



TRANSITIONAL PROGRESSIVE REHABILITATION AND CLOSURE PLAN

YANDAN GOLD PROJECT

PREPARED FOR
STRAITS GOLD PTY LTD

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Table of Abbreviations

EA	Environmental Authority
EP Act	<i>Environmental Protection Act 1994</i>
ERA	Environmentally relevant activity
FOS	Factor of safety
LOD	Land outcome document
ML / MLs	Mining Lease / Mining Leases
NUMA	Non-use management area
PMLU	Post-mining land use
PoO	Plan of Operations
PRCP	Progressive Rehabilitation and Closure Plan
PRCP Guideline	Progressive Rehabilitation and Closure Plan Guideline
RUSLE	Revised Universal Soil Loss Equation
SEP	Stakeholder Engagement Plan

1 Introduction

AARC Environmental Solutions Pty Ltd (AARC) has been commissioned by Straits Gold Pty Ltd (Straits Gold) to develop a Progressive Rehabilitation and Closure Plan (PRCP) for the Yandan Gold Mine (the Project) in accordance with the requirements of the *Environmental Protection Act 1994* (EP Act).

Straits Gold Pty Ltd is a wholly owned subsidiary of GBM Resources Limited (GBM), which acquired the Project site (and the Straits Gold Pty Ltd entity) in January 2021, from the previous owner, Aeris Resources Limited.

This PRCP is applicable to Mining Leases (MLs) ML 1095 and ML 1096. The current version of the Environmental Authority (EA) for the Project (EPML00771913) was issued on 20 December 2012 to Straits Gold Pty Ltd; then a wholly owned subsidiary of Aeris Resources Limited.

The Project EA authorises the environmentally relevant activity (ERA) of mining gold ore under Schedule 3 of the Environmental Protection Regulation 2019 (EP Regulations).

2 Scope and objective

The purpose of this PRCP is to describe how progressive rehabilitation will be carried out at the Project. The PRCP has been developed in accordance with the requirements of the *Progressive Rehabilitation and Closure Plan Guideline* (DES 2021) (PRCP Guideline), which states that the PRCP must include the following parts:

1) Rehabilitation planning part

The purpose of the rehabilitation planning part of the PRCP is to provide evidence and justification to support the development of the proposed PRCP schedule. This part must detail how progressive rehabilitation and closure will be carried out over the entire Project. The PRCP planning part is required to address the following:

- community consultation (refer Section 3.2);
- post-mining land use (PMLU) and/or non-use management area (NUMA) determination (refer Section 3.3 and Section 3.4);
- the rehabilitation and management methodology to be implemented (refer Section 3.5);
- an assessment of rehabilitation risk (refer Section 3.6); and
- a program for monitoring and maintenance of rehabilitation (refer Section 3.7).

2) Rehabilitation schedule part

The development and implementation of the schedule part is an essential element of a PRCP. Once approved, the schedule part becomes a legally binding and enforceable instrument with which the Project must comply. The schedule part must include:

- nomination of either a PMLU or NUMA for all land within the relevant resource tenures;
- identification of when land becomes available for rehabilitation or improvement;
- rehabilitation or management milestones to achieve the PMLU and/or NUMA outcomes;
- milestone criteria that demonstrate when each milestone has been completed;
- completion dates for each milestone to be achieved; and
- any conditions considered necessary or desirable.

The administering authority may impose a condition on a draft PRCP schedule or a PRCP schedule if it considers the condition is necessary or desirable (Section 4.2 of the Guideline). Two deemed conditions are to be included in all PRCP schedules in accordance with Section 206A of the EP Act. The first condition states that when carrying out a relevant activity under the PRCP schedule, the holder must comply with a requirement stated in the EA relevant to carrying out the activity.

The second condition states that the holder must comply with the following matters stated in the schedule:

- each rehabilitation milestone and management milestone; and
- when each rehabilitation milestone and management milestone is to be achieved.

3 Project planning part

3.1 Project planning

3.1.1 Project description

The Project is situated in the Drummond Basin, central Queensland, located approximately 50 km to the west of the township of Mount Coolon and approximately 150 km southeast of Charters Towers (Figure 1). The Project falls on the boundary of the Whitsunday Regional Council and Charters Tower Regional Council local government areas.

Yandan Gold Mine consists of two MLs, being ML 1095 and ML 1096, comprising a total area of 1,971.3 ha. Table 1 indicates the current status of the MLs. The Project MLs and tenement boundaries are shown in Figure 2.

Table 1: Yandan tenements

Permit Number	Authorised Holder	Grant	Expiry	Area (ha)	Real Property Description
ML 1095	Straits Gold Pty Ltd	27/06/1991	30/06/2036	1368.9	Lot 5060 on PH387
ML 1096	Straits Gold Pty Ltd	27/06/1991	30/06/2036	602.4	Lot 5060 on PH387

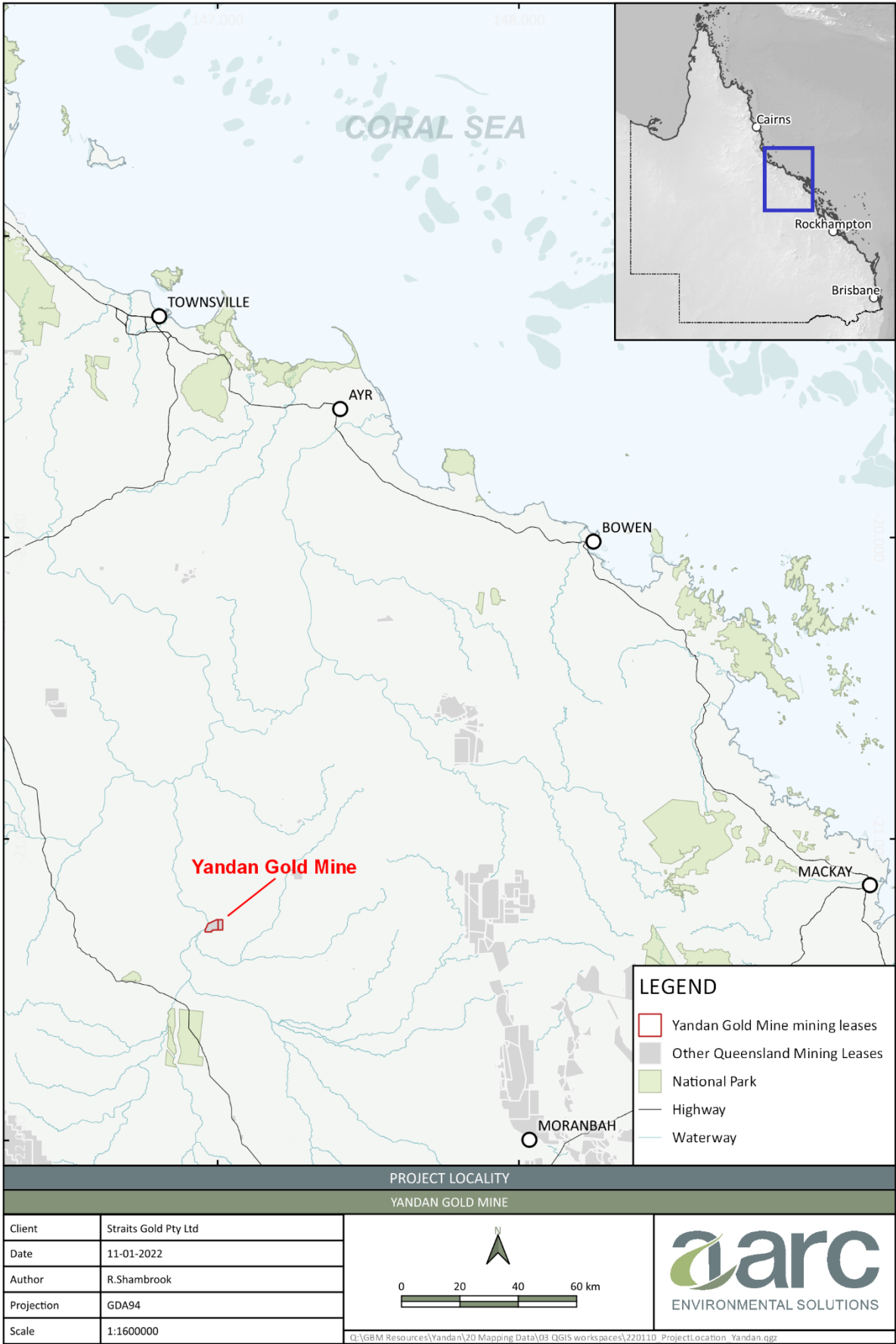


Figure 1: Project locality

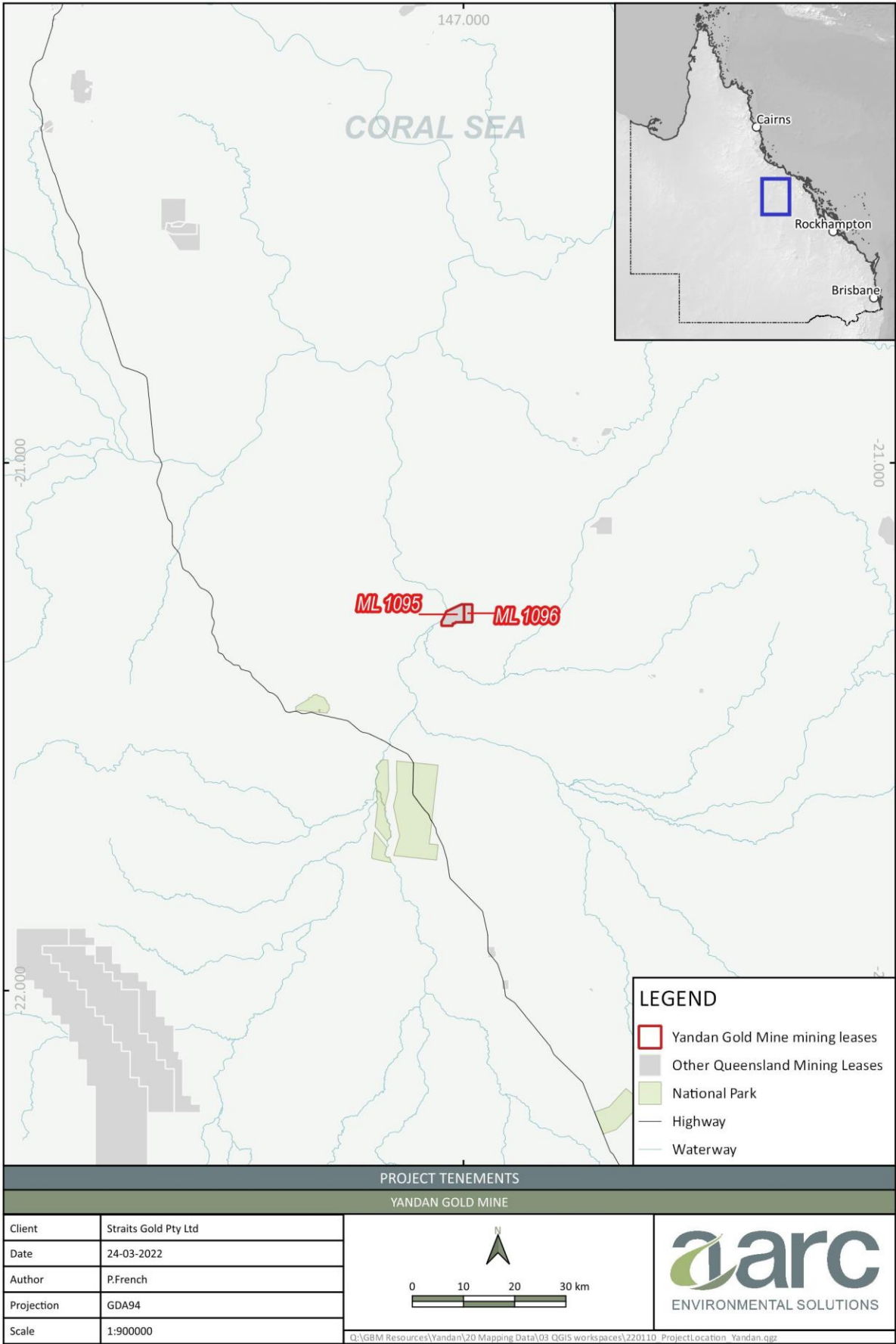


Figure 2: Project tenements

3.1.1.1 Past operations

Ross Mining N.L. operated the Project between 1993–2002, producing over 350,000 ounces of gold from heap leach operations and a Carbon in Leach (CIL) process plant. Ore was sourced from three open cut pits during operation, principally being Main Pit and South Pit, with a small pit also excavated at East Hill. During operations, low grade oxide ore (predominately clay rich) sourced from the three open cut pits was placed on a Heap Leach Pad.

Open cut mining operations ceased in 1998, with the Heap Leach Pad remaining operational until September 2002 (Figure 3). The site was placed into care and maintenance in April 1999, pending final closure works. The gold processing plant was later removed in 2006/2007, prior to the acquisition of the Project by Straits Gold; a wholly owned subsidiary of Aeris Resources Ltd at that time. The Project has remained in care and maintenance since cessation of operations in 1999, with some exploration activities undertaken since that time.

EP Act Schedule 3 Notifiable activities which are deemed likely to have been conducted at the Project site include:

- *Notifiable Activity 7 – Chemical storage (other than petroleum products or oil under item 29) – storing more than 10 t of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code;*
- *Notifiable Activity 15 – Explosives production or storage– operating an explosives factory under the Explosives Act 1999;*
- *Notifiable Activity 20 - Landfill—disposing of waste (excluding inert construction and demolition waste).*
- *Notifiable Activity 24 – Mine wastes;*
 - (a) Storing hazardous mine or exploration wastes, including, for example, tailings dams, overburden or waste rock dumps containing hazardous contaminants; or*
 - (b) Exploring for, or mining or processing, minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants;*
- *Notifiable Activity 25 - Mineral processing—chemically or physically extracting or processing metalliferous ores.*
- *Notifiable Activity 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 (AS) 1940, 'The storage and handling of flammable and combustible liquids' published by Standards Australia – more than 25,000 L capacity.*

Rehabilitation has been approached progressively, with some domains fully or partially rehabilitated. Rehabilitated domains include South Pit, the run-of-mine (ROM) pad, Cell A of the Tailings Storage Facility (TSF), the village infrastructure area, and the infrastructure/hardstand area.

Key existing infrastructure at Yandan includes the following (refer Figure 3):

- a Tailings Storage Facility (TSF);
- a Heap Leach Pad and associated treatment ponds;
- infrastructure and hardstand area;
- Main Pit;
- East Hill Pit; and
- a number of water storage structures for the management of raw and mine affected water, including the Tailings Return Water Dam (TWRD), Water Storage Dam, Mine Water Dam, Heap Leach Pregnant and Barren Ponds, and the Heap Leach Stormwater Pond.

Following the introduction of the *Mineral and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act) and the new financial provisioning scheme, the first Estimated Rehabilitation Cost (ERC) application for the Project was submitted in September 2021. An information request related to the application was subsequently received on 23 September 2021, requiring further information to be submitted by 30 July 2022. Activities proposed for the first ERC period (nominally commencing late 2022, subject to approval of the ERC application), comprise exploration and resource optimisation.

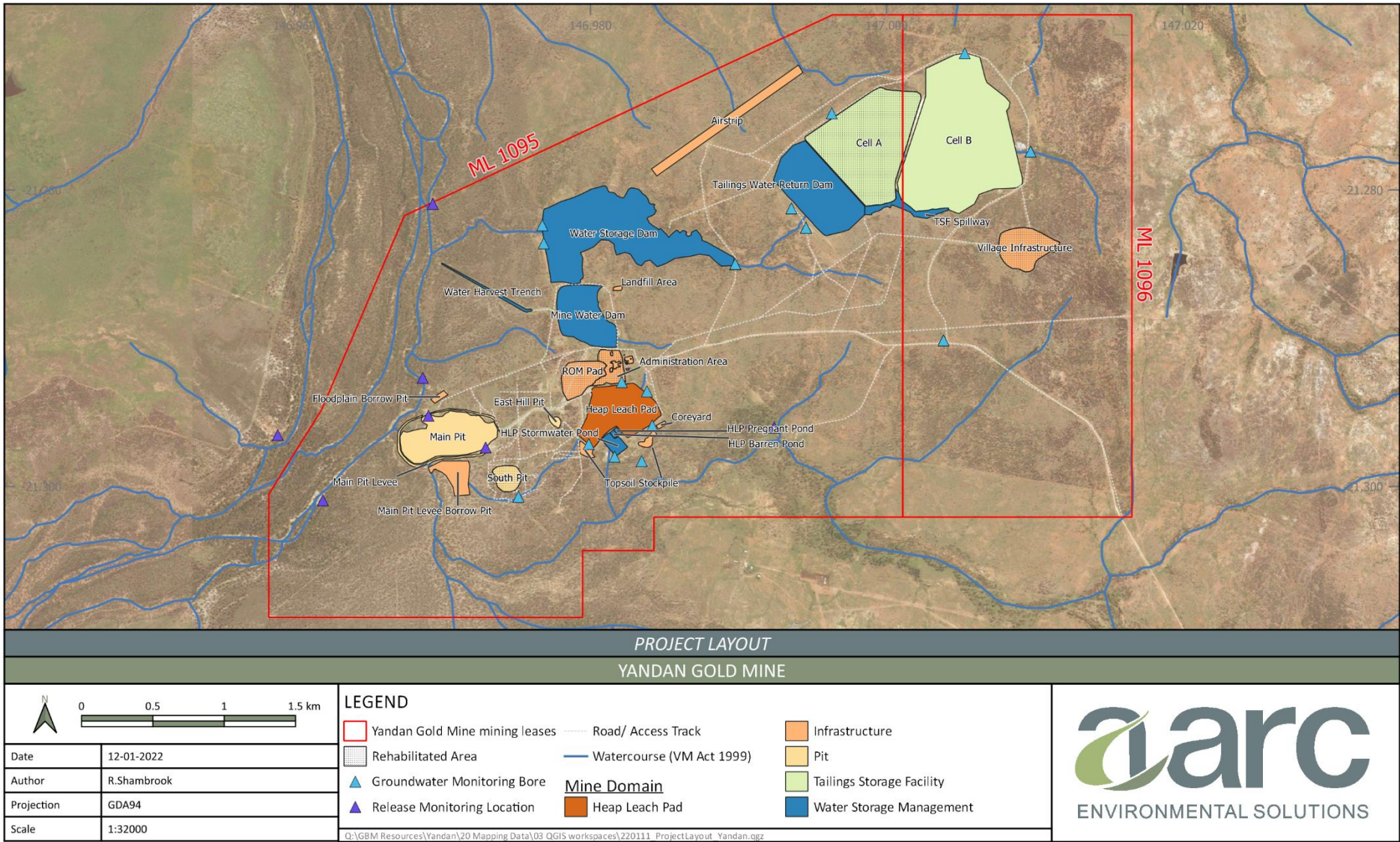


Figure 3: Project layout

3.1.1.2 Future mining activity

Exploration and resource optimisation

Since acquiring the Yandan Gold Mine in January 2021, GBM have identified opportunities to extract additional value from Yandan, and consider Yandan to be under explored and prospective for further gold discoveries.

Under GBM's new ownership, exploration has re-commenced at Yandan. In April 2021, a Phase 1 diamond and reverse circulation drilling program commenced. The drilling program targeted high grade mineralisation lying east of the Main Pit for potential open cut targets, with the aim of expanding existing resources located between the Main Pit and East Hill deposits. At the completion of Phase 1 drilling in July 2021, a total of 13 holes had been drilled for a total of 5,676 m.

Results from the Phase 1 drilling program have confirmed the potential to further expand the current gold resources at East Hill. At the time of this report, existing resources at Yandan total 521,000 ounces gold (JORC 2012 'inferred' resource estimate). It is anticipated that a significant component of the resource estimate will be upgraded to the 'indicated' category in the near-term. The current phase of active exploration and resource optimisation aims to upgrade, as well as grow, the Yandan resource estimate to support development of a life of mine (LOM) plan for the Project.

Disturbance caused by exploration activities will be progressively rehabilitated during this phase. The approved post-mining land use (PMLU) for areas disturbed by exploration activities is 'open pasture'. The rehabilitation methodology to achieve this PMLU involves:

- removal of all equipment;
- capping or permanently plugging drill holes;
- a drying out period to allow water to evaporate from the drilling mud in the sumps;
- backfilling of drill sumps to natural surface;
- scarifying disturbed areas to promote revegetation;
- seeding of disturbed areas; and
- all exploration tracks (earthen) are to be ripped, graded and re-seeded, with soil to be salvaged from track windrows.

Mine planning and development

Yandan is a key asset in GBM's 'processing halo strategy' for the Drummond Basin, joining the nearby Mount Coolon asset and the recently acquired Twin Hills asset. It is proposed that the Yandan site will provide a central processing hub for ore from the three projects, with existing infrastructure at Yandan supporting and accelerating the development of a gold mining and processing operation.

Subject to the resource optimisation work being completed across the three projects and forward market trends, the Project will move into a detailed mine planning phase. This planning work will ensure the development of an efficient and sustainable mine plan, with a focus on achieving progressive rehabilitation milestones at Yandan.

It is anticipated that the duration of the resource optimisation and mine planning phases will collectively be five years (i.e. to the end of 2025), noting that at the time of submission the Project is currently within the exploration and resource optimisation phase.

Construction

Construction works to return Yandan to a state of operation are predicted to start in 2026. Construction activities will focus on preparing the site for safe operations. These activities will include:

- acquiring a suitable workforce and contractors;
- securing accommodation;
- clearing infrastructure and laydown areas;
- installation of roads and tracks;
- construction of temporary offices and other infrastructure;
- earthworks to ensure safe operating areas;
- installation of services such as power and water transfer equipment; and
- re-activation of the existing water storage structures.

Operation

Processing and operational activities are planned to restart at Yandan, with mined ore from Yandan, Mount Coolon and Twin Hills to be processed at the Yandan site, once confirmed by project evaluation steps and approvals.

Future activities at Yandan are anticipated to include open cut mining operations. Exploration has identified that economic reserves remain within the East Hill and South Pit area, with this being the target of the current resource optimisation phase (Figure 5). New open cut mining activities are anticipated within this area.

Open cut mining is authorised under the Yandan EA, with the current authorised disturbance limit allowing a further 0.5 ha of new open cut mining. It is anticipated that an EA amendment would be sought to authorise any new open pits and/or expand existing resource and supporting infrastructure footprints.

GBM are also currently exploring the potential for re-processing the tailings within the existing TSF footprint, and re-irrigating the Heap Leach Pad using a bacterial treatment method. These concepts will be considered and refined within the detailed mine planning phase.

Water supply to the Project will be provided through existing water licences that permit water harvesting from the Suttor River (valid to 2111). Management of raw and mine affected waters on the Project will be through the existing water storage network.

Project duration

It is anticipated that operations will recommence at Yandan post-construction, on or before 2026.

Operations are expected to occur for a duration of approximately ten years, with operations expected to cease late in 2035. This timing is subject to mine planning and the broader development plans for GBMs assets within the Drummond Basin.

The current proposed LOM plan for Yandan is summarised in Figure 4. Note that key rehabilitation milestones (e.g. landform development, achievement of surface requirements, establishment of target PMLU) would generally occur within these periods, with rehabilitation to be approached progressively as land becomes available. Refer to Appendix A for rehabilitation timeframes specific to each rehabilitation and improvement area.

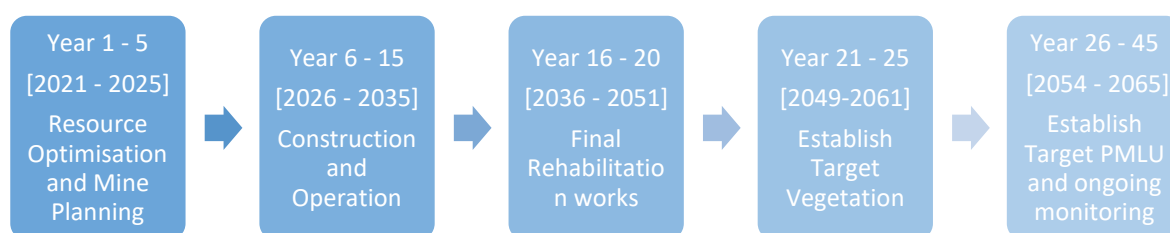


Figure 4: Proposed life of mine plan

Much of the existing infrastructure at Yandan is planned to be re-commissioned for processing and operational activities, with rehabilitation to follow the operational phase of the Project. The following key considerations have been made with regards to the availability of land for rehabilitation:

- Commencement of mining—Yandan contains gold ore reserves which will be mined within five (5) years; following a sequence of:
 - resource optimisation and mine planning (1–5 years); and
 - construction activities (1–2 years).
- GBMs broader developmental plans incorporate its three Drummond Basin assets; Yandan Gold Project, Mount Coolon Gold Project, and the newly acquired Twin Hills Operation. Yandan is proposed to be a central processing hub for ore from all three assets; with ore from Yandan to be initially processed, followed by ore from Twin Hills and then Mount Coolon.
- Existing infrastructure—Yandan has existing infrastructure to accelerate the development of a gold mining operation and central processing facility for ore from its Drummond Basin assets. As such, infrastructure at Yandan will be required for processing the material from other projects following the cessation of mining activities at Yandan. Centralising processing activities at Yandan has the dual benefit of minimising new disturbance by using existing infrastructure footprints, and maximising project efficiencies by limiting the need for new infrastructure.
- Improvement of voids—Main Pit and East Hill Pit present future open cut mining potential, and as such, are not planned to undergo any significant rehabilitation until mining has been completed.
- Rehabilitation of the Heap Leach Pad—GBM have identified potential for irrigating the Heap Leach Pad using a bacterial treatment to maximise recovery of the remaining mineral resource. Rehabilitation of the Heap Leach Pad will therefore be completed following re-treatment activities.
- Rehabilitation of Cell B of the TSF—GBM have identified potential for re-use of the existing facility for additional tailings storage (subject to raising the existing embankments), and/or placement of a heap leaching facility within the existing disturbance footprint. Installation of a suitable capping system would therefore occur following the completion of mining and processing or when the future storage capacity is exhausted, and/or following the decommissioning of the proposed heap leach facility.
- Rehabilitation of water storage dams and processing ponds—water storage dams and processing ponds will remain operational to support future operations, unless it is determined through the detailed mine planning phase that the facility would not be required. All remaining water storage dams and processing ponds would be decommissioned on closure (unless subject to a landholder agreement or identified as having a post mining land use of ‘water storage’).
- Rehabilitation of infrastructure / hardstand areas—infrastructure / hardstand areas will remain operational to facilitate mine operations and rehabilitation activities.

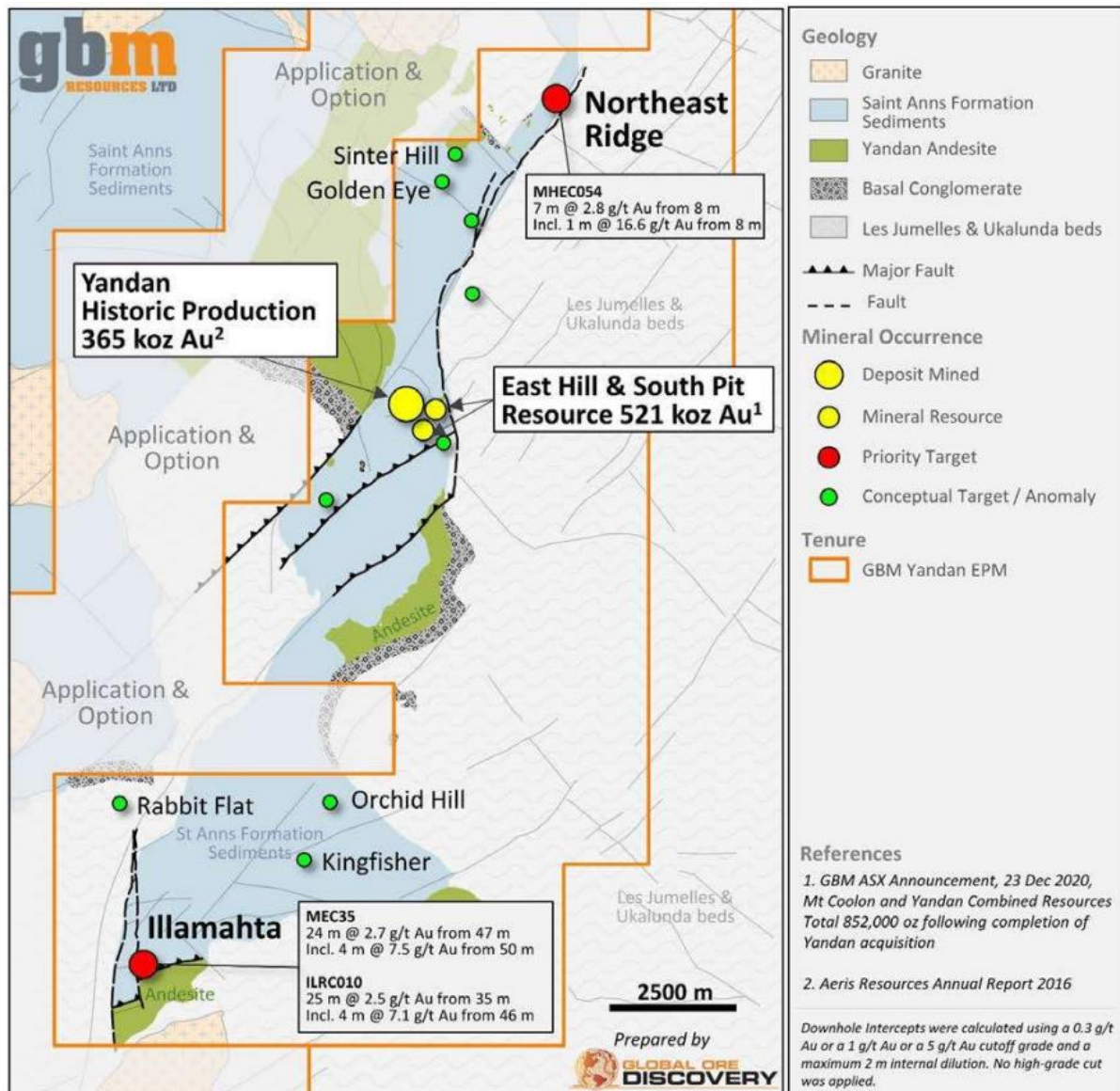


Figure 5: Yandan reserve targets

3.1.2 Existing rehabilitation

Rehabilitation has been approached progressively at Yandan since operations ceased in 2002, with some domains fully or partially rehabilitated. Rehabilitation has been completed for Cell A of the TSF, South Pit (including a complete backfill), and much of the infrastructure and mine village infrastructure areas (with the minor exception of some remaining concrete footings and hardstands); refer Figure 3. A detailed description of rehabilitations works for these domains is provided below.

Cell A of the TSF

Rehabilitation of Cell A of the Yandan Tailings Dam was completed circa 1999–2000 (Wirralie Gold Mine 2004), informed by geochemical assessments and revegetation trials (Ross Mining N.L. 1999).

Geochemical assessment included sampling of the oxide tailings and composite samples of grasses found growing on the tailings surface, in addition to sampling for physical parameters and nutritional information to assist in assessing vegetation growth. Results from this analysis found that salinity (EC) values for the oxide tailings were low, with a median value of 1,558 $\mu\text{S}/\text{cm}$ (range: 201 – 16,010 $\mu\text{S}/\text{cm}$). Minor elevations of some metals were identified (antimony, arsenic and chromium) from the initial geochemical assessment however, follow-up assessments¹ have confirmed metals concentrations have decreased from the initial reported concentrations (RGS Environmental 2015). Material classification assessments have classified the oxide tailings as ‘barren’, confirming that the material is non-acid forming (NAF) and that there is no potentially acid forming (PAF) material present (RGS Environmental 2015).

Results from the geochemical assessment were used to characterise the substrate of Cell A for subsequent revegetation trials (Ross Mining N.L. 2000). Three revegetation trials (A1, A2 and pot trials) were undertaken with the objectives of determining the suitability of the tailings material as a growth medium for a number of grass and tree species, and determining a suitable fertilisation rate to achieve a sustainable vegetation cover across the facility (Ross Mining N.L. 2000).

Revegetation trials identified that grasses, such as *Cenchrus* spp. and *Chloris* spp., were suitable for direct seeding into the tailings surface. Tree species such as *Eucalyptus argophloia* (Queensland Western White Gum) and *E. camaldulensis* (River Red Gum) were identified as primary species for tree vegetation, performing well in the tailings rooting medium trials. These species were sown directly into the tailings material and have become well established over time.

Rehabilitation monitoring undertaken between 2014–2020 as part of the Rehabilitation Monitoring Program (RMP) has identified that vegetation on Cell A has become well established, with vegetation characteristics comparable to reference sites (AARC 2018, AARC 2019, AARC 2021a). Key findings include:

- ground cover (total live cover) of the Cell A monitoring sites is established and relatively stable;
- species richness of the Cell A monitoring sites is comparable to reference sites;
- a high proportion of woody stemmed species (shrubs and trees) was identified at Cell A monitoring sites;
- weed species groundcover is low at Cell A monitoring sites and comparable to reference sites;
- consistent canopy coverage has been observed at Cell A monitoring sites throughout the monitoring period, with an overall increasing trend; and
- Erosion monitoring has not recorded anything above a ‘minor’ classification for rill erosion.

Overall, the established vegetation cover on Cell A appears to be trending toward an open woodland type community consistent with reference sites, and the rehabilitation objective for this area; and with demonstrable progress towards rehabilitation.

¹ RGS Environmental completed a geochemical assessment of the oxide and sulphide tailings stored in Cell B of the Yandan Tailings Dam in 2015. As the source rock for the oxide tailings in Cell A and Cell B is the same, it is anticipated that the updated geochemical assessment provides a more recent assessment on the oxide tailings geochemistry.

Over the six year duration of rehabilitation monitoring, the collated data set appears to be confirming the rehabilitation strategy as successfully trending toward a rehabilitated area that can be regarded as being safe, stable, non-polluting and generally self-sustaining. Monitoring of the receiving environment of the Yandan Tailings Dam (including Cell A) is being provided by the surface water and groundwater monitoring program as well as the Receiving Environment Monitoring Program. This monitoring indicates that the Yandan Tailings Dam has had negligible impact on the receiving environment. Furthermore, seepage from the facility capable of causing environmental harm has not been identified.

Some minor rehabilitation maintenance is planned to be undertaken for a small central zone (approximately 4.5 ha) located centrally on Cell A that exhibits poor vegetation establishment due to localised ponding of rainwater. Either placement of fill (growth medium followed by topsoil) to form a water shedding surface, or recontouring to allow free surface drainage is proposed to address this issue. Existing shallow drainage channels in the surface of Cell A are to be filled with coarse rock gravel to facilitate their proper functioning.

South Pit

Rehabilitation of South Pit was completed in 1998 prior to the site entering into care and maintenance (Wirralie Gold Mine 2004). The rehabilitation methodology for South Pit involved complete backfill of the pit, followed by profiling and the application of topsoil, seeding (mixed grasses) and topdressing with fertiliser (Straits Exploration 2005). Backfilling of the facility was achieved using sulphide-bearing waste rock from the former Waste Rock Dump, encapsulated with oxidised waste rock and clay sourced from the South Pit and flood bund (Straits Exploration 2005).

Rehabilitation monitoring sites were established on the rehabilitated South Pit in 2017, as part of the annual RMP. Results from this program have recorded total live cover on this domain exceeding reference site values (four years of data), with species richness also comparable to, or greater than reference sites (five years of data), and woody stem density comparable to, or greater than reference sites (three years of data, AARC 2021a). Established vegetation on this domain includes a variety of native and exotic pasture grasses, and native shrubs (e.g. *Acacia holosericea*, AARC 2021a).

Overall, the rehabilitated South Pit area supports a well-established pasture community that is generally consistent with reference sites. The data demonstrates sustainable ecosystem function over at least 4 years, including periods of variable rainfall and livestock grazing pressures. Erosion monitoring indicates surface soils are stable and non-erosive. Erosion modelling for this domain also confirms that the rehabilitated South Pit area presents erosion levels that are within acceptable limits, with no evidence of ongoing active erosion recorded (AARC 2022b). As such, the South Pit is considered to be meeting rehabilitation objectives.

ROM Pad

Interim rehabilitation of the ROM Pad was completed in 1999, with rehabilitation works including re-contouring and ripping of the surface (comprised of oxide waste), followed by seeding (with multiple re-seeding events during 2000–2002 to assist in the development of a sustainable vegetation cover). Species selection for revegetation consisted mainly of pasture grasses and *Acacia* species (Straits Exploration 2005).

Rehabilitation monitoring completed for the 2021 RMP confirms that various *Acacia* spp. have established on the rehabilitated ROM Pad, with groundcover consisting of a variety of native and exotic pasture grasses (AARC 2021a). Vegetation is well established on the rehabilitated ROM Pad, with this site consistently recording woody stem density, species richness and canopy cover comparable to or greater than reference sites (AARC 2021a). Further time is required to increase total live cover on the rehabilitated ROM Pad sites.

It is considered that previous rehabilitation of the ROM Pad has provided interim rehabilitation to this domain, acknowledging that this domain may be used again in future operations, subject to outcomes from the mine planning and development phase. Should the ROM Pad be used in future operations, the rehabilitation sequence would re-commence from the first applicable rehabilitation milestone.

Village infrastructure

Rehabilitation of the village infrastructure area was completed in 2000, with all buildings from the village accommodation area disconnected and removed from site (Wirralie Gold Mine 2004). The footprint of the village infrastructure area was subsequently seeded, with results from the 2021 RMP indicating that a variety of native and pasture grasses have established, with some *Eucalyptus* spp. present (AARC 2021a). Species richness at the rehabilitated village infrastructure area is reaching comparable values to reference sites, however, further time is required for total live cover and woody stem density to increase (AARC 2021a).

Further rehabilitation of this area will include the removal of some remnant concrete footings.

Hardstand/infrastructure area

Some progressive rehabilitation to the infrastructure/hardstand area was completed between 1999–2000 (Wirralie Gold Mine 2004). Completed rehabilitation has included the disconnection and removal of former buildings, with the surface ripped and seeded. This area has been monitored annually as part of the RMP since 2017. Monitoring results indicate that species richness and woody stem density at these sites is comparable to, or great than reference site values however, further time is required for total live cover to increase (AARC 2021a).

Further rehabilitation to this area will include the removal of some remaining concrete footings, hardstand and tanks. Some new portable buildings have also recently been established on-site for the exploration program and will require disconnection and removal. Following the removal of this infrastructure, land investigations will be carried out across the area, with the residual infrastructure footprint to then be ripped and seeded with pasture species.

3.1.3 Climate

3.1.3.1 Rainfall

The Yandan Gold Project is located in the Queensland Central Highlands, a region with a sub-tropical to semi-arid savannah climate, with hot, dry to wet summers and mild, dry winters. The Yandan area frequently experiences extended dry periods interrupted by tropical wet season rainfall, often associated with downpours or larger tropical low systems crossing the coast (SBE 2022). When rain does occur, it can be intense and highly localised, capable of depositing large depths of rain and varying significantly across the landscape (SBE 2022).

Specific rainfall data for the Yandan site area is not available, however good records are available from Bureau of Meteorology (BoM) sites' Mount Douglas (BoM station 034022) (50km south) and St Anns Station (BoM station 34063) (10km north).

Since 1900, rainfall has predominantly varied between 400–800 mm/year, though can range from as low as 200 mm/year to up to 1,100 mm/year when there are significant rainfall events on the east coast (e.g. cyclones and tropical lows) (Figure 6)(SBE 2022). Dry conditions prevail, with an average of 315 days without rain per year, with most of the annual rainfall received during just a few rainfall events each year. Daily and seasonal cumulative rainfall (July to June) for the past 20 years is plotted in Figure 7 (SBE 2022).

Rainfall also varies over time: a residual rainfall chart (deviation from average) in Figure 8 shows the seasonal cycle of rainfalls, with broader cycles of wetter and drier periods over the record, with clear capacity for extreme wets events and severe dry periods (SBE 2022). The site has generally experienced dry conditions since its operation, with the exception of the wet conditions experienced in 2012, followed by ongoing drought conditions (SBE 2022).

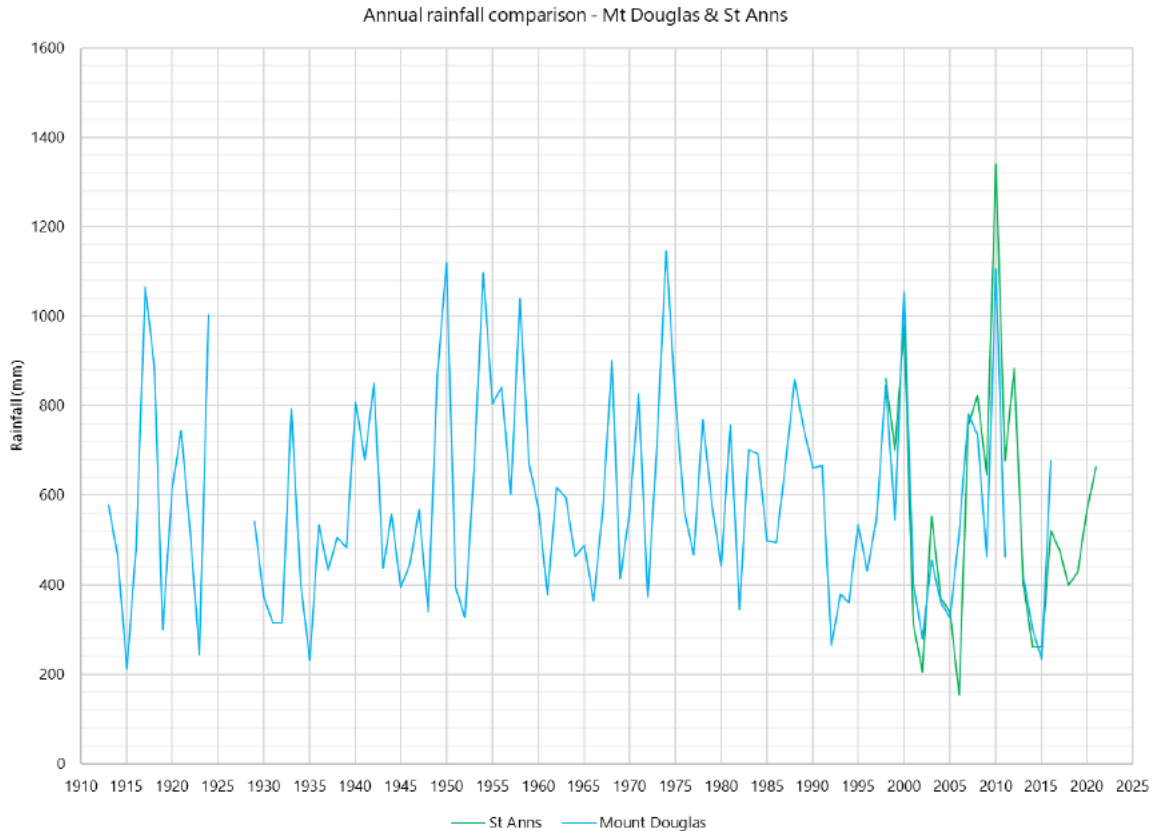


Figure 6: Annual rainfall recorded at local stations (SBE 2022)

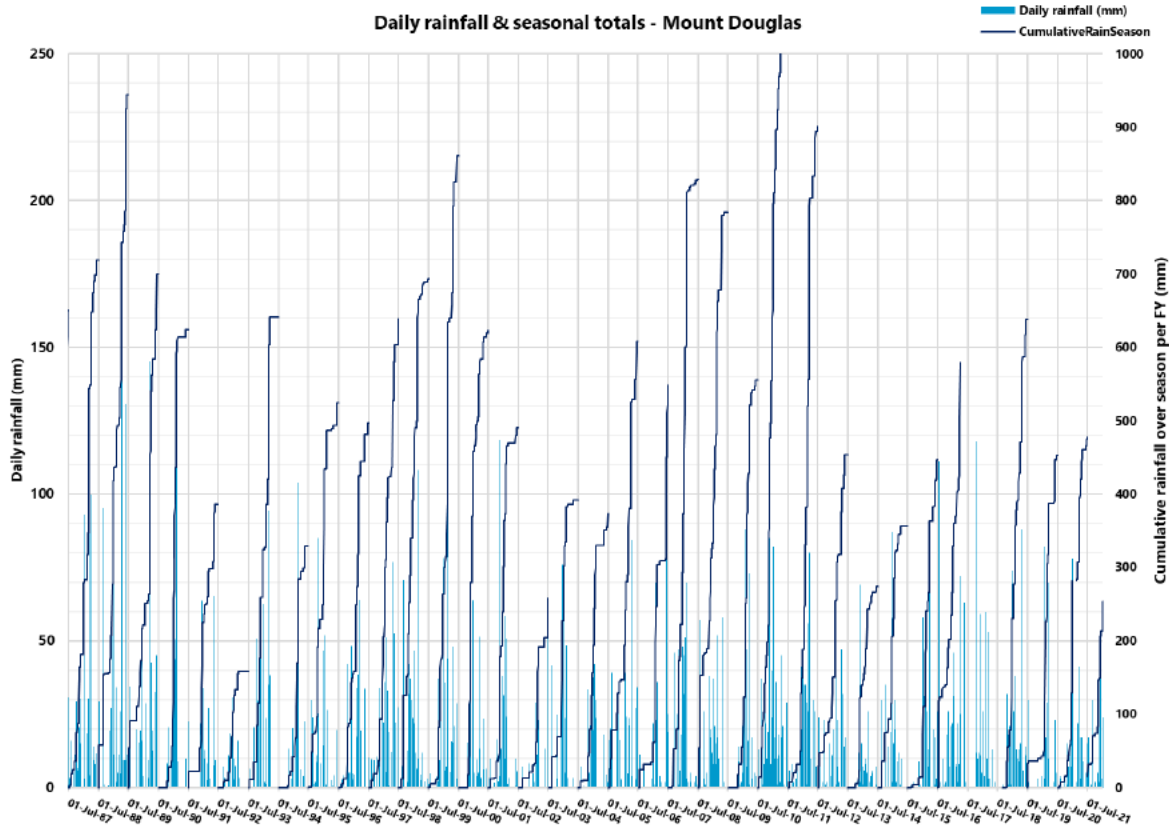


Figure 7: Seasonal annual rainfall in the Yandan region (rainfall data: 1987 – 2021) (SBE 2022)

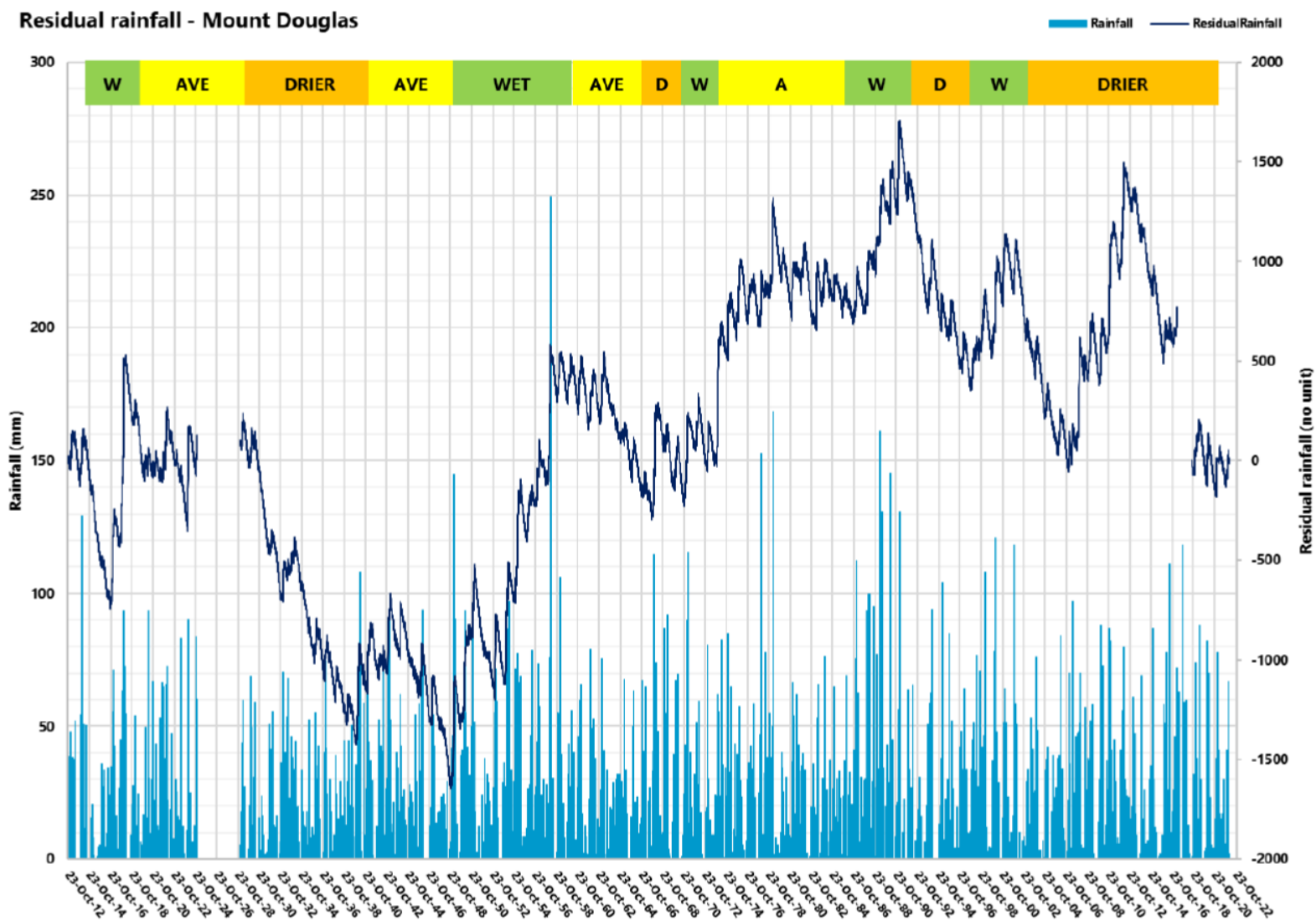


Figure 8: Residual rainfall - Mount Douglas (SBE 2022)

3.1.3.2 Evaporation and wind

Daily rates of evaporation and average wind speeds for the Project are adapted from pan evaporation measured at the closest regional stations available, being the Moranbah Water Treatment plant, Twin Hills and the Collinsville Post office (SBE 2022). Average daily evaporation by month for each station is summarised in Table 2.

Evaporation ranges from approximately 3 mm/day over the cooler winter period, through to approximately 8.0 mm/day in November-December, in demonstration of the heat capacity in summer, particularly in the absence of seasonal rains (SBE 2022). Average annual potential evaporation equates to approximately 2,094 mm. Wind speeds range around 5 kph to 9.6 kph across a year (see Table 3).

Table 2: *Evaporation rates for the Project region (SBE 2022)*

Station	Dir	J	F	M	A	M	J	J	A	S	O	N	D	Average/day	Total/year
Moranbah Water Treatment	SE	8	7.4	6.8	5.7	4.3	3.5	3.7	4.9	6.6	8	8.5	8.5	6.3mm	2,306mm
Twin Hills	SW	7.5	6.5	6.1	5.2	3.6	2.9	3.1	4.2	6.1	7.9	8.6	8.7	5.9mm	2,140mm
Collinsville Post Office	NE	6.2	5.7	5.2	4.4	3.5	2.9	3.2	4.1	5.3	6.5	6.9	6.9	5.1mm	1,840mm
Average/month		7.2	6.5	6.0	5.1	3.8	3.1	3.3	4.4	6.0	7.5	8.0	8.0	5.8mm	2,094mm

Table 3: *Temperature and wind speeds at Moranbah Water Treatment Plant (SBE 2022)*

Station	J	F	M	A	M	J	J	A	S	O	N	D	Average annual
9am temperature (°C)	26.4	25.8	24.7	22.1	18.9	15.4	14.7	16.6	20.6	24.0	25.3	26.4	21.7
9am wind (km/h)	7.5	7.7	8.1	7.6	6.2	5.5	5.3	6.6	7.7	8.4	8.4	8.4	7.3
3pm temperature (°C)	32.7	31.9	31.2	28.6	25.8	22.9	22.9	24.6	28.3	31.4	32.2	33.0	28.8
3pm wind (km/h)	8.8	9.6	9.4	8.7	6.9	6.6	7.0	7.7	8.3	8.4	8.9	8.8	8.3

3.1.3.3 Climate change projections

The Queensland Government's Future Climate Dashboard (Queensland Government 2021) provides climate change projections at time series snapshots of 2030, 2050, 2070, 2090. This resource brings together scenarios predicted by twelve major climate models and provides a magnitude change ranked by probability (percentiles) of changes to daily precipitation and evaporation (pan) rates.

Model outcomes for the Yandan region per season and time series are shown in Figure 9 (Queensland Government 2021). Expected median rainfall suggests rates will continue, however with potential to vary much more widely over time, particularly after 2050 (SBE 2022). Evaporation rates are predicted to increase, with median rates up 1.8 mm/day in 2090 (increase of approximately 30%), but at least 0.7 mm/day and at most 3.6 mm/day.

Projected climate scenarios for the Project region in 2090 are shown in Figure 10 and Figure 11.

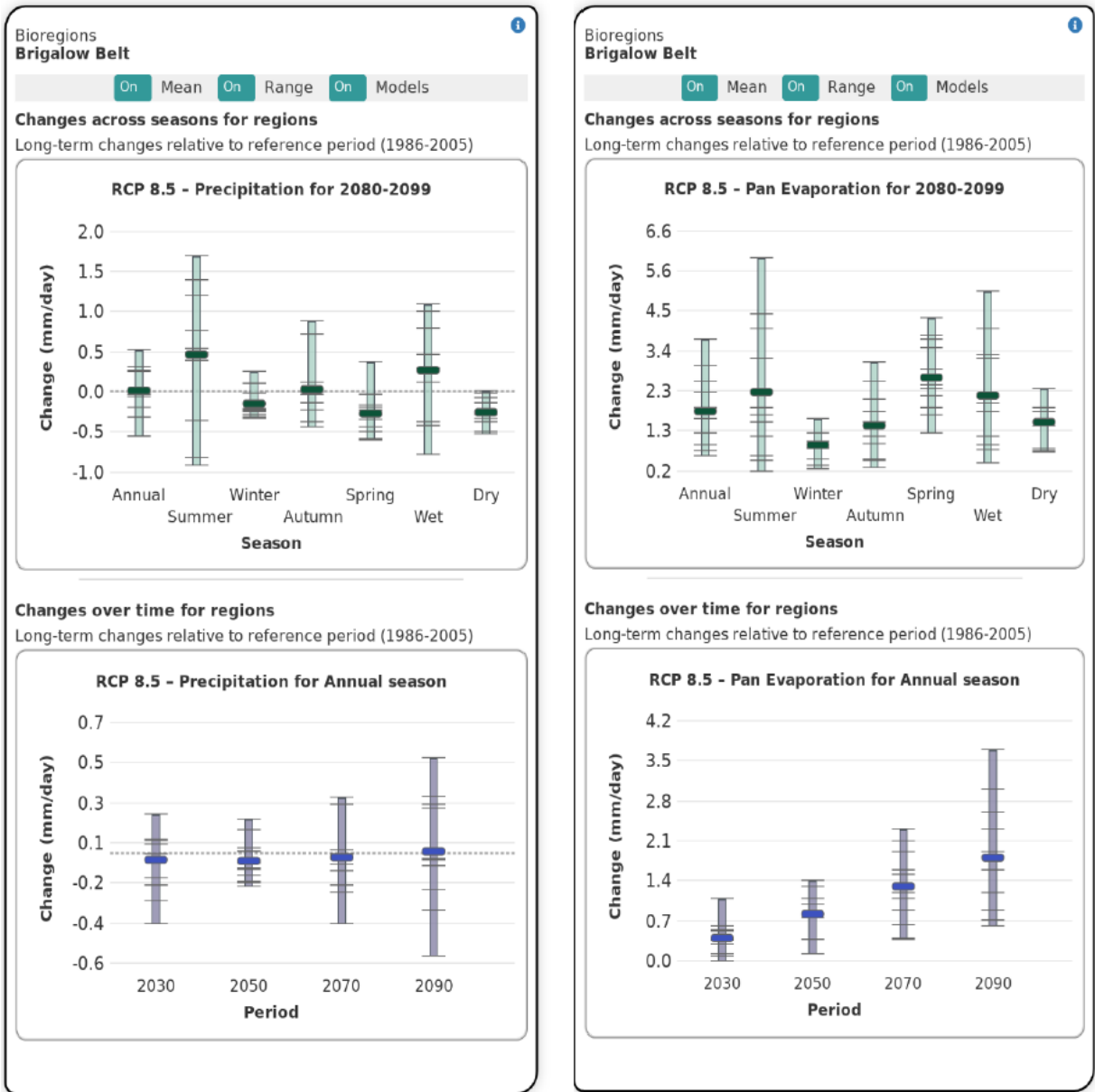


Figure 9: Climate change predictions (Queensland Government 2021 from within SBE 2022)

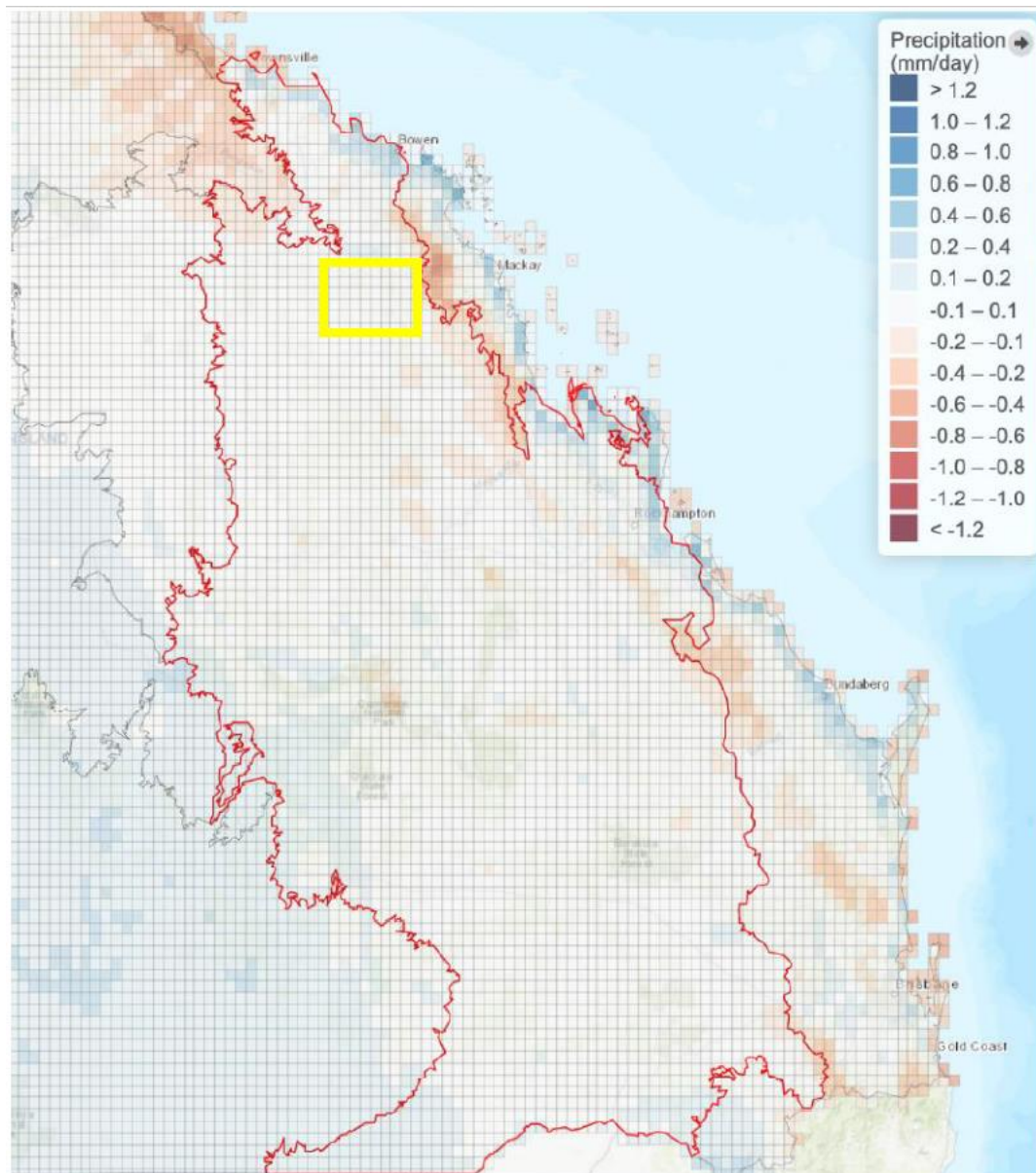


Figure 10: 2090 median precipitation changes across region (Queensland Government 2021 from within SBE 2022)
(note: Project region indicated in yellow)

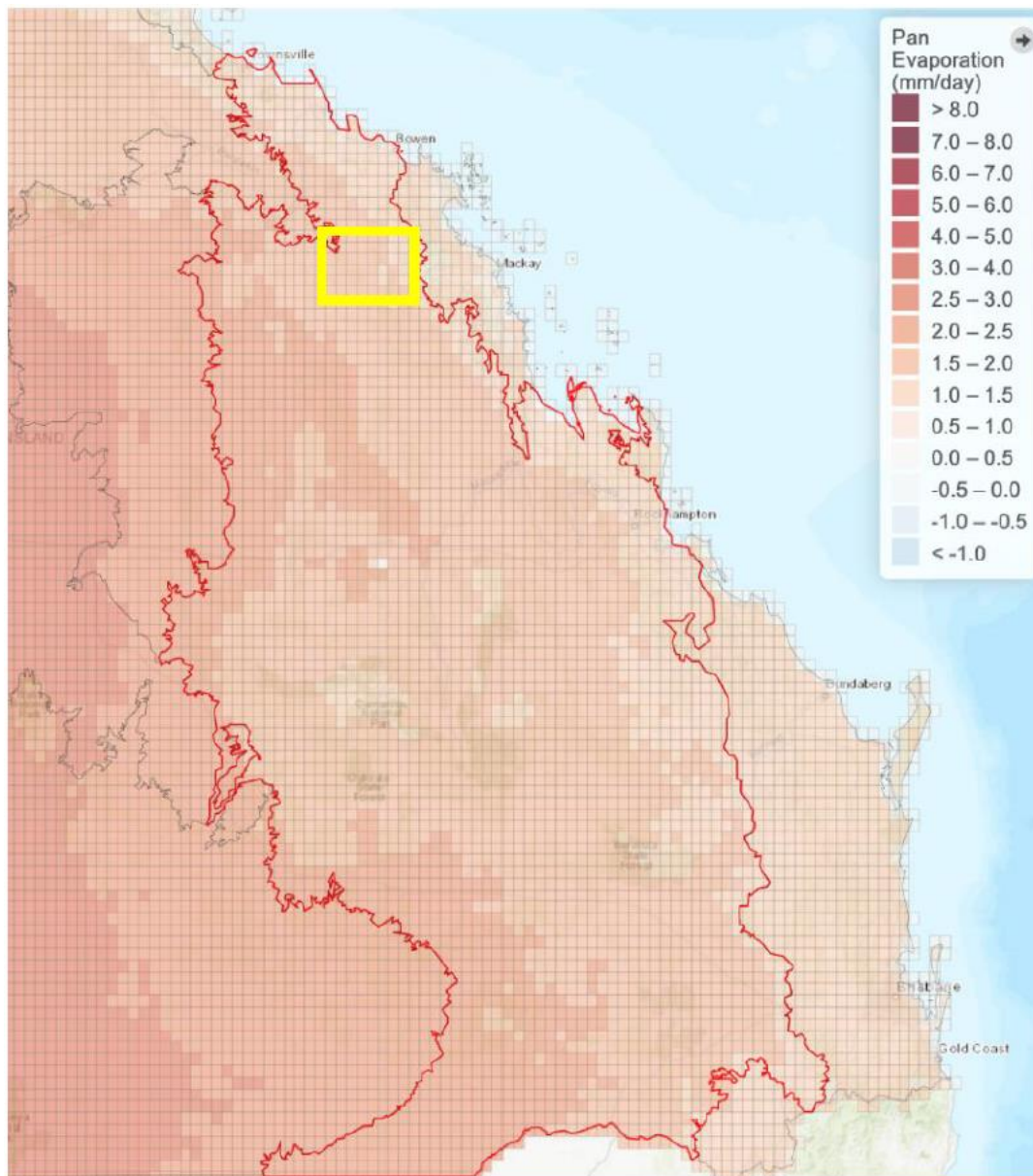


Figure 11: 2090 median evaporation changes across region (Queensland Government 2021 from within SBE 2022) (note: Project region indicated in yellow)

3.1.4 Geological setting

The Yandan Gold Project is located on the eastern margin of the western arm of the Drummond Basin, a geological basin comprised of Middle Devonian to Early Carboniferous sedimentary and volcanic rocks (Straits n.d.). The Project area is proximal to the Anakie Inlier, a north-trending basement block of greenschist facies metavolcanic and metasedimentary rocks of Lower Cambrian age (de Caritat & Braun 1992).

The Yandan resources consists of low-sulphidation epithermal gold deposits, mined from surface via open pits. Mineralisation occurs as oxide in the altered and weathered zone, or in fresh rock lenses and veins at depth (SBE 2022). The site is heavily faulted and structures are tight, without void development. Structural trends follow north/south and north-east/south-west orientations and are likely to present a barrier to groundwater flow (SBE 2022).

The host geology underlying the Project is comprised of basement Anakie Inlier Les Jumelles metasediments, unconformably overlain by Middle Devonian Ukalunda Beds, which in turn are unconformably overlain by the

St Anne's Formation of the Middle Devonian to Early Carboniferous Drummond Basin Sequence (Straits n.d.). On the western side of the tenement, parts of the Project have been unconformably overlain by fluvial deposits of the Scartwater Formation and Mount Hall Formation (Straits n.d.). The general composition of the three main geological units is summarised as follows.

Basement geology

The basement Les Jumelles metasediments are metamorphosed quartz-muscovite sandstones and siltstones (Townend 2005, within Straits n.d) and chloritic black shale. Also within the basement geology, the Ukalunda Formation sediments are various interbedded massive and bedded lithologies containing quartzose, calcareous and carbonaceous sandstones, siltstones and mudstones (Straits n.d.).

Lower St Anne's Formation

The Lower St Anne's Formation generally consists of three lithologies: andesite flows, andesite clastics and polyolithic volcanic breccia (Straits n.d.). Overlying this are primarily feldspar-lithic sandstone and siltstone (Yandan Host), formed through weathering and erosion of the Yandan Andesite. Calcareous sandstone and Yandan Limestone is the youngest unit in the local stratigraphy, overlying parts of the Yandan Host in Main Pit (Straits n.d.).

Gold mineralisation on the Project has been substantially mined out, with the East Hill area containing the most encouraging remaining mineralisation (Straits n.d.). Three phases of gold mineralised silica have been identified within the East Hill area, including crustiform banded veining which is commonly high grade gold mineralisation (Straits n.d.).

Surface geology

Tertiary and Quaternary sediments cover much of the Project area. In the south and east, the surface geology is predominantly Tertiary Suttor Formation comprised of lateritised sandstone, mudstone, claystone, oil shale, diatomite and carbonaceous claystone (Hutton *et al.* 1991, within Straits n.d.). Channels incise the Suttor Formation and contain Quaternary alluvial channels that drain to flood plains (Straits n.d.). Quaternary alluvium covers much of the underlying Drummond Basin Sequence on the Project, with the depth of this stratum increasing towards major drainage lines (i.e. Suttor River, Rosetta Creek, Belyando River) (Straits n.d.).

Geological units and structures on the Project are shown through Figure 12. A conceptual geological model of the East Hill area (the primary remaining resource deposit on the Project) is provided in Figure 13.

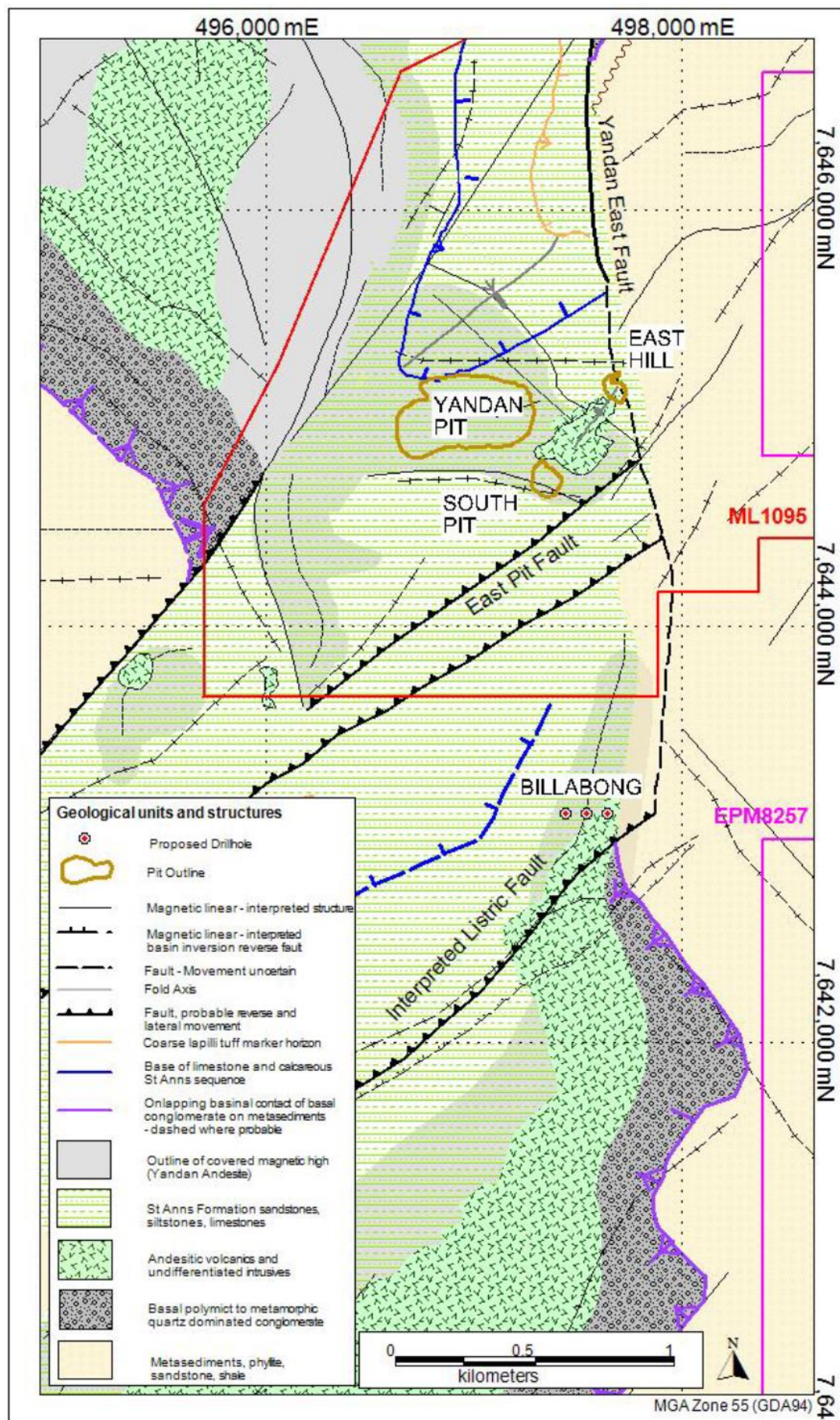


Figure 12: Geology of Yandan (Source: Straits n.d.)

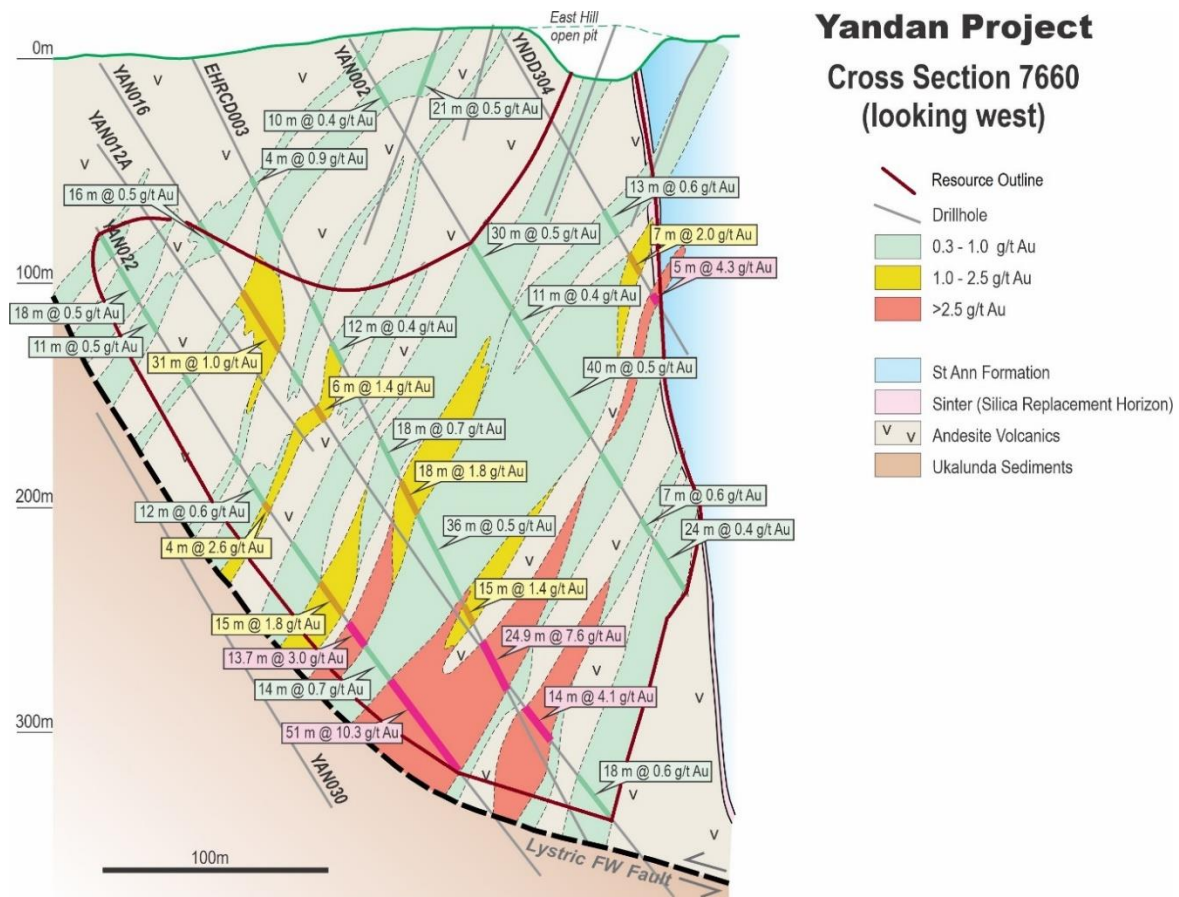


Figure 13: Conceptual geological model of the East Hill area

3.1.5 Topography and surface hydrology

Local and regional topography

The Yandan Gold Project is situated alongside the Suttor River on gently undulating plains. Elevations in the area range between 160 mAHD in the west along the Suttor River, gradually increasing to 190 mAHD in the east, with some areas reaching 200 mAHD outside of the infrastructure footprint of the Project. Travelling through the site notable areas of elevation are associated with East Hill (rising to 190 mAHD) (Figure 18).

The topography within the surrounding region is similarly level, punctuated by the occasional hill or mountain. Crossing the Suttor River and approximately 17 km to the west of the Project is the Llanarth Range. The Llanarth Range is the dominant topographical feature of the landscape, rising to approximately 280 mAHD, with the Llanarth Back Ranges further behind to the west and north, rising further to approximately 350 mAHD. Approximately 20km to the north of the Project is the Rottenstone Range, with an elevation of approximately 300 mAHD.

Waterways and drainage features

The Yandan Gold Mine is situated within the Suttor River sub-basin of the Burdekin Basin. The Suttor River drainage sub-basin spans an area of approximately 74,000km².

The Suttor River is located on the western boundary of the Project, with a number of ephemeral tributaries traversing the site and draining to the Suttor River (Figure 19Figure 3). The receiving environment of the Project includes the following waterways:

- the braided channels of the Suttor River;
- Yandan Creek; and
- Sandy Creek.



Figure 14: View of Suttor River approximately 50 km upstream of Yandan (SBE 2022)

Tributaries of Yandan Creek and Sandy Creek are common across the Project area, forming mainly first to third order ephemeral streams that flow only after rainfall and act as losing streams (i.e. are not fed by groundwater) (SBE 2022). Both watercourses drain to the Suttor River to the west of the Project.

The Suttor River is a wide, ephemeral river, flowing after rainfall over wet seasons in wide low energy flow (SBE 2022). The Suttor River flows from the south to the north, with braided channels of seventh and eighth order within the immediate receiving environment of the Project. The Suttor River ultimately drains into Lake Dalrymple, formed by the damming of the Burdekin River (HLA – Envirosiences Pty Ltd 2000). The Suttor River also flows into the wetlands associated with Lake Dalrymple and the Scartwater Aggregate, both identified as nationally important wetlands in the *Directory of Important Wetlands in Australia* (DAWE 2019).

Stream flow in the rivers and tributaries of the Suttor River sub-basin are dependent on the frequency and intensity of rainfall events within the catchment. Periods of flow are directly related to large rainfall events in the catchment; which is typical of ephemeral systems (SBE 2022).

There are two gauging sites upstream and downstream of Yandan which record river flow, water levels and quality, with records available from the 1970's:

- Belyando near Gregory Highway (Mount Douglas) (120301A/B upstream); and
- St Anns Station (120303A downstream).

Flow records for both stations indicate the seasonal nature of flow, and capacity of the system to convey large volumes of water (Figure 15). Notably flow at St Anns generally increases from flow measured at Mt Douglas given St Anns lays further down the catchment. With an interpolated base of river at 163 mAHD, the Suttor River regularly rises 5-8 m in flood, at 168-170 mAHD.

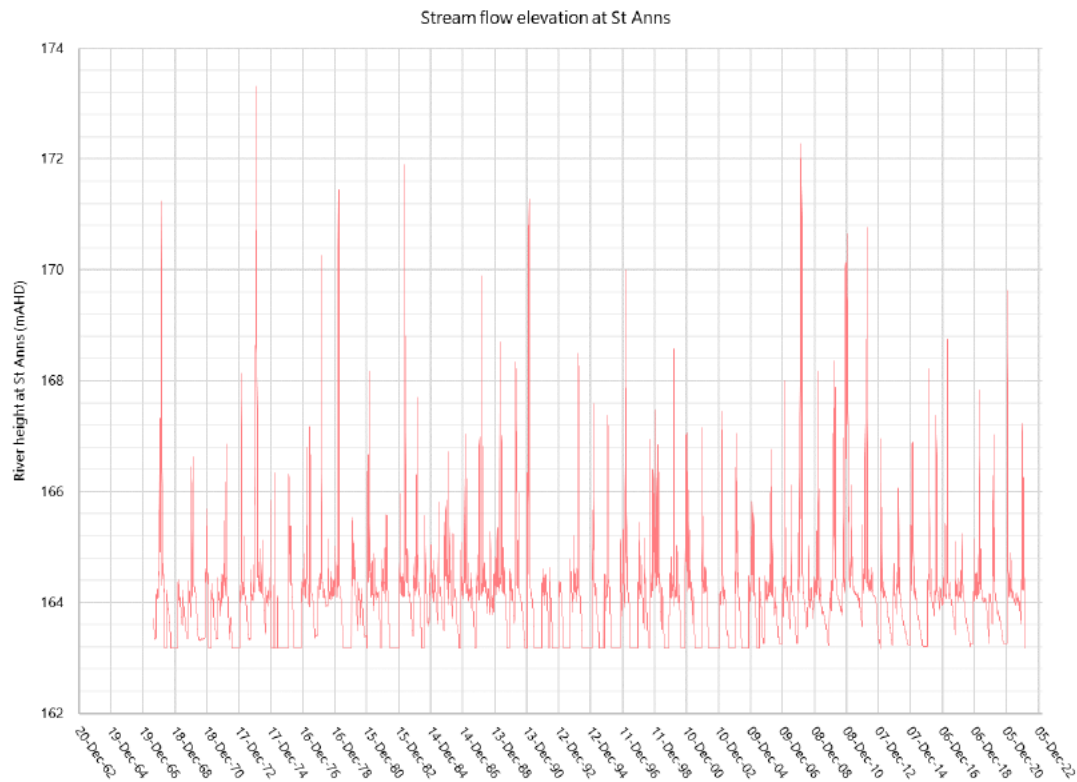


Figure 15: River heights at St Anns Station (downstream from Yandan) (SBE 2022)

Surface water catchments

Drainage of the Yandan site is formed through a combination of natural topography and mining landforms (SBE 2022). The Project area sits close to the top of a small sub-catchment draining to the Sutor River. Generally, drainage follows east to west with topography, with some bund walls creating flow diversions or containment. Surface water catchments and drainage directions within the Project area are shown through Figure 17 and detailed in Table 4.

Table 4: Yandan surface water catchments (SBE 2022)

Code	Description	Area m ²	Area ha	Status
B-01	Borrow pit catchment (Yandan Creek)	60,537,540	6,054	Undisturbed
B-WS	Borrow pit water surface	26,258	2.6	
E-01	Catchment reporting to East Pit	28,827	2.9	Mine impacted
E-Pit	East pit direct area	9,048	0.9	Mine impacted
E-WS	Water surface of East pit	1,190	0.1	
L-02	Leach pad stormwater area	53,560	5.4	Mine impacted
L-Dam	Leach pad stormwater pond	16,344	1.6	Mine impacted
L-Pad	Leach pad direct catchment	174,152	17.4	Mine impacted
L-Pond	Leach pad ponds	3,990	0.4	Mine impacted
M-01	Catchment reporting to Main Pit	112,553	11.3	Mine impacted
M-Pit	Main pit area	219,256	21.9	Mine impacted
M-WS	Main pit water surface	156,207	15.6	
S-Pit	South pit direct area (rehabilitated)	29,567	3.0	Undisturbed
T-01	Catchment reporting to tailings storage	919,825	92.0	Undisturbed
T-02	Catchment reporting to tailings storage	260,723	26.1	Undisturbed
T-03	Catchment reporting to tailings storage	282,502	28.3	Undisturbed
T-CellA	Cell A of tailings storage	426,307	42.6	Mine impacted
T-CellB	Cell A of tailings storage	726,984	72.7	Mine impacted
T-Dam	Tailings dam water catchment	36,689	3.7	Mine impacted
WS-01	Catchment reporting to water supply dam	3,257,776	325.8	Undisturbed
WS-Dam	Water supply dam surface	410,325	41.0	
MW-01	Mine water dam catchment	42,336	4.2	Undisturbed

Constructed drainage features on-site include the Suttor River / Yandan Creek Diversion Channel, and the Main Pit water management bund. Both features were constructed during mining of Main Pit, to prevent waters from flowing into the pit.

The Suttor River / Yandan Creek Diversion Channel was constructed in 1997 and is a referable structure (Water Licence 55019A). The approximate 400 m long diversion diverts waters from Yandan Creek around the perimeter of Main Pit.

Also constructed in 1997 was the Main Pit water management bund, similarly built to protect open pit operations from floodwaters from Yandan Creek and Suttor River. The Main Pit bund was initially constructed to be a temporary structure to be removed on the completion of mining in Main Pit, however, this has been retained subject to demonstrating that the removal or modification of the structure would not result in an unacceptable risk of potential environmental harm.

Following the completion of mining in Main Pit, it was determined that the best long-term rehabilitation option was to allow the pit to flood to form a permanent water cover over sulphidic materials in the walls and base of the pit (Ross Mining N.L 2000). This water cover was formed initially following the 1999/2000 wet season.

Connectivity with the Suttor River and Yandan Creek has continued to maintain this water cover. Two spillways have been installed on the north-west and south-east walls of the pit to enable recharge as well as discharge (Figure 16). Releases from Main Pit are limited to when flows are sufficient, where the pit water level exceeds 169 mAHD (SBE 2022). The most recent discharge event from the pit occurred in April 2017. Water quality monitoring completed during this event did not identify any contaminant issues in the receiving environment.



Figure 16: View of Suttor River near release point of Main Pit (SBE 2022)

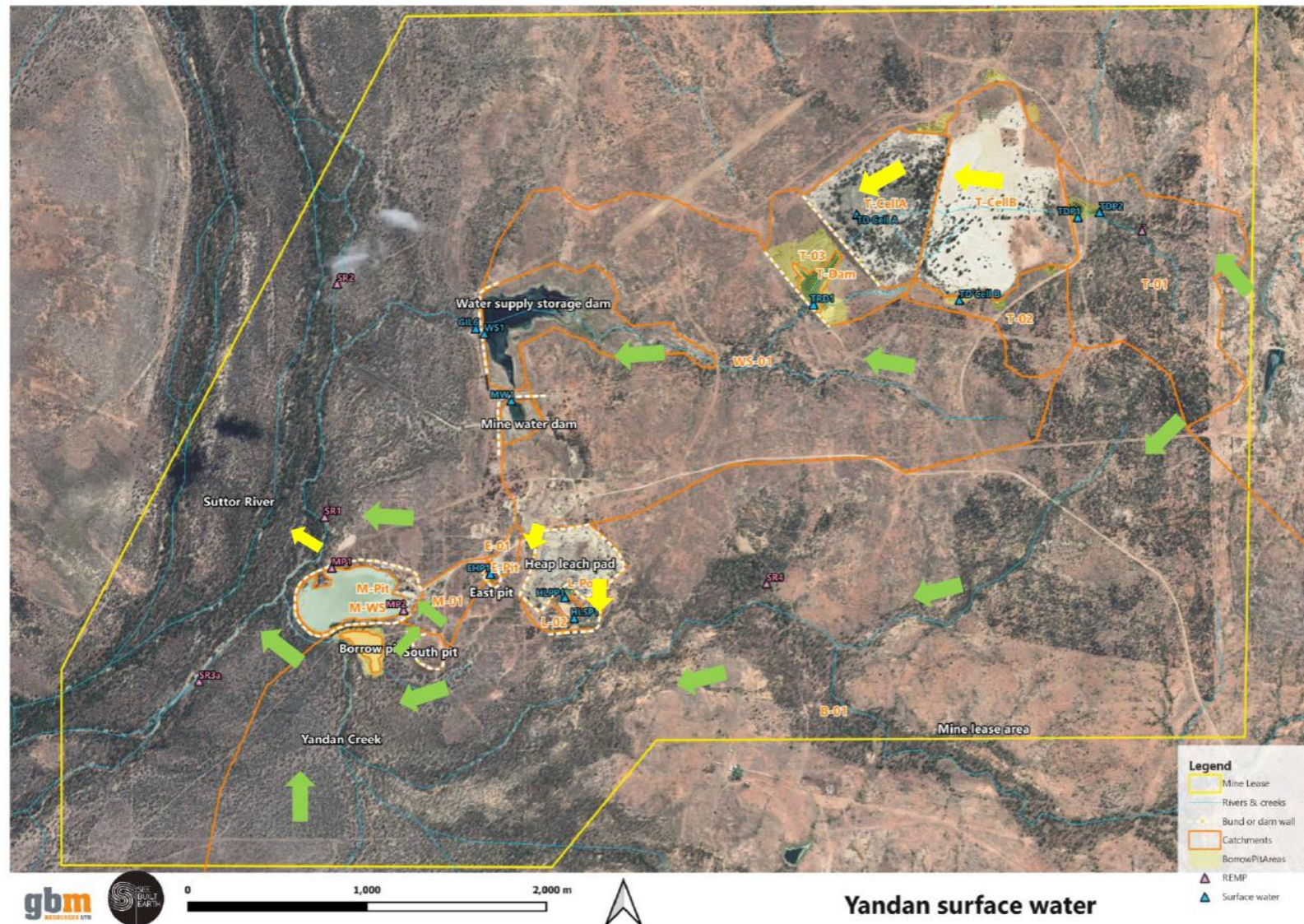


Figure 17: Yandan surface water catchments and drainage directions (SBE 2022)(Note: green – undisturbed catchment, yellow – potentially mine impacted).

Water management system

The Yandan water management system currently focuses on passive management, noting that the site is currently in an extended period of care and maintenance with limited exploration activities occurring on-site. Once operations recommence on-site, water will be required for processing activities, dust suppression, general site activities (including vehicle wash down) and amenities.

Water storages required for the operational phase of the Project will be re-activated during construction. Depending on operational requirements, this will include the Heap Leach Pregnant Pond and Barren Pond.

The water management system for the operational phase of the Project is detailed in Table 5, and shown in Figure 18.

Table 5: *Water management system*

Clean water	Potentially Mine affected water	Water management infrastructure
Water Storage Dam	- Yandan Tailings Dam - Tailings Water Return Dam - Heap Leach Pregnant Pond and Barren Pond - Heap Leach Stormwater Pond - Mine Water Dam - Main Pit - East Hill Pit	- The water management bund around the Heap Leach ponds (Heap Leach Stormwater Pond, Pregnant and Barren Ponds) - The water management bund around Main Pit to protect the pit from flooding. - The diversion of Yandan Creek around Main Pit.

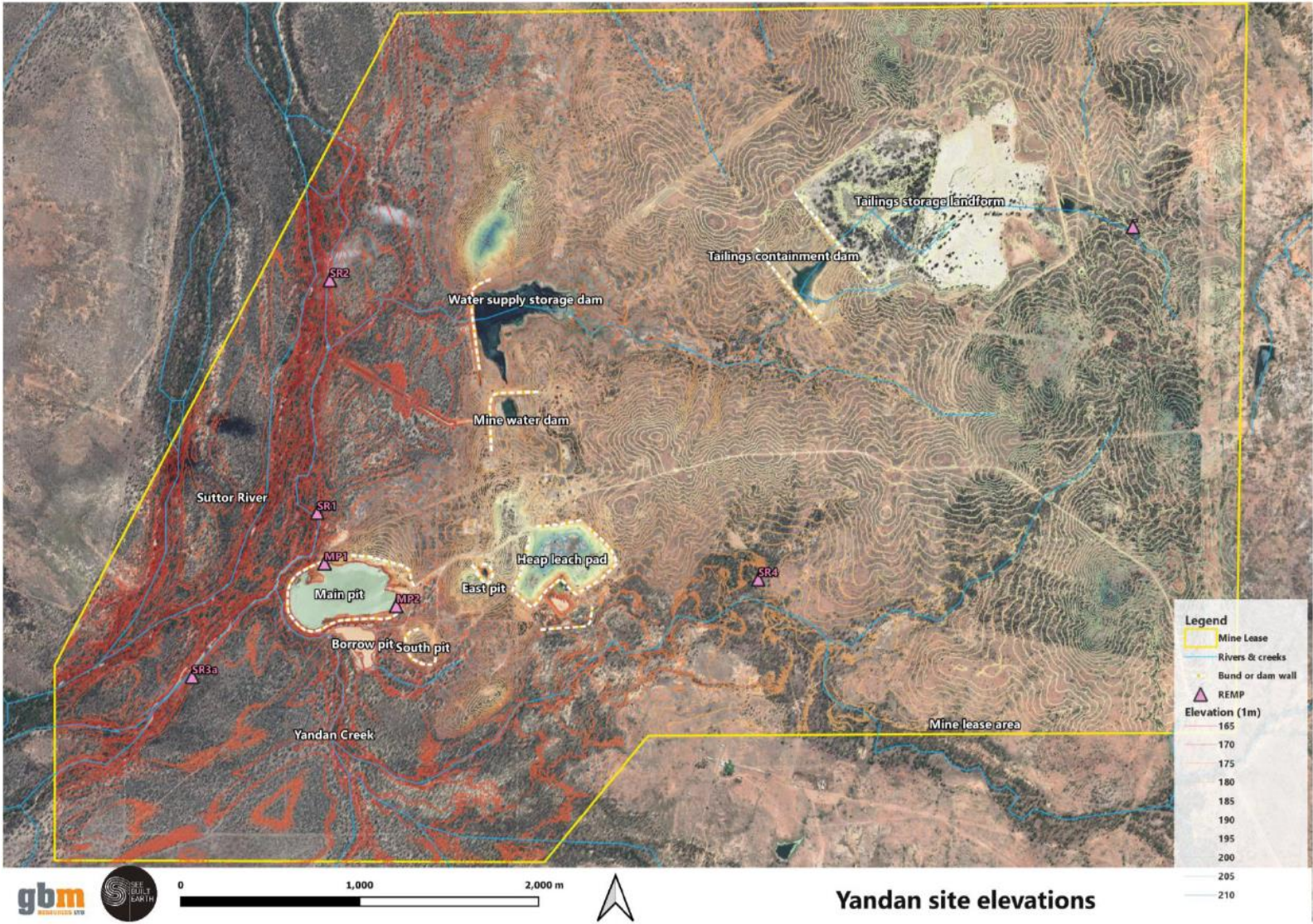


Figure 18: Yandan site elevations and water storages (SBE 2022)

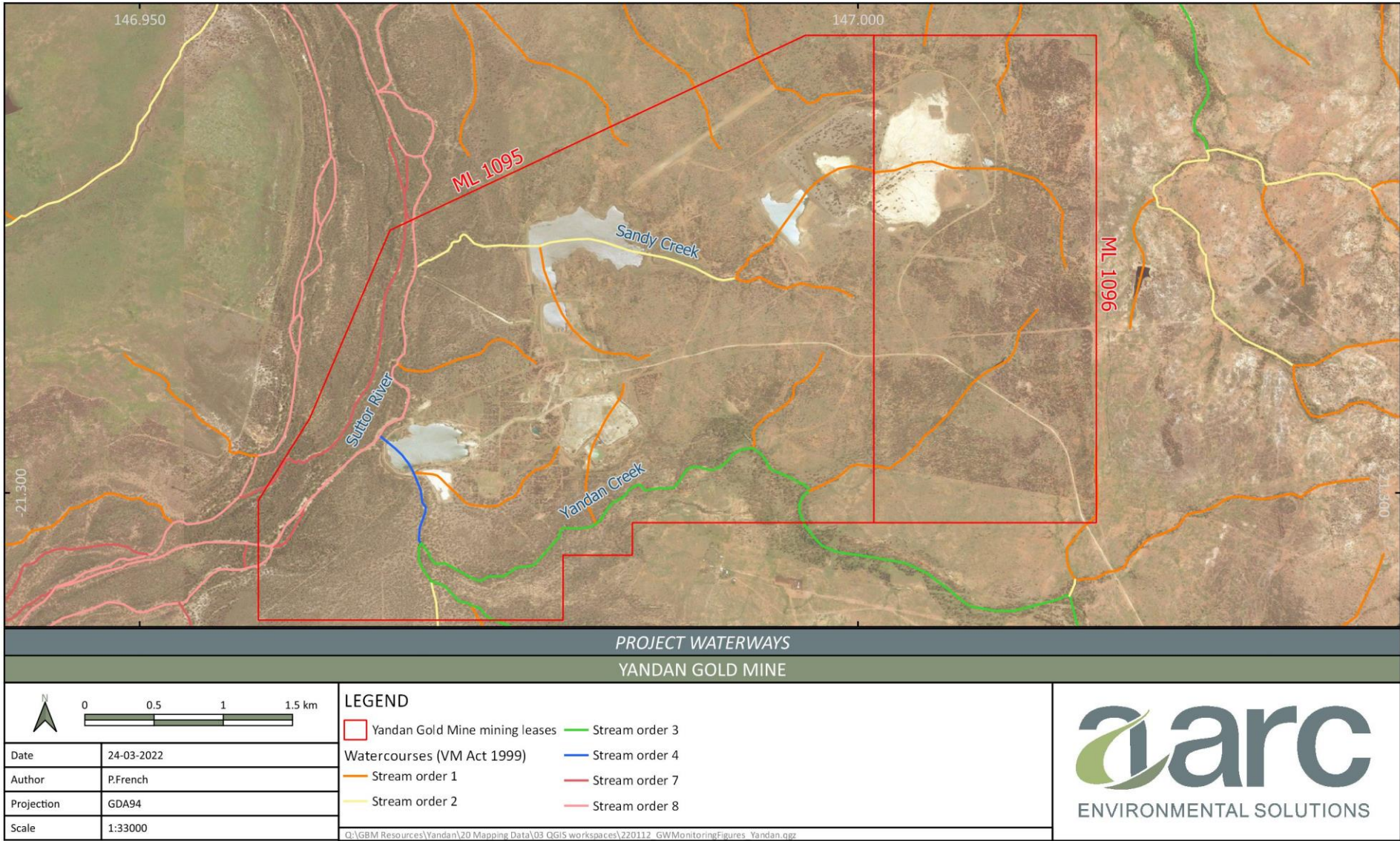


Figure 19: Waterways within the Project area

3.1.6 Groundwater

Groundwater values within the Yandan Project area were assessed as part of the Project's feasibility studies (Forbes 1988). From available information, the conceptual hydrogeological framework across the Project area is described as (Forbes 1988):

- 1) East of the mining area – low to very low permeability siltstones, sandstones and metamorphics, with limited groundwater occurrence.
- 2) Through the central area, a limited extent fracture hosted aquifer associated with the Yandan Fault.
- 3) West of the Yandan Fault in the mineralised zone, a porous unit associated with mineralisation and is likely the boiling zone of the epithermal system.
- 4) Alluvial aquifer as part of the Suttor River alluvium, reaching up to 30m depth.

Aquifers associated with the boiling zone and Yandan Fault appear to be relatively conductive, with pre-Project dewatering studies suggesting dewatering demand rates of up to 5,000m³/d to keep Main Pit dry, and pump test finding the fault and (what would appear to be) the boiling zone yielding draining storativity and transmissivities of 50-1,000m²/d (Forbes 1988, Greater Boulder Holdings Ltd 1988, within SBE 2022). It is noted that an objective of the study was to determine whether there was any potential connection to alluvial aquifers, however this was not identified at the time (Forbes 1988). It is not known of actual dewatering rates experienced during mining.

Groundwater is described as flowing from east to west with topography (Forbes 1988), but with strong changes of hydraulic head changes between wells, indicating structural control & potential hydraulic separation (SBE 2022). Recent water level monitoring results from the Project's groundwater monitoring network ('RB1D', 'RB2D' and 'SH3') support a westward flow, moving from 177.7 mAHD at monitoring bore 'RB1D' in the east, to 168.4 mAHD westward, and to 162.5 mAHD at 'SH3' near Main Pit (SBE 2022). Groundwater monitoring bore networks are shown through Figure 20.

Groundwater level records from the Project's monitoring network indicate that groundwater levels have steadily declined since 2012 (RLA 2019) (Figure 21). Generally, groundwater levels demonstrated a muted but delayed response to incident rainfall, indicating that the aquifers underlying the Project area of low permeability as it takes three months or more for groundwater levels to rise following peak rainfall events (RLA 2019).

Groundwater within the region is poorly developed, generally being of low quality and availability. Baseline groundwater quality testing indicated that groundwater within the region is typically saline with total dissolved salts (TDS) ranging between 4,000 to 15,000 mg/l (Forbes 1988), therefore being considered mostly unsuitable for livestock watering, irrigation or domestic uses. Review of the registered water bores within the greater region suggests groundwater use by landholder is low, with only a few bores registered within the area (Queensland Government 2022).

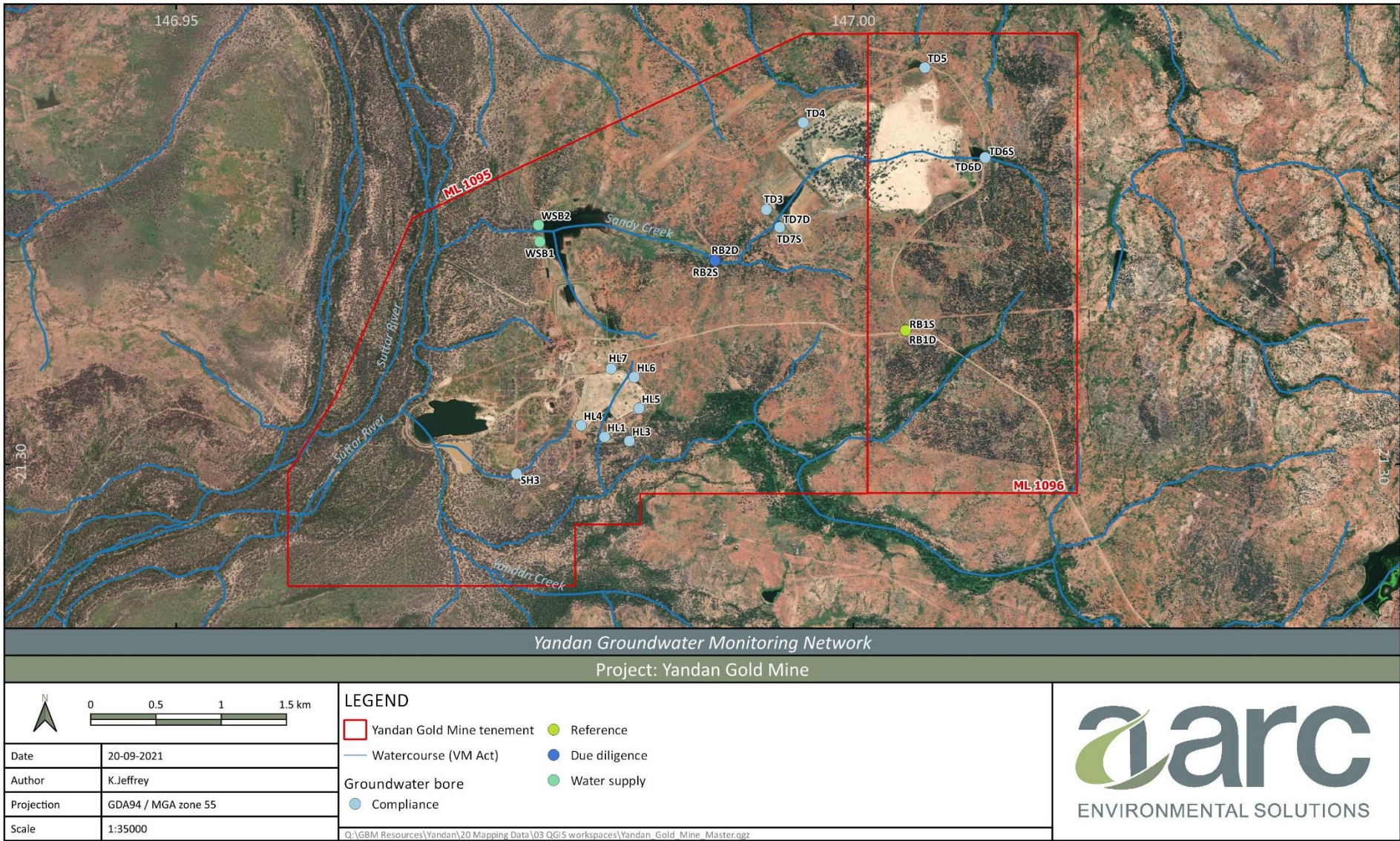


Figure 20: Yandan groundwater monitoring network

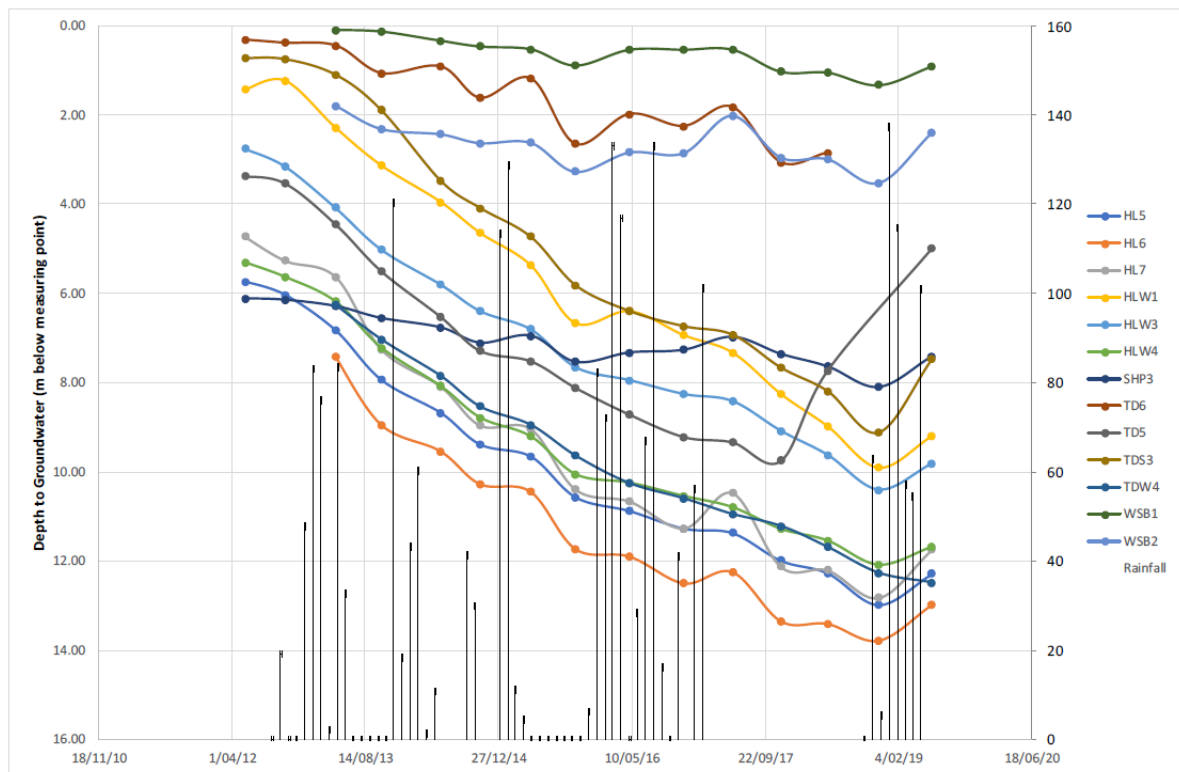


Figure 21: Groundwater level records (2012 – 2019) from the Yandan monitoring network (RLA 2019)

3.1.7 Land and soil

3.1.7.1 Pre-mining land use and underlying landholders

Low intensity beef cattle grazing is the primary land use for the region, with much of the naturally occurring open forest and woodlands cleared for this purpose. Limitations of the soil, together with low rainfall and high rainfall variability render the stock carrying capacity relatively low. Information obtained from the Department of Primary Industries indicated that the carrying capacity of the land is approximately one beast per 15 ha (GHD 2008).

All rehabilitated areas of the Project are currently used by the local landholder for livestock grazing, which is consistent with the surrounding land use and the intended post mining land use for most of the Project site.

3.1.7.2 Soil types, properties and productivity

A Soil and Land Suitability Assessment (SLSA) was undertaken by AARC in 2021 (AARC 2022a). This assessment identified and characterised the soil management units (SMUs) within the MLs, evaluated management requirements, and calculated the rehabilitation material balance for the site. Standard soil survey procedures were adopted.

The SLSA identified five (5) SMUs on the Project, as summarised in Table 6 and illustrated in Figure 22. Dominant SMUs across the Project were the Clayey SMU and the Sandy SMU. Both SMUs were characterised as being non-sodic (low exchangeable sodium percentage) and non-saline.

The Clayey SMU is associated with brown chromosols on imperfectly drained soils and slowly permeable profiles. The Clayey SMU was identified with a land suitability class of 4: described as marginal land which is considered presently unsuitable for agricultural land uses due to severe limitations.

The Sandy SMU is associated with yellow arenosols, with rapidly drained soils and highly permeable profiles. The Sandy SMU was identified with a land suitability class of 5: described as unsuitable land due to extreme limitations that currently preclude its use for agricultural land uses.

It is noted that the land suitability assessment framework provides guidance in determining land suitability outcomes, however, this determination should also provide consideration to historical and existing land uses. In this instance, it is acknowledged that the pre-mining land use for the Project area was low intensity cattle grazing, as is the current use for the local area. It is therefore inferred that native pastures are adapted to the adverse soil characteristics. On this basis, it is considered that the Project area is suitable for low intensity cattle grazing, carefully managed with the implementation of appropriate management regimes to support this land use.

Table 6: Yandan soil types, properties and productivity

SMU	Australian Soil Classification	Description	Properties	Land Suitability Class (Grazing)
Clayey	Brown Chromosols	Greyish brown duplex soil	- weak angular block to subangular blocky structure with iron mottling observed in lower profile - slightly acidic to slightly alkaline with depth (pH 6.6–7.2) - low sodicity (ESP 1–1.9 %) - low Emerson dispersion class (2) - moderate plant available water capacity (100–125 mm) - predominantly Brigalows (<i>Acacia harpophylla</i>)	4***
Sandy	Yellow Arenosols	Reddish yellow shallow and sandy soil	- weak granular structure, with shallow profile - moderately acidic throughout solum (pH 5.6–5.8) - low sodicity (ESP 1.9–3.3 %) - low Emerson dispersion class (2) - low plant available water capacity (75–100 mm) - predominantly narrow-leaved ironbark (<i>Eucalyptus crebra</i>)	5***
Shallow*	Red Calcarosols	Reddish soil with calcium carbonate segregations	- weak granular structure with moderate subangular blocky structure between 0.2–0.3 m - field pH is slightly to moderately alkaline (pH 7–9) - Contains calcareous and ferruginous segregations - predominantly Brigalows (<i>Acacia harpophylla</i>)	-
Silty*	Brown Tenosols	Yellowish brown loamy sand soils	- weak granular structure with moderate polyhedral structure between 0.2–0.4 m - field pH is slightly acid to slightly alkaline (pH 6.5–7.5) - Contains ferruginous segregations - predominantly Gidgees (<i>Acacia cambagei</i>)	-
Alluvial**	Grey Vertosols	Grey fine cracking clays	Smooth faced peds, underlain by mottled clay	-

Note:

* SMUs were grouped without chemical and physical analysis. Assessments were conducted based on soil profile descriptions, field observations and available desktop resources.

**SMU was grouped and mapped based on the Digital Atlas of Australian Soils (Bureau of Rural Science 1991) – CC53, due to land access restrictions

*** Considered suitable based on current land use of low intensity grazing.

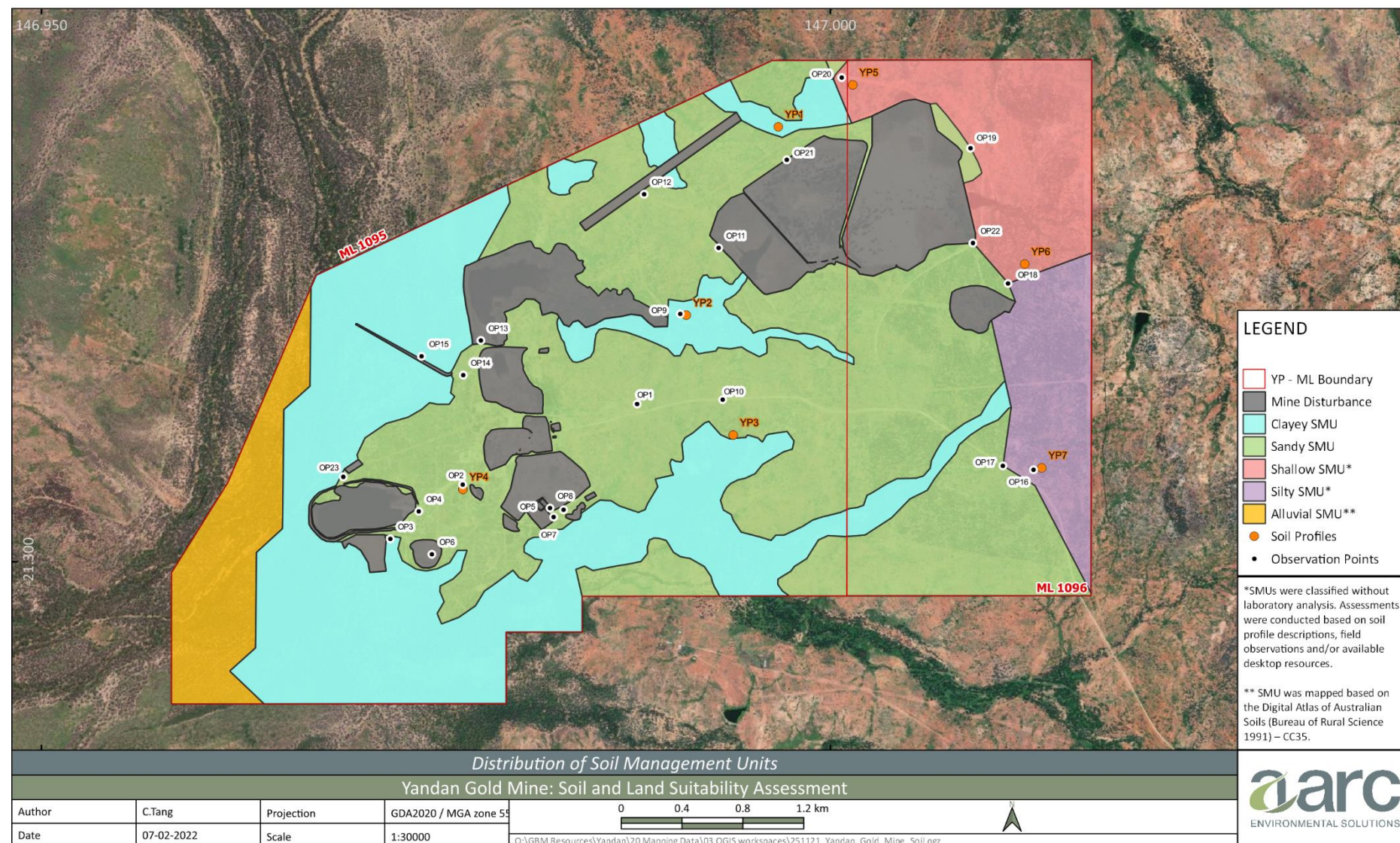


Figure 22: Distribution of soil management units (1:30,000)

3.1.7.3 Land stability

The soils within the Project area are described to be non-sodic, due to extremely low sodium ions leading to low exchangeable sodium percentage (ESP) values. However, both SMUs present with low to deficient calcium levels, relative to magnesium, indicating a risk of dispersion. In addition, Emerson aggregate tests demonstrate slaking and some dispersion in both Clayey and Sandy SMUs (Emerson Class Number 2).

Surface erosion is noted in field observations throughout the Project area, especially within the Sandy SMU. Areas of surface erosion are associated with soil properties, slopes, and low intensity grazing; predisposing the Project to ongoing land stability issues. Management methods for mitigating land stability issues on the Project include erosion and sediment control methods, and include the following:

- good topsoil management practices;
- the addition of fertilisers and soil ameliorants;
- grading and shaping;
- timely seeding with suitable species; and
- post-establishment management of rehabilitated areas.

Further details on soil management on the Project are provided in the SLSA.

3.1.8 Flora and fauna

3.1.8.1 Flora

The Project area lies at the northern end of the Brigalow Belt, an area of open forests and woodlands dominated by *Acacia harpophylla* (Brigalow). Since European settlement, the Brigalow Belt has undergone extensive clearing, particularly with the aid of machinery, mainly for the establishment of improved pastures with intermittent cropping where the soil type and slope is viable.

Prior to the commencement of mining, much of the original open forest and woodland communities had been cleared from site for agricultural purposes (Greater Boulder Holdings Ltd 1988). A long history of agricultural use was considered to have resulted in the degradation of the remaining vegetation (Greater Boulder Holdings Ltd 1988).

Remaining vegetation on the Project occurs predominantly in the west and east of the mining lease and generally in association with drainage lines. Queensland Government Vegetation Management remnant regional ecosystem (RE) mapping (DES 2022) identifies eight REs on the Project site, including six composite REs, as listed in Table 7 and illustrated in Figure 23.

Queensland Government mapping identifies remnant REs on the Project that are listed as 'of concern' and 'endangered' under the Queensland *Vegetation Management Act 1999* (VM Act). The distribution of endangered composite REs is restricted to drainage lines associated with the Suttor River and Yandan Creek, with these areas being retained throughout the period of mining. Remnant vegetation containing of concern REs occurs mainly in the south-west and north-west of the site.

Table 7: Queensland Government mapped remnant REs within the Project (DES 2022)

Regional Ecosystem (composition %)	Short description	Vegetation Management Act Class
11.11.13/11.11.15/11.3.10 (60/30/10)	<i>Acacia harpophylla</i> or <i>A. argyrodendron</i> low open forest with a secondary tree layer of <i>Terminalia oblongata</i> on deformed and metamorphosed sediments and interbedded volcanics / <i>Eucalyptus crebra</i> woodland to open woodland on deformed and metamorphosed sediments and interbedded volcanics / <i>Eucalyptus brownii</i> woodland on alluvial plains	Of concern / Least Concern / Least Concern
11.11.9/11.11.16 (80/20)	<i>Eucalyptus populnea</i> or <i>E. brownii</i> woodland on deformed and metamorphosed sediments and interbedded volcanics / <i>Eucalyptus cambageana</i> , <i>Acacia harpophylla</i> open forest to woodland on old sedimentary rocks with varying degrees of metamorphism and folding. Lowlands	Least Concern / Of Concern
11.3.10/11.3.25/11.3.3 (70/20/10)	<i>Eucalyptus brownii</i> woodland on alluvial plains / <i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines / <i>Eucalyptus coolabah</i> woodland on alluvial plains	Least Concern / Least Concern / Of Concern
11.3.25 (100)	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines	Least Concern
11.3.25/11.3.37/11.3.1 (80/10/10)	<i>Eucalyptus tereticornis</i> or <i>E. camaldulensis</i> woodland fringing drainage lines / <i>Eucalyptus coolabah</i> fringing woodland on alluvial plains / <i>Acacia harpophylla</i> and/or <i>Casuarina cristata</i> open forest on alluvial plains	Least Concern / Least Concern / Endangered
11.3.3 (100)	<i>Eucalyptus coolabah</i> woodland on alluvial plains	Of Concern
11.3.3/11.3.8 (60/40)	<i>Eucalyptus coolabah</i> woodland on alluvial plains / <i>Acacia argyrodendron</i> woodland on alluvial plains	Of Concern /Least Concern
11.5.3/11.7.3 (80/20)	<i>Eucalyptus populnea</i> +/- <i>E. melanophloia</i> +/- <i>Corymbia clarksoniana</i> woodland on Cainozoic sand plains and/or remnant surfaces / <i>Eucalyptus persistens</i> , <i>Triodia mitchellii</i> open woodland on stripped margins of Cainozoic lateritic duricrust	Least Concern / Least Concern

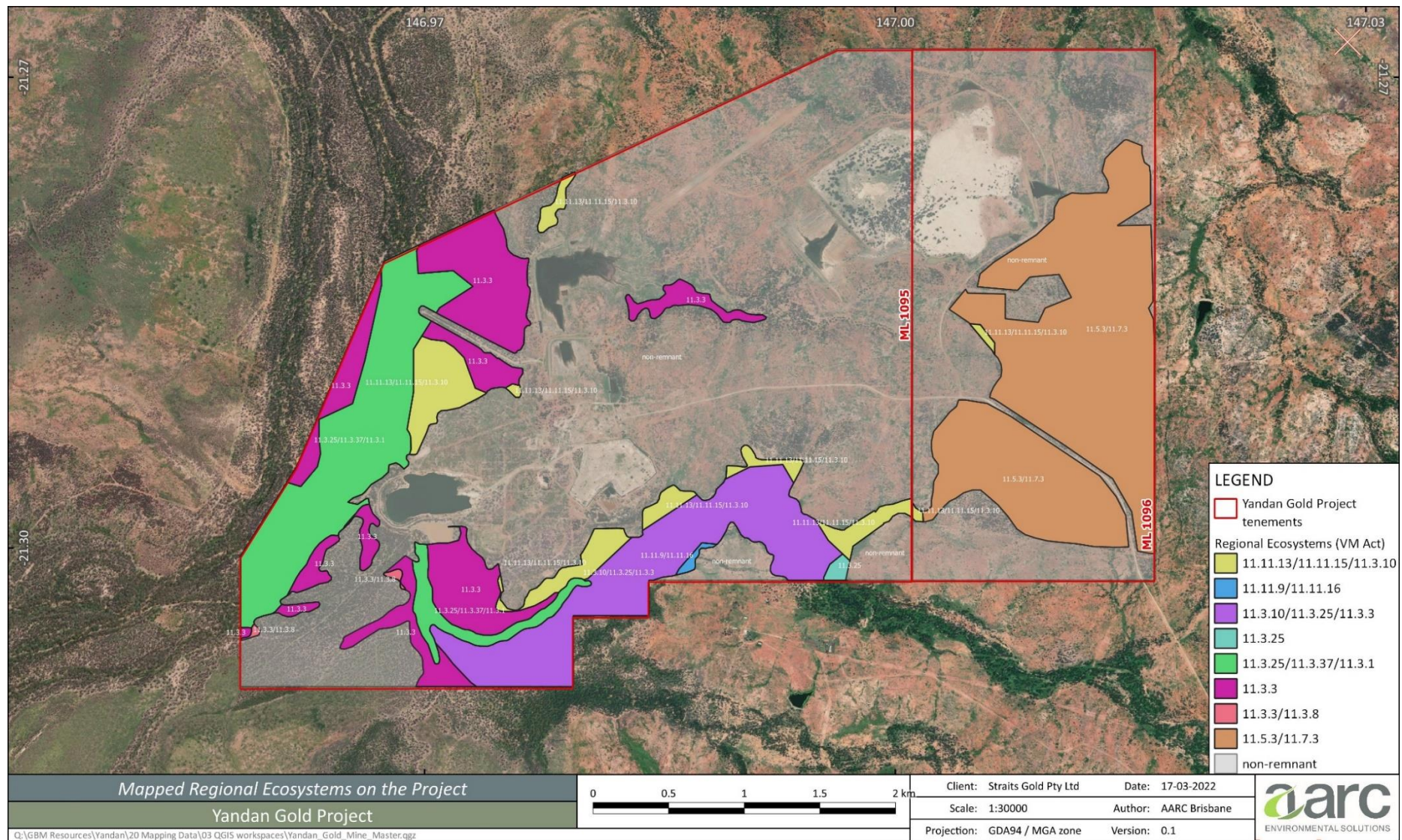


Figure 23: Queensland Government mapped remnant REs on the Project (Source: DES 2022)

3.1.8.2 Fauna

A terrestrial fauna assessment was completed as part of the Impact Assessment Study for the Project (Greater Builder Holdings Ltd 1988). The assessment indicated low species diversity of vertebrate fauna and low population densities compared with the surrounding area, considered to be the result of the condition of the remaining vegetation on-site (Greater Builder Holdings Ltd 1988).

Fauna species observed on the site included amphibians, reptiles, birds, and mammals, as detailed in Table 8.

Conservation significant fauna

Conservation significant fauna observed at Yandan during the baseline terrestrial assessment included *Phascolarctos cinereus* (Koala) and *Tachyglossus aculeatus* (Short-beaked Echidna). The Koala is listed as vulnerable under the Queensland *Nature Conservation Act 1992* (NC Act) and endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Short-beaked Echidna is listed as special least concern under the NC Act.

Past mine activity is not anticipated to have significantly impacted these species due to the significant amount of clearing and vegetation degradation that had occurred pre-mining (see Section 3.1.8.1). No new vegetation disturbance is considered in this PRCP.

