



REPORT

Surface Water Impact Assessment

Ardmore Phosphate Rock Project - Start-up Operation

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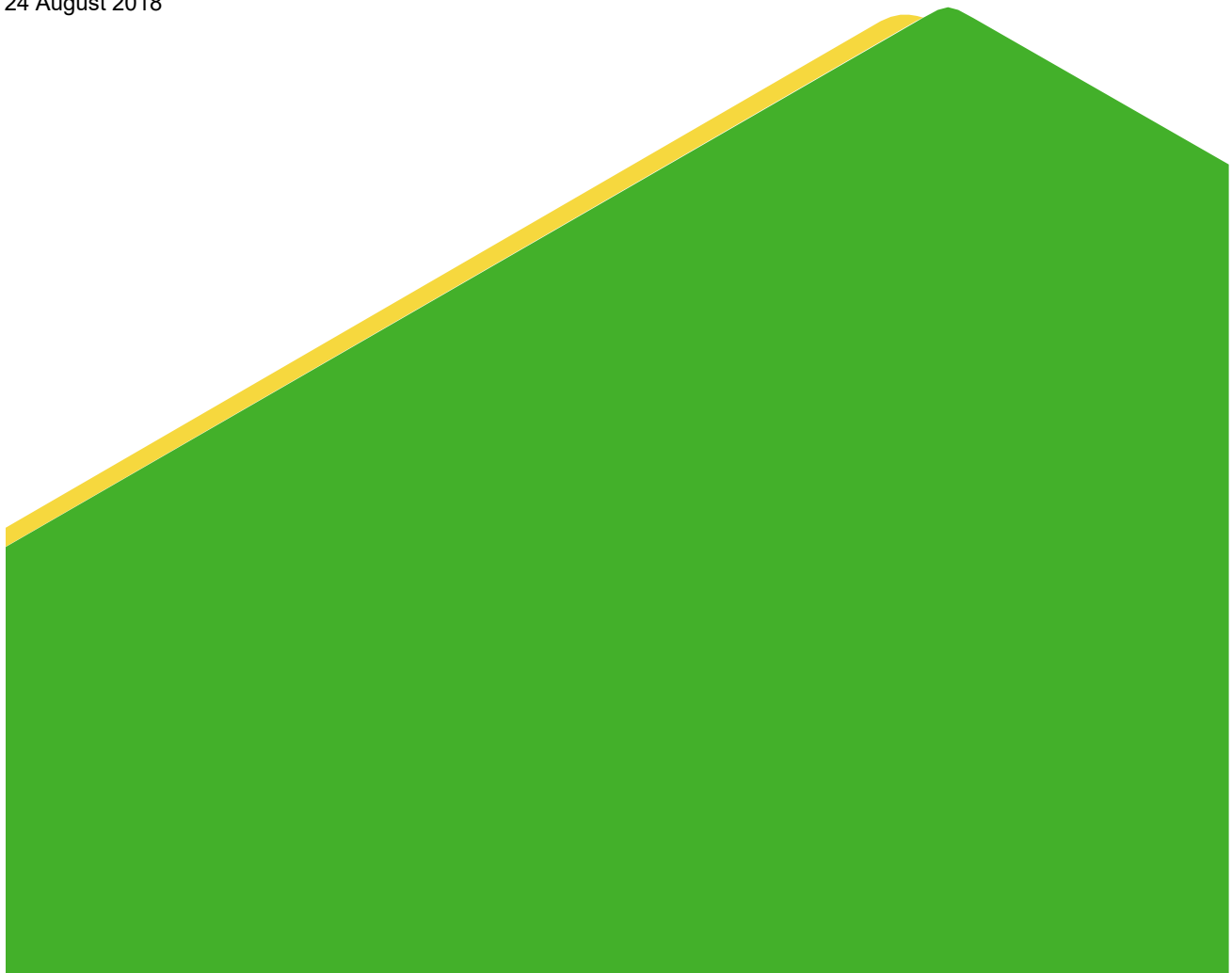
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Executive Summary

Introduction

Centrex Phosphate Pty Ltd (Centrex) have engaged Golder Associates (Golder) to prepare the application for the Environmental Authority (EA) for the Start-up Operation of the Ardmore Phosphate Rock Project. The EA application will include this report, the surface water impact assessment for the Start-up Operation.

The development and operation of the Start-up Operation is expected to change surface water regimes on the project site. This surface water impact assessment presents the baseline surface water condition, then assesses the potential impacts of the Start-up Operation on the surface water condition.

The surface water impacts discussed in this assessment have been presented in terms of water quality, annual and monthly surface water yield, and peak flows on the project site.

Methodology

The surface water impact assessment was conducted in three parts: a water quality assessment, surface water yield modelling, and peak event runoff modelling.

The water quality assessment was conducted as a desktop study. Regional water quality data from publicly available data and site-specific water quality data from baseline surveys (Northern Resource Consultants, 2018) were used to determine the baseline water quality condition. Potential impacts of the Start-up Operation were estimated by identifying potential contaminants at the project site and by calculating soil loss potential as an indication of available sediment.

Surface water yield modelling was conducted using water balancing modelling software, Goldsim. Two water balance models were created to simulate potential surface water yield for the baseline, pre-mine condition and Start-up Operation site condition. A stochastic rainfall generator was created informed by rainfall extracted from the SILO data drill from the township of Dajarra. Stochastic rainfall generators attempt to reproduce the statistical characteristics of historical records in synthetic sequences of arbitrary length. The surface water yield model estimated the volume of water available in baseline and Start-up Operation scenarios to determine the project's impact on water yield.

Peak event runoff modelling was conducted to estimate peak runoff values using the xpstorm modelling package. xpstorm utilises the Laurenson Method which considers design rainfalls and physical catchment conditions to perform runoff routing. Existing catchments as well as Start-up Operation catchments were modelled to assess the potential hydrologic impacts of the project.

Results

Contaminant sources likely to be on the Start-up Operation site were identified as ore and tailings streams, overburden, basement units, vehicles, mine plant and equipment, storage areas, and washdown areas. Contaminants from these sources have potential to negatively impact the receiving environment although the contamination are expected to be pulse events coinciding with rainfall and impacts are expected to be short term. However, with the appropriate stormwater management controls, these impacts are expected to have minimal impact.

Surface water yield modelling found that the Start-up Operation had very little impact on surface water yield on the site. Annual and monthly yield was calculated for the baseline and Start-up Operation condition. From Catchment B, annual median yield for the developed case increased by only 3 ML annually. Monthly yield volumes only increased marginally, and median yield remained at 0 ML across all months.

Similarly, the Start-up Operation was assessed to have very little impact on peak flow from the site catchments. Catchment B with Start-up Operation infrastructure generated approximately the same peak flows as Catchment B with baseline conditions. This is attributed to the minimal footprint of the Start-up Operation infrastructure.

Table of Contents

1.0 INTRODUCTION	1
1.1 Background and Purpose.....	1
1.2 Description of Study Area	1
1.2.1 Spatial Boundaries	1
1.2.2 Temporal Boundaries.....	1
1.2.3 Hydrometeorology	4
1.2.4 Regional Hydrological Setting	4
1.2.5 Site Hydrological Setting	5
2.0 LEGISLATIVE FRAMEWORK.....	6
3.0 METHODOLOGY	6
3.1 Water Quality Assessment.....	6
3.2 Yield Modelling	6
3.3 Peak Event Runoff Modelling	6
4.0 EXISTING ENVIRONMENTAL VALUES.....	7
4.1 Water Quality.....	7
4.1.1 Regional Sampling	7
4.1.2 Site Sampling	8
4.2 Water Quantity	12
4.3 Yield Assessment Modelling	12
4.3.1 Catchments	12
4.3.2 Australian Water Balance Model.....	15
4.3.3 Stochastic Rainfall Generator	17
4.3.4 Estimated Catchment Yield.....	19
4.4 Peak Runoff Assessment.....	20
4.4.1 Catchment.....	20
4.4.2 Rainfall	20
4.4.3 Peak Flows.....	21
5.0 IMPACT ASSESSMENT	22
5.1 Key Questions/Issues to be Considered.....	22

5.2	Emissions and Releases.....	22
5.2.1	Water Quality	22
5.2.2	Sediment	23
5.2.3	Surface Water Yield	23
5.2.4	Peak Flow	23
5.3	Potential Impacts.....	23
5.3.1	Water Quality Impacts.....	23
5.3.2	Surface Water Yield	26
5.3.3	Peak Flows.....	28
5.3.4	Risk of Unplanned Events.....	28
6.0	MITIGATION AND MANAGEMENT MEASURES.....	29
6.1	Water Quality Monitoring and Discharge Criteria.....	29
6.2	Contaminant Containment	29
6.2.1	Spill Control Procedures	29
6.2.2	TSF Storage Allowances	30
6.3	Erosion and Sediment Control	30
6.4	Mine Closure and Rehabilitation	30
7.0	RESIDUAL IMPACTS	31
8.0	CONCLUSIONS	31
9.0	IMPORTANT INFORMATION.....	31
10.0	REFERENCES	32

TABLES

Table 1:	Regional water quality monitoring sites (DNRM).....	7
Table 2:	Summary water quality parameters compared to guideline values (Burke River at Boulia)	7
Table 4:	Monitoring locations for the baseline 2018 survey	11
Table 5:	Streamflow gauging stations	12
Table 6:	Site catchments	13
Table 10:	AWBM Parameters.....	17
Table 7:	Annual Surface Water Yield results.....	19
Table 8:	Monthly Surface Water Yield from Catchment B (ML)	20
Table 9:	Rainfall intensity frequency duration (mm/hr) - Ardmore.....	21

Table 10: Peak Flow Results - Baseline Catchments	22
Table 11: RUSLE calculations	25
Table 12: Start-up Operation Development Catchment B Subcatchment Land Uses	26
Table 13: AWBM Parameters – Catchment B Start-up Operation Development.....	26
Table 14: Annual Runoff from Catchment B (ML)	27
Table 15: Monthly Surface Water Yield from Catchment B (ML) – Start-up Operation Development	27
Table 16: Peak Flow Results for Catchment B (m ³ /s)	28
Table 17: Proposed monitoring locations	29
Figure 1: Mean monthly rainfall and evaporation (Mount Isa Aero - Station ID 029127)	4
Figure 2: Typical ground cover and vegetation	5
Figure 3: AWBM conceptual schematic.....	16

FIGURES

Figure 1: Site location map	2
Figure 2: Start-up Operation infrastructure plan	3
Figure 3: Mean monthly rainfall and evaporation (Mount Isa Aero - Station ID 029127)	4
Figure 4: Typical ground cover and vegetation	5
Figure 6: Catchment delineation map.....	14
Figure 7: AWBM conceptual schematic (CRC, 2004)	16
Figure 8: Observed and calculated runoffs for Williams River calibration (RRL AWBM output).....	16
Figure 9: Comparison of monthly mean rainfalls in mm from SILO and stochastically generated values for Dajarra	18
Figure 10: Cumulative probability distribution of annual total rainfall stochastic rainfall data vs. SILO records for the location of Dajarra	18

APPENDICES

APPENDIX A

Summary of Regional Water Quality Monitoring Results

APPENDIX B

Important Information

1.0 INTRODUCTION

Centrex Phosphate Pty Ltd (Centrex) has recently acquired the rights to Mining Lease ML 5542. The mining lease (ML) is located approximately 25 km west of Dajarra and 120 km south of Mount Isa in Queensland, Australia. This site will be the location of the Ardmere Phosphate Rock Project (the Project). To proceed with the Start-up Operation phase of the Project, Centrex are required to submit an application for a site specific Environmental Authority (EA) for the Start-up Operation. Golder Associates Pty Ltd (Golder) have been engaged by Centrex to prepare the application for this new EA. The EA application and associated supporting documentation will include this report, the surface water impact assessment for the Start-up Operation.

1.1 Background and Purpose

Centrex proposes to develop the Start-up Operation to be constructed within the Southern zone of the ML, with a target to extract 70 000 t of ore using shallow open-cut strip mining over a 2 to 3-month period.

The development and operation of the Ardmere Phosphate Rock Project Start-up Operation will result in changes to the surface water regime of the site. The purpose of the surface water impact assessment is to present the baseline surface water condition of the site, then to assess and discuss changes in the surface water condition as a result of the Start-up Operation.

