noise Modelling Results

The predicted noise levels at nearby sensitive receptors for the three mining year scenarios are presented for 'adverse' night and day scenarios below (Table 62, Table 63 and Table 64). The results are compared against the proposed noise limits of 35 dBA $L_{Aeq,adj,1hr}$ (night) and 40 dBA $L_{Aeq,adj,1hr}$ (day/evening). From this, potential noise impacts associated with the Project include the following:

- no exceedances are recorded during day/evening operations; and
- night exceedances are limited to:
    - Year 2 (SR10: 2 dBA and SR22: 1 dBA); and
    - Year 8 (SR10: 3 dBA).

Therefore, the maximum exceedance is limited to 3dBA at sensitive receptor SR10 located 1.4 km to the east of the Project.

Model Mining Conditions and the EPP (Noise) for sleep disturbance recommend the assessment of L_{Amax}, L_{A01} and L_{A10}, however these parameters have not been included in this assessment. Most mine noise source data is available in the L_{Aeq} parameter and where noise limits of L_{Amax}, L_{A01} and L_{A10} are specified for the Project, they would be 15, 10 and 5 dBA higher than the L_{Aeq} noise limits, respectively. It is noted that L_{A01} and L_{A10} noise limits cannot be accurately used for compliance during warmer months as noise levels are commonly dominated by insect noise (i.e., removal of insect noise is not strictly possible from these noise parameters). The L_{Amax} parameter can also be challenging for compliance monitoring as extraneous L_{Amax} events (e.g., birds, animals, farm activities) need to be removed from the noise monitoring data.

In this instance, L_{Aeq} is the preferred parameter. If L_{Aeq} noise levels comply with relative limits, no further assessment is proposed for the L_{Amax}, L_{A01} and L_{A10} parameters as they would subsequently comply (refer to Appendix M).

The predicted noise levels are displayed graphically as noise contours below (Figure 79 through to Figure 84).

Table 62 Predicted Noise Levels - Year 2

Receptor	Predicted Noise Emission Levels (L_{eq} dBA)																	
	Day Meteorological Scenarios									Night Meteorological Scenarios								
	Mine Only			Mine & Rail Loadout			Night Criterion Exceedance (35 dBA)			Mine Only			Mine & Rail Loadout			Night Criterion Exceedance (35 dBA)		
Scenario	D1	D2	D3	D1	D2	D3	D1	D2	D3	N1	N2	N3	N1	N2	N3	N1	N2	N3
SR01	23	24	15	24	24	15	(-16)	(-16)	(-25)	24	24	18	24	24	19	(-11)	(-11)	(-16)
SR03	31	23	31	31	23	31	(-9)	(-17)	(-9)	32	30	32	32	30	32	(-3)	(-5)	(-3)
SR05	26	25	17	26	25	17	(-14)	(-15)	(-23)	26	27	20	26	28	20	(-9)	(-7)	(-15)
SR07	31	24	31	31	24	31	(-9)	(-16)	(-9)	32	32	32	32	32	32	(-3)	(-3)	(-3)
SR08	24	25	15	24	25	15	(-16)	(-15)	(-25)	25	25	19	25	26	19	(-10)	(-9)	(-16)
SR10	36	29	36	26	29	36	(-4)	(-11)	(-4)	37	37	37	37	37	37	2	2	2
SR13	33	25	33	33	25	33	(-7)	(-15)	(-7)	34	33	34	34	33	34	(-1)	(-2)	(-1)
SR16	29	30	29	29	30	29	(-11)	(-10)	(-11)	30	30	30	30	30	30	(-5)	(-5)	(-5)
SR17	26	27	17	26	27	17	(-14)	(-13)	(-23)	27	27	21	27	27	21	(-8)	(-8)	(-14)
SR22	33	34	24	35	35	25	(-5)	(-5)	(-15)	35	35	29	36	36	30	1	1	(-5)
SR26	26	18	26	26	18	26	(-14)	(-22)	(-14)	27	25	27	27	25	27	(-8)	(-10)	(-8)
SR27	27	20	27	27	20	27	(-13)	(20)	(-13)	28	28	28	28	28	28	(-7)	(-7)	(-7)
SR28	27	20	27	27	20	27	(-13)	(-20)	(-13)	28	28	28	28	28	28	(-7)	(-7)	(-7)
SR30	27	20	27	27	20	27	(-13)	(-20)	(-13)	28	29	28	28	29	28	(-7)	(-6)	(-7)
SR31	31	31	21	31	22	(-9)	(-9_	(-8)	(-18)	32	32	26	33	33	26	(-2)	(-2)	(-9)
SR32	29	29	20	30	30	20	(-10)	(-10)	(-20)	30	30	24	31	31	25	(-4)	(-4)	(-10)

Noise levels that exceed the EPP (Noise) and the *Planning For Noise Control guideline* (EHP 2004) are highlighted in pink.
Noise levels below exceedance criterion are included in brackets.

Table 63 Predicted Noise Levels – Year 8

Receptor	Predicted Noise Emission Levels (L_{eq}, dBA)																	
	Day Meteorological Scenarios									Night Meteorological Scenarios								
	Mine Only			Mine & Rail Loadout			Night Criterion Exceedance (35 dBA)			Mine Only			Mine & Rail Loadout			Night Criterion Exceedance (35 dBA)		
Scenario	D1	D2	D3	D1	D2	D3	D1	D2	D3	N1	N2	N3	N1	N2	N3	N1	N2	N3
SR01	21	22	12	21	22	12	(-19)	(-18)	(-28)	22	22	16	22	22	16	(-13)	(-13)	(-19)
SR03	32	24	32	32	24	32	(-8)	(-16)	(-8)	33	31	33	33	31	33	(-2)	(-4)	(-2)
SR05	24	23	15	24	23	15	(-16)	(-17)	(-25)	25	26	18	25	26	18	(-10)	(-9)	(-17)
SR07	32	24	32	32	24	32	(-8)	(-16)	(-8)	33	33	33	33	33	33	(-2)	(-2)	(-2)
SR08	22	23	13	23	23	13	(-17)	(-17)	(-27)	23	24	17	24	24	17	(-11)	(-11)	(-18)
SR10	37	30	37	37	30	37	(-3)	(-10)	(-3)	38	38	38	38	38	38	3	3	3
SR13	34	26	34	34	26	34	(-6)	(-14)	(-6)	35	35	35	35	35	35	(0)	(0)	(0)
SR16	28	29	28	28	29	28	(-12)	(-11)	(-12)	29	29	30	29	29	30	(-6)	(-6)	(-5)
SR17	24	25	15	24	25	15	(-16)	(-15)	(-25)	25	25	19	25	25	19	(-10)	(-10)	(-16)
SR22	32	32	22	34	34	23	(-6)	(-6)	(-17)	33	33	27	35	32	29	(0)	(0)	(-6)
SR26	27	18	27	27	18	27	(-13)	(-22)	(-13)	28	26	28	28	26	28	(-7)	(-9)	(-7)
SR27	28	20	28	28	20	28	(-12)	(-20)	(-12)	29	29	29	29	29	29	(-6)	(-6)	(-6)
SR28	28	20	28	28	20	28	(-12)	(-20)	(-12)	29	29	29	29	29	29	(-6)	(-6)	(-6)
SR30	27	20	27	27	20	27	(-13)	(-20)	(-13)	28	30	28	28	30	28	(-7)	(-5)	(-7)
SR31	28	30	19	30	30	20	(-10)	(-10)	(-20)	30	30	24	31	31	24	(-4)	(-4)	(-11)
SR32	27	28	17	28	29	18	(-12)	(-11)	(-22)	29	29	22	30	30	23	(-5)	(-5)	(-12)

Noise levels that exceed the EPP (Noise) and the Planning For Noise Control guideline (EHP 2004) are highlighted in pink.
Noise levels below exceedance criterion are included in brackets.

Table 64 Predicted Noise Levels – Year 15

Receptor	Predicted Noise Emission Levels (L_{eq}, dBA)																	
	Day Meteorological Scenarios									Night Meteorological Scenarios								
	Mine Only			Mine & Rail Loadout			Night Criterion Exceedance (35 dBA)			Mine Only			Mine & Rail Loadout			Night Criterion Exceedance (35 dBA)		
Scenario	D1	D2	D3	D1	D2	D3	D1	D2	D3	N1	N2	N3	N1	N2	N3	N1	N2	N3
SR01	22	23	13	23	23	13	(-17)	(-17)	(-27)	23	23	18	23	23	18	(-12)	(-12)	(-17)
SR03	24	18	24	24	18	25	(-16)	(-22)	(-15)	25	28	25	25	28	25	(-10)	(-7)	(-10)
SR05	28	28	18	28	28	18	(-12)	(-12)	(-22)	28	29	22	28	29	22	(-7)	(-6)	(-13)
SR07	24	19	24	24	19	24	(-16)	(-21)	(-16)	24	27	24	25	27	25	(-10)	(-8)	(-10)
SR08	24	24	14	24	24	14	(-16)	(-16)	(-26)	25	25	19	25	25	19	(-10)	(-10)	(-16)
SR10	27	23	27	27	23	27	(-13)	(-17)	(-13)	28	29	28	28	29	28	(-7)	(-6)	(-7)
SR13	25	21	26	25	21	26	(-15)	(-19)	(-14)	26	28	26	26	28	26	(-9)	(-7)	(-9)
SR16	20	21	21	21	21	22	(-19)	(-19)	(-18)	21	21	21	21	22	21	(-14)	(-13)	(-14)
SR17	26	26	16	26	26	16	(-14)	(-14)	(-24)	27	27	21	27	27	21	(-8)	(-8)	(-14)
SR22	32	32	23	33	33	24	(-7)	(-7)	(-16)	33	33	29	35	35	30	(0)	(0)	(-5)
SR26	21	15	21	21	15	21	(-19)	(-25)	(-19)	21	24	21	22	24	22	(-13)	(-11)	(-13)
SR27	22	16	22	22	16	22	(-18)	(-24)	(-18)	22	25	22	22	25	22	(-13)	(-10)	(-13)
SR28	22	16	22	22	16	22	(-18)	(-24)	(-18)	22	25	22	22	25	22	(-13)	(-10)	(-13)
SR30	22	17	22	22	17	22	(-18)	(-23)	(-18)	22	25	22	22	25	22	(-13)	(-10)	(-13)
SR31	30	30	20	30	30	21	(-10)	(-10)	(-19)	31	31	26	32	32	26	(-3)	(-3)	(-9)
SR32	28	28	19	28	29	19	(-12)	(-11)	(-21)	29	29	24	30	30	25	(-5)	(-5)	(-10)

Noise levels that exceed the EPP (Noise) and the Planning For Noise Control guideline (EHP 2004) are highlighted in pink.
Noise levels below exceedance criterion are included in brackets.

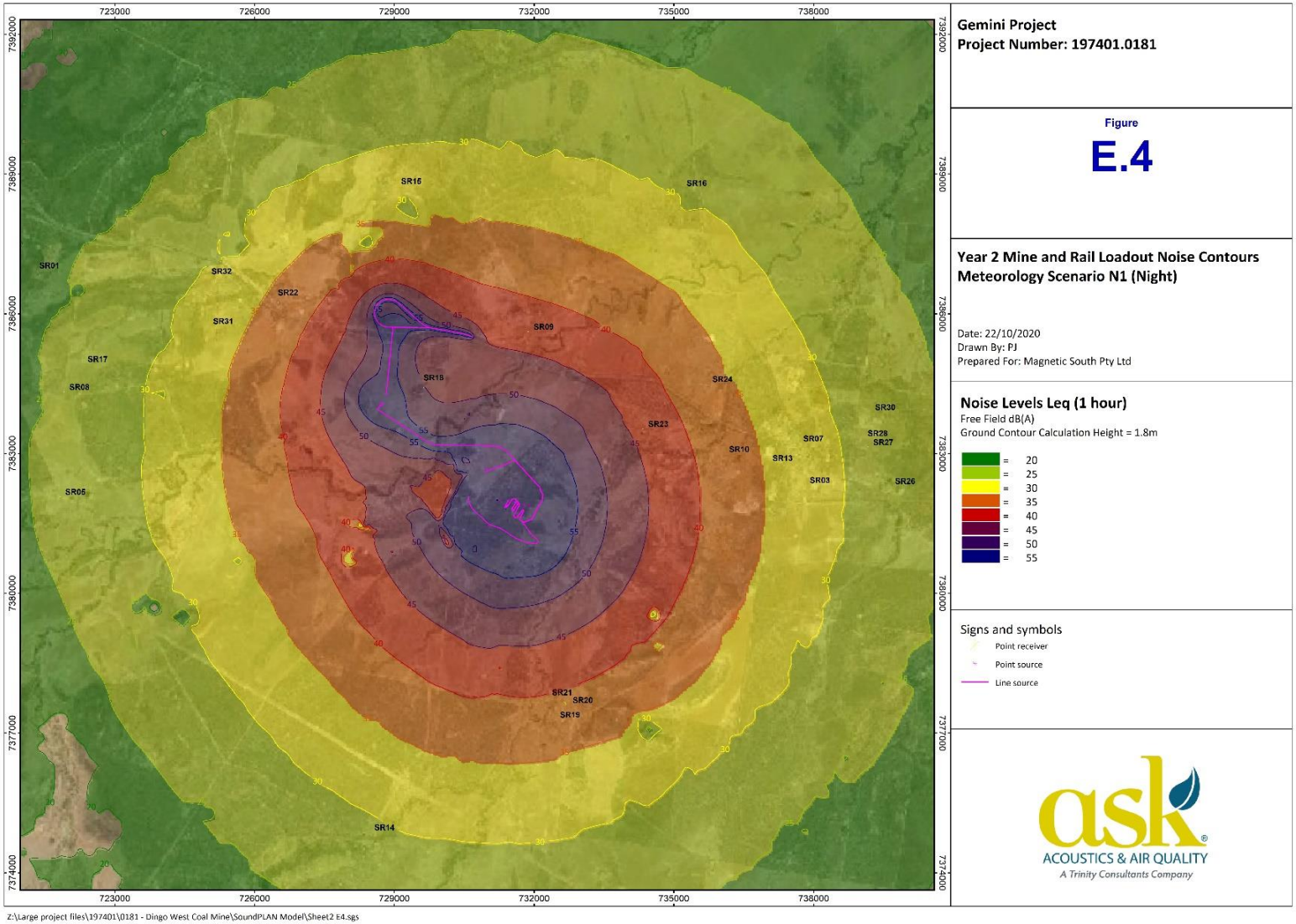


Figure 79 Year 2 - Night 'Adverse' Scenario (Mine and Rail Loadout)

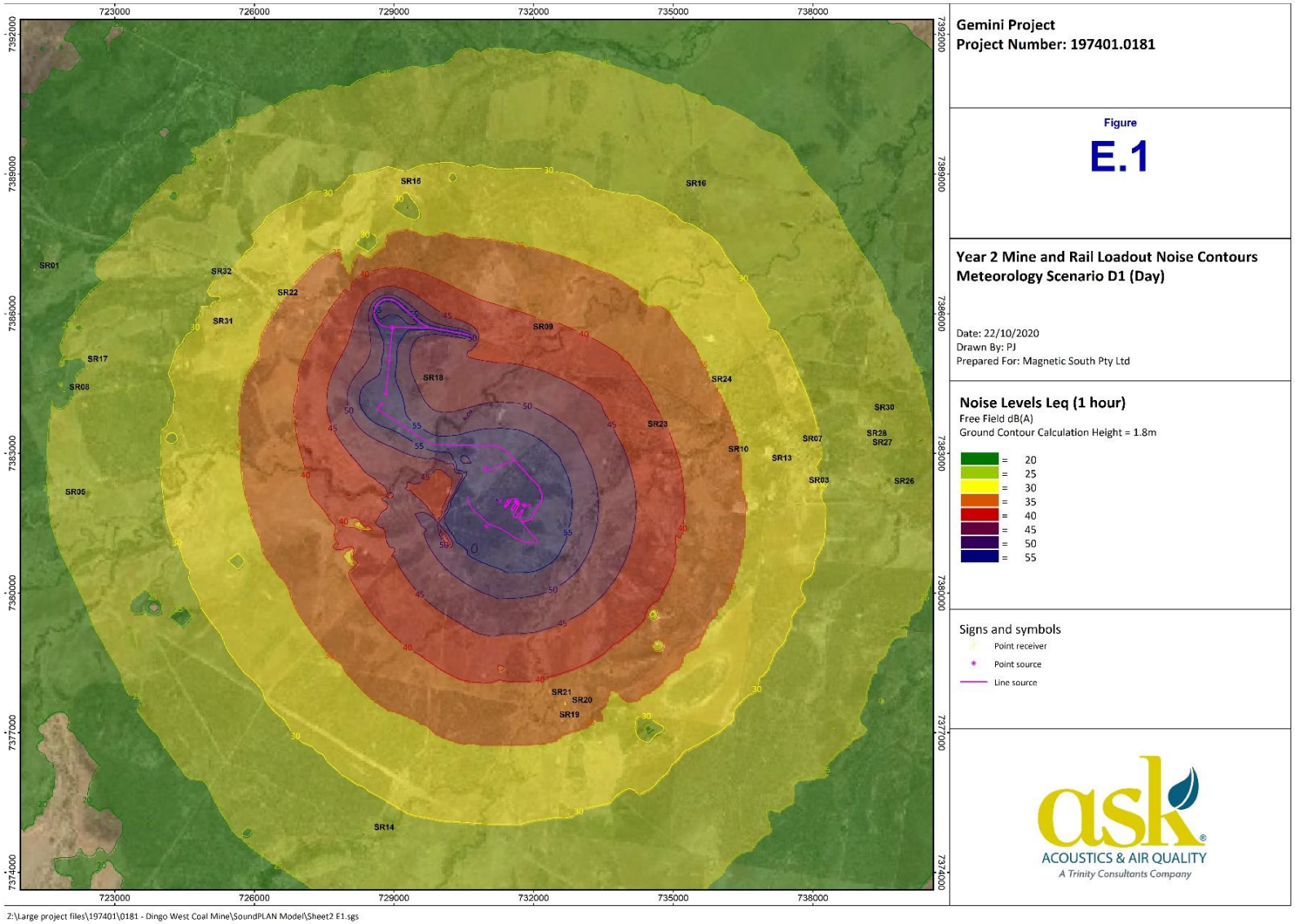


Figure 80 Year 2 - Day 'Adverse' Scenario (Mine and Rail Loadout)

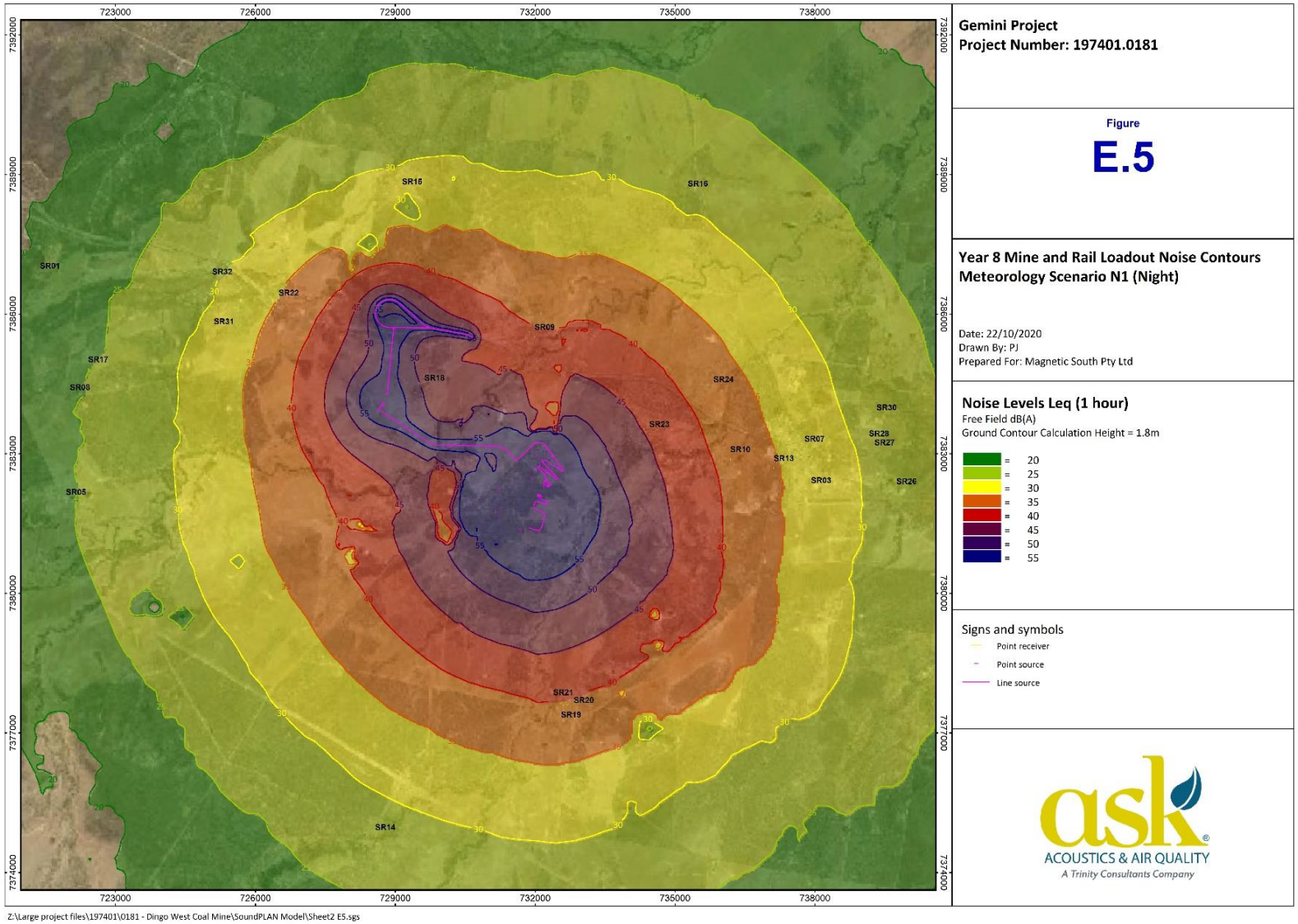


Figure 81 Year 8 - Night 'Adverse' Scenario (Mine and Rail Loadout)

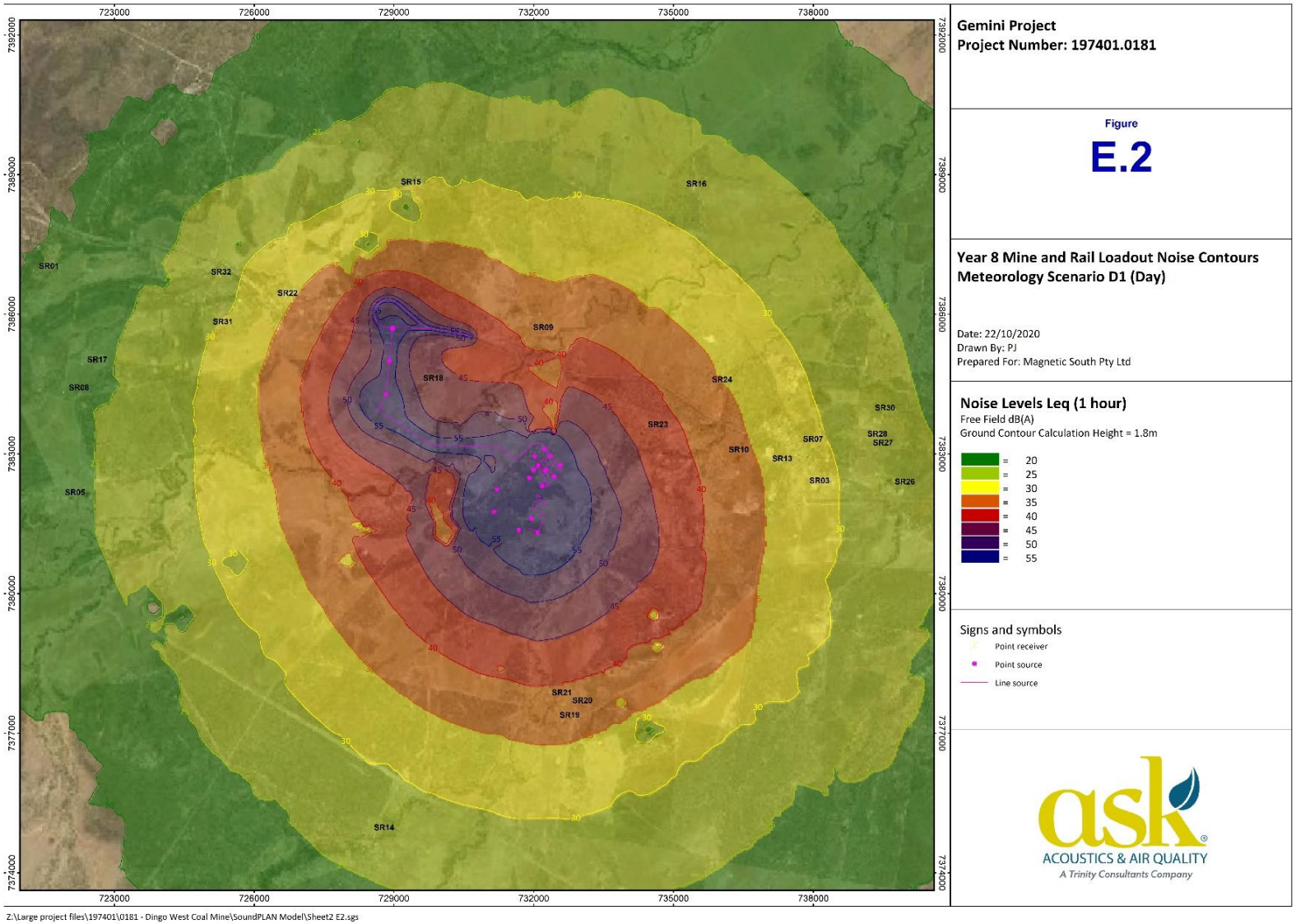


Figure 82 Year 8 - Day 'Adverse' Scenario (Mine and Rail Loadout)

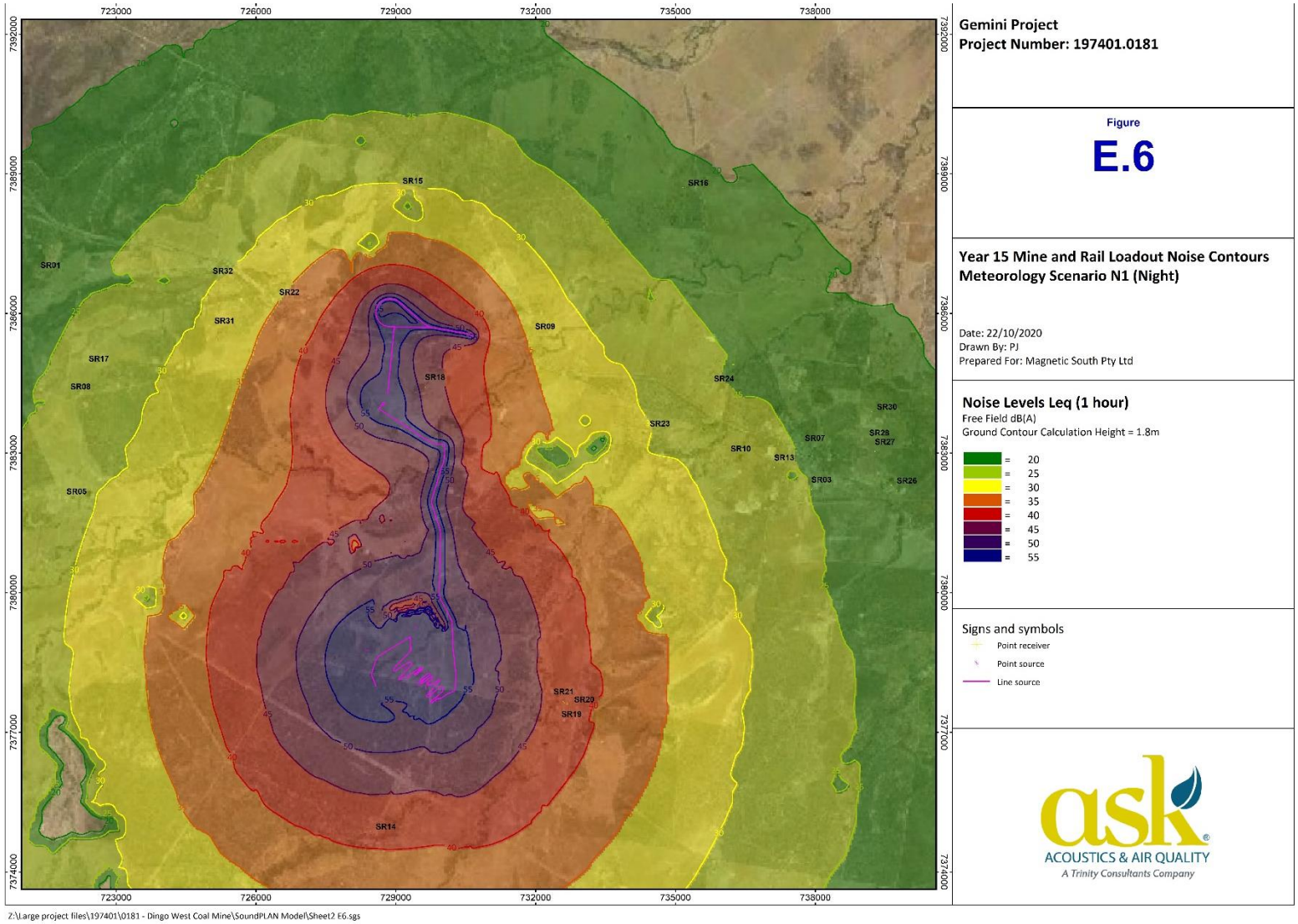


Figure 83 Year 15 - Night 'Adverse' Scenario (Mine and Rail Loadout)

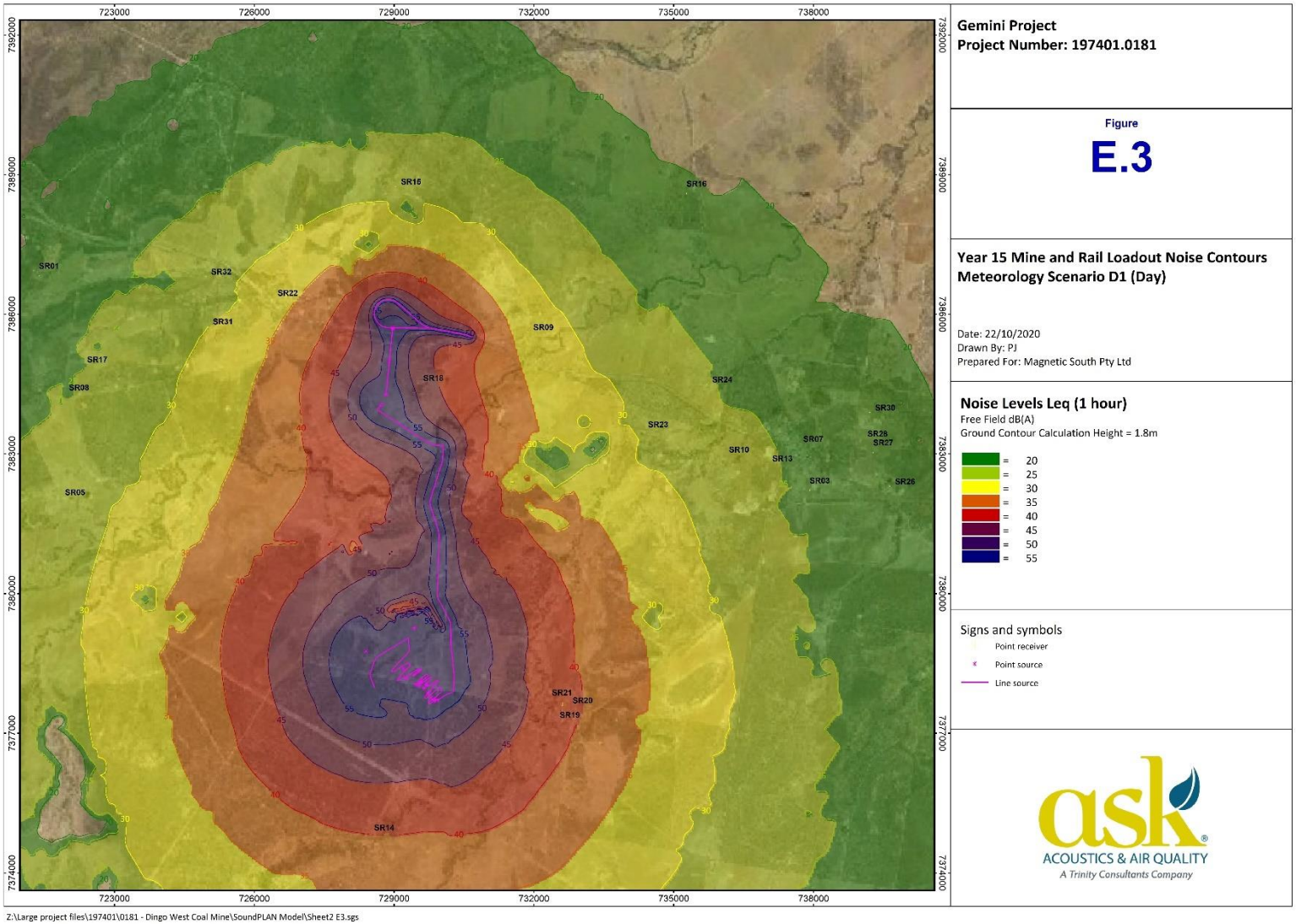


Figure 84 Year 15 - Day 'Adverse' Scenario (Mine and Rail Loadout)

11.3.4 Background Creep

The EPP (Noise) no longer contains criteria for background creep, but states that background creep should be prevented or minimised, to the extent that it is reasonable to do so. In consideration of the *Noise Measurement Manual (ESR/2016/2195 - formerly EM1107*), background creep is defined as 'a gradual increase in the total amount of background noise in an area or place.' Therefore, consideration of cumulative impacts, including other developments, is required to ensure background creep is minimised in accordance with the EPP (Noise) recommendations.

The nearest existing mine is Bluff Mine to the west of the Project. The sensitive receptors that have the most potential to be impacted by the Project to the west are SR22, SR31 and SR32, with noise levels of up to 36 dBA, 33 dBA and 31 dBA L_{Aeq} respectively. The Bluff Mine is over 12 km from these receptors (SR22, SR31 and SR32) and only 1 km from the township of Bluff. Given the requirement to comply with noise criteria in the township, it would be expected that Bluff mine noise levels at the receptors would be well below the 35 dBA noise limit and would not significantly contribute to exceedances at these locations. In addition to this, cumulative impacts from adverse wind conditions cannot occur for both mines simultaneously at these receptors since they are in opposite directions. Similarly, due to the broadscale consistency of adopted noise limits for the Project with other mining operations such as the Bluff Mine and Jellinbah Mine in the surrounding region (limits detailed above in Section 11.3.1), a 'no wind scenario' is considered to produce the same outcome. Additionally, it is noted that, at the time of submission, Bluff mine is under care and maintenance, with no certainty of returning to operations during the life of the Gemini Project. Therefore, it is unlikely that cumulative noise impacts from surrounding mines would contribute to background creep.

11.3.5 Vibration Assessment

It is anticipated that the existing vibration levels around the Project and at the location of sensitive receptors will generally be negligible, except at locations which are close to roads, rail lines or near major items of fixed plant. The only vibration source of significance from the mining of the Project would be blasting. Blasting activities within the pits have been assessed for both ground vibration and airblast.

Ground vibration and airblast levels caused by blasting activities were predicted based on the formulas and methodology of *Australian Standard AS2187.2: Explosives - Storage Transport and Use - Use of Explosives*, which predicts the PPV in mm/s and the airblast over pressure (peak pressure) in dB. Technical details of assessment methodology and inputs for ground vibration and airblast can be found in Section 7 of the *Noise Impact Assessment* (ASK 2020) (Appendix M).

Based on the ASK (2020) blasting calculations, the ground vibration and airblast levels from the Project are predicted to be acceptable at the nearest sensitive receptors based on the nominated criteria (Table 61).

Table 65 shows that the 10 mm/s PPV criterion would not be exceeded at distances greater than 1.0 km from the blast, whilst the 5 mm/s PPV criterion would not be exceeded at distances greater than 1.5 km from the blast. The nearest sensitive receptor is approximately 1.9 km away from the nearest pit shell area where blasting would occur. Therefore, ground vibration due to blasting is predicted to be compliant with the nominated criteria at all sensitive receptors.

Table 65 Ground Vibration Levels at Various Distances from The Blast

Distance from Blast (km)	Vibration Level (mm/s)	
	K = 800	K = 1600
1.0	2.9	5.9
1.5	1.5	3.1
2.0	1.0	1.9
2.5	0.7	1.4
3.0	0.5	1.0
3.5	0.4	0.8
4.0	0.3	0.6
4.5	0.3	0.5
5.0	0.2	0.4
5.5	0.2	0.4
6.0	0.2	0.3
6.5	0.1	0.3
7.0	0.1	0.3
7.5	0.1	0.2
8.0	0.1	0.2
8.5	0.1	0.2
9.0	0.1	0.2
9.5	0.1	0.2
10.0	0.1	0.1

Notes: K site and rock constant. Assumed to be in the range of 800 to 1600 for the Gemini Project (ASK 2020).

Table 66 contains the separation distances and the reduction of airblast noise levels due to distance. The distance to the airblast criterion contour line of 120 dB (linear) was calculated to be 880 m. The distance to the 115 dB (linear) contour line is calculated to be 1,290 m. Based on these calculations and blast parameters, the airblast criteria would not be exceeded at any sensitive receptors.

Table 66 Airblast Noise Levels At Various Distances From The Blast

Distance from Blast (km)	Airblast Level (dB (linear))
1.0	118.3
1.5	113.0
2.0	109.3
2.5	106.4
3.0	104.0
3.5	102.0
4.0	100.3
4.5	98.8
5.0	97.4
5.5	96.2
6.0	95.0
6.5	94.0
7.0	93.0
7.5	92.2
8.0	91.3
8.5	90.5
9.0	89.8
9.5	89.1
10.0	88.4

11.3.6 Impact Summary

The Project has potential to impact on EVs as a result of Project related noise impacts. Noise criteria was proposed (Table 60) in line with current policy.

From the predicted noise levels in Section 11.3.3, of the properties that are not owned by Magnetic South at the time of submission, exceedances of the 35 dBA night objective is predicted at two receptors:

- SR10 (Year 2 and Year 8);
- SR22 (Year 2).

Compliance is predicted at all other sensitive receptors during both day and night 'averse' conditions.

Of these potentially impact receptors, SR22 is located within the MLA, whilst SR10 is located 1.4 km east of the MLA. Given there is a potential for exceedances, a range of mitigation measures will be implemented, as necessary, to achieve compliance for residual sensitive receptors in the area. These measures are detailed in the subsection below.

11.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING

The management hierarchy for noise as set out in the EPP (Noise) requires that for an activity involving noise that affects, or may affect, an EV, to the extent that it is reasonable to do so, noise must be dealt with in the following order of preference:

1. avoid the noise (e.g., locating an activity in an area that is not near a sensitive receptor);
2. minimise the noise by preferably:
    a. orientating an activity to minimise the noise (e.g., facing a part of an activity that makes noise away from a sensitive receptor); or alternatively
    b. using the best available technology to minimise the noise; or
3. manage the noise (e.g., using heavy machinery only during business hours).

The potential requirements for noise mitigation at this time are based solely on noise modelling for the Project. Magnetic South will monitor and verify noise levels before considering the implementation of mitigation measures.

11.4.1 Noise Monitoring

Prior to mining operations, noise level compliance will be undertaken by real time noise monitoring at the most noise affected receptor/s (i.e., SR10 and SR22). A noise monitoring survey will be then conducted at the commencement of operations to verify the noise emissions within the Project and the level of noise impact at sensitive receptors. The verified noise levels will direct the noise limits that will be administered under the EA and subsequent auditing compliance.

The following noise monitoring measures will be undertaken to inform the ongoing design of operations and any noise mitigation requirements:

- Develop and implement a noise monitoring program at sites representative of surrounding sensitive receptors for verification of modelling results. All noise monitoring will be conducted in accordance with *Australian Standard AS1055: Acoustics – Description and measurement of environmental noise* and the *Noise Measurement Manual* (EHP 2013b).
- Operate a real time noise monitoring system that will report one-third octave band noise levels (including L_{eq} ,L_1, L_{10} and L_{90}.) over 15-minute periods and provide audio recording/snapshots and 1 second time period noise levels. The system will have the capability to email, text message, or otherwise transmit alerts to mine operators to enable the mine to react to potential exceedances and may also provide a web portal interface where mine operators can track the noise during night periods.
- A blast monitoring program will be developed to monitor the airblast overpressure and blast vibration levels during all blast events. The blast design details will be the responsibility of the blast contractor and observations before and after blasting will also be recorded.

Where the monitoring programs indicate a potential exceedance, the following mitigation measures below would be implemented, as necessary.

11.4.2 Noise Mitigation Management and Scenarios

Noise and vibration management and mitigation measures will be undertaken for the Project to ensure all noise objectives and limits have been achieved. Magnetic South is committed to implementing the following measures:

- Develop a *Noise and Blast Management Plan* that will detail noise monitoring frequency and a range of available measures to be implemented as necessary to ensure compliance with approval conditions.