Table 8: Fauna species found on the Project site

Family	Scientific Name	Common Name	NC Act Status	EPBC Status
Amphibians				
Hylidae	<i>Litoria rubella</i>	Desert Tree Frog	LC	Unlisted
Reptiles				
Gekkonidae	<i>Gehyra australis</i>	Northern Dtella	LC	Unlisted
Scincidae	<i>Carlia pectoralis</i>	Open-litter Rainbow-skink	LC	Unlisted
Scincidae	<i>Cryptoblepharus plagiocephalus</i>	Arboreal Snake-eyed Skink	LC	Unlisted
Boidae	<i>Morelia spilota</i>	Carpet Python	LC	Unlisted
Elapidae	<i>Hoplocephalus bitorquatus</i>	Pale-headed Snake	LC	Unlisted
Elapidae	<i>Pseudonaja textilis</i>	Eastern Brown Snake	LC	Unlisted
Elapidae	<i>Simonselaps australis</i>	Coral Snake	LC	Unlisted
Birds				
Anhingidae	<i>Anhinga novaehollandiae</i>	Australasian Darter	LC	Unlisted
Ardeidae	<i>Ardea pacifica</i>	White-necked Heron	LC	Unlisted
Accipitridae	<i>Milvus migrans</i>	Black Kite	LC	Unlisted
Accipitridae	<i>Haliastur spenurus</i>	Whistling Kite	LC	Unlisted
Accipitridae	<i>Aquila audax</i>	Wedge-tailed Eagle	LC	Unlisted
Falconidae	<i>Falco longipennis</i>	Australian Hobby	LC	Unlisted

Family	Scientific Name	Common Name	NC Act Status	EPBC Status
Falconidae	<i>Falco berigora</i>	Brown Falcon	LC	Unlisted
Falconidae	<i>Falco cenchroides</i>	Nankeen Kestrel	LC	Unlisted
Columbidae	<i>Geopelia placida</i>	Peaceful Dove	LC	Unlisted
Columbidae	<i>Ocyphaps lophotes</i>	Crested Pigeon	LC	Unlisted
Columbidae	<i>Geophaps scripta</i>	Squatter Pigeon	LC	Unlisted
Cacatuidae	<i>Calyptorhynchus banksii</i>	Red-tailed Black Cockatoo	LC	Unlisted
Cacatuidae	<i>Eolophus roseicapilla</i>	Galah	LC	Unlisted
Cacatuidae	<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	LC	Unlisted
Psittacidae	<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	LC	Unlisted
Psittacidae	<i>Aprosmictus erythropterus</i>	Red-winged Parrot	LC	Unlisted
Psittacidae	<i>Platycercus adscitus</i>	Pale-headed Rosella	LC	Unlisted
Cuculidae	<i>Chrysococcyx basalis</i>	Horsefield's Bronze Cuckoo	LC	Unlisted
Cuculidae	<i>Eudynamys scolopacea</i>	Common Koel	LC	Unlisted
Cuculidae	<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo	LC	Unlisted
Cuculidae	<i>Centropus phasianinus</i>	Pheasant Coucal	LC	Unlisted
Podargidae	<i>Podargus strigoides</i>	Tawny Frogmouth	LC	Unlisted
Halcyonidae	<i>Dacelo novaeguineae</i>	Laughing Kookaburra	LC	Unlisted
Halcyonidae	<i>Dacelo leachii</i>	Blue-winged Kookaburra	LC	Unlisted
Meropidae	<i>Merops ornatus</i>	Rainbow Bee-eater	LC	Unlisted
Campephagidae	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	LC	Unlisted
Pachycephalidae	<i>Pachycephala rufiventris</i>	Rufous Whistler	LC	Unlisted
Pachycephalidae	<i>Colluricincla harmonica</i>	Grey-shrike Thrush	LC	Unlisted
Rhipiduridae	<i>Rhipidura leucophrys</i>	Willie Wagtail	LC	Unlisted
Pomatostomus	<i>Pomatostomus temporalis</i>	Grey-crowned Babbler	LC	Unlisted
Maluridae	<i>Malurus lamberti</i>	Variegated Fairy-wren	LC	Unlisted
Maluridae	<i>Malurus melanocephalus</i>	Red-backed Fairy-wren	LC	Unlisted
Acanthizidae	<i>Smicrornis brevirostris</i>	Weebill	LC	Unlisted
Acanthizidae	<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill	LC	Unlisted
Meliphagidae	<i>Philemon corniculatus</i>	Noisy Friar-bird	LC	Unlisted

Family	Scientific Name	Common Name	NC Act Status	EPBC Status
Meliphagidae	<i>Philemon citreogularis</i>	Little Friar-bird	LC	Unlisted
Meliphagidae	<i>Manorina flavigula</i>	Yellow-throated Miner	LC	Unlisted
Meliphagidae	<i>Meliphaga virescens</i>	Singing Honeyeater	LC	Unlisted
Nectariniidae	<i>Dicaeum hirundinaceum</i>	Mistletoe-bird	LC	Unlisted
Pardalotidae	<i>Pardalotus striatus</i>	Striated Pardalote	LC	Unlisted
Corcoracidae	<i>Struthidea cinerea</i>	Apostle-bird	LC	Unlisted
Monarchidae	<i>Grallina cyanoleuca</i>	Magpie-lark	LC	Unlisted
Artamidae	<i>Artamus minor</i>	Little Woodswallow	LC	Unlisted
Artamidae	<i>Cracticus torquatus</i>	Grey Butcherbird	LC	Unlisted
Artamidae	<i>Cracticus nigrogularis</i>	Pied Butcherbird	LC	Unlisted
Corvidae	<i>Corvus coronoides</i>	Australian Raven	LC	Unlisted
Corvidae	<i>Corvus orru</i>	Torresian Crow	LC	Unlisted
Mammals				
Tachyglossidae	<i>Tachyglossus aculeatus</i>	Short-beaked Echidna	SL	Unlisted
Dasyuridae	<i>Sminthopsis crassicaudata</i>	Fat-tailed Dunnart	LC	Unlisted
Phascolarctidae	<i>Phascolarctos cinereus</i>	Koala	V	E
Potoroidae	<i>Aepyprmnus rufescens</i>	Rufous Bettong	LC	Unlisted
Macropodidae	<i>Macropus giganteus</i>	Eastern Grey Kangaroo	LC	Unlisted
Pteropodidae	<i>Pteropus scapulatus</i>	Little Red Flying-fox	LC	Unlisted
Vespertilionidae	<i>Nyctophilus bifax</i>	North Queensland Long-eared Bat	LC	Unlisted
Leporidae	<i>Orytolagus cuniculus*</i>	European Rabbit	Unlisted	Unlisted

Note: * Indicates an introduced species

3.2 Community consultation

Throughout the life of the Yandan Gold Project the respective owners have maintained communications with the local community, with consultation ongoing as part of approval processes and through operational periods, as well as throughout the current care and maintenance period.

3.2.1 Project and ownership history

Ownership of the Yandan Gold Project has been transferred multiple times since development of the Project in the early 1990s. To provide context to community consultation efforts over this time, the following provides an overview of the Project's ownership against the key milestones in the life of the Project.

Applications for the Project MLs (now ML1095 and ML1096) were lodged in August 1988 by Great Boulder Holdings Limited, a member of the Western Mining Corporations Limited Group of Companies. Mining

operations commenced under Western Mining Corporations Limited as manager for Great Boulder Holdings Limited.

The Impact Assessment Study for the Project approval was submitted in December 1988, with the Project MLs granted in June 1991.

In July 1992, Ross Mining N.L. acquired the Project, as well as the Wirralie Gold Mine, a controlling interest in the Mount Coolon joint venture, and exploration tenements associated with the three assets.

Ross Mining N.L. operated the Project between 1993–2000, producing over 350,000 ounces of gold from heap leach operations and a CIL process plant. Mining operations ceased in 1998, with the Heap Leach Pad remaining operational until September 2002. The site was placed into care and maintenance in April 1999, pending final closure works. The gold processing plant was later removed in 2006/2007, prior to the acquisition of the Project by Straits Gold, a wholly owned subsidiary of Aeris Resources Ltd at the time. The Project has remained in care and maintenance since closure in 1999.

GBM Resources acquired the Project and the Straits Gold entity on 13 January 2021.

Table 9: History of mining lease holders of Yandan Gold Project

Permit	Permit holder	Share (%)	Held from ..	Held to ..
ML 1095	Straits Gold Pty Ltd (as subsidiary of GBM Resources Ltd)	100	13 January 2021	Present
	Straits Gold Pty Ltd (as subsidiary of Aeris Resources Ltd)	100	02 August 2006	13 January 2021
	Drummond Gold Limited Farm in Agreement & Joint Venture with Straits Exploration (Australia) Pty Ltd	Unknown	May 2009	27 July 2011
	Straits Exploration (Australia) Pty Ltd (as subsidiary of Aeris Resources Ltd)	Unknown	03 May 2006	02 August 2006
	Straits Exploration (Australia) Pty Ltd Joint Venture with Wirralie Mines Pty Ltd (as subsidiary of Ashburton Minerals Ltd)	Unknown	26 February 2004	03 May 2006
	Ashburton Minerals Ltd	Unknown	2003	2004
	Delta Gold Ltd	Unknown	2000	2003
	Ross Mining N.L.	Unknown	July 1992	2000
	Greater Boulder Holdings Limited	Unknown	27 June 1991	July 1992
ML 1096	Straits Gold Pty Ltd (as subsidiary of GBM Resources Ltd)	100	13 January 2021	Present
	Straits Gold Pty Ltd (as subsidiary of Aeris Resources Ltd)	100	02 August 2006	13 January 2021
	Drummond Gold Limited Farm in Agreement & Joint Venture with Straits Resource	Unknown	May 2009	27 July 2011
	Straits Exploration (Australia) Pty Ltd (as subsidiary of Aeris Resources Ltd)	Unknown	03 May 2006	02 August 2006
	Ashburton Minerals Ltd	Unknown	2003	03 May 2006
	Delta Gold Ltd	Unknown	2000	2003

Permit	Permit holder	Share (%)	Held from ..	Held to ..
	Ross Mining N.L	Unknown	July 1992	2000
	Greater Boulder Holdings Limited	Unknown	27 June 1991	July 1992

3.2.2 Previous stakeholder and community engagement activities

Over the life of the Yandan Gold Project and prior to the implementation of the PRCP legislation in 2019, GBM and the previous mine owners have actively engaged with the community.

Existing community management practices include regular consultation with affected stakeholders, particularly the sole underlying landholder. This is generally undertaken on an as needs basis.

Recent community engagement has been relatively limited due the ongoing care and maintenance status of the Project. Generally, the broader community is consulted in advance of exploration or care and maintenance works being carried out on the site. During these periods, GBM utilises existing services within the town where practical (e.g., the Mount Coolon Hotel).

Past engagement with the owners of Lot 5060 of Plan PH387 (the underlying landholder) has included exploration and environmental monitoring activities, and rehabilitation and closure. Planning for closure was only discussed at a high level, as future mining activity was always planned for the Project. The landholder has provided written agreement for the retention of the Water Storage Dam, all tracks/roads, and the airstrip.

3.2.3 Stakeholder engagement plan

Yandan Gold Project operates under a Stakeholder Engagement Plan (SEP) (Appendix E), prepared in accordance with the requirements set out in section 126C(1)(c)(iv) and (iv) of the EP Act and the PRCP Guideline.

The SEP was developed to be a practical tool for effective stakeholder engagement, to ensure stakeholders are provided the opportunity to engage on various aspects of the Project, including rehabilitation and closure matters relating to the Project. The SEP provides details on the stakeholder engagement process, engagement objectives, and how stakeholder feedback is managed. Stakeholder engagement objectives established in the SEP are described in Table 10.

Table 10: Stakeholder engagement plan objectives

SEP objective	Description
Strengthen corporate social responsibility and maintain ongoing community relationships and trust.	Stakeholder interests and concerns will continue to be incorporated into rehabilitation planning/management and where available, communicated to the relevant stakeholder upon completion.
Ensure transparent, open and informative stakeholder communication.	Information disclosed to stakeholders will be undertaken in an appropriate format to ensure a common understanding of any potential concerns or issues. Where appropriate, this information will be made available without hesitation and promptly.
Inform and liaise with key stakeholders to ensure rehabilitation activities are undertaken to achieve the agreed PMLU.	Engagement methods and frequencies will ensure ongoing updates on the status of rehabilitation as a progression towards the agreed PMLU using a wide range of engagement materials and tools, such as fact sheets and online materials.

SEP objective	Description
Enhance and outline key avenues that stakeholders can utilise to provide feedback on Project rehabilitation activities.	Existing communication channels available to the general public/and or key stakeholders will continue to be made available such as primary engagement methods (face-to-face meetings and webpage) and additional methods, if needed (i.e., community advisory groups, public displays and information sessions).
Identify processes for GBM to respond to community concerns and appropriately manage stakeholder expectations	Feedback protocols will be adopted as part of a comprehensive response process to ensure community concerns (received in all formats - email, phone call, text or meeting) are responded to promptly and with the correct information. All forms of feedback will be categorised and recorded within a register to identify any stakeholder engagement trends which can be appropriately responded to, managed and addressed.

The SEP, including the corresponding list of identified stakeholders, will be reviewed periodically following any Project changes or updates. Further details of community consultation are provided in the SEP which is attached as Appendix E.

3.3 Post-mining land use

This section of the PRCP describes and discusses the PMLUs prescribed and proposed for the Project post-closure.

3.3.1 Land outcome document

The Project EA authorising mining activities at Yandan was issued on 20 January 2012. Schedule F of the EA relates to land and rehabilitation requirements, with Condition F2-1 and Schedule F – Table 1 identifying post mine land uses for the Project (refer Table 11). In accordance with Condition F3-1 of the Project EA, a Post Mine Land Use Plan (PMLUP) has been developed to assist achievement of the nominated post mine land uses. It is considered that the EA and the PMLUP meet the requirements of land outcome documents (LODs) as defined by section 750 of the EP Act. The PMLUP provides some additional understanding of the intent for PMLUs and NUMAs for the Project.

By virtue of the existence of a LOD, and in accordance with section 213 of the Environmental Protection Regulation 2019, Schedule 8A, part 3, Table 1 *Final site design assessment* and Table 2 *Post-mining land use assessment – rehabilitation milestones*, do not apply to the objective assessment to be undertaken for this PRCP.

In relation to the *progressive rehabilitation* component of Table 2, this PRCP will:

- describe how rehabilitation areas are planned in a way that achieves progressive rehabilitation;
- illustrate how progressive rehabilitation has already commenced at the Project site;
- identify risks and discuss their incorporation within, and their impact on, the milestone schedule; and
- describe community consultation approaches appropriate for the Project.

3.3.2 Pre-mining and existing land uses

Prior to the development of the mine, land underlying the Project area was used for low intensity beef cattle grazing. At the time of the commencement of mining at Yandan in 1993, much of the naturally occurring open forest and woodlands had been cleared for this purpose, with remnant stands of native vegetation remaining alongside the Suttor River.

Soil limitations of the region, together with low rainfall and high rainfall variability, have limited the stock carrying capacity of the region, limiting the land use of the area to low intensity cattle grazing only.

Review of Queensland Government land use mapping (DES 2019, 2020) indicates that lands within the surrounding region consist predominantly of grazing lands on relatively natural environments. These lands are typically comprised of native vegetation, with limited or no deliberate attempt at pasture modification (ABARE 2016). It is noted however, that land clearing within the surrounding region has been relatively significant, with remnant vegetation generally limited to drainage lines.

Lands underlying the Project area are classified as rehabilitation with pockets of mining (DES 2020). The PMLU of open pasture grazing for the majority of the Project is therefore consistent with this broader land use. It is noted that the PMLU for the ROM Pad and Heap Leach Pad is listed as 'low hill'.

The Project area falls predominantly within the Whitsunday Regional Council local government area, acknowledging a small proportion of the area on the western side of the Suttor River (outside of the Project footprint) lies within the Charters Towers Regional Council local government area. The majority of land underlying the Project is therefore subject to the *Whitsunday Regional Council Planning Scheme 2017* (Whitsunday Regional Council 2017).

Lands underlying the Project are zoned as 'Rural', defined as providing primarily for a range of rural uses, including cropping, intensive horticulture, intensive animal industries, animal husbandry, animal keeping and primary production activities.

The PMLUs prescribed by the Project EA are considered to be generally compatible with the *Whitsunday Regional Council Planning Scheme 2017*.

3.3.3 Prescribed post-mining land uses

In accordance with Condition F2-1 of the Project EA:

Land disturbed by mining activities must be rehabilitated in accordance with Schedule F - Table 1 (Post Mine Land Description) and the objectives of the Post Mine Land Use Plan required under condition (F3-1).

Schedule F – Table 1 of the Project EA has been reproduced here as Table 11 below, providing 'post mine land descriptions' for various disturbance types. Descriptions of the post mine land classifications detailed in Table 11 for the Project are provided in Table 12. Prescribed post mine land descriptions include 'open pasture', 'water storage', and 'low hill' (Table 11). The post mine land classification of VII is appropriately aligned with both the pre-existing land use and the SLISA suitability classification of 4/5 (AARC 2022a). The PMLUP (AARC 2018) redefines the post mine land descriptions as PMLUs.

Table 11: Post mining land use areas (after Schedule F-Table 1, Project EA and Table 1, PMLUP)

Tenure ID	Disturbance type	Associated infrastructure ¹	Maximum surface area (ha)	Post-mine land description	Post mine land classification
ML1095	Backfilled pit	South Pit	4	Open pasture	VII
	Tailings dam	Cell A Cell B TWRD Spillway	39	Open pasture	VII
	Stockpile area	Topsoil Stockpile	8.3	Open pasture	VII
	Runoff dam	Mine Water Dam	16.6	Water storage	VII
	ROM pad	ROM Pad	3.8	Low hill	VII
	Processing Plant	Hardstand Area	1.8	Open pasture	VII
	Open pit	Main Pit East Hill Pit	18.8	Lake	Void
	Infrastructure	Tailings Water Return Dam Water Storage Dam ² Water Harvest Trench Roads ¹ Airstrip	79.8	Open pasture	VII
	Heap Leach	Heap Leach Pad (HLP) HLP Stormwater Pond Pregnant Pond Barren Pond	21	Low hill	VII
	Borrow pit	Borrow pit	8	Open pasture	VII
ML 1096	Village infrastructure	Village infrastructure	15	Open pasture	VII
	Tailings Dam	Cell A Cell B	75	Open pasture	VII

¹ Associated infrastructure column added for clarity.

² Approved for retention in the final landform subject to landholder agreement

Table 12: Description of post mine land classifications

Class	Description
Class I	Land suitable for all agricultural and pastoral uses
Class II	Land suitable for all agricultural uses with slight restrictions to cropping
Class III	Land suitable for all agricultural uses with moderate restrictions to cropping
Class IV	Land primarily used for pastoral uses but can be carefully cropped occasionally
Class V	Land primarily used for pastoral uses but can be carefully cropped if limitations were removed
Class VI	Land not suited to cultivation but well suited to pasture improvement
Class VII	Land not suitable for cultivation and only careful pastoral use possible
Class VIII	Land not suitable for agricultural or grazing purposes

3.3.4 Proposed post-mining land use

It is acknowledged that some of the LOD PMLUs (Table 11) provide limited descriptions of the target rehabilitation that is to be achieved. This is particularly so for the 'low hill' PMLU, which more describes the intended resulting landform topography rather than the actual land use to be achieved.

In an effort to improve rehabilitation outcomes for the Project, the LOD PMLUs have been reviewed and better defined, where appropriate, to provide greater clarity of the PMLU intent for the Project; including the landform and vegetation type to be achieved. It should be noted that, in accordance with PRCP Guideline requirements, and in describing PMLUs, significant focus has been placed on the current land use of the area.

Proposed PMLUs are detailed in Table 13 below, with changes indicated in blue text. It should be noted that no changes to disturbance type footprints are proposed, however post mine land classifications have been translated to the more current land use suitability classification system based on the SLSA (AARC 2022a).

Further to the discussion at Section 3.3.3, two non-use management areas (NUMAs) are identified; being the Main Pit, described as a 'lake', but with the specific purpose of managing the potential for acid drainage; and East Hill Pit, described as a residual void with no PMLU ascribed.

Table 13: Proposed post-mining land uses

Tenure ID	Disturbance type	Associated infrastructure	Maximum surface area (ha)	Post-mine land description	Post mine land classification
ML1095	Backfilled pit	South Pit	4	Open pasture – grazing	VII
	Tailings dam	- Cell A - Cell B - WRD Spillway	39	Open pasture – grazing	VII
	Stockpile area	Topsoil Stockpile	8.3	Open pasture – grazing	VII

	Runoff dam	Mine Water Dam	16.6	Retained water storage	VII
	ROM pad	ROM Pad	3.8	Low hill – pasture grazing	VII
	Processing Plant	Hardstand Area	1.8	Open pasture – grazing	VII
	Open pit	- Main Pit - East Hill Pit	18.8	Void (None Use Management Area)	Void (Non Use Management Area)
	Infrastructure	- Tailings Water Return Dam - Water Storage Dam2 - Water Harvest Trench - Roads1 - Airstrip	79.8	Open pasture – grazing	VII
	Heap Leach	- Heap Leach Pad - HLP Stormwater Pond - Pregnant Pond - Barren Pond	21	Low hill – pasture grazing	VII
	Borrow pit	Borrow pit	8	Open pasture – grazing	VII
	Exploration	Exploration areas	4.5	Open pasture – grazing	VII
ML 1096	Village infrastructure	Village infrastructure	15	Open pasture – grazing	VII
	Tailings Dam	- Cell A - Cell B	75	Open pasture – grazing	VII

Note: proposed changes to the LOD PMLUs are shown in blue

2 Approved for retention in the final landform subject to landholder agreement

Proposed changes to the PMLUs are to clarify the following:

- 1) the target vegetation type of 'grazing' for the LOD PMLUs of 'open pasture' and 'low hill';
- 2) the existing Water Storage Dam is to be retained in the final landform; and
- 3) Main Pit and East Hill Pit are established in the LOD as NUMAs.

Pasture grazing has been proposed as the target vegetation type for the 'open pasture' and 'low hill' PMLUs, on the basis of the pre-mining land use and the land use of the surrounding area.

As summarised in Sections 3.3.2, pasture grazing was the pre-mining land use of the Project area, and remains the principal land use within the surrounding region. Dominant soil types within the Project area predominantly support pasture grasses. While limitations for these soil types have been identified (Section 3.1.7), it is inferred that local pastures are adapted to these soil characteristics on the basis of the pre-mining land use and local land use. On this basis, it is considered that the Project area is suitable for low intensity cattle grazing, carefully managed with the implementation of intensive management regimes to support this land use.

Other minor amendments to the LOD PMLUs for the 'Runoff dam' (i.e. Mine Water Dam) and the 'Open pit' (i.e. Main Pit and East Hill Pit) have been made to clarify that the existing Mine Water Dam is to be retained in the final landform (following desilting and 'make safe' rehabilitation works), and that the open pits are to remain as residual voids (following improvement works).

In summary, proposed PMLUs for the Project are consistent with the LOD PMLUs, with the following consideration given to the proposed target vegetation of 'grazing':

- is generally considered viable, having regard to the use of land in the surrounding region;
- is consistent with how the land was used before the mining activity was carried out on the land;
- is consistent with the land zoning code in the *Whitsunday Regional Council Planning Scheme 2017*; and
- will deliver, or aim to deliver, a beneficial environmental outcome that is acceptable to the local community.

3.3.5 Infrastructure subject to landholder agreement

A landholder agreement between Straits Gold and the registered owner of Lot 5060 PH387, the Scott Family (landholder), was signed in 2019. This agreement declared Straits Gold will not, upon closure of the Project and surrender of the MLs, remove the following infrastructure to be retained for use by the landholder:

- all tracks/roads;
- the airstrip; and
- the Water Storage Dam.

3.4 Non-use management areas

This section of the PRCP describes the disturbance types that will remain as NUMAs post closure.

NUMAs relevant to the Project are referred to in the LODs, being the Project EA and PMLUP.

Condition F2-1 and Schedule F – Table 1 of the Project EA identifies the post-mine land description for the 'Open pit', comprising Main Pit and East Hill Pit, as being a 'lake', with a post mine land classification of 'void' (refer Table 11).

The PMLUP (AARC 2018) provides some additional understanding of the intent for the two open pits associated with the Project; variously referring to these as 'lakes', 'residual voids' and 'pits'. Section 6.1.2 of the PMLUP notes the requirement for Main Pit to retain a minimum water level for the purpose of providing a cover for any potentially acid producing rock material exposed in the pit highwalls. Section 6.1.2 goes on to describe the other remaining pit, East Hill Pit, as having a fence and bund constructed, with decommissioning involving the maintenance of these safety measures to prevent livestock and human access. No specific, further PMLU is ascribed to this feature.

Given this NUMA classification for the open pits, these disturbance areas have been included within this PRCP as improvement areas that are to be subject to various management milestones.

Furthermore, with the existence of a LOD establishing the NUMAs at the Project, section 213 of the EP Regulation and Schedule 8A, part 3, Table 1 *Final site design assessment* and Table 3 – *Non-use management area assessment – management milestones* do not apply to the objective assessment to be undertaken for the PRCP. In relation to the *Progressive Improvement* component of Table 3, this PRCP will:

- describe how non-use areas will undergo improvement to a safe and stable condition post-closure;
- illustrate how improvement will commence at the Project;

- identify risks and discuss their incorporation within the improvement schedule; and
- detail the timeframe for improvement areas to progress through management milestones.

In summary, NUMAs on the Project are associated with the Main Pit and East Hill Pit voids. The open cut pit NUMAs are prescribed by the existing LODs; the details of which are established in Schedule F – Table 1 from the Project EA and Table 1 in the PMLUP, summarised here in Table 14.

Table 14: Non-use management areas (after Schedule F-Table 1, Project EA and Table 1, PMLUP)

Tenure ID	Disturbance type	Associated infrastructure ¹	Maximum surface area (ha)	Post-mine land description	Post mine land classification
ML1095	Open pit	• Main Pit • East Hill Pit	18.8	Lake	Void

Rehabilitation requirements for residual voids on the Project relevantly include:

Condition F7-1: Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself, and subject to any other condition within this environmental authority.

Condition F7-2: Mining voids must be managed during the operation and decommissioning phases to maximise the potential post mine beneficial uses, by consideration of the following:

- a) Limiting sulphide exposures in void walls; and*
- b) Capping of sulphide exposures in void base; and*
- c) Limiting period of exposure of sulphides in void walls and base to oxidising conditions; and*
- d) Managing catchment into the void; and*
- e) Geotechnical stability of final void.*

Rehabilitation requirements specific to the water management bund around Main Pit are also established in the Project EA, being:

Condition G6-1: The integrity of the bund wall for the Main Pit must be maintained until its removal or modification is authorised by the administering authority. This authorisation will be on the basis that the authority holder can demonstrate that the removal or modification of the bund would not result in an unacceptable risk of potential environmental harm.

Condition G6-2: Prior to removing or modifying the Main Pit bund wall, the holder of the environmental authority must submit to the administering authority for acceptance of a design plan that has been certified by a suitably qualified and experienced person, as compliant in all respects with this environmental authority, and in accordance with accepted engineering standards.

Condition G6-3: Removal or modification of the Main Pit bund wall shall be done only in accordance with an accepted design plan.

Condition G6-4: When removal or modification of the Main Pit bund wall is complete, the holder of this environmental authority must submit to the administering authority a set of 'as constructed' drawings, and a certification by a suitably qualified and experienced person that either:

- The construction is substantially as per the accepted design plan, or*
- The suitably qualified and experienced person certifies that the as constructed plan is compliant in all respects with this environmental authority, and in accordance with accepted engineering standards.*

The above rehabilitation requirements are addressed within Section 3.5.

With respect to the requirements of Section 126C(d) of the EP Act, Section 3.2 describes the previous and proposed engagement activities relevant to the Project. Given the remoteness of the Project location and the legacy of mining associated with the area, past approval processes and compensation discussions will have been the primary vehicles for consultation associated with the current land use expectations for the Project. The current, contemporary rehabilitation and closure planning for this site will make no changes to the size and location of the approved NUMAs defined in the EA.

The Project area is located within the Whitsunday Regional Council Planning Scheme, within the Rural Zone. While the NUMAs will not specifically contribute to the objectives of the Rural Zone, their small size and nature are such that they are considered not to detrimentally impact the objectives of the Planning Scheme. It should be noted that the Whitsunday Regional Council Planning Scheme is acknowledged as integrating all State government planning policy interests and provisions.

The NUMAs in this PRCP are consistent with the prescribed NUMAs for the Project. As such, it can be inferred that the NUMAs are entirely consistent with the outcomes of past consultation processes (undertaken as part of the EA and ML approvals).

Under Section 754 of the EP Act, with the existence of an approved LOD that defines the NUMAs at the Project, this transitional PRCP is not required to comply with section 126C(1)(g) or (h), or section 126D(2) or (3). As such, no further justification of NUMAs is provided.

3.5 Rehabilitation management methodology

3.5.1 Rehabilitation objectives

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 (Queensland Government 2018) which intends to ensure that, for land disturbed by mining activities:

- the land is safe and structurally stable;
- there is no environmental harm being caused by anything on or in the land; and
- the land can sustain a PMLU (section 111A of the EP Act).

These three objectives are the general rehabilitation goals for all areas disturbed by mining in Queensland.

The proposed PMLUs for the Project are open pasture – grazing, low hill – pasture grazing, retained water storage and retained infrastructure; the authorised NUMAs for the open pits are referred to as voids in the LOD. Rehabilitation activities have been, and will continue to be, conducted towards these outcomes.

As discussed in Section 3.1.2, rehabilitation has previously been completed for a number of domains. Remaining rehabilitation activities are principally associated with:

- Cell B of the TSF – installation of an appropriate cover system design, surface preparation and revegetation activities.
- Heap Leach Pad and associated treatment ponds – landform development and installation of an appropriate cover system design, surface preparation and revegetation activities.
- Water storage structures – decommissioning of water storage structures not required for PMLU, landform development, surface preparation and revegetation activities.
- Infrastructure areas – remediation of infrastructure areas, landform development, surface preparation and revegetation activities.
- Maintenance of existing rehabilitation areas:
 - Cell A – re-development of water shedding landform profile (limited to small central zone only), continued progress towards rehabilitation completion criteria;
 - Village Infrastructure area – removal of some remaining concrete footings, continued progress towards rehabilitation completion criteria;
 - South Pit - continued progress towards rehabilitation completion criteria, certification of rehabilitation; and
 - ROM Pad - continued progress towards rehabilitation completion criteria (subject to outcomes of the detailed mine planning phase), certification of rehabilitation.
- Isolated areas of surface disturbance – landform development, surface preparation, revegetation.
- Infrastructure to be retained (water storages and infrastructure) – infrastructure cleaned and made safe as required.

Infrastructure components (refer Section 3.3.5) have been nominated for retention to support the open pasture - grazing PMLU and will be transferred to the landholder upon surrender. As required to support the open pasture – grazing PMLU, rehabilitation works will be completed. For example, water storage structures to be retained by the landholder will be cleaned and made safe prior to surrender.

3.5.2 Rehabilitation areas and improvement areas

To allow the development of a PRCP schedule that satisfies the requirements of the PRCP Guideline, discrete rehabilitation areas (RAs) and improvement areas (IAs) have been defined for the Project. RAs or IAs have been nominated for all areas of disturbance at Yandan, summarised as follows and detailed in Table 17 and presented in Figure 24.

RAs 1 to 4 and IAs 1 and 2 are based off the major infrastructure areas identified in the Project EA and the sequence of rehabilitation activities deemed appropriate for each RA or IA.

RAs 5 and 6 include maintenance areas of existing rehabilitation as outlined in Section 3.1.2 of this document and includes the South Pit, ROM Pad, village infrastructure and TSF Cell A.

RA7 represents the extent of authorised disturbance demarcated by the EA and includes other intermittent surface disturbance types associated with mining operations, such as minor laydown areas, exploration, borrow pits, or residual topsoil stockpile areas that will not be retained by the landholder.

RA8 includes water storages that will be cleaned and retained; being the Mine Water Dam and the Water Storage Dam.

RA9 includes infrastructure that is subject to a landholder agreement and is to be retained post-closure.

It is important to note that the remaining surface area within the MLs will remain undisturbed for the duration of this PRCP. As such, no RA is defined for this area and the existing land use (Rural Zone as per the Whitsunday Regional Council Planning Scheme) will be retained post-closure.

Table 15: Nominated rehabilitation and improvement areas

Rehabilitation Area (RA) / Improvement Area (IA)	Description	Associated approved PMLU / NUMA
Rehabilitation Areas		
RA1	TSF Cell B	Open pasture - grazing
RA2	Heap Leach Pad and associated ponds	Low Hill – pasture grazing
RA3	Rehabilitated water management structures	Open pasture - grazing
RA4	Infrastructure areas	Open pasture - grazing
RA5	Maintenance of existing rehabilitation (South Pit, TSF Cell A, village infrastructure)	Open pasture - grazing
RA6	ROM Pad	Low Hill – pasture grazing
RA7	Other isolated areas of surface disturbance within approved disturbance extent	Open pasture - grazing
RA8	Retained water storages	Retained water storage
RA9	Retained infrastructure	Retained infrastructure
Improvement Areas		
IA1	Main Pit Final Void	Lake (None Use Management Area)
IA2	East Hill Pit Final Void	Void (None Use Management Area)

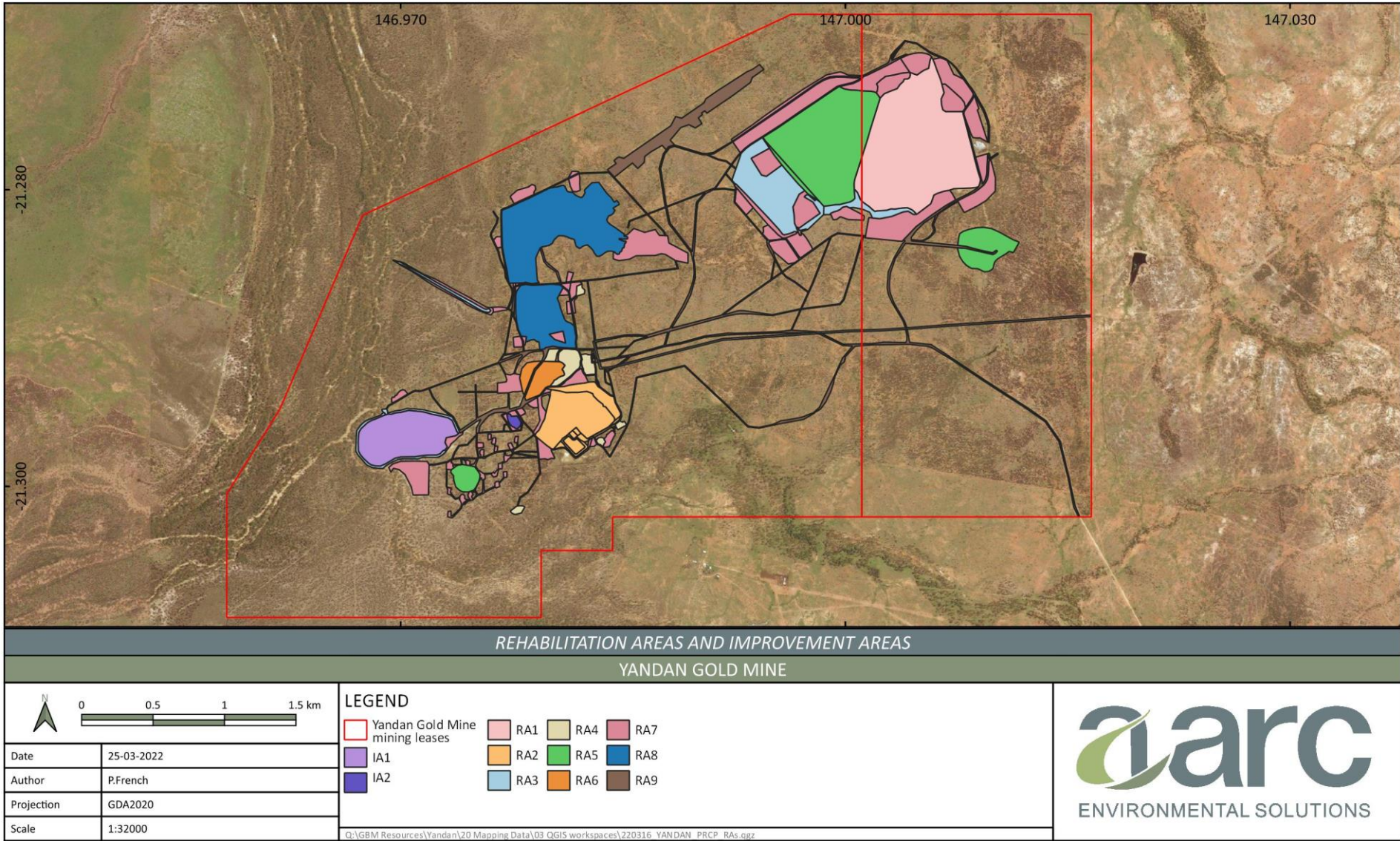


Figure 24: Rehabilitation and improvement areas nominated for Yandan

3.5.3 Rehabilitation milestones

The nominated rehabilitation milestones considered relevant to the Project are outlined in Table 18. Not all rehabilitation milestones are applicable to all RAs. The applicability of rehabilitation milestones to the various RAs is also shown in Table 18.

Table 16: Milestones and their applicability to rehabilitation areas

Milestone reference	Description	Applicability								
		RA1 TSF Cell B	RA2 Heap Leach Pad and associated ponds	RA3 Rehabilitated water management structures	RA4 Infrastructure areas	RA5 Maintenance of existing rehabilitation (South Pit, TSF Cell A, Village infrastructure)	RA6 Maintenance of existing rehabilitation (ROM Pad)	RA7 Other isolated areas of surface disturbance within approved disturbance extent	RA8 Retained water storages	RA9 Retained infrastructure
RM1	Infrastructure decommissioning and removal	√	√	√	√	√	√	√	√	√
RM2	Remediation of contaminated land (where required)	√	√		√					
RM3	Landform development of infrastructure areas				√	√		√		
RM4	Landform development of rehabilitated water management structures			√						
RM5	Landform development of TSF Cell B	√								

Milestone reference	Description	Applicability								
		RA1 TSF Cell B	RA2 Heap Leach Pad and associated ponds	RA3 Rehabilitated water management structures	RA4 Infrastructure areas	RA5 Maintenance of existing rehabilitation (South Pit, TSF Cell A, Village infrastructure)	RA6 Maintenance of existing rehabilitation (ROM Pad)	RA7 Other isolated areas of surface disturbance within approved disturbance extent	RA8 Retained water storages	RA9 Retained infrastructure
RM6	Landform development of Heap Leach Pad		√							
RM7	Surface preparation	√	√	√	√	√		√		
RM8	Revegetation	√	√	√	√	√		√		
RM9	Achievement of surface requirements (open pasture – grazing and low hill – pasture grazing)	√	√	√	√	√	√	√		
RM10	Achievement of target post mining land use (open pasture – grazing and Low hill – pasture grazing)	√	√	√	√	√	√	√		

Milestone reference	Description	Applicability								
		RA1 TSF Cell B	RA2 Heap Leach Pad and associated ponds	RA3 Rehabilitated water management structures	RA4 Infrastructure areas	RA5 Maintenance of existing rehabilitation (South Pit, TSF Cell A, Village infrastructure)	RA6 Maintenance of existing rehabilitation (ROM Pad)	RA7 Other isolated areas of surface disturbance within approved disturbance extent	RA8 Retained water storages	RA9 Retained infrastructure
RM11	Achievement of target post-mining land use (retained water storages)								✓	
RM12	Achievement of target post-mining land use (retained infrastructure)									✓

3.5.4 Management milestones

The nominated management milestones for NUMAs in the final landform are outlined in Table 15. All the management milestones are applicable to both IAs.

Table 17: Milestones and their applicability to improvement areas

Milestone reference	Description	Applicability	
		IA1	IA1
MM1	Achievement of final landform design	√	√
MM2	Achievement of surface and safety requirements	√	√
MM3	Achievement of sufficient improvement	√	√

3.5.5 Milestone criteria and completion criteria

Key to assessing the success of rehabilitation and improvement is the definition of milestone criteria. Milestone criteria are preferably specific, measurable, achievable, realistic and timely. They should:

- be outcome-based (linked to the end land use);
- be flexible to adapt to changing circumstances;
- be able to evolve as the mine life progresses;
- include metrics suitable to demonstrate that rehabilitation is trending positively; and
- undergo periodic review,

The rehabilitation milestones (RMs) and management milestones (MMs) nominated for the RAs and IAs of the Project are provided below in Table 18 and Table 19. These will be used to track rehabilitation progress and the final rehabilitation outcome of each RM and MM.

Table 18: Rehabilitation Milestone criteria

Rehabilitation milestone	Applicable rehabilitation areas	Milestone criteria
RM1 - Infrastructure decommissioning and removal	All	a) All non-required services disconnected and removed. b) All non-required concrete and gravel removed. c) All non-required operational pipelines drained and removed. d) All fencing that is not part of PMLU requirements removed. e) All buildings and footings demolished and/or removed off-site. f) All machinery and equipment removed. g) All non-retained surface water drainage infrastructure removed. h) All rubbish removed.
RM2 - Remediation of contaminated land (where required)	RA1, RA2, RA4	a) Contaminated material either remediated in-situ or removed/transported to an approved landfill for disposal and waste tracking information recorded and submitted. b) Contaminated land assessment undertaken by an appropriately qualified person ¹ indicates that no contamination unsuitable for the post mining land use is occurring. If required, a site investigation report including a site suitability statement prepared and submitted in accordance with the provisions of Chapter 7, Part 8 of the EP Act.
RM3 - Landform development of infrastructure areas	RA4, RA7, RA5	a) All bulk earthworks completed. b) Geotechnical assessment by an appropriately qualified person ¹ confirming that long-term geotechnical stability has been achieved for each relevant landform. c) Final landform slopes meet design specifications: i. TSF Cell A embankments – i. Maximum slope of 30% subject to geotechnical and erosional stable conditions.
RM4 - Landform development of rehabilitated water management structures	RA3	General: a) All earthworks completed. b) Water drainage lines reinstated and stabilised to allow natural flow. Dams: a) Sediment dams cleaned (desilted). b) Where landform incorporates slopes > 17%, geotechnical assessment by an appropriately qualified person ¹ confirming that long-term geotechnical stability has been achieved. Main Pit water management bund: a) Design plan certified by an appropriately qualified person ¹ is developed for the final landform. Design plan demonstrates that modification of the levee does not result in potential environmental harm. b) Assessment by an appropriately qualified person to confirm the post-closure regulated status of the water management bunding structure. c) All earthworks completed as per the approved design plan. d) Assessment by an appropriately qualified person ¹ confirming that long-term geotechnical stability has been achieved.

Rehabilitation milestone	Applicable rehabilitation areas	Milestone criteria
RM5 - Landform development of TSF Cell B	RA1	a) All bulk earthworks completed. b) Cover system is installed with the appropriate QA/QC measures to: i. Compact tailings surface to form a low permeability layer; ii. Cover tailings with at least 1.0 m of top rock, followed by 0.15 m of growth media. c) Assessment by an appropriately qualified person¹ confirming that long-term geotechnical stability has been achieved. d) An assessment by an appropriately qualified person of groundwater monitoring data (collected in accordance with monitoring and maintenance program), confirms cover system is functioning as designed and risk of environmental harm is mitigated.
RM6 - Landform development of Heap Leach Pad	RA2	a) All bulk earthworks completed. b) Cover system is installed with the appropriate QA/QC measures to: a. comprise at least 0.5 m of top rock, followed by 0.15 m of growth media. c) Final slopes meet design specifications: ii. Maximum slope of 25 % subject to geotechnical and erosional stable conditions. d) Assessment by an appropriately qualified person¹ confirming that long-term geotechnical stability has been achieved. e) An assessment by an appropriately qualified person of groundwater monitoring data (collected in accordance with monitoring and maintenance program), confirms cover system is functioning as designed and risk of environmental harm is mitigated.
RM7 - Surface preparation	RA1, RA2, RA3, RA4, RA5, RA6, RA7	a) Ripping of soil profile /subsoil profile along the contour of any slope to a depth of at least 200 mm. b) Prior to seeding, assessment of soil health and suitability for target vegetation establishment undertaken by an appropriately qualified person¹ and a recommendation made for ameliorants suitable to achieve the post-mining land use revegetation program. c) Ameliorants applied and incorporated into subsoil and/or topsoil if required, as per recommendations of the soil health and suitability assessment.
RM8 - Revegetation	RA1, RA2, RA3, RA4, RA5, RA6, RA7	a) Seeding of target key species completed at a sowing rate of 6 kg/ha drawn from Table 23 Recommended species for revegetation (Yandan Gold Mine Transitional PRCP). b) No later than 12 months from planting, a >50% survival rate for any given perennial species is achieved.
RM9 - Achievement of surface requirements (open pasture – grazing and low hill – pasture grazing)	RA1, RA2, RA3, RA4, RA5, RA6, RA7	a) Total percentage of vegetation groundcover² is not significantly lower ($P < 0.05$) than that recorded at reference sites. b) Species diversity is not significantly lower ($P < 0.05$) than that recorded at reference sites. c) Species composition not significantly different ($P < 0.05$) to reference sites. d) Total percentage of weed groundcover is not significantly higher ($P < 0.05$) than reference sites. e) Erosion classification³ (per the Rehabilitation Monitoring Program methodology) to be comparable with erosion classifications from reference sites.

Rehabilitation milestone	Applicable rehabilitation areas	Milestone criteria
RM10 - Achievement of target post mining land use (open pasture – grazing and Low hill – pasture grazing)	RA1, RA2, RA3, RA4, RA5, RA6, RA7	a) Land suitability assessment by an appropriately qualified person¹ confirming land has achieved a post-mine land suitability⁴ of a. 4 for low intensity grazing, or b. 5 for low intensity grazing, supported by an appropriate management regime. b) Demonstration within the final rehabilitation report that vegetation groundcover², species diversity and species composition in rehabilitation areas is not significantly lower ($P < 0.05$) than reference sites for a minimum of three consecutive years. c) Demonstration within the final rehabilitation report that total percentage of weed groundcover in rehabilitation areas is not significantly higher ($P < 0.05$) than reference sites for a minimum of three consecutive years. d) Evidence of recruitment from rehabilitation monitoring data. e) Erosion classification³ (per the Rehabilitation Monitoring Program methodology) to be comparable with erosion classifications from reference sites for a minimum of three consecutive years. f) Written agreement obtained from the land owner/holder and administering authority that rehabilitation is successful. g) Hazard and Safety Assessment completed by an appropriately qualified person¹ demonstrates that hazards in rehabilitation areas are of a similar type and not significantly different to hazards in reference sites.
RM11 - Achievement of target post-mining land use (retained water storages)	RA8	a) Assessment by an appropriately qualified person confirms the structure is not regulated. b) All retained water storages to be assessed and approved as safe and stable by an appropriately¹ qualified person. c) Hazard and Safety Assessment completed by an appropriately qualified person¹ demonstrates that hazards in retained water storages are of a similar type and not significantly different to hazards in neighbouring unmined water storages subject to similar use d) Retained storage water quality parameters to be below the trigger values for livestock drinking water defined in Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 3 Primary Industries — Rationale and Background Information (ANZECC and ARMCANZ 2000).
RM12 - Achievement of target post-mining land use (retained infrastructure)	RA9	a) Final landform survey confirms no built structures remain other than those that form part of a landholder agreement. b) All retained structures and landforms assessed and approved as safe and stable by an appropriately qualified person¹.

Table 19: Management milestone criteria

Management milestone	Applicable improvement areas	Milestone criteria
MM1 - Achievement of final landform design	IA1, IA2	a) Final void high walls comply with maximum safe and stable slope angles as nominated in geotechnical stability assessment.
MM2 - Achievement of surface requirements	IA1, IA2	a) Standard barbed wire fencing erected around the perimeter of the residual void to prevent access by humans and fauna. b) Warning signage posted every 100 m around the perimeter of the residual void. c) Safety bund constructed around perimeter of the residual void.
MM3 - Achievement of sufficient improvement	IA1, IA2	a) Assessment by an appropriately qualified person ¹ that the residual void will not cause environmental harm outside of the relevant tenure boundary. b) Assessment by an appropriately qualified person that the water quality and/or level in the void will not cause environmental harm to the surrounding environment: i. Main Pit – water balance modelling confirms that long-term pit water depth will remain greater than 160 m AHD for the maintenance of a permanent water cover over sulphide material in the pit walls and floor. ii. East Hill Pit - water balance modelling confirms that long-term pit water depth will remain above the sandstone unit within the pit for the prevention of potential groundwater contamination.

Footnotes:

1. *Appropriately qualified person* means a person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relating to the subject matter using the relevant protocols, standards, methods, or literature.

2. *Vegetation groundcover* incorporates native pasture grass species, exotic pasture grass species, non-pasture grass species, shrubs (woody plant multi-stemmed at base or, if single stemmed, <2 m tall), forbs and other non-grass species.

3. Erosion classification framework:

Erosion classifications	Minor	Moderate	Severe	Extreme
No. of rills / gullies	< 15	15-30	31-50	>50
Average depth (cm)	< 10	10 - 30	30-60	>60

4. Department of Science, Information Technology and Innovation and Department of Natural Resources and Mines (2015) *Guidelines for Agricultural Land Evaluation in Queensland* (Second Edition), State of Queensland or later version. (<https://www.publications.qld.gov.au/dataset/qld-agricultural-land-evaluation-guidelines/resource/d6591386-08e2-453f-a6fa-dff2a756215f>)

3.5.6 Rehabilitation timeframes

The nominated rehabilitation timeframes considered for scheduling the rehabilitation and management milestones are shown in Table 20 and Table 21.

Table 20: Rehabilitation milestones timeframe

Milestone Timeframe	Summary rehabilitation methodology	Associated risks	Risk level assigned	Typical time frame (years)	Justification for assigned timeframe
Available for rehab → Landform Development (RM1, RM2, RM3, RM4, RM5, RM6)	- Infrastructure decommissioning and removal. - Remediation of contaminated land, as required. - Bulk earthworks reshaping. - Water drainage lines reinstated and stabilised to allow natural flow (RM4). - Sediment removal from dams (RM4). - Development of design plan for Main Pit water management bund (RM4). - Installation of cover system designs for the TSF Cell B (RM5) and the Heap Leach Pad (RM6). - Geotechnical assessment confirming long-term geotechnical stability. - Hydrogeological assessment, as required.	- Surface roughness (rockiness, depressions) in excess of that expected for the PMLU - Significant slope failure. - Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas. - Identification and management of contaminated land.	Moderate	2 - 6	Bulk earthworks and installation of drainage features are to be completed according to rehabilitation design specifications, including assessment as geotechnically stable by a suitably qualified person. Given the relatively large scale of RA1 and RA2, the timeframe assigned to these RAs is 5 and 6 years, respectively. An additional year for RA2 is proposed as some coarse rock from RA2 may be used for RA1. For smaller RAs, a timeframe of 2 years has been proposed, with 3 years where remediation of contaminated land (RM2) is potentially required.

Milestone Timeframe	Summary rehabilitation methodology	Associated risks	Risk level assigned	Typical time frame (years)	Justification for assigned timeframe
Landform development (RM3, RM4, RM5, RM6) → Surface preparation (RM7)	- Ripping of soil profile/subsoil - Soil health and suitability assessment - As required, application of ameliorants to subsoil and topsoil.	- Erodible topsoils and subsoils not able to be rectified with amelioration. - Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Moderate	1	Soil health and suitability assessment, amelioration and prompt vegetation establishment are key processes to minimise the identified risks. Given the moderate scale of the RAs and the low risk associated with the activity itself, the timeframe assigned is 1 year.
Surface preparation (RM7) → Revegetation (RM8)	Seeding of target key species completed at specified sowing rates (refer Section 3.5.5)	Failure to meet seeding rate of key target species.	Low	1	The seeding of key target species has been assigned a low level risk. Rates of seeding and seeding species are specified in Section 3.5.14. A typical time frame of 1 year has been assigned.
Revegetation (RM8) → Achievement of surface requirements (RM9)	Revegetated areas to be assessed against ground cover and stability related completion criteria (refer Section 3.5.5).	- Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (Moderate to Significant) - Erodible topsoils and subsoil; - Excessive rainfall, droughts or fire events that may directly affect groundcover establishment; and - pests and weeds.	Moderate	10	Achievement of target revegetation criteria is dependent on good climatic conditions soil preparation. The timeframe assigned considers the time necessary for establishment of mature, self-sustaining vegetation (i.e., multiple seasons of successful recruitment) and the various risks identified. Allowance is made for poor growing seasons and extreme events such as droughts or storms that will negatively impact vegetation establishment, and consequent maintenance actions that may be required. Given these factors and the moderate risk classification, the timeframe assigned is 10 years.

Milestone Timeframe	Summary rehabilitation methodology	Associated risks	Risk level assigned	Typical time frame (years)	Justification for assigned timeframe
Achievement of surface requirements (RM9) → Achievement of target post mining land use (RM10)	Revegetated areas to be assessed against all completion criteria developed with reference to analogue sites of similar characteristics and land use (refer Section 3.5.5).	- Ongoing gully, pipe and/or sheet erosion of rehabilitated areas - Water quality in retained storages not meeting PMLU water quality requirements (Low) - Insufficient pasture productivity or density/diversity of vegetation in native PMLUs - Pests and weeds	Moderate	10	Achievement of a sustainable and non-polluting target PMLU is dependent on establishment of mature, self-sustaining vegetation demonstrated through multiple seasons and evidence of successful recruitment. As the target PMLU has not yet been achieved, allowance is provided for uncertainty associated with any required maintenance activities, the likelihood of natural hazard events such as fires or severe storms, and challenges associated with pest/weed control. Given these factors and the moderate risk classification, the timeframe assigned is 10 years.

Table 21: Management milestones timeframe

Milestone Timeframe	Summary of completion criteria	Associated risks	Risk level assigned	Typical time frame (years)	Justification for assigned timeframe
Available for rehab → Achievement of final landform design (MM1) and achievement of surface and safety requirements (MM2)	MM1 - Final void high walls comply with maximum safe and stable slope angles as nominated in geotechnical stability assessment. MM2 - Safety infrastructure established around the void, including the following: - Adequate bunding in place; and - Perimeter fencing and signage erected to prevent access to fauna and humans.	- Slope failure; and - Inundation by floodwaters, rising pit water levels.	Moderate	6	For both residual voids, the process for creating the stable final void landform will require alignment with nominated geotechnical specifications regarding safe highwall design other mitigation strategies such as the establishment of catch benches and buttressing, as to be identified by a geotechnical assessment. Safety infrastructure will be installed around both residual voids. It is estimated it will require a timeframe of 5 years post-mining before a safe and final landform surface design is achieved.
achievement of final landform design (MM1) and achievement of surface and safety requirements (MM2) → Achievement of sufficient improvement (MM3)	- Assessment to confirm the residual void will not cause environmental harm outside of the relevant tenure boundary. - Hydrogeological assessment to confirm that pit water quality and/or level will not cause environmental harm to surrounding environment.	- Significant slope failure; - Potential groundwater quality impacts; - Localised land impact and downstream water quality impacts; - Potential erosion of residual void walls and spillways.	Moderate	10	Ten years has been assigned to provide sufficient time to monitor water quality, water level and slope stability to comply with final landform design. Furthermore, it allows for extreme rainfall events that may affect groundwater flow to the pits and potentially impact the groundwater quality.

3.5.7 General rehabilitation practice

The rehabilitation practices used at any mining site inevitably evolve as a result of increasing knowledge gained from experience in the following areas:

- early rehabilitation successes and failures;
- weather, subsoils, soils, local flora and fauna and revegetation species; and
- site preparation, seeding practices, the maintenance and repair of previously rehabilitated areas and/or local agricultural practices.

For this reason, the rehabilitation practices outlined in the following subsections should not be interpreted as the precise method that will be used from this point on, but rather as a record of the current rehabilitation knowledge and intent at the time of writing; and with the expectation that rehabilitation practices will further evolve and develop from this point on. A record of the existing rehabilitation efforts at site is provided at section 3.1.2.

While rehabilitation objectives, performance indicators and completion criteria for the Project are detailed at sections 3.5.1 and 3.5.2, from the perspective of operational rehabilitation planning and practice, the following overarching principles are considered key:

- Ensuring that reshaped areas proposed for rehabilitation meet the required landform design principles, that prepared areas meet the rehabilitation design specification for the area, and that local site drainage has been considered and surrounding areas graded to mitigate any rainfall runoff from adjacent areas to run-on to prepared RAs.
- Topdressing materials, final surface preparation methods and soil amelioration activities have the objective of supporting vegetative growth.
- Revegetation species selection, seeding and/or planting methods, and fertiliser applications target rapid vegetative ground cover effective at mitigating soil erosion, during the period of initial revegetation when areas are most at risk.
- Ongoing monitoring and maintenance are used both to assess rehabilitated area performance against completion criteria as well as to feedback to, and update rehabilitation practices; and to identify maintenance or modification requirements such that RAs are proceeding along a trajectory towards the designated PMLU.

There will be circumstances when rehabilitation practices outside of those discussed within this PRCP are utilised. For example, discrete areas of steeper slopes, rehabilitation failures or other scenarios that may necessitate more intensive rehabilitation practices. These circumstances will be identified, assessed and rehabilitation activities planned for as required.

3.5.8 Hydrogeology

Hydrogeological units within the Project area are described in Section 3.1.6. Four water bearing formations are considered to be aquifers, namely:

- 4) east of the mining area – low to very low permeability siltstones, sandstones and metamorphics, with limited groundwater occurrence;
- 5) through the central mining area, a limited extent fracture hosted aquifer associated with the Yandan Fault;
- 6) west of the Yandan Fault in the mineralised zone; a porous unit associated with mineralisation and is likely the boiling zone of the epithermal system; and
- 7) an alluvial aquifer as part of the Suttor River alluvium; reaching up to 30m depth.

Pumping tests as part of impact studies for the Project around Main Pit encountered groundwater flow boundaries and identified two possible groundwater sources: either the Yandan Fault, or a porous 'boiling zone' alteration horizon formed as part of hydrothermal activity (Forbes 1988, SBE 2022).

Hydraulic assessments suggest groundwater transmissivities in the order of 60–200 m²/day, with no connectivity identified between these groundwaters and the alluvial aquifers associated with the Suttor River (SBE 2022). Like many ephemeral drainage systems, the Suttor River is likely to be a losing river system, where water recharges into alluvial aquifers rather than being permanently groundwater fed (SBE 2022).

Inside the fault boundaries the lithologies of Main Pit and East Hill Pit are comprised of altered andesite and sinter, with shears and silicified veining hosting the mineralisation (SBE 2022). Oxidised zones in the geology will likely be more porous/conductive than fresh, crystalline rock, and there is likely a change in hydraulic conductivity between the types of materials that is expected to be depth and fault dependent (SBE 2022). The conductivity of crystalline rock is low given the lack of porosity, which suggests much of the transmissivity observed in early pumping tests is primarily through the boiling zone unit, or alternatively, that the fault can potentially deliver reasonable groundwater flow volumes (SBE 2022).

It is considered unlikely that groundwater flow within the Project is via other pathways, given the low conductivity of crystalline rocks (SBE 2022). Guidance published on the typical conductivity of crystalline rock units indicates very low hydraulic conductivity, as per Figure 25 below. As such, it is considered that groundwater flow within the Project is mainly via faults and the boiling zone unit (SBE 2022), with groundwater flow generally described as flowing from east to west with topography (Forbes 1988) (Figure 26).

Crystalline Rocks	
Material	Hydraulic Conductivity (m/sec)
Permeable basalt	4×10^{-7} to 2×10^{-2}
Fractured igneous and metamorphic rock	8×10^{-9} to 3×10^{-4}
Weathered granite	3.3×10^{-6} to 5.2×10^{-5}
Weathered gabbro	5.5×10^{-7} to 3.8×10^{-6}
Basalt	2×10^{-11} to 4.2×10^{-7}
Unfractured igneous and metamorphic rock	3×10^{-14} to 2×10^{-10}

Figure 25: Typical conductivity values of crystalline rocks (Domenico & Schwartz 1990)

Groundwater recharge and discharge

Due to low groundwater transmissivity within the Project area, recharge to the groundwater system is limited, accounting for the poor quality of the groundwater (Forbes 1988).

It is considered that Main Pit is likely connected with groundwater, with groundwater inflows to the pit rather than outflows (SBE 2022). It is likely that groundwater connectivity occurs at about current pit water levels, supporting the apparent consistency in pit water level (SBE 2022).

Groundwater and pit water level data for East Hill Pit is acknowledged to be limited for the determination of groundwater interactions with this system (SBE 2022). Observations are that pit water levels are consistently low, with water quality data indicating deteriorating water quality in the pit over time in response to a combination of exposed sulphides, limited inflows and evaporation effects (SBE 2022).

Preliminary reviews of the East Hill Pit system suggest a potential hydraulic link between Main Pit and East Hill Pit, acknowledging however that present data to support this is very limited (SBE 2022). It is considered that any potential hydraulic connectivity between the two pits would be via a bounding fault connection, noting that there would be limited impacts outside of any potential structural link given the low conductivity of the crystalline rock units (SBE 2022). As such, there is potential for groundwater leakage from East Hill Pit via this fracture line, but groundwater flow would be limited and likely towards Main Pit (SBE 2022).

The risk of groundwater discharge out of the voids is considered low as a result of the following (SBE 2022):

- Main Pit is likely a gaining pit with the lowest groundwater level in the landscape, and therefore will act as a groundwater sink, with groundwater flow into the void.
- East Hill Pit is either hydraulically separate or with limited connectivity to Main Pit. If hydraulic connection is present, groundwater will only flow towards Main Pit when the hydraulic gradient allows this (i.e. East Hill Pit water level would need to have greater elevation than Main Pit). In this scenario, groundwater contributions from East Hill Pit would be relatively small, with significant dilution achieved in the much larger volume of Main Pit (noting this is an order of magnitude greater even at full supply level).
- No known connection with alluvial aquifers is present.

Conceptual models for Main Pit and East Hill Pit groundwater interactions are provided within Figure 27 and Figure 28.

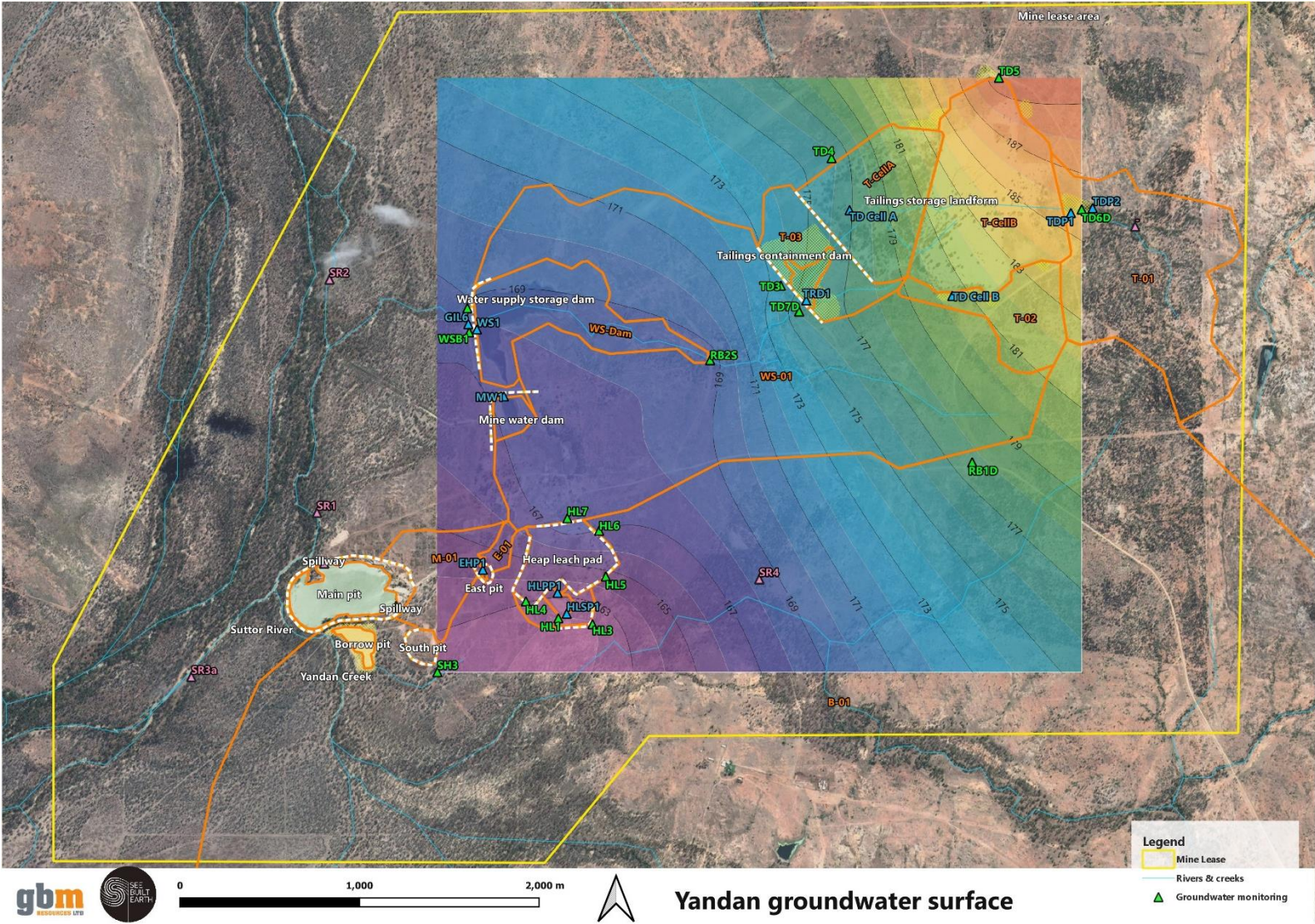


Figure 26: Groundwater surface (SBE 2022)

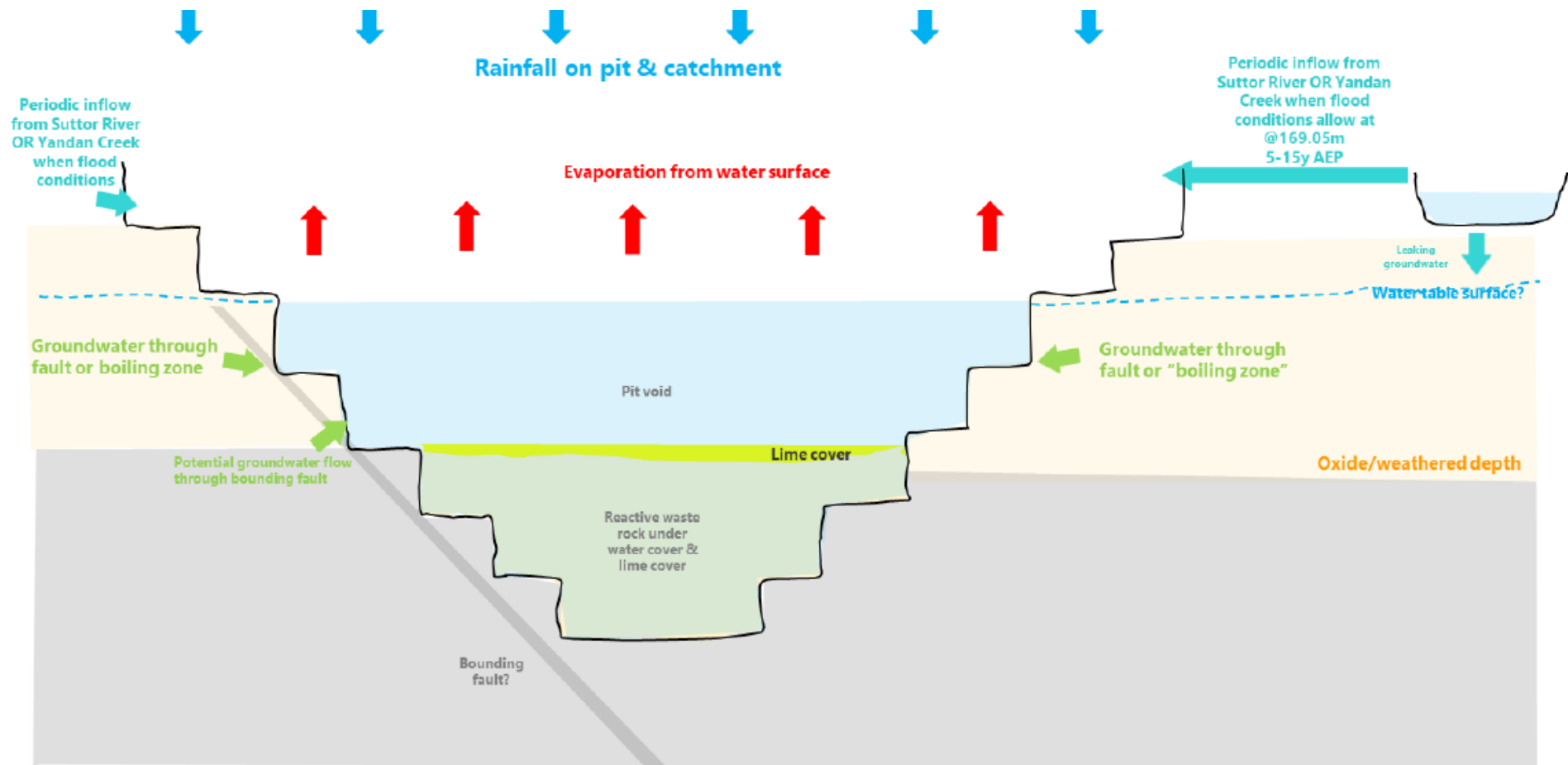


Figure 27: Conceptual model for Main Pit

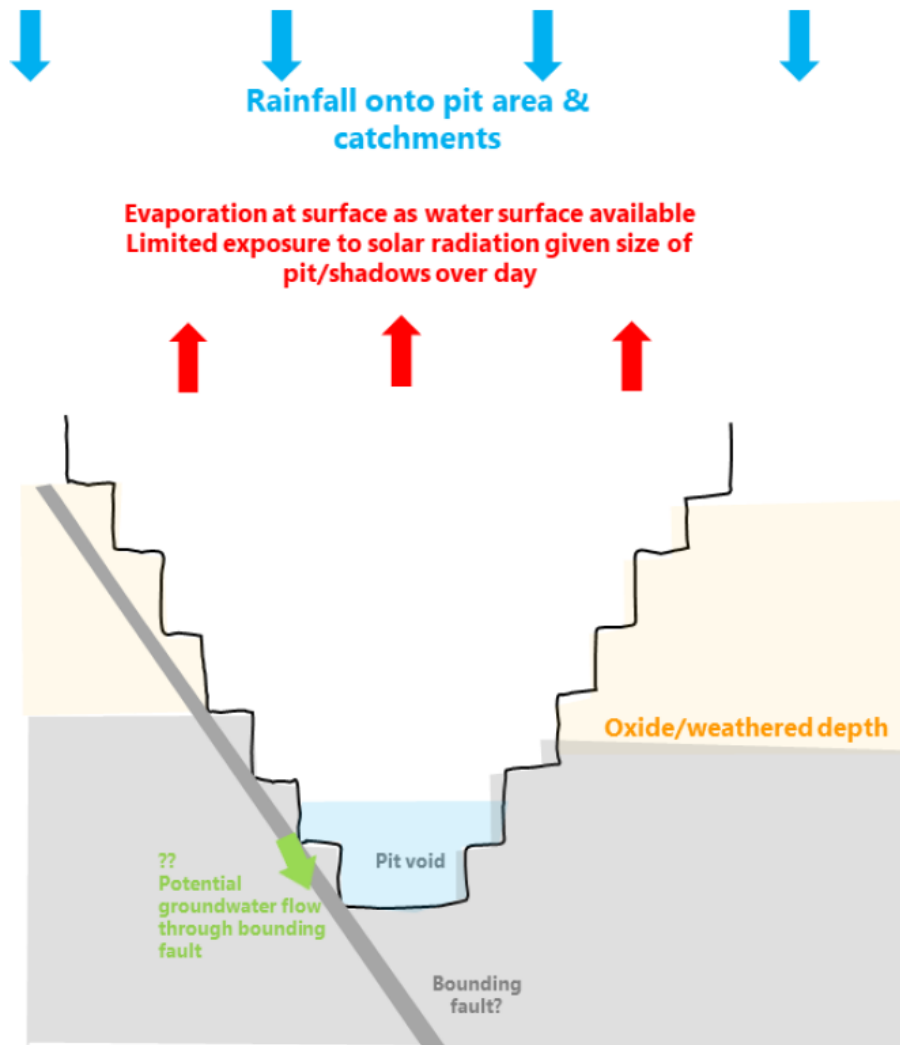


Figure 28: East Hill Pit conceptual model (SBE 2022)

3.5.9 Flooding

The Suttor River flows within the western boundary of the Yandan MLs, with this joined by the minor tributaries of Sandy Creek and Yandan Creek which traverse the Project area. A flood assessment was completed by See Built Earth (SBE) in 2022 to assess the Project's susceptibility and influence to flooding (SBE 2022).

Flood extents for the Project were assessed based on a regional assessment of a 1% annual exceedance probability (AEP) event and a probable maximum flood (PMF) event (SBE 2022). Flood contours for a 1% AEP event and PMF event have been calculated at 179 mAHD and 187 mAHD, respectively (DoR 2021). Flood extent modelling is provided in Figure 29 and Figure 30.

On the basis of a 1% AEP flood event, the western part of the Project area is susceptible to flooding, including Main Pit and the water storage dams (Water Storage Dam and Mine Water Dam). The Yandan Tailings Dam, Heap Leach Pad and East Hill Pit are situated above the 1% AEP event (SBE 2022).

A PMF event was calculated using the Generalised Short Duration Method (SBE 2022). The PMF event represents an extreme rainfall event equivalent to 1,233 mm in six hours. In the instance of a PMF event, the flood extent within the tenements moves further to the east. The Yandan Tailings Dam would remain above the PMF flood extent.

There is potential for partial flooding through the base of the Heap Leach Pad during a PMF event. On the basis of available flood modelling data, it is expected that the level of inundation for the Heap Leach Pad during a PMF event would be between 0–1 m (SBE 2022). Similarly, there is potential for floodwaters to egress East Hill Pit from the north during a PMF event, where the lowest point in the landform lies. It is noted that floodwaters during a PMF event are not expected to flow into the pit from other directions (i.e., floodwaters would not rise sufficiently up gradient to flow into East Hill Pit).

Consideration to final landform designs to mitigate flooding risk is provided in Section 3.5.13.

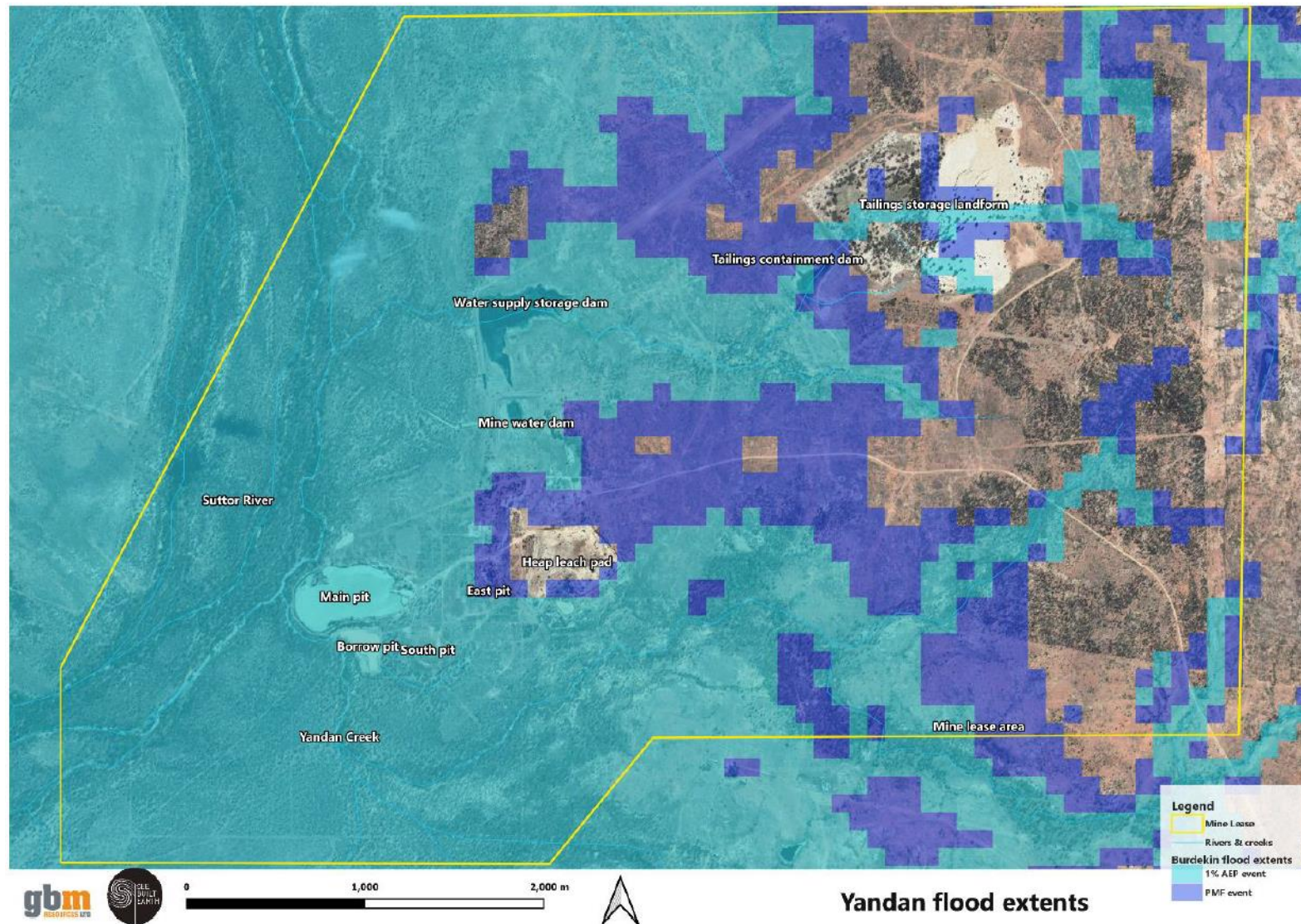


Figure 29: Yandan flood extent – 1% AEP and PMF events (SBE 2022)

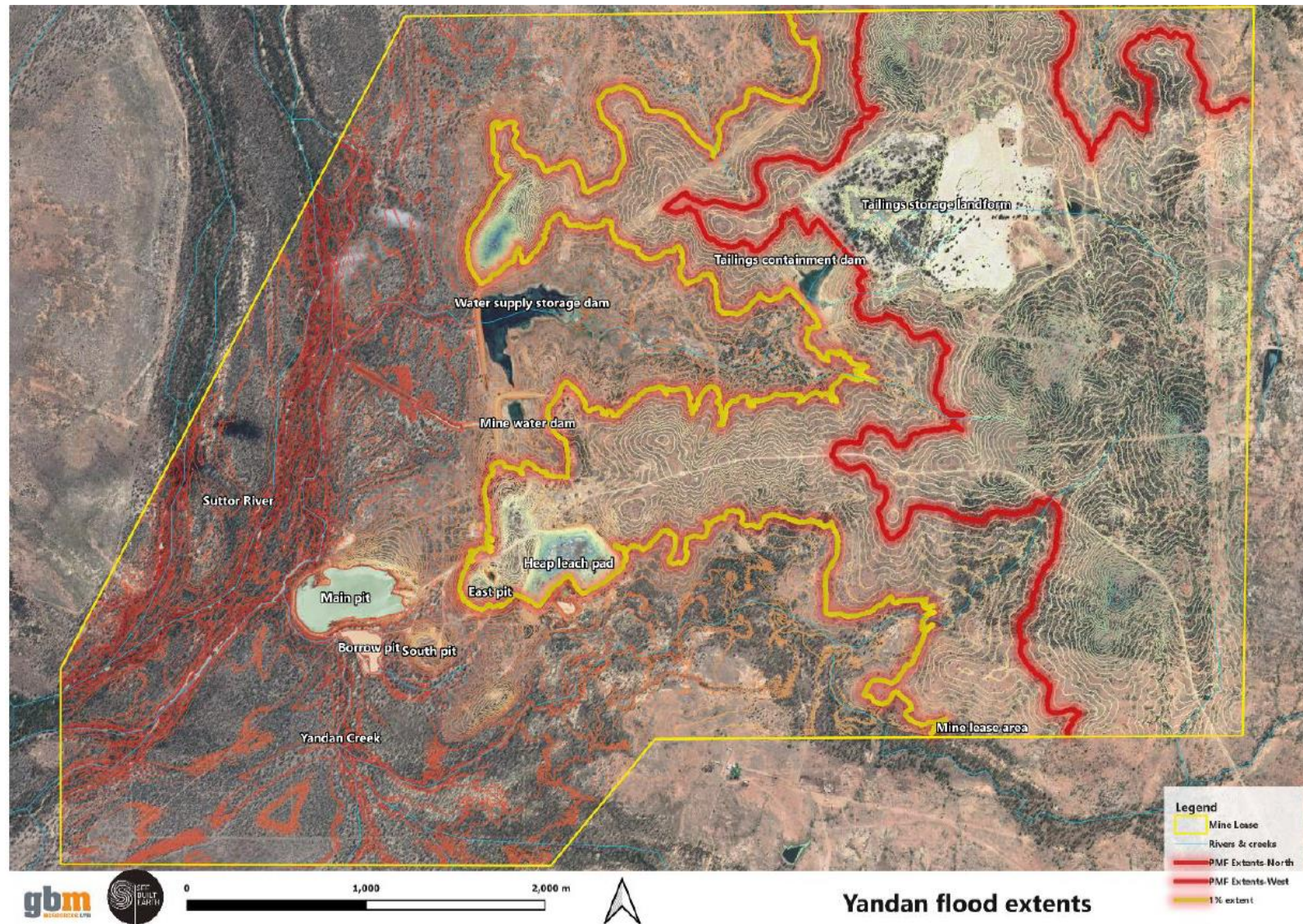


Figure 30: Yandan flood boundaries— 1% AEP and PMF events (SBE 2022)

Direct connectivity between Main Pit waters and the Suttor River is established if the Suttor River reaches a sufficient height (SBE 2022), with two spillways permitting inflows and outflows with the Suttor River as part of the ‘flushing pit’ design. River inflows to Main Pit are established when the height of the Suttor River reaches 3.8 m, or when flow elevation is established at 169.05 mAHD at Yandan (SBE 2022).

River height records for the Project are inferred from the St Ann’s gauging station, located downstream from the Project on the Suttor River. Based on a river height records, connectivity between Main Pit and the Suttor River has occurred six times since the establishment of the flushing pit design (i.e. in 2001, 2003, 2004, 2007 and 2011) (SBE 2022).



Figure 31: Main Pit inflows during flooding of the Suttor River in February 2000

3.5.10 Soil and capping material assessment

3.5.10.1 Available rehabilitation materials

Estimates of available rehabilitation materials (including topsoil, growth medium and clay) are available from material volume assessments completed as part of the 2022 SLISA soil survey (AARC 2022a), and as part of the material characterisation work completed by O’Kane Consultants (2019) for the Cell B cover system design assessment. Estimated volumes of rehabilitation materials are detailed in Table 22, with locations shown in Figure 32.

Table 22: Estimated rehabilitation materials available and required

Material type	Source	Estimated maximum volume (m ³) of material available
Clay	HL Pond Embankment (clay core) ¹	2,430

Material type	Source	Estimated maximum volume (m ³) of material available
	Upstream of MWD (clay borrow)	8,000
	Upstream of Water Storage Dam (clay borrow)	380,000
Topsoil	Topsoil (borrows north and south of the TWRD)	80,000
	HLP topsoil stockpile #1	22,000
	HLP topsoil stockpile #2	9,400
	Floodplain Borrow Pit	11,150
	North WSD topsoil stockpile	12,000
	Gravelly topsoil (around the TSF and TWRD)	60,000
	Borrow pits	593,500
Growth medium (including coarse rock)	Gravel / coarse rock (around the TSF and TWRD)	510,000
	Coarse rock from Heap Leach Pad ²	480,000
Dam embankment material (combined)	Mine Water Dam embankment	83,200
	Water Storage Dam embankment	28,200
	Water Harvest Trench embankments	58,500
	Tailings Water Return Dam embankment	104,500
	HL Pond Embankment ¹	1,800

¹ HL Pond Embankment was constructed using two materials which has been taken into account for the volume calculation. The HL Pond embankment consists of a 3 m width and 3 m high clay core (for the entire length of the embankment) in addition to being capped with dam embankment material (combined).

² Physical properties of the Heap Leach Pad material indicate the material is suitable for use as coarse rock capillary break layers. Prior to any potential use, a QC/QA and testing program would need to be developed to confirm use of the material. Additional material from the Heap Leach Pad may be suitable for rehabilitation purposes, if required.

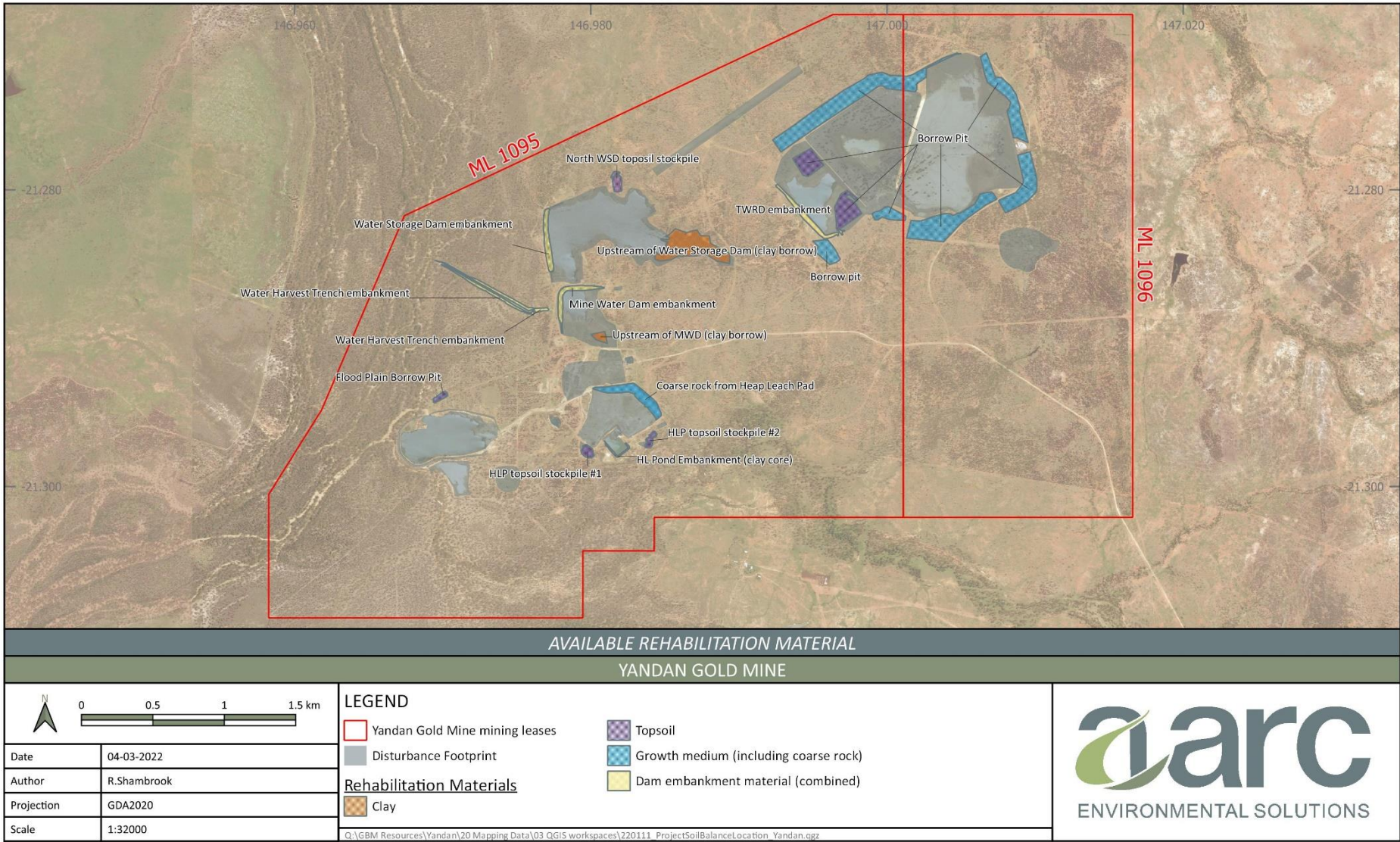


Figure 32: Available rehabilitation material on the Project

3.5.10.2 Quality of rehabilitation materials

Assessments of material suitability have been completed to determine topsoil fertility and the physical characteristics of other rehabilitation materials such as growth media and coarse rock (AARC 2022a, O’Kane Consultants 2019).

Plant growth and establishment may be significantly inhibited by unfavourable soil conditions. Parameters important for soil fertility include pH, electrical conductivity (i.e. salinity), nitrogen, phosphorus, potassium and sulphur. Assessing the suitability of materials to be used for rehabilitation is therefore an important step towards ensuring the establishment of vegetation and ultimately achieving successful rehabilitation.

The suitability of soil sources on the Project for rehabilitation is summarised as follows:

- Topsoil sources adjacent to Heap Leach Pad (AARC 2022a): soil analysis results show topsoil sources have suitable pH for plant growth, are non-saline and non-sodic. Soil fertility is considered adequate with high levels of plant available nitrogen (nitrate) and adequate levels of potassium and sulphur. The topsoil resource may benefit from phosphorus addition to improve soil fertility before application.
- Main Pit water management bund (AARC 2022a): soil resources were measured with low pH values, presenting the risk of aluminium toxicity to plant growth. Lime addition would benefit to raise pH into plant growth suitable range. EC and ESP values were low, indicating non-saline and non-sodic soils. Soil potassium and sulphur levels are considered adequate. Soil phosphorus concentrations are relatively high, with potential to cause toxic conditions to plant growth. However, nitrate levels are extremely low therefore requiring fertiliser addition to improve soil fertility before application.
- Various topsoil sources, including borrow pits on TWRD (O’Kane Consulting 2019): soil fertility testing confirmed acceptable fertility characteristics and grading of soils on-site. Some topsoil sources exhibited dispersive qualities and limited water holding capacities. However, it is considered that these materials may still be suitable for use as topsoil.

The suitability of other rehabilitation materials (growth media, clay, coarse rock) is also summarised as follows: (O’Kane Consulting 2019):

- Potential clay sources: materials from the embankment of the Heap Leach Pond embankment core, upstream of Mine Water Dam and upstream of the Water Storage Dam were found to have good consistency for constructing a barrier layer.
- Potential growth medium sources: the particle size of material located immediately north of Cell A confirms the suitability of this material as growth medium. Other suitable material adjacent to the TSF has been identified with positive permeability and fertility characteristics. One potential growth medium source displayed slight dispersive characteristics, however, given that growth medium will be located under a topsoil layer this property is not considered a concern.
- Potential coarse rock sources: material from the Heap Leach Pad and adjacent to Cell B found to be coarse, well-graded material suitable for use as a capillary break layer. Initial geochemical assessments of the heap leach rock material have indicated this material is geochemically benign and likely suitable for rehabilitation use (RGS 2013). RGS considered that this type of rock material should not present any significant risk to the environment with respect to total metal concentrations in solids and poses negligible risk of potential impact on the quality of surface and groundwater (2013). In addition, it is considered that the heap leach rock is unlikely to have structural stability problems related to potential dispersion and erosion (RGS 2013). Prior to any potential use, further QC/QA assessments and a testing program would be developed to further assess the use of the material.

Results from the material suitability assessment indicate that materials are generally suitable for use in rehabilitation activities and are able to support vegetation. Topsoil resources have generally proven to be fertile, with indications of erosion potential from some sources. Amelioration could therefore benefit some material sources to improve rehabilitation outcomes, with amelioration methods to be considered including fertiliser, lime and gypsum applications (AARC 2022a). The application of these ameliorants is discussed further

within the SLSA (AARC 2022a). Prior to use in rehabilitation, the suitability of materials and the requirement for any amelioration would be confirmed.

Topsoil sources on the Project have been confirmed to be fertile and generally well suited for vegetation growth and establishment. On the basis of the SLSA, it is anticipated that rehabilitated landforms will be able to support a PMLU of open pasture – grazing.

3.5.11 Tailings and processing facilities

Mining waste materials on the Project comprise the tailings stored in the Yandan Tailings Dam (comprising Cell A and Cell B) and low grade ore within the Heap Leach Pad. Both waste containment structures were operated during the 1990s and are currently non-operational. For the purposes of this PRCP, this document focuses on Cell B of the Yandan Tailings Dam and the Heap Leach Pad, noting that Cell A has been rehabilitated.

Geochemical characteristics of the tailings material within TSF Cell B and the low grade ore within the Heap Leach Pad are described below.

3.5.11.1 Tailings management facilities

The Yandan Tailings Dam (comprising Cell A and Cell B) was operated between 1993 – 1998, with an estimated 7,500,000 tonnes (t) of tailings pumped into the facility during this time (Scott 2000). It is estimated that 2,900,000 t and 4,600,000 t of tailings are stored within Cell A and Cell B, respectively (RGS 2021).

Cell B of the tailings dam is predominantly an oxide tailings dam, containing also a small proportion of sulphide tailings. The original Environmental Management Overview Strategy estimated that sulphide ore was likely to represent less than 15 % of the total mined ore on-site (Ross Mining N.L 1992). Over the operational life of Cell B, a sequence of oxide then sulphide and then oxide tailings were deposited (Scott 2000). As such deposition of sulphide ore is limited to the upper portion of TSF Cell B, with this underlain and overlain in most areas by oxide tailings.

Material characterisation

Geochemical assessments of Cell B tailings material have been undertaken on multiple occasions since the TSF's decommissioning. Recent assessments have been completed by RGS Environmental Pty Ltd (RGS) (2015) and O'Kane Consultants Pty Ltd (O'Kane Consultants) (2019), with a subsequent review of results from the 2015 assessment also completed by RGS in 2021 (RGS 2021).

RGS completed a comprehensive geochemical assessment of Cell B in late 2014, collecting 85 tailings (oxide and sulphide) and soil samples (RGS 2015) (refer to Figure 33). Soil sampling included samples taken from the cover trial sites monitored as part of the Rehabilitation Monitoring Program.

Material characterisation (using static) methods involved the following (RGS 2015):

- pH (1:5 w:v);
- Electrical Conductivity (EC) (1:5 w:v);
- Total sulphur [LECO Australia Pty Ltd (LECO) high temperature method];
- Acid Neutralising Capacity (AMIRA 2000);
- Net Acid Producing Potential (NAPP);
- Chromium reducible sulphur testing (Scr) [AS 4969.7-2008 method] (n=43);
- Net acid generating (NAG) analysis (n=26);
- Total metals (aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), mercury (Hg), lead (Pb), manganese (Mn), molybdenum (Mo), nitrogen (N), nickel (Ni), antimony (Sb), selenium (Se), vanadium (V), zinc (Zn)) in solids [hydrochloric acid (HCl) and nitric acid (HNO₃) acid digest followed by ICP-AES and selected ICP-MS] (n=13);

- Total mercury [Flow Injection Mercury System method] (n=13)
- Total cations (calcium (Ca), magnesium (Mg), sodium (Na), potassium (K)) and Exchangeable cations (Ca, Mg, Na, K) (n=13)
- 1:5 (solid to water) water soluble metals (Al, As, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Mo, N, Ni, Sb, Se, V, Zn) by ICP-AES or ICP-MS (n=13)
- 1:5 (solid to water) water soluble metals (Ca^{2+} , Mg^{2+} , K^+ , Na^+ , Cl^- , SO_4^{2-} , pH, EC, alkalinity and acidity) (n=13)
- Cation Exchange Capacity (eCEC) (n=7)
- Exchangeable Sodium Percentage (ESP) (n=7).

Kinetic leach column (KLC) test methods were undertaken to verify the results of the static testing (as above), quantify the rate of sulphide oxidation and acid consumption, and for the prediction of potential mine drainage quality (RGS 2015).

Kinetic test methodology broadly involved (RGS 2015):

- Sample classification, in terms of -
 - Total Sulphur (TS) > 0.3 %
 - NAPP >10 kg H_2SO_4 /tonne
 - Acid Neutralising Capacity (ANC) / Maximum Potential Acidity (MPA) ratio <1
- Standard KLC Test Cells (using 2 kg sample)
- Large KLC Test Cells (using 20 kg sample)

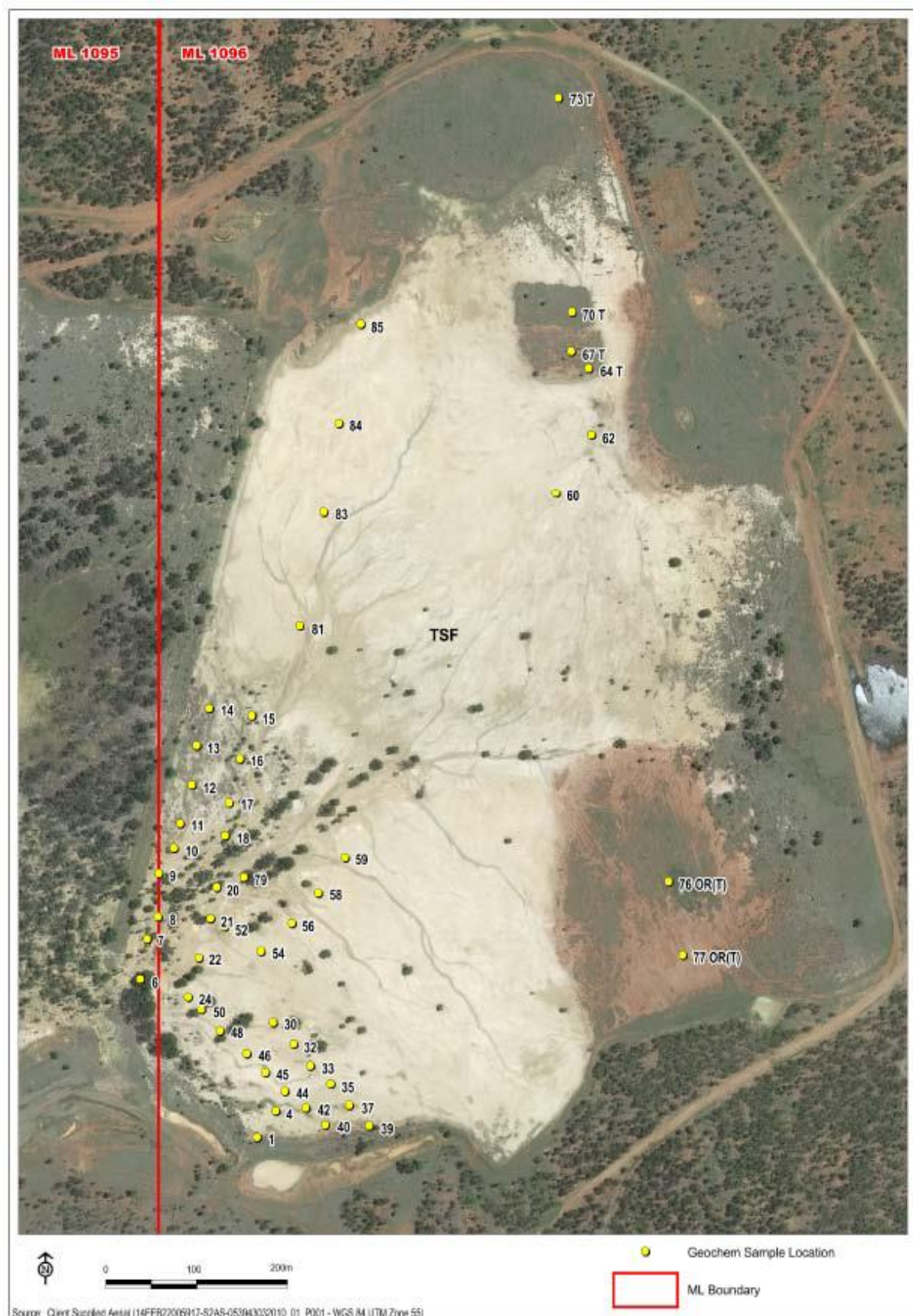


Figure 33: Sample points from the geochemical assessment (RGS 2015)

Static test results

Salinity (EC) values for the 85 samples collected from Cell B varied from 159 – 2,950 $\mu\text{S}/\text{cm}$, with the oxide tailings paste EC ranging from 600 – 2,950 $\mu\text{S}/\text{cm}$, and the sulphidic tailings paste EC ranging from 600 – 2,400 $\mu\text{S}/\text{cm}$ (RGS 2015). The average salinity for tailings and soil samples was 1,498 $\mu\text{S}/\text{cm}$ and 1,017 $\mu\text{S}/\text{cm}$, respectively (RGS 2015). A small minority of samples (10 of 85) had low to moderate salinity, exceeding 3,000 $\mu\text{S}/\text{cm}$. It is noted that water extracts with an EC of < 2,000 $\mu\text{S}/\text{cm}$ are considered suitable for irrigation, and that the majority (75 of 85) samples fell within this category (RGS 2015). It is noted that this is also below the known threshold at which soil salinity may impact agronomic plants (Hazelton & Murphy 2007), and well within the threshold at which salinity may affect beef cattle (ANZECC & ARCANZ 2000). These results support that the tailings material is of low to moderate salinity.

Most trace metals/metalloids were low compared with average crustal abundance, being below the Laboratory Limit of Reporting value and the livestock drinking water guideline (ANZECC & ARCANZ 2000). A limited number of samples provided minor exceptions, with some exceedances of Al, Cd, Fe, and Mn identified (RGS 2015). It is considered unlikely that dissolved metal/metalloid concentrations from the soil and tailings material would impact surface and groundwater resources (RGS 2015). These results support that the tailings material is of low reactivity.

Material Classification Methods

All tailings have been classified as NAF. The material classification methods are set out below.

Total sulphur (TS) testing supports that the sulphide minerals have undergone significant or complete oxidation, resulting in essentially no residual sulphide minerals present within the top 600 mm of tailings (RGS 2015). TS measurements for all sulphur species (e.g. organic S, sulphide S, sulphate minerals) indicated a TS range of 0.02 – 0.53%, with the majority of samples having a TS < 0.4 %. Sulphide sulphur (SS) testing was conducted to verify the proportion of SS present in the TS mass; as TS can overestimate the MPA of a sample (RGI 2015). SS testing verified that the concentration of SS in the material is effectively zero, with a chromium reducible sulphur (CRS) % < 0.005%.

Material classification methods typically use the Acid Base Account (ABA) scheme to classify whether mine waste samples are potentially acid forming (PAF) (Table 23). This standard scheme is used to determine whether material has the potential to produce acidity from sulphide oxidation at some point in the future. Under this classification scheme, all 85 samples were classified as 'barren', indicating that the tailings material is NAF. Any future very low acid forming potential would come from the pore water or secondary minerals, such as Jarosite (Williams 2021). Again, this supports that the material is of low reactivity, and confirms that there is no PAF material present.

Table 23: Standard ABA Classification Criteria typically used for material classification

Geochemical Classification	Sulfide Sulfur ¹ (%)	NAPP (kg H ₂ SO ₄ /t)	ANC:MPA Ratio
Barren ²	≤ 0.1	-	-
Acid Consuming	> 0.1	> -50	≥ 2
Non-Acid Forming	> 0.1	≤ 0 and -50	≥ 2
Potentially Acid Forming - Low Capacity	> 0.1	> 0 and ≤ +10	< 2
Potentially Acid Forming-Moderate Capacity	> 0.1	> +10 and ≤ +50	< 1
Potentially Acid Forming – High Capacity	> 0.1	> +50	< 1

Notes:

1. If total sulfur or sulfide sulfur is less than or equal to 0.1 %, the NAPP and ANC: MPA ratio is not required for material classification as the sample is essentially barren of oxidisable sulfur.
2. A sample classified as NAF can be further described as 'barren' if the total sulfur and/or sulfide sulfur content is less than or equal to 0.1 per cent, as the sample essentially has negligible acid generating capacity from future sulfide oxidation.

Given the tailings material has already weathered/oxidised *in situ*, pH criteria have been used to describe the samples in terms of their Acid Forming Potential (AFP), as per Table 24. Under the existing APF classification method, soil and tailings samples from Cell B are classified as having a low acid forming potential (LAPF). The measured acidity of the samples was considered quite low, with an average measured acidity of 19 mg/L.

Table 24: pH Classification Criteria – Existing Acid Forming Samples

Existing Acid Forming Potential (AFP) (Sulfide minerals have oxidised and acid neutralising capacity is consumed)		AFP Criteria
No Acid Forming Potential	Inert	pH 6 to 7
Low Acid Forming Potential	LAFP	pH 4 to 6
Mild Acid Forming Potential	MAFP	pH 3 to 4

Based on the above classification methods, all tailings materials were classified as NAF (with no potential to produce acid through sulphide oxidation) and being inert and having a LAFP (i.e. dominated by pH values of 4 – 6) (RGS 2015). Other methods have further determined that the salinity values of the material is low (meeting relevant guideline values). Dissolved metal/metalloid concentrations of the tailings material are also low and are considered unlikely to impact upon surface water and groundwater quality (RGS 2015).

Kinetic test results

KLC tests were conducted to provide information on the reaction kinetics of the tailings material and investigate metal release and the quality of any potential seepage from the Cell B facility.

Under extreme conditions isolated to laboratory testing, it was possible to produce mild acidic drainage of around pH 4 – 5 from the tailings material (RGS 2015). It is acknowledged however, that these results assume 100 % permeability and significant physical re-disturbance of the tailings, characteristics that were intentionally created for the purposes of the test and which are not present *in situ* (RGS 2015). RGS considered that the leachate sampling “has probably resulted in tailings/water interaction in the laboratory that will not occur in the field, even if the tailings mass remained uncovered” (RGS 2015). *In situ* however, the tailings material is well consolidated and essentially impermeable, and therefore it is likely that runoff is significantly greater than infiltration (RGS 2015).

RGS considered it unlikely that soluble concentrations of major ions and trace elements in the Cell B tailings material are causing chronic or acute eco-toxic impacts, noting that healthy vegetation has established in the drainage channels of the Cell B facility (RGS 2015) (Figure 34). RGS considered that the revegetation of the Cell B tailings, apart from along drainage lines (as per Figure 34 below) is likely limited by the availability of water (2015). Geochemical assessment indicates that the tailings material is of low permeability, limiting deep drainage (RGS 2015). Monitoring of the receiving environment also supports that there has been no observed contaminated seepage capable of causing environmental harm.



Figure 34: Established vegetation in the drainage channels of Cell B

Cover design and rehabilitation

Rehabilitation of the Yandan Tailings Dam has been approached progressively, with Cell A of the facility rehabilitated. Cell B of the TSF has remained unrehabilitated pending further operation, and is therefore the focus of this section.

The Yandan Tailings Dam was constructed in a valley with cross dams on clayey weathered materials of low permeability, estimated at 10^{-9} m/s (Douglas and Partners 1988, within Greater Boulder Holdings Ltd 1988). Cell B of the facility has a surface footprint of approximately 70 ha, with a capacity of 4,700 ML. As the facility is not a regulated structure, no hydraulic performance requirements apply (PSM 2021b).

The facility is primarily contained by two embankments, with the eastern perimeter wall being the principal containment structure. The eastern perimeter wall was constructed with a central clay core (Fraser Osborn 1997), with earth and rockfill embankments (PSM 2021a) (Figure 35). The eastern perimeter wall is approximately 530 m in length, with a maximum wall height of 5 m (PSM 2021a). The spillway for the facility is located to the south-west, spilling to the TWRD (Figure 35). No contaminated seepage capable of causing environmental harm from the facility has been identified through the regular dam inspections.

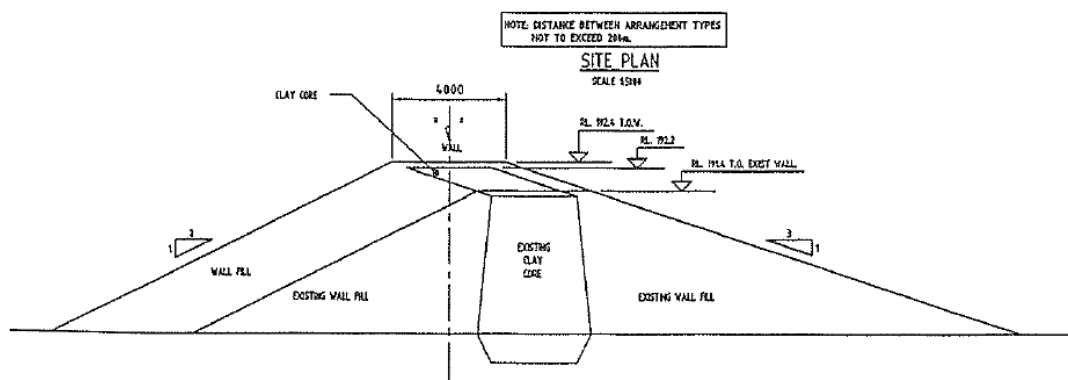


Figure 35: TSF Cell B - Eastern perimeter wall construction (Fraser Osborne 1997)

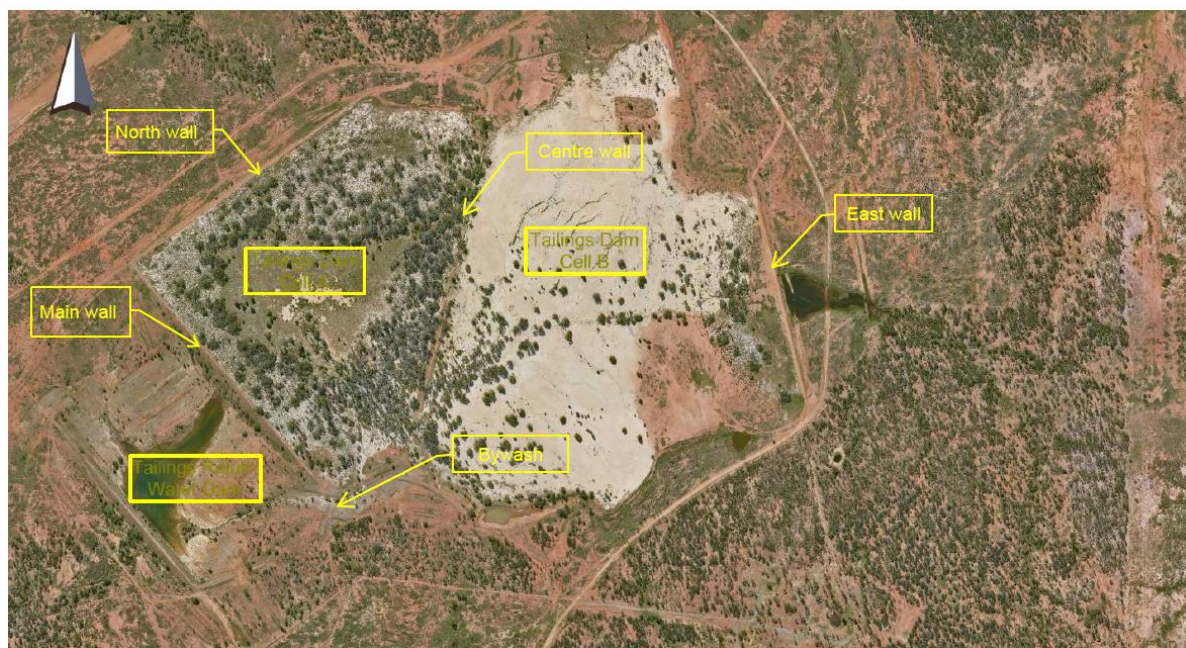


Figure 36: Containment structures for Cell A and Cell B (PSM 2021b)

Geochemical assessment of the Cell B tailings material indicates that the stored material poses a low geochemical risk. The tailings material is classified as NAF, is considered unlikely to generate acidic drainage, and there are no saline issues apparent (RGS 2015).

The rehabilitation objective for the facility is to restore a post mining land use of open pasture grazing. To achieve this a store-and-release cover system is proposed.

A store-and-release cover system has been recommended as the 'best fit' cover system for the Cell B facility, as determined by an independent expert (Williams 2021). This review confirmed that Cell B satisfies the ERC 'low' risk category for TSFs, fulfilling all relevant risk category characteristics established in the *User Guide for Estimated Rehabilitation Cost Calculator for Mining* (DES 2020), being (Williams 2021):

- *Sulfide minerals in the tailings are completely oxidised to a depth of at least 600 mm.*
- *Metals, such as aluminium, iron and manganese, are low compared with average crustal abundance, and other metals, such as arsenic and mercury, are sparingly soluble; hence salinity is low.*
- *The tailings support traffic.*
- *The TSF embankments are <15 m high.*
- *The compacted tailings are of low permeability; that is, suitable as a low permeability layer to hold-up rainfall infiltration, limit net percolation into the underlying tailings and hence limit seepage to the environment, and limit potential uptake of salts into the cover.*
- *Revegetation of 400 to 600 mm of gravelly topsoil placed on the Cell B tailings achieved similar success to reference sites, with similar minor erosion, over a 7-year period.*

On this basis, the planned cover system for Cell B is to be the 'low risk' cover system design described in the Departments' *'User Guide for Estimated Rehabilitation Cost Calculator for Mining'* (ESR/2019/4626) (DES 2020) (ERC User Guideline), with this comprising a 1.0 m top rock layer and 0.15 m of growth media.

It is acknowledged that the development of the proposed Cell B cover system design has been an extensive process, involving numerous assessments to test the suitability of various cover system designs in combination with long-term field trials (8 years +). During this process it was determined that the cover system design for the facility did not require a capillary break layer or low permeability layer (Williams 2021).

In terms of the longer-term stability and functioning of cover systems, it is noted that capillary break layers are considered prone to failure due to settlement and fines migration (Williams 2021). A capillary break layer is also not considered to be required for the Cell B facility due to the absence of residual sulphide minerals in the upper tailings and low permeability of this material (Williams 2021).

While a low permeability layer is not necessarily required for the facility, with the existing compacted tailings being already of low permeability, consideration is being given to further compaction of the tailings to enhance the store-and-release function of the cover design (Williams 2021). Further compaction of the existing tailings would provide a low permeability layer that would function to limit net percolation and seepage and potential salt uptake into the cover (Williams 2021). As such, it is planned to install an enhanced store-and-release cover system, based on the default 'low risk' cover system described in the Department's ERC User Guideline, enhanced with a low permeability layer.

In proposing an enhanced store-and-release cover system for Cell B, consideration has been given to the local climatic conditions at Yandan. *The Global Acid Rock Drainage Guide* (International Network for Acid Prevention (INAP) 2009) identifies that the local climate conditions (being semi-arid and tropical) indicate that a store-and-release cover system is most appropriate. In terms of the Project's rehabilitation objectives, a store-and-release cover system design is also recognised to assist in limiting erosion and sustaining vegetation (Williams 2020).

Construction of the cover system is to involve compaction of the existing TSF surface using a smooth drum roller making multiple passes to achieve a low permeability layer. Following this, a 1.0 m layer of coarse rock will be spread over the facility, followed by 0.15 m of growth media. Suitable rehabilitation materials for this cover system are available on-site (refer to Section 3.5.10). Coarse rock to be used for the cover system is to come from borrow pits around the Cell B facility, with additional coarse rock material to be sourced from the decommissioned Heap Leach Pad. Material characterisation studies have confirmed that the heap leach material's physical characteristics are suitable for this material to be used in rehabilitation. Geochemical assessments have also indicated that the material is geochemically benign and likely suitable for rehabilitation use (RGS 2013). Prior to any potential use, further QC/QA assessments and a testing program would be developed to confirm the use of the material.

It is noted that preparation of the TSF surface for rehabilitation works will not be required, given the facility has completed its drying phase and formed a stable landform (PSM 2021a). California Bearing Ratio (CBR) testing was undertaken in 2013 in preparation for rehabilitation works. Results of this testing confirmed that the tailings material is well consolidated, with CBR values generally greater than 10 (Fraser Osborn 2013), which is considered sufficient for the operation of large earth moving equipment.

3.5.11.2 Processing facilities

The Heap Leach Pad is approximately 550 m (L) x 450 m (W) x 26 m (H), covering an area of approximately 16.9 ha. The coarse rock material has been end-dumped and dozed in two ten metre lifts, and one six metre lift, at or below the natural angle of repose. As such, the existing structure is inherently stable. Evidencing this is vegetation coverage that has established over the benches.

The facility is lined with high density polyethylene (HDPE) that extends over the bund walls to the two processing ponds. Low grade oxide ore (predominately clay rich) sourced from the three open cut pits (Main Pit, South Pit and East Hill Pit) was placed on the Heap Leach Pad during the Project's operation (1994 – 1998) (EGI 2002). An estimated 3,200,000 m³ (or an estimated 2,880,000 t) of ore is contained within the facility, which covers an area of 16.9 ha. Gold and silver were extracted from the facility utilising conventional cyanide leach processes up until September 2002.

Material characterisation

Environmental Geochemistry International Pty Ltd (EGI) completed a geochemical assessment of the Heap Leach Pad material in 2002 (EGI 2002). With further sampling also completed by RGS in 2013 (RGS 2013).

Sampling during the 2002 assessment included twenty samples from a depth interval of 300 – 500 mm, with a further 20 samples collected from a depth interval of 5 – 10 m. Samples were assessed by a comprehensive analytical program, which included the following tests (EGI 2002):

- pH and EC determinations;
- Total S assay;
- ANC determinations;
- Multi-element scans on solids;
- NAG testing;
- Multi-element scans on water extracts and EDTA extracts; and
- Leach column tests and elemental analysis of leachates.

The results of the geochemical assessment are summarised in the below subsections.

Acid forming potential

Acid-base analyses and NAG test results were used to classify the AFP of the heap leach material. Acid-base analyses estimate the balance between the potential for material to generate acid and to neutralise acid; and

provide the net acid producing potential (NAPP) value and the ANC/MPA ratio. NAG testing is further used to confirm geochemical classification for the estimation of acid and metalliferous drainage (AMD) potential.

Sulphur concentrations of the material were low, ranging from 0.02 – 0.42 %S, with a mean value of 0.15 %S (EGI 2002). The ANC of the samples was low to moderate, ranging from 5 – 89 kg H₂SO₄/t, with a mean value of 31 kg H₂SO₄/t (EGI 2002). It is noted that this excluded three samples with values exceeding 100 kg H₂SO₄/t that had been collected from areas of the pad that had been treated with lime. The relationship between ANC and sulphide content for the samples is shown in the acid-base account plot (refer Figure 37).

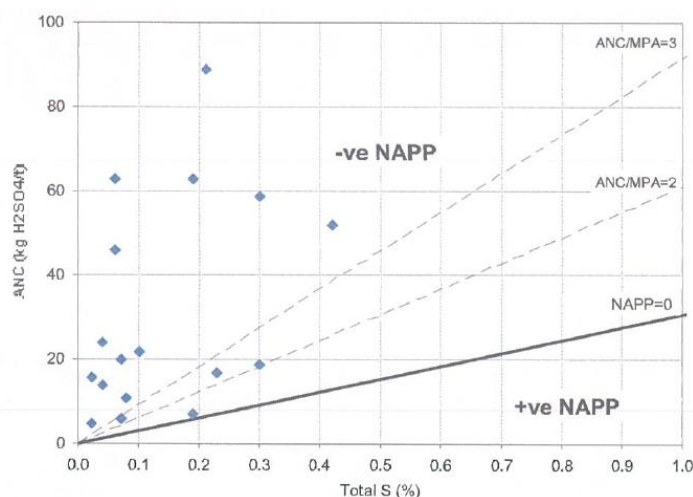


Figure 37: Acid-base account plot for Heap Leach Pad samples (Source: EGI 2002)

The acid-base account plot demonstrates the distribution of samples between the higher risk (NAPP positive) and lower risk (NAPP negative) domains (Australian Government 2016). Samples that fall in the lower risk domain have a reduced potential of generating a net acidic pH, and are therefore unlikely to generate AMD. Results from the geochemical assessment confirm that the Heap Leach Pad material is NAPP negative and the material has an excess capacity to neutralise acid (EGI 2002). The ANC/MPA ratio for the samples was generally greater than 3, noting that values greater than 2 are generally considered to indicate a high probability that the material will remain near-neutral in pH and is unlikely to generate acidic drainage (Australian Government 2016).

Samples with ANC/MPA ratio values of 3 or less were selected for NAG testing to further confirm their geochemical classification. Testing confirmed that all samples had NAG pH values greater than 4.5 (NAG pH 6.8 – 7.9), confirming that these samples are NAF. It is noted that subsequent sampling has continued to indicate that the material is NAF and slightly alkaline (range 8.1 – 10, n = 6) (RGS 2013).

In summary, the AFP analyses confirmed that the Heap Leach Pad material is NAF (EGI 2002, RGS 2013) and of low reactivity.

Salinity

At the time of the assessment, salinity (EC) values for the Heap Leach Pad material ranged from 232 – 2730 μ S/cm (EGI 2002). Approximately 50% of samples were considered 'non saline' and 'slightly saline', with 30% of samples falling within the 'highly saline' range (>1500 μ S/cm). It is noted that this sampling was undertaken in 2002, following the decommissioning of the facility in September 2002. At the time of the assessment, EGI considered it likely that the Heap Leach Pad would generate highly saline runoff and seepage for a short period after decommissioning, however, that this would rapidly stabilise post-closure, following flushing of the facility (EGI 2002) (refer Figure 38). Indeed, a subsequent geochemical assessment in 2013 found that water extract from the heap leach materials had a relatively low EC/salinity value of 551 μ S/cm, with heap leach material also being of low salinity (median: 201 μ S/cm, range: 131 – 440 μ S/cm) (RGS 2013).

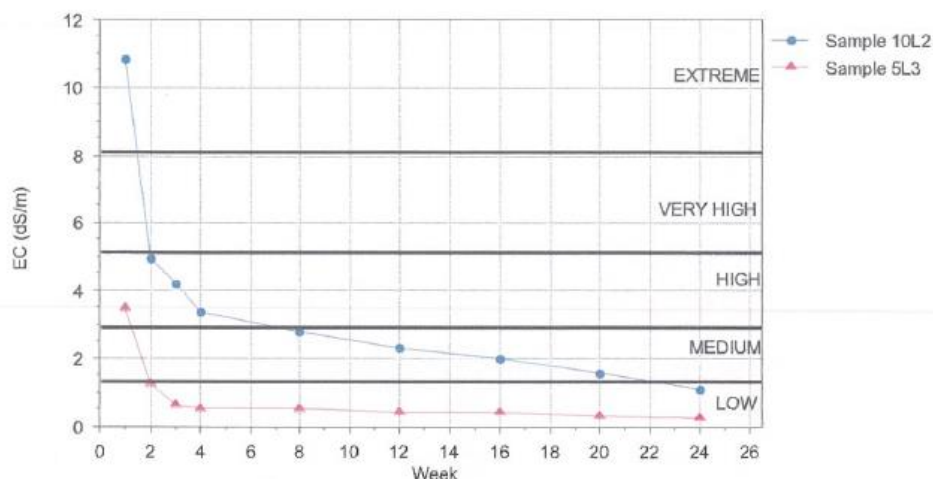


Figure 38: Line plot of column leachates EC. Irrigation water salinity ratings are also shown (ANZECC 2000) (Source: after 'Figure 4', EGI 2002)

Element composition and solubility

At the time of the assessment, multi-element scans found the following metals were enriched in the majority of samples: As, Hg, Sb and Se (EGI 2002). A minor number of samples were significantly enriched in silver (Ag) and Pb (EGI 2002). Some metals were found to be slightly soluble under test conditions (being As, Co, Cu, Sb and Se); Ag and Hg were not soluble in any samples (EGI 2002). During decommissioning and as the material reverts to more neutral conditions it is possible that the solubility of some of these elements may increase (EGI 2002). Initial flushing of the facility was anticipated to result in some leaching of Co, Mo and Se, however, this was anticipated to reduce after a relatively short period to low levels, being below the ANZECC (2000) irrigation water criteria (EGI 2002). Longer-term releases of arsenic was noted as a potential concern post closure (EGI 2002).