Surface water impacts of the Start-up Operation have been presented in this report in terms of water quality, annual and monthly surface water yield, and peak flow. In addition, secondary environmental impacts resulting from changes in water quality, water quantity, and peak flows have been discussed.

1.2 Description of Study Area

The spatial and temporal boundaries for the surface water impact assessment are outlined below.

1.2.1 Spatial Boundaries

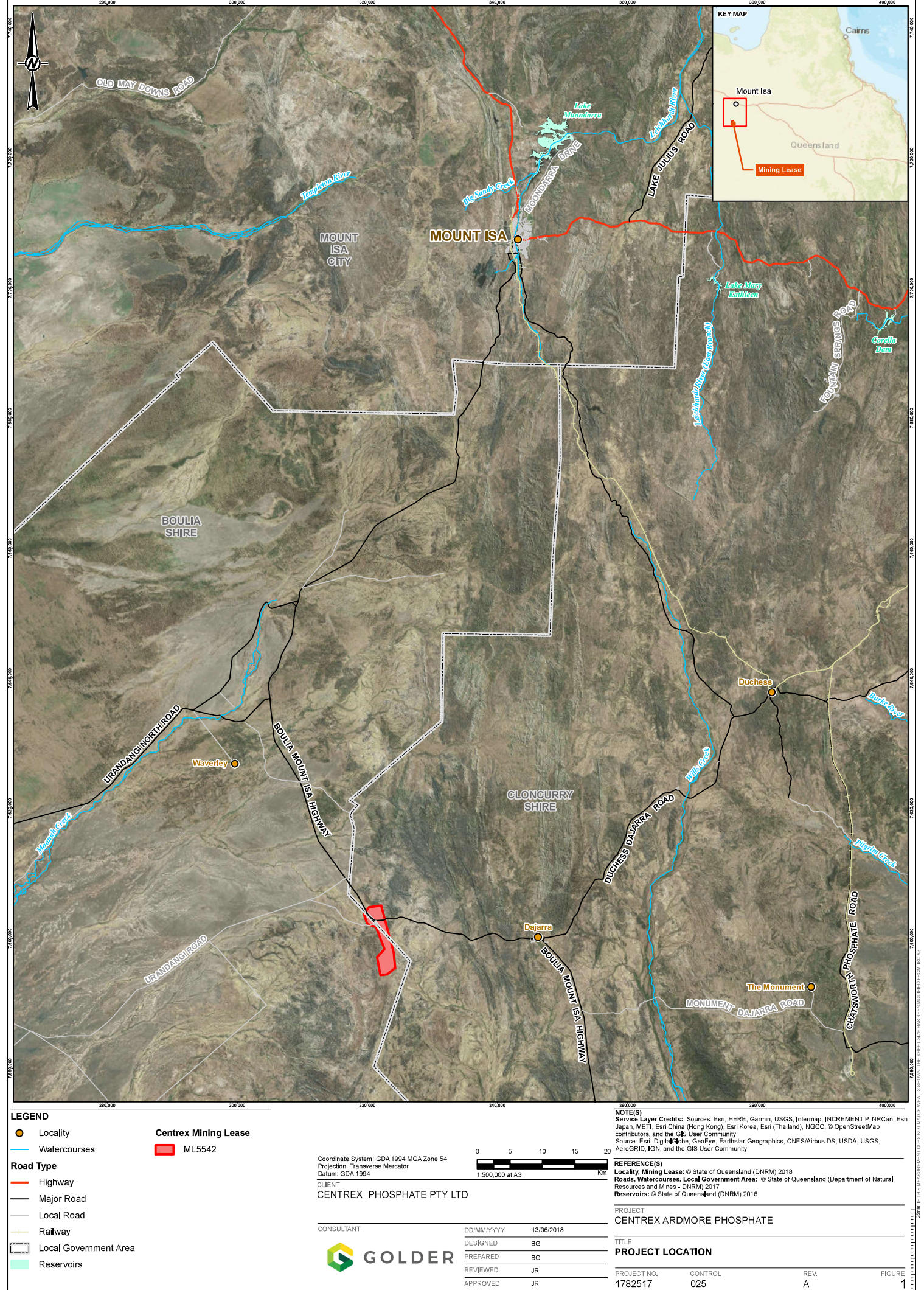
The Ardmere Phosphate Rock Project is located in western Queensland, approximately 25 km west of Dajarra, 130 km south of Mt Isa and 135 km from the Northern Territory border. The Boulia Mount Isa Highway which connects Mount Isa to Charleville via Dajarra intersects with the northern part of the mining lease. The mining lease is at the head of the Georgina and Burke River catchments with Split Creek running directly east west through the lease and smaller streams draining to the north-east and south-west.

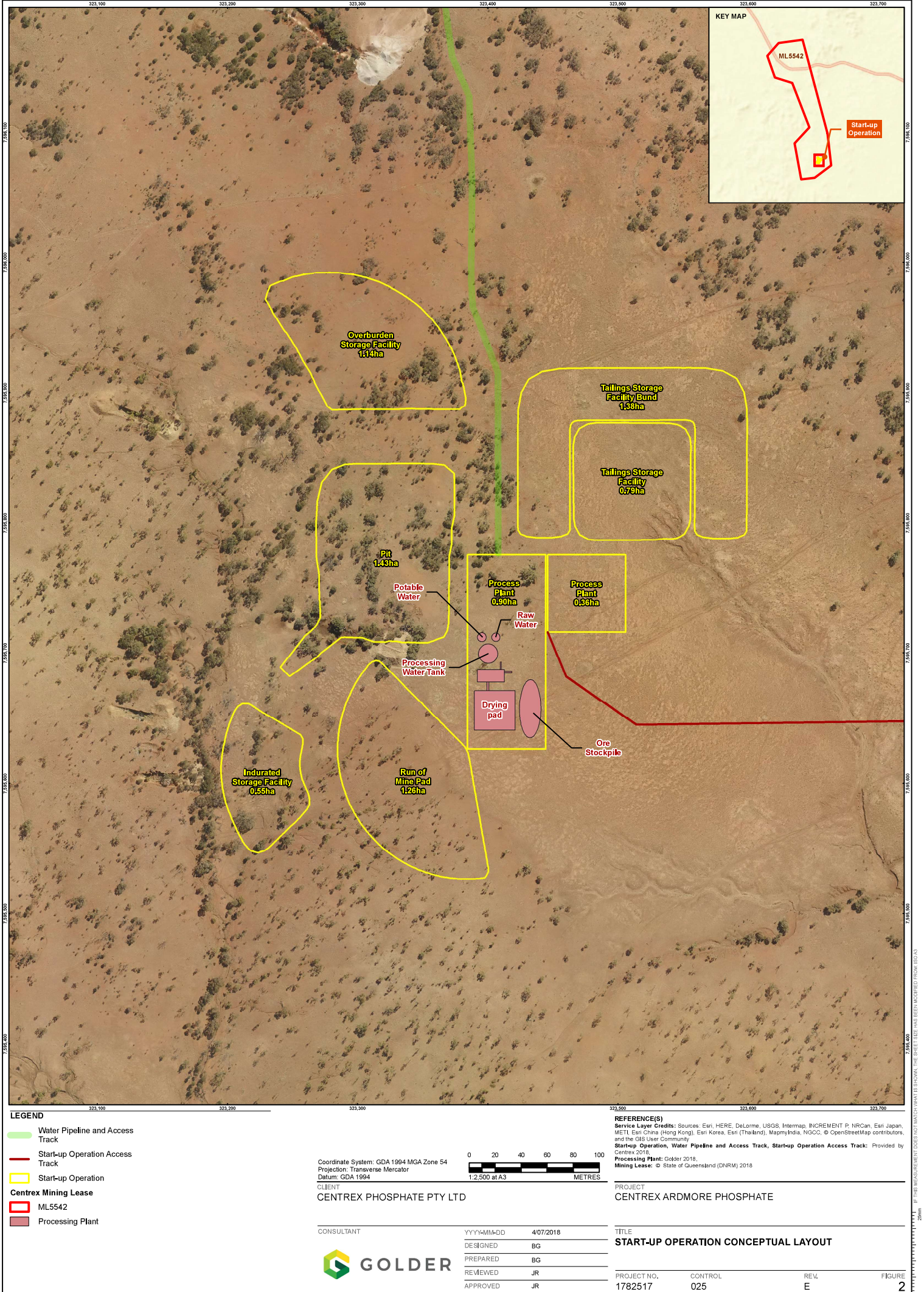
A site location map is provided in Figure 1.

Infrastructure plans for the Start-up Operation are limited to a small area of the mining lease. The surface water impact assessment will focus largely on the catchment impacted by the development of the Start-up Operation. Start-up Operation infrastructure location map is provided in Figure 2.

1.2.2 Temporal Boundaries

This surface water impact assessment considers the life-cycle of the proposed project. This includes existing (pre-construction), construction, operation, and decommissioning phases of the Start-up Operation.





1.2.3 Hydrometeorology

The climate at Ardmore is characterised as hot, semi-arid with a pronounced wet season from December to March. This coincides with very high temperatures with maximums averaging 36.5°C and very high potential evapotranspiration. Minimal rain falls from June to September while daytime maximum temperatures remain moderate at an average 24.3°C and potential evapotranspiration drops significantly.

The Bureau of Meteorology (BOM) identifies this seasonality as three main seasons experienced in Mount Isa.

- Hot temperatures with high humidity (January to April).
- Mild temperatures with low humidity (May to August).
- Hot temperatures with low humidity (September to December).

Average annual potential evaporation (3041 mm) far exceeds average annual rainfall (464 mm) recorded at Mount Isa Aero (ID 029127). Figure 3 shows the seasonal variability of the mean monthly rainfall and evaporation recorded at Mount Isa.

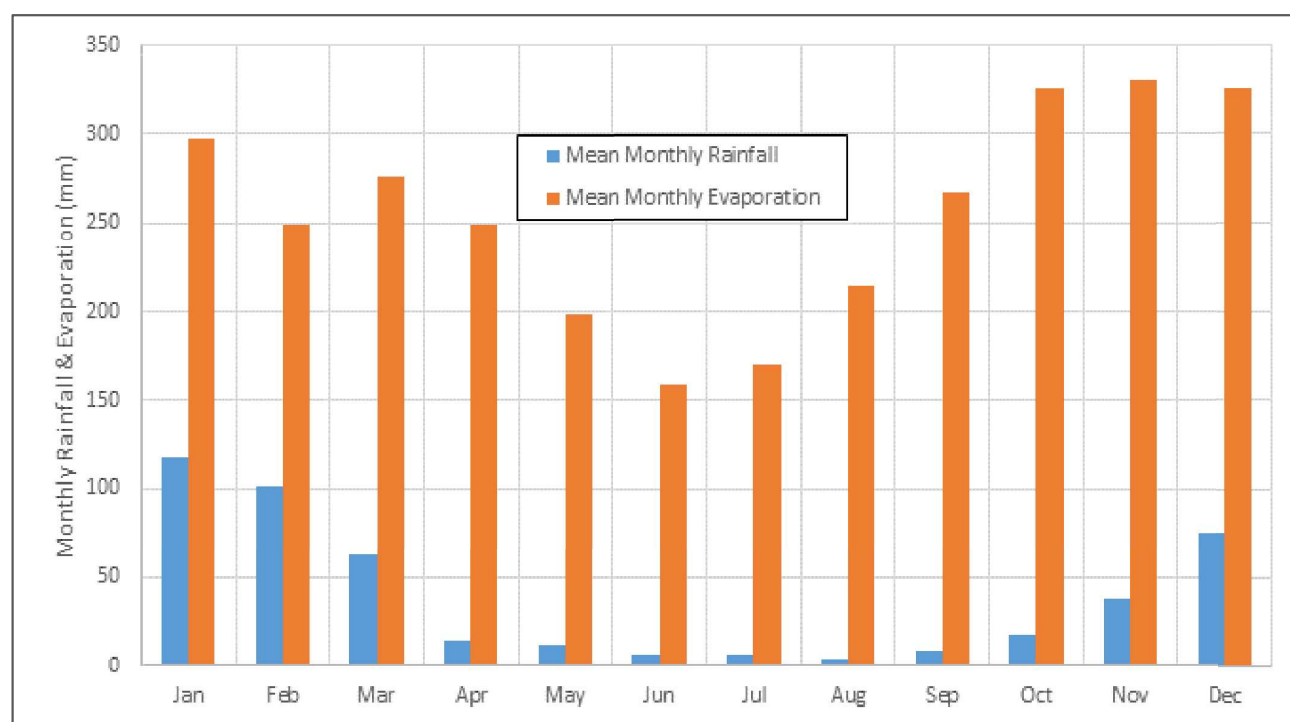


Figure 3: Mean monthly rainfall and evaporation (Mount Isa Aero - Station ID 029127)

The majority of the site is classified as open woodland (DNRME, 2018) and the soils are listed as Kandosols and Chromosols according to the Queensland Combined Soils dataset (DSITI, 2017). Due to the pronounced wet and dry seasons, the majority of streamflow occurs in the summer months often associated with monsoonal activity. For runoff to occur the precipitation needs to be significant or prolonged enough to fill the soil surface stores and generate runoff. A significant amount of this runoff will also then infiltrate to the alluvium of the ephemeral streams.