  Measures that will be considered for inclusion in the *Noise and Blast Management Plan* as opportunities for noise reduction and additional remedial actions for noise control in the event of complaints being received, exceedances of criteria being recorded, or other trigger levels being breached include:

  - management of mining equipment locations (i.e., moving mine equipment further from the most-affected receptors);
  - where appropriate, ceasing operations at times of the day that are predicted to result in exceedances (i.e., night-time) is considered to minimise effects;
  - where appropriate, ceasing operations under meteorological conditions that are predicted to result in exceedances at highly affected receptors (real time noise monitors can inform reactive operation to meteorological conditions if limits are exceeded);
  - reducing the number of equipment in operation during the night (e.g., halving of equipment numbers would be expected to provide a reduction of 3 dBA, assuming the shutdown equipment was spread around the mine operations);
  - attenuation of equipment, particularly the mobile fleet, could result in noise reductions of the order of 3 to 8 dBA, at $250,000 to $750,000 per item of equipment;
  - construction of bund walls where possible nearest to the noise source (i.e., adjacent a haul road, or sensitive receptors);
  - the requirement that Magnetic South will investigate, if monitoring indicates unexpected exceedances of noise or blast objectives; and/or
  - roles and responsibilities for implementation, monitoring and review of the *Noise and Blast Management Plan*.

- Enter into discussions and, as appropriate, commercial arrangements with any affected surrounding landholders which could include:

  - measures (e.g., purchase or relocation) which results in homesteads no longer being considered a sensitive receptor; or
  - installation of receptor-side mitigation (e.g., air conditioners and glazed windows in affected residences to allow for closed windows).

Based on the modelled noise results in Section 11.3.3, a number of noise mitigation scenarios are outlined below (Table 67). These optional scenarios focus on removing or relocating equipment and should be considered as examples only as other acoustically equivalent scenarios could be developed. The mine could operate compliantly by selecting and operating to one of the optional scenarios below.

Table 67 Example Mitigation Scenarios

Year	Scenario	Example Scenarios and Resulting Noise Levels Under Adverse Conditions for Each Time Period	
		Day and Evening (7am to 10pm)	Night (10pm to 7am)
Year 2	Original	36 dBA at SR10 and 35 dBA at SR22, as per Table 62.	37 dBA at SR10 and 36 dBA at SR22, as per Table 62.
	Option 2A	No change to day/evening operations. Results as per Original scenario already achieve compliance.	35 dBA at SR10 and 35 dBA at SR22, i.e., compliance achieved when 5 of 12 x OB haul trucks removed.
Year 8	Original	37 dBA at SR10, as per Table 63	38 dBA at SR10, as per Table 63.
	Option 8A	No change to day/evening operations. Results as per original scenario already achieve compliance.	35 dBA at SR10, i.e., compliance achieved when 1 of 6 x D11 dozers are removed from dump and 6 of 15 x OB haul trucks are removed.

12.0 WASTE GENERATION

This section provides a description of the waste streams that are likely to be produced over the life of the Project and describes the proposed measures for minimising and managing waste generated. This section refers to general and regulated waste streams to be managed at the Project. Other waste products not addressed here include water, air, GHG and waste rock. These are addressed in the relevant technical sections:

- surface water runoff and wastewater is addressed in Section 7.0;
- groundwater inflows into the open pits is addressed in Section 8.0;
- airborne wastes excluding GHGs is addressed in Section 9.0;
- GHGs and fugitive emissions is addressed in Section 10.0; and
- excavated waste rock and coal rejects is addressed in Section 13.0.

12.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES

The environmental objective relevant to waste, as described in the EA guideline for *Application requirements for activities with waste impacts [ESR/2015/1836]* (DES 2019), is:

Any waste generated, transported, or received as part of carrying out the activity is managed in a way that protects all environmental values.

The Project would achieve the following performance outcomes identified in Schedule 8, Part 3, Division 1 of the EP Regulation:

a) waste generated, transported, or received, is managed in accordance with the waste and resource management hierarchy in the Waste Reduction and Recycling Act 2011; and

b) if waste is disposed of, it is disposed of in a way that prevents or minimises adverse effects on environmental values.

12.2 DEFINITION OF WASTE

The EP Act defines 'waste' as anything that is:

a) left over, or an unwanted by-product, from an industrial, commercial, domestic or other activity; or

b) surplus to the industrial, commercial, domestic or other activity generating the waste.

Section 42 of the EP Regulation defines 'regulated waste' as waste that is:

a) commercial waste or industrial waste; and

b) a type, or contains a constituent of a type, mentioned in schedule 9, part 1, column 1.

Classified under 'regulated waste' –

Schedule 2 of the EP Regulation defines 'limited regulated' waste to include –

a) *animal effluent and residues, asbestos, biosecurity waste that has been rendered non-infectious, food processing waste, tyres, and sewage sludge or residue produced in carrying out an activity.*

Schedule 19 of the EP Regulation defines 'commercial waste' as:

a) *waste produced as a result of the ordinary use or occupation of commercial or premises; and*

b) *waste other than green waste, recyclable waste, interceptor waste or waste discharged to a sewer.*

Schedule 19 of the EP Regulation defines 'industrial waste' as:

a) *interceptor waste; or*

b) *waste other than the following—*

i. *domestic waste, domestic clean-up waste, green waste, recyclable waste, recyclable interceptor waste, waste discharged to a sewer.*

Schedule 19 of the EP Regulation defines 'biosecurity waste' as:

a) *waste that is goods subject to biosecurity control under the Biosecurity Act 2015 (Cwlth); or*

b) *goods under the Biosecurity Act 2015 (Cwlth) that are or were in contact with waste mentioned in paragraph (a).*

Schedule 19 of the EP Regulation defines 'general waste' as:

a) *waste other than regulated waste;*

b) *chapter 6, part 2, any of the following –*

i. *commercial waste, other than regulated waste;*

ii. *domestic waste;*

iii. *recyclable waste.*

c) *general waste composition includes –*

i. *putrescibles, paper, cardboard, glass, office waste, industrial waste and construction waste.*

Schedule 19 of the EP Regulation defines 'green waste' as:

a) *organic waste from vegetation (e.g., trees, shrubs, and grass).*

Schedule 19 of the EP Regulation defines 'clinical waste' as:

a) *waste that has the potential to cause disease*

b) *clinical waste composition includes –*

i. *animal waste, discarded sharps, human tissue waste and laboratory waste.*

12.3 IDENTIFIED WASTE TYPES

The primary source of waste from mining operations is excavated waste (overburden and interburden), coarse rejects and fine rejects (tailings) from the CHPP. Other wastes (regulated and non-regulated) expected to be produced from activities pertaining to the Project include:

- general waste;
- recyclable waste;
- refurbishable items;
- green waste;
- scrap metal;
- personal protective equipment (ppe);
- air filters;
- timber and reusable pallets;
- waste oils;
- engine oil/fuel filters;
- waste greases;
- sewage effluent;
- empty waste oil containers;
- paints;
- hydrocarbon contaminated material;
- miscellaneous chemicals;
- batteries;
- E-waste;
- ozone depleting substances; and
- tyres.

Table 68 describes the expected quantity of each generated waste type, stream and disposal locations during the construction and operational phases of the Project based on different waste definitions listed in the EP Regulation.

Table 68 Anticipated Waste Generation From The Construction and Operation of the Project

Waste Type/ Waste Category	Form	Source	Approximate Quantity (per annum)		Management Strategies	Waste Management Hierarchy	Proposed Disposal Location
			Construction	Operation			
General Waste							
General waste *(i.e., food scraps, non-Class 1, 2 and 5 plastics)*	Solid	Kitchenettes, crib rooms, administration areas, workshop, etc.	<130 t	<170 t	General waste will be stored onsite in bins for regular transport offsite by a licensed waste transport contractor to a licensed landfill.	Waste disposal	General waste will be transported offsite by a licenced waste contractor to an approved landfill.
Recyclable waste *(i.e., aluminium, steel cans, Class 1, 2 and 5 plastics, paper towels, paper and cardboard)*	Solid	Kitchenettes, crib rooms, administration areas, workshop, etc.	<40 t	<70 t	Recyclable waste will be stored onsite in bins for regular transport offsite by a licensed waste transport contractor for recycling.	Waste recycling	Recyclable waste will be transported offsite by a licenced recycling contractor to an approved recycling facility.
Timber/reusable pallets	Solid	Workshop and administration areas	<20 t	<20 t	Reusable pallets will be returned to the supplier.	Waste reuse	Return to supplier for reuse.
					Where pallets are unable to be reused, they will be sent to general waste.	Waste disposal	Pallets that are not reusable will be transported offsite by a licenced waste contractor to an approved landfill.
Refurbishable items *(i.e., pipe work and associated components and fittings, wing nuts, conveyor rollers and belt)*	Solid	CHPP and workshops	<10 t	<10 t	Refurbishable items will be stockpiled within a designated area. If condition is acceptable, items will be reused directly.	Waste reuse	Reuse onsite.
					Where items are unable to be reused, they will be collected and disposed by a licensed waste contractor. Where items are contaminated with hydrocarbons, they will be managed as regulated waste.	Waste disposal	Refurbishable items will be disposed of offsite by a licenced waste contractor to an approved waste facility.

Waste Type/ Waste Category	Form	Source	Approximate Quantity (per annum)		Management Strategies	Waste Management Hierarchy	Proposed Disposal Location
			Construction	Operation			
PPE and other small items *(i.e., gloves, hard hats, safety glasses and face masks)*	Solid	Bathhouse and contractor facilities	<100 kg	<200 kg	Equipment that is not damaged will be reused onsite.	Waste reuse	Reuse onsite.
					Equipment that is sufficiently used and/or damaged will be disposed.	Waste disposal	PPE will be transported offsite by a licenced waste contractor to an approved landfill.
Scrap metal *(i.e., stainless steel, aluminium and any item considered to be metal [ferrous or non-ferrous] including machine and vehicle parts)*	Solid	Construction activities, infrastructure maintenance and workshops	<50 t	<100 t	Small scrap metals will be placed in scrap metal skips. All grease and oils will be removed prior to placement in skips. Specific arrangements will be made for the collection of larger scrap metals. A licensed contractor will remove all scrap metals for segregation at a licensed recycling facility.	Waste recycling	Scrap metal will be transported offsite by a licensed contractor to an approved recycling facility.
Air filters *(i.e., engine air filters)*	Solid	Vehicle and machinery maintenance at workshops	<1 t	<7 t	Air filters will be temporarily stored in the appropriate air filter skip and will be disposed of offsite by a licensed waste contractor.	Waste recycling	Air filters will be transported offsite by a licenced waste contractor to be recycled.
Green & Biosecurity							
Green waste *(i.e., grass, cleared timber and weeds)*	Solid	Clearing of vegetation	As per schedule	As per schedule	Green waste will be mulched and/or placed in timber stacks for reuse onsite during rehabilitation.	Waste reuse	Reuse onsite.
Regulated							
Excavated waste *(i.e., overburden, interburden)*	Solid	Mining activities	n/a	Up to 473.4 Mbcm	Excavated waste rock will be placed in an out-of-pit waste rock emplacement and in-pit waste rock emplacements of Pit AB and Pit C when space becomes available behind the advancing mining operations.	Waste disposal	Excavated waste rock will be disposed of within Pit AB and Pit C and out-of-pit waste rock emplacements.

Waste Type/ Waste Category	Form	Source	Approximate Quantity (per annum)		Management Strategies	Waste Management Hierarchy	Proposed Disposal Location
			Construction	Operation			
Coal rejects *(i.e., coarse and fine rejects)*	Solid	Mining activities	n/a	Up to 0.5 Mt	Coal rejects will be disposed of in out-of-pit waste rock emplacements and in-pit waste rock emplacements of Pit AB and Pit C when space becomes available behind the advancing mining operations.	Waste disposal	Coal rejects will be disposed of within Pit AB and Pit C and out-of-pit waste rock emplacements.
Waste oils	Liquid	Machinery and vehicle maintenance and workshop	30 kL	199 kL	Waste oils will be transported offsite by a licensed regulated waste contractor and will be reused or recycled by a licensed regulated waste receiver.	Waste reuse or recycling	Waste oils will be recycled by a licenced regulated waste contractor.
Engine oil/fuel filters	Solid/ Liquid	Vehicle and machinery maintenance at workshop	50 each	780 each	Engine oil filters will be collected and stored in sealed oil filter disposal pod. They will be transported by a licensed regulated waste contractor to a licensed regulated waste receiver for treatment to recover oil for reuse.	Waste reuse	Re-use onsite.
					If filters are unable to be recovered, they will be recycled by a licensed regulated waste contractor.	Waste recycling	Engine oil/fuel filters will be recycled by a licenced regulated waste receiver at an approved recycling facility.
Waste grease *(i.e., from machinery)*	Liquid	Workshop, large machinery maintenance	<0 kL	<0.5 kL	Waste grease will be stored in sealed containers or tanks in a designated bunded area, which will then be transported offsite by a licensed regulated waste contractor. Waste grease will be recycled at a licensed waste facility.	Waste recycling	Waste grease will be recycled at an approved offsite facility by a licenced regulated waste contractor.

Waste Type/ Waste Category	Form	Source	Approximate Quantity (per annum)		Management Strategies	Waste Management Hierarchy	Proposed Disposal Location
			Construction	Operation			
Empty waste oil containers	Solid	Workshop	<1 t	<1 t	All drums will be segregated and sealed prior to collection by a licensed regulated waste contractor and transported to a licensed waste receiver for recycling.	Waste recycling	Empty waste oil containers will be recycled offsite by a licenced regulated waste receiver.
Paints *(i.e., general paint, air dried insulating varnish)*	Liquid /Gas	Industrial area infrastructure and workshop	<1 t	<1 t	Paints will be transported to a designated sealed and bunded area to be collected by a licensed regulated waste contractor and transported to a licensed regulated waste receiver for treatment before disposal.	Treat waste before disposal	Empty waste oil containers will be recycled by a licenced regulated waste contractor.
Hydrocarbon contaminated material *(i.e., oily rags)*	Solid/ Liquid	Workshop servicing trucks and light/heavy vehicles	<1 t	<5 t	Hydrocarbon contaminated material will be stored in temporary storage facilities in the MIA, which will then be collected for offsite disposal.	Waste disposal	Hydrocarbon contaminated material will be disposed of by licenced waste transport operators at an appropriately licensed waste disposal facility.
Miscellaneous chemicals *(i.e., engine coolant, solvents, sealants, etc.)*	Liquid / Gas	Workshop and administration	<1 kL	40 kL	Miscellaneous chemicals will be transported to a designated sealed and bunded area for collection by a licensed regulated waste contractor and transported to a licensed regulated waste receiver for treatment and disposal.	Treat waste before disposal	Miscellaneous chemicals will be disposed offsite by a licenced regulated waste contractor at an approved licenced facility.
Batteries *(i.e., dry cell, gel cell, lead acid)*	Solid	Operation of portable electrical equipment (radios, phones, etc.) within the	<1 t	<2 t	Batteries will be segregated and stored within dedicated containers in the battery storage area, which will then be collected and transported by a licensed regulated waste contractor to a licensed regulated waste facility for recycling.	Waste recycling	Batteries will be recycled by a licensed regulated waste contractor at a licensed regulated waste facility.

Waste Type/ Waste Category	Form	Source	Approximate Quantity (per annum)		Management Strategies	Waste Management Hierarchy	Proposed Disposal Location
			Construction	Operation			
		workshop and other areas			Remaining batteries that are not recyclable will be disposed of by a licensed regulated waste contractor.	Waste disposal	Batteries will be disposed offsite by a licenced regulated waste contractor at a licensed regulated waste facility.
Ozone depleting substance *(i.e., refrigerants and air conditioning substances)*	Liquid / Gas	Air conditioning units, fridges and cars throughout site	<1 kg	<1 kg	Ozone depleting substances will be stored at the source in cylinders and returned to the supplier for reuse and recycling.	Waste reuse and recycling	Ozone depleting substances will be recycled by a licenced regulated waste contractor.
Limited Regulated							
Tyres *(i.e., light and heavy vehicle tyres)*	Solid	Tyres from light and heavy vehicles	20	50	Tyres will be segregated and re-purposed onsite in a designated area where there will be no flammable materials within a 10 m radius. Tyres will then be transported offsite to a supplier for re-treading.	Waste reuse	Reuse onsite for alternate purposes.
					The remainder of tyres that will not be re-purposed will be disposed onsite in a designated tyre disposal area of the backfilled Pit AB and/or Pit C.	Waste disposal	Tyres will be disposed onsite within a designated tyre disposal area of the backfilled Pit AB and/or Pit C.
Sewage	Liquid	Offices, workshops and accommodation facility	<7,665 kL	<7,665 kL	Sewage generated onsite will be pumped to the STP located west of the accommodation facility. Treated effluent will be irrigated with sprinklers to a designated area located at a distance of at least 500 m away from site offices and residences.	Treat waste before disposal	Treated effluent will be irrigated with sprinklers to a designated area.

Waste Type/ Waste Category	Form	Source	Approximate Quantity (per annum)		Management Strategies	Waste Management Hierarchy	Proposed Disposal Location
			Construction	Operation			
			Low	Low	Sewage sludge will be directed to the septic systems and will be removed as required by a certified regulated waste contractor for offsite disposal.	Disposal	Waste sludge will be disposed of by a regulated waste contractor

12.4 REGIONAL WASTE MANAGEMENT FACILITIES

The CHRC provides a network of 18 waste management facilities available for communities and businesses to dispose waste materials (CHRC 2016). The waste management facilities comprise eight small facilities (<2,000 t/a), three with a landfill capacity of 2,000-5,000 t/a, one large facility with a capacity of 10,000-20,000 t/a located in Emerald, and six bulk bin/transfer stations.

CHRC is currently progressing through an infrastructure rationalisation program in order to ensure environmental and licence compliance with DES requirements, while increasing opportunities for recycling, and ultimately, reducing the amount of waste sent to landfill (CHRC 2016).

Regional and local industry in general and the regional coal industry in particular, has created sufficient demand for waste management services such that the region is well serviced by all major waste service providers. Access to these services has resulted in a relatively mature approach by businesses in the area to waste sorting and recycling.

Current bulk bin, landfill and transfer station facilities are indicated in Figure 85.

12.5 WASTE MANAGEMENT

Waste from the Project will be managed in accordance with the waste and resource management hierarchy from the *Waste Reduction and Recycling Act 2011*, which lists waste and resource management strategies in the order of most to least preferred option:

(a) ***avoid*** *unnecessary resource consumption;*

(b) ***reduce*** *waste generation and disposal;*

(c) ***re-use*** *waste resources without further manufacturing;*

(d) ***recycle*** *waste resources to make the same or different products;*

(e) ***recover*** *waste resources, including the recovery of energy;*

(f) ***treat*** *waste before disposal, including reducing the hazardous nature of waste; and*

(g) ***dispose*** *of waste only if there is no viable alternative.*

Appropriate waste management strategy for each waste stream in accordance with the hierarchy is addressed in Table 68.

Wastes that are not able to undergo processes of onsite reuse, recycling or treatment would be able to do so at offsite waste facilities. Where practicable, consumable suppliers will collect and recycle the waste product, and consider off-site recycling services that may be available. Before disposing waste to landfill, Magnetic South will consider the reuse and recycling of the waste within practicable measures.

Avoid or Reduce

Avoiding the production of waste is predominantly achieved through procurement practices, where the expected life and disposal requirements of materials or products are considered during the purchasing process.

Raw materials would be delivered in bulk where feasible. Otherwise, material that is not purchased in bulk will be determined based on minimal packaging and use of biodegradable and compostable

materials. Magnetic South will also consider the use of alternative products, implementation of appropriate technology and procurement processes to ensure that unnecessary waste is not produced.

Magnetic South will aim to reduce the amount of waste produced by limiting the amount of materials being transported to and stored onsite. Waste reduction efforts will also be towards reducing unnecessary consumption of electricity and water resources, along with the use of materials and products such as paper.

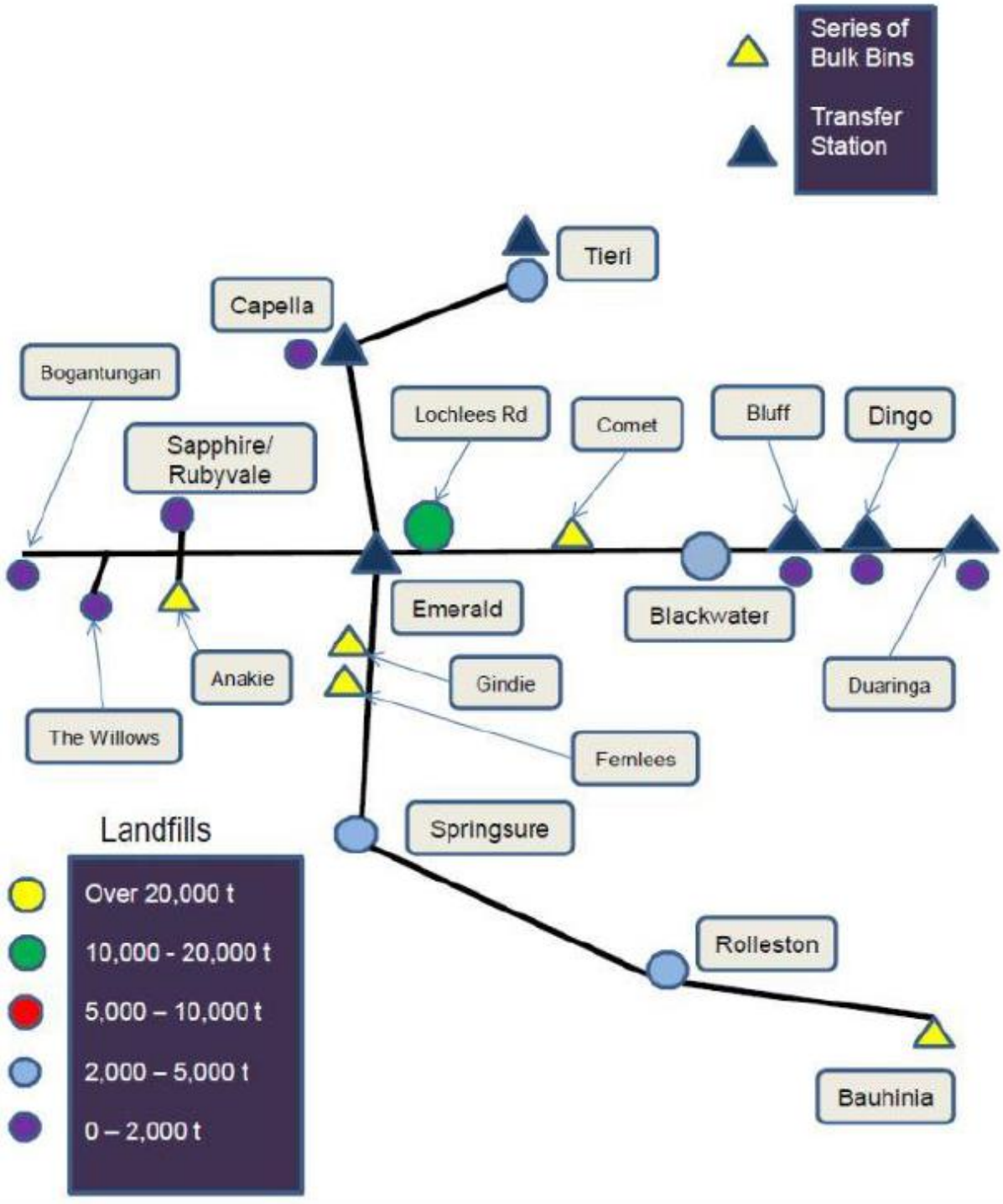


Figure 85 **Current CHRC Waste Infrastructure Plan**

Reuse

Waste streams will be reused wherever ongoing health, safety and reliability can be ensured. Where possible, waste will be reused onsite or will be returned to the suppliers to enable reuse.

Air filters will be collected and cleaned by local facility, Filter Resources Qld, and reused until considered unsuitable where they will be collected and recycled by Filter Resources Qld.

Recycle

The Project will generate a number of waste materials that can be recycled to generate products for a beneficial reuse.

Wastes that are recyclable, including includes aluminium, steel cans, Class 1, 2 and 5 plastics, paper towels, paper and cardboard will be collected and stored in designated bins, sealed containers or bunded areas, which will then be taken offsite by a licensed waste contractor and recycled at a licensed recycling facility.

Recover

Waste recovery is not proposed to be undertaken at the Project.

Treatment

Treatment of waste before disposal can minimise the environmental impact of waste disposal.

Paints and miscellaneous chemicals will be transported offsite by a licensed regulated waste contractor and treated at a licensed waste facility before disposal.

Hydrocarbon contaminated material will be treated and disposed off-site by licenced waste transport operators at an appropriately licensed waste disposal facility. Cleanaway provides contaminated soil remediation services delivering safe, compliant, and environmentally responsible solutions.

Onsite treatment of waste will be limited to the treatment of sewage effluent within a STP at the on-site accommodation facility towards the northwest boundaries of the MLA. Treatment will comprise standard primary, secondary removal of solids alongside nutrient removal and disinfection. Treated effluent will be released for irrigation in accordance with the EA conditions. Sludge will be treated offsite by Cleanaway, where it may be reused to generate energy or alternatively turned into compost and biosolids for non-agriculture purposes (Cleanaway 2019c).

Dispose

Disposal of waste is to be considered when no other economically feasible option for reuse or treatment exists. The disposal method will seek to minimise environmental effects and the potential for land contamination. In most instances, where waste is proposed to be transported to a licenced landfill facility. Magnetic South will arrange for the waste to be transported offsite. This commitment will form part of the contractual arrangements which will be developed with licenced contractors.

Waste that will be disposed of offsite includes general waste, tyres, and wastes that are no longer in reusable or recyclable conditions such as wooden pallets, refurbishable items and PPE. These waste streams are fundamental to daily operations and other waste management avenues (e.g., avoid, reduce, reuse, and treat) were considered unsuitable.

For instance, it is of preference that tyres will be transported offsite to a supplier for re-treading for reuse. Subject to demonstrating to the administering authority that no other use higher in the waste management hierarchy can be practically implemented, waste tyres will be disposed onsite in a designated tyre disposal area of the backfilled Pit AB and/or Pit C. These disposal areas will be managed to avoid any impedance on saturated aquifers, cause contamination or compromise the stability of the final landform. Tyre recycling was considered unsuitable and not economically feasible as the nearest facility for an accredited member of the Australia Tyre-Recycling Association is approximately 700km south-east.

Burial of waste tyres can lead to environmental impacts associated with contamination, fire risk and health risks. There is also a risk that compounds may leach from the tyres and contaminate soil, groundwater and surface water, and a possibility that tyre piles may become breeding grounds for insects, particularly mosquitoes, rodents and other animals. Tyres have also been known to cause fires that release pyrolytic oils and other compounds into the soil and groundwater and through smoke, coupled with contaminated runoff of water used to extinguish the fire. To mitigate these impacts, the storage and disposal of tyres generated by mining activities will be in accordance with *Operational Policy for Disposal and storage of scrap tyres at mine sites* (ESR/2016/2380). Further details of the disposal of scrap tyres will be addressed in a *Non-Mineral Waste Management Plan,* described in Section 12.8.1.

Excavated waste (over-burden and inter-burden) will be disposed of onsite as its unlikely to pose a significant risk to the quality of surface and groundwater when management measures are implemented.

12.6 CLEANER PRODUCTION

Cleaner production refers to the continuous application of an integrated preventative environmental strategy to processes, products and services to increase energy efficiency and reduce risks to people and the environment.

Cleaner production techniques could be implemented during construction, operational or decommissioning phases of the Project through:

- input substitution – Use of process auxiliaries less polluting and/or raw materials;
- product selection – Use non-hazardous products over hazardous materials;
- improved operation and maintenance – Select and use the most appropriate and practicable fixed and mobile equipment for use in coal extraction, transportation and processing, and high levels of maintenance to ensure items are operating efficiently;
- reuse of resources – Reuse resources onsite that would otherwise be classified as wastes;
- technology modifications – Improve process automation, process optimisation, equipment redesign and process substitution through use of available modern technology; and
- closed-loop cycling – Recycle and reuse the product in the same form.

Magnetic South will progressively seek cleaner production to maximise operational efficiency whilst minimising energy consumption and waste generation and disposal. Potential cleaner production techniques include, but not limited to, the following:

- improving operation and maintenance practices to reduce the resource consumption and minimise waste generation (e.g., reuse of water within the mine water management system and CHPP system);

- selecting best available technology for the CHPP, with consideration of the environmental and economic factors to maximise water use and energy efficiency, minimise dust emissions and waste generation;
- site extraction design to minimise the volume of waste rock respective to the excavated coal;
- reusing resources on-site that would be otherwise classified as wastes; and
- closed-loop recycling where a product is recycled and used again in the same form (e.g., wooden pallets, tyres).

Magnetic South seeks to prioritise cleaner production and waste management strategies for all generated waste types, unless it is not feasible.

12.7 REGULATED WASTE MANAGEMENT

The EP Regulation requires that the administering authority be provided with appropriate information to manage the associated environmental risks of 'trackable wastes' listed in Schedule 11 of the EP Regulation.

Trackable waste will only be transported offsite by a licensed transporter (Section 96 of the EP Regulation). Magnetic South will also be required to provide information to the waste transporter in accordance with Schedule 12 of the EP Regulation.

A register will be developed and maintained for all regulated wastes generated on-site, which will include the following details:

- source, type and quantity of waste;
- storage location;
- dates of collection and recycling/disposal; and
- name and details (including licencing details) of transporter and waste disposal facility.

A full list of regulated waste has been identified for the Project based on the definitions listed in the EP Regulation which is detailed in Table 68.

12.7.1 Regulated Waste Treatment and Disposal

Treating and disposing of waste will predominantly occur offsite and will be carried out in a way that causes least harm to the environment and can be achieved through the following methods:

- employing a bio-treatment to degrade material into a compound or mixture;
- employing a physico-chemical treatment (for example, evaporation, drying, calcination, catalytic processing, neutralisation, precipitation, or encapsulation) to obtain a compound or mixture;
- blending or mixing waste to obtain a compound or mixture storing or repackaging waste;
- employing thermal processes, with or without catalysts, to convert waste into a non-hazardous material;
- disposal to a landfill; or

- thermal destruction without recovering heat or another secondary product.

Regulated waste types that will undergo treatment before disposal include sewage, paints, and miscellaneous chemicals.

Magnetic South will use waste management services within the region such as Cleanaway Emerald Liquid Waste Services (Cleanaway). Cleanaway seeks to prioritise the recycling of waste paint and its by-products and processing to be turned from waste to valuable resources before considering disposal. Cleanaway facilities offer services for metal and plastic paint containers to be recycled and turned into new packaging materials. Water-based paint can be processed, with the by-products used in a variety of industrial applications, such as cement mixer, industrial water or in composting (Cleanaway 2019b). Solvent based paint can be recycled and used as an alternative fuel source for local cement and manufacturers (Cleanaway 2019b).

Cleanaway will be responsible for all waste oil and coolant removal and treatment as their facilities operate onsite treatment plants for liquid and hazardous waste (Cleanaway 2019a). Liquid and hazardous waste can undergo a chemical reaction process called Base Catalysed Dechlorination to treat high concentration persistent organic pollutants oils and reduce polychlorinated biphenyls concentrations. The process will be monitored to ensure the reaction continues to completion (Cleanaway 2019a).

12.7.1.1 Sewage Waste Treatment

A *Land-Based Effluent Disposal Assessment* (Cardno 2020) was undertaken in accordance with the current industry standards for wastewater management set out in *AS/NZ 1547:2012 On-site Domestic Wastewater Management* and provided in Appendix N. As described in Section 12.3 (Table 68), sewage generated onsite will be treated at a STP through a standard primary, secondary removal of solids alongside nutrient removal and disinfection.

A MEDLI was used to assess the suitability of dispersal in the surrounding area. Treated effluent will be released within a designated irrigation area on-site and is expected to achieve the water quality parameters set out in the *Eligibility Criteria and Standard Conditions for Sewage Treatment Works (ERA 63) – Version 2)*. These limits also align with the quality which would be expected from a basic sewage treatment plant as per *Table A3.2 of the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)*. These are detailed below (Table 69).

Table 69 Wastewater Quality Limits

Quality Characteristic	Release Limit	Limit Type
Total Nitrogen	30 mg/L	Maximum
Total Phosphorus	10 mg/L	Maximum
Electric Conductivity	1600 µs/cm	Maximum
pH	5.0 – 8.5	Range
Total Residue Chlorine (if used for disinfection)	1 mg/L	Maximum
E.Coli	<1000 cfu/100mL	Maximum
Total Suspended Solids	20 mg/L	Maximum
Biochemical Oxygen Demand	30 mg/L	Maximum

To ensure sewage effluent does not pose any risks to surrounding environmental values (water logging, surface runoff or excessive deep drainage), the soil profile of the site (category 6 soil) governs the following application parameters and schedules day in accordance with *AS 1547:2012*:

- construction – expected secondary treated effluent generation (56m^3), irrigation area (3.8 ha), rate (2mm/day); and

- operations – expected secondary treated effluent generation (28m^3), irrigation area (1.9 ha), rate (2mm/day);

The designed irrigation rate, area and chosen pasture were sufficient to prevent waterlogging, surface runoff or excessive deep drainage in two extreme soil types (i.e., extremely permeable sand and extremely impermeable clay) without requiring trigger limits. Conservative modelling identified no overflows predicted to occur throughout both construction and operational phases. However, it has been noted that during substantial rain events, irrigation should not occur when the ground is showing signs of saturation (such as surface water pooling).

In order to account for such events, 3 days of wet weather storage (168 m^3 tank capacity) was accounted for in the MEDLI model as recommended by the *QLD Government Technical Guideline for Disposal of Effluent via Irrigation.* Once detailed design information is available, a site-specific contingency plan will be developed to manage the wet weather storage tanks, STP shutdowns and maintenance periods when >3 days storage may be required. As closed tanks will be used instead of ponds, a negligible risk is expected for algae blooms or leaching into the groundwater. All released effluent will be monitored for pH and faecal coliforms to comply with the appropriate limits prescribed by the EA for the Project.

Rhodes grass was assumed to be the pasture which will be irrigated on-site. Modelling using Rhodes Grass (moderately salt-tolerant) indicates the resulting salinity would be too low to impact upon the health of the grass. The proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction) was 0% for both construction and operations. The MEDLI model indicates that mowing (with removal of clippings) would only be required approximately 3 times per year to maintain sufficient growth and subsequent nutrient uptake. Modelling of design irrigation rate, area and chosen pasture resulted in negligible concentrations of nutrient leaching to groundwater in either extreme soil type.

The MEDLI model confirms the suitability of the proposed wet weather storage and effluent irrigation areas to cater for the expected volume of wastewater generated, inclusive of climatic conditions, vegetation being irrigated and effluent quality (total nitrogen, total phosphorous, TDS, EC and soil properties). It concludes that no runoff from the effluent irrigation management area and wet weather storage will occur under the proposed irrigation regime with minimal irrigation-induced deep drainage (Appendix N). When combined with the setback distances discussed above (section 3.5.3.1), the risk of aerosol drift and odour is considered negligible.

12.7.1.2 Sludge Treatment

Sludge will be dewatered on site and the resulting dried sludge will be removed via a licensed regulated waste contractor. No waste residues are anticipated, and tank system sludge accumulation is expected to be 0.0 kg dwt/year.

12.7.2 Regulated Waste Transport

All regulated waste generated onsite will be arranged by the Magnetic South to be transported offsite for recycling, treatment, or disposal at a licensed facility. Regulated waste must only be removed and transported from the site by a person who holds a current licence to transport such waste under the EP Act.

Contractors within the region such as JJ Richards & Sons will be responsible for collection of regulated waste bins as well as collection of recyclable wastes (e.g., cardboard). Waste handlers are required to

submit waste tracking information to DES as part of the system for tracking waste listed in Schedule 9 Part 1 of the EP Regulation (i.e., regulated wastes). Waste handlers are defined as generators, transporters and receivers of wastes. Waste Transport Certificates are to be completed by waste handlers (i.e., generators, transporters, and receivers of waste) and submitted to DES as part of the process for tracking wastes in Queensland.

The transport of regulated wastes from the Project will be conducted in compliance the system requirements outlined by DES in *Waste tracking guideline – Overview of managing waste tracking in Queensland (ESR/2016/2425) Version 2.01* (DES 2018e).

Skip bulk or lift trucks will be used for heavier and/or bulkier waste materials such as empty waste oil containers, scrap metals and timber pallets. Mine affected water may be piped, trucked via liquid tankers or transferred in compliance with EA conditions.

Further information regarding the machinery and proposed method of regulated waste transportation will be detailed in a *Non-Mineral Waste Management Plan*, which will be developed at a later stage (refer to Section 12.8.1 for further details). The commitment will form part of the contractual arrangements and will be developed with licenced contractors.

12.8 WASTE AUDITING, MONITORING AND REPORTING

The waste streams and quantities produced would be recorded by Magnetic South over the life of the Project. Audits of the waste management activities will include:

- assessing actual generated wastes against the predicted waste quantities;
- monitoring the actual and potential impacts from wastes;
- reviewing the waste transportation records to ensure compliance; and
- identifying potential improvements in waste management practices, including establishment of waste reduction targets, where practicable.

Magnetic South will also monitor the implementation and effectiveness of the *Non-Mineral Waste Management Plan* and its compliance with relevant Commonwealth and Queensland legislation detailed below.

12.8.1 Non-Mineral Waste Management Plan

A *Non-Mineral Waste Management Plan* will be developed for all non-mining wastes prior to the construction of the Project. The plan will be developed in consideration of the waste hierarchy outlined in Section 12.5 to identify all waste streams and volumes, baseline data, compliance protocols, set measurable waste reduction targets, describe management controls and related environmental impacts. The following principles will be incorporated into the proposed plan:

- waste will be segregated into general waste, various recyclable wastes and regulated waste;
- the collection of general waste will be in clearly designated bins;
- recyclable waste will be separated and stored for collection into streams, including paper and cardboard, metals and recyclable plastics;

- all used tyres will be managed in accordance with the operational policy '*Disposal and storage of scrap tyres at mine sites*' (DES, 2014b). This may result in used heavy machinery tyres being disposed of within spoil dumps if other higher order options are not feasible. In this case, the locations of spoil dumps containing used tyres will be recorded on the Environmental Management Register;

- different forms of waste (e.g., metals, paper, oils, batteries, general waste, etc) will be stored on-site according to their corresponding waste stream. The design of the waste storage facility will consider public health, hygiene and safety standards. For example, flammable material or combustible liquid wastes will be stored in facilities designed to meet '*AS 1940:2017, The storage and handling of flammable and combustible liquids*' (Standards Australia 2017);

- waste oils, chemicals, batteries and other hazardous and/or regulated substances will be stored in bunded areas or on bunded pallets within the waste collection area;

- bins located within offices and workshops will be appropriately labelled to avoid cross-contamination and provide for separation of different waste streams. Bins will be emptied regularly to minimise vermin and pests; and

- regulated and/or hazardous waste will be stored in a separate storage area to ensure that the potential for environmental harm is minimised.

The *Non-Mineral Waste Management Plan* will include procedures and programs that detail monitoring frequency, collection methodologies, performance indicators and reporting requirements to ensure compliance with regulatory frameworks.

13.0 WASTE ROCK AND COAL REJECT GEOCHEMISTRY

This section discusses the characterisation of waste rock and coal rejects for the Gemini Project. The *Geochemical Assessment of Mining Waste Materials* (RGS 2019) (Appendix G) and *Geochemical Assessment of Coal Reject Material* (RGS 2020) (Appendix H) were undertaken with the aim of understanding any potential geochemical risks. The assessments provide a geochemical characterisation of samples representative of the mining wastes (overburden and interburden materials) and coal reject materials.

Both static and kinetic testing methods were utilised to indicate the presence and degree of risk from the oxidation of reactive sulfides, and the potential for acid generation and leaching of soluble metals/metalloids and salts. The assessments also included characterisation of chemical parameters related to sodicity and material stability. The assessments were completed in accordance with relevant industry guidelines:

- *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME 1995);
- *Application requirements for activities with impacts to water [ESR/2015/1837]* (DES 2017c);
- *Leading Practice Sustainable Development Program for the Mining Industry: Mine Closure* (DFAT 2016a);
- *Leading Practice Sustainable Development Program for the Mining Industry: Mine Rehabilitation* (DFAT 2016b);
- *Leading Practice Sustainable Development Program for the Mining Industry: Preventing Acid and Metalliferous Drainage* (DFAT 2016c); and
- *Global Acid Rock Drainage Guide (GARD Guide)* (INAP 2009).

13.1 ENVIRONMENTAL OBJECTIVES AND PERFORMANCE OUTCOMES

Surface waters and groundwaters could potentially be impacted from any adverse geochemical by-product associated with waste rock and coal rejects. The EVs have been determined given that waste rock is being disturbed, placed and rehabilitated, and that coal rejects are a waste stream from coal processing that need to be managed. The relevant environmental objectives were therefore determined to be associated with potential impacts to water.

The environmental objective relevant to water, as described in the EA guideline for *Application requirements for activities with impacts to water [ESR/2015/1837]* (DES 2017c); are:

- *the activity will be operated in a way that protects environmental values of waters; and*
- *the activity will be operated in a way that protects the environmental values of groundwater and any associated surface ecological systems.*

The Project would generally achieve these performance outcomes through implementation of the following measures as outlined in Part 3, Schedule 8, Division 1 of the EP Regulation:

a) the storage and handling of contaminants will include effective means of secondary containment to prevent or minimise releases to the environment from spillage or leaks.

b) contingency measures will prevent or minimise adverse effects on the environment due to unplanned releases or discharges of contaminants to water.

c) the activity will be managed so that stormwater contaminated by the activity that may cause an adverse effect on an environmental value will not leave the site without prior treatment.

d) the disturbance of any acid sulphate soil, or potential acid sulphate soil, will be managed to prevent or minimise adverse effects on environmental values.

e) acid producing rock will be managed to ensure that the production and release of acidic waste is prevented or minimised, including impacts during operation and after the environmental authority has been surrendered.

f) any discharge to water or a watercourse or wetland will be managed so that there will be no adverse effects due to the altering of existing flow regimes for water or a watercourse or wetland.

g) the activity will be managed so that adverse effects on environmental values are prevented or minimised.