Review of total metal concentrations in 2013 confirmed that values were unlikely to present a significant risk to the environment or rehabilitation (RGS 2013). Arsenic concentrations (67 mg/kg) were noted to be significantly less than the health-based investigation level (HIL (E)) (200 mg/kg) established for parks and recreational open spaces (RGS 2013). RGS considered that the applicability of the HIL (E) guideline value was appropriate given the final land use of low intensity grazing (RGS 2013). It is also noted that monitoring of the receiving environment has not detected contaminated seepage capable of causing environmental harm.

Overall, the results from these investigations have identified that the heap leach material is of low reactivity, being NAF, and is not expected to produce saline drainage. EGI considered that reprofiling and a "relatively simple soil cover" would therefore be appropriate for the rehabilitation of the Heap Leach Pad (2002). This rehabilitation methodology remains valid today, further supported by the extended duration (19 years) that the facility has had to stabilise.

Cover design and rehabilitation

The rehabilitation objective for the facility is to achieve a post mining land use of pasture grazing on a low hill landform. To achieve this a simple store-and-release cover system is proposed.

Assessment of the Heap Leach Pad's characteristics against the Department's ERC User Guideline confirms that the facility meets the ERC 'low' risk category for Heap Leach Pads, on the basis that:

- the material is NAF;
- the material is of low reactivity;
- the material is of low salinity;

- some seepage issues have been identified, however, there is no indication that contaminants are reaching, or would be expected to reach, the receiving environment and cause environmental harm; and
- the facility will not impact on the proposed end land use.

On this basis, the planned cover system for the Heap Leach Pad is to be the 'low risk' cover system design described in the Departments' *'User Guide for Estimated Rehabilitation Cost Calculator for Mining'* (ESR/2019/4626) (DES 2020) (ERC User Guideline), with this comprising a 0.5 m top rock layer and 0.15 m of growth media.

It is noted that the heap leach material is not considered to present risks to the environment with respect to total metal concentrations in solids and is considered to pose negligible risk of impact on the quality of surface waters and groundwaters (RGS 2013). Therefore, it is considered that a low permeability system is not required for the facility.

Construction of the final landform will involve reshaping activities, involving relatively high productivity down slope pushing using a dozer to reduce the slope gradient to improve the stability of the final landform. The leachate treatment ponds adjacent to the facility will also be integrated under the final landform. Following reshaping, a 0.5 m top rock layer will be established, followed by the application of 0.15 m of topsoil.

The heap leach material has been confirmed to be texturally suitable for use as coarse rock in rehabilitation works (O'Kane Consulting 2019). As such, the existing in situ material would be used to comprise the required 0.5 m top rock layer, with QA/QC testing to confirm the textural suitability of this material over the landform, in addition to further assessments of its geochemical suitability (Section 3.5.10). Topsoil sources for the cover system would be sourced from the topsoil stockpiles located at the toe of the facility, to the south-west and south-east (refer Section 3.5.10)

3.5.12 Final landform design

Final landform design planning has been informed by a combination of monitoring data (including environmental monitoring and material characterisation) and various assessments to predict the long-term stability of final landforms. The following sub-sections summarises the assessments completed to inform this design, and the methodology to be used to construct safe and structurally stable final landforms.

3.5.12.1 Heap Leach Pad

An Erosion Stability Assessment was completed to inform final landform planning and predict the long-term stability of key final landform features at Yandan (AARC 2022b).

Erosion modelling for this assessment used the Revised Universal Soil Loss Equation (RUSLE) approach to predict long-term stability outcomes for the final landform of the Heap Leach Pad. The RUSLE analysis predicts long-term average annual soil loss values based on factors such as rainfall erosivity, slope steepness and length, soil properties, groundcover, and land management factors. Site specific soils data and vegetation data was also incorporated into the RUSLE analysis.

The RUSLE calculation for mean annual soil loss (t/ha/yr) as used for the Project is a product of five variables:

$$A = R \times K \times L \times S \times C \times P$$

Where:

A = Average annual soil loss (t/ha/yr)

R = Rainfall erosivity factor - measure of the ability of rainfall to cause erosion

K = Soil erodibility factor - measure of the susceptibility of the soil to erosion

LS = Slope Length/gradient factor – the combined effect of slope length and slope gradient on soil loss

C = ground cover and management factor – ratio of soil loss from land under specific cover conditions to the corresponding loss from bare soil

P = Supporting practice factor - ratio of soil loss with a specific supporting practice as compared to soil loss in regular conditions.

Results from this assessment have provided general landform design guidance for the final landform of the Heap Leach Pad (and also the TSF embankments, see below), having evaluated the erosional stability of the conceptual final landform.

From the erosion assessment a final landform design for the Heap Leach Pad was proposed, with this involving grading of the existing landform to a slope grade of 25%, with 5 m benches every 30 meters (Figure 39). Benches have been proposed to break an otherwise continuous slope. It is noted that special care would be taken when constructing benches, to ensure these do not concentrate water and potentially cause erosion. The top of the facility would be graded from centre to edge to achieve a water shedding design.

Following re-shaping works, the facility is to be capped using a minimum of 0.5 m of top rock and a minimum of 0.15 m of topsoil, with the final landform to be seeded with pasture species. The erosional stability of the Heap Leach Pad has been done considering the proposed design.

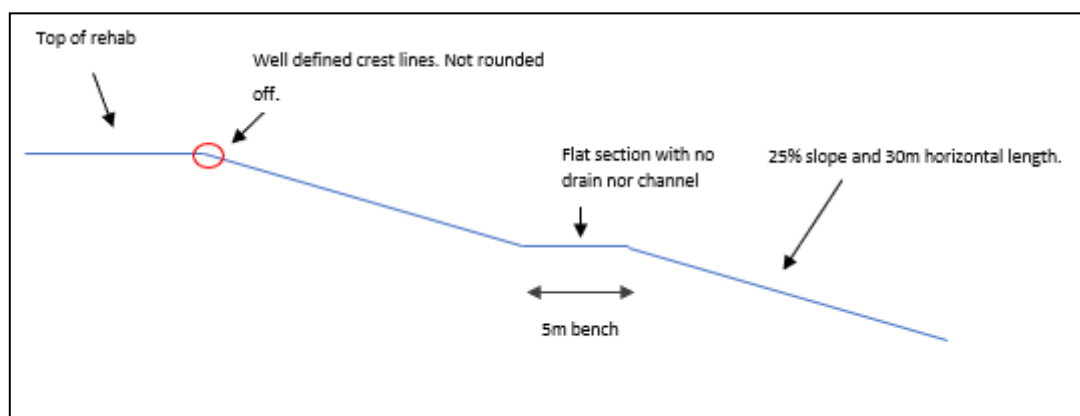


Figure 39: Final Landform Design of Heap Leach Pad

It is anticipated that relatively high ground coverage will be required to achieve surface erosion stability of the rehabilitated Heap Leach Pad (AARC 2022b). A rock mulch groundcover (cross-rippled with topsoil) may be applied on the embankment to provide additional cover and stability while reducing surface water runoff and potential erosion. This is consistent with RUSLE literature (Rosewell 1993, Lu *et al.* 2003) where it is stipulated that rock cover should be used in combination with vegetation cover to estimate the total groundcover for the cover and management factor (C-factor) of the RUSLE equation. Total groundcover (rock and/or vegetation) proposed for the final landform is 65% (i.e. a C-factor value of 0.035) (AARC 2022b).

Overall, RUSLE values for the proposed final landform design of the Heap Leach Pad are within acceptable limits (i.e. being <10t/ha/year) (Table 25). Surface erosion of this structure is predicted to be manageable under these conditions (AARC 2022b).

Table 25: RUSLE values for the Heap Leach Pad

Location	Cross Section	R-factor	K-factor	LS-factor	C-factor	P-factor	RUSLE value t/ha/year
Heap Leach Pad	-	2197.17	0.028	4.43	0.035	1.00	9.60

3.5.12.2 Yandan Tailings Dam

The existing landform of the Yandan Tailings Dam is one of low relief, with 1-3 m embankments in the top of the catchment to a 12 m earthen embankment downstream, over a broad 115 ha landform (SBE 2022). The landform sits above the modelled flood extents (Section 3.5.9).

It is understood that the embankment of the TSF was constructed with a central clay core, with this material borrowed from around the perimeter of the TSF (Greater Boulder Holdings Ltd 1988). Clay cores are effective in restricting seepage from reporting to the receiving environment, and in this instance, it is also understood to have the dual purpose of preventing upstream waters from infiltrating the facility and wetting the tailings. Given the TSF was constructed across a minor drainage channel, some ponding occurs against the upstream wall which is located within the top of the catchment. The inclusion of a clay core in the embankment walls was therefore an important consideration for the long term stability and function of the facility.

A slope analysis was conducted over the current (unrehabilitated) embankment of the TSF, principally on the Main Wall (downstream face of the TSF) (AARC 2022b). Several cross sections were analysed on the Main Wall showing a slope length of 35 meters and a slope gradient of 33% (Figure 40).

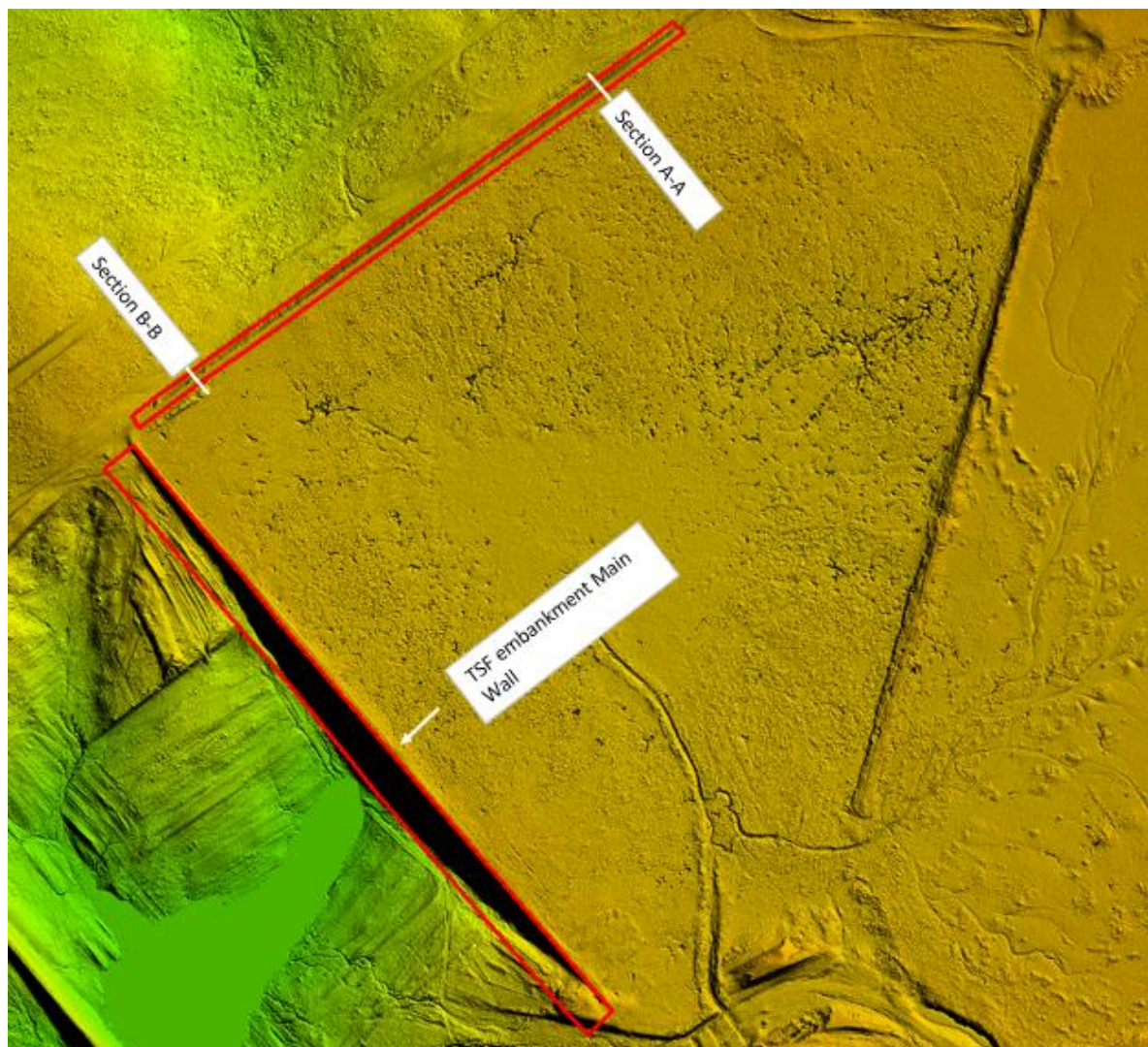


Figure 40: Erosion stability assessment area: TSF embankment (AARC 2022b)

To minimize the potential of surface / soil erosion as a consequence of steep slopes, backfilling on the downstream face of the wall is proposed to achieve 30% grade slopes with a 20 m horizontal length, and a single, intermediate flat bench of 5 m (Figure 41).

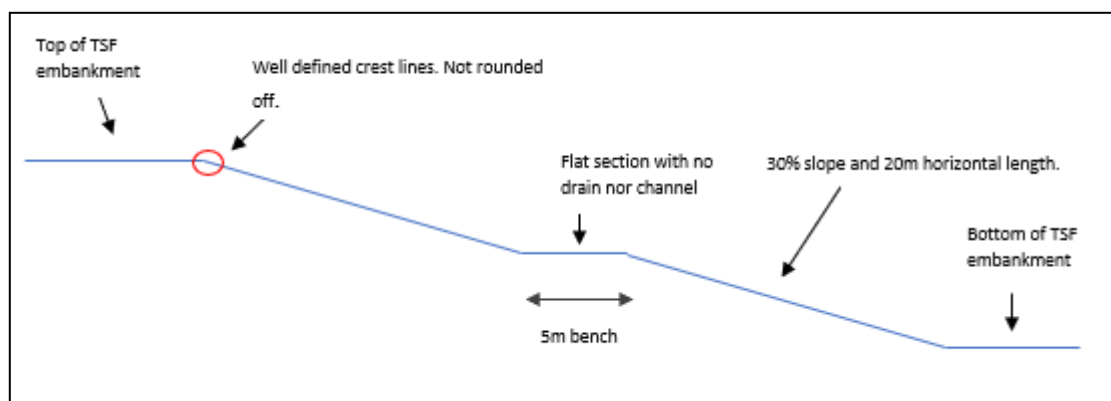


Figure 41: Final landform design of Main Wall

As per the rehabilitation approach for the Heap Leach Pad, it is anticipated that relatively high ground coverage will be required to achieve surface erosion stability of the rehabilitated TSF embankments (AARC 2022b). Similarly, a rock mulch groundcover (cross-rippled with topsoil) may be applied on the TSF embankment to provide additional cover and stability while reducing surface water runoff and potential erosion. Total groundcover (rock and/or vegetation) proposed for the final landform is 65% (i.e. a C-factor value of 0.035) (AARC 2022b).

Overall, RUSLE values for the proposed final landform design of the TSF embankments are within acceptable limits (i.e. being <10t/ha/year) (Table 26). Surface erosion of this structure is predicted to be manageable under these conditions (AARC 2022b).

Table 26: RUSLE results for the TSF embankment

Location	Cross Section	R-factor	K-factor	LS-factor	C-factor	P-factor	RUSLE value t/ha/year
TSF embankment	A-A	2197.17	0.028	1.09	0.035	1.00	2.36
	B-B	2197.17	0.028	0.8	0.035	1.00	1.73
	Main Wall	2197.17	0.028	3.86	0.035	1.00	8.37

The cover system design for Cell B of the Yandan Tailings Dam is discussed in Section 3.5.11.1.

3.5.12.3 Residual voids

Residual voids are areas of the post mining landform that are below the natural ground level and will not be rehabilitated to achieve a PMLU (i.e. are NUMAs). Approved residual voids at Yandan are associated with Main Pit and East Hill Pit, having a combined surface area of approximately 22.9 ha (Figure 3).

Main Pit

Main Pit is to remain as a residual void post-closure with a permanent water cover (refer Section 3.5.13).

Most rehabilitation works for Main Pit were completed following the decommissioning of the pit in 1999. Prior to flooding the pit, sulphidic material in the pit was dozed flat, treated with lime and capped with compacted oxide material (Ross Mining 2000). A water layer was established during the 1999/2000 wet season (Ross Mining 2000).

Two spillways were installed on the north-west and south-east walls of the pit to enable connectivity with the Suttor River. These spillways have been lowered to ensure frequent inflows from the Suttor River. At the present spillway level (3.8 m), pit inflows have an annual occurrence probability of approximately 68% (Fletcher 2012).

Further rehabilitation planned for Main Pit includes a geotechnical assessment of the existing void batter angles, to determine residual void angle requirements.

Stock fencing and safety signage will be installed around the perimeter of the pit on closure for the protection of livestock and people.

Additionally, further works to the existing bund around Main Pit may be required. As discussed in Section 3.5.13, additional monitoring data (to provide at least 3–5 years data) is required to improve site water balance modelling for Main Pit to enable a final position on the long term use of the bund (SBE 2022). For the purposes of PRCP planning, it is presently assumed that the bund will be retained within the final landform, subject to appropriate assessments (as described in the PRCP Schedule, see Section 3.5.5).

East Hill Pit

East Hill Pit is to remain as a small residual void post-closure. To reduce exposure of reactive materials within the pit (see Section 3.5.13), a partial backfill of the pit will be undertaken.

A geotechnical assessment of the existing void batter angles will also be undertaken to determine residual void angle requirements.

An existing safety bund and stock fence are in place for the protection of livestock. Safety signage will be installed around the perimeter of the pit on closure, noting however the remoteness of the site.

As discussed in Section 3.5.13, to ensure that floodwaters do not enter the pit from the north during an extreme flood event (PMF event, see Section 3.5.9), a small (approximately 3 m) permanent landform bund will be constructed.

Void Water balance

Long term (present–2090) water simulations were completed for the residual voids to determine the water balance of these voids post-closure (SBE 2022). A void mass balance method was selected, with modelling accounting for rainfall, evaporation, pit lake levels, groundwater, and river inflows and outflows to the system. Long term rainfall records (1913–2021) were used as inputs to the model, while also accounting for various climate change scenarios (3.1.3.3), thus informing on projected future conditions also. Detailed methodology on this modelling (including calibration and parameters) is provided in *Water performance of Yandan Mine landscape at closure* (SBE 2022).

Existing void geometries of Main Pit and East Hill Pit used in the water balance modelling are summarised in Table 27.

Table 27: Key void geometry parameters

Parameter	Base (mAHD)	Spill level (mAHD)	Capacity (ML)
Main Pit	110	169	6,800
East Hill Pit	166	184	45

The water storage curve for each void based on void geometries is presented in Figure 42 and Figure 43.

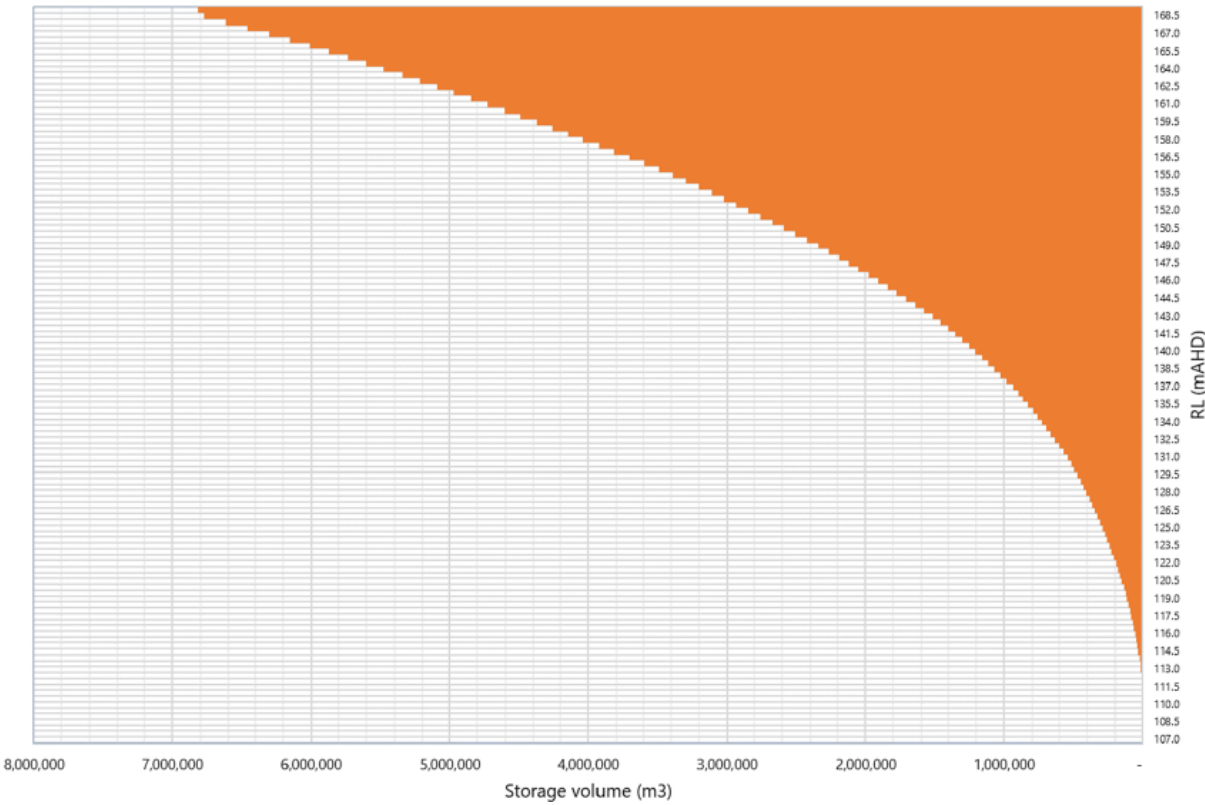


Figure 42: Main Pit storage curve (SBE 2022)

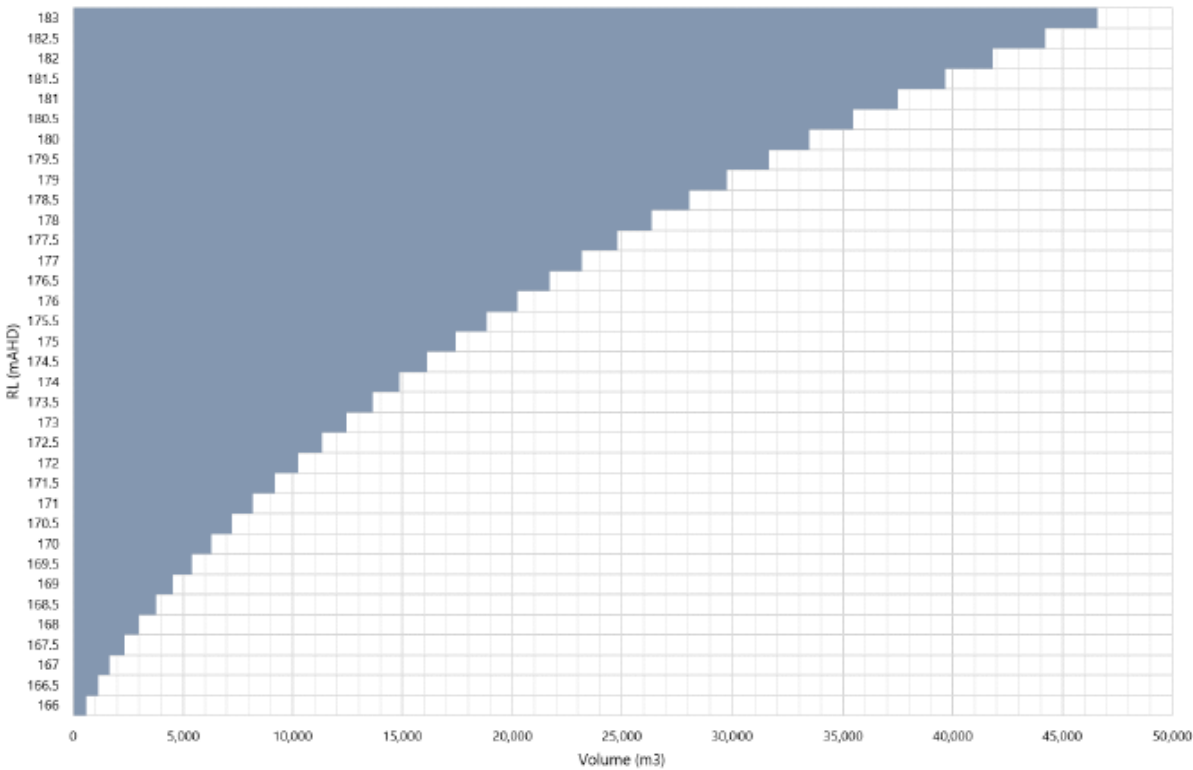


Figure 43: East Hill Pit storage curve (SBE 2022)

Model outcomes for the 'base case' (i.e. based on observations over the past 20 years) are shown in Figure 44.

Under base case conditions, water volumes within Main Pit indicate relative stability. For Main Pit, the model demonstrates that minimum pit water levels remain above 160 mAHD (as required by the Project EA), even when the model omits river inflows (SBE 2022). Generally, modelling suggests that inflows from the Sutor River will occur simultaneously with pit release events, thus ensuring adequate mixing of floodwaters with pit waters on release (SBE 2022).

For East Hill Pit, the model predicts that water levels will vary more widely within the pit, though overall remaining low (SBE 2022). The risk of overtopping from East Hill Pit is considered to be very low to almost negligible, with only the extremely rare scenario of a PMF flood event providing any level of potential risk (refer Section 3.5.9). In this scenario, it is possible for floodwaters to egress the pit from the north where the access road to the pit is located (SBE 2022). In the exceptional event of a PMF flood, there would be regional flooding that would facilitate significant dilution of any potential contaminants in the pit water (SBE 2022).

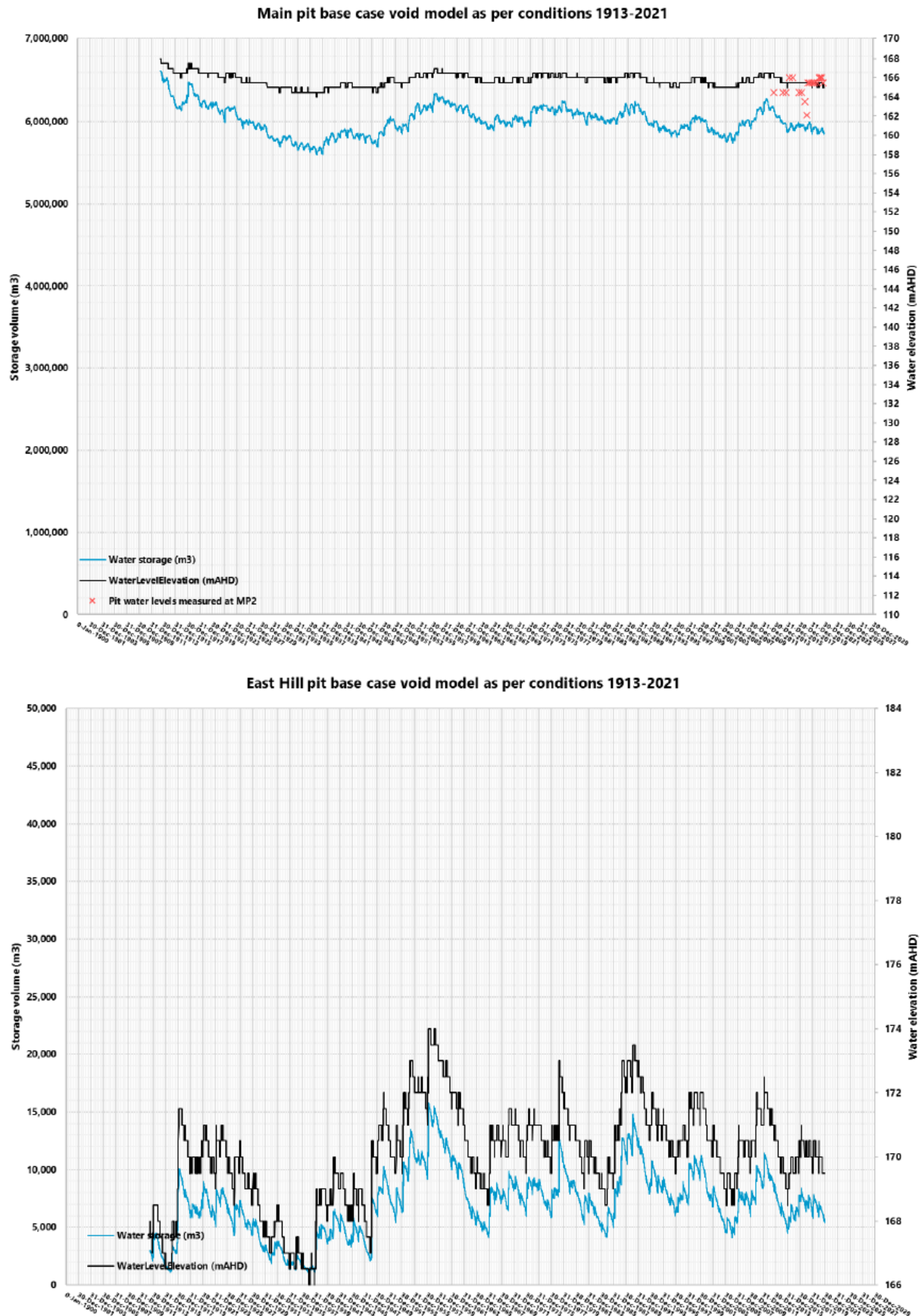


Figure 44: Base case void model outcomes for Main Pit (top) and East Hill Pit (bottom) (SBE 2022)

Responses to climate change have also been modelled for the residual pits. This assessment has considered potential impacts and implications of changing rainfall and evaporation to Main Pit and East Hill Pit (SBE 2022).

The Queensland Government Future Climate predictions for the region were used to assess impacts to void mass balance under changing climate. The following model scenarios were chosen:

- the 50th percentile for changes in rain and evaporation rates for 2030, 2050, 2070, and 2090; and
- to capture the potential for extreme bounds, the 10th and 90th percentiles for 2090 were adopted to simulate extremely wet, low evaporation scenarios and extremely dry, high evaporation scenarios.

A summary of the expected changes to the climate component of the void water model is provided in Table 28.

Table 28: Summary of climate change values

Year	Probability profile	Rainfall (mm/y)	Evaporation (mm/d)
2030	50 th percentile (mean)	18.2	0.36
2050	50 th percentile (mean)	-29.2	0.8
2070	50 th percentile (mean)	-21.9	1.2
2090	50 th percentile (mean)	-10.96	1.6
2090 wet	90 th /10 th percentile (upper bound)	116.9	0.7
2090 dry	90 th /10 th percentile (upper bound)	-113.2	3.0

For Main Pit, under the climate change scenarios '2050' and '2090 wet', pit water levels are predicted to be maintained above 160 mAHD. Under scenarios '2070', '2090' and '2090 dry' however, it is predicted that the pit water level falls below 160 mAHD without additional river inflow. However, with application of an average flow event every 10 years pit water levels are maintained. Model predictions for Main Pit are shown in Figure 45.

In East Hill pit, climate scenarios of '2070', '2090' and '2090 dry' result in a relatively dry pit which supports containment. Scenarios '2030', '2050' and '2090 wet' maintain contained water levels within the pit, although '2050' may have periods of dry and wet for pit storage. Model predictions for East Hill Pit are shown in Figure 46.

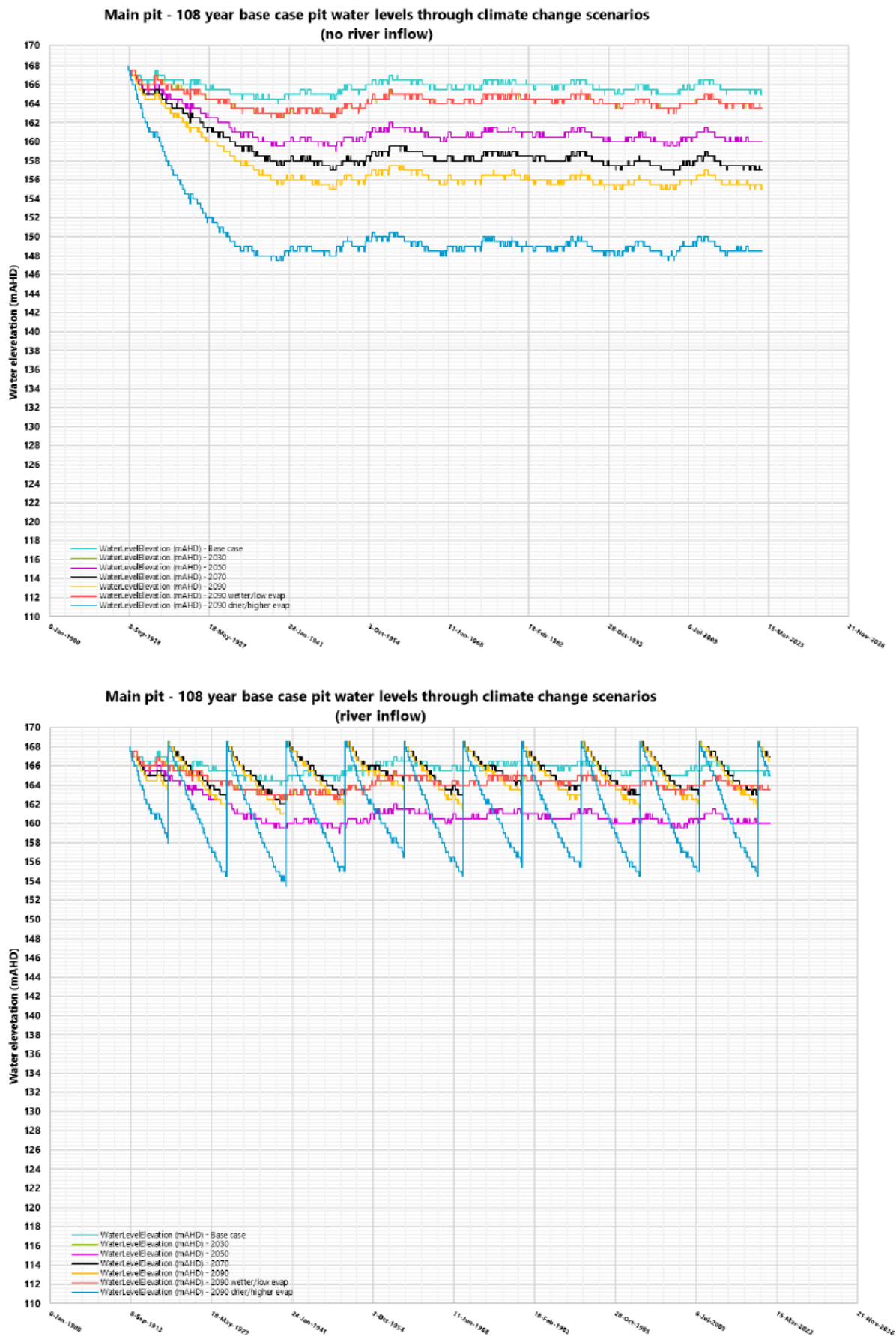


Figure 45: Main Pit void model under climate change scenarios – without and with river inflow (SBE 2022)

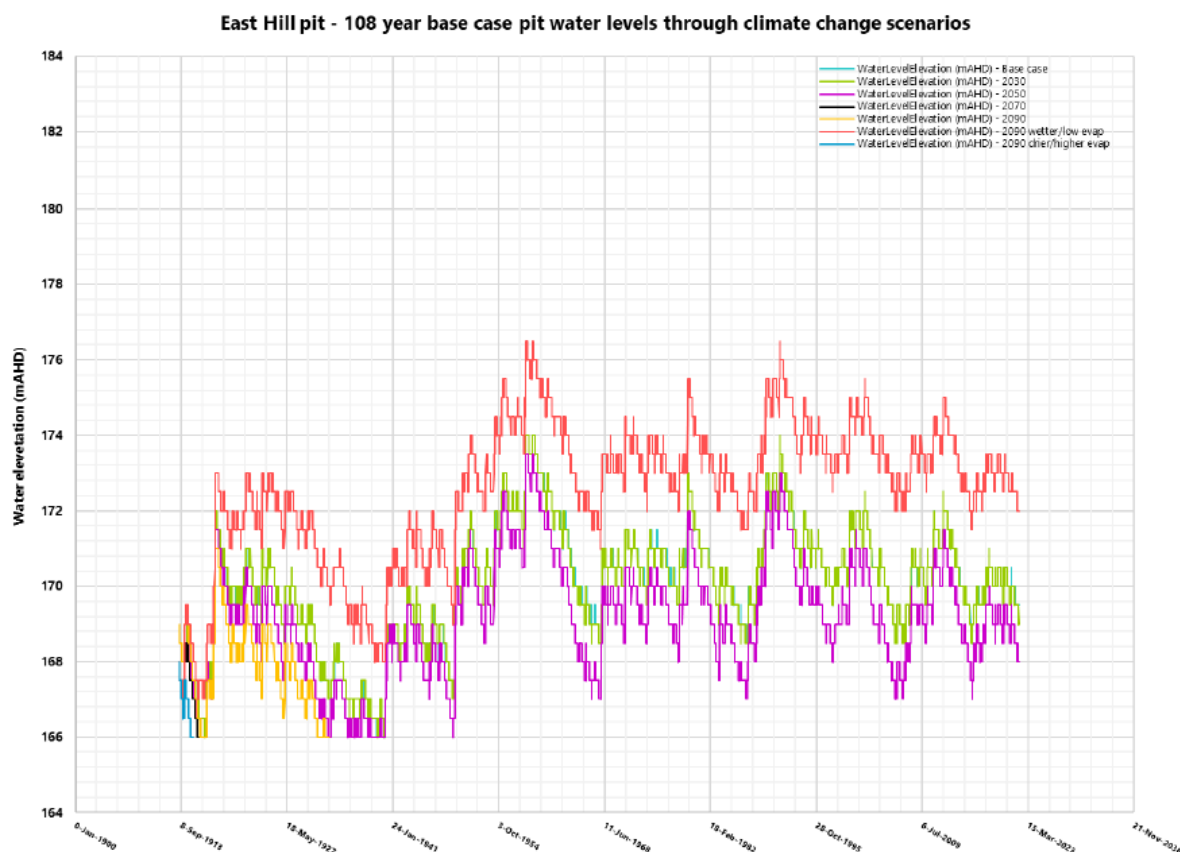


Figure 46: East Hill Pit void model outcomes under climate change scenarios (SBE 2022)

Void water quality and potential for stratification

Pit lake stratification occurs where vertical layering of the water column develops, based on physical or chemical factors, such as temperature or salinity (SBE 2022). Stratification can influence the state of safety and health of the pit lake, for example, in oxygenation of water, or if gases are produced.

As part of the established water monitoring program at Yandan, water samples are collected from two locations within Main Pit using a Van Dorn water sampler, with samples collected at 5 m depth intervals. This monitoring has collected stratigraphic water quality data since 2011.

Review of Main Pit water quality data indicates complete mixing of the water column across all parameters, with river and groundwater inflows resulting in increased oxygenation and mixing of waters (SBE 2022). Wind is present throughout the year across the pit lake surface, and there are strong temperature differentials throughout the year, creating conditions conducive to mixing and oxygenation of the water column (SBE 2022). Any future potential of stratification of Main Pit waters is considered unlikely (SBE 2022).

Given the minimal water storage of East Hill Pit (being only a few metres), the pit water is not conducive to the development of thermoclines or the development of density gradients (SBE 2022).

3.5.12.4 Built Infrastructure

The rehabilitation strategy for the built infrastructure areas is summarised below:

- tracks and roads – the established roads and tracks will remain post-closure as part of the agreement with the landowner;
- airstrip – the existing airstrip will also remain post-closure as part of the agreement with the landowner;

- portable buildings – any portable buildings that exist on-site upon completion of mining operations and rehabilitation activities will be removed, including any mechanical and electrical connections, and transported off-site; and
- concrete pads - concrete pads will be removed and disposed of on-site.

The exposed areas remaining after infrastructure removal will undergo a Phase 1 contaminated land assessment to ensure contaminants, if any, are identified and removed. The area will then be graded and seeded using pasture species, with fertiliser applied as required.

3.5.12.5 Water storage structures

Water storages to be retained in the final landform are the Water Storage Dam and Mine Water Dam. Following closure, both facilities are to be cleaned (desilted) and made safe for use by the landholder, as per the existing landholder agreement. Rehabilitation activities will be completed during the dry season as far as practicable. It is noted that the site water balance is in a net-deficit water balance position (Straits Gold 2008), as such it is likely that dewatering requirements will be minimal.

Prior to transfer to the landholder, the following rehabilitation activities will be completed for the dams:

- As required, water will be transferred on-site to other available water storage structures;
- Spoil will be removed from the drained dam footprint;
- As required, minor earthworks to make the dam structurally safe and stable; and
- Additionally, a small section of the dam wall of the Water Storage Dam will be directly seeded.

3.5.13 Water management

3.5.13.1 Operational water management

Ongoing water management at Yandan is undertaken as per the Water Management Plan (WMP) (AARC 2021b). The Yandan water management system focuses on passive management, noting that the site is currently in an extended period of care and maintenance. Active water management is required only occasionally, with many of the water storages being seasonally dry as a result of the site's net-deficit water balance (Straits Gold 2008).

GBM Resources have actively maintained the water storage network with the objective of reactivating these facilities as needed to support site activities. As such, no rehabilitation of water structures has occurred with this planned for closure. The voids associated with Main Pit and East Hill Pit are to remain as NUMAs in the final landform (Section 3.4).

The current water management system involves a network of containment dams for the capture and management of mine affected water on-site, with mainly passive mechanisms (e.g. spillways) facilitating any potential release to other water storages within the site water management system. The water management system provides for the transfer of water between water storages to maximise available storage capacity where it is needed. Water inventories within the water management system are generally low, minimising the potential for releases from site.

Details of the water management network are provided in Table 29.

Table 29: Yandan water storage structures

Water storage	Volume (ML)	Description	Regulated structure?	Retained post-closure
Yandan Tailings Dam	9,000	Tailings storage facility (comprises Cell A and Cell B)	No	No
Tailings Water Return Dam	381	Catches runoff from the Yandan Tailings Dam	Yes – ‘low’ rating for both ‘failure to contain – overtopping’ and ‘dam break’ failure modes (PSM 2021b)	No
Mine Water Dam	370	Process water storage	Yes – ‘low’ rating for both ‘failure to contain – overtopping’ and ‘dam break’ failure modes (PSM 2021b)	Yes
East Hill Pit	50	Open cut mining void	Yes – ‘low’ rating for ‘failure to contain – overtopping’; ‘dam break’ failure mode not applicable	Yes
Heap Leach Stormwater Pond	55	Receives discharge from the Pregnant Pond and Barren Pond	Yes – ‘low’ rating for both ‘failure to contain – overtopping’ and ‘dam break’ failure modes (PSM 2021b)	No
Water Storage Dam	1,371	Raw water storage	No	Yes
Main Pit	2,800	Open cut mining void	No	Yes
Pregnant Pond and Barren Pond	5.5	During operation were used to treat leachate from the Heap Leach Pad	No	No
Water Harvest Trench / Channel	17	Channels any discharge received from the Mine Water Dam during significant rainfall events towards to the Suttor River. Also used for harvesting water from the Suttor River	No	No

3.5.13.2 Long term water management and closure planning

As part of site closure planning, SBE completed a technical evaluation of water performance to identify potential risks to rehabilitation outcomes and to inform rehabilitation processes (SBE 2022). Important water management considerations for site closure relate to the Yandan Tailings Dam, Heap Leach Pad and the residual voids (Main Pit and East Hill Pit).

Observations and recommendations made from this assessment are summarised below.

Tailings

Material characterisation assessments have identified that potential water quality threats associated with the tailings material relate to salinity, sulphate, mercury, arsenic, copper, zinc, manganese, chromium, antimony and cobalt (SBE 2022). Monitoring records for surface waters and groundwater associated with the Yandan Tailings Dam are available from 2012–2022, with key findings summarised in Table 30.

A review of water quality data identified the following (SBE 2022):

- Tailings impacts are characterised by low-risk saline drainage and not acid rock processes (either pH or sulphate). Sulphate may be elevated; however, levels have been stable for some time which indicates that the production of sulphate has reduced (Figure 47).
- The primary mobile metals of interest are arsenic, cadmium, copper, nickel, zinc (mobile at neutral to alkaline pH). Most metals were not detected, with the minor exception of arsenic values at monitoring bore 'TD4'. It is considered likely that this bore is monitoring water in direct contact with tailings, noting this bore is positioned close to a ponding area of Cell A and directly adjacent to the facility.
- Downgradient monitoring bores demonstrate containment of potential impacts is effective: in surface water, the TWRD is capturing surface water runoff. Whilst there may be some quality concerns for perimeter monitoring bores, these impacts are likely to be limited by topography and geology.
- The current landform of the TSF captures and stores water on the facility, which maximises infiltration and percolation of water through stored tailings: the final landform design should seek to avoid this.
- Groundwater bores on the perimeter of the TSF are generally located in borrow pits and in close proximity to the facility and are therefore likely to be directly monitoring tailings water (Figure 48, Figure 49). Likewise, monitoring bore 'TD6S/D' as an upgradient bore is further away, but at a much lower relative level and therefore will be in a direct area of the potentiometric surface.

Table 30: Summary of surface water and groundwater quality trends for the Yandan Tailings Dam

Parameter	Groundwater	Surface storage
pH	Stable and within normal ranges	Varies with rainfall for both TRD1/3 (dam downgradient) and TDP (dam upgradient), approaching pH 10
Salinity (EC)	Elevated in TD4 to 25,000 $\mu\text{S}/\text{cm}$ (north Cell A), TDS (prior to breakdown) at 15,000 $\mu\text{S}/\text{cm}$ (north Cell B), TD6S/D (upstream) at 35,000 $\mu\text{S}/\text{cm}$, and stable downgradient at 1,000 $\mu\text{S}/\text{cm}$ at TD3 and TD7 D/S well within background	<5,000 $\mu\text{S}/\text{cm}$ for all sites, TRD1 varies with rainfall, likely TDS through dilution with freshwater
Sulphate	All relatively stable at 1,000 mg/L or less, except for TD6S/D (upgradient) at 1,400 mg/L	Peaks at TRD1 after rainfall, <5,000 mg/L. Either dilution or pulse driven through rainfall (not tested at TDP)
Arsenic	All stable to not detected except for TD4, which is on an increasing trend	Peaks at low levels associated with rainfall or lack of rainfall
Antimony	Not currently monitored	Not tested.
Cadmium	Not detected to detection limit	Peaks associated with rainfall above compliance
Chromium	Not detected to detection limit	Single sampling event (not detected)
Cobalt	Not currently monitored	Not currently monitored
Copper	Not detected to detection limit	Peaks at low levels associated with rainfall
Cyanide	Not detected	Not detected
Lead	Not detected to detection limit	Not detected to detection limit
Manganese	Single sampling event	Single sampling event
Mercury	Not detected	Not detected
Molybdenum	Not detected to detection limit	Not currently monitored

Parameter	Groundwater	Surface storage
Nickel	Single sampling event	Peaks at low levels associated with rainfall
Selenium	Not detected to detection limit	Not currently monitored
Zinc	Not detected to detection limit	Peaks at low levels associated with rainfall

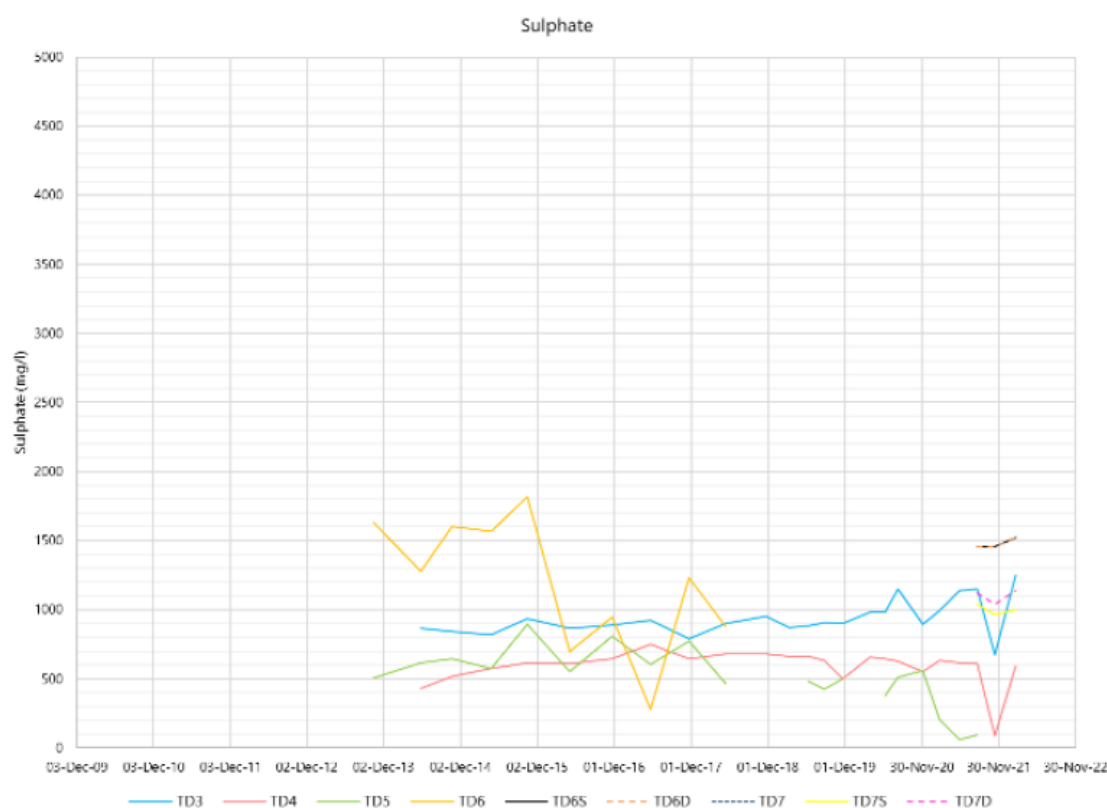


Figure 47: Groundwater sulphate concentrations (2013–2021) (SBE 2022)

Important water management considerations for the rehabilitation of the Yandan Tailings Dam relate to installation of a water-shedding cover design and enhanced groundwater monitoring (SBE 2022).

As discussed in Section 3.5.11.1, installation of an enhanced store-and-release cover design is proposed for Cell B of the Yandan Tailings Dam, with the enhanced component of this system associated with a low permeability layer to limit net percolation into the tailings (Williams 2021). As identified above, the current landform is incidentally capturing water on the facility and thus promoting water infiltration to the tailings. To reduce water interaction with the tailings, the installed cover system will be designed to be water-shedding; so that water flow is managed across the surface of the facility (SBE 2022). To further prevent interaction of water with tailings, borrow pits on the perimeter of the facility will be regraded to prevent water ponding against the TSF embankments.

Additional groundwater monitoring bores are proposed to be installed following rehabilitation works, setback from the facility to provide for monitoring of groundwater outside of the facility (SBE 2022). The additional monitoring bores will be established on the north, south and eastern sides of the TSF, and will function as 'life of mine' monitoring bores for closure criteria monitoring (SBE 2022).

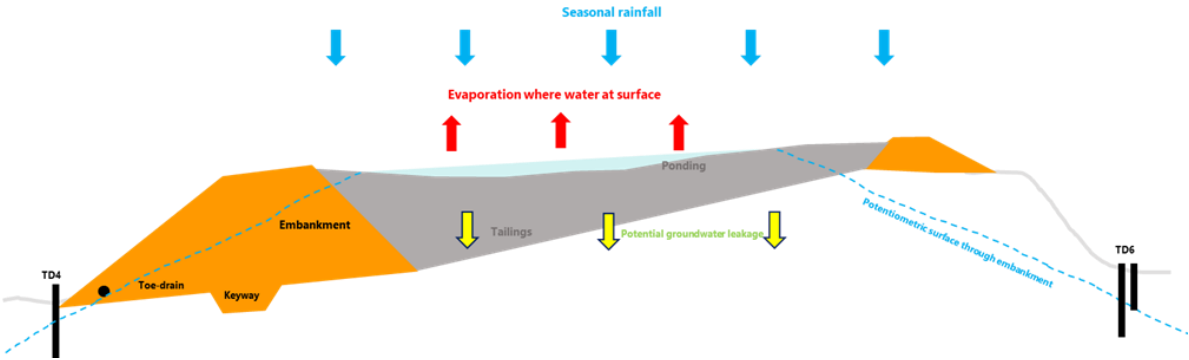


Figure 48: Conceptual model of Yandan Tailings Dam (SBE 2022)

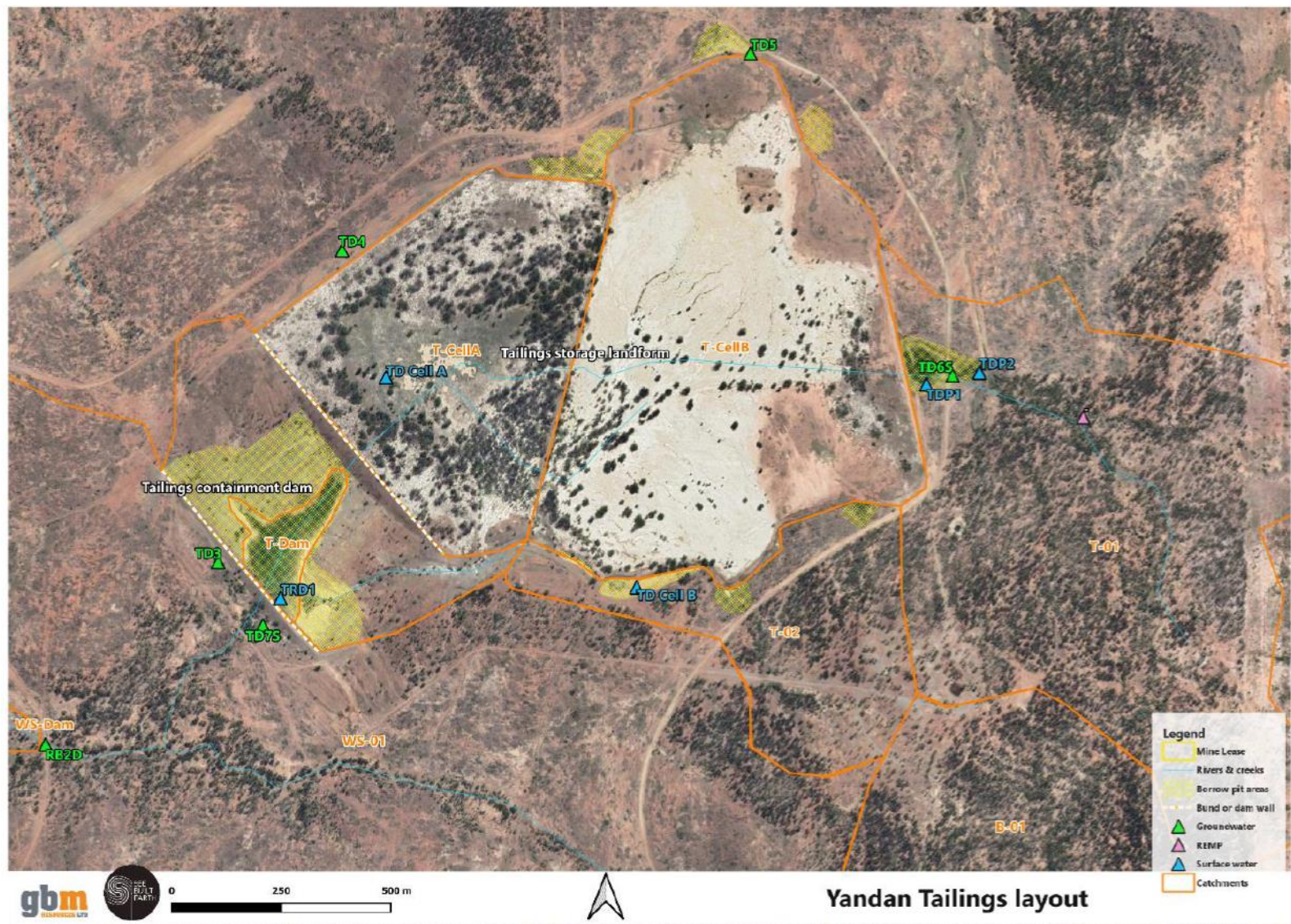


Figure 49: Yandan Tailings dam domain (SBE 2022)

Heap Leach Pad

The legacy Heap Leach Pad is constructed at the top of a hill and above the 1% AEP flood levels to direct water flow downgradient (SBE 2022)(Figure 50). During construction and operation, the leaching process involved the application of lime within the facility, and cyanide to liberate the fine gold. The process of leaching works on the principal of infiltration of the landform, spraying a low cyanide concentration water across the facility, which percolates through the ore to be captured as leachate by the HDPE liner for subsequent processing and gold recovery.

The Heap Leach Pad drains from north to south with a perimeter capture drain directing flows towards a remnant leach collection pond area and stormwater capture dam (SBE 2022). A bund wall lays further to the south of the stormwater capture dam (i.e. the Heap Leach Stormwater Pond) as a secondary precaution for any overland flow. Groundwater monitoring is provided by six shallow monitoring bores around the perimeter of the facility (Figure 51).

Materials characterisation identified the heap leach material as non-acid forming, with some potential for saline runoff, as well as the potential to increase calcium, sulphate, chloride and sodium runoff given the extent of lime addition through the heap leach. Metals of interest include arsenic, mercury, antimony, silver, lead and selenium (SBE 2022).

Monitoring records for surface waters and groundwater associated with the Heap Leach Pad are available from 2011; the key findings are (SBE 2022):

- Potential impacts are characterised by low-risk saline drainage, not acid rock processes (either pH or sulphate). Sulphate may be elevated; however, levels are stable and likely indicate that the rate of sulphate production has reduced.
- The landform has been actively draining since operations ceased (approximately 20 years ago), groundwater is likely to continue to improve in quality over time. The current form of the heap leach actively sheds water effectively, though some sedimentation of the perimeter drains may not keep all surface runoff water within the heap leach catchment during periods of heavy rainfall.
- The primary mobile metals of interest are arsenic, and potentially copper and zinc. Mobility in arsenic is localised to monitoring bore 'HL6' on the north eastern extent, and is demonstrating a decreasing trend.
- Downgradient monitoring bore 'HL3' shows elevated salinity but limited impacts from other contaminants and is potentially useful as an indicator of overall risk and impact.
- Leakage from the leach ponds is likely contributing to elevated conductivity and sulphate in the groundwater of monitoring bore 'HL1', with quality likely reflecting remnant quality from within and around the ponds.

The rehabilitation approach for the Heap Leach Pad includes landform development (principally focusing on slope reduction and stabilisation) and installation of a store-and-release cover system. In regard to water management considerations, the leach ponds will be fully rehabilitated and integrated into the final landform. Additional groundwater monitoring bores downgradient of existing monitoring bores 'HL1' and 'HL3' will be installed to provide for closure monitoring.

As identified through the flood assessment (Section 3.5.9) in the extremely rare scenario of a PMF event there is potential for 0–1 m of floodwaters through part of the Heap Leach Pad domain. Given the relatively low flood levels predicted in this scenario, it is anticipated that flood water velocities would be sufficiently low to not warrant additional protection to the base of the Heap Leach Pad.



Figure 50: View of Heap Leach Pad (SBE 2022)

Table 31: Summary of water quality trends for Heap Leach Pad surface water and groundwater (SBE 2022)

Parameter	Groundwater	Surface storage
pH	Stable and within normal ranges	Stable and within normal ranges
Salinity (EC)	HL1 and HL3 at 15,000 $\mu\text{S}/\text{cm}$	Typically approximately 20,000 $\mu\text{S}/\text{cm}$
Sulphate	HL1 approximately 2,500 mg/L, others <1,000 mg/L	Typically around 5,000 mg/L
Arsenic	Stable except for HL6	Leach ponds elevated
Aluminium	Not detected to detection limit	Not detected to detection limit
Cadmium	Not detected to detection limit	Single sampling event
Chromium	Single sampling event	Not currently monitored
Cobalt	Not currently monitored	Not currently monitored
Copper	Not detected to detection limit	Not detected to detection limit
Cyanide	Not detected	Not detected
Lead	Not detected to detection limit	Not detected to detection limit
Manganese	Single sampling event	Single sampling event
Mercury	Not detected	Not detected

Parameter	Groundwater	Surface storage
Molybdenum	Not detected to detection limit	Single sampling event
Nickel	Single sampling event	Not detected to detection limit
Selenium	Not detected to detection limit	Not currently monitored
Zinc	Not detected to detection limit	Not detected to detection limit

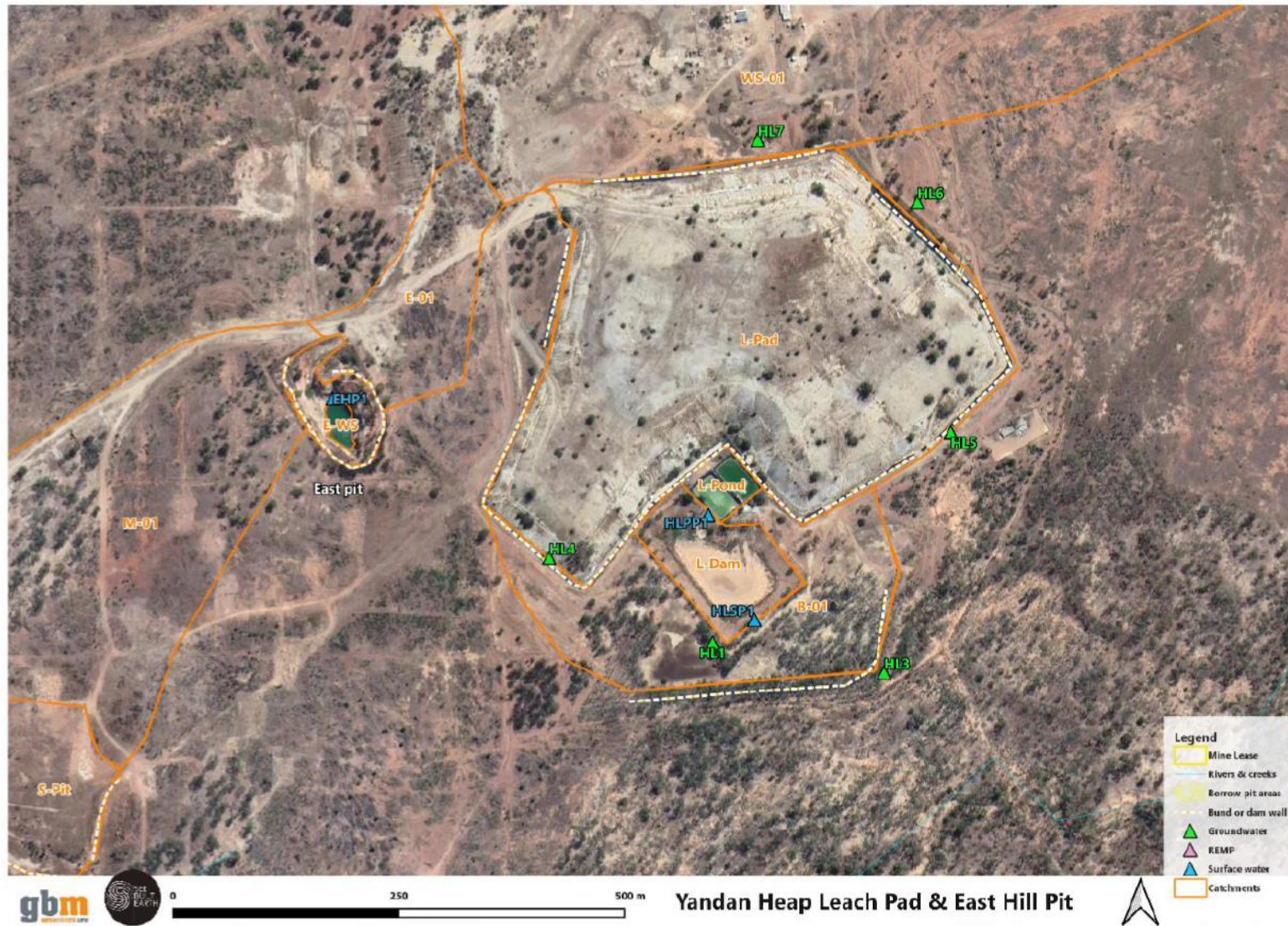


Figure 51: Heap Leach Pad domain (SBE 2022)

Main Pit

As introduced in Section 3.5.9, the rehabilitation strategy for the Main Pit residual void has been to establish a permanent water cover over sulphide materials in the pit walls and floor, based on the principle of a 'flushing pit' design. For this rehabilitation outcome to be successful, the water cover is required to be maintained above 160 mAHd. The permanent water cover was initially established during the 1999/2000 wet season, and has been maintained since.

Main Pit is located in close proximity to the Suttor River and within its floodplain. When the Suttor River reaches a height of 169 mAHd, connectivity between the Suttor River and the pit waters is established, allowing inflows and outflows via the excavated spillways (SBE 2022). There are two ways for water to enter the pit: from the Suttor River when at level >169 mAHd, or from Yandan Creek (to the south) where the borrow pit constructed to the south fills and water flows to the pit (Figure 53)(SBE 2022). To manage water levels within the pit and limit interactions with the Suttor River to appropriate river flows, there are two primary bunds with the following functions (SBE 2022):

- Along the northern catchment of the pit (a relatively clean catchment): to divert river flow around the pit to the Suttor River without interaction with pit waters. This bund is required to ensure pit water levels do not increase dramatically due to flow from the catchment without ensuring appropriate flow in the Suttor River. This enables mixing of river water with pit water to increase the dilution of pit release waters and protect the receiving environment water quality.
- Along the western extent (between the pit and the Suttor River): to hold a short head of water within the pit and manage flow by the constructed spillways.

Review of Main Pit water quality monitoring (including stratification sampling) indicates that pit waters are of neutral pH, consistent temperature, low salinity (350 $\mu\text{S}/\text{cm}$), and with low sulphate levels (<100 mg/L) (SBE 2022) (Table 32). As a water body, it is lower in dissolved oxygen than for a healthy lake environment, and similar to other parts of the site, elevated arsenic occurs (Figure 52), with trace copper and zinc (though at trace levels) (SBE 2022).

Table 32: Summary of water quality trends for Main Pit in-pit water and receiving environment (SBE 2022)

Parameter	Pit water	Receiving environment
pH	Stable and average	Stable and within normal ranges
Temperature	Stable and average	
Sulphate	<100 mg/L	<50mg/L
Electrical conductivity	<350 $\mu\text{S}/\text{cm}$	1300 and <200 $\mu\text{S}/\text{cm}$
Dissolved oxygen	10 mg/L	N/A
Arsenic	Elevated <0.07 mg/L	Not detected to detection limit
Cadmium	Not detected to detection limit	Not detected to detection limit
Copper	Elevated to trace levels	Not detected to detection limit
Lead	Not detected to detection limit	Not detected
Mercury	Not detected	Not detected
Molybdenum	Not detected to detection limit	Not detected
Selenium	Not detected to detection limit	Not detected
Zinc	Elevated to trace levels	Not detected to detection limit

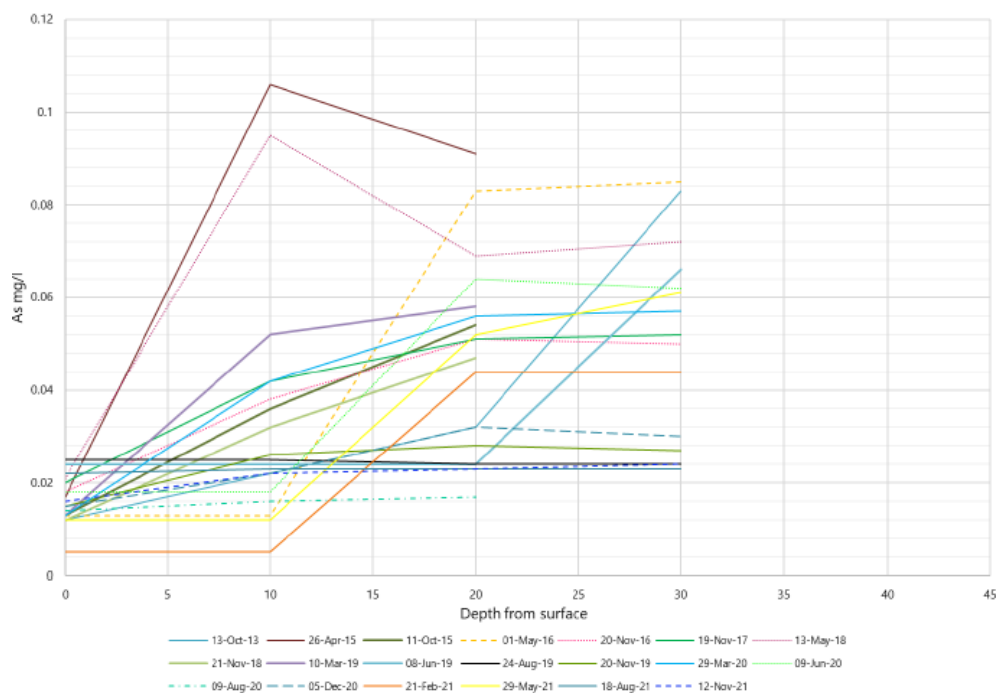


Figure 52: Main Pit arsenic concentrations with depth at 'MP1' (SBE 2022)

Given the existing pit water quality, minimal mixing is required with site or river water to meet receiving environment requirements (SBE 2022). Recent releases (2011 and 2017) were successful, with samples taken at release points and downstream demonstrating compliance with no impact on the environment (SBE 2022).

Water quality monitoring of pit water and the receiving environment demonstrate the success of the flushing pit rehabilitation approach applied to Main Pit. It is considered that the water cover has successfully managed the risk of materials exposure in the pit, while being relatively self-sustaining and suitable as a long-term strategy (SBE 2022). Given the success of this rehabilitation approach, the water cover is proposed to be maintained post-closure.

For final closure, the existing permanent water cover and flushing pit design will be maintained using bunds. Additional monitoring infrastructure (monitoring bores around the Main Pit and a pit water level gauge) will be installed to obtain groundwater information and assist water balance modelling. As additional data becomes available, a review of the Yandan Creek diversion will be completed to determine whether this structure requires further engineering for the longer term, as well as inform on the long-term requirement of the bund (SBE 2022).

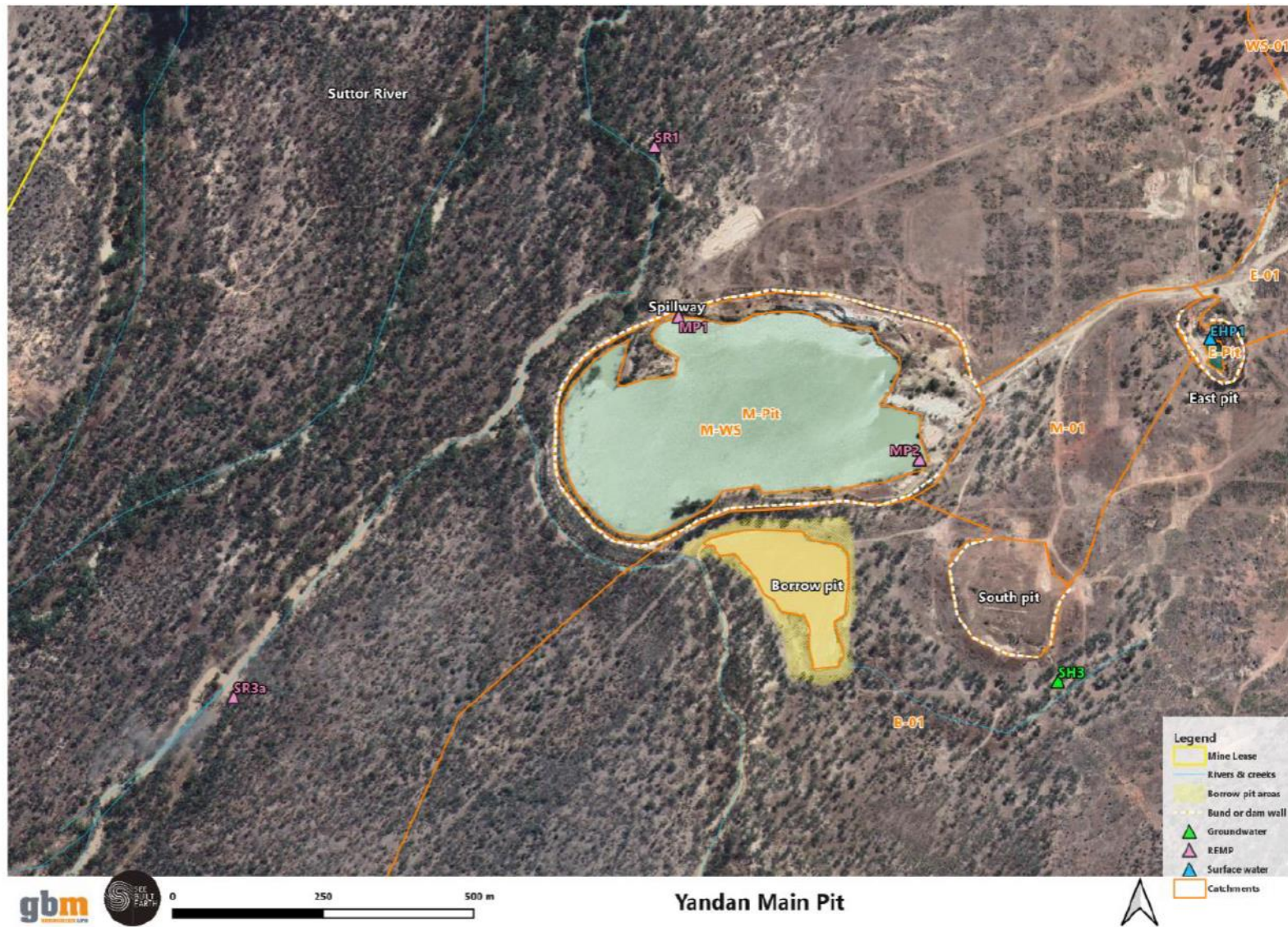


Figure 53: Main Pit domain (SBE 2022)

East Hill Pit

East Hill Pit is a small open cut pit with a limited footprint of only 0.9 ha, with pit walls reaching approximately 20 m above a small pit lake (Figure 55). The surface catchment reporting to East Hill Pit is 2.9 ha (refer to Section 3.1.5).

A small volume of poor quality water has accumulated in the base of East Hill Pit. Water monitoring results indicate this water has stabilised around pH 4 since 2011. Over time, electrical conductivity and sulphate concentrations have increased and are now approximately 20,000 $\mu\text{S}/\text{cm}$ and 5,000 mg/L, respectively (SBE 2022). Materials characterisation assessments have identified that arsenic, copper, nickel and zinc exist as potentially mobile metals. No mercury or cyanide has been detected (SBE 2022).

As identified through water quality monitoring, East Hill Pit has developed a small reactive, acid pit lake with indications of increasing salts and metal loads (SBE 2022) (Figure 54). In terms of managing the pit water quality post closure, the following options have been recommended by SBE (2022):

- leave the pit as a restricted area for closure; and
- filling or partial filling of the pit to reduce exposure to reactive materials or change landform.

This aligns with site plans to complete a partial backfill of East Hill Pit, whilst ultimately maintaining it as a residual void in the final landform.

Further rehabilitation is also planned for East Hill to mitigate flood risk. As noted in Section 3.5.9, there is potential for floodwaters to enter East Hill Pit during an extremely rare flood event (i.e. a PMF event). The lowest point of East Hill Pit is 183 m AHD, presenting some opportunity for floodwaters to flow around the pit and enter from the north during a PMF event (SBE 2022). To prevent this scenario, a small permanent landform bund will be constructed around the north of the pit.

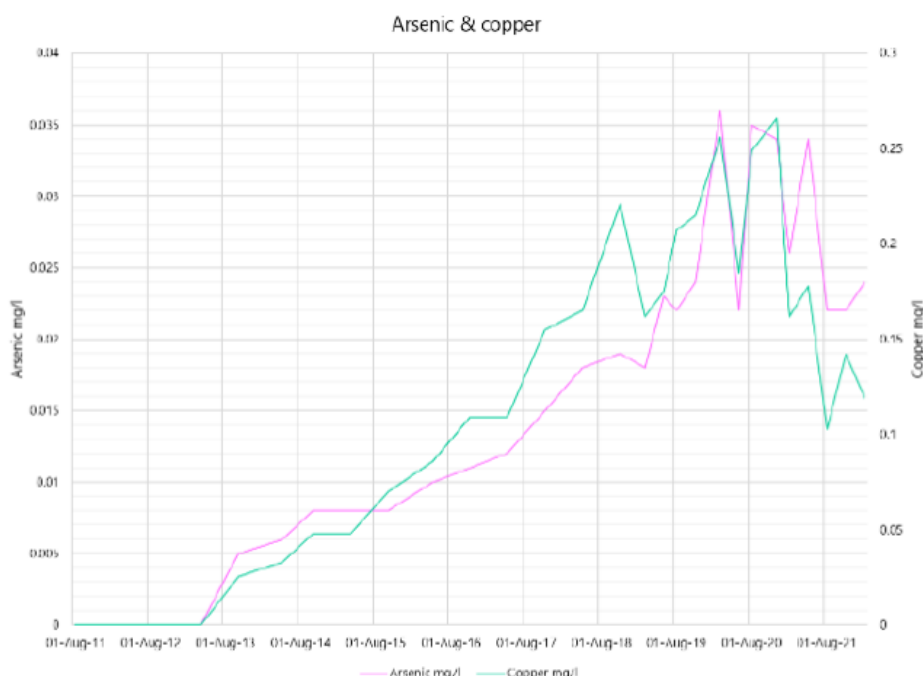


Figure 54: Arsenic and copper concentrations in East Hill Pit water (SBE 2022)



Figure 55: East Hill Pit domain (SBE 2022)

Retained water storage dams

The Water Storage Dam and the Mine Water Dam are to be retained in the final landform to support the open pasture – grazing PMLU. Prior to landholder use, these dams will be cleaned (silt removed) and minor earthworks completed to make the dams structurally safe and stable. If required, the water would be treated to ensure this meets relevant stock watering guidelines. Follow-up testing will be undertaken for a period to ensure the continued suitability of the water for livestock.

3.5.14 Revegetation

Revegetation of the Project site aims to restore the land to pasture grazing, being the target vegetation type for the ‘open pasture’ and ‘low hill’ PMLUs. Revegetated areas will be developed to form vegetation cover and species that are comparable to the surrounding area, with no greater management input than for surrounding areas of the same use of low intensity cattle grazing. The methodology to achieve the target vegetation for the PMLUs is described in the below section.

3.5.14.1 Flora species selection

Flora species to be used in revegetating the Project include a mix of native and introduced pasture species to achieve the target final land use of low intensity cattle grazing. Flora species to be used for revegetation have been proposed on the basis of baseline ecological assessments and the long-term monitoring results from the RMP, which provides for monitoring of undisturbed areas of the lease. Recommended flora species are listed in Table 33.

It is noted that this list is provisional and is subject to change based on suitability and availability and as new information becomes available from rehabilitation monitoring and research.

Table 33: Recommended species for revegetation

Vegetation type	Target Species
Groundcover	<i>Aristida latifolia</i> (Feathertop wiregrass) (Native) <i>Chloris truncata</i> (Windmill grass) (Native) <i>Dactylon radulans</i> (Button Grass) (Native) <i>Urochloa mosambicensis</i> (Sabi Grass) (Exotic)
Shrub	<i>Carrissa spinarum</i> (Currant Bush) <i>Capparis lasiantha</i> (Nipan) <i>Stylosanthes scabra</i> (Shrubby stylo)
Trees	-

Although ongoing rehabilitation monitoring indicates *Cenchrus ciliaris* (Buffel grass) is the most dominant species at reference sites, this species has not been included in the recommended species list. If not suitably managed, Buffel grass can develop into a thick monoculture, thereby constraining the establishment of other species. Furthermore, it is expected that Buffel grass will naturally repopulate areas from existing seedbanks or future seed dispersal. For this reason, it is recommended that other species are used to encourage greater species diversity.

For large areas that require revegetation, particularly on sloped landforms, a fast-establishing sterile annual cover crop will be included in the seed mix. This cover crop will help rapidly establish ground cover and minimise topsoil loss. This approach will help suppress weed colonisation and aid the re-establishment of

integral biological and nutrient cycling that naturally occur in soil, creating a favourable micro-environment for the germination and emergence of the native seeds. This should also provide a rapid ground cover and assist in achieving soil stabilisation. *Echinochloa esculenta* (Japanese Millet) is intended to be used for summer applications and *Lolium* sp. (Rye Grass) for winter applications. In the transition between seasons, a combination of both species will be used.

3.5.14.2 Method for surface preparation and seeding

Following final landform development, the surface of rehabilitated areas will be prepared for revegetation. This process will involve ripping of the soil surface and subsoil profile to create a rough surface for water retention. Soil health assessments will be completed prior to revegetation to determine requirements for fertiliser or other soil ameliorants.

For project efficiencies, surface preparation and seeding process will occur simultaneously. A dozer will be used to rip the surface, with an air seeder attachment to broadcast the seed mix and fertiliser at the same time. Seed mix will be applied at a rate of 6 kg/ha, with fertiliser applied at 150 kg/ha.

As far as practicable, revegetation will occur during the spring months (September, October and November), and prior to the onset of the wet season.

3.6 Risk assessment

3.6.1 Risk assessment requirements

Section 126C(1)(f) of the EP Act requires the PRCP to identify the risks, for each PMLU, of a stable condition not being achieved and how the applicant intends to manage or minimise the risk.

A risk assessment has been carried out in accordance with the following standards:

- AS/NZS ISO 31000:2018 Risk management - Guidelines; and
- HB203:2012 Managing environment-related risk.

3.6.2 Risk assessment process

Any risk assessment needs to be undertaken with 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:

- identify the risks of a stable condition for land not being achieved for the agreed PMLUs nominated;
- identify the risks of sufficient improvement not being achieved for the agreed NUMAs nominated; and
- identify the approach to be taken by the Project to manage and minimise the risks identified.

For this risk assessment, risk scenarios (or 'threats') were identified and considered for each RA and NUMA associated with the Project. The causes attributable to each risk scenario were documented as well as the potential impacts. Existing controls were noted, defined as those reasonably expected to be in place for a Project of this nature and having appropriate and contemporary management systems. Each risk scenario was then assessed with respect to health, safety, the environment and compliance against the risk assessment schema outlined in section 3.6.3.

3.6.3 Risk assessment schema

Risks specific to the rehabilitation of the Yandan Gold Project were classified using the risk classification schema which is described below. The risk assessment schema used is comparable to those used widely within the mining industry and comprises the following components:

- a control effectiveness ranking (Table 34) used for assessing the operational controls expected to be in place for a project of this type;
- a likelihood classification descriptors table (Table 35); and
- a consequence classification descriptors table (Table 36) intended to guide a consistent assessment of consequence.

Following a consensus determination of likelihood and consequence, the risk level was determined using the matrix shown in Table 37. For any risks classified as 'significant' or above, mitigation and management measures were identified and documented.

Table 34: Control effectiveness ranking

Control Rank	Description	Guidance
C1	Substantially effective/adequate design	Controls considered adequate and operating effectively on almost all occasions
C2	Mostly effective/adequate design	Controls considered adequate and operating effectively on most occasions
C3	Inadequate design/partially effective	Controls are considered inadequately designed or are only operating to partial effectiveness on most occasions
C4	No controls/ineffective	There are no controls designed or the existing controls are operating ineffectively on all occasions

Table 35: Likelihood of exposure to the hazard

	Likelihood				
	Rare	Unlikely	Possible	Likely	Almost certain
Frequency interval (multiple events)	<1/100 years	1/10 – 1/100 years	1/year – 1/10 years	2/year – 1/year	>2/year
Probability (single events)	<0.1%	0.1% – 1%	1% – 10%	10% – 25%	>25%

Table 36: Consequence classification descriptors

Category	Consequence Scale				
	Very low	Low	Moderate	High	Very high

Safety	Low level short term subjective inconvenience or symptoms. First aid treatment.	Reversible injuries requiring treatment but does not lead to restricted duties. Medical treatment.	Reversible injury or moderate irreversible damage or impairment to one or more persons. Lost time injury.	Single fatality and/or severe irreversible damage or severe impairment to one or more persons.	Multiple fatalities or permanent damage to multiple people.
On-site environmental	Near-source confined and promptly reversible impact (typically a shift).	Near-source confined and short-term reversible impact (typically a week).	Near-source confined and medium-term recovery impact (typically a month).	Impact that is unconfined and requiring long-term recovery, leaving residual damage (typically years).	Impact that is widespread unconfined and requiring long-term recovery, leaving major residual damage (typically years).
Off-site environmental	Not applicable.	Near-source confined and promptly reversible impact (typically a shift).	Near-source confined and short-term reversible impact (typically a week).	Near-source confined and medium-term recovery impact (typically a month).	Impact that is unconfined and requiring long-term recovery, leaving residual damage typically years).
Compliance	Non-conformance with internal requirement with very low potential for impact. Non-compliance with community commitment goes unnoticed by external party/parties, requiring minimal effort to correct.	Non-compliance with external or internal requirement with low potential for impact. Formal censure. Non-compliance with community commitment, requiring limited effort to correct.	Non-compliance with internal or external requirement with moderate impact. Moderate penalties for breach of legislation, contract, permit or licence. Non-compliance with community commitment reported formally, with significant effort to correct.	Breach of licence(s), legislation, regulation-high potential for prosecution. Contract breach-significant penalty. Systemic internal standards breach-high impact. Community commitment breach-high potential business impact-significant effort to fix.	Suspended or severely reduced operations imposed by regulators. Breach of community commitment results in direct loss of established consents with widespread secondary effects.

Table 37: Risk level classification matrix

Likelihood	Consequence				
	Very low	Low	Moderate	High	Very High
Almost certain	Class II	Class III	Class IV	Class IV	Class IV

Likely	Class II	Class III	Class III	Class IV	Class IV
Possible	Class I	Class II	Class III	Class IV	Class IV
Unlikely	Class I	Class I	Class II	Class III	Class III
Rare	Class I	Class I	Class II	Class III	Class III

3.6.4 Risk assessment outcomes and management

Detailed risk assessment outcomes are provided in Appendix F. For this Project, a total of 82 individual risk assessment scenarios were identified resulting in no risk scenarios classified as 'Class IV', 10 risk scenarios classified as 'Class III', 57 classified as 'Class II', and the remainder (15) classified as 'Class I'. A summary of the risk outcomes is shown in Table 38.

Table 38: Risk assessment outcomes by risk category

Risk category	Risk level				
	Class I	Class II	Class III	Class IV	Total
Heap leach pad	4	4	3	0	11
Tailings storage facility (Cell A)	1	5	2	0	8
Tailings storage facility (Cell B)	2	6	0	0	8
Retained infrastructure	1	2	0	0	3
Retained water storages	1	4	0	0	5
Built infrastructure areas	2	5	0	0	7
Rehabilitated water management structures	1	5	0	0	6
ROM pad	1	5	3	0	9
Main pit bund	1	5	2	0	8
South pit (backfilled)	1	7	0	0	8
Final voids (NUMAs)	0	9	0	0	9
Total	15	57	10	0	82

The risk scenarios classified as 'Class III' were associated with the risk of erosion on rehabilitated landforms with steeper slopes. Management measures identified as appropriate for lowering this risk include:

- landform design to moderate slopes;
- good topsoil management practices;
- adequate and effective soil amelioration;
- surface grading and shaping;
- the application of rock mulch;
- prompt revegetation; and
- revegetation monitoring and maintenance as required.

3.7 Monitoring and maintenance

For the purposes of developing the PRCP Schedule, twelve rehabilitation milestones (RM) and three management (MM) milestones have been proposed as being applicable for the Project. The PRCP Guideline (DES 2021) requires consideration of measures to be undertaken to demonstrate that milestones and milestone criteria have been achieved.

With respect to determining the achievement of rehabilitation and management milestones, completion criteria and corresponding indicators have been developed for each RM and MM (Section 3.5.5). Assessment of rehabilitation and improvement areas against completion criteria will be incorporated into the Projects' ongoing environmental management. Assessment of rehabilitation areas against the completion criteria that pertain to vegetation and achievement of post mining land uses will be undertaken as part of the annual Rehabilitation Monitoring Program that exists for the Project.

Table 39 and Table 40 provides a summary of the measures to be undertaken with respect to determining the achievement of each rehabilitation milestone and management milestone, respectively. Determination of the boundary of an area reaching a given milestone at a given point in time, will be done with standard survey techniques, including land based survey and airborne survey at an appropriate frequency – nominally annually – to achieve satisfactory geolocation of areas.

Table 39: Rehabilitation milestones - management and monitoring measures

Rehabilitation milestone	Description / criteria	Proposed management/ monitoring measure(s)
RM1: Infrastructure decommissioning and removal	Applicable to all RAs. Applicable to all infrastructure identified to be decommissioned/ disposed of. Considered to be met when the area can be transitioned to RM2, RM3, RM4, RM9, RM11 or RM12, where applicable.	Infrastructure decommissioned/ disposed at closure will be subject to strict environment and safety planning requirements including completion inspections.
RM2: Remediation of contaminated land (where required)	Applicable to RA1, RA2 and RA4. This milestone is applicable to any areas where notifiable activities have been carried out and involves as a minimum the completion of a phase 1 contaminated land investigation undertaken by an appropriately qualified person. Where required, remediation activities will be undertaken and recorded, and notifications completed.	A completed phase 1 contaminated land investigation report, as well as any consequent reports where required.

Rehabilitation milestone	Description / criteria	Proposed management/ monitoring measure(s)
RM3: Landform development of infrastructure areas	Applicable to RA4, RA5 and RA7. Considered to be met when all bulk earthworks are completed, and former infrastructure area is assessed as geotechnically stable by a suitably qualified person. Areas can transition to RM7 where applicable.	Regular meetings (at least six monthly) will be held between the mining contractor and the GBM mining and environment team to track the progress of areas subject to this activity within the Schedule. Survey of completed areas.
RM4: Landform development of rehabilitated water management structures	Applicable to RA3. Includes bulk earthworks and water drainage lines reinstated. For dams, considered to be met when dams are cleaned and assessed as geotechnically stable by an appropriately qualified person. For Main Pit bund, considered to be met when assessed as not being a regulated structure; certified design plan for the bund is developed and approved by the administering authority; all subsequent earthworks are completed as per the approved design plan, as required; and assessed as geotechnically stable by an appropriately qualified person. Area can transition to RM7 when applicable.	Regular meetings (at least six monthly) will be held between the mining contractor and the GBM mining and environment team to track the progress of areas subject to this activity within the Schedule. Survey of completed areas.
RM5: Landform development of TSF Cell B	Applicable to RA1. Considered to be met when all bulk earthworks completed and cover system is installed; area is assessed as geotechnically stable by an appropriately qualified person; and assessment by an appropriately qualified person confirms cover system is functioning as designed and there is no migration of contaminants. Area can transition to RM7 when applicable.	Land based survey techniques will be implemented to confirm that specified design for RA1 has been met. Additionally, visual inspection determines if any future maintenance/repair action is required.
RM6: Landform development of Heap Leach Pad	Applicable to RA2. Considered to be met when all bulk earthworks completed and cover system is installed; area is assessed as geotechnically stable by an appropriately qualified person; and assessment by an appropriately qualified person confirms cover system is functioning as designed and there is no migration of contaminants. Area can transition to RM7 when applicable.	Land based survey techniques will be implemented to confirm that specified design for RA2 has been met. Additionally, visual inspection determines if any future maintenance/repair action is required.
RM7: Surface preparation	Applicable to RA1, RA2, RA3, RA4, RA7. Includes final profiling and application of topsoil or alternative topdressing materials as required; soil health assessment for determination of ameliorant requirements;	Regular meetings (at least six monthly) will be held including the mining contractor and the GBM mining and environment teams to track the progress of areas subject to this activity within the mine plan.

Rehabilitation milestone	Description / criteria	Proposed management/ monitoring measure(s)
	application of final surface amelioration and/or preparation activities. Areas can transition to RM8 when applicable.	Survey of completed areas.
RM8: Revegetation	Applicable to RA1, RA2, RA3, RA4, RA5, RA7. Revegetation of prepared areas (RM7) as outlined in Section 3.5.14. Areas can transition to RM9 when applicable.	Regular meetings (at an appropriate frequency) will be held including the mining contractor and the GBM mining and environment teams to plan revegetation activities with consideration of the areas available for revegetation and weather conditions. Survey of completed areas, and record of revegetation method retained.
RM9: Achievement of surface requirements (open pasture – grazing and low hill – pasture grazing)	Applicable to RA1, RA2, RA3, RA4, RA5, RA6, RA7, RA9. Revegetated areas to be assessed against ground cover and stability related completion criteria (refer Section 3.5.5). Areas can transition to RM10 when applicable.	Regular meetings (at an appropriate frequency) will be held to track progress towards the achievement of surface requirements. Ongoing rehabilitation activities to manage and achieve successful revegetation will include, as required: • repair of erosion prone areas; • application of hay mulching (or similar technique) to control erosion at the early stages of seeding (window of erosional risk); • weed management and control; and • re-seeding and/or additional planting when required. Erosion monitoring to identify and control severe or extreme rill and gully erosion as defined in Section 3.5.5. Field survey monitoring will be supplemented with remote sensing to improve data analysis and provide a more accurate measures to determine if rehabilitation objectives are being met.
RM10: Achievement of target post mining land use (open pasture – grazing and Low hill – pasture grazing)	Applicable to RA1, RA2, RA3, RA4, RA5, RA6, RA7. Revegetated areas to be assessed against all completion criteria developed with reference to analogue sites of similar characteristics and land use (refer Section 3.5.5). Considered to be met when land is able to be transitioned to progressive certification.	Field surveys, drone and satellite data analysis as part of the annual rehabilitation monitoring. The following assessments will be undertaken to demonstrate that the land has achieved RM10: • closure post-mining soil and land suitability assessments; • vegetation, erosion and weed assessments to be provided in a final rehabilitation report; • hazards, safety and stability assessment completed; and • written agreement obtained from the land owner/holder and administering authority that rehabilitation is successful.
RM11: Achievement of	Applicable to RA8.	A hazards, safety and stability assessment is to be done for all retained water structures.

Rehabilitation milestone	Description / criteria	Proposed management/ monitoring measure(s)
target post-mining land use (retained water storages)	Considered to be met when the area is rehabilitated to be safe, stable and non-polluting as per the completion criteria in Section 3.5.5.	Retained storage water quality is to achieve ANZECC guidelines for water quality objectives for livestock drinking water.
RM12: Achievement of target post-mining land use (retained infrastructure)	Applicable to RA9. Considered to be met when the area is rehabilitated to be safe, stable and non-polluting as per the completion criteria in Section 3.5.5.	A hazards, safety and stability assessment is to be done for all retained infrastructure.

Table 40: Management milestones - management and monitoring measures

Management milestone	Description / criteria	Proposed management/ monitoring measure(s)
MM1: Achievement of final landform design	Improvement areas to be assessed against the landform design completion criteria developed for voids in Section 3.5.5. Considered to be met when void batter slopes are within the nominated target slope range and confirmation that voids act as groundwater sinks.	Regular meetings (at least six monthly) will be held between the mining contractor and the GBM mining and environment team to track the progress of areas subject to this activity within the schedule. Land based survey techniques will be implemented to confirm that specified batter and graded slopes have met design specifications Geotechnical modelling and hydrogeological survey of completed areas by suitably qualified persons.
MM2: Achievement of surface requirements	Bunding and safety warning signage erected around perimeter of each void. Considered to be met when voids are inaccessible	Regular meetings (at least six monthly) will be held between the mining contractor and the GBM mining and environment team to track the progress of areas subject to this activity within the schedule. Visual inspection and land based survey around perimeter of all voids.
MM3: Achievement of sufficient improvement	Improvement areas to be assessed against the landform design completion criteria developed for voids. Considered to be met when improvement areas can be transitioned to progressive certification.	Survey of completed areas. Geotechnical modelling and hydrogeological survey of completed areas by suitably qualified persons.

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Appendix A. PRCP Schedule

Post-mining land uses (PMLU)										
Rehabilitation area	RA1									
Relevant activities	TSF Cell B									
Total rehabilitation area size (ha)	62.4									
Commencement of first milestone: RM1	10/12/2035									
PMLU	Open pasture - grazing									
Date area is available	10/12/35									
Cumulative area available (ha)	62.4									
Milestone completed by	10/12/37	10/12/44	10/12/54	10/12/64						
Milestone Reference	Cumulative area achieved (ha)									
RM1	62.4									
RM2	62.4									
RM5		62.4								
RM7		62.4								
RM8		62.4								
RM9			62.4							
RM10				62.4						

- 1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
- 2) Insert new columns to the blue table to match rehabilitation milestone dates.
- 3) Insert new rows to the blue table to include additional rehabilitation milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA2									
Relevant activities	Heap Leach Pad and associated ponds									
Total rehabilitation area size (ha)	21									
Commencement of first milestone: RM1	10/12/2035									
PMLU	Low hill - pasture grazing									
Date area is available	10/12/35									
Cumulative area available (ha)	21									
Milestone completed by	10/12/37	10/12/45	10/12/55	10/12/65						
Milestone Reference	Cumulative area achieved (ha)									
RM1	21									
RM2	21									
RM6		21								
RM7		21								
RM8		21								
RM9			21							
RM10				21						

- 1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
- 2) Insert new columns to the blue table to match rehabilitation milestone dates.
- 3) Insert new rows to the blue table to include additional rehabilitation milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA3									
Relevant activities	Rehabilitated water management structures									
Total rehabilitation area size (ha)	24.8									
Commencement of first milestone: RM1	10/12/2045									
PMLU	Open pasture - grazing									
Date area is available	10/12/45									
Cumulative area available (ha)	24.8									
Milestone completed by	10/12/49	10/12/59	10/12/69							
Milestone Reference	Cumulative area achieved (ha)									
RM1	24.8									
RM4	24.8									
RM7	24.8									
RM8	24.8									
RM9		24.8								
RM10			24.8							

- 1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
- 2) Insert new columns to the blue table to match rehabilitation milestone dates.
- 3) Insert new rows to the blue table to include additional rehabilitation milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area		RA4								
Relevant activities		Infrastructure areas								
Total rehabilitation area size (ha)		10.6								
Commencement of first milestone: RM1		10/12/2046								
PMLU		Open pasture - grazing								
Date area is available	10/12/46									
Cumulative area available (ha)	10.6									
Milestone completed by	10/12/51	10/12/61	10/12/71							
Milestone Reference	Cumulative area achieved (ha)									
RM1	10.6									
RM2	10.6									
RM3	10.6									
RM7	10.6									
RM8	10.6									
RM9		10.6								
RM10			10.6							

- 1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
- 2) Insert new columns to the blue table to match rehabilitation milestone dates.
- 3) Insert new rows to the blue table to include additional rehabilitation milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA5									
Relevant activities	Maintenance of existing rehabilitation (South Pit, TSF Cell A, Village infrastructure)									
Total rehabilitation area size (ha)	55.7									
Commencement of first milestone: RM1	Prior to 2022									
PMLU	Open pasture - grazing									
Date area is available	Prior to 2022		10/12/41							
Cumulative area available (ha)	54.4		55.7							
Milestone completed by	Prior to 2022	10/12/40	10/12/45	10/12/50	10/12/55	10/12/65				
Milestone Reference	Cumulative area achieved (ha)									
RM1	54.4		55.7							
RM3	54.4		55.7							
RM7	54.4		55.7							
RM8	54.4		55.7							
RM9		54.4			55.7					
RM10				54.4		55.7				

- 1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
- 2) Insert new columns to the blue table to match rehabilitation milestone dates.
- 3) Insert new rows to the blue table to include additional rehabilitation milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA6									
Relevant activities	ROM Pad									
Total rehabilitation area size (ha)	5.8									
Commencement of first milestone: RM1	10/12/2035									
PMLU	Low hill - pasture grazing									
Date area is available	10/12/35									
Cumulative area available (ha)	5.8									
Milestone completed by	10/12/39	10/12/49	10/12/59							
Milestone Reference	Cumulative area achieved (ha)									
RM1	5.8									
RM3	5.8									
RM7	5.8									
RM8	5.8									
RM9		5.8								
RM10			5.8							

- 1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
- 2) Insert new columns to the blue table to match rehabilitation milestone dates.
- 3) Insert new rows to the blue table to include additional rehabilitation milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA7									
Relevant activities	Other isolated areas of surface disturbance within approved disturbance extent									
Total rehabilitation area size (ha)	90									
Commencement of first milestone: RM1	10/12/2035									
PMLU	Open pasture - grazing									
Date area is available	Prior to 2022	10/12/35		10/12/43						
Cumulative area available (ha)	3.9	22.6		90						
Milestone completed by	Prior to 2022	10/12/39	10/12/40	10/12/47	10/12/49	10/12/2050	10/12/2057	10/12/59	10/12/67	
Milestone Reference	Cumulative area achieved (ha)									
RM1	3.9	22.6		90						
RM3	3.9	22.6		90						
RM7	3.9	22.6		90						
RM8	3.9	22.6		90						
RM9			3.9		22.6		90			
RM10						3.9		22.6	90	

- 1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
- 2) Insert new columns to the blue table to match rehabilitation milestone dates.
- 3) Insert new rows to the blue table to include additional rehabilitation milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA8									
Relevant activities	Retained water storages									
Total rehabilitation area size (ha)	52.2									
Commencement of first milestone: RM1	10/12/2045									
PMLU	Retained water storage									
Date area is available	10/12/45									
Cumulative area available (ha)	52.2									
Milestone completed by	10/12/46	10/12/56								
Milestone Reference	Cumulative area achieved (ha)									
RM1	52.2									
RM11		52.2								

- 1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
- 2) Insert new columns to the blue table to match rehabilitation milestone dates.
- 3) Insert new rows to the blue table to include additional rehabilitation milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA9									
Relevant activities	Retained infrastructure									
Total rehabilitation area size (ha)	45									
Commencement of first milestone: RM1	10/12/2045									
PMLU	Retained infrastructure									
Date area is available	10/12/45									
Cumulative area available (ha)	45									
Milestone completed by	10/12/46	10/12/47								
Milestone Reference	Cumulative area achieved (ha)									
RM1	45									
RM12		45								

- 1) Insert new columns to the yellow table to include further rehabilitation milestone dates.
- 2) Insert new columns to the blue table to match rehabilitation milestone dates.
- 3) Insert new rows to the blue table to include additional rehabilitation milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Non-use management area (NUMA)										
Improvement area	IA1									
Relevant activities	Main Pit Final Void									
Total size (ha)	20.3									
Commencement of first milestone: MM1	10/12/2035									
NUMA	Lake									
Date area is available	10/12/35									
Cumulative area available (ha)	20.3									
Milestone completed by	10/12/40	10/12/41	10/12/51							
Milestone Reference	Cumulative area achieved (ha)									
MM1	20.3									
MM2		20.3								
MM3			20.3							

- 1) Insert new columns to the yellow table to include further management milestone dates.
- 2) Insert new columns to the blue table to match management milestone dates.
- 3) Insert new rows to the blue table to include additional management milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. MM1).

Non-use management area (NUMA)										
Improvement area				IA2						
Relevant activities				East Hill Pit Final Void						
Total size (ha)				0.7						
Commencement of first milestone: MM1				10/12/2046						
NUMA				Void						
Date area is available	10/12/46									
Cumulative area available (ha)	0.7									
Milestone completed by	10/12/51	10/12/52	10/12/62							
Milestone Reference	Cumulative area achieved (ha)									
MM1	0.7									
MM2		0.7								
MM3			0.7							

- 1) Insert new columns to the yellow table to include further management milestone dates.
- 2) Insert new columns to the blue table to match management milestone dates.
- 3) Insert new rows to the blue table to include additional management milestone references.
- 4) Insert the relevant number in the "Milestone reference" column (i.e. MM1).

Milestone reference	Rehabilitation milestone	Milestone criteria	Applicable RA
RM1	Infrastructure decommissioning and removal	a) All non-required services disconnected and removed. b) All non-required concrete and gravel removed. c) All non-required operational pipelines drained and removed. d) All fencing that is not part of PMLU requirements removed. e) All buildings and footings demolished and/or removed off-site. f) All machinery and equipment removed. g) All non-retained surface water drainage infrastructure removed. h) All rubbish removed.	All
RM2	Remediation of contaminated land	a) Contaminated material either remediated in-situ or removed/transported to an approved landfill for disposal and waste tracking information recorded and submitted. b) Contaminated land assessment undertaken by an appropriately qualified person ¹ indicates that no contamination unsuitable for the post mining land use is occurring. If required, a site investigation report including a site suitability statement prepared and submitted in accordance with the provisions of Chapter 7, Part 8 of the EP Act.	RA1, RA2, RA4
RM3	Landform development of infrastructure areas	a) All bulk earthworks completed. b) Geotechnical assessment by an appropriately qualified person ¹ confirming that long-term geotechnical stability has been achieved for each relevant landform. c) Final landform slopes meet design specifications: i. TSF Cell A embankments – i. Maximum slope of 30% subject to geotechnical and erosional stable conditions.	RA4, RA6, RA7, RA5
RM4	Landform development of water storages	General: a) All earthworks completed. b) Water drainage lines reinstated and stabilised to allow natural flow. Dams: a) Sediment dams cleaned (desilted). b) Where landform incorporates slopes > 17%, geotechnical assessment by an appropriately qualified person ¹ confirming that long-term geotechnical stability has been achieved. Main Pit water management bund: a) Design plan certified by an appropriately qualified person ¹ is developed for the final landform. Design plan demonstrates that modification of the levee does not result in potential environmental harm. b) Assessment by an appropriately qualified person to confirm the post-closure regulated status of the water management bunding structure. c) All earthworks completed as per the approved design plan. d) Assessment by an appropriately qualified person ¹ confirming that long-term geotechnical stability has been achieved. e) Certification from an appropriately qualified person that the area has achieved stable condition.	RA3
RM5	Landform development of TSF Cell B	a) All bulk earthworks completed. b) Cover system is installed with the appropriate QA/QC measures to: i. Compact tailings surface to form a low permeability layer; ii. Cover tailings with at least 1.0 m of top rock, followed by 0.15 m of growth media. c) Assessment by an appropriately qualified person ¹ confirming that long-term geotechnical stability has been achieved. d) An assessment by an appropriately qualified person of groundwater monitoring data (collected in accordance with monitoring and maintenance program), confirms cover system is functioning as designed and risk of environmental harm is mitigated.	RA1

RM6	Landform development of Heap Leach Pad	a) All bulk earthworks completed. b) Cover system is installed with the appropriate QA/QC measures to: i. Comprise at least 0.5 m of top rock, followed by 0.15 m of growth media. c) Final slopes meet design specifications: ii. Maximum slope of 25 % subject to geotechnical and erosional stable conditions. d) Assessment by an appropriately qualified person¹ confirming that long-term geotechnical stability has been achieved. e) An assessment by an appropriately qualified person of groundwater monitoring data (collected in accordance with monitoring and maintenance program), confirms cover system is functioning as designed and risk of environmental harm is mitigated.	RA2
RM7	Surface preparation	a) Ripping of soil profile /subsoil profile along the contour of any slope to a depth of at least 200 mm. b) Prior to seeding, assessment of soil health and suitability for target vegetation establishment undertaken by an appropriately qualified person¹ and a recommendation made for ameliorants suitable to achieve the post-mining land use revegetation program. c) Ameliorants applied and incorporated into subsoil and/or topsoil if required, as per recommendations of the soil health and suitability assessment.	RA1, RA2, RA3, RA4, RA5, RA6, RA7
RM8	Revegetation	a) Seeding of target key species completed at a sowing rate of 6 kg/ha drawn from Table 23 Recommended species for revegetation (Yandan Gold Mine Transitional PRCP). b) No later than 12 months from planting, a >50% survival rate for any given perennial species is achieved.	RA1, RA2, RA3, RA4, RA5, RA6, RA7
RM9	Achievement of surface requirements (open pasture – grazing and low hill – pasture grazing)	a) Total percentage of vegetation groundcover² is not significantly lower ($P < 0.05$) than that recorded at reference sites. b) Species diversity is not significantly lower ($P < 0.05$) than that recorded at reference sites. c) Species composition not significantly different ($P < 0.05$) to reference sites. d) Total percentage of weed groundcover is not significantly higher ($P < 0.05$) than reference sites. e) Erosion classification³ (per the Rehabilitation Monitoring Program methodology) to be comparable with erosion classifications from reference sites.	RA1, RA2, RA3, RA4, RA5, RA6, RA7
RM10	Achievement of target post mining land use (open pasture – grazing and Low hill – pasture grazing)	a) End suitability assessment by an appropriately qualified person¹ confirming land has achieved a post-mine land suitability⁴ of i. for low intensity grazing, or ii. for low intensity grazing, supported by an appropriate management regime. b) Demonstration within the final rehabilitation report that vegetation groundcover², species diversity and species composition in rehabilitation areas is not significantly lower ($P < 0.05$) than reference sites for a minimum of three consecutive years. c) Demonstration within the final rehabilitation report that total percentage of weed groundcover in rehabilitation areas is not significantly higher ($P < 0.05$) than reference sites for a minimum of three consecutive years. d) Evidence of recruitment from rehabilitation monitoring data. e) Erosion classification³ (per the Rehabilitation Monitoring Program methodology) to be comparable with erosion classifications from reference sites for a minimum of three consecutive years. f) Written agreement obtained from the land owner/holder and administering authority that rehabilitation is successful. g) Hazard and Safety Assessment completed by an appropriately qualified person¹ demonstrates that hazards in rehabilitation areas are of a similar type and not significantly different to hazards in reference sites.	RA1, RA2, RA3, RA4, RA5, RA6, RA7
RM11	Achievement of target post-mining land use (retained water storages)	a) Assessment by an appropriately qualified person confirms the structure is not regulated. b) All retained water storages to be assessed and approved as safe and stable by an appropriately¹ qualified person. c) Hazard and Safety Assessment completed by an appropriately qualified person¹ demonstrates that hazards in retained water storages are of a similar type and not significantly different to hazards in neighbouring unmined water storages subject to similar use d) Retained storage water quality parameters to be below the trigger values for livestock drinking water defined in Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 3 Primary Industries – Rationale and Background Information (ANZECC and ARMCANZ 2000).	RA8
RM12	Achievement of target post-mining land use (retained infrastructure)	a) Final landform survey confirms no built structures remain other than those that form part of a landholder agreement. b) All retained structures and landforms assessed and approved as safe and stable by an appropriately qualified person¹.	RA9

Footnotes:

1. Appropriately qualified person means a person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relating to the subject matter using the relevant protocols, standards, methods, or literature.
2. Vegetation groundcover incorporates native pasture grass species, exotic pasture grass species, non-pasture grass species, shrubs (woody plant multi-stemmed at base or, if single stemmed, <2 m tall), forbs and other non-grass species.
3. Erosion classification framework:

Erosion classifications	Minor	Moderate	Severe	Extreme
No. of rills / gullies	< 15	15-30	31-50	>50
Average depth (cm)	< 10	10 - 30	30-60	>60

4. Department of Science, Information Technology and Innovation and Department of Natural Resources and Mines (2015) Guidelines for Agricultural Land Evaluation in Queensland (Second Edition), State of Queensland or later version. (<https://www.publications.qld.gov.au/dataset/qld-agricultural-land-evaluation-guidelines/resource/d6591386-08e2-453f-a6fa-dff2a756215f>)

- 1) Insert new rows below the table to record more Rehabilitation Area Milestones for the project
- 2) Ensure all Rehabilitation Milestones recorded in this table align with those included in the RA sheets in this form.
- 3) See the PRCP guideline before developing site-specific Rehabilitation Area Milestones

Milestone reference	Management milestone	Milestone criteria
MM1	Achievement of final landform design	a) Final void high walls comply with maximum safe and stable slope angles as nominated in geotechnical stability assessment.
MM2	Achievement of surface requirements	a) Standard barbed wire fencing erected around the perimeter of the residual void to prevent access by humans and fauna. b) Warning signage posted every 100 m around the perimeter of the residual void. c) Safety bund constructed around perimeter of the residual void.
MM3	Achievement of sufficient improvement	a) Assessment by an appropriately qualified person ¹ that the residual void will not cause environmental harm outside of the relevant tenure boundary. b) Assessment by an appropriately qualified person that the water quality and/or level in the void will not cause environmental harm to the surrounding environment: i. Main Pit – water balance modelling confirms that long-term pit water depth will remain greater than 160 m AHD for the maintenance of a permanent water cover over sulphide material in the pit walls and floor. ii. East Hill Pit - water balance modelling confirms that long-term pit water depth will remain above the sandstone unit within the pit for the prevention of potential groundwater contamination.

Footnotes:

1. Appropriately qualified person means a person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relating to the subject matter using the relevant protocols, standards, methods, or literature.