1.2.4 Regional Hydrological Setting

The mining lease is situated in the Georgina River Basin, which is based around the Georgina, Burke, and Hamilton Rivers. The main surface water resource of the Georgina River Basin is the Georgina River. The basin is approximately 325 000 km² in area and extends from north-western Queensland and into the Northern Territory (Geoscience Australia, 2017). Split Creek, a tributary of Georgina River, flows east to west through the

centre of the Mining Lease. Within the ML, a smaller drainage line flows southward from the southern catchment which flows into Sulieman Creek, into Burke River, and eventually into Georgina River.

1.2.5 Site Hydrological Setting

The Start-up Operation will be in the southern catchment of the mining lease [see Figure 2]. In this area, runoff is expected to be in the form of overland flow to the south east until reaching a natural drainage line which flows east until the confluence with the Sulieman Creek, a point about 6 km downstream of the Start-up Operation.

The area around the Start-up Operation generally slopes to the south east at around 1.4 degrees (°) and generally flattens towards the alluvial plains.

Surface soils in the Start-up Operation area have been sampled and identified as sandy clay loam (Golder Associates, 2018). Surface soils have been found to be largely benign, though local overburden materials in some areas consist of elevated calcium, phosphorus and EC (RGS, 2018).

The ground cover generally consists of grasses and shrubbery and intermittent trees. Figure 4 shows typical ground cover and vegetation present on the project site. The local area is generally degraded by long term stock grazing. Clearing of land, as well as continued physical damage to waterways from stock movement contributes to erosion and sedimentation within waterways.



Figure 4: Typical ground cover and vegetation

2.0 LEGISLATIVE FRAMEWORK

The development of the Start-up Operation at Ardmore Phosphate Rock Project and its surface water impacts must comply with all relevant government acts, by-laws and regulations, both state and federal, including but not limited to the following:

- The *Water Act* 2000 (Queensland)
- *Environmental Protection Act* 1994 (Queensland)

3.0 METHODOLOGY

3.1 Water Quality Assessment

A desktop review of publicly available surface water information as well as results from the Baseline Survey (Northern Resource Consultants, 2018) has been undertaken to determine the baseline water quality of watercourses on the ML.

Potential water quality impacts have been estimated through a desktop review of potential contaminants at the project site and also by calculating soil loss potential. Soil loss potential gives an indication of the volume of sediment available to be transported by runoff into downstream watercourses (IECA, 2008).

3.2 Yield Modelling

A desktop review of publicly available surface water information has been undertaken to inform the model to estimate of potential surface water yield. A yield assessment using a water balance model was completed utilising Goldsim. The purpose of the yield assessment is to estimate the potential quantity of surface water from local creeks that traverse the mining lease that may be available for use in processing of mined ore and any changes to water quantity as a result of mining activities. Two water balance models were created – one for the existing, pre-mine land condition, and the second including the Start-up Operation infrastructure. Daily rainfall data extracted from the SILO data drill from Dajarra (Latitude: -21.69, Longitude: 139.51) was used to inform a stochastic rainfall generator in all yield modelling. Stochastic rainfall generators are necessary for probabilistic modelling of hydrologic systems beyond limits of the historical record, which is typically less than 100 years at Australian sites. Stochastic generators attempt to reproduce the statistical characteristics of the historical records in synthetic sequences of arbitrary length (Srikanthan & Zhou, 2003).

3.3 Peak Event Runoff Modelling

Peak event modelling uses design rainfalls, topography, and catchment development to simulate catchment runoff. To estimate peak runoff values at the site, methodology prescribed in Australian Rainfall and Runoff (ARR) 2016 (Geoscience Australia, 2016) was used. For each Annual Exceedance Probability (AEP) a range of durations and an ensemble of 10 rainfall temporal patterns per duration was modelled to assess the critical duration and corresponding peak flow. AEPs from 1:5 or rarer were modelled (1:5, 1:10, 1:20, 1:50, 1:100 AEP). This was conducted for each of the catchments A-E shown in Figure 6.

A discrete hydrological model utilising the Laurenson Method was developed for this site using the xpstorm modelling package. The Laurenson Method considers the design rainfalls as well as catchment physical conditions to estimate peak flows for each catchment.

Existing catchments as well as Start-up Operation catchments were modelled in order to assess the impact of the Start-up Operation on the hydrology of the project site.

4.0 EXISTING ENVIRONMENTAL VALUES

4.1 Water Quality

4.1.1 Regional Sampling

The Department of Natural Resources and Mines Water Monitoring Information Portal (DNRME, 2017), provides an online register of water quality data from monitoring locations throughout Queensland. Two water quality monitoring locations are located within 150 km of the site and provide some indication of potential background water quality at Ardmore. A summary of the monitoring site locations is provided in Table 1.

Table 1: Regional water quality monitoring sites (DNRM)

Station	Location	Coordinates	Catchment size (km ²)	Period of record	Distance from Mining Lease (km)
001202A	Burke River at Boulia	22.9 S; 139.92 E	14 850	1971 - 2016 (19 samples)	145
001203A	Georgina River at Roxborough Downs	22.52 S; 138.85 E	118 400	1971 - 2016 (29 samples)	100

Relevant measured water quality parameters are provided in Table 2 including pH, Total Dissolved Solids (TDS), Turbidity, Electrical Conductivity (EC), Total Suspended Solids (SS), Total Hardness as CaCO₃ (Total Hardness) and Dissolved Oxygen (DO). Water quality parameters are provided as the 5th percentile, mean and 95th percentile of available records and are compared to the Australian Drinking Water Guidelines (NHMRC, NRMCC, 2011) and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Stock Water (ANZECC, ARMCANZ, 2000).

Of those parameters recorded at Burke River at Boulia, the only exceedances of the Drinking Water Guidelines (NHMRC, NRMCC, 2011) are for Turbidity for the 5th percentile, mean and 95th percentile results. There are no exceedances of the Stock Water Guidelines (ANZECC, ARMCANZ, 2000).

Table 2: Summary water quality parameters compared to guideline values (Burke River at Boulia)

Analyte	Unit	Drinking Water (NHMRC, NRMCC, 2011)	Livestock (ANZECC, ARMCANZ, 2000)	5 th Percentile	Mean	95 th Percentile
pH	pH Unit	6.5 - 8.5	NA	7.4	7.6	8.0
TDS	mg/L	600	4000	61	125	269
Turbidity	NTU	5	NA	8	149	460
EC	µS/cm	746	NA	88	215	446
TSS	mg/L	NA	NA	3	105	400
Total Hardness	mg/L	200	NA	34	82	147

NA: No value available

Of those parameters recorded at Georgina River at Roxborough Downs, the 95th percentile pH, TDS, EC and Total Hardness as CaCO₃ values exceed the Drinking Water Guidelines (NHMRC, NRMMC, 2011). Turbidity exceeds the Drinking Water Guideline (NHMRC, NRMMC, 2011) for 5th percentile, mean and 95th percentile measured results (refer to **Table 3**). There are no exceedances of the Stock Water Guidelines (ANZECC, ARMCANZ, 2000).

Table 3: Summary water quality parameters compared to guideline values (Georgina River at Roxborough Downs)

Analyte	Unit	Drinking Water (NHMRC, NRMMC, 2011)	Livestock (ANZECC, 2000)	5th Percentile	Mean	95th Percentile
pH	pH Unit	6.5 - 8.5	NA	7.0	7.6	8.6
TDS	mg/L	600	4000	77	362	1004
Turbidity	NTU	5	NA	8	149	460
EC	µS/cm	746	NA	114	556	1677
TSS	mg/L	NA	NA	7	86	211
Total Hardness	mg/L	200	NA	40	163	418
DO	% saturation	NA	NA	4.9	6.3	7.7

The recorded values are representative of the surrounding river systems; however, they may not reflect site specific conditions. The values are sourced from available data and from locations more than 100 km away with significantly larger catchments than those on site. An assessment of site baseline water quality will provide a better representation of site conditions, as presented in the section below.

Further water quality monitoring results are provided in APPENDIX A.

4.1.2 Site Sampling

Northern Resource Consultants conducted a 2018 baseline wet season receiving environmental monitoring program within the ML (Northern Resource Consultants, 2018). This consisted of surface water quality sampling at three sites, as well as stream sediment quality sampling at 11 sites. The sampling locations have been shown in Figure 5 and described in Table 4. Findings of the monitoring program have been summarised below.

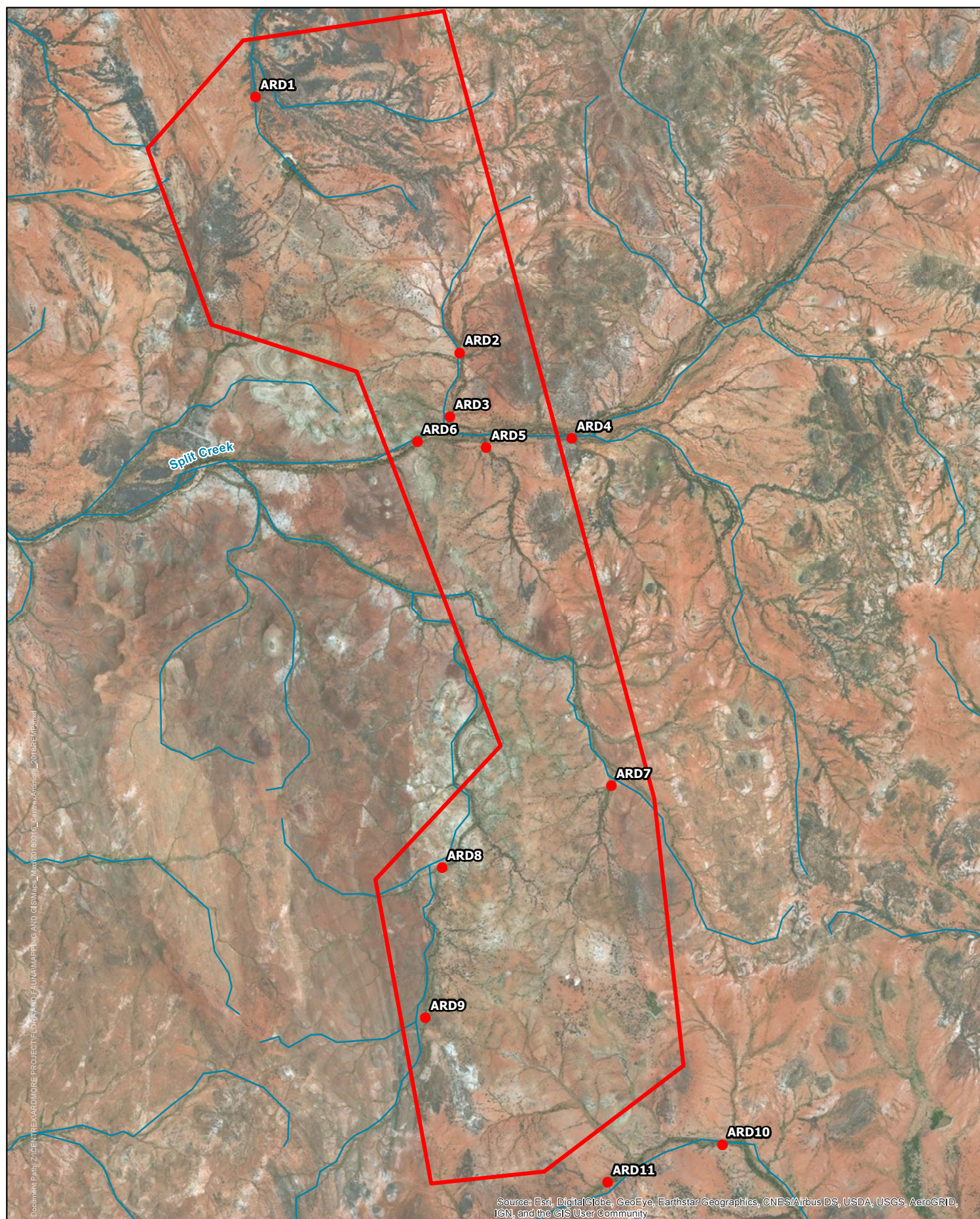
Note due to the intermittent nature of flow on the site, only one round of surface water samples was collected. Only three of the eleven sites had sufficient water for surface water quality sampling. Sites with water were two on Split Creek (ARD4 and ARD6), and one on its tributaries (ARD5). A summary of surface water quality results is presented below.