With respect to the groundwater-related objective, the following measures apply (DES 2017c):

a) there will be no direct or indirect release of contaminants to groundwater from the operation of the activity; and

b) there will be no actual or potential adverse effect on groundwater from the operation of the activity.

In addition, the activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.

13.2 DESCRIPTION OF ENVIRONMENTAL VALUES

From a geochemical perspective, the EPP (WWB) is the primary instrument for protecting Queensland waters to achieve the object of the EP Act in relation to water. The EPP (WWB) establishes EVs and management goals for waters and wetlands.

A key relevant document for the Project is the *Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin* (EHP 2011a). The document is made pursuant to the provisions of the EPP (WWB). It contains EVs and WQOs for waters in the Mackenzie River sub-basin. The WQOs and EVs are detailed Section 7.0 and Section 8.0.

13.2.1 Surface Water and Groundwater Resources

A description of surface water resources is provided in Section 7.2.1, including several illustrative figures.

All waterways of the Project area are ephemeral and experience flow only after sustained or intense rainfall in the catchment. Stream flows are highly variable, with most channels drying out during winter to early spring when rainfall and runoff is historically low, although some pools hold water for extended periods. Therefore, physical attributes, water quality, and the composition of aquatic flora and fauna communities are expected to be highly variable over time.

The land within the Project boundary is currently used for low intensity cattle grazing and resource exploration activities. The reaches of Springton Creek and Charlevue Creek in the proposed mining area have well-defined channels, typically with alluvial clay beds and well established in-channel vegetation.

Further details regarding the surface water management of the Project have been included in Section 3.4 and Section 7.4.

Groundwater resources are described in detail in Section 8.2.1and Section 8.2.2, including several illustrative figures.

13.3 POTENTIAL IMPACTS

Detailed geochemical assessments were undertaken of waste rock material (RGS 2019) (Appendix G) and coal reject material (RGS 2020) (Appendix H) associated with the Project. Geochemical test work undertaken was based on industry recognised procedures for the geochemical characterisation and assessment of mine materials. Refer to the relevant appendix report for technical details of the methodology and results of each assessment.

13.3.1 Coal Reject Geochemistry

A total of 80 coal reject samples from coal quality washability tests were provided from 14 different drill holes, comprising 52 coarse reject and 28 fine reject samples.

The $pH_{(1:5)}$ of the 22 composite coal reject samples from the Project ranged from 5.1 to 8.3 with a median value of 7.4 indicating that coal reject materials are typically in the pH neutral range. There does not appear to be any significant correlation between pH and reject type or coal seam.

$EC_{(1:5)}$ ranges from 398 to 1,062 µS/cm (median 774 µS/cm), with no apparent correlation between EC and reject type or coal seam. Based on the median pH and EC values, the coal reject samples tested are generally regarded as having ‘high’ soil pH and ‘medium’ salinity values with respect to the criteria for mining waste materials as defined by the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME 1995).

The total sulphur content (measure as total sulphur concentration - %S) of the samples ranges from 0.23-4.20 %S with a median value of 1.03 %S. This compares to a median crustal abundance value of 0.07 %S in unmineralised soils (Bowen 1979; INAP 2009). Materials with a total sulphur content less than or equal to 0.1 %S have negligible capacity to generate acidity. The reject samples used in the kinetic leach column (KLC) tests retained at least about 95.6% of their inherent total sulphur content after three months of exposure to idealised oxidising conditions. This reflects a relatively slow rate of sulfide oxidation (and potential acid generation) for these materials.

The results of the multi-element analysis were assessed against the geochemical abundance index in accordance with relevant guidelines and practices (Bowen 1979; INAP 2009). The geochemical abundance index results indicate that of the metals/metalloids measured, none are significantly enriched compared to median crustal abundance. The main findings of the coal reject geochemical assessment (RGS 2020) (Appendix H) are:

- the coal reject samples represent materials with a variety of geochemical characteristics ranging from non-acid forming (NAF) to PAF. As a bulk material, coal reject is expected to be NAF with excess acid neutralising capacity. Overall, most coal reject materials have a relatively low risk of acid generation and an increased factor of safety with respect to potential for AMD;

- initial and ongoing surface runoff and seepage from coal reject materials is expected to be pH neutral and have a moderate level of salinity. The salinity of leachate from higher sulphur coal reject materials could increase over time if exposed to atmospheric conditions, due to the release of sulphate through sulphide oxidation;

- comparison with guideline values and median crustal abundance in unmineralised soils indicates that the coal reject materials are not significantly enriched with metals/metalloids; and

- most metals/metalloids are sparingly soluble at the current pH of the leachate from coal reject materials. Dissolved metal/metalloid concentrations in surface runoff and leachate from bulk coal reject materials are expected to be relatively low and unlikely to pose a significant risk to the quality of surface and groundwater resources at relevant storage facilities.

13.3.2 Waste Rock Geochemistry

A total of 70 waste samples were collected from three drill holes within the Project area; representative of the main overburden, interburden and potential coal reject materials likely to be encountered during development of the Project. Samples were collected from the surface down through the stratigraphic profile (including economic and uneconomic coal seams) to the base of the open pit. The number of samples was selected to provide a good statistical representation of the amount and types of mining waste materials expected to be generated at the Project.

The $pH_{(1:5)}$ of samples across all sample types, ranged from 5.0 to 9.7 with a median value of 9.2. The samples with the lowest pH values (pH 5.0 to 5.5) represent clay and soil materials.

$EC_{(1:5)}$ ranges from 270 to 1,440 µS/cm with a median of 646 µS/cm, considered to be moderate. The weathered material tends to have a higher EC value than the fresh material.

Total sulphur content ranges from less than 0.01-0.60 %S (median 0.06 %S). Compared to the median crustal abundance of sulphur (0.07%) (INAP 2009), the median value of the mining waste materials is relatively low. The sulphur content of carbonaceous siltstone and coal are both higher than natural background values and both lithologies show greater variation in sulphur content than the weathered material, sandstone and siltstone.

The results of the multi-element analysis were assessed against the geochemical abundance index in accordance with relevant guidelines and practices (Bowen 1979; INAP 2009). The geochemical abundance index results indicate that, compared to median crustal abundance, only one of the 10 selected samples was enriched and then only with respect to cobalt. It should be noted that the nature of a coal deposit means some metals/metalloids are expected to be slightly elevated in various minerals.

Sample analysis indicated that the CEC of the materials varies between 4.2-18 meq/100g with a mean value of 10 meq/100g. The resulting effective CEC rating for the materials is from very low to moderate.

The ESP of the 10 selected samples ranged from low (4.5%) to very high (31.5%) with a median of 19.3%, indicating that some of the sample materials are likely to be sodic.

The findings of the geochemical assessment of waste rock samples (RGS 2019) (Appendix G) can be summarised as follows:

- all of the mining waste samples tested are NAF, have excess acid neutralising capacity and typically have low sulphur content. The sulphur content of coal and carbonaceous siltstone can be elevated compared to typical background concentrations, but is mainly present in a non-

sulfidic form, which does not contribute to acid generation. Overall, these materials have a low risk of acid generation and a high factor of safety with respect to potential for AMD;

- initial and ongoing surface runoff and seepage from mining waste materials is expected to be moderately alkaline and have a moderate level of salinity;
- KLC test results indicate that mining waste materials are unlikely to generate acid conditions and more likely to generate pH neutral to alkaline conditions;
- metal/metalloid enrichment in mining wastes, compared to median crustal abundance in unmineralised soils, is limited to cobalt in a single carbonaceous siltstone sample;
- most metals/metalloids are sparingly soluble at the neutral to alkaline pH of leachate expected from bulk mining waste materials. Dissolved metal/metalloid concentrations in surface runoff and leachate from bulk mining waste materials are therefore expected to be low and unlikely to pose a significant risk to the quality of surface and groundwater resources at relevant storage facilities;
- mining waste materials should be amenable to revegetation as part of rehabilitation activities, although, gypsum and fertiliser will be used as necessary for sodic materials to limit dispersion and erosion and to provide a reasonable growth medium for revegetation and rehabilitation; and
- as most mining materials appear to be susceptible to dispersion and erosion, additional testing including field trials, may be needed when the mine is operational and bulk materials are being generated. Such tests would help to determine the most appropriate management option for progressive rehabilitation of these materials during operations at mine closure.

13.3.3 Potential Impacts on Surface and Groundwater Resources

The potential impacts which may arise as a result of adverse mineral waste characteristics are primarily related to acid and saline leachate production and landform stability. With respect to acid and saline leachate potential, the majority of both the coal reject and waste rock material to be produced is classified as NAF, with excess acid neutralising capacity, and essentially devoid of sulphur. These materials have a very low risk of acid generation and a high factor of safety with respect to potential acid generation in leachate from waste dumps and storage facilities.

The static and kinetic geochemical test results indicate that surface runoff and seepage from both coal reject and waste rock materials is likely to be pH neutral and have a moderate salinity value. The pH of surface runoff and seepage from these materials is likely to fall within the range for 95% species protection in freshwater aquatic ecosystems as set out in ANZG (2018).

The major ion concentrations in surface runoff and seepage from both coal reject and the leachate from NAF mining materials are relatively low. The major ions from coal reject are dominated by calcium, magnesium, sodium, sulphate, chloride (and bicarbonate), and the leachate from NAF mining waste materials are dominated by bicarbonate, sodium, chloride and to a lesser extent sulphate. The sulphate concentration in leachate from all mining waste samples tested is well below the applied ANZG (2018) livestock water quality guideline criterion (1,000 mg/L).

The concentration of most trace metals/metalloids tested for water in contact with both coal reject and mining waste materials is low, typically below the LOR for the laboratory analysis, and below the applied water quality guideline criteria. KLC tests exhibit a LOR of below applied water quality guideline criteria. As a result, for these course reject dissolved metal concentrations of Se, Zn, Cr, Cu and Cd exceeded the trigger values for freshwater aquatic ecosystems (95 % species protection). Additionally, Se

exceeded trigger values for livestock drinking water guideline values. Similar results were observed for fine reject dissolved concentrations.

Whilst there are no specific regulatory criteria for metal/metalloid concentrations in leachate from mining waste material on mine sites in Queensland. The Australian guideline values for livestock drinking water and aquatic freshwater eco-systems are provided for context are not intended to be interpreted as "maximum permissible levels" for site water storage or discharge" (ANZG 2018).

These trace metals/metalloids are sparingly soluble at the expected pH of coal reject materials. All of the metals/metalloid concentrations are less than the applied livestock drinking water guideline trigger values.

For water in contact with mining waste materials, the static water extract results for a few samples. suggest that the concentrations of arsenic and selenium can be above applied aquatic freshwater ecosystem water quality guideline concentrations for 95 % species protection (ANZG 2018). However, the concentration of these metals/metalloids in surface runoff and seepage from bulk mining waste materials is likely to be much lower and within the applied guideline concentrations described. Whilst one carbonaceous siltstone water extract sample had a selenium concentration marginally above the applied livestock drinking water guideline value, all other water extract samples displayed trace metal/metalloid concentrations at or below the applied livestock drinking water guideline values.

Overall, the static geochemical test results indicate that dissolved metal/metalloid concentrations in initial surface runoff and seepage from coal reject materials are unlikely to significantly impact upon the quality of surface and groundwater resources. However, some coal reject materials, if left exposed to oxidising conditions, may have the potential to generate brackish leachate containing elevated concentrations of sulphate and some metals/metalloids, in comparison to applied water quality guideline values. Therefore, coal reject materials should be encapsulated within spoil storage areas, well away from the outside surface of the final rehabilitated landforms. If coal reject materials are left exposed to oxidising conditions for an extended period of time prior to encapsulation, dosing with agricultural limestone (e.g., fine limestone) could be considered as a contingency measure.

In addition, the results of the CEC and ESP tests on the selected mining waste samples indicate that most of the materials represented by these samples are likely to have elevated sodicity levels and may be susceptible to dispersion and erosion, although these characteristics may be improved to some extent by the addition of gypsum. In addition, fertiliser addition will need to be considered for some mining waste materials to provide a reasonable growth medium for revegetation and rehabilitation.

The management strategies discussed in Section 13.4, will ensure the risk of impact to waters remains low throughout the life of the Project, and will provide for water monitoring activities appropriate to assess any potential adverse effects.

13.3.4 Spontaneous Coal Combustion Potential

The geochemical properties of the Gemini coal deposit are considered high rank for the Project and therefore of lower propensity for spontaneous combustion. Intrinsic factors such the presence of pyrite, moisture, mineral matter, and particle size are known to influence the risk of combustion (Kaymakci, E and Didari 2002). The presence of pyrite within the coal reject materials can generally increase the risks, however the identified qualities within both geochemical assessments (Appendix G; Appendix H) are noted to be relatively low risk of acid generation and below 0.1% (nonsulfide sulfur (ie., non-acid generating). Further to this, the moderate content of ash known to occur in the Rangal measures negatively correlates with the propensity for coal to self-heat and lowers risk based on coal quality (Beamish and Blazak 2005).

The potential for spontaneous combustion of stockpiles is driven by the oxidation of coal and other carbonaceous materials. The reactivity of material contained within spoil dumps is known to vary considerably and therefore assessing combustion risk is often based on external factors (temperature, oxygen concentration, barometric pressure, ventilation, and surrounding strata). Most strategies for control and prevention of spontaneous combustion focus on removing oxygen, or rather, preventing its access to the reactive material.

If not managed, spontaneous combustion in open-cut coal mines poses a number of potentially serious impacts on the receiving environment, of which include:

- toxic emissions such as particulates and trace elements, carbon monoxide, sulfur dioxide, hydrogen sulfide, polynuclear aromatic hydrocarbons and volatile organic compounds;
- greenhouse gas emissions of CO_2 and CH_4;
- destabilisation of spoil piles and long-term problems with rehabilitation; and
- damage of the nearby ecosystems, vegetation loss, windblown dust, and pollution of surface and ground water.

13.4 MITIGATION MEASURES, MANAGEMENT AND MONITORING

13.4.1 Coal Reject Materials

As a result of the geochemical assessment work completed on coal reject materials (RGS 2020) (Appendix H) at the Project, the following management strategies are proposed for all coal reject material to minimise the risk of any significant environmental harm to the immediate and downstream environment:

- operational sampling and geochemical testing of representative samples of all coal reject material (coarse rejects and tailings) will be strategically undertaken at the CHPP to verify and extend the findings of the assessment for management;
- coal reject materials will be transferred from the CHPP and encapsulated within a much larger volume of NAF overburden material in spoil emplacements with excess neutralising capacity well away from the outside surface of the final rehabilitated landforms.
- coal reject material will be placed where there is a lower risk of connectivity to surface water or groundwater resources;
- if coal reject materials are left exposed to oxidising conditions for an extended period of time prior to encapsulation, dosing with agricultural limestone would be considered as a contingency measure; and
- surface water and seepage from the coal reject storage areas will be monitored to ensure that key water quality parameters remain within appropriate criteria.

13.4.2 Mining Waste Materials

As a result of the geochemical assessment work completed on mining waste materials (RGS 2019) (Appendix G) at the Project, a number of management strategies are proposed for these materials to minimise the risk of any significant environmental harm to the immediate and downstream environment.

- placement of any carbonaceous mining waste material encountered during mining at the surface and outer batters of waste rock emplacement areas will be avoided;

- additional overburden/interburden testing and rehabilitation field trials will be completed during operations when bulk materials become available on an as needed basis to confirm the most appropriate management option for progressive rehabilitation of these materials during operations and at mine closure; and

- surface water and seepage from the proposed mining and mining waste storage areas will be monitored to ensure that key water quality parameters remain within appropriate criteria. Water quality monitoring parameters will include pH, EC and total suspended solids on a quarterly basis and the suite of water quality analyses described in Appendix G (refer to Table B4 – Multi-element test results for water extracts from mining waste from the Project).

13.4.3 Spontaneous Combustion

The following prevention and control measures will be adopted to maintain a low risk of spontaneous combustion:

- dispersal and burying of reactive materials within the spoil;

- controlling ventilation through compaction and capping;

- design of spoil dumps to minimize erosion & cracking of capping material avoiding the risk of air ingress;

- firefighting equipment readily available at appropriate locations;

- regular inspections and maintenance of firefighting equipment; and

- operator training.

Magnetic South will develop a *Spontaneous Combustion Management Plan* to ensure long-term management is maintained to:

- identify the source, quantity and timing of potentially reactive carbonaceous material that will be stockpiled;

- identify the main inert materials within the spoil;

- identify availability of local capping material (clays); and

- on-going gas and temperature monitoring around spoil piles.

13.4.4 Waste Rock Emplacement Rehabilitation

Progressive rehabilitation of all waste rock emplacements will be carried out when final placement has been attained and areas are no longer required for mining operations. The geochemical assessment (Appendix G) and soil and land suitability assessment (Appendix I) identified no significant risks for rehabilitation and waste rock materials were considered suitable.

As areas progressively become available, they will be classified as ‘available for rehabilitation’ (illustrated in Figure 23). The sequence of rehabilitation activities as described in section 4.0 will then commence, staring behind Pit AB and progress systematically north-east (Figure 23 – Figure 32). Three

waste rock emplacements (one temporary) will be progressively constructed throughout the course of the operations and be designed to have externally draining slopes of a maximum of 6°, elevation 175-190 mAHD and slope length 530 m – 540 m. The design of waste rock emplacements is detailed in Table 18.

Overburden placement will be undertaken using rear dump trucks in accordance with mine planning schedules. Standard mine survey controls will be utilised to ensure that disturbance footprints are not exceeded and that design slopes will be attained. Regrading to final landform will be undertaken using bulldozers to push to grade utilising standard survey controls. Final trimming of reshaped areas will be undertaken as required to remove excess rock and ensure correct graded bank slopes.

Where highly sodic and/or dispersive spoil are identified, this material would not be placed in final landform surfaces and would not be used in construction activities. As described in section 5, subsoils of the Geoffrey and Kosh SMUs are considered strongly sodic (ESP > 14%). Furthermore, physical assessment of soils within the Project area reveal the medium to medium-heavy clay texture (>45% clay) of subsoils of the Geoffrey and Kosh SMU. Clay rich soils may be more susceptible to erosion due to the small size (<0.002 mm) of clay-sized particles, particularly if soils are dispersive. However, the topsoil layers are not considered sodic. Stripping depths have accounted for this and have been determined to exclude any sodic subsoil material from the topsoil resource.

Coal reject materials and any potentially acid forming waste rock materials identified will be selectively handled and encapsulated within waste rock emplacements and well away from the outside surface of rehabilitated landforms, where there is a low risk of connectivity to surface water or groundwater resources.

Surface drainage will be managed using graded banks and rock-protected spine drains to allow drainage from long rehabilitated slopes to be conveyed to natural ground level. Ongoing monitoring of climate, geotechnical properties of materials, revegetation progress and surface water runoff quality throughout all rehabilitation phases will provide systematic feedback for assessment of the rehabilitation measures to be used.

Topsoil resources have been characterised as suitable for rehabilitation and sufficient material will be available to ensure the recommended respreading depth of 0.3m. A growth medium 0.3m will provide sufficient depth to hold water and support revegetation. Topsoil will be deep ripped into the underlying spoil surface, to encourage surface water infiltration and minimise soil loss due to erosion. Seeding will typically be scheduled to occur prior to wet season to maximise the benefits of subsequent rainfall.

On-going rehabilitation maintenance and monitoring including earthworks repairs, re-seeding supplementary tube-stock planting, fertiliser application and drainage repairs will occur, as necessary.

Low intensity grazing has been determined the preferred PMLU for waste rock emplacements. This PMLU has been determined on the basis of pre-mining land suitability, landholder/stakeholder preferences, the existing land use and EVs of the surrounding landscape. Other rehabilitation management options such as dryland cropping, improved pastures and native pastures were considered, however on the basis of economic value, deemed unsuitable due to limited soil nutrient deficiencies, soil water availability, soil wetness, erosion and surface condition. A conceptual layout for the PMLU is illustrated in Figure 36.

A progressive rehabilitation schedule, including the rehabilitation of waste rock emplacements is provided within schedule calculations (Section 4.6).

13.4.5 Erosion and Sediment Run-Off

Erosion and sediment from waste rock dumps will be managed in accordance with an ESCP that has been designed for the Project by a suitably qualified person. The plan has been designed to address the construction, operational and rehabilitation/closure phases of the Project to prevent adverse impacts from waste rock dumps to nearby local environmental values (i.e., Charlevue Creek and Springton Creek). Management measures to address the risks associated with waste rock dumps will include the following:

- limit land clearing to the minimum required for safe operations of the Project;
- retention of riparian vegetation where possible along Charlevue Creek and Springton Creek;
- diversion of clean overland flow/runoff from the upper reaches of Springton Creek and Charlevue Creek around the out-of-pit waste rock emplacement associated with Pit C and Pit AB;
- rapid revegetation of disturbed areas and hydromulching of areas subject to short term exposure;
- waste rock emplacements have been designed to a slope of 1V:10H (adhering to a maximum slope of 6°) and a maximum height of 190 mAHD;
- installation of sediment entrapment devices and infrastructure between receiving waters and disturbed areas, including:
    - silt fences, coir logs, hay bales or other flow reduction devices;
    - pit protection levees & diversion channels;
    - sediment traps and dams;
    - cleaning protocols of sediment drains and entrapment devices; and
    - traffic control measures and haul route bunding.
- flood protection levee and clean water drains to minimise flood water interaction with waste rock emplacements.

Erosion and sediment control structures will be designed and installed in accordance with *Best Practice Erosion and Sediment Control* (IECA Australasia 2008) and *Soil Erosion and Sediment Control: Engineering Guidelines for Queensland Construction Sites* (Witheridge & Walker 1996), as appropriate.

As described in Section 13.4.2, surface water and seepage from mining waste storage areas will be monitored to ensure that key water quality parameters remain within the appropriate criteria. Sediment and water quality monitoring will be undertaken in accordance with a REMP to ensure the effectiveness of employed control measures, including the enforcement of sediment quality trigger values (refer to Section 7.4.4.1).

13.4.6 Monitoring Program

Environmental monitoring to identify and assess any impacts arising from seepage or contamination associated with the geochemistry of waste rock and coal rejects will comprise the following components:

- Ongoing groundwater monitoring to verify baseline groundwater information. It should be noted that groundwater data collected to date has indicated high EC groundwater associated with all groundwater units (refer to Section 8.0).

- Ongoing surface water monitoring will be undertaken principally to validate water management system performance against the design assumptions, both in terms of water quality and water quantity, so that adaptive management decisions can be undertaken where necessary to protect the surface water environment. Surface runoff and seepage water collection in the mine water dams and process water dam will be monitored for standard water quality parameters including, but not limited to pH, EC, major anions (sulphate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS and a broad suite of soluble metals/metalloids.

- Validation test work will be undertaken on potential spoil materials as the Project develops to enable appropriate spoil management measures to be planned and implemented as required. Where highly sodic and/or dispersive spoil is identified, this material would not be placed in final landform surfaces and would not be used in construction activities. Regardless of the spoil type, especially where engineering or geotechnical stability is required, testing would be undertaken during construction to determine the propensity of such materials to erode. Surface runoff and seepage from spoil piles, including any rehabilitated areas, would be monitored for 'standard' water quality parameters including, but not limited to, pH, EC, major anions (sulphate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS and a broad suite of soluble metals/metalloids.

- A REMP will also be developed and implemented in accordance with the *Model Mining Conditions* (DES 2017e). The REMP would be implemented to monitor, identify and describe any adverse impacts to surface water EVs, quality and flows due to the authorised mining activity. Water quality monitoring will be undertaken upstream and downstream of the Project to detect downstream water quality impacts and to demonstrate compliance with the EA release conditions. Further details of the REMP are provided in Section 7.4.4.1, including the location of proposed receiving water monitoring points (Table 45).

14.0 RISK ASESSMENT

14.1 RISK ASSESSMENT REQUIREMENTS

A preliminary risk assessment has been undertaken for the Project, to address the potential or actual impacts on environmental values during the construction, operation, decommissioning and rehabilitation stages.

The risk assessment has been carried out in accordance with the following objectives to identify and address associated Project risks, these include:

- the likelihood of an impact occurring;
- the management/mitigation measures proposed;
- the consequence of the managed impact;
- potential levels of residual impacts on environmental and community values; and
- the cumulative impacts on environmental values.

The risk assessment was carried out in accordance with *AS ISO 31000:2018 Risk management – guidelines.* The corresponding management of environmental risk was informed by both expert opinion and the Project specific technical studies detailed within this EA application.

14.2 RISK IDENTIFICATION

For this assessment, a risk assessment was undertaken by a panel of environmental consultants. In accordance with *Section 6.4.2 of AS ISO 31000:2018,* hazards and risks were considered from three different perspectives (environmental impact, impacted receptors and introduced/exacerbated hazards).

The cohort of risks, segregated by each perspective, can be summarised as:

- environmental impact -
    - land impacts (e.g., loss of land resources and constraints on future land use);
    - noise and air blast related impacts;
    - visual impacts (e.g., landscape and lighting);
    - surface water (e.g., hydrology and water quality);
    - groundwater (e.g., geohydrology and groundwater quality);
    - air quality (e.g., dust and other contaminants);
    - occupational health and safety impacts (e.g., impacts on personnel);
    - impacts arising from pests and diseases (either exacerbated or introduced by the Project);
    - socio-economic impacts; and

  - exacerbation of impacts from natural events (e.g., fire, flood, cyclone/ extreme weather, landslide, climate change);

- impacted receptor -
  - impacts on important environmental receptors (e.g., identified MSES, nature refuges, national parks); and
  - impacts on local, regional and state residents;
- introduced or exacerbated hazard -
  - workplace occupational and health risks and hazards;
  - mining-related hazards including:
    - heavy earthmoving equipment;
    - light vehicles;
    - hazardous materials and dangerous goods; and
    - geochemical and geotechnical hazards (e.g., waste rock materials, carbonaceous materials, waste rock dumps and final void).

The identified set of risks and hazards were transferred to a risk assessment template designed for the specific purpose of assessing environmental risks, identifying associated causes, potential impacts and the expected base level of controls.

14.3 RISK ASSESSMENT PROCESS

Any risk assessment needs to be undertaken in consideration of the scope, context and criteria relevant to the assessment. For this risk assessment, the following scope and purpose was discussed and agreed to:

- The purpose of this risk assessment is to identify and analyse any risks arising because of the Project that may impact on environmental aspects, including socioeconomic aspects; at the local, regional and state levels and across the construction, operational and closure stages of the Project.

Several important assumptions and/or criteria have also been identified, including:

- Occupational Health and Safety hazards are assumed to be assessed and managed at an operational level in accordance with legislated requirements and contemporary mining industry practice.
- The risk assessment is a preliminary and high-level assessment set at the overall project level. Therefore, while some risk scenarios may be viewed as being generic, the assessment process interrogates the risk scenarios sufficiently to focus on project and site-specific aspects in assessing hazards and risks.
- Risks are assessed on the basis that expected, contemporary operational controls will be in place on the assumption that the proponent's view of legal and constructive obligations,

statutory controls and management systems are in line with current industry standards and expectations.

The risk assessment was undertaken to analyse and evaluate the risks and hazards identified with the following process steps established:

- The basis and purpose of the risk identification was agreed on, as well as the process used to develop the risk scenarios, causes and impacts proposed in the risk assessment template.
- The risk assessment scheme, including the consequence descriptors for each consequence type, the likelihood classifications and the control effectiveness rankings were evaluated and agreed on.
- Each of the identified risk scenarios or descriptions was then considered in turn. In most cases, one or more of the 'risk/hazard title', 'causes' and 'impacts' proposed were refined as a result.
- The likelihood of each risk/hazard, subject to the expected control level, was then considered and a ranking was provided in accordance with the consensus view.
- The consequence category for the relevant impact or impacts was similarly assessed and ranked.
- The risk class was then determined based on the risk matrix (Table 72).
- For risks and hazards determined as being of Class III and IV, additional control measures were discussed and assessed and, where effective and appropriate, proposed.

A summary of the complete risk assessment outcomes is provided at Table 74.

14.3.1 Risk Assessment Scheme

The risk assessment scheme used is representative of risk schemes used widely within the mining industry. For this risk assessment, the scheme comprised the following components:

- a likelihood classification table (Table 70);
- a severity and consequence classification table (Table 71); and

Table 70 Likelihood of Exposure

Likelihood	Description	Frequency	Probability
Almost certain	The event will occur often.	More than once a year	> 95%
Likely	The event could easily happen.	At least once in 1 year	60%–95%
Possible	The event could happen and has happened elsewhere.	At least once in 3 years	30%–60%
Unlikely	The event has not happened but could.	At least once in 10 years	5%–30%
Rare	Conceivable but only in extreme circumstances.	Less than once in 30 years	< 5%

Table 71 Severity and Consequence Classification

Severity level	Consequence		
	Human Health and Safety	Natural Environment	Community/ Cultural Heritage
Catastrophic	Multiple fatalities, significant irreversible impairment to multiple persons	Very serious, long-term environmental impairment of ecosystem functions	N/A
Major	Single fatality, significant irreversible impairment to a person	Very serious, long-term environmental impairment of ecosystem functions	Ongoing serious social issues. Significant damage to structures/items of cultural significance
Moderate	Significant reversible impairment to one or more persons (lost time injury, disabling injury)	Serious medium-term environmental effects	Ongoing serious social issues. Significant damage to structures/items of cultural significance
Minor	Reversible impairment requiring medical treatment (medical treatment injury)	Moderate, short-term effects but not affecting ecosystem functions	Ongoing social issues. Permanent damage to items of cultural significance
Insignificant	No treatment or first aid treatment	Negligible/minor effects on biological or physical environment	Minor medium-term social impacts on local population. Mostly repairable

Following the hazard identification, and assessment of likelihood and consequence criteria, the risk level was determined using Table 72, which then defines the assessed risk level. Table 73 describes the appropriate level of action required for each assessed risk level.

Table 72 Risk Level Matrix

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	II	III	III	IV	IV
Likely	II	II	III	III	IV
Possible	I	II	III	III	III
Unlikely	I	I	II	II	III
Rare	I	I	II	II	III

Table 73 Risk Level Actions

Risk Level Actions	
Very High Risk	Board and/or board level committee attention required; action plans and management responsibility specified.
High Risk	Senior executive management attention required; action plans and management responsibility specified.
Medium Risk	Manage by specific monitoring or response procedures, with management responsibility specified.
Low Risk	Manage by routine procedures, unlikely to need specific application of resources.

14.4 RISK ASSESSMENT OUTCOMES

In total, 47 risks and/or hazards were identified and assessed. There are a number of risks identified where the risk or hazard impacts on more than one environmental aspect or category, resulting in 68 discrete risk assessments in total. Unnecessary duplication was avoided by only including a duplicate scenario where it was felt that there was a legitimate reason to assess both risk scenarios by virtue of either a significantly different environmental impact outcome or, for a high ranked risk, where significantly different mitigation measures might be required. The risk profile for the Project and the risk profile by consequence area are illustrated at Figure 86 and Figure 87 respectively, and the summary of identified risks and mitigation measures is presented in Table 74.

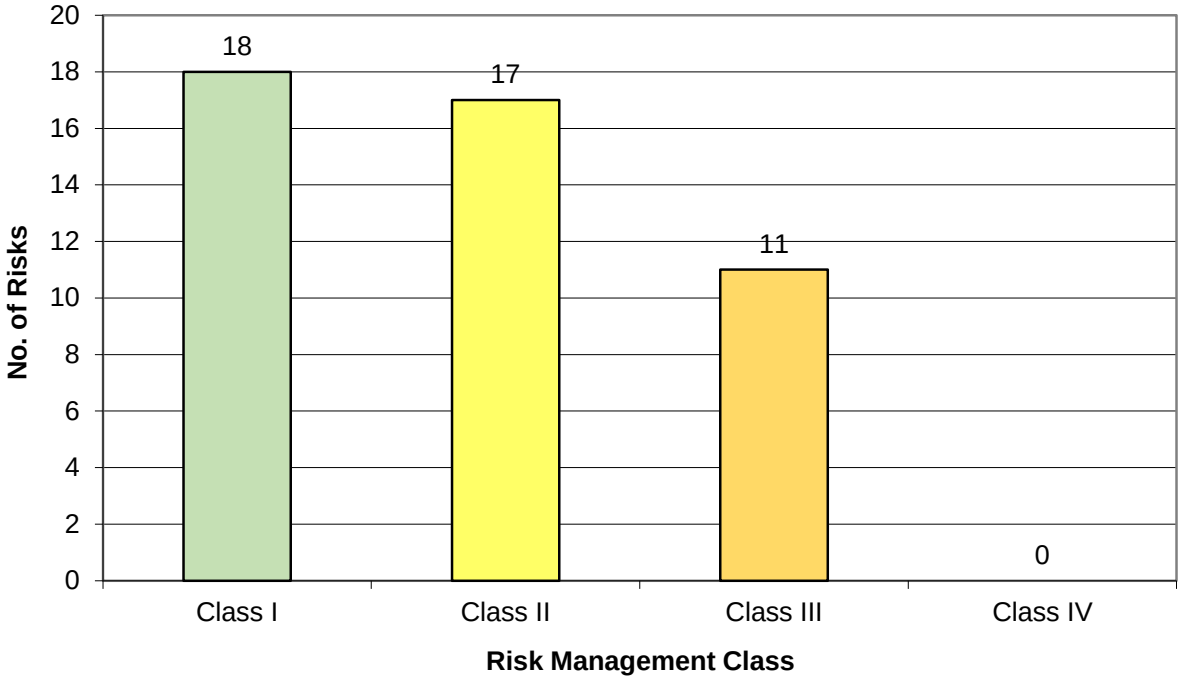


Figure 86 Risk Profile

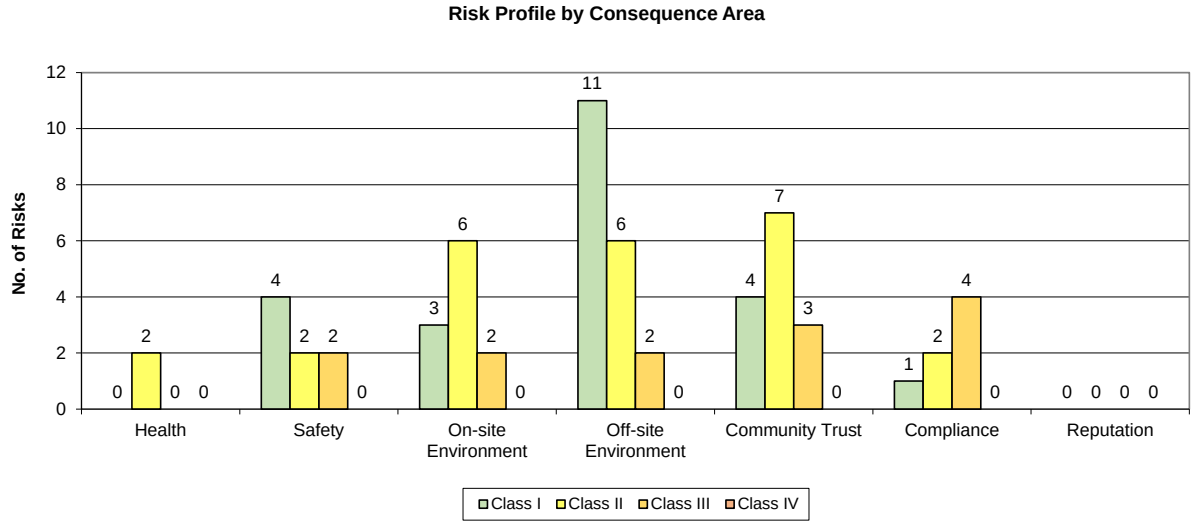


Figure 87 Risk Profile by Consequence Area

14.5 RISK MITIGATION

The following processes and measures will be implemented in addition to expected and standard controls to reduce the risk of impacts on health, safety and the environment associated with the Project:

- Fatigue management/fitness for work, alcohol and drug testing and road safety awareness training to manage the increased risk of motor vehicle incidents.
- Occupational health and safety performance to be closely monitored and assessed and, where required, individual issue specific risk assessments to be undertaken to identify fit-for-purpose safety initiatives.
- Long term monitoring of noise and dust impacts at sensitive receptors.
- Active management of equipment locations and operating hours if required to reduce the likelihood of noise and air quality impacts on sensitive receptors.
- Geochemical characterisation of topsoils and waste rock materials and amelioration measures as appropriate to manage impacts to the environment (downstream watercourses) from erosion of rehabilitated areas.
- Cultural heritage surveys to be undertaken prior to site clearing, and implementation of procedures for the management of any identified cultural heritage values or artefacts.