Appendix B. PRCP Reference Map and Final Site Design

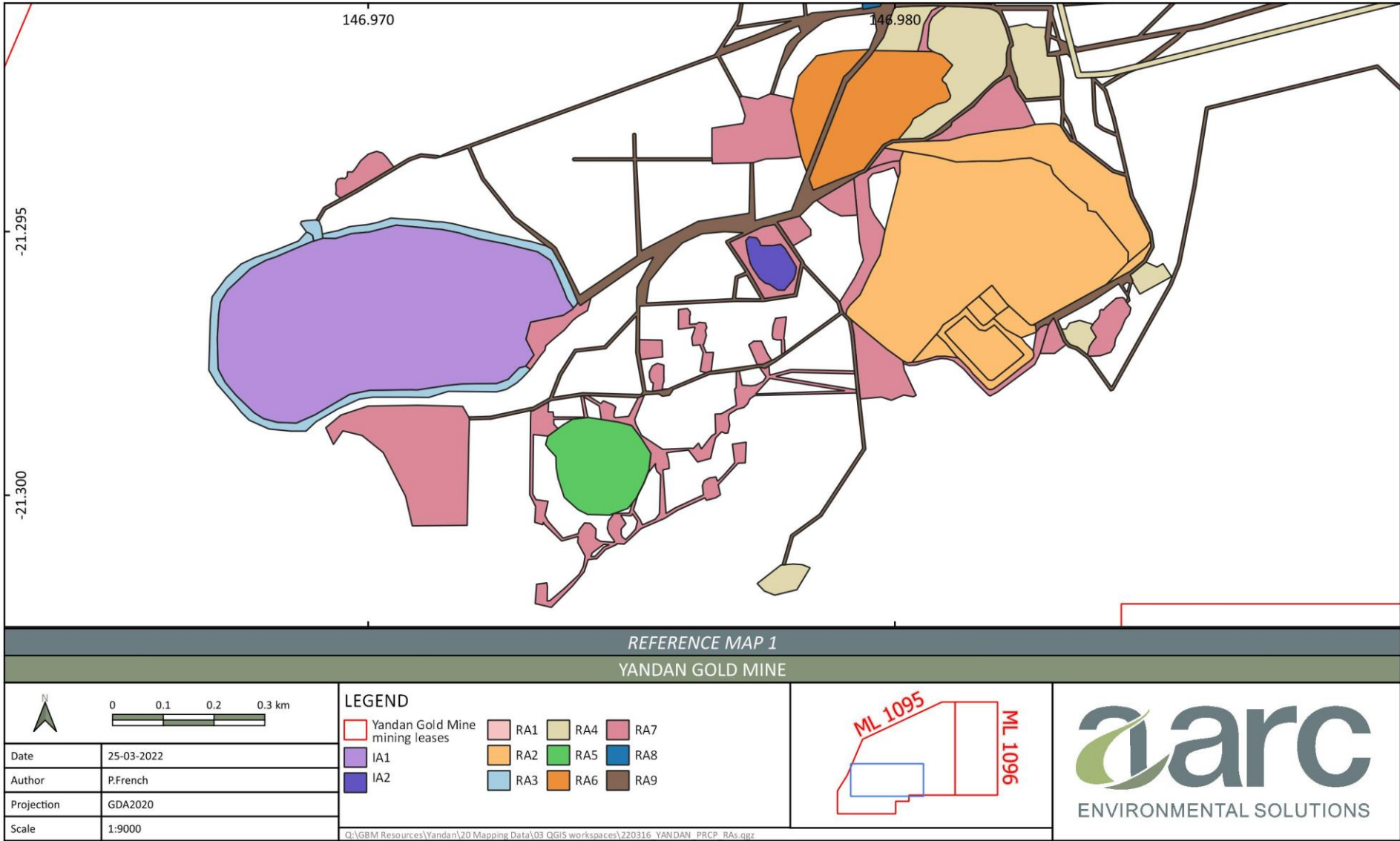


Figure 56: Reference Map No.1

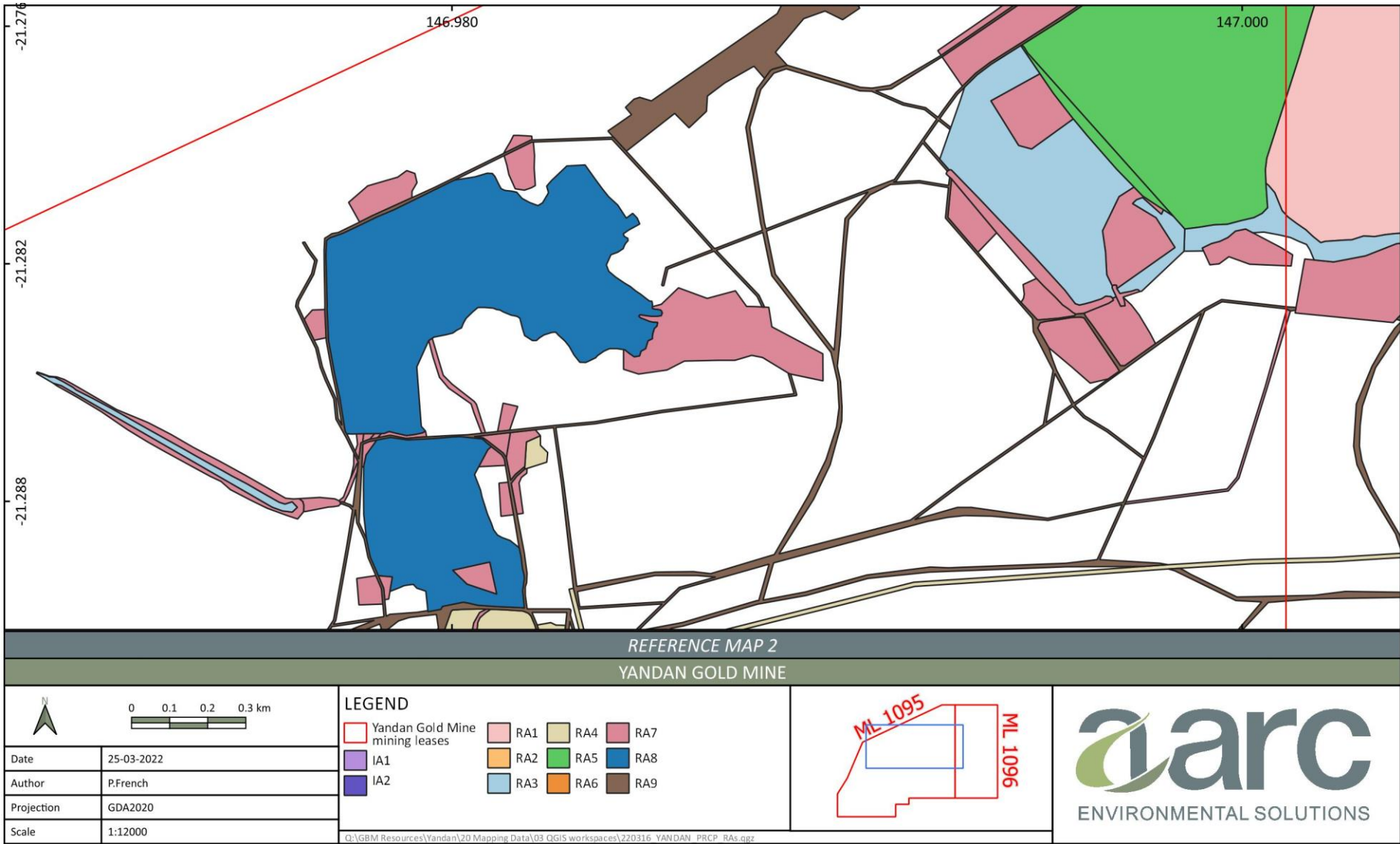


Figure 57: Reference Map No. 2

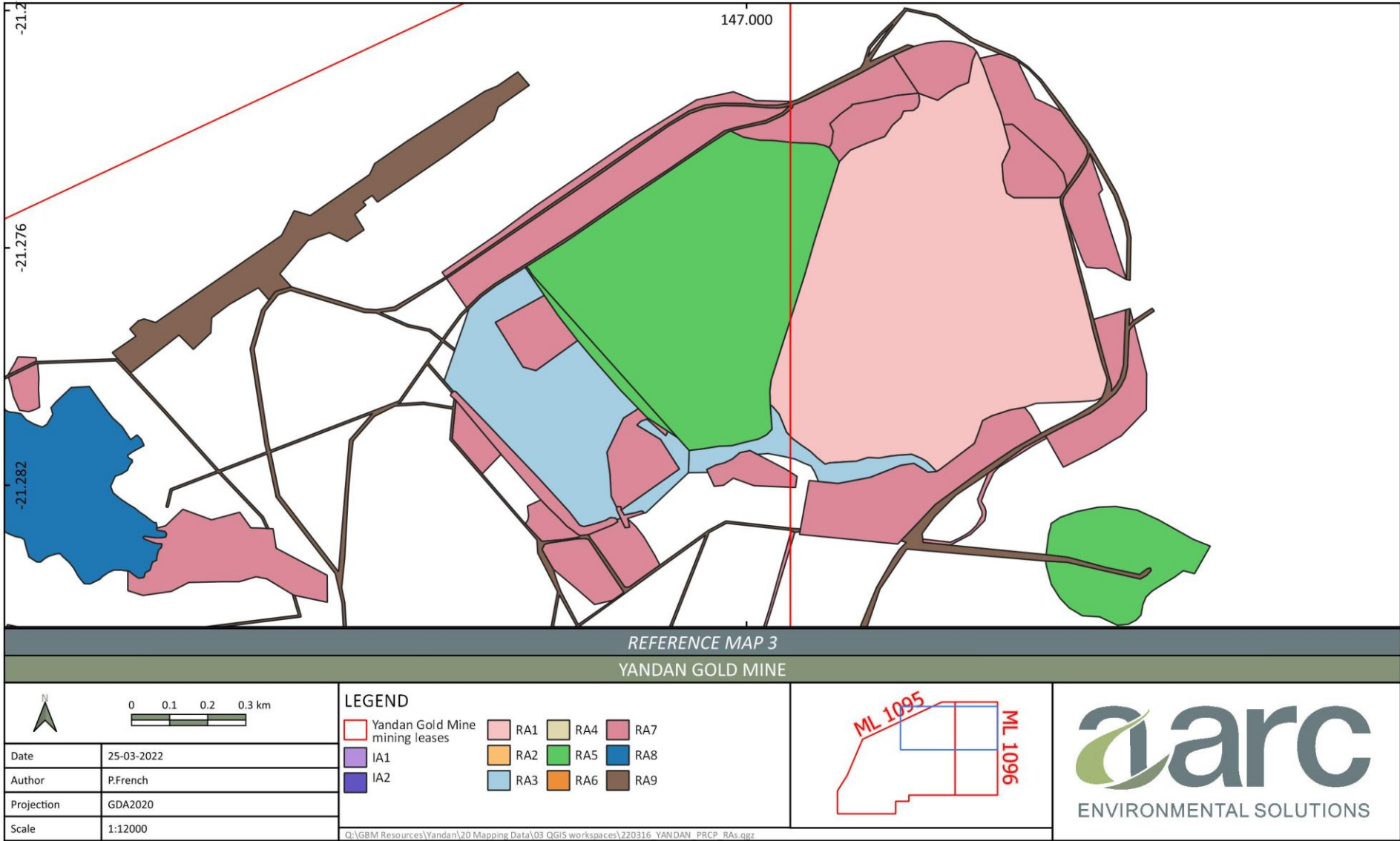


Figure 58: Reference Map No.3

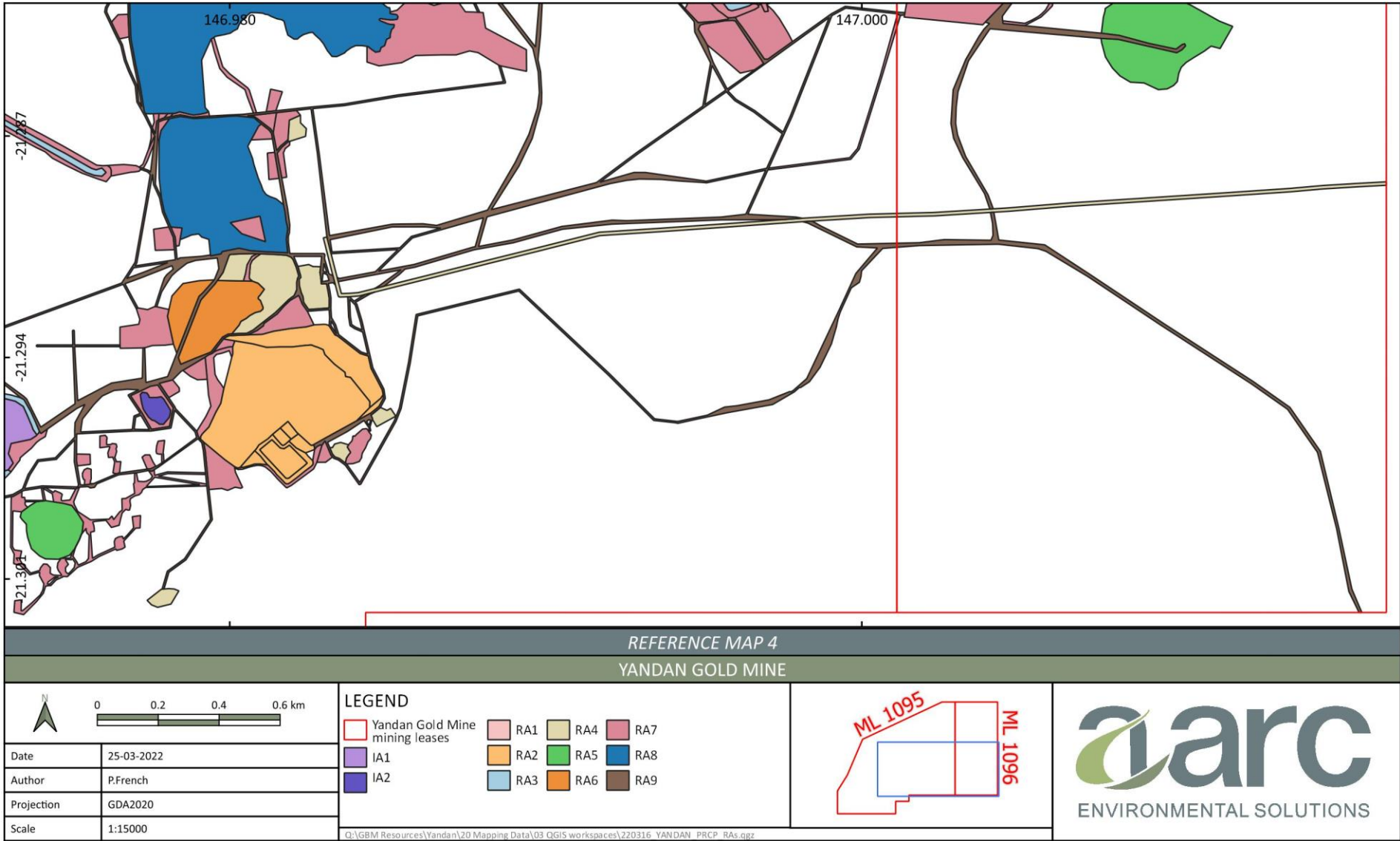


Figure 59: Reference Map No. 4

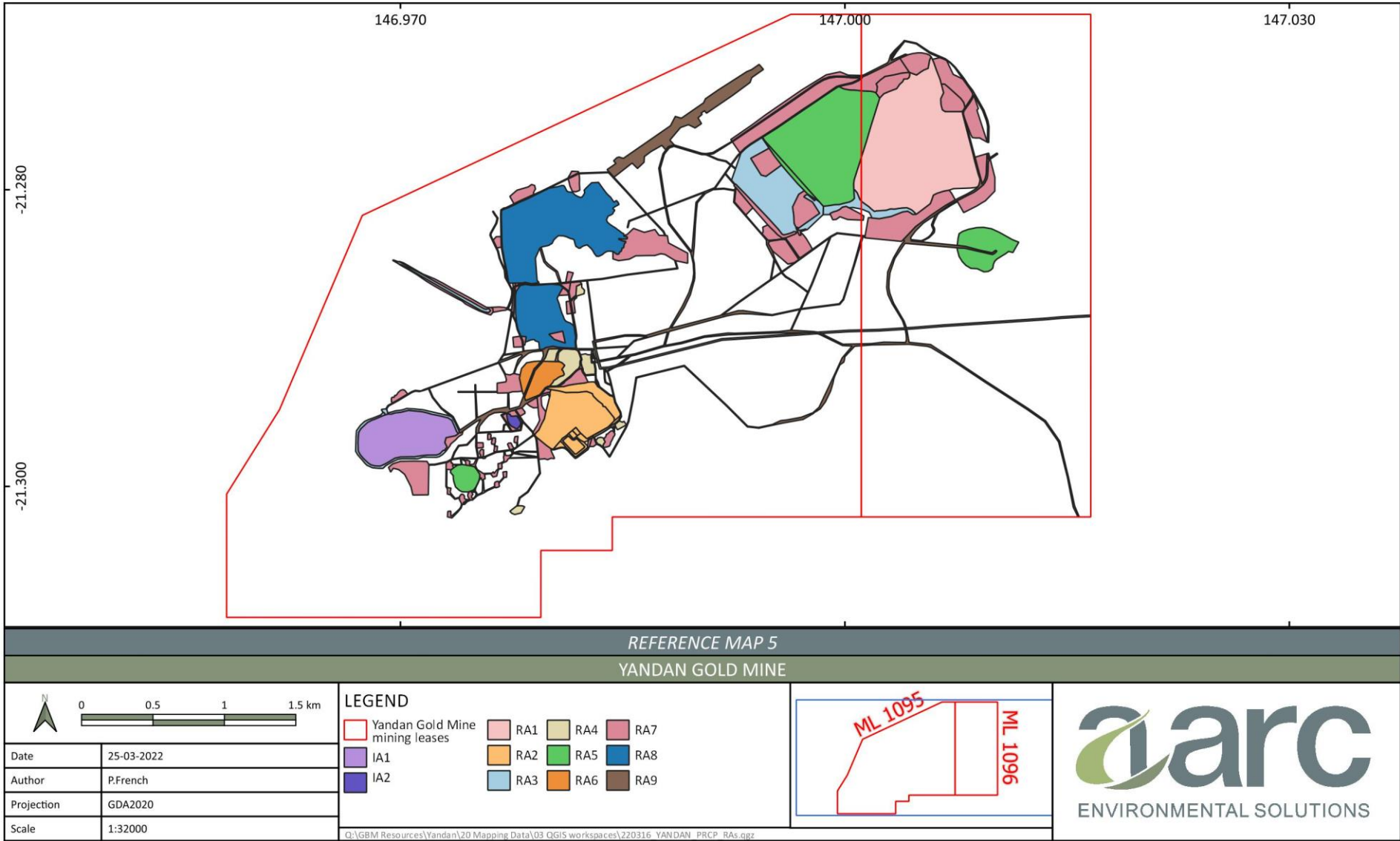


Figure 60: Reference map No.5

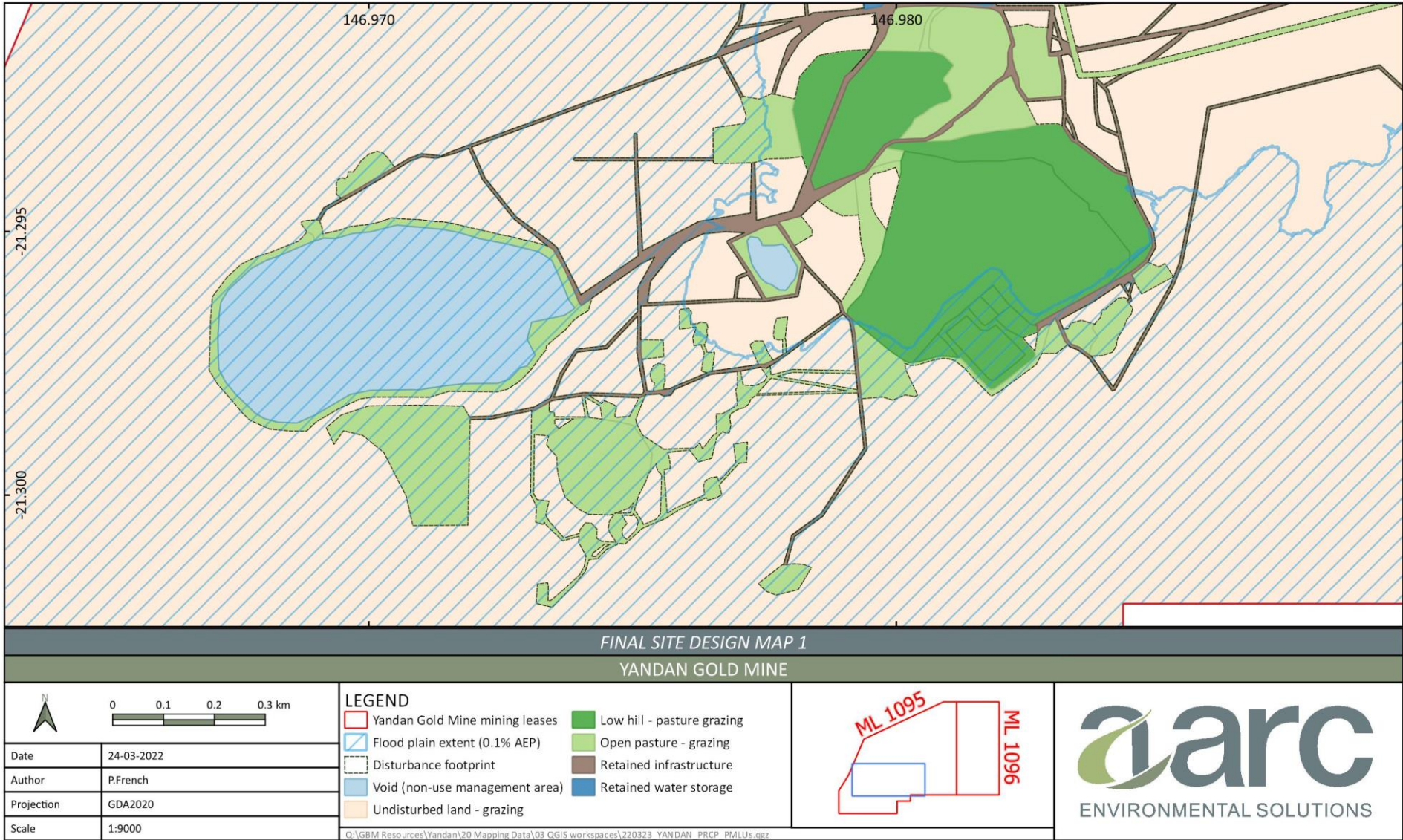


Figure 61: Final site design map No.1

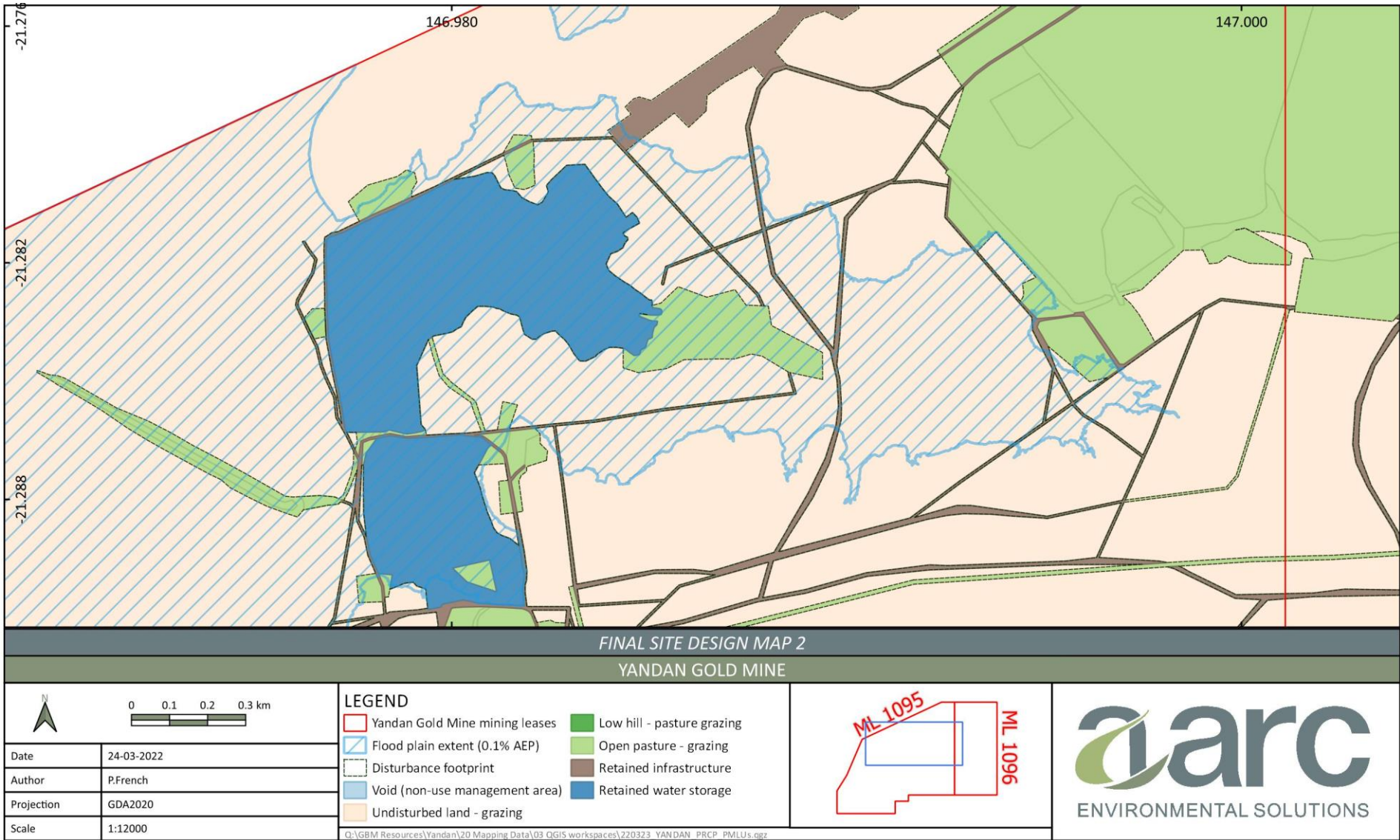


Figure 62: Final site design map No.2



Figure 63: Final site design map No.3

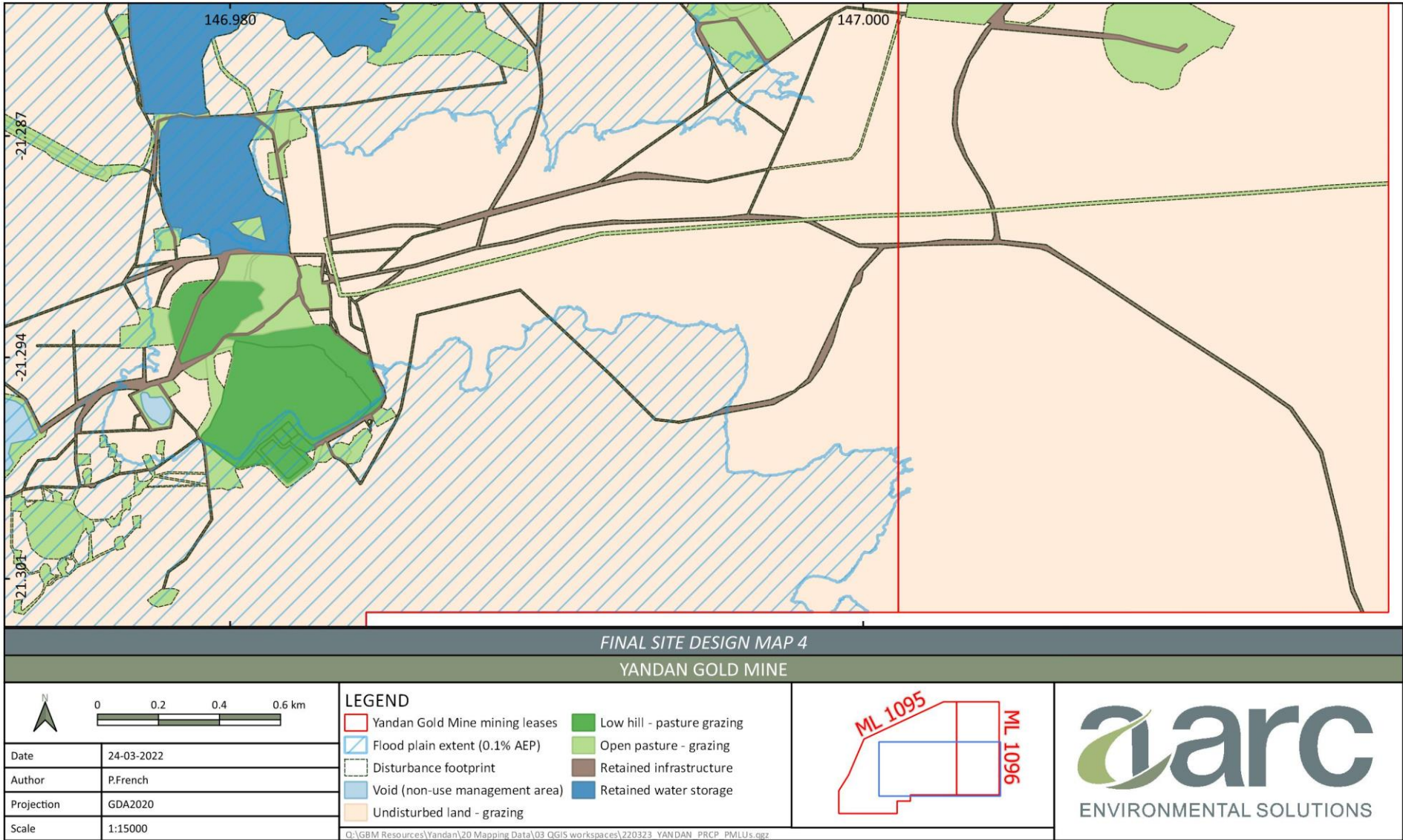


Figure 64: Final site design map No.4

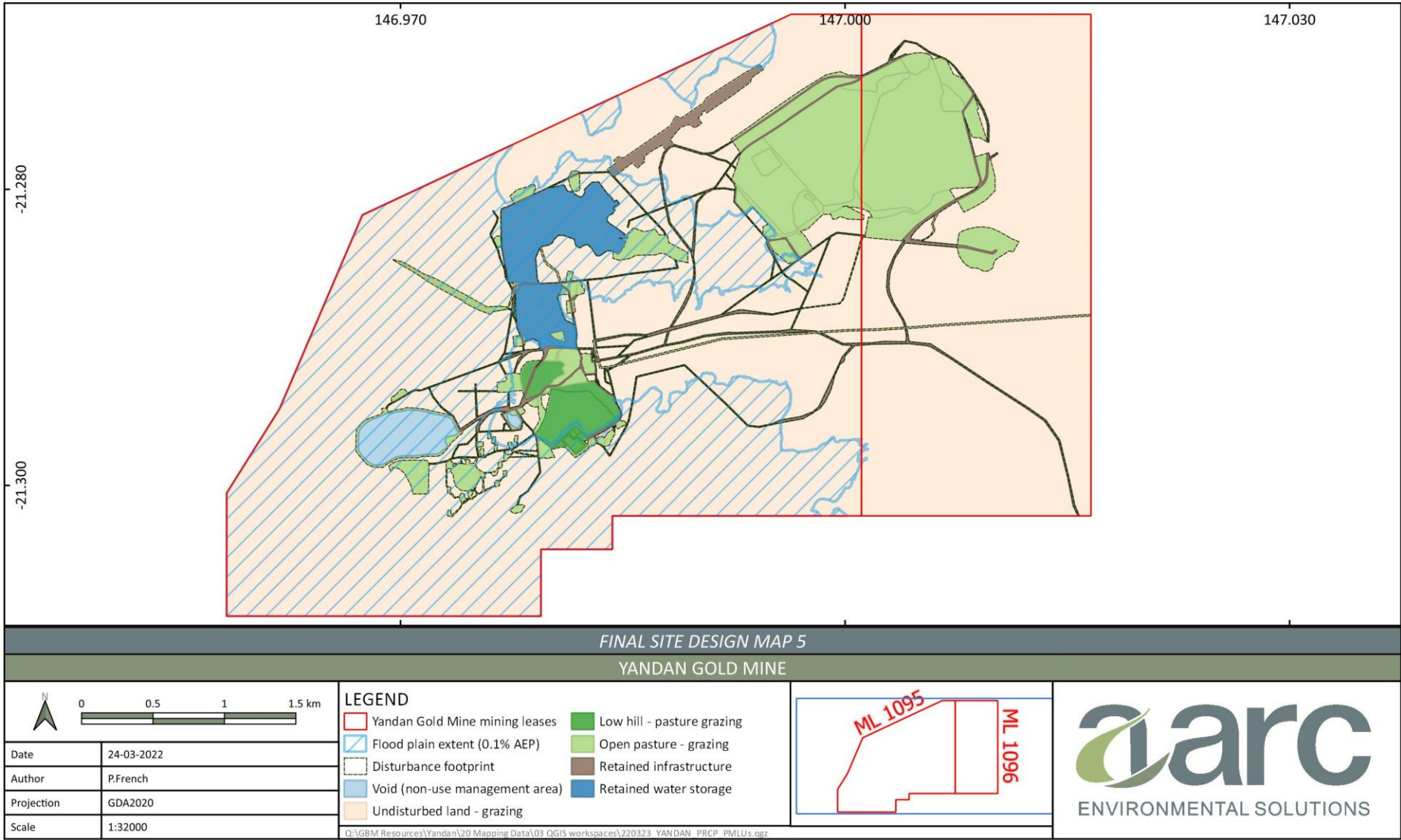


Figure 65: Final site design map No.5

Appendix C. Schedule stage plans

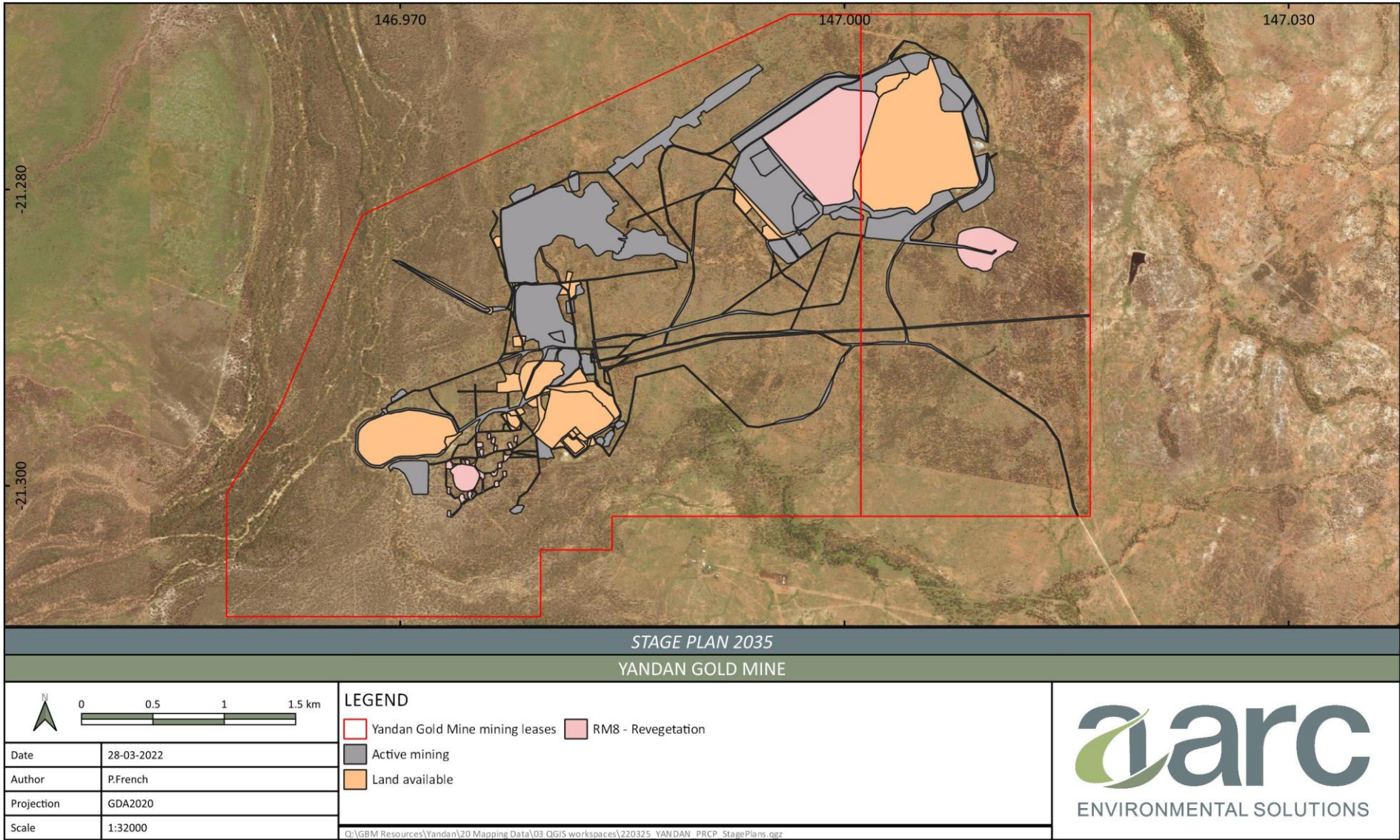


Figure 66: Stage Plan - 2035

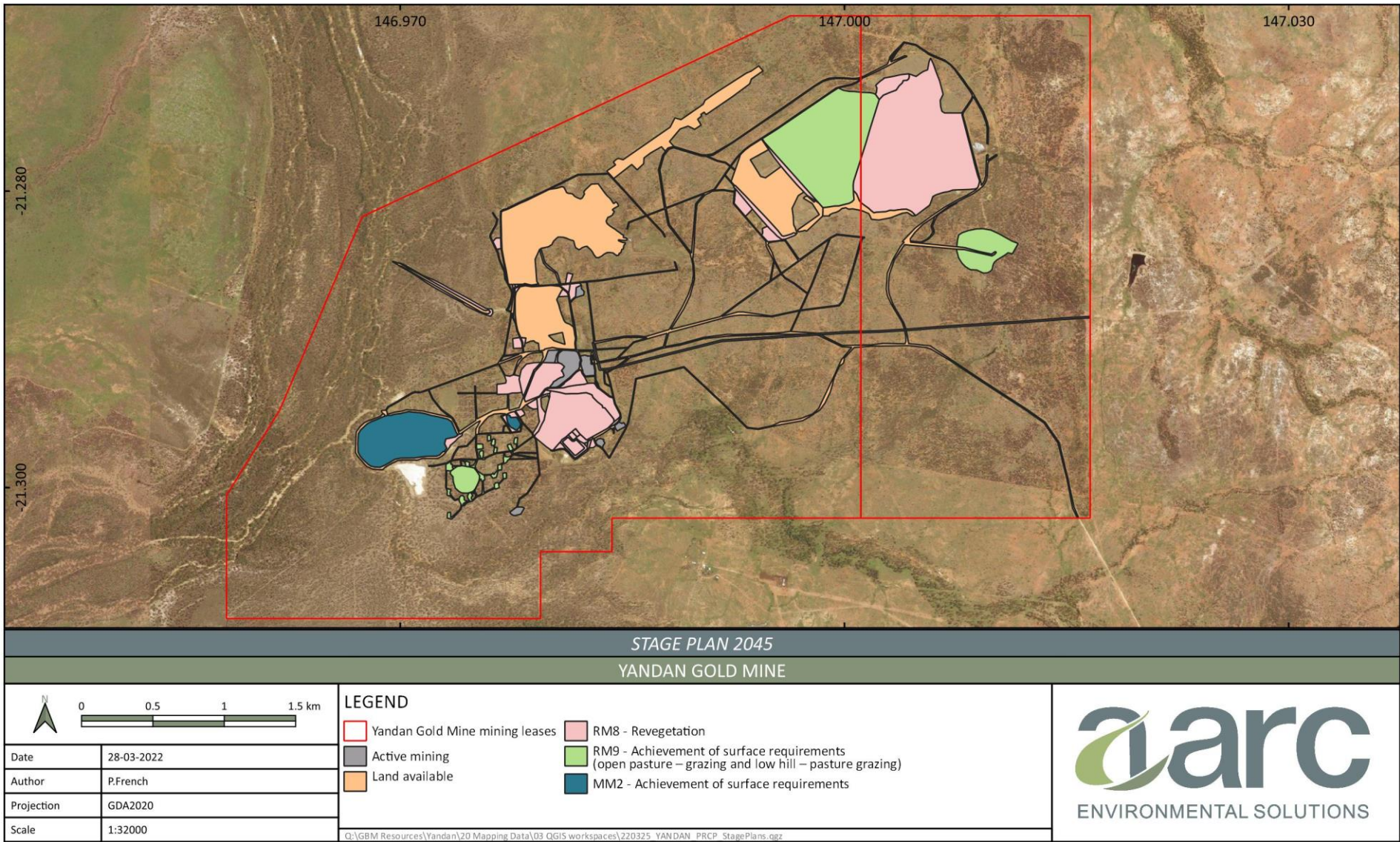


Figure 67: Stage Plan – 2045

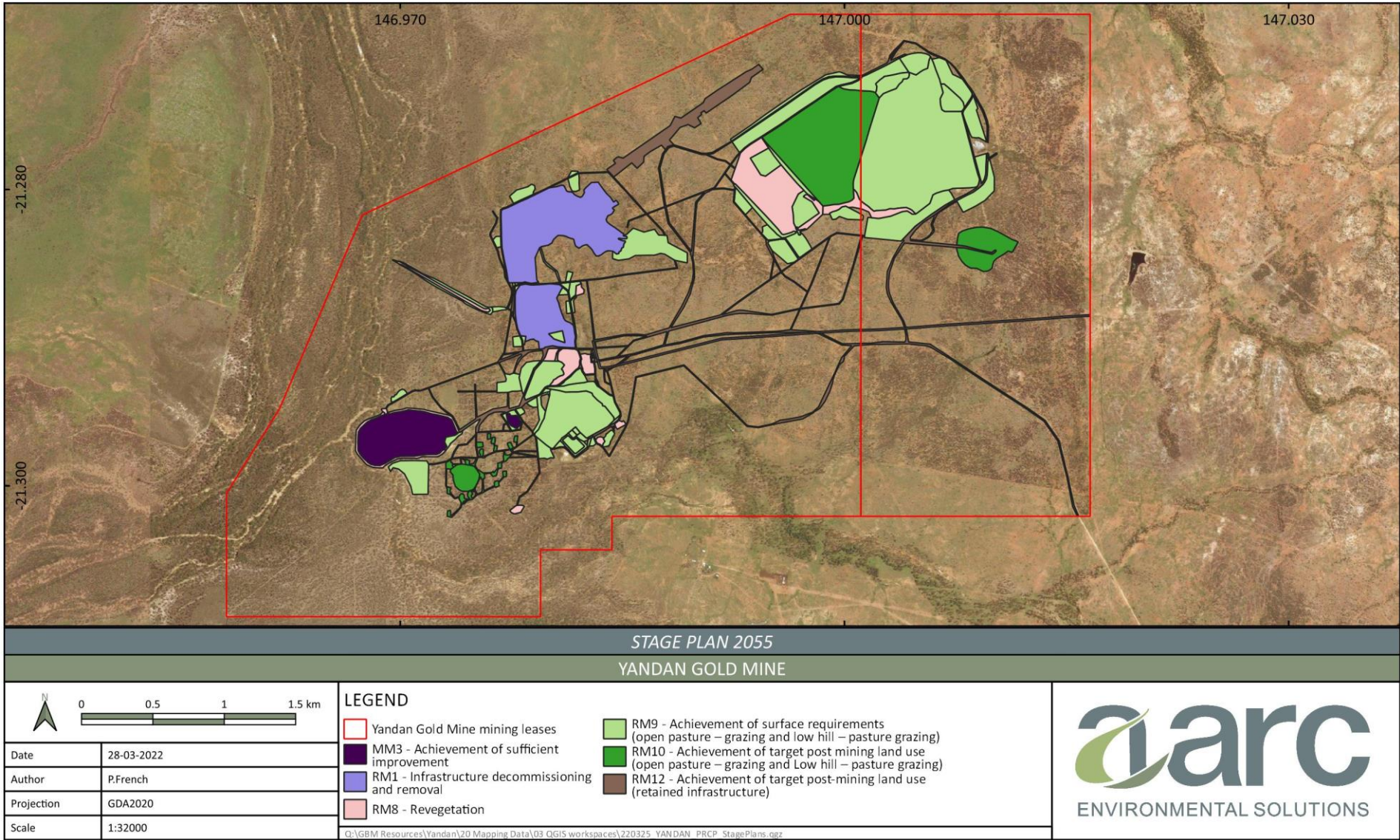


Figure 68: Stage Plan – 2055

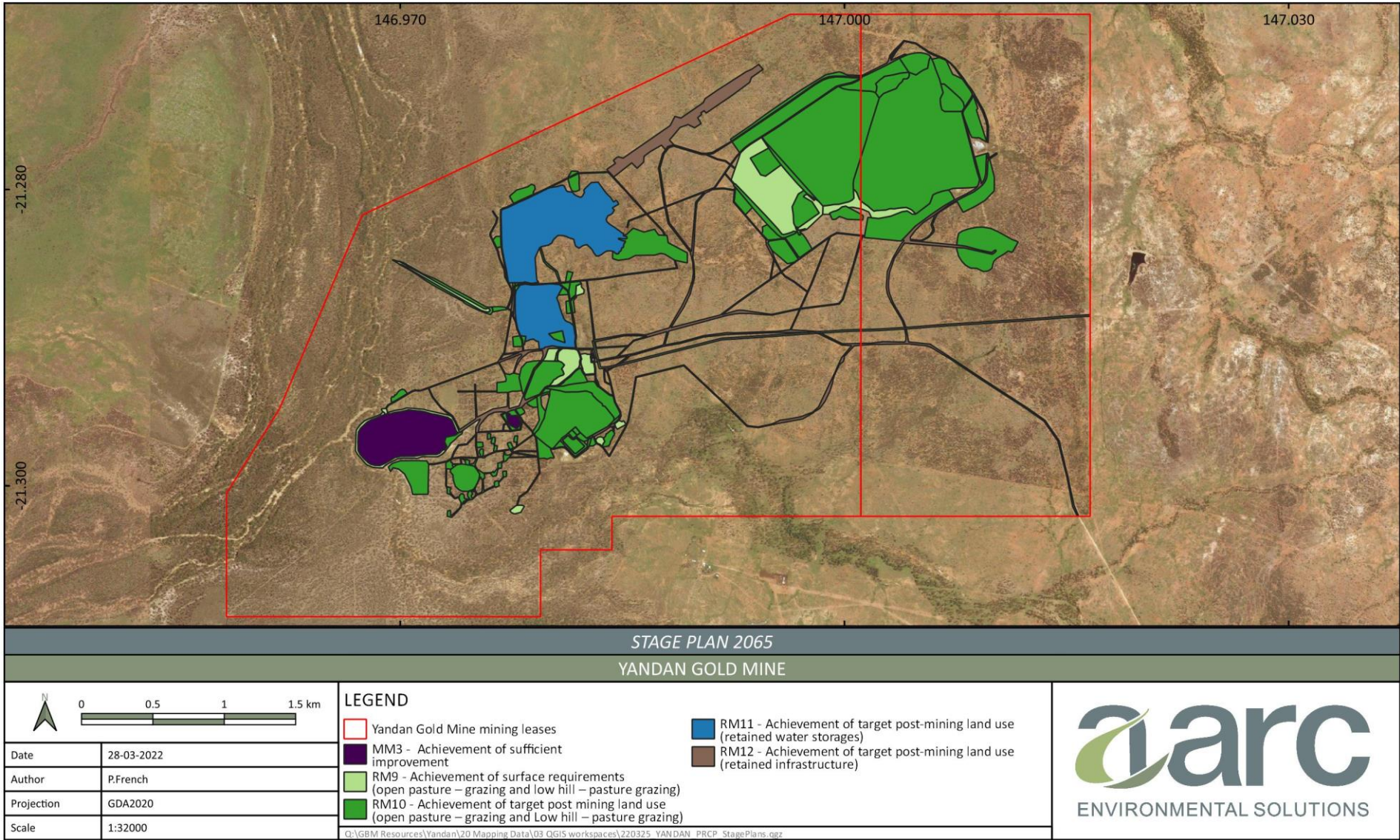


Figure 69: Stage Plan - 2065

Appendix D. Spatial information

Spatial information prepared in accordance with the guideline '*Spatial Information Submission*' (DES 2018) to accompany this PRCP has been submitted electronically to the administering authority.

Appendix E. Stakeholder Engagement Plan



PREPARED FOR
STRAITS GOLD PTY LTD
JANUARY 2022

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Project Name:	Yandan Gold Project
Report Title:	Stakeholder Engagement Plan
Client:	Straits Gold Pty Ltd
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1 Introduction

The Yandan Gold Project (the Project) is located in the Drummond Basin in Central Queensland, approximately 50 kilometres (km) to the west of the Mount Coolon township and approximately 150 km southeast of Charters Towers (Figure 1). GBM Resources Limited (GBM) acquired the Project and the Straits Gold Pty Ltd (Straits Gold) identity in January 2021.

This Stakeholder Engagement Plan (SEP) has been prepared to provide a summary of the consultation provided on the Project and detail ongoing community consultation in relation to the rehabilitation planned to be carried out under the Project's Progressive Rehabilitation and Closure Plan (PRCP) for the Project.

1.1 Purpose

The purpose of this SEP is to comply with the requirements set out in section 126C(1)(c)(iv) and (iv) of the *Environmental Protection Act 1994* (EP Act), being the inclusion of the following in the proposed PRCP:

- details of the consultation undertaken by the applicant in developing the proposed PRC plan, and
- details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.

1.2 Project description

The Impact Assessment Study for the Project approval was submitted in December 1988, with the Project mining leases (ML) (ML1095 and ML1096) granted in June 1991. In July 1992, Ross Mining N.L. acquired the Project; in addition to the Wirralie Gold Mine, a controlling interest in the Mount Coolon joint venture, and exploration tenements associated with the three assets.

Ross Mining N.L. operated the Project between 1993 - 2002, producing over 350,000 ounces (oz) of gold from heap leach operations and a Carbon in Leach (CIL) process plant. Mining operations ceased in 1998, with the Heap Leach Pad remaining operational until September 2002. The site was placed into care and maintenance in April 1999, pending final closure works. The gold processing plant was later removed in 2006/2007, prior to the acquisition of the Project by Straits Gold, which was a wholly owned subsidiary of Aeris Resources Ltd at the time. The Project has remained in care and maintenance since closure in 1999.

GBM acquired the Project and the Straits Gold entity on 13 January 2021, and have since taken significant steps towards restoring operations. This has included re-commencing exploration at Yandan, most recently including the 2021 drilling program which focused on the identification of potential open pits targets in the area between Main Pit and East Hill deposits.

Yandan is a key asset in GBM's 'processing halo strategy' for the Drummond Basin, joining the nearby Mount Coolon asset and the recently acquired Twin Hills asset. It is proposed that Yandan will provide a central processing hub for material from the three projects, with existing infrastructure at Yandan supporting and accelerating the development of a gold mining and processing operation.

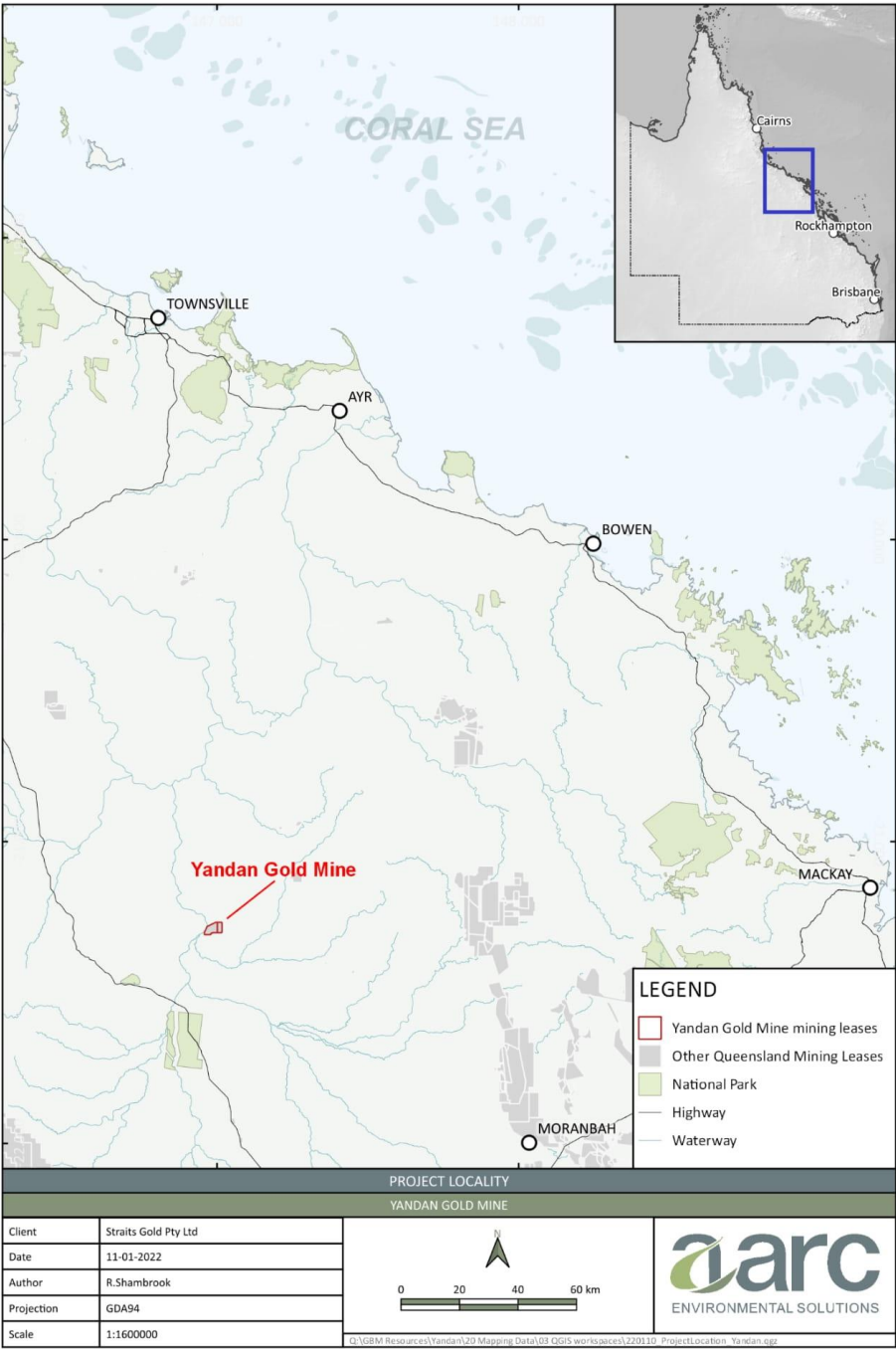


Figure 1: Project locality

Yandan Gold Project: Stakeholder Engagement Plan

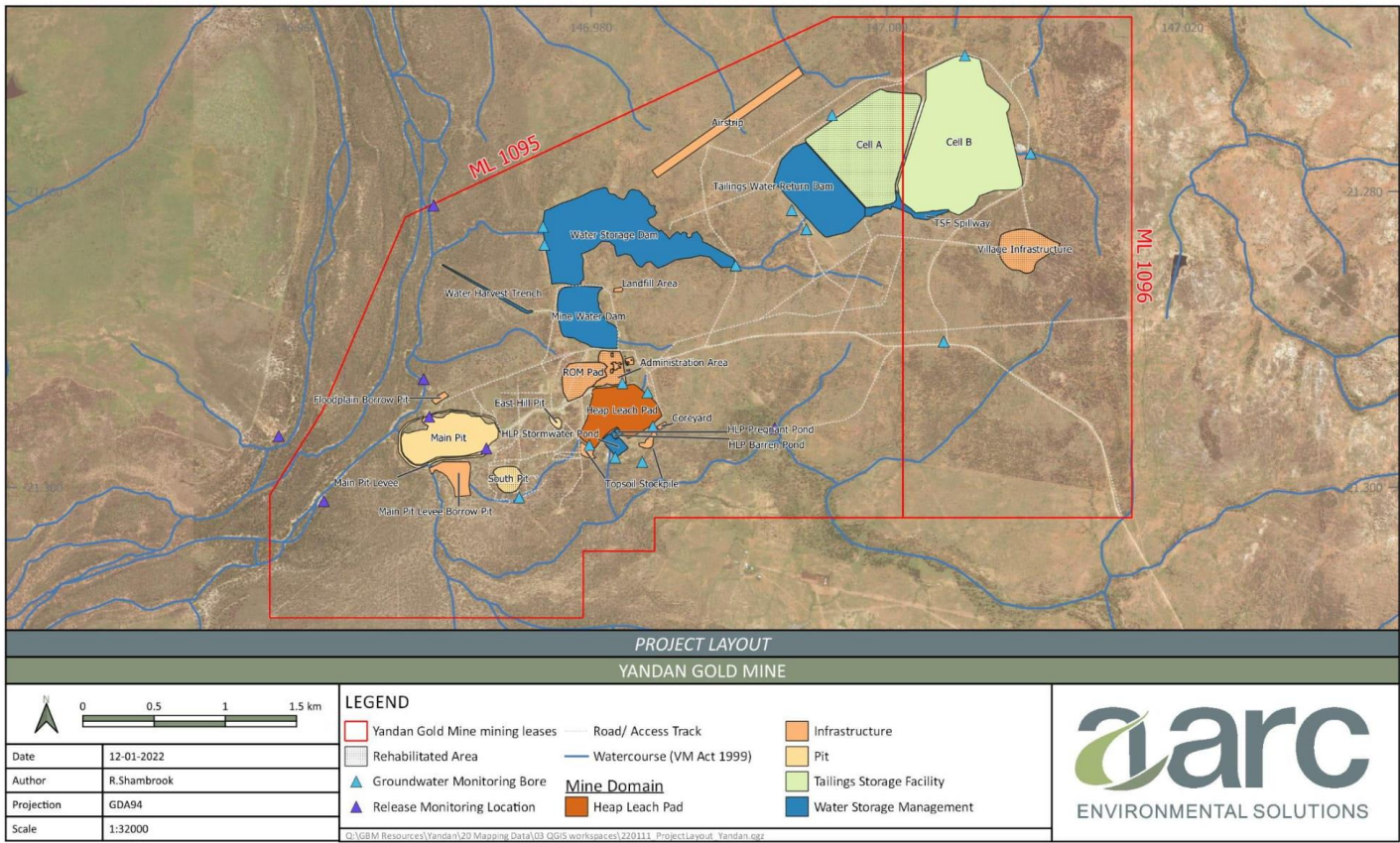


Figure 2: Project layout

2 Communication Engagement Approach

2.1 Key objectives

The objectives of the SEP are to achieve the following:

- strengthen the company's corporate social responsibility and effectively maintain an on-going community relationship and trust;
- define opportunities to provide transparent, open and informative information to key stakeholders and increase awareness on progressive rehabilitation activities and schedules;
- inform and liaise with key stakeholders to ensure rehabilitation activities outlined in the PRCP are undertaken to achieve the historically agreed post-mining land use (PMLU) or non-use management area (NUMA);
- enhance and outline key avenues that stakeholders can utilise to provide feedback on Project rehabilitation activities; and
- identify measures for GBM to respond to community concerns and appropriately manage stakeholder expectations.

2.2 Responsibilities

The responsibility to facilitate and uphold the SEP objectives are distributed to the following roles:

- GBM Directors -
 - ultimate responsibility for environmental and social governance falls to the GBM executive team; and
 - final approval of all company policy;
- Site Manager -
 - manage the overall direction of the Project;
 - responds to media enquiries;
 - manage direct, formal notification of intentions and actions relating to the Project;
 - interacts with community and engages on issues/concerns at all levels;
- Environment and Community Support officer -
 - development of the SEP with GBM;
 - technical support in regulatory and community engagement, led by GBM;
 - technical support for GBM media releases and responses; and
 - technical input for development of Project materials (fact sheets, posters, newsletters, etc).

3 Stakeholders Mapping

3.1 Affected and interested stakeholder groups

Yandan Gold Mine is located approximately 35 km north-west of the small township of Mount Coolon, which has an approximate population of 64 people (ABS 2016). Mount Coolon is located at the intersection of the Bowen Development Road and Sutton Development Road. The town is primarily in an agricultural and rural setting, with mining activities in the surrounding region. Nearby mining activities include the Mount Coolon Gold Mine and the Twin Hills Operation, also owned by GBM Resources.

The identification of all relevant stakeholders, such as interested and affected peoples, groups and statutory bodies, is important to ensure that consultation on the Project's planned rehabilitation activities is provided to relevant parties.

Interested and affected stakeholders to the Project have been identified in Table 1 below. Due to the isolated nature of the Project region, the small population size in the surrounding region, and the current care and maintenance status of the Project, there are currently only a small number of key stakeholders.

Table 1: Affected and interested stakeholders

Stakeholder Classification	Stakeholder	Status
Affected	Scott Family	Landholder on Lot 5060 of PH387
	Jangga People Traditional Owners	Native Title Determination over Project area QCD2012/009
	Neighbouring and downstream landholders	Landholders of properties directly downstream (e.g. Lot 22 on SP218335, Lot 1 on SM47)
	Whitsunday Regional Council Andrew Willcox (Mayor)	Local Government
	Charters Towers Regional Council ¹ Frank Beveridge (Mayor)	Local Government
	Department of Environment and Science	State Government
	Department of Transport and Main Roads	State Government
	Department of Resources	State Government
	Department of Regional Development, Manufacturing and Water	State Government
	Mount Coolon Community	Township
Interested	Mount Coolon Hotel	Local Business
	Collinsville Hospital	Nearby Medical Facility
	Mount Coolon Rural Fire Brigade	Fire Service

¹ Majority of the Project falls under the Whitsunday Regional local government area (LGA), with a small area of the mining lease falling under the Charters Tower Regional LGA.

4 Stakeholder Engagement Methods and Frequency

4.1 Principle engagement methods

4.1.1 Face-to-face meetings or phone calls

Additional face-to-face meetings or phone calls will be a principal engagement method during both the operational and rehabilitation phases. These meetings will occur on a complaint basis and offer stakeholders the opportunity to discuss in-person any concerns or issues relating to rehabilitation in accordance with the PRCP.

Consultation will be undertaken on an as required basis, such as when a change in activities or circumstances on the ground occurs that may have an impact on stakeholders.

The purpose of face-to-face meetings is to:

- continue the on-going point of contact for stakeholders of the Project;
- provide current information and updates on the Project and proposed rehabilitation activities;
- allow opportunity for stakeholders to initiate enquiries relating to the Project; and
- operate as a feedback function to allow the collation and reporting of community concerns in relation to the Project.

4.1.2 Project webpage

A 'Yandan Gold Project' specific webpage already exists and is a resource for disseminating current information relating to the on-going Project status. The Project-specific webpage can be found at:

<https://www.gbm.com.au/projects/yandan-gold-project/>

Announcements relevant to the Project and GBM's other projects are also regularly released:

<https://www.gbm.com.au/asx-announcements/>

The above webpages are updated regularly with the following information:

- references to the approvals regulatory body (Department of Environment and Science (DES));
- historic mining activities;
- future exploration intentions and mineral resource estimates;
- technical report findings;
- company policies; and
- any other public documents relevant to Project such as newsletters and fact sheets that may be published as part of consultation activities.

A contact form linked to the existing reception@gbmex.com.au feedback email address is available on the above webpages and guarantees a response within 72 hours. A contact number (with contact times) and mailing address are also listed to provide stakeholders with three communication avenues to voice any concerns or queries.

GBM will update the relevant websites regularly as part of this SEP to ensure content is current and representative of the Project's operations.

4.2 Additional engagement options

4.2.1 Public displays and community information sessions

Where available, community events provide GBM the opportunity to disseminate information and receive feedback from a broad community cross-section. These events allow the two-way flow of information between the community and GBM personnel.

For such events, stalls and or poster displays are options to provide access to information including the fact sheets already developed, as well as additional contextual information relevant to mining and the local area, as well as providing information promoting contact and Project feedback.

Due to the remote location of the Project and its surrounding small population, community social events are limited. However, current information on local community events can be found at:

<https://www.whitsundayrc.qld.gov.au/community-and-environment/our-community/events?yearMonthStart=01-2022>

Where suitable opportunities exist, GBM will consider a company presence at any upcoming events as an additional avenue of stakeholder engagement.

5 Stakeholder Engagement Tools and Materials

5.1 Contact telephone and email

The company contact phone number and email address are the two primary stakeholder engagement tools to facilitate open, honest and timely communication streams.

Phone number: +61 493 239 674

Email: reception@gbmex.com.au

The general phone contact number is available for assistance by an office manager on weekdays, Monday to Friday between 9.00am - 5.00pm. Out-of-hours phone traffic will be responded to as soon as possible the following weekday. It is proposed that the office manager who fields these calls will be advised to forward messages to the designated GBM team responder for action and recording. The email address is available at any time for stakeholders to send any queries or concerns, with these directed to the designated team responder.

5.2 Fact sheets and newsletters

Fact sheets may be developed to support engagement with the immediate and broader community. Factsheets are likely to include the most updated and relevant Project information, particularly relating to exploration and rehabilitation, and be distributed to stakeholders via stakeholder meetings. Factsheets can also be used at any community events that might be attended by GBM for the Project. It is anticipated that factsheets will cover the following topics:

- general Project updates;
- Project maps and diagrams;
- information on the status of the Project rehabilitation studies;
- information on planned consultation activities; and
- progressive rehabilitation success and scheduled timelines.

Newsletters tend to be Project-specific and of a more regular nature, also typically more suited for a broader community audience. Due to the current status of the Project (being in care and maintenance), it is not proposed to publish regular newsletters until notable activities are scheduled. All fact sheets and newsletters will also be made available online and accessible through the existing webpage.

5.3 Community consultation register

In accordance with section 126C(1)(c)(iii) of the EP Act and as required by DES' *'Progressive rehabilitation and closure plans (PRC plans) Guideline'* (ESR/2019/4964) (PRCP Guideline), GBM have developed a community consultation register as part of the approval requirements for the PRCP.

GBM have actively engaged with the community prior to the implementation of the PRCP Guideline, and concerns raised by stakeholders have been integrated into rehabilitation planning. Following the approval of the PRCP, the register will continue to be used to document each individual stakeholder consultation event (including all meetings, presentations, feedback, phone calls and written submissions). The register will enable record keeping that details consultation dates, engaged community member(s), communication type, information provided, key issues raised, response actions and/or outcomes and any GBM commitments made.

This will provide an efficient mechanism to track, respond, and report, on any feedback received. It will also provide a mechanism to measure stakeholder perception and collate public consultation and response records.



The community consultation register template is provided below in Table 2.

Table 2: Community consultation register template

Date	Community Members	Consultation Type	Information Supplied	Issues Raised Discussed	Straits Gold Response and Outcome

6 Feedback protocols

Routine protocols will be implemented to facilitate a transparent and timely feedback process and respond to all existing communications received from the general public, and or other key stakeholders. The process has been designed in accordance with the company’s approach to establishing and maintaining a constructive relationship with all key stakeholders. GBM are committed to integrity in the reporting of stakeholder engagement and to demonstrate accountability during the consultation process.

The feedback protocol to ensure a timely response to stakeholders and achieve feedback handling efficiency is outlined below (Figure 3).



Figure 3: Feedback protocol

7 References

Australian Bureau of Statistics (ABS) 2016, *Mount Coolon 2016 Census Quick Status*, Available from:
https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/SSC31967?opendocument Accessed 2 March 2021

Appendix F. Rehabilitation Risk Assessment

Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Type (T=Threat) Category Subcategory Item	Risk Description				Risk Evaluation		Risk Rating							Count				Risk Management Class	Manageability
		Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls	Control Effectiveness	Likelihood - Frequency Likelihood - Probability	Health Safety	On-site Environment Off-site Environment Compliance	Health Safety	On-site Environment Off-site Environment Community Trust Compliance Stakeholders	IV	III	II	I	0	1	0	0	
T A 01	01	Heap leach pad Safe																		
T A 01	01	Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Erosion gullies etc due to challenging subsoils/ topsoils, inadequate surface preparation, localised settlement	Safety hazard for personnel, stock and wildlife	Surface preparation measures (initial), monitoring and maintenance controls	C2	P	M			III					0	1	0	0	III
T A 01	02	Slope steepness in excess of that expected for the PMLU	Inappropriate landform design	Safety hazard for personnel, stock and wildlife	Landform design appropriate to PMLU, slope controls embedded in design	C1	U	M			II					0	0	1	0	II
T A 02	01	Stable - geotechnical risk Significant slope failure	Excessive slope steepness, physical material properties, poor drainage, adverse rainfall event	Localised land impacts and downstream water quality impacts	Slope moderation (coarse rock material end dumped at or below the natural angle of repose), geotechnical assessment required for completion criteria	C1	U	M			II					0	0	1	0	II
T A 02	02	Significant slope failure	Inundation by floodwaters	Localised land impacts and downstream water quality impacts	Maximum PMF flood depth est. < 1 m, low flood water velocities only at HLP	C1	R	L			I					0	0	0	1	I
T A 03	01	Stable - erosional risk Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping, rock mulch, prompt revegetation establishment, revegetation monitoring and management as required	C2	P	M			III					0	1	0	0	III
T A 03	02	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ revegetation disease, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	P	M			III					0	1	0	0	III
T A 03	03	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U	M			II					0	0	1	0	II
T A 04	01	Non-polluting - geochemical risk Acid and saline drainage generation	Adverse material geochemistry	Revegetation performance impacts, downstream receiving environment water quality	Confirmed NAF, low salinity material. Regular water quality monitoring and assessment	C2	U	L			I					0	0	0	1	I
T A 04	02	Impacts to groundwater and surface water	Adverse material geochemistry	Groundwater and surface water impacts	Confirmed NAF and low salinity material. Confirmed low risk with respect to total metal concentrations. Regular water quality monitoring and assessment	C2	U	L			I					0	0	0	1	I
T A 05	01	Non-polluting - other environmental harm Not applicable														0	0	0	0	
T A 06		Sustainable - PMLU																		

Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Type (=Threat)	Category	Subcategory	Item	Risk Description				Risk Evaluation				Risk Rating				Count				Risk Management Class	Manageability																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
					Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls	Control Effectiveness	Likelihood - Frequency	Likelihood - Probability	Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment			Community Trust	Compliance	Stakeholders																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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20220328_Yandan_Rehabilitation Risk Assessment
Threats

Commercial-in-Confidence

Page 2 of 11

Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Type (T=Threat) Category Subcategory Item	Risk Description				Risk Evaluation		Risk Rating							Count				Risk Management Class	Manageability
		Evaluated 58 of 73 risks (15 Remaining)				Control Effectiveness	Likelihood - Frequency Likelihood - Probability	Health Safety	On-site Environment Off-site Environment Compliance	Health Safety	On-site Environment Off-site Environment Community Trust Compliance	Stakeholders								
		Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls								IV	III	II	I				
T B 06		Sustainable - PMLU																		
T B 06 01		Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations.	C2	P		L			II			0	0	1	0	II	
T B 06 02		Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, suitable fertilisation rates based on vegetation trials, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U		L			I			0	0	0	1	I	
T B 01		Tailings storage facility (Cell B) Safe																		
T B 01 01		Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Challenging subsoils/ topsoils, inadequate surface preparation, localised settlement, erosion gullies	Safety hazard for personnel, stock and wildlife	Minimal batters present, surface preparation measures (initial), monitoring and maintenance controls	C2	U		M			II			0	0	1	0	II	
T B 02		Stable - geotechnical risk																		
T B 02 01		Significant slope failure	Excessive slope steepness, physical material properties, poor drainage, adverse rainfall event	Localised land impacts and downstream water quality impacts	Minimal batters present, slope moderation, max. slopes subject to engineered design, geotechnical assessment required for completion criteria	C1	R		L			I			0	0	0	1	I	
T B 03		Stable - erosional risk																		
T B 03 01		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping, prompt revegetation establishment, revegetation monitoring and management as required	C2	U		M			II			0	0	1	0	II	
T B 03 02		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ revegetation disease, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U		M			II			0	0	1	0	II	
T B 03 03		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U		M			II			0	0	1	0	II	
T B 04		Non-polluting - geochemical risk																		

Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Description Evaluated 58 of 73 risks (15 Remaining)					Control Effectiveness	Risk Evaluation					Risk Rating					Count					Risk Management Class	Manageability				
Risk Type (T=Threat)	Category	Subcategory	Item	Threat Title	Causes (Triggers / Indicators)		Impacts (Consequences)	Existing Controls	Likelihood - Frequency	Likelihood - Probability	Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance			Stakeholders	IV	III	II
T B 04 01				Contaminants from tailings material impacting receiving environment	Adverse tailings geochemistry	Revegetation performance impacts, downstream receiving environment water quality	Material confirmed as low to moderate salinity and NAF with no PAF material present. Use of oxide rock from heap leach pad as capping material lowers geochemical risk. Regular monitoring of surface water and groundwater	C2	U			M					II						0	0	1	0	II
T B 05				Non-polluting - other environmental harm																							
T B 05 01				Not applicable																			0	0	0	0	
T B 06				Sustainable - PMLU																							
T B 06 01				Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations.	C2	P			L					II						0	0	1	0	II
T B 06 02				Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, suitable fertilisation rates based on vegetation trials, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U			L					I						0	0	0	1	I
T C				Retained infrastructure																							
T C 01				Safe																							
T C 01 01				Not applicable																			0	0	0	0	
T C 02				Stable - geotechnical risk																							
T C 02 01				Not applicable																			0	0	0	0	
T C 03				Stable - erosional risk																							
T C 03 01				Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Grading and shaping, monitoring and management as required	C2	U			M					II						0	0	1	0	II
T C 03 02				Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Sedimentation controls, monitoring and maintenance	C2	U			M					II						0	0	1	0	II
T C 04				Non-polluting - geochemical risk																							
T C 04 01				Not applicable																			0	0	0	0	
T C 05				Non-polluting - other environmental harm																							
T C 05 01				Not applicable																			0	0	0	0	
T C 06				Sustainable - PMLU																							
T C 06 01				Not consistent with surrounding land use	Not consistent with post-mining land use	Not consistent with post-mining land use	Obtain landowner agreement for retained infrastructure at relinquishment. Assessment by an appropriately qualified person that use is consistent with surrounding land use	C1	R			L							I				0	0	0	1	I
T D				Retained water storages																							
T D 01				Safe																							

Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Description					Risk Evaluation										Risk Rating					Count					Risk Management Class	Manageability					
	Risk Type (T=Threat)	Category	Subcategory	Item		Control Effectiveness	Likelihood - Frequency	Likelihood - Probability	Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	IV	III	II	I	0			0	0	0		
	T	D	01	01	Dam overtopping	Extreme rainfall events beyond the hydrological model predicted, insufficient monitoring of water level, wall failure/dam break	Failure to achieve targets of rehabilitation completion criteria, local land and downstream receiving environment water quality and dependent ecosystem impacts	Regulated structures have 'low' rating for 'failure to contain - overtopping' and 'dam break' failure models. Landholder agreement to address any residual regulated structure liability. Geotechnical assessment required for completion criteria applicable to all retained water structures	C2	U			M			II						0	0	1	0	0	0	0	II			
	T	D	02		Stable - geotechnical risk																											
	T	D	02	01	Wall failure/dam break (see dam overtopping risk)				C1	U			M			II						0	0	1	0	0	0	0	II			
	T	D	03		Stable - erosional risk																											
	T	D	03	01	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Increased risk of not achieving designated PMLU	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping of dam banks, prompt revegetation establishment of dam banks, revegetation monitoring and management as required	C2	U			M			II						0	0	1	0	0	0	0	II			
	T	D	04		Non-polluting - geochemical risk																											
	T	D	04	01	Water quality in retained storages not meeting PMLU water quality objectives	Adverse physio-chemical characteristics from materials in catchment or Landform not constructed to design	Livestock health	Landform constructed to design, regular water quality monitoring and assessment	C2	P		L				II						0	0	1	0	0	0	0	II			
	T	D	05		Non-polluting - other environmental harm																											
	T	D	05	01	Not applicable																	0	0	0	0	0	0	0				
	T	D	06		Sustainable - PMLU																											
	T	D	06	01	Water quality in retained storages not meeting PMLU water quality objectives	Adverse physio-chemical characteristics from materials in catchment or Landform not constructed to design	Livestock health, wildlife hazard	Landform constructed to design, regular water quality monitoring and assessment, water treatment (where necessary) to ensure water meets relevant stock watering guidelines	C2	U		L				I						0	0	0	1	0	0	0	I			
	T	E	01		Built infrastructure areas																											
	T	E	01	01	Safe																											
	T	E	01	01	Surface roughness (rockiness, depressions) in excess of that expected for PMLU	Inadequate surface preparation, localised settlement, erosion gullies	Safety hazard for personnel, stock and wildlife	Surface preparation measures (initial), monitoring and maintenance controls	C2	U			L			I						0	0	0	1	0	0	0	I			
	T	E	02		Stable - geotechnical risk																											
	T	E	02	01	Not applicable																	0	0	0	0	0	0	0				
	T	E	03		Stable - erosional risk																											
	T	E	03	01	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U			M			II						0	0	1	0	0	0	0	II			

Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Description				Risk Evaluation								Risk Rating					Count					Risk Management Class	Manageability	
	Risk Type (T=Threat)	Category	Subcategory	Item	Control Effectiveness	Likelihood - Frequency	Likelihood - Probability	Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	IV	III	II			I
T E 03 02				Threat Title Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Causes (Triggers / Indicators) Rehabilitation failure/ vegetation disease/loss, climatic events (drought)	Impacts (Consequences) Localised land impacts and downstream water quality impacts	Existing Controls Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U			M				II					0	0	1	0	II
T E 03 03				Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U			M				II					0	0	1	0	II
T E 04				Non-polluting - geochemical risk																					
T E 04 01				Not applicable																	0	0	0	0	
T E 05				Non-polluting - other environmental harm																					
T E 05 01				Contaminated land	Operational phase industrial use of land	Land contamination, surface water impacts	Phase 1 contaminated land assessment following removal of infrastructure	C1	U			M				II					0	0	1	0	II
T E 06				Sustainable - PMLU																					
T E 06 01				Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations, development of a site specific weed management plan.	C2	P			L				II					0	0	1	0	II
T E 06 02				Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, suitable fertilisation rates based on vegetation trials, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U			L				I					0	0	0	1	I
T F				Rehabilitated water management structures																					
T F 01				Safe																					
T F 01 01				Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Erosion gullies etc due to some dispersive topsoils, inadequate surface preparation, localised settlement	Safety hazard for personnel, stock and wildlife	Slope moderation, surface preparation measures (initial), monitoring and maintenance controls	C2	U			M				II					0	0	1	0	II
T F 02				Stable - geotechnical risk																					
T F 02 01				Significant slope failure	Excessive slope steepness, physical material properties, poor drainage, adverse rainfall event	Localised land impacts and downstream water quality impacts	Slope moderation achieved by grading	C2	U			M				II					0	0	1	0	II
T F 03				Stable - erosional risk																					
T F 03 01				Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U			M				II					0	0	1	0	II

Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Description					Risk Evaluation										Risk Rating					Count					Risk Management Class						
Risk Type (T=Threat)	Category	Subcategory	Item																							Risk Management Class						
						Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls	Control Effectiveness	Likelihood - Frequency	Likelihood - Probability	Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders								
T	F	03	02			Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ vegetation disease/loss, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U				M					II					0	0	1	0	II			
T	F	04				Non-polluting - geochemical risk																					0	0	0	0		
T	F	05				Non-polluting - other environmental harm																						0	0	0	0	
T	F	05	01			Not applicable																			0	0	0	0				
T	F	06				Sustainable - PMLU																						0	0	0	0	
T	F	06	01			Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations, development of a site specific weed management plan.	C2	P				L					II					0	0	1	0	II			
T	F	06	02			Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, suitable fertilisation rates based on vegetation trials, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U				L					I					0	0	0	1	I			
T	F					ROM pad																										
T	F	01				Safe																										
T	F	01	01			Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Erosion gullies etc due to some dispersive topsoils, inadequate surface preparation, localised settlement	Safety hazard for personnel, stock and wildlife	Surface preparation measures (initial), monitoring and maintenance controls	C2	P			M						III					0	1	0	0	III			
T	F	01	02			Slope steepness in excess of that expected for the PMLU	Inappropriate landform design	Safety hazard for personnel, stock and wildlife	Landform design appropriate to PMLU, slope controls	C2	U			M						II					0	0	1	0	II			
T	F	02				Stable - geotechnical risk																										
T	F	02	01			Significant slope failure	Excessive slope steepness, physical material properties, poor drainage, adverse rainfall event	Localised land impacts and downstream water quality impacts	Slope moderation, max. slopes subject to design, geotechnical assessment required for completion criteria	C1	U			M						II					0	0	1	0	II			
T	F	03				Stable - erosional risk																										
T	F	03	01			Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping, rock mulch, prompt revegetation establishment, revegetation monitoring and management as required	C2	P			M						III					0	1	0	0	III			

Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Description					Risk Evaluation					Risk Rating					Count					Risk Management Class									
Risk Type (=Threat)	Category	Subcategory	Item	Evaluated 58 of 73 risks (15 Remaining)					Control Effectiveness	Likelihood - Frequency		Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	Count					Risk Management Class	Manageability
				Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls	Likelihood		Frequency	IV													III	II	I				
T	F	03	02	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ revegetation disease, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	P					M					III					0	1	0	0	III		
T	F	03	03	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U					M					II					0	0	1	0	II		
T	F	04		Non-polluting - geochemical risk																										
T	F	04	01	Acid drainage generation	Adverse material geochemistry	Revegetation performance impacts, downstream receiving environment water quality	Confirmed NAF material, no evidence of downstream impacts on vegetation monitoring, monitoring and maintenance	C2	U					M					II					0	0	1	0	II		
T	F	05		Non-polluting - other environmental harm																										
T	F	05	01	Not applicable																				0	0	0	0			
T	F	06		Sustainable - PMLU																										
T	F	06	01	Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations, development of a site specific weed management plan.	C2	P					L					II					0	0	1	0	II		
T	F	06	02	Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, soil health assessment and fertiliser / ameliorants application prior to revegetation, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U					L					I					0	0	0	1	I		
T	F	01		Main pit bund																										
T	F	01	01	Safe																										
T	F	01	01	Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Erosion gullies etc due to challenging subsoils/ topsoils, inadequate surface preparation, localised settlement	Safety hazard for personnel, stock and wildlife	Surface preparation measures (initial), monitoring and maintenance controls	C2	P					M					III					0	1	0	0	III		
T	F	02		Stable - geotechnical risk																										
T	F	02	01	Structural failure during flood event	Bunding constructed not in accordance with design plan	Localised land impacts and downstream water quality impacts	Construction to follow design requirements. Geotechnical assessment required for completion criteria	C1	U					M	M				II	II				0	0	2	0	II		
T	F	03		Stable - erosional risk																										
T	F	03	01	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping, prompt revegetation establishment, revegetation monitoring and management as required	C2	U					M					II					0	0	1	0	II		

20220328_Yandan_Rehabilitation Risk Assessment Threats

Commercial-in-Confidence

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Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Type (T=Threat) Category Subcategory Item	Risk Description				Risk Evaluation				Risk Rating				Count				Risk Management Class	Manageability					
		Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls	Control Effectiveness	Likelihood - Frequency	Likelihood - Probability	Health Safety	On-site Environment	Off-site Environment	Compliance	Health Safety	On-site Environment	Off-site Environment	Community Trust	Compliance			Stakeholders	IV	III	II	I
	T F 03 02	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ revegetation disease, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	P			M				III					0	1	0	0	III	
	T F 03 03	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U			M				II					0	0	1	0	II	
	T F 04	Non-polluting - geochemical risk																						
	T F 04 01	Not applicable																		0	0	0	0	
	T F 05	Non-polluting - other environmental harm																						
	T F 05 01	Not applicable																		0	0	0	0	
	T F 06	Sustainable - PMLU																						
	T F 06 01	Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations.	C2	P			L				II					0	0	1	0	II	
	T F 06 02	Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, soil health assessment and fertiliser / ameliorants application prior to revegetation, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U			L				I					0	0	0	1	I	
	T F 01	South pit (backfilled) Safe																						
	T F 01 01	Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Erosion gullies etc due to challenging subsoils/ topsoils, inadequate surface preparation, localised settlement	Safety hazard for personnel, stock and wildlife	Low slopes, surface preparation measures (initial), monitoring and maintenance controls	C2	U			M				II					0	0	1	0	II	
	T F 02	Stable - geotechnical risk																						
	T F 02 01	Significant slope failure	Excessive slope steepness, physical material properties, poor drainage, adverse rainfall event	Localised land impacts and downstream water quality impacts	Slope moderation, max. slopes subject to design, geotechnical assessment required for completion criteria	C1	U			M				II					0	0	1	0	II	
	T F 03	Stable - erosional risk																						
	T F 03 01	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping, prompt revegetation establishment, revegetation monitoring and management as required	C2	U			M				II					0	0	1	0	II	

Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Description					Risk Evaluation										Risk Rating					Count					Risk Management Class	Manageability
	Risk Type (T=Threat)	Category	Subcategory	Item		Control Effectiveness	Likelihood - Frequency	Likelihood - Probability	Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	IV	III	II	I			
	T	F	03	01	Threat Title Poor pit lake water quality (applicable to Main pit)	Causes (Triggers / Indicators) Exposure of sulphidic materials to air (oxidising conditions) resulting in accumulation of soluble salts and acidity	Impacts (Consequences) Worsening void water quality and potential for negative impacts to groundwater and Suttor River / Yandan Creek	Existing Controls Capping of sulphide material and design of final landform maintains permanent water cover of sulphidic materials in walls and base of pit, including spillways between the pit lake and Suttor River and Yandan Creek	C2	U			M	M			II	II				0	0	2	0	II	
	T	F	05		Achievement of sufficient improvement																						
	T	F	05	01	Sufficient improvement not achieved due to excessive slopes, not constructed to design, adverse rainfall event	Excessive slopes, not constructed to design, adverse rainfall event	Localised land impacts	VOIDS to follow design requirements for maximum slope, geotechnical assessment required for completion criteria	C2	U			M				II					0	0	1	0	II	
	T	F	05	02	Sufficient improvement not achieved due to poor water quality (applicable to Main pit)	Exposure of sulphidic materials to air (oxidising conditions) resulting in accumulation of soluble salts and acidity	Localised land impacts and downstream water quality impacts	Assessment by an appropriately qualified person that the water level and quality meet design requirements	C2	U			M	M			II	II				0	0	2	0	II	
	T	F	05	03	Groundwater contamination (applicable to East Hill pit)	rising water level accessing the sandstone unit	Groundwater quality impacts	Water balance model, catchment area controls, assessment by an appropriately qualified person that the water level meet design requirements	C2	U			M				II					0	0	1	0	II	
	T	F	05	04	Inundation by flood waters (applicable to East Hill pit)	Inundation by floodwaters resulting in water level rising above known unit of sandstone	Groundwater quality impacts	Maximum PMF flood depth est. < 1 m, minor permanent bunding constructed around the north of the pit	C1	R			M				II					0	0	1	0	II	
					End of record																	0	10	57	15		

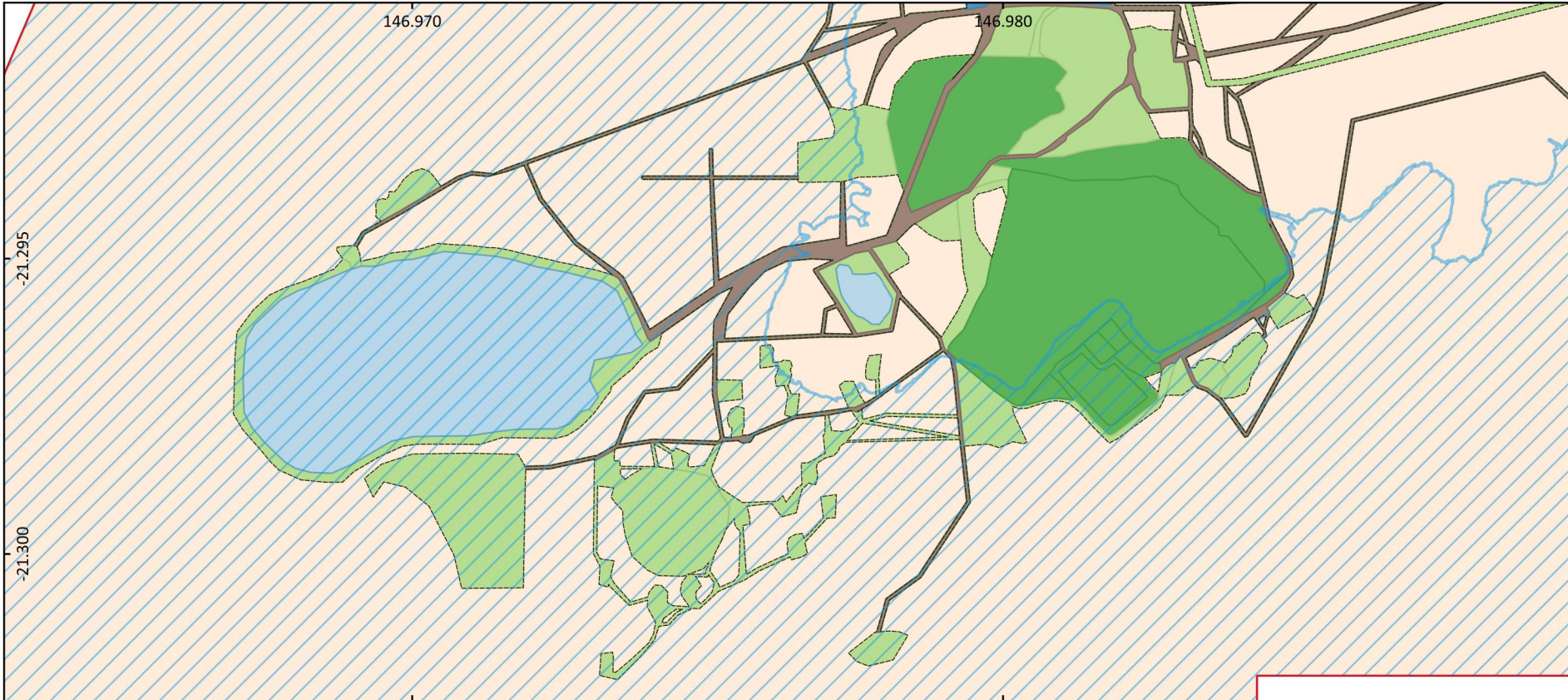
Product Group/ Business Unit / Division / Department Name

ABC Closure Risk Analysis

Ref.	Risk Description				Risk Evaluation										Risk Rating					Count					Risk Management Class	Manageability
	Risk Type (T=Threat)	Category	Subcategory	Item	Control Effectiveness	Likelihood - Frequency	Likelihood - Probability	Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	IV	III	II	I			
	T	F	03	02	Threat Title Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Causes (Triggers / Indicators) Rehabilitation failure/ revegetation disease, climatic events (drought)	Impacts (Consequences) Localised land impacts and downstream water quality impacts	Existing Controls Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U				M				II			0	0	1	0	II	
	T	F	03	03	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U				M				II			0	0	1	0	II	
	T	F	04		Non-polluting - geochemical risk																					
	T	F	04	01	Acid drainage generation	Adverse material geochemistry	Revegetation performance impacts, downstream receiving environment water quality	Oxidised waste rock and clay capping material lowers geochemical risk. Oxide waste material confirmed NAF	C2	U				M				II			0	0	1	0	II	
	T	F	05		Non-polluting - other environmental harm																					
	T	F	05	01	Not applicable																0	0	0	0		
	T	F	06		Sustainable - PMLU																					
	T	F	06	01	Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations, development of a site specific weed management plan.	C2	P				L				II			0	0	1	0	II	
	T	F	06	02	Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, soil health assessment and fertiliser / ameliorants application prior to revegetation, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U				L				I			0	0	0	1	I	
	T	F	01		Final void(s) - NUMAs																					
	T	F	01		Safe																					
	T	F	01	01	Void areas are accessible by public and/or fauna	Insufficient warnings, barriers preventing access to hazardous areas (highwalls, pit lake)	Falls, slips, trips impacting humans, livestock, fauna	Signage, physical barriers, slope moderation included in monitoring and maintenance procedures for Improvement Areas, remoteness of site and landowner controls	C2	U				M				II			0	0	1	0	II	
	T	F	02		Stable - geotechnical risk																					
	T	F	02	01	Significant slope failure	Excessive slopes, not constructed to design, adverse rainfall event	Localised land impacts	VOIDs to follow design requirements for maximum slope.	C2	U				M				II			0	0	1	0	II	
	T	F	03		Non-polluting - geochemical risk																					

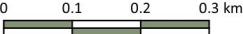
Appendix G. Provided technical studies

- Environmental Geochemical Assessment of the Yandan Heap Leach Dump (EGI 2002)
- Geochemical Assessment of TSF Cell B cover materials, tailings and heap leach rocks at Yandan Gold Mine (RGS 2013)
- Independent desktop review of risk level and appropriate capping strategy for TSF Cell B at Yandan Gold Mine (Williams 2021)
- Soil and Land Suitability Assessment (AARC 2022a)
- Water Performance of Yandan Mine landscape at closure (SBE 2022)
- Yandan Gold Mine - TSF Cell B Conceptual Cover System Design Update (O’Kane Consultants 2019)
- Yandan Gold Mine: Water Management Plan (AARC 2021b)
- Yandan Gold Project: Erosion Stability Assessment (AARC 2022b)
- Yandan Oxide and Sulfide Tailings Assessment (RGS 2015)
- Yandan Tailings Storage Facility: Technical Memorandum (RGS 2021)



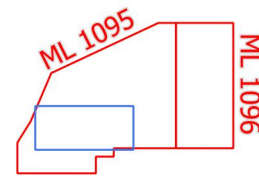
FINAL SITE DESIGN MAP 1

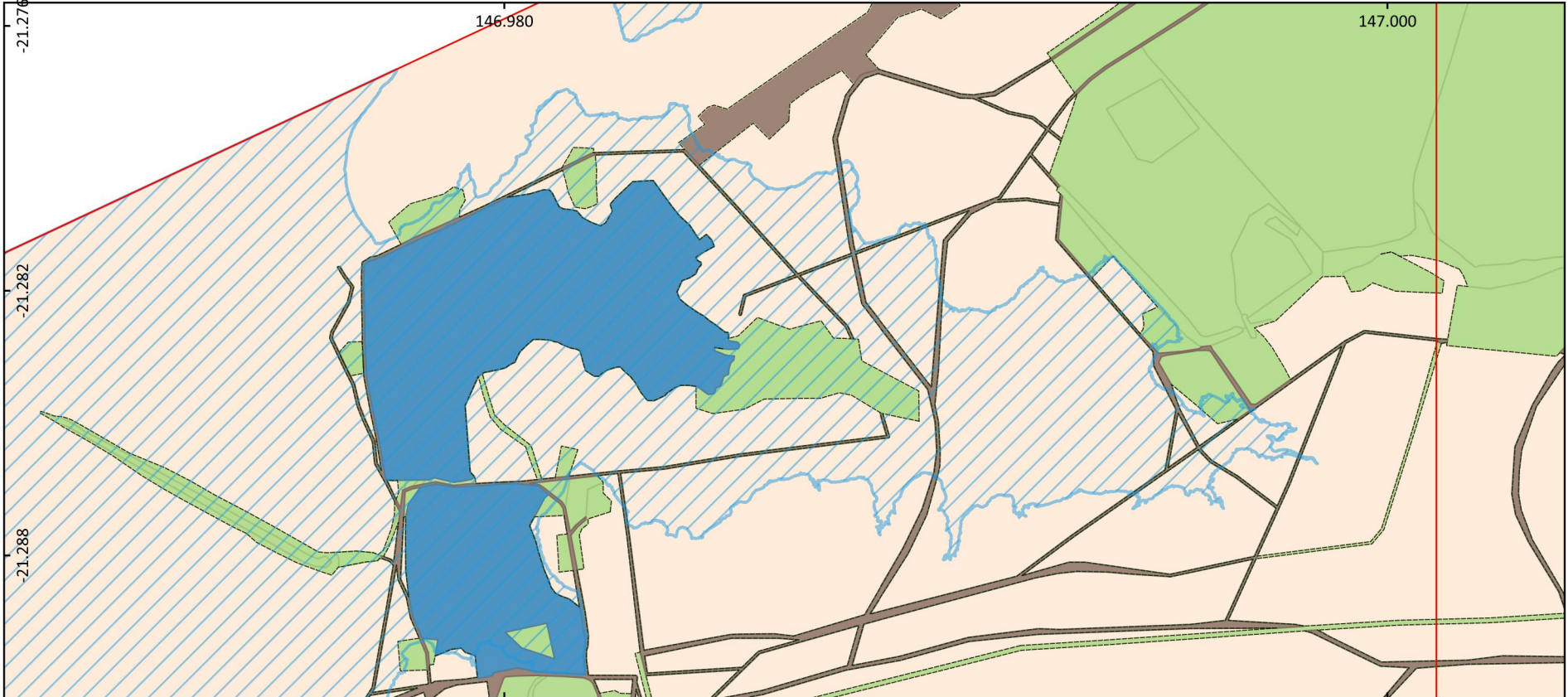
YANDAN GOLD MINE

 	
Date	24-03-2022
Author	P.French
Projection	GDA2020
Scale	1:9000

LEGEND

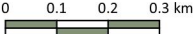
 Yandan Gold Mine mining leases	 Low hill - pasture grazing
 Flood plain extent (0.1% AEP)	 Open pasture - grazing
 Disturbance footprint	 Retained infrastructure
 Void (non-use management area)	 Retained water storage
 Undisturbed land - grazing	





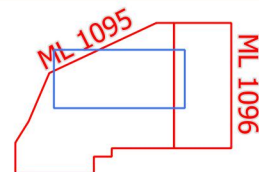
FINAL SITE DESIGN MAP 2

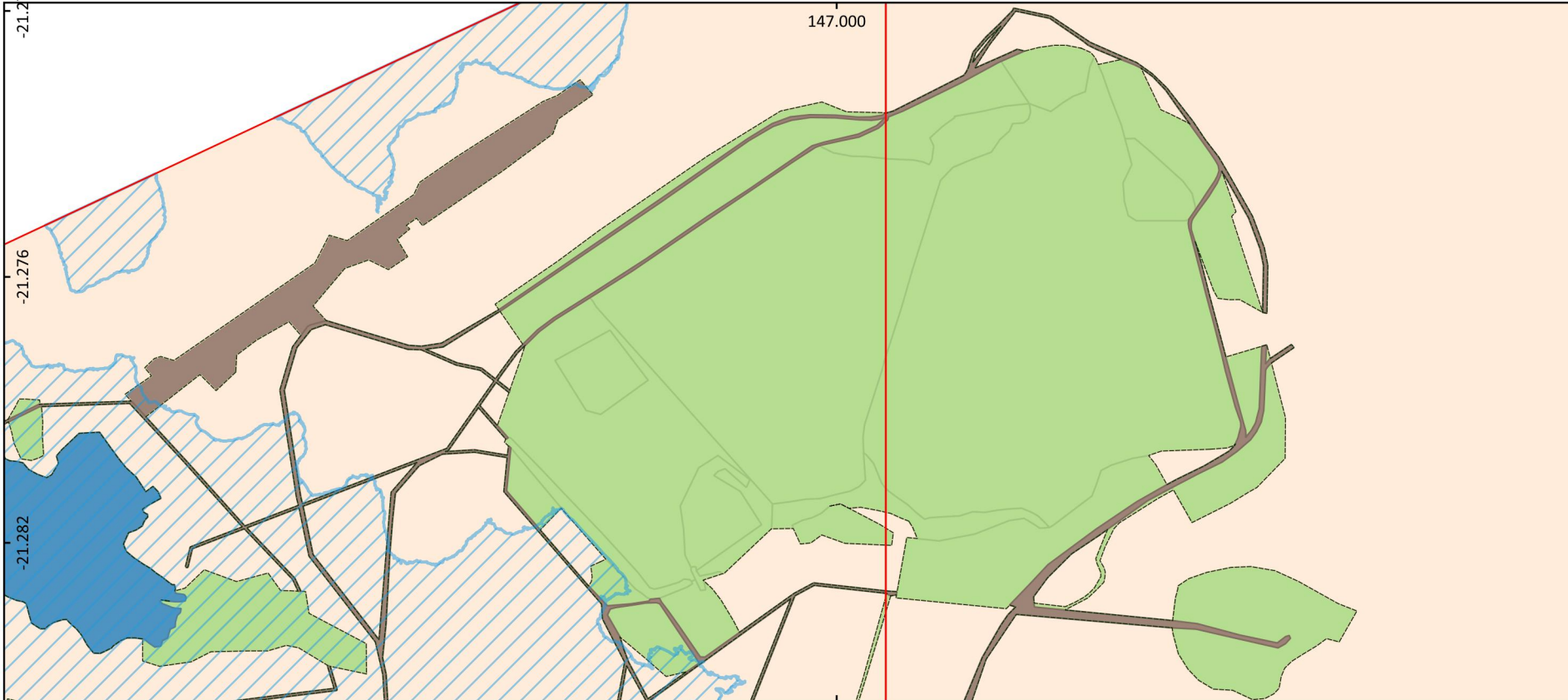
YANDAN GOLD MINE

 	
Date	24-03-2022
Author	P.French
Projection	GDA2020
Scale	1:12000

LEGEND

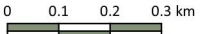
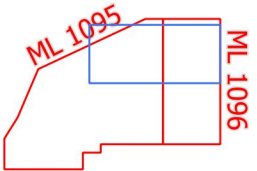
- | | |
|--|--|
|  Yandan Gold Mine mining leases |  Low hill - pasture grazing |
|  Flood plain extent (0.1% AEP) |  Open pasture - grazing |
|  Disturbance footprint |  Retained infrastructure |
|  Void (non-use management area) |  Retained water storage |
|  Undisturbed land - grazing | |

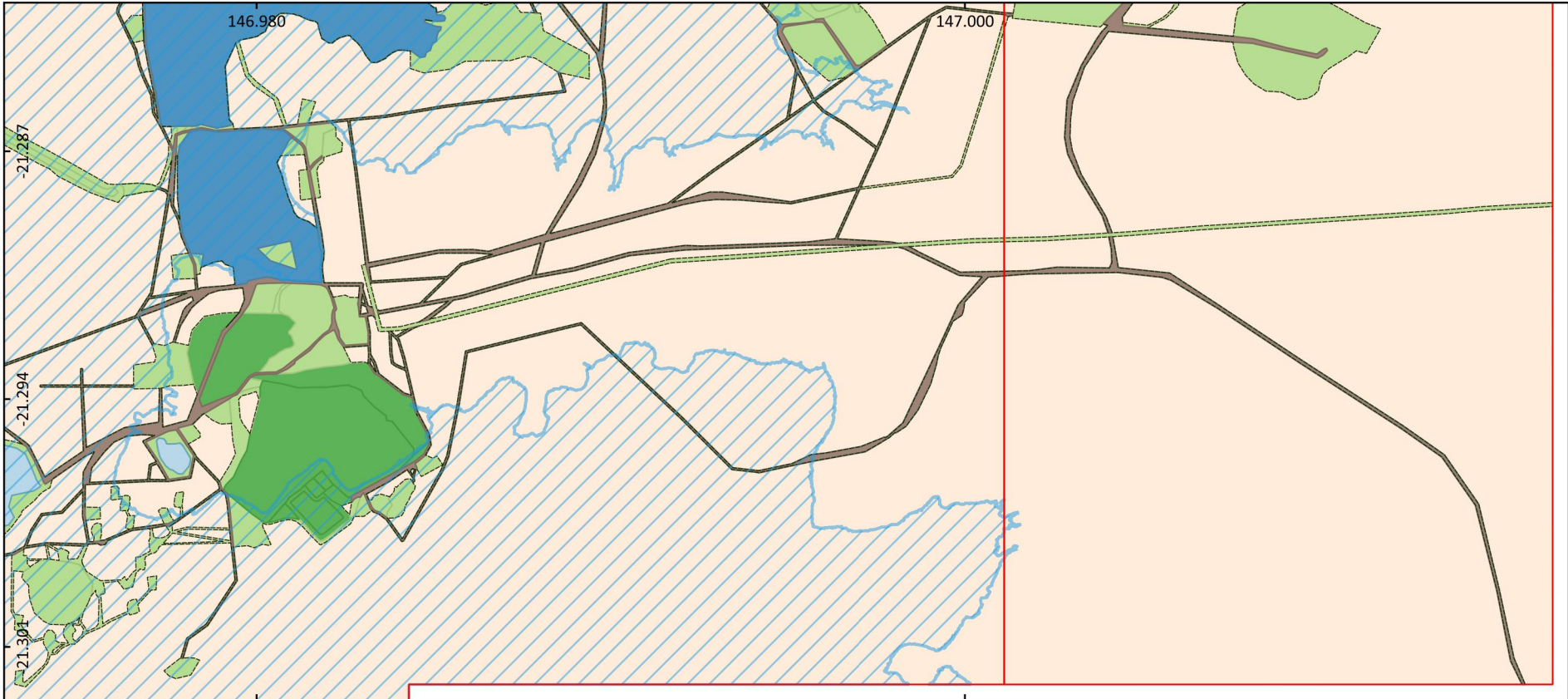




FINAL SITE DESIGN MAP 3

YANDAN GOLD MINE

 		LEGEND  Yandan Gold Mine mining leases  Flood plain extent (0.1% AEP)  Disturbance footprint  Void (non-use management area)  Undisturbed land - grazing  Low hill - pasture grazing  Open pasture - grazing  Retained infrastructure  Retained water storage	
Date	24-03-2022		
Author	P.French		
Projection	GDA2020		
Scale	1:12000		
			



FINAL SITE DESIGN MAP 4

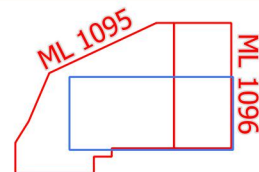
YANDAN GOLD MINE

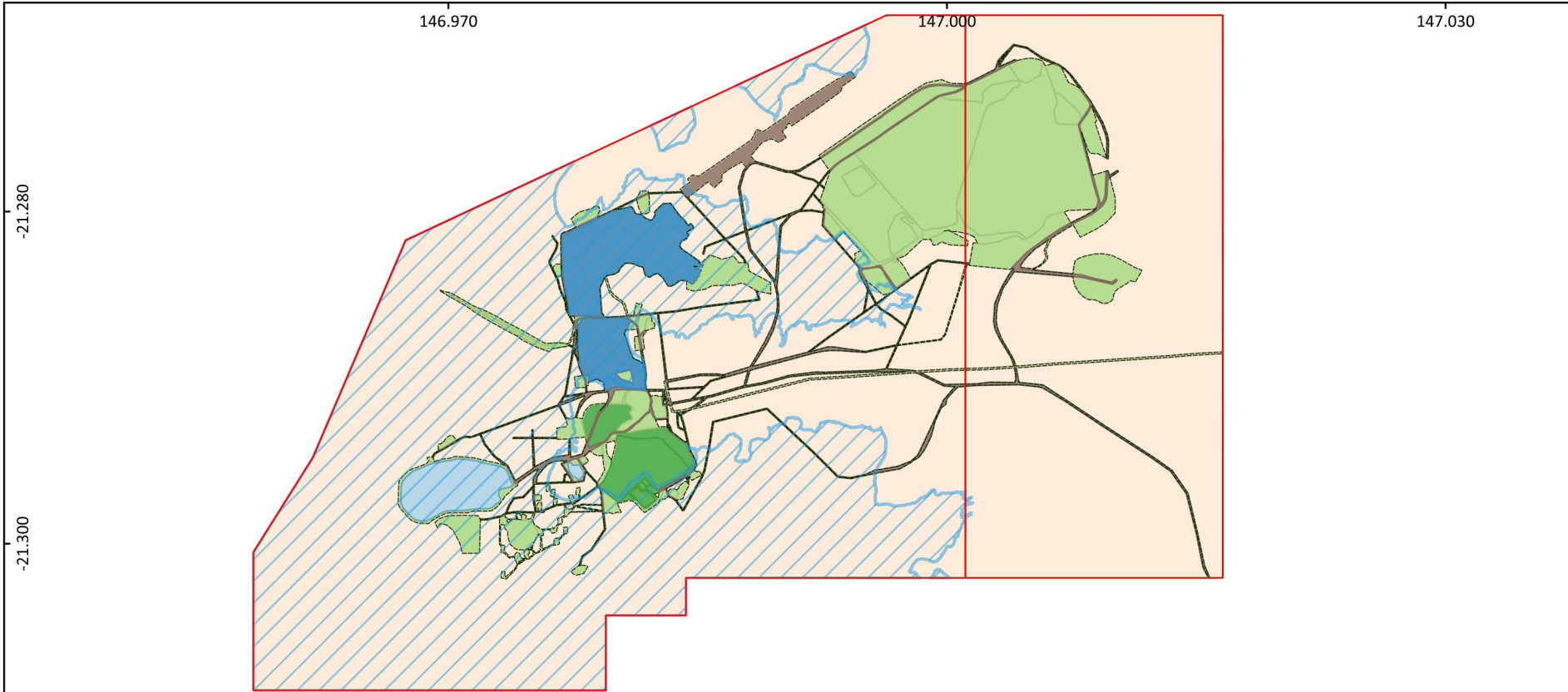
 	
Date	24-03-2022
Author	P.French
Projection	GDA2020
Scale	1:15000

LEGEND

- | | |
|--|--|
|  Yandan Gold Mine mining leases |  Low hill - pasture grazing |
|  Flood plain extent (0.1% AEP) |  Open pasture - grazing |
|  Disturbance footprint |  Retained infrastructure |
|  Void (non-use management area) |  Retained water storage |
|  Undisturbed land - grazing | |

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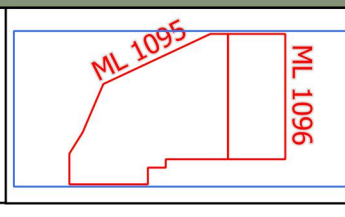
FINAL SITE DESIGN MAP 5

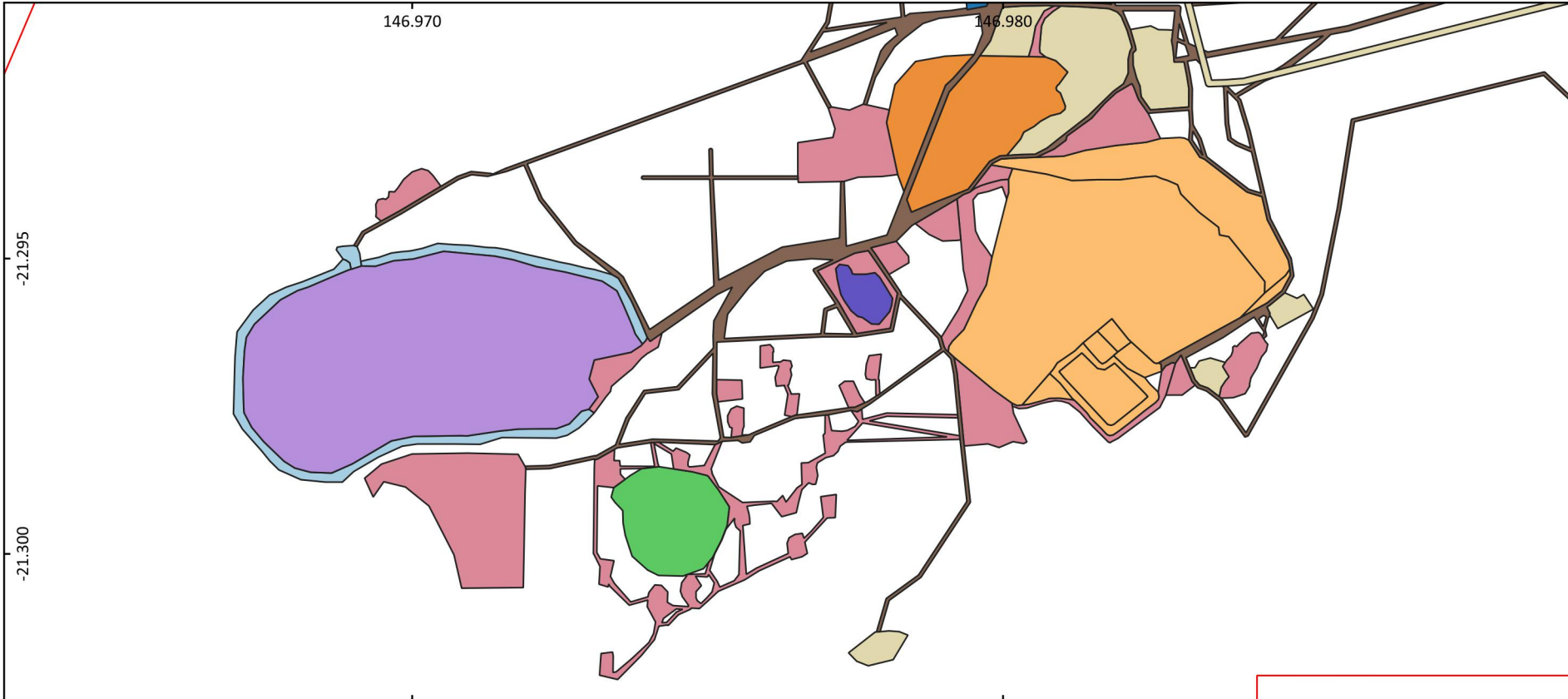
YANDAN GOLD MINE

 	
Date	24-03-2022
Author	P.French
Projection	GDA2020
Scale	1:32000

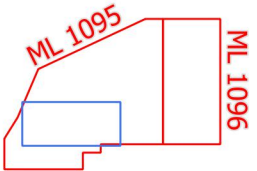
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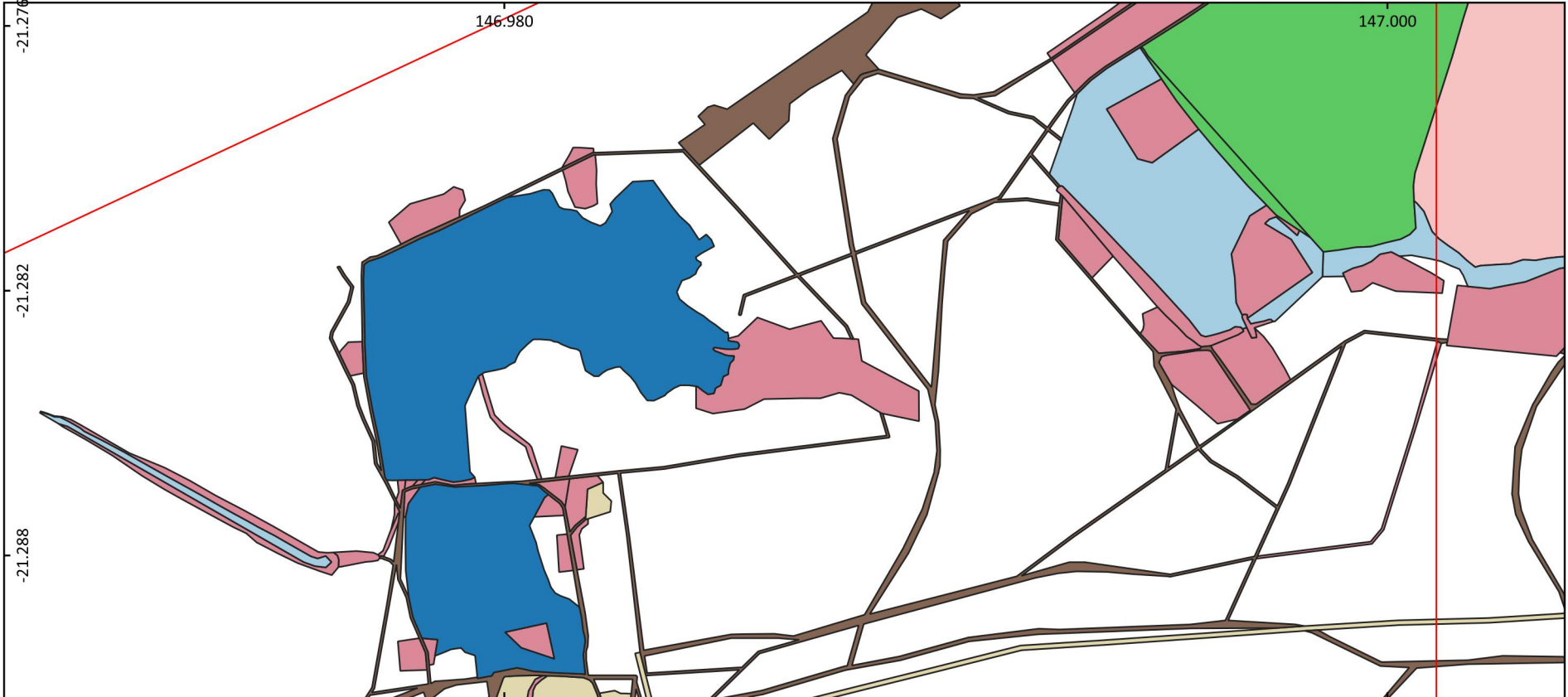
-  Yandan Gold Mine mining leases
-  Flood plain extent (0.1% AEP)
-  Disturbance footprint
-  Void (non-use management area)
-  Undisturbed land - grazing
-  Low hill - pasture grazing
-  Open pasture - grazing
-  Retained infrastructure
-  Retained water storage



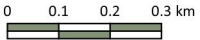


REFERENCE MAP 1
YANDAN GOLD MINE

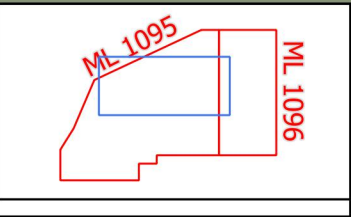
 		LEGEND  Yandan Gold Mine mining leases  IA1  IA2  RA1  RA2  RA3  RA4  RA5  RA6  RA7  RA8  RA9					
Date	25-03-2022						
Author	P.French						
Projection	GDA2020						
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REFERENCE MAP 2
YANDAN GOLD MINE

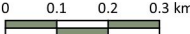
 	
Date	25-03-2022
Author	P.French
Projection	GDA2020
Scale	1:12000

LEGEND			
 Yandan Gold Mine mining leases	 RA1	 RA4	 RA7
 IA1	 RA2	 RA5	 RA8
 IA2	 RA3	 RA6	 RA9

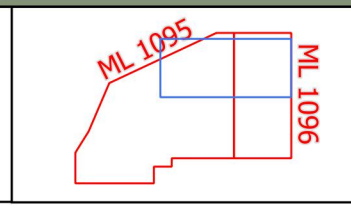





REFERENCE MAP 3
YANDAN GOLD MINE

 	
Date	25-03-2022
Author	P.French
Projection	GDA2020
Scale	1:12000

LEGEND	
 Yandan Gold Mine mining leases	 RA1
 IA1	 RA2
 IA2	 RA3
	 RA4
	 RA5
	 RA6
	 RA7
	 RA8
	 RA9



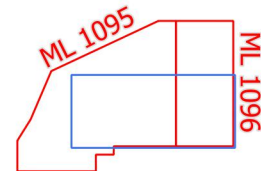


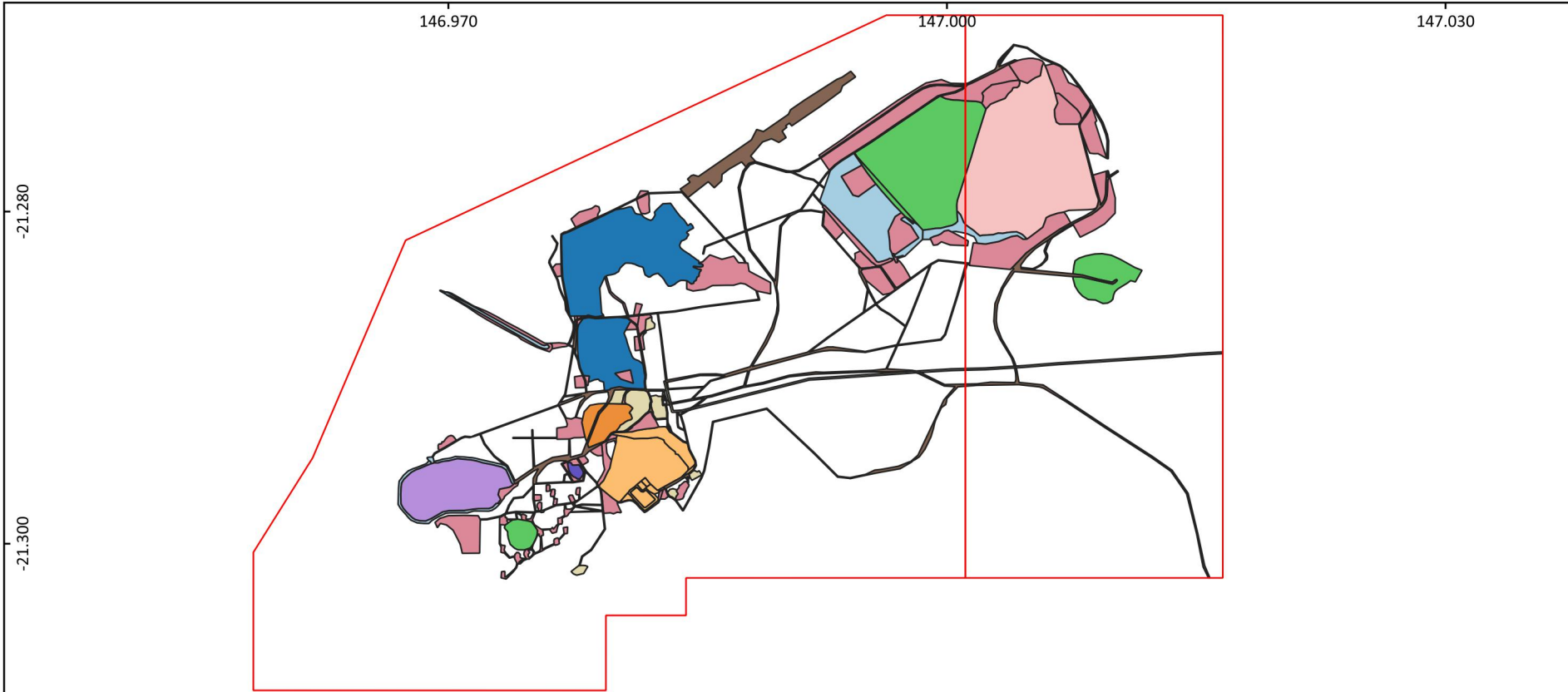

REFERENCE MAP 4
YANDAN GOLD MINE

 	
Date	25-03-2022
Author	P.French
Projection	GDA2020
Scale	1:15000

LEGEND

 Yandan Gold Mine mining leases	 RA1	 RA4	 RA7
 IA1	 RA2	 RA5	 RA8
 IA2	 RA3	 RA6	 RA9



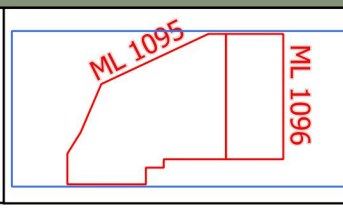


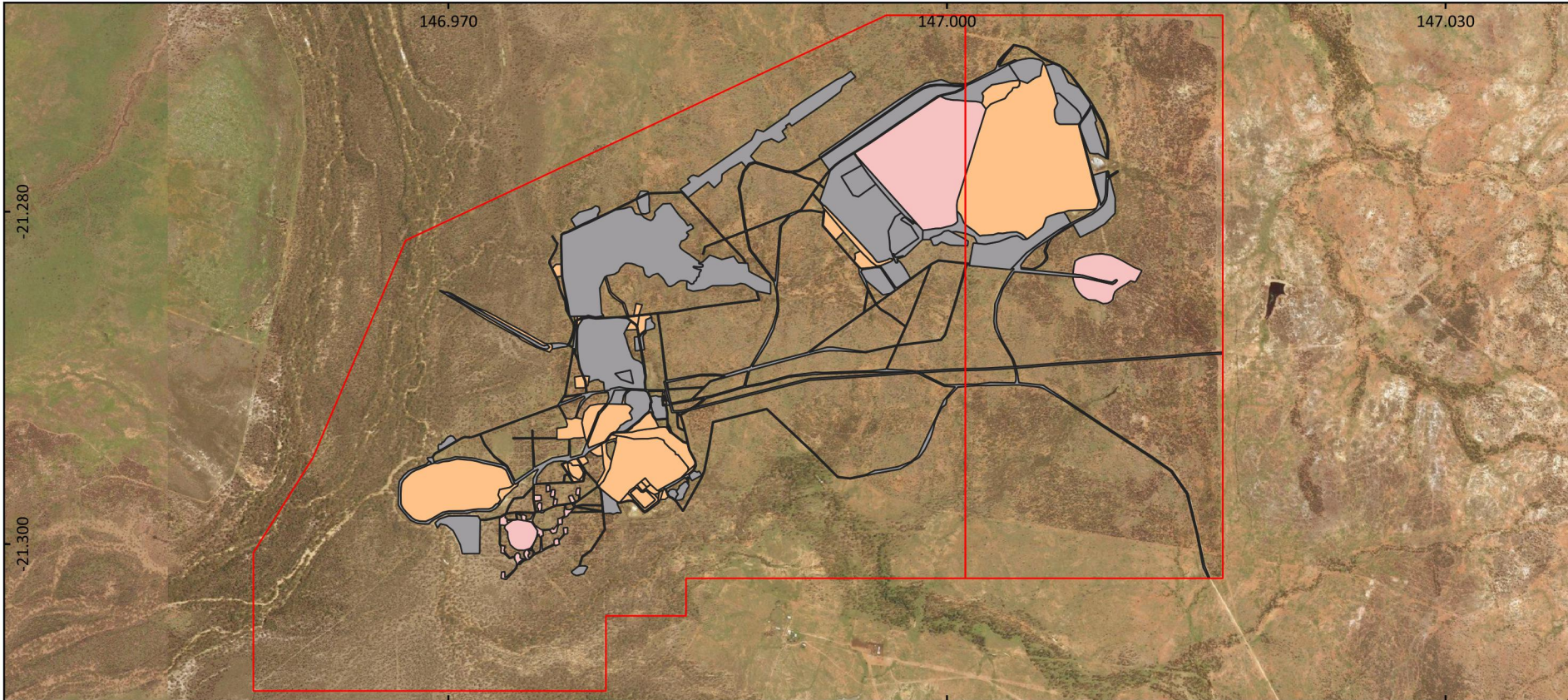
REFERENCE MAP 5
YANDAN GOLD MINE

Date	25-03-2022
Author	P.French
Projection	GDA2020
Scale	1:32000

LEGEND

Yandan Gold Mine mining leases	RA1	RA4	RA7
IA1	RA2	RA5	RA8
IA2	RA3	RA6	RA9





STAGE PLAN 2035
YANDAN GOLD MINE



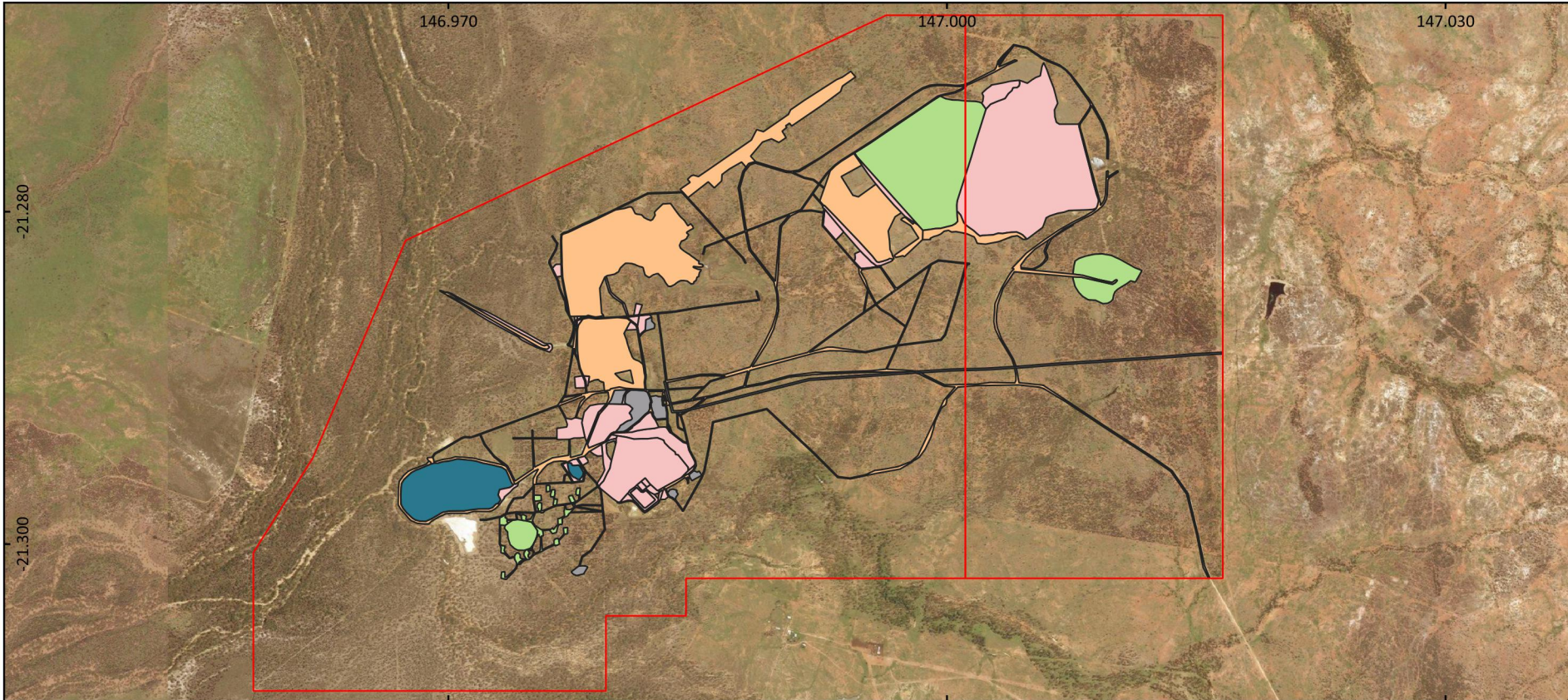
LEGEND

- Yandan Gold Mine mining leases
- RM8 - Revegetation
- Active mining
- Land available

Date	28-03-2022
Author	P.French
Projection	GDA2020
Scale	1:32000

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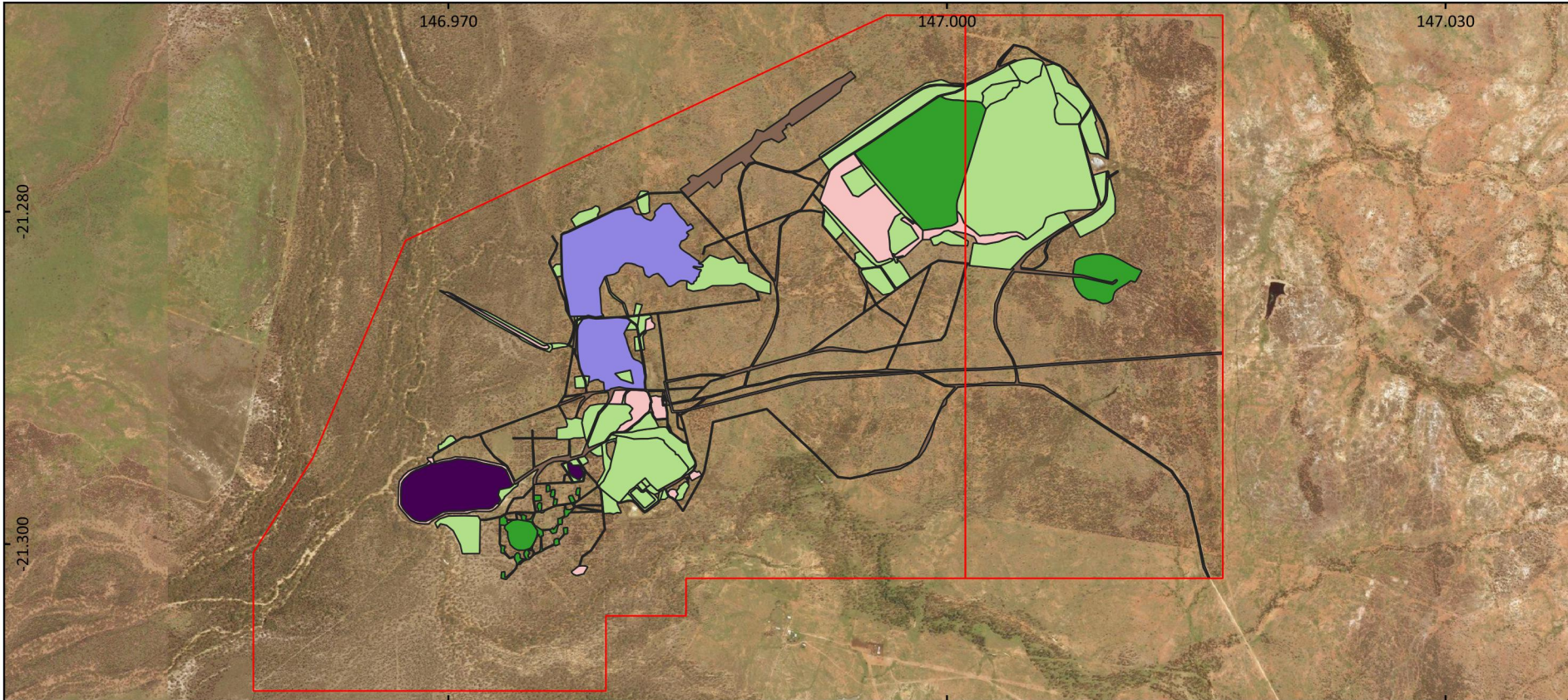
STAGE PLAN 2045
YANDAN GOLD MINE

 	
Date	28-03-2022
Author	P.French
Projection	GDA2020
Scale	1:32000

LEGEND

- Yandan Gold Mine mining leases
- Active mining
- Land available
- RM8 - Revegetation
- RM9 - Achievement of surface requirements
(open pasture – grazing and low hill – pasture grazing)
- MM2 - Achievement of surface requirements



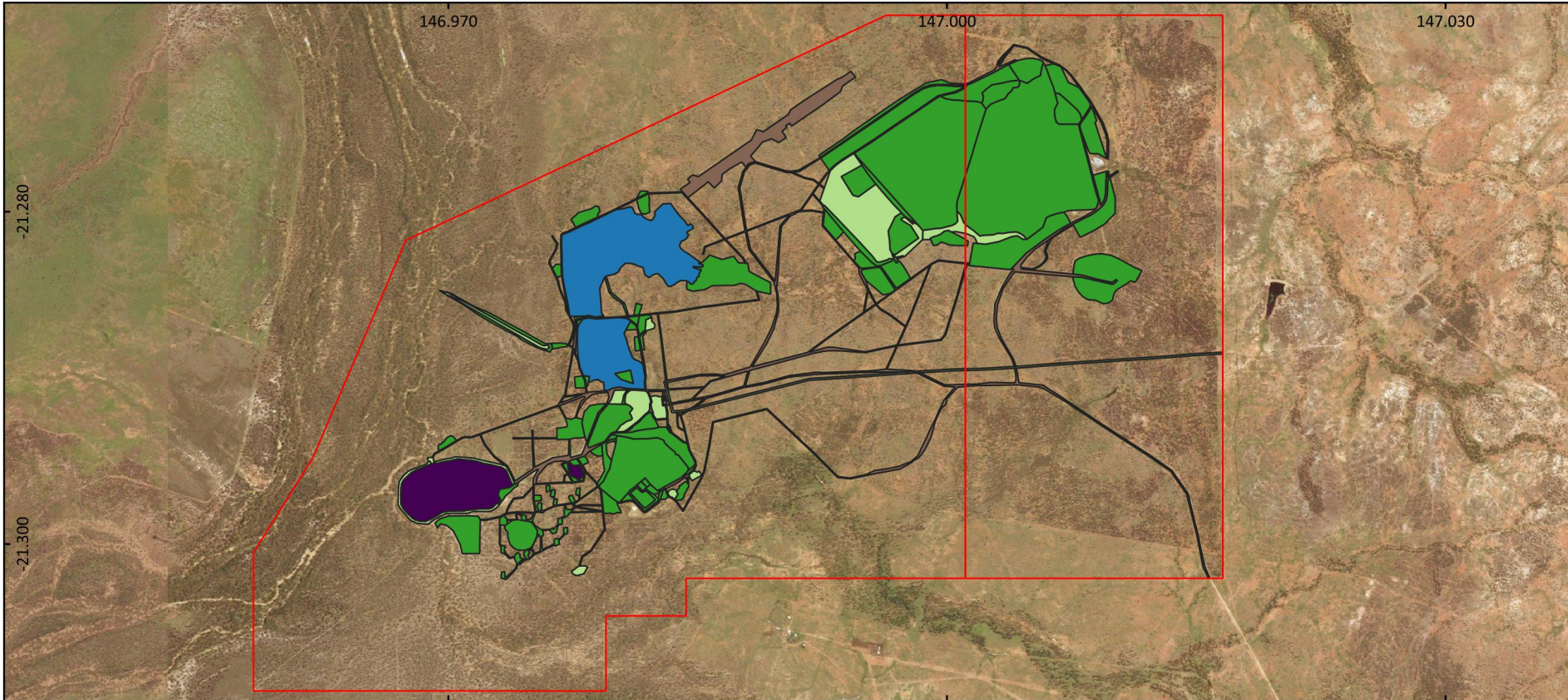


STAGE PLAN 2055
YANDAN GOLD MINE

	
Date	28-03-2022
Author	P.French
Projection	GDA2020
Scale	1:32000

LEGEND

- | | |
|--|--|
|  Yandan Gold Mine mining leases |  RM9 - Achievement of surface requirements
(open pasture – grazing and low hill – pasture grazing) |
|  MM3 - Achievement of sufficient improvement |  RM10 - Achievement of target post mining land use
(open pasture – grazing and Low hill – pasture grazing) |
|  RM1 - Infrastructure decommissioning and removal |  RM12 - Achievement of target post-mining land use
(retained infrastructure) |
|  RM8 - Revegetation | |



STAGE PLAN 2065
YANDAN GOLD MINE

 	
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LEGEND

-  Yandan Gold Mine mining leases
-  MM3 - Achievement of sufficient improvement
-  RM9 - Achievement of surface requirements (open pasture – grazing and low hill – pasture grazing)
-  RM10 - Achievement of target post mining land use (open pasture – grazing and Low hill – pasture grazing)
-  RM11 - Achievement of target post-mining land use (retained water storages)
-  RM12 - Achievement of target post-mining land use (retained infrastructure)



YANDAN GOLD PROJECT STAKEHOLDER ENGAGEMENT PLAN

PREPARED FOR
STRAITS GOLD PTY LTD

JANUARY 2022

Document Control

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Report Title:	Stakeholder Engagement Plan
Client:	Straits Gold Pty Ltd
Project Manager:	Gareth Bramston

Version	Comments	Author	Reviewer	Date
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1 Introduction

The Yandan Gold Project (the Project) is located in the Drummond Basin in Central Queensland, approximately 50 kilometres (km) to the west of the Mount Coolon township and approximately 150 km southeast of Charters Towers (Figure 1). GBM Resources Limited (GBM) acquired the Project and the Straits Gold Pty Ltd (Straits Gold) identity in January 2021.