- pH was above the ANZECC trigger values for toxicants for the protection of slightly to moderately disturbed systems (ANZECC, ARMCANZ, 2000) (pH 6.0 – 7.5) at ARD4 (pH 7.6).
- EC was above the QWQG salinity guideline (200 µS/cm) at ARD4 (398 µS/cm).

- DO was below ANZECC (ANZECC, ARMCANZ, 2000) guideline range (90 – 120 %saturation) at all sites sampled (69.1, 6.8, 20.9 %saturation at ARD4, ARD5, ARD6 respectively).
- Filterable reactive phosphorus (FRP) was above the ANZECC (ANZECC, ARMCANZ, 2000) guideline (0.005 mg/L) at all of the sites sampled (0.016, 0.049, 0.015 mg/L at ARD4, ARD5, ARD6 respectively).
- Total aluminium concentration was elevated above the (ANZECC, ARMCANZ, 2000) guideline value (0.055 mg/L) at ARD5 (0.15 mg/L).
- Total and dissolved uranium concentrations were below the Limit of Reporting (LOR) at all sites; however, the LOR (1 µm/L) was higher than the relevant guideline value (0.5 µm/L).
- All other physico-chemical parameters and metal concentrations were below published guideline values.

Stream sediment quality was sampled at eleven sites. A summary of sediment quality has been presented below.

- Most sites consisted of sediment of coarse and large-medium sand (300 µm – 2 mm), which accounted for 67% on average of stream sediment.
- Fine fraction sediment (<63 µm) represented less than 10% of the sediment at each site, with the exception of ARD10 which consisted of over 20% fines.
- Concentrations of metals in stream sediment varied considerably between sites however, there were no exceedances of metals exceeding guideline values.
- Significant variation in stream sediment nitrogen and phosphorus. Total Kjeldahl phosphorous (TKP) have been shown to range from 170 mg/kg at AD4 and 17 000 mg/kg at ARD7.



CENTREX - ARDMORE PHOSPHATE PROJECT

Legend

- Mining Lease
- REMP 2018
- Vegetation Management
- Watercourse/Drainage Feature

ARDMORE PHOSPHATE PROJECT - 2018 REMP

Credits:
 Mine Lease boundary
 Watercourse, Lot and Plan
 © State of Queensland
 (Department of Natural
 Resources and Mines) 2016.

Coordinate System: GDA 1994 MGA Zone 54
 Projection: Transverse Mercator
 Datum: GDA 1994
 Date: 02-May-18

510 255 0 510
 Metres
 Scale: 1:32 000 at A3



Table 4: Monitoring locations for the baseline 2018 survey

Site	Stream	Easting	Northing	Description
ARD1	Horse Creek	320382	7604247	On Horse Creek, 600 m downstream of a cattle dam.
ARD2	Split Creek	322245	7601917	On a tributary of Split Creek, 70 m upstream of the access track.
ARD3	Split Creek	322157	7601318	On a tributary of Split Creek, 600 m downstream of ARD2.
ARD4	Split Creek	323350	7601159	Upstream site on Split Creek, immediately upstream of a large tributary.
ARD5	Split Creek	322481	7601085	On a tributary of Split Creek immediately upstream of its confluence. Tributary merges with Split Creek 900 m downstream of ARD4.
ARD6	Split Creek	321953	7601163	On Split Creek, downstream of the tributaries represented by ARD2/ARD3 and ARD7/ARD5.
ARD7	Split Creek	323598	7597905	On a tributary of Split Creek, approximately 5.5 km upstream of its confluence with Split Creek. The confluence is 1.8 km downstream of ARD6.
ARD8	Split Creek	322180	7597254	On a tributary of Split Creek that meets the tributary containing ARD7 prior to joining Split Creek.
ARD9	Split Creek	321935	7595807	On a tributary of Split Creek, 1.6 km upstream of ARD8.
ARD10	Sulieman Creek	324497	7594684	On a tributary of Sulieman Creek, downstream of potential mining impacts.
ARD11	Sulieman Creek	323577	7594287	On a tributary of Sulieman Creek, upstream of potential mining impacts and 1.1 km upstream of ARD10.

4.2 Water Quantity

As there is no measured streamflow on the mining lease, for the purposes of characterizing the hydrology and streamflow, streamflow data was accessed from current and historic regional gauging station (DNRME, 2017). The available streamflow gauging stations and their characteristics are provided in Table 5. It is noted that the gauged catchments are significantly larger than the catchments on the Project site – for reference, the largest catchment reporting to the ML is 78 km².

Table 5: Streamflow gauging stations

Station	Location	Coordinates	Catchment size (km ²)	Period of record	Distance from Mining Lease (km)
915211A	Williams River at Landsborough Highway	20.87 S 140.83 E	415	1970 - Present	180
001202A	Burke River at Boulia	22.91 S 139.92 E	14 850	1966 - Present	145
001203A	Georgina River at Roxborough Downs	22.52 S 138.85 E	118 400	1967 - Present	100
001204A	Georgina River at Camooweal	19.92 S 138.11 E	1152	1968 - 1988	225
001101A	Eyre Creek at Glengyle	24.78 S 139.59 E	317	1966 - 1988	340
002105A	Mills Creek at Oondoroo	22.18 S 143.16 E	2642	2007 - Present	400

4.3 Yield Assessment Modelling

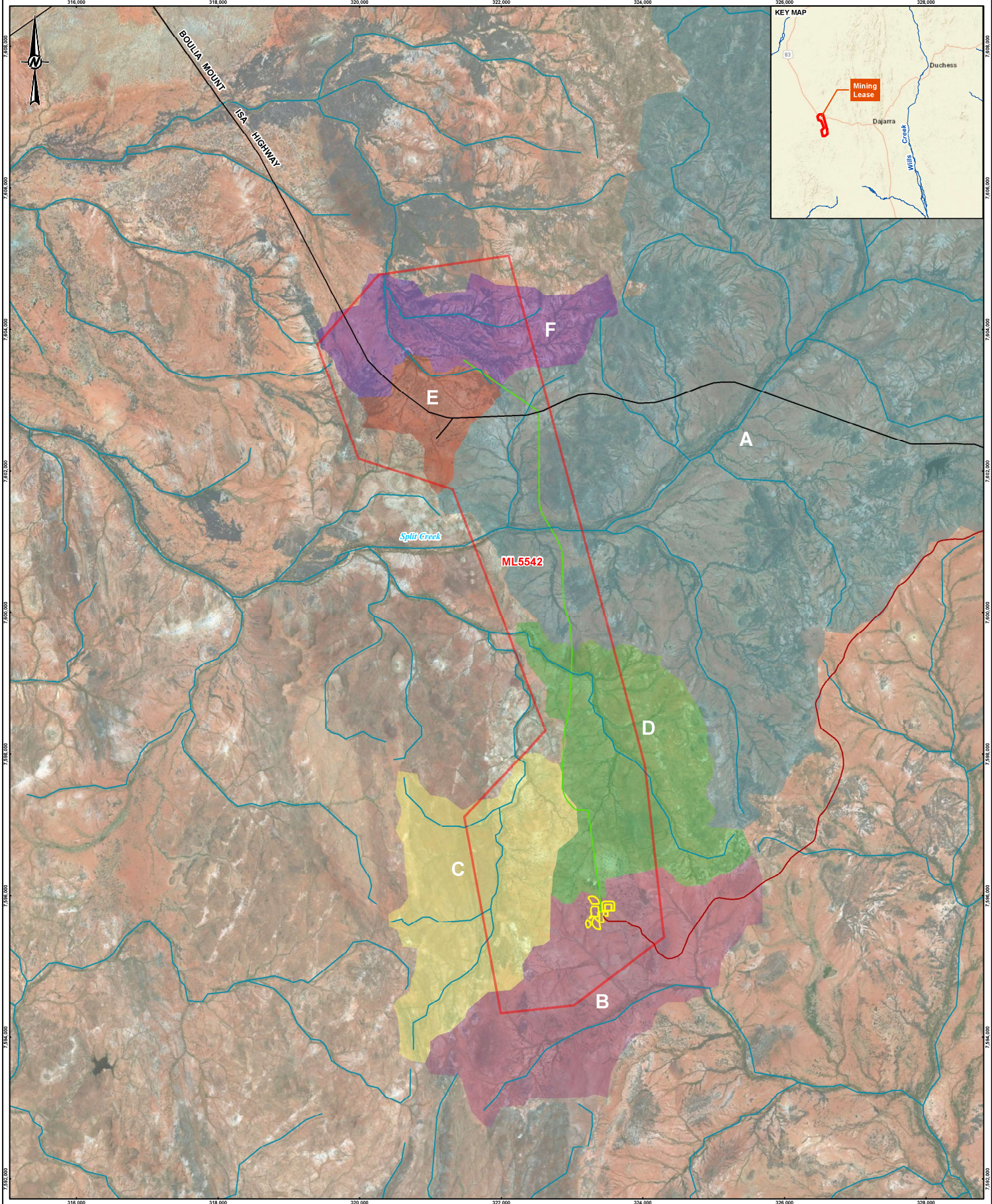
4.3.1 Catchments

For the purposes of determining the individual site catchments an extracted Digital Elevation Model (DEM) was accessed from Geoscience Australia (2017). This provided the spatial coverage to include the full extent of the site catchments. Using ARCGIS spatial analysis tools the DEM was used to delineate the catchments to a set of fixed points on watercourse lines at catchment outlets. For the purposes of this assessment the catchments have been measured as if the collection point for flows is set at the boundary of the mining lease. Defined catchments are shown in Figure 6.

The largest site catchment has been labelled as Catchment A and is on Split Creek. Catchment B has been defined from the confluence of 2 watercourses downstream of the Start-up Operation location. Catchments C and D will join at a point just to the west of the mining lease while Catchment E has been identified at the existing northern farm dam. Catchment F is further north of Catchment E and within the mining lease area. The area of each defined catchment is provided in Table 6.

Table 6: Site catchments

Catchment	Area (km ²)
A	78.1
B	8.6
C	7.0
D	7.3
E	1.8
F	4.6



- LEGEND**
- Watercourses
 - Water Pipeline and Access Track
 - Start-up Operation Access Track
 - Start-up Operation
 - Centrex Mining Lease
 - ML5542
- Site Catchments**
- A
 - B
 - C
 - D
 - E
 - F

Coordinate System: GDA 1994 MGA Zone 54
Projection: Transverse Mercator
Datum: GDA 1994

CLIENT
CENTREX PHOSPHATE PTY LTD

CONSULTANT



YYYY-MM-DD	19/07/2018
DESIGNED	BG
PREPARED	BG
REVIEWED	JR
APPROVED	JR

NOTE(S)
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
REFERENCE(S)
Roads, Watercourse, Cadastre, Essential Habitat: © State of Queensland (Department of Natural Resources and Mines - DNRM) 2017
Mining Lease: © State of Queensland (DNRM) 2018
All other data: Provided by Centrex 2018

PROJECT
CENTREX ARDMORE PHOSPHATE

TITLE
SITE CATCHMENTS

PROJECT NO.	CONTROL	REV.	FIGURE
1782517	025	B	6

4.3.2 Australian Water Balance Model

Surface runoff in the watercourses that traverse the mining lease has been estimated using the Australian Water Balance Model (AWBM). AWBM is an industry standard method for estimating streamflow from rainfall based on calibration parameters for a specific catchment or similar regional catchment. Calibration establishes certain parameters for the AWBM model based on a known rainfall and gauged (measured) streamflow records. These calibrated parameters are then used in the catchment of interest to develop an estimated streamflow record without measurement.