Table 74 Summary of Identified Risks and Mitigation Measures

Risk Description				Risk Evaluation										Risk Ranking								Risk Management	
Risk /Hazard Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Expected/Standard Controls	Likelihood / Probability	Greenhouse	Health	Safety	Environment On-site	Environment Off-site	Community Trust	Compliance	Stakeholders	Cultural Heritage	Greenhouse	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	Cultural Heritage	Risk Management Class	Additional Risk Mitigation
Amenity																								
Amenity of local residents																								
Increased risk of motor vehicle incidents	Increase light and heavy vehicle movements associated with the Project	Ranges from inconvenience to fatality	Road access design (subject to regulatory controls) and public road controls	R			H									III							III	Fatigue management/fitness for work, alcohol and drug testing, road safety awareness training
Impacts to local farmers	Construction phase specific Impeding access to properties	Inconvenience	Road access design (subject to regulatory controls)	p						L									II				II	
Increased rail movements	Increase in production	Annoyance, amenity	Restricted TLO operating hours to reduce noise impacts	p						L	M								II	III			III	
Increased heavy vehicle movements	Operational phase only	Impacts limited largely to north of site at intersection with Capricorn Hwy	Road access design (subject to regulatory controls) and public road controls. Road approved for required capacity.	L						L									III				III	
Increased activism associated with coal mining impacts on environmental values	Existence of operation	Inconvenience, worker safety	Media monitoring, community/ stakeholder engagement program	P		L				L					II				II					
Bushfire																								
Impacts to surrounding properties and existing mine rehabilitation	Project-related activities Surrounding land management activities Natural causes	Destruction to surrounding properties, operational cost and rehabilitation failure	Distance from source, firebreaks, ERT with fire-fighting capacity	R			M			M						II			II				II	
Flood																								
Detrimental flooding impacts within Project area	Altered flood regimes due to project	Flooding of project operations and infrasructure	Site Water Management System design to minimise flooding to operations Levee and clean water dams to contain and redirect flows	R				L				VL					I				I		I	REMP, groundwater and surface water monitoring, water management plan, progressive rehabilitation to limit disturbance, flood protection levee surveillance, communications/ consultation with stakeholders
Detrimental flooding impacts to neighbouring residents	Altered flood regimes due to project	Flood depth afflux, velocity, inundation 1% to 10% AEP range	Flood study indicates negligible increase to the extent of inundation up to 0.1% AEP, and duration increases up to 48 hours	R					L			L						I			I		I	REMP, groundwater and surface water monitoring, water management plan, progressive rehabilitation to limit disturbance, flood protection levee surveillance, communications/ consultation with stakeholders
Detrimental flooding impacts to neighbouring residents	Project location and extents (floodplain extents defined by levee location)	Stream power and shear stress	Modelling indicates minimal increase in flow velocities	R					L		L							I		I			I	
Flooding impacts to Dingo township	Project location and extents (floodplain extents defined by levee location)	Increase in flood inundation duration and extent	Modelling shows no significant change at Dingo township	R			VL		VL			VL				I		I			I		I	
Flooding impacts to mine / final void	Project location and extents (floodplain extents defined by levee location)	Pit/ final void flooding, loss of access, property damage	Levee and final landforms designed to provide flood protection to 0.1% AEP and PMF event	R				H									III						III	Effective rehabilitation and final landform design. Ongoing maintenance of water management infrastructure. Business Continuity Plan

Risk Description				Risk Evaluation										Risk Ranking								Risk Management	
Risk /Hazard Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Expected/Standard Controls	Likelihood / Probability	Greenhouse	Health	Safety	Environment On-site	Environment Off-site	Community Trust	Compliance	Stakeholders	Cultural Heritage	Greenhouse	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	Cultural Heritage	Risk Management Class	Additional Risk Mitigation
Hazards																							
OHS																							
OHS consequences	Construction, mining and industrial activities	Health, safety, operational cost	Staff awareness and training, safety management system	R		M	VH								II	III							III	OHS performance to be closely monitored and assessed and, where required individual, issue-specific risk assessments to be undertaken to identify fit-for purpose safety initiatives
Hazardous chemicals																							
Impacts on emergency services	Significant incident involving major hazardous facility	Health, safety, operational cost	Emergency Response Plan, staff awareness and training	U			L			VL						I			I				I	
Physical Environment																							
Noise																							
Noise impacts to sensitive receptors (residents)	Noise emissions from plant, equipment and processes, road haulage	Annoyance, amenity, harm to wildlife	Distance from source, positioning of equipment for evening shift, attenuation packages for equipment, construction of noise bunds	L						L	L								III	III			III	Implementation of Noise Management Plan Noie Monitoring Management of equipment locations and operating hours
Air quality																							
Dust impacts to sensitive receptors	Equipment, processes and vehicle movements on unsealed roads, and increased bare areas (waste rock dumps, TSF)	Annoyance, amenity (sensitive receptors), harm to wildlife, crop impact, contamination of water tanks	Distance from source, routine haul road watering, progressive rehabilitation, speed limits	L						L	L								III	III			III	Implementation of Air Quality Management Plan Dust Monitoring Management of equipment locations and operating hours
Impacts to air quality (bushfire) - see 'Bushfire'	Project-related activities	Health, safety, amenity, harm to wildlife, annoyance	Onsite containment and control measures, staff training	R						M										II			II	
Visual amenity																							
Visual impact to sensitive receptors	Changed landforms and prominent plant and equipment	Annoyance, amenity	Progressive revegetation of waste rock dumps, visual impact assessment	U						VL									I				I	

Risk Description				Risk Evaluation											Risk Ranking										Risk Management
Risk /Hazard Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Expected/Standard Controls	Likelihood / Probability	Greenhouse	Health	Safety	Environment On-site	Environment Off-site	Community Trust	Compliance	Stakeholders	Cultural Heritage		Greenhouse	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	Cultural Heritage	Risk Management Class	Additional Risk Mitigation
Land																									
Impacts to the environment arising from geotechnical instability	Blasting, wet weather, or a combination of both	Health, safety, rehabilitation landform failure and rehabiliation scheduling delays	Geotechnical advice on levee, landforms, low-walls and high-walls	R				M										II						II	Engineering and blasting design to consider geotechnical stability
Impacts to the environment (downstream watercourses) from erosion of rehabilitated areas	Dispersive soil characteristics, rehabilitated landform (slope, surface preparation, revegetation success, climate)	Downstream water quality, operational cost, compliance	Rehabilitation practices, ESC practices	P					M		L								III		II			III	Geochemical characteriation of topsoils and amelioration if necessary
Impacts to the environment (surface water and groundwater)	Waste rock inherent geochemical issues	Downstream water quality, flora, fauna, aquatic fauna, operational cost, compliance	Waste rock characterisations, short residence time on stockpiles, mining schedule	U					M										II					II	Waste rock characterisation program scaled to match findings and identified geochemical risk
Impacts to the environment (land contamination)	Presence of contaminants or potential for acid mine drainage from overburden	Localised land contamination and potential delay in rehabilitation remediation works	Decontamination works, appropriate storage of hazardous chemicals and fuels, training, emergency spill procedures and registers.	R				L										I						I	
Impacts to the environment (revegetation and rehabilitation success)	Unfavourable soil characteristics, climate, inappropriate or unavailable seed mix, weeds and premature grazing	Insufficient tree canopy, poor seedling survival, unfavourable plant community species composition, erosion due to lack of vegetation cover, poor pasture productivity and diversity leading to failure in achieving PMLU	Soil ameliorants and/or fertilisers, seed requirements determined early and purchased to be maintained on site, unavailable seeds planted as tubestocks in the following wet season, weed management, fencing and vegetation monitoring	U				M										II						II	
Impacts to the environment and workforce health	Presence of carbonaceous materials (spontaneous combustion)	Air quality, safety	Appropriate storage and handling of carbonaceous materials, staff training	R			L		L								I		I					I	
Surface water																									
Impacts to local/regional surface water quality	Overtopping of mine pit/ final void	Adverse changes water quality in receiving waterways	Site Water Management System designed to contain mine affected water on site, with releases only under favourable conditions	R					M										II					II	Water management plan, REMP and water quality monitoring, flood protection levee/ landform, progressive rehabilitation to limit disturbance
Impacts to local/regional surface water quality	Catchment disturbance, release of sediment laden waters	Adverse changes to TSS, turbidity, water quality in receiving waterways, HES wetland	Provision of engineered sedimentation structures and ESC measures	U					L										I					I	ESC Plan, SWMS, REMP and water quality monitoring, progressive rehabilitation to limit disturbance
Impacts to local/regional surface water quality	Releases of mine affected water	Adverse changes to salinity, water quality in receiving waterways	Water balance, engineered water management system, licensed release conditions	U					L										I					I	Water management plan, REMP and water quality monitoring, water management system, progressive rehabilitation to limit disturbance
Impacts on surface water resources	Loss of catchment reporting to receiving waterways and wetlands	Impacts to local and regional surface water quality, aquatic ecology and other uses	Water efficiency programs, water management plan	L						VL										II				II	Water management plan, REMP and water quality monitoring, flood protection levee/ landform, progressive rehabilitation to limit disturbance

Risk Description				Risk Evaluation											Risk Ranking										Risk Management
Risk /Hazard Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Expected/Standard Controls	Likelihood / Probability	Greenhouse	Health	Safety	Environment On-site	Environment Off-site	Community Trust	Compliance	Stakeholders	Cultural Heritage	Greenhouse	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	Cultural Heritage	Risk Management Class	Additional Risk Mitigation
Groundwater																								
Impacts to groundwater quality	Seepage from MAW water storages	Contamination of groundwater	Engineered MAW water storages	U				M	M								II	II					II	Groundwater and surface water monitoring, REMP, groundwater model validation, make good agreements where required, regular site inspections and housekeeping checklists
Impacts to groundwater resources	Leakage to mine/ final void	Aquifer drawdown	Modelling indicates limited extent of impact	U					M									II					II	Groundwater and surface water monitoring, REMP, groundwater model validation, make good agreements where required
Impacts to groundwater resources	Aquifer disturbance, leakage to mine/ final void	Diminished resource for other users	Modelling indicates limited extent of impact	U					L									I					I	Groundwater and surface water monitoring, REMP, groundwater model validation, make good agreements where required
Impacts to groundwater dependent ecosystems	Aquifer disturbance, leakage to mine/ final void	Impacts to stygofauna habitat	Modelling indicates limited extent of impact	U					L									I					I	Groundwater and surface water monitoring, REMP, groundwater model validation, make good agreements where required
Impacts to groundwater/ surface water	Aquifer disturbance, leakage to mine/ final void	Diminished watercourse baseflow	Modelling indicates limited extent of impact	U					L									I					I	Groundwater and surface water monitoring, REMP, groundwater model validation
Safety																								
Increased safety risk	Steeper landforms, rougher surfaces	Safety, community trust	Relinquishment, exclusion areas and barriers	P			VL	M		L						I	III		II				III	Modify landform design and surface preparation regime to reduce risk
Increased incidence of pests	Introduction of, or creation of conditions to promote, potentially dangerous pest species	Safety	Pest management program, monitoring, raising awareness	R			M									II							II	
Socio-economic																								
Negative impacts to the local and regional economy	Equity of economic contribution	Community trust	DIDO with limited FIFO, local employment opportunities	P						VL									I				I	
Negative impacts to the local and regional economy	Changes associated with closure	Community trust	Wind-down of operations into closure	P						L									II				II	
Cultural Heritage																								
Impacts to cultural heritage values	Planned and/or unplanned disturbance	Degradation of cultural heritage values, compliance	CHMP (presence of CH has not currently been surveyed).	P									L									II	II	Cultural Heritage surveys prior to site clearance Implementation of procedures if cultural heritage values or artefacts are identified
Incident																								
Impacts to the environment (Surface water, groundwater, land contamination, flora, fauna, air quality)	Significant operational/process incident occurring on site (spill, fire, explosion)	Physical environment (soil, landforms, water source), harm to wildlife, compliance	Emergency Response Planning and Training, staff training, awareness, spill control, bunding, containment practices	U				M	H		H						II	III		III			III	Systematic implementation of identified controls
Flora																								
Impacts to flora	Land disturbance, increase in pest species	Loss of native flora outside of approved disturbance area	Land Disturbance Permit System Weed management plan (staff training, equipment/vehicle wash-downs)	P				L	L								II	II					II	
Impacts to flora from bushfire	Project-related activities	Loss of native flora	Containment and control measures, Distance from source, firebreaks, ERT with fire-fighting capacity	R					L									I					I	

Risk Description				Risk Evaluation											Risk Ranking										Risk Management
Risk /Hazard Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Expected/Standard Controls	Likelihood / Probability	Greenhouse	Health	Safety	Environment On-site	Environment Off-site	Community Trust	Compliance	Stakeholders	Cultural Heritage		Greenhouse	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	Cultural Heritage	Risk Management Class	Additional Risk Mitigation
Fauna																									
Impacts to fauna	Land disturbance, presence of introduced pests and/or disease	Fauna	Pest management program, habitat offset strategy	P					L										II					II	
Impacts to fauna from bushfire	Project-related activities	Fauna, fauna habitat	Containment and control measures, staff training	R					L										I					I	
Climate change																									
Impacts to climate change	Direct and indirect greenhouse gas emissions from the Project	Localised and regional air quality, extreme weather events (droughts, cyclones and heat waves) with subsquent rehabilitation or mine scheduling delays	Annual review program, efficient and minimal energy use, fuel efficient equipment, equipment maintenance	AC	VL										II									II	
Essential services																									
Impacts on essential services (power, telecoms, potable water)	Additional pressure from the Project	Wearing out of service infrastructure, economic (repair and maintenance)	Annual review, efficient and minimal energy use, audit and monitoring	P						VL										I				I	
Future land use																									
Loss of land resource value	Construction and operation of the Project	Loss of lands having agricultural value	Rehab and closure plan to ensure post mining land use returned to equivalent value and use as pre-mining	L								L										III		III	
Scheduled infrastructure decomissioning and removal delayed or inadequately communicated	Mine planning or changes in the market	Rehab milestones not achieved and failure to remove infrastucture for rehabilitation	Mine scheduling meetings and additonal workforce employed if anticipated that the completion of works in accordance with mine schedule is unlikely	P				L				L						II				II		II	• Infrastructure decommission schedule to be incorporated into annual mine planning. • A register of infrastructure to track which structures exist in each rehabilitation area and which have been removed.
Restrictions on possible future land uses in and around the project area	Post-closure of the Project	Land suitability	Rehabilitation practices, land use assessments, alternative post mining land uses	U				VL										I						I	

15.0 DRAFT EA CONDITIONS

The presentation of the following EA conditions is intended to assist with the process of developing appropriate EA conditions for the Project in consultation with DES. This section does not intend to replace or replicate the Notice of Decision stage of the EA application process under Chapter 5, Division 3, subdivision 2 of the EP Act.

The *Guideline (Mining): Model mining conditions [ESR/2016/1936]* (DES 2017e) provide a basis for proposing environmental protection commitments in EA application documents. The guideline allows for modification of the *Model Mining Conditions* to address the site-specific conditions and circumstances of the Project.

The conditions proposed within this section have been developed to address the anticipated impacts of the Project as described within the EA application, and to be measurable and auditable. Where alternative conditioning has been proposed, an explanatory box is provided beneath the condition. For ease of application and review, the proposed EA conditions have been structured as per the guidelines.

15.1 ENVIRONMENTALLY RELEVANT ACTIVITIES

ERAs include resource activities or specific agricultural activities, or other activities prescribed by the EP Act. Current prescribed ERAs and resource activities are defined in Schedules 2 and 3 respectively of the EP Regulation. The Project will include the resource activity of 'Mining Black Coal' as well as the ancillary activities outlined in Table 75.

Table 75 Environmentally Relevant Activities

Environmentally Relevant Activity	Description
Schedule 2 (Prescribed ERAs)	
8 (1) (c) Chemical storage	Chemical storage (the relevant activity) consists of storing more than 500 m^3 of class C1 or C2 combustible liquids under AS1940 or dangerous goods class 3. Threshold 3) Storing more than 500 m^3 of chemicals of class C1 or C2 combustible liquids under AS1940 or dangerous goods class 3 under subsection (1)(c). *Aggregate Environmental Score: 85*
31 (1) Mineral processing	Mineral processing (the relevant activity) consists of processing, in a year, a total of 1,000t or more of coke or mineral products. Threshold 2) Processing, in a year, the following quantities of mineral products, other than coke (b) more than 100,000 t. *Aggregate Environmental Score: 280*
33 (1) Crushing, milling, grinding or screening	Crushing, milling, grinding or screening (the relevant activity) consists of crushing, grinding, milling or screening more than 5,000 t of material in a year. Threshold Crushing, grinding, milling or screening more than 5,000 t of material in a year. *Aggregate Environmental Score: no score*
60 (1)(ii)(A) Waste disposal	Waste disposal (the relevant activity) consists of operating a facility for disposing of general waste and a quantity of limited regulated waste that is no more than 10% of the total amount of waste received at the facility in a year. Threshold 2) Operating a facility for disposing of, in a year, (h) more than 200,000 t. *Aggregate Environmental Score: 107*
63 (1)(b) (i) Sewage treatment	Sewage treatment (the relevant activity) consists of operating 1 or more sewage treatment works at a site that have a total daily peak design capacity of at least 21EP. Threshold 1) Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (b) more than 100 but not more than 1500 EP (i) if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme. *Aggregate Environmental Score: 27*
Schedule 3 (Resource Activity)	
13 Mining black coal	*Aggregate Environmental Score: 128*

15.2 PROPOSED CONDITIONS

Schedule A – General Conditions

General

A1 This environmental authority authorises environmental harm referred to in the conditions. Where there is no condition or this environmental authority is silent on a matter, the lack of a condition or silence does not authorise environmental harm.

A2 In carrying out the mining activity, the holder of this EA must not exceed the allowed disturbance area as detailed in **Schedule 1 – Figure A2 (Approved Plan)**.

A3 This environmental authority authorises the mining of 1.9 million tonnes per annum (Mtpa) ROM (run-of-mine) coal.

A4 The holder of this environmental authority must:

a) install all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority;

b) maintain such measures, plant and equipment in a proper and efficient condition;

c) operate such measures, plant and equipment in a proper and efficient manner; and

d) ensure all instruments and devices used for the measurement or monitoring of any parameter under any condition of this environmental authority are properly calibrated.

Monitoring and Records

A5 Except where specified otherwise in another condition of this environmental authority, all monitoring records or reports required by this environmental authority must be kept for a period of no less than five years.

A6 Where monitoring is a requirement of this environmental authority, ensure that a competent person conducts all monitoring in accordance with:

a) the most recent *Monitoring and Sampling Manual* released by the administering authority, or

b) an appropriate method described in Australian Standards (AS), or;

c) any other document approved by the administering authority.

A7 All analyses and tests required to be conducted under this environmental authority must be carried out by a laboratory that has National Association of Testing Authorities (NATA) certification for such analyses and tests, expect as otherwise authorised by the administering authority.

A8 All instruments, equipment and measuring devices used for measuring or monitoring in accordance with any condition of this authority must be:

a) appropriately and competently calibrated, operated and maintained; and

b) calibration reports must be supplied upon request to the administering authority, in accordance with Condition A19.

Estimated Rehabilitation Calculation

A9 The activity must not be carried out until the environmental authority holder has given surety or paid a contribution to the scheme fund, as required by section 297 of the Act.

Risk Management

A10 The holder of this environmental authority must develop and implement a risk management system for mining activities which mirrors the content requirement of the *Standard for Risk Management (ISO31000:2009),* or the latest edition of an Australian standard for risk management, to the extent relevant to environmental management, by 3 months from date of issue.

Notification of Emergencies, Incidents and Exceptions

A11 The holder of this environmental authority must notify the administering authority by written notification within 24 hours, after becoming aware of any emergency or incident which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with, the conditions of this environmental authority.

A12 Within 10 business days following the initial notification of an emergency or incident, or receipt of monitoring results, whichever is the latter, further written advice must be provided to the administering authority, including the following:

a) results and interpretation of any samples taken and analysed;

b) outcomes of actions taken at the time to prevent or minimise unlawful environmental harm; and

c) proposed actions to prevent a recurrence of the emergency or incident.

Complaints

A13 The holder of this environmental authority must record all environmental complaints received about the mining activities including:

a) name, address and contact number for of the complainant;

b) time and date of complaint;

c) reasons for the complaint;

d) investigations undertaken;

e) conclusions formed;

f) actions taken to resolve the complaint;

g) any abatement measures implemented; and

h) person responsible for resolving the complaint.

A14 The holder of this environmental authority must, when requested by the administering authority, undertake relevant specified monitoring within a reasonable timeframe nominated or agreed to by the administering authority to investigate any complaint of environmental harm. The results of the investigation (including an analysis and interpretation of the monitoring results) and abatement measures, where implemented, must be provided to the administering authority within 10 business days of completion of the investigation, or no later than 10 business days after the end of the timeframe nominated by the administering authority to undertake the investigation.

Third-Party Reporting

A15 The holder of this environmental authority must:

a) within one year of the commencement of this environmental authority, obtain from an appropriately qualified person a report on compliance with the conditions of this environmental authority;

b) obtain further such reports at regular intervals, not exceeding three-yearly intervals, from the completion of the report referred to above; and

c) provide each report to the administering authority within 90 days of its completion.

A16 Where a condition of this environmental authority requires compliance with a standard, policy or guideline published externally to this environmental authority and the standard is amended or changed subsequent to the issue of this environmental authority, the holder of this environmental authority must:

a) comply with the amended or changed standard, policy or guideline within two years of the amendment or change being made, unless a different period is specified in the amended standard or relevant legislation, or where the amendment or change relates specifically to regulated structures referred to in a condition, the time specified in that condition; and

b) until compliance with the amended or changed standard, policy or guideline is achieved, continue to remain in compliance with the corresponding provision that was current immediately prior to the relevant amendment or change.

Schedule B – Air

Dust and Particulate Matter Monitoring

B1 The environmental authority holder shall ensure that all reasonable and feasible avoidance and mitigation measures are employed so that the dust and particulate matter emissions generated by the mining activities do not cause exceedances of the following levels when measured at any sensitive or commercial place:

a) dust deposition of 120 milligrams per square metre per day (mg/m^2/day), averaged over one month, when monitored in accordance with the most recent version of *AS3580.10.1: Methods for sampling and analysis of ambient air - Method 10.1: Determination of particulate matter - Deposited matter - Gravimetric method*;

b) a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometres (PM_{10}) suspended in the atmosphere of 50 micrograms per cubic metre over a 24-hour averaging time, when monitored in accordance with the most recent version of either:

i) *AS3580.9.6 Methods for sampling and analysis of ambient air Part 9.6: Determination of suspended particulate matter - PM_{10} high volume sampler with size-selective inlet - Gravimetric method;* or

ii) *AS3580.9.9 Methods for sampling and analysis of ambient air Part 9.9: Determination of suspended particulate matter - PM_{10} low volume sampler - Gravimetric method.*

c) a concentration of particulate matter with an aerodynamic diameter of less than 2.5 micrometres ($PM_{2.5}$) suspended in the atmosphere of 25 micrograms per cubic metre over a 24-hour averaging time, when monitored in accordance with the most recent version of *AS3580.9.10 Methods for sampling and analysis of ambient air - Determination of suspended particulate matter - $PM_{2.5}$ low volume sampler—Gravimetric method*; and

d) a concentration of particulate matter suspended in the atmosphere of 90 micrograms per cubic metre over a 1-year averaging time, when monitored in accordance with the most recent version of *AS3580.9.3 Methods for sampling and analysis of ambient air – Method 9.3: Determination of suspended particulate matter - Total suspended particulate matter (TSP) - High volume sampler gravimetric method*.

B2 The holder of this environmental authority must undertake monitoring of air quality at the locations specified in **Table B1 – Air Quality Monitoring** in accordance with the standards listed above in Condition B1, which must include:

a) continuous real-time monitoring of PM_{10} at one location;

b) continuous real-time monitoring of dust deposition at one location;

c) meteorological monitoring (including temperature, wind speed and direction) at one location;

d) each location listed in **Table B1 – Air Quality Monitoring** is monitored for a continuous month each year; and

e) regular reporting of the measured PM_{10} and dust deposition concentrations, including investigations into any possible exceedances, must occur.

B3 When requested by the administering authority or as a result of a complaint, dust and particulate monitoring (including dust deposition, TSP, PM_{10} and $PM_{2.5}$) must be undertaken, and the results thereof notified to the administering authority within 14 days following completion of monitoring.

B4 If the monitoring, which is carried out in accordance with Condition B3, indicates an exceedance of the relevant limits in Condition B1, then the environmental authority holder must investigate whether the exceedance is due to emissions from the activity. If the mining activity is found to be the cause of the exceedance, then the environmental authority holder must:

a) notify the administering authority within seven days of an exceedance of the relevant limits in Condition B3.

b) address the complaint including the use of appropriate dispute resolution if required; and

c) implement dust abatement measures so that emissions of dust from the activity do not result in further environmental nuisance.

Table B1 – Air Quality Monitoring Locations

Monitoring Site ID	Monitoring Location		Air Quality Indicator	Frequency
	Monitoring Point (Eastings)	Monitoring Point (Northings)		
Northwest Primary Site	TBC	TBC	PM_{10}	Continuous
			Dust Deposition	Continuous monthly period as per AS
			Meteorological Conditions	Hourly
Dingo Township	TBC	TBC	PM_{10}	Continuous
			Dust Deposition	Continuous monthly period as per AS
			Meteorological Conditions	Hourly
South Secondary Site	TBC	TBC	PM_{10}	Continuous
			Dust Deposition	Continuous monthly period as per AS
			Meteorological Conditions	Hourly

Schedule C – Waste Management

C1 All general and regulated waste (except tyres) must be removed from site to a facility that is lawfully able to accept the waste under the *Environmental Protection Act 1994*.

C2 An effective firebreak must be installed and maintained around all waste laydown and tyre storage areas.

C3 Subject to demonstrating to the administering authority that no other use higher in the waste management hierarchy can be practicably implemented, waste tyres generated from mining activities may be disposed of onsite in waste rock emplacements.

C4 Scrap tyres resulting from mining activities disposed within the operational land must not impede saturated aquifers, cause contamination or compromise the stability of the consolidated landform.

C5 Unless otherwise permitted by the conditions of this environmental authority or with prior approval from the administering authority and in accordance with a relevant standard operating procedure, waste must not be burnt.

C6 Coarse and fine rejects from the CHPP must be managed in accordance with management plan that provides for:

a) containment of tailings;

b) the management of seepage and leachates both during operation and the foreseeable future;

c) the control of fugitive emissions to air;

d) a program of progressive sampling and characterisation to verify the effective containment of rejects within spoil; and

e) maintaining records of the relative locations of rejects disposed of in spoil.

Schedule D – Noise

D1 The holder of this environmental authority must ensure that noise generated by the mining activities does not cause the criteria in **Table D1 – Noise Limits** to be exceeded at a sensitive place or commercial place.

Table D1 – Noise Limits

Noise Level dBA Measured As:	Sensitive or Commercial Place		
	7:00 am to 6:00 pm	6:00 pm to 10:00 pm	10:00 pm to 7:00 am
$L_{Aeq,adj,1hr}$	40	40	35

In accordance with Note 6 of the Model Mining Conditions, criteria were developed in accordance with the EPP (Noise) and the Planning For Noise Control guideline (EHP 2004).

Airblast Overpressure Nuisance

D2 The holder of this environmental authority must ensure that blasting does not cause the limits for peak particle velocity and air blast overpressure in **Table D2 – Blasting Limits** to be exceeded at a sensitive place or commercial place.

Table D2 – Blasting Limits

Blasting Parameter	Sensitive or Commercial Place Limits	
	7:00 am to 6:00 pm	6:00 pm to 7:00 am
Airblast overpressure	115 dBZ peak for 4 out of 5 consecutive blasts initiated; or Not greater than 120 dBZ peak at any time.	No blasting is allowed during these times.
Ground vibration peak particle velocity	For vibrations of more than 35 Hz – more than 25 mm per second ground vibration, peak particle velocity, or For vibrations of no more than 35 Hz – more than 10 mm of second peak particle velocity.	No blasting is allowed during these times.

D3 Every explosive blast for the mining activity shall be designed by a competent person and be in accordance with a blast monitoring and management program, to achieve the criteria specified in **Table D2 – Blasting Limits**.

Monitoring and Reporting

D4 Noise monitoring and recording must include the following descriptor characteristics and matters:

a) the level and frequency of occurrence of impulsive or tonal noise and any adjustment and penalties to statistical levels;

b) atmospheric conditions including temperature, relative humidity and wind speed and directions;

c) effects due to any extraneous factors such as traffic noise; and

d) location, date and time of monitoring.

D5 The holder of this environmental authority must develop and implement a blast monitoring and management program to monitor compliance with **Table D2 – Blasting Limits** for:

a) at least 50% of all blasts undertaken on this site in each month at the nearest sensitive place or commercial place; and

b) all blasts conducted during any time period specified by the administering authority at the nearest and most affected sensitive place(s) or commercial place(s) or another such place to investigate an allegation of environmental nuisance caused by blasting.

Schedule E – Groundwater

E1 The holder of this environmental authority must not release contaminants to groundwater.

E2 All determinations of groundwater quality must be performed by an appropriately qualified person.

E3 Groundwater quality and levels must be monitored at the locations and frequencies defined in **Table E1 – Groundwater Monitoring Locations and Frequency** for quality characteristics identified in **Table E2 - Groundwater Quality**

Bore Construction and Maintenance and Decommissioning

E4 The construction, maintenance and management of groundwater bores (including groundwater monitoring bores) must be undertaken in a manner that prevents or minimises impacts to the environment and ensures the integrity of the bores to obtain accurate monitoring.

Table E1 – Groundwater Monitoring Locations and Frequency

Site	Bore ID	Easting	Northing	Type	Bore Depth (m)	Unit Monitored	Monitoring Frequency
1	DW7065W	730860	7382307	SP	77.27	Permian Coal Seams (Aries 3)	Quarterly
	DW7066W	730863	7382304	SP	17.35	Tertiary sediments	Quarterly
3	DW7069W	730397	7382699	SP	71.38	Permian Coal Seams (Pollux Upper Seam)	Quarterly
	DW7071W	730394	7382703	SP	31.59	Permian Coal Seams (Aries 3)	Quarterly
	DW7072W	730403	7382687	SP	14.01	Tertiary sediments	Quarterly
4	DW7073W	729926	7382666	SP	82.1	Permian Coal Seams (Castor/Pollux Seams)	Quarterly
	DW7074W	729922	7382666	SP	55.78	Permian Coal Seams (Castor Upper Seams)	Quarterly
	DW7075W	729918	7382666	SP	14.03	Tertiary sediments	Quarterly
5	DW7076W	729750	7382723	SP	12	Quaternary alluvium	Quarterly
6	DW7033W1	731543	7383768	SP	45.23	Tertiary sediments	Quarterly
	DW7033W2	731546	7383773	SP	74.77	Permian Coal Seams (Orion 5)	Quarterly
	DW7033W3	731548	7383777	SP	81	Permian Coal Seams (Interburden)	Quarterly
10	DW7105W1	730192	7380733	SP	23.04	Tertiary sediments (Basalt)	Quarterly
	DW7105W2	730193	7380729	SP	69.25	Permian Coal Seams (Pollux Lower Upper Seam)	Quarterly
14	DW7225W1	730467	7378359	SP	37	Tertiary sediments	Quarterly
	DW7225W2	730466	7378355	SP	78.9	Permian Coal Seams (Aries 3)	Quarterly
	DW7225W3	730465	7378351	SP	112.8	Permian Coal Seams (Castor Seam)	Quarterly
17	DW7292W1	732905	7381108	SP	15	Quaternary alluvium	Quarterly

Notes: SP Stand pipe

Table E2 – Groundwater quality triggers and limits

Parameter	Groundwater Unit		
	Quaternary Alluvium	Tertiary	Permian
pH (pH units)	5.5 – 8.5	5.5 – 8.5	5.5 – 8.5
Electrical conductivity (µS/cm)	16209	22362	28692
Metals/metalloids (dissolved – mg/L) (5)			
Aluminium	0.09	0.13	0.13
Arsenic	0.013	0.013	0.019
Boron	4.66 (3)	1.46	1.42
Cadmium	0.0002 (2)	0.0002	0.0002
Cobalt	0.004 (3)	0.004	0.019
Chromium	0.001 (3)	0.001	0.001

Parameter	Groundwater Unit		
	Quaternary Alluvium	Tertiary	Permian
Copper	0.069 (2)	0.065	0.083
Mercury	0.0001 (4)	0.0001	0.0001
Manganese	0.227 (2)	0.19	0.468
Molybdenum	0.004 (2)	0.017	0.081
Nickel	0.056 (2)	0.02	0.002
Lead	0.034 (3)	0.034	0.034
Selenium	0.005 (3)	0.005	0.005
Uranium	0.058 (2)	0.01	0.018
Vanadium	0.026 (2)	0.006	0.006
Zinc	0.46 (2)	0.17	0.015
Major Ions (mg/L)			
Sulphate	226 (2)	346	766
Calcium, chloride, potassium, magnesium, sodium, alkalinity	For interpretation purposes only		

Schedule F – Water (Fitzroy Model Conditions)

F1 A *Water Management Plan* must be developed by an appropriately qualified person and implemented for all stages of mining activities on the site.

F2 The *Water Management Plan* must:

a) Provide for the effective management of actual and potential environmental impacts result from water management associated with the mining activities carried out under this environmental authority.

b) Be developed by an appropriately qualified person and in accordance with administering authority's current guideline for preparation of a water management plan for mining activities, and include:

i) a study of the source of contaminants;

ii) a water balance model for the site;

iii) a water management system for the site;

iv) measures to manage and prevent and/or minimise saline drainage;

v) measures to manage and prevent and/or minimise acid mine drainage; and

vi) contingency procedures for emergencies.

F3 The *Water Management Plan* must be reviewed each calendar year and a report prepared by an appropriately qualified person. The report must:

a) assess the plan against the requirements under Condition F2;

b) include recommended actions to ensure actual and potential environmental impacts are effectively managed for the coming year; and

c) identify any amendments made to the water management plan following the review.

F4 The holder of this environmental authority must attach to the review a report required by Condition F3, a written response to the report and recommended actions, detailing the actions take or to be taken by the environmental authority holder on stated dates:

a) to ensure compliance with this environmental authority; and

b) to prevent a recurrence of any non-compliance issues identified.

F5 A copy of the *Water Management Plan* must be provided to the administering authority on request.

Contamination Release

F6 Contaminants that will, or have the potential to, cause environmental harm must not be released directly or indirectly to any waters as a result of the authorised mining activities, except as permitted under the conditions of this environmental authority.

F7 Unless otherwise permitted under the conditions of this environmental authority, the release of mine affected water to waters must only occur from the release points specified in **Table F1 – Mine Affected Water Release Points and Sources** and depicted in **Schedule 2 – Figure H1 (Post-mining Land Use Areas)** attached to this environmental authority.

Table F1 – Mine Affected Water Release Points and Sources

Release Point	Easting (MGA94 Zone 55)	Northing (MGA94 Zone 55)	Mine Affected Water Source and Location
Mine Water Dam	731,377	7,383,379	Mine affected water system

F8 The release of mine affected water to internal water management infrastructure installed and operated in accordance with a water management plan that complies with Condition F1 - F4 is permitted.

F9 The release of mine affected water to waters in accordance with Condition F7 must not exceed the release limits stated in **Table F2 – Mine Affected Water Release Limits** when measured at the monitoring points specified in **Table F1 – Mine Affected Water Release Points and Sources** for each quality characteristic.

Table F2 – Mine Affected Water Release Limits

Quality Characteristic	Release Limits	Monitoring Frequency
Electrical conductivity (EC) (µS/cm)	Release limits specified in **Table F4 – Mine Affected Water Release During Flow Events**.	Daily during release (the first sample must be taken within two hours of commencement of release).

pH (pH Unit)	6.5 (minimum) 9.0 (maximum)	Daily during release (the first sample must be taken within two hours of commencement of release).
Turbidity (NTU)	TBA	Daily during release (first sample within two hours of commencement of release).

F10 The release of mine affected water to waters from the release points must be monitored at the locations specified in **Table F1 – Mine Affected Water Release Points and Sources** for each quality characteristic and at the frequency specified in **Table F2 – Mine Affected Water Release Limits** and **Table F3 - Release Contaminant Trigger Investigation Levels, Potential Contaminants**.

Table F3 - Release Contaminant Trigger Investigation Levels, Potential Contaminants

Quality Characteristic	Trigger Levels (µg/L)	Comment on Trigger Level	Monitoring Frequency
Aluminium	55	For aquatic ecosystem protection, based on SMD guideline.	Commencement of release and thereafter weekly during release.
Arsenic	13	For aquatic ecosystem protection, based on SMD guideline.	
Cadmium	0.2	For aquatic ecosystem protection, based on SMD guideline.	
Chromium	1	For aquatic ecosystem protection, based on SMD guideline.	
Copper	2	For aquatic ecosystem protection, based on LOR for ICPMS.	
Iron	300	For aquatic ecosystem protection, based on low reliability guideline.	
Lead	4	For aquatic ecosystem protection, based on SMD guideline.	
Mercury	0.2	For aquatic ecosystem protection, based on LOR for ICPMS.	
Nickel	11	For aquatic ecosystem protection, based on SMD guideline.	
Zinc	8	For aquatic ecosystem protection, based on SMD guideline.	
Boron	370	For aquatic ecosystem protection, based on SMD guideline.	
Cobalt	90	For aquatic ecosystem protection, based on low reliability guideline.	
Manganese	1,900	For aquatic ecosystem protection, based on SMD guideline.	
Molybdenum	34	For aquatic ecosystem protection, based on low reliability guideline.	
Selenium	10	For aquatic ecosystem protection, based on LOR for ICPMS.	
Silver	1	For aquatic ecosystem protection, based on LOR for ICPMS.	
Uranium	1	For aquatic ecosystem protection, based on LOR for ICPMS.	

Quality Characteristic	Trigger Levels (µg/L)	Comment on Trigger Level	Monitoring Frequency
Vanadium	10	For aquatic ecosystem protection, based on LOR for ICPMS.	
Ammonia	900	For aquatic ecosystem protection, based on SMD guideline.	
Nitrate	1,100	For aquatic ecosystem protection, based on ambient Qld WQ Guidelines (2006) for TN.	
Petroleum Hydrocarbon (C6 – C9)	20		
Petroleum Hydrocarbon (C10 – C36)	100		
Fluoride (total)	2,000	Protection of livestock and short-term irrigation guideline.	

ICPMS inductively coupled plasma mass spectrometry

*The quality characteristics required to be monitored as per **Table F3 - Release Contaminant Trigger Investigation Levels, Potential Contaminants** can be reviewed once the results of two years monitoring data is available, or if sufficient data is available adequately demonstrate negligible risk, and it may be determined that a reduced monitoring frequency is appropriate or that certain quality characteristics can be removed from **Table F3 - Release Contaminant Trigger Investigation Levels, Potential Contaminants** by amendment.*

F11 If quality characteristics of the release exceed any of the trigger levels specified in **Table F3 - Release Contaminant Trigger Investigation Levels, Potential Contaminants** during a release event, the environmental authority holder must compare the downstream results in the receiving waters to the trigger values specified in Table F3 - Release Contaminant Trigger Investigation Levels, Potential Contaminants and:

a) Where the trigger values are not exceeded then no action is to be taken; or

b) Where the downstream results exceed the trigger, values specified **Table F3 - Release Contaminant Trigger Investigation Levels, Potential Contaminants** for any quality characteristic, compare the results of the downstream site to the data from background monitoring sites and:

i) if the result is less than the background monitoring site data, then no action is to be taken; or

ii) if the result is greater than the background monitoring site data, complete an investigation into the potential for environmental harm and provide a written report to the administering authority in the next annual return, outlining:

1. details of the investigations carried out; and

2. actions taken to prevent environmental harm.

Note: *Where an exceedance of a trigger level has occurred and is being investigated, in accordance with Condition F11 (b)(i) of this condition, no further reporting is required for subsequent trigger events for that quality characteristic.*

F12 If an exceedance in accordance with Condition F11 (b)(ii) is identified, the holder of the environmental authority must notify the administering authority in writing within 24 hours of receiving the result.

Mine Affected Water Release Events

F13 The holder must ensure a stream flow gauging station/s is installed, operated and maintained to determine and record stream flows at the locations and flow recording frequency specified in **Table F4 – Mine Affected Water Release During Flow Events**.

Table F4 – Mine Affected Water Release During Flow Events

Receiving Water	Release Points	Gauging Station	Easting	Northing	Minimum flow
Charlevue Creek	Mine Water Dam	Downstream Charlevue Creek	TBA	TBA	TBA

*No mine affected waters will be released from site until a stream flow gauging, station as required under **Table F4 – Mine Affected Water Release During Flow Events**.*

F14 Notwithstanding any other condition of this environmental authority, the release of mine affected water to waters in accordance with Condition F7 must only take place during periods of natural flow in accordance with the receiving water flow criteria for discharge specified in **Table F4 – Mine Affected Water Release During Flow Events** for the release point(s) specified in **Table F1 – Mine Affected Water Release Points and Sources**.

F15 The 80th percentile of electrical conductivity (EC) values recorded at the downstream monitoring points listed in **Table F4 – Mine Affected Water Release During Flow Events** must not exceed 310 µS/cm over the duration of the release influence period and have a maximum value of no greater than 20 per cent of 310 µS/cm. The 80th percentile must be calculated using all EC values recorded by the monitoring station during the release influence period.

F16 The daily quantity of mine affected water released from each release point must be measured and recorded.

F17 Releases to waters must be undertaken so as not to cause erosion of the bed and banks of the receiving waters or cause a material build-up of sediment in such waters.

Notification of Release Event

F18 The environmental authority holder must notify the administering authority as soon as practicable and no later than 24 hours after commencing to release mine affected water to the receiving environment. Notification must include the submission of written advice to the administering authority of the following information:

a) release commencement date / time;

b) details regarding the compliance of the release with the conditions of department interest: water of this environmental authority (that is, contaminant limits, natural flow, discharge volume);

c) release point/s;

d) release rate;

e) release salinity; and

f) receiving water/s including the natural flow rate.

***Note**: Notification to the administering authority must be addressed to the Manager and Project Manager of the local Administering Authority via email or facsimile.*

F19 The environmental authority holder must notify the administering authority as soon as practicable and nominally no later than 24 hours after cessation of a release event of the cessation of a release notified under Condition F13 and within 28 days provide the following information in writing:

a) release cessation date/time;

b) natural flow rate in receiving water;

c) volume of water released;

d) details regarding the compliance of the release with the conditions of department interest; water of this environmental authority (i.e., contaminant limits, natural flow, discharge volume);

e) all in-situ water quality monitoring results; and

f) any other matters pertinent to the water release event.

***Note**: Successive or intermittent releases occurring within 24 hours of the cessation of any individual release can be considered part of a single release event and do not require individual notification for the purpose of compliance with Conditions F14 and F15, provided the relevant details of the release are included within the notification provided in accordance with Conditions F14 and F15.*

Notification of Release Event Exceedance

F20 If the release limits defined in **Table F2 – Mine Affected Water Release Limits** are exceeded, the holder of the environmental authority must notify the administering authority within 24 hours of receiving the results.

F21 The environmental authority holder must, within 28 days of a release that is not compliant with the conditions of this environmental authority, provide a report to the administering authority detailing:

a) the reason for the release;

b) the location of the release;

c) the total volume of the release and which (if any) part of this volume was non-compliant;

d) the total duration of the release and which (if any) part of this period was non-compliant;

e) all water quality monitoring results (including all laboratory analyses);

f) identification of any environmental harm as a result of the non-compliance;

g) all calculations; and

h) any other matters pertinent to the water release event.

Receiving Environment Monitoring and Contaminant Trigger Levels

F22 The quality of the receiving waters must be monitored at the locations specified in **Table F6 – Receiving Water Upstream Background Sites and Downstream Monitoring Sites** for each quality characteristic and at the monitoring frequency stated in **Table F5 – Receiving Waters Contaminant Trigger Levels**.

Table F5 – Receiving Waters Contaminant Trigger Levels

Quality Characteristic	Trigger Level	Monitoring Frequency
pH (pH Units)	6.5-8.5	Daily during the release
Electrical conductivity (EC) (µS/cm)	310	
Sulphate (SO_4^{2-}) (mg/L)	10	

Table F6 – Receiving Water Upstream Background Sites and Downstream Monitoring Sites

Description	Latitude (decimal degree, GDA94)	Longitude (decimal degree, GDA94)
Upstream Background Monitoring Points		
Springton Ck Upstream (SC1)	-23.6976	149.2738
Charlevue Ck Upstream (CC1)	-23.6305	149.2715
Downstream Monitoring Points		
Springton Ck Downstream (SC2)	-23.6434	149.3145
Charlevue Ck Downstream (CC2)	-23.6469	149.2104

F23 If quality characteristics of the receiving water at the downstream monitoring points exceed any of the trigger levels specified in **Table F5 – Receiving Waters Contaminant Trigger Levels** during a release event the environmental authority holder must compare the downstream results to the upstream results in the receiving waters and:

a) Where the downstream result is the same or a lower value than the upstream value for the quality characteristic, then no action is to be taken; or

b) Where the downstream results exceed the upstream results, complete an investigation into the potential for environmental harm and provide a written report to the administering authority in the next annual return, outlining:

i) details of the investigations carried out; and

ii) actions taken to prevent environmental harm.

Note: *Where an exceedance of a trigger level has occurred and is being investigated, in accordance with Condition F18 (b) of this condition, no further reporting is required for subsequent trigger events for that quality characteristic.*

F24 All determinations of water quality monitoring must be performed by suitably experienced and qualified person.

Receiving Environment Monitoring Program (REMP)

F25 The environmental authority holder must develop and implement a Receiving Environment Monitoring Program (REMP) to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity. This must include monitoring the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site.