This Stakeholder Engagement Plan (SEP) has been prepared to provide a summary of the consultation provided on the Project and detail ongoing community consultation in relation to the rehabilitation planned to be carried out under the Project's Progressive Rehabilitation and Closure Plan (PRCP) for the Project.

1.1 Purpose

The purpose of this SEP is to comply with the requirements set out in section 126C(1)(c)(iv) and (iv) of the *Environmental Protection Act 1994* (EP Act), being the inclusion of the following in the proposed PRCP:

- details of the consultation undertaken by the applicant in developing the proposed PRC plan, and
- details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.

1.2 Project description

The Impact Assessment Study for the Project approval was submitted in December 1988, with the Project mining leases (ML) (ML1095 and ML1096) granted in June 1991. In July 1992, Ross Mining N.L. acquired the Project; in addition to the Wirralie Gold Mine, a controlling interest in the Mount Coolon joint venture, and exploration tenements associated with the three assets.

Ross Mining N.L. operated the Project between 1993 - 2002, producing over 350,000 ounces (oz) of gold from heap leach operations and a Carbon in Leach (CIL) process plant. Mining operations ceased in 1998, with the Heap Leach Pad remaining operational until September 2002. The site was placed into care and maintenance in April 1999, pending final closure works. The gold processing plant was later removed in 2006/2007, prior to the acquisition of the Project by Straits Gold, which was a wholly owned subsidiary of Aeris Resources Ltd at the time. The Project has remained in care and maintenance since closure in 1999.

GBM acquired the Project and the Straits Gold entity on 13 January 2021, and have since taken significant steps towards restoring operations. This has included re-commencing exploration at Yandan, most recently including the 2021 drilling program which focused on the identification of potential open pits targets in the area between Main Pit and East Hill deposits.

Yandan is a key asset in GBM's 'processing halo strategy' for the Drummond Basin, joining the nearby Mount Coolon asset and the recently acquired Twin Hills asset. It is proposed that Yandan will provide a central processing hub for material from the three projects, with existing infrastructure at Yandan supporting and accelerating the development of a gold mining and processing operation.

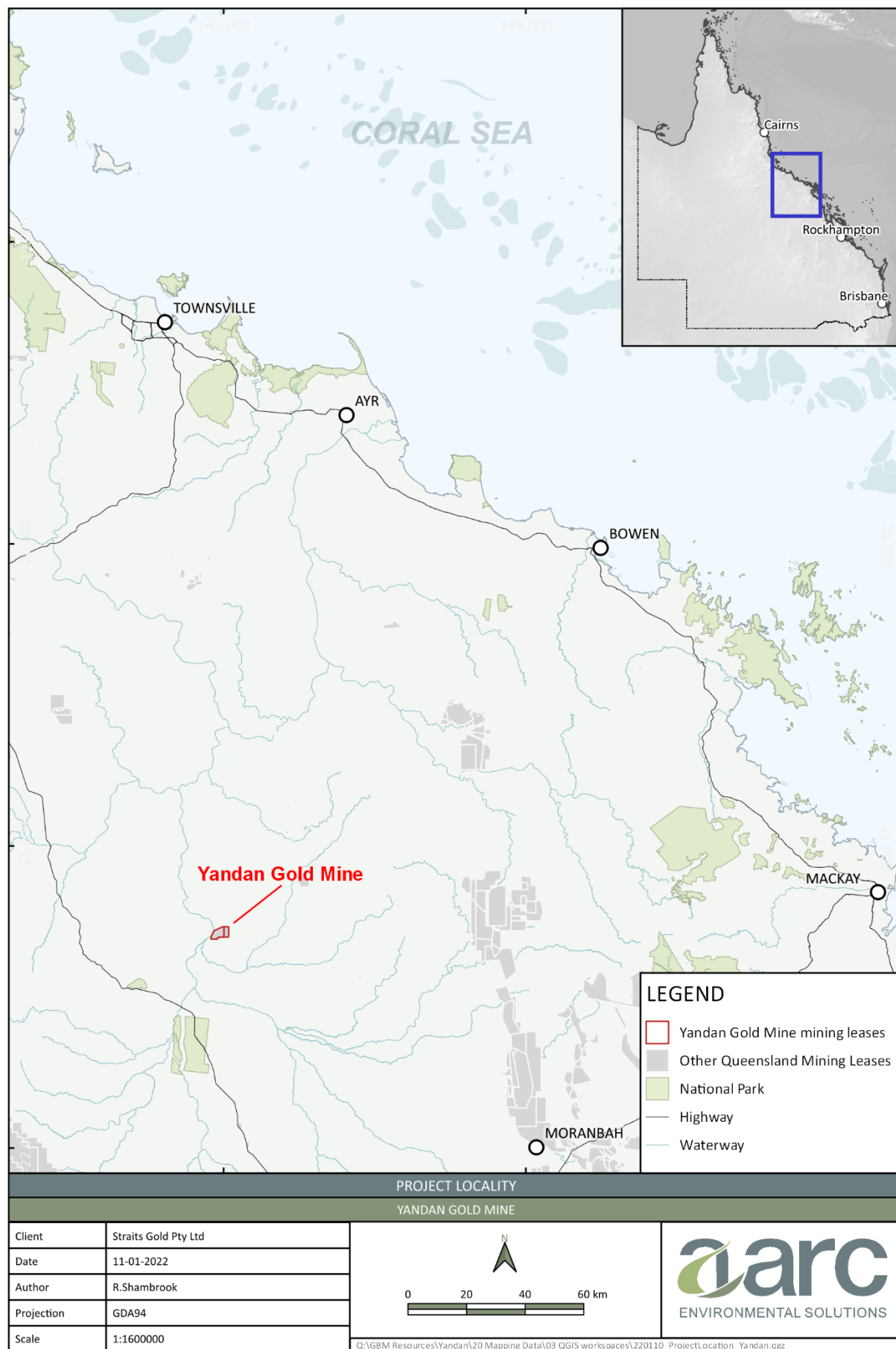


Figure 1: Project locality

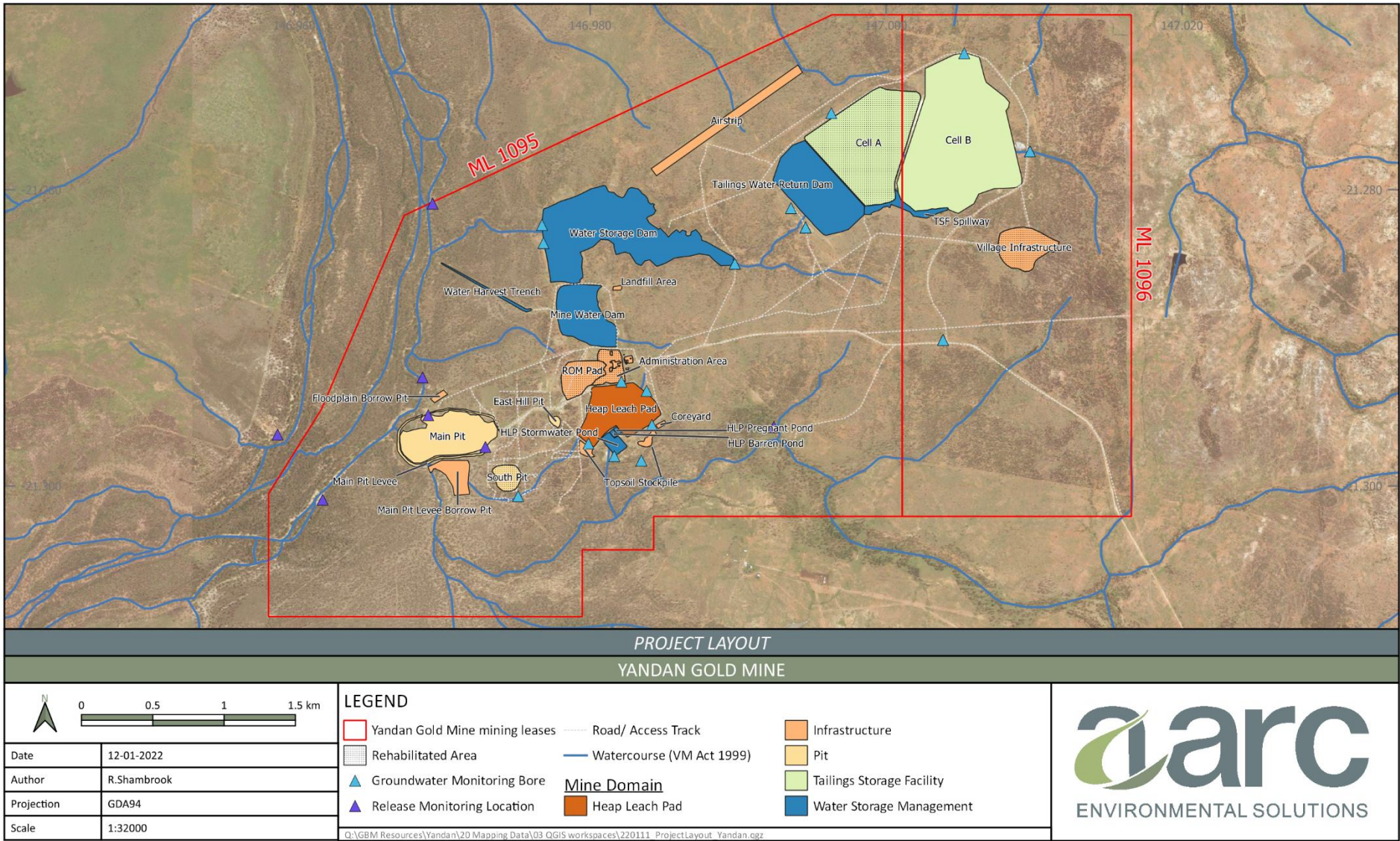


Figure 2: Project layout

2 Communication Engagement Approach

2.1 Key objectives

The objectives of the SEP are to achieve the following:

- strengthen the company's corporate social responsibility and effectively maintain an on-going community relationship and trust;
- define opportunities to provide transparent, open and informative information to key stakeholders and increase awareness on progressive rehabilitation activities and schedules;
- inform and liaise with key stakeholders to ensure rehabilitation activities outlined in the PRCP are undertaken to achieve the historically agreed post-mining land use (PMLU) or non-use management area (NUMA);
- enhance and outline key avenues that stakeholders can utilise to provide feedback on Project rehabilitation activities; and
- identify measures for GBM to respond to community concerns and appropriately manage stakeholder expectations.

2.2 Responsibilities

The responsibility to facilitate and uphold the SEP objectives are distributed to the following roles:

- GBM Directors -
 - ultimate responsibility for environmental and social governance falls to the GBM executive team; and
 - final approval of all company policy;
- Site Manager -
 - manage the overall direction of the Project;
 - responds to media enquiries;
 - manage direct, formal notification of intentions and actions relating to the Project;
 - interacts with community and engages on issues/concerns at all levels;
- Environment and Community Support officer -
 - development of the SEP with GBM;
 - technical support in regulatory and community engagement, led by GBM;
 - technical support for GBM media releases and responses; and
 - technical input for development of Project materials (fact sheets, posters, newsletters, etc).

3 Stakeholders Mapping

3.1 Affected and interested stakeholder groups

Yandan Gold Mine is located approximately 35 km north-west of the small township of Mount Coolon, which has an approximate population of 64 people (ABS 2016). Mount Coolon is located at the intersection of the Bowen Development Road and Sutton Development Road. The town is primarily in an agricultural and rural setting, with mining activities in the surrounding region. Nearby mining activities include the Mount Coolon Gold Mine and the Twin Hills Operation, also owned by GBM Resources.

The identification of all relevant stakeholders, such as interested and affected peoples, groups and statutory bodies, is important to ensure that consultation on the Project's planned rehabilitation activities is provided to relevant parties.

Interested and affected stakeholders to the Project have been identified in Table 1 below. Due to the isolated nature of the Project region, the small population size in the surrounding region, and the current care and maintenance status of the Project, there are currently only a small number of key stakeholders.

Table 1: *Affected and interested stakeholders*

Stakeholder Classification	Stakeholder	Status
Affected	Scott Family	Landholder on Lot 5060 of PH387
	Jangga People Traditional Owners	Native Title Determination over Project area QCD2012/009
	Neighbouring and downstream landholders	Landholders of properties directly downstream (e.g. Lot 22 on SP218335, Lot 1 on SM47)
	Whitsunday Regional Council Andrew Willcox (Mayor)	Local Government
	Charters Towers Regional Council ¹ Frank Beveridge (Mayor)	Local Government
	Department of Environment and Science	State Government
	Department of Transport and Main Roads	State Government
	Department of Resources	State Government
	Department of Regional Development, Manufacturing and Water	State Government
	Mount Coolon Community	Township
Interested	Mount Coolon Hotel	Local Business
	Collinsville Hospital	Nearby Medical Facility
	Mount Coolon Rural Fire Brigade	Fire Service

¹ Majority of the Project falls under the Whitsunday Regional local government area (LGA), with a small area of the mining lease falling under the Charters Tower Regional LGA.

4 Stakeholder Engagement Methods and Frequency

4.1 Principle engagement methods

4.1.1 Face-to-face meetings or phone calls

Additional face-to-face meetings or phone calls will be a principal engagement method during both the operational and rehabilitation phases. These meetings will occur on a complaint basis and offer stakeholders the opportunity to discuss in-person any concerns or issues relating to rehabilitation in accordance with the PRCP.

Consultation will be undertaken on an as required basis, such as when a change in activities or circumstances on the ground occurs that may have an impact on stakeholders.

The purpose of face-to-face meetings is to:

- continue the on-going point of contact for stakeholders of the Project;
- provide current information and updates on the Project and proposed rehabilitation activities;
- allow opportunity for stakeholders to initiate enquiries relating to the Project; and
- operate as a feedback function to allow the collation and reporting of community concerns in relation to the Project.

4.1.2 Project webpage

A 'Yandan Gold Project' specific webpage already exists and is a resource for disseminating current information relating to the on-going Project status. The Project-specific webpage can be found at:

<https://www.gbmr.com.au/projects/yandan-gold-project/>

Announcements relevant to the Project and GBM's other projects are also regularly released:

<https://www.gbmr.com.au/asx-announcements/>

The above webpages are updated regularly with the following information:

- references to the approvals regulatory body (Department of Environment and Science (DES));
- historic mining activities;
- future exploration intentions and mineral resource estimates;
- technical report findings;
- company policies; and
- any other public documents relevant to Project such as newsletters and fact sheets that may be published as part of consultation activities.

A contact form linked to the existing reception@gbmex.com.au feedback email address is available on the above webpages and guarantees a response within 72 hours. A contact number (with contact times) and mailing address are also listed to provide stakeholders with three communication avenues to voice any concerns or queries.

GBM will update the relevant websites regularly as part of this SEP to ensure content is current and representative of the Project's operations.

4.2 Additional engagement options

4.2.1 Public displays and community information sessions

Where available, community events provide GBM the opportunity to disseminate information and receive feedback from a broad community cross-section. These events allow the two-way flow of information between the community and GBM personnel.

For such events, stalls and or poster displays are options to provide access to information including the fact sheets already developed, as well as additional contextual information relevant to mining and the local area, as well as providing information promoting contact and Project feedback.

Due to the remote location of the Project and its surrounding small population, community social events are limited. However, current information on local community events can be found at:

<https://www.whitsundayrc.qld.gov.au/community-and-environment/our-community/events?yearMonthStart=01-2022>

Where suitable opportunities exist, GBM will consider a company presence at any upcoming events as an additional avenue of stakeholder engagement.

5 Stakeholder Engagement Tools and Materials

5.1 Contact telephone and email

The company contact phone number and email address are the two primary stakeholder engagement tools to facilitate open, honest and timely communication streams.

Phone number: +61 493 239 674

Email: reception@gbmex.com.au

The general phone contact number is available for assistance by an office manager on weekdays, Monday to Friday between 9.00am - 5.00pm. Out-of-hours phone traffic will be responded to as soon as possible the following weekday. It is proposed that the office manager who fields these calls will be advised to forward messages to the designated GBM team responder for action and recording. The email address is available at any time for stakeholders to send any queries or concerns, with these directed to the designated team responder.

5.2 Fact sheets and newsletters

Fact sheets may be developed to support engagement with the immediate and broader community. Factsheets are likely to include the most updated and relevant Project information, particularly relating to exploration and rehabilitation, and be distributed to stakeholders via stakeholder meetings. Factsheets can also be used at any community events that might be attended by GBM for the Project. It is anticipated that factsheets will cover the following topics:

- general Project updates;
- Project maps and diagrams;
- information on the status of the Project rehabilitation studies;
- information on planned consultation activities; and
- progressive rehabilitation success and scheduled timelines.

Newsletters tend to be Project-specific and of a more regular nature, also typically more suited for a broader community audience. Due to the current status of the Project (being in care and maintenance), it is not proposed to publish regular newsletters until notable activities are scheduled. All fact sheets and newsletters will also be made available online and accessible through the existing webpage.

5.3 Community consultation register

In accordance with section 126C(1)(c)(iii) of the EP Act and as required by DES' *'Progressive rehabilitation and closure plans (PRC plans) Guideline'* (ESR/2019/4964) (PRCP Guideline), GBM have developed a community consultation register as part of the approval requirements for the PRCP.

GBM have actively engaged with the community prior to the implementation of the PRCP Guideline, and concerns raised by stakeholders have been integrated into rehabilitation planning. Following the approval of the PRCP, the register will continue to be used to document each individual stakeholder consultation event (including all meetings, presentations, feedback, phone calls and written submissions). The register will enable record keeping that details consultation dates, engaged community member(s), communication type, information provided, key issues raised, response actions and/or outcomes and any GBM commitments made.

This will provide an efficient mechanism to track, respond, and report, on any feedback received. It will also provide a mechanism to measure stakeholder perception and collate public consultation and response records.

The community consultation register template is provided below in Table 2.

Table 2: Community consultation register template

Date	Community Members	Consultation Type	Information Supplied	Issues Raised Discussed	Straits Gold Response and Outcome

6 Feedback protocols

Routine protocols will be implemented to facilitate a transparent and timely feedback process and respond to all existing communications received from the general public, and or other key stakeholders. The process has been designed in accordance with the company's approach to establishing and maintaining a constructive relationship with all key stakeholders. GBM are committed to integrity in the reporting of stakeholder engagement and to demonstrate accountability during the consultation process.

The feedback protocol to ensure a timely response to stakeholders and achieve feedback handling efficiency is outlined below (Figure 3).

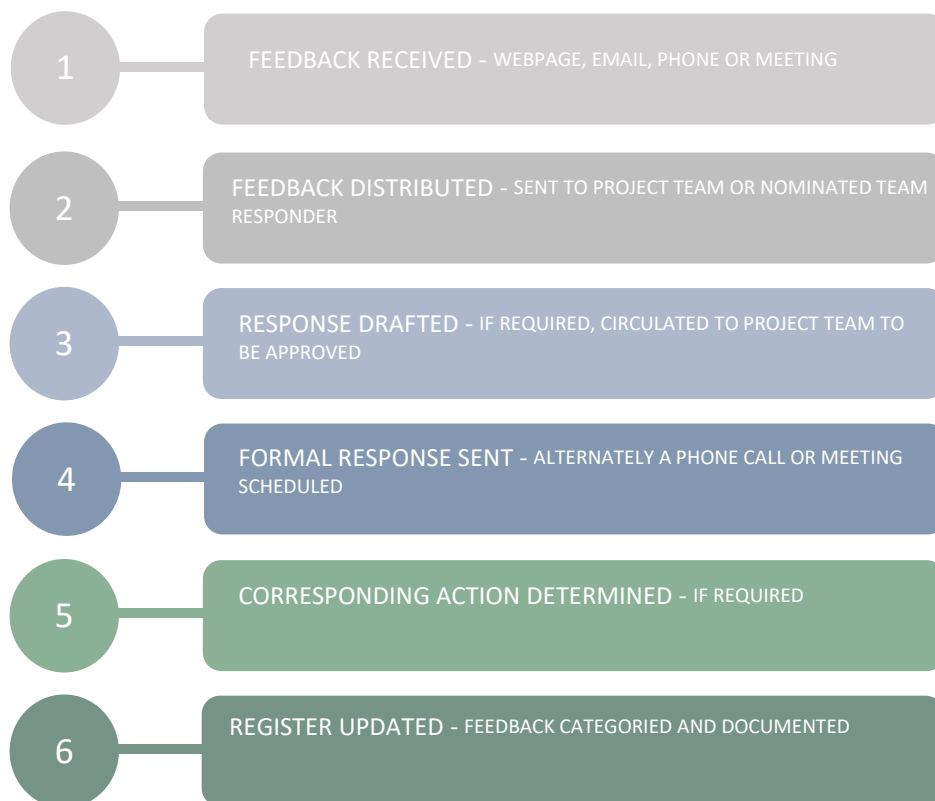


Figure 3: Feedback protocol

7 References

Australian Bureau of Statistics (ABS) 2016, *Mount Coolon 2016 Census Quick Status*, Available from: https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/SSC31967?opendocument Accessed 2 March 2021

Ref.	Risk Description				Risk Evaluation										Risk Rating										Count				Risk Management Class		Manageability																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
	Evaluated 58 of 73 risks (15 Remaining)				Control Effectiveness	Likelihood - Frequency		Likelihood - Probability		Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders					Risk Management Class																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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Ref.	Risk Type (T=Threat)				Risk Description				Risk Evaluation										Risk Rating					Count					Risk Management Class		
	Category	Subcategory	Item		Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls	Control Effectiveness	Likelihood - Frequency	Likelihood - Probability	Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	IV	III	II	I	Risk Management Class	Manageability		
	T	A	06	01	Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations.	C2	P				L					II					0	0	1	0	II			
	T	A	06	02	Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, soil health assessment and fertiliser / ameliorants application prior to revegetation, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U				L					I					0	0	0	1	I			
	T	B			Tailings storage facility (Cell A)																										
	T	B	01		Safe																										
	T	B	01	01	Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Challenging subsoils/ topsoils, inadequate surface preparation, localised settlement, erosion gullies	Safety hazard for personnel, stock and wildlife	Surface preparation measures (initial), monitoring and maintenance controls	C2	P			M						III					0	1	0	0	III			
	T	B		02	Stable - geotechnical risk																										
	T	B	02	01	Significant slope failure	Excessive slope steepness, physical material properties, poor drainage, adverse rainfall event	Localised land impacts and downstream water quality impacts	Slope moderation, max. slopes subject to engineered design, geotechnical assessment required for completion criteria	C1		U			M					II					0	0	1	0	II			
	T	B		03	Stable - erosional risk																										
	T	B	03	01	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping, prompt revegetation establishment, revegetation monitoring and management as required	C2	U				M					II					0	0	1	0	II			
	T	B	03	02	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ revegetation disease, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	P				M					III					0	1	0	0	III			
	T	B	03	03	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U				M					II					0	0	1	0	II			
	T	B		04	Non-polluting - geochemical risk																										
	T	B	04	01	Contaminants from tailings material impacting receiving environment	Adverse tailings geochemistry	Revegetation performance impacts, downstream receiving environment water quality	Material confirmed as NAF with no PAF material present. Regular monitoring of surface water and groundwater	C2	U				M					II					0	0	1	0	II			
	T	B		05	Non-polluting - other environmental harm																										
	T	B	05	01	Not applicable																			0	0	0	0				

Risk Type (T=Threat)	Category	Subcategory	Item	Ref.	Risk Description				Risk Evaluation						Risk Rating						Count				Risk Management Class		Manageability				
					Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls	Control Effectiveness	Likelihood - Frequency		Likelihood - Probability		Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders						
										IV	III	II	I																		
T	B	06			Sustainable - PMLU				C2	P				L					II						0	0	1	0		II	
T	B	06	01		Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations.	C2	P				L					II						0	0	1	0		II	
T	B	06	02		Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, suitable fertilisation rates based on vegetation trials, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U				L					I					0	0	0	1		I		
T	B				Tailings storage facility (Cell B)																										
T	B	01			Safe																										
T	B	01	01		Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Challenging subsoils/ topsoils, inadequate surface preparation, localised settlement, erosion gullies	Safety hazard for personnel, stock and wildlife	Minimal batters present, surface preparation measures (initial), monitoring and maintenance controls	C2	U			M						II						0	0	1	0		II	
T	B	02			Stable - geotechnical risk																										
T	B	02	01		Significant slope failure	Excessive slope steepness, physical material properties, poor drainage, adverse rainfall event	Localised land impacts and downstream water quality impacts	Minimal batters present, slope moderation, max. slopes subject to engineered design, geotechnical assessment required for completion criteria	C1		R			L						I					0	0	0	1		I	
T	B	03			Stable - erosional risk																										
T	B	03	01		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping, prompt revegetation establishment, revegetation monitoring and management as required	C2	U				M					II						0	0	1	0		II	
T	B	03	02		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ revegetation disease, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U				M					II						0	0	1	0		II	
T	B	03	03		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U				M					II						0	0	1	0		II	
T	B	04			Non-polluting - geochemical risk																										

Risk Type (T=Threat)	Ref.	Category	Subcategory	Item	Risk Description				Risk Evaluation				Risk Rating				Count				Risk Management Class	Manageability							
					Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls	Control Effectiveness	Likelihood - Frequency		Likelihood - Probability		On-site Environment		Off-site Environment		Community Trust		Stakeholders			Count						
										Health	Safety	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	IV	III			II	I					
T		B	04	01	Contaminants from tailings material impacting receiving environment	Adverse tailings geochemistry	Revegetation performance impacts, downstream receiving environment water quality	Material confirmed as low to moderate salinity and NAF with no PAF material present. Use of oxide rock from heap leach pad as capping material lowers geochemical risk. Regular monitoring of surface water and groundwater	C2	U					M				II					0	0	1	0	II	
T		B	05		Non-polluting - other environmental harm																								
T		B	05	01	Not applicable																			0	0	0	0		
T		B	06		Sustainable - PMLU																								
T		B	06	01	Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations.	C2	P					L				II					0	0	1	0	II	
T		B	06	02	Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, suitable fertilisation rates based on vegetation trials, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U					L				I					0	0	0	1	I	
T		C			Retained infrastructure																								
T		C	01		Safe																								
T		C	01	01	Not applicable																			0	0	0	0		
T		C	02		Stable - geotechnical risk																								
T		C	02	01	Not applicable																			0	0	0	0		
T		C	03		Stable - erosional risk																								
T		C	03	01	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Grading and shaping, monitoring and management as required	C2	U					M				II					0	0	1	0	II	
T		C	03	02	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Sedimentation controls, monitoring and maintenance	C2	U					M				II					0	0	1	0	II	
T		C	04		Non-polluting - geochemical risk																								
T		C	04	01	Not applicable																			0	0	0	0		
T		C	05		Non-polluting - other environmental harm																								
T		C	05	01	Not applicable																			0	0	0	0		
T		C	06		Sustainable - PMLU																								
T		C	06	01	Not consistent with surrounding land use	Not consistent with post-mining land use	Not consistent with post-mining land use	Obtain landowner agreement for retained infrastructure at relinquishment. Assessment by an appropriately qualified person that use is consistent with surrounding land use	C1		R					L					I			0	0	0	1	I	
T		D			Retained water storages																								
T		D	01		Safe																								

Ref.				Risk Description				Risk Evaluation										Risk Rating										Count					Risk Management Class		Manageability
Risk Type (T=Threat)				Evaluated 58 of 73 risks (15 Remaining)				Control Effectiveness	Likelihood - Frequency		Likelihood - Probability		Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders						Risk Management Class					
Category	Subcategory	Item		Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls																												
T	D	01	01	Dam overtopping	Extreme rainfall events beyond the hydrological model predicted, insufficient monitoring of water level, wall failure/dam break	Failure to achieve targets of rehabilitation completion criteria, local land and downstream receiving environment water quality and dependent ecosystem impacts	Regulated structures have 'low' rating for 'failure to contain - overtopping' and 'dam break' failure models. Landholder agreement to address any residual regulated structure liability. Geotechnical assessment required for completion criteria applicable to all retained water structures	C2	U					M					II						0	0	1	0	II						
T D 02				Stable - geotechnical risk																															
T	D	02	01	Wall failure/dam break (see dam overtopping risk)				C1		U				M					II						0	0	1	0	II						
T D 03				Stable - erosional risk																															
T	D	03	01	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Increased risk of not achieving designated PMLU	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping of dam banks, prompt revegetation establishment of dam banks, revegetation monitoring and management as required	C2	U					M					II						0	0	1	0	II						
T D 04				Non-polluting - geochemical risk																															
T	D	04	01	Water quality in retained storages not meeting PMLU water quality objectives	Adverse physio-chemical characteristics from materials in catchment or Landform not constructed to design	Livestock health	Landform constructed to design, regular water quality monitoring and assessment	C2	P			L						II							0	0	1	0	II						
T D 05				Non-polluting - other environmental harm																															
T	D	05	01	Not applicable																					0	0	0	0							
T D 06				Sustainable - PMLU																															
T	D	06	01	Water quality in retained storages not meeting PMLU water quality objectives	Adverse physio-chemical characteristics from materials in catchment or Landform not constructed to design	Livestock health, wildlife hazard	Landform constructed to design, regular water quality monitoring and assessment, water treatment (where necessary) to ensure water meets relevant stock watering guidelines	C2	U			L						I							0	0	0	1	I						
T E 01				Built infrastructure areas Safe																															
T	E	01	01	Surface roughness (rockiness, depressions) in excess of that expected for PMLU	Inadequate surface preparation, localised settlement, erosion gullies	Safety hazard for personnel, stock and wildlife	Surface preparation measures (initial), monitoring and maintenance controls	C2	U				L						I						0	0	0	1	I						
T E 02				Stable - geotechnical risk																															
T	E	02	01	Not applicable																					0	0	0	0							
T E 03				Stable - erosional risk																															
T	E	03	01	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U					M					II						0	0	1	0	II						

Risk Type (T=Threat)	Ref.	Category	Subcategory	Item	Risk Description				Control Effectiveness	Risk Evaluation		Risk Rating							Count				Risk Management Class	Manageability					
					Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls		Likelihood - Frequency	Likelihood - Probability	Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance			Stakeholders				
																										IV	III	II	I
T	E	03	02		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ vegetation disease/loss, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U				M			II						0	0	1	0	II		
T	E	03	03		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U				M			II						0	0	1	0	II		
T	E	04			Non-polluting - geochemical risk																								
T	E	04	01		Not applicable																		0	0	0	0			
T	E	05			Non-polluting - other environmental harm																								
T	E	05	01		Contaminated land	Operational phase industrial use of land	Land contamination, surface water impacts	Phase 1 contaminated land assessment following removal of infrastructure	C1	U				M			II						0	0	1	0	II		
T	E	06			Sustainable - PMLU																								
T	E	06	01		Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations, development of a site specific weed management plan.	C2	P				L			II						0	0	1	0	II		
T	E	06	02		Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, suitable fertilisation rates based on vegetation trials, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U				L			I						0	0	0	1	I		
T	F				Rehabilitated water management structures																								
T	F	01			Safe																								
T	F	01	01		Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Erosion gullies etc due to some dispersive topsoils, inadequate surface preparation, localised settlement	Safety hazard for personnel, stock and wildlife	Slope moderation, surface preparation measures (initial), monitoring and maintenance controls	C2	U				M			II						0	0	1	0	II		
T	F	02			Stable - geotechnical risk																								
T	F	02	01		Significant slope failure	Excessive slope steepness, physical material properties, poor drainage, adverse rainfall event	Localised land impacts and downstream water quality impacts	Slope moderation achieved by grading	C2	U				M			II						0	0	1	0	II		
T	F	03			Stable - erosional risk																								
T	F	03	01		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U				M			II						0	0	1	0	II		

Ref.				Risk Description				Risk Evaluation				Risk Rating				Count				Risk Management Class											
Risk Type (T=Threat)	Category	Subcategory	Item	Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls	Control Effectiveness	Likelihood - Frequency		Likelihood - Probability		Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance	Stakeholders	Count				Risk Management Class	Manageability	
									U	P	U	P													IV	III	II	I			
T	F	03	02	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ vegetation disease/loss, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U						M					II					0	0	1	0	II		
T	F	04		Non-polluting - geochemical risk																						0	0	0	0		
T	F	04	01	Not applicable																					0	0	0	0			
T	F	05		Non-polluting - other environmental harm																						0	0	0	0		
T	F	05	01	Not applicable																					0	0	0	0			
T	F	06		Sustainable - PMLU																											
T	F	06	01	Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations, development of a site specific weed management plan.	C2	P						L					II					0	0	1	0	II		
T	F	06	02	Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, suitable fertilisation rates based on vegetation trials, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U						L					I					0	0	0	1	I		
T	F	01		ROM pad Safe																											
T	F	01	01	Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Erosion gullies etc due to some dispersive topsoils, inadequate surface preparation, localised settlement	Safety hazard for personnel, stock and wildlife	Surface preparation measures (initial), monitoring and maintenance controls	C2	P					M						III					0	1	0	0	III		
T	F	01	02	Slope steepness in excess of that expected for the PMLU	Inappropriate landform design	Safety hazard for personnel, stock and wildlife	Landform design appropriate to PMLU, slope controls	C2	U					M						II					0	0	1	0	II		
T	F	02		Stable - geotechnical risk																											
T	F	02	01	Significant slope failure	Excessive slope steepness, physical material properties, poor drainage, adverse rainfall event	Localised land impacts and downstream water quality impacts	Slope moderation, max. slopes subject to design, geotechnical assessment required for completion criteria	C1	U					M						II					0	0	1	0	II		
T	F	03		Stable - erosional risk																											
T	F	03	01	Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping, rock mulch, prompt revegetation establishment, revegetation monitoring and management as required	C2	P					M						III					0	1	0	0	III		

Ref.	Risk Type (T=Threat) Category Subcategory Item				Risk Description Evaluated 58 of 73 risks (15 Remaining)				Risk Evaluation					Risk Rating					Count					Risk Management Class Manageability								
									Control Effectiveness	Likelihood - Frequency		Likelihood - Probability	Health	Safety	On-site Environment		Off-site Environment	Compliance	Health	Safety	On-site Environment		Off-site Environment			Community Trust	Compliance	Stakeholders				
T	F	03	02		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ revegetation disease, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	P				M				III						0	1	0	0	III				
T	F	03	03		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U				M				II						0	0	1	0	II				
T	F	04	Non-polluting - geochemical risk																													
T	F	04	01		Acid drainage generation	Adverse material geochemistry	Revegetation performance impacts, downstream receiving environment water quality	Confirmed NAF material, no evidence of downstream impacts on vegetation monitoring, monitoring and maintenance	C2	U				M				II						0	0	1	0	II				
T	F	05	Non-polluting - other environmental harm																													
T	F	05	01		Not applicable																			0	0	0	0					
T	F	06	Sustainable - PMLU																													
T	F	06	01		Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations, development of a site specific weed management plan.	C2	P				L				II						0	0	1	0	II				
T	F	06	02		Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, soil health assessment and fertiliser / ameliorants application prior to revegetation, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U				L				I						0	0	0	1	I				
T	F	01	Main pit bund Safe																													
T	F	01	01		Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Erosion gullies etc due to challenging subsoils/ topsoils, inadequate surface preparation, localised settlement	Safety hazard for personnel, stock and wildlife	Surface preparation measures (initial), monitoring and maintenance controls	C2	P				M				III						0	1	0	0	III				
T	F	02	Stable - geotechnical risk																													
T	F	02	01		Structural failure during flood event	Bunding constructed not in accordance with design plan	Localised land impacts and downstream water quality impacts	Construction to follow design requirements. Geotechnical assessment required for completion criteria	C1		U			M	M			II	II					0	0	2	0	II				
T	F	03	Stable - erosional risk																													
T	F	03	01		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping, prompt revegetation establishment, revegetation monitoring and management as required	C2	U				M				II						0	0	1	0	II				

Ref.	Risk Type (T=Threat)	Category	Subcategory	Item	Risk Description				Control Effectiveness	Risk Evaluation			Risk Rating						Count				Risk Management Class	Manageability						
					Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls		Likelihood - Frequency	Likelihood - Probability	Health	Safety	On-site Environment	Off-site Environment	Compliance	Health	Safety	On-site Environment	Off-site Environment	Community Trust	Compliance			Stakeholders	IV	III	II	I	
					Evaluated 58 of 73 risks (15 Remaining)																									
T	F	03	02		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ revegetation disease, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	P				M				III						0	1	0	0	III		
T	F	03	03		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U				M				II						0	0	1	0	II		
T	F	04			Non-polluting - geochemical risk																									
T	F	04	01		Not applicable																			0	0	0	0			
T	F	05			Non-polluting - other environmental harm																									
T	F	05	01		Not applicable																			0	0	0	0			
T	F	06			Sustainable - PMLU																									
T	F	06	01		Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations.	C2	P				L				II						0	0	1	0	II		
T	F	06	02		Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, soil health assessment and fertiliser / ameliorants application prior to revegetation, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U				L				I						0	0	0	1	I		
T	F	01			South pit (backfilled)																									
T	F	01	01		Surface roughness (rockiness, depressions) in excess of that expected for the PMLU	Erosion gullies etc due to challenging subsoils/ topsoils, inadequate surface preparation, localised settlement	Safety hazard for personnel, stock and wildlife	Low slopes, surface preparation measures (initial), monitoring and maintenance controls	C2	U			M					II						0	0	1	0	II		
T	F	02			Stable - geotechnical risk																									
T	F	02	01		Significant slope failure	Excessive slope steepness, physical material properties, poor drainage, adverse rainfall event	Localised land impacts and downstream water quality impacts	Slope moderation, max. slopes subject to design, geotechnical assessment required for completion criteria	C1	U				M				II						0	0	1	0	II		
T	F	03			Stable - erosional risk																									
T	F	03	01		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Erodible topsoils, adverse weather events	Localised land impacts and downstream water quality impacts	Good topsoil management practices; adequate/effective soil amelioration, grading and shaping, prompt revegetation establishment, revegetation monitoring and management as required	C2	U				M				II						0	0	1	0	II		

Risk Type (T=Threat)	Ref.	Category	Subcategory	Item	Risk Description				Risk Evaluation							Risk Rating							Count				Risk Management Class	Manageability						
					Threat Title	Causes (Triggers / Indicators)	Impacts (Consequences)	Existing Controls	Control Effectiveness	Likelihood - Frequency		Likelihood - Probability			Health	Safety	On-site Environment		Off-site Environment	Compliance	Health	Safety	On-site Environment		Off-site Environment	Community Trust			Compliance	Stakeholders	IV	III	II	I
										Evaluated 58 of 73 risks (15 Remaining)																								
T	F	03	02		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk)	Rehabilitation failure/ revegetation disease, climatic events (drought)	Localised land impacts and downstream water quality impacts	Landform design moderating slope, adequate/effective soil amelioration, prompt revegetation establishment, revegetation monitoring and management as required	C2	U					M					II						0	0	1	0	II				
T	F	03	03		Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas	Adverse climatic events and/or climatic sequences beyond design capacity	Localised land impacts and downstream water quality impacts	Rehabilitation of slope, sedimentation controls, revegetation, monitoring and maintenance	C2	U					M					II						0	0	1	0	II				
T	F	04			Non-polluting - geochemical risk																													
T	F	04	01		Acid drainage generation	Adverse material geochemistry	Revegetation performance impacts, downstream receiving environment water quality	Oxidised waste rock and clay capping material lowers geochemical risk. Oxide waste material confirmed NAF	C2	U					M					II						0	0	1	0	II				
T	F	05			Non-polluting - other environmental harm																													
T	F	05	01		Not applicable																					0	0	0	0					
T	F	06			Sustainable - PMLU																													
T	F	06	01		Weeds	Weeds could invade via wind, vehicle or footwear during vegetation development. Unsterilised equipment / vehicle, and insufficient weed monitoring	Inhibit the establishment of desirable species and preventing achievement of revegetation targets	Regular weed monitoring program to allow early detection and treatment of new weed infestations, development of a site specific weed management plan.	C2	P					L					II						0	0	1	0	II				
T	F	06	02		Low pasture productivity	Insufficient vegetation development, pasture species become shaded out, intruding livestock & other fauna, insufficient monitoring	Insufficient pasture density and species richness to meet completion criteria, increased risk of erosion	Seed mixes based on native and introduced pasture species, soil health assessment and fertiliser / ameliorants application prior to revegetation, supplementary sowing and fertilising in bare patches, monitoring of weeds, pests or diseases and early detection of failure undertaken as part of the monitoring and maintenance of rehabilitated areas	C2	U					L					I					0	0	0	1	I					
T	F	01			Final void(s) - NUMAs Safe																													
T	F	01	01		Void areas are accessible by public and/or fauna	Insufficient warnings, barriers preventing access to hazardous areas (highwalls, pit lake)	Falls, slips, trips impacting humans, livestock, fauna	Signage, physical barriers, slope moderation included in monitoring and maintenance procedures for Improvement Areas, remoteness of site and landowner controls	C2	U					M					II						0	0	1	0	II				
T	F	02			Stable - geotechnical risk																													
T	F	02	01		Significant slope failure	Excessive slopes, not constructed to design, adverse rainfall event	Localised land impacts	Voids to follow design requirements for maximum slope.	C2		U				M					II						0	0	1	0	II				
T	F	03			Non-polluting - geochemical risk																													

Ref.				Risk Description				Risk Evaluation										Risk Rating										Count					Risk Management Class																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
Risk Type (T=Threat)				Evaluated 58 of 73 risks (15 Remaining)				Control Effectiveness		Likelihood - Frequency		Likelihood - Probability		Health		Safety		On-site Environment		Off-site Environment		Compliance		Health		Safety		On-site Environment		Off-site Environment		Community Trust		Compliance		Stakeholders							Risk Management Class																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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YANDAN GOLD MINE - WATER MANAGEMENT PLAN

PREPARED FOR
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UPDATED NOVEMBER 2021



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Project Manager:	Rod Hailstone

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1 Introduction

The Yandan Gold Mine (the Project) is located in the Drummond Basin in Central Queensland, approximately 50 kilometres (km) to the west of the Mount Coolon township and approximately 150 km southeast of Charters Towers (Figure 1). The Project is currently operated by Straits Gold Pty Ltd (a wholly owned subsidiary of GBM Resources Limited).

This water management plan (WMP) has been prepared as an update to the former site WMP (Straits Resources 2013), and pursuant to the Yandan Gold Mine EA (EPML00771913, last updated 20 January 2012) (Project EA). This WMP overviews the Project's environmental setting (as this relates to water management) and relevant compliance framework, while also describing the site water management system and the water monitoring activities undertaken on-site.

1.1 Project background

Yandan Gold Mine was operated by Ross Mining N.L between 1993 - 2002, producing over 350,000 ounces (oz) of gold from heap leach operations and a Carbon in Leach (CIL) process plant. Mining operations ceased in 1998, with the Heap Leach Pad remaining operational until September 2002. The site was placed into care and maintenance in April 1999, pending final closure works. The gold processing plant was later removed in 2006/2007, prior to the acquisition of the Project by Straits Gold, which was a wholly owned subsidiary of Aeris Resources at the time. The Project has remained in care and maintenance for the past ~ 21 years.

Since acquiring the Project and the Straits Gold Pty Ltd entity on 13 January 2021, GBM Resources have taken significant steps towards restoring operations. This has included the 2021 Drilling Program, which focused on the identification of potential open pits targets in the area between Main Pit and East Hill deposits.

GBM are also exploring tailings/heap re-treatment options and the construction of a new heap leach facility on Cell B of the TSF. To support these projects, GBM are also seeking to re-activate a number of the existing water storage structures to secure water supply and more actively manage site water levels.

The Project spans across two mining leases (ML), as detailed in Table 1 below.

Table 1: Project tenements

Permit Number	Permit Name	Grant Date	Expiry Date	Area (ha)	Underlying land parcel
ML 1095	Yandan West	27/06/1991	30/06/2021*	1368.9	Lot 5060 on PH387
ML 1096	Yandan East	27/06/1991	30/06/2021*	602.4	Lot 5060 on PH387

*Renewal pending



Figure 1: Project locality

1.2 Purpose of the Water Management Plan

The Yandan Gold Mine WMP is prepared to meet the operational and regulatory requirements for the safe, efficient management and protection of water resources.

The Project EA establishes the following conditions in regard to the WMP:

(C10 – 1) A Water Management Plan must be developed and implemented within 3 months of the date of approval of this environmental authority that provides for the proper and effective management of the actual and potential environmental impacts resulting from the mining activity and to ensure compliance with the conditions of this environmental authority.

(C10 – 2) The Water Management Plan must be developed in accordance with the most recent edition of the administering authority's Guideline for Preparing a Water Management Plan 2009 and must include at least the following components:

- (a) Contaminant Source Study;*
- (b) Site Water Balance and Model;*
- (c) Water Management System;*
- (d) Saline Drainage Prevention and Management Measures;*
- (e) Acid Rock Drainage Prevention and Management Measures (if applicable);*
- (f) Emergency and Contingency Planning; and*
- (g) Monitoring and Review*

(C10 – 3) Each year the holder of the environmental authority must undertake a review of the Water Management Plan prior to the wet season (i.e. by 1 November) and a further review following the wet season (i.e. by 1 May the following year) to ensure that proper and effective measures, practices or procedures are in place so that the mine is operated in accordance with the conditions of this environmental authority and that environmental harm is prevented or minimised.

(C10 – 4) A copy of the Water Management Plan and/or a review of the Water Management Plan must be provided to the administering authority on request.

It is noted that the 'Guideline for Preparing a Water Management Plan 2009' document is no longer current or available, and has not been replaced.

1.3 Relevant licences

Four waterworks licences are held for the Project, including three water licences and one licence permitting the diversion of Yandan Creek, as detailed in Table 2.

During operation of the Project, water was harvested from the Suttor River to meet processing water demands. With the Project currently in care and maintenance, these extraction quotas are not being drawn on. The Yandan Creek Diversion was constructed during mining of Main Pit, and diverts the creek around the pit.

Table 2: Water licences

Licence number	Details
55019A	Purpose: Yandan Creek Diversion (gravity diversion works on the Suttor River) Expires: 30 June 2111

Licence number	Details
57220A	Purpose: Water harvesting from Suttor River Extraction: 450 litres per second, permitted only during periods when the flow of water in Suttor River at Anns Gauge Station 120303A exceeds two (2) cubic metres per second. Expires: 30 June 2111
57382A	Purpose: Water harvesting from Suttor River Extraction: 100 litres per second, permitted only during periods when the flow of water in Suttor River at Anns Gauge Station 120303A exceeds two (2) cubic metres per second. Expires: 30 June 2111
57383A	Purpose: Water harvesting from Suttor River Extraction: 100 litres per second, permitted only during periods when the flow of water in Suttor River at Anns Gauge Station 120303A exceeds two (2) cubic metres per second. Expires: 30 June 2111

1.4 Accountability – roles and responsibilities

This Water Management Plan applies to all Straits Gold personnel, including employees, contractors (including subcontractors), agents and persons acting on Straits Gold's behalf at Yandan Gold Mine. The responsibilities for relevant personnel are listed, but not limited to, those listed in Table 3.

Table 3: Roles and responsibilities of Yandan Gold Mine water management

Role	Responsibility
Straits Gold personnel	- Ensuring systems and resources are adequate for delivery of the WMP - Implementation of the WMP, including organising all monitoring and reporting, and management and mitigation measures. - Scheduling and implementing the environmental monitoring programs, audits and inspections - Environmental performance reporting to regulatory authorities - Implementation of management measures and risk management - Duty of care as part of safe and sound environmental operation
Environmental consultant (contracted)	- Management and review of water monitoring data - Day-to-day correspondence with the regulatory authority - Environmental reporting to Straits Gold personnel - Fulfilling the agreed scope of works and following the directions given by Straits Gold management
All other contractors and sub-contractors	- Fulfilling the agreed scope of works and following the directions given by Straits Gold management - Ensuring appropriate records are taken, maintained and made available as required - Reporting any incidents or health and safety concerns to management. - Immediately reporting any environmental incidents or potential environmental incidents to management

1.5 Stakeholders

Relevant stakeholders for the Yandan Gold Mine include local community members, Traditional Owners and statutory bodies, as detailed in Table 4.

Table 4: Relevant stakeholders of Yandan Gold Mine

Community	Statutory	Employees
• Scott Family (landholder on Lot 5060 of PH387) • Jangga People Traditional Owners (QCD2012/009) • Neighbouring and downstream landholders	• Department of Environment and Science (DES) • Department of Resources (DoR) • Department of Regional Development, Manufacturing and Water (DRDMW) • Whitsunday Regional Council	• Straits Gold personnel, contractors (including sub-contractors) and consultants

2 Project description and approach

2.1 Project overview and general setting

The Project currently remains in an extended period of care and maintenance with limited exploration activities occurring on site. Potential future investment is considered the best means to fund future rehabilitation and closure of the Project site.

Previous work has been undertaken to assess the potential development of the East Hill deposit and identify additional mineral resources in the region, with the view to developing a new gold mining operation on site. An initial Mineral Resource Estimate (JORC 2004 compliant) has previously been determined for the East Hill mineralised system, at 4 Million tonnes (Mt) at 2.4 g/t for 308,000 ounces of gold Inferred Resource with no lower cut-off.¹

The Yandan Gold Mine site currently retains infrastructure from past operations, alongside rehabilitated mining domains, with the landscape on site currently consisting of:

- Main Pit – an existing open cut pit which is to remain as a ‘flushing pit’ on final closure, with connectivity to Suttor River. The Main Pit covers an approximate 15.9 ha area, with a permanent water layer. A levee bank and two spillways have been constructed to regulate the water depth in Main Pit;
- East Hill Pit – a relatively small open cut pit, covering an approximate 0.5 ha area with a depth of approximately 25 m;
- Yandan Tailings Dam – a historic tailings dam comprised of Cell A (42 ha) and Cell B (61 ha), with the latter being unrehabilitated. Collectively this facility holds an estimated 7,500,000 tonnes of tailings, and is at full capacity;
- Heap Leach Pad – an existing unrehabilitated heap leach pad containing an estimated 3,200,000 m³ of low grade ore, over an approximate 18.9 ha area;
- existing water storage facilities, including:
 - Water Storage Dam – an unlined raw water storage dam with a capacity of 1300 ML;
 - Mine Water Dam – an unlined process water storage dam with a capacity of 478 ML;
 - Heap Leach Pregnant and Barren ponds – lined processing dams previously used to treat leachate from the Heap Leach Pad;
 - Heap Leach Stormwater Pond – unlined dam receiving stormwater overflow from the Heap Leach Pregnant and Barren ponds during extreme rainfall events;
 - Tailings Return Water Dam – unlined dam receiving runoff from the Yandan Tailings Dam during extreme rainfall events;
- infrastructure domain – consisting of mine haul roads, portable buildings, electricity infrastructure, concrete pads and hardstands; and
- rehabilitated domains – including South Pit, ROM Pad and the Village infrastructure area.

¹ Mineral Resource figures reported from three domains which represent high grade epithermal vein systems. All block estimates within each domain have been reported (0 g/t Au cut-off) (Aeris Resources 2020, Available: <https://www.aerisresources.com.au/exploration/yandan/>)

2.2 Terminology

The WMP addresses the management of water from the following categories:

- mine affected water – contaminated water that has been generated as a result of surface runoff from disturbed mining areas, encompassing runoff from the Yandan Tailings Dam, Heap Leach Pad, decommissioned processing area and pit water;
- raw water – surface runoff from undisturbed mining areas; and
- release water – water released from the Project's water management network.

3 Water setting and systems

3.1 Landscape and host geology

The Yandan Gold Mine is located on the eastern margin of the western arm of the Drummond Basin, a geological basin comprised of Middle Devonian to Early Carboniferous sedimentary and volcanic rocks (Straits n.d.). The Project area is proximal to the Anakie Inlier, a north-trending basement block of greenschist facies metavolcanic and metasedimentary rocks of Lower Cambrian age (de Caritat & Braun 1992).

The host geology underlying the Project is comprised of basement Anakie Inlier Les Jumelles metasediments, unconformably overlain by Middle Devonian Ukalunda Beds, which in turn are unconformably overlain by the St Anne's Formation of the Middle Devonian to Early Carboniferous Drummond Basin Sequence (Straits n.d.). On the western side of the tenement, parts of the Project have been unconformably overlain by fluvial deposits of the Scartwater Formation and Mount Hall Formation (Straits n.d.). The general composition of the three main geological units is summarised as follows.

Basement geology

The basement Les Jumelles metasediments are metamorphosed quartz-muscovite sandstones and siltstones (Townend 2005, within Straits n.d.) and chloritic black shale. Also within the basement geology, the Ukalunda Formation sediments are various interbedded massive and bedded lithologies containing quartzose, calcareous and carbonaceous sandstones, siltstones and mudstones (Straits n.d.).

Lower St Anne's Formation

The Lower St Anne's Formation generally consists of three lithologies: andesite flows, andesite clastics and polyolithic volcanic breccia (Straits n.d.). Overlying this are primarily feldspar-lithic sandstone and siltstone (Yandan Host), formed through weathering and erosion of the Yandan Andesite. Calcareous sandstone and Yandan Limestone is the youngest unit in the local stratigraphy, overlying parts of the Yandan Host in Main Pit (Straits n.d.).

Gold mineralisation on the Project has been substantially mined out, with the East Hill area containing the most encouraging remaining mineralisation (Straits n.d.). Three phases of gold mineralised silica have been identified within the East Hill area, including crustiform banded veining which is commonly high-grade gold mineralisation (Straits n.d.).

Surface geology

Tertiary and Quaternary sediments cover much of the Project area. In the south and east, the surface geology is predominantly Tertiary Suttor Formation comprised of lateritised sandstone, mudstone, claystone, oil shale, diatomite and carbonaceous claystone (Hutton *et al.* 1991). Channels incise the Suttor Formation and contain Quaternary alluvial channels that drain to flood plains (Straits n.d.). Quaternary alluvium covers much of the underlying Drummond Basin Sequence on the Project, with the depth of this stratum increasing towards major drainage lines (i.e. Suttor River, Rosetta Creek, Belyando River) (Straits n.d.).

Geological units and structures on the Project are shown through Figure 2.

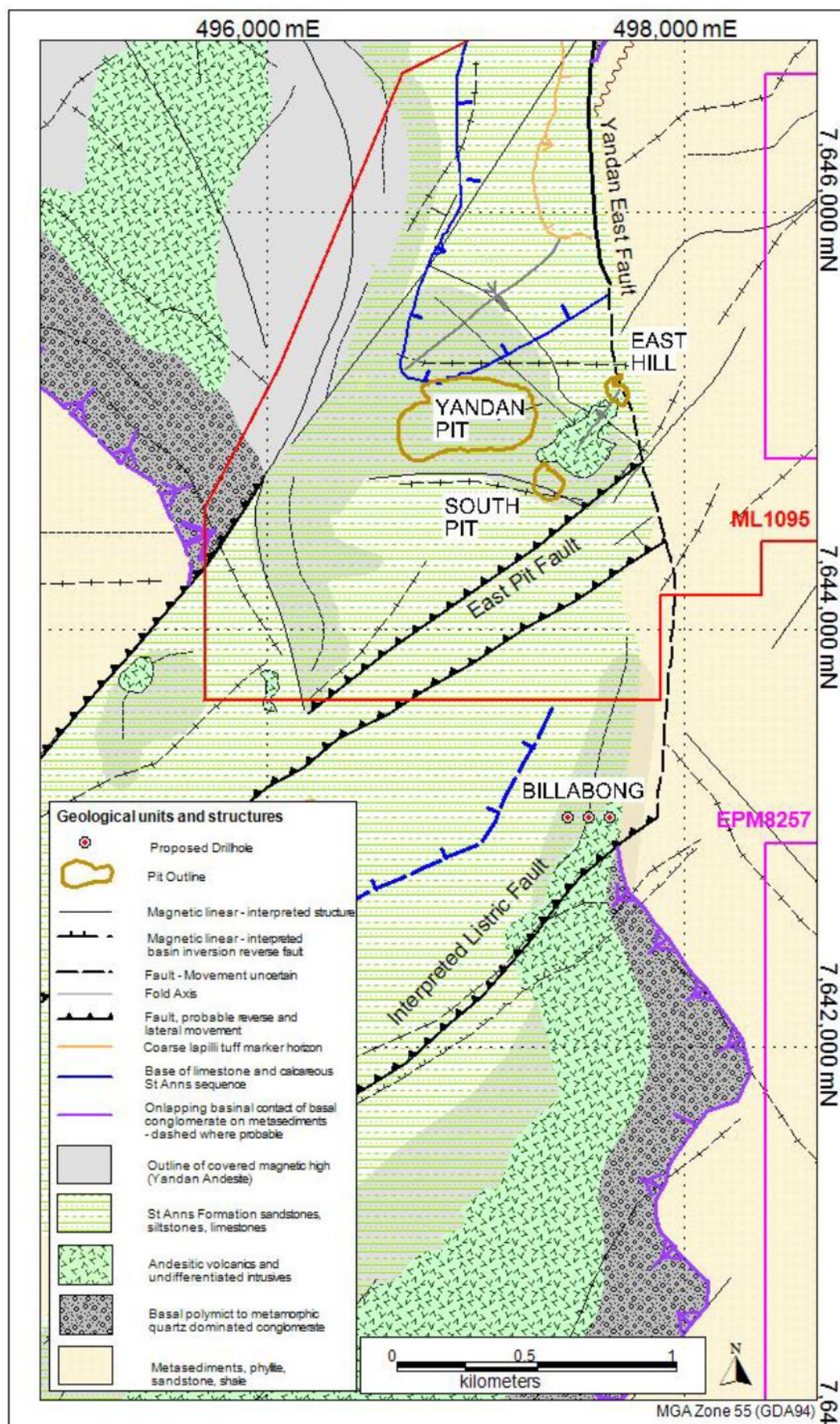


Figure 2: Geology of Yandan (Source: Straits n.d.)

3.2 Materials reactivity - acidic and metalliferous drainage

Exposure of minerals to water and air has the potential to cause acidic and metalliferous drainage (AMD), including acid mine drainage, pH neutral mine drainage and saline drainage (Commonwealth of Australia 2016). All these forms of drainage are generally caused by the oxidation of sulfide minerals, which once exposed, have the potential to generate run-off and/or leachate with high solute concentrations (Commonwealth of Australia 2016). Sulfidic materials with the potential to cause AMD were identified during mining of Main Pit.

During mining of the Main Pit, sulphide rich ore was progressively revealed in the pit wall and floor. Low grade ore from this pit was subsequently placed in the Heap Leach Pad (in combination with ore from South Pit and East Hill Pit), and sulphide tailings were deposited into Cell B of the Yandan Tailings Dam. Targeted geochemical investigations of the Heap Leach Pad and Cell B have assessed the potential for AMD from this infrastructure. The methodology and key finding of these assessments are summarised below. Mitigation measures for potential AMD are discussed within Section 4.4.

Cell B – Geochemical Assessment

Geochemical assessment of 85 tailings and soil samples from Cell B was completed in October 2014 (RGS Environmental Pty Ltd (RGS) 2015). Comprehensive geochemical testing confirmed the following key results (RGS 2015):

- Sulfide testing supports that the majority of sulphide material has oxidised into sulfate.
- Sulfide minerals have undergone significant or complete oxidation, resulting in essentially no residual sulfide minerals present within the top 600 mm of tailings.
- All tailings materials were classified as NAF (with no potential to produce acid through sulphide oxidation) and being inert and having a LAFP (i.e. dominated by pH values of 4 – 6).
- Salinity (EC) values varied from 159 – 2,950 $\mu\text{S}/\text{cm}$, with the oxide tailings paste EC ranging from 600 – 2,950 $\mu\text{S}/\text{cm}$, and the sulfidic tailings paste EC ranging from 600 – 2,400 $\mu\text{S}/\text{cm}$. The average salinity for tailings and soil samples was 1,498 $\mu\text{S}/\text{cm}$ and 1,017 $\mu\text{S}/\text{cm}$, respectively.
- It is considered unlikely that soluble concentrations of major ions and trace elements are causing chronic or acute eco-toxic impacts, noting that healthy vegetation has established in the drainage channels of TSF Cell B.

Heap Leach Pad – Geochemical Assessment

Geochemical assessment of 40 samples from the Heap Leach Pad surface was completed in 2002, with the following key results (Environmental Geochemistry International Pty Ltd (EGI) 2002):

- All samples tested negative for Net Acid Production Potential (NAPP), indicating an excess capacity to neutralise acid.
- Heap Leach Pad materials are Non-Acid Forming (NAF).
- Sulphur concentrations are low – averaging 0.15%S and ranging between 0.02 – 0.42%S.
- Salinity (EC) values are generally moderately to highly saline, with values ranging from 232 – 2,730 $\mu\text{S}/\text{cm}$. Approximately 50% of samples were classified as moderately (1,000 -1,500 $\mu\text{S}/\text{cm}$) and highly saline (<1,500 $\mu\text{S}/\text{cm}$).
- It is considered likely that the Heap Leach Pad would generate highly saline run-off and seepage for a period after decommissioning, stabilising post-closure following flushing of the facility. Indeed, a subsequent geochemical assessment by RGS in 2013 found that water extract from the heap leach materials had a relatively low EC/salinity value of 551 $\mu\text{S}/\text{cm}$, with heap leach material also being of low salinity (median: 201 $\mu\text{S}/\text{cm}$, range: 131 – 440 $\mu\text{S}/\text{cm}$) (RGS 2013)
- A number of metals were highly enriched in the Heap Leach Pad material, including arsenic (As), mercury (Hg), antimony (Sb) and selenium (Se); and a minor number of samples were significantly enriched in silver

(Ag) and lead (Pb)). Some metals were found to be slightly soluble under test conditions (being As, cobalt (Co), copper (Cu), Sb and Se); Ag and Hg were not soluble in any samples.

Other considerations – Main Pit and East Hill Pit

Geochemical testing and water quality monitoring have indicated the presence of sulphide minerals within Main Pit and East Hill Pit. Sulphide minerals in Main Pit were confirmed during the excavation of the pit, with a suitable post-closure strategy now in place. The potential presence of sulphide minerals within East Hill Pit has been indicated by water monitoring results.

Review of water quality monitoring results (2011 – 2020) from the East Hill Pit confirm that pit water is generally lower than pH 4 (median: 3.96 range: 2.87 – 4.96), high in salinity (as EC, median: 11,850 $\mu\text{S}/\text{cm}$, range: 4,010 – 22,364 $\mu\text{S}/\text{cm}$), and high in sulphate (median: 3,350 mg/L, range: 1,700 – 5,000 mg/L). These observations indicate the potential presence of sulphide minerals within the host geology.

Water quality results from Main Pit (2011 – 2020) indicate a median pH of 7.1 (range: pH 6.1 – 9.18), median EC of 198 $\mu\text{S}/\text{cm}$ (range: 79 – 400 $\mu\text{S}/\text{cm}$), and median sulphate concentrations of 20 mg/L (range: 12-27 mg/L). These values are within the contaminant limit values set for other on-site water storages, indicating that the closure strategy in-place for Main Pit is effective.

3.3 Climate and rainfall

The Yandan Gold Mine is located within a region identified as having a ‘sub-tropical’ climate with moderately dry winters and hot summers (Bureau of Meteorology (BoM) 2001). Most of the rainfall for this region occurs during the November to March period (the ‘wet season’), with limited rainfall recorded throughout the rest of the year. Rainfall records (for the 1899 – 2020 period) for the surrounding region are available from the nearby Mount McConnell BoM weather station (located approximately 66 km north-east of the Project site) and are shown below in Figure 3.

Rainfall records (1899 – 2020) indicate annual rainfall totals are within the range of 189.7 – 1480.4 mm/year, with a median annual total of 596.8 mm/year. The majority of rainfall occurs during rainfall events in the wet season, with dry conditions persisting for the majority of the year (on average 321 days per year).

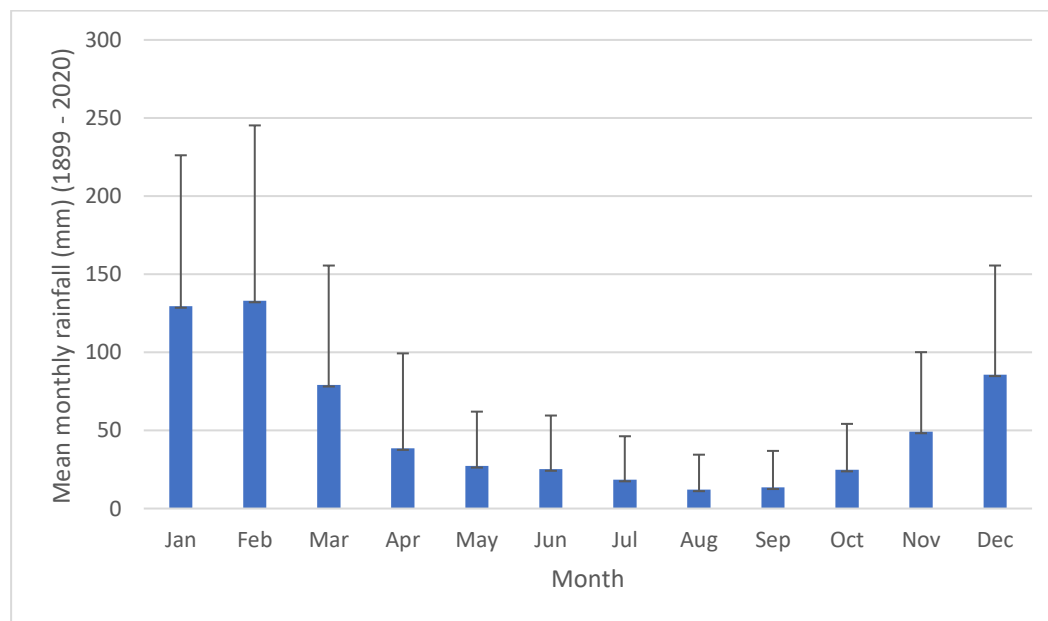


Figure 3: Mean monthly rainfall within the surrounding Project region (Source: Mount McConnell BoM weather station)

3.4 Evaporation

Evaporation records from the surrounding region are available from the Collinsville Post Office (33013) and Moranbah Water Treatment Plant (34038) weather stations through the Queensland Government's SILO climate database² (Table 5). The Collinsville Post Office and Moranbah Water Treatment are approximately 120 km northeast and 133 km southeast of the Project, respectively.

The BoM has mapped total annual evaporation (Class A evaporation pan) of between 2,000 – 2,400 mm³ for the Project region, with an annual evapotranspiration total of between 500 – 600 mm or 600 – 700 mm, depending on interpretation of the BoM map⁴. Therefore, approximately 30% of evaporation can be attributed to evapotranspiration.

Evaporation rates within this region are generally lower over the cooler winter months, ranging from approximately 3 – 4.5 mm/day. During the summer months, this increases to approximately 7.2 – 7.8 mm/day. On average, the daily evaporation rate is 5.5 mm/day with annual evaporation totalling 1,984 mm/year.

Table 5: Evaporation rates for the Yandan Gold Mine region

Weather Station	Median Daily Evaporation Rate (2010 – 2020) (mm/day)												Average Daily Evaporation Rate (mm/day) (2010 – 2020)	Average Annual (mm/year) (2010 – 2020)
	January	February	March	April	May	June	July	August	September	October	November	December		
Collinsville Post Office	6.8	6.2	5	4.25	3.6	2.9	3.2	4.4	6	7	7.6	7.6	5.3	1,928
Moranbah Water Treatment Plant	7.6	6.7	5.5	4.8	3.8	3.1	3.4	4.5	6	7.3	8	8	5.6	2,041
Average	7.2	6.5	5.3	4.5	3.7	3	3.3	4.5	6	7.2	7.8	7.8	5.5	1,984

Source: Queensland Government²

3.5 Regional water balance

The Yandan Gold Mine is located within a region with a strongly negative water balance, with annual rainfalls of approximately 600 mm/year counterweighted by an average evaporation capacity of approximately 2,000 mm/year. The relationship between rainfall and evaporation in this region has implications for communities

² Queensland Government (2020) SILO – Australian climate data from 1889 to yesterday, retrieved from <https://www.longpaddock.qld.gov.au/silo/point-data/>

³ BoM (2020) Evaporation: Average Monthly & Annual Evaporation, retrieved from <http://www.bom.gov.au/watl/evaporation/>

⁴ BoM (2020) Average annual & monthly evapotranspiration, retrieved from http://www.bom.gov.au/jsp/ncc/climate_averages/evapotranspiration/index.jsp

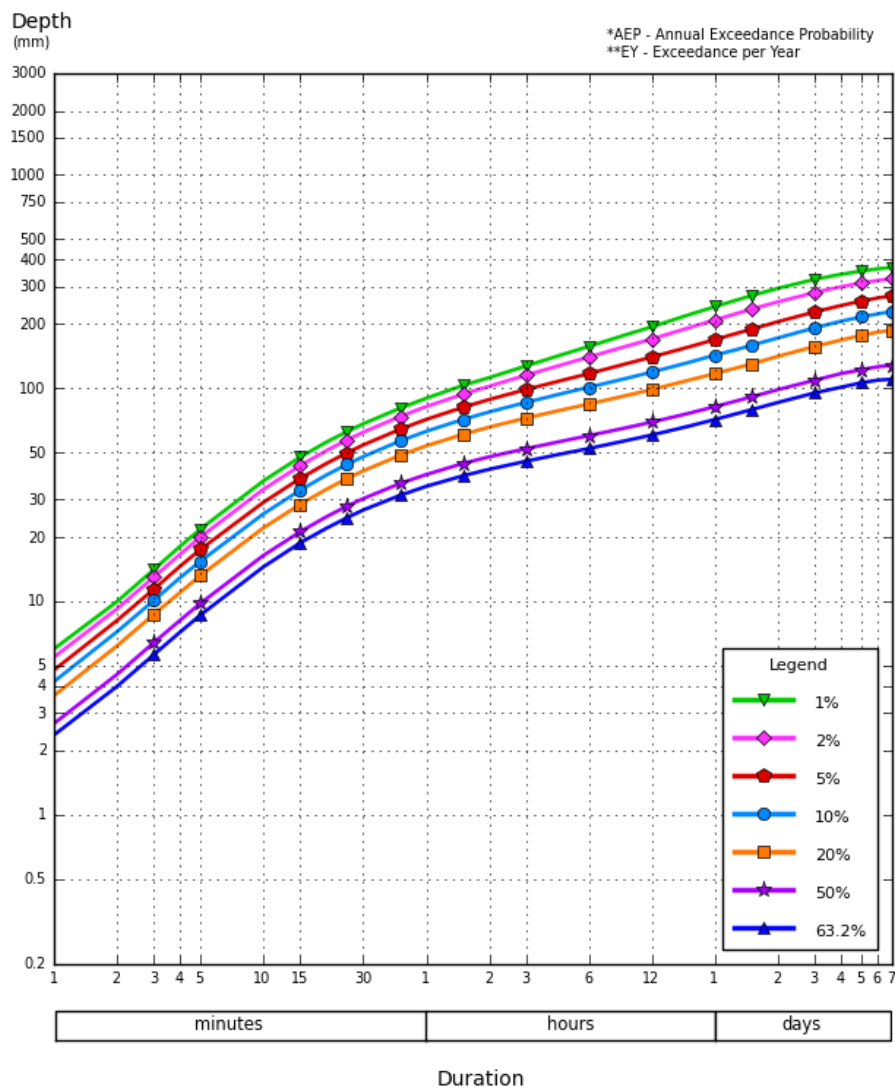
and operations, with water security likely to be determined by sufficient storage capacity and water supply. For Yandan Gold Mine, water security is provided by a number of existing on-site water storages and water extraction licences. Being in care and maintenance however, water supply is not an active issue.

3.6 Design rainfall

The BoM provides design rainfall information such as Intensity-Frequency-Duration (IFD) information, which is useful for guiding the design of hydraulic structures. The IFD information provides estimates of annual exceedance probabilities (AEP), being the probability of a given rainfall total accumulated over a given duration will be exceeded in any one year. A rainfall event with a 1% AEP has a 1% probability of occurring in any one year, and is equivalent to a 1:100 rainfall event or a 1: 100 year average recurrence interval (ARI).

Using the BoM's Design Rainfall Data System (2016)⁵ IFD design rainfall depths were retrieved for Yandan Gold Mine. The 1% AEP for Yandan Gold Mine is 241 mm, as per Figure 4 and Table 6. It is acknowledged that water storage structures on-site are required to have a spillway capacity and design storage allowance sufficient to provide for a 1: 100 year ARI, equivalent to the 1% AEP.

⁵ BoM (2020) Design Rainfall Data System (2016), retrieved from http://www.bom.gov.au/water/designRainfalls/revised-ifd/?coordinate_type=en&easting=498774.92&northing=7646083.61&zone=55&user_label=Yandan&design=ifds&sdmin=true&sdhr=true&sdday=true&nsd%5B%5D=&nsdunit%5B%5D=m&values=depths&update=



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Figure 4: IFD Design Rainfall Depth (mm) – Yandan Gold Mine

Table 6: IFD Design Rainfall Depth (mm)

Duration	Annual Exceedance Probability (AEP)						
	63.2%	50%#	20%	10%	5%	2%	1%
1 min	2.36	2.67	3.61	4.20	4.76	5.47	5.98
2 min	3.99	4.54	6.18	7.20	8.13	9.22	9.97
3 min	5.62	6.40	8.69	10.1	11.4	13.0	14.1
4 min	7.17	8.14	11.0	12.9	14.6	16.6	18.1
5 min	8.61	9.77	13.2	15.4	17.5	20.0	21.8
10 min	14.5	16.4	22.1	25.7	29.1	33.5	36.7
15 min	18.8	21.2	28.5	33.2	37.7	43.3	47.5
20 min	22.0	24.9	33.5	39.1	44.3	50.9	55.8
25 min	24.6	27.9	37.6	43.8	49.6	57.0	62.4
30 min	26.8	30.3	40.9	47.7	54.1	62.1	68.0

Duration	Annual Exceedance Probability (AEP)						
	63.2%	50%#	20%	10%	5%	2%	1%
45 min	31.4	35.7	48.4	56.5	64.1	73.6	80.5
1 hour	34.6	39.3	53.6	62.7	71.3	81.9	89.6
1.5 hour	38.8	44.3	60.7	71.3	81.3	93.7	103
2 hour	41.6	47.6	65.6	77.3	88.4	102	112
3 hour	45.4	52.0	72.4	85.7	98.5	115	127
4.5 hour	49.3	56.5	79.2	94.5	109	129	144
6 hour	52.1	59.9	84.3	101	117	140	157
9 hour	56.7	65.1	92.2	111	130	157	178
12 hour	60.3	69.3	98.5	119	140	170	194
18 hour	66.3	76.2	109	132	156	192	221
24 hour	71.3	81.9	117	143	169	209	241
30 hour	75.6	86.8	124	151	180	223	258
36 hour	79.3	91.1	130	159	189	235	272
48 hour	85.7	98.4	141	172	205	254	294
72 hour	95.0	109	157	192	228	281	324
96 hour	101	117	168	206	244	299	342
120 hour	106	122	177	216	256	311	354
144 hour	109	126	183	223	265	320	363
168 hour	110	128	187	229	271	326	368

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.

3.7 Surface water

3.7.1 Host catchments and regional features

The Yandan Gold Mine is situated within the Burdekin Drainage Basin and the Suttor River drainage sub-basin. The Suttor River is located on the western boundary of the Project within ML 1095, with a number of minor ephemeral tributaries running across the Project site (Figure 5). The Suttor River drainage sub-basin spans an area of approximately 74,000km². The Suttor River drains into Lake Dalrymple, formed by the damming of the Burdekin River (HLA – Envirosciences Pty Ltd 2000).

The Suttor River flows South to North into two nationally important wetlands, as identified through the 'Directory of Important Wetlands in Australia' (DIWA) (DAWE 2019). These DIWA wetlands include Lake Dalrymple and the Scartwater Aggregate. Lake Dalrymple was historically formed from the damming of the Burdekin River, located further upstream (HLA - Envirosciences 2000).

Stream flow in the rivers and tributaries of the Suttor River Sub-basin are dependent on the frequency and intensity of rainfall events within the catchment. Periods of flow are directly related to large rainfall events in the catchment; which is typical of ephemeral systems.

3.7.2 Site catchments

Drainage systems on Yandan Gold Mine are influenced by distinct mining domains and the region's gentle sloping topography. The principal catchments on-site are associated with the Yandan Tailings Dam and Water Storage Dam facilities, with these facilities having catchment sizes of 130 ha and 498 ha respectively (refer to Table 7).

Surface runoff collected within these catchments is managed within the Project's water management network, as summarised below and illustrated through Figure 6:

- Surface runoff from the Yandan Tailings Dam is captured within the Tailings Water Return Dam. In the event of extreme rainfall, overflow from this dam is received by the Water Storage Dam.
- Surface runoff from the Heap Leach Pad reports to the Heap Leach Pad Pregnant and Barren Ponds. In the event of extreme rainfall, stormwater overflows to the Heap Leach Stormwater Pond.
- Surface runoff from the Decommissioned Processing Area is captured by the Mine Water Dam.
- Note – the Main Pit and East Hill Pit are bunded structures with limited surface catchment areas.

Table 7: Site catchments (as per Site Water Balance – refer to Section 4.5)

Domain	Associated catchment area (ha)
Yandan Tailings Dam & Tailings Water Return Dam	130
Mine Water Dam	22.5
Water Storage Dam Catchment (less Yandan Tailings Dam sub catchment)	498
Heap Leach Facility	38
Main Pit	21
East Hill Pit	2

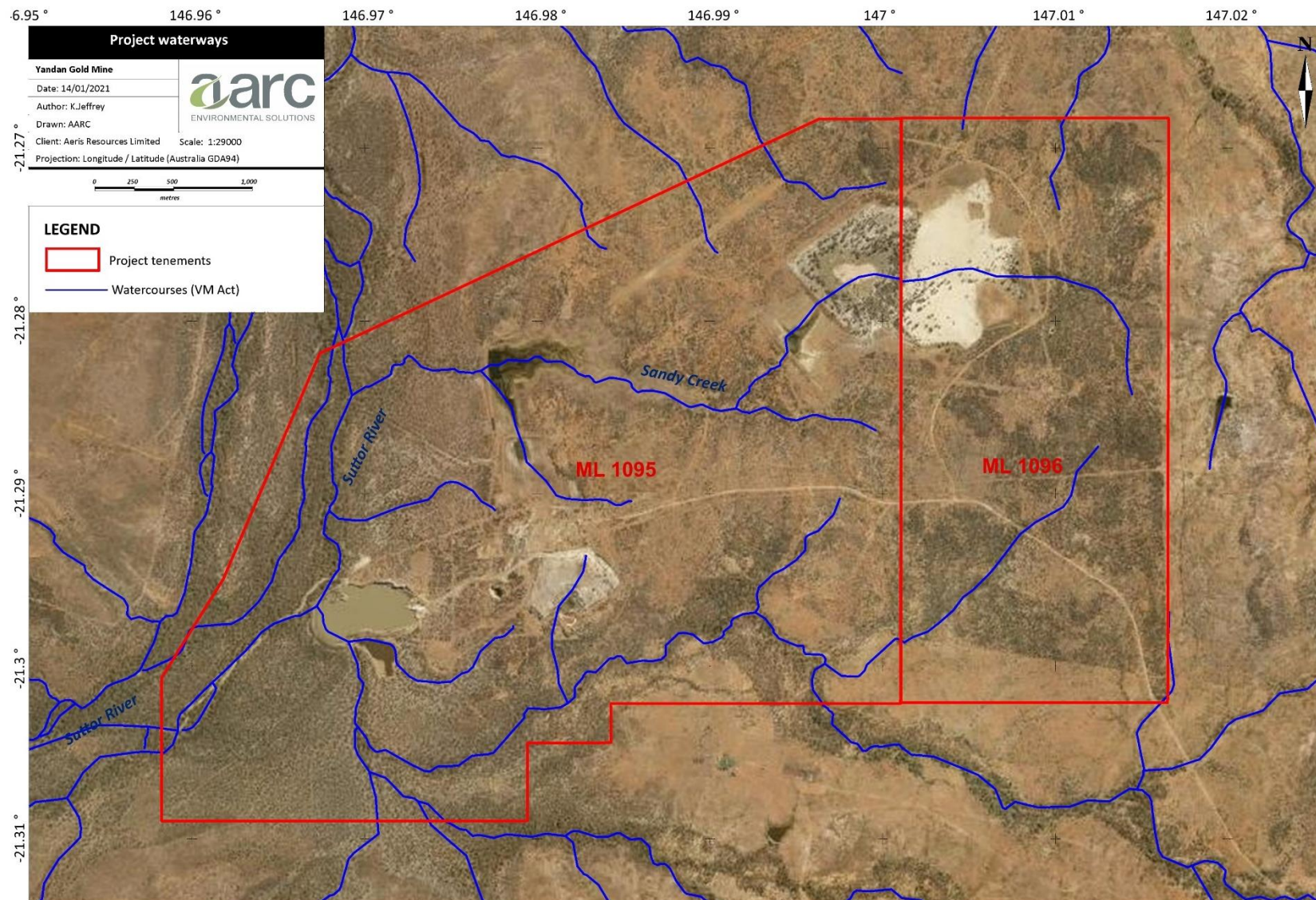


Figure 5: Project waterways

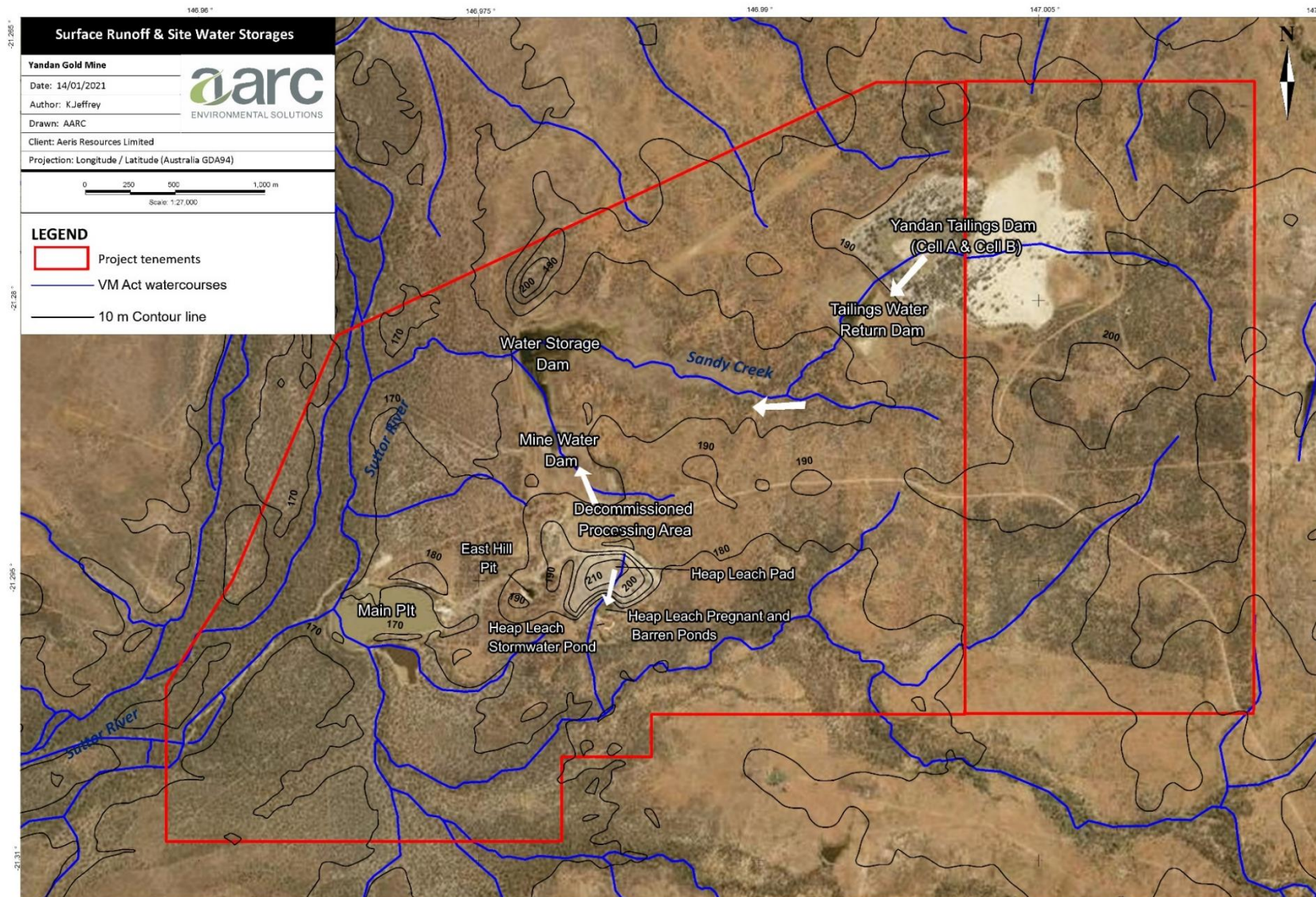


Figure 6: Surface runoff and site water storages

3.8 Regional flood modelling – 1% AEP rainfall event

Regional flood modelling for the Project region is available through Queensland Globe (Queensland Government 2020). Government mapping for the Project region indicates that in a 1% AEP rainfall event (defined as 241 mm over a 24-hour period, refer to Section 3.6), that flooding would occur in association with the Suttor River and its floodplains and tributaries (refer Figure 7).

The 1% AEP flood modelling identifies that areas of the Project site are at risk of flooding. Inundation would affect the western side of the tenements primarily (ML 1095), due to flooding associated with the Suttor River. The eastern side of the Project (ML 1096) is generally less susceptible to flooding owing to the naturally higher elevations on this side of the Project. It is noted that the EA requires regulated structures to be designed to tolerate a 1: 100 year ARI, equivalent to the 1% AEP.

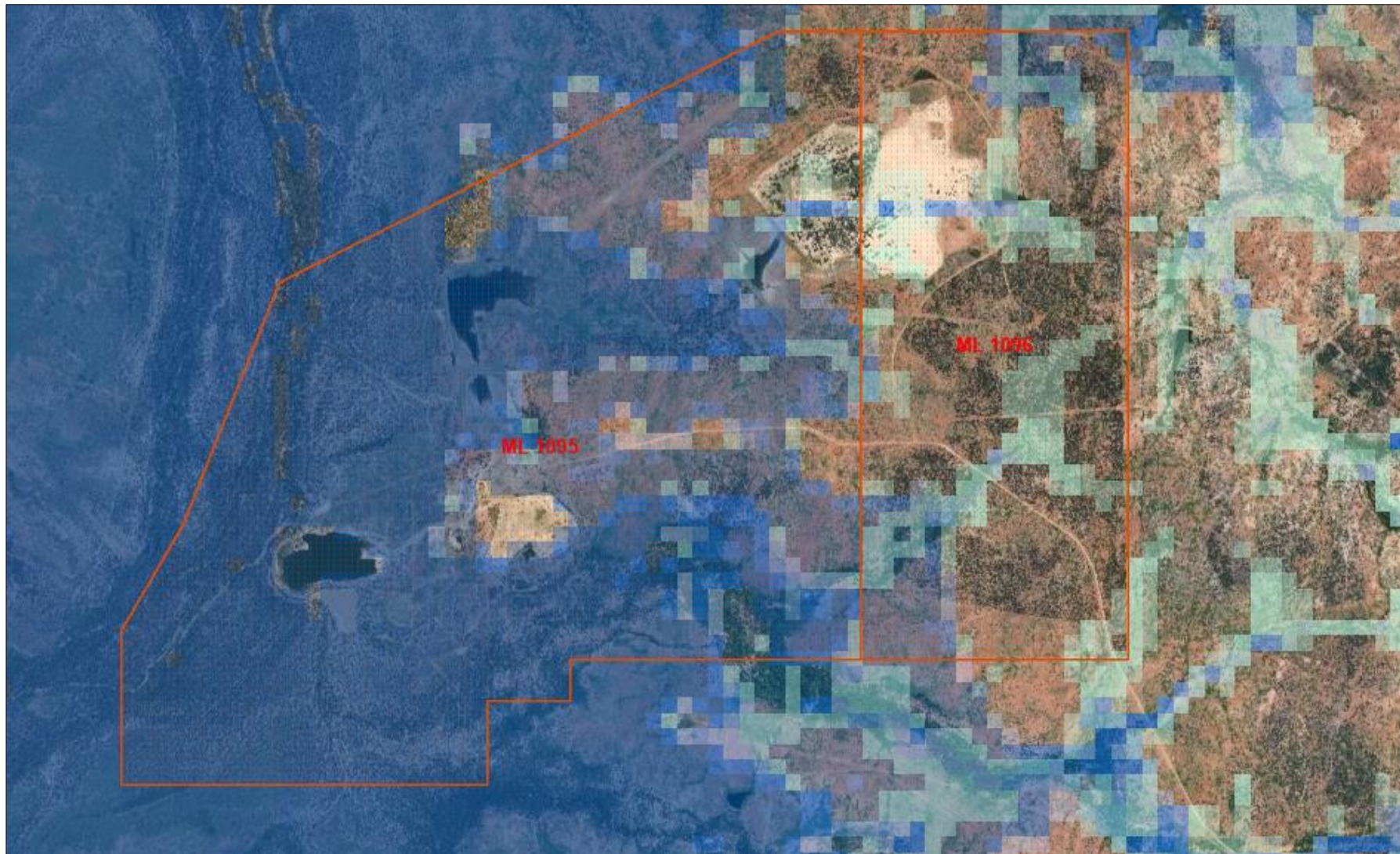


Figure 7: 1% AEP Flood event on Yandan Gold Mine (Source: Queensland Government 2020)

3.9 Groundwater

Historic groundwater assessments have indicated that hydrogeological units within the Project region consist of alluvium associated with the Suttor River floodplain and fractured rock aquifers (Forbes 1988).

Water level measurements indicate a westerly groundwater flow pathway towards the Suttor River, with considerable variability in water levels across the Project site (Forbes 1988). Recent groundwater monitoring (2012 – 2019) indicates the depth to groundwater is approximately 1 – 14 m, acknowledging that groundwater levels are steadily declining in all groundwater monitoring bores (RLA 2019). Groundwater monitoring has demonstrated that groundwater levels tend to increase following rainfall events, with levels generally peaking approximately three months after the rainfall event. This trend indicates that the aquifers underlying the site are of low permeability (RLA 2019).

3.10 Surface water and groundwater quality

Available water quality monitoring results (2011 – 2020) were reviewed to provide a profile for water storages, Main Pit water and groundwater.

Water storages

Average water quality parameter values for the on-site water storages (as per Table 5 of the Project EA) are shown through Figure 8 (pH, EC and sulphate) and Figure 9 (metal concentrations).

Key results from the water storage monitoring are summarised as follows:

- Water storages are generally within the EA pH range limit (4 – 9), with the exception of East Hill Pit, which on average is marginally (pH 3.9) below the EA limit.
- EC and sulphate levels are typically exceeded for the Heap Leach Stormwater Pond, East Hill Pit and Mine Water Dam, with the Tailings Water Return Dam typically exceeding the sulphate EA limit. The high salinity (EC) levels in the Heap Leach Stormwater Pond and Mine Water Dam are considered to likely be the result of evaporation and concentrating of dissolved salts, and historical levels of sulphate and salts in the sediment (noting these facilities are unlined).
- Metal concentration EA limits are typically met, with the exception of aluminium concentrations within the East Hill Pit. It is noted that aluminium concentration results were only available for 2014 – 2015; however recent monitoring (March 2021) supports that aluminium exceedances are specific to East Hill Pit only.

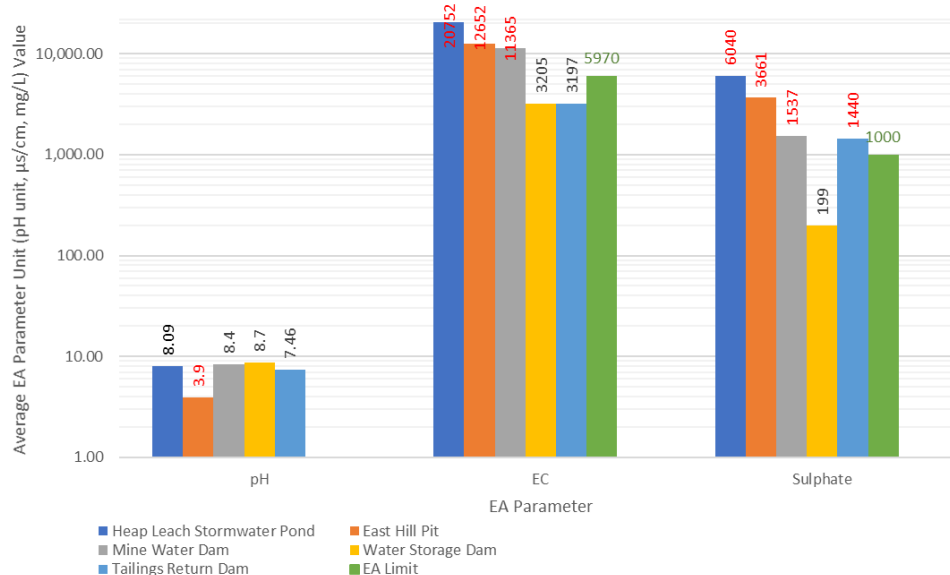


Figure 8: Average EA Parameter Values (2010 – 2020) for Water Storages (pH, EC, Sulphate)

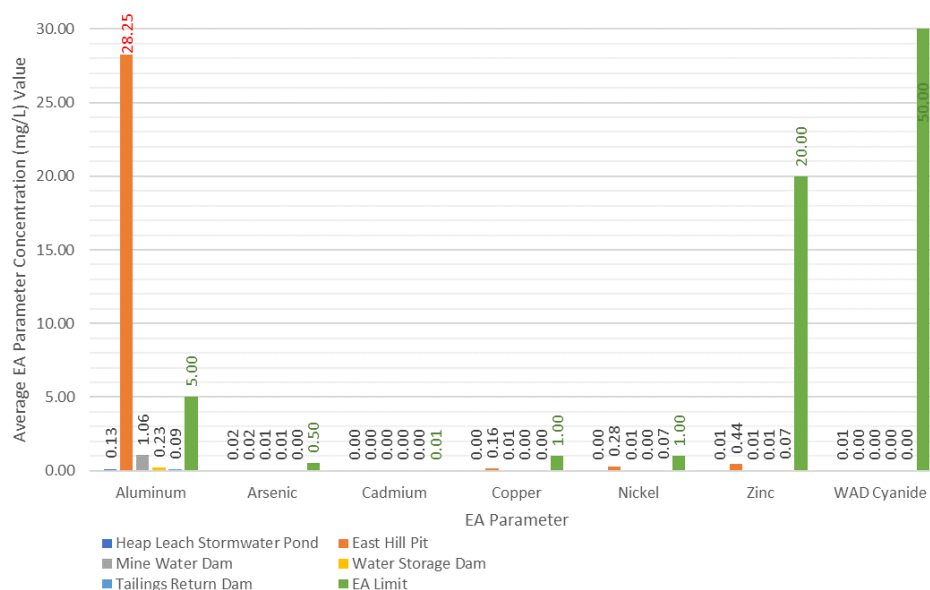


Figure 9: Average EA Parameter Values (2010 – 2020) for Water Storages (metal concentrations)

Main Pit – water quality

Results collected over 2011 – 2020 indicate that on average (calculated using averaged measurements from across the depth profile) that pit water is within contaminant limits set for other on-site water storages (refer Figure 10). Water within Main Pit is near-neutral (average of pH 7.2), with relatively low salinity (EC) (205 $\mu\text{S}/\text{cm}$) and sulphate (20.46 mg/L) concentrations. These results confirm that the sporadic outflows and inflows from the Suttor River are maintaining water quality within the pit, limiting the concentration of salts. In residual voids without continuing recharge, water quality generally declines over time, as salts / contaminants concentrate following pit water evaporation.

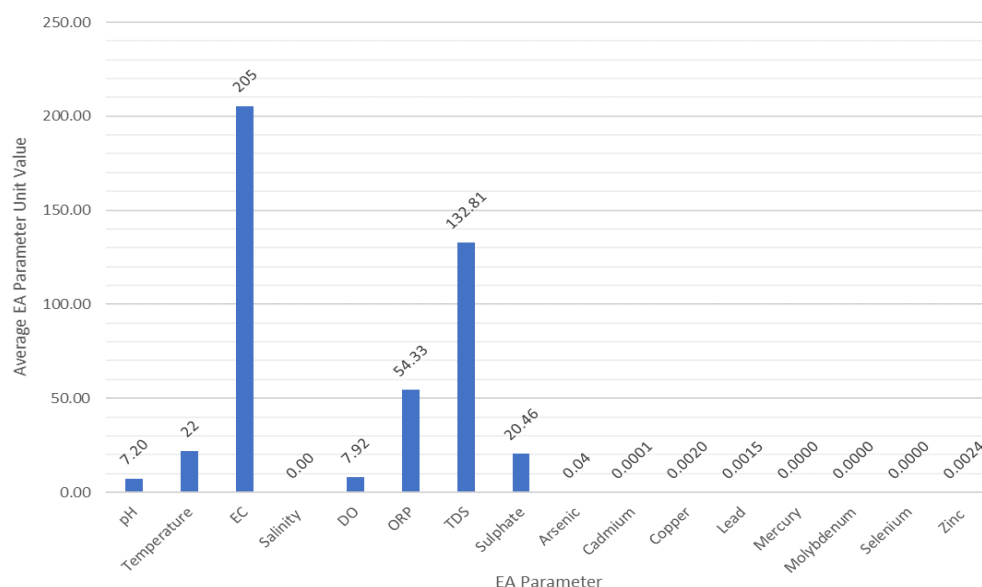


Figure 10: Average EA Parameter Values (2011 – 2020) for Main Pit

Groundwater

Groundwater chemistry data collected from the onsite monitoring network indicate that groundwater is generally of poor quality, being highly saline and high in sulphate (RLA 2019). Historic reporting has stated that bores outside the area of mining disturbance have recorded TDS values ranging up to 22,500 mg/L, with sulphate background values found to often exceed 1,000 mg/L, with this attributed to oxidation of the sulphide minerals within the host geology.⁶

Average water quality parameter values (calculated across the 2011 – 2020 period) for the EA groundwater monitoring bores are shown through Figure 11 (pH and sulphate) and Figure 12 (metal concentrations).

Key results from EA groundwater monitoring bores are summarised as follows:

- Groundwater bores are within EA limits for pH.
- On average, sulfate concentrations are exceeded at HL1 (average: 2,475 mg/L) and SH3 (average: 3,036 mg/L). During commission, sulfate concentrations were often exceeded at TD6 (average: 1,252 mg/L).
- On average, metal concentration EA limits are typically met, with exceptions for average selenium concentrations at HL1 (average: 0.0394 mg/L). It is noted that SH3 and TD6⁶ recorded an average selenium concentration of 0.0250 mg/L, however it is noted that the limit of detection (LOD) for some sampling events was higher (<0.05 mg/L) than the EA limit (0.02 mg/L), therefore it is not possible to determine whether the EA limit was exceeded.

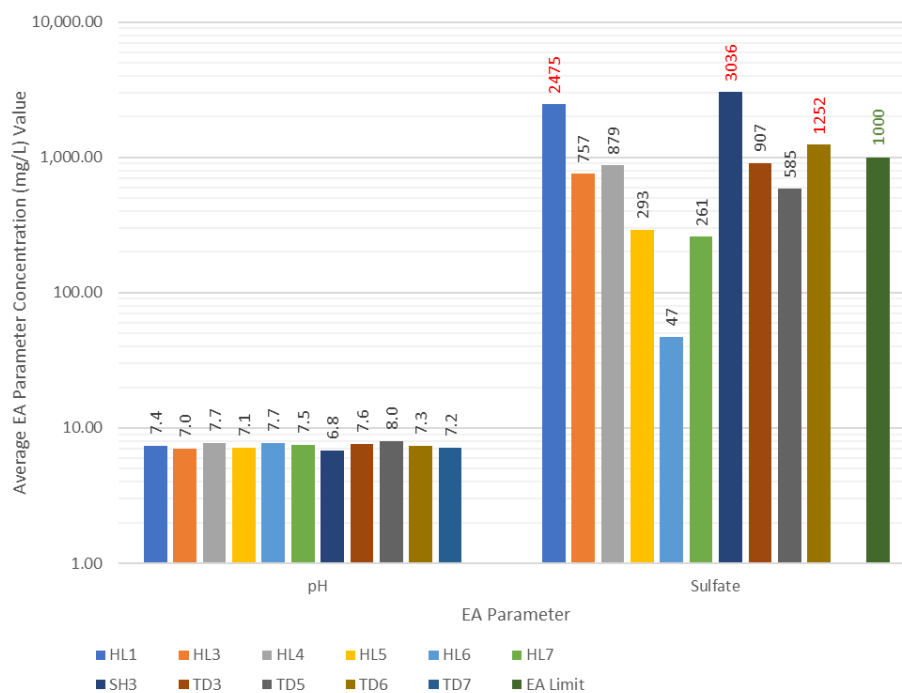


Figure 11: Average EA Parameter Values (2011 – 2020) for EA groundwater monitoring bores (pH, sulfate)

⁶ TD6 was destroyed mid-2018 and is no longer monitored.

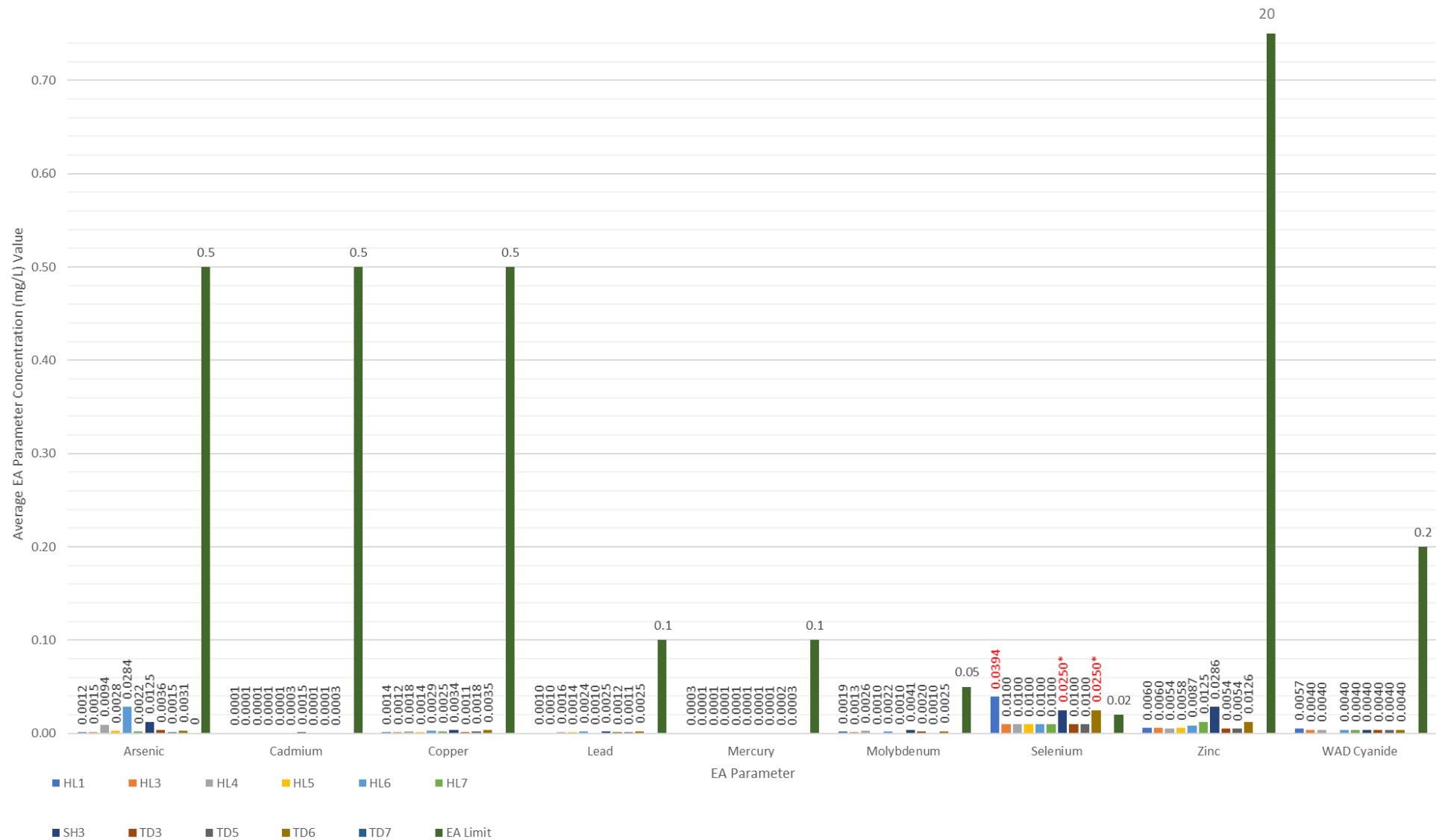


Figure 12: Average EA Parameter Values (2011 – 2020) for EA groundwater monitoring bores (metal concentrations)

4 Water management system

4.1 Overview of water management system

The Yandan water management system focuses on passive management, noting that the site is currently in an extended period of care and maintenance with limited exploration activities occurring on-site. Non-passive management activities (e.g. water sampling and pumping between containment dams) are occasionally required in preparation for and during significant rainfall events. Overall, the site water balance is in a net-deficit position, with effective evaporation exceeding annual rainfall for all water bodies. Water storages are therefore seasonally dry, negating the need for active water management.

The current water management system involves a network of containment dams for the capture and management of mine affected water on-site, with mainly passive mechanisms (i.e. spillways) facilitating any potential discharge to other water storages within the site water management system. The key elements of the water management system can be summarised as follows:

- Yandan Tailings Dam - a bunded 'turkeys nest' structure, capturing only direct rainfall.
- Tailings Water Return Dam (TWRD) – receives any discharge received from the Yandan Tailings Dam. In the unlikely event of overtopping, the TWRD passively discharges *via* the spillway to the Water Storage Dam.
- Water Storage Dam - receives surface water runoff from the Project site catchment, any potential overflow from the TWRD, and (during operation) water harvested from the Suttor River.
- Heap Leach Pregnant Pond and Barren Pond - receives surface water runoff from the Heap Leach Pad. During significant rainfall events these ponds passively discharge to the Heap Leach Stormwater Pond, located immediately adjacent to these ponds and connected *via* a spillway.
- Heap Leach Stormwater Pond - receives stormwater overflow from the adjacent processing ponds during extreme rainfall events where it is stored for evaporation. If required, non-passive methods (i.e. pumping) are used for the transfer of water from the Heap Leach Stormwater Pond to the Mine Water Dam.
- Mine Water Dam - captures surface water runoff from the decommissioned processing area and any water transferred from the Heap Leach Stormwater Pond.
- Main Pit – a residual void to be retained as a pit lake post closure. Designed to function as a 'flushing pit', with two spillways permitting inflows and outflows with the Suttor River.
- East Hill Pit – a small residual void that has developed a small pit lake.
- The levee bank around the Heap Leach ponds (Heap Leach Stormwater Pond, Pregnant and Barren Ponds) to contain overflow during extreme rainfall events.
- The levee bank around Main Pit to protect the pit from flooding (during operation). The levee is to be partially removed on closure.
- The diversion of Yandan Creek around Main Pit.

4.2 Recent improvements made to the water management system

The 2021 annual statutory dam inspection for Yandan's regulated and non-regulated dams was completed in January 2021 by Pells Sullivan Meynink (PSM), with a subsequent inspection completed during October 2021.

The annual inspection report made recommendations in regards to the management of the dams and maintenance required. Recommendations made from this report have progressively been actioned throughout the year.

The following improvements were made to the Yandan water management system during the 2021 dry season:

- General maintenance activities – includes removal of large trees from embankment faces, backfilling of erosion gullies, regrading of settled and cracked embankment crests, maintenance of damaged monitoring bores, installation of water level indicator poles.
- Fencing – water storages with water quality that often exceeds the water quality limits for stock watering suitability fenced (e.g. Water Storage Dam), with additional fencing added to some dams (e.g. Mine Water Dam, Yandan Tailings Dam).
- Groundwater bores - installation of new groundwater monitoring bores to replace decommissioned/damaged monitoring bores around the TSF, and new reference bores for the development of site-specific groundwater limits.
- Hazard Consequence Category Assessment – assessment of the hazard consequence categories for regulated, non-regulated dams and other water containment structures completed September 2021. All structures classified as having a 'low' risk of over-topping or dam break.
- Review and monitoring of seepage – preliminary assessment of seepage from the TWRD and Water Storage Dam completed. Regular monitoring for seepage to continue as per the operational plan for the dams.
- Operational Plans – operations and maintenance manual for regulated, non regulated dams and other water containment structures prepared.

4.3 Contaminant sources and pathways

It is a requirement of the Project EA (as per Condition C10-2) that the Water Management Plan includes a Contaminant Source Study. As the Yandan Gold Mine has been in care and maintenance since 1998, the original study has not been able to be located.

Historical assessments (including geochemical assessments) and recent water quality monitoring have indicated that potentially contaminated (mine affected) water is associated with the Yandan Tailings Dam, Heap Leach Pad, Main Pit, and the decommissioned processing area (Straits Resources 2013). Potential contamination and flow pathways associated with these areas are summarised below.

Yandan Tailings Dam

Surface runoff from the Yandan Tailings Dam is generated across an area of approximately 100 ha. As discussed in Section 3.2, geochemical testing indicates that the tailings material is highly weathered and unlikely to cause acidic and metalliferous drainage.

In the event of extreme rainfall, mine affected water from Yandan Tailings Dam is significantly diluted, prior to potential overflow from the Tailings Dam, to the downstream Tailings Water Return Dam. In such a scenario, the Tailings Water Return Dam would again effect significant dilution. Should the Tailings Water Return Dam potentially overtop (which would require significant rainfall) further dilution would again be effected, as water flows to the downstream Water Storage Dam. In the unlikely event of the Water Storage Dam overtopping, the aforementioned series of controls (effecting significant dilution at each stage) is not anticipated to result in a level contaminants reaching the receiving environment, at a level where environmental harm is likely.

It is noted however, that groundwater seepage from the Tailings Water Return Dam and Water Storage Dam is apparent at the toe of the downstream face of these facilities (PSM 2019). A series of drains have been excavated to capture seepage from these facilities, with this seepage discharged to small catchment dams for evaporation.

Heap Leach Pad

Geochemical testing of the heap leach material has confirmed that it is non-acid forming (NAF) with low sulphur concentrations, however, the material is enriched in some metals (particularly, As, Hg, Sb and He), with historic reporting also indicating a potential for saline drainage runoff (although later reporting has suggested that this is low risk).

Surface runoff from the Heap Leach Pad is received within the Pregnant and Barren Ponds, before discharging to the Heap Leach Stormwater Pond during significant rainfall events. The water level in the Heap Leach Stormwater Pond is passively managed, with the water level within this facility generally maintained by evaporation. If required, excess water can be pumped to the Mine Water Dam for evaporation. A levee bank

has also been constructed around the Heap Leach Pad water storages, to contain any overflow during significant rainfall events.

Main Pit

Potentially acid-producing material (sulphide rich ore and waste rock) was exposed in the lower sections of the Main Pit wall during operation (Straits Resources 2013). The closure strategy for Main Pit has been to establish a permanent water cover, to prevent the continued oxidation of the sulphidic waste rock and contamination of pit water. Without the water cover, oxidation of the sulphidic materials may result in the accumulation of soluble sulphate salts and the increased acidity of the pit water. Rather than containing deteriorating quality pit water onsite, this closure strategy provides for a 'flushing pit' design, facilitating pit inflows and outflows with the Suttor River and thereby facilitating discharge quality water within the pit.

During the last release event in April 2017, mine affected water from the Main Pit was released into the Suttor River. Water quality monitoring during this event did not identify contaminant issues in the receiving environment.⁷

Decommissioned Processing Area

Potentially contaminated runoff from the decommissioned processing area is captured within the Mine Water Dam catchment, located adjacent and immediately north (Straits Resources 2013). While there is no obvious contaminated flow from this area (Straits Resources 2013), water quality monitoring of Mine Water Dam indicates that on average, water captured within this dam is highly saline, with a high sulphate concentration (refer Section 3.10).

During significant rainfall events, discharge from the Mine Water Dam is directed through an excavated channel and then overland to the Suttor River, with a second spillway designed to spill into the Water Storage Dam (AECOM 2016). In the event that this facility reached capacity, the limited catchment area (22.5 ha) versus the capacity (478 ML) of this facility would create a significant dilution effect that would result in an extremely low risk of any contaminated water being discharged from the Mine Water Dam.

4.4 Acid and metalliferous drainage - prevention and management measures

It is a requirement of the Project EA (as per Condition C10-2) that the WMP addresses management measures for both saline drainage and acid rock drainage. As noted within Section 3.2, these forms of drainage are generally caused by the oxidation of sulphide minerals and can be collectively referred to as acid and metalliferous drainage (AMD, with this collectively referring to acidic, pH neutral and saline mine drainage) (Commonwealth of Australia 2016). The potential for AMD has been identified on the Project in association with the residual voids and Cell B of the Yandan Tailings Dam. Historic reporting for the Heap Leach Pad also indicated some potential for saline drainage from the Heap Leach Pad, however later reporting has not identified this. Nevertheless, the Heap Leach Pad has been included here for completeness.

The '*Preventing Acid and Metalliferous Drainage*' guideline document (Commonwealth of Australia 2016) suggests that management of AMD falls into three main categories:

- minimising oxidation and the transport of oxidation products;

⁷ During the release event in April 2017, mine affected water from the Main Pit was released off-site into the Suttor River. Monitoring during this event (at impact monitoring point SR1, located downstream of release point REMP6), identified that release waters exceeded EA limits for aluminium, copper and zinc. Comparative upstream monitoring (at reference monitoring point SR3a), identified elevated concentrations for these dissolved metals in the upstream environment. All elevated metals observed at downstream locations also exceeded at upstream locations. In the absence of any other resource projects within the region, it is likely that the elevated metal concentrations are indicative of natural mineralisation in the Project region.

- controls to reduce contaminant loads escaping to the environment; and
- active or passive treatment to allow water re-use or discharge.

Prevention and management measures for AMD on-site have been developed with reference to these principles and are overviewed for each relevant facility within Table 8.

Table 8: Acid and metalliferous drainage – prevention and management measures

Facility	Acid and metalliferous drainage (AMD) – Prevention and Management Measures
Yandan Tailings Dam	• Bunding around the perimeter of the Yandan Tailings Dam to capture surface runoff within the catchment and prevent mine affected runoff from reporting to the receiving environment. Perimeter bunding further reduces the associated catchment area and the amount of mine affected water requiring management and/or evaporation. • Successive water management structures (being the TWRD and the Water Storage Dam) are used for the dilution of mine affected water from the Yandan Tailings Dam, in the unlikely event that passive discharge occurs from the Yandan Tailings Dam spillway. • Seepage interception trenches have been excavated adjacent to the TWRD and Water Storage Dam, for the collection of any potentially contaminated seepage from these downstream facilities. • On closure, a cover design system will be applied to Cell B to reduce the potential exposure and transport of sulphide minerals.
Main Pit	• Maintenance of a permanent water cover to limit oxidation of sulphide materials and increase the dilution factor of pit water (enabling release of pit water). • Construction of a levee bank around the western side of the Main Pit along the Suttor River, for the retention of the permanent water layer. • Two spillways located on the south-eastern and north-eastern corners of the pit, to 'flush' accumulating solutes from the pit lake.
Heap Leach Pad	• Surface runoff from the Heap Leach Pad flows towards the adjacent Pregnant and Barren Ponds. • Flood levee around the perimeter of the Heap Leach Pad, to prevent overflow from these facilities reporting to the receiving environment during significant rainfall events. • Pump infrastructure installed at the Heap Leach Stormwater Pond, for the transfer of water to the Mine Water Dam, as required (to prevent any potential spills into the receiving environment). • On closure, a suitable cover system will be applied to the Heap Leach Pad to reduce the exposure and transport of sulphide minerals.
East Hill Pit	• Bunding around the perimeter of the East Hill Pit, limiting the associated catchment area and the amount of mine affected water captured within the pit. • Maintenance of the pit water level below the known level of sandstone (for the prevention of groundwater contamination). • On closure, a significant backfill is proposed to be completed to cover any potential sulphide materials.

4.5 Site Water Balance

It is a requirement of the Project EA (as per Condition C10-2) that the WMP includes a Site Water Balance and Model. A number of site water balances have been developed for the Project, with the most recent revision completed for the 2008 – 2013 Plan of Operations (Straits Gold 2008). There have been no changes to the Project's water management network since the operation was entered into care and maintenance in 1998; therefore, this site water balance remains valid.

The site water balance is in a net-deficit water balance position, with effective evaporation exceeding annual rainfall for all water bodies; consistent with the regional water balance for the area (refer to Section 3.5). Given the site is in care and maintenance, there is no input to water storages other than rainfall, with the exception of passive inflows into Main Pit when the river height is sufficiently high, and occasional transfers between the Heap Leach Stormwater Pond and Mine Water Dam. The site water balance is therefore dependent primarily on wet season rainfall input, with subsequent evaporation outputs and infrequent releases from site.

The water balance model is summarised in Table 9.

Table 9: Site Water Balance (source: Straits Gold 2008)

Domain	Catchment area (ha)	Catchment area (m ²)	Rainfall input (m ³)	Effective rainfall (m ³)	Open area (ha)	Open area (m ²)	Effective evaporation (m)	Net change (m ³)	Dam storage capacity (m ³)
Tailings Storage Facility & Tailings Water Return Dam	130	1,300,000	756,600	340,470	16.6	166,000	347,018.85	-6,549	1,100,000
Mine Water Dam	22.5	225,000	130,950	65,475	5.7	57,000	119,157.075	-53,682	478,000
Water Storage Dam catchment (less TSF) sub catchment	498	4,980,000	2,898,360	1,449,180	69.5	695,000	1,452,880.13	-3,700	1,400,000
Heap Leach Facility	38	380,000	221,160	110,580	21	210,000	438,999.75	-328,420	73,000
Main Pit	21	210,000	122,220	61,110	15.9	159,000	332,386	-271,276	2,800,000
East Hill Pit	2	20,000	11,640	5,820	1.7	17,000	35,538.075	-29,718	100,000

Notes:

The model is calibrated with the following values: 0.58 m rainfall, 2.09 m pan evaporation, and 0.5 m run-off co-efficient.

Water storage dam and mine water dam combined area when full

TSF runoff coefficient is 0.45 based on surface characteristics

Rainfall data from Mt Douglas Station – HLA report

Pan Evaporation from Twin Hills Station 50th percentile with 0.95 correction factor

TWRD storage capacity is an estimate only (with TSF 900,000m³ and TWRD 200,000m³)

4.6 Water monitoring network and compliance framework

Schedule C of the Project EA establishes water monitoring requirements for releases, stream sediment, water storages, groundwater and the receiving environment. These monitoring requirements and associated monitoring networks/points are summarised in the following subsections.