The AWBM has been simulated using the GoldSim modelling platform. GoldSim is a graphical object-oriented modelling environment with a capacity to address dynamic probabilistic simulations. The inputs for the GoldSim model are the AWBM parameters obtained in the calibration stage as well as catchment areas and site-specific rainfall and evapotranspiration.

The AWBM is a catchment scale water balance model that relates runoff to rainfall. It is based on a conceptualised representation of a catchment's temporary surface and baseflow stores, rainfall loss to evaporation and gradual release of water from both stores to streamflow. A schematic of the AWBM model is provided in Figure 7.

The AWBM was calibrated using the reference site Williams River at Landsborough Highway near Cloncurry (location as provided in Table 6). This site was selected for calibration purposes as it is one of the smaller sized catchments within the region. Figure 8 shows the relative temporal relationship and scaling between observed and calculated flow events in the Williams River catchment. The AWBM calculated flow (runoff) is slightly underestimated for the peak events and some minor observed events are not captured, however, the figure demonstrates a fair representation of the modelled system to the measured data.

The correlation between measured and modelled results for the calibration catchment was 0.831 (a perfect correlation being 1.0). The cumulative total observed runoff depth during the calibration period was 722 mm that is fairly represented in the modelled record as a predicted runoff of 732 mm.

Calibration parameters are provided in Table 13.

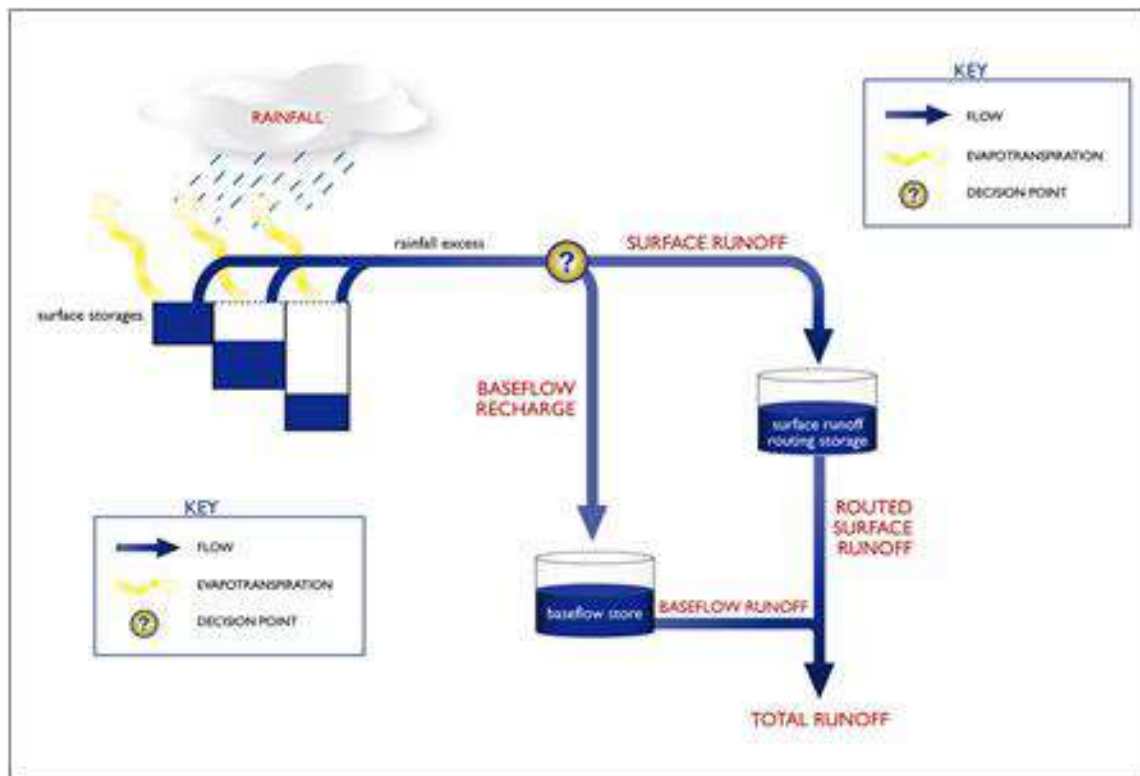


Figure 7: AWBM conceptual schematic (CRC, 2004)

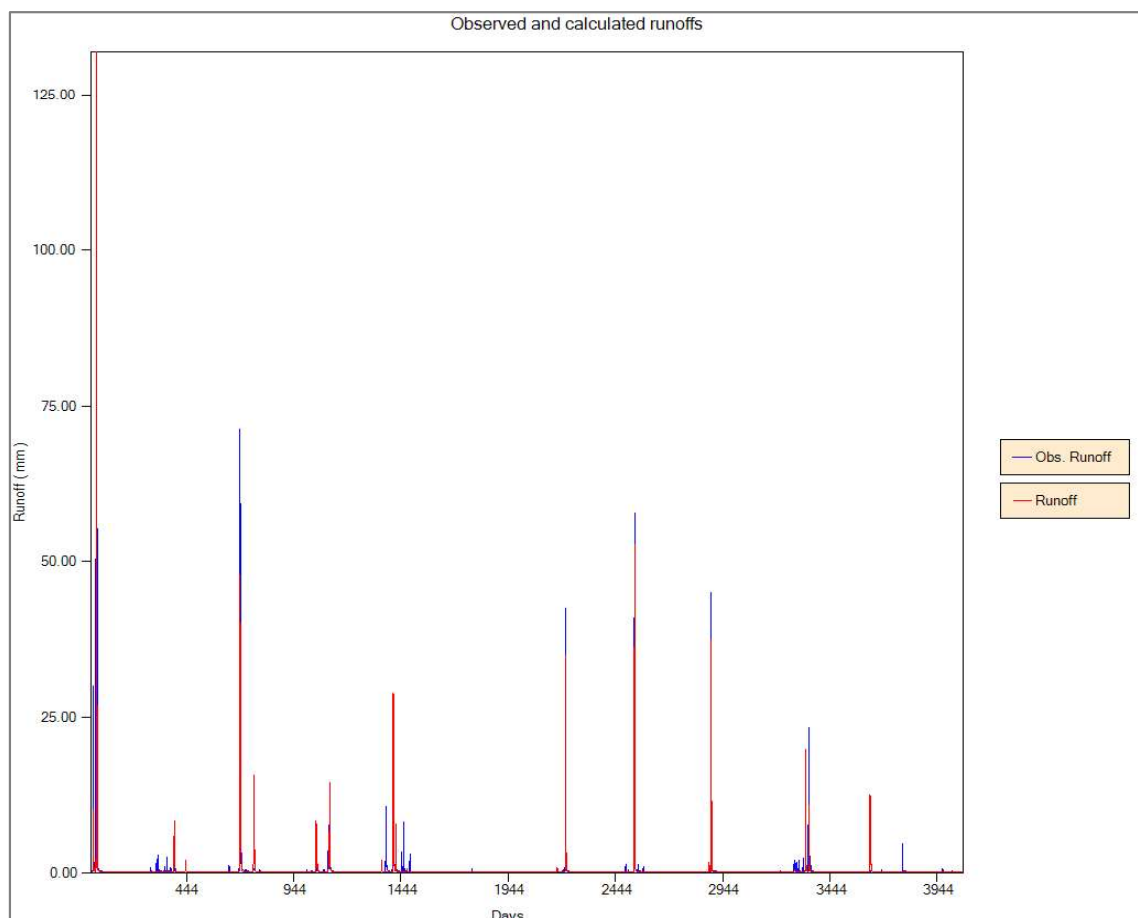


Figure 8: Observed and calculated runoffs for Williams River calibration (RRL AWBM output)

Table 10: AWBM Parameters

Parameter	Description	Calibrated Value
A1	Fraction of area	0.134
A2	Fraction of area	0.433
BFI	Baseflow index	0.561
C1	Surface store 1	48.8
C2	Surface store 2	76.1
C3	Surface store 3	482.3
Kb	Baseflow recession constant	0.345
Ks	Surface recession constant	0.141

4.3.3 Stochastic Rainfall Generator

For this assessment, a stochastic rainfall generator module developed in GoldSim has also been implemented to understand how the catchments respond during a range of variable climatic conditions. The stochastic rainfall generator provides extended records of rainfall data for simulation purposes based on site rainfall records or SILO data.

To capture the expected variability in rainfall and runoff response, the model was run for a period of 1000 years using stochastically generated rainfall records. Stochastic rainfall generators are necessary for probabilistic modelling of hydrologic systems beyond limits of the historical record, which is typically less than 100 years at Australian sites. Stochastic generators attempt to reproduce the statistical characteristics of the historical records in synthetic sequences of arbitrary length (Srikanthan & Zhou, 2003).

Golder has programmed a stochastic climate generator module for use in GoldSim which is based on the Transition Probability Matrix (TPM) method developed by Srikanthan and McMahon (2000). The TPM method uses a state-Markov approach to generate today's rainfall based on yesterday's rainfall state and a random variate. Today's rainfall is generated by linear interpolation between the rainfall state probabilities tabulated in the TPM for yesterday's rainfall state.

A Gamma distributed excess is added in the top state to generate the wettest days. The TPM is developed by simple transition counting in the rainfall record (in this case the Data Drill record) done separately for each calendar month to impose seasonality.

Observing that Australian rainfall in many areas is highly correlated with the Southern Oscillation Index (SOI), Golder developed an in-house SOI-driven TPM method. Performance testing indicates that driving the TPM method with a stochastic SOI increases annual variance closer to the observed variance at most sites. The generated rainfalls are expected to better represent observed long-term variation in rainfall sites with a significant SOI correlation.

A comparison of the monthly average rainfall from the SILO Data Drill record and a 1000-year stochastic generated record is shown in Figure 9. The SILO Data Drill and stochastic monthly rainfall are similar in value and seasonality.

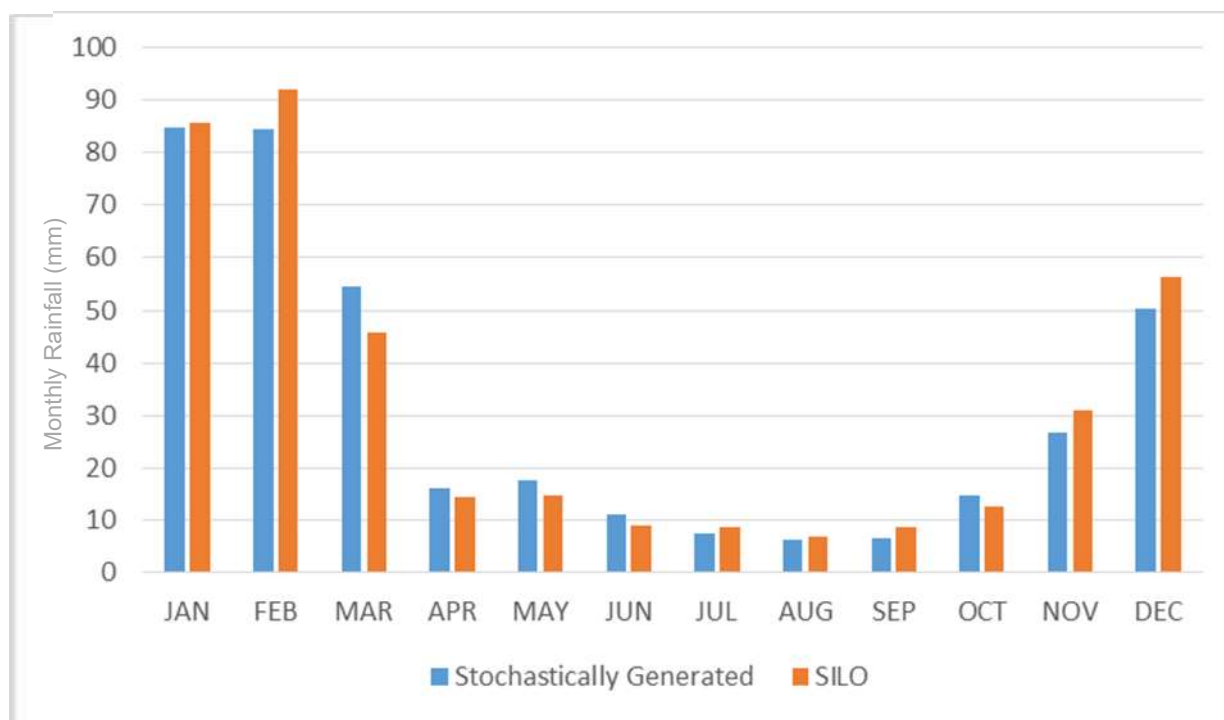


Figure 9: Comparison of monthly mean rainfalls in mm from SILO and stochastically generated values for Dajarra

By ranking the annual rainfall totals a further comparison has been made of the cumulative probability of annual rainfall (as shown in Figure 10). The stochastic rainfall generator provides annual total rainfalls that are similar to the range of variability in the SILO data record for the location of Dajarra.