For the purposes of the REMP, the receiving environment is the waters of Creek and connected or surrounding waterways within 15 km downstream of the release. The REMP should encompass any sensitive receiving waters or environmental values downstream of the authorised mining activity that will potentially be directly affected by an authorised release of mine affected water.

F26 The REMP must:

a) assess the condition or state of receiving waters, including upstream conditions, spatially within the REMP area, considering background water quality characteristics based on accurate and reliable monitoring data that takes into consideration temporal variation (e.g., seasonality);

b) be designed to facilitate assessment against water quality objectives for the relevant environmental values that need to be protected;

c) include monitoring from background reference sites (e.g., upstream or background) and downstream sites from the release (as a minimum, the locations specified in **Table F6 – Receiving Water Upstream Background Sites and Downstream Monitoring Sites**);

d) specify the frequency and timing of sampling required in order to reliably assess ambient conditions and to provide sufficient data to derive site-specific background reference values in accordance with the *Queensland Water Quality Guidelines 2009*. This should include monitoring during periods of natural flow irrespective of mine or other discharges;

e) include monitoring and assessment of dissolved oxygen saturation, temperature and all water quality parameters listed in **Table F5 – Receiving Waters Contaminant Trigger Levels** and **Table F3 - Release Contaminant Trigger Investigation Levels, Potential Contaminants**;

f) include, where appropriate, monitoring of metals/metalloids in sediments (in accordance with ANZG (2018). BATLEY and/or the most recent version of *AS5667.1 Water quality - Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples*);

g) include, where appropriate, monitoring of macroinvertebrates in accordance with the AusRivAS methodology;

h) apply procedures and/or guidelines from ANZG (2018) and other relevant guideline documents;

i) describe sampling and analysis methods and quality assurance and control; and

j) incorporate stream flow and hydrological information in the interpretations of water quality and biological data.

F27 A REMP Design Document that addresses the requirements of the REMP must be prepared and made available to the administrating authority upon request.

F28 A report outlining the findings of the REMP, including all monitoring results and interpretations must be prepared annually and made available on request to the administrating authority. This must include an assessment of background reference water quality, the condition of downstream water quality compared against water quality objectives, and the suitability of current discharge limits to protect downstream environmental values.

Water Reuse

F29 Mine affected water may be piped or trucked or transferred by some other means that does not contravene the conditions of this environmental authority and deposited into artificial water storage structures, such as farm dams or tanks, or used directly at properties owned by the environmental authority holder or a third party (with the consent of the third party).

Annual Water Monitoring Report

F30 The following information must be recorded in relation to all water monitoring required under the conditions of this environmental authority and submitted to the administering authority in the specified format:

a) the date on which the sample was taken;

b) the time at which the sample was taken;

c) the monitoring point at which the sample was taken;

d) the measured or estimated daily quantity of mine affected water released from all release points;

e) the release flow rate at the time of sampling for each release point;

f) the results of all monitoring and details of any exceedances of the conditions of this environmental authority; and

g) water quality monitoring data must be provided to the administering authority in the specified electronic format upon request.

Stormwater and Water Sediment Controls

F31 An *Erosion and Sediment Control Plan* must be developed by an appropriately qualified person and implemented for all stages of the mining activities on the site to minimise erosion and the release of sediment to receiving waters and contamination of stormwater.

F32 Stormwater, other than mine affected water, is permitted to be released to waters from:

a) Erosion and sediment control structures that are installed and operated in accordance with the *Erosion and Sediment Control Plan* required by Condition F31; and

b) Water management infrastructure that is installed and operated, in accordance with a *Water Management Plan* that complies with Conditions F2-F4 for the purpose of ensuring water does not become mine affected water.

Schedule G – Sewage Treatment

G1 The only contaminant permitted to be released to land is treated sewage effluent in compliance with the release limits stated in **Table G1 – Contaminant Release Limits To Land**.

Table G1 – Contaminant Release Limits To Land

Contaminant	Unit	Release Limit	Limit Type	Frequency
5-day biochemical oxygen demand	mg/L	20	Maximum	Monthly
total suspended solids	mg/L	30	Maximum	Monthly
Nitrogen	mg/L	30	Maximum	Monthly
Phosphorus	mg/L	15	Maximum	Monthly
E-coli	Organisms/100ml	1,000	Maximum	Monthly
pH	pH units	6.0 – 9.0	Range	Monthly

G2 Treated sewage effluent may only be released to land in accordance with the conditions of this approval.

G3 The application of treated effluent to land must be carried out in a manner such that:

a) vegetation is not damaged;

b) there is no surface ponding of effluent; and

c) there is no run-off of effluent.

G4 If areas irrigated with effluent are accessible to employees or the general public, prominent signage must be provided advising that effluent is present, and care should be taken to avoid consuming or otherwise coming into unprotected contact with the effluent.

G5 All sewage effluent released to land must be monitored at the frequency and for the parameters specified in **Table G1 – Contaminant Release Limits To Land**.

G6 The daily volume of effluent release to land must be measured and records kept of the volumes of effluent released.

G7 When circumstances prevent the irrigation or beneficial reuse of treated sewage effluent such as during or following rain events, waters must be directed to a wet weather storage or alternative measures must be taken to store/lawfully dispose of effluent.

G8 Treated sewage effluent must only be supplied to another person or organisation that has a written plan detailing how the user of the treated sewage effluent will comply with their general environmental duty under section 319 of the *Environmental Protection Act 1994* whilst using the treated sewage effluent.

Schedule H – Land and Rehabilitation

H1 Land disturbed by mining must be rehabilitated in accordance with **Table H1 – Rehabilitation Areas and Post-Mining Land Use** and **Schedule 2 – Figure H1 (Post-mining Land Use Areas)**.

Table H1 – Rehabilitation Areas and Post-Mining Land Use

Rehabilitation Area	Post-mining Land Use	Approximate Footprint Area (ha)	Approximate Proportion of Total Disturbance
In-pit and out-of-pit waste emplacements, including dry rejects disposal areas	Grazing	722.4	37%
Temporary waste emplacements	Grazing	17.54	1%
Residual void lakes	Fauna habitat	76.5	4%
Residual void high walls	Native vegetation supporting fauna habitat	133.1	7%
Residual void low walls	Grazing	187.2	9%
Water management infrastructure	Grazing/native vegetation	85	4%
Mine infrastructure areas	Grazing	731.8	38%

Impacts to Prescribed Environmental Matters

H2 The significant residual impacts to prescribed environmental matters are not authorised under this environmental authority or the *Environmental Offsets Act 2014* unless the impact(s) is specified in **Table H2 – Significant Residual Impacts To Prescribed Environmental Matters**.

H3 Records demonstrating that each impact to a prescribed environmental matter not listed in **Table H2 – Significant Residual Impacts To Prescribed Environmental Matters** did not, or is not likely to, result in a significant residual impact to that matter must be:

a) Completed by an appropriately qualified person; and

b) Kept for the life of the environmental authority.

Table H2 – Significant Residual Impacts To Prescribed Environmental Matters

Prescribed Environmental Matter	Description		Maximum Extent of Impact (ha)
Regulated Vegetation	Of concern regional ecosystem	RE 11.3.2	2.57
	Regional ecosystems within a defined distance of a vegetation management watercourse (RE 11.3.25, 11.5.2, 11.3.2 and 11.7.2)		58.32
Connectivity Areas			710.72

H4 An environmental offset made in accordance with the *Environmental Offsets Act 2014* and the *Queensland Environmental Offsets Policy*, as amended from time to time, must be undertaken for the maximum extent of impact to each prescribed environmental matter authorised in **Table H2 – Significant Residual Impacts To Prescribed Environmental Matters**, unless a lesser extent of the impact has been approved in accordance with Condition H8.

H5 The significant residual impacts to a prescribed environmental matter authorised in Condition H2 for which an environmental offset is required by Condition H2 may be carried out in stages. An environmental offset can be delivered for each stage of the impacts to prescribed environmental matters.

Staged Impacts

H6 The significant residual impacts to a prescribed environmental matter authorised in Condition H2 for which an environmental offset is required by Condition H11 may be carried out in stages. An environmental offset can be delivered for each stage of the impacts to prescribed environmental matters.

H7 Prior to the commencement of each stage, a report completed by an appropriately qualified person, that includes an analysis of the following must be provided to the administering authority:

a) For the forthcoming stage—the estimated significant residual impacts to each prescribed environmental matter; and

b) For the previous stage, if applicable—the actual significant residual impacts to each prescribed environmental matter, to date.

H8 The report required by Condition H7 must be approved by the administering authority before a notice of election for the forthcoming stage, if applicable, is given to the administering authority.

H9 A notice of election for the staged environmental offset referred to in Condition H8, if applicable, must be provided to the administering authority no less than three months before the proposed commencement of that stage, unless a lesser timeframe has been agreed to by the administering authority.

H10 Within six months from the completion of the final stage of the project, a report completed by an appropriately qualified person, that includes the following matters must be provided to the administering authority:

a) An analysis of the actual impacts on prescribed environmental matters resulting from the final stage; and

b) If applicable, a notice of election to address any outstanding offset debits for the authorised impacts.

Chemical and Flammable or Combustible Liquids

H11 All flammable and combustible liquids must be contained within an onsite containment system and controlled in a manner that prevents environmental harm and maintained in accordance with the current edition of *AS1940 The storage and handling of flammable and combustible liquids*.

H12 All explosive, corrosive substances, toxic substances, gases and dangerous goods must be stored and handled in accordance with the relevant Australian Standards.

H13 All chemicals and flammable or combustible liquids stored onsite that have the potential to cause environmental harm must be stored in, or serviced by, an effective containment system that is impervious to the materials stored and managed to prevent the release of liquids to water or land. Where no relevant Australian Standard is available, the following must be applied:

a) Storage tanks must be bunded so that the capacity and construction of the bund is sufficient to contain at least 110% of a single storage tank or 100% of the largest storage tank plus 10% of the second largest storage tank in multiple storage areas; and

b) Drum storage must be bunded so that the capacity and construction of the bund is sufficient to contain at least 25% of the maximum design storage volume within the bund.

Spills

H14 Any spills or release of flammable and combustible liquids; or chemicals, must be controlled in a manner that prevents environmental harm.

H15 An appropriate spill kit, personal protective equipment and relevant operator instructions/emergency procedure guides for the management of wastes, chemicals and flammable and combustible liquids associated with the activity must be kept at the site.

H16 Anyone operating with wastes, chemicals or flammable and combustible liquids under this approval must be trained in the use of the spill kit.

Infrastructure

H17 All infrastructure constructed by, or for, the environmental authority holder during the licensed activities include water storages, must be removed from the site prior to surrender, except where agreed in writing by the post mining landowner.

Note: *This is not applicable where the landowner/holder is also the environmental authority holder.*

Schedule I - Regulated Structures

Assessment of consequence category

I1 The consequence category of any structure must be assessed by a suitably qualified and experienced person in accordance with the *Manual for assessing consequence categories and hydraulic performance of structures [ESR/2016/1933]* (DES 2016) at the following times:

a) prior to the design and construction of the structure, if it is not an existing structure; or

b) prior to any change in its purpose or the nature of its stored contents.

I2 A consequence assessment report and certification must be prepared for each structure assessed and the report may include a consequence assessment for more than one structure.

I3 Certification must be provided by the suitably qualified and experienced person who undertook the assessment, in the form set out in the *Manual for assessing consequence categories and hydraulic performance of structures [ESR/2016/1933]* (DES 2016).

I4 Conditions I5 to I9 inclusive do not apply to existing structures.

I5 All regulated structures must be designed by, and constructed under the supervision of, a suitably qualified and experienced person in accordance with the requirements of the *Manual for assessing consequence categories and hydraulic performance of structures [ESR/2016/1933]* (DES 2016).

I6 Construction of a regulated structure is prohibited unless:

a) the holder has submitted a consequence category assessment report and certification to the administering authority; and

b) certification for the design, design plan and the associated operating procedures has been certified by a suitably qualified and experienced person in compliance with the relevant condition of this authority.

I7 Certification must be provided by the suitably qualified and experienced person who oversees the preparation of the design plan in the form set out in the *Manual for assessing consequence categories and hydraulic performance of structures [ESR/2016/1933]* (DES 2016) and must be recorded in the Register of Regulated Structures.

I8 Regulated structures must:

a) be designed and constructed in compliance with the *Manual for assessing consequence categories and hydraulic performance of structures [ESR/2016/1933]* (DES 2016).

b) be designed and constructed with due consideration given to ensuring that the design integrity would not be compromised on account of:

i) floodwaters from entering the regulated dam from any watercourse or drainage line; and

ii) wall failure due to erosion by floodwaters arising from any watercourse or drainage line.

I9 Certification by the suitably qualified and experienced person who supervises the construction must be submitted to the administering authority on the completion of construction of the regulated structure, and state that:

a) the 'as constructed' drawings and specifications meet the original intent of the design plan for that regulated structure; and

b) construction of the regulated structure is in accordance with the design plan.

Notification of affected persons

I10 All affected persons must be provided with a copy of the emergency action plan in place for each regulated structure:

a) for existing structures that are regulated structures, within 10 business days of this condition taking effect;

b) prior to the operation of the new regulated structure; and

c) if the emergency action plan is amended, within 5 business days of it being amended.

Operation of a regulated structure

I11 Operation of a regulated structure, except for an existing structure, is prohibited unless the holder has submitted to the administering authority in respect of regulated structure, all of the following:

a) one paper copy and one electronic copy of the design plan and certification of the 'design plan' in accordance with Condition I6;

b) a set of 'as constructed' drawings and specifications;

c) certification of the 'as constructed drawings and specifications' in accordance with Condition I9;

d) where the regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the design storage allowance (DSA) volume across the system, a copy of the certified system design plan;

e) the requirements of this authority relating to the construction of the regulated structure have been met;

f) the holder has entered the details required under this authority, into a Register of Regulated Structures; and

g) there is a current operational plan for the regulated structure.

Mandatory reporting level

I12 Conditions I13 to I16 inclusive only apply to Regulated Structures which have not been certified as low consequence category for 'failure to contain – overtopping'.

I13 The mandatory reporting level (the MRL) must be marked on a regulated dam in such a way that during routine inspections of that dam, it is clearly observable.

I14 The holder must, as soon as practicable but within forty-eight (48) hours of becoming aware, notify the administering authority when the level of the contents of a regulated dam reaches the MRL.

I15 The holder must, immediately on becoming aware that the MRL has been reached, act to prevent the occurrence of any unauthorised discharge from the regulated dam.

I16 The holder must record any changes to the MRL in the Register of Regulated Structures.

Design storage allowance

I17 The holder must assess the performance of each regulated dam or linked containment system over the preceding November to May period based on actual observations of the available storage in each regulated dam or linked containment system taken prior to 1 July of each year.

I18 By 1 November of each year, storage capacity must be available in each regulated dam (or network of linked containment systems with a shared DSA volume), to meet the DSA volume for the dam (or network of linked containment systems).

I19 The holder must, as soon as practicable but within forty-eight (48) hours of becoming aware that the regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year, notify the administering authority.

I20 The holder must, immediately on becoming aware that a regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1

November of any year, act to prevent the occurrence of any unauthorised discharge from the regulated dam or linked containment systems.

Annual inspection report

I21 Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.

I22 At each annual inspection, the condition and adequacy of all components of the regulated structure must be assessed and a suitably qualified and experienced person must prepare an annual inspection report containing details of the assessment and include a recommendations section, with any recommended actions to ensure the integrity of the regulated structure or a positive statement that no recommendations are required**.**

I23 The suitably qualified and experienced person who prepared the annual inspection report must certify the report in accordance with the *Manual for assessing consequence categories and hydraulic performance of structures [ESR/2016/1933]* (DES 2016).

I24 The holder must within 20 business days of receipt of the annual inspection report, provide to the administering authority:

a) the recommendations section of the annual inspection report;

b) if applicable, any actions being taken in response to those recommendations; and

c) if, following receipt of the recommendations and (if applicable) recommended actions, the administering authority requests a copy of the annual inspection report from the holder, provide this to the administering authority within 10 business days11 of receipt of the request.

Transfer arrangements

I25 The holder must provide a copy of any reports, documentation and certifications prepared under this authority, including but not limited to any Register of Regulated Structures, consequence assessment, design plan and other supporting documentation, to a new holder on transfer of this authority.

Decommissioning and rehabilitation

I26 Regulated structures must not be abandoned but be either:

a) decommissioned and rehabilitated to achieve compliance with Condition I27; or

b) be left in-situ for a use by the landholder provided that:

i) it no longer contains contaminants that will migrate into the environment; and

ii) it contains water of a quality that is demonstrated to be suitable for its intended use(s); and

c) the holder of the environmental authority and the landholder agree in writing that the;

i) dam will be used by the landholder following the cessation of the environmentally relevant activity(ies); and

ii) landholder is responsible for the dam, on and from an agreed date.

I27 Before surrendering this environmental authority the site must be rehabilitated to achieve a safe, stable, non-polluting landform and grazing.

Register of Regulated Structures

I28 A Register of Regulated Structures must be established and maintained by the holder for each regulated structure:

I29 The holder must provisionally enter the required information in the Register of Regulated Structures when a design plan for a regulated dam is submitted to the administering authority.

I30 The holder must make a final entry of the required information in the Register of Regulated Structures once compliance with Condition I11 and I12 has been achieved.

I31 The holder must ensure that the information contained in the Register of Regulated Structures is current and complete on any given day.

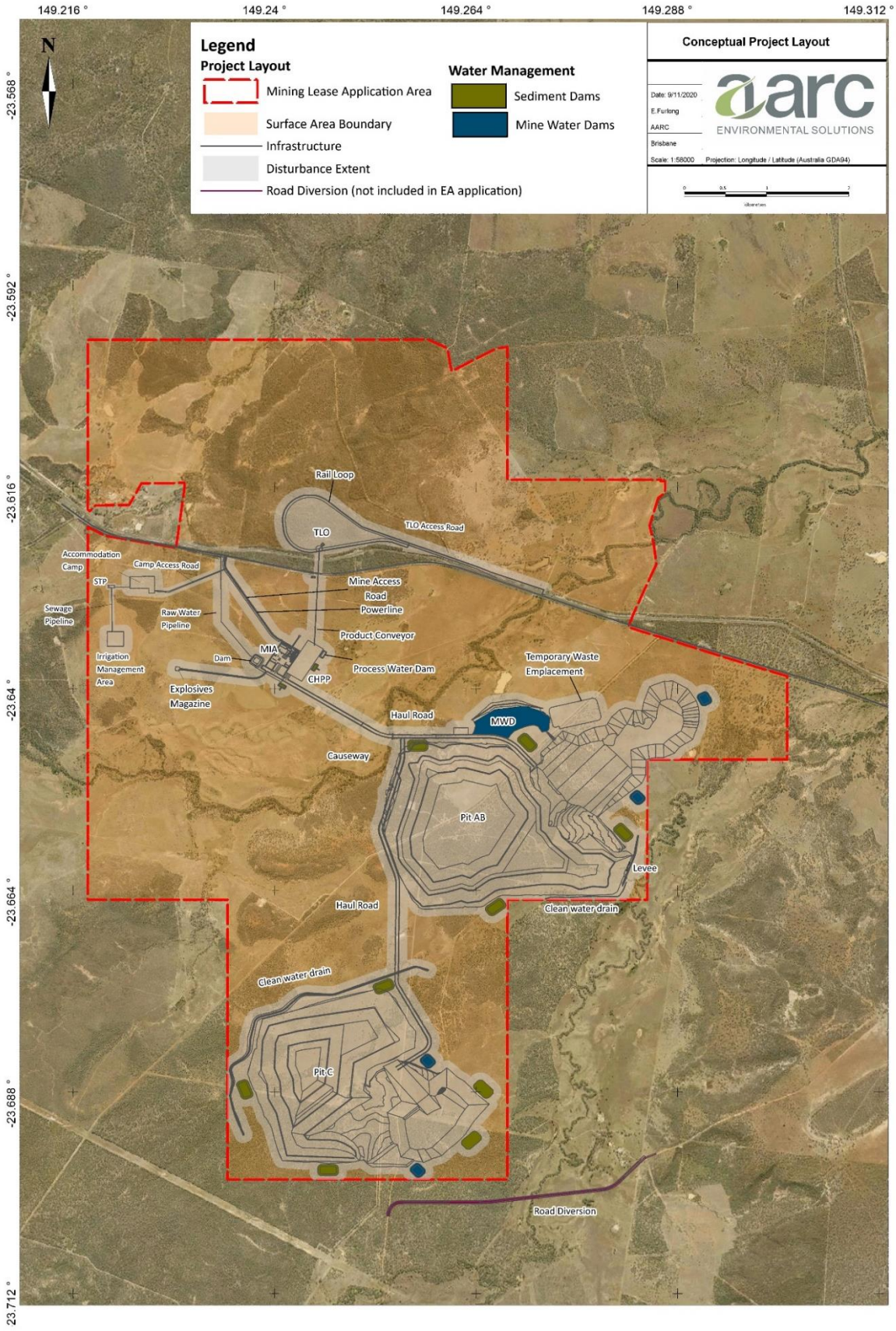
I32 All entries in the Register of Regulated Structures must be approved by the chief executive officer for the holder of this authority, or their delegate, as being accurate and correct.

I33 The holder must, at the same time as providing the annual return, supply to the administering authority a copy of the records contained in the Register of Regulated Structures, in the electronic format required by the administering authority.

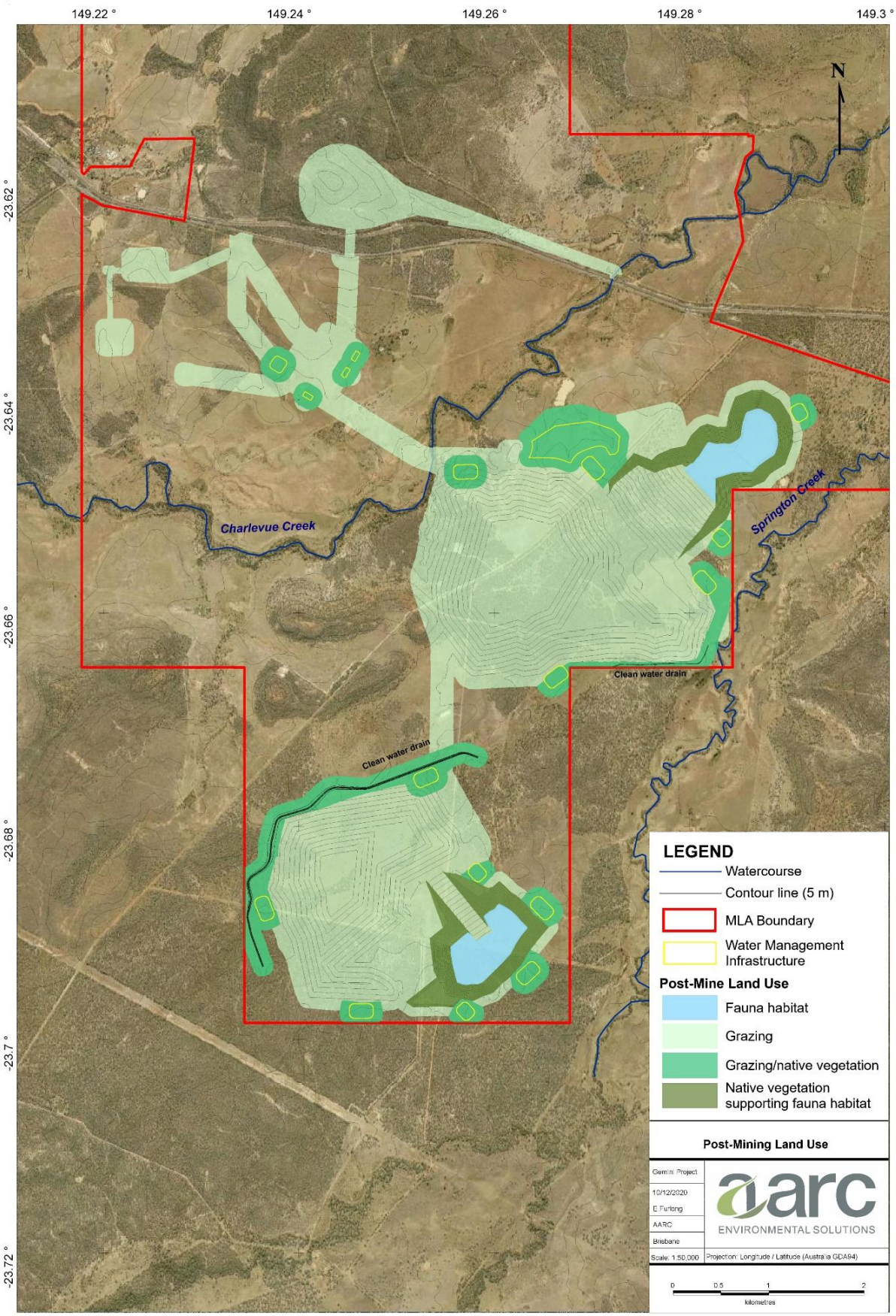
Definitions

The words and phrases used throughout this proposed EA are as per the *Model Mining Conditions* (DES 2017e). Where a definition for a term used in this environmental authority is not provided by the *Model Mining Conditions* but is provided in the EP Act 1994 or subordinate legislation, the definition in the EP Act or subordinate legislation must be used.

Schedule 1 – Figure A2 (Approved Plan)



Schedule 2 – Figure H1 (Post-mining Land Use Areas)



16.0 REFERENCES

AARC Environmental Solutions Pty Ltd (AARC) 2020a, *Aquatic Ecology Assessment*, prepared for Magnetic South Pty Ltd.

AARC Environmental Solutions Pty Ltd (AARC) 2020b, *Terrestrial Ecology Assessment*, prepared for Magnetic South Pty Ltd.

AARC Environmental Solutions Pty Ltd (AARC) 2020c, *Visual Amenity Assessment,* prepared for Magnetic South Pty Ltd.

AARC Environmental Solutions Pty Ltd (AARC) 2019, *Soil and Land Suitability Assessment*, prepared for Magnetic South Pty Ltd.

Atlas of Living Australia (ALAS) 2020, *Chalinolobus gouldii (J.E. Gray, 1841)*, Atlas of Living Australia, viewed August 2020 https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:f2ecb3e3-a6e2-45cc-a986-716a69eec650

Australian Coal Association Research Program (ACARP) 2015, *Mobile Sampling Of Dust Emissions From Unsealed Roads C20023,* Judith Cox, Pacific Environmental Limited, ACARP.

Australian Museum 2020, *Eastern Horseshoe Bat,* Australian Museum, viewed August 2020 https://australian.museum/learn/animals/bats/eastern-horseshoe-bat/.

ASK Consulting Engineers (ASK) 2020, *Noise Impact Assessment,* prepared for Magnetic South Pty Ltd.

Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) 2018, *Water Quality Guidelines*, Australia and New Zealand Guidelines for Fresh and Marine Water Quality, Commonwealth of Australia, viewed October 2020 https://www.waterquality.gov.au/anz-guidelines.

Australian and New Zealand Minerals and Energy Council (ANZMEC) and the Minerals Council of Australia (MCA) 2000, *Strategic Framework for Mine Closure*, ISBN 0642721386, Australian and New Zealand Minerals and Energy Council and the Minerals Council of Australia, Canberra, Australian Capital Territory.

Austroads Ltd 2017, *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections (3rd ed.)*, ISBN 9781925451733, Austroads Ltd, Sydney, New South Wales.

Beamish, B.B. and Blazak, D.G 2005, Relationship between ash content and R70 self-heating rate of Callide coal, *International Journal of Coal Geology*, 64(1-2), pp.126-132.

Blakers, M, Davies, SJJF & Reilly, PN, 1984, *The Atlas of Australian Birds*, ISBN 0522842852, Melbourne University Press, Melbourne, Victoria.

Boland, DJ, Brooker, MIH, Chippendale, GM, Hall, N, Hyland, BPM, Johnson, RD, Kleinig, DA, McDonald, MW & Turner, JD 2006, *Forest Trees of Australia*, ISBN 9780643069695, CSIRO Publishing, Collingwood, Victoria.

Bowen, HJM 1979, *Environmental Chemistry of the Elements*, pp. 36-37, ISBN 9780121204501, Academic Press, London, New York.

Bureau of Meteorology (BoM) 2018, *Queensland River Basins*, Commonwealth of Australia, Canberra, viewed 20 May 2019, <http://www.bom.gov.au/qld/flood/brochures/qld/map.pdf>.

Bureau of Meteorology (BoM) 2019a, *Design Rainfall Data System (2016)*, Commonwealth of Australia, Canberra, viewed 7 October 2019, <http://www.bom.gov.au/water/designRainfalls/revised-ifd/>.

Bureau of Meteorology (BoM) 2019b, *Groundwater Dependent Ecosystems Atlas*, Commonwealth of Australia, Canberra, viewed 1 May 2019, <http://www.bom.gov.au/water/groundwater/gde/map.shtml>.

Cardno (Qld) Pty Ltd (Cardno) 2019, *Gemini Project Traffic Impact Assessment,* prepared for Magnetic South Pty Ltd.

Cardno (Qld) Pty Ltd (Cardno) 2020, *Land-Based Effluent Disposal Assessment Report,* prepared for Magnetic South Pty Ltd.

Cayley, JWD & Bird PR, 1996, *Techniques for measuring pastures*. Pastoral and Veterinary Institute, Hamilton, ISBN 0 7306 64295.

Central Highlands Regional Council (CHRC) 2016, *Waste Reduction and Recycling Plan 2016-2026*, prepared by pitt&sherry and JustWaste Consulting, Emerald, Queensland.

Churchill, S 2009, *Australian Bats (second edition),* Allen and Unwin, Sydney.

Cleanaway 2019a, Hazardous Chemical Waste Disposal, accessed 6th March 2020, https://www.cleanaway.com.au/waste/chemicals/

Cleanaway 2019b, Paint waste disposal, accessed 6th March 2020, https://www.cleanaway.com.au/waste/paint/

Cleanaway 2019c Contaminated Sludges, viewed December 2019 https://www.cleanaway.com.au/waste/contaminated-sludge/

Cooper RM, McAllan IAW and Curtis BR 2014, *The Atlas of the Birds of NSW and the ACT*, Mini- Publishing, Gordon, New South Wales.

Cropper, SC 1993, *Management of endangered plants*, ISBN 0643055339, CSIRO Publications, Melbourne, Victoria.

Department of Aboriginal and Torres Strait Islander Partnerships (DATSIP) 2004, *Aboriginal Cultural Heritage Act 2003 Duty of Care Guidelines*, State of Queensland, Brisbane.

Department of Agriculture (DA) 2002, *Salinity tolerance of plants for agriculture and revegetation*, Government of Western Australia, Perth, viewed 20 August 2019, <http://www.plantstress.com/articles/salinity_m/salinity_m_files/salt%20tol%20australia.htm>.

Department of Agriculture and Fisheries (DAF) 2013, *Guide for the determination of waterways using the spatial data layer Queensland waterways for waterway barrier works*, State of Queensland, Brisbane.

Department of Agriculture and Fisheries (DAF) 2018a, *Restricted invasive plants of Queensland*, State of Queensland, Brisbane.

Department of Agriculture and Fisheries (DAF) 2018b, *Accepted development requirements for operational work that is constructing or raising waterway barrier works*, prepared by the Department of Agriculture and Fisheries, State of Queensland, Brisbane.

Department of Environment and Heritage Protection (EHP) 2004, *Guideline (Noise): Planning for noise control,* State of Queensland, Brisbane.

Department of Environment and Heritage Protection (EHP) 2011a, *Environmental Protection (Water) Policy 2009 – Mackenzie River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Mackenzie River Sub-basin*, State of Queensland, Brisbane.

Department of Environment and Heritage Protection (EHP) 2011b, *WQO1310 Fitzroy Basin Groundwater Zones Basin 130*, Environmental Protection (Water) Policy 2019 Central Queensland Map Series, State of Queensland, Brisbane.

Department of Environment and Heritage Protection (EHP) 2013a, *Guideline (Resource activity – mining): Model water conditions for coal mines in the Fitzroy Basin [ESR/2015/1561]*, State of Queensland, Brisbane.

Department of Environment and Heritage Protection (EHP) 2013b, *Noise Measurement Manual [EM1107] (Version 4),* State of Queensland, Brisbane.

Department of Environment and Heritage Protection (EHP) 2014, *Queensland Environmental Offsets Policy, Significant Residual Impact Guideline*, State of Queensland, Brisbane.

Department of Environment and Heritage Protection (EHP) 2016, *Guideline (Noise): Noise and vibration from blasting [EM2402],* State of Queensland, Brisbane.

Department of Environment and Resource Management (DERM) 2011, *Managing Grazing Lands in Queensland,* prepared by Science Strategy and Integration, State of Queensland, Brisbane.

Department of Environment and Science (DES), 2011, *Troughton's sheathtail bat,* Department of Environment and Science, Queensland, Brisbane, viewed August 2020 https://environment.des.qld.gov.au/wildlife/animals/living-with/bats/micro-bats/troughtons-sheathtail.

Department of Environment and Science (DES) 2013, *Model water conditions for coal mines in the Fitzroy basin [ESR/2015/1561]*, State of Queensland, Brisbane.

Department of Environment and Science (DES) 2014a, *Guideline (Resource Activities): Rehabilitation requirements for mining resource activities [ESR/2016/1875]*, State of Queensland, Brisbane.

Department of Environment and Science (DES) 2014b, *Operational Policy* (*Mining): Disposal and storage of scrap tyres at mine sites [ESR/2016/2380]*, State of Queensland, Brisbane.

Department of Environment and Science (DES) 2016, *Manual for assessing consequence categories and hydraulic performance of structures [ESR/2016/1933]*, State of Queensland, Brisbane.

Department of Environment and Science (DES) 2017a, *Application requirements for activities with impacts to air [ESR/2015/1840],* State of Queensland, Brisbane.

Department of Environment and Science (DES) 2017b, *Application requirements for activities with impacts to land [ESR/2015/1839]*, State of Queensland, Brisbane.

Department of Environment and Science (DES) 2017c, *Application requirements for activities with impacts to water {ERS/2015/1837]*, State of Queensland, Brisbane.

Department of Environment and Science (DES) 2017d, *Application requirements for activities with noise impacts [ESR/2015/1838],* State of Queensland, Brisbane.

Department of Environment and Science (DES) 2017e, *Guideline (Mining): Model mining conditions [ESR/2016/1936],* State of Queensland, Brisbane.

Department of Environment and Heritage Protection (DES) 2017f, *Guideline: Stormwater and environmentally relevant activities,* Department of Environment and Science, Brisbane, viewed October 2020 https://environment.des.qld.gov.au/__data/assets/pdf_file/0028/89119/pr-gl-stormwater-guideline-era.pdf.

Department of Environment and Science (DES) 2018a, *A Biodiversity Planning Assessment for the Brigalow Belt Bioregion (Version 2.1): Summary Report,* State of Queensland, Brisbane.

Department of Environment and Science (DES) 2018b, *Fitzroy Drainage Basin – Facts and Maps,* State of Queensland, Brisbane, viewed 20 May 2019, <https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/basin-fitzroy/>.

Department of Environment and Science (DES) 2018c, *Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009*, State of Queensland, Brisbane.

Department of Environment and Science (DES) 2018d, *Plants, animals, soils, water and more,* WetlandInfo, State of Queensland, Brisbane, viewed 9 May 2019, <https://wetlandinfo.des.qld.gov.au/wetlands/ecology/components/>.

Department of Environment and Science (DES) 2018e, *Waste tracking guideline – Overview of managing waste tracking in Queensland (ESR/2016/2425) Version 2.01*, Department of Environment and Science, Brisbane.

Department of Environment and Science (DES) 2019, *Application requirements for activities with waste impacts [ESR/2015/1836]*, State of Queensland, Brisbane.

Department of Environment and Science (DES) 2020, *Noise Measurement Manual [ESR/2016/2195 - formerly EM1107 Version 4.01*, State of Queensland, Brisbane.

Department of Foreign Affairs and Trade (DFAT) 2016a, *Leading Practice Sustainable Development Program for the Mining Industry: Mine Closure*, Commonwealth of Australia, Canberra.

Department of Foreign Affairs and Trade (DFAT) 2016b, *Leading Practice Sustainable Development Program for the Mining Industry: Mine Rehabilitation*, Commonwealth of Australia, Canberra.

Department of Foreign Affairs and Trade (DFAT) 2016c, *Leading Practice Sustainable Development Program for the Mining Industry: Preventing Acid and Metalliferous Drainage*, Commonwealth of Australia, Canberra.

Department of Infrastructure, Local Government and Planning (DILGP), 2020, *State Code 18: Constructing or raising waterway barrier works in fish habitats,* State development assessment provisions, version 2.1, State of Queensland, Brisbane.

Department of Minerals and Energy (DME),1995, *Technical Guidelines for Environmental Management of Exploration and Mining in Queensland*, ISBN 0724252606, State of Queensland, Brisbane.

Department of Natural Resources and Mines (DNRM) & Department of Science, Information Technology and Innovation (DSITI) 2013, *Regional Land Suitability Frameworks for Queensland*, Ch 10: Suitability Framework for the Inland Fitzroy and Southern Burdekin area, State of Queensland, Brisbane.

Department of Natural Resources and Mines (DNRM) 2001, *AusRivAS Sampling and Processing Manual*, State of Queensland, Brisbane.

Department of Natural Resources, Mines and Energy, RS 17 Recognised Standard for Hazardous Chemicals Coal *Mining Safety and Health Act 1999 (2019),* State of Queensland, Brisbane.

Department of Science, Information Technology and Innovation (DSITI) & Department of Natural Resources and Mines (DNRM) 2015, *Guidelines for Agricultural Land Evaluation in Queensland* (2nd edition), State of Queensland, Brisbane.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC) 2012a, *National Pollutant Inventory: Emission Estimation Technique Manual for Mining (Version 3.1),* Commonwealth of Australia, Canberra.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC) 2012b, *Aquatic Ecosystems Toolkit. Module 2: Interim Australian National Aquatic Ecosystem Classification Framework*, Version 1.0, prepared by Aquatic Ecosystems Task Group, Commonwealth of Australia, Canberra.

Department of the Environment and Energy (DoEE) 2017, *National Greenhouse and Energy Reporting Scheme Measurement: Technical Guidelines for the estimation of emissions by facilities in Australia,* Commonwealth of Australia, Canberra.

Department of the Environment and Energy (DoEE) 2019a, *Quarterly Update of Australia's National Greenhouse Gas Inventory: March 2019,* Commonwealth of Australia, Canberra.

Department of the Environment and Energy (DoEE) 2019b, *State and Territory Greenhouse Gas Inventories 2017*, Commonwealth of Australia, Canberra.

Department of the Environment, Water, Heritage and the Arts (DEWHA) 2010a, *Survey guidelines for Australia's threatened bats*, Commonwealth of Australia, Canberra.

Department of the Environment, Water, Heritage and the Arts (DEWHA) 2010b, *Survey guidelines for Australia's threatened birds,* Commonwealth of Australia, Canberra.

Department of the Environment, Water, Heritage and the Arts (DEWHA) 2011a, *Survey guidelines for Australia's threatened mammals,* Commonwealth of Australia, Canberra.

Department of the Environment, Water, Heritage and the Arts (DEWHA) 2011b, *Survey guidelines for Australia's threatened reptiles*, Commonwealth of Australia, Canberra.

Diete RL, Adamczyk SM, Meek PD, Dickman CR, and Leung LKP 2015, 'Burrowing behaviour of the delicate mouse (Pseudomys delicatulus) and the management implications for a threatened sympatric rodent (Notomys auilo)', *Australian Mammalogy*, Vol. 37, pp. 260-263.

Environmental Protection Agency (EPA) 1998, *Western Surface Coal Mining, Chapter 11.9* within *Compilation of Air Pollutant Emissions Factors (AP-42) (5th ed.) (Volume 1),* Office of Air Quality Planning and Standards, United States Government, Washington DC.

Environmental Protection Agency (EPA) 2006, *Aggregate Handling and Storage Piles, Chapter 13.2.4* within *Compilation of Air Pollutant Emissions Factors (AP-42) (5th ed.) (Volume 1),* Office of Air Quality Planning and Standards, United States Government, Washington DC.

Environmental Protection Agency Victoria (EPA Victoria) 2007, *Protocol for Environmental Management: State Environment Protection Policy (Air Quality Management) – Mining and Extractive Industries*, Publication 1191, State of Victoria, Melbourne.

Environmental Protection Agency (EPA), 2020, *Salinity,* viewed 20 April 2020, <https://www.epa.sa.gov.au/environmental_info/water_quality/threats/salinity>

Eyre, TJ, Ferguson, DJ, Hourigan, CL, Smith, GC, Mathieson, MT, Kelly, AL, Venz, MF, Hogan, LD & Rowland, J 2018, *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (Version 3.0),* Department of Environment and Science, State of Queensland, Brisbane.

Fondriest Environmental Inc. 2014, *Fundamentals of Environmental Measurements: Turbidity, Total Suspended Solids & Water Clarity*, viewed 20 May 2019, <http://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/>.

Goff, FG, Dawson, GA & Rochow, JJ 1982, *Site examination for threatened and endangered plant species*, Environmental Management, vol. 6, pp. 307-316.

Goodsell JT 1990, 'Distribution of Waterbird Broods Relative to Wetland Salinity and pH in South-western Australia', *Australian Wildlife Research,* Vol. 17, pp. 219-29.

Greig-Smith, P 1964, *Quantitative Plant Ecology*, Butterworths, London.