It is noted that there are currently no personnel stationed on-site and that specialist consultants are engaged to fulfill site water monitoring requirements.

4.6.1 Release monitoring

In accordance with Condition C2-1 of the Project EA, the release of contaminants to waters is only permitted from two specified contaminant release points (MP1, MP2) which are associated with the northwest and southwest spillways of Main Pit (refer to Table 10 and Figure 13). Release water at the specified contaminant release points must meet the contaminant release limits set out in Table 10, as per Condition C2-2.

Additional monitoring during release events is required at compliance and reference points, located upstream and downstream from the contaminant release points (refer to Table 12 and Figure 13). Water quality must be monitored at these points for each water quality characteristic and at the frequency specified in Table 15, as per Condition C2-3.

It is noted that when the release contaminant trigger levels (as per Table 13) are exceeded during a release event, that additional reporting is required in accordance with Condition C2-5.

Table 10: Contaminant Release Points (Source: Table 1 from Project EA)

Release Point	Easting GDA94	Northing GDA94	Description of Release Point	Monitoring Point	Receiving Waters Description
MP1	496790	7645177	Northwest Main Pit Dam Spillway Overflow	Dam Spillway	Suttor River
MP2	497191	7644940	Southeast Main Pit Dam Spillway Overflow	Dam Spillway	Suttor River

Table 11: Contaminant Release Limits (Source: Table 2 from Project EA)

Parameter	Units	Limit type	Limit	Monitoring Frequency
pH	pH Unit	Range	6 – 9	A first flush sample at commencement of release A sample within 48 hours of the commencement of release Weekly sampling thereafter until the release ceases
EC	µS/cm	Maximum	1000 ² or 95th percentile ³ of reference, whichever is higher	
Sulfate	mg/L	Maximum	1000 ¹ or 95th percentile ³ of reference, whichever is higher	
Arsenic	mg/L	Maximum	0.5 ¹ or 95th percentile ³ of reference, whichever is higher	
Cadmium	mg/L	Maximum	0.01 ¹ or 95th percentile ³ of reference, whichever is higher	
Copper	mg/L	Maximum	0.5 ¹ or 95th percentile ³ of reference, whichever is higher	
Lead	mg/L	Maximum	0.5 ¹ or 95th percentile ³ of reference, whichever is higher	
Mercury	mg/L	Maximum	0.002 ¹ or 95th percentile ³ of reference, whichever is higher	
Molybdenum	mg/L	Maximum	0.05 ¹ or 95th percentile ³ of reference, whichever is higher	
Selenium	mg/L	Maximum	0.02 ¹ or 95th percentile ³ of reference, whichever is higher	

Parameter	Units	Limit type	Limit	Monitoring Frequency
Zinc	mg/L	Maximum	20 ¹ or 95th percentile ³ of reference, whichever is higher	

1. Measured as a total unfiltered concentration and based on ANZECC (2000) stock water quality guidelines
2. DERM Scientific services, 2009
3. Where the 95th percentile of reference is exceeded and the reference site also exceeds the value during the same event, the value of the reference for the same event applies.

Table 12: Release Monitoring Points (Source: Table 3 from Project EA)

Monitoring Point	Easting GDA94	Northing GDA94	Description of Monitoring Point
Compliance Points			
SR1	496750	7645460	Monitoring point in the Suttor River at Suttor River causeway approximately 150 meters downstream of the MP1 contaminant release point
SR2	496820	7646759	Monitoring point in the Suttor River approximately 1.7 kilometres downstream of MP1 contaminant release point
Reference Points			
SR3a	496050	7644545	Monitoring point in Suttor River upstream of the main pit on the western side
SR3b	495734	7645032	Monitoring point in the Suttor River upstream of the main pit on the western side. (Alternative monitoring point to SR3a to be used when access to SR3a is restricted due to flood waters)
SR4	498842	7645095	Monitoring point upstream of the main pit in Yandan Creek branch on the eastern side of the Suttor River

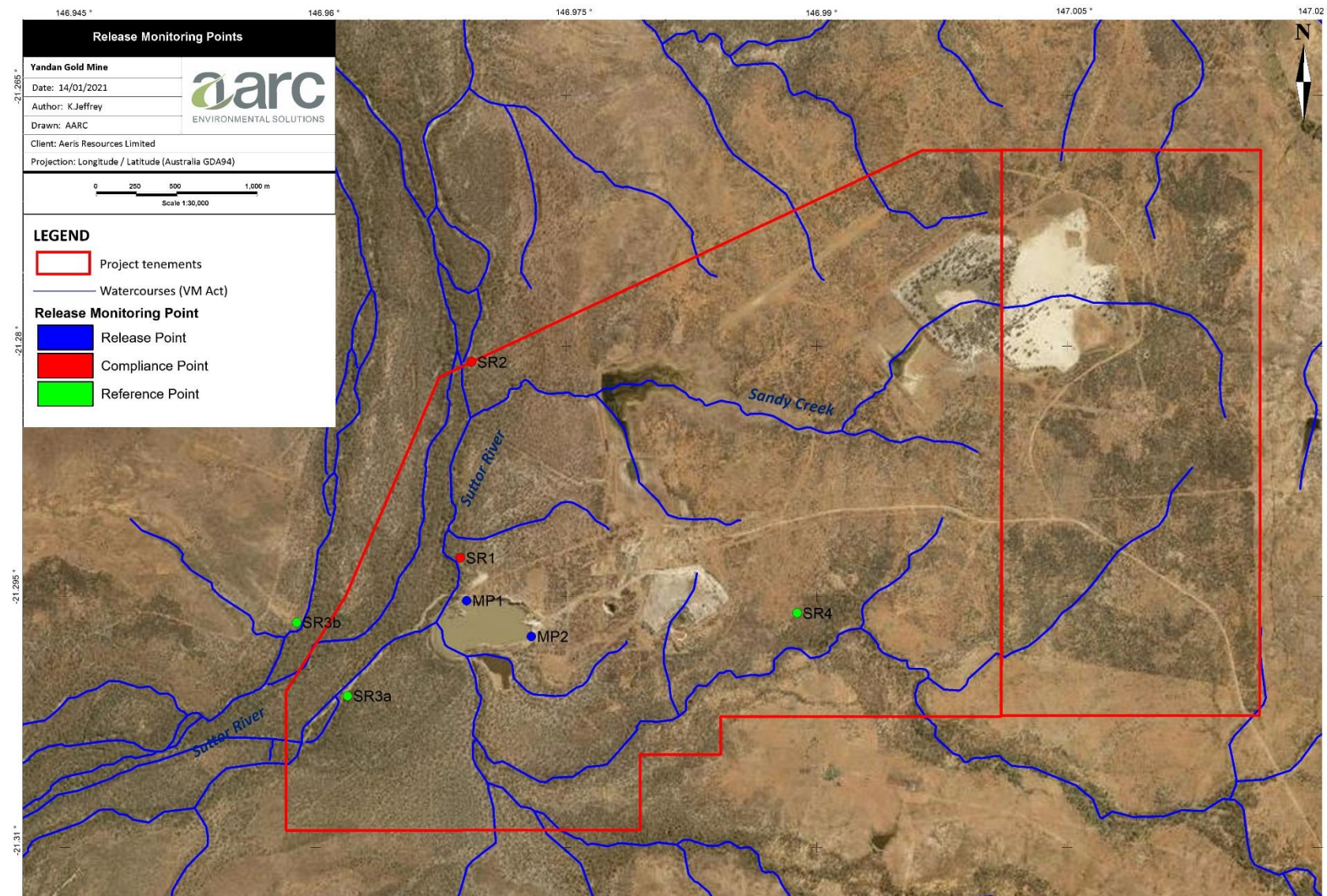


Figure 13: Location of release monitoring points

Table 13: Release Contaminant Trigger Levels (Source: Table 4 from Project EA)

Quality Characteristic	Unit	Trigger Levels	Monitoring Frequency
pH	pH Unit	20 th percentile ^{2,5} of reference or 6.0 ⁴ , whichever is lower. 80 th percentile ^{2,5} of reference or 7.5 ⁴ , whichever is higher	A first flush sample at commencement of release A sample within 48 hours of the commencement of release Weekly sampling thereafter until the release ceases
EC	µS/cm	80 th percentile ^{2,5} of reference or 250 ⁴ , whichever is higher	
Sulphate	µg/L	80 th percentile ^{2,5} of reference	
Aluminium	µg/L	80 th percentile ^{3,5} of reference or 55 ⁴ , whichever is higher	
Arsenic	µg/L	80 th percentile ^{3,5} of reference or 13 ^{4,6} , whichever is higher	
Cadmium	µg/L	80 th percentile ^{3,5} of reference or 0.2 ⁴ , whichever is higher	
Copper	µg/L	80 th percentile ^{3,5} of reference or 1.4 ⁴ , whichever is higher	
Lead	µg/L	80 th percentile ^{3,5} of reference or 3.4 ⁴ , whichever is higher	
Mercury	µg/L	80 th percentile ^{3,5} of reference or 0.6 ⁴ , whichever is higher	
Selenium	µg/L	80 th percentile ^{3,5} of reference or 11 ⁴ , whichever is higher	
Nickel	µg/L	80 th percentile ^{3,5} of reference or 11 ⁴ , whichever is higher	
Zinc	µg/L	80 th percentile ^{3,5} of reference or 8 ⁴ , whichever is higher	
Hardness	mg/L	N/A	

1. All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered). Trigger levels for metal/metalloids apply if dissolved results exceed trigger.
2. An interim trigger value can be derived from ≥ 8 but ≤ 17 consecutive reference site samples, derived using the methodology described in the Queensland Water Quality Guidelines (2009).
3. For toxicants, trigger values are based on the 80th percentile of at least 10 and no more than 24 consecutive reference site samples, derived using the methodology described in the Queensland Water Quality Guidelines (2009).
4. Default trigger values from ANZECC (2000) 20th, 80th and 95th percentiles are calculating using ANZECC (2000) methodology (Section 7.4.4.1)
5. If arsenic (soluble) exceeds 13 µg/L then speciation to As(III) and As(V) must be conducted. The As(III) and As(V) levels must not exceed the 80th percentile of reference site samples or the respective trigger level: As(III) – 24 µg/L; As(V) - 13 µg/L
6. Hardness may be used to adjust trigger value for some metal toxicants. Hardness is defined as the sum of Calcium (Ca) and Magnesium (Mg) concentrations expresses as Calcium Carbonate (CaCO₃) in milligrams per litre (mg/L)

4.6.2 Water storage monitoring

In accordance with Condition C3-1 of the Project EA, a number of on-site water storage facilities must be monitored quarterly (refer to Table 14) for the water quality characteristics specified in Table 15. Water storages requiring monitoring are shown through Figure 11.

Water storage monitoring is required to determine the suitability of the water for livestock, with these water storages generally accessible to cattle onsite. In the event that contaminant limits are exceeded in these water storages, the EA holder is required to implement measures that prevent livestock access (as practicable) (as per Condition C3-2).

Water storage monitoring is currently undertaken quarterly by Northern Groundwater Solutions Pty Ltd, with field monitoring results and laboratory results provided to AARC for archival and reporting purposes.

Table 14: Water Storage Monitoring (Source: Table 5 from Project EA)

Water Storage Description	Monitoring Location	Easting GDA94	Northing GDA94	Frequency of Monitoring
Heap Leach Stormwater Pond	HLSP1	498141	7644897	Quarterly
East Hill Pit	EHP1	497674	7645142	
Mine Water Dam	MW1	497777	7646120	
Water Storage Dam	WS1	497612	7646474	
Tailings Return Dam	TRD1	499461	7646637	

Table 15: Onsite Water Storage Contaminant Limits (Source: Table 6 from Project EA)

Quality Characteristic	Test Value	Contaminant Limit ³
pH (pH Unit)	Range	Greater than 4, less than 9 ²
EC (µS/cm)	Maximum	5970 ¹
Sulphate (mg/L)	Maximum	1000 ¹
Aluminium (mg/L)	Maximum	5 ¹
Arsenic (mg/L)	Maximum	0.5 ¹
Cadmium (mg/L)	Maximum	0.01 ¹
Copper (mg/L)	Maximum	1 ¹
Lead (mg/L)	Maximum	0.1 ¹
Nickel (mg/L)	Maximum	1 ¹
Zinc (mg/L)	Maximum	20 ¹
WAD Cyanide (mg/L)	Maximum	50 ⁴

Notes:

¹Contaminant limit based on ANZECC & ARMCANZ (2000) stock water quality guidelines.²Page 4.2-15 of ANZECC & ARMCANZ (2000) "Soil and animal health will not generally be affected by water with pH in range of 4-9".³Total measurements (unfiltered) must be taken and analysed.⁴International Cyanide Management Code For the Manufacture, Transport, and Use of Cyanide In the Production of Gold

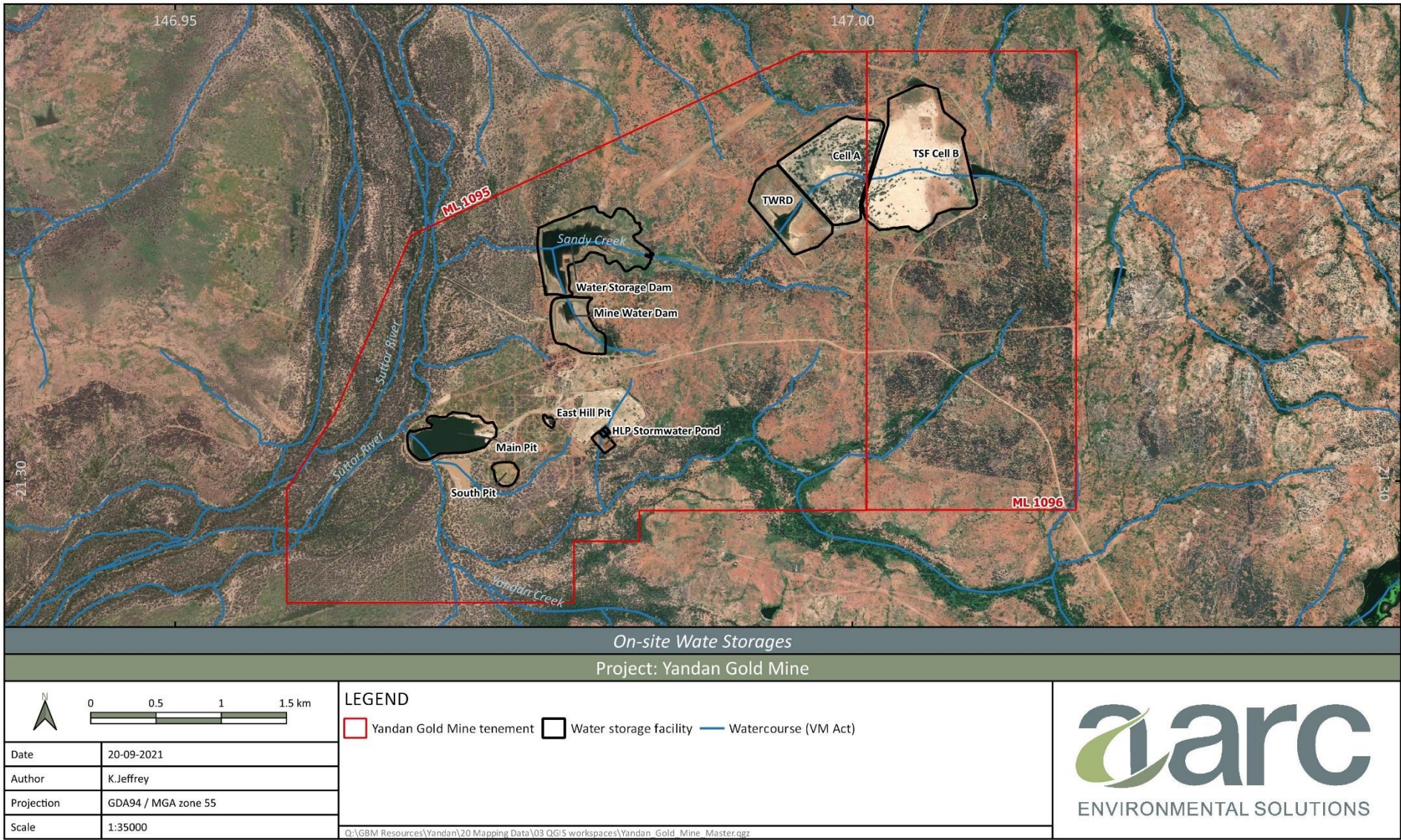


Figure 14: Water storages on the Project site

4.6.3 Main Pit water cover

The Project EA requires a permanent water cover to be maintained in Main Pit. In accordance with Conditions C4-1 and C4-2, quarterly water depth and water quality monitoring is required. It is noted that this monitoring is undertaken for due diligence purposes only, with no water quality criteria specified in the Project EA. Parameters and the relevant depth intervals required for Main Pit sampling are detailed in Table 16.

Main Pit water cover monitoring is currently undertaken quarterly by Northern Groundwater Solutions Pty Ltd, with field monitoring results and laboratory results provided to AARC for archival and reporting purposes. Water samples are collected from two locations within the Main Pit (accessed *via* boat) using a Van Dorn water sampler, with samples collected at 5 m depth intervals.

Table 16: Main pit water quality parameters (Source: Table 7 from Project EA)

Parameter	Units	Depth intervals
pH		5m and 10m
Temperature	°C	5m and 10m
Electrical Conductivity	µS/cm	5m and 10m
Salinity	Ppm	5m and 10m
Dissolved Oxygen	DO	5m and 10m
Oxidation Reduction Potential	mV/Eh	5m and 10m
Total Dissolved Solids	mg/L	10m
Sulfate	mg/L	10m
Arsenic	mg/L	10m
Cadmium	mg/L	10m
Copper	mg/L	10m
Lead	mg/L	10m
Mercury	mg/L	10m
Molybdenum	mg/L	10m
Selenium	mg/L	10m
Zinc	mg/L	10m

4.6.4 Stream sediment

Conditions C5-1 to C5-5 of the Project EA establishes stream sediment monitoring and management requirements. In accordance with Condition C5-2, stream sediment quality must be undertaken biannually (once at the end of the wet season and once at the end of the dry season) at the monitoring points listed in Table 17 (note these points correspond with the release monitoring points). Stream sediment quality must be monitored for the parameters listed in Table 18.

It is noted that when the stream sediment trigger levels (as per Table 18) are exceeded, that additional reporting is required in accordance with Condition C5-3.

Stream sediment monitoring is conducted biannually, concurrent with the quarterly water storage monitoring. This monitoring is currently undertaken by Northern Groundwater Solutions Pty Ltd, with field monitoring results and laboratory results provided to AARC for archival and reporting purposes.

Table 17: Sediment Monitoring Points (Source: Table 8 from Project EA)

Monitoring Point	Easting GDA94	Northing GDA94	Description of Monitoring Point
Compliance Points			
SR1	496750	7645460	Suttor River downstream sediment sampling location at Suttor River causeway approximately 150 meters downstream of the MP1 contaminant release point
SR2	496820	7646759	Northern boundary sediment sampling location located in the Suttor River approximately 1.7 km downstream of the MP1 contaminant release point
Reference Points			
SR3	496050	7644545	Monitoring point in Suttor River upstream of the main pit on the western side
SR4	498842	7645095	Monitoring point upstream of the main pit in Yandan Creek branch on the eastern side of the Suttor River

Table 18: Stream Sediment Trigger and Contaminant Levels (Source: Table 9 from Project EA)

Parameter	Unit	Contaminant Limit	Trigger Level
Antimony	mg/kg	25 ³ or 3 times the reference value	Reference value ¹ or 2 ² , whichever value is higher.
Arsenic	mg/kg	70 ³ or 3 times the reference value	Reference value ¹ or 20 ² , whichever value is higher.
Cadmium	mg/kg	10 ³ or 3 times the reference value	Reference value ¹ or 1.5 ² , whichever value is higher.
Chromium	mg/kg	370 ³ or 3 times the reference value	Reference value ¹ or 80 ² , whichever value is higher.
Copper	mg/kg	270 ³ or 3 times the reference value	Reference ¹ or 65 ² , whichever value is higher.
Lead	mg/kg	220 ³ or 3 times the reference value	Reference value ¹ or 50 ² , whichever value is higher.
Mercury	mg/kg	1 ³ or 3 times the reference value	Reference value ¹ or 0.15 ² , whichever value is higher.
Nickel	mg/kg	52 ³ or 3 times the reference value	Reference value ¹ or 21 ² , whichever value is higher.
Zinc	mg/kg	410 ³ or 3 times the reference value	Reference value ¹ or 200 ² , whichever value is higher.
Particle size distribution for interpretation purposes	N/A	N/A	N/A

- 1 Reference sites are the upstream sediment monitoring sites defined in Schedule C – Table 8 (Sediment Monitoring Points)
- 2 ANZECC (2000) Interim Sediment Quality Guidelines – low values based on total sediments
- 3 ANZECC (2000) Interim Sediment Quality Guidelines – high values based on total sediments

4.6.5 Groundwater monitoring

Groundwater monitoring is required across the Project site at the locations specified in Table 19. Groundwater monitoring must consist of level measurements and the quality characteristics detailed in Table 20. In the event that the trigger levels are exceeded, additional monitoring is required in accordance with Condition C7-3.

It is noted that the existing groundwater monitoring network differs from the Project EA coordinates, and that additional monitoring bores have been added to this network for due diligence purposes. Groundwater bores TD6 and TD7 are no longer monitored, with TD6 destroyed and TD7 blocked at 0.92 m below the measuring point (RLA 2019). Additional monitoring bores have been established around the Water Storage Dam (i.e. WSB1 and WSB2). The full monitoring network is detailed in Table 21 and shown through Figure 15.

It is noted that when groundwater quality parameters (as per Table 20) are exceeded at the EA monitoring locations, that additional reporting is required in accordance with Condition C7-3.

Groundwater monitoring is currently undertaken quarterly by Northern Groundwater Solutions Pty Ltd, with field monitoring results and laboratory results provided to AARC for archival and reporting purposes.

Table 19: Groundwater monitoring locations and frequency (Source: Table 10 from Project EA)

Monitoring Point	Easting (GDA94)	Northing (GDA94)	Surface RL ¹ (m)	Monitoring Frequency
Compliance Bores				
Yandan – Tailings Dam (TD) South Bore 3	499333	7646724	To be advised ³	Quarterly
Yandan – TD West Bore 4	499616	7647434	To be advised ³	Quarterly
Yandan – TD North Bore 5	500548	7647882	To be advised ³	Quarterly
Yandan – TD East Bore 6	500941	7647110	To be advised ³	Quarterly
Yandan – TD South Bore 7	499440	7646580	To be advised ³	Quarterly
Yandan – South Hill pit bore 3	497420	7644570	To be advised ³	Quarterly
Yandan – Heap Leach west bore 1	498094	7644870	To be advised ³	Quarterly
Yandan – Heap Leach west bore 3	498284	7644837	To be advised ³	Quarterly
Yandan – Heap Leach west bore 4	497913	7644964	To be advised ³	Quarterly
Yandan – Heap Leach west bore 5	498308	7645064	To be advised ³	Quarterly
Yandan – Heap Leach west bore 6	498321	7645358	To be advised ³	Quarterly
Yandan – Heap Leach west bore 7	498144	7645427	To be advised ³	Quarterly
Reference Bores ²				
To be determined within 12 months of the date of approval of this licence, in accordance with condition C7-1				

¹ RL measurement to be taken from top of bore casing and measured to nearest 0.05m

² Reference sites must:

- (a) be from the same bio-geographic and climatic region; and
- (b) have similar geology, soil types and topography; and
- (c) not be so close to the test sites that any disturbance at the test site also results in a change at the reference site

³ within three months of the date of approval of this environmental authority

Table 20: Groundwater Contaminant and Trigger Limits (Source: Table 11 from Project EA)

Parameter	Units	Limit type	Contaminant limit	Trigger Level
pH		Range	6 – 8.5 ³	6.0 – 7.5
Sulfate	mg/L	Maximum	1000 ⁵	The 80% percentile of the background reference
Arsenic	mg/L	Maximum	0.5 ¹	0.013 ^{2,4} or the 80% percentile of the background reference
Cadmium	mg/L	Maximum	0.5 ¹	0.0002 ⁴ or the 80% percentile of the background reference
Copper	mg/L	Maximum	0.5 ¹	0.0014 ⁴ or the 80% percentile of the background
Lead	mg/L	Maximum	0.1 ¹	0.0034 ⁴ or the 80% percentile of the background
Mercury	mg/L	Maximum	0.1 ¹	0.0006 ⁴ or the 80% percentile of the background
Molybdenum	mg/L	Maximum	0.05 ¹	The 80% percentile of the background reference
Selenium	mg/L	Maximum	0.02 ¹	0.0011 ⁴ or the 80% percentile of the background
Zinc	mg/L	Maximum	20 ¹	0.008 ⁴ or the 80% percentile of the background
WAD Cyanide	mg/L	Maximum	0.2	0.007 ⁴ or the 80% percentile of the background

1. All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered).
2. If arsenic (soluble) exceeds 13ug/L then speciation to As(III) and As(V) must be conducted. The As(III) and As(V) levels must not exceed the 80th percentile of reference site samples or the respective trigger level: As(III) – 24 ug/L; As(V) – 13 ug/L.
3. Based on ANZECC (2000) primary industries guidelines
4. Default trigger values from ANZECC 2000 for aquatic ecosystems
5. Based on ANZECC (2000) Livestock Drinking Water Guidelines

Table 21: Existing groundwater monitoring bore locations

Groundwater bore	Easting (MGA94)	Northing (MGA94)
HL1	498094	7644870
HL3	498284	7644837
HL4	497913	7644964
HL5	498358	7645103
HL6	498321	7645358
HL7	498144	7645427
SH3	497420	7644570
TD3	499333	7646724
TD4	499616	7647434
TD5	500548	7647882
WSB1	497597	7646463
WSB2	497587	7646598
RB1S	500400	7645740
RB1D	500400	7645740
RB2S	498940	7646310
RB2D	498940	7646310
TD7D	499436	7646581
TD7S	499436	7646581
TD6D	501010	7647150
TD6S	501010	7647150

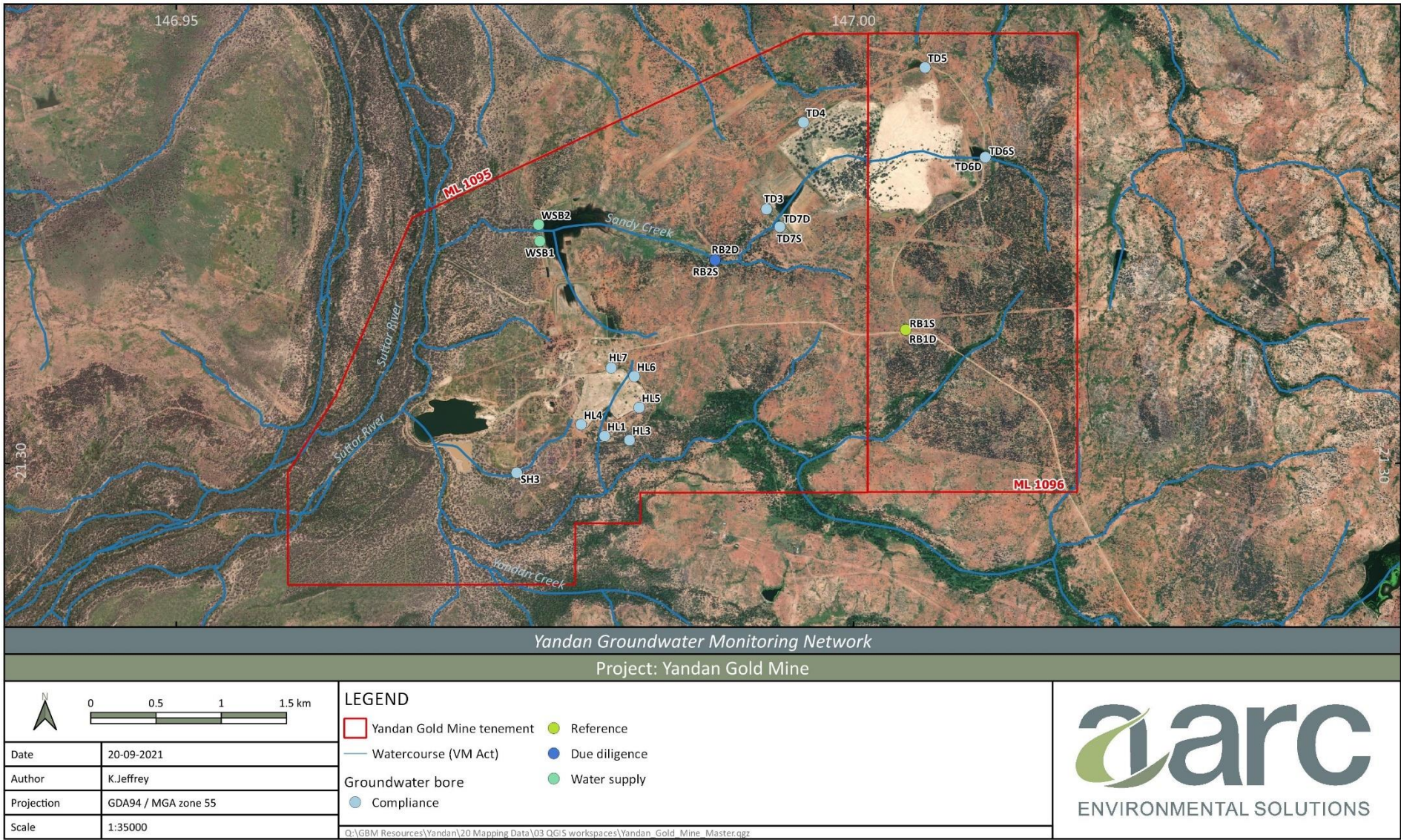


Figure 15: Groundwater monitoring locations

4.6.6 Receiving environment monitoring

In accordance with the Project EA (Conditions C8-1 to C8-2) a receiving environment monitoring program (REMP) is required for monitoring and recording the effects from releases and discharges to the receiving environment. Relevant monitoring for this program includes surface water quality, stream flow, stream sediment quality, riparian vegetation condition, aquatic macroinvertebrate bioindicators and other physical assessment parameters (e.g. bank slope and shape). The specific monitoring requirements of this program are set out in the REMP design document (AARC 2019) and are not considered further within this WMP.

Annual REMP monitoring and reporting is undertaken by AARC personnel.

4.6.7 Annual Reporting Requirements

In addition to the above monitoring requirements, the Project EA establishes annual reports that must be provided to the administering authority.

Annual groundwater monitoring report

An annual groundwater monitoring report must be prepared in accordance with condition C7-6:

Annual groundwater monitoring reports analysing groundwater chemistry and hydro-geological status of all groundwater bores and groundwater conditions must be prepared and submitted to the administering authority with each annual return.

Annual water monitoring reporting

All water monitoring activities (release water, stream sediment, water storages, groundwater, receiving environment) are required to record and annually submit relevant information to the administering authority, as per condition C9-1:

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 with each annual return:

- (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 the contaminants 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 with 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.*

4.7 Emergency and contingency planning

Effective water management is supported by risk planning for various scenarios, including those triggered by significant rainfall events and flooding. Potential scenarios relate to the failure of water storage infrastructure, water quality non-compliances and uncontrolled discharge from on-site water storages. In the event of these scenarios occurring or potentially occurring, appropriate preventative and action responses would be implemented (as per Table 22).

The potential for uncontrolled discharge from on-site water storages is relevant for the Heap Leach Stormwater Pond and Water Storage Dam. To prevent potential releases from the Heap Leach Stormwater Pond and Water Storage Dam, preventative and triggered action responses are listed below.

In addition to routine environmental monitoring undertaken on the Project by specialised consultants (e.g. EA water monitoring, annual regulatory structure inspections, REMP monitoring, etc) some monitoring (e.g. monitoring of Suttor River heights, inflows to Main Pit) is also undertaken by Straits Gold personnel stationed on-site.

Table 22: Significant event triggers, prevention and action responses

Event	Trigger	Prevention and action response
Monitoring results exceed EA compliance limits	Monitoring results exceed EA compliance limits relevant to releases, water storages, Main Pit or groundwater.	- Immediately resample the relevant monitoring point, collecting two additional samples (as practicable). - If further sampling confirms non-compliance, undertake necessary investigations (e.g. as per C2-5, or C7-3) and mitigation measures (C3-2). - Report non-compliance to the regulatory authority within 24 hours, pursuant to Condition A7-2 of the Project EA. - Following any required investigations, report the findings to the regulatory authority within 10 business days, pursuant to Condition A7-6 of the Project EA.
Uncontrolled discharge from Water Storage Dam	Water Storage Dam overflows flood levee or breach of facility	- Annual regulatory structure monitoring to inform on facility condition. - Capacity observations to be made during the quarterly water storage monitoring. - If an uncontrolled release occurs, sample Water Storage Dam water and release water. Report incident to the regulatory authority pursuant to Condition A7-1 of the Project EA.
Uncontrolled discharge from Heap Leach Stormwater Pond	Heap Leach Stormwater Pond unable to hold design capacity or breach of facility	- Annual regulatory structure monitoring to inform on facility condition. - Capacity observations during the quarterly water storage monitoring. - Water pipeline has been installed to pump water to the Mine Water Dam as required. - In the event of a potential trigger, water from the Heap Leach Stormwater Pond will be pumped to the Mine Water Dam for evaporation. - Sufficient diesel will be stored on-site to ensure pump availability is maintained. - If an uncontrolled release occurs, sample Heap Leach Stormwater Pond water and release water. Report incident to the regulatory authority pursuant to Condition A7-1 of the Project EA.

Event	Trigger	Prevention and action response
Discharge from Main Pit	- Suttor River water levels exceed the 3.8 m spillway height, permitting inflow into Main Pit. Discharge from Main Pit anticipated from the NW spillway once Main Pit reaches capacity. - The Project EA (condition C2-2) requires that a first flush sample is collected upon commencement of release, within 48 hours of commencement of release, and weekly thereafter until release ceases.	- Straits Gold environmental personnel will monitor the Suttor River water level <i>via</i> the St Ann's gauging station, located approximately 11 km downstream from site. Discharge from Main Pit is considered likely when the Suttor River water level exceeds 3.8 m. - Straits Gold environmental personnel will ensure that the helicopter (owned by a local landholder) is available at short notice for monitoring and sampling any potential discharge from Main Pit (for the within 48 hours of commencement of release and weekly sampling events). It is noted that due to limited personnel on site and helicopter-only access during significant rainfall events, that collection of the first flush sample is unlikely to be practicable. - If an exceedance during release monitoring occurs, report to the regulatory authority pursuant to Condition A7-1 of the Project EA.
Dam embankment or spillway failure	Loss of dam embankment or spillway integrity	- Annual regulatory structure inspections to inform on structural integrity of dam embankments and spillways. - Completion of maintenance activities recommended by the annual regulatory structure inspection, pursuant to Condition G5-6 of the Project EA. - In the event of a potential trigger, completion of any additional maintenance required.

4.7.1 Notification of emergencies, incidents and uncontrolled releases

In the event of a non-compliant water monitoring result or an uncontrolled release it is a requirement that the administering authority is notified as per Conditions A7-1 – A7-2:

(A7-1) The holder of this environmental authority must notify the administering authority by telephone and email promptly but within twenty-four (24) hours, after becoming aware of any emergency, incident or release 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.

(A7-2) The holder of this environmental authority must notify the administering authority by telephone, email or facsimile as soon as practicable but within forty-eight (48) hours, after becoming aware of any monitoring result that demonstrates an exceedance of any approval limit

Notifications made to the administering authority must be consistent with Condition A7-3:

(A7-3) The notification must include, but not be limited to, the following:

- (a) The environmental authority number and name of the holder;*
- (b) The name and telephone number of the designated contact person;*
- (c) The location of the emergency, incident or release;*

- (d) The date and time of the emergency, incident or release;*
- (e) The time the holder of the environmental authority became aware of the emergency, incident or release;*
- (f) The estimated quantity and type of substances involved in the emergency, incident or release;*
- (g) The actual or potential cause of the emergency, incident or release;*
- (h) A description of the nature and effects of the emergency, incident or release including environmental risks, and any risks to environmental values;*
- (i) Any sampling conducted or proposed, relevant to the emergency, incident or release;*
- (j) Immediate actions taken to prevent or mitigate any further environmental harm caused by the emergency, incident or release; and*
- (k) What notification of stakeholders who may be affected by the emergency, incident or release has occurred/is being undertaken.*

Follow-up reporting is required following the initial notification of the event, as per Condition A7-6:

(A7-6) Within ten (10) business days following the initial notification of an emergency, incident or release, 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, incident or release.*

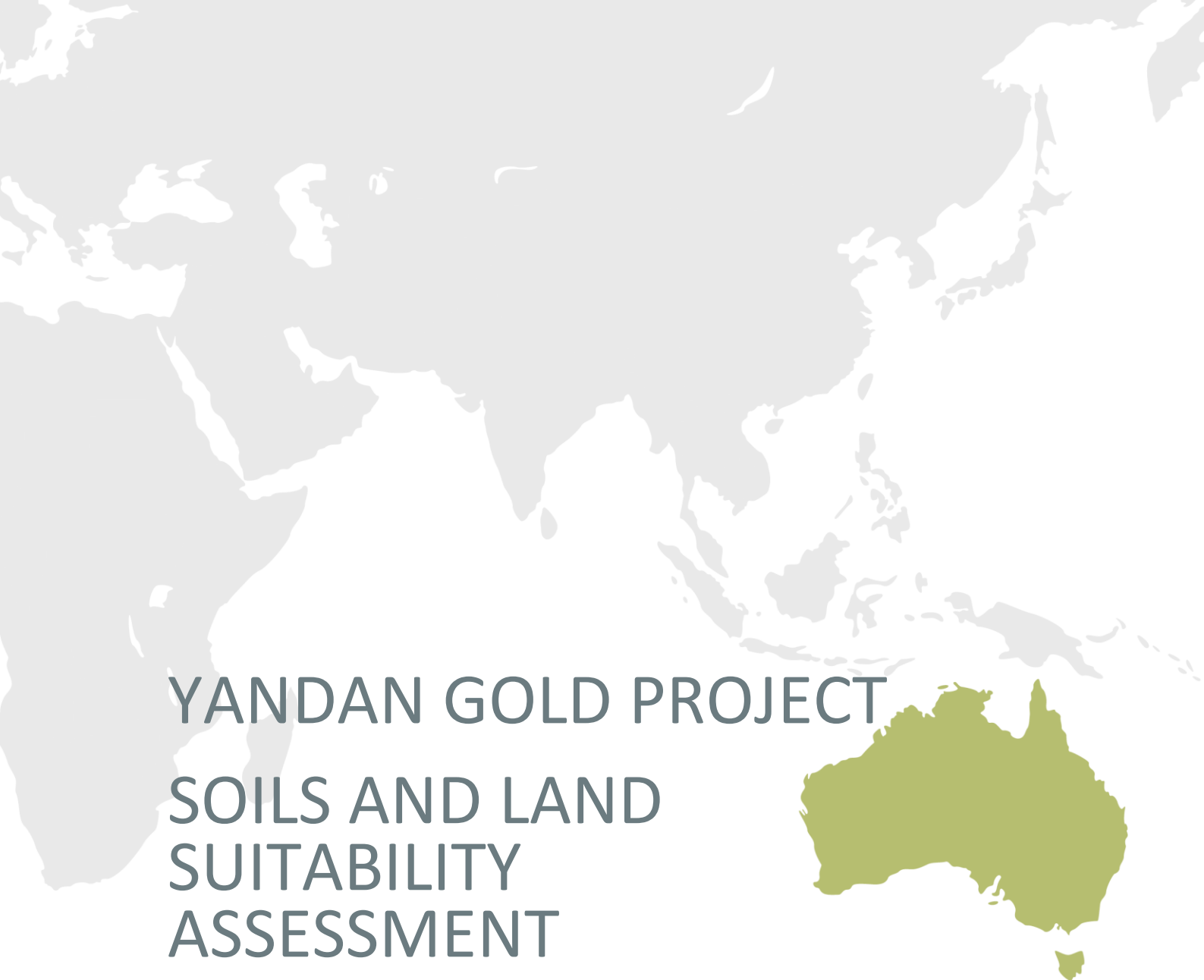
Relevant stakeholders (e.g. local landholders or downstream water users) with the potential to be impacted by any emergency, incident or release must also be notified immediately upon becoming aware of the event, as per Conditions A7-4 and A7-5.

5 Review

In accordance with the requirements of Condition C10-3 of the Project EA, the WMP will be reviewed biannually. These reviews will be undertaken prior to the wet season (01 November) and post wet season (01 May) to ensure that proper and effective measures, practices and / or procedures are in place to ensure compliance with the Project EA.

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YANDAN GOLD PROJECT SOILS AND LAND SUITABILITY ASSESSMENT

PREPARED FOR
STRAITS GOLD PTY LTD

19 MARCH 2022

Document Control

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Report Title:	Soil and Land Suitability Assessment
Client:	Straits Gold Pty Ltd
Project Manager:	Gareth Bramston

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Table of Abbreviations

AARC	AARC Environmental Solutions Pty Ltd
ASC	Australian soil classification
BoM	Bureau of Meteorology
CEC	Cation exchange capacity
DIWA	Directory of Important Wetlands in Australia
EA	Environmental authority
EC	Electrical conductivity
ESP	Exchangeable sodium percentage
HLP	Heap leach pad
ML	Mining lease
PAWC	Plant available water capacity
PMLU	Post mining land use
SLSA	Soil and Land Suitability Assessment
SMU	Soil management units
TSF	Tailings storage facility

1 Introduction

AARC Environmental Solutions Pty Ltd (AARC) was commissioned by Straits Gold Pty Ltd (Straits Gold) to conduct a Soil and Land Suitability Assessment (SLSA) on the Yandan Gold Project (the Project). The Project is authorised by Environmental Authority (EA) EPML00771913. The EA encompasses mining lease (ML) 1095 and ML 1096.

This SLSA documents the nature and distribution of major soil types in the study area and assesses their suitability for the land use of cattle grazing. This assessment establishes reference environmental characteristics and values relating to land use and suitability and provides recommendations for the management of soil resources within the Project area.

1.1 Objectives

This report provides an assessment of the soils and land suitability of the study area and includes the following objectives:

- Describe and map soil management units (SMUs) within the Project area, focusing on the area mapped as 'Oc27' (hard pedal red duplex soils), according to the *Australian Soil and Land Survey Field Handbook* (National Committee on Soil and Terrain 2009), *Guidelines for Surveying Soil and Land Resources* (McKenzie et. al. 2008) and *Australian Soil Classification* (Isbell and National Committee on Soil and Terrain 2021). This area contains the majority of the Project's infrastructure and has been indicated as relevant to future development.
- Describe and map land suitability classes of the survey area in accordance with *The Technical Guidelines for Environmental Management of Exploration and Mining in Queensland – Land Suitability Assessment Techniques* (State of Queensland 1995), *The Guidelines for Agricultural Land Evaluation in Queensland – Second Edition* (DSITI and DNRM 2015) and *The Regional Land Suitability Frameworks for Queensland* (State of Queensland 2013).
- Identify soils that require specialised management due to soil characteristics (e.g. erosivity and salinity), and soils that have a predisposition to land stability issues.
- Review the potential requirement for soil ameliorants and fertilisers, based on the results of the soil laboratory analyses and existing reporting.
- Review the suitability of soil sources for the post mining land use (PMLU) and rehabilitation methodology.
- Develop a material balance for the site, to identify:
 - the quality of available resources for rehabilitation use; and
 - the location and accessibility of cover materials for rehabilitation use.

2 Project background

The Project is situated in the Drummond Basin, central Queensland, located approximately 50 km to the west of the township of Mount Coolon and approximately 150 km southeast of Charters Towers (Figure 1). The Project falls on the boundary of the Whitsunday Regional Council and Charters Tower Regional Council local government areas.

The Impact Assessment Study for approval of the Project was submitted in December 1988, with ML1095 and ML1096 granted in June 1991. In July 1992, and in addition to the Wirralie Gold Mine, Ross Mining N.L. acquired the Project, a controlling interest in the Mount Coolon joint venture and exploration tenements associated with the three assets.

Ross Mining N.L. operated the Project between 1993–2002, producing over 350,000 ounces of gold from heap leach operations and a carbon in leach process plant. Mining operations ceased in 1998, with the heap leach pad remaining operational until September 2002. The site was placed into care and maintenance in April 1999, pending final closure works. The gold processing plant was later removed in 2006/2007, prior to the acquisition of the Project by Straits Gold, at the time a wholly owned subsidiary of Aeris Resources Ltd. The Project has remained in care and maintenance since closure in 1999.

GBM Resources acquired the Project and the Straits Gold entity on 13 January 2020 and have since taken significant steps towards restoring operations. This has included the 2021 drilling program, which focused on the identification of potential open pit targets in the area between the existing Main Pit and East Hill deposits.

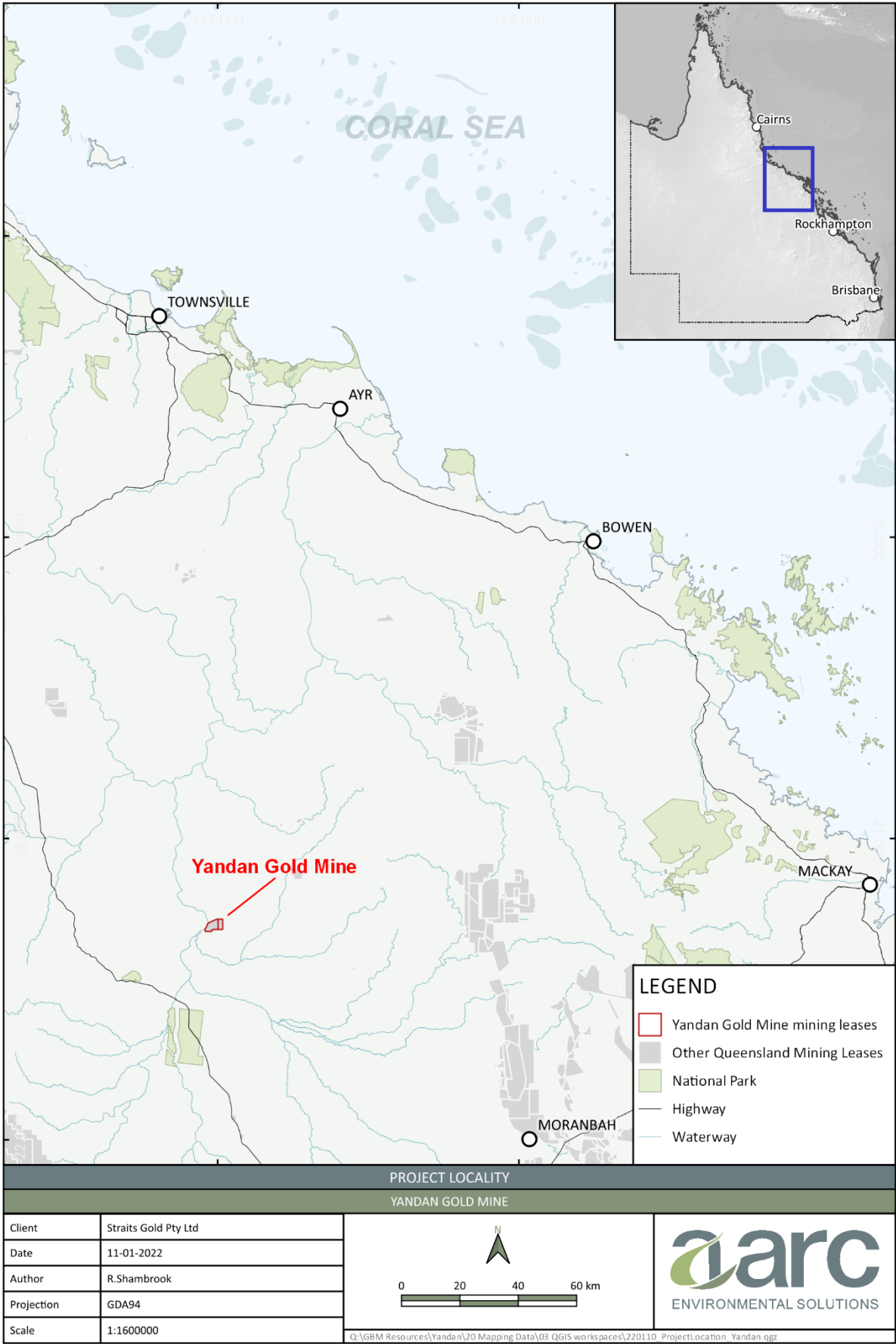


Figure 1: Project locality

2.1 Local topography and waterways

The Yandan Gold Project is situated within the Burdekin Drainage Basin and the Suttor River drainage sub-basin. The Suttor River is located on the western boundary of the Project within ML 1095, with a number of minor ephemeral tributaries running across the Project site (Figure 1). The relief at the Project site is about 30 m above sea level, elsewhere locally the undulating terrain has much less relief – approximately 5-10 m. The land rises gently away from the Suttor River towards the east. The highest elevation in the area is 212 m approximately 2 km north of the site.

The Suttor River is a braided stream occupying a broad depression. The Suttor River drainage sub-basin spans an area of approximately 74,000 km². The Suttor River flows south to north into two nationally important wetlands, as identified in the *Directory of Important Wetlands in Australia* (DIWA) (DAWE 2019). These DIWA wetlands include Lake Dalrymple and the Scartwater Aggregate. Lake Dalrymple was historically formed from the damming of the Burdekin River, which is located further upstream (HLA - Envirosciences 2000).

Stream flow in the rivers and tributaries of the Suttor River Sub-basin are dependent on the frequency and intensity of rainfall events within the catchment. Periods of flow are directly related to large rainfall events in the catchment, which is typical of ephemeral systems.

A number of ephemeral drainage lines intersect the Project area, being associated with Sandy Creek in the north, and Yandan Creek in the south (Figure 2). Both waterways drain to the Suttor River.

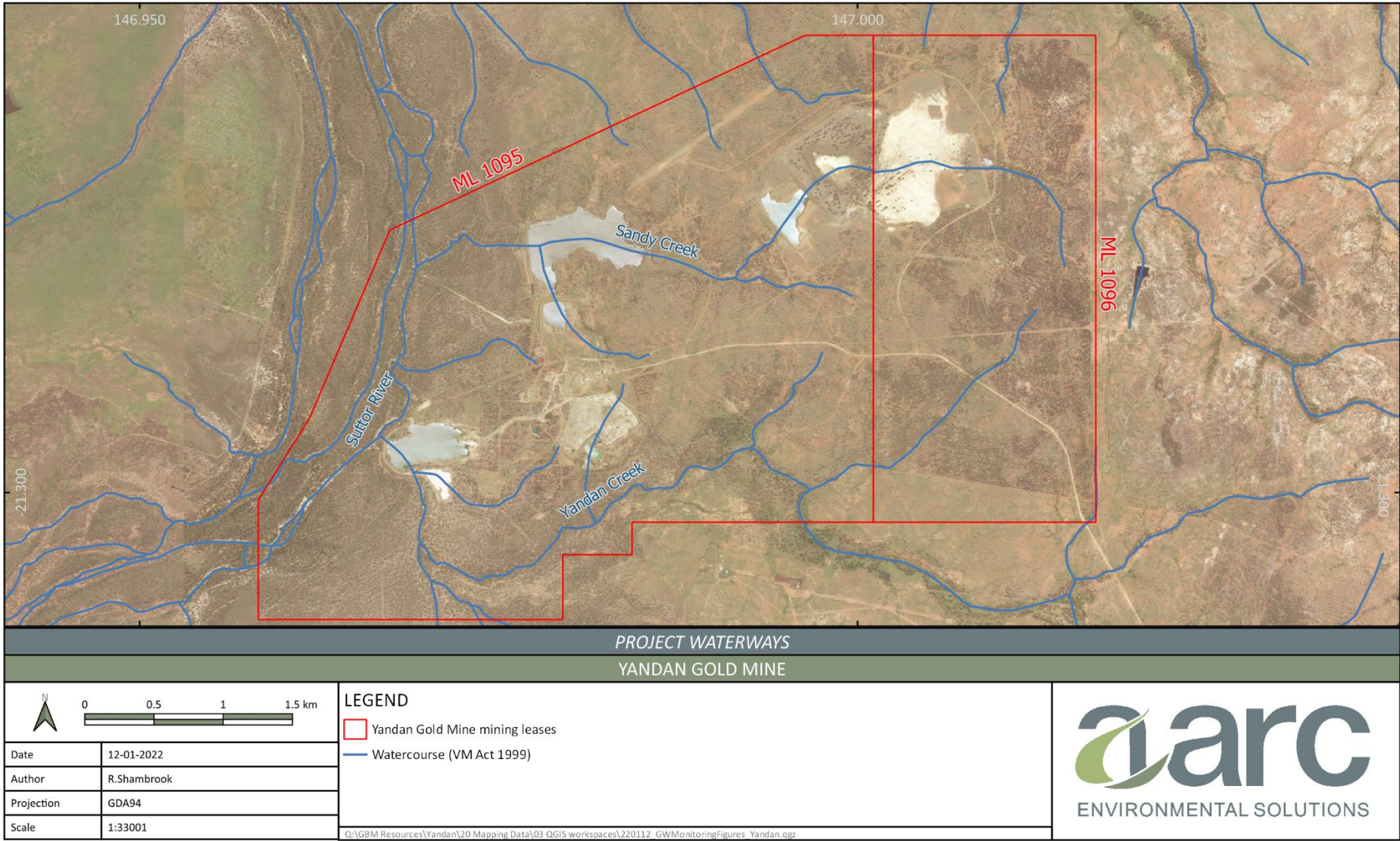


Figure 2: Yandan surface drainage system

2.2 Regional geology

The Yandan Gold Project is located on the eastern margin of the western arm of the Drummond Basin, a geological basin comprised of Middle Devonian to Early Carboniferous sedimentary and volcanic rocks (Straits n.d.). The Project area is proximal to the Anakie Inlier, a north-trending basement block of greenschist facies metavolcanic and metasedimentary rocks of Lower Cambrian age (de Caritat & Braun 1992).

The host geology underlying the Project is comprised of basement Anakie Inlier Les Jumelles metasediments, unconformably overlain by Middle Devonian Ukalunda Beds, which in turn are unconformably overlain by the St Anne's Formation of the Middle Devonian to Early Carboniferous Drummond Basin Sequence (Straits n.d.). On the western side of the tenement, parts of the Project have been unconformably overlain by fluvial deposits of the Scartwater Formation and Mount Hall Formation (Straits n.d.). The general composition of the three main geological units is summarised as follows.

Basement geology

The basement Les Jumelles metasediments are metamorphosed quartz-muscovite sandstones and siltstones (Townend 2005, within Straits n.d) and chloritic black shale. Also, within the basement geology, the Ukalunda Formation sediments are various interbedded massive and bedded lithologies containing quartzose, calcareous and carbonaceous sandstones, siltstones and mudstones (Straits n.d.).

Lower St Anne's Formation

The Lower St Anne's Formation generally consists of three lithologies: andesite flows, andesite clastics and polyolithic volcanic breccia (Straits n.d.). Overlying this are primarily feldspar-lithic sandstone and siltstone (Yandan Host), formed through weathering and erosion of the Yandan Andesite. Calcareous sandstone and Yandan Limestone is the youngest unit in the local stratigraphy, overlying parts of the Yandan Host in Main Pit (Straits n.d.).

Gold mineralisation on the Project has been substantially mined out, with the East Hill area containing the most encouraging remaining mineralisation (Straits n.d.). Three phases of gold mineralised silica have been identified within the East Hill area, including crustiform banded veining which commonly suggests high-grade gold mineralisation (Straits n.d.).

Surface geology

Tertiary and Quaternary sediments cover much of the Project area. In the south and east, the surface geology is predominantly Tertiary Suttor Formation comprised of lateralised sandstone, mudstone, claystone, oil shale, diatomite and carbonaceous claystone (Hutton *et al.* 1991). Channels incise the Suttor Formation and contain Quaternary alluvial channels that drain to flood plains (Straits n.d.). Quaternary alluvium covers much of the underlying Drummond Basin Sequence on the Project, with the depth of this stratum increasing towards major drainage lines (i.e. Suttor River, Rosetta Creek, Belyando River) (Straits n.d.).

Geological units and structures on the Project are shown through Figure 3.

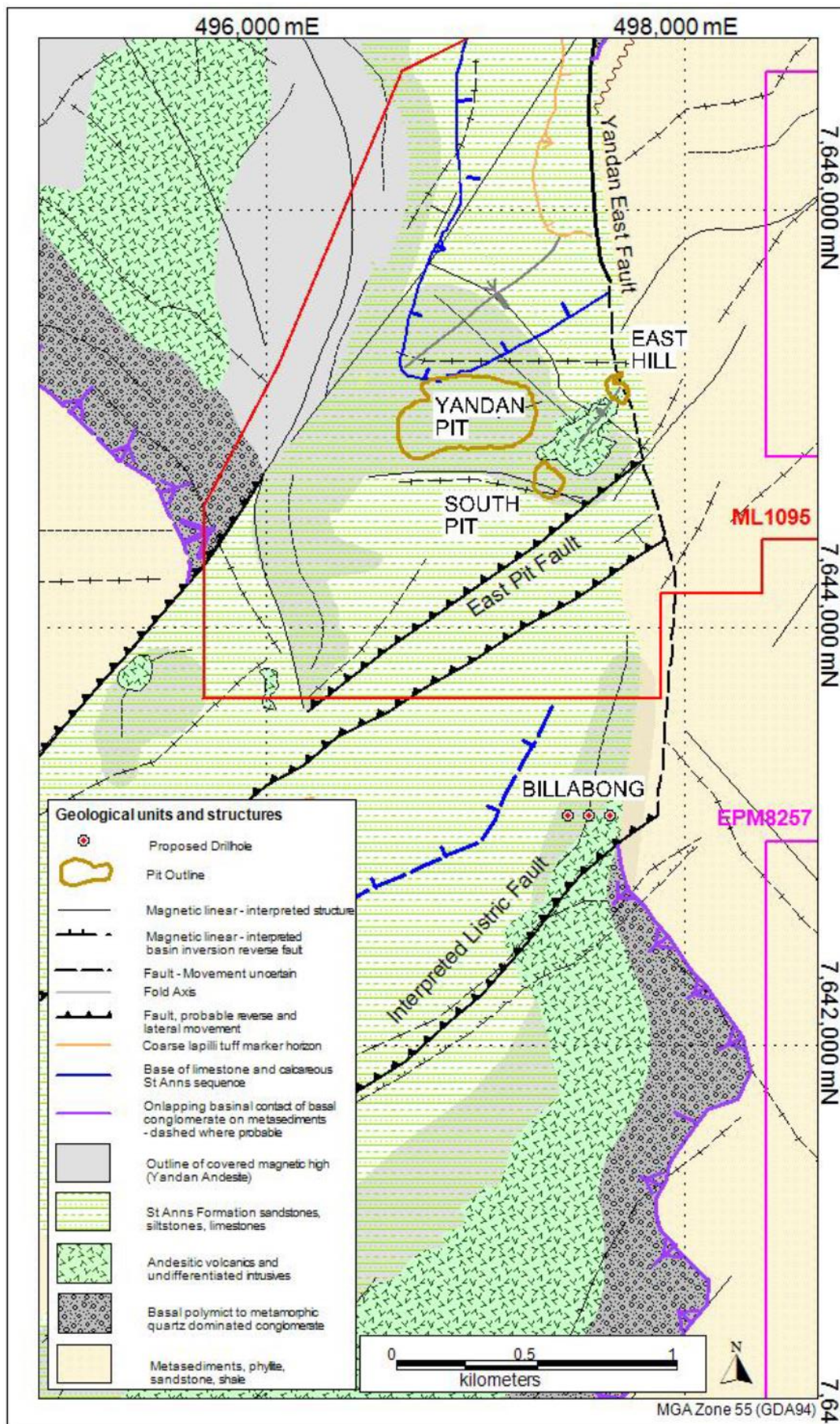


Figure 3: Geology of Yandan (Source: Straits n.d.)

2.3 Regional climate

The Yandan Gold Project is located within a region identified as having a sub-tropical climate with moderately dry winters and hot summers (BoM 2001). Most of the rainfall for this region occurs during the November to March wet season, with limited rainfall recorded throughout the rest of the year. Rainfall records (for the 1899 – 2020 period) for the surrounding region are available from the nearby Mount McConnell Bureau of Meteorology weather station (located approximately 66 km north-east of the Project site) and represented in Figure 3.

Rainfall records (1899 – 2020) indicate annual rainfall totals are within the range of 190–1,480 mm/year, with a median annual total of 597 mm/year. The majority of rainfall occurs during rainfall events in the wet season, with dry conditions persisting for the majority of the year (on average 321 days per year).

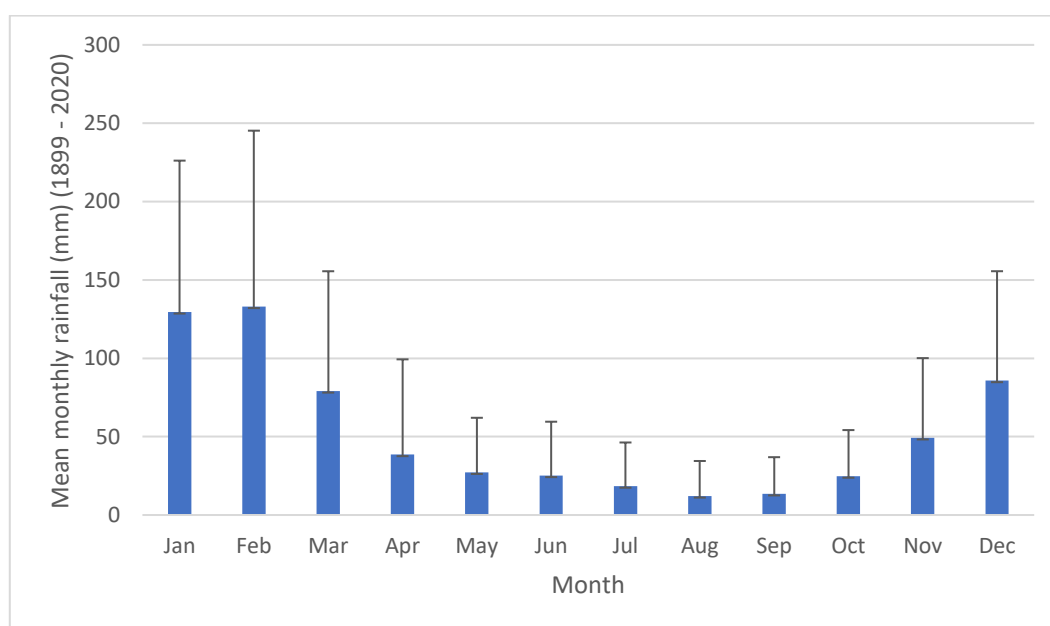


Figure 4: Mean monthly rainfall within the surrounding Project region (Mount McConnell BoM station)

2.4 Current land use

Low intensity beef cattle grazing is the primary land use for the region, with much of the naturally occurring open forest and woodlands cleared for this purpose. Limitations of the soil, together with low rainfall and high rainfall variability render the stock carrying capacity relatively low. Information obtained from the then Department of Primary Industries indicated that the carrying capacity of the land is approximately one beast per 15 ha (GHD 2008).

The pre-mining land use for the Project area was low intensity livestock grazing, which is consistent with the surrounding land use.

2.5 Strategic cropping land

The Project is not located in a Priority Agricultural Area or a Strategic Cropping Area, as defined by the *Regional Planning Interests Act 2014*.

2.6 Land systems

The report *Lands of The Nogoa-Belyando area, Queensland* (Gunn *et al.* 1967) (mapped at a scale of 1:500,000) notes the study area as containing the land system units described in the following sub-sections.

2.6.1 Disney Land System

The Disney Land System is characterised by small lateritic mesas with ironbark and red or yellow earths on Tertiary sandstone. The surrounding lowlands are texture contrast soils on weathered Drummond Basin sediments, occupied with Box *Eucalyptus spp.* and *Acacia harpophylla* (Brigalow).

The potential use of the Disney Land System is limited cultivation and/or pasture improvement due to limitations including moderate erosion, shallow soils, salinity, alkalinity and/or microrelief (gilgai soils).

2.6.2 Peak Vale Land System

The Peak Vale Land System comprises undulating terrain on granite with texture contrast soils under Silver-Leaved Ironbark woodland and eastern mid-height pasture. The rolling country consists of moderately deep soils but diversified by occasional rocky tors up to 15 m high and basalt plugs up to 150 m. The limitations found in the Disney Land Systems also occurs in this landscape, including moderate erosion, shallow soils, salinity, alkalinity and/or microrelief (gilgai soils).

2.6.3 Blackwater Land System

The Blackwater Land System is mostly found within the Belyando catchment, where the tertiary land surface and weathered zone have been partially removed. It is a depositional land system described as Brigalow plains with cracking clay soils on acid clay exposed within the Tertiary weathered zone. Gravel is common in this material and gilgai microrelief occurs in the lower sites. The landscape may be limited by moderate erosion, salinity, alkalinity, unreliable rainfall, and microrelief.

2.6.4 Banchory Land System

The Banchory Land System is within a post tertiary alluvial system, within the lower alluvial plains. It is characterised by alluvial plains with gidgee and cracking clay soils. The landscape is susceptible to flooding, hence, very frequent overflow from streams/drainage lines limits the potential land use to intensive grazing.

2.6.5 Humboldt Land System

The Humboldt Land System consists of *Eucalyptus cambageana* (Dawson Gum) woodland, which usually forms scrubs with Brigalow. These woodlands are on texture contrast soils formed on acid clay exposed within the Tertiary weathered zone. Relief is generally gently undulating but both plains and hills are present, the land system is stony in places.

3 Soil survey methodology

3.1 Desktop analysis

A 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* (Bureau of Rural Science 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 study area.
- Government maps featuring regional topography, geology, contour data and watercourse locations were used to help refine mapping boundaries, particularly where soil types are a function of gradient.
- Reference information for land systems: *Land Systems of the Nogoa-Belyando Area, Queensland* (Gunn *et al.* 1967)
- Reference information for grazing land management: *Land types of Queensland* (FutureBeef 2011)
- High resolution imagery and digital elevation data for the Project area was captured in late 2022 and provided by GBM Resources.

3.2 Survey design

Methodologies employed throughout this study followed procedures detailed in the *Australian Soil and Land Survey Field Handbook* (National Committee on Soil and Terrain 2009) and the *Guidelines for Surveying Soil and Land Resources* (McKenzie *et al.* 2008).

The conventional form of soil survey is commonly referred to as free survey (Steuer 1961). It is suited to detailed-scale survey and has been utilised in this study with the intention to map soil boundaries. Soil profile and observation sites were selected to best represent all soil types present in the study area.

Mapping scales for the study area were selected in order to satisfy the requirements of a Progressive Rehabilitation and Closure Plan, taking into consideration available resources, land access and soil complexity.

For the study area, a scale between 1:25,000 to 1:100,000 was deemed most appropriate based on McKenzie *et al.* (2008). The final mapping scale of 1:30,000 for the study area 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 sampling density of one site per 100 ha with data collection comprising detailed soil profile descriptions (15 to 35% of sites), representative profile sampling for lab analysis (1 to 5%) and mapping observations sites (55 to 83%).

The lower range of recommended ground observations was selected (a total of 39 observations), which exceeded the minimum requirements of a conventional qualitative land resource survey (Table 1). The number of laboratory analysis samples also exceeded the upper recommended range to improve the accuracy of soil descriptions and mapping.

Table 1: Chosen survey observation quantities

Survey site	Scale	Objectives	Detailed soil profiles	Representative profiles for analysis	Mapping observations	Total
Study area (,1971 ha)	1:50,000	• General suitability for various forms of land use • Planning for low intensity land uses	7	4	28	39

3.3 Field investigations

AARC completed field sampling for the SLSA during 11–12 December 2021, with this consisting of primary sampling sites (profiles) and secondary visual assessments (observations).

Sampling site locations were determined based on the desktop analysis, land management units, landform and vehicle access. Visual assessments were conducted continually while traversing the landscape to confirm major soil types and boundaries between soil units. The GPS coordinates of each location were recorded.

Detailed soil profiles were undertaken at seven (7) sites within the Project boundaries. A soil auger was used to excavate cores to a maximum depth of 80 cm. Soil samples were collected from profiles at standard depths of 0–10 cm, 20–30 cm, 50–60 cm and 70–80 cm, where possible. Samples were sealed in clean, plastic zip-lock bags and labelled with the site number, date and depth of sampling.

Parameters recorded included micro relief, permeability, drainage, substrate, site disturbance, landform (slope, relief, elevation, morphological type, landform element and landform pattern), runoff, erosion, surface coarse 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.

Field pH was measured using a Manutec soil pH test kit. To test the pH, few drops of the pH dye indicator liquid is placed on a small soil sample. Barium sulphate powder was dusted over the sample and the colour change was observed. The pH value was determined comparing the colour of the sample with the colour chart provided in the kit. The sampling equipment was washed thoroughly between samples to avoid contamination.

The field assessment also involved refinement of the existing material balance for the site. Potential rehabilitation materials identified during the desktop assessment were verified in the field, with this involving the verification of the location and extent, and soil sampling to confirm suitability for use. Confirmed footprints of material sources were later analysed in a three-dimensional model of the site, with the material resources within these footprints then calculated.

3.4 Laboratory analysis

Samples from a total of four (4) sites were chosen for analysis through Australian Laboratory Services for NATA approved physical and chemical analyses. Samples from all standard depths at the chosen sites were analysed to:

- confirm the classification of the described soil profile;
- assist in the description of soil physical and chemical characteristics;
- assist in the determination of land suitability classes; 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 (Ca, Mg, Na, 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 (Fe, Cu, Zn, Mn);
- boron (CaCl₂ extractable);
- nitrogen as nitrate;
- sulphate (water-soluble S as sulphate);
- 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 and the National Committee on Soil and Terrain 2021). SMUs were then defined based on grouping soils of like soil morphology, parent material, and land attributes in accordance with the (McKenzie *et al.* 2008). Each SMU has been described in terms of its soil profile class with the attributes and limitations of the soil interpreted using the *Guidelines for Agricultural Land Evaluation in Queensland – Second Edition* (DSITI and DNRM 2015) to determine their suitability for cattle grazing. SMUs were mapped at a scale of 1:30,000 across the study area.

3.6 Interpretation of chemical data

The characteristics and chemical data for each SMU have been described in section 4. The following guidelines were used to assist in interpretation of the SMU physical and chemical properties and to determine ratings and categories of the assessed soil parameters:

- *Interpreting Soil Test Results* (Hazelton and Murphy 2016);
- *Soil Chemical Methods of Australasia* (Rayment GE and Lyons D 2011); and
- *Standard Soil Test Methods and Guidelines for Interpretation of Soil Results* (Government of South Australia 2013).

Broad descriptions for each soil parameter have been provided below and where applicable, a summary of the rating system used.

3.6.1 pH

Soil pH influences the availability of plant available nutrients and toxic elements by controlling the solubility of these elements. At extreme pH, the availability of essential plant nutrients can be severely reduced while toxic elements can become mobile within the soil solution in acidic environments. The soil pH ratings used are shown in Table 2. In general, a suitable soil pH ranges from 5.5–9.0 as at this pH all essential nutrients are available to some degree.

Table 2: Interpretation of pH measured in water (1:5 soil/water ratio) (Hazelton and Murphy 2016)

pH _{water}	Rating	Soil chemistry indications
<4.0	Very strongly acid	Typical of disturbed acid sulphate soils
4.0 to <5.0	Strongly acid	Acidified soils
5.0 to <6.0	Moderately acid	Range most suitable for plant growth
6.0 to <7.0	Slightly acid	
7.0	Neutral	
>7.0 to <8.0	Slightly alkaline	
8.0 to <9.0	Moderately alkaline	Some nutrients becoming unavailable, indication of sodicity
9.0 to 10.0	Strongly alkaline	
>10.0	Very strongly alkaline	

3.6.2 Electrical conductivity

Soil salinity is determined by measuring the electrical conductivity of soil:water suspensions in soil. This provides an indication of the presence of water-soluble salts, including sodium, calcium and magnesium, which can be chlorides, sulphates or carbonates, in the soil profile.

Electrical conductivity is determined by converting the EC_(1:5) (soil:water suspension) to saturated extract (EC_{SAT}) (dS/m), which is based on the estimated water holding capacity of the soil based on soil texture. To convert EC_(1:5) to EC_{SAT}, the following formula is used:

$$EC_{SAT} \text{ (dS/m)} = EC_{(1:5)} \text{ (dS/m)} \times \text{multiplier factor (Hazelton and Murphy 2016)}$$

High soil salinity can increase soil erosion, severely effecting plant growth and land use. Highly saline conditions compromise the ability of a plant to take up water as needed, resulting in water stress regardless of the water content in the soil. The texture of soil needs to be considered when interpreting EC as the clay content determines the amount of salt present that will affect plant growth. Table 3 provides the multiplier factors to be applied to the formula for converting EC_(1:5) (dS/m) to EC_{SAT} (dS/m), as described in Hazelton and Murphy (2016).

Table 3: Soil salinity ratings (based on EC values in dS/m)

Soil texture	Multiplier factors
Sand, loamy sand, clayey sand	23
Sandy loam, fine sandy loam, light sandy clay loam	14
Loam, fine sandy loam, silty loam, sandy clay loam	9.5
Clay loam, silty clay loam, fine sandy clay loam, sandy clay, silty clay, light clay	8.6
Light medium clay	8.6
Medium clay	7.5

Soil texture	Multiplier factors
Heavy clay	5.8

Saline soils are defined as having an $EC_{SAT} > 4$ dS/m (Table 4).

Table 4: Salinity ratings for soil based on EC_{SAT}

Rating	EC dS/m	Effect on plants
Non-saline	<2	Salinity effects are mostly negligible
Slightly saline	2 – 4	Yields of sensitive crops are affected
Moderately saline	4 – 8	Yields of many crops are affected
Highly saline	8 – 16	Only tolerant crops yield satisfactorily
Extremely saline	>16	Only very tolerant crops yield satisfactorily

3.6.3 Chloride

Chloride is associated with EC as soluble salts contain chloride, thus the presence of soluble salts in soils is directly proportional to chloride in soil. A high chloride concentration can induce chloride toxicity and interfere with the osmotic capacity of plants. Table 5 below provides chloride ratings (Rayment and Bruce 1984).

Table 5: Chloride concentration ratings

Chloride rating	Cl concentration (mg/kg)
Very Low	< 100
Low	100 – 300
Medium	300 – 600
High	600 – 2,000
Very High	> 2,000

3.6.4 Cation exchange capacity and exchangeable cations

Cation Exchange Capacity (CEC) is an indication of the capacity of a soil to adsorb cationic nutrients to the surface of soil particles. This process of adsorption prevents nutrients leaching from the soil and buffers the concentration of plant available nutrients in the soil solution. A high CEC of the soil contributes to larger quantities of exchangeable cations (Ca, K, Mg, Na) available. The ratio of cations on the exchange is also an important consideration as cations that dominate the exchange can interfere with the availability of other cations. Table 6 and Table 7 provide ratings for soil CEC and extractable cations sourced from Hazelton and Murphy (2016).

Table 6: Soil CEC ratings

CEC rating	CEC (cmol(+)/kg)
Very Low	< 6
Low	6–12
Medium	12–25
High	25–40
Very High	> 40

Table 7: Extractable cations (cmol(+)/kg) ratings

Cation	Very Low	Low	Moderate	High	Very High	Ideal range (% of CEC)
Ca	0–2	2–5	5–10	10–20	> 20	65–80
K	0–0.2	0.2–0.3	0.3–0.7	0.7–2	> 2	1–5
Mg	0–0.3	0.3–1	1–3	3–8	> 8	10–15
Na	0–0.1	0.1–0.3	0.3–0.7	0.7–2	> 2	< 1

3.6.5 Exchangeable sodium percentage

Exchangeable sodium percentage (ESP) is defined as the amount of exchangeable sodium as a percentage of the total CEC of the soil. It provides a measure of how much of the CEC of the soil is dominated by sodium. Due to the chemical characteristics of sodium ions, an increasing ESP indicates increasing sodicity thus increasing the risk of dispersion. Table 8 provides ESP ratings sourced from Hazelton and Murphy (2016).

Table 8: Soil ESP ratings

ESP (%)	ESP rating
< 6	Non-sodic
6–15	Sodic
> 15	Strongly sodic

3.6.6 Organic matter

Organic matter is an essential constituent of soil. It is an important component of microbial processes and nutrient cycling. Furthermore, it contributes to the ability of a soil to buffer changes to pH and nutrient content and supports the aggregation of soils thereby improving the structural stability of the soil. Table 9 provides soil organic matter ratings sourced from Hazelton and Murphy (2016).

Table 9: Soil organic matter ratings

Organic matter rating	Organic matter content (g/100 g)
Extremely low	< 0.7
Very low	0.7–1
Low	1–1.7
Moderate	1.7–3
High	3–5.15
Very High	> 5.15

3.6.7 Particle size analysis

Particle size analysis determines the percentage composition of sand, silt and clay sized particles which controls the soil texture. Soil texture influences the structural stability and water holding characteristics of a soil as the particle size distribution influences the porosity and permeability of soil.

3.6.8 Extractable trace elements/metals

Trace elements such as copper, iron, manganese, zinc and boron are essential nutrients required for plant growth, although needed in much smaller quantities than exchangeable cations. Table 10 provides trace element/metal ratings sourced from Government of South Australia (2013).

Health investigation levels (HILs) are generic assessment criteria outlined in *Schedule B1 – Investigation Levels for Soils and Groundwater* (National Environmental Protection Measure, 2011), designed to be used in the first stage of an assessment of potential risks to human health from chronic exposure to contaminants. The HILs for soil contaminants of standard residential with accessible soils are provided in Table 11.

Table 10: Ideal concentration ranges for trace elements/metals

Trace element/metal	Rating	Concentration (mg/kg)
Boron	Low	< 0.5
	High	> 15
Copper	Low	< 0.3
	High	> 1
Iron	Low	< 10
	High	> 70
Manganese	Low	< 1
	High	> 10
Zinc	Low	< 0.5
	High	> 1

Table 11: Health investigation levels for soil contaminants (Residential A)

Trace element/ metal	Health-based Investigation Levels (mg/kg) Residential A
Boron	5,000
Copper	7,000
Manganese	3,000
Zinc	8,000

3.6.9 Nitrate

Nitrate is a plant available form of nitrogen. It is an essential nutrient and is often the most limiting to plant growth. It is also susceptible to nitrification and leaching which reduces nitrate concentration in soil. Table 12 provides soil nitrate ratings sourced from Hazelton and Murphy (2016).

Table 12: Soil nitrate ratings

Rating	Nitrate concentration (mg/kg)
Very low	0–6
Low	7–15
Moderate	16–22
High	23–30
Very High	> 30

3.6.10 Sulphate

Sulphate is another essential plant nutrient and has a similar behaviour to nitrate in that it is susceptible to leaching and is important in microbial processes. Table 13 provides soil sulphate ratings sourced from Government of South Australia (2013).

Table 13: Soil sulphate ratings

Rating	Sulphate concentration (mg/kg)
Low	< 5
Marginal	5–10
High	> 10

3.6.11 Phosphorous and potassium

Both phosphorous and potassium are the next most essential nutrients after nitrogen and sulphate. Phosphorous and potassium are involved in several chemically- and microbially-driven processes within the

soil with most forms of these nutrients being unavailable for plant uptake. Table 14 and Table 15 provide ratings for soil phosphorous and potassium levels sourced from Hazelton and Murphy (2016).

Table 14: Soil phosphorus ratings

Rating	Phosphorous concentration (mg/kg)
Very low	< 5
Low	5–10
Moderate	10–17
High	17–25
Very High	> 25

Table 15: Soil potassium ratings

Soil Texture	Potassium critical concentration (mg/kg)*
Sand	126
Sandy loam	129
Sandy clay loam	143
Clay loam	161

* Critical concentration is that concentration where 95% of maximum yield is achieved

3.6.12 Emerson class

Emerson class is a class assigned to soil that is determined on the stability of dry aggregates in water. The Emerson class number of a soil is assigned as an indication of the dispersion and slaking ability of a soil. Table 16 below describes the Emerson Dispersion Class (Emerson 1967).

Table 16: Emerson class numbers

Emerson dispersion class	Level of dispersion
1	Slaking and complete dispersion
2	Slaking and some dispersion
3	Slaking and no dispersion
4	CaCO ₃ /CaSO ₄ present. No dispersion at field capacity
5	No CaCO ₃ /CaSO ₄ present. No dispersion at field capacity, however, dispersion in an aggregate-water suspension
6	No CaCO ₃ /CaSO ₄ present. No dispersion at field capacity, however, flocculation in an aggregate-water suspension
7	No slaking and swelling
8	No slaking and no swelling

3.7 Land suitability assessment

Land suitability refers to the adequacy of land for a defined use. Land suitability assessment considers environmental factors including climate, soils, geology, geomorphology, erosion, topography and the effects of past land uses. The classification does not always represent the current land use. Rather, it indicates the potential of the land to be used for specific agricultural activities. The aim of this land suitability assessment is to evaluate the suitability of the Project area for agricultural land uses, specifically cattle grazing, prior to further development of the mine.

The assessment for land suitability (cattle grazing) has been carried out in accordance with the methodologies described in:

- *Guidelines for Agricultural Land Evaluation in Queensland* (2nd edition) (DSITI and DNRM 2015).
- *Regional Land Suitability Frameworks for Queensland* (State of Queensland 2013)

The five land suitability classes used for assessing land are defined in Table 17. 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;
- increased inputs to achieve an acceptable level of production;
- increased inputs to prepare the land for successful production; and/or
- increased inputs required to prevent land degradation.

Table 17: Land suitability class description

Class	Agricultural description	Conservation description
Class 1	Suitable land with negligible limitations. This is highly productive land requiring only simple management practices to maintain economic production.	Areas well suited for conservation uses must possess significant conservation benefits in the pre-mining environment and be capable of being returned to that use post-mining.
Class 2	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.	Areas suited to conservation use in that a significant component of the pre-mining conservation values can be restored post-mining. There will however, be some loss in conservation values where soil terrain or hydrological post-mining conditions may inhibit the full replication of the pre-mining values.
Class 3	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.	These lands contain significant conservation values pre-mining, however, restoration of all of these values may not be feasible. These areas could, however, be restored to a form of conservation use which provides alternative conservation benefits.

Class	Agricultural description	Conservation description
Class 4	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.	These lands contain limited conservation value pre-mining and/ or are incapable of being effectively restored post-mining to any alternative conservation use which provides similar benefits. The area could however, be restored to provide a stable form of use which does not impact on surrounding conservation values.
Class 5	Unsuitable land with extreme limitations that preclude its use.	These lands contain no significant conservation values.

A list of limitations has been compiled for districts throughout Queensland in the *Regional Land Suitability Frameworks for Queensland* (State of Queensland 2013). The Project area is located within the Inland Fitzroy and southern Burdekin area. The limitations outlined for the assessment of land suitability for land uses are:

- Water erosion;
- Erosion hazard, subsoil erodibility;
- Soil water availability;
- Narrow moisture range;
- Surface condition;
- Rockiness;
- Microrelief; and
- Wetness

A land use is a combination of a crop and its management options (e.g. dryland pastures, rain-fed sorghum etc.). The regional frameworks outline limitation criteria for various dryland cropping land uses. However, the suitability for dryland native pastures was not described for the Project district. It is inferred that the suitability of dryland agricultural crops can be applied to native dryland pastures due to the development of similar tolerance traits.

Native grasses are mostly perennials and persist well in the Australian environment. They are well adapted to the harsh and varying climate (e.g. severe droughts and low rainfall) and highly-weathered soils. Hence, many native species tolerate low fertility, acid soils and water stress, as well as being more resistant to disease (Victoria State Government 2021).

Where land uses have been grouped due to differing limitation rankings, the most lenient criteria for dryland conditions were applied as pastures generally have lower requirements, as previously discussed.

The following sections discuss the definitions, attribute assessment and subclass determination of each limitation.

3.7.1 Water erosion (E)

The water erosion limitation considers the potential impact of accelerated erosion of the land surface caused by various human activities. Most agricultural land uses (including pasture) increase the potential for soil loss from water erosion due to an increased volume of runoff, increased velocity of water flow, and decreased protection of the soil surface when devoid of surface cover. The rate of soil loss will increase above natural levels in many localities where surface water is concentrated, such as at water outlets and cross drains, particularly where these are located in flood-prone areas.

Subclasses are based on the added management operations required to control erosion (Table 18). Subclasses may then be described in terms of the slope ranges permitted for each land use and soil type.

Table 18: Water erosion limitation description and suitability subclass

Water erosion description	Suitability subclass
Slopes of 0-0.5% with non-dispersive moderate to strongly coherent soil in the surface 200mm	1
Slopes of 0-0.5% with non-dispersive weakly coherent soil in the surface 200mm	1
Slopes of 0-0.5% with dispersive soil in the surface 200mm	3
Slopes of 0.5-1% with non-dispersive moderate to strongly coherent soil in the surface 200mm	1
Slopes of 0.5-1% with non-dispersive weakly coherent soil in the surface 200mm	2
Slopes of 0.5-1% with dispersive soil in the surface 200mm	4
Slopes of 1-3% with non-dispersive moderate to strongly coherent soil in the surface 200mm	2
Slopes of 1-3% with non-dispersive weakly coherent soil in the surface 200mm	3
Slopes of 1-3% with dispersive soil in the surface 200mm	5
Slopes of 3-5% with non-dispersive moderate to strongly coherent soil in the surface 200mm	3
Slopes of 3-5% with non-dispersive weakly coherent soil in the surface 200mm	4
Slopes of 3-5% with dispersive soil in the surface 200mm	5
Slopes of 5-8% with non-dispersive moderate to strongly coherent soil in the surface 200mm	3
Slopes of 5-8% with non-dispersive weakly coherent soil in the surface 200mm	4
Slopes of 5-8% with dispersive soil in the surface 200mm	5
Slopes greater than 8% with non-dispersive moderate to strongly coherent soil in the surface 200mm	5
Slopes greater than 8% with non-dispersive weakly coherent soil in the surface 200mm	5
Slopes greater than 8% with dispersive soil in the surface 200mm	5

3.7.2 Erosion hazard, subsoil erodibility (Es)

Some soils have a low surface erodibility, but high subsoil erodibility – for example Sodosols with hard setting surfaces. Therefore, it is recommended that subsoil erodibility be considered as a separate limitation or included as a distinct diagnostic attribute within the water erosion limitation. Although a potential for subsoil erosion does not necessarily correlate with increased erosion risk at the soil surface.

The major soil profile properties assessed for this limitation are the dispersibility of the subsoil and the depth at which dispersible subsoil occurs. Subclasses are typically based on soil data and slope classes (Table 19). Soil types, or some Australian Soil Classification (ASC) soil classes, were referred for the allocation of subclasses.

Table 19: Subsoil erodibility limitation description and suitability subclass

Subsoil erodibility description	Suitability subclass
Slopes of 0–0.5% with no subsoil (200–1,000mm) dispersion	1
Slopes of 0–0.5% with low to moderate dispersive subsoil (200–1,000mm) and clay content greater than 20%	1
Slopes of 0–0.5% with strongly dispersive subsoil (200–1,000mm) on 2 or more tests and clay content greater than 20%	2
Slopes of 0.5–1% with no subsoil (200–1,000mm) dispersion	1
Slopes of 0.5–1% with low to moderate dispersive subsoil (200–1,000mm) and clay content greater than 20%	2
Slopes of 0.5–1% with strongly dispersive subsoil (200–1,000mm) on 2 or more tests and clay content greater than 20%	3
Slopes of 1–3% with no subsoil (200–1,000mm) dispersion	1
Slopes of 1–3% with low to moderate dispersive subsoil (200–1,000mm) and clay content greater than 20%	3
Slopes of 1–3% with strongly dispersive subsoil (200–1,000mm) on 2 or more tests and clay content greater than 20%	4
Slopes of 3–5% with no subsoil (200–1,000mm) dispersion	3
Slopes of 3–5% with low to moderate dispersive subsoil (200–1,000mm) and clay content greater than 20%	3
Slopes of 3–5% with strongly dispersive subsoil (200–1,000mm) on 2 or more tests and clay content greater than 20%	5
Slopes of 5–8% with no subsoil (200–1,000mm) dispersion	3
Slopes of 5–8% with low to moderate dispersive subsoil (200–1,000mm) and clay content greater than 20%	4
Slopes of 5–8% with strongly dispersive subsoil (200–1,000mm) on 2 or more tests and clay content greater than 20%	5
Slopes >8% with no subsoil (200–1,000mm) dispersion	5
Slopes greater than 8% with low to moderate dispersive subsoil (200–1,000mm) and clay content greater than 20%	5
Slopes >8% with strongly dispersive subsoil (200–1,000mm) on 2 or more tests and clay content greater than 20%	5

3.7.3 Soil water availability (M)

All plants require adequate moisture to achieve optimum production. Soil water availability is assessed in terms of the capacity of the soil to retain and supply water for plant use, while recognising that different species will differ in their ability to extract soil water. Plant available water capacity (PAWC) provides the best estimate of a soil's moisture storage capacity.

The criteria of Group B were applied to determine the suitability subclass of soil water availability for dryland native pastures. Native grasses are well adapted to severe drought and low rainfall conditions and developed a variety of mechanisms for drought avoidance. These include prolonged dormancy, deep root systems or

through having a below-ground crown which is capable of surviving drought and grazing (Wang and Bughrara 2008, McWilliam 1968). Hence, it is understood that native pastures will be more tolerant in conditions of low PAWC.

Group B consists of criteria for crops with greater capacity to extract water from soil in dryland conditions, e.g. severe limitations (subclass 4) as opposed to extreme limitations (subclass 5) in some areas of low PAWC.

Table 20: Soil water availability limitation description and suitability subclass

	Soil water availability description	Suitability subclass		
		Group A	Group B	Group C
1	PAWC greater than 150mm/100cms	1	2	2
2	PAWC 125-150mm/100cms	2	2	3
3	PAWC 100-125mm/100cms	3	3	4
4	PAWC 75-100mm/100cms	3	4	5
5	PAWC 50-75mm/100cms	4	5	5
6	PAWC less than 50mm/100cms	5	5	5

3.7.4 Soil physical factors – narrow moisture range (Pm)

The moisture content of a soil can be an important factor in determining its capacity to be cultivated efficiently to achieve the desired result within the constraints of available machinery. Some soils may be cultivated at virtually any moisture content, while others can only be cultivated efficiently over a very narrow moisture range. Soils with moisture contents above that range will be too wet to cultivate; and cultivation of the soil at moisture contents below that range gives a coarse seedbed.

Table 21: Narrow moisture range limitation description and suitability subclass

	Narrow moisture range descriptions	Suitability subclass
1	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
2	Moderate moisture range for cultivation – moderately well drained to rapidly drained; not hard setting when dry and not ‘spewy’ when wet. Moderately to strongly self-mulching clays	1
3	Moderate moisture range for cultivation – moderately well drained to rapidly drained; predominantly hard setting when dry and not ‘spewy’ when wet. Well drained earths and moderately well drained hard setting loamy surfaced soils	2
4	Moderate moisture range for cultivation (but less than Pm3) – imperfectly drained to moderately well drained; not hard setting (or only weakly) when dry and ‘spewy’ when wet. Sandy surfaced (less than 0.4m), sodic texture contrast soils	3
5	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, firm or weakly self-mulching, pedal clays	3

	Narrow moisture range descriptions	Suitability subclass
6	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), sodic texture contrast soils or dermosols	3
7	Very narrow moisture range for cultivation – imperfectly drained to moderately well drained; very hard setting when dry and ‘spewy’ when wet. Very hard setting, sodic clays	4

3.7.5 Surface conditions (Ps)

Seedling emergence and establishment are affected by adverse physical conditions of the surface soil including hard setting, crusting, coarse self-mulching, hydrophobic or tough clay conditions. This limitation is used to downgrade suitability where poor surface conditions affect production, or where increased management inputs are required to manage those soils.

Table 22: Surface conditions limitation description and suitability subclass

	Surface conditions description	Suitability subclass
1	Soils with soft or loose sandy to sandy loam surface horizons	1
2	Very fine self-mulching clays (peds less than 2mm)	1
3	Soils with soft, firm or only weakly hard setting, sandy to loamy surface horizons	2
4	Fine self-mulching clays (peds greater than 2-5mm)	2
5	Coarse self-mulching clays (peds greater than 5-10mm); poor seed-soil contact due to separation of large peds with drying	3
6	Clay soils with hard setting, firm pedal or weakly self-mulching surface horizons	3
7	Very coarse self-mulching clays (peds greater than 10mm)	4
8	Loamy, fine sand, silty or clayey surface soils that are extremely hard setting, massive or crusting	4

3.7.6 Rockiness (R)

Rockiness refers to rock outcrop and coarse fragments at the soil surface. Assessment of rockiness is based on the size, abundance and distribution of coarse fragments and stone on the surface and/or in the surface soil and on the abundance of rock outcrop using the categories outlined in McDonald *et al.* (2009), as outlined in Table 23. Subclasses for grazing are based on the decreased productivity associated with large amounts of surface stones and rock outcrop and possibly the potential impacts on mustering and other operations.

The criteria of Group A were applied to determine the suitability subclass of rockiness for dryland native pasture. Native grasses may be found in areas with harsh surface conditions, among rocky outcrops, sandy surface soils or shallow stony soils (Government of South Australia 2017, State of Queensland 2013). It is understood that native pasture species will be better adapted to establishing on rocky surface conditions, with greater productivity than most agricultural crops.

Group A consists of criteria for crops with greater productivity on rocky areas, e.g. moderate limitations (subclass 3) as opposed to severe limitations (subclass 4) in some areas with greater size, abundance and distribution of coarse fragments.

Table 23: *Rockiness limitation and suitability subclass*

Rockiness description	Suitability subclass	
	Group A	Group B
Cobbles 60 to 200mm and abundance less than 10%	3	3
Cobbles 60 to 200mm and abundance 10-20%	3	4
Cobbles 60 to 200mm and abundance 20-50%	4	4
Cobbles 60 to 200mm and abundance greater than 50%	4	4
Gravel less than 20mm and abundance less than 10%	1	1
Gravel less than 20mm and abundance 10-20%	2	2
Gravel less than 20mm and abundance 20-50%	2	3
Gravel less than 20mm and abundance greater than 50%	3	3
Pebbles 20 to 60mm and abundance less than 10%	2	2
Pebbles 20 to 60mm and abundance 10-20%	2	2
Pebbles 20 to 60mm and abundance 20-50%	3	4
Pebbles 20 to 60mm and abundance greater than 50%	4	4
Stones greater than 200mm and abundance less than 10%	3	3
Stones greater than 200mm and abundance 10-20%	3	4
Stones greater than 200mm and abundance 20-50%	5	5
Stones greater than 200mm and abundance greater than 50%	5	5

3.7.7 Microrelief (Tm)

This limitation includes the overall slope of the land surface as well as an uneven land surface due to microrelief. Suitability subclasses are based on the amount of earthworks required to level the land or create a required slope to an extent sufficient for grazing (

Table 24).

Table 24: Microrelief limitation description and suitability subclass

Microrelief description	Suitability subclass
No microrelief across the majority (greater than 70%) of the land surface	1
Very weakly developed microrelief (VI less than 0.1m) that occurs across much (30-70%) of the land surface	2
Normal, lattice or linear gilgai (VI 0.1–0.3m) that occurs across less than 30% of the land surface	2
Normal, lattice or linear gilgai (VI 0.1–0.3m) that occurs across much (30–70%) of the land surface	2
Normal, lattice or linear gilgai (VI 0.1–0.3m) across majority (greater than 70%) of the land surface	2
Shallow, melonhole gilgai (VI 0.3–0.6m) that occurs across less than 30% of the land surface	2
Shallow, melonhole gilgai (VI 0.3–0.6m) that occurs across much (30–70%) of the land surface	3
Shallow, melonhole gilgai (VI 0.3–0.6m) across the majority (greater than 70%) of the land surface	4
Strongly developed, deep, melonhole gilgai (VI 0.6–1.5m) that occurs across less than 30% of the land surface	4
Strongly developed, deep, melonhole gilgai (VI 0.6–1.5m) that occurs across much (30–70%) of the land surface	5
Strongly developed, deep, melonhole gilgai (VI 0.6–1.5m) across the majority (greater than 70%) of the land surface	5

3.7.8 Wetness (W)

The wetness limitation is an assessment of site drainage; determined by considering both internal (soil profile permeability) and external (landscape) factors (Table 25).

Soil permeability is the potential of the soil to transmit water internally. It is controlled by the saturated hydraulic conductivity of the least permeable layer in the soil. This can be inferred from soil attributes such as structure, the presence of hardpans, colour, texture and cracking. The supply and removal of water from the site is a function of slope, topographic position and depth to the water table.

Subclasses are established by relating site drainage attribute levels to yield reduction caused by poor aeration.

The criteria of Group A were applied to determine the suitability subclass of wetness for dryland native pasture. Forage grass species can develop flood tolerant roots, hence, better adapted to unfavourable drainage or permeability conditions (Baruch and Merida 1995).

Group A consists of criteria for crops with greater tolerance to imperfectly drained conditions, e.g. minor limitations (subclass 2) as opposed to moderate limitations (subclass 3) in imperfectly drained and highly permeable areas.

Table 25: Wetness limitation description and suitability subclass

Wetness description	Suitability subclass		
	Group A	Group B	Group C
Very poorly to poorly drained	5	5	5
Imperfectly drained and highly permeable	2	3	3
Imperfectly drained and moderately permeable	3	3	3
Imperfectly drained and slowly permeable	4	4	4
Moderately well drained and highly permeable	1	1	2
Moderately well drained and moderately permeable	1	1	2
Moderately well drained and slowly permeable	2	2	2
Well drained	1	1	1
Rapidly drained	1	1	1

4 Soil survey results

Five SMUs have been described within the study area. Table 26 details the SMUs present, with the spatial distribution of the mapped SMUs (mapped at a scale of 1:30,000) shown in Figure 5. The coordinates for each sampling site are provided in Appendix Appendix B.

Table 26: Soil management units identified within the survey area

Soil management unit	Surface area (ha)	Per cent of study area
Clayey	541	27.4
Sandy	800	40.6
Shallow*	153	7.4
Silty*	99	5
Alluvial**	105	5.3
Mine disturbance	280	14.3
Total area	1,971	100

*SMUs were grouped without laboratory analysis. Assessments were conducted based on soil profile descriptions, field observations and available desktop resources.

**SMU was mapped based on Bureau of Rural Science (1991) mapped unit 'CC35'.

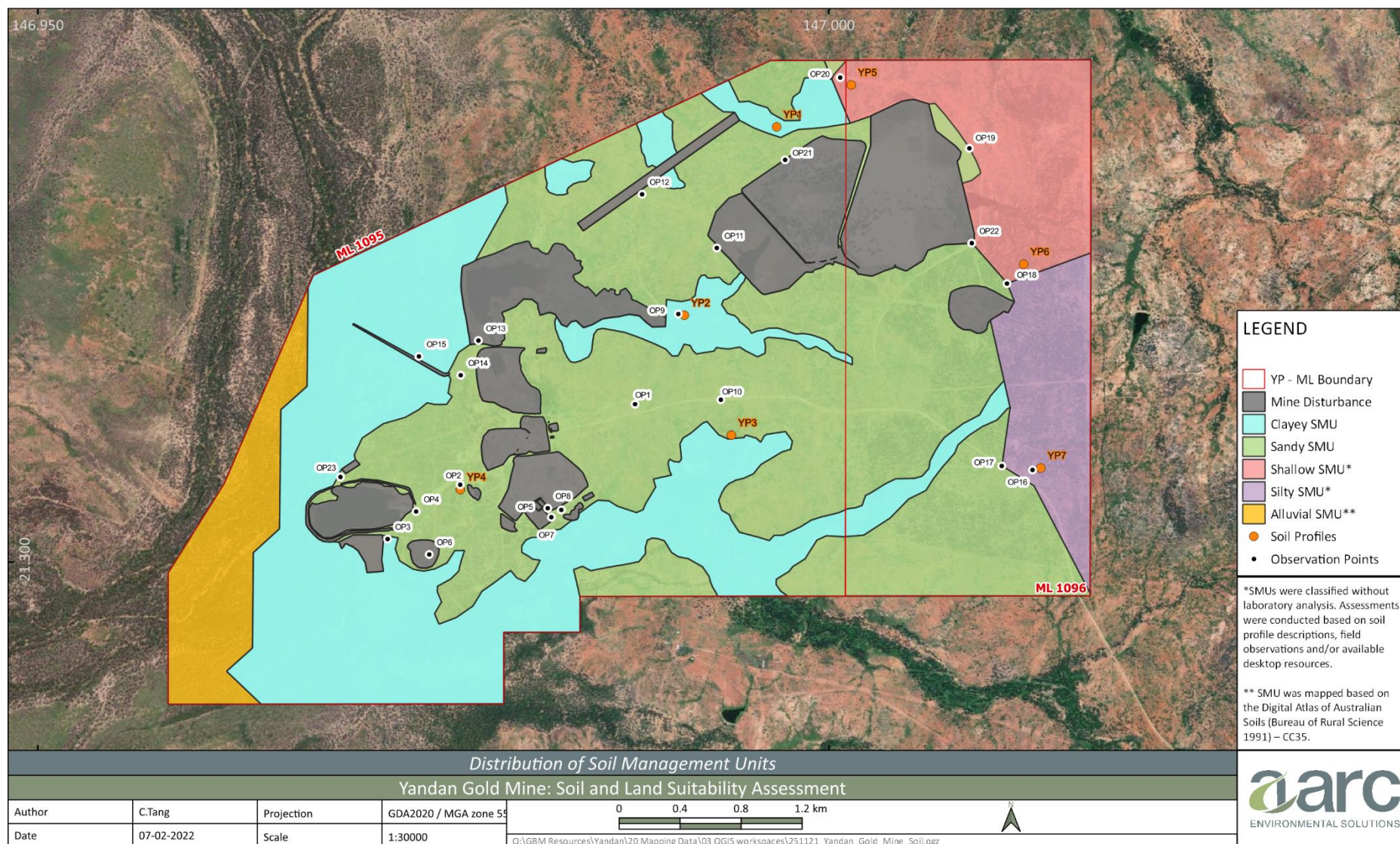


Figure 5: Distribution of soil management units (1:30,000)

4.1 Clayey soil management unit

4.1.1 Soil unit description

Greyish brown earths occurring on gently inclined or level landforms, distributed on the northern half of the study area. Soil textures grade from light clay to light medium clay at the surface to medium clays with depth. Vegetation associated with this unit is predominantly Brigalow.



Photo Plate 1: Clayey SMU Vegetation

Table 27: Key Clayey SMU Parameters

Parameter	Soil unit description
Profile Site Numbers	YP1, YP2
Observation Site Numbers	OP9, OP15, OP20, OP23
Landform	Plains
Australian Soil Classification	Brown Chromosol
Land System	Disney
Slope	0%
Geology	Saint Anns Formation
Vegetation	Brigalow (<i>Acacia harpophylla</i>), Narrow-Leafed Ironbark (<i>Eucalyptus creba</i>), False sandalwood (<i>Eremophila mitchelli</i>)
Runoff	Very slow
Permeability	Slowly permeable (5–50 mm/day)
Drainage	Imperfectly drained

4.1.2 Profile description

The soil profile was described up to 0.8 m depth, as detailed in Table 28. Surface conditions were defined as firm with 90% ground cover. Field pH ranged from slightly acid to slightly alkaline with depth. The profile consists of a very thin A1 horizon observed to be slightly darker in colour than underlying horizons, containing humified organic matter. Soil structure is generally weak, single grain, grading from angular blocky to sub angular blocky, size of peds increase with depth.

Moisture was noted in the lower 0.4 m of the profile. Mottling was observed within the moderately moist horizons, described as many (20–50%), medium (5–15 mm) and clear, orange ferruginous segregations.

Table 28: Soil profile characteristics of Clayey SMU

Depth (m)	Horizon	Field pH	Field Colour	Field Texture	Structure	Soil profile
0–0.05	A1	6	2.5Y 3/2 Very Dark Greyish Brown	Clay Loam	< 0.2 mm, Single grain, Weak, Angular blocky	
0.05–0.2	B21	6.5	2.5Y 4/2 Dark Greyish Brown	Silty Clay Loam	< 0.2 mm, Single grain, Weak, Angular blocky	
0.2–0.4	B22	6.5	2.5Y 4/2 Dark Greyish Brown	Light Clay	< 0.2 mm, Single grain, Weak, Subangular blocky	
0.4–0.6	B23	7	10YR 4/2 Dark Greyish Brown	Silty Loam	5–10 mm, Single grain, Weak, Subangular blocky	
0.6–0.8	B24	7.5	10YR 4/2 Dark Greyish Brown	Medium Clay	2–5 mm, Single grain, Weak, Subangular blocky	

4.1.3 Chemical and physical analysis

The Clayey SMU gradually increases from slightly acid (pH 6.6) to very slightly alkaline (pH 7.2) at depth, and is non saline and non-sodic (Table 29). The pH throughout the soil profile is within a suitable range for plant growth; it is not expected to limit the availability of essential nutrients. EC_{SAT} values are very low, ranging between 0.00052 dS/m to 0.00135 dS/m. Chloride concentration remains below 10 mg/kg. This SMU is not affected by issues associated with salinity and toxic chloride concentrations (Rayment and Lyons 2011).

CEC levels for this SMU are considered low throughout the profile (6.9–10.9 milliequivalents (meq)/100g), CEC decreases with depth before an increase in the lower horizon due to an increase in clay content. The increase in CEC results in increased concentrations of exchangeable cations in the lower 10 m of the profile. The generally low CEC contributes to poor availability of nutrients in subsoil, with calcium (Ca), potassium (K) and sodium (Na) below levels ideal for plant growth. The soil profile contains moderate to high magnesium (Mg) levels. The distribution of nutrients in the topsoil shows Na concentrations are within the ideal range of the exchange. Mg and K occupy a relatively larger proportion of the CEC, while Ca concentrations are below the ideal range.

The calcium to magnesium ratio (Ca/Mg) indicates that relative to Mg, soil Ca is considered low to deficient. Soil ESP levels suggest non-sodic conditions due to the extremely low Na content in the soil profile. However, low Ca concentrations are an indication of dispersive soils, demonstrated by the low Emerson class number of 2–3. Aggregates were prone to breaking into microaggregates with some dispersion in the top 60 cm of the profile. The lower 10 cm of the profile is prone to slaking with no dispersion.

Table 29: Chemical properties of the Clayey SMU - representative site YP1

Depth (m)	pH	ECSAT (dS/m)	Cl (mg/kg)	ESP (%)	Moisture (%)
0–10	6.6	0.00077	<10	1.0	19.9
20–30	6.7	0.00052	<10	1.0	14.3
50–60	6.8	0.00067	<10	1.4	14.8
70–80	7.2	0.00135	<10	1.9	22.7

Depth (m)	CEC (meq / 100g)	Exchangeable cations (meq/100g)				Ca/Mg Ratio	Emerson class no.
		Ca	Mg	K	Na		
0–10	8.6	5.2	2.5	0.8	<0.1	2.1	2
20–30	7.2	4.3	2.4	0.4	<0.1	1.8	2
50–60	6.9	3.6	3.0	0.2	<0.1	1.2	2
70–80	10.9	4.8	5.6	0.2	0.2	0.8	3
Nutrient distribution in topsoil (%)		60.5	29.1	9.3	1.1	-	-

The topsoil is dominated by sand (37%) and silt (36%), with 16% clay and 11% gravel, contributing to a loose and incoherent structure when dry (Table 30). Poor structure is also demonstrated by the low Emerson class number (2) and low Ca:Mg ratio (2.1), indicating a risk of dispersion upon disturbance. However, moderate organic matter content (2.1%) may provide average stability to the surface horizon.

Extractable nutrients are considered poorly balanced with both phosphorus (<5 mg/kg) and nitrate (0.5 mg/kg) concentration well below appropriate levels for plant growth (Hazelton and Murphy 2016). Sulphate (<10 mg/kg) presence in the topsoil is considered marginal and only potassium (1,190 mg/kg)

content is well above suitable concentrations. Extractable metals were mostly highly concentrated within the topsoil, which may induce toxic conditions to plant growth (Government of South Australia 2013). However, boron was detected below suitable concentrations (<0.2 mg/kg) and iron was present at a suitable concentration (35.5 mg/kg) for plant growth. Extractable metal concentrations are significantly under HILs and do not pose a risk to human health (National Environment Protection Measure 2011).

Table 30: Surface soil (0-10 cm) properties of the Clayey SMU

Particle Size Analysis %				Soil Particle Density (g/cm3)	Organic Matter (%)			
Clay	Silt	Sand	Gravel					
16	36	37	11	2.68	2.1			
Extractable Nutrients (mg/kg)				Extractable Metals (mg/kg)				
Phosphorous	Potassium	Sulphate	Nitrate	B	Cu	Fe	Mn	Zn
<5	1190	<10	0.5	<0.2	1.38	35.5	22.7	12.9

4.2 Sandy soil management unit

4.2.1 Soil unit description

Shallow sandy soil unit occupying the southern region of the study area, with extremely low relief (<3%). The profile only consists of a B horizon with clay loam to sandy clay loam textures. Vegetation associated with this unit includes Narrow-Leafed Ironbark (*Eucalyptus crebra*).



Photo Plate 2: Sandy SMU Vegetation

Table 31: Key Sandy SMU Parameters

Parameter	Soil unit description
Profile Site Numbers	YP3, YP4
Observation Site Numbers	OP1, OP2, OP3, OP4, OP5, OP6, OP7, OP8, OP10, OP11, OP12, OP13, OP14, OP17, OP18, OP19, OP21, OP22
Landform	Plains
Australian Soil Classification	Yellow Arenosols
Land System	Disney
Slope	2%
Geology	Wondoola beds
Vegetation	Narrow-Leafed Ironbark (<i>Eucalyptus crebra</i>), Whitewood (<i>Atalaya hemiglauc</i>), Sally wattle (<i>Acacia salicina</i>), Currant Bush (<i>Carissa ovata</i>)
Runoff	Slow
Permeability	Highly permeable (>500 mm/day)
Drainage	Rapidly drained

4.2.2 Profile description

The soil profile was described up to 0.65 m depth, as detailed in Table 32. Surface conditions were defined as loose with 30% ground cover. Field pH is slightly acidic throughout the solum. The profile consists of only a reddish yellow B2 horizon of clay loam texture. Soil structure is described as weak and granular.

No mottling was observed in the dry soil profile.

Table 32: Soil profile characteristics of Sandy SMU

Depth (m)	Horizons	Field pH	Field Colour	Field Texture	Structure	Soil profile
0–0.65	B2	6.5	7.5YR 6/6 Reddish Yellow	Clay Loam	<2 mm Single Grain, Weak, Granular	

4.2.3 Chemical and physical analysis

The pH of the Sandy SMU is moderately acidic throughout the profile with pH values increasing with depth; but remaining within a suitable range for plant growth. The profile is non-saline and non-sodic, indicated by low EC_{SAT} and ESP values. Chloride values are also very low and not expected to impact the osmotic capacity of plants.

CEC is low throughout the solum (7.5–7.7 meq/100g), influenced by the sandy soil texture. Mg cations were detected with moderate to high levels on the soil exchange. Other extractable cations (Ca, K and Na) were present at low concentrations; below the ideal range present on the soil exchange. The nutrient distribution in the topsoil is not favourable as there is an imbalanced proportion of Ca and Mg cations, where Mg concentrations are well above the ideal range. K and Na are present within a suitable percentage.

The Ca/Mg ratio of the profile indicates soil Ca cations are low to deficient, compared to Mg concentration. The solum has a risk of dispersion, supported by the low Emerson class number of 2, where aggregates break down and disperses slightly. Although ESP values suggests non-sodic conditions, it is likely contributed by the extremely low Na concentrations.

Table 33: Chemical properties of the Sandy SMU – representative site YP3/4

Depth (m)	pH	EC _{SAT} (dS/m)	Cl (mg/kg)	ESP (%)	Moisture (%)		
0–10	5.6	0.0219	20	1.9	4.6		
20–30	5.8	0.0260	20	1.7	3.9		
50–60	5.8	0.0223	30	3.3	4.3		
Depth (m)	CEC (meq / 100g)	Exchangeable cations (meq/100g)				Ca/Mg Ratio	Emerson class no.
		Ca	Mg	K	Na		
0–10	7.5	4.4	2.6	0.3	0.1	1.7	2
20–30	7.4	3.9	3.1	0.2	0.1	1.2	2
50–60	7.7	1.8	5.4	0.1	0.2	0.3	2
Nutrient distribution in topsoil (%)		59.5	35.1	4.2	1.2	-	-

The topsoil is dominated by sand (48%), followed by gravel (15%), silt (18%) and clay (13%), described in Table 34. The sandy profile contributes to loose and weak granular structure. This, in conjunction with the low organic matter content (1.3%) suggests poor structural stability of topsoil layer. The topsoil is prone to erosive conditions.

Apart from phosphorus, extractable nutrients were present in the topsoil at concentration suitable for plant life (Hazelton and Murphy 2016). Extractable metals were mostly highly concentrated within the topsoil, potentially inducing toxic conditions for plant growth (Government of South Australia 2013). With the exception of boron, detected below suitable concentrations (<0.2 mg/kg), only iron was present at a suitable concentration (26.9 mg/kg) for plant growth. HILs were not exceeded, and do not pose risks to human health (National Environment Protection Measure 2011).

Table 34: Surface soil (0 -10 cm) properties of the Sandy SMU

Particle Size Analysis %				Soil Particle Density (g/cm³)	Organic Matter (%)			
Clay	Silt	Sand	Gravel					
13	18	48	15	2.61	1.3			
Extractable Nutrients (mg/kg)				Extractable Metals (mg/kg)				
Phosphorous	Potassium	Sulphate	Nitrate	B	Cu	Fe	Mn	Zn
10	536	30	46.7	<0.2	1.18	26.9	53.2	1.95

4.3 Shallow soil management unit

Reddish brown earths containing calcareous segregations, occupy the northeast region of the study area which displays low topographical relief (<3%). The soil profile is made up of a B horizon that grades from loam to light clay. Vegetation associated with this unit includes Brigalow.



Photo Plate 3: Shallow SMU Vegetation

4.3.1 Soil unit description

Table 35: Key Shallow SMU Parameters

Parameter	Soil unit description
Profile Site Numbers	YP5, YP6
Observation Site Numbers	OP18, OP22
Landform	Plains
Australian Soil Classification	Red Calcarosol
Land System	Disney
Slope	0%
Geology	Anakie Metamorphic
Vegetation	Brigalow (<i>Acacia harpophylla</i>), Sally wattle (<i>Acacia salicina</i>), Currant bush (<i>Carissa ovata</i>)
Runoff	Slow
Permeability	Moderately permeable (50–500 mm/day)
Drainage	Imperfectly drained

4.3.2 Profile description

The relatively shallow soil profile was described up to 0.55 m depth (representative site defined as 'YP6', see Appendix B), as detailed in Table 36.

Surface conditions were described as firm with 40% ground cover. Field pH ranged from slightly to moderately alkaline. The profile consists of a relatively shallow B2 horizon, before reaching unconsolidated purplish material defined as the C horizon at 0.3 m depth.

The majority of the profile was noted to be dry except the B22 horizon, which was moist with mottling observed. Segregations were described as common (10–20%) and fine (<2 mm), calcareous and ferruginous. The presence of calcium carbonate segregations contributed to greater pH levels as observed in the field pH tests.

Table 36: Soil profile characteristics of Shallow SMU

Depth (m)	Horizons	Field pH	Field Colour	Field Texture	Structure	Soil profile
0–0.2	B21	7	5YR 5/4 Reddish Brown	Loam	< 2mm, Single Grain, Weak, Granular	
0.2–0.3	B22	8 ½	5YR 4/6 Yellowish Red	Light Clay	5–10 mm, Massive, Moderate, Subangular Blocky	
0.3–0.55	C	9	5YR 6/3 Light Reddish Brown	Light Clay	< 2 mm, Single Grain, Weak, Granular	

4.3.3 Chemical and physical analysis

Laboratory analysis was not conducted for this SMU.

4.4 Silty soil management unit

Yellowish brown soils occurring on level landforms; mapped on the southeast corner of the study area. Soil texture is generally silty, grading from clay loam to silty loam. Vegetation associated with this unit is predominantly *Acacia cambagei* (Gidgee).



Photo Plate 4: Silty SMU Vegetation

4.4.1 Soil unit description

Table 37: Key Silty SMU Parameters

Parameter	Soil unit description
Profile Site Numbers	YP7
Observation Site Numbers	OP16, OP17, OP18
Landform	Plains
Australian Soil Classification	Brown Tenosol
Land System	Disney
Slope	0%
Geology	Anakie Metamorphic
Vegetation	Gidgee (<i>Acacia cambagei</i>), Brigalow (<i>Acacia harpophylla</i>), Sally wattle (<i>Acacia salicina</i>), Currant bush (<i>Carissa ovata</i>), False sandalwood (<i>Eremophila mitchellii</i>)
Runoff	Slow
Permeability	Moderately permeable (50–500 mm/day)
Drainage	Imperfectly drained

4.4.2 Profile description

The soil profile was described up to 0.7 m depth, with the representative site labelled as 'YP7' (Appendix A2). Surface conditions were described as firm with 30% ground cover. Field pH was noted as slightly acidic to slightly alkaline with depth. The profile consists of yellowish brown B2 horizons of loamy texture.

Moisture was noted in the B22 horizon, mottling was noted as common (10 – 20%), fine (<5 mm), distinct, orange and clear ferruginous segregations. The lower profile consisted of weathered bedrock, observed with a gravelly soil texture.

Table 38: Soil profile characteristics of Silty SMU

Depth (m)	Horizons	Field pH	Field Colour	Field Texture	Structure	Soil profile
0–0.2	B21	6.5	10YR 5/8 Yellowish Brown	Clay Loam	< 2mm, Single Grain, Weak, Granular	
0.2–0.4	B22	7	10YR 3/4 Dark Yellowish Brown	Silty Clay Loam	5–10 mm, Massive, Moderate, Polyhedral	
0.4–0.7	B23	7.5	10YR 5/6 Yellowish Brown	Silty Loam	< 2mm, Single Grain, Weak, Granular	

4.4.3 Chemical and physical analysis

Laboratory analysis was not conducted for this SMU.

4.5 Alluvial soil management unit

No soil profile descriptions or field observations were made on the western edge of the study area due to safety and land access constraints. The Alluvial SMU was mapped based on the Digital Atlas of Australian Soils (Bureau of Rural Science 1991), mapped unit 'CC35'. The unit is described as alluvial plains associated with major streams subject to irregular flooding. Soils are grey fine cracking clays with smooth faced peds, underlain by mottled clay.

Field observations noted a section of brown cracking clays (approximately 30 m) among red soil at the flooded water channel (OP15). The presence of cracking clays was likely contributed by flooded conditions detaching and moving soil particles downstream from the Alluvial SMU.

5 Land suitability assessment outcomes

Land suitability assessments were only conducted on SMUs where chemical and physical analyses were available. The land suitability outcomes for the Clayey SMU and Sandy SMU are described in the following sub-sections.

5.1 Water erosion

Table 39 provides the outcomes of the land suitability class assessment on the basis of water erosion. Water erosion is ranked based on slope and soil dispersive characteristics. Soil with steep slopes and strong dispersive characteristics negatively impacts land suitability for agriculture as it can remove valuable topsoil resource, reduce the ability of soil to store water and nutrients, expose subsoil with poor physical and chemical properties, as well as cause deposition in low-lying areas.

Table 39: Suitability subclass on the basis of water erosion

Soil management unit	Limiting features	Suitability subclass
Clayey	Slopes of 0–0.5 % with dispersive soil in the surface 200 mm	1
Sandy	Slopes of 1–3% with dispersive soil in the surface 200 mm	5

5.2 Erosion hazard, subsoil erodibility

Table 40 provides the subclass determination of SMUs identified in the survey area on the basis of erosion hazard and subsoil erodibility. Exposure of subsoil with poor physical and chemical properties may result in hazards such as gully, tunnel or stream bank erosion. Erosion hazards can reduce the available land for agriculture, increase turbidity and nutrient loads in streams, and cause land access issues due to safety concerns.

Table 40: Suitability subclass on the basis of subsoil erodibility

Soil management unit	Limiting features	Suitability subclass
Clayey	Slopes of 0–0.5% with low to moderate dispersive subsoil (200–1,000 mm)	1
Sandy	Slopes of 1–3 % with low to moderate dispersive subsoil (200–1,000 mm)	3

5.3 Soil water availability

Soil water availability may restrict dryland pastures because of the effect on productivity. The PAWC of soil is difficult to measure in the field, so surrogate soil properties are used instead to allocate soils into a subclass as outlined in the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (1995). The surrogate field properties associated with PAWC, and for the subclass determination of SMUs are provided in Table 41.

Table 41: Suitability subclass on the basis of soil water availability

Soil management unit	Limiting features	Suitability subclass
Clayey	Gradational earths, 75–125 cm depth to weathered or hard rock PAWC 100–125 mm	3
Sandy	Clay loams, 50–75 cm depth to weathered or hard rock PAWC 75–100 mm	4

5.4 Narrow moisture range

Narrow moisture range may be considered a limitation for any land uses where cultivation is required. The workability of soils affects the capacity of the soil to support machinery during management practices such as tillage. Table 42 provides the assessment of soil physical properties to infer the narrow moisture range and associated subclass.

Table 42: Suitability subclass on the basis of narrow moisture range

Soil management unit	Limiting features	Suitability subclass
Clayey	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, firm or weakly self-mulching, pedal clays	3
Sandy	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

5.5 Surface conditions

Soil surface conditions for each SMU identified have been assessed with suitability outcomes presented in Table 43. Conditions of surface soil when dry play a direct role in seed germination and establishment. Adverse conditions such as hard setting or crusting of surface soils creates a barrier, reducing seed-soil contact, subsequently impacting plant establishment.

Table 43: Suitability subclass on the basis of surface conditions

Soil management unit	Limiting features	Suitability subclass
Clayey	Soils with soft, firm or only weakly hard setting, sandy to loamy surface horizons	2
Sandy	Soils with soft or loose sandy to sandy loam surface horizons	1

5.6 Rockiness

Table 44 provides the subclass determination of SMUs identified in the survey area on the basis of rockiness. The presence of high stone content in soils may influence soil properties such as increasing infiltration rates while decreasing soil erosion, susceptibility to compaction, soil water storage and the surface area available for plant establishment.

Table 44: Suitability subclass on the basis of rockiness

Soil management unit	Limiting features	Suitability subclass
Clayey	Gravel less than 20 mm and abundance 10–20%	2
Sandy	Gravel less than 20 mm and abundance 10–20%	2

5.7 Microrelief

The microrelief for each SMU identified has been assessed, with subclass presented in Table 45. Microrelief refers to local relief (up to several metres) around the plane of the land (National Committee on Soil and Terrain 2009). Impacts of microrelief on the suitability of land for agriculture are only experienced when soil is severely melonholed. Ponding of water in the depressions can compromise growing conditions directly impacting on productivity.

Table 45: Suitability subclass on the basis of microrelief

Soil management unit	Limiting features	Suitability subclass
Clayey	No microrelief across the majority (greater than 70%) of the land surface	1
Sandy	No microrelief across the majority (greater than 70%) of the land surface	1

5.8 Wetness

The wetness limitation refers to any excess water both in and 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 46 provides the assessment of site drainage and subclass determination.

Table 46: Suitability subclass on the basis of wetness

Soil management unit	Limiting features	Suitability subclass
Clayey	Imperfectly drained and slowly permeable	4
Sandy	Rapidly drained	1

5.9 Summary of land suitability for cattle grazing

Table 47 provides a summary of the assessed land suitability limitation for beef cattle grazing land use.