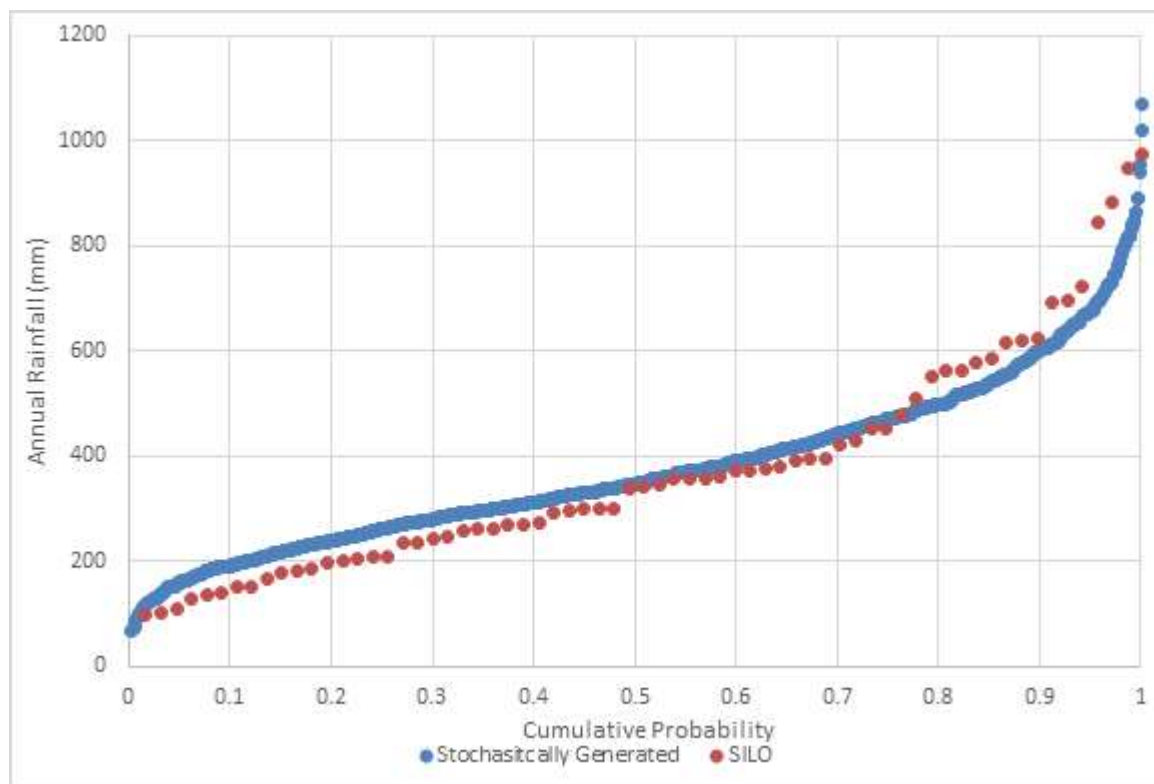


Figure 10: Cumulative probability distribution of annual total rainfall stochastic rainfall data vs. SILO records for the location of Dajarra

4.3.4 Estimated Catchment Yield

The rainfall-runoff model (described in Section 4.3.2) was simulated using the 1000 year stochastically generated rainfall record (described in Section 4.3.3) and the selected catchments on lease (described in Section 4.3.1) to determine the range of potential surface water yield from site watercourses.

The range of estimated potential flow on an annual basis is provided in Table 7. As expected in an ephemeral system located at the head of the catchments there is significant variability in rainfall, and in some years there is no runoff at the catchment outlets identified. The median runoff (of 1000 years simulated) is highest in the largest catchment where it is estimated that 50% of the time 206 ML exits Catchment A at the catchment outlet. The maximum runoff of the 1000 years simulated was 19242 ML. Smaller catchments have smaller median annual yields.

Table 7: Annual Surface Water Yield results

Catchment	A	B	C	D	E	F
Catchment Area (km2)	78.1	8.6	7.0	7.3	1.8	4.6
Minimum runoff (ML)	0	0	0	0	0	0
5th percentile (ML)	0	0	0	0	0	0
25th percentile (ML)	0	0	0	0	0	0
50th percentile - median (ML)	206	23	18	19	5	12
75th percentile (ML)	1546	170	138	143	36	91
95th percentile (ML)	5798	637	519	537	133	341
Maximum runoff (ML)	19242	2113	1722	1782	443	1131

The range of estimated potential flow on monthly basis is provided in Table 8 for Catchment B, on which the Start-up Operation will be located. The ephemeral nature of the system is reflected in the results with no volume expected across all months in the median case. When interrogating the 95th percentile surface water yield, the seasonality of the catchment is visible with significant yield occurring only December through March.

Table 8: Monthly Surface Water Yield from Catchment B (ML)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
5th percentile	0	0	0	0	0	0	0	0	0	0	0	0
25th percentile	0	0	0	0	0	0	0	0	0	0	0	0
Median	0	0	0	0	0	0	0	0	0	0	0	0
75th percentile	3	8	1	0	0	0	0	0	0	0	0	0
95th percentile	209	276	307	1	1	0	0	0	0	0	0	26
Maximum	1068	1194	1791	459	830	144	339	29	0	68	40	680

4.4 Peak Runoff Assessment

4.4.1 Catchment

xpstorm models were developed for the hydrologic routing of catchments shown in Figure 6. The catchment properties applied within the xpstorm models are provided in Table 6. The current land use of the existing catchment is considered natural and model inputs for existing catchments are as below. Infiltration losses were derived from the ARR Data Hub (Geoscience Australia, 2017).

- Initial loss: 40 mm
- Continuing loss: 3.5 mm/hr
- Manning's n roughness coefficient: 0.30

4.4.2 Rainfall

Australian Rainfall and Runoff (ARR) (Geoscience Australia, 2016) provides guidance on the estimation of rainfall depths for a range of Annual Exceedance Probabilities (AEP). This estimation is completed for a range of durations and achieved through the development of a site-specific Intensity-Frequency-Duration (IFD) relationship. The Bureau of Meteorology's (BOM) online IFD system was used to derive the IFD relationship for the Project site (latitude -21.66, longitude 139.19). The IFD has been provided in Table 9.

Temporal rainfall patterns represent the distribution of rainfall over a period of time. A wide range of temporal patterns can be observed in nature; the period of peak intensity can occur early, centrally, or late in the storm

event. Understanding the variability in representative temporal patterns is important as temporal patterns can cause variation in peak flows between rainfall events of comparable magnitude.

In order to consider this variability, ARR (Geoscience Australia, 2016) have generated an ensemble of 10 temporal patterns for each AEP range, duration, and region. These have been made available on the ARR Data Hub (Geoscience Australia, 2017) and the 'Central Slopes' temporal patterns have been incorporated into the hydrologic model.

Table 9: Rainfall intensity frequency duration (mm/hr) - Ardmore

Annual Exceedance Probability (AEP)								
Duration	Duration in minutes	63.20% (1:1)	50%# (1:2)	20%* (1:5)	10% (1:10)	5% (1:20)	2% (1:50)	1% (1:100)
15 min	15	47.8	56.7	84.7	104	123	148	167
30 min	30	33.4	39.7	59.5	73.1	86.4	104	118
1 hour	60	21.6	25.6	38.6	47.5	56.3	68.2	77.5
2 hour	120	13.4	15.9	23.9	29.5	35.1	42.7	48.8
3 hour	180	10.1	12	17.9	22.1	26.4	32.2	36.8
6 hour	360	6.28	7.37	11	13.5	16.1	19.7	22.6
12 hour	720	3.89	4.55	6.72	8.28	9.85	12.1	13.9
24 hour	1440	2.37	2.78	4.11	5.05	6	7.35	8.42
72 hour	4320	1.01	1.2	1.82	2.25	2.68	3.29	3.76

Note: # The 50% AEP IFD does not correspond to the 2-year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.

* The 20% AEP IFD does not correspond to the 5-year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

4.4.3 Peak Flows

Peak flow estimates for the baseline condition have been modelled using the runoff routing hydrologic model xstorm using the Laurenson Method. The method computes storage delay coefficients of each catchment to develop non-linear runoff hydrographs.

ARR (2016) provides guidance about peak flow estimation. Flow representative of the median is determined for each storm duration ensemble. The storm duration associated with the highest median flow is considered the peak flow from the catchment. The hydrological modelling was conducted considering a rainfall events for 1:5, 1:10, 1:20, 1:50, 1:100 AEPs.

The catchment area and calculated peak flow from each catchment is presented below in Table 10.

Table 10: Peak Flow Results - Baseline Catchments

Catchment	Area (ha)	Catchment Slope (m/m)	AEP (1:x)				
			5	10	20	50	100
A	7 810	0.005	29	58	93	148	194
B	860	0.014	20	20	27	35	43
C	700	0.008	13	13	19	25	31
D	730	0.006	12	12	17	24	30
E	180	0.011	5	5	6	8	30
F	460	0.014	12	12	16	20	24

5.0 IMPACT ASSESSMENT

Division 3, Section 125 of the *Environment Protection Act 1994* specifies the requirements for new 'site specific' environmental authority applications. This technical report supports the EA application and provides the identification of potential impacts to surface water quality and quantity environmental values.

5.1 Key Questions/Issues to be Considered

The Start-up Operation infrastructure footprint as shown in Figure 2, is a small development relative to the area of the ML, and to the catchment (Catchment B) on which the footprint is located. The surface water impact assessment focuses on the following:

- Impact of the Start-up Operation on water quality of stormwater runoff and consequently the receiving watercourse;
- Impact of land disturbance caused by the development of the Start-up Operation infrastructure on water quality of stormwater runoff and consequently the receiving watercourse;
- Impact of the Start-up Operation infrastructure footprint on the volume of runoff (annual yield) produced by stormwater runoff; and
- Impact of the Start-up Operation infrastructure footprint on the peak flows of stormwater runoff.

5.2 Emissions and Releases

5.2.1 Water Quality

Surface water generated within the Start-up Operation can be categorised into the following:

- **Clean** – surface runoff from areas undisturbed by mining operations or from fully rehabilitated areas. Clean water can be discharged off the project site.
- **Dirty** – surface runoff from areas disturbed by mining operations but has not come into contact with contaminants. This runoff may contain increased sediment loads, and will require sediment removal prior to release into receiving watercourses.

- **Contaminated** – surface runoff that has come into contact with contaminants. Contaminated water will require treatment before discharging off the project site. Alternatively, contaminated water can be stored on site.