Griffiths SR, Donato DB, Lumsden LF and Coulson G 2014a, 'Hypersalinity reduces the risk of cyanide toxicosis to insectivorous bats interacting with wastewater impoundments at gold mines'*, Ecotoxicology and Environmental Safety,* Vol. 99, pp. 28-34.

Griffiths SR, Donato DB, Coulson G and Lumsden LF 2014b, 'High levels of activity of bats at golf mining water bodies: implications for compliance with International Cyanide Management Code', *Environmental Science and Pollution Research*, Vol. 21, pp. 7263-7275.

Hart BT, Bailey P, Edwards R, Hortle K, James K, McMahon A, Meredith C and Swadling K 1991, *'A review of the salt sensitivity of the Australian freshwater biota', Hydrobiologia*, Vol. 210, pp. 105-144.

International Erosion Control Association (IECA) Australasia 2008, *Best Practice Sediment and Erosion Control Guideline*, Picton, New South Wales.

International Network on Acid Prevention (INAP) 2009, *Global Acid Rock Drainage Guide*, prepared by Golder Associates on behalf of INAP.

JBT Consulting Pty Ltd (JBT) 2019, *Groundwater Impact Assessment,* prepared for Magnetic South Pty Ltd.

John T. Boyd Company (BOYD) 2019, *Assessment of Final Landform Options*, prepared for Magnetic South Pty Ltd.

Katestone Environmental Pty Ltd (Katestone) 2011, *NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining,* Prepared for Office of Environment and Heritage KE1006953 June 2011.

Katestone Environmental Pty Ltd (Katestone) 2020, *Gemini Project: Air Quality and Greenhouse Gas Assessment,* prepared for Magnetic South Pty Ltd.

Kaymakci, E and Didari, V 2002, Relations between coal properties and spontaneous combustion parameters, *Journal of Engineering & Environmental Sciences*, vol.26, 1, pp.59-64.

Keipert, N.L 2005, *Effect of different stockpiling procedures in open cut coal mine rehabilitation in the Hunter Valley*, NSW, Australia (Doctoral dissertation, PhD thesis, University of New England).

Lavery HJ 1972, 'The Grey Teal at saline drought refuges in north Queensland*', Wildfowl,* Vol. 23, No. 23, pp. 56-63.

Loch RJ, 2000, 'Effects of vegetation cover on runoff and erosion under simulated rain and overland flow on a rehabilitated site on the Meandu mine Tarong, Queensland', *Australian Journal of Soil Research*, 38, pp. 299-312.

Luek A and Rasmussen JB 2017, 'Chemical, Physical and Biological Factors Shape Littoral Invertebrate Community Structure in Coal-Mining End-Pit Lakes', *Environmental Management,* Vol. 59, pp. 652-664.

Lund MA and Blanchette ML 2014, *C21038 Enhancing Ecological Values of Coal Pit Lakes with Simple Nutrient Additions and Bankside Vegetation*, Mine Water and Environment Research/Centre for Ecosystem Management report No. 2014-3, unpublished report to the Australian Coal Association Research Program, Perth.

Marszelewski W, Dembowska EA, Napiorkowski P and Solarczyk A 2017, 'Understanding abiotic and biotic conditions in post-mining pit lakes for efficient management: A case study (Poland)', *Mine Water and Environment*, Vol. 36, pp.418-428.

McFarland, D, Haseler, M, Venz, M, Reis, T, Ford, G & Hines, B 1999, *Terrestrial Vertebrate Fauna of the Brigalow Belt South Bioregion: Assessment and Analysis for Conservation Planning*, Queensland Environmental Protection Agency, State of Queensland, Brisbane.

McKenzie, NJ, Grundy, MJ, Webster, R & Ringrose-Voase, AJ 2008, *Guidelines for Surveying Soil and Land Resources,* Australian Soil and Land Survey Handbook Series, CSIRO Publishing, Melbourne, Victoria.

Miguel-Chinchilla L, Boix D, Gascon S and Comin FA 2014, '*Taxonomic and Functional Successional Patterns in Macroinvertebrates Related to Plying Dispersal Abilities: A Case Study from Isolated Manmade Ponds at Reclaimed Opencast Coal Mines'*, Hydrobiologia, Vol. 732, pp. 111-2.

National Committee on Soil and Terrain (NCST) 2009, *Australian Soil and Land Survey Field Handbook* (3rd edition), Australian Soil and Land Survey Handbook Series, CSIRO Publishing, Melbourne, Victoria.

Neldner, VJ, Wilson, BA, Dillewaard, HA, Ryan, TS & Butler, DW 2019, *Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland (Version 5.0),* Queensland Herbarium, Science and Technology Division, Department of Environment and Science, State of Queensland, Brisbane.

O'Donnell WB and Debus SJS 2012, 'Nest-sites and foraging of the White-bellied Sea-Eagle *Haliaeetus leucogaster* on the subtropical eastern coast of Australia', *Australian Field Ornithology*, Vol. 29, pp. 149-59.

Parsons, M, Ransom, G, Thoms, M & Norris, R 2002, *Australian River Assessment System: AusRivAS Physical and Chemical Assessment Module,* Monitoring River Heath Initiative Technical Report Number. 23, ISBN 0642548897, Environment Australia, Canberra.

Potts RT and Donato DB 2008, 'Peregrine Falcon *Falco pereginus* breeding success in a disused mining pit while taking prey from cyanide-bearing tailings dams', *Australian Field Ornithology*, Vol. 25, pp. 132-5.

Proctor H and Grigg A 2006, 'Aquatic invertebrate in final void water bodies at an open-cute coal mine in central Queensland', *Australian Journal of Entomology*, Vol. 45, pp. 107-121

RGS Environmental Pty Ltd (RGS) 2020, *Geochemical assessment of coal reject material*, prepared for Magnetic South Pty Ltd.

RGS Environmental Pty Ltd (RGS) 2019, *Geochemical Assessment of Mining Waste Materials*, prepared for Magnetic South Pty Ltd.

Standards Australia 1997, *Control of the obtrusive effects of outdoor lighting (AS 4282 – 1997),* Standards Australia (Standards Association of Australia)

Standards Australia 2006, *Explosives—Storage, transport and use (*AS 2187:2006), Standards Australia (Standards Association of Australia).

Standards Australia 2017, *The storage and handling of flammable and combustible liquids (AS1940:2017)*, Standards Australia (Standards Association of Australia).

State of Queensland 2018, *Mined Land Rehabilitation Policy*, prepared by Department of Environment and Heritage Protection, the Department of Natural Resources and Mines, and the Queensland Treasury, State of Queensland, Brisbane.

The Australasian Virtual Herbarium (AVH) 2019, *The Australasian Virtual Herbarium*, Council of Heads of Australasian Herbaria, viewed 2 August 2019, <http://avh.chah.org.au>.

Threatened Species Scientific Committee (TSSC) 2016, *Commonwealth Conservation Advice Petauroides volans greater glider*, Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Trinity Consultants Australia Pty Ltd trading as ASK Consulting Engineers (ASK) 2019, *Noise Impact Assessment,* prepared for Magnetic South Pty Ltd.

van Etten EJB 2011, The role and value of riparian vegetation for mine pit lakes, in *Mine Pit Lakes: Closure and Management,* McCullough CD (ed.), Australian Centre for Geomechanics, Perth, pp. 91-106.

Van Dyck S, Gynther I and Baker A (eds.) 2013, *Field Companion to The Mammals of Australia*, New Holland, Sydney.

Witheridge, G & Walker, R 1996, *Soil erosion and sediment control: engineering guidelines for Queensland construction sites*, Institute of Engineers; Queensland Division, Brisbane.

WRM Water & Environment Pty Ltd (WRM) 2020a*, Flood Impact Assessment*, prepared for Magnetic South Pty Ltd.

WRM Water & Environment Pty Ltd (WRM) 2020b*, Surface Water Impact Assessment*, prepared for Magnetic South Pty Ltd.

Young, PAR, Wilson, BA, McCosker, JC, Fensham, RJ, Morgan, G, & Taylor, PM 1999, 'Chapter 11: Brigalow Belt' in *The Conservation Status of Queensland's Bioregional Ecosystems* (eds. Sattler, PS &

Williams, RD), Ch. 11, pp. 1-81, Queensland Environmental Protection Agency, State of Queensland, Brisbane.

3D Environmental 2020, *Groundwater Dependent Ecosystems Assessment*, prepared for Magnetic South.

Appendix A Traffic Impact Assessment

Appendix B Surface Water Assessment

Appendix C Groundwater Impact Assessment

Appendix D Groundwater Monitoring Data

Appendix E Groundwater Monitoring and Management Plan

Appendix F Groundwater Dependent Ecosystem Assessment

Appendix G Geochemical Assessment of Mining Waste Materials

Appendix H Geochemical Assessment of Coal Reject Material

Appendix I Soil and Land Suitability Assessment

Appendix J Terrestrial Ecology Assessment

Appendix K Aquatic Ecology Assessment

Appendix L Air Quality and Greenhouse Gas Assessment

Appendix M Noise Impact Assessment

Appendix N Land-Based Effluent Disposal Assessment

Appendix O Visual Amenity Assessment

Appendix P Erosion and Sediment Control Plan

Appendix Q Receiving Environment Monitoring Program Design Document

Appendix R Environmental Offsets Strategy

GEMINI PROJECT

EA Application: Response to Secondary Information Request

PREPARED FOR

MAGNETIC SOUTH

AUGUST 2021

aarc ENVIRONMENTAL SOLUTIONS

BRISBANE OFFICE
Suite 5, 1 Swann Road
Taringa, QLD 4068
P +61 7 3217 8772

CAIRNS OFFICE
PO Box 4887
Cairns, QLD 4879
P +61 7 4057 9402

E info@aarc.net.au
AARC.NET.AU
ABN: 620 818 920
ACN: 71 620 818 920

Document Control

Project Name:	Gemini Project
Report Title:	EA Application: Secondary Information Request Response
Client:	Magnetic South
Project Manager:	Gareth Bramston

Version	Comments	Author	Reviewer	Date
Draft issued for client review		BM	GB	25 May 2021
DES preliminary submission		BM	GB	31 May 2021
Final DES submission		BM	GB	17 August 2021

This document is the property of AARC Environmental Solutions Pty Ltd ('AARC') and all rights are reserved in respect of it. This document has been prepared for the exclusive of AARC's client and may not be reproduced or disclosed in any manner whatsoever, in whole or in part, without the prior written consent of AARC. AARC expressly disclaims, to the maximum extent permitted by law, all responsibility for or liability arising from the use of this document by any third party. This document has been prepared subject to the instructions and scope of work agreed to with AARC's client. Any opinions or judgements expressed herein are based on our understanding and interpretation of current regulatory standards relevant to the specific needs of the client and should not be construed as legal opinions or legal advice. Information provided by the client while instructing AARC has been assumed to be correct and complete, and, where this report relies on field information, the condition of the assessed area as at the time of conducting any field assessment. AARC assumes no liability or responsibility for any inaccuracies or omissions outside of AARC's direct control. AARC makes no statement, representation or warranty about the accuracy or completeness of information relating to items not visible, accessible, or able to be inspected at the sites at the time of the site visits.

Table of Contents

1 Introduction 1

1.1 Background 1

2 Conceptual Project Layout 3

2.1 Geotechnical stability of Pit AB high wall 3

2.1.1 DES Comment 3

2.1.2 DES Requirement 3

2.1.3 Response 3

3 Traffic and Train Load Out Facility Construction 5

3.1 Train Load Out Facility access 5

3.1.1 DES Question 5

3.1.2 DES Requirement 5

3.1.3 Response 5

3.2 Traffic impacts of mine accommodation access 6

3.2.1 DES Question 6

3.2.2 DES Requirement 6

3.2.3 Response 6

3.3 Red Hill Road / Capricorn Highway intersection traffic impacts 6

3.3.1 DES Question 6

3.3.2 DES Requirement 6

3.3.3 Response 7

4 Groundwater 8

4.1 Relationship between streamflow and groundwater levels 8

4.1.1 DES Comment 8

4.1.2 DES Requirement 8

4.1.3 Response 8

4.2 Major anions and cations 12

4.2.1 DES Comment 12

4.2.2 DES Requirement 12

4.2.3 Response 13

4.3 Groundwater flow direction, identification of impact and reference bores 14

4.3.1 DES Comment 14

4.3.2 DES Requirement 15

4.3.3 Response 15

5 Geochemical Assessment of mine waste materials 19

5.1 Drill hole sample depth 19

5.1.1 DES Comment 19

5.1.2 DES Requirement 19

5.1.3 Response 19

5.2 Drill hole locations 19

5.2.1 DES Comment 19

5.2.2 DES Requirement 19

5.2.3 Response 20

6 Geochemical assessment of Coal Reject Material 21

6.1 Placement and encapsulation of rejects material 21

6.1.1 DES Comment 21

6.1.2 DES Requirement 21

6.1.3 Response 21

6.2 Coal reject sampling methodology 21

6.2.1 DES Comment 21

6.2.2 DES Requirement 22

6.2.3 Response 22

6.2.4 DES Comment 22

6.2.5 DES Requirement 22

6.2.6 Response 23

7 Soils and Land Suitability 24

7.1 Post Mining Land Use (PMLU) 24

7.1.1 DES Comment 24

7.1.2 DES Requirement 24

7.1.3 Response 24

8 Terrestrial ecology and Environmental Offsets Strategy 29

8.1 Area of impact for prescribed environmental matters 29

8.1.1 DES Comment 29

8.1.2 DES Requirement 29

8.1.3 Response 29

9 Aquatic ecology 33

9.1 Environmental Values for water quality 33
9.1.1 DES Comment 33
9.1.2 DES Requirement 33
9.1.3 Response 33
10 Air Quality and Greenhouse Gases 34
10.1 Ambient air quality monitoring data 34
10.1.1 DES Comment 34
10.1.2 DES Requirement 34
10.1.3 Response 34
10.2 Impact of revised mine camp location 36
10.2.1 DES Comment 36
10.2.2 DES Requirement 37
10.2.3 Response 37
10.3 Impact to sensitive receivers SR31 and SR32 38
10.3.1 DES Comment 38
10.3.2 DES Requirement 38
10.3.3 Response 38
10.4 Emission quantities over years of mine 38
10.4.1 DES Comment 38
10.4.2 DES Requirement 38
10.4.3 Response 38
10.5 Meteorological data used in modelling 39
10.5.1 DES Comment 39
10.5.2 DES Requirement 39
10.5.3 Response 39
11 Noise 40
11.1 Impact of revised mine camp location 40
11.1.1 DES Comment 40
11.1.2 DES Requirement 40
11.1.3 Response 40
11.2 Sensitive receivers SR31 and SR32 41
11.2.1 DES Comment 41
11.2.2 DES Requirement 41
11.2.3 Response 41

List of Figures

Figure 1: Revised conceptual project layout and location of adjacent sensitive receivers 2

Figure 2: Location of monitoring bores and water gauge stations 9

Figure 3: Alluvium and stream flow monitoring data 10

Figure 4: Groundwater level in, and base of, Tertiary sediments 16

Figure 5: Groundwater level and contours in Permian coal seams 17

Figure 6: Proposed Post Mining Land Use (PMLU) LSC for cattle grazing 26

Figure 7: Regulated Vegetation (Of Concern Regional Ecosystem (RE)) 30

Figure 8: Regulated vegetation (RE within a defined distance to a Vegetation Management Act 1999 (VM) watercourse 31

Figure 9: Connectivity Areas 32

Figure 10: Annual distribution of winds at the Project site predicted by TAPM/CALMET 35

Figure 11: Seasonal distribution of winds at the Project site predicted by TAPM/CALMET 36

List of Tables

Table 1: Pit design parameters for excavated eastern highwall 4

Table 2: Existing and proposed alluvial groundwater monitoring bores 18

Table 3: Pre and post mining cattle grazing LSC areas 25

Table 4: Post mining land suitability class that will be achieved for areas with a post mining land-use of grazing 27

Table 5: Significant Residual Impacts to Prescribed Environmental Matters 29

Appendices

Appendix A: Revised Traffic Impact Assessment

Appendix B: Groundwater Technical Memorandum

Appendix C: Figures for Groundwater Technical Memorandum

Appendix D: Mine Waste Geochemistry Technical Memorandum

Appendix E: Air Quality Technical Memorandum

Appendix F: Revised Noise Impact Assessment

1 Introduction

1.1 Background

The Gemini Project is a greenfield, open-cut metallurgical coal mine project, which will produce pulverised coal injection (PCI) coal and coking coal for export to the international steel making industry. The Project will be developed and managed by Magnetic South Pty Ltd, a private Australian based company which was founded in 2006. The executive team of Magnetic South has some 60 years' experience in the development and operation of metallurgical coal assets and agribusiness in central Queensland.

The Project is located in the Bowen Basin, approximately 110 km east of Emerald and 125 km southwest of Rockhampton, in central Queensland. Blackwater, a larger town serving mines in the region, is located approximately 34 km to the west.

An application for a site-specific environmental authority was submitted by Magnetic South on 23 October 2019 (application reference number APP0043095). The administering authority considered the EA application, and issued Magnetic South with an information request on 31 January 2020. Magnetic South provided a response to this information request in December 2020, accompanied by a revision to the EA Application Supporting Information document.

A notification of change for the Project was submitted to DES in Jan 2021, notifying of changes to the project layout in response to landholder consultation.

The minor revisions to the Project layout include the following:

- Relocation of the camp and associated infrastructure to the south of the Capricorn Highway, on Lot 4 on RP801280 and Lot 1 on HT424, to be accessed via the main mine access road.
- Removal of the Train Load Out Facility (TLO) access road from the Redrock Park Property to an alternate location further to the east.

An application to amend the ML surface area has also recently been made, to reflect the change in infrastructure location described in the EA application. The revised conceptual project layout, showing the updated camp location, surface rights extent and the nearest sensitive receivers is provided in Figure 1.

A secondary information request was received from DES in February 2021, which included questions in relation to the traffic, air and noise quality impacts of the revised Project layout, as well as a number of additional questions in relation to groundwater, geochemistry, water quality objectives, vegetation disturbance areas, post mining land use and Pit AB geotechnical stability.

In response to the secondary information request, a revision to the Traffic Impact Assessment (Appendix A) and Noise Impact Assessment (Appendix F) has been prepared. Supplementary technical memorandums have also been provided in relation to groundwater, mine waste geochemistry, air quality and noise (Appendices B-E). The purpose of this document is to provide a response to each question, specifically addressing each of the issues raised in the secondary information request and directing the administering authority to further information contained within the additional assessments and supplementary technical memorandums, where applicable.

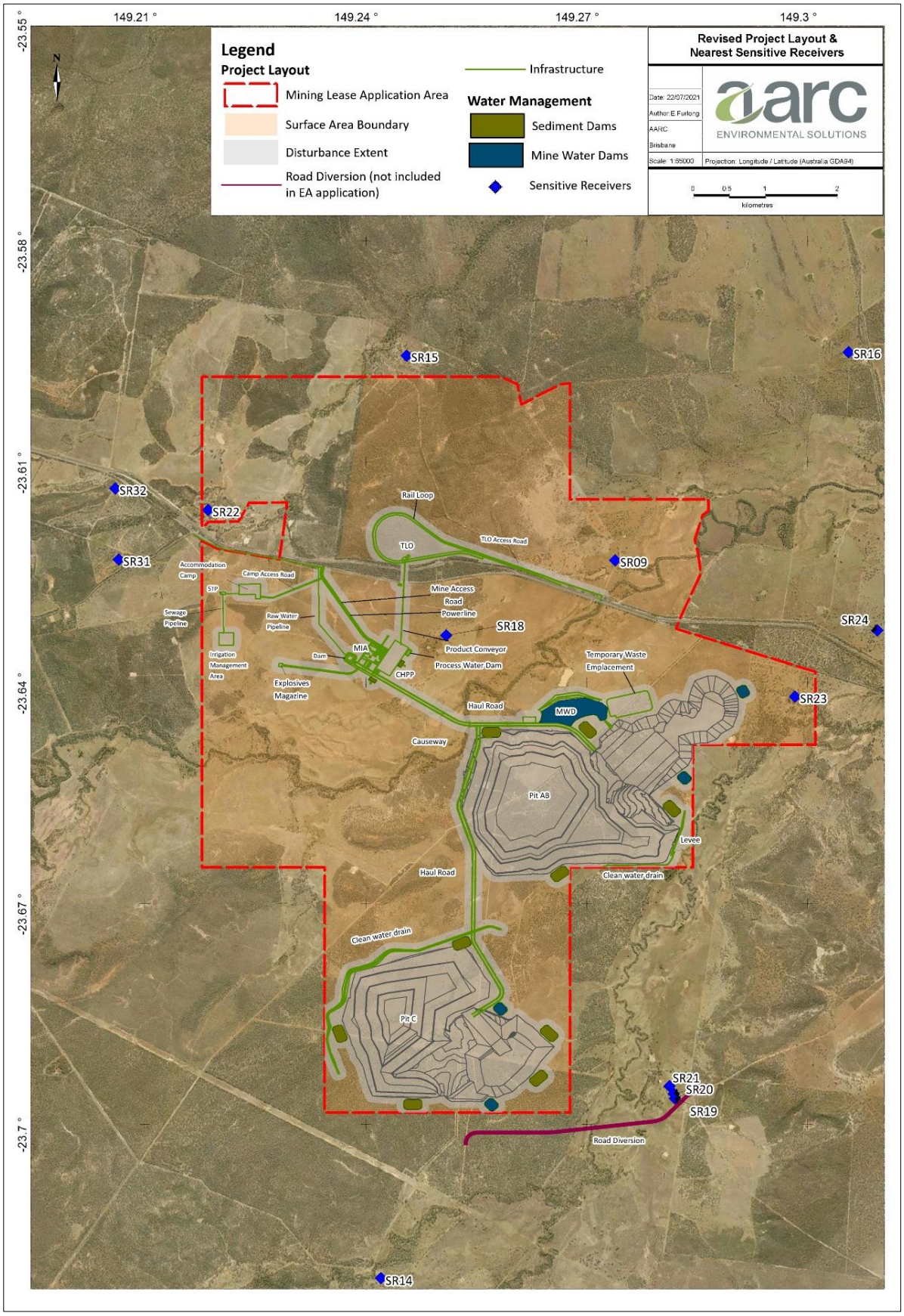


Figure 1: Revised conceptual project layout and location of adjacent sensitive receivers

2 Conceptual Project Layout

2.1 Geotechnical stability of Pit AB high wall

2.1.1 DES Comment

Figure 7 - Conceptual Layout of the Gemini Project shows that the crest of the high wall on the southern end of the Pit AB final void is proposed to extend right to a corner boundary of the tenure, MLA 700056. Table 7 states that a 100 metre buffer has been included around the perimeter of the disturbance footprint, but it is not clear if the buffer has been applied to this part of Pit AB final void area. The Revised Supporting Information does not sufficiently address information requirements, such as, the expected geotechnical stability of the final battered high wall and potential liability of high wall failure. The assessing officer's concern is that as the final landform is proposed to be so close to the tenure boundary, there is a possibility that high wall failure may cause impacts outside of the tenure boundary.

2.1.2 DES Requirement

Provide further information to justify the position of the final void for Pit AB with regard to the concerns of creating disturbance and impacts to environmental values (EVs) outside of the tenure boundary. Alternatively, provide a revised conceptual project layout that includes an appropriate buffer between the battered high wall of Pit AB final void and MLA 700056 boundary.

2.1.3 Response

2.1.3.1 Buffer around perimeter of disturbance footprint

Figure 7 in Section 3.1 of the *Revised EA Application Supporting Information* shows the conceptual project layout, including a 100m buffer within which disturbance may occur (also shown in Figure 1 of this report). The authorised disturbance areas provided in Table 7 include this 100 m buffer. The purpose of this 100 m buffer is to provide design flexibility for activities that may require disturbance beyond the original design infrastructure footprint. This 100m disturbance area has been reduced on the eastern edge of the AB Pit, due to the proximity of the mining lease (ML) boundary. The eastern edge of the AB Pit will be located approximately 50m from the edge of ML during mine operations, and the top of the final battered highwall (following backfill, regrading and rehabilitation activities) will be located approximately 15m from the edge of lease.

It was not intended that a 100 m buffer would be maintained between mining activities and the edge of the ML.

2.1.3.2 Geotechnical stability of the final battered high walls

The conceptual mine plan was based on preliminary geotechnical studies completed for the Project. The excavated eastern high wall slopes were designed to achieve a factor of safety of 1.3 during mine operations (refer to Table 1). The highwall slopes will then be flattened during rehabilitation, in order to achieve a stable post mining landform.

Geotechnical assessment of the post mining landform has now been undertaken for the Project. A final slope of 18° is proposed for the weathered upper sections of the void high walls (alluvium, Tertiary clay and weathered Permian zone) (instead of the previously described 22°). This additional geotechnical control will ensure the final void design achieves a minimum Factor of Safety of 1.5 for the entire Project. Where space is limited by proximity to the ML boundary, minor adjustments will be made in the detailed design phase of the Project, to ensure all disturbance is contained within the ML footprint both during and post-mining.

These minor changes will not result in significant changes to the mine plan layout and the location of the highwall in relation to the mining lease will remain unchanged to that which is shown in Figure 1.

It is proposed that the void design parameters summarised in Table 1 will replace previous design criteria described in Sections 4 and 5 of the *Revised EA Application Supporting Information*.

Table 1: Pit design parameters for excavated eastern highwall

Material / area	**High wall slope during mine operations to achieve SF of 1.3**	**High wall slope for final rehabilitated landform to achieve SF of 1.5**
Cenozoic soil (alluvium and Tertiary clay) (0-55m) and distinctly weathered Permian material	45° slopes with 20m batters in Cenozoic soil/distinctly weathered Permian material. A 15 m wide catch bench is proposed at the base of this horizon.	Maximum slope of 18°
Unweathered strata / coal measures	65° batters in slightly weathered/fresh coal measures. A 15 m catch bench is required every 50 m.	Maximum slope of 22°

3 Traffic and Train Load Out Facility Construction

3.1 Train Load Out Facility access

3.1.1 DES Question

An existing access road off the Capricorn Highway, Red Hill Road, is proposed to be the revised intersection and access road for the Train Load Out Facility (TLO). No detail has been provided regarding:

- existing condition of the intersection and road
- justification for its suitability for TLO construction and operation access
- whether upgrades will be necessary to make the intersection and road suitable for intended uses
- reference to a traffic impact assessment for the Capricorn Highway / Red Hill Road intersection.

The original application states, in section 3.3.4 of the supporting information, that Red Hill Road is only suitable for light vehicles but the revised section 3.3.4 and the notice of changed application state that construction equipment can be mobilised to the TLO along this access; however, no further detail has been provided about how this will be possible.

3.1.2 DES Requirement

Provide further detail and justification to demonstrate that Red Hill Road / Capricorn Highway intersection and Red Hill Road will be suitable for access to the TLO during construction and operation phases by addressing the concerns raised.

3.1.3 Response

Additional modifications have been proposed to the TLO access to address the concerns raised in the information request. A revised *Gemini Project Traffic Impact Assessment* (Cardno April 2021) (TIA) is provided in Appendix A.

3.1.3.1 TLO heavy vehicle access

To address concerns, heavy vehicle access to the TLO facility during construction is now proposed via a short temporary access track from the Capricorn Highway, to be located within the footprint of the product conveyor belt. This temporary heavy vehicle access will include a temporary level crossing over the existing rail line, to be in operation for the construction of the TLO and rail loop only, when larger volumes of materials are expected to be trucked to the site.

During operations, heavy vehicle access to the TLO is not required. Bulk materials required for maintenance will be transported to the Project via rail.

An assessment of the proposed temporary intersection with the Capricorn Highway is provided in Section 7.6 of the revised TIA. A figure showing the location of the proposed temporary access track is provided in Section 5.1.1 of the revised TIA (Appendix A).

3.1.3.2 TLO light vehicle access

Light vehicle (LV) access to the TLO during construction and operation will be via the existing Capricorn Highway / Red Hill Road intersection. An assessment of the existing road condition is provided in Section 3.1.5 of the revised TIA. It is anticipated that during peak construction and operations there will be approximately 4

light vehicle movements per day. The existing intersection is therefore considered to be suitable for the required light vehicle access requirements during construction and operations.

3.2 Traffic impacts of mine accommodation access

3.2.1 DES Question

Figure 1-1 and Figure 1-2 do not show the revised mine layout as per the notice of change application.

It is not clear what impacts the revised location of mine accommodation – which is now proposed to be accessed from the main mine access road – will have in terms of the potential increase in drive-in-drive-out traffic entering the mine access road, given that it is predicted that 80% of the operation workforce will be drive-in-drive-out on a weekly basis.

3.2.2 DES Requirement

Provide updated mine layout figures in the traffic impact assessment report. Provide a revised Appendix A: Traffic Impact Assessment to address the potential impacts of the proposed relocation of mine accommodation on traffic using the Capricorn highway and mine access intersection, as per the written notice of changed application. Alternatively, provide a justification of why the potential impact does not warrant updates to the Traffic Impact Assessment.

3.2.3 Response

The intersection impact assessment for the mine access road has been updated to include camp accommodation traffic (refer to Section 7.4 of the revised TIA (Appendix A)).

3.3 Red Hill Road / Capricorn Highway intersection traffic impacts

3.3.1 DES Question

The intersection Capricorn Highway / Red Hill Road has not been included in the assessment scope for State Intersections, and, as per the notice of changed application, this is the only proposed access road to the TLO. The written notice of change states that the road will only be used for two vehicle movements daily. It is not clear if this includes construction equipment during the TLO construction phase. Red Hill Road is directly adjacent to Charlevue Creek. Queensland Globe mapping indicates this is a watercourse with a stream order of 5 and contains Matters of State Environmental Significance (MSES) downstream. According to Figure 61 of the revised supporting information, Red Hill Road also falls within flood zone levels. However, the potential impacts to EVs related to Charlevue Creek have not been clearly addressed with regard to Red Hill Road use during construction and operation phases and contingency plans to access the TLO in case of flooding.

3.3.2 DES Requirement

Provide more information about the potential impacts to traffic of using Red Hill Road and the intersection with the Capricorn Highway, differentiating between the frequency and intensity of impact during TLO construction and operation phases and including consideration to the potential for flooding.

3.3.3 Response

An assessment of the Capricorn Highway / Red Hill Road intersection has now been included in Section 3.1.5 of the revised TIA (Appendix A). The revised TIA also included information about the frequency and intensity of traffic using the Capricorn Highway / Red Hill Road intersection during mine construction and operation (refer to Section 5.1 of the revised TIA) and an assessment of the traffic impacts of the project (Section 7.5).

It is anticipated that during both peak mine construction and operations there will be approximately 4 light vehicle movements per day. Heavy vehicle access to the TLO during construction is now proposed via an alternate temporary access. The minor increase in traffic associated with a small number of light vehicle movements is unlikely to impact environmental values outside of the existing road footprint. It is therefore not expected that there will be any impacts to downstream environmental values as a result of use of this intersection for light vehicles.

It is anticipated that on average the Red Hill Road train underpass will flood every one to two years. Should flooding occur emergency access to the TLO will be maintained via the rail level crossing or through private property via landholder agreements.

An erosion and sediment control plan (ESCP) has been prepared for the Project, which outlines the strategies to manage erosion, and the release of sediment into receiving waters, during Project construction and operations (including the potential impacts of Project traffic) (refer to section 6.1.6 of the *Gemini Project Erosion and Sediment Control Plan* (AARC 2020).

Water quality monitoring will be undertaken during mine operations (including at a location downstream of Red Hill Road in Charlevue Creek) in accordance with the *Gemini Project Receiving Environment Monitoring Program Design Document* (AARC 2020) to ensure the effectiveness of employed control measures, including the enforcement of sediment quality trigger values.

4 Groundwater

4.1 Relationship between streamflow and groundwater levels

4.1.1 DES Comment

Two downstream gauging and water quality monitoring stations are noted to have been installed on Charlevue and Springton Creeks (CC2 and SC2). It is understood that flow will be recorded continuously during a flow event. The date of installation and the data collected should be provided. These monitoring stations are considered to be important in establishing the relationship between creek flow and ground water levels.

4.1.2 DES Requirement

Provide the date of installation of the downstream flow gauging and water quality monitoring stations.

Provide the stream flow and water quality data that has been collected to date.

Collate this information with alluvial and groundwater dependent ecosystem (GDE) aquifer information to identify the relationship between streamflow and groundwater levels.

4.1.3 Response

Water gauge stations were installed at Charlevue Creek and Springton Creek on 19 November 2020.

Groundwater level data loggers have been installed in the Charlevue Creek alluvium monitoring bore (DW7076W) and Springton Creek alluvium monitoring bore (DW7292W1) since December 2018 and July 2020, respectively.

The location of existing groundwater monitoring bores and surface water gauging stations, along with identified potential GDE areas in the project area, are shown in Figure 2.

Time series plots of rainfall (derived from the SILO data drill), water level and water quality data (collected from the gauging stations and alluvium bores) are provided in Figure 3 and a summary of the key findings is provided below. A more detailed analysis is also provided in the *Response to DES Comments on the EA Submission – Gemini Project* (JBT Consulting, May 2020) (Groundwater Technical Memorandum) (Appendix B).

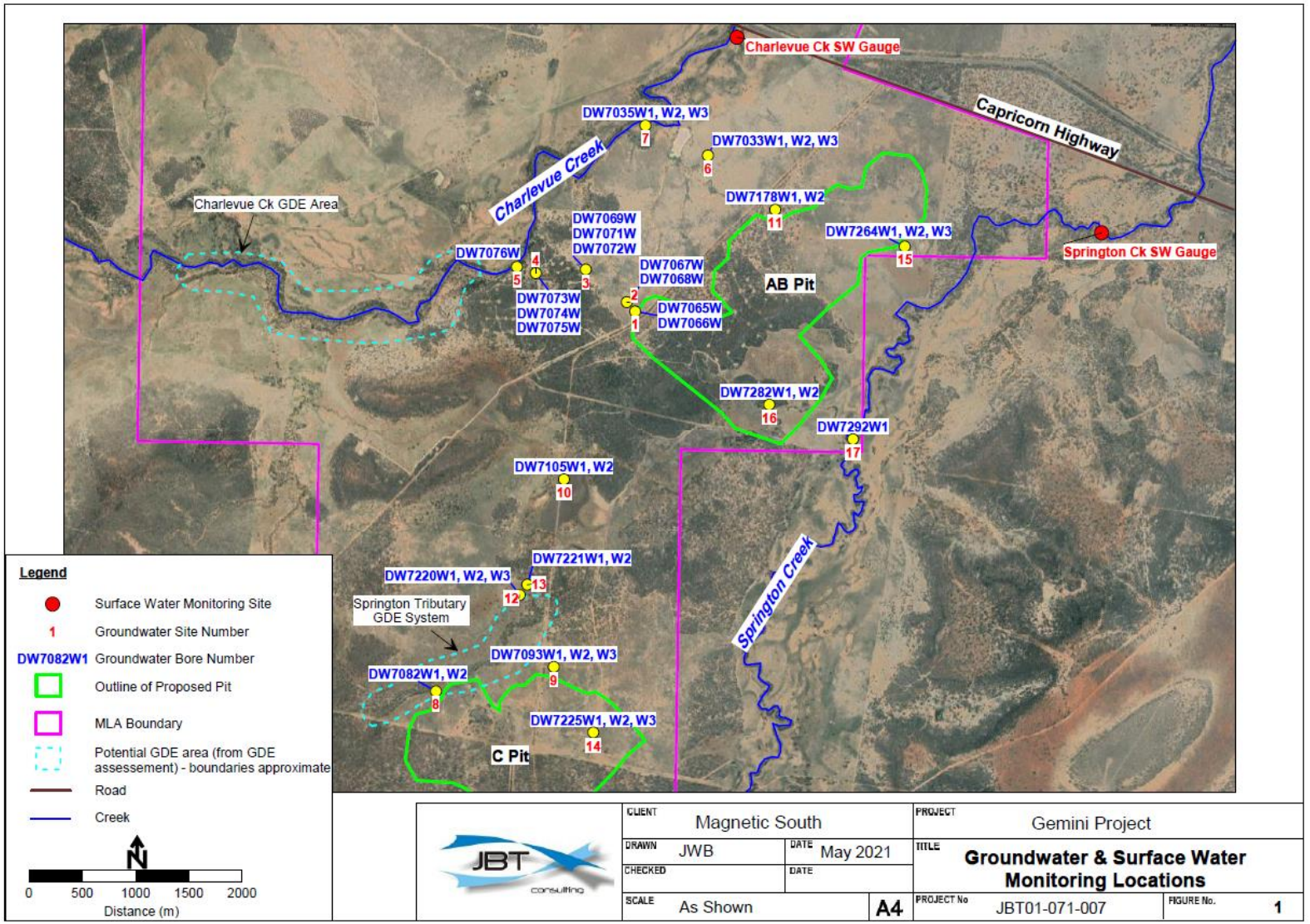


Figure 2: Location of monitoring bores and water gauge stations

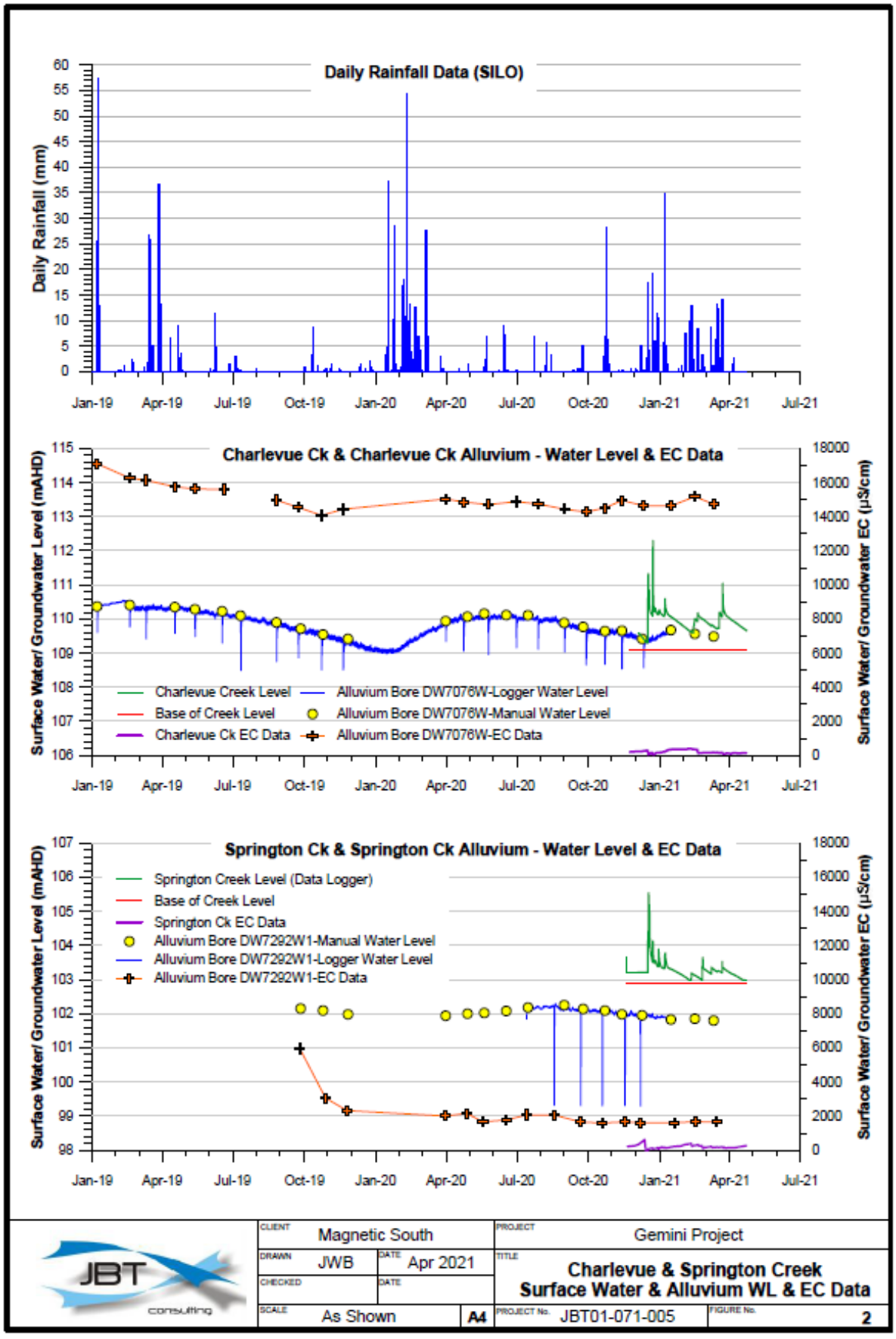


Figure 3: Alluvium and stream flow monitoring data

4.1.3.1 Charlevue Creek surface water and alluvium

The analysis of groundwater level data and stream flow data as it relates to the potential Charlevue Creek GDE (provided in Appendix B) concluded the following:

- Surface water levels in Charlevue Creek are highly reactive to rainfall, with water levels rising by more than 3 m in response to rainfall and failing relatively quickly towards the base of creek level during non-rainfall periods.
- Alluvial groundwater levels in the Charlevue Creek alluvium monitoring bore (DW7076W) are also shown to respond to high rainfall/streamflow events, rising and falling by up to 1.5 m between the wet season and dry season. Although less pronounced than the surface water reactivity to rainfall, seasonal (wet season/dry season) rise and fall in alluvial water level can be seen in the data, indicating that the alluvium is seasonally recharged by wet season streamflow events.
- The electrical conductivity (EC) of Charlevue Creek surface water is low, ranging between ~65 and 400 µS/cm. By contrast, the EC of groundwater within the Charlevue Creek alluvium at DW7076W is very high, ranging between ~14,000 to 17,000 µS/cm.
- A distinct seasonal variation in groundwater EC is not evident at DW7076W. This could indicate that a lens of fresh, low EC, low density water (from seasonal recharge) is occurring over a deeper zone of denser, higher EC groundwater. This interpretation is consistent with the findings of the *Groundwater Dependent Ecosystem Assessment* (3D Environmental 2020) (GDE Assessment), which postulates that the Charlevue Creek GDE area is supported by an unconfined, fresh alluvial aquifer perched above older Quaternary alluvium and Tertiary sediments. To further investigate this theory an additional groundwater monitoring bore could be installed within the sandy interval at this site (i.e. adjacent to bore DW7076W) and fitted with a water level/EC data logger.
- To monitor and detect future changes in the relationship between surface water flow, alluvium and the underlying groundwater units, a nested groundwater monitoring site will be designed and installed adjacent to the water gauge station prior to the commencement of mining activities, i.e:
    - Install one bore screened within the Charlevue Creek alluvium
    - Install one bore screened within underlying Tertiary strata
    - Install one bore screened within the underlying Permian strata at the shallowest depth where groundwater occurs
    - Install water level data loggers within all bores and undertake regular testing
    - Undertake hydraulic conductivity testing (i.e. slug testing) on all bores.