In the study area, the suitability of land for cattle grazing is most limited by wetness in the Clayey SMU and water erosion in the Sandy SMU.

The Clayey SMU is restricted by soil properties causing imperfectly drained and low permeability profiles. This is demonstrated by mottling observed within the moderately moist horizons of the soil profile, indicating the risk of waterlogged soils with heavy rainfall. Livestock production may be impacted by a reduction in pasture growth.

The overall land suitability class for the Clayey SMU is Class 4; defined as marginal land, and comprising 588 ha of the study area. Additional studies are required to determine whether soil ameliorants (see section 7.3.1) can reduce the limitations of this soil to achieve sustained economic production.

The Sandy SMU was observed on slightly inclined slopes of 2%, with dispersive qualities, causing increased risk of erosion and soil loss. Erosive conditions are evident through field observations, with active rill erosion present within the SMU. Livestock production on this SMU may be impacted through topsoil loss and plant establishment failure.

The overall land suitability class of the Sandy SMU is Class 5; defined as unsuitable land, and occupying 800 ha of the study area. The SMU has extreme limitations that preclude its use for agricultural activities. Some areas within this SMU were previously disturbed by mining activities. Erosive properties contribute to safety hazards within this SMU.

It is noted that the land suitability framework provides guidance in determining land suitability outcomes, however, this determination should also provide consideration to historical and existing land uses. In this instance, it is acknowledged that the pre-mining land use for the Project area was low intensity cattle grazing, as is the current use for the surrounding region. It is therefore inferred that native pastures are adapted to the adverse soil characteristics. On this basis, it is considered that the Project area is suitable for low intensity cattle grazing, carefully managed with the implementation of intensive management regimes to support this land use (see section 6 and section 7).

Figure 6 shows the distribution of land suitability classes for cattle grazing across the study area.

Table 47: Summary of land suitability assessment

Limitation	Clayey SMU	Sandy SMU
Water erosion	1	5
Erosion hazard, subsoil erodibility	1	3
Soil water availability	3	4
Narrow moisture range	3	1
Surface condition	2	1
Rockiness	2	2
Microrelief	1	1
Wetness	4	1
Overall suitability rating	4	5

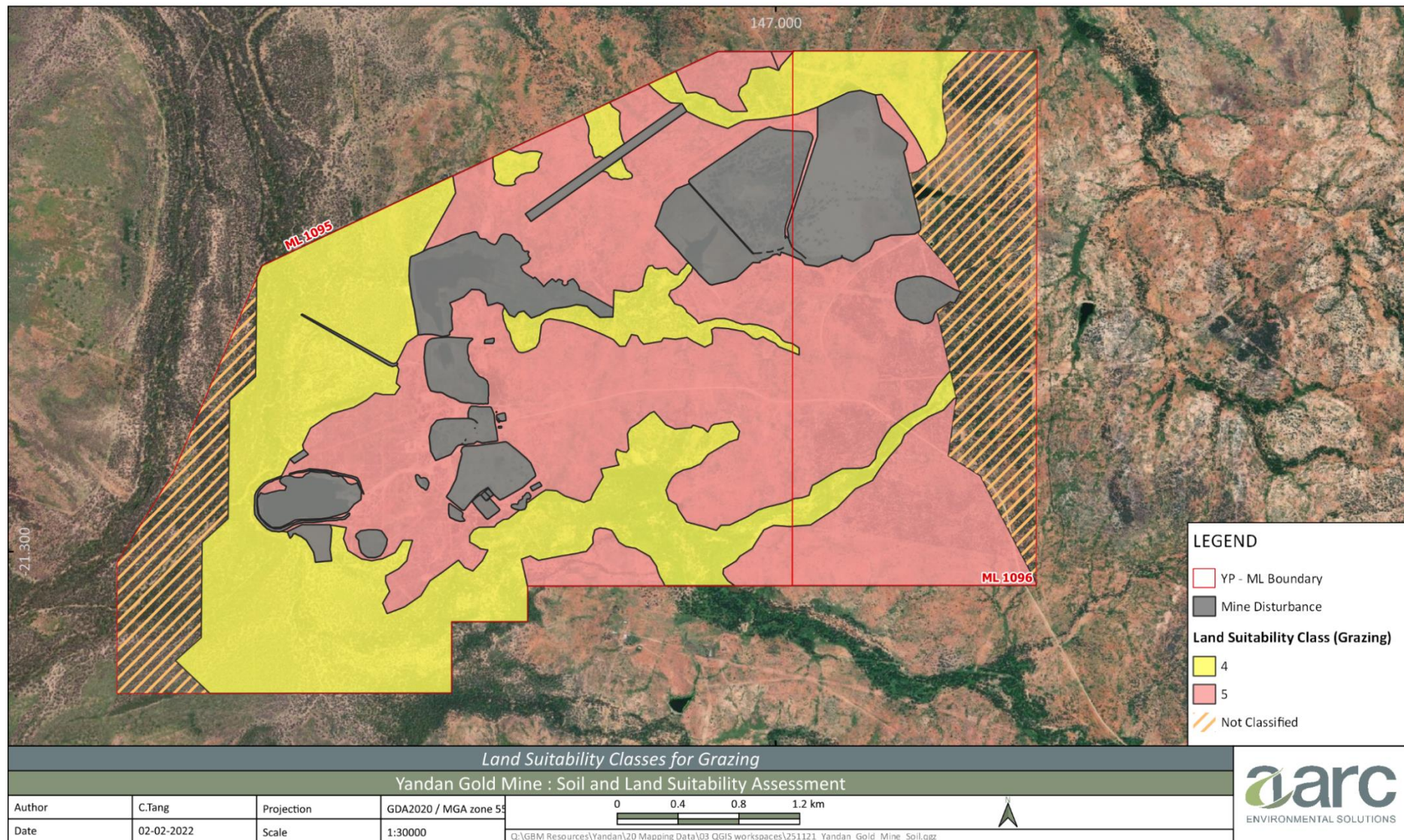


Figure 6: Land suitability classes for grazing pastures

6 Potential impacts and management

Further development on the Project is anticipated in the near-future, subject to resource development and mine planning. Future development is likely to cause additional disturbance within the Project area, and may potentially impact the existing land suitability of the area. To mitigate potential impacts to land suitability a number of measures have been proposed, as detailed within this section.

The existing land suitability classes are detailed in section 5 and summarised in Table 48.

Table 48: Summary of land suitability classes and area of SMUs in the study area

SMU	Land Suitability Class (Grazing)	Area (ha)
Clayey	4*	588
Sandy	5*	800

Note: Green = suitable; red = unsuitable. Items displayed with an asterisk (*) are considered suitable based on current land use of low intensity grazing.

The outcomes of the land suitability assessment indicate the Project area is capable of supporting the land use of cattle grazing, as per the pre-mining land use of the Project area and the surrounding land use.

The economic viability of using rehabilitated land for grazing will be considered based on post-mine land suitability, as well as the total area available for cattle grazing. If developed, improved pastures will likely incorporate 3P (perennial, persistent and palatable) species such as Buffel grass (*Cenchrus ciliaris*) and other exotic grasses to reflect reference conditions. Legume species such as Seca (*Seca stylo*) may also be incorporated in the seed mix for long-term improvements in soil fertility and self-sustaining vegetation.

Mining activities, including stripping, stockpiling and handling of soil, have the potential to impact the physical, chemical and biological properties of soil. Therefore, the land suitability outcome for cattle grazing can be reduced for rehabilitated landforms. The impact of mining activities on soils can be mitigated through:

- good topsoil management practices (see section 7);
- the addition of fertilisers and soil ameliorants (see section 7.3.1);
- grading and shaping (see section 7.4.1);
- timely seeding with suitable species; and
- post-establishment management of rehabilitated areas.

Where 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 reflect that of the pre-mining landscape.

6.1 Topsoil and subsoil stripping impacts and mitigation

Topsoil and/or subsoil stripping is required where land is planned to be disturbed by mining activities to recover soil resources for rehabilitation purposes. The soil is commonly stockpiled until land is available for rehabilitation, or preferably, is stripped and applied directly.

Stripping activities may lead to negative impacts on the chemical and physical attributes of soil, and subsequently the land suitability classification. Impacts associated with topsoil stripping include the following:

- Exposure of dispersive subsoil during soil stripping;
- Loss of soil physical structure due to excavation and handling;

- Loss of soil seedbank; and
- Impacts on soil fertility due to mixing of inviable subsoils and resulting changes in soil chemistry.

Mitigation measures recommended to monitor topsoil stripping procedures include development of a Topsoil Management Plan with the following management aspects:

- Minimising the handling of topsoil.
- Supervision of stripping to determine recovery depth and identify suitable soils.
- Delineation of areas to be stripped and date of stripping.
- Delineation of suitable stockpile areas (as required).
- Ensuring stockpiles are generally less than 2 m high and contours encourage water drainage.
- If topsoil resources are to be stockpiled for a period in excess of six months, testing of soil properties prior to use in rehabilitation should be carried out. The proponent could consider conducting soil physiochemical analysis of stockpiled topsoil resources to assess for changes in topsoil quality (changes to soil chemistry and biological activity as a result of being stockpiled). Key parameters that should be considered during this additional testing, if undertaken, include pH, ESP, CEC (major cations), organic matter content and other essential nutrients such as nitrate, phosphorous and sulphate.
- Delineation of planned areas for direct return of topsoil (as required).
- The application of fertilisers, soil ameliorants and an appropriate seed mix as to increase the likelihood of rehabilitation success (See section 7.3).

6.2 Erosion impacts and mitigation

Disturbance of vegetation and the topsoil layer can lead to the mobilisation of soil through the process of erosion, particularly water erosion from 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 be considered, as appropriate, to reduce the risk and impacts of erosion include:

- limiting land clearing to the minimum amount of land required for the safe operation of the Project;
- diversion of overland flow/runoff around disturbed areas;
- amelioration of dispersive soils through the addition of gypsum, if used in rehabilitation (see section 7.3.2);
- hay mulching using non-feed quality hay/stubble at a rate of 8 t/ha, to be applied immediately after sowing/deep ripping and should be maintained until >50% groundcover is achieved;
- 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 mitigating erosion;
- placing of topsoil stockpiles away from drainage areas, roads, machinery, transport corridors, and stock grazing areas;

- as required, seeding or covering topsoil stockpiles 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 Soil handling recommendations

The following subsections discuss soil management recommendations for identified SMUs within the study area. Recommendations are provided based on the characteristics of SMUs described in section 4.1 (Clayey SMU) and section 4.2 (Sandy SMU).

7.1 Topsoil suitability and stripping

Topsoil stripping is required in planned mining disturbance areas to recover valuable topsoil resource for rehabilitation purposes. The identification and stripping of suitable topsoil is necessary to ensure removal of the maximum volume of viable topsoil and reduce wastage. Subsequent maintenance of topsoil viability must be supervised through employing best practices in soil stripping, stockpiling and spreading activities.

Generally, soil fertility decreases with depth in response to the variation within a number of factors including soil texture, pH, organic matter content etc. Chemical and physical analysis of the SMUs identified in the study area indicates usable soil resources are mainly confined to the surface horizons, which contain seedstock, micro-organisms and nutrients necessary for plant growth.

Where practicable, stripping should be timed to avoid periods of excessive rain or prolonged dry periods. Topsoil should be directly placed in prepared rehabilitation areas and used immediately rather than stockpiled for later use. Where topsoils have been identified as requiring amelioration and where practicable, the areas where they have been re-spread and/or the stockpiles where they have been stored should be delineated and recorded to ensure the appropriate treatment subsequently occurs.

Table 49 summarises the maximum stripping depth recommended for each SMU; a detailed discussion of the recommended topsoil resource depth follows.

Table 49: Recommended topsoil stripping depth for Clayey and Sandy soil management units

SMU	Topsoil stripping depth (m)
Clayey	0.1
Sandy	0.1

Clayey soil management unit (stripping depth 0.1 m)

The Clayey SMU contains low CEC, contributing to limited capacity to retain nutrients on pedal surfaces throughout the profile. Although the solum does not indicate sodicity concerns, it presents dispersive characteristics. However, moderate organic matter content in the top 10 cm of the profile may provide additional stability to the surface horizon along with further nutrients upon decomposition.

A stripping depth of 0.1 m is recommended for the Clayey SMU. The application of this topsoil resource for rehabilitation purposes would benefit from further amelioration to improve productivity of cattle grazing as a PMLU.

Sandy soil management unit (stripping depth 0.1 m)

The top 0.1 m of the Sandy SMU is suitable for most rehabilitation uses, as it contains most nutrients, seedstock and organic matter. The nutrient composition and distribution of this SMU is generally low and unfavourable, therefore would benefit from additional fertiliser application.

The topsoil of this SMU is predominantly composed of sand (48%) and should not be placed on slopes exceeding 3% without consideration of appropriate measures to manage stability. Organic matter content is low, contributing to poor structural stability of topsoil. The profile is non-sodic, however, presents dispersive characteristics and is susceptible to erosive conditions. Amelioration is recommended to improve structural stability of topsoil through the addition of organic matter and/or gypsum (refer section 7.3.1).

7.2 Topsoil stockpiling

Stockpiling of topsoil for extended periods can lead to physiochemical and biological deterioration in the soil and affect the viability of the soil seed bank. Where possible, topsoil should be directly placed in prepared rehabilitation areas rather than stockpiled to assist in maintaining a viable seedbank and promote timely revegetation.

Where stockpiling of topsoil is required, the following recommendations for soil management will reduce the risk of soil degradation and improve the chances of rehabilitation success:

- Stockpiles should generally be less than 2 m high and be constructed and positioned in a manner that encourages water drainage and discourages erosion; and with appropriate erosion and sediment controls in place.
- If there is a risk of a grass cover not establishing voluntarily, stockpiles will need to be ripped and seeded with a quick establishment pasture. Topsoil should ideally be stockpiled for the minimum time. Studies in the Hunter Valley have shown that most deterioration occurs within the first year (Keipert *et al.* 2005).
- Stockpiles should be monitored for erosion and weeds and control measures implemented as appropriate.
- Where soil has been stockpiled for extended periods, soil testing is recommended before use for rehabilitation purposes. If required, fertilisers and soil ameliorants should be applied.

Table 50 shows the estimated volumes of topsoil resource per SMU within the study area, given the stripping depths outlined in Section 7.1.

Table 50: Estimated topsoil resource volumes – study area

SMU	Topsoil stripping depth (m)	SMU area (m ²)	Potential soil volume (m ³)
Clayey*	0.1	5,880,000	588,000
Sandy*	0.1	8,000,000	800,000
Total Topsoil = 1,388,000 m ³			

Notes: SMUs with an asterisk (*) indicate soils where amelioration measures (e.g. liming agents, fertiliser), or actions (e.g. mixing) are considered beneficial to achieve a grazing land use outcome.

7.3 Topsoil placement

The estimated topsoil volumes suggests that the topsoil resource will be sourced predominantly from the Sandy SMU. The Sandy SMU is characterised as having low organic matter content and relatively high sand content, therefore at a greater risk of erosion-induced movement (section 0). For this SMU, establishing a sufficient vegetative cover to mitigate erosion risk is important, particularly as rehabilitated slopes increase. To create a favourable environment for vegetation growth, topsoil from the Sandy SMU will require application of one or more of the amelioration measures outlined in the following sub-sections.

Where possible, placement of topsoil at a minimum thickness of 0.2 m is recommended for rehabilitation areas to create a growth medium of sufficient depth to hold water and support revegetation. For all rehabilitated areas, deep ripping to a depth of 90 cm of the landform after topsoil placement should be undertaken to key the topsoil and subsoil layers together, and to improve seed germination conditions.

7.3.1 Topsoil amelioration

7.3.1.1 Organic matter application

Sandy soils, represented by the Sandy SMU, are characterised by poor soil structure, low moisture retention and low available nutrient concentrations. The addition of organic matter to such soils improves soil structure by creating a binding effect. Humus molecules bind soil particles into aggregates which are more resistant to physical breakdown. The humus molecules increase soil moisture retention, minimise erosion, and provide an important source of nitrogen, phosphorus and sulphur. Where possible, topsoil should be stripped with its existing ground cover vegetation and, if subject to stockpiling, relocated with its cover crop vegetation.

Depending on availability, additional organic matter (such as mulches, manures, or compost), could be incorporated into the topsoil. Organic materials incorporated into the topsoil will increase organic carbon levels, providing more exchange sites for necessary cations, increase water holding capacity, and ensure less organic matter is oxidised into carbon dioxide and nitrous oxide or reduced into methane (Smith *et al.* 2018). Application rates will vary depending on mulch type. Straw mulch should be applied at a rate of 8 t/ha. Note that fresh mulch should not be used in acidic soils. Manure should be incorporated at rates of 5–30 t/ha (depending on the type of manure) (MLA n.d.). If available, compost can be applied at 70–150 t/ha (Kelly 2006).

7.3.1.2 Fertiliser application

The low concentration and imbalanced distribution of nutrients in soils can be ameliorated through fertiliser application. It is noted that some ameliorants (such as ammonium-based fertilisers) can contribute to an acidifying effect, hence, care must be taken when selecting fertiliser types to be applied on acidic soils. The Sandy SMU is moderately acidic (pH of 5.6), requiring lime (calcium carbonate) application to neutralise the acidifying effects of certain fertilisers upon application.

Urea (47% N) is widely applied as it is the most economical nitrogen fertiliser. This fertiliser must be applied in combination with lime as it contributes to acidifying effects. A rate of 150 kg/ha of urea is recommended for soils in low rainfall areas where soil nitrate content is below 3 mg/kg. For best results, nitrogen fertiliser should be incorporated into the ground, either through rainfall soon after broadcasting on the surface or by burying into the soil.

The suggested rate of calcium carbonate is approximately 1 t/ha of lime. It is expected that 1 t/ha of lime (incorporated in the top 10 cm of soil) can increase the pH of sandy soils by 0.57 units (Department of Primary Industries n.d.). A follow up pH test is necessary to evaluate the need for additional lime applications. Lime should be applied initially in small doses, gradually increasing application rates as necessary.

Alternatively, calcium nitrate-based fertilisers such as calcium ammonium nitrate (15 to 27% N) may be selected for their near neutral effect on soil pH, providing both nitrogen and calcium cations. An application rate of 25–50 kg N/ha should be sufficient for successful vegetation establishment (CRDC 2020). Sulphate of potash (41% K) may be applied in conjunction with calcium ammonium nitrate to increase potassium and sulphate levels in soils. The fertiliser is drilled with seeds before spreading onto the soil surface (unlike other potassium fertilisers such as muriate of potash which can have negative effects on seed germination). Typical application rates of potassium for pastures in light soils are 20 kg K/ha (Department of Primary Industries n.d.).

The natural Australian landscape is low in available phosphorus, causing native species to be adapted to low soil phosphorus concentrations. Phosphorus application rates should be considered carefully. Application rates of 10–20 kg P/ha have been suggested for grazing pastures (Victoria Government 2013) and mine restoration (Daws *et al.* 2013). Single superphosphate (8.8% P) may be applied, which satisfies the phosphorus requirements as well as supplying sulphate. It should be noted that this fertiliser should not be blended with urea.

Upon application of soil ameliorants, it is important to incorporate fertilisers into the soil, preferably to a depth of approximately 0.3 m (using a scarifier or ripper tynes). This is to prevent loss of nutrients through wind erosion (blown away) or water erosion (carried/washed away by rainfall). Following vegetation establishment (6 to 12 months after sowing), it is recommended to analyse the chemical and physical properties of topsoil to determine the requirement for any further ameliorants.

Natural methods of increasing soil nitrogen levels may be applied through the incorporation of native leguminous forbs such as *Rhynchosia minima* (Rhynchosia) and *Glycine tabacina* (Variable Glycine) to the seed mix. The legume species are capable of fixing nitrogen, as well as establishing a natural nitrogen cycle within the topsoil resulting in long-term improvements in soil fertility and self-sustaining vegetation.

7.3.2 Gypsum application

The poor structural stability of the Sandy SMU is not aided by the low organic matter content and soil texture. Structural stability issues may be enhanced through addition of gypsum (calcium sulphate), allowing clay particles to form stable aggregates. Soil aeration and water infiltration rates should be improved, minimising runoff and formation of rill erosion. The recommended gypsum application rate (based on the light textured soils of the Sandy SMU) is 2.5–5t/ha of fine grade gypsum to be broadcasted every few years, assuming water application rate of up to 10 mm/h (equivalent to moderately intense rain) (Abbott and McKenzie 1996).

7.3.3 Cover crops

Topsoil loss to erosive processes may be minimised through the establishment of ground cover vegetation. A fast-establishing sterile annual cover crop is recommended to be included in the seed mix. This approach will also suppress weeds and assist in reviving biological processes in the soil, creating a favourable micro-environment for the germination and emergence of the native seeds. Considering the sandy nature of the Sandy SMU topsoil resource, it is recommended that a cover crop is sown at a high seed density, of approximately 30 kg/ha. This should provide a rapid ground cover and assist in achieving soil stabilisation. *Echinochloa esculenta* (Japanese Millet) could be used for summer applications and *Lolium sp.* (Rye Grass) for winter applications. In the transition between cold and warm seasons, a combination of both species should be used.

7.3.4 Hydromulching

The use of hydromulching as an alternative to direct seeding is a further option that can be considered in zones at higher risk of erosion. Hydromulch consists of a semi-liquid water-based mixture composed of seed, water, mulch and other components (such as fertiliser, coir and tackifiers) which can be added depending on the amelioration requirements. The seed mix is included in the hydromulch slurry, which is sprayed onto the revegetation site as a thin layer (approximately 10 mm) to the soil surface, usually at a rate of approximately 50 m³/ha for topsoil applications. The aim of using hydromulch is to cover and protect the soil, together with providing a suitable germination environment for seeds. The use of hydromulch can be effective at controlling erosion and stabilising the soil, by providing an erosion resistant layer for the period of time it takes for vegetation to become established.

7.4 Subsoil management

The study area consists of low ESP soil, with a high risk of dispersion due to low Ca:Mg ratios. Use of subsoil as a resource is not recommended as dispersive soils contribute to low porosity, low air movement and subsequent low oxygen availability for plants.

Dispersive subsoils left exposed after soil stripping presents an erosion and potential downstream sedimentation risk. Appropriate erosion and sediment control methods must be implemented in conjunction with topsoil stripping plans throughout the study area.

7.4.1 Grading and shaping

The Sandy SMU is most prone to water erosion due to its dispersive topsoil qualities with risk increasing as slopes increase. Grading and shaping can improve final appearance, stability, enhance vegetation establishment and reduce overall erosion risk. It is recommended that slopes are graded to as low as possible to improve the chance of achieving a suitable land outcome. Flat terrain minimises runoff and sediment yield, subsequently improving effectiveness of amelioration (e.g. fertiliser and gypsum) and vegetation establishment.

However, in situations where gentle slopes are not achievable, gypsum application (section 7.3.2) and cover crops (section 7.3.3) are recommended as a minimum to manage dispersive characteristics.

8 Material suitability for rehabilitation

Materials suitable for rehabilitation include stripped and stockpiled soil resources, accumulated in various locations throughout the Project area (refer to Section 9).

A number of material characterisation programs have assessed the suitability of these materials for rehabilitation, including sampling conducted by O’Kane Consultants in 2019 (with the suitability of capping materials being the focus of this program). Additional sampling was completed during the 2022 SLSA, with sampling completed for topsoil stockpiles adjacent to the heap leach pad and for the soils contained in the Main Pit levee.

Results from the material characterisation assessments completed by AARC for the 2022 SLSA and previously, by O’Kane Consultants (2019), are summarised in the following sub-sections.

8.1 Available resources and fertility results

Soil fertility of soil resources are assessed as it relates to the chemical properties of the soils and their influence on vegetation growth and establishment. Soil fertility results were assessed against criteria described by Hazelton and Murphy (2016), provided below in Table 51.

Parameters important for soil fertility include pH, electrical conductivity (relates to salinity), nitrogen, phosphorus, potassium and sulphur. Plant growth and establishment may be significantly inhibited by unfavourable concentrations of these parameters, such as high alkalinity (e.g. excess of OH⁻ ions) or high sodicity (e.g. excess sodium ions). Assessing the fertility of topsoil sources to be used for rehabilitation is therefore an important step towards ensuring the establishment of vegetation and ultimately achieving successful rehabilitation.

The suitability of soil sources for rehabilitation are summarised as follows:

- Topsoil sources adjacent to heap leach pad: soil analysis results show topsoil sources have suitable pH for plant growth, are non-saline and non-sodic. Soil fertility is considered adequate with high levels of plant available nitrogen (nitrate) and adequate levels of potassium and sulphur. The topsoil resource may benefit from phosphorus addition to improve soil fertility before application.
- Main Pit levee: soil resources were measured with low pH values, presenting the risk of aluminium toxicity to plant growth. Lime addition would benefit to raise pH into plant growth suitable range. EC and ESP values were low, indicating non-saline and non-sodic soils. Soil potassium and sulphur levels are considered adequate. Soil phosphorus concentrations are relatively high, with potential to cause toxic conditions to plant growth. However, nitrate levels are extremely low therefore requiring fertiliser addition to improve soil fertility before application.
- Various topsoil sources (previously assessed by O’Kane Consulting 2019): soil fertility testing confirmed acceptable fertility characteristics and grading of soils on-site. Some topsoil sources exhibited dispersive qualities and limited water holding capacities. However, it is considered that these materials may still be suitable for use as topsoil.

Table 51: Rehabilitation material fertility results.

		O'Kane Consulting 2019			Yandan SLSA 2022			
Test	Units	Offsite Dam Topsoil (YAN-001)	Tailings Embankment Topsoil (YAN-018)	Tailings Embankment Gravel and Topsoil (YAN-021)	HLP topsoil stockpile #1	HLP topsoil stockpile #2	Main Pit levee	Comments
pH	-	5.7	8.3	6.5	6.2	6.0	4.4	Ranging between strongly acidic to moderately alkaline. Most are within suitable range for plant growth except Main Pit levee, presenting potential for aluminium toxicity to plants.
Electric Conductivity	dS/cm	0.00067	0.00562	0.00637	0.00052	0.00388	0.0327	All considered non-saline, with negligible effects.
Exchangeable Sodium Percentage	%	2.6	9.7	3.7	1.6	<0.1	3.4	ESP values above 6 is considered sodic. YAN-018 is sodic but still within acceptable range (O'Kane Consulting 2019).
Sulphur	%	0.01	0.02	0.02	-	-	-	Negligible impact.
Sulphur	mg/kg	-	-	-	<10	20	400	Negligible impact.
Nitrate	mg/kg	-	-	-	25.6	131	1.8	HLP stockpiles contain high nitrate levels. Main Pit levee has very low concentrations, fertiliser addition would benefit.
Total Nitrogen	mg/kg	690	450	800	600	820	400	Negligible impact.
Total Kjeldahl Nitrogen	mg/kg	660	450	780	580	600	400	Negligible impact.
Extractable Phosphorus	mg/kg	-	-	-	14	<5	34	HLP Stockpile #2 contains low phosphorus levels and would benefit from fertiliser application. High phosphorus concentrations in Main Pit levee may present potential for toxic conditions to plants.

		O'Kane Consulting 2019			Yandan SLSA 2022			
Organic Matter	%	1.4	0.5	1.2	1.5	0.8	0.6	Negligible impact.
Total Organic Carbon	%	0.8	<0.5	0.7	-	-	-	Negligible impact.
Exchangeable Aluminium	meq/100 g	<0.1	-	-	-	<0.1	0.2	Within desired range.
Exchangeable Calcium	meq/100 g	2.9	12	3.3	5.7	2.6	6.1	YAN-001, YAN-021 and HLP stockpile #2 are lower than desired.
Exchangeable Magnesium	meq/100 g	1.1	1.9	2.7	3.1	4.6	7.9	YAN-001 is lower than desired.
Exchangeable Potassium	meq/100 g	0.2	<0.2	0.2	0.5	0.8	0.3	YAN-001, YAN-018 and YAN-021 are lower than desired.
Exchangeable Sodium	meq/100 g	0.10	1.5	0.2	0.2	<0.1	0.5	YAN-018 is higher than desired.
Cation Exchange Capacity	meq/100 g	4.3	15.6	6.6	9.4	8.0	15.5	YAN-001 below desired range.
Calcium/Magnesium Ratio	-	2.6	6.3	1.2	1.8	0.6	0.8	1 – 4 is low in Calcium. 6 – 10 is low in Magnesium.
Magnesium/Potassium Ratio	-	6.4	-	10.9	6.4	5.6	29.5	Within desirable range.

8.2 Material suitability Summary

The results of the material characterisation program are summarised as follows (O’Kane Consultants 2019):

- Potential clay sources: materials from the embankment of the Heap Leach Pond embankment core, upstream of Mine Water Dam and upstream of the Water Storage Dam were found to have good consistency for constructing a barrier layer.
- Potential topsoil sources: soil fertility testing confirmed acceptable fertility characteristics and grading of soils on-site. Some topsoil sources exhibited dispersive qualities and limited water holding capacities. However, it is considered that these materials may still be suitable for use as topsoil.
- Potential growth medium sources: the particle size of material located immediately north of Cell A confirms the suitability of this material as growth medium. Other suitable material adjacent to the tailings storage facility (TSF) has been identified with positive permeability and fertility characteristics. One potential growth medium source displayed slight dispersive characteristics, however, given that growth medium will be located under a topsoil layer this property is not considered a concern.
- Potential coarse rock sources: material sources adjacent to Cell B and the heap leach pad were found to be coarse, well-graded material suitable for use as a capillary break layer.

8.2.1 Amelioration requirements

The results indicate the materials sampled are generally suitable to support vegetation and could be used for as a topsoil and/or growth medium layer of a cover system.

Resources would benefit from amelioration to improve plant establishment and rehabilitation success, as described in section 7.3.1. The SMUs identified in this SLSA describes non-sodic soil profiles with dispersive qualities, soil resources are likely susceptible to erosion. Appropriate erosion and sediment control methods must be implemented throughout the study area.

Based on soil fertility results, amelioration requirements may include:

- lime application to neutralise acidic soil resources;
- gypsum application to improve structural stability; and
- various fertiliser applications to improve nutrient availability in soil.

According to pre-mining and current land use, as well as outcomes of this SLSA, it is anticipated that rehabilitated landforms may be able to support a post-mining land use of cattle grazing. Additional studies are required to determine whether the effect of the limitations can be reduced to achieve sustained economic production.

9 Material balance

Estimates of available rehabilitation materials (including topsoil, growth medium and clay) are available from material volume assessments completed as part of this 2022 SLISA soil survey, and as part of the material characterisation work completed by O’Kane Consultants (2019) for the Cell B cover system design assessment.

Estimated volumes of rehabilitation materials are detailed in Table 52 with locations shown in Figure 7.

Table 52: *Estimated rehabilitation materials available and required*

Material type	Source	Estimated maximum volume (m ³) of material available
Clay	HL Pond Embankment (clay core) ¹	2,430
	Upstream of MWD (clay borrow)	8,000
	Upstream of Water Storage Dam (clay borrow)	380,000
Topsoil	Topsoil (borrows north and south of the TWRD)	80,000
	HLP topsoil stockpile #1	22,000
	HLP topsoil stockpile #2	9,400
	Floodplain Borrow Pit	11,150
	North WSD topsoil stockpile	12,000
	Gravelly topsoil (around the TSF and TWRD)	60,000
	Borrow pits	593,500
Growth medium (including coarse rock)	Gravel / coarse rock (around the TSF and TWRD)	510,000
	Coarse rock from Heap Leach Pad ²	480,000
Dam embankment material (combined)	Mine Water Dam embankment	83,200
	Water Storage Dam embankment	28,200
	Water Harvest Trench embankments	58,500
	Tailings Water Return Dam embankment	104,500
	HL Pond embankment ¹	1,800

¹ HL Pond Embankment was constructed using two materials which has been taken into account for the volume calculation. The HL Pond embankment consists of a 3 m width and 3 m high clay core (for the entire length of the embankment) in addition to being capped with dam embankment material (combined).

² Physical properties of the heap leach pad material indicate the material is suitable for use as coarse rock capillary break layers. Prior to any potential use, a QC/QA and testing program would need to be developed to confirm use of the material. Additional material from the heap leach pad may be suitable for rehabilitation purposes, if required.

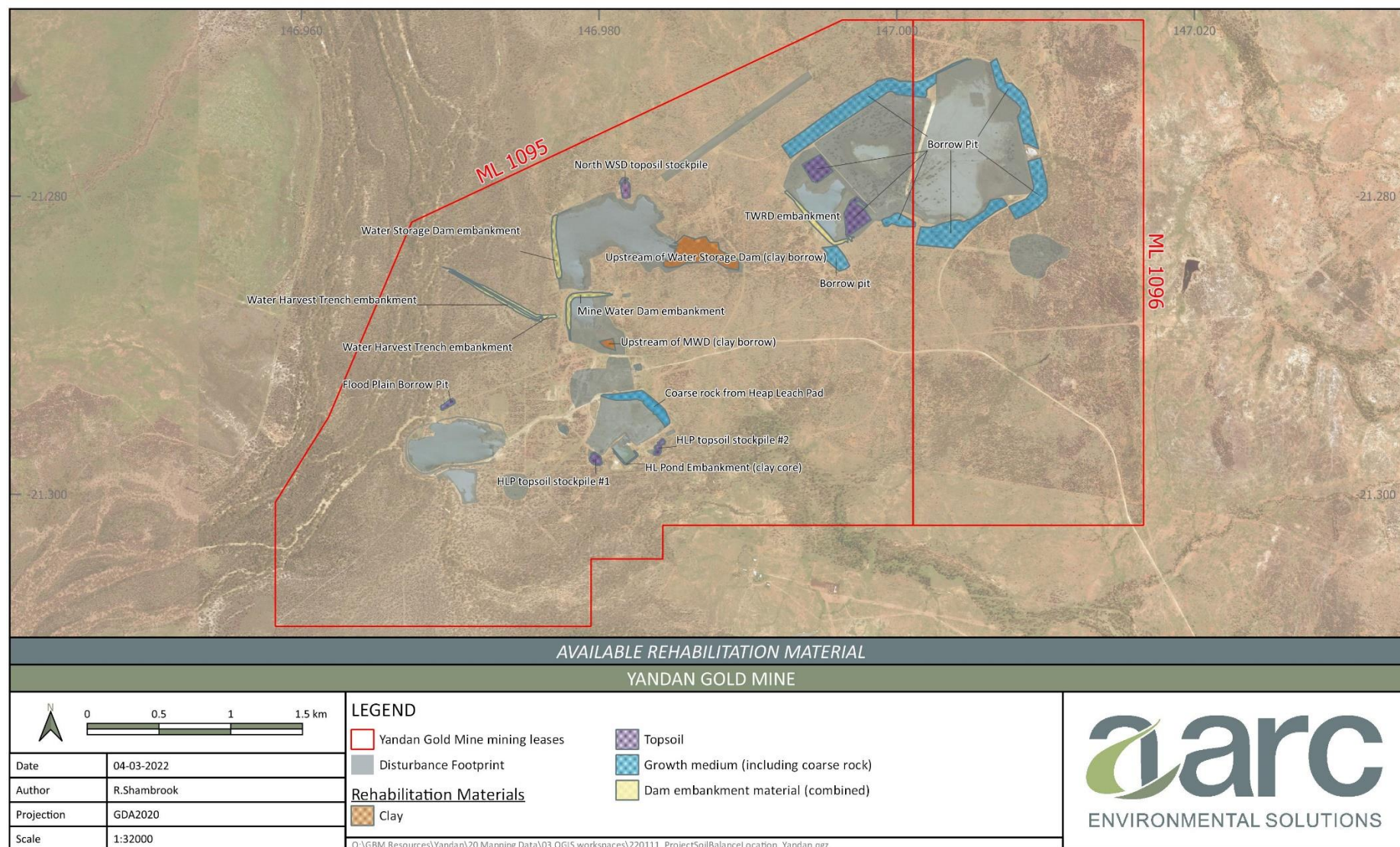


Figure 7: Available rehabilitation material on the Project

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Appendix A. Laboratory Results

Appendix B. Soil Profile Field Data

Site Description

Date:	12/12/21		Site:	YP1	
Location:	North of Cell A		Coordinates:	E 146.9967	N -21.2724
Landform Pattern:	PLA		Micro Relief:	-	
Landform Element:	PLA		Rock Outcrops:	-	
Morphological Type:	F		S C Fragments:	-	
Site Disturbance:	1		Substrate:	-	
Erosion:	0		Surface Condition:	F	
Landform	Elevation:	192m	Permeability:	2	
	Slope (%):	0	Drainage:	3	
	Relief:	0	Run-off:	1	

- dark grayish brown
- mottling in lower profile, making it appear orange (many, fine/medium sized, prominent, clear boundaries)
- Clay loam to silty material to medium clay
- Iron segregations: common occurrence, concretion, very coarse
- slightly acid to neutral pH
- subplastic in last 20cm
- GLM: BD05?

Soil Description

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH
A1	0 – 5		2.5 Y 3/2	NA	CL	-	GW2AB	-	D00N1	6
B11	5 – 20	G	2.5 Y 4/2	NA	ZCL	-	GW1AB	-	D01N1	6.5
B12	20 – 35	A	2.5 Y 4/2	NA	LC	-	GW1SB	-	D01N2	6.5
B13	35 – 60	S	10 YR 4/2	M41POC	ZL	-	GW3SB	3FC32M	T22N1	7
B14	60 – 80	S	10 YR 4/2	M42POC	MC	-	GW2SB	3FC32M	T22U3	7.5

Vegetation: predominantly Brigalow/Gidgee; White Gum

Notes: Very vegetated with grass

Site Description

Date:	11/12/21		Site:	YP2	
Location:	Southwest of Tailings Dam		Coordinates:	E 146.9908	N -21.2843
Landform Pattern:	PLA		Micro Relief:	-	
Landform Element:	PLA		Rock Outcrops:	ME	
Morphological Type:	F		S C Fragments:	-	
Site Disturbance:	1		Substrate:	-	
Erosion:	0		Surface Condition:	F	
Landform	Elevation:	221m	Permeability:	2	
	Slope (%):	0	Drainage:	3	
	Relief:	0	Run-off:	1	

- dark grayish brown
- mottling in lower profile, making it appear orange (many, fine/medium sized, prominent, clear boundaries)
- Clay loam to silty material to medium clay
- Iron segregations: common occurrence, concretion, very coarse
- slightly acid to neutral pH
- subplastic in last 20cm
- GLM: BD05?

Soil Description

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH
O	0 – 2	-	-	-	-	-	-	-	-	6
A2e	2 – 10	-	10 YR 5/4	-	CL	-	GW3SB	-	D01N2	6
B21	10 – 30	A	10 YR 5/6	-	MC	-	GW3PO	-	D01N3	6
B22	30 – 45	A	10 YR 5/4	-	MC	-	GW3PO	-	D01N3	7
B23	45 – 80	G	10 YR 4/4	-	MHC	-	GW2PO	-	D01U3	7 ½

Vegetation: Brigalow/gidgee, wattles

Notes: undisturbed area, sedimentary material, dry creek nearby

Site Description

Date:	11/12/21		Site:	YP3	
Location:	MID of ML		Coordinates:	E 146.9938	N -21.2919
Landform Pattern:	PLA		Micro Relief:	-	
Landform Element:	PLA		Rock Outcrops:	SA/ME/Schist	
Morphological Type:	F		S C Fragments:	-	
Site Disturbance:	8		Substrate:	-	
Erosion:	A R3		Surface Condition:	L	
Landform	Elevation:	196m	Permeability:	4	
	Slope (%):	2	Drainage:	6	
	Relief:	0 – 9m	Run-off:	2	

- dark grayish brown
- mottling in lower profile, making it appear orange (many, fine/medium sized, prominent, clear boundaries)
- Clay loam to silty material to medium clay
- Iron segregations: common occurrence, concretion, very coarse
- slightly acid to neutral pH
- subplastic in last 20cm
- GLM: BD05?

Soil Description

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH
B2	0 – 65	-	7.5 YR 6/6	-	CL	-	GW1GR	-	D0000	6 ½

Vegetation: wattle, bauhinia, ironbark?

Notes: visible erosion, 20% ground cover, slight incline, rocky outcrop east of hole (15m)

Site Description

Date:	11/12/21		Site:	YP4	
Location:	between HLP and MainPit		Coordinates:	E 146.9767	N -21.2954
Landform Pattern:	RIS		Micro Relief:	-	
Landform Element:	HSL		Rock Outcrops:	5SA	
Morphological Type:	S		S C Fragments:	-	
Site Disturbance:	8		Substrate:	-	
Erosion:			Surface Condition:	F	
Landform	Elevation:	188m	Permeability:	4	
	Slope (%):	3	Drainage:	6	
	Relief:	9 – 30m	Run-off:	2	

- dark grayish brown
- mottling in lower profile, making it appear orange (many, fine/medium sized, prominent, clear boundaries)
- Clay loam to silty material to medium clay
- Iron segregations: common occurrence, concretion, very coarse
- slightly acid to neutral pH
- subplastic in last 20cm
- GLM: BD05?

Soil Description

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH
B2	0 – 30	-	5YR 4/4	-	L	-	GW1GR	-	M0000	6

Vegetation: wattle, bauhinia, ironbark?

Notes: very rocky outcrop, surface 5cm dry moist underneath with roots, rock refusal

Site Description

Date:	12/12/21		Site:	YP5	
Location:	Northwest of ML1096		Coordinates:	E 147.0014	N -21.2698
Landform Pattern:	PLA		Micro Relief:	-	
Landform Element:	PLA		Rock Outcrops:	3ME	
Morphological Type:	S		S C Fragments:	-	
Site Disturbance:	5		Substrate:	-	
Erosion:	0		Surface Condition:	F	
Landform	Elevation:	202m	Permeability:	2	
	Slope (%):	2	Drainage:	3	
	Relief:	0 – 9m	Run-off:	1	

- dark grayish brown
- mottling in lower profile, making it appear orange (many, fine/medium sized, prominent, clear boundaries)
- Clay loam to silty material to medium clay
- Iron segregations: common occurrence, concretion, very coarse
- slightly acid to neutral pH
- subplastic in last 20cm
- GLM: BD05?

Soil Description

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH
B21	0 – 10	-	5 YR 4/4	-	L	-	GW1GR	-	D0000	6 ½
B22	10 – 40	S	5 YR 4/6	M1FRD	MC	-	VM3AB	1KFS1	T21U3	7
B23	40 – 60	A	5 YR 4/6	M1FRD	MHC	-	GW2SB	1KFS1	D21U3	8 ½
B24	60 – 70	G	5 YR 3/4	M1FRD	LMC	-	GW2SB	1KFS1	D01U3	8 ½
B25	70 – 80	S	5 YR 3/4	-	LC	-	GW1GR	-	D03N2	9

Site Description

Date:	12/12/21		Site:	YP6	
Location:	East edge of ML1096		Coordinates:	E 147.0123	N -21.2811
Landform Pattern:	PLA		Micro Relief:	-	
Landform Element:	PLA		Rock Outcrops:	-	
Morphological Type:	F		S C Fragments:	-	
Site Disturbance:	1		Substrate:	-	
Erosion:	A R1		Surface Condition:	F	
Landform	Elevation:	209m	Permeability:	2	
	Slope (%):	0	Drainage:	3	
	Relief:	0 – 9m	Run-off:	3	

- dark grayish brown
- mottling in lower profile, making it appear orange (many, fine/medium sized, prominent, clear boundaries)
- Clay loam to silty material to medium clay
- Iron segregations: common occurrence, concretion, very coarse
- slightly acid to neutral pH
- subplastic in last 20cm
- GLM: BD05?

Soil Description

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH
B21	0 – 20		5 YR 5/4	-	L	-	GW1GR	-	D0000	7
B22	20 – 30	G	5 YR 4/6	-	LC	-	VM3SB	3KFS1	M11N2	8 ½
C	30 – 55	A	5 YR 6/3	-	LC	-	GW1GR	-	D11N2	9

Vegetation: gidgee, gum tree

Notes: hit bedrock (purple material); sedimentary

Site Description

Date:	12/12/21		Site:	YP7	
Location:	Southeast edge of ML 1096		Coordinates:	E 147.0134	N -21.2940
Landform Pattern:	PLA		Micro Relief:	-	
Landform Element:	PLA		Rock Outcrops:	-	
Morphological Type:	F		S C Fragments:	-	
Site Disturbance:	0		Substrate:	-	
Erosion:	A G3 (40cm gully)		Surface Condition:	F	
Landform	Elevation:	191m	Permeability:	3	
	Slope (%):	0	Drainage:	4	
	Relief:	0 – 9m	Run-off:	3	

- dark grayish brown
- mottling in lower profile, making it appear orange (many, fine/medium sized, prominent, clear boundaries)
- Clay loam to silty material to medium clay
- Iron segregations: common occurrence, concretion, very coarse
- slightly acid to neutral pH
- subplastic in last 20cm
- GLM: BD05?

Soil Description

Horizon	Depth (cm)	Boundary	Colour	Mottles	Texture	Coarse Fragments	Structure	Segregations	Consistency	Field pH
B21	0 – 20		10 YR 5/8	-	CL	-	GW1GR	-	T01-0	6.5
B22	20 – 40	C	10 YR 3/4	M31DOC	ZCL	-	VM3PO	3FS2	M21N1	7
B23	40 – 70	A	10 YR 5/6	-	ZL	52STRVS (?)	GW1GR	-	D02-0	7.5
						B23 (weathered stuff structure) >> GW4AB				

Vegetation: Brigalow melaleuca, wattle, gidgee

Notes: lower profile consists of weathered bedrock, gravelly; visible erosion

Appendix C. Soil Field Observation Data

Obs	Date	Site ID	Vegetation	Soil description/unit	Notes
1	11/12/21	Centre of ML	Cleared, juvenile ironbark, sparse Sally wattles	Red soil, loose	More densely covered grassland
2	11/12/21	Next to YP4	Ironbark, sally wattle, whitewood	Red soil, very rocky outcrop	Plains in the north and steep slope in the south where the HLP is
3	11/12/21	Close to main pit	Brigalows?	Looks lighter red	Flooded pond, dense vegetation
4	11/12/21	Main pit levee	Brigalows?	Rocky, very red	High elevation of levee, pronounce erosion (40cm depth)
5	11/12/21	HLP	Brigalows?	Brownish red, boulders around, rocky	-
6	11/12/21	South of pit	Cleared, with vegetation further south	Brownish red, rocky	No sign of active erosion, large channel/ depression from previous erosion?
7	11/12/21	HLP 2	Brigalows?	Brownish red, boulders around, rocky	-
8	11/12/21	HLP 2	Brigalows?	Brownish red, boulders around, rocky	Erosion observed
9	11/12/21	Close to Sandy Creek	Ironbark	Clayey soils, reddish/yellowish brown	
10	11/12/21	Centre of ML	Cleared juvenile ironbark, sparse	Sandy, red	On road
11	11/12/21	Tailings return water dam	Gidgee?	Red soils, sandstone	On stockpile
12	11/12/21	Near airstrip Water dam	Gidgees/ Brigalow	Red soils	Looking east

Obs	Date	Site ID	Vegetation	Soil description/unit	Notes
13	11/12/21	Water storage dam	Gidgees/Brigalow to west	Lighter red soil	-
14	11/12/21	Water channel	Brigalow, sally wattle	Rocky reddish brown	-
15	11/12/21	Mid water channel	Brigalow	Cracking clay, brown, only 30m of it	Washed up from creek when flooded
16	12/12/21	Edge of ML	Mostly Brigalow and gidgee	Brownish red, silty stuff	A lot of erosion
17	12/12/21	Soil boundary edge ML	Gidgee more abundant in the east	Lighter red	erosion
18	12/12/21	Soil boundary NW ML edge	Brigalow/gidgee in east, ironbark NW		Between S19 and Qa14?
19	12/12/21	NE ML Edge	Brigalow/gidgee in east, west cleared	Redder soil to west	-
20	12/12/21	North ML edge	Brigalow/gidgee	Qa14? red duplex?	Next to cleared area
21	12/12/21	Cell A embankment	Brigalow/gidgee to east	Red, rocky surface soil, loose	Mine disturbed
22	12/12/21	Boundary between soil Atlas types	Brigalow/gidgee in east Ironbark in west	-	-
23	12/12/21	Main pit overflow	Brigalow/gidgee	Brown reddish	



Yandan Gold Project

Erosion Stability Assessment

PREPARED FOR
Straits Gold Pty Ltd

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List of Abbreviations

AARC	AARC Environmental Solutions Pty Ltd
EA	Environmental authority
ML	Mining lease
PMLUP	Post mine land use plan
PRCP	Progressive rehabilitation and closure plan
RMP	Rehabilitation monitoring program
RUSLE	Revised Universal Soil Loss Equation
TSF	Tailings storage facility

1 Introduction

AARC Environmental Solutions Pty Ltd (AARC) has been commissioned by Straits Gold Pty Ltd (Straits Gold) to complete an erosion stability assessment for the Yandan Gold Project (the Project, Yandan).

This assessment has been prepared to satisfy information requirements of the *Guideline — Progressive rehabilitation and closure plans* (PRCP Guideline, DES 2021). Specifically, being the completion of erosion modelling to predict the long term stability of final landforms at the Project.

Erosion modelling for this assessment uses the Revised Universal Soil Loss Equation (RUSLE) to predict long term stability outcomes for final landforms (both existing and proposed) on site. The RUSLE analysis predicts long term average annual soil loss values based on factors such as rainfall erosivity, slope steepness and length, soil properties, groundcover, and land management factors.

This modelling was used to assess the erosional stability of specific rehabilitation areas of the Project that have a high-risk of erosion, being the tailings storage facility (TSF) embankments and the Heap Leach Pad. This modelling also assessed the erosional stability of the existing rehabilitated South Pit area.

1.1 Scope

The following scope of works has been completed for the erosion stability assessment:

- review of landform design for the rehabilitated South Pit area, the TSF embankment and the Heap Leach Pad;
- review of rehabilitation monitoring data associated with the rehabilitated South Pit area;
- collection of soils data from the three areas of interest for input into the erosion model;
- erosion modelling (RUSLE analysis) for slopes in the final landform;
- provide recommendations of suitable landform design criteria and vegetation cover criteria for inclusion in the PRCP; and
- provide recommendations of other management actions and measurable objectives to ensure long term stability of rehabilitated slopes.

This assessment incorporates modelling and analysis of theoretical surface erosion risk for structures. The assessment does not address geotechnical stability of the constructed landforms or the associated risk of mass failure.

2 Background

2.1 Rehabilitation areas potentially subject to erosion

The assessment identified key areas considered to be at risk of long term surface erosion based on:

- characteristics of the final landform design;
- existing erosion / rehabilitation monitoring data;
- site specific environmental factors; and
- an understanding of material properties available for use in rehabilitation on the site.

Rehabilitation of existing mine disturbance was partially complete across the site at the time of this report. Three rehabilitation areas were identified for further analysis including:

- the backfilled and rehabilitated South Pit area;
- the TSF main embankment (yet to be rehabilitated); and
- the Heap Leach Pad (yet to be rehabilitated).

Although the recommendations of this assessment apply directly to these three structures. It is reasonable to assume that equivalent measures could be adopted for other similar landforms at the Yandan site.

2.2 EA Landform design requirements

Post mining land use descriptions for land disturbed by mining activities are established in the Project's Post Mine Land Use Plan (PMLUP) (identified as an applicable land outcome document for PRC Plan purposes) (AARC 2018), as detailed in Table 1. Post mining land use descriptions established in the PMLUP are consistent with Condition F2-1, Schedule F – Table 1 of the Environmental Authority (EA) for the Project (EPML00771913).

Landform design criteria (e.g. slope angle, maximum slope length) for final landforms are not defined in the Project EA.

Table 1 : Post Mine Land Description (after Table 1 from AARC 2018)

Tenure ID	Disturbance type	Associated infrastructure ¹	Maximum surface area (ha)	Post-mine land description	Post mine land classification
ML1095	Backfilled pit	South Pit	4	Open pasture	VII
	Tailings dam	Cell A Cell B TWRD Spillway	39	Open pasture	VII
	Stockpile area	Topsoil Stockpile	8.3	Open pasture	VII
	Run-off dam	Mine Water Dam	16.6	Water storage	VII
	ROM pad	ROM Pad	3.8	Low hill	VII
	Processing Plant	Hardstand Area	1.8	Open pasture	VII
	Open pit	Main Pit East Hill Pit	18.8	Lake	Void

Tenure ID	Disturbance type	Associated infrastructure ¹	Maximum surface area (ha)	Post-mine land description	Post mine land classification
	Infrastructure	Tailings Water Return Dam Water Storage Dam ¹ Water Harvest Trench Roads Airstrip	79.8	Open pasture	VII
	Heap Leach	Heap Leach Pad (HLP) HLP Stormwater Pond Pregnant Pond Barren Pond	21	Low hill	VII
	Borrow pit	Borrow pit	8	Open pasture	VII
	Exploration	Exploration areas	4.5	Open pasture	VII
ML 1096	Village infrastructure	Village infrastructure	15	Open pasture	VII
	Tailings Dam	Cell A Cell B	75	Open pasture	VII

¹ Water Storage Dam to be retained in final landform under landholder agreement

2.3 Additional landform design considerations

The final landform design for key infrastructure is provided below.

TSF Embankment

Yandan Tailings Dam is comprised of two cells: being Cell A (containing exclusively oxide tailings) and Cell B (containing predominantly oxide tailings, overlaying sulphide tailings). Cell A of the facility has been fully rehabilitated (circa 1999–2000), while Cell B has remained unrehabilitated since closure pending use for future mining operations.

It is understood that the embankment of the TSF was constructed with a central clay core, with this material borrowed from around the perimeter of the TSF (Greater Boulder Holdings Ltd 1988). Clay cores are effective in restricting seepage from reporting to the receiving environment, and in this instance, it is also understood to have the dual purpose of preventing upstream waters from infiltrating the facility and wetting the tailings. Given the TSF was constructed across a minor drainage channel, some ponding occurs against the upstream wall which is located within the top of the catchment. The inclusion of a clay core in the embankment walls was therefore an important consideration for the long term stability and function of the facility.

A slope analysis was conducted over the current (unrehabilitated) embankment of the TSF, principally on the Main Wall (downstream face of the TSF). Several cross sections were analysed on the Main Wall showing a slope length of 35 m and a slope gradient of 33%. To minimise the potential of surface / soil erosion as a consequence of steep slopes an alternate design is proposed. Backfilling on the downstream face of the wall is proposed to achieve 30% grade slopes with 20 m horizontal length and a single, intermediate flat bench of 5 m (Figure 1). This proposed final landform design forms the basis of further erosion assessment in this report.

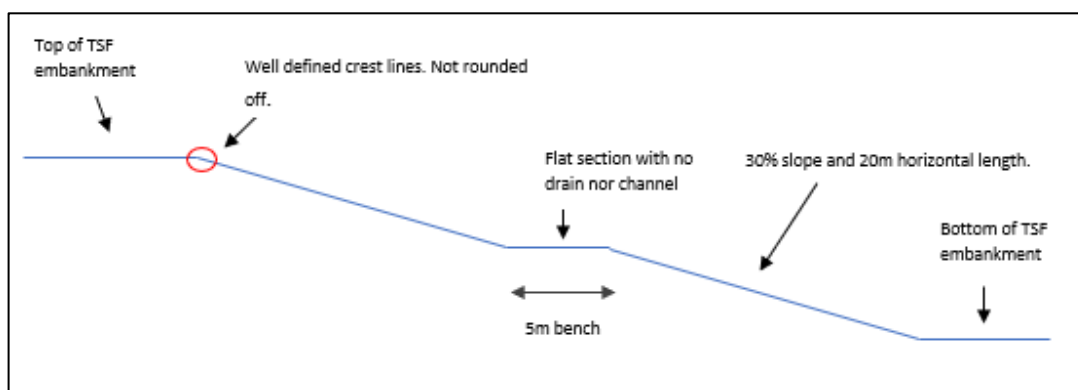


Figure 1: Final landform design of TSF Cell A Main Wall

Heap Leach Pad

The existing Heap Leach Pad is approximately 550 m (L) x 450 m (W) x 26 m (H), covering an area of approximately 16.9 ha. The coarse rock material has been end-dumped and dozed in two ten m lifts, and one six m lift, at or below the natural angle of repose.

The final landform design proposes a downward push of material from the top of the Heap Leach Pad, to regrade the existing landform to a slope of grade of 25% with 5 m benches every 30 m (Figure 2). Benches are used to break continuous slopes and special care should be taken when constructing the benches, to ensure they do not concentrate water and potentially cause erosion. The top of the facility will also be graded from centre to edge to achieve a water shedding design.

Following re-shaping works, the facility is to be capped using a minimum of 0.5 m of top rock and a minimum of 0.15 m of topsoil, with the final landform to be seeded with pasture species. The erosional stability of the Heap Leach Pad has been done considering the proposed design. This proposed final landform design forms the basis of further erosion assessment in this report.

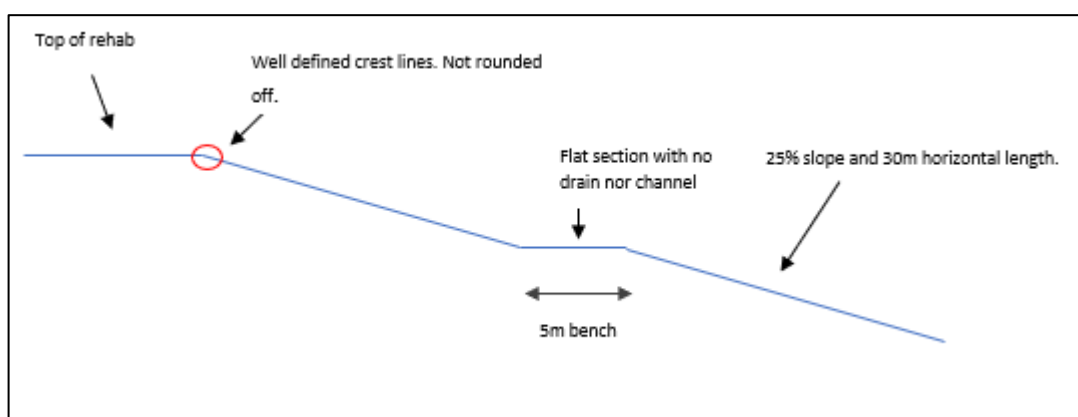


Figure 2: Final landform design of the Heap Leach Pad

3 Rehabilitation monitoring

The Yandan Rehabilitation Monitoring Program (RMP) was established in 2014, providing annual monitoring of the progress of rehabilitated domains towards successful rehabilitation. The RMP assesses the ecological condition of rehabilitated sites, using metrics related to vegetation cover and structure, vegetation composition, and erosion stability. The ecological data collected from rehabilitated sites was compared to reference site data, with a view to measuring the long term success of rehabilitated areas.

The rehabilitated South Pit area is a fully rehabilitated domain at Yandan, with results of the RMP suggesting that the site is on trajectory to achieving completion criteria. The rehabilitated South Pit area is proposed as a site specific benchmark for successful rehabilitation at the Yandan site, and as such forms the focus of this section.

3.1 Monitoring locations

The RMP provides for monitoring over a total of 21 sites, with these located across progressive rehabilitation sites, cover trial sites on Cell B of the TSF, and reference sites. Three of these sites are located within the rehabilitated South Pit area, as shown in Table 2 and Figure 3.

Table 2: Rehabilitation monitoring sites in the rehabilitated South Pit area

Site Name	Start MGA (GDA 94)		End MGA (GDA 94)	
	Easting	Northing	Easting	Northing
SP1	497367	7644773	497316	7644776
SP2	497379	7644712	497335	7644738
SP3	497373	7644677	497322	7644670

3.2 Rehabilitation monitoring methodology

The RMP methodology includes the following components:

- vegetation monitoring at established monitoring transects using standard methods adapted from the Queensland Herbarium survey technique titled *Methodology for Surveying and Mapping of Regional Ecosystems and Vegetation Communities in Queensland* (Version 5.1) (Neldner *et al.* 2020), and the *Method for the Establishment and Survey of Reference Sites for BioCondition* (Eyre *et al.* 2017);
- photographic monitoring from permanent photo points within the rehabilitated areas; and
- erosion monitoring including feature type, rill number and depths.

Monitoring data for the rehabilitated South Pit area was available for the 2017–2021 period.



Figure 3: Monitoring transects in the rehabilitated South Pit area

3.3 Monitoring results

3.3.1 Groundcover

Rehabilitation monitoring indicates total live cover was similar between the 2020 and 2021 monitoring events, with the rehabilitated South Pit area found to have slightly decreased in vegetation cover over the monitoring period. This finding was consistent with the reference sites and is considered reflective of local rainfall patterns and grazing activity within the rehabilitated areas and reference sites. Generally, total live cover provided a dominant portion of ground cover at the South Pit, with an average over the three monitoring points of 39% in 2021. Furthermore, average for the 2017–2021 period yields an average of 42%, with SP2 having the highest value at 51% (Table 3).

Table 3: Total live cover at rehabilitated South Pit area sites

Site	Monitoring Survey	Total Live Cover (%)	Average for site (%)
SP1	Jul-17	41	41
	May-18	34	
	Feb-19	41	
	Aug-20	46	
	Mar-21	41	
SP2	Jul-17	61	51
	May-18	41	
	Feb-19	62	
	Aug-20	54	
	Mar-21	39	
SP3	Jul-17	43	35
	May-18	20	
	Feb-19	56	
	Aug-20	22	
	Mar-21	36	
TOTAL			42

The composition of total live cover at the rehabilitated South Pit area was predominantly from exotic pasture species followed by forbs. Non pasture species have had a marginal contribution during the five monitoring periods while native pasture species, shrubs and invasive weed species have had no contribution (Table 4).

Table 4: Live cover composition at rehabilitated South Pit area monitoring sites

Site	Monitoring Survey	Non-Pasture Species (%)	Exotic Pasture Species (%)	Native Pasture Species (%)	Shrubs (%)	Forbs (%)	Invasive Weed Species (%)	Total Live Cover (%)
South Pit	Jul-17	1	42	0	0	5	0	48
	May-18	1	27	0	0	3	0	31

Site	Monitoring Survey	Non-Pasture Species (%)	Exotic Pasture Species (%)	Native Pasture Species (%)	Shrubs (%)	Forbs (%)	Invasive Weed Species (%)	Total Live Cover (%)
	Feb-19	1	47	0	0	7	0	56
	Aug-20	0	37	0	0	3	0	41
	Mar-21	0	33	0	0	5	0	38

3.3.2 Species richness

The mean total species richness across reference and the rehabilitated South Pit area sites was lower in the 2021 monitoring period when compared to the 2020 monitoring period. Total species richness across the rehabilitated South Pit area appears to have reduced slightly in comparison with the four preceding monitoring events (2017–2020), with an average of 21 species recorded during 2017–2020, and an average of 18 species during the current monitoring event. Nevertheless, in comparison with the reference sites, the rehabilitated South Pit area species richness has consistently been higher for the last three monitoring periods (2019–2021) (Figure 4).

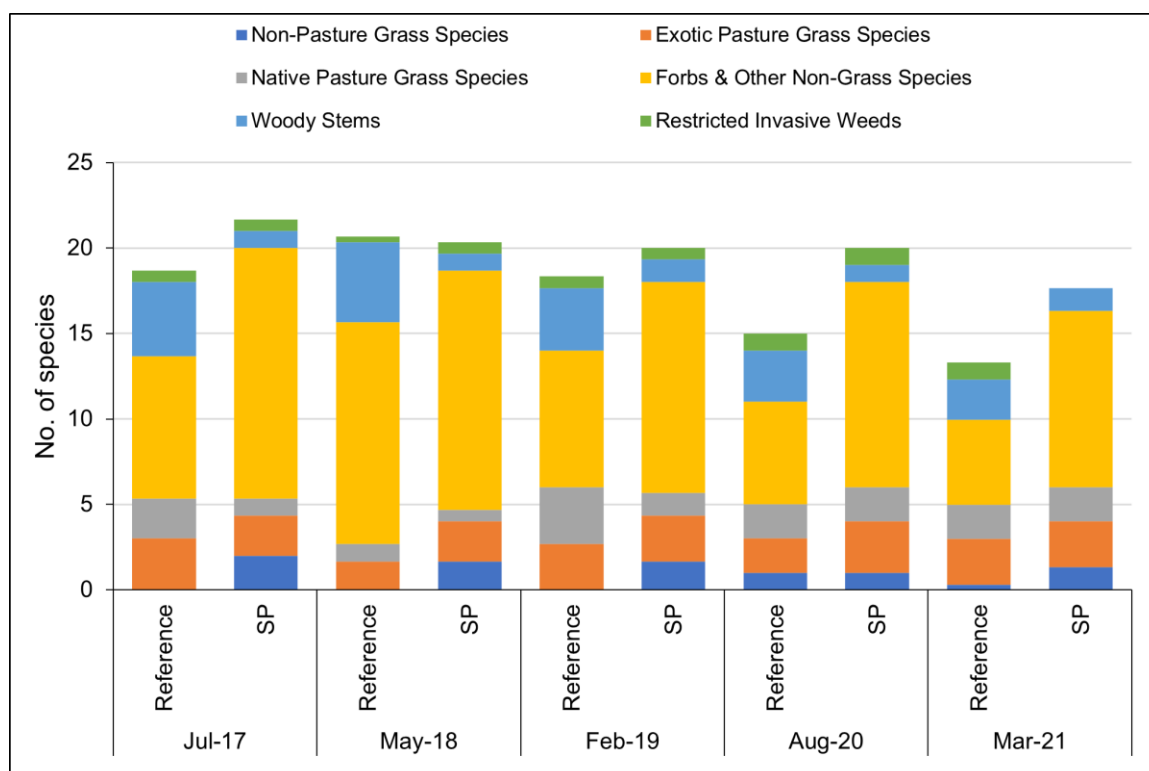


Figure 4: Mean species richness at reference and the South Pit sites

3.3.3 Erosion characteristics

A summary of erosion monitoring from 2017 to 2021 surveys is provided in Table 5. Erosion conditions at the reference and rehabilitated South Pit area sites have been recorded as minor over the past five monitoring years. All sites consistently observed 0 to 15 cm rills. Low levels of erosion in the form of small rills and short depths have remained constant at most rehabilitation transects with no further deterioration since the 2017 survey.

3.3.4 Monitoring conclusions

Overall, the rehabilitated South Pit area supports a well-established pasture community that is generally consistent with reference sites. The data demonstrates sustainable ecosystem function over at least 4 years, including periods of variable rainfall and livestock grazing pressures. Erosion monitoring indicates surface soils are stable and non-erosive. Monitoring data indicates that rehabilitation objectives are generally met for the rehabilitated South Pit area. Erosion modelling of the rehabilitated South Pit area in the following sections provides a performance benchmark for comparison with future rehabilitation areas.

Table 5: Extent of erosion at reference and South Pit sites

Monitoring Sites		R1	R2	R3	SP1	SP2	SP3
Jul-17	Number of rills	<15	<15	<15	<15	<15	<15
	Average depth of rills (cm)	<10	<10	<10	<10	<10	<10
	Erosion classification	minor	minor	minor	minor	minor	minor
May-18	Number of rills	<15	<15	<15	<15	<15	<15
	Average depth of rills (cm)	<10	<10	<10	<10	<10	<10
	Erosion classification	minor	minor	minor	minor	minor	minor
Feb-19	Number of rills	<15	<15	<15	<15	<15	<15
	Average depth of rills (cm)	<10	<10	<10	<10	<10	<10
	Erosion classification	minor	minor	minor	minor	minor	minor
Aug 20	Number of rills	<15	<15	<15	<15	<15	<15
	Average depth of rills (cm)	<10	<10	<10	<10	<10	<10
	Erosion classification	minor	minor	minor	minor	minor	minor
Mar-21	Number of rills	<15	<15	<15	<15	<15	<15
	Average depth of rills (cm)	<10	<10	<10	<10	<10	<10

Monitoring Sites		R1	R2	R3	SP1	SP2	SP3
	Erosion classification	minor	minor	minor	minor	minor	minor

4 RUSLE analysis

The RUSLE analysis was developed to predict long term average annual soil loss based on factors that include rainfall erosivity, slope steepness and length, soil properties, groundcover and management factors (Loch and Roswell 1992). The equation was originally developed by US Department of Agriculture in the late 1950s for plot scale soil conservation purposes, although it later gained acceptance in broad scale applications. As noted by Lu et al. 2001, erosion is considered unacceptable when soil loss is more than 10 t/ha/yr; this value has been used as the threshold for comparison of assessed values for the Project

RUSLE analysis was applied to the rehabilitated South Pit area, TSF embankments and the Heap Leach Pad to assess existing and proposed landform design criteria and assist in identifying suitable completion criteria for inclusion in the PRCP.

Methodology and calculation for each RUSLE parameter is described in section 4.1 and the results are presented in section 5.

4.1 Methodology

The RUSLE calculation for mean annual soil loss (t/ha/yr) as used for the Project is a product of five variables.

$$A = R K L S C P$$

Where:

A = Average annual soil loss (t/ha/yr)

R = Rainfall erosivity factor

K = Soil erodibility factor

LS = slope length/gradient factor

C = ground cover and management factor

P = Supporting practice factor

The following considerations are taken for each of the RUSLE variables:

- the rainfall erosivity factor (R) and the supporting practice factor (P) are the same for all three areas of study (section 4.1.1 and section 4.1.5).
- the soil erodibility factor (k) and the slope length/gradient factor (LS) are specific for each of the three areas of study (section 4.1.2 and section 4.1.3).
- the cover and management factor (C) has been empirically calculated for the South Pit only, as that area has established and well-sustained ground cover. Assumed cover values were adopted for the two areas of future rehabilitation. Adopted values considered the slope risk and expected achievable revegetation outcomes.

4.1.1 Rainfall erosivity factor (R)

This factor is a measure of the ability of rainfall to cause erosion. It was calculated utilising the dataset available from the Queensland Spatial Catalogue and then overlaying the Project mining leases. Individual pixel values of rainfall erosivity were then obtained within the ML boundaries. The total range of R values for the different Project locations are shown in Table 6. The average of all values was selected for the analysis.

Table 6: Rainfall Erosivity Factors

R - value	
R ₁	2191.7
R ₂	2207.6
R ₃	2192.2
Average	2197.17

4.1.2 Soil erodibility factor (K)

Soil erodibility factor (*K*) is a measure of the susceptibility of the soil to erosion. For this Project the calculation of the *K*-factor was done using the following equation elaborated for Australian soils (Lu *et al.* 2001):

$$K = 2.77 (100 P_{125})^{1.14} (10^{-7}) (12 - 2 O_c) + 3.29 (10^{-3})(Pr - 3)$$

Where:

P_{125} = Percentage of particles with diameter less than 0.125mm

O_c = Percentage of organic carbon

Pr = Soil permeability rating

In December 2021, 22 soil samples from across the Project were collected and sent for laboratory analysis. The results were used to calculate the *K*-factor for the soils within the areas of interest (being the rehabilitated South Pit area, Heap Leach Pad and TSF embankment). The P_{125} and O_c values were directly obtained from the lab results. The soil permeability rating was estimated from the soil management units and according to the following scale (Rosewell 1993):

6 = very slow (<1 mm per hour)

5 = slow (1 to 5 mm per hour)

4 = slow to moderate (5 to 20 mm per hour)

3 = moderate (20 to 60 mm per hour)

2 = moderate to rapid (60 to 130 mm per hour)

1 = rapid (> 130 mm per hour)

Typically, Queensland soil *K* factors range between <0.01 (very low) to >0.06 (very high). Table 7 provides typical *K* factors for different soil groups in Queensland.

Table 7: Soil erodibility classes (Hazelton & Murphy 2016)

Rating	<i>K</i> value	Expected soil erodibility of soil groups
Very low	0.00-0.01	Red Chromosol
Low	0.01-0.02	Dermosol
Moderate	0.02-0.04	Red Chromosol, Red Ferrosol, Red Dermosol
High	0.04-0.06	Vertosols, Dermosols, Red Chromosol
Very High	>0.06	Exposed sodic soils

4.1.2.1 Rehabilitated South Pit area

The outcomes of the soil analysis for the rehabilitated South Pit area are shown in Table 8. Results show that soils have low erodibility.

Table 8: *K values for the South Pit*

Location	Sample	P ₁₂₅ (%)	O _c (%)	Permeability Rating	K value
South Pit	South Pit 0-10	38.64	0.93	1	0.028

4.1.2.2 TSF embankment

The outcomes of the soil analysis for the TSF embankment are shown in Table 9. Results show that local soils / growth mediums range from moderate to high erodibility class. This is due to a combination of low organic carbon content and high content of sand in the soil which results in poor soil structure.

Table 9: *K values for the TSF embankment*

Location	Sample	P ₁₂₅ (%)	O _c (%)	Permeability Rating	K value
TSF Embankment	Cell A – Main Wall #1	46.64	0.93	1	0.036
	Cell A – Main Wall #2	53.42	1.28	1	0.039
	Cell A – northern perimeter embankment	72.75	0.47	1	0.071

Where alternate topsoil sources are not otherwise available, amelioration measures are proposed for soils placed on the final TSF main embankment slope to reduce its erodibility. Organic matter (such as hay mulch) and gypsum application is recommended to improve soil structure by creating a binding effect and it will increase organic carbon levels. Gypsum (calcium carbonate) will increase the structural stability of sandy soils by allowing clay particles to form stable aggregates. Soil aeration and water infiltration rates may also be improved, minimising runoff and formation of rill erosion. In consideration of the proposed amelioration actions, a *K*-factor similar to that recorded at the rehabilitated South Pit area (*K* = 0.028) was applied in the RUSLE analysis.

4.1.2.3 Heap Leach Pad

The outcomes of the soil analysis for the Heap Leach Pad are shown in Table 10. Like the results of the TSF embankment, the Heap Leach Pad results show that soils range from moderate to high erodibility class as a consequence of low organic carbon content and a high content of sand.

Table 10: *K values for the Heap Leach Pad*

Location	Sample	P ₁₂₅ (%)	O _c (%)	Permeability Rating	K value
Heap Leach Pad	Heap Leach Pad	36.89	0.29	1	0.030
	Heap topsoil stockpile #1	75.82	0.87	1	0.069
	Heap topsoil stockpile #2	49.57	0.47	1	0.043

Where alternate topsoil sources are not otherwise available, amelioration measures are proposed for soils placed on the final heap leach slopes to reduce its erodibility. Organic matter (such as hay mulch) and gypsum application is recommended to improve soil structure by creating a binding effect and it will increase organic carbon levels. Gypsum (calcium carbonate) will increase the structural stability of sandy soils by allowing clay particles to form stable aggregates. Soil aeration and water infiltration rates may also be improved, minimising runoff and formation of rill erosion. In consideration of the proposed amelioration actions, a K-factor similar to that recorded at South Pit ($K = 0.028$) was applied in the RUSLE analysis.

4.1.3 Slope length/gradient factor (LS)

4.1.3.1 Rehabilitated South Pit area

The slope length/gradient factor (LS) describes the combined effect of slope length and slope gradient on soil loss. A digital elevation model of the site was utilised to calculate the LS -factor from representative cross sections at the South Pit as shown in Figure 5 to Figure 7.

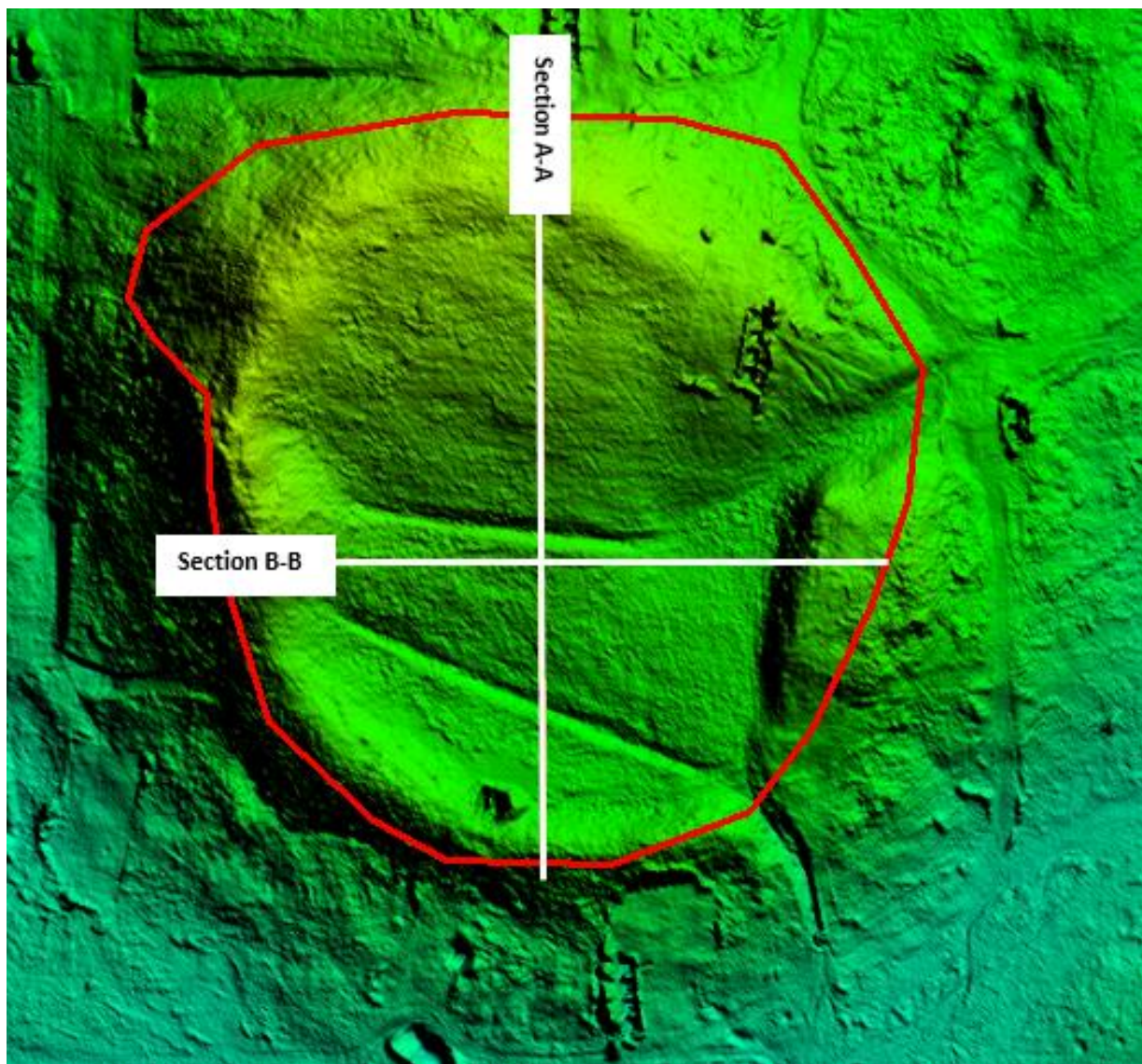


Figure 5: Cross Sections from the rehabilitated South Pit area

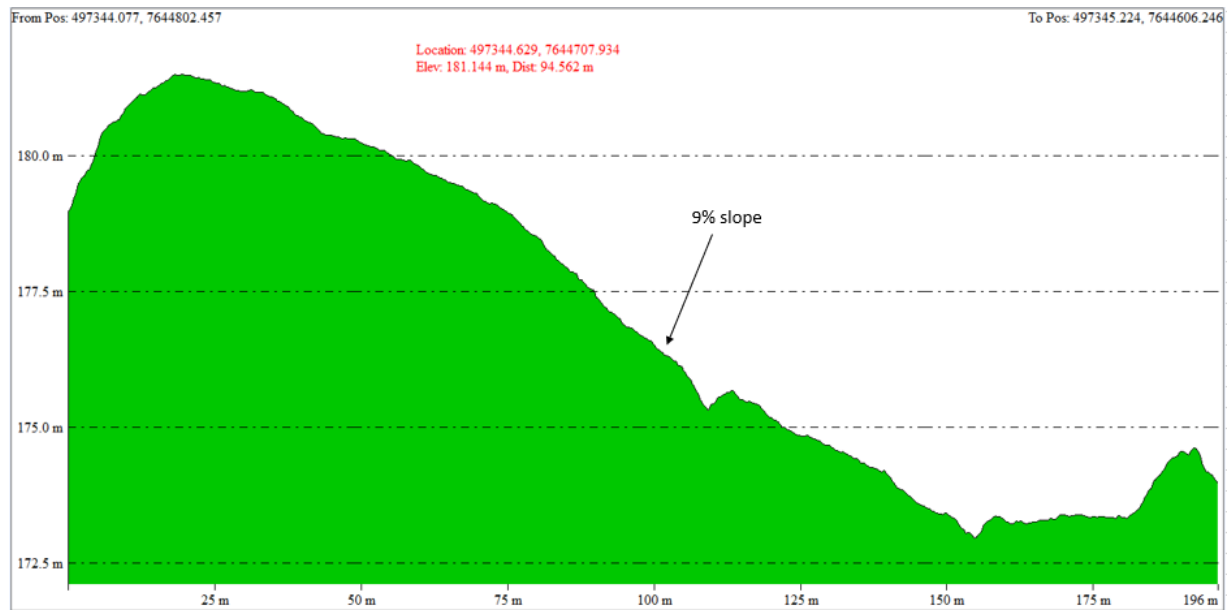


Figure 6: Cross section A-A at the rehabilitated South Pit area

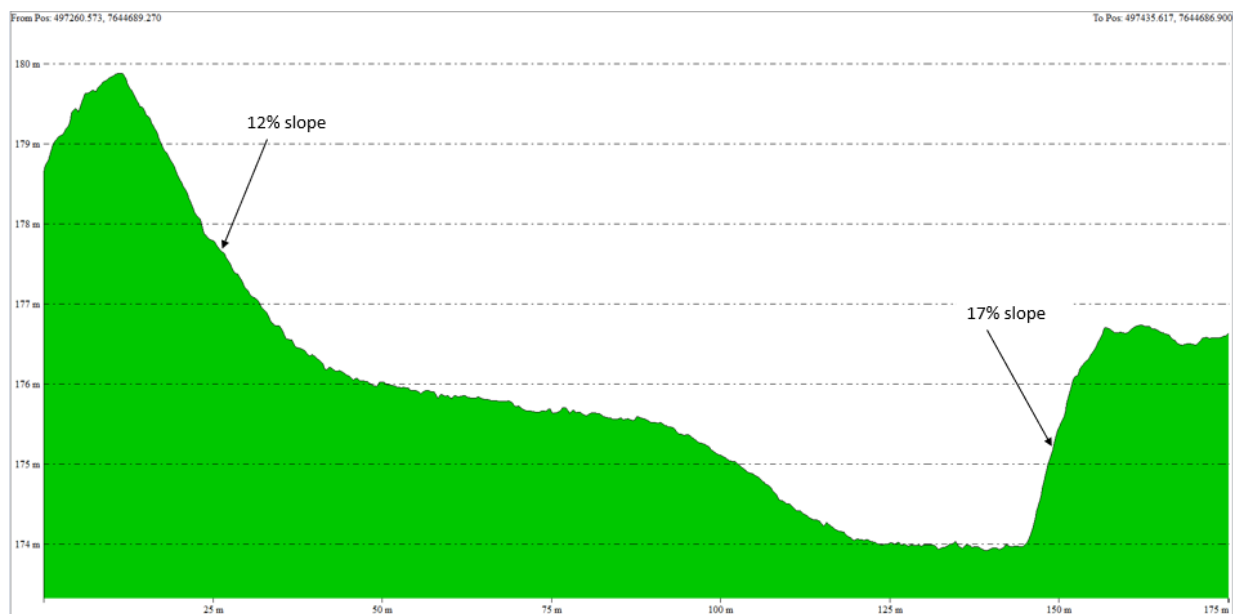


Figure 7: Cross section B-B at the rehabilitated South Pit area

Once the gradient and length were calculated for each section, Figure 8 was used to obtain the actual LS value for each slope. If the Project values did not match exactly with the table values, simple interpolation was done to obtain the final LS value. Results are shown in Table 11.

Slope ratio	Slope gradient (%)	Slope length (m)														
		5	10	20	30	40	50	60	70	80	90	100	150	200	250	300
100:1	1	0.09	0.11	0.13	0.15	0.16	0.17	0.18	0.19	0.19	0.20	0.20	0.23	0.24	0.26	0.27
50:1	2	0.14	0.18	0.24	0.28	0.31	0.34	0.36	0.39	0.41	0.43	0.44	0.52	0.58	0.64	0.69
33.3:1	3	0.17	0.24	0.34	0.41	0.47	0.52	0.57	0.61	0.65	0.69	0.72	0.87	1.00	1.11	1.22
25:1	4	0.21	0.30	0.44	0.54	0.63	0.71	0.78	0.85	0.91	0.97	1.03	1.26	1.47	1.65	1.82
20:1	5	0.24	0.36	0.54	0.68	0.80	0.91	1.01	1.10	1.19	1.27	1.35	1.70	2.00	2.28	2.53
16.6:1	6	0.28	0.42	0.64	0.81	0.97	1.11	1.24	1.36	1.47	1.58	1.68	2.14	2.54	2.91	3.25
12.5:1	8	0.34	0.53	0.83	1.08	1.31	1.51	1.70	1.88	2.05	2.21	2.37	3.07	3.70	4.28	4.82
10:1	10	0.42	0.68	1.09	1.44	1.75	2.04	2.31	2.56	2.81	3.04	3.27	4.06	4.94	5.75	6.52
8.3:1	12	0.52	0.85	1.39	1.85	2.27	2.66	3.02	3.37	3.70	4.02	4.33	5.77	7.07	8.28	9.42
7.1:1	14	0.62	1.02	1.69	2.26	2.79	3.28	3.74	4.18	4.61	5.02	5.42	7.27	8.95	10.52	12.01
6.3:1	16	0.71	1.19	1.98	2.67	3.31	3.90	4.46	5.00	5.52	6.02	6.51	8.78	10.86	12.81	14.65
5.5:1	18	0.80	1.35	2.27	3.07	3.82	4.51	5.17	5.81	6.42	7.02	7.59	10.30	12.78		
5:1	20	0.89	1.50	2.55	3.47	4.32	5.12	5.88	6.61	7.32	8.01	8.68	11.92	14.84		
4:1	25	1.09	1.88	3.23	4.43	5.54	6.59	7.60	8.57	9.51	10.43	11.32				
3.3:1	30	1.28	2.23	3.86	5.32	6.69	7.99	9.23	10.43	11.60	12.74	13.85				
2.5:1	40	1.61	2.83	4.98	6.92	8.74	10.48	12.15	13.77							
2:1	50	1.88	3.33	5.89	8.22	10.42	12.52	14.55								

Figure 8: LS factors (Rosewell 1993)

Table 11: LS factors for the rehabilitated South Pit area

Cross Section	LS-Factor
A-A	1.44 ^a
B-B	1.85 ^b

^aSlope gradient 10%. Slope length 30m. ^bSlope gradient 12%. Slope length 30m.

4.1.3.2 TSF embankment

Existing TSF embankment cross sections are shown in Figure 9 to Figure 10.

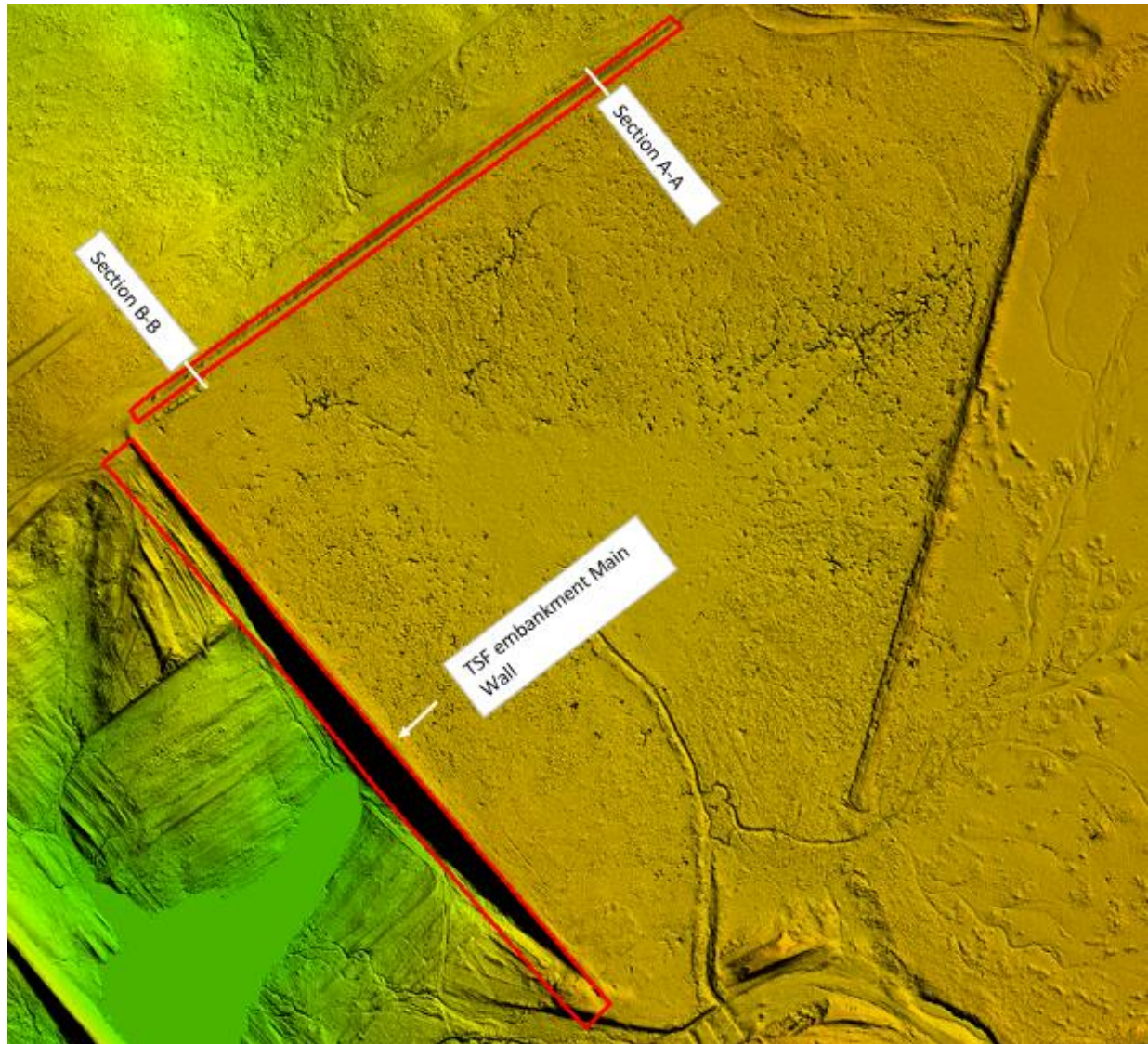


Figure 9: LS analysis areas for the TSF embankment

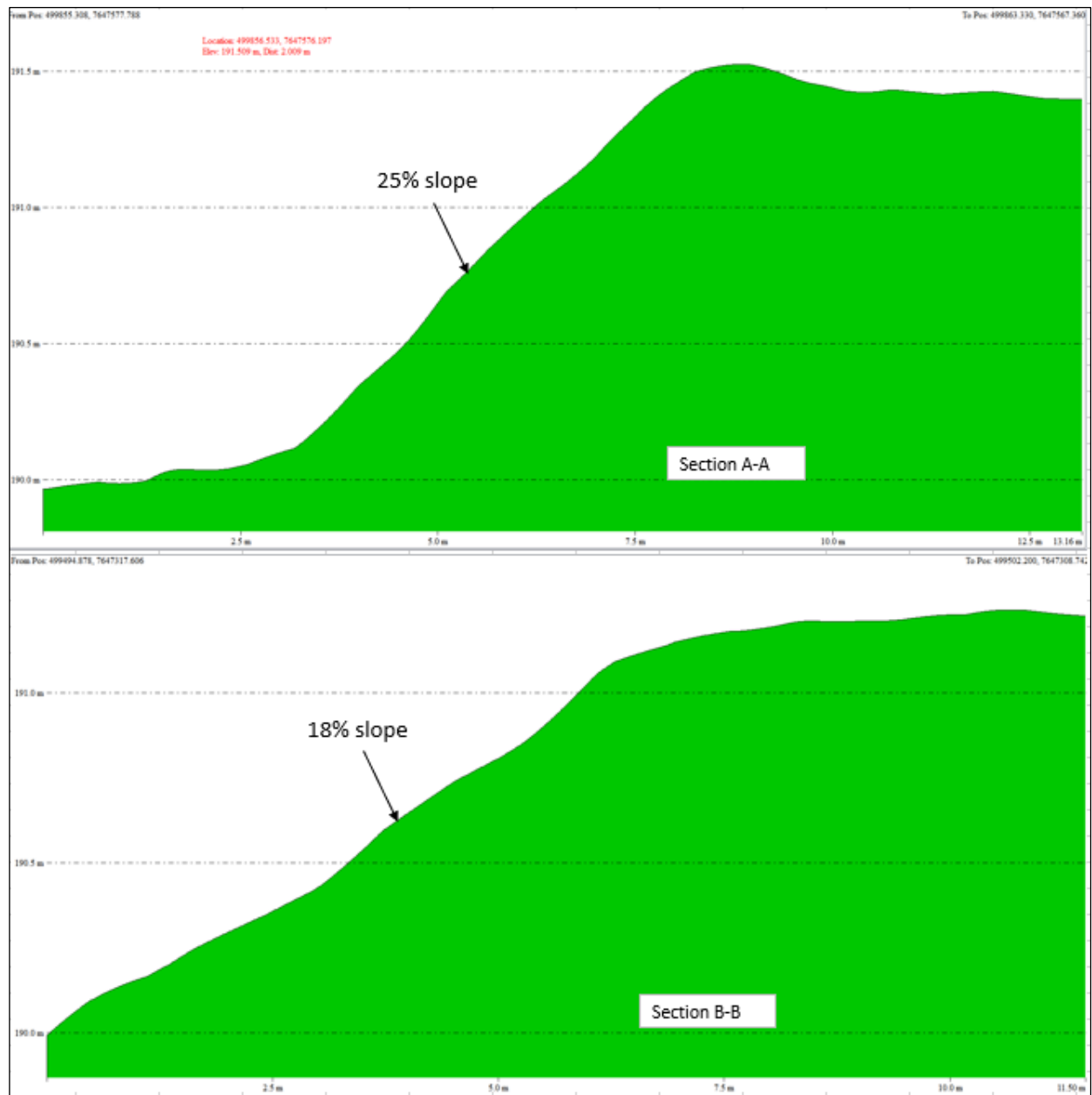


Figure 10: Cross sections A-A and B-B at TSF embankment

The TSF embankment Main Wall will be reprofiled to a final landform with slope length of 20m and a slope gradient of 30% as specified in section 2.3. LS factors are shown below for all TSF sections.

Table 12: LS factors for the TSF embankment

Cross Section	LS-Factor
A-A	1.09
B-B	0.8
Main Wall	3.86

4.1.3.3 Heap Leach Pad

The proposed final landform design for the Heap Leach Pad includes slope lengths of 30 m and a slope gradient of 25% with intermediate flat benches of 5 m every 30 m (refer Section 2.3). This single design will be applied along the whole perimeter of the Heap Leach Pad and therefore, a single LS-factor is calculated for this area.

Table 13: *LS-factor for the Heap Leach Pad*

Cross Section	LS-Factor
Heap Leach Pad	4.43

4.1.4 Cover and management factor (C)

The cover and management factor (C) is a value that ranges from 0 to 1 as it represents the ratio of soil loss from land under specified cover conditions to the corresponding loss from continuously bare soil. Hence, as higher the groundcover, the lower the C-factor is going to be, as shown in Figure 11. Furthermore, as stated by Lu et. al (2003) cover and management factors results can be improved by combining surface rock cover and the estimated vegetation cover. Rosewell (1993) further states that any rock protection on the surface should be treated as surface cover and allowed for in the C-factor.

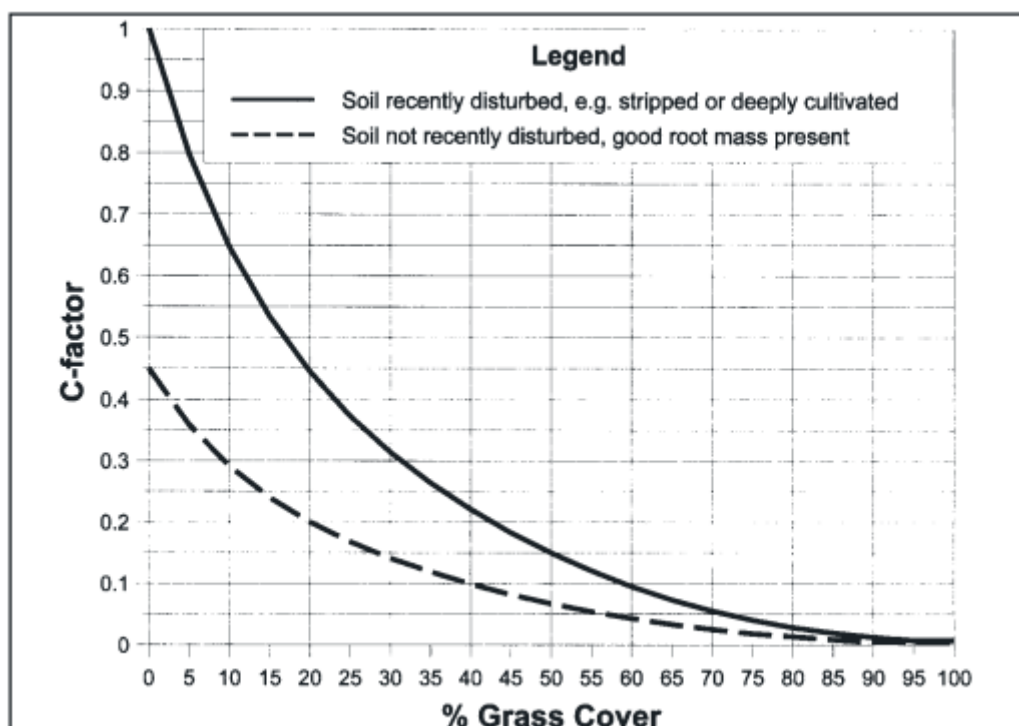


Figure 11: *C factors (Rosewell 1993)*

As the scenarios being evaluated are landforms assumed to be at a mature rehabilitation stage (more than 12 months since establishment), the values obtained correspond to soils not recently disturbed (the dashed line in Figure 12). Furthermore, given it is hard to get exact C-factor values from the curve, an equation for the line was developed to calculate the C-factor more accurately.

The formula is the following:

$$Y = 0.4459e^{-0.039x}$$

4.1.4.1 Rehabilitated South Pit area

To obtain the specific groundcover of the rehabilitated South Pit area, rehabilitation monitoring data from the last five monitoring periods (2017–2021) was used to estimate total live groundcover. As shown in Table 14, the total live groundcover averages for the rehabilitated South Pit area are consistent with reference sites (42% vs 40%). Groundcover for the rehabilitated South Pit area was used in the C – factor formula to obtain a value of 0.08667.

Table 14: Live groundcover distribution in the South Pit and reference sites

Site	Transect ID	Monitoring Period	Average live groundcover (%)	Total average for site (%)
South Pit	SP1	2017-2021	41	42
	SP2	2017-2021	51	
	SP3	2017-2021	35	
Reference Site	R1	2017-2021	24	40
	R2	2017-2021	23	
	R3	2017-2021	74	

4.1.4.2 TSF embankment

The proposed final landform for the TSF main embankment represents a relatively steep slope, in comparison to landform of the backfilled South Pit. As such, a higher groundcover is anticipated to be required to achieve surface erosion stability in the rehabilitated landform. A rock mulch groundcover (cross-rippled with topsoil) may be applied on the embankment to provide additional cover and stability while reducing surface water runoff and potential erosion. This is consistent with RUSLE literature (Rosewell 1993, Lu *et al.* 2003) where it is stipulated that rock cover should be used in combination with vegetation cover to estimate the total groundcover for the C-factor. Total groundcover (rock and/or vegetation) proposed for the final landform is 65%, resulting in a C-factor value of 0.035 adopted into the model.

4.1.4.3 Heap Leach Pad

The proposed final landform for the Heap Leach Pad represents a relatively steep slope, in comparison to landform of the backfilled South Pit. As such, a higher groundcover is anticipated to be required to achieve surface erosion stability in the rehabilitated landform. A rock mulch groundcover (cross-rippled with topsoil) may be applied on the embankment to provide additional cover and stability while reducing surface water runoff and potential erosion. This is consistent with RUSLE literature (Rosewell 1993, Lu *et al.* 2003) where it is stipulated that rock cover should be used in combination with vegetation cover to estimate the total groundcover for the C-factor. Total groundcover (rock and/or vegetation) proposed for the final landform is 65%, resulting in a C-factor value of 0.035 adopted into the model.

4.1.5 Supporting practice factor (P)

Supporting practice factor (*P*) is defined as the ratio of soil loss with a specific supporting practice as compared to soil loss in regular conditions. It is reduced by practices that reduce both the velocity of runoff and the tendency of runoff to flow directly downhill. Due to lack of reliable data, it is assumed that for all modelled cases, the value is equal to 1. Thus, it reflects the potential for soil loss under current conditions with no soil conservation support practices.

5 Results

5.1 Rehabilitated South Pit area

The current landform design and rehabilitation status of the rehabilitated South Pit area present soil erosion values within acceptable limits as shown in Table 15. No management measures are needed for any of the RUSLE variables in this area.

Table 15: RUSLE results for the rehabilitated South Pit area

Location	Cross Section	R-factor	K-factor	LS-factor	C-factor	P-factor	RUSLE value t/ha/year
South Pit	A-A	2197.17	0.028	1.44	0.08667	1.00	7.65
	B-B	2197.17	0.028	1.85	0.08667	1.00	9.83

5.2 TSF embankment

In consideration of the proposed landform design, soil characteristics and cover characteristics detailed in section 4.1, RUSLE values for the TSF embankment are within acceptable limits. Surface erosion of these structures is predicted to be manageable under these conditions.

Table 16: RUSLE results for the TSF embankment

Location	Cross Section	R-factor	K-factor	LS-factor	C-factor	P-factor	RUSLE value t/ha/year
TSF embankment	A-A	2197.17	0.028	1.09	0.035	1.00	2.36
	B-B	2197.17	0.028	0.8	0.035	1.00	1.73
	Main Wall	2197.17	0.028	3.86	0.035	1.00	8.37

5.3 Heap Leach Pad

In consideration of the proposed landform design, soil characteristics and cover characteristics detailed in section 4.1, RUSLE values for the Heap Leach Pad are within acceptable limits. Surface erosion of these structures is predicted to be manageable under these conditions.

Table 17: RUSLE values for the Heap Leach Pad

Location	Cross Section	R-factor	K-factor	LS-factor	C-factor	P-factor	RUSLE value t/ha/year
Heap Leach Pad	-	2197.17	0.028	4.43	0.035	1.00	9.60

6 Discussion and conclusions

Rehabilitation monitoring data shows that the rehabilitated South Pit area has maintained a high self-sustaining groundcover since 2017 and is comparable to groundcover in reference sites, with no evidence of ongoing active erosion recorded. When analysed using RUSLE, the rehabilitated South Pit area presents erosion levels that are within acceptable limits (<10 t/ha/yr) for all cross sections analysed. As such, the South Pit is considered to be meeting rehabilitation objectives.

The proposed final landform of the TSF embankment and the Heap Leach Pad present steeper landform conditions and more erodible soils than the rehabilitated South Pit area. Management actions are recommended to achieve acceptable erosion levels, including soil amelioration and rock mulching in combination with vegetation cover to enhance the total groundcover. Considering these management actions for the RUSLE calculation, values fall below 10t/ha/yr and are therefore considered acceptable.

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December 2002

Report No.: 6301/1/579

Wirralie Gold Mine

FINAL REPORT

**ENVIRONMENTAL GEOCHEMICAL ASSESSMENT
OF THE YANDAN HEAP LEACH DUMP**

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1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) were commissioned by Wirralie Mines Pty Limited to perform a geochemical assessment of the Yandan Heap Leach dump for closure planning. The findings from this assessment are presented in this report.

1.1 Background

Details on the construction and operation of the Yandan heap leach have been provided by Wirralie Gold Mine personnel.

It is understood that placement of low-grade ore on the heap leach dump was completed in 1998. The dump currently consists of 3,200,000 m³ of ore comprising 6 pads and covering an area of 20.1 ha. The total pad thickness is approximately 26 m, comprising two 10 m benches and one 6 m bench. Gold and silver were extracted from the low-grade ore using conventional cyanide leach processes. The dump was irrigated with the cyanide leach solution at a pH of 10 and the pregnant solution was collected and pumped to the treatment plant for extraction of the gold and silver. Cyanide leaching ceased in August 2002 and the heap is currently being flushed.

A Plan of Operation submitted by Ross Mining Pty Limited (January, 2000) provides a preliminary rehabilitation strategy for the Yandan Heap Leach dump. This rehabilitation strategy includes:

- On completion of the cyanide leach, the dump will be flushed with a hypochlorite solution to treat the residual cyanide until the leachate quality is acceptable for direct release.
- The outer slopes of the dump will be reshaped to a 1:4 slope and contour banks and other drainage works will be installed as required.
- The dump will be covered with topsoil to a depth of about 0.15 m. The topsoil will be ripped, seeded and fertilised.
- The stormwater pond bunds, consisting of sub-soil, will be used to cover the pond's clay liner.

Wirralie Mines, as the operators of the mine, are currently preparing a new Environmental Management Overview Strategy, involving further investigations to refine the final closure strategy for the heap leach dump.

1.2 Study Objectives

The primary objectives of this study were to review the existing geochemical data and perform additional testing as required in order to identify any geochemical concerns for closure and rehabilitation of the dump. The specific objectives of the study were to:

- Assess the acid forming potential of the spent heap leach material.
- Identify any enriched and/or soluble elements that may present a concern for rehabilitation, water quality or contamination of surrounding areas.
- Provide recommendations for closure and rehabilitation of the spent heap leach dump.

This report presents the results and findings of the geochemical test work. The implications these findings have for environmental management of the site and recommendations for management and closure of the dump are also provided.

2.0 Geochemical Assessment Program

The results and findings from previous geochemical testing and the site water quality monitoring program, and the current geochemical testing program have been used for this geochemical assessment. An outline of the previous geochemical test work and water quality monitoring program is provided in Section 3 (Previous Investigations) and details of the current geochemical testing program are provided below.

2.1 Sample Selection and Preparation

Twenty heap leach samples were provided by Wirralie Mines personnel for the current geochemical characterisation program. The samples were collected from 20 different locations across the dump surface from a depth interval of 300 to 500 mm. Approximately 5 kg of samples was provided for testing and each sample was split, with 500 g being pulverised to minus 75µm. The pulverised and 'as received' portions of each sample were retaining for testing.

2.2 Analytical Program

The analytical program included the following geochemical tests:

- pH & EC determination
- Total S assay
- Acid Neutralising Capacity (ANC) determination
- Multi-element scans on solids
- Net Acid Generation (NAG) test
- Multi-element scans on water extracts and EDTA extracts
- Leach column tests and elemental analysis of leachates

The total S assays were performed by Sydney Environmental and Soil Laboratory Pty Limited (SESL) and the multi-element scans were performed by Genalysis Pty Limited in Perth. All other test work was carried out by EGi in Sydney. The NAG tests and EDTA extractions were performed on selected samples only. Leach column tests were performed on 2 composite heap leach samples for a period of 24 weeks at the EGi laboratory. An explanation of the testing program commonly used by EGi for the assessment of the acid forming characteristics of mine waste materials is provided in Appendix A.

Multi-element scans are performed on solid samples in order to identify any significantly enriched elements. The element concentrations are compared to nominated standard compositions, typically the average crustal abundance, in order to highlight significantly enriched elements. The extent of enrichment is reported as the Geochemical Abundance Index (GAI) which relates the actual concentration to the crustal abundance on a log 2 scale. The GAI is expressed in 7 integer increments (i.e. 0

through to 6), where a GAI of 0 indicates the element is present at a concentration similar to, or less than, average crustal abundance; and a GAI of 6 indicates approximately a 100-fold, or greater, enrichment above average crustal abundance. As a general rule, a GAI of 3 or greater signifies enrichment that warrants further examination.

The EDTA extraction procedure was used to obtain information on the readily available buffering capacity and composition of oxidation products on the surface of the spent heap leach particles. This procedure involves the extraction of metallic species by chelation using an EDTA (ethylene diamine tetra-acetic acid) solution. EDTA is a very strong chelating reagent. The extraction procedure involves mixing 1 g of sample with 125 ml of the EDTA solution in the absence of oxygen (N₂ used). The solution is extracted through a 0.2µm filter after being agitated for 2 hours. This extraction procedure is also performed using a deionised water solution. The EDTA and deionised water extract solutions are assayed and the composition of precipitates and oxidation products removed from the particle surfaces by the EDTA is determined by difference as shown below:

$$\text{net EDTA conc.} = \text{EDTA conc.} - \text{deionised water conc.}$$

Based on the geochemical characteristics of the solid samples, 2 heap leach samples were selected for free-draining leach column testing. The primary objective of this test was to further investigate the solubility and potential environmental risk of identified enriched or soluble elements in the heap leach material. This test involved cyclic wetting and drying of approximately 2 kg of the 'as received' sample, and stepped water flushing and leachate collection (weekly for first month then stepped out to monthly for remainder) for a 24 week period. The rate of cyclic wetting was 100 ml/kg/week and of water flushing was 400 ml/kg/week. The surface of the leach columns was maintained at 30 to 35°C to ensure sufficient drying between wetting events.

3.0 Previous Investigations

Previous geochemical investigations carried out on the Yandan heap leach include site water quality monitoring and geochemical characterisation of the leached material. The details and results from these investigations have been provided by Wirralie Mines for review.

3.1 Geochemical Characterisation

The acid-base and NAG test results of 20 samples collected from upper 5 to 10m of the Yandan heap leach dump were provided by Wirralie Mines personnel. The analyses were performed by Australian Laboratory Services Pty Ltd (ALS) in Brisbane and the results are presented in Appendix B (Table B1).

The saturated paste pH ($\text{pH}_{\text{sat.}}$) values were alkaline and generally ranged from 8.2 to 12.4 (except 1 sample that has a $\text{pH}_{\text{sat.}}$ of 6.0). These high pH values are most likely attributed to the high pH (pH 10) of the CN irrigation solution and the direct placement of lime on the surface of the ore lifts during construction of the pads. Generally, the saturated paste electrical conductivity ($\text{EC}_{\text{sat.}}$) values were below 1.0 dS/m and these samples are classified as non-saline. However, 2 samples had $\text{EC}_{\text{sat.}}$ greater than 2.0 dS/m (2.46 & 7.33 dS/m) and these samples are classified as slightly saline to saline. These 2 samples also had the highest $\text{pH}_{\text{sat.}}$ values (11.9 & 12.4), indicating a high lime content.

The results of the acid-base analyses performed by ALS indicate that the samples had a relatively low sulphur (S) content ranging from 0.01 to 0.35 %S (mean 0.15%S) and that a large proportion of this S occurred as sulphate (mean 80%). Samples with a total S content greater than 0.2%S were selected for further acid-base and NAG testing to determine their acid forming characteristics.

The ANC values were low to moderate ranging from 8 to 37 kg $\text{H}_2\text{SO}_4/\text{t}$. However, determination of the samples acid consumption (AC) using an acid titration method with a pH 3.5 end-point indicates that the available or effective ANC of these samples was higher than the reported total ANC. This unusual finding may reflect reactions caused by the lime added during construction. For this reason the NAPP shown on Table 1 has been calculated using the acid consumption values rather than the ANC. The NAPP values are all negative and range from minus 4 to minus 45 kg $\text{H}_2\text{SO}_4/\text{t}$. The NAGpH values for these samples are all greater than 4.5 (pH range 7.1 to 8.1) confirming a non-acid forming (NAF) classification for these samples.

3.2 Water Quality Monitoring

The chemical composition of run-off and bore-hole water samples collected from around the heap leach and from the heap leach launder and pad drainage are presented in Appendix B (Tables B2 and B3). The water samples are neutral to alkaline with a pH range of 7.0 to 9.0 (run-off and groundwater), and highly saline (TDS generally 5,000mg/L). Chloride (Cl) and sulphate (SO₄) are the dominant cations and calcium (Ca) and sodium (Na) are the dominant anions. Extremely high TDS values (>10,000mg/L) are reported for some groundwater samples and are characterised by having high concentrations of Na (approx. 2,000mg/L) and Cl (approx. 5,000mg/L). Additional to the major elements, cobalt (Co) is shown to be relatively soluble (<0.01 to 8.77mg/L) in the majority of the samples including the run-off, groundwater and pad leachate. The water chemistry results presented indicate that As is not highly soluble in the run-off, groundwater or pad leachates (<0.001 to 0.099mg/L).

Cyanide (CN) and nitrogen (N) concentration data for the run-off and groundwater samples are also presented in Appendix B (Table B3). These results indicate that total CN concentrations in the run-off range from 0.1 to 0.4 mg/L and detectable concentrations occur in some of the groundwater samples (0.005 to 0.05 mg/L). Cyanide leaching ceased in August 2002 and the latest water monitoring results from the launder (29 October 2002) indicates a significant reduction in total CN (0.26 mg/L) through the process of natural decay (pers comm Glenn Creed). These results indicate that CN release is not likely to be a concern for dump closure.

The concentration of N in the run-off and groundwater is variable with some samples having concentrations as high as 200 to 500 mg/L. The source of this N is most likely from the decomposition of CN. High N concentrations in run-off and seepage may have implications for water quality (excess nutrient) during decommissioning and after closure of the dump. However, high N concentrations may have a beneficial effect on rehabilitation if the leach solution is to be recycled during decommissioning.

4.0 Geochemistry of Heap Leach Material

Based on the findings from the previous geochemical investigation, 20 additional heap leach samples were subjected to detailed geochemical characterisation to confirm the NAF nature of the heap leach materials and to further investigate salinity and metal contamination concerns. The results from this work are provided below.

4.1 Acid Forming Potential

The acid-base analyses and NAG test results for the Yandan heap leach samples are presented on Table 1. These results confirm the NAF nature of the heap leach materials as represented by sample tested.

The sulphur concentrations are low ranging from 0.02 to 0.42 %S with a mean value of 0.15 %S. Fifty percent of the samples have a total S content at or below 0.1 %S. The ANC values range from 5 to 341 kg H₂SO₄/t and the mean value is 65 kg H₂SO₄/t. Three samples had ANC values greater than 100 kg H₂SO₄/t (175 to 341 kg H₂SO₄/t) and these samples (1L2, 7L2 & 10L2) were most likely collected from areas of the pad where lime was added during construction. Excluding these samples the ANC values are low to moderate ranging from 5 to 89 kg H₂SO₄/t with a mean value of 31 kg H₂SO₄/t.

Figure 1 is an acid-base plot showing total S content compared to ANC. The ANC/MPA¹ ratio lines of 1 (NAPP=0), 2 and 3 are also shown on the plot. This plot shows that all of the samples tested are NAPP negative and have an excess capacity to neutralise acid over the potential to generate acid. The ANC/MPA can be used as a measure of the 'factor of safety' in terms of acid rock drainage (ARD) risk. Ratios values greater than 3 indicate that the material has a significant excess capacity to neutralise acid and therefore it is highly unlikely to generate acid. Hence, the samples with an ANC/MPA ratio of 3 or less (1L3, 2L3, 6L3, 9L3) and the highest S sample (8L2) were selected for NAG testing to confirm their geochemical classification. All of these samples had NAGpH values greater than 4.5 (NAGpH 6.8 to 7.9) confirming that these samples non-acid forming (NAF).

Based on these results, the samples collected from the upper 0.5m of the Yandan heap leach dump are alkaline and NAF.

¹ The Maximum Potential Acidity (MPA) is calculated by multiplying the total S content by 30.6.

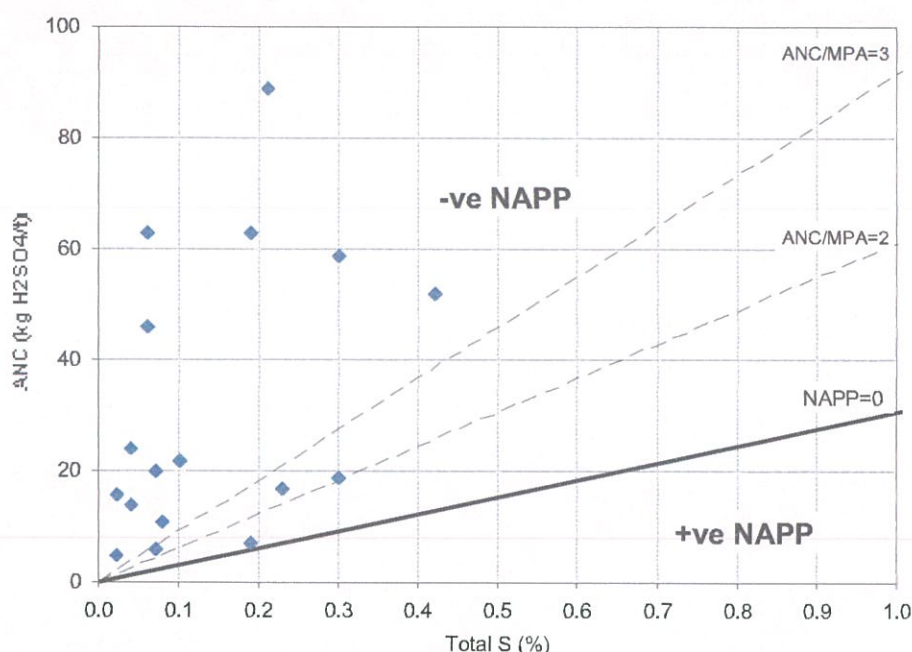


Figure 1: Acid-base plot for the Yandan Heap Leach Dump samples.

4.2 Existing pH and Salinity

The $pH_{1:2}$ and $EC_{1:2}$ results for the Yandan heap leach samples are also presented on Table 1. These results indicate that the samples are alkaline with $pH_{1:2}$ values ranging from 8.7 to 11.5. These high pH values are most likely due to a combination of the high pH of the CN irrigation solution and the direct placement of lime during pad construction. The $EC_{1:2}$ values range from 0.232 to 2.73 dS/m and the samples are classified as non- to highly saline based on the criteria provided below:

$EC_{1:2}$ Range	Salinity Rating	Proportion of Samples
0 - 0.5 dS/m	Non-saline	25 %
0.5 - 1.0 dS/m	Slightly saline	25 %
1.0 - 1.5 dS/m	Moderately saline	20 %
> 1.5 dS/m	Highly saline	30 %

4.3 Element Composition and Solubility

The results of the multi-element scans performed on the solid samples are presented on Table 2 and the respective geochemical abundance indices (GAI) are presented in Table 3. These results indicate that arsenic (As), mercury (Hg), antimony (Sb) and selenium (Se) are significantly enriched in the majority of the samples tested. Silver (Ag) and

lead (Pb) were also significantly enriched in 1 or 2 of the samples. The concentration range and average crustal abundance of these elements are provided below:

<i>Element</i>	<i>Concentration Range (mg/kg)</i>	<i>Average Crustal Abundance² (mg/kg)</i>	<i>Proportion of Samples Enriched</i>
As	31 to 257	1.5	100%
Hg	0.06 to 2.66	0.05	45%
Sb	15.6 to 144.9	0.2	100%
Se	0.47 to 7.31	0.05	100%
Ag	<0.1 to 4.1	0.07	10%
Pb	11 to 121	14	5%

Elemental scans were performed on the water extracts (1 sample:2 water) from 5 selected samples. The results from these scans are presented on Table 4 and indicate that the dominant soluble cations are Ca and Na. These results also indicate that, under the test conditions, As, Co, Cu, Sb and Se are slightly soluble in some of the samples and Ag and Hg are not soluble in any of the samples.

EDTA extraction tests were performed on the same five samples that were selected for elemental analyses on 1: 2 water extracts. The EDTA and deionised water assay data are provided in Appendix C. The deionised water, EDTA and net EDTA extracted element loads are presented on Table 5 and the extracted element load proportional to the total element content are presented on Table 6. Histograms of the average results for these are presented on Figures 2 and 3, respectively.

These results indicate that the heap leach materials contain a significant quantity of oxidation product or other secondary mineral precipitates. Calcium is the major cation in both the water and EDTA extracts and dominates the surface precipitate composition. Other cations that occur in significant quantities in this form include; Al, Fe, K and Mg, along with As, Mn and Cu. Due to the large quantity of stored oxidation products and precipitates in the heap leach material it is likely that the solubility of some of the stored elements will increase during decommissioning and post-closure as the pH reverts to more neutral conditions. NOTE: Based on the samples tested it is expected that the bulk of the heap leach materials are NAF and that the pH of the dump will revert to relatively neutral conditions post closure.

Nearly all of the Ca contained in the solid phase of the heap leach material occurs in an EDTA soluble form and it is likely that a significant proportion of this is due to lime dosing and direct lime addition to the heap leach material rather than from oxidation processes. This readily available form of Ca will buffer the heap leach interstitial water and may stabilise elements such as As and limit long-term leaching.

2 from Bowen, H.J.M. (1979) Environmental Chemistry of the Elements. Academic Press, New York, p 36-37.

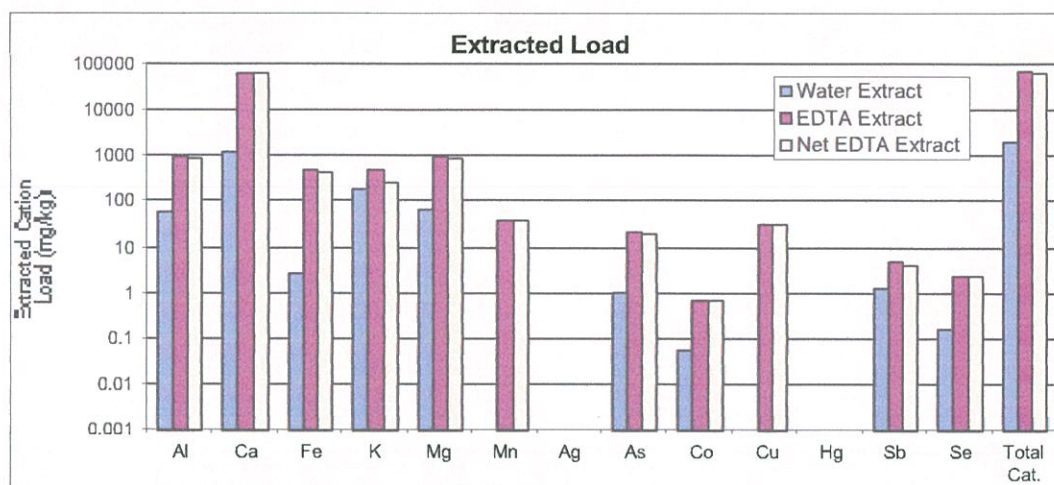


Figure 2: Histogram of extracted cation loads in the deionised water, EDTA and net EDTA extracts.