Potential sources of contamination to surfacewater at the Start-up Operation are as follows:

- **Ore and tailings streams** – Sampling has found ore and tailings are non-acid forming (NAF) and geochemically benign, with low risk of generating acidic or saline drainage. Elevated calcium and phosphorus in samples may be of some concern to receiving watercourses (RGS, 2018).
- **Overburden** – Sampling indicates overburden materials taken from the south of the ML are NAF. Some samples showed elevated EC measurements (RGS, 2018).
- **Basement/Footwall units** – Sampling has identified basement/footwall units to have high potential to produce acid, saline, and metalliferous drainage in the northern zone. This area is outside of the Start-up Operation project area. The Southern Zone contains footwall material which is completely oxidised and the potential for PAF material in this area is negligible (RGS, 2018).
- **Vehicles, mine plant and equipment, storage areas, and washdown areas** – Leaks and spills of chemicals and hydrocarbons are possible from these areas.

Further geochemical detail can be found in the Geochemical Investigation Report by RGS (2018).

The impact of water quality changes due to the Start-up Operation has been discussed in Section 5.3.1 below.

5.2.2 Sediment

Sedimentation due to land disturbance is likely to be the most relevant water quality issue for the development of the Start-up Operation. Soil losses expected from existing and expected site conditions have been calculated to give indication of the magnitude of potential water quality issues. The impact of soil losses and resulting sedimentation have been discussed in Section 0 below.

5.2.3 Surface Water Yield

The volume of surface water available on the project site is likely to increase slightly from the development of the Start-up Operation. Natural land cover generally infiltrates more water than cleared or developed surfaces. As the natural land cover of the existing site is cleared and turned into hardstand areas with diminished infiltration properties, more runoff will be available on the surface. This will result in minimal increased annual surface water yield which has been quantified in Section 4.3.

5.2.4 Peak Flow

Peak flows are expected to increase due to the development of the Start-up Operation. Natural land cover generally has higher surface roughness properties. Rough surfaces increase the time taken for runoff to flow, and thus reduces the magnitude of peak flow. As the area of natural land cover is reduced by the Start-up Operation development, it is expected that peak flow off the catchment will increase albeit marginally. Section 5.3.3 quantifies the increase in peak flows.

5.3 Potential Impacts

5.3.1 Water Quality Impacts

There are many sources of contaminants on the Start-up Operation site which can be mobilised by surface runoff and result in the pollution of the environment.

As discussed in Section 5.2.1, the likely sources of contaminants during are drainage containing elevated EC, or calcium and phosphorus levels from geological units, and chemical and hydrocarbon spills from the site. Although elevated EC, calcium, or phosphorus levels can be attributed to already existing geological units on

site, when soils from lower horizons are exposed to air and water, the chemicals can leach into surface soils that have already been depleted and result in contamination of groundwater and runoff.

The contaminants have potential impacts to receiving environments including:

- reduction of soil productivity due to excess salts (Queensland Government, 2013),
- impact the suitability of habitats for some aquatic flora and fauna (Cavanagh, et al., 2014),
- physically damage tissues and organs of aquatic fauna (Cavanagh, et al., 2014),
- alter movement and behaviour of aquatic fauna which can impact growth rates, community structure, and/or population sizes (Kemp, et al., 2011).

These impacts are expected to be contained to waterways and soils downstream of the contaminant within the ML. The duration of these impacts are predicted to be short term due to the ephemeral nature of the drainage lines in this area – watercourses often dry out within a few weeks after rainfall events. The impacts are expected at a low frequency associated with rainfall events. Furthermore, stormwater management practices will be implemented on the Start-up Operation site to minimise contaminant mobilisation.

Analysis of aerial photography suggests there are no dam structures within 10 km downstream of the Start-up Operation. It is expected that there are no users accessing this watercourse as a potable source of water.

There is possibility that livestock may use the watercourse as drinking water. It is expected that should contaminants be mobilised by rainfall into watercourses, their dilution will result in minimal impacts to livestock.

Sediment and Soil Loss
Soil losses in the catchment results in sedimentation in runoff. Sediment in runoff from disturbed lands is considered a major source of pollutants in Australian waterways (Landcom, 2004). Based on the 1:100 000 Ardmore geology map (Australia 1:100 000 geological series, Sheet Number 6754) indicates the Start-up Operation will be located on the Beetle Creek Formation which consists of chert, siliceous shale with trilobite fossils, and basal conglomerate. This geological formation is likely to have relatively high sediment supply potential due to its strength and structure (Tomkins, 2013). Additionally, the existing land has been historically degraded from land-clearing and stock grazing contributing to erosion and sedimentation.

Impacts of sediment and other suspended solids in waterways can have impacts described in 5.3.1, and additionally, can reduce the capacity of downstream channels and water bodies, worsening flood impacts (Landcom, 2004).

Sediment contamination of downstream waterways is considered a one-off (pulse) effect during a rain event. A pulse event results in a temporary disturbance to the ecosystem from which it is likely to recover (Hogan, 2012).

The Revised Universal Soil Loss Equation (RUSLE) can be used to predict long-time average soil loss rates from sheet and rill flow.

RUSLE calculates annual erosion rates based on the following equation.

$$A = R.K.LS.C.P$$

Where:

A	=	annual soil loss due to erosion [t/ha/yr]
R	=	rainfall erosivity factor
K	=	soil erodibility factor
LS	=	topographic factor derived from slope length and slope gradient
C	=	cover and management factor
P	=	erosion control practice factor

A summary of RUSLE calculations for existing, during construction (vegetation cleared), overburden stockpiles, and operational conditions have been presented in Table 11. Values in the table have been extracted and interpolated from reference tables within the *Best Practice Erosion and Sediment Control* Guideline by IECA (2008) and informed by soil characterisation analysis by Golder (2018).

Table 11: RUSLE calculations

RUSLE factors	Existing (established vegetation)	Construction and Operation (cleared vegetation)	Overburden Stockpiles	Rehabilitated (newly established vegetation)
R	1219 ^a	1219 ^a	1219 ^a	1219 ^a
K	0.025 ^b	0.025 ^b	0.025 ^b	0.025 ^b
LS	0.38 ^c	0.38 ^c	0.38 ^c	0.38 ^c
C	0.24 ^d	-	-	0.45 ^e
P	-	-	1.3 ^f	-
A (t/ha/yr)	2.78	11.58	15.05	5.21

^a based on Mt Isa values from Table E1 (IECA, 2008).

^b based on soil type of sandy clay loam based on soil sampling results in the southern catchment (Golder, 2018) using Table E4 (IECA, 2008).

^c based on Slope gradient 1.3%, Slope length 200 m from Table E3 (IECA, 2008).

^d interpolated from Table E10 (IECA, 2008).

^e based on 20% ground cover for newly established grass cover, taken from Table E9 (IECA, 2008).

^f based on compacted and smooth surface condition (default construction phase), taken from Table E11 (IECA, 2008).

Assuming there will be clearing for the mine development area, soil erosivity is expected to increase significantly compared to existing site conditions where established vegetation exists. Overburden stockpiles have significant potential for soil loss of 15.05 t/ha/yr without implementation of erosion and sediment control practices.

Under the assumption that vegetation will be re-established for closure of the Start-up Operation, soil losses will be lessened from the construction and operation phases, however, soil losses greater than existing conditions are to be expected until the vegetation becomes fully established in closure of the site.

These impacts are expected to be contained to waterways downstream of the Start-up Operation. The duration of impacts to aquatic environments are predicted to be short term due to the ephemeral nature of the drainage lines in this area – watercourses often dry out within a few weeks after rainfall events. The impacts are expected at a low frequency associated with rainfall events.

5.3.2 Surface Water Yield

In addition to the natural land surface on the ML, the Start-up Operation development will add 'spoil' and 'hardstand' land surfaces in catchment B. The areas attributed to each of the surfaces have been presented in Table 12. The AWBM parameters attributed to the surfaces modelled in the water balance of the Start-up Operation development are presented in Table 13.

Table 12: Start-up Operation Development Catchment B Subcatchment Land Uses

Land Use	Area (km ²)
Natural	8.52
Spoil	0.05
Hardstand	0.03

Table 13: AWBM Parameters – Catchment B Start-up Operation Development

Parameter	Calibrated Value		
	Natural	Spoil	Hardstand
A1	0.134	0.134	0.134
A2	0.433	0.433	0.433
BFI	0.561	0.561	0.00
C1	48.8	10	5
C2	76.1	30	15
C3	482.3	300	30
Kb	0.345	0.345	1.00
Ks	0.141	0.141	0.141

The range of estimated runoff volumes on an annual basis is provided in Table 14. As expected, the Start-up Operation development increases the volume of runoff off catchment B. However, the increase is minimal, considering the spread of this yield across a year.

Table 14: Annual Runoff from Catchment B (ML)

Statistic	Existing	Start-up Operation Development	Annual Runoff increase
Minimum	0	0	0
5th percentile	0	0	0
25th percentile	0	2	2
50th percentile	23	26	3
75th percentile	170	175	5
95th percentile	637	645	8
Maximum	2113	2130	17

Table 15: Monthly Surface Water Yield from Catchment B (ML) – Start-up Operation Development

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
5th percentile	0	0	0	0	0	0	0	0	0	0	0	0
25th percentile	0	0	0	0	0	0	0	0	0	0	0	0
50th percentile	0	0	0	0	0	0	0	0	0	0	0	0
75th percentile	4	9	2	0	0	0	0	0	0	0	0	0
95th percentile	212	279	311	2	3	1	0	0	0	0	0	29
Maximum	1074	1200	1801	462	835	147	343	31	0	70	43	685

5.3.3 Peak Flows

Peak flows for catchment B including trail mine infrastructure were modelled using the subcatchment areas presented in Table 12. Conservatively, the spoil and hardstand areas were modelled as impervious areas, with no infiltration. No other catchments are impacted by the Start-up Operation.

Table 16 presents the peak flows expected for existing catchment B conditions and catchment B under Start-up Operation conditions. The peak flow does not increase greatly between the two scenarios. This can be attributed to the small area of the Start-up Operation footprint. The Start-up Operation area makes up approximately 1% of catchment B.

Increases in peak flows can result in increased erosion through channels, and increased flood extents. However, the small increase in peak flows through catchment B is likely to have negligible impact on the receiving environment.

Table 16: Peak Flow Results for Catchment B (m³/s)

AEP (1:x)	Existing	Start-up Operation Development	Peak Flow increase
5	11	11	0
10	20	20	0
20	27	28	1
50	35	35	0
100	56	56	0

5.3.4 Risk of Unplanned Events

It is likely that in the event of contaminant spills or leaks from the operation of the Start-up Operation, contaminants will be able to be contained through implementation of spill management procedures. The topography across the ML is quite flat, minimising the reach of any spills or leaks and the likelihood of contaminants reaches watercourses. Furthermore, due to the ephemeral nature of the watercourses on the ML, even if the contaminant reaches a drainage line, it is likely that there will be low or no flows in the watercourse to receive and propagate the contaminant downstream.

In the event that a spill or a leak occurs concurrently to a rain event, this scenario can be hydraulically modelled to quantify contaminant reach length. However, the magnitude of such a spill or leak event is expected to be minor during the Start-up Operation and in-depth modelling of contaminant reach length has not been conducted at this stage. It is also likely that if a rain event occurs concurrently to the spill, the volume of runoff will dilute the concentration of contaminant in the stream which would minimise damage, if any, to the receiving watercourse.

6.0 MITIGATION AND MANAGEMENT MEASURES

6.1 Water Quality Monitoring and Discharge Criteria

During the Start-up Operation, water quality monitoring should be conducted in the event of runoff generation at discharge locations to ensure only clean or treated water is released to the environment.

Based on the potential contaminants identified from the start-up operation, the monitoring suite presented in Table 17 is proposed.

Table 17: Proposed monitoring suite

Parameter	Units
pH	pH unit
Electrical conductivity	µS/cm
TDS	mg/L
TSS	mg/L
Calcium: Total Dissolved	mg/L mg/L
Phosphorus: Total Dissolved	mg/L mg/L

The proposed monitoring locations are presented in Table 18. Monitoring locations are shown in Figure 5.

Table 18: Proposed monitoring locations

Monitoring Point	Easting	Northing
ARD10	324497	7594684
ARD11	323577	7594287

6.2 Contaminant Containment

6.2.1 Spill Control Procedures

Centrex should ensure that all plant and equipment used in the construction and operation of the Start-up Operation is maintained appropriately to minimise spills and leaks of contaminants. Any activities that may carry a high risk of spills or leaks should be managed to minimise the risk.