4.1.3.2 Springton Creek surface water and alluvium

The analysis of groundwater level data and stream flow data as it relates to the potential Springton Creek Tributary System GDE (provided in Appendix B) concluded the following:

- Streamflow response to rainfall and seasonal trends in the alluvial groundwater levels in the Springton Creek alluvium monitoring bore (DW7292W1) were similar to those described above for Charlevue Creek (although there was less variation in wet season/dry season water levels). This indicates that the Springton Creek alluvium is also seasonally recharged by wet season streamflow events.
- Springton Creek surface water EC had a similar EC range to Charlevue Creek. However, the EC of alluvial groundwater from DW7292W1 was much lower than at Charlevue Creek (generally <2,000 µS/cm).
- As with Charlevue Creek, EC levels do not appear to reduce with wet season recharge. It is therefore possible that this alluvial groundwater system is also stratified, as has been postulated above for Charlevue Creek. This is an interpretation consistent with the GDE Assessment, which indicates that the Springton Creek Tributary System GDE is supported by a seasonally variable perched aquifer.
- There are already a number of existing nested bores installed in the Tertiary and Permian groundwater in/ adjacent to the Springton Creek Tributary System GDE (DW7220, DW7221, DW7082, DW7093) (refer to Figure 2). Site DW7082 has been identified as a suitable location to install an alluvium bore, which would

provide a better understanding of the relationship between the alluvium and the underlying groundwater units in this location. This would also provide an additional impact monitoring bore for Pit C (also outlined in Section 4.3.3.3).

- To better understand the relationship between surface water and alluvium in Springton Creek an additional alluvium groundwater monitoring bore could be installed within the sandy interval at the eastern extent of the mining lease on Springton Creek. This would also provide an additional downstream / impact monitoring bore for Pit AB (also outlined in Section 4.3.3.3).
- In order to provide an upstream/reference bore for Pit C mining activities, it is also proposed to install an additional monitoring bore in the Springton Creek alluvium upstream of Pit C, prior to mining activities commencing in this area (Year 12) (also outlined in Section 4.3.3.3).

4.2 Major anions and cations

4.2.1 DES Comment

The information supporting the conclusions that have been made in relation to the limited hydraulic connectivity between the regional groundwater table and the perched aquifer that supports the GDE's (Appendix F: Groundwater Dependent Ecosystems Assessment) as well as the limited connectivity between the perched alluvium and deeper groundwater systems remain of concern to the department.

The conclusion is that it is unlikely that the project will reduce surface flows that replenish the perched GDE aquifer and that impacts of drawdown will not be propagated into the perched aquifer system, which is likely disconnected.

The proportions of major cations and anions within different monitoring bores can provide an indication of the degree of connectivity between groundwater bores. The major cations include sodium, potassium, calcium and magnesium and the major anions include chloride, sulphate, bicarbonate and carbonate.

Hydraulic conductivity has only been calculated for one (1) of the alluvial bores using the result from a single test to demonstrate that the alluvium is hydraulically isolated. Hydraulic conductivity testing should be provided to justify the conclusions drawn relating to the hydraulic conductivity of the GDE and alluvial aquifers.

The department has been unable to identify indicators/ thresholds/triggers that have been identified specifically for the purpose of protecting GDE values. While it is noted that conclusions have been drawn around the lack of connectivity between surface water, deeper groundwater and the GDE aquifers; there is little data to support the conclusions. A trigger of 2m/year has been assigned for an unconsolidated quaternary alluvial aquifer, and it is unclear how a 2m/year drawdown is believed to afford the relevant necessary protection to GDE's.

The department still considers it necessary to include indicators, thresholds and limits in drawdown that will be relevant to the protection of GDE values.

4.2.2 DES Requirement

All major anions and cations must be monitored for all bores in accordance with the current proposed monitoring regime. Produce a figure(s) that visualise the ionic chemistry of the groundwater samples, for example, a piper diagram.

Conduct adequate hydraulic conductivity testing of alluvial aquifers and include the data and results in the response. Identify and justify appropriate draw down triggers and management actions for the protection of GDE values.

4.2.3 Response

4.2.3.1 Box and whisker plots

Box and whisker plots for pH, field EC and sulphate have been produced for surface water, Quaternary alluvium, Tertiary sediments and Permian sediments, and are provided in Figures 3 - 5 of Appendix C. A summary of the relevant key findings is provided below. A more detailed analysis of these plots is provided in the Groundwater Technical Memorandum (Appendix B).

The EC ranges are highly variable, but showed the following trends:

- Surface water EC was generally relatively low, ranging from 65 to 392 µS/cm in Charlevue Creek and 1 to 615 µS/cm in Springton Creek.
- Quaternary alluvium EC was relatively high (particularly at Charlevue Creek), ranging from 14,079 µS/cm to 17,106 µS/cm at Charlevue Creek and 1,594 to 5,948 µS/cm at Springton Creek.
- Tertiary sediment EC is generally >7000 µS/cm
- Permian sediment EC is generally >10,000 µS/cm.

A number of observations were also made in relation to EC and groundwater levels in the nested bores located in/adjacent to the Springton Creek Tributary GDE area (DW7220, DW7221, DW7105) (refer to Figure 2 for locations):

- At site DW7220, both the Tertiary bore (W1) and shallow Permian bore (W2) recorded an EC of <2,000 µS/cm, which is much lower than was generally observed for these units. While the deeper Permian bore at this site (W3) had an EC range of 17,398 to 20,693 µS/cm.
- At site DW7221 the shallow Permian bore (W1) also recorded a relatively low EC ranging from 3,325 to 3,979 µS/cm. The deeper Permian bore (W2) records a higher EC range of 7,851 to 16,059 µS/cm.
- The data from these nested bores supports the theory in the GDE Assessment that the potential GDE's in this area are supported by a seasonally variable perched aquifer. This theory is further supported by the water level data collected from bores in this area, as follows:
    - Tertiary bore DW7220W1 records a water level that is approximately 16 mbgl while the deeper bores at this location record a water level of approximately 20 mbgl, indicating a potential for downward flow (i.e. recharge) at this site. The depth to groundwater at this site is considered too deep to support vegetation.
    - Tertiary bore DW7105W1 is dry, while the adjacent shallow Permian bore DW7105W2 records a water level of approximately 32 mbgl. The high EC range of the Permian bore at this location (949 to 1,367 µS/cm) indicates that recharge is occurring from the shallow groundwater system to the Permian strata at this site. The depth to groundwater at this site is also considered too deep to support vegetation.

4.2.3.2 Piper diagrams

Separate Piper diagrams for Tertiary bores, Permian Bores and surface water/Quaternary alluvium bores are provided in Figure 6 of Appendix C, as well as a combined diagram showing the data from all these water sources. A summary of the relevant key findings is provided below. A more detailed analysis of these diagrams is provided in the Groundwater Technical Memorandum (Appendix B).

- Plots for the surface water and alluvium bores are indicative of surface water recharge to the alluvial groundwater system.
- Plots for the Tertiary and Permian bores show increasing sodium and chloride with depth, indicating increased groundwater residence time (i.e. increasing salinity as groundwater moves downwards through the sediments).

- This data further supports the interpretation that the alluvium is receiving surface water recharge (as outlined in Section 4.1.3).

4.2.3.3 Conclusion

- Streamflow and alluvium water level and EC data indicates that recharge is occurring seasonally from the Springton Creek and Charlevue Creek into the adjacent alluvial groundwater.
- Salinity data presented in the box and whisker plots further supports the theory from the GDE Assessment (outlined in Section 4.1.3 above) that the potential GDE's identified in the ML are supported by a shallow seasonally variable perched aquifer systems.
- The depth to groundwater in the Springton Creek Tributary GDE area is generally considered too deep to support vegetation.
- Ongoing monitoring of major cations and anions will be included in the groundwater monitoring program for interpretive purposes, and to enhance the understanding of hydraulic isolation/connectivity between aquifer systems.

4.2.3.4 GDE drawdown triggers

Isotopic testing of groundwater samples and twig (xylem) samples taken from potential GDE areas do not demonstrate any overlap, with groundwater demonstrating much more depleted isotopic values (refer to section 4.3 of the GDE Assessment for details). However, twig samples did overlap with isotopic values of surface waters. These results indicate that trees within the identified potential GDE areas are not utilising groundwater in the regional Tertiary or alluvial aquifers, even when groundwater would be within reach of maximum rooting depth. The GDE Assessment further postulates that any groundwater usage by trees on the Project site is from fresh perched aquifers that are recharged from surface water and are disconnected from the regional aquifer. This theory is supported by the groundwater data (as discussed in Section 4.1 and 4.2 above).

It is therefore considered that if GDEs are present within the Project area, they are dependent on perched aquifers which are disconnected from the regional aquifer system.

However, to further understand the system, installation of additional monitoring bores is proposed prior to the commencement of mining activities (as detailed in Section 4.1.3).

As further data is collated and the system is better understood, specific GDE drawdown indicators/thresholds /limits will be developed if appropriate, prior to the commencement of mining activities.

4.3 Groundwater flow direction, identification of impact and reference bores

4.3.1 DES Comment

The groundwater network is representative of the groundwater units present, in that bores are located within each of the groundwater units; however, the bore locations have not been demonstrated to be representative of the directional flow of groundwater and reflect the up and down gradient for each groundwater unit. Furthermore, bore location continues to appear to be random and the spatial distribution is not well justified in terms of anticipated impacts from potential sources of contamination. Locations of reference bores should be located upgradient as opposed to just being 'distant'. The demonstration of conceptual understanding of ionic chemistry and groundwater flow direction is important to evaluate if the bore network is appropriate and representative. There does not currently appear to be an upgradient or reference bore proposed for the alluvial aquifers.

4.3.2 DES Requirement

Detailed conceptual understanding of the direction of groundwater flow needs to be demonstrated. Provide a figure illustrating ground water level contours indicating directional flow of groundwater. To demonstrate that the bore network is entirely representative of up and down gradient for each groundwater unit, produce a figure that visualises the ionic chemistry of the groundwater samples, for example, a piper diagram.

Provide justification for a lack of reference bores and up/down gradient bores for the alluvial aquifer or alternatively install the necessary bores.

4.3.3 Response

4.3.3.1 Groundwater flow direction in Tertiary sediments

A map of the elevation base of the Tertiary sediments (based on date for the site geological model) and the water level data for Tertiary sediment monitoring bores is provided in Figure 4. The Tertiary groundwater system in the ML area is shown to be intersected by a Permian ridge (shown in Grey), which separates the northern and southern parts of the mining lease. The groundwater flow direction in the Tertiary sediments in the ML area is therefore interpreted as being quite localised – moving towards the areas of lower Tertiary base elevation from areas where the preferential recharge occurs (e.g. the area around bore DW7220W1 (refer to Section 2.1.2 of Appendix B. A more detailed analysis is provided in Section 2.1.3 of Appendix B.

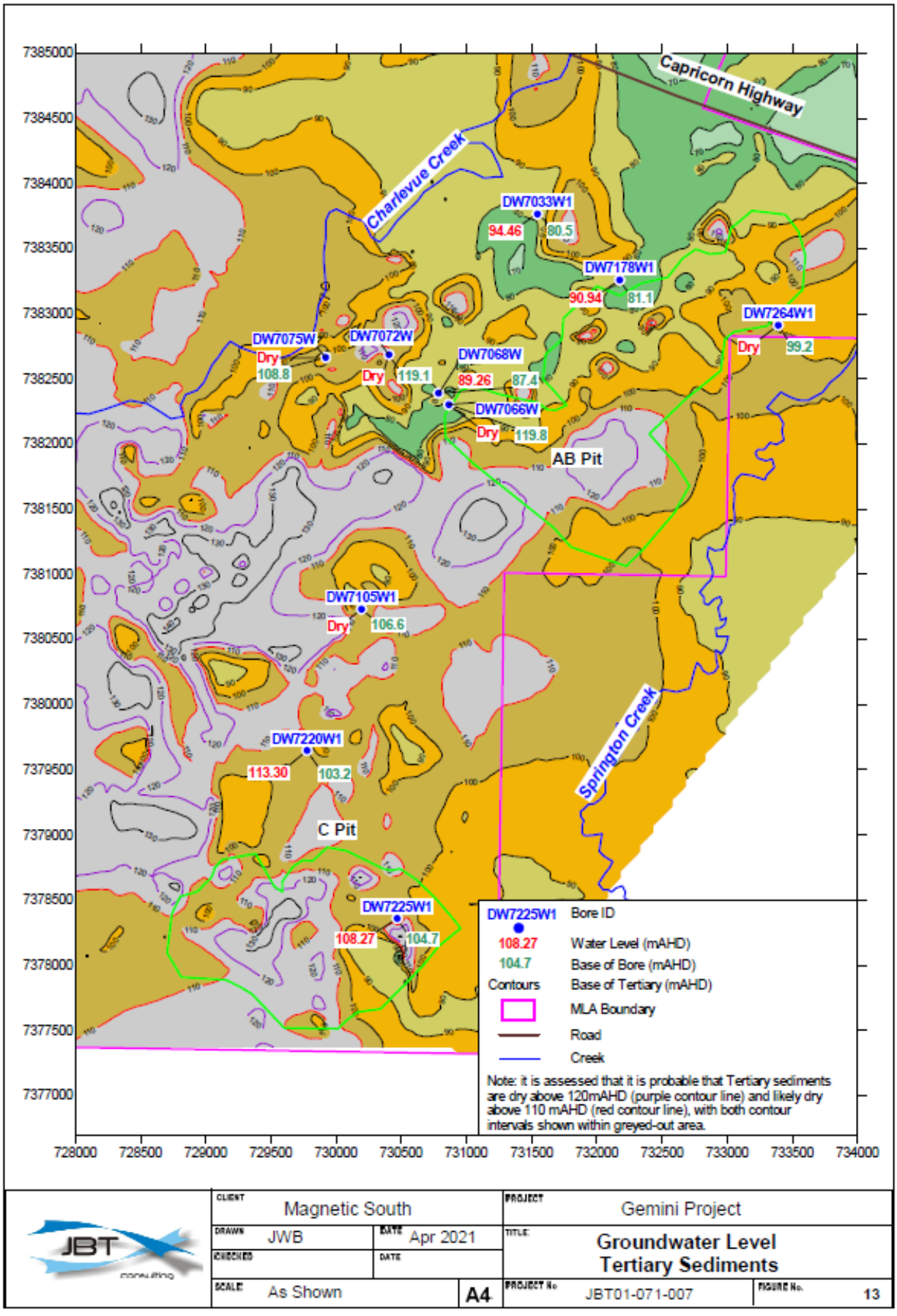


Figure 4: Groundwater level in, and base of, Tertiary sediments

4.3.3.2 Groundwater flow direction in Permian sediments

Groundwater level contours for the Permian sediments are shown in Figure 5. The data indicates that the groundwater flow direction in the Permian sediments is from the south-southwest to north-north-east.

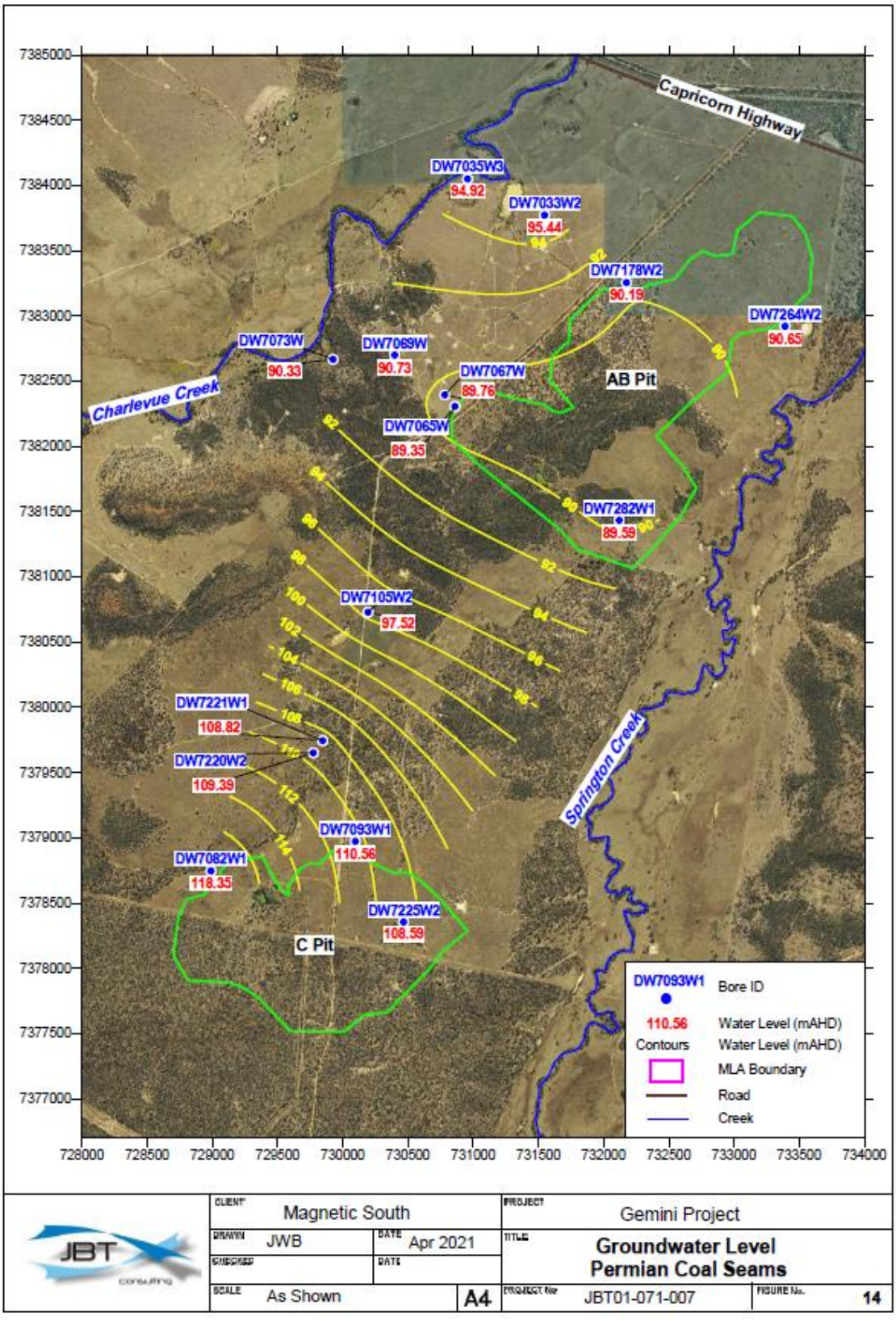


Figure 5: Groundwater level and contours in Permian coal seams

4.3.3.3 Alluvium monitoring bores

The location of existing/proposed groundwater monitoring reference/impact bores for the alluvial aquifer is shown in Table 2. The proposed new monitoring bores are to be installed prior to commencement of mining activities.

Table 2: Existing and proposed alluvial groundwater monitoring bores

	Charlevue Creek alluvium	**Springton Creek alluvium**
Upstream/reference bore	Charlevue Creek alluvium monitoring bore DW7076W Additional alluvium monitoring bore proposed to be installed (refer to Section 4.1.3.1).	Springton Creek alluvium monitoring bore DW7292W1 Additional alluvium monitoring bore proposed to be installed upstream of Pit C prior (refer to section 4.1.3.2).
Downstream/impact bore	Additional alluvium monitoring bore proposed to be installed adjacent to the water gauge station (refer to Section 4.1.3.1).	Alluvium monitoring bore proposed to be installed upstream of the water gauge station (refer to Section 4.1.3.2) Alluvium monitoring bore proposed to be installed at site DW7082 (refer to Section 4.1.3.2).

5 Geochemical Assessment of mine waste materials

5.1 Drill hole sample depth

5.1.1 DES Comment

In Section 2.1, it states, “recoverable coal will come from the Rangal coal seams but may also target the Upper Burngrove formation.” Figure A2 in Attachment A indicates that the Upper Burngrove coals seams are found at depths of approximately 175 metres (m) to 250m. However, in section 3.1, Table 3-1 indicates the maximum sample depth was 158.00 metres. It is not clear how these samples are representative of the geochemical characteristics of the Upper Burngrove Formation.

5.1.2 DES Requirement

Provide further explanation for the maximum sample depth, including justification that it is representative of geochemical characteristics and amount of potential mining waste materials expected to be encountered in the Upper Burngrove Formation given that Figure A2 identifies the coal seam presence at 175m to 250m, while the samples were taken at a shallower depth.

5.1.3 Response

The Gemini Project will target the Rangal Coal Measures (Aries, Castor and Pollux seams). It is not planned to mine coal seams in the Upper Burngrove Formation. Please refer to Section 2.1 of the *RGS Technical Memorandum: Geochemical Assessment of Mine Waste Materials* (RGS, May 2021) (Mine Waste Geochemistry Technical Memorandum) (Appendix D) for further information.

5.2 Drill hole locations

5.2.1 DES Comment

Table 3-1 in Section 3.1 of the Appendix G: Geochemical Assessment of Mining Waste Materials (RGS, Sep 2019) presents the drill hole identification (ID) numbers from which samples were taken for geochemical assessments, that is DW7002, DW7003 and DW7012. The drill hole ID numbers correspond to locations provided in Figure A3 (Attachment A) of Appendix G. Figure A3 shows that the three (3) drill holes sample sites are in the centre of MLA 700056 tenure area, in an area that is not proposed to be disturbed by activities associated with the mining project. Neither Appendix G nor the Revised Supporting Information document provide discussion of the sufficiency of the geochemical sampling sites to be representative of the characteristics of the mining waste materials likely to be encountered. It is not clear how the drill hole samples sites are representative of mining waste materials likely to be encountered for Gemini Project when the samples have been taken from outside the proposed areas for Pit AB and Pit C.

5.2.2 DES Requirement

Ensure a representative sampling regime is conducted for the assessment of geochemical properties of mining waste materials likely to be encountered. Provide a statement to justify that the chosen sampling regime sufficiently reflects the likely characteristics of mining waste materials encountered for Gemini Project, given the samples have been taken from outside the areas proposed to be disturbed by Pit AB and C.

5.2.3 Response

The three drill holes (DW7002, DW7003 and DW7012) used to collect representative samples of mining waste (spoil) materials were drilled in 2017 from an additional resource area that was targeted in early mine planning and subsequently dropped (as shown in Figure 1).

While it is acknowledged that the three drill holes are located outside the planned open pit areas, the chosen sampling regime is considered to sufficiently reflect the likely characteristics of mining waste materials encountered for the Gemini Project for the following reasons:

- Magnetic South has drilled 36 partially cored coal quality holes in the Pit AB and Pit C areas. The drilling consisted of five 150 mm large diameter (LD) cores twinned with four 100 mm cores at four sites. The major coal seams AR3, CAS, PLU1 and PLU2 were intersected in all holes as well as roof and floor samples.
- The cores were subjected to pre-treatment, washability and flotation testing on samples from both the thicker and thinner plies, and also provided sufficient coal and dilution mass to make up a simulated bulk ROM sample for bulk processing to generate product, reject and tailings material. This material was subjected to specialist handleability, thickening and dewatering test work, as well as physical, chemical, XRD and geotechnical characterization of the potentially clay rich reject and tailings.
- Results from quality testing showed very little variation between trace elements concentrations such as Sulphur, Phosphorus and Chlorine.
- The sedimentary stratigraphic profile, and overburden and interburden materials encountered at the drill hole locations DW7002, DW7003 and DW7012 is very similar to those encountered at the planned open pit areas (soil, clay, sandstone and siltstone).
- The Rangal Coal Measures are mined at a number of locations in the Bowen Basin. Mine spoil is typically very low in sulphur, has excess acid neutralising capacity (ANC) and is classified as Non-Acid Forming (NAF). These characteristics are typical of spoil characteristics at proposed and actual coal mines in close proximity to the Project such as the Walton Coal Project, Baralaba, Jellinbah and Yarrabee mines.

The three holes (DW7002, DW7003 and DW7012) are located in the same overburden and interburden strata at Pit AB and Pit C. This provides geological justification that these samples are representative of the material proposed to be mined from Pit AB and Pit C. Validation sampling will be undertaken during operations to confirm this conclusion.

6 Geochemical assessment of Coal Reject Material

6.1 Placement and encapsulation of rejects material

6.1.1 DES Comment

Regarding the expected coal reject material disposal, the Revised Supporting Information document states in Section 12.3, Table 68: "Coal rejects will be disposed of within Pit AB and Pit C and out-of-pit waste rock emplacements." Further in Section 13.4.1 and 13.4.4, respectively, it is stated: "Coal reject material will be placed where there is a lower risk of connectivity to surface water or groundwater resources." "Coal reject materials and any potentially acid forming waste rock materials identified will be selectively handled and encapsulated within waste rock emplacements and well away from the outside surface of rehabilitated landforms, where there is a low risk of connectivity to surface water or groundwater resources." Appendix H and the Revised Supporting Information document do not give clear locations of where coal reject material will be disposed of other than, generally, within the waste rock or spoil emplacements and at a depth where there is a lower risk of connectivity to surface water or groundwater resources.

Further information is required to ensure that there is sufficient capacity for the achievement of the proposed disposal requirements with respect to the proposed final landform.

6.1.2 DES Requirement

Provide a discussion of the likely position of disposed coal reject material within the out-of-pit and in-pit waste rock emplacements and demonstrate that there is sufficient capacity for proposed coal reject material disposal, including sufficient quantities of benign material to encapsulate potentially acid forming waste.

6.1.3 Response

It is estimated that less than 10 Mt of coal reject material will be generated over the life of the mine, while the volume of waste rock materials to be generated is estimated to be over 1000 Mt. The volume of coal reject material will make up a very small proportion of the total spoil materials (<1%).

It is anticipated that most coal reject materials have a relatively low risk of acid generation, while the overwhelming majority of waste rock waste samples are classified as non-acid forming, with excess acid neutralising capacity.

Reject material will be placed at least 10 m from the edge of the final spoil storage areas, such that it remains encapsulated and is not exposed near the surface of the final rehabilitated landforms/edge of void.

Ongoing sampling and geochemical testing of mining waste materials will be strategically undertaken during mine operations to verify the findings of the geochemical assessments and additional management measures will be employed where necessary to ensure reject materials are adequately neutralised.

Please refer to Section 2.3 of the Mine Waste Geochemistry Technical Memorandum (Appendix D) for further information.

6.2 Coal reject sampling methodology

6.2.1 DES Comment

Table 2.1 in Section 2.1 assigns geochemical samples to a sample number according to the coal seam (AR2, AR3, CAS, PLU1, PLU2); however, it is unclear what consideration was given to spatial variability across the coal

seams. It is noted that the samples are composite. It is not clear what influence this has on geochemical characteristics of the samples where quality may be variable across the coal seam.

6.2.2 DES Requirement

Provide a list of the coal reject drillhole ID numbers for each generated composite coal reject sample detailed in Table 2.1 of section 2.1. Provide further information on how the geochemical characteristics across a coal seam is considered in the assessment of the quality of coal reject material from each coal seam or each composite sample.

6.2.3 Response

6.2.3.1 Drill hole ID numbers contributing to each composite sample

Geochemical testing was undertaken for each of the target coal seams (Aries, Castor and Pollux). Evaluation of the anticipated geochemistry of coal reject materials requires a number of tests, including coal quality, processing methodologies and reject material geochemistry. This requires a high volume of material to be provided to the laboratory. It was therefore necessary to form composite samples for each coal seam using material from multiple drill holes. In consideration of the proportionately small volume of rejects to be produced and disposed of over the life of mine and the fact that reject waste streams will comprise a mixture of any number of coal seam waste products, the approach of composite sample testing across coal seams is considered appropriate.

Section 2.4 of the Mine Waste Geochemistry Technical Memorandum (Attachment D) provides details on which drill holes were used to form each of the composite samples.

6.2.3.2 Geochemical characteristics across coal seams

Sulphur contours plotted for the main target seams indicate that the total sulphur content of the coal seams is relatively consistent across the open pit areas. It is therefore considered that the average geochemical nature of bulk coal reject materials generated from processing the target coal seams is also likely to be consistent (although some natural variability will occur). Further detail, including figures showing total sulphur contours for the main target coal seams, is provided in Section 2.4 of the Mine Waste Geochemistry Technical Memorandum, describing coal reject sampling drill hole locations and overall representativeness.

6.2.4 DES Comment

Figure A3 provides the locations of the drill hole sites from which samples were extracted for geochemical assessment of coal rejects material. Figure A3 shows that one (1) drill hole was taken from the proposed area of Pit C (drill hole ID number DW7253C), while eight (8) where taken from the proposed area of Pit AB. Neither Appendix H nor the Revised Supporting Information document provide discussion of the sufficiency of the geochemical sampling sites to be representative of the characteristics of the mining waste materials likely to be encountered. It is not clear how the drill hole samples sites are representative of mining waste materials likely to be encountered for Gemini Project when the samples have been taken from outside the proposed areas for Pit AB and Pit C.

6.2.5 DES Requirement

Ensure a representative sampling regime is conducted for the assessment of geochemical properties of coal reject material likely to be produced. Provide a statement to justify that the chosen sampling regime sufficiently reflects the likely characteristics of coal reject material produced by the Gemini Project.

6.2.6 Response

It is acknowledged that the majority of coal reject material samples were taken from the Pit AB area.

As outlined in Section 6.2.3.2 above the average total sulphur content of the coal seams is relatively consistent across the open pit areas. The average geochemical nature of the bulk coal reject materials generated from processing the target coal seams is also likely to be relatively consistent. The coal reject samples are therefore expected to reflect the characteristics of the coal reject material at the Project. However, validation sampling and geochemical testing of mining waste materials will be undertaken during mine operations to verify the findings of the geochemical assessments. Please refer to Section 2.5 of the Mine Waste Geochemistry Technical Memorandum (Attachment D) for further detail.

7 Soils and Land Suitability

7.1 Post Mining Land Use (PMLU)

7.1.1 DES Comment

Appendix I provides pre-mining land suitability classes for grazing, which range from Class 2 to 4. It is stated that, "the majority of areas in the final landform will aim to restore a post-mining land use of grazing." However, "grazing" is not defined by a land suitability class that it will aim to achieve. Further discussion in this section describes areas that may not achieve the pre-mining land suitability class, "such as steeper outer slopes of spoil", but these areas are not referenced by a specific location.

For the mining disturbance domains that have a post-mining land use of grazing, it is unclear which areas are proposed to achieve the pre-mining land suitability class and which areas will not, and furthermore, what land suitability class for grazing they are proposed to achieve.

7.1.2 DES Requirement

Provide more detailed explanation and acceptance criteria for the post-mining land use "grazing", particularly:

- The land suitability class/es that will be achieved for areas with a post mining land-use of "grazing", including if it will return to pre-mining land suitability class or different
- If an area will have a different class to pre-mining, provide justification for how the proposed post-mining land suitability class is appropriate
- If "grazing" will achieve varying land suitability classes in the post-mining landform, provide proposed areas and locations for each class
- Given land suitability classes are assessed against limitations, provide the parameters that will demonstrate that an area has achieved the proposed post-mining land suitability class.

7.1.3 Response

The post mining cattle grazing Land Suitability Class (LSC) proposed to be achieved for each mine domain is shown in Figure 6. This was determined based on the *Land Suitability Assessment Technique* (DME 1995)), with consideration of the pre-mining LSC (refer to Figure 7 SLSA Assessment) and physical characteristics of the post mining landscape, such as topography, recreated soil profiles and the underlying substrate (e.g. mine waste).

The pre mining cattle grazing LSC that was determined for the project area is shown in Figure 7 of the *Gemini Project Soil and Land Suitability Assessment* (AARC, July 2019) (SLSA Assessment)).

The calculated area (in hectares) for each pre and post mining LSC within the project disturbance area is provided in Table 3.

Justification for the proposed post mining LSC of each Rehabilitation Area (RA) is provided in Table 4.

The parameters that will be used to demonstrate achievement of the post mining cattle grazing LSC are the same parameters which were used to assess the pre-mining land use suitability, as identified in the *Land Suitability Assessment Technique* (DME 1995): water availability, nutrient deficiency, soil physical factors, salinity, rockiness, ESP, wetness, topography, water erosion, flooding and vegetation regrowth.

Table 3: Pre and post mining cattle grazing LSC areas

Area (ha)						
	Class 2	**Class 3**	**Class 4**	**Class 5**	**Class 3/5**	**Total**
Pre-mining	63.2	1644.0	246.3	0	0	1953.5
Post-mining	0	631.5	1027.1	224.4	70.5	1953.5
Change from pre to post	-63.2	-1012.5	+780.8	+224.4	+70.5	0

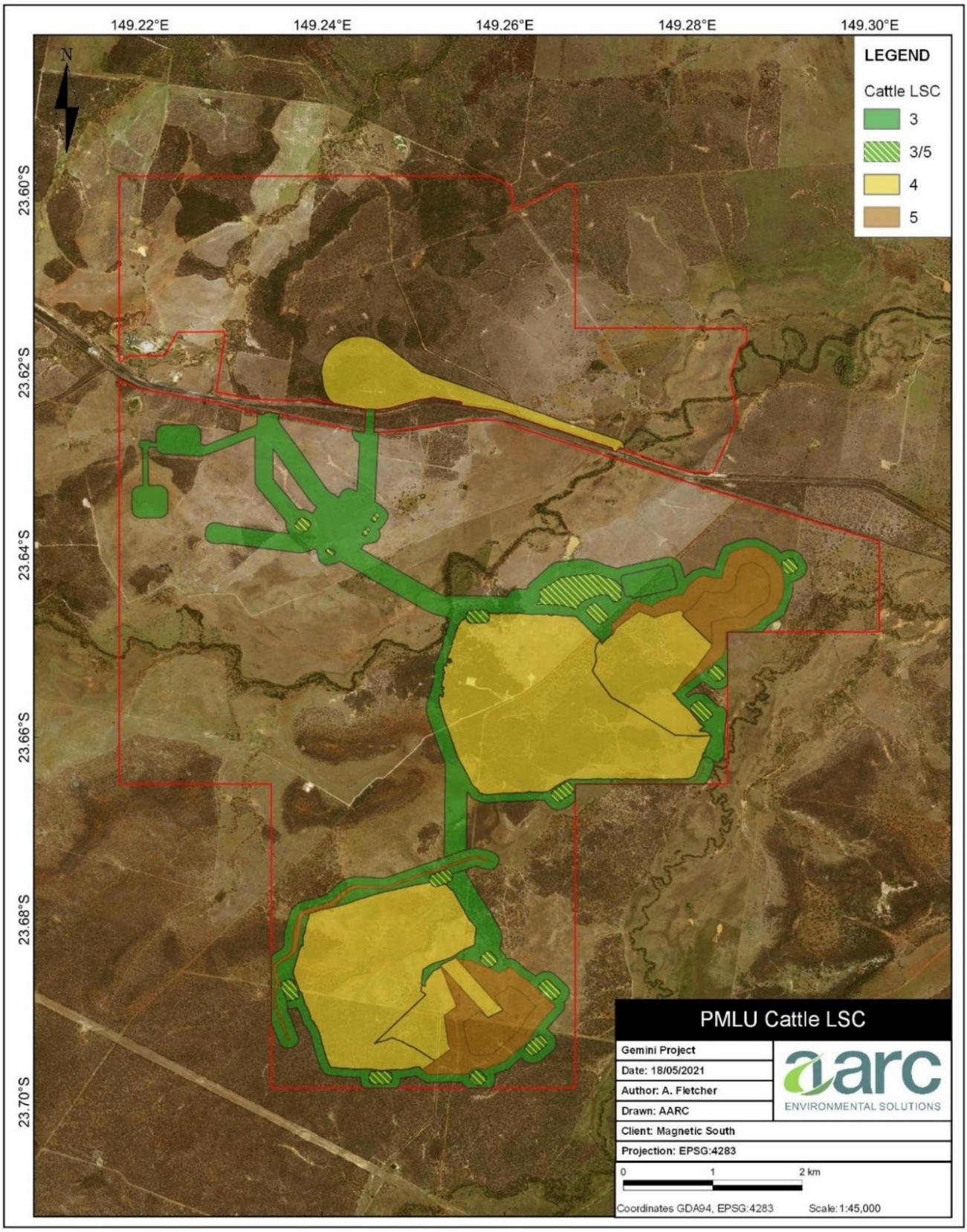


Figure 6: Proposed Post Mining Land Use (PMLU) LSC for cattle grazing

Table 4: Post mining land suitability class that will be achieved for areas with a post mining land-use of grazing

Area	Rehabilitation area description	Proposed PMLU	Pre-mining LSC (cattle grazing)	Post-mining LSC (cattle grazing)	Justification proposed post-mining LSC
RA1	Pit AB in pit and out of pit waste emplacements	Grazing	Class 3 & 4	Class 4	Slope It is planned that the final waste emplacements will have a maximum slope of approximately 6°, which is not anticipated to greatly impact the productivity for cattle grazing. However, the soil characteristics and nature of the underlying waste is anticipated to lead to increased limitations of land productivity in these areas, as outlined below. Soils The Pit AB footprint is comprised of areas with a cattle grazing LSC of 3 and 4, which are associated with the Geoffrey and Charlevue soil management units (SMUs), respectively. The Charlevue SMU has a variable pH, ranging from 5.4 (strongly acid) in the topsoil to 7.9 (moderately alkaline) in the lower subsoil. EC is medium in the surface soil (0.28-0.43 dS/m) and increases to high in the subsoil (0.46 dS/m). Chloride is considered to be high from 0.2 m depth downwards (>600 mg/kg), which can cause toxicity by interfering with plants' osmotic capacity. Due to the stark difference in textures between the topsoil and subsoil layers, pH for the Geoffrey SMU changes quite dramatically down the soil profile. Sandy, massive horizons (0.0-0.6 m) are moderately acidic, with pH gradually increasing with depth from 5.8 to 6.0. The clay B2 horizon has a pH value over two units higher (8.1) and is classified as 'moderately alkaline'. This is likely due to the increased CEC of the clay in the B2 horizon compared with the sand in the upper horizons. As such, it is expected that the recreated soil profile in this area would practically achieve a cattle grazing LSC of 4. Plant Available Water Capacity The pre-mining plant available water capacity (PAWC) for the Charlevue and Geoffrey SMUs have been assessed at 75-100mm (LSC 3). PAWC is identified as one of the limiting factors for productivity of these SMUs. It is anticipated that the chemical and physical properties of the underlying spoil material, combined with anticipated post mining soil depths, is such that the growth medium will be reduced to the top 20-40cm, effectively reducing the LSC for cattle grazing to Class 4 in this area. Erosion Risk Recreated post-mining landforms, such as in pit and out of pit spoil, will initially present an increased risk of erosion. Particularly on the slopes of the out of pit spoil dumps. Cattle grazing at a reduced intensity is therefore recommended, until such time that landforms stabilise and soil profiles further develop. This change in productivity is expected to be consistent with cattle grazing LSC 4.
	Pit C in pit and out of pit waste emplacements	Grazing	Class 3	Class 4	Slope It is planned that the final waste emplacements will have a maximum slope of approximately 6°, which is not anticipated to greatly impact the productivity for cattle grazing. However, the soil characteristics and nature of the underlying waste is anticipated to lead to increased limitations of land productivity in these areas, as outlined below. Soils The Pit C footprint is comprised of LSC3 areas, associated with the Geoffrey, Namoi and Cooinda SMUs. Plant Available Water Capacity The pre-mining plant available water capacity (PAWC) for the Geoffrey and Cooinda SMUs have been assessed at 75-100mm (LSC 3), with Namoi assessed at 100-125mm (LSC 2). PAWC is identified as one of the limiting factors for productivity of the Geoffrey and Cooinda SMUs. It is anticipated that the chemical and physical properties of the underlying spoil material, combined with anticipated post mining soil depths, is such that the growth medium will be reduced to the top 20-40cm, effectively reducing the PAWC to LSC (cattle grazing) 4 in this area. Erosion Risk Recreated post-mining landforms, such as in pit and out of pit spoil, will initially present an increased risk of erosion. Particularly on the slopes of the out of pit spoil dumps. Cattle grazing at a reduced intensity is therefore recommended, until such time that landforms stabilise and soil profiles further develop. This change in productivity is expected to be consistent with cattle grazing LSC 4.
RA2	Temporary waste rock emplacements	Grazing	Class 3	Class 3	No change to the LSC for cattle grazing is predicted.