In relation to the operations expected at the Start-up Operation, the management of ore loading, transport, and unloading should be addressed within a management plan. Such a plan should identify training requirements for personnel to ensure proper operation of loading/unloading equipment, as well as spill emergency response procedures. Ore dust suppression measures may be required over the ore stockpile, and drainage and water management systems for stockpile areas should be implemented.

6.2.2 TSF Storage Allowances

Tailings dams require different storage capacities and water management requirements to normal water storage dams to deliver dam safety as well as environmental safety. The tailings and water stored in the temporary TSF are likely to be of quality exceeding the water quality guidelines discussed in Section 3.1. Appropriate storage allowances are to be provided in the design to reduce the risk of spill from the dam. Guidelines on applicable storage allowances are provided in the ANCOLD Guidelines on Tailings Dams (2012).

6.3 Erosion and Sediment Control

To minimise the impact of the plant development on the environment, erosion and sediment control strategies should be implemented.

Erosion and sediment control principles relevant to this site include the following:

- Fit the project to the existing topography, soils vegetation;
- Minimise disturbance and retain natural vegetation;
- Schedule works to minimise soil exposure during rainy season;
- Vegetate and mulch denuded areas;
- Minimise slope steepness and slope length by using benches, terraces, contour furrows or diversion ditches;
- Stockpiles to be located outside limits of drainage lines;
- Keep sediment on-site by using sediment traps, bunding, or sediment barriers; and
- Monitor and inspect sites frequently and correct problems promptly.

6.4 Mine Closure and Rehabilitation

This section assumes that the full mining project is not developed after the trial. In the case that the full mine project proceeds, the footprint of the Start-up Operation will be encompassed into the disturbance area of the full mine.

The Start-up Operation is expected to have a short life, in the order of 2 to 3 months for mining, and 1 to 2 months for processing, and the areas available for progressive rehabilitation will be minimal.

Disturbed areas are expected to be rehabilitated as follows:

- **Open pit.** The open pit will be backfilled with any remaining stockpiled ore and waste rock. These areas will be contoured, topsoil will be spread and direct seeded to encourage revegetation with native species of local provenance.
- **Tailings Storage Facility.** The TSF will be backfilled with material from the TSF Bund. The surface will be rehabilitated with stockpiled soil.
- **Waste rock.** Waste rock will be used to backfill the open pit. The surface will be returned to the original surface level, contoured, and spread with topsoil and direct seeded to encourage revegetation with native species of local provenance.
- **Mine infrastructure areas.** The processing plant and infrastructure will be removed from site. Once infrastructure has been removed, any areas of contamination will be remediated and the areas will then be revegetated with native species.

By rehabilitating these areas, the disturbed areas will be returned to a condition as close as possible to its original state. This will result in the reinstatement of the original hydrology and hydraulic conditions on the Start-up Operation site.

7.0 RESIDUAL IMPACTS

It is unlikely that a site disturbance caused by the development and operation of the Start-up Operation at Ardmore Phosphate Rock Project is likely to cause any long lasting residual impacts to the hydrology and hydraulics of the catchment. The Start-up Operation footprint is quite minimal in comparison to the broader catchment (approximately 0.9%) and its impacts on surface water are expected to be negligible once the site is rehabilitated and revegetated.

8.0 CONCLUSIONS

The impacts of the Ardmore Phosphate Rock Project Start-up Operation on surface water were assessed considering water quality – specifically sedimentation, annual surface water yield, and peak flows.

Soil loss analyses determined that development of the Start-up Operation will increase sediment generation. Best practice erosion and sediment control measures will minimise soil loss, and capture sediment that may become mobilised by rainfall.

Surface water yield is likely to increase, as development will impact catchment B's runoff response to rainfall. However, as the footprint of the Start-up Operation makes up only 1% of catchment B, its impact is minimal, with only 17 ML increase of maximum annual yield between the existing and Start-up Operation scenarios.

The impact of the Start-up Operation on peak flow values was also assessed and found to have negligible impact. This is also attributed to the small disturbance area in comparison to the greater catchment.

9.0 IMPORTANT INFORMATION

Your attention is drawn to the document - "Important Information Relating to this Report", which is included as an Appendix B of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the services provided for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

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APPENDIX A

Summary of Regional Water Quality Monitoring Results

Table 8: *In-situ* and laboratory surface water quality results from the wet season 2018 baseline survey

ANALYTE		UNIT	SPLIT CREEK CATCHMENT					
			GV [*]	ARD4	GV [*]	ARD5	GV [*]	ARD6
pH		pH unit	6.0 – 7.5 ¹	7.61	6.0 – 7.5 ¹	6.89	6.0 – 7.5 ¹	7.33
Electrical Conductivity		µS/cm	200 ²	398	200 ²	105	200 ²	196
Dissolved Oxygen		% Sat	90 – 120 ¹	69.1	90 – 120 ¹	6.8	90 – 120 ¹	20.9
Temperature		°C	-	31.90	-	28.54	-	26.85
Turbidity		NTU	50 ¹	8.3	50 ¹	15	50 ¹	1.4
TSS		mg/L	-	38	-	24	-	26
Alkalinity		mg/L	-	170	-	49	-	170
Fluoride		µg/L	-	0.1	-	0.1	-	0.1
Sulfate		mg/L	-	1.3	-	3.5	-	1.2
TKN		mg/L	-	1.2	-	1.3	-	1.2
NOx		mg/L	0.03 ¹	<0.005	0.03 ¹	<0.005	0.03 ¹	<0.005
TKP		mg/L	-	0.10	-	0.32	-	0.09
FRP		mg/L	0.005 ¹	0.016	0.005 ¹	0.049	0.005 ¹	0.015
Calcium		mg/L	-	38	-	11	-	38
Potassium		mg/L	-	13	-	7.8	-	13
Sodium		mg/L	-	27	-	3.2	-	27
Magnesium		mg/L	-	14	-	3.1	-	14
Hardness		mgCaCO ₃ /L	-	120	-	38	-	130
Aluminium	Total	mg/L	0.055 ¹	<0.02	0.055 ¹	0.15	0.055 ¹	<0.02
	Dissolved	mg/L	0.055 ¹	<0.02	0.055 ¹	<0.02	0.055 ¹	<0.02
Arsenic	Total	mg/L	13 ¹	<0.003	13 ¹	<0.003	13 ¹	<0.003
	Dissolved	mg/L	13 ¹	<0.003	13 ¹	<0.003	13 ¹	<0.003
Cadmium	Total	mg/L	0.2 ¹	<0.0001	0.2 ¹	<0.0001	0.2 ¹	0.0001
	Dissolved	mg/L	0.2 ¹	<0.0001	0.2 ¹	<0.0001	0.2 ¹	<0.0001
Chromium	Total	mg/L	3.3 ¹	<0.001	3.3 ¹	<0.001	3.3 ¹	<0.001
	Dissolved	mg/L	3.3 ¹	<0.001	3.3 ¹	<0.001	3.3 ¹	<0.001
Cobalt	Total	mg/L	2.8 ³	0.003	2.8 ³	0.003	2.8 ³	0.004
	Dissolved	mg/L	2.8 ³	0.002	2.8 ³	0.002	2.8 ³	0.003
Copper	Total	mg/L	1.4 ¹	0.003	1.4 ¹	0.002	1.4 ¹	0.002
	Dissolved	mg/L	1.4 ¹	0.002	1.4 ¹	0.001	1.4 ¹	0.001
Lead	Total	mg/L	3.4 ¹	0.002	3.4 ¹	0.003	3.4 ¹	0.002
	Dissolved	mg/L	3.4 ¹	0.001	3.4 ¹	<0.001	3.4 ¹	0.001
Mercury	Total	mg/L	0.6 ³	<0.00005	0.6 ³	<0.00005	0.6 ³	<0.00005
	Dissolved	mg/L	0.6 ³	<0.00005	0.6 ³	<0.00005	0.6 ³	<0.00005
Nickel	Total	mg/L	11 ¹	0.002	11 ¹	0.002	11 ¹	0.001
	Dissolved	mg/L	11 ¹	0.002	11 ¹	0.001	11 ¹	0.001
Uranium	Total	µg/L	0.5 ³	<1	0.5 ³	<1	0.5 ³	<1
	Dissolved	µg/L	0.5 ³	<1	0.5 ³	<1	0.5 ³	<1
Zinc	Total	mg/L	8 ¹	<0.005	8 ¹	<0.005	8 ¹	<0.005
	Dissolved	mg/L	8 ¹	<0.005	8 ¹	<0.005	8 ¹	<0.005

¹ Australian and New Zealand Environmental Conservation Council (ANZECC, 2000) Trigger values for toxicants for the protection of slightly to moderately disturbed systems (95% protection for aquatic ecosystems) used for total and dissolved metals. Where values exceeded this guideline, they were hardness modified according to ANZECC (2000). ANZECC 2000 aquatic ecosystem (Tropical Australia for upland rivers) default trigger values used for physico-chemical parameters (except EC) as no QWQG guidelines for the Lake Eyre basin currently exist.

² QWQG (EHP, 2009b) Lake Eyre salinity zone (75th percentile) used for EC as salinity zones are defined differently to other parameters in the QWQG.

³ Indicates where ANZECC (2000) low reliability trigger values were used.

* GV = Guideline value

Guideline exceedances are highlighted in red. Cases in which the value is below the LOR, but the LOR is above the guideline value, are highlighted in yellow.

Table 9: Stream sediment results from the wet season 2018 baseline survey

PARAMETER	FRACTION	UNITS	ISQG TRIGGER VALUE		HORSE CREEK		SPLIT CREEK CATCHMENT										SULIEMAN CREEK			
			Low	High	ARD1	ARD4	ARD5	ARD2	ARD3	ARD6	ARD7	ARD9	ARD8	ARD11	ARD10					
Nitrate/Nitrite	Whole	mg/kg	-	-	1.7	0.4	0.8	<0.1	<0.1	0.6	<0.1	<0.1	0.9	0.4	17					
TKN	Whole	mg/kg	-	-	300	35	130	44	68	34	100	49	250	54	420					
WSP	Whole	mg/kg	-	-	0.47	1.2	2.7	2.0	1.4	1.5	7.6	1.9	3.4	0.47	1.2					
TKP	Whole	mg/kg	-	-	220	170	3700	580	790	240	17000	990	6700	200	1700					
Arsenic	Whole	mg/kg	20	70	2.1	0.8	2.2	1.9	1.4	0.5	11	1.3	1.9	1.4	2.2					
	Fine	mg/kg	-	-	5.1	4.5	4.8	5.1	5.2	5.7	7.2	2.9	4.2	2.7	3.8					
Cadmium	Whole	mg/kg	1.5	10	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1					
	Fine	mg/kg	-	-	0.3	<0.1	<0.1	<0.1	<0.1	0.1	0.2	<0.1	0.2	<0.1	<0.1					
Chromium	Whole	mg/kg	80	370	12	6.6	13	7.7	9.8	5.5	24	22	22	11	15					
	Fine	mg/kg	-	-	21	25	23	34	27	22	26	48	33	35	26					
Copper	Whole	mg/kg	65	270	6.5	3.2	6.4	4.9	5.9	3.1	19	12	22	6.1	13					
	Fine	mg/kg	-	-	21	33	25	22	23	31	26	46	38	30	24					
Lead	Whole	mg/kg	50	220	3.8	2.4	6.0	5.7	25	2.5	16	5.8	6.9	3.4	5.7					
	Fine	mg/kg	-	-	19	50	28	85	28	59	25	29	20	21	12					
Mercury	Whole	mg/kg	0.15	1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01					
	Fine	mg/kg	-	-	<0.01	<0.01	0.04	<0.01	<0.01	0.04	0.03	0.01	0.03	0.02	0.02					
Nickel	Whole	mg/kg	21	52	8.3	2.4	7.4	4.1	5.4	2.2	12	14	15	7.5	11					
	Fine	mg/kg	-	-	27	18	18	21	20	17	16	31	23	21	17					
Silver	Whole	mg/kg	1	3.7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2					
	Fine	mg/kg	-	-	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2					
Zinc	Whole	mg/kg	200	410	15	7.2	22	12	16	7.1	45	32	40	11	21					
	Fine	mg/kg	-	-	47	56	57	58	53	56	46	68	65	38	33					

APPENDIX B

Important Information

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

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