Area	Rehabilitation area description	Proposed PMLU	Pre-mining LSC (cattle grazing)	Post-mining LSC (cattle grazing)	Justification proposed post-mining LSC
RA5	Residual void low walls	Grazing	Class 3 & 4	Class 4	<u>Slope</u> It is planned that the final waste emplacements will have a maximum slope of approximately 6°, which is not anticipated to greatly impact the productivity for cattle grazing. However, the soil characteristics and nature of the underlying waste is anticipated to lead to increased limitations of land productivity in these areas, as outlined below. <u>Soils</u> The Charlevue SMU has a variable pH, ranging from 5.4 (strongly acid) in the topsoil to 7.9 (moderately alkaline) in the lower subsoil. EC is medium in the surface soil (0.28-0.43 dS/m) and increases to high in the subsoil (0.46 dS/m). Chloride is considered to be high from 0.2 m depth downwards (>600 mg/kg), which can cause toxicity by interfering with plants' osmotic capacity. Due to the stark difference in textures between the topsoil and subsoil layers, pH for the Geoffrey SMU changes quite dramatically down the soil profile. Sandy, massive horizons (0.0-0.6 m) are moderately acidic, with pH gradually increasing with depth from 5.8 to 6.0. The clay B2 horizon has a pH value over two units higher (8.1) and is classified as 'moderately alkaline'. This is likely due to the increased CEC of the clay in the B2 horizon compared with the sand in the upper horizons. As such, it is expected that the recreated soil profile in this area would practically achieve a cattle grazing LSC of 4. <u>Plant Available Water Capacity</u> The pre-mining plant available water capacity (PAWC) for the Charlevue and Geoffrey SMUs have been assessed at 75-100mm (LSC 3). PAWC is identified as one of the limiting factors for productivity of these SMUs. It is anticipated that the chemical and physical properties of the underlying spoil material, combined with anticipated post mining soil depths, is such that the growth medium will be reduced to the top 20-40cm, effectively reducing the LSC (cattle grazing) to Class 4 in this area. <u>Erosion Risk</u> Recreated post-mining landforms, such as in pit and out of pit spoil, will initially present an increased risk of erosion. Particularly on the slopes of the out of pit spoil dumps. Cattle grazing at a reduced intensity is therefore recommended, until such time that landforms stabilise and soil profiles further develop. This change in productivity is expected to be consistent with cattle grazing LSC 4.
RA6	Clean water drains	Native vegetation	Class 3	Class 5	Clean water drains will become permanent landforms, which will incorporate geomorphic and riparian vegetation features and provide ongoing habitat and connectivity to Springton Creek.
	Other water Management Infrastructure (mine water dams, sediment dams, raw water dams)	Grazing/native vegetation	Class 2 & 3	Class 3 / Class 5	The pre-mining footprint of these areas is predominantly comprised of LSC 3 areas (associated with the Geoffrey and Namoi SMUs), with a small pocket of LSC 2 area located near the Mine infrastructure Area (associated with the Kosh SMU). If water storage facilities are identified by the post-mining landholder as of value to their future use of the land, an agreement may be is entered into to retain water storages, in which case these areas will have a post mining LSC of 5. Otherwise, they will be regraded to natural surface levels and returned to a grazing land use. It is anticipated that areas returned to a post mining land use of cattle grazing can be returned to LSC 3. Given the small area of Class 2 soils that will be stripped for the project, it is considered that the most viable and beneficial option for these soils will be to use them for mixing with other more problematic soils.
RA7	Train loadout facility (TLO)	Grazing	Class 3 &4	Class 4	<u>Soils</u> The TLO footprint is comprised of LSC 3 and 4 areas associated with the Geoffrey and Nigel soil management units (SMU). The area is predominantly Class 4 land. The pH within the Nigel SMU is highly variable, changing from 6.3 (slightly acid) in the topsoil to 8.5 (strongly alkaline) in the lower subsoil. EC follows a similar pattern, changing from very low between 0.0-0.3 m depth, to medium in the subsoil. CEC increases with depth from low (6.8 meq/100g) to moderate (17.4 meq/100g), likely due to the increased clay content in the subsoil layers. It is therefore anticipated that this area can returned to a post mining cattle grazing LSC of 4.
	Mine infrastructure areas (CHPP, camp, STP, effluent irrigation area, roads).	Grazing	Class 2 & 3	Class 3	<u>Soils</u> The majority of these areas have a cattle grazing LSC of 3 (associated with the Geoffrey SMU), with an area of cattle grazing LSC 2 in the road and effluent irrigation area footprints, associated with Kosh and Normanby SMUs. As described above, the pH for the Geoffrey SMU changes quite dramatically down the soil profile. Sandy, massive horizons (0.0-0.6 m) are moderately acidic, with pH gradually increasing with depth from 5.8 to 6.0. The clay B2 horizon has a pH value over two units higher (8.1) and is classified as 'moderately alkaline'. This is likely due to the increased CEC of the clay in the B2 horizon compared with the sand in the upper horizons. As these infrastructure areas will remain relatively flat, consistent with the surrounding landscape, it is anticipated these areas can be returned to post-mining cattle grazing LSC of 3. Given the small area of Class 2 soils that will be stripped for the project, it is considered that the most viable and beneficial option for these soils will be to use them for mixing with more problematic soils.

8 Terrestrial ecology and Environmental Offsets Strategy

8.1 Area of impact for prescribed environmental matters

8.1.1 DES Comment

The maximum extent of impact (ha) has been provided as a total area for all regulated vegetation that are regional ecosystems within a defined distance of a vegetation management watercourse and for connectivity areas that are regional ecosystems. It is unclear the maximum extent of impact (ha) to each regional ecosystem identification for both these prescribed matters. The draft EA conditions for impacts to prescribed environmental matters does not include reference figures associated with Table H2 to provide context about the locations of prescribed environmental matters being offset and therefore, it is unclear the locations within the project area they are located.

8.1.2 DES Requirement

As per the mining guideline for Model Mining Conditions (ESR/2016/1936, Version 6.02, Effective 07 Mar 17) for Impacts to Prescribed Environmental Matters, provide the location of impact and area (ha) of maximum extent of impact for each regional ecosystem (RE) within the prescribed environmental matters for regulated vegetation and connectivity areas. For the location of impact, multiple figures that reference only the areas of the prescribed environmental matters that are being impacted by the resource activity, is preferable.

8.1.3 Response

A revised Table H2 has been prepared providing a breakdown of the area of each regional ecosystem (RE) for each of the Prescribed Environmental Matters (Table 5).

Table 5: Significant Residual Impacts to Prescribed Environmental Matters

Prescribed Environmental Matter	Description		Maximum Extent of Impact (ha)		Figure
Regulated Vegetation	Of concern regional ecosystem	RE 11.3.2	2.57		Figure 7
	Regional ecosystems within a defined distance of a vegetation management watercourse	RE 11.5.2	31.01	58.32	Figure 8
		RE 11.3.2	0.59		
		RE 11.7.2	17.82		
		RE 11.3.25	8.9		
Connectivity Areas		RE 11.3.2	3.15	710.7	Figure 9
		RE 11.3.25	21.85		
		RE 11.5.2	374.02		
		RE 11.7.2	311.68		

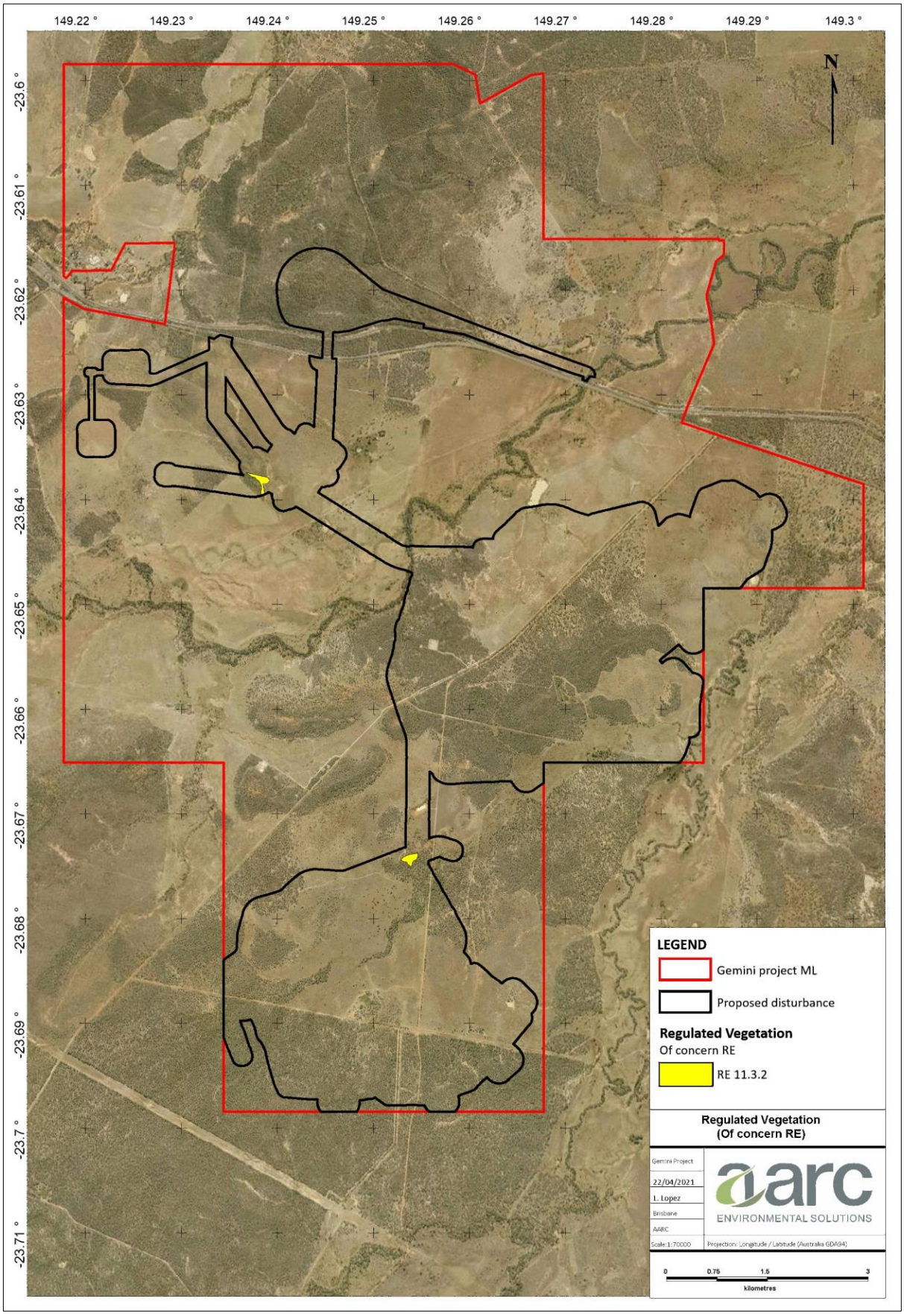


Figure 7: Regulated Vegetation (Of Concern Regional Ecosystem (RE))

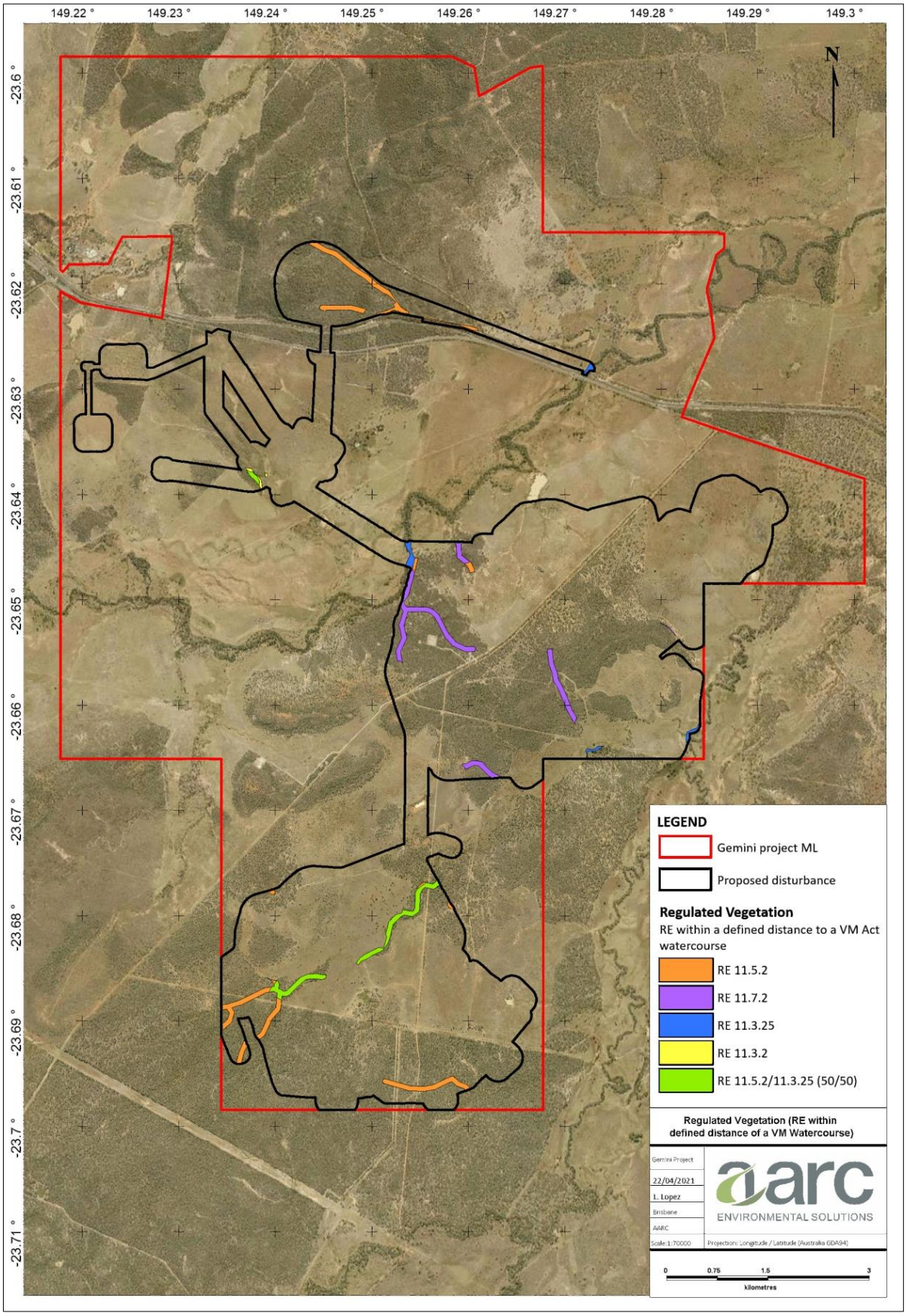


Figure 8: Regulated vegetation (RE within a defined distance to a Vegetation Management Act 1999 (VM) watercourse

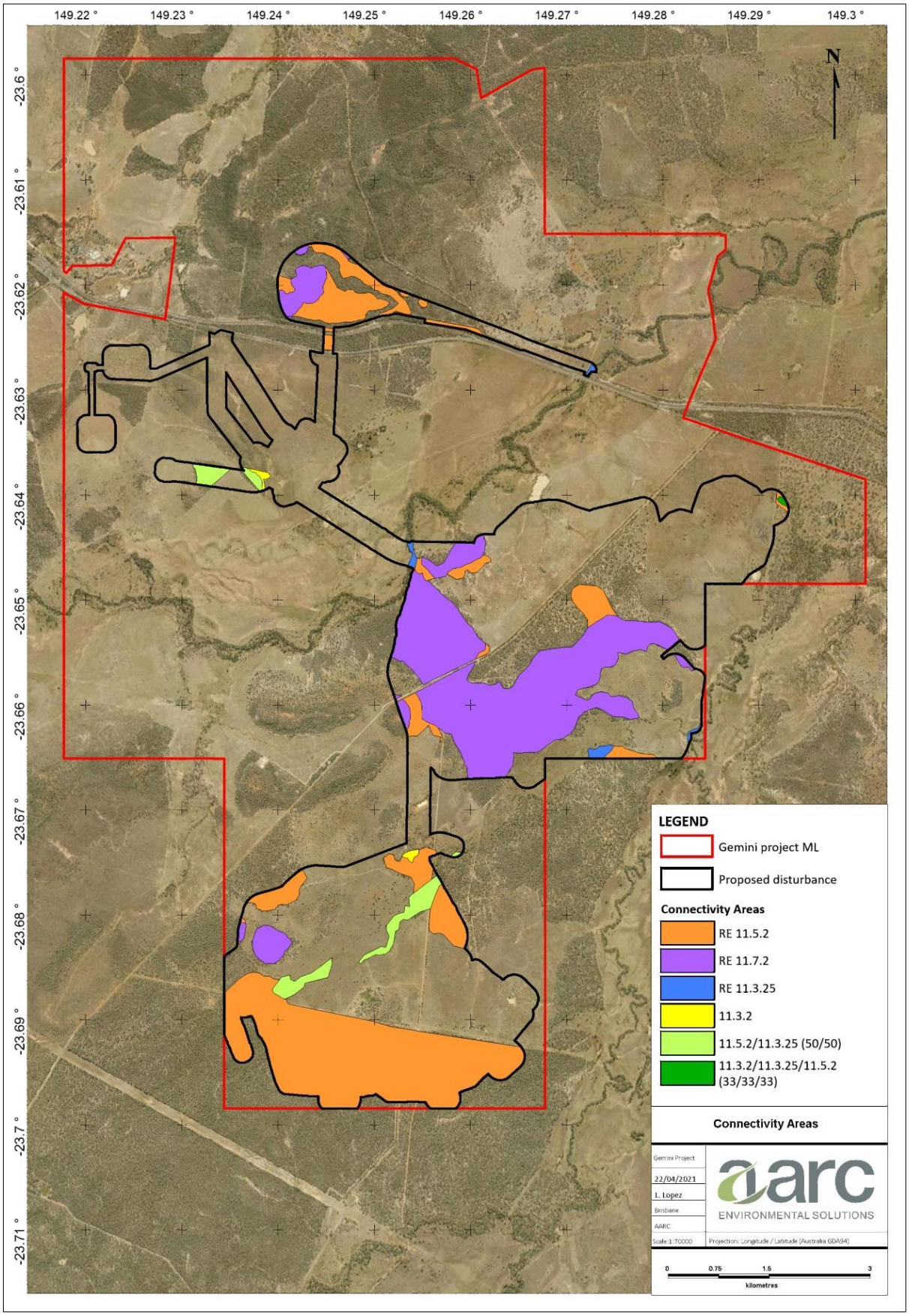


Figure 9: Connectivity Areas

9 Aquatic ecology

9.1 Environmental Values for water quality

9.1.1 DES Comment

Section 4.1 states: "EHP identifies ten EVs in the Mackenzie River (2013b) sub- basin. Two of these are deemed relevant for the waters surrounding the study area: 1. protection of aquatic ecosystem values; and 2. suitability for stock watering." Discussion about the other eight (8) EVs for waters listed in the Environmental Protection (Water) Policy 2009 has not been addressed to provide sufficient explanation for why only two (2 EVs are relevant. Please also note, the original application for Gemini Project was submitted on 23 October 2019. Environmental Protection (Water) Policy 2009 was superseded by Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP Water 2019) on 1 September 2019. Section 6 of the EPP Water 2019 defines eleven (11) EVs for waters to be enhanced and protected.

9.1.2 DES Requirement

Ensure references to subordinate legislation are current for the time of original submission of the EA application for Gemini Project. Address all EVs for waters providing justification for why they may or may not be relevant.

9.1.3 Response

Section 7.2.3 of the application is to be removed and replaced with the following:

In accordance with section 6 and Schedule 1 of the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP (Water)), environmental values (EVs) and water quality objectives (WQOs) for the Mackenzie River Sub-basin area are those described in the *Mackenzie River Sub-basin Environmental Values and Water Quality Objectives* document (DES 2011) (Mackenzie River WQOs document). Charlevue Creek and Springton Creek form part of the basin's southern tributaries.

EVs ascribed to the southern tributaries of the Mackenzie River Sub-basin are:

- Protection of aquatic ecosystems (moderately disturbed)
- Suitability for farm supply and use
- Suitability for stock water
- Suitability for human consumption of aquatic foods
- Suitability for primary contact recreation
- Suitability for secondary contact recreation
- Suitability for visual recreation
- Suitability for drinking water
- Suitability for industrial use
- Cultural and spiritual values

A list of WQOs for the environmental values described above is provided in the *Mackenzie River WQOs document*.

10 Air Quality and Greenhouse Gases

10.1 Ambient air quality monitoring data

10.1.1 DES Comment

It is noted from Section 3.3.3.2.1 of Appendix L that air quality data from Department of Environment and Science (the department) monitoring station in Blackwater has been used to provide ambient background concentrations. Section 9.2.3.1 of Revised Supporting Information states that data from the department's monitoring station in Blackwater adequately accounts for potential cumulative contributions from surrounding industry, including Bluff Coal Mine. Bluff Coal Mine is 12 kilometres (km) from Gemini Project. Blackwater is located a further 23km west of Bluff Coal Mine, i.e., a total of 35 km from Gemini Project. Ambient background concentrations measured at Blackwater would, therefore, not be representative of the ambient air quality at Gemini, which is a lot closer to Bluff, for example, than Bluff is to Blackwater. Gemini Project is also located in a different direction from Bluff than Blackwater, and therefore, ambient air quality as influenced by prevailing winds, for example, would be quite different.

Section 9.2.3.1 also states that Bluff Coal Mine is currently in care and maintenance with no certainty of return to operations. Therefore, it is not clear if air quality modelling for Gemini Project has accounted for the worst case scenario which assumes Bluff Coal Mine is operating at full capacity at the same time as Gemini Project.

10.1.2 DES Requirement

Explain how Blackwater monitoring data is expected to adequately account for the potential contributions to existing air quality and adequately represent cumulative impacts to air quality in the assessment model, with particular reference to Bluff Coal Mine.

10.1.3 Response

An explanation for how the Blackwater monitoring data adequately accounts for potential contributions to air quality, and adequately represent cumulative impacts to air quality in the assessment model, is provided below. Refer to Item 1 in the *Response to Further Information Request: Gemini Project: Air Quality and Greenhouse Gas Assessment* (Katestone, May 2021) (Air Quality Technical Memorandum) (Appendix E)) for further detail.

10.1.3.1 Period of data available for analysis

DES commenced monitoring PM10 and PM2.5 at Bluff in November 2020. Consequently, there is insufficient data available from DES's Bluff monitoring station to adequately characterise air quality. The Bluff Coal Mine is currently in care and maintenance with no certainty of return to operation.

At the time of the current Air Quality and Greenhouse Gas Assessment (Katestone, Dec 2020) (AQGGA), DES's Blackwater monitoring station was the closest monitoring station to the Project which had more than 12 months of PM10 and PM2.5 data available for analysis.

10.1.3.2 Proximity to other mines

The Blackwater monitoring station is located approximately 35 km west of the project and is surrounded by five mines located between 6km and 18km from the station, with three of the mines located within 11km. Those three mines are estimated to have emitted 21,242 tonnes of PM10 to air for the 2019/2010 based on NPI reporting.

The Bluff monitoring station is located within 1km of the Bluff Coal Mine. There are no other mines located within 11km of the Bluff monitoring station. The Gemini Project has only one mine within 11km and that is the Bluff Coal Mine, located 11km to the west. The Bluff Coal Mine was estimated to have emitted 1,098 tonnes of PM10 to air for the 2019/2020 reporting period.

10.1.3.3 Wind direction

The Bluff Coal Mine is located approximately 11km to the west of the Project site. As detailed in Appendix A of the AQGGA and shown in Figure 10 and Figure 11 of this report, the meteorological data for the Gemini Project illustrates that winds occur infrequently from the west (less than 8% of the time).

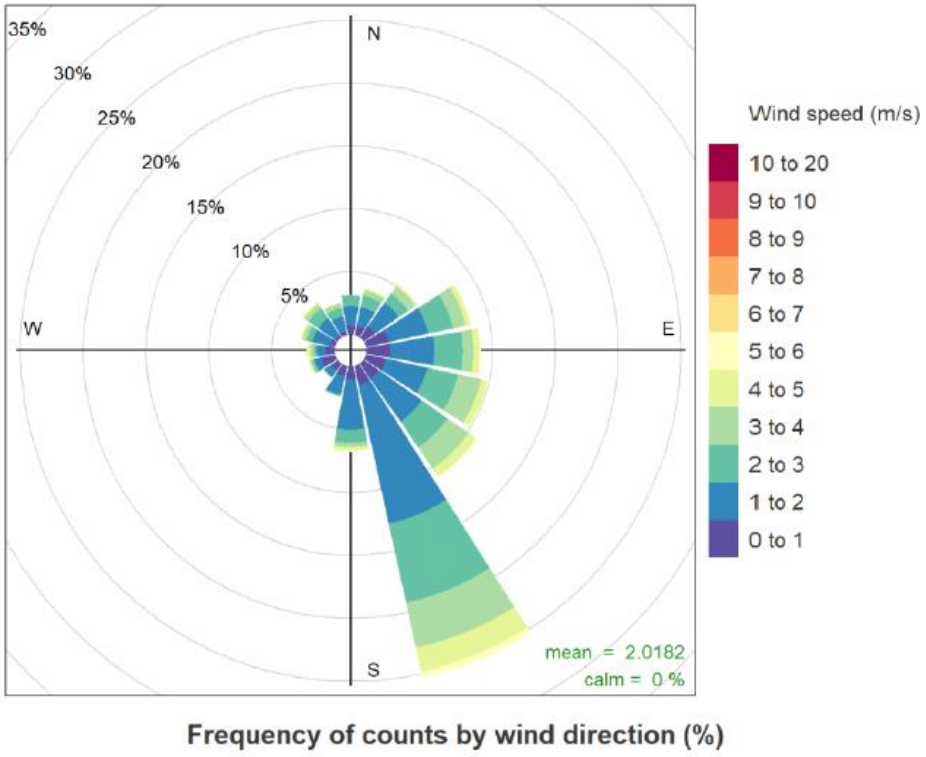


Figure 10: Annual distribution of winds at the Project site predicted by TAPM/CALMET

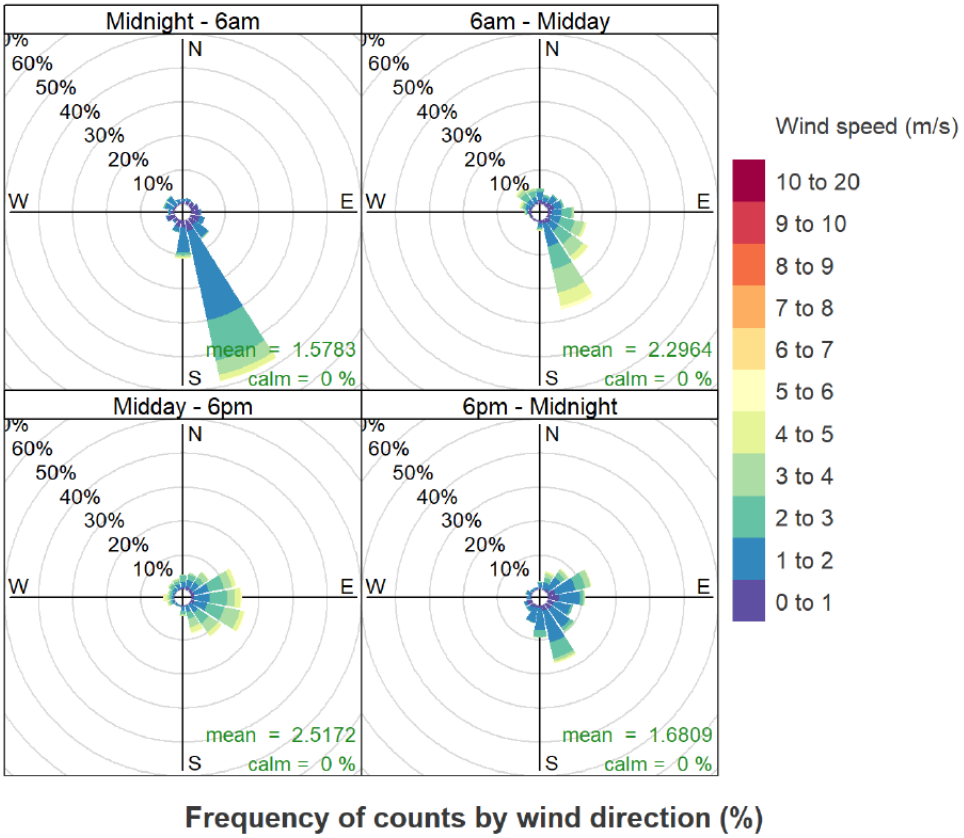


Figure 11: Seasonal distribution of winds at the Project site predicted by TAPM/CALMET

10.1.3.4 Summary

In summary, DES's Blackwater monitoring station is expected to adequately account for the potential contribution from the Bluff Coal mine on sensitive receptors near to the Gemini Project for the following reasons:

- There are three mines located within 11km of Blackwater monitoring station, which are closer than the Bluff Coal Mine is to the Gemini Project.
- The emissions to air from those mines are estimated to be 20 times higher than the emissions from the Bluff Coal Mine.
- Given the low frequency of the winds from the west and distance from Bluff Coal mine to the Gemini Project, it is unlikely that Bluff Coal mine will contribute significantly to dust at the sensitive receptors surrounding the Gemini Project.

10.2 Impact of revised mine camp location

10.2.1 DES Comment

The list of main activities (included in Section 2 and Table 7 in Section 3.4.4) associated with Gemini Project does not include "workers' accommodation and associated infrastructure (camp access road, sewage treatment plant, sewage pipeline and effluent irrigation management area)" as proposed by the written notice of changed application and the revised conceptual mine layout. Furthermore, workers' accommodation and associated infrastructure was not included as key dust-generating activities for Gemini Project (Section 3.4.1). It is noted that these activities were not considered as a source in air quality modelling and assessment in the original EA application submission. However, given the changed application,

it is not clear how the revised mine layout has the potential to impact the EVs of air at nearby sensitive receptors.

10.2.2 DES Requirement

Provide justification for why workers' accommodation and associated infrastructure, which includes camp access road, sewage treatment plant, sewage pipeline and effluent irrigation management area, has been excluded as sources from the air quality modelling and assessment. Demonstrate how the EVs of air will be enhanced or protected given the change to the conceptual mine layout.

10.2.3 Response

The AQGGA completed in December 2020 was undertaken using the revised mine layout (as shown in Figure 2 of the AQGGA). There have been no subsequent changes to the conceptual mine layout.

In response to this information request, further assessment has been undertaken to justify why the workers accommodation and associated infrastructure (camp access road, sewage treatment plant, sewage pipeline and effluent irrigation management area) have not been included in the air quality model (refer to Item 2 in in the Air Quality Technical Memorandum) (Appendix E)). The assessment deemed these sources too insignificant to be able to differentiate in the model. A summary of the key findings of the assessment is provided below.

10.2.3.1 Camp and access road

The workers accommodation camp is now located to the northwest corner of the ML, south of the highway. As shown in Figure 1 the nearest sensitive receivers (SR) to the revised mine camp location are SR22, SR31 and SR32. The revised camp location is approximately 1km south of sensitive receiver SR22, 1.5km east of sensitive receiver SR31 and 2km south east of SR32.

The camp access road to the workers' accommodation and to the mine infrastructure area will be sealed.

Traffic projections indicate that during peak operations there will be 122 trips per day when light vehicles will travel from the highway to the workers' accommodation camp, which is a distance of 0.45km, and five trips per day when the mine bus transports workers from the accommodation camp to the mine infrastructure area, which is a distance of 1.65km.

Emissions of TSP, PM10 and PM2.5 are estimated to be 0.23g/s, 0.04g/s and 0.01g/s, respectively. This is negligible, being less than 0.3% of emissions generated from the mining operations. Inclusion of these emissions would not change the outcome of the assessment.

10.2.3.2 Sewage Treatment Plant and effluent irrigation management area

The proposed STP and the effluent irrigation area are located approximately 1.5km east of sensitive receiver SR31, 2.1km south east of SR32 and 750m south of SR22.

It is estimated that during operation, up to 140 workers may be accommodated on site, and during construction up to 280 workers may be accommodated on site. The STP will be designed for a 280 EP maximum capacity (56,000 L/day). The STP will be a modular containerised design with very low odour emissions, designed in accordance with AS/NZS 1546.1:2008. This is conventional technology that is widely deployed throughout Queensland with minimal odour issues.

The following management measures will be implemented to manage aerosol drift, odour nuisance and potential impacts to human health as a result of effluent irrigation activities:

- Irrigation volumes have been designed to prevent surface run-off.
- Irrigation will cease in significant rainfall events when there is the risk of surface runoff.

- Spray drift control (low-throw sprinklers - 180º inward throw).
- Irrigation will be restricted when wind direction is not favourable, or temperature inversions present.
- Suitable wet weather storage (3 days) is to be provided in tanks, to prevent potential overflow events.

Given the STP design, proximity to nearest receptors and management measures to be put in place, it is not anticipated that there will be any impacts associated with aerosol drift and odour nuisance at the nearest sensitive receivers.

10.3 Impact to sensitive receivers SR31 and SR32

10.3.1 DES Comment

Table 2 lists sensitive receptors surrounding the project. The property name for SR31 and SR32 is “unknown”. It is not clear if the revised conceptual mine layout affects and alters the impacts to air quality at these sensitive receptors from the original application.

10.3.2 DES Requirement

Provide more information about SR31 and SR32 and the potential impacts to air at these locations given the change to the conceptual mine layout.

10.3.3 Response

SR31 and SR32 are private homesteads located on Lot 1RP61678, shown in Queensland Globe as being the ‘Dunbea’ property. As outlined in Section 10.2, given the distance of the revised camp accommodation and associated infrastructure from these receptors, and the controls to be implemented (road sealing, STP design and effluent irrigation management measures), the assessment predicts no adverse impact on environmental values at these sensitive receivers.

10.4 Emission quantities over years of mine

10.4.1 DES Comment

Table 7 presents the list of activities that will create dust emissions and provides estimates of the quantity (kg/year) of emissions that will be produced during mine operational year 2, 5 and 15. However, it is not clear how this data has been applied to conclusions of the air quality assessment.

10.4.2 DES Requirement

Provide a summary or conclusion that interprets the data in Table 7 to help provide understanding of how the emission quantities differ between years of mine operation and explain what might cause differences.

10.4.3 Response

Table 7 of the AQGGA presents the emissions to air (kg/year) of TSP, PM10 and PM2.5 per year for each mining activity (for example blasting, drilling, hauling of ROM, wind erosion). The emission rates of TSP, PM10 and PM2.5 for each activity are proportional to the activity rate for each year (as summarised in Appendix D of the AQGGA. For example, emissions of TSP from haul trucks are proportional to vehicle kilometres travelled. In Year 2 91,440 vehicle kilometres are travelled within 6 months to transport ROM coal from the pit to the CHPP, whereas in Year 15 289,108 vehicle kilometres are travelled over 12 months. The

haul distance in Year 15 is 1.6 times higher than in Year 2 when taking into account period over which the haulage is undertaken. This is reflected in the emission rates in that for Year 15 it is estimated that 365,959 kg/year of TSP is emitted due to ROM coal haul compared to Year 2 where it is estimated 231,494 kg/year of TSP is emitted.

It can be seen from Table 7 of the AQGGA that overall emissions of dust are highest in Year 15. This is predominately due to emissions associated with ROM haulage and overburden haulage as well as wind erosion of rehabilitation areas. In Year 15, haul distances are the longest due to location of the pit relative to the CHPP and dumps (refer to Appendix D Table B1 of the AQGGA). In Year 15, the area assigned for rehabilitation is the greatest due to it being the year when there is the most land available for rehabilitation (refer to Appendix D Table B1 of the AQGGA).

10.5 Meteorological data used in modelling

10.5.1 DES Comment

The Air Pollution Model (TAPM) was configured using meteorological data from 2016. Configuring TAPM based on one year of historical 24-hourly data is acceptable if that year represents the worst case scenario.

10.5.2 DES Requirement

Explain and demonstrate that meteorological data from 1 January 2016 to 31 December 2016 represents the worst case meteorological conditions, very low rainfall and strong windy conditions, compared to 5 years of hourly site meteorological data.

10.5.3 Response

Meteorological modelling was conducted using the TAPM/CALMET modelling approach (refer to Appendix A of the AQGGA). This was conducted in accordance with standard industry practice.

In terms of “worst case”, the AQGGA assesses the worst-case in terms of emissions of dust to air from the proposed mining activities. For meteorology, strong wind conditions do not necessarily correlate with worst case impacts from a mining activity. For example, strong winds may give rise to dust lift off, but strong winds also help disperse the dust. Very light to calm winds on the other hand can result in elevated dust concentrations due to poor mixing and dispersion of emissions sources such as haul dust. It is important that the meteorological data that is used for the site is representative of average conditions for dust assessments.

The year 2016 was chosen as the most recent year at the time of the commencement of the assessment. Notwithstanding this, an analysis of five years of meteorological data from the Bureau of Meteorology’s station at Blackwater has been conducted. Figure 11 presents annual windroses for 2015 to 2020. Wind frequencies including the frequency of strong winds are consistent between the years. There is very little difference in average wind speeds. Therefore, the choice of 2016 as the meteorological year is adequate.

The regulatory emission estimation techniques cannot account for the effect of rainfall on dust emissions. The emissions model uses average material moisture contents. Whilst the dispersion model can characterise the effect of rainfall to reduce dust levels in the atmosphere (wet deposition), it has been conservatively assumed that rainfall does not remove dust from the atmosphere. This results in higher predicted dust levels rather than lower.

Therefore, the choice of a year with high or low rainfall does not affect the outcomes of this assessment.

11 Noise

11.1 Impact of revised mine camp location

11.1.1 DES Comment

The list of main activities associated with Gemini Project does not include "workers' accommodation and associated infrastructure (camp access road, sewage treatment plant, sewage pipeline and effluent irrigation management area)" as proposed by the written notice of changed application and the revised conceptual mine layout. It is noted that these activities were not considered as a source in noise quality modelling and assessment in the original EA application submission. However, given the changed application, it is not clear how the revised mine layout has the potential to impact the EVs of noise at nearby sensitive receptors.

11.1.2 DES Requirement

Provide justification for why workers' accommodation and associated infrastructure, which includes camp access road, sewage treatment plant, sewage pipeline and effluent irrigation management area, has been excluded as sources from the noise modelling and assessment. Demonstrate how the EVs of noise will be enhanced or protected given the change to the conceptual mine layout.

11.1.3 Response

In response to the secondary information request, a revision to the Noise Impact Assessment (NIA) has been prepared (Appendix F), which includes the workers' accommodation and associated infrastructure. As outlined in Table 1.1 of the revised NIA the following noise sources have been added:

- Vehicles on camp access road
- Air-conditioning units and people talking at the camp
- Sewerage Treatment Plant (STP)
- Pumping at the irrigation management area.

Details of the additional modelled noise source data is provided in Table 6.2 and 6.3 of the revised NIA (Appendix F).

Inclusion of these additional noise sources did not result in any new exceedances of criteria. However, there were slight increases to the predicted noise outcomes at the nearest sensitive receivers. Exceedances for night-time scenarios N1 and N2 at SR10 in Mine Year 8 increased slightly from 38dBA to 39dB, (refer to Table 6.7 of the revised NIA). There were also slight increases at other sensitive receivers, but as the increase was minimal (less 0.5dB) no other updates were required for Tables 6.6 – 6.8 of the NIA.

A number of operational scenarios have previously been modelled to demonstrate that changes to mining operations (i.e. reduction in the number of machines in operation) can be implemented to prevent exceedances and ensure that compliance can be achieved at all sensitive receivers. Mitigation measures previously proposed for SR10 in Mine Year 8 were already more than sufficient to ensure night-time compliance at this location. Updates to the modelled mitigation measures were therefore not required. However, to achieve night-time compliance at SR10 and SR22 in Year 2, modelling indicate an additional 2 trucks may need to be temporarily shut down during high risk conditions in order to achieve compliance (refer to Table 8.1 of the revised NIA). It should be noted that the scenarios presented in Table 8.1 should be considered examples only, and other acoustically equivalent scenarios may be developed.

As outlined in section 8.4 of the NIA, real time noise monitoring will be undertaken at the most noise affected receptors (i.e. SR10 and SR22) prior to mining commencing. A noise monitoring survey will be then conducted at the commencement of operations to verify noise emissions for the Project and the level of noise impact at sensitive receptors. Real time noise monitoring will be implemented throughout mine operations to track noise trends, develop appropriate mitigation strategies and react to potential noise exceedances, should they occur.

11.2 Sensitive receivers SR31 and SR32

11.2.1 DES Comment

Table 2.1 lists sensitive receptors surrounding the project. The real property description for SR31 and SR32 is not provided. It is not clear if the revised conceptual mine layout affects and alters the impacts to noise at these sensitive receptors from the original application.

11.2.2 DES Requirement

Provide more information about SR31 and SR32 and the potential impacts to the EVs of noise at these locations given the change to the conceptual mine layout.

11.2.3 Response

SR31 and SR32 are private homesteads on Lot 1 on RP61678. An assessment of the noise impact at these sensitive receivers, including the camp and associated infrastructure, has been included in the revised NIA. Refer also to Section 11.1.3.

Appendix A: Revised Traffic Impact Assessment

Appendix B: Groundwater Technical Memorandum

Appendix C: Figures for Groundwater Technical Memorandum

Appendix D: Mine Waste Geochemistry Technical Memorandum

Appendix E: Air Quality Technical Memorandum

Appendix F: Revised Noise Impact Assessment