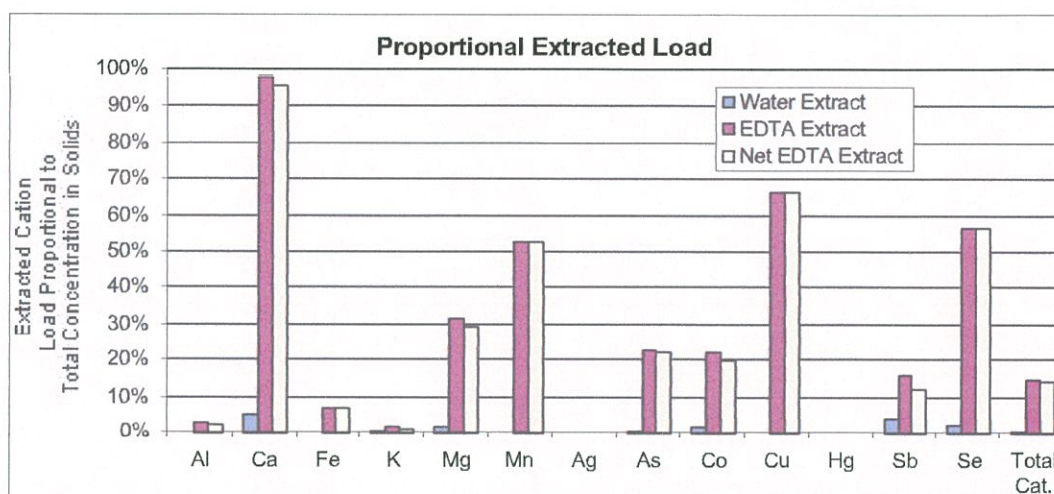


Figure 3: Histogram of proportion of cations in the solid sample extracted using EDTA procedure.

Silver and Hg were not detected in the EDTA or deionised water solution indicating that these cations occur in their primary mineral form and are not likely to present a solubility concern during decommissioning and post-closure.

Two leach column tests were operated for a 24 week period to further investigate the leaching behaviour and predicted metal release from the heap leach material. The selected samples represent material with a relatively low content of EDTA extractable material (sample 5L3) and material with a relatively high content of EDTA extractable material (sample 10L2).

The results from the leach column tests are presented on Tables 7 and 8 for sample 5L3 and 10L2, respectively. These results indicate relatively rapid flushing of the dominant soluble constituents including Ca, Na, Cl and SO₄. Figure 4 is a line plot of the

electrical conductivity (EC) of the leachates over time and shows the rapid depletion of EC caused by flushing of readily soluble salts from these materials. Using irrigation water criteria³ leachates from these material initially had a high to extreme rating and after 2 weeks for sample 5L3 and 24 weeks for sample 10L2 the rating dropped to low.

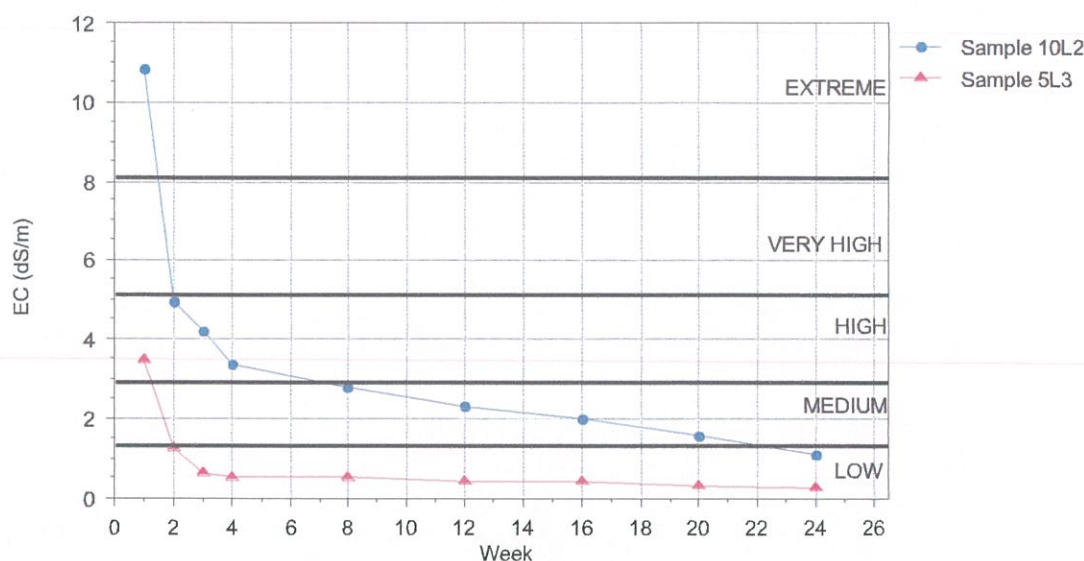


Figure 4: Line plot showing the electrical conductivity (EC) of column leachates through time. Irrigation water salinity ratings are also shown (Ref. ANZECC 2000).

Line plots showing As, Co, Mo and Se concentrations in the column leachates over time are presented on Figures 5 to 8, respectively. These plots show that, as with the EC values, Co, Mo and Se occur in lower concentrations in sample 5L3 compared to sample 10L2 (NOTE: sample 5L3 has a lower content of EDTA extractable material than sample 10L2). Additionally, these plots show a rapid decreasing trend in Co, Mo and Se concentrations during the initial phase of the leaching program. This trend indicates rapid flushing of readily soluble Co, Mo and Se phases such as secondary surface precipitates and oxides.

Cobalt, Mo and Se concentrations exceeded the ANZECC (2000) irrigation water criteria during the initial phase of the leaching program. However, the concentration of elements in sample 5L3 decreased to below the respective criteria within the first few weeks of leaching, and for sample 10L2 showed a trend that indicates the concentrations will decrease to below these criteria within 24 to 48 weeks of leaching.

Differing from these trends, the As concentrations (Figure 5) were an order of magnitude higher in leachates from 5L3 compared to 10L2 and no marked decreasing trends were evident. Leachates from sample 10L2 had As concentrations well below the irrigation water criteria, however those for sample 5L3 remained above the criteria throughout the leaching period. These trends indicate continual release of moderate

³ ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

concentrations of As from sample 5L3 rather than flushing of high concentrations during the initial phase of leaching as with the other identified soluble elements.

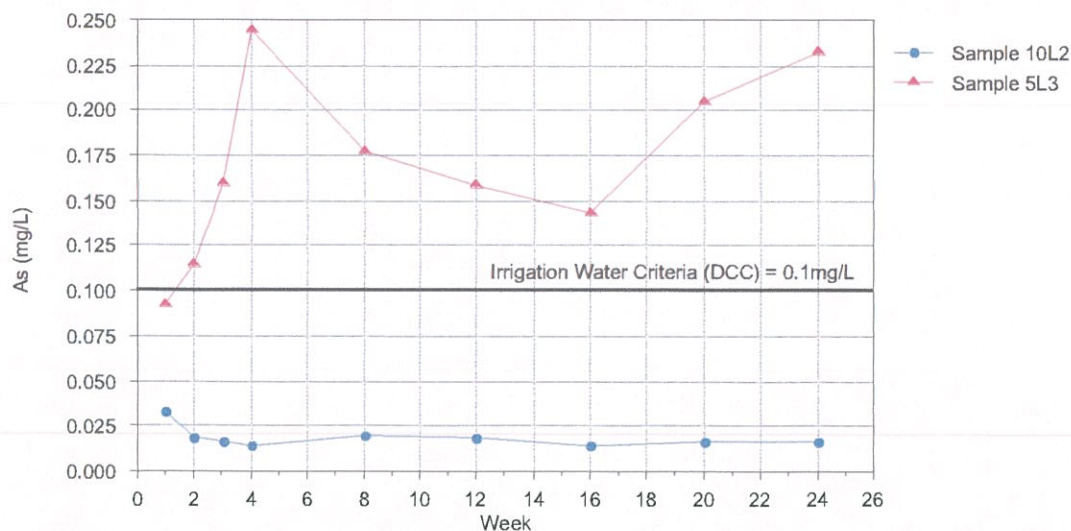


Figure 5: Line plot showing arsenic concentration in column leachates through time. Irrigation water criteria for Desirable Contamination Concentration (DCC) is also shown (Ref. ANZECC 2000).

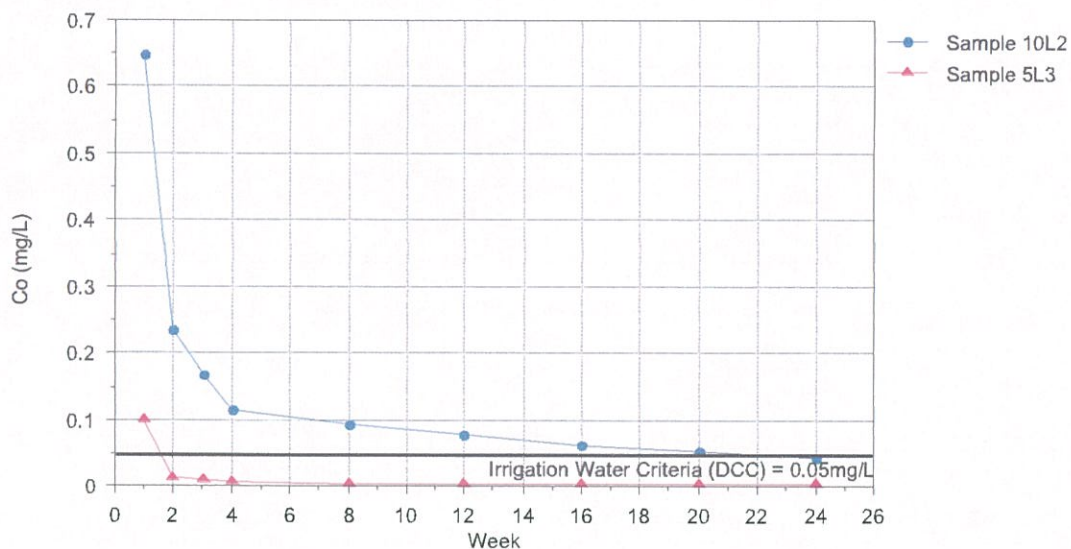


Figure 6: Line plot showing cobalt concentration in column leachates through time. Irrigation water criteria for Desirable Contamination Concentration (DCC) is also shown (Ref. ANZECC 2000).

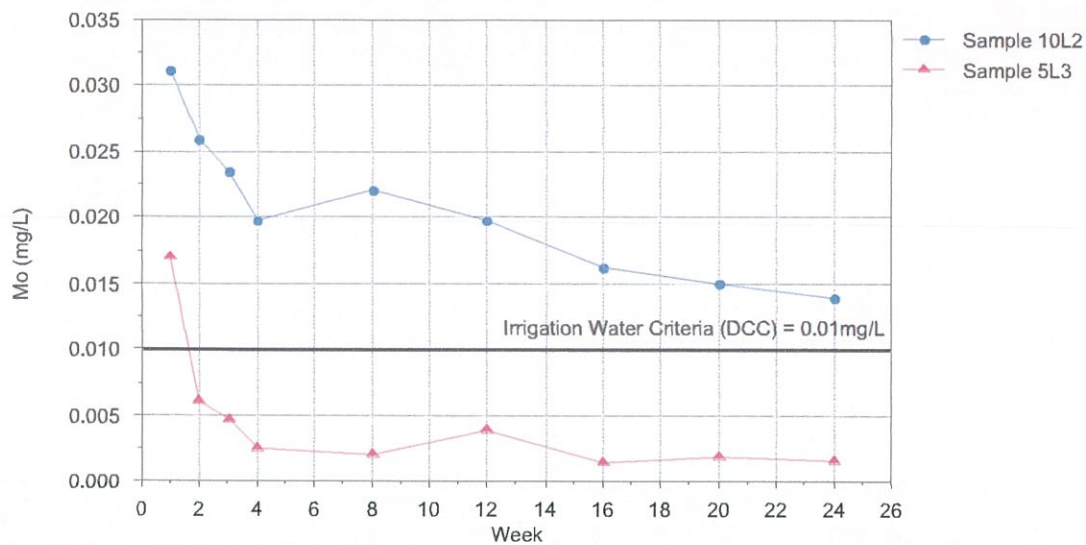


Figure 7: Line plot showing molybdenum concentration in column leachates through time. Irrigation water criteria for Desirable Contamination Concentration (DCC) is also shown (Ref. ANZECC 2000).

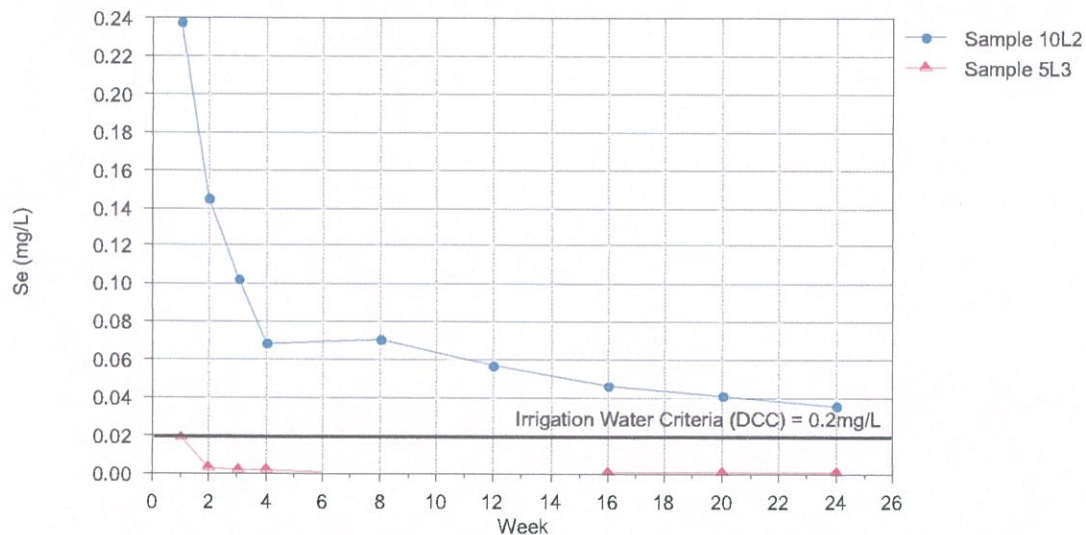


Figure 8: Line plot showing selenium concentration in column leachates through time. Irrigation water criteria for Desirable Contamination Concentration (DCC) is also shown (Ref. ANZECC 2000).

Figure 9 is a plot of SO_4 compared to Ca in leachates from both columns. The relationship between Ca and SO_4 indicates strong gypsum control on the solubility of these constituents in sample 10L2, whereas there is no indication of gypsum solubility control in sample 5L3. Following on from this, Figure 10 is a plot of As compared to Ca in leachates from the columns. This plot shows that the sample containing high soluble Ca, which is currently under gypsum solubility control (sample 10L2), has relatively low As solubility. This relationship confirms that the solubility of As in this material type is being partially controlled through Ca buffering mechanisms and this

control is expected to continue while gypsum solubility control is in effect. However, once gypsum dissolution is complete, Ca solubility control will be lost and therefore increased As release, similar to sample 5L3, can be expected.

These results indicate a likely primary mineral source for the soluble As in sample 5L3. This sample has a total As concentration of 141 mg/kg in the solid phase (see Table 2) and an EDTA extractable concentration (ie As that occurs in oxidation products or other secondary mineral precipitates) of 7.9 mg/kg (see Table 5). After 24 weeks of leaching less than 1 % of the total As in the sample had been released.

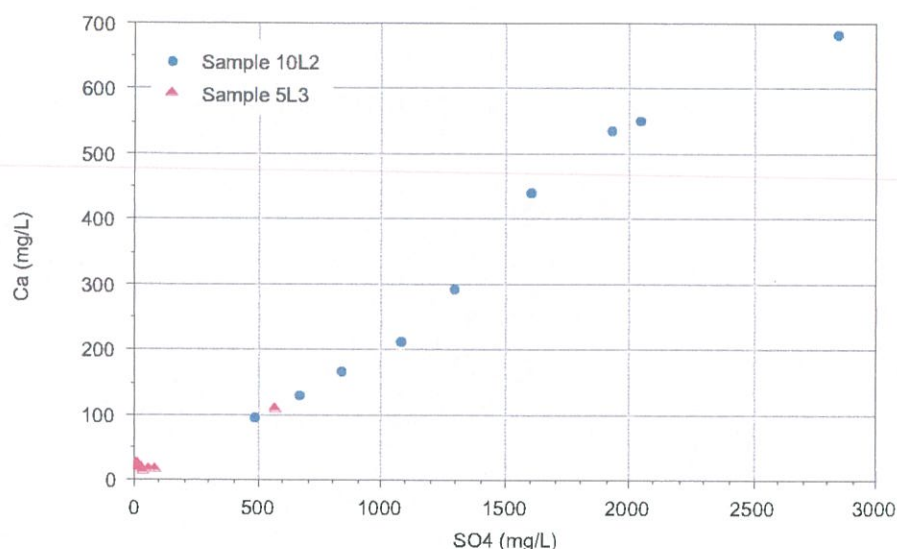


Figure 9: Scatterplot showing sulphate concentrations compared to calcium concentrations in leachates from both columns.

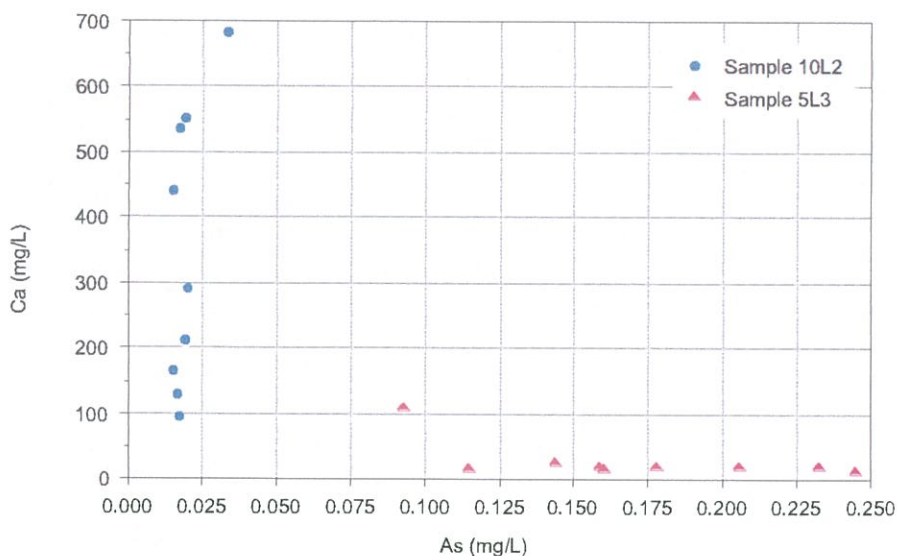


Figure 10: Scatterplot showing arsenic concentrations compared to calcium concentrations in leachates from both columns.

5.0 Conclusions and Recommendations

Previous and current geochemical test work results from the Yandan heap leach have been used to identify the geochemical concerns for closure and rehabilitation of the dump. Based on the results available to-date the following conclusions and recommendations for closure planning are provided:

- Based on the samples tested and the information provided, the spent heap leach materials are expected to be non-acid forming.
- The heap leach is expected to generate highly saline run-off and seepage for a period after decommissioning, however, as the heap is flushed post-closure the salinity will stabilise and run-off and seepage is expected to have a low irrigation rating.
- Based on the samples tested, arsenic (As), mercury (Hg), antimony (Sb) and selenium (Se) are enriched in the solid phase of the heap leach materials.
- The heap leach materials contain significant quantities of surface precipitate (oxidation product or other secondary mineral precipitates) consisting primarily of Ca and other cations including; Al, Fe, K and Mg, along with As, Mn and Cu. Nearly all of the Ca contained in the solid samples occurs as a secondary product (mostly gypsum – CaSO_4) which is most likely a product of lime dosing and direct lime addition to the heap leach pads. This available form of Ca, by buffering the heap leach interstitial water, helps stabilise elements such as As therefore controlling its solubility and release. However, this control on As solubility will only occur while gypsum solubility control is an active process (ie until gypsum dissolution is complete).
- Water chemistry results from the site water quality monitoring program confirm that run-off and seepage from the heap leach is neutral to alkaline and highly saline comprising predominantly soluble salts of Ca, Na, Cl and SO_4 . Additionally, the concentration of N in solution is high which may have implications for water quality. Relatively high concentrations of Co and to a lesser degree As were also detected in the site water.
- An initial flush of high Co, Mo and Se from secondary mineral products in the heap leach material is likely to occur after closure of the heap. However, after a relatively short period the local release concentrations (not allowing for dilution or concentration) are expected to decrease to below the ANZECC (2000) irrigation water criteria. Mercury is not expected to present a solubility concern during decommissioning or post-closure.
- Arsenic release may be a concern for water quality during and post-closure. The results from the leaching program indicate that some materials are likely to release As concentrations that exceed the ANZECC irrigation criteria, however this does not take into consideration dilution effects and therefore a detailed monitoring program will be required during and post-closure to establish the overall As release from the dump.

- These investigations indicate that the Yandan heap leach dump will require re-profiling and a relatively simple soil cover to reduce the risk of As contaminated dust impacting the surrounding area, and adverse salinity effects on re-vegetation and water quality. Additionally, controlled release of water, whereby dump drainage is released during periods of high flow due to increased dilution, may be required due to the flushing of Co, Mo and Se, after closure and expected longer-term release of As. To determine the need for controlled water release a detailed monitoring program will be required. This program should primarily be designed to monitor the overall initial release loads of Co, Mo and Se during closure and the longer-term release load of As, and therefore will need to include rainfall and flow monitoring.

Appendix A

Assessment of Acid Forming Characteristics

Appendix A

Assessment of Acid Forming Characteristics

Introduction

Acid rock drainage (ARD) is produced by the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water. The ability to identify in advance any mine materials that could potentially produce ARD is essential for timely implementation of mine waste management strategies.

A number of procedures have been developed to help assess the acid forming characteristics of mine waste materials. The most widely used assessment methods for ARD characterisation are the Acid-Base Account (ABA) and the Net Acid Generation (NAG) test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid-Base Account

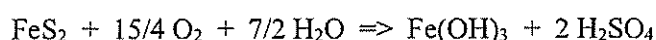
The acid-base account involves static laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulphide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates).

The values arising from the acid-base account are referred to as the maximum potential acidity (MPA) and the acid neutralising capacity (ANC), respectively. The difference between the MPA and ANC value is referred to as the net acid producing potential (NAPP).

The chemical and theoretical basis of the ABA are discussed below.

Maximum Potential Acidity

The MPA that can be generated by a sample is determined from the sample sulphur content. The total sulphur content of a sample is commonly determined by the Leco high temperature combustion method. The calculation assumes that all the sulphur measured in the sample occurs as pyrite (FeS₂) and that the pyrite reacts under oxidising conditions to generate acid according to the reaction:



According to this reaction, the MPA of a sample containing 1 %S as pyrite would be 30.6 kilograms of H₂SO₄ per tonne of material (*i.e.* kg H₂SO₄/t). Hence the MPA of a sample is calculated from the total sulphur content using the following formula:

$$\text{MPA (kg H}_2\text{SO}_4\text{/t)} = (\text{Total \%S}) \times 30.6$$

The use of the total sulphur assay to estimate the MPA is a conservative approach because some sulphur may occur in forms other than pyrite. Sulphate-sulphur and native sulphur, for example, are non-acid generating sulphur forms. Also, some sulphur may occur as other metal sulphides (e.g. covellite, chalcocite, sphalerite, galena) which yield less acidity than pyrite when oxidised or, in some cases, may be non-acid generating.

The total sulfur content is commonly used to assess MPA because of the difficulty and costs involved in routinely determining the speciation of sulfur forms within samples and determining reactive sulphide-sulfur contents. However, if the sulphide mineral forms are known then allowance can be made for non- and lesser acid generating sulfur forms to provide a better estimate of the MPA.

Acid Neutralising Capacity

The acid formed from pyrite oxidation will to some extent react with acid neutralising minerals contained within the sample. This inherent acid buffering is quantified in terms of the ANC.

The ANC is commonly determined by the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back-titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the MPA, that is kg H₂SO₄/t.

Net Acid Producing Potential

This is a theoretical calculation commonly used to indicate if a material has potential to produce acidic drainage. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H₂SO₄/t and is calculated as follows:

$$\text{NAPP} = \text{MPA} - \text{ANC}$$

If the MPA is less than the ANC then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

ANC/MPA Ratio

The ANC/MPA ratio is frequently used as a means of assessing the risk of acid generation from mine waste materials. The ANC/MPA ratio is another way of looking at the acid base account. A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. A NAPP of zero is equivalent to an ANC/MPA ratio of 1.

The purpose of the ANC/MPA ratio is to provide an indication of the relative margin of safety (or lack thereof) within a material. Various ANC/MPA values are reported in the literature for indicating safe values for prevention of acid generation. These values typically range from 1 to 3. As a general rule, a ANC/MPA ratio of 2 or more generally signifies that there is a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to acid rock drainage.

Acid-Base Account Plot

Sulphur and ANC data are often presented graphically in a format similar to that shown in Figure 1. This figure includes a line indicating the division between NAPP positive samples from NAPP negative samples. Also shown are lines corresponding to ANC/MPA ratios of 2 and 3.

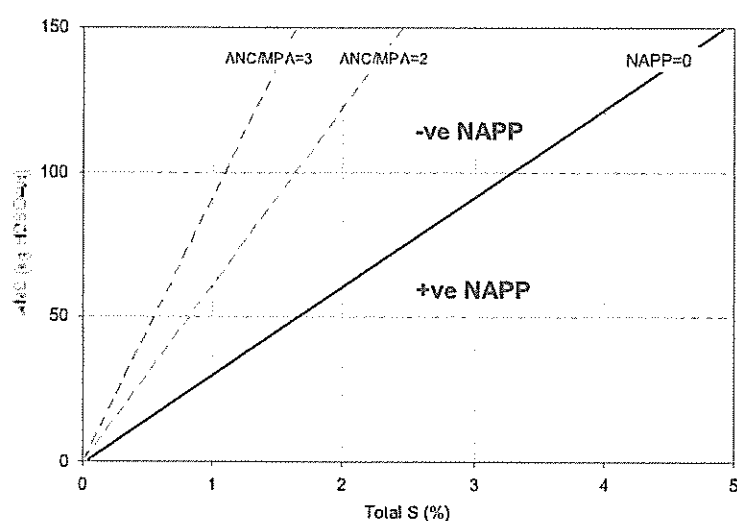


Figure A-1. Acid-base account (ABA) plot

Net Acid Generation (NAG) Test

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously. Therefore, the end result represents a direct measurement of the net amount of acid generated by the sample. This value is commonly referred to as the NAG capacity and is expressed in the same units as NAPP, that is kg H₂SO₄/t.

Several variations of the NAG test have been developed to accommodate the wide geochemical variability of mine waste materials. The three main NAG test procedures currently used by EGI are the single addition NAG test, the sequential NAG test, and the kinetic NAG test.

Single Addition NAG Test

The single addition NAG test involves the addition of 250 mL of 15% hydrogen peroxide to 2.5 gm of sample. The peroxide is allowed to react with the sample overnight and the following day the sample is gently heated to accelerate the oxidation of any remaining sulphides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the pH and acidity of the NAG liquor are measured. The acidity of the liquor is then used to estimate the net amount of acidity produced per unit weight of sample.

An indication of the form of the acidity is provided by initially titrating the NAG liquor to pH 4.5, then continuing the titration up to pH 7. The titration value at pH 4.5 includes acidity due to free acid (*i.e.* H_2SO_4) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides at pHs between 4.5 and 7.

Sequential NAG Test

When testing samples with high sulphide contents it is not uncommon for oxidation to be incomplete in the single addition NAG test. This can sometimes occur when there is catalytic breakdown of the hydrogen peroxide before it has had a chance to oxidise all of the sulphides in a sample. To overcome this limitation, a multi-stage sequential NAG test is often carried out. This test may also be used to assess the relative geochemical lag of PAF samples with high ANC.

The sequential NAG test is a multi-stage procedure involving a series of single addition NAG tests on the one sample (*i.e.* 2.5 g of sample is reacted two or more times with 250 mL aliquots of 15% hydrogen peroxide). At the end of each stage, the sample is filtered and the solution is used for measurement of NAGpH and NAG capacity. The NAG test is then repeated on the solid residue. The cycle is repeated until such time that there is no further catalytic decomposition of the peroxide, or when the NAGpH is greater than pH 4.5. The overall NAG capacity of the sample is then determined by summing the individual acid capacities from each stage.

Kinetic NAG Test

The kinetic NAG test is the same as the single addition NAG test except that the temperature, pH and sometimes EC of the liquor are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulphide oxidation and acid generation during the test. This, in turn, can provide an insight into the behaviour of the material field under field conditions. For example, the pH trend gives an estimate of relative reactivity and may be related to prediction of lag times and oxidation rates similar to those measured in leach columns. Also, sulphidic samples commonly produce a temperature excursion during the NAG test due to the

decomposition of the peroxide solution, catalysed by sulphide surfaces and/or oxidation products.

Sample Classification

The acid forming potential of a sample is classified on the basis of the acid-base and NAG test results into one of the following categories:

- Barren,
- Non-acid forming (NAF),
- Potentially acid forming (PAF), and
- Uncertain (UC).

Barren

A sample classified as barren essentially has no acid generating capacity and no acid buffering capacity. This category is most likely to apply to highly weathered materials. In essence, it represents an 'inert' material with respect to acid generation. The criteria used to classify a sample as barren may vary between sites, but for hard rock mines it generally applies to materials with a total sulfur content $\leq 0.1\%$ S and an ANC ≤ 5 kg H₂SO₄/t.

Non-acid forming (NAF)

A sample classified as NAF may, or may not, have a significant sulfur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulphide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP negative and the final NAG pH ≥ 4.5 .

Potentially acid forming (PAF)

A sample classified as PAF always has a significant sulfur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5 .

Uncertain (UC)

An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (*i.e.* when the NAPP is positive and NAGpH > 4.5 , or when the NAPP is negative and NAGpH ≤ 4.5). Uncertain samples are generally given a tentative classification that is shown in brackets *e.g.* UC(NAF).

Figure A-2 shows the format of the ARD classification plot which is commonly typically used for presentation of geochemical data. Marked on this plot are the quadrat representing the NAF, PAF and UC classifications.

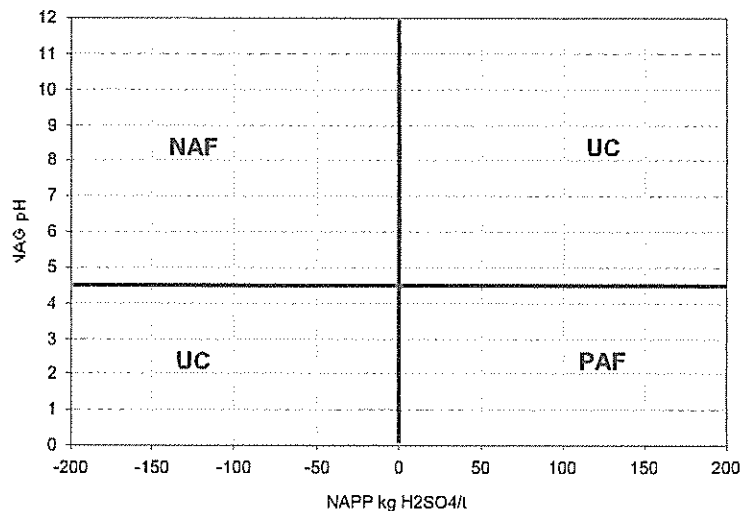


Figure A-2 ARD classification plot

Other Methods

Other test procedures may be used to define the acid forming characteristics of a sample.

pH and Electrical Conductivity

The pH and electrical conductivity (EC) of a sample is determined by equilibrating the sample in deionised water for a minimum of 1 hour, typically at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

Acid Buffering Characteristic Curve (ABCC) Test

The ABCC test involves slow titration of a sample with acid while continuously monitoring pH. This data provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation.

Appendix B

Results from Previous Geochemical Investigations

Table B1: Acid forming characteristics of the Yandan Heap Leach samples from the ALS results.

Sample Code	pH _{sat.}	EC _{sat.} (uS/cm)	ACID-BASE ANALYSIS							NAG TEST	
			Total S	SO ₄ -S	Sulph-S	MPA	ANC	AC	NAPP	NAGpH	NAG
			(%)			(kg H ₂ SO ₄ /t)					(kg H ₂ SO ₄ /t)
1 L2	8.9	428	0.10	0.07	0.03	1	-	-	-	-	-
1 L3	10.0	820	0.35	0.21	0.14	4	11	14	-4	7.6	0
2 L2	10.4	490	0.20	0.16	0.04	1	-	-	-	-	-
2 L3	10.0	901	0.19	0.19	0.00	0	-	-	-	-	-
3 L2	9.7	248	0.01	0.01	0.00	0	-	-	-	-	-
3 L3	9.1	614	0.23	0.15	0.08	3	8	11	-4	7.1	0
4 L2	9.7	152	0.03	0.02	0.01	0	-	-	-	-	-
4 L3	10.1	800	0.13	0.13	0.00	0	-	-	-	-	-
5 L2	12.4	7330	0.23	0.23	0.00	0	37	52	-45	8.1	0
5 L3	9.4	297	0.08	0.06	0.02	1	-	-	-	-	-
6 L2	9.5	380	0.10	0.09	0.01	0	-	-	-	-	-
6 L3	9.5	328	0.14	0.13	0.01	0	-	-	-	-	-
7 L2	11.9	2460	0.10	0.10	0.00	0	-	-	-	-	-
7 L3	8.2	592	0.09	0.04	0.05	2	-	-	-	-	-
8 L2	9.5	835	0.28	0.24	0.04	1	14	24	-15	7.9	0
8 L3	6.0	467	0.05	0.03	0.02	1	-	-	-	-	-
9 L2	10.1	718	0.18	0.18	0.00	0	-	-	-	-	-
9 L3	9.5	722	0.18	0.08	0.10	3	-	-	-	-	-
10 L2	8.2	1010	0.18	0.18	0.00	0	-	-	-	-	-
11 L2	9.3	362	0.05	0.02	0.03	1	-	-	-	-	-

KEY

sat. - Saturation Paste Extract
 MPA - Maximum Potential Acidity calculated using Sulphide S content
 ANC - Acid Neutralising Capacity
 AC - Acid Consumption
 NAPP - Net Acid Producing Potential
 NAGpH - pH of NAG test solution
 NAG - Net Acid Generation

Table B2: Chemical composition of runoff and bore-hole water samples from the Yandan Heap Leach.

Parameter	Units	Detection Limit*	RUNOFF SAMPLES			BORE-HOLE SAMPLES													
			HL Runoff		Leak	HL1			HL2		HL3			HL4		HL5	HL6		HL7
			Feb-01	Aug-01	Aug-01	Feb-01	Jul-01	Aug-01	Jan-00	Aug-01	Jan-00	Jul-01	Jan-00	Feb-01	Jul-01	Jan-00	Jan-00	Jul-01	Jan-00
pH		0.1	8.8	8.0	7.4	8.0	8.0	7.9	8.2	7.6	7.8	9.0	8.0	9.0	7.9	7.0	7.0	8.0	7.1
TDS	mg/l	1	5000	4950	4970	5370	4580	10700	4600	436	1780	1970	10900	11900	5410	4630	1250	5550	7460
CO3	mg/l	1	<	<	<	<	-	<	-	<	-	-	-	<	<	-	-	-	-
HCO3	mg/l	1	44	32	131	320	-	2070	-	282	-	-	-	491	325	-	-	-	-
SO4	mg/l	1	1290	1070	1060	870	-	447	-	16	-	-	-	760	920	-	-	-	-
Cl	mg/l	1	1270	1300	1280	1600	-	5520	-	110	-	-	-	5300	2090	-	-	-	-
N	mg/l	1	226	317	281	165	1.4	503	-	31.5	-	1.9	-	2.2	145	-	-	151	-
Al	mg/l	0.05	0.14	<	<	0.22	<	<	0.02	<	<	<	<	0.18	<	<	<	<	0.42
As	mg/l	0.001	0.022	0.099	0.003	0.003	0.006	0.024	0.014	0.012	0.004	0.011	0.018	0.005	0.001	0.01	0.009	0.001	0.013
B	mg/l	0.1	<	<	0.1	0.2	0.5	0.8	0.3	0.1	0.4	<	1.1	0.8	0.8	0.5	0.3	0.7	1.2
Ba	mg/l	0.1	0.1	<	<	<	<	0.2	0.12	<	0.02	<	0.07	<	<	0.02	0.05	<	0.02
Ca	mg/l	1	217	235	231	54	151	69	41	6	18	39	167	161	57	146	22	54	51
Cd	mg/l	0.001	<	0.009	0.001	<	<	<	0.0003	0.007	0.0008	<	0.013	0.008	0.006	0.0031	0.0004	0.0004	0.0023
Co	mg/l	0.01	0.3	0.45	0.45	0.28	0.04	<	0.01	<	<	1.37	<	<	0.27	<	<	1	<
Cr	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Cu	mg/l	0.001	0.01	0.008	0.003	0.007	0.037	0.018	0.012	0.004	0.006	0.003	0.014	0.011	0.008	0.004	0.004	0.007	0.01
Fe	mg/l	0.1	0.04	0.11	0.16	0.07	<	0.64	0.4	<	<	0.07	<	0.14	<	<	<	<	0.09
Hg	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	mg/l	1	104	98	70	8	14	85	57	7	5	4	32	50	7	12	4	7	34
Mg	mg/l	1	20	12	53	205	426	581	352	26	81	157	836	782	199	397	114	207	458
Mn	mg/l	0.01	<	0.01	1.0	0.05	0.01	0.97	0.6	0.65	<	<	0.22	0.22	0.15	0.07	0.22	0.06	0.05
Mo	mg/l	0.01	<	0.02	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Na	mg/l	1	1480	1400	1310	1420	900	1650	939	88	477	552	2510	2300	1590	892	234	1560	1970
Ni	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
P	mg/l	1	<	<	<	<	<	2	2.54	<	0.39	<	<	<	<	<	<	<	<
Pb	mg/l	0.01	<	<	<	<	<	<	0.002	<	<	<	0.022	0.004	<	<	<	<	0.001
Si	mg/l	0.01	5.48	13	14.1	9.84	7.76	13.9	6.1	12.2	11.1	9.93	6.2	9.09	9.05	6.7	4.9	8.92	9.3
Sr	mg/l	0.01	2.10	2.50	2.00	1.60	2.10	3.50	2.07	0.20	0.46	0.70	3.98	4.00	1.70	2.13	0.35	1.60	2.65
V	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	4.40
Zn	mg/l	0.001	0.008	0.011	0.009	0.021	0.107	0.037	0.073	0.004	0.081	0.002	0.273	0.132	0.063	0.108	0.038	0.012	0.163
Total CN	mg/l	0.005	0.09	0.365	0.455	0.105	<	<	0.005	<	0.005	<	<	<	0.045	<	<	<	<
Free CN	mg/l	0.005	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
WAD CN	mg/l	0.005	0.035	0.025	0.06	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<

* The highest detection limit reported has been used.

Table B3: Chemical composition of leach water samples from the Yandan Heap Leach.

Parameter	Units	Detection Limit	Lauder		PAD 2	PAD 3	PAD 4	PAD 5
			Aug-01	Sep-01	Oct-01	Oct-01	Oct-01	Aug-01
pH	mg/l	0.1	-	-	-	-	-	-
TDS	mg/l	1	<	<	5780	5150	5770	6290
CO ₃	mg/l	1	<	<	<	<	<	<
HCO ₃	mg/l	1	13	13	<	<	<	<
SO ₄	mg/l	1	1100	1100	953	968	1010	1050
Cl	mg/l	1	1310	1310	3080	2480	2980	3480
N	mg/l	1	264	-	252	247	245	237
Al	mg/l	0.05	0.44	0.44	<	<	<	<
As	mg/l	0.001	0.022	0.022	0.088	0.069	0.081	<
B	mg/l	0.1	<	<	<	<	<	<
Ba	mg/l	0.1	<	<	0.1	<	<	<
Ca	mg/l	1	12	12	236	225	247	277
Cd	mg/l	0.001	<	<	<	<	<	<
Co	mg/l	0.001	0.44	0.44	0.43	0.43	0.44	0.44
Cr	mg/l	0.01	<	<	<	<	<	<
Cu	mg/l	0.001	0.072	0.072	0.018	0.024	0.019	0.001
Fe	mg/l	0.001	0.23	0.23	0.14	0.31	0.09	0.08
Hg	mg/l	0.0001	0.0005	0.0005	<	0.0018	0.0003	0.0009
K	mg/l	1	85	85	74	80	78	71
Mg	mg/l	1	12	12	22	16	11	13
Mn	mg/l	0.01	0.03	0.03	0.05	0.06	<	0.04
Mo	mg/l	0.01	0.03	0.03	<	0.02	0.03	0.02
Na	mg/l	1	1320	1320	1410	1380	1430	1400
Ni	mg/l	0.01	<	<	<	0.02	<	<
P	mg/l	1	<	<	<	<	<	<
Pb	mg/l	0.001	<	<	<	<	<	<
Si	mg/l	0.1	12.1	12.1	13.4	11.7	11.7	11.8
Sr	mg/l	0.1	2.5	2.5	1.7	2.2	2.7	2.6
V	mg/l	0.01	<	<	1.05	1.05	1.05	1.05
Zn	mg/l	0.001	0.009	0.009	0.007	0.010	0.007	<

Appendix C

EDTA Extraction Test Data

Multi-element assay data for the EDTA and deionised water extracts.

Water	5L3		7L2		8L3		10L2		BLANK	
	EDTA	D/Water	EDTA	D/Water	EDTA	D/Water	EDTA	D/Water	EDTA	D/Water
1001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
46	3.56	0.35	10.59	0.37	5.74	0.37	19.25	0.61	0.03	0.02
104	0.103	0.024	0.142	0.002	0.132	0.019	0.447	0.007	<0.001	<0.001
31	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01
387	0.2644	0.0108	0.4150	0.0108	0.4904	0.0125	0.6261	0.0225	0.0009	0.0005
301	0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001
39	66.42	6.31	998.45	15.81	93.83	6.76	1348.83	20.8	0.79	0.64
1002	<0.0002	<0.0002	0.0003	<0.0002	<0.0002	<0.0002	0.0004	<0.0002	<0.0002	<0.0002
2	6	<2	12	6	6	<2	8	2	4	<2
101	0.002	<0.001	0.007	0.001	0.004	<0.001	0.011	0.001	<0.001	<0.001
.01	0.01	<0.01	0.05	<0.01	0.01	<0.01	0.07	<0.01	<0.01	<0.01
.01	0.07	<0.01	0.31	<0.01	0.03	<0.01	0.98	<0.01	0.02	<0.01
2	<0.2	0.2	<0.2	0.2	<0.2	0.2	0.2	0.2	<0.2	0.2
301	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
0	5.1	2.5	4.8	2.2	4.2	1.5	4.7	1.6	0.4	<0.1
51	2.11	0.16	14.69	0.61	3.17	0.24	18.52	2.03	0.20	0.03
.01	0.09	<0.01	0.37	<0.01	0.30	<0.01	0.77	<0.01	<0.01	<0.01
101	0.0008	<0.0005	0.0022	<0.0005	0.0007	<0.0005	0.0041	<0.0005	<0.0005	<0.0005
.6	-	0.9	-	9.9	-	2.9	-	3.2	-	1.3
.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	0.12	<0.01	<0.01	<0.01
1.1	0.3	0.1	1.4	<0.1	0.4	<0.1	2.6	<0.1	0.2	<0.1
305	0.052	<0.005	0.895	<0.005	0.038	<0.005	0.212	<0.005	<0.005	<0.005
124	0.0047	0.0010	0.0419	0.0085	0.0030	0.0008	0.1684	0.0464	0.0002	<0.0001
305	<0.005	<0.005	0.030	<0.005	<0.005	<0.005	0.080	0.008	<0.005	<0.005
46	3.70	1.32	18.98	2.68	6.38	1.50	33.10	1.54	0.39	<0.05
301	0.004	<0.001	0.005	0.001	0.005	<0.001	0.005	<0.001	0.005	<0.001
.7	6.3	2.4	46.3	28.1	8.5	3.3	62.6	35.7	3.2	<0.3
34	1.38	0.02	4.18	0.02	0.89	<0.01	9.99	0.05	0.30	<0.01
.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	0.13	<0.01	<0.01	<0.01
31	0.03	0.01	0.09	0.01	0.03	0.01	0.14	0.02	0.03	0.02

Yandan Gold Mine TSF Cell B Conceptual Cover System Design Update

11 December 2019



Integrated Mine Waste Management
and Closure Services
Specialists in Geochemistry and
Unsaturated Zone Hydrology

Yandan Gold Mine

TSF Cell B Conceptual Cover System Design Update

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EXECUTIVE SUMMARY

Okane Consultants Pty Ltd. (Okane) has been retained by Straits Gold Pty Ltd (Straits Gold) to assist with developing a cover system design for Cell B of the tailings storage facility (TSF) at the Yandan Gold Mine (Yandan) in Central Queensland. The overarching project objective is to inform Straits Gold on suitable cover system options that incorporates a barrier layer for rehabilitation of the TSF Cell B at Yandan. Cell B of the TSF comprises oxide tailings of variable thickness over sulfidic tailings material. The DES requirement for a 'low permeability' layer stems from the need to limit potential for acid and metalliferous drainage (AMD) occurring through control of atmospheric interactions with the sulfidic tailings material.

In order to achieve the project objective, Okane has completed the following scope of work:

- Phase 1: Material Characterisation and Sampling;
- Phase 2: Laboratory Analysis of Potential Cover System Materials;
- Phase 3: Numerical Modelling and Detailed Cover System Design; and
- Phase 4: Cost Benefit Comparison of Cover System Variations

Okane completed a site visit in July 2019 to collect material samples and make observations relating to the suitability of the available materials for use in a suitable cover system. Geotechnical, and limited geochemical, testing was completed over a two stage approach to develop a database of the available material's physical and hydraulic characteristics on which a subsequent numerical modelling program was based. Materials were placed into four main groups; topsoil, growth medium, coarse rock and clay. A review of the clayey material was undertaken to assess the ability of available sources capable of producing a low permeability layer within the cover system.

Outcomes of the material characterisation program indicated:

- Material from the cores of the Tailings Return Water Dam and the Mine Water Dam embankments contain considerable oversize material and is therefore not considered suitable for constructing the barrier layer unit of a cover system designed to control infiltration into the underlying tailings material.
- Materials sampled from the Heap Leach Pond embankment core, upstream of the Mine Water Dam and upstream of the Water Storage Dam were found to have generally good consistency and are considered suitable for constructing a barrier layer. However further investigations will need to be completed to confirm the required volume of material can be won from these locations.
- Material from the offsite clay borrow location were found to be suitable for construction a barrier layer.

- The material adjacent to Cell A is generally coarser than the material adjacent to the Cell B and would be suitable for use in a capillary break layer. Waste rock from the heap leach pad also demonstrated appropriate physical characteristics for use in a capillary break layer.
- Several locations were considered suitable for use as a growth medium. However, as this unit of the cover system requires the most material to construct, the available volumes should be further investigated.
- Fertility testing of potential topsoil material did not identify any significantly limiting factors for vegetation growth or establishment.

Following material characterisation works, a 1-D numerical modelling program was utilised to investigate the following four cover system designs:

- 1) The previously proposed store-and-release cover system design (Base Case);
- 2) A double capillary break cover system;
- 3) A single capillary break cover system using the Queensland Government Department of Environment and Science's (DES) minimum prescribed cover system layer thicknesses; and
- 4) A single capillary break cover system using alternative cover system layer thicknesses based on Okane's experience and knowledge of the region.

These cover system alternatives were assessed in three categories:

- 1) Net Percolation (NP) Assessment: each cover system alternative was simulated to determine the water balance, including the amount of water that enters the underlying tailings (i.e. NP).
- 2) Water Stored within cover system available for vegetation: defined as the volume of water that is stored within the growth medium and topsoil component of the cover system, helps determine which cover system alternatives are best to provide sufficient water for vegetation establishment and survival.
- 3) Salt Uptake Assessment: determines relative potential for salt uptake into the cover system based on the alternatives.

The numerical modelling program concluded:

- The double capillary break and single capillary break with DES minimum thickness provided a moderate reduction in NP under a scenario modelled without established vegetation. The single capillary break with alternative layer thicknesses provided the greatest reduction in NP (4% of average annual rainfall) and was classified as a low NP system. Without established vegetation, the Base Case design only limited NP to approximately 54% of average annual rainfall and was classified as a very high NP system.

- Modelling with an established vegetation cover reduced NP for all three alternative cover system designs to low level NP systems. The introduction of established vegetation to the Base Case design reduced NP for this design from 54% to 8%, or from a very high to a moderate NP system.
- The double capillary break and both single capillary break designs can store more water within the cover system compared to the Base Case design.
- The single capillary break with the DES minimum thicknesses performed the best in terms of limiting salt uptake into the root zone of the cover systems. All three alternative cover system designs are expected to provide adequate control of salt uptake into the growth medium. The Base Case design resulted in moderate salinity levels at average tailings electrical conductivity levels and high to very high salinity levels when modelled using maximum potential tailings electrical conductivity values.

A cost benefit comparison was undertaken following the numerical modelling program to provide an indication of the relative difference between alternative cover system designs in terms of NP performance. The comparison provided an indication of the cost burden associated with a performance improvement relative to the Base Case. The estimated construction costs for all three alternative designs were considerably higher than those estimated for the Base Case. The cost benefit comparison identified the single capillary break with alternative layer thicknesses as the design providing the greatest relative improvement (47%) in NP performance and lowest construction costs when compared to the Base Case under the scenario with no vegetation coverage (bare surface).

However, when compared under the scenario with established vegetation coverage, the difference in performance between the Base Case design and the much higher cost alternatives was greatly reduced. Established vegetation coverage was modelled at 28% and is considered achievable based on observations made during the site visit. Under the established vegetation scenario, the predicted reduction in NP provided by the higher cost alternative cover system designs, when compared to the Base Case, is limited to 5-6%. As the construction costs remain the same under both scenarios, the relative costs accompanying the much smaller improvements achieved by the alternative cover systems designs are approximately eight times greater under an established vegetation scenario than a bare surface scenario.

Based on the results and findings from the material characterisation program, numerical modelling and cost benefit comparison, Okane recommend Straits Gold adopt the single capillary break with alternative layer thicknesses design to address both the DES requirement for a cover system incorporating a barrier layer and the rehabilitation objectives defined in the Yandan Post Mine Land Use Plan (AARC, 2015) for Cell B of the TSF.

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1 INTRODUCTION

Okane Consultants Pty Ltd. (Okane) was retained by Straits Gold Pty Ltd (Straits Gold) to assist with further developing a cover system design for Cell B of the tailings storage facility (TSF) at the Yandan Gold Mine (Yandan) located in Central Queensland. Previous work, completed by Okane in 2015 (Okane, 2015), developed a conceptual cover system design, suitable of meeting the following objectives:

- 1) Create clean surface runoff from the TSF Cell B surface;
- 2) Limit upward movement of oxidation products and salts;
- 3) Limit net percolation to restrict flushing of stored acidity;
- 4) Form a stable landform with limited erosion; and
- 5) Support vegetation and end land use:
 - a. Cattle grazing
 - b. Avoid deep rooted vegetation (trees).

Okane understands that during discussions between Straits Gold and the Queensland Government Department of Environment and Science (DES) in 2019, the 2015 conceptual cover system design was identified as unsuitable by DES as it did not incorporate a 'low permeability' unit within the cover system of Cell B.

1.1 Project Objective and Scope

The overarching project objective is to inform Straits Gold on suitable cover system options that incorporates a barrier layer for rehabilitation of the TSF Cell B at Yandan. Cell B of the TSF comprises oxide tailings of variable thickness over sulfidic tailings material. The DES requirement for a 'low permeability' layer stems from the need to limit potential for acid and metalliferous drainage (AMD) occurring through control of atmospheric interactions with the sulfidic tailings material.

Throughout this report Okane refers to the cover system unit designed to limit AMD as a barrier layer. The term 'low-permeability' layer is typically associated with, and is used by Okane, to define a specific level of performance, in terms of permeability (field saturated hydraulic conductivity $<1 \times 10^{-9}$ m/s). A barrier layer performs the same function as a 'low-permeability' layer but is not tied to a specific level of performance. The barrier layers investigated in this project would be constructed using a compacted clay type material identified during the material characterisation phase.

In order to achieve the project objective, Okane has completed the following scope of work:

- Phase 1: Material Characterisation and Sampling;

- Phase 2: Laboratory Analysis of Potential Cover System Materials;
- Phase 3: Numerical Modelling and Detailed Cover System Design; and
- Phase 4: Cost Benefit Comparison of Cover System Variations

Material sampling was undertaken during a four day site visit in July 2019. Samples collected during the site visit were subjected to a two-stage laboratory analysis program to characterise the available materials and identify their potential for use in a cover system.

Following material characterisation, a numerical modelling program evaluated the relative performance of the following four cover system designs in terms of NP, water storage and salt uptake:

- 1) The previously proposed 2015 conceptual cover system design (base case cover design);
- 2) A double capillary break cover system;
- 3) A single capillary break cover system using the Queensland Government Department of Environment and Science (DES) minimum layer thickness; and
- 4) A single capillary break cover system using alternative layer thicknesses for cover system layers.

A cost benefit comparison was completed to assess the relative cost increases associated with improvement in performance, measured as a percentage improvement, achieved by the alternative configurations when assessed against the original conceptual design from 2015.

1.2 Report Organisation

For convenient reference, this report has been subdivided into the following sections:

- Section 1 – Introduction, objectives and scope;
- Section 2 – Background information;
- Section 3 – Field sampling and material characterisation;
- Section 4 – Cover system design filters/site attributes;
- Section 5 – Modelling program and inputs;
- Section 6 – Modelling results;
- Section 7 - Cost benefit comparison;
- Section 8 – Findings and recommendations; and
- Section 9 – References.

2 BACKGROUND

The following section provides:

- A brief description of the Yandan mine site and its current rehabilitation objectives;
- Definition and classification of performance indicators; and
- Summary of cover system design filters and site attributes.

2.1 Site Background and Closure Objectives

The Yandan Gold Mine is located in central Queensland, approximately 50 km west of the township of Mount Coolon and 150 km south-east of Charters Towers. The project encompasses Mining Leases (ML) 1095 and ML 1096 and is authorised by Environmental Authority (EA) EPML00771913 (formerly MIN100902609). The Yandan deposit was originally discovered in 1986 before its acquisition by Ross Mining NL in 1992. Gold mining operations commenced in 1993 (GHD Pty Ltd, 2008). Ownership of Yandan has mostly recently been transferred to Straits Gold Pty Ltd, a subsidiary of Aeris Resources.

A total of three pits, Main Pit, South Hill Pit and East Hill Pit, were mined and other site facilities were constructed to support mining operations including a heap leach, a carbon-in-leach processing plant and a two-cell Tailings Storage Facility (TSF) (GHD Pty Ltd, 2008). The site has been under a period of care and maintenance since its closure in 1998 (Straits Gold, 2013). Figure 2.1 shows a satellite image of the main facilities / landforms within Yandan.

The north-west region of the Project site is characterised by undulating low hills and foot slopes with rock outcrops, while the south-east section is characterised by clay plains with temporary minor lakes during wet seasons being a feature. Yandan is situated on the east bank of the Suttor River in proximity to a junction with two minor ephemeral tributaries – Yandan Creek and Sandy Creek. Yandan Creek has a catchment of approximately 7,200 ha, while Sandy Creek has a catchment of approximately 900 ha. The Suttor River drains into Lake Dalrymple, formed by the damming of the Burdekin River.



Figure 2.1: Annotated Satellite image of Yandan.

Aeris Resources, 2010

The Main Pit is situated adjacent to the Suttor River is considered to require no further works to rehabilitate and decommission (AARC, 2015). Two spillways have been installed on the north-west and south-east walls on the pit such that inflows are allowed at least once in two years. Previous calculations have indicated that there is low potential for the Main Pit to fill to the level of the spillway and discharge water to the Suttor River. The South Pit has been filled in and rehabilitated. Minor work was conducted to stabilise a rock-lined waterway draining the upper slope (AARC, 2015).

The TSF is located in the north-eastern part of the site and contains two cells, Cell A and Cell B. The TSF covers a maximum surface area of 100 ha, holds a maximum volume of 9,000,000 m³ and has a maximum depth of 9m (GHD Pty Ltd, 2008). A return water pond is located immediately to the west of TSF Cell A, designed to collect runoff from the TSF.

Establishing a comprehensive closure plan requires the identification of clear closure objectives and articulation of the necessary design criteria required to meet those objectives. Design criteria typically take the form of specific numerical limitations that are required to be met, such as a maximum contaminant concentration at a monitoring location or a limitation of acceptable erosion volumes. The conceptual and detailed cover systems and landforms are then designed to meet these criteria.

Rehabilitation objectives developed for Yandan in accordance with the *Guidelines: Rehabilitation Requirements for Mining Projects* (EHP, 2014) that incorporate the principles of Ecologically Sustainable Development (ESD) include:

- 1) Ensure mine sites are rehabilitated to sound environmental and safety standards, and to a level at least consistent with the condition of surrounding land;
- 2) Provide appropriate community returns for using mineral resources and achieve better environmental protection and management in the mining sector; and
- 3) Improve community consultation and information. Improve performance in occupational health and safety and achieve social equity objectives.

In addition to the ESD objectives, site-specific rehabilitation objectives developed for Yandan in order to satisfy rehabilitation goals include (AARC, 2015):

- Sites are safe for humans and animals now and in the foreseeable future;
- Hazardous and contaminated material adequately managed;
- Polluted runoff and seepage contained on site;
- Acid and metalliferous drainage (AMD) will not cause serious environmental harm;
- Dams to remain on closure will not contribute contaminants to the environment;
- Rehabilitated dams will not contribute contaminants to the environment;
- Establish safe and stable waterbody with a low risk of environmental harm;
- Landform design achieves appropriate erosion rates;
- Minimal probability of wall failure or rock falls that will cause significant environmental harm;
- Adequate vegetation cover to minimise erosion;
- Very low probability of slope slippage with serious consequences;
- Soil properties that support and will continue to support desired land use; and
- Self-sustaining vegetation cover and species similar to adjoining undisturbed areas.

The layout of the Yandan TSF is shown in Figure 2.2. Previous rehabilitation works have been completed at TSF Cell A where vegetation has established directly on the tailings. Except for a central zone exhibiting poor drainage, rehabilitation of Cell A has largely been considered effective in establishing vegetation and adequate drainage (Straits Gold, 2013a).

Cell B comprises oxide tailings of variable thickness over sulfidic tailings material. Several cover system trials have been initiated on Cell B of the TSF. The first trial involved gravelly topsoil spread directly onto the tailings in varying thickness. However, the surface was not adequately graded to shed runoff and lead to ponding with capillary salt rise occurring in

these areas. Another trial was established in 2009, but again, inadequate surface drainage led to inconsistent results (Okane, 2015).

Recent discussions between Straits Gold and the DES have resulted in the requirement for a barrier layer to be incorporated within the cover system design for Cell B so as to limit NP into the underlying sulfidic tailings material and prevent AMD causing serious environmental harm. A conceptual cover system design developed in 2015 (Okane, 2015) was deemed unsuitable by the DES as it operates on the moisture 'store-and-release' principle and does not incorporate a barrier layer.

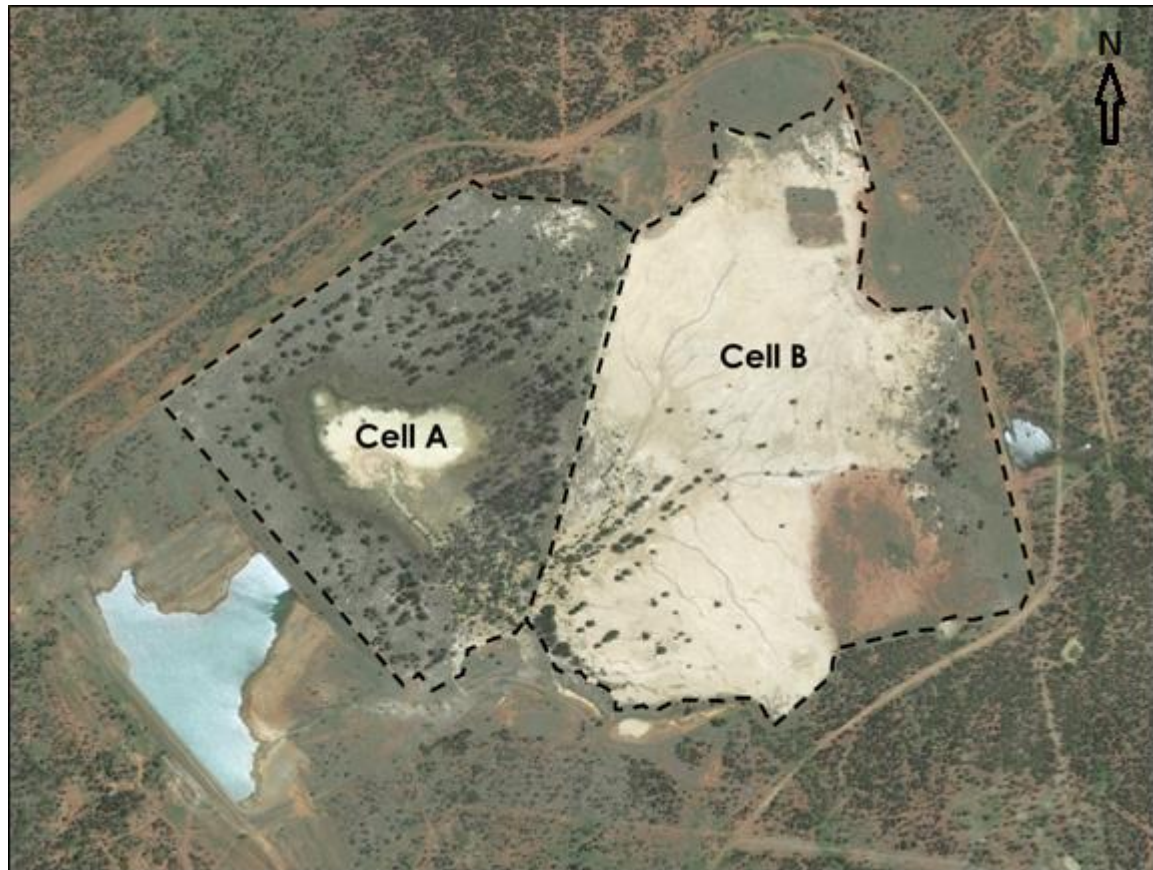


Figure 2.2: Cell A and Cell B approximate location for TSF cover system design.

The Tailings Return Water Dam (TRWD), located to the west of the TSF, will be decommissioned and the embankment removed. Material from the embankment and dam floor of this structure was identified as potential source for cover system construction and was sampled during the site visit.

2.2 Cover System Performance Indicators/Classifications

Cover system performance, within this scope of work, has been assessed using the following three performance indicators:

- Net percolation (NP);

- Soil water deficit; and
- Salt uptake.

These performance indicators, as well as their classifications, are defined herein.

2.2.1 Net Percolation

The term net percolation (NP) is used throughout this report and is defined as presented in Figure 2.3. Rainfall (R) will either be intercepted by vegetation, runoff (RO), or infiltrate into the surface. A portion of the water that infiltrates will be stored in the active zone (ΔS) and subsequently exfiltrate back to the surface and evaporate (E) or be removed by transpiration (ET). Infiltration can also move laterally downslope within and below the active zone (referred to as interflow). A percentage of the infiltrating water will migrate beyond the active zone as a result of gravity overcoming the influence of atmospheric forces (i.e. evaporation) and result in NP to the underlying material.

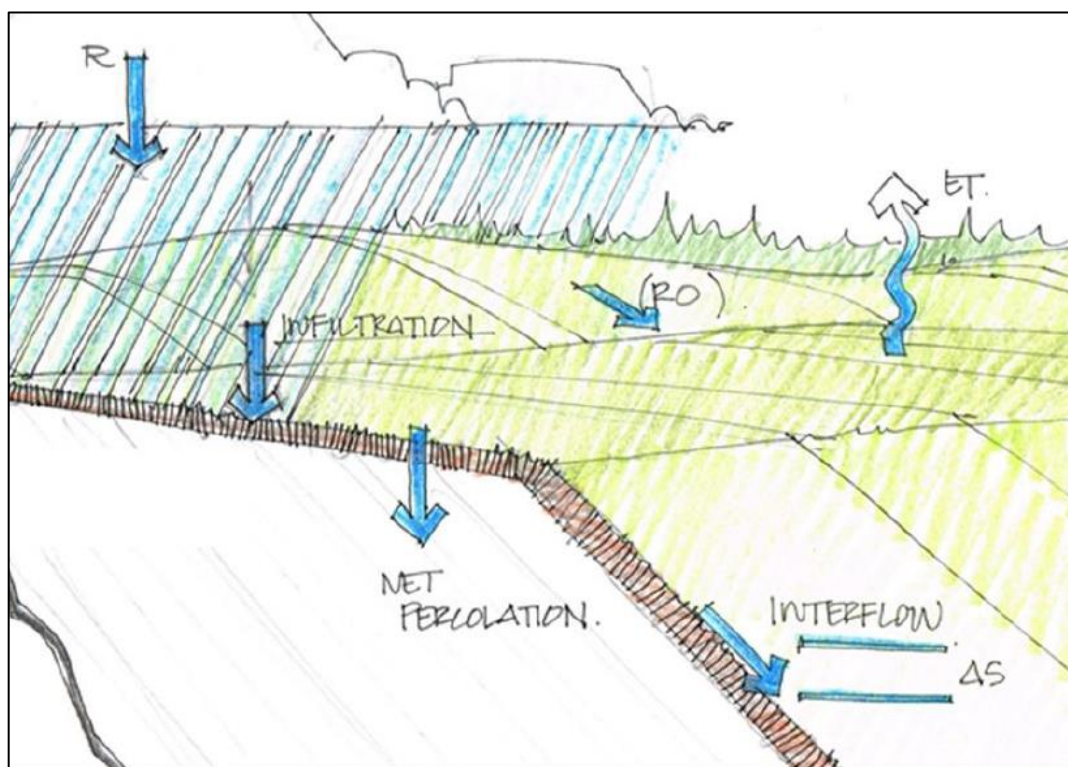


Figure 2.3: Schematic of hydrologic processes that influence performance of cover systems.

The following NP classifications have been adapted from the INAP guide (Figure 2.4) for Yandan based on the anticipated climate, whereby NP is expressed as a percentage of rainfall:

- Very low (<1 %): Cover systems with geosynthetic materials;
- Low (1 – 5 %): Barrier-type cover systems;
- Moderate (5 – 10 %): Enhanced store and release;
- High (10 – 20 %): Store and release;
- Very high (>20 %): Erosion Protection – Vegetation.

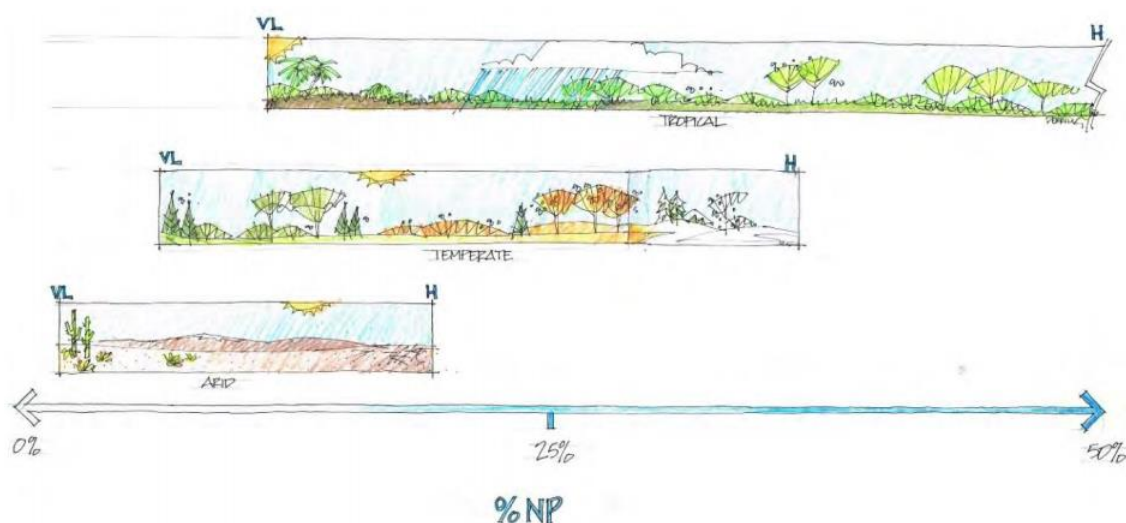


Figure 2.4: Qualitative NP rates for arid, temperate, and tropical regimes.

INAP, 2017

2.2.2 Water Stored within Cover System

The water stored within a cover system has been defined as the total volume of water within the growth medium and topsoil that can be utilised by vegetation and removed through evapotranspiration. This volume is largely governed by texture with some influence from organic matter. Generally, soils with smaller particle sizes have larger surface area and retain more water when compared to larger particle sizes. The amount of water stored within this section of the cover system is generally shown contrasted to the permanent wilting point (PWP), defined as the minimum soil water required for a plant to resist wilting. Additionally, the saturation of the soil is used to provide a guide as comparison for the total potential volume of water stored.

2.2.3 Salt Uptake

The primary objective of the salt uptake analysis is to assess whether transport of solutes from the tailings into the overlying cover system material may present a critical failure of the cover system design. A critical flaw from a solute transport perspective would be

where concentrations of solutes in the overlying cover system increased to a point where cover system performance would be adversely affected. For example, increased concentrations of solutes could have an adverse effect on plant growth or could alter the hydraulic characteristics of the cover material; leading to performance that differs from design values. Electrical conductivity (EC) is used as the parameter by which salt uptake is assessed. Modelled EC is then compared against soil salinity criteria prepared by the former Queensland Department of Environment and Resource Management (DERM) (Table 2.1).

Table 2.1: Soil salinity criteria.

Plant salt-tolerance	Corresponding EC range (dS/m)	Soil salinity rating
Sensitive vegetation	< 0.95	Very low
Moderately sensitive vegetation	0.95 – 1.9	Low
Moderately tolerant vegetation	1.9 – 4.5	Medium
Tolerant vegetation	4.5 – 7.7	High
Very tolerant vegetation	7.7 – 12.2	Very high
Generally, too saline for vegetation	> 12.2	Extreme

DERM, 2011

3 FIELD SAMPLING AND MATERIAL CHARACTERISATION

A field sampling and materials characterisation program was undertaken to characterise available materials at targeted locations both on and offsite. A material testing program was developed with the results used to inform numerical modelling, as further discussed in Section 5.2.2.

3.1.1 Sampling Methodology

Between 16 and 19 July 2019, two Okane personnel visited the Yandan Gold Mine and a potential offsite clay and topsoil borrow source approximately 25 km northeast of the site. During the site works samples of clay, topsoil, heap leach waste rock, gravel and tailings were collected for geotechnical and fertility analysis. A site walkover was completed to gather information including but not limited to the types of materials available, access to these materials, vegetation coverage, remnant facilities and signs of surface contamination likely to prevent a material being suitable for using in cover system construction. A total of 25 test pits were excavated across both the Yandan Mine site and an offsite borrow source, with samples collected from 23 of the test pits (as depicted in Dwg's 0956-007-001 to 0956-007-003 provided as Appendix A). Two test pits, TP#9A and TP#9B, were excavated to assess material homogeneity around TP#9, no samples were collected from these pits.

Based on discussions between Okane and Straits Gold, and the review of available background documentation and site plans, materials considered to have potential for use in a cover system were targeted prior to arriving onsite. The offsite clay and topsoil borrow source was also sampled and tested for suitability should materials on-site not exhibit appropriate geotechnical characteristics or be available in sufficient quantities.

Table 3.1 details the samples collected and their corresponding test pits, collection date, material type, sample depth, total excavation depth and their coordinates in UTM. Sampling locations are provided in Appendix A and stratigraphic logs and photographs of each test pit are provided in Appendix B.

Test pits were excavated to variable depths using a 35 Tonne excavator, reaching a maximum depth of 4 m at YAN-011. Due to localised rainfall near the offsite clay and topsoil borrow source prior to commencement of site work, boggy conditions on the track leading into the clay borrow source prohibited access by the excavator/float. For this reason, a telehandler was parked adjacent to the dam and used to loosen soil and access the underling clay for YAN-002 and YAN-003, and a shovel was used to access topsoil at YAN-001. All other test locations at Yandan Mine were accessible with the excavator.

Table 3.1: Summary of samples collected for geotechnical analysis.

Sample ID	Test Pit	Location (Material)	Sample Depth (m)	Total Excavation Depth (m)	Easting	Northing
YAN-001-(A/B/C/D)	TP#1	Offsite Dam (Topsoil)	0.1	0.1	522472	7650127
YAN-002-(A/B/C/D)	TP#2	Offsite Dam (Clay)	0.4	0.4	522472	7650127
YAN-003-(A/B/C/D)	TP#3	Offsite Dam (Clay)	0.3	0.3	522452	7650100
YAN-004-(A/B/C/D)	TP#4	Heap Leach Rock	0.5	0.5	497399	7645374
YAN-005-(A/B/C/D)	TP#5	HL Pond Embankment (Clay)	1.2	1.2	498191	7644949
YAN-006-(A/B/C/D)	TP#6	HL Pond Embankment (Clay)	3.5	3.5	498104	7644883
YAN-007-(A/B/C/D)	TP#7	Mine Water Embankment (Clay)	1.7	1.7	497846	7646133
YAN-008-(A/B/C/D)	TP#8	Mine Water Embankment (Clay)	3.0	3.0	497715	7645987
YAN-009-(A/B/C/D)	TP#9	Downstream Mine Water Embankment (Clay)	1.5	2.2	498035	7645730
YAN-010-(A/B/C/D)	TP#10	East Mine Water (Clay)	0.3	1.2	498884	7646389
YAN-011-(A/B/C/D)	TP#11	East Mine Water (Clay)	2.4	4.0	498777	7646386
YAN-012-(A/B/C/D)	TP#11	East Mine Water (Clay)	3.9	4.0	498777	7646386
YAN-013-(A/B/C/D)	TP#13	Tailings Embankment (Clay)	2.0	2.0	499303	7646818
YAN-014-(A/B/C/D)	TP#14	Tailings Embankment (Clay)	1.8	1.8	499384	7646721
YAN-015-(A/B/C/D)	TP#15	Tailings Embankment (Gravel and Topsoil)	1.2	1.2	499556	7646462
YAN-016-(A/B/C/D)	TP#16	Tailings Embankment (Topsoil)	0.4	0.4	499605	7646590
YAN-017-(A/B/C/D)	TP#17	Tailings Embankment (Topsoil)	0.4	0.4	499412	7646940

Sample ID	Test Pit	Location (Material)	Sample Depth (m)	Total Excavation Depth (m)	Easting	Northing
YAN-018-(A/B/C/D)	TP#18	Tailings Embankment (Topsoil)	0.8	0.8	499382	7646961
YAN-019-(A/B/C/D)	TP#19	Tailings Embankment (Gravel)	1.0	1.0	499373	7647253
YAN-020-(A/B/C/D)	TP#20	Tailings Embankment (Gravel)	0.7	0.7	499872	7647632
YAN-021-(A/B/C/D)	TP#21	Tailings Embankment (Gravel and Topsoil)	0.5	1.3	500359	7647808
YAN-022-(A/B/C/D)	TP#22	Tailings Embankment (Gravel)	1.8	1.8	500872	7647441
YAN-023-(A/B/C/D)	TP#23	Tailings Embankment (Tailings)	1.1	2.0	500548	7647328
YAN-024-(A/B/C/D)	TP#23	Tailings Embankment (Tailings)	2.0	2.0	500548	7647328
YAN-025-(A/B/C/D)	TP#24	Tailings Embankment (Gravel)	1.2	1.2	500670	7646736

Bulk samples comprising four 20 L pails were collected from each test pit, with two bulk samples collected from both YAN-011 and YAN-023. Four pails for each sample were half filled (approximately 10 kg) with material collected either directly from the base of test pits or from the excavator bucket. Additionally, two 500 g plastic bag samples were collected alongside each bulk sample for select fertility and Water Retention Curve (WRC) testing.

Stratigraphic logs of each test pit are provided as Appendix B, each detailing the soil profile at each location, samples collected, presence of organic material / roots in the soil, results of the paste pH/EC testing and a photograph of the test pit. Select photographs showing each different material sampling type are included herein for reference (Figure 3.1 to Figure 3.10).

Generally, any roots or organic material was confined to the upper topsoil layer (if present) to a depth of up to 0.1 m in the material with higher clay content. Topsoil at the offsite dam was light to dark brown and comprised predominantly silty sand with traces of clay and organics. Topsoil adjacent to the tailings embankment comprised orange brown sandy clay with some gravel and organic material tending towards gravel and cobble content at the southern side of the runoff dam.

In situ pH and EC test results are provided in Table 3.2. pH and EC testing were completed for each sample collected for geotechnical testing. Results collectively indicate the materials sampled at Yandan are of very low salinity and suitable for establishment of sensitive vegetation in accordance with the soil salinity criteria developed by DERM (Table 2.1). The exception comprises a tailings sample collected from TP23 which measured an EC value of 5.8 dS/m. This value is comparable with previous testing of the tailings where an average EC value of 5.19 dS/m was measured (Dwyer, 2014).

Table 3.2: pH / EC Testing Results

Test Pit	Material Type	Sample	Sample Depth (m)	SP Cond (dS/m)	pH
TP#1	Topsoil	YAN-001E	0.0-0.1	0.028	4.93
TP#2	Sandy Silt Clay	YAN-002E	0.3 – 0.4	0.015	6.03
TP#3	Gravelly Clay	YAN-003E	0.2-0.3	0.034	6.56
TP#4	Sandy Clay	YAN-004E	0.4-0.5	0.030	8.90
TP#5	Sandy Silty Clay	YAN-005E	1.1-1.2	0.019	7.98
TP#6	Sandy Silty Clay	YAN-006E	3.4-3.5	0.013	8.37
TP#7	Silty Clay	YAN-007E	1.6-1.7	0.106	8.15
TP#8	Sandy Gravelly Clay	YAN-008E	2.9-3.0	0.011	8.45
TP#9	Silty Clay	YAN-009E	1.4-1.5	0.251	7.41
TP#10	Silty Sandy Clay	YAN-010E	0.3-0.4	0.410	9.04
TP#11	Sandy Silty Clay	YAN-011E	2.3-2.4	0.310	8.75
TP#11	Silty Sandy Clay	YAN-012E	3.9-4.0	0.032	9.17
TP#13	Gravelly Sandy Clay	YAN-013E	1.9-2.0	0.010	7.67
TP#14	Gravelly Sandy Clay	YAN-014E	1.7-1.8	0.016	7.73
TP#15	Gravelly Sandy Topsoil	YAN-015E	1.1-1.2	0.138	7.0
TP#16	Sandy Clay with Shale/Basalt	YAN-016E	0.3-0.4	0.314	7.68
TP#17	Sandy Clay with Shale/Basalt	YAN-017E	0.3-0.4	0.027	8.91
TP#18	Sandy Clay Topsoil	YAN-018E	0.7-0.8	0.015	7.74
TP#19	Silty Sand Topsoil	YAN-019E	0.9-1.0	0.011	6.56

Test Pit	Material Type	Sample	Sample Depth (m)	SP Cond (dS/m)	pH
TP#20	Silty Sand Topsoil	YAN-020E	0.6-0.7	0.003	6.63
TP#21	Silty Sandy Topsoil	YAN-021E	0.4-0.5	0.494	7.02
TP#22	Gravel	YAN-022E	1.7-1.8	0.181	6.34
TP#23	Oxide Tailings	YAN-023E	1.0-1.1	5.813	3.59
TP#23	Sulfide Tailings	YAN-024E	1.9-2.0	0.295	5.92
TP#24	Gravel	YAN-025E	1.1-1.2	0.851	7.0



Figure 3.1: Test Pit #13, tailings water dam embankment (clay core)



Figure 3.2: Test Pit #23, Tailings.



Figure 3.3: Test Pit #5, HL Pond Embankment



Figure 3.4: Test Pit #7, MWD Embankment (Clay Core)



Figure 3.5: Test Pit 1, off-site clay borrow material.



Figure 3.6: Test Pit #11, on-site clay borrow material.



Figure 3.7: Test Pit #18, Topsoil.



Figure 3.8: Test Pit #20, gravel borrow source.



Figure 3.9: Test Pit #15, gravel and topsoil borrow source.



Figure 3.10: Test Pit #4, Heap Leach Pad.

3.1.2 Geotechnical Material Characterisation

To ensure a high degree of confidence in any cover system design, a thorough understanding of the materials available for construction and how they perform is required. A preliminary material characterisation analysis was completed (Phase 1) including; particle size distributions (PSD) and gravimetric moisture content testing on all 23 samples collected during the 2019 sampling program. Of these samples the following subset was selected for Phase 2 analysis:

- Six (6) to determine Atterberg limits (AL);
- Seven (7) for Emerson aggregate testing;
- Five (5) for modified compaction testing;
- Three (3) for moisture retention (or soil-water characteristic curves, SWCC); and
- Six (6) for permeability (falling-head and constant-head) testing.

Samples selected for additional testing were based on Phase 1 preliminary laboratory characterisation results which gave an indication of which sampled materials would most likely be suitable within a cover system.

The majority of testing was completed by Trilab Pty Ltd at their Brisbane laboratory. SWCCs were completed by the University of Queensland in Brisbane and fertility testing was completed by ALS Environmental, also located in Brisbane. All laboratory testing was

completed to applicable and relevant standards. Testing certificates are presented in Appendix C.

The following section outlines the results from the material characterisation testing, with stratigraphic logs of the soil profiles encountered at each test pit provided in Appendix B. During the field sampling program attention was paid to physical soil properties including material type, grain size, colour, presence of organic material, greater than 100 mm size fraction and any other observations. Photographs of each test pit were taken and added to the final test pit logs (Appendix B), as well as the results of *in situ* field permeability and pH/EC testing.

3.1.2.1 Particle Size Distribution

The particle size distribution (PSD) curve indicates the relative proportions of the different particle sizes that make up the material on a mass basis. Testing was completed according to AS 1289.3.6.1 and AS 1289.3.6.3. The standard size fractions include:

- Cobble and Gravel: > 4.75 mm;
- Sand: 0.075 – 4.75 mm;
- Silt: 0.005 – 0.075 mm; and
- Clay: < 0.005 mm.

The PSD can be used to develop material texture, as an indicator of erosion, water holding capacity or the suitability of a material for a low permeability layer. Fine soils such as clays or silts will hold more water and generally have a lower hydraulic conductivity, while coarser materials will tend to erode less. Furthermore, PSD curves may be used as a guide for material consistency, if a major part of the curve is steep then the soil has a size distribution extending over a limited range with most particles being approximately the same size. However, if the soil exhibits a flat section or plateau, then the soil is considered gap graded and a large percentage of it is bigger and smaller particles with less intermediate particles in between.

Results from Phase 1 testing, including oversize estimation, particle density and percentages of particle size are shown in Table 3.3. All test pits maintained their stability during excavation, with no side-wall collapses encountered. In the absence of a grizzly screen, material was passed through an excavator sieve bucket with 115 mm spacings. The >115 mm fraction was placed aside and estimated. Generally, the gravel borrow sources contained the most material with a size fraction >100mm. The clay borrow source at the tailings runoff dam embankment, topsoil borrow source areas and heap leach generally contained few particles >100mm.

The PSD curves for potential topsoil borrows (Figure 3.11) indicate finer options located at the offsite dam (YAN-001), to more coarse options located to the north adjacent the tailings embankment (YAN-017).

For potential coarse rock sources (Figure 3.12), the light brown / light grey heap leach waste rock (YAN-004) provides well graded material, as do the borrows located adjacent to the south and east of TSF Cell B (YAN-022 and YAN-025). Potential growth medium (Figure 3.12) consisting of slightly finer material than the coarse rock is available adjacent to the north of the TSF Cell A (YAN-019 and YAN-021).

Examining potential clay sources (Figure 3.13), it can be seen that based on the test results the finest material is located upstream of the Water Storage Dam (WSD) (YAN-011) and upstream of the Mine Water Dam (MWD) (YAN-009). Two distinct layers of clay were present at YAN-011, a grey brown sandy silty clay and a dark grey mottled light brown silty sandy clay. The fine grained, dark red brown silty clay material available in the vicinity of TP#9 is located upstream of the MWD in the flow path between the previous processing areas and dam. The MWD is considered a hazardous dam and therefore it is recommended if material is used from this location it should be subjected to further geochemical analysis to determine if contamination of this material has occurred and if so, does it prohibit the use of the material for certain purposes, e.g. as a growth medium.

The red brown mottled grey silty clay, light grey brown mottled red sandy gravelly clay and the red brown gravelly sandy clay sampled from the MWD embankment (YAN-007 and YAN-008) and the TRWD embankment (YAN-013 and YAN-014) had the coarsest PSD curves from the potential clay sources. This indicates these materials are likely to have a higher saturated hydraulic conductivity than the clays from YAN-009 and YAN-011. The PSD of the red/grey/brown sandy silty clay core of the Heap Leach (HL) Pond embankment (YAN-005 and YAN-006) placed in between these two end members.

Table 3.3: Phase 1 testing results, including oversize estimation.

Sample ID	Particle Density (t/m ³)	Moisture (%)	% > 115 mm	Oversize (%)	Coarse (>4.75 mm) (%)	Sand (4.75 mm - 0.075 mm) (%)	Clay and Silt (<0.075 mm) (%)
YAN-001	2.55	3.0	0%	0	1	57	42
YAN-002	2.58	4.1	0%	0	6	54	40
YAN-003	2.66	3.6	0%	0	9	49	42
YAN-004	2.57	7.3	~ 40%	57	80	14	6
YAN-005	2.64	6.9	0%	0	14	69	17
YAN-006	2.64	8.1	0%	0	16	42	42
YAN-007	2.68	9.0	0%	0	43	33	24
YAN-008	2.73	8.5	~ 5%	0	40	40	20
YAN-009	2.65	16.2	0%	0	5	28	67
YAN-010	2.65	10.6	0%	0	25	30	45
YAN-011	2.66	7.6	0%	0	3	38	59

Sample ID	Particle Density (t/m ³)	Moisture (%)	% > 115 mm	Oversize (%)	Coarse (>4.75 mm) (%)	Sand (4.75 mm - 0.075 mm) (%)	Clay and Silt (<0.075 mm) (%)
YAN-012	2.72	11.3	0%	0	26	45	29
YAN-013	2.64	8.9	~ 10%	16	40	30	30
YAN-014	2.70	9.1	~ 10%	0	43	28	29
YAN-015	2.64	7.4	~ 15%	5	46	27	28
YAN-016	2.71	10.6	0%	0	33	21	46
YAN-017	2.68	7.7	0%	0	61	29	10
YAN-018	2.69	15.5	~ 5%	0	8	63	29
YAN-019	2.60	10.4	~ 5%	5	43	17	40
YAN-020	2.63	6.3	~ 30%	30	58	23	18
YAN-021	2.67	9.7	0%	0	19	47	34
YAN-022	2.61	6.5	~ 45%	45	73	20	7
YAN-023	2.53	12.2	0%	0	0	32	68
YAN-024	2.60	13.1	~ 80%	0	0	45	55
YAN-025	2.65	9.7	0%	80	43	44	13

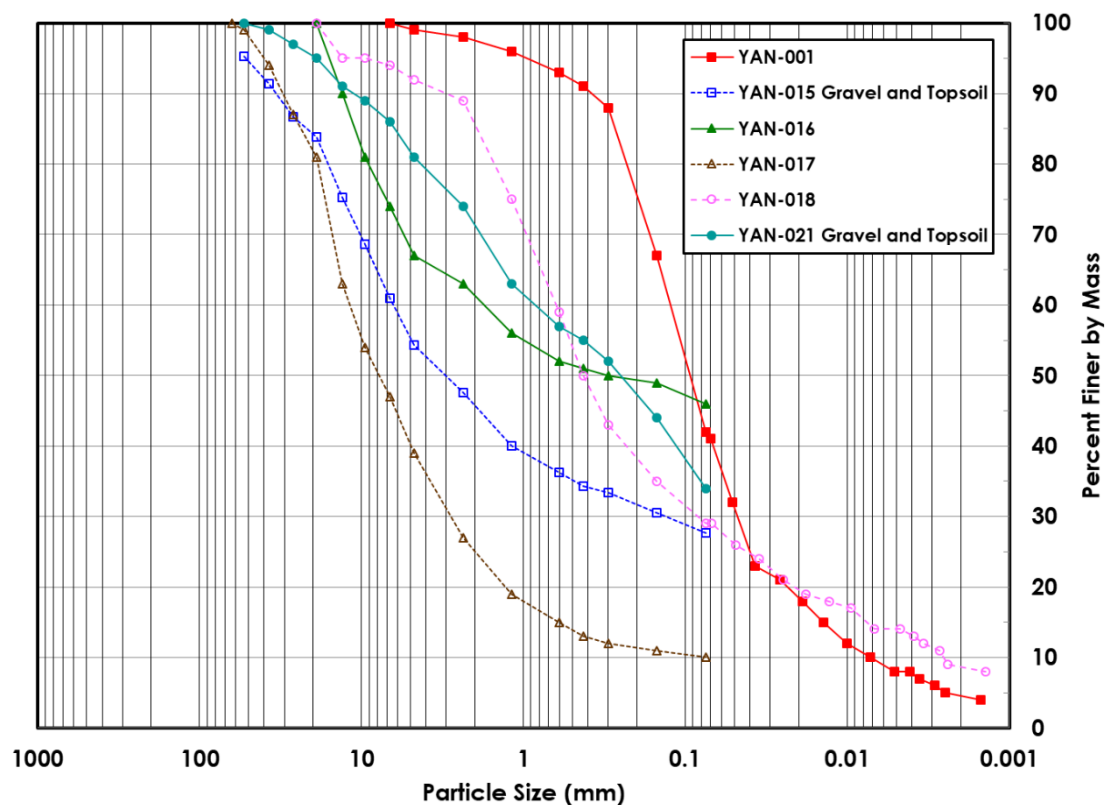


Figure 3.11: PSD curve for potential topsoil borrows.

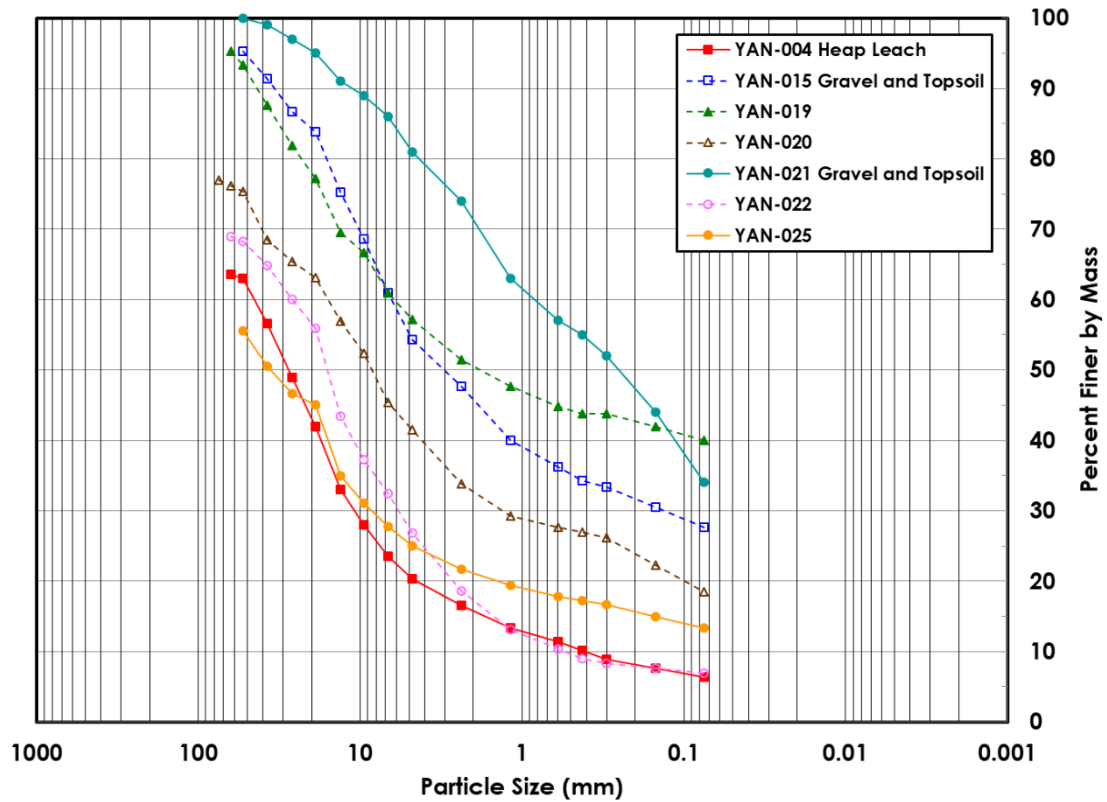


Figure 3.12: PSD curves for potential coarse rock and growth medium borrows.

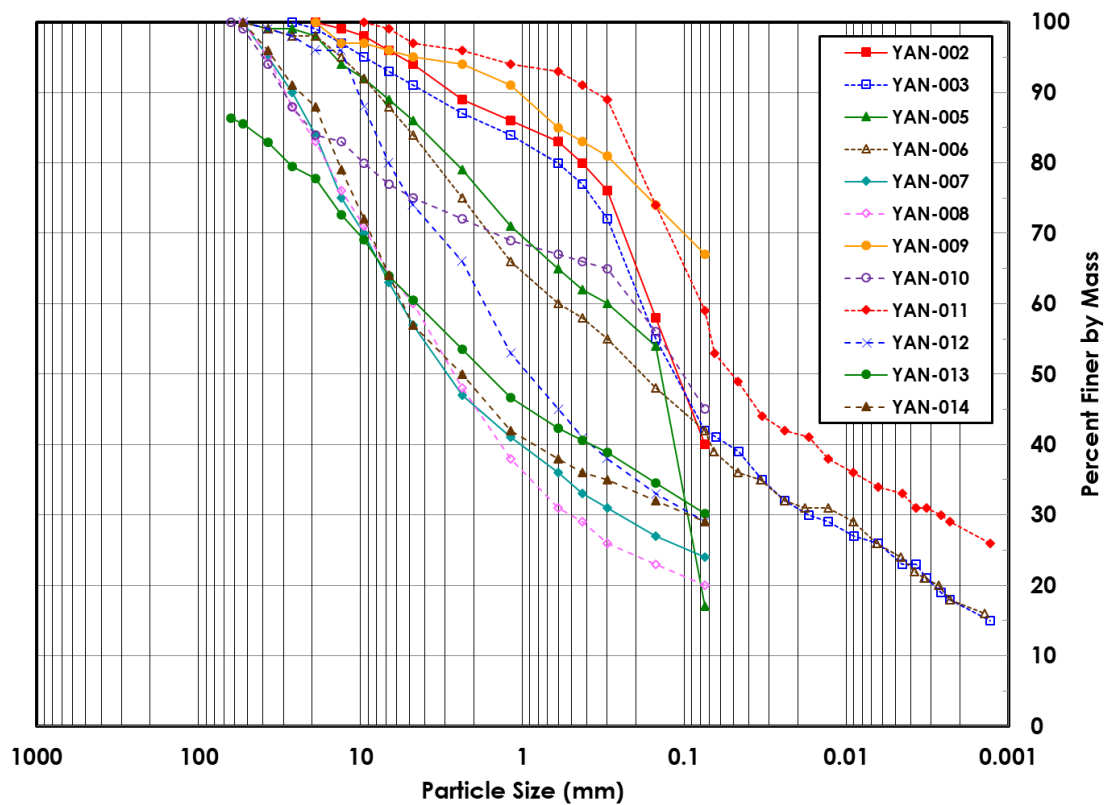


Figure 3.13: PSD curves for potential clay borrows.

3.1.2.2 Atterberg Limits

The physical behaviour of soil changes with increasing moisture content. To describe how the properties of soils change with moisture content, such as becoming more plastic, or cohesionless, critical moisture limits have been defined using the Atterberg limits. The Atterberg limits are used primarily in classifying fine-grained cohesive soil materials and tests the limits of these various soil states. These include the plastic limit (PL), where the soil is no longer brittle and cracks, but instead begins to mould easily and display plastic behaviour and the liquid limit (LL), where soil no longer displays plastic behaviour but instead flows like a liquid. The plastic index (PI) is the difference between LL and PL and defines the range of water content a material is plastic. Testing was completed according to AS 1289.3.1.1, AS1289.3.1.1 and AS 1289.3.2.1. Figure 3.14 shows the plasticity index (PI) and liquid limit (LL) for each test pit sample as developed from Atterberg limit tests.

The characteristics of various fine-textured materials, such as clay content and mineralogy, can be determined through the relationship between the LL and PI. The plot of LL-PI can be used to identify clay mineralogy of a sample. Montmorillonites are highly active clay minerals and plot above the A-line near the U-line. Illites plot directly above the A-Line and are less active than Montmorillonites, and Kaolinites plot below the A-Line and are relatively inactive. Active clay minerals provide additional water storage capacity as a bound water volume. Figure 3.14 shows that the Yandan samples plot above the A-Line and below the U-Line with low plastic and inorganic clays (CL), indicating moderately active clays containing predominately illites and montmorillonites.

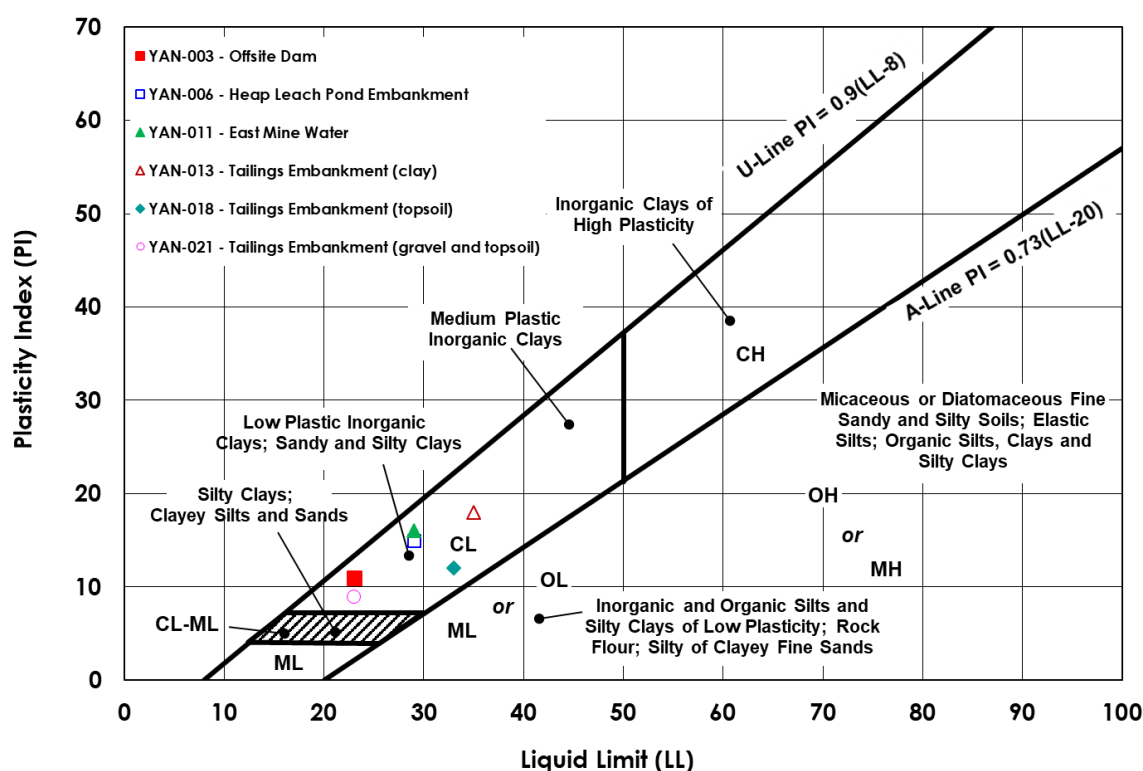


Figure 3.14: Atterberg limit results for fine-grained material tested as potential clay source.

3.1.2.3 Emerson Aggregate

Emerson tests are used to classify the behaviour of soil aggregates, when immersed, on the coherence in water. Once aggregates are immersed in water, an osmotic stress arises between the negatively charged particles, this stress increases gradually as the soluble salts present in the aggregates diffuse out. The increase may be sufficient to cause dispersion. Soils are divided into seven classes based on their dispersion and slaking behaviour. Class 1 disperses completely, Class 2 partially. Classes 3-6 do not disperse initially but may do so upon remoulding and may also exhibit flocculation or slaking behaviour. Class 7 involves no slaking or dispersion but swelling instead, typical of organic matter. Testing was completed according to AS 1289.3.8.1.

All samples placed in Classes 2 to 5 (Table 3.4). The only sample that dispersed without remoulding (Class 2) was YAN-015, collected from the area identified as a gravel/topsoil located to the south of the TRWD embankment. Gravel (YAN-020) from the area north of Cell A of the TSF demonstrated the least amount of dispersion and was the only sample to be classified as Class 5.

Table 3.4: Emerson Aggregate results.

Samples	Depth (m)	Description	Class
YAN-001	0.1	Sandy Silt	3
YAN-013	2.0	Sandy Clay	4
YAN-015	1.2	Silty Sand	2
YAN-018	0.8	Clayey Sand	4
YAN-020	0.7	Silty Sandy Gravel	5
YAN-021	0.5	Silty Sand	4
YAN-025	1.2	Silty Sandy Gravel	4

3.1.2.4 Modified Compaction

When soils are used as construction materials in any type of fill or embankment, they nearly always require compaction, this helps to prevent settlement, increase strength and slope stability and reduce permeability. This is particularly relevant when the aim of the soil layer is to reduce permeability to as low as practical, such as a clay barrier layer within a cover system. However, there is a limit to the density that can be achieved by compaction under a given effort. This maximum density can be attained only at a particular moisture content, known as the optimum moisture content (OMC). Below the OMC the soil is stiff and difficult to compact, above the OMC, pore pressure begins to develop, and the water tends to keep the soil particles apart (Smith, 2014).

A compaction test is used to determine the OMC to achieve a maximum dry density (MDD), resulting in a Proctor curve. For the Yandan samples a modified compaction test was used in accordance with AS 1289.5.2.1. In general, fine-textured materials have a

higher OMC and lower MDD than coarse-textured materials. Thus, as a material becomes coarser, the Proctor Curve will move towards the top left of the chart (see Figure 3.15). This trend is shown whereby material sampled from upstream of the WSD (YAN-011) contains 59% clay and silt size particles, resulting in this sample being the lowest (with regards to dry density) relative to the other samples. In contrast, the gravel and topsoil material collected from the area to the north of the TSF (YAN-021), which contains 34% of clay and silt size particles plots above the curves measured for the other sampled materials.

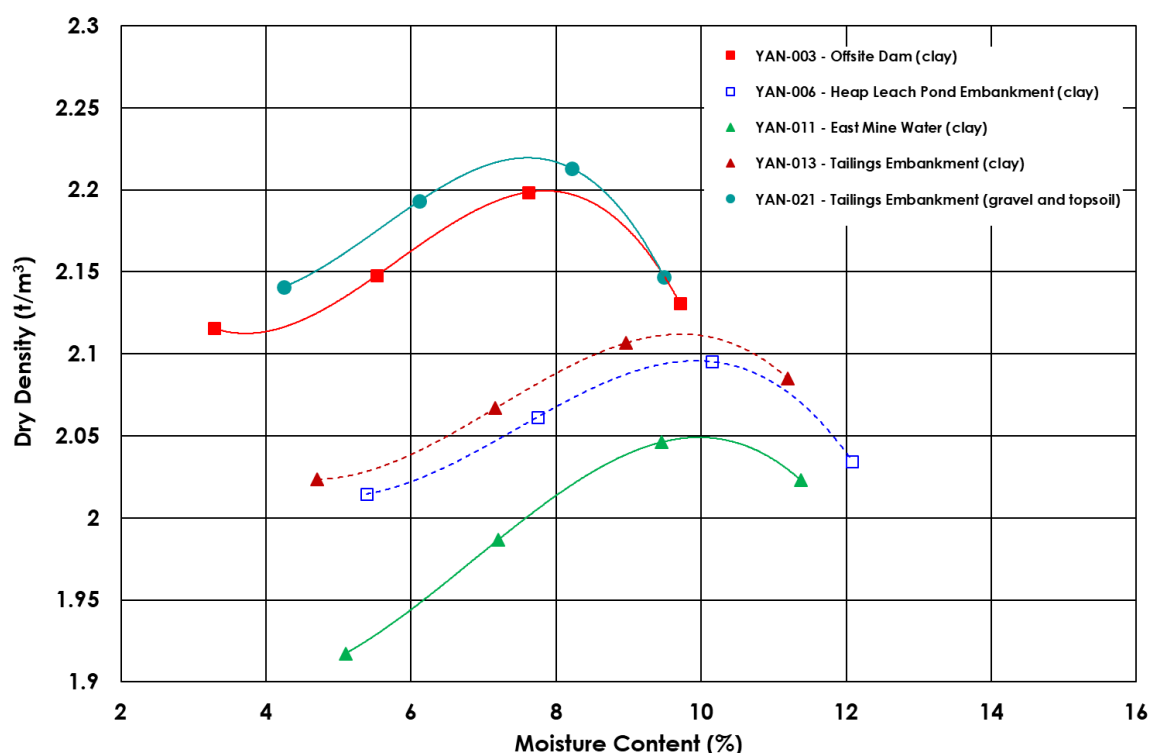


Figure 3.15: Modified Proctor Curves for potential cover materials.

3.1.2.5 Hydraulic Conductivity (Falling-head and Constant-head)

Hydraulic conductivity is a measurement or rate of a soil's ability to let water flow through it. Hydraulic conductivity is often measured using the falling-head and constant-head tests. Results can be used as a guide to further refine the expected performance of a cover system design. Hydraulic conductivity is not a fundamental property but depends on a number of factors such as particle size and shape, texture, mineralogical composition, void ratio, saturation and even temperature (Steffen, 2014). Testing was focused on potential low permeability materials and potential topsoil sources (Table 3.5) and was conducted in accordance with Australian Standards AS 1289 3.6.3., 3.5.1 and 2.1.1.

A 'low permeability' layer is typically considered to be a layer with a field saturated hydraulic conductivity of less than 1×10^{-9} m/s. Falling head testing of samples YAN-003 and YAN-011 indicated these materials may be able to achieve this level of performance, or close to, when tested under laboratory conditions. Whilst not achieving a performance

level considered 'low permeability', results for YAN-013 indicated this material could achieve a relatively low level of saturated hydraulic conductivity (7.6×10^{-8} m/s) when compared to the remaining materials. However, sample YAN-013 contained particles greater than 19 mm in diameter. This makes the material unsuitable for use as a 'low permeability' layer as the ability to compact the material is reduced and the larger grain sizes present weaknesses to the unit which overtime may lead to preferential cracking and desiccation, thereby allowing localised preferential flowpaths.

The offsite clay source (YAN-003) and onsite clay source located upstream of the WSD (YAN-011) recorded no oversize material. Whilst both samples resulted in similar OMCs, the compactive effort required to achieve this level of hydraulic conductivity is greater for sample YAN-003.

Table 3.5: Falling-head and constant-head test results

Sample	Location and material	Hydraulic conductivity, k_{20} (m/s)	Oversize (%)	Corrected k_{20} (m/s)
YAN-003	Offsite Dam (Clay)	5.6×10^{-10}	0 / 9.5 mm	5.6×10^{-10}
YAN-006	HL Pond Embankment (Clay)	6.6×10^{-10}	2 / 19 mm	6.5×10^{-10}
YAN-011	Upstream of WSD (Clay)	2.4×10^{-9}	0 / 9.5 mm	2.4×10^{-9}
YAN-013	TRWD Embankment (Clay)	7.6×10^{-8}	10 / 19 mm	6.8×10^{-8}
YAN-018*	TRWD (Topsoil)	2.8×10^{-5}	0 / 19 mm	2.8×10^{-5}
YAN-021	North of TSF (Gravel and Topsoil)	8.7×10^{-7}	14 / 19 mm	7.5×10^{-7}

*Constant-head test was performed.

Guelph Hydraulic Conductivity tests were performed during the site visit to estimate the *in situ* hydraulic conductivity of several materials (Section 3.1.3).

3.1.2.6 Soil Water Characteristic Curve

The SWCC is a continuous function relating energy and the state of water and describes the water content of a material as a function of soil suction, or negative pore-water pressure. SWCC testing was completed by the University of Queensland using a SWC-150 Fredlund device. Results for samples YAN-003, YAN-006 and YAN-011 are shown in Table 3.6 and Figure 3.16. The results display good consistency between borrow sources with a porosity and air entry value (AEV) that would be expected from a clayey material capable of producing a barrier layer. Results were used to develop an estimate of the SWCC input for the modelling program (as discussed in Section 5.2).

Table 3.6: Laboratory SWCC of Yandan materials.

Sample	Location and material	Particle Density (t/m ³)	Dry Density (t/m ³)	Porosity	AEV (kPa)
YAN-003	Offsite Dam (Clay)	2.68	1.645	0.40	5 – 10
YAN-006	HL Pong Embankment (Clay)	2.71	1.578	0.42	5 – 10
YAN-011	Upstream of WSD (Clay)	2.67	1.545	0.42	5 – 10

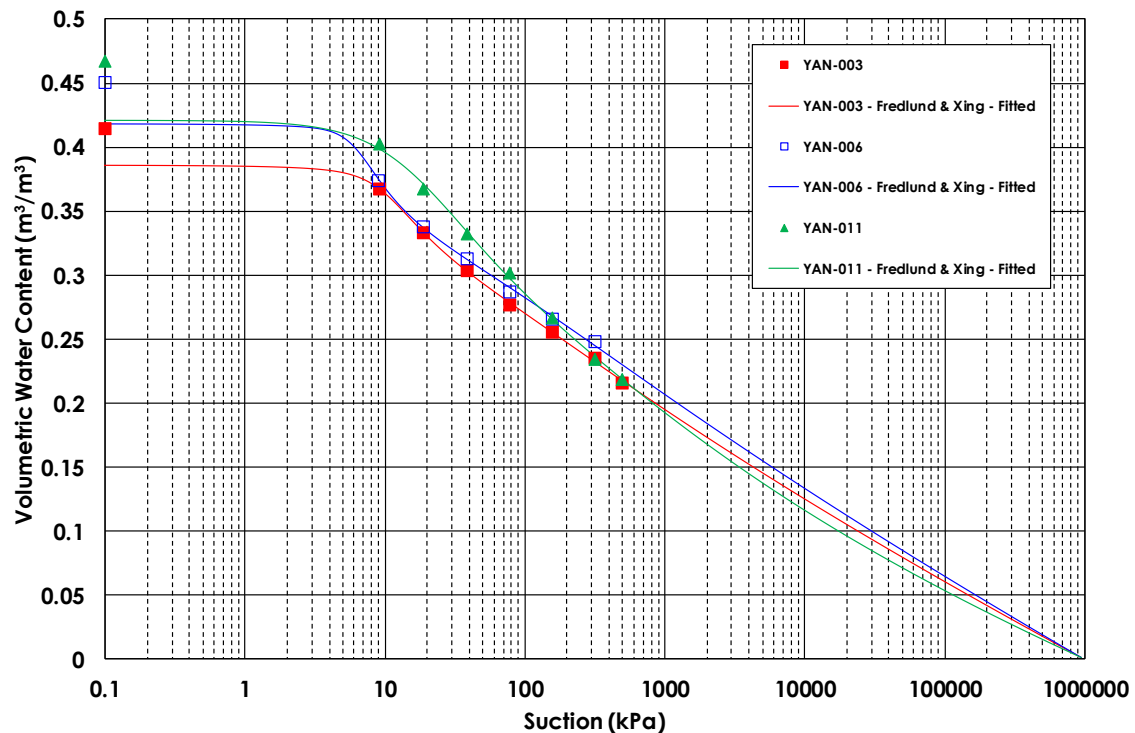


Figure 3.16: SWCC results and fitted curves for potential low permeability layer material.

3.1.3 Guelph Hydraulic Conductivity

During the site visit, a total of seven (7) Guelph Hydraulic Conductivity tests were performed both on-site and at the offsite clay borrow source (Table 3.7). Field permeability testing is completed to provide an estimate of the *in situ* hydraulic conductivity of materials and provides further data to support a material's suitability for use in a cover system. Field testing allows evaluation of a material in field conditions rather than laboratory conditions where samples have been disturbed during the collection process and are then remoulded and compacted to a level reflective of the compaction anticipated to be applied when constructing the cover system.

In situ hydraulic conductivity of material tested onsite ranged between 4.17×10^{-8} m/s for the compacted gravelly clay material within the TRWD Embankment and 4.26×10^{-6} m/s for material on the MWD embankment. The *in situ* hydraulic conductivity of the offsite clay borrow source was measured at 8.51×10^{-7} m/s. Generally, clays with higher gravel and

sand contents showed higher soil hydraulic conductivity and denser, more homogeneous clays showed lower soil hydraulic conductivity. The *in situ* results were reasonably consistent with the laboratory results where testing was completed on areas previously subjected to compaction forces, such as dam embankments. For other, non-compacted or virgin areas, *in situ* hydraulic conductivity was greater than that observed in laboratory conditions. This is expected due to the *in situ* tests being generally conducted on near surface materials that have been subjected to weathering processes and which have not been mechanically compacted. For example, clay from upstream of the WSD was measured as having an *in situ* hydraulic conductivity of 8.51×10^{-7} . Under laboratory conditions, where sample preparation involved imparting a compaction force intended to reflect the compactive effort the material is likely to be subjected to when used as a compacted clay layer within a barrier type cover system, this material achieved a hydraulic conductivity of 2.4×10^{-9} .

Table 3.7: Guelph Hydraulic Conductivity.

Test Number	Location	Material Type	Hydraulic Conductivity (m/s)
GP1	Offsite Dam	Sandy clay	8.51×10^{-7}
GP2	HL Pond Embankments	Gravel/clay	1.31×10^{-7}
GP3	MWD Embankment	Sandy/clay	4.26×10^{-6}
GP4	Upstream of MWD	Topsoil/clay	8.51×10^{-7}
GP5	Upstream of WSD	Clay	1.34×10^{-7}
GP6	TRWD Embankment	Compacted gravel/clayey material	4.17×10^{-8}
GP7	Tailings	Tailings	6.31×10^{-7}

3.1.4 Soil Fertility

Soil fertility relates to the chemical properties of the soils and their influence on vegetation growth and establishment. Properties analysed to assess soil fertility include pH, electrical conductivity (related to salinity), nitrogen, phosphorus, potassium and sulfur. If these properties are either too high or too low, depending on the property in question, plant growth can be significantly inhibited. The soil fertility testing focused on potential topsoil and growth medium sources and was completed by ALS Environmental at their Brisbane laboratory. Results, including assessment against ranges published by Hazelton and Murphy (2016), are provided in Table 3.8. Multiple results were found to be marginally out of optimal ranges but still within growth ranges. The results indicate the materials sampled are generally suitable to support vegetation and could be used for as a topsoil and/or growth medium layer of a cover system.

Table 3.8: Soil fertility results.

Test	Units	YAN-001	YAN-018	YAN-021	Comments
pH	-	5.7	8.3	6.5	Ranging from moderately acidic to moderately alkaline, all within suitable range for plant growth
Electrical Conductivity	µS/cm	67	562	637	All considered non-saline, with negligible effects.
Exchange Sodium	%	2.6	9.7	3.7	0-6 is non-sodic, 6-14 is considered sodic. YAN-018 is sodic but still within acceptable range.
Sulfur	%	0.01	0.02	0.02	Negligible impact.
Total Nitrogen	mg/kg	690	450	800	Negligible impact.
Total Kjeldahl Nitrogen	mg/kg	660	450	780	Negligible impact.
Total Phosphorus	mg/kg	283	872	160	Negligible impact.
Organic Matter	%	1.4	0.5	1.2	Negligible impact.
Total organic carbon	%	0.8	< 0.5	0.7	Negligible impact.
Exchangeable Aluminium	meq/100g	<0.1	-	-	Within desirable range.
Exchangeable Calcium	meq/100g	2.9	12	3.3	YAN-001 and YAN-021 are lower than desired.
Exchangeable Magnesium	meq/100g	1.1	1.9	2.7	YAN-001 is lower than desired.
Exchangeable Potassium	meq/100g	0.2	<0.2	0.2	All samples are lower than desired
Exchangeable Sodium	meq/100g	0.1	1.5	0.2	YAN-018 is higher than desired.
Cation Exchange Capacity	meq/100g	4.3	15.6	6.6	Within desirable range.
Calcium/Magnesium Ratio		2.6	6.3	1.2	1-4 is low Calcium, 6-10 is low Magnesium.
Magnesium/Potassium Ratio		6.4		10.9	Within desirable range.

Hazelfon and Murphy, 2016

3.1.5 Estimated Material Volumes

High-level estimates of available material volumes were calculated based on field observations of approximate areas and depths reached during test pit excavations. The estimates provided are based on limited exploration and should be considered indicative only. The available volumes of each material should be investigated more thoroughly prior to commencing design and construction activities.

- TRWD Embankment (Clay core): Based on an approximate total length of the L-shaped embankment of 600 m and an assumed average clay core cross sectional area of 9 m², the estimate of clay available at this location is approximately **5,000 – 6,000 m³** bank cubic meters (BCM).

- MWD Embankment (Clay core): Based on an approximate total length of the L-shaped embankment of 460 m and an assumed average clay core cross sectional area of 16 m², the estimate of clay available at this location is approximately **7,00 – 8,000 m³ BCM**.
- HL Pond Embankment (Clay core): Based on an approximate total perimeter of the embankment of 530 m, and an assumed average clay core cross sectional area of 9 m², the estimate of clay available at this location is approximately **4,000 – 5,000 m³ BCM**.
- Upstream MWD (Clay borrow): Based on visual observations and the three test pits excavated in this area, the clay appears variable and localised primarily to lower lying gullies and could be accurately quantified in the time available during the site visit. However, based on a total surface area of approximately 5,000 m², and a clay thickness ranging between 0.2 m and 1.6 m, the estimate volume of clay is between approximately **1,000 m³ and 8,000 m³ BCM**.
- Upstream of WSD (Clay borrow): Based on visual observations, satellite imagery and the two test pits excavated in this area, the clay in this area appears variable and could be accurately quantified in the time available during the site visit. However, based on a total surface area of approximately 100,000 m² determined using satellite imagery, and a clay thickness ranging between 0.2 m and 3.8 m, the estimated volume of clay is between approximately **20,000 m³ and 380,000 m³ BCM**.
- Offsite Dam (Clay borrow): Developing an estimate of any real value for the volume of clay available from this source was not possible. Due to ground conditions at the time of the site visit, it was not possible to float the excavator to this location and sampling was limited to the near surface (<0.4 m). However, based on anecdotal information from the excavator operator, visual observations and the dam footprint, it is expected a significant volume of clay material is available and would likely satisfy volume requirements for at least a 0.3 m compacted clay barrier layer.
- Topsoil (borrow): The areas previously identified as topsoil borrow areas, north and south of the TRWD have a total surface area of approximately 155,000 m². Test pits were excavated in these areas to between 0.4 m and 0.8 m. Based on site observations and historical aerial imagery, approximately 55,000m² of this area appears to have been previously stripped and has not been included in the volume estimate. Based on test pit results and observations, it is estimated between **40,000 m³ and 80,000 m³ BCM** of material from this location has physical properties suitable for use as a topsoil. However, the depth to which material from this area could be considered reasonably likely to also contain a viable seed bank and/or organic matter is limited to 0.2 m. The estimated volume of currently viable topsoil from this area is **20,000m³ BCM**.
- Gravel and topsoil (borrow): Based on visual observations, satellite imagery and test pits excavated in the gravel and topsoil borrow areas, the topsoil gravel source areas

have a collective surface area of approximately 50,000 m². Test pits were excavated to between 0.5 and 1.2 m, giving an estimated total volume of topsoil between approximately **25,000 m³** and **60,000 m³** BCM.

- Gravel (borrow): Based on visual observations, satellite imagery and test pits excavated in the gravel and topsoil areas, the gravel source areas have a collective surface area of approximately 300,000 m². Four test pits were excavated into gravel material, comprising gravel beds between 0.55 m and 1.7 m thick, giving an estimated total volume of gravel between **165,000 m³** and **510,000 m³** BCM.

3.1.6 Summary Material Characterisation

A material characterisation program was carried out to determine site-specific geotechnical and hydraulic properties for potential cover materials for the Yandan TSF Cell B. The materials characterisation program comprised materials sampling, field testing, *in situ* permeability testing and a full laboratory testing program. The main findings of the material characterisation program are summarised herein, with discussion grouped based on potential material usage/s:

- Potential Clay Sources: Clay sources were investigated as potential material for constructing a barrier layer within the cover system to limit net percolation into the underlying sulfidic tailings. The TRWD embankment core (YAN-013 and YAN-014) and the MWD embankment core (YAN-007 and YAN-008) contain a significant amount of oversize material and are considered to be quite coarse. Approximately 30% of particles in these materials were found to be greater than 10 mm. The potential clay borrow located upstream of the WSD (YAN-010 and YAN-11) was found to contain fine material with good consistency. Similar results were found in the core of the HL Pond (YAN-005 and YAN-006), upstream of the MWD (YAN-009) and at the offsite clay borrow (YAN-002 and YAN-003).
- Potential Topsoil Sources: Important characteristics for a topsoil resource include providing a supply of beneficial nutrients, minimal plant growth limiting properties, and having a good water holding capacity. Ideally, topsoils will also show low erosion potential and no dispersive qualities. When examining the potential topsoil sources, Emerson testing results indicated material represented by YAN-015 exhibited dispersive potential. The PSD curve for YAN-017 is quite coarse and as such the water holding capacity of this source is limited. However, given the proximity of YAN-017 to YAN-018 and the heterogeneity nature of soil, the material from this borrow may still be suitable for usage in topsoil. YAN-001, YAN-018 and YAN-021 were subjected to fertility testing and all displayed acceptable fertility characteristics and grading.
- Potential Growth Medium Sources: Materials located immediately adjacent to the north of Cell A are a suitable source for a growth medium based on their particle sizes (YAN-019 and YAN-020). One potential growth medium source (YAN-015) displayed

slight dispersive characteristics, however given the growth medium is generally located below a topsoil layer and the relatively shallow grades anticipated for the cover system, this property should not be a concern. YAN-018 and YAN-021 both provide a mix with topsoil that displays positive permeability and fertility characteristics.

- Potential Gravel Sources: PSD is the key property used to identify sources with potential for use as capillary break layers. Material sources adjacent to the TSF Cell B (YAN-022 and YAN-025) and the Heap Leach waste rock (YAN-004) were assessed as being coarse, well-graded material suitable for use as a capillary break layer.

4 COVER SYSTEM DESIGN FILTERS/SITE ATTRIBUTES

The purpose of a cover system is to aid in the reclamation of surface mine waste storage facilities to provide a stable, reliable and sustainable engineered interface between the receiving environment and the mine waste (INAP, 2017). It supports agreed-upon land uses while minimising degradation of the surrounding environment. To support this aim, the cover system design requires analysis of all site attributes that constrain design alternatives to achieve desired performance. Four main site attributes that constrain design alternatives include climate, hydrogeological setting, materials and vegetation, shown in Figure 4.1 with each discussed in more detail herein.

The post mining land use and classification for the Yandan YSF is Open Pasture VII, with acceptance criteria stating the rehabilitated TSF must accommodate the following (Straits Gold, 2013b):

- Controlled grazing;
- Runoff shedding landform with no obvious erosion gullies;
- No obvious acid generation or runoff;
- Pasture grass cover >40%; and
- Landowner acceptance.

More specifically for the Yandan TSF Cell B, closure aims to address the following identified hazards related to closure of Cell B (AARC, 2015):

- “AMD resulting from oxidation of sulfide tailings material, leading to mobilisation (and enhancing the bio-availability) of metals into the receiving environment”;
- “Temporary rise of the water table, allowing water characterised by low pH to come into contact with cover vegetation. This results in failure to sustain a grass pasture on the cell surface”; and
- “Salt rise from the tailings into the growth medium due to capillary action, resulting in failure of vegetation”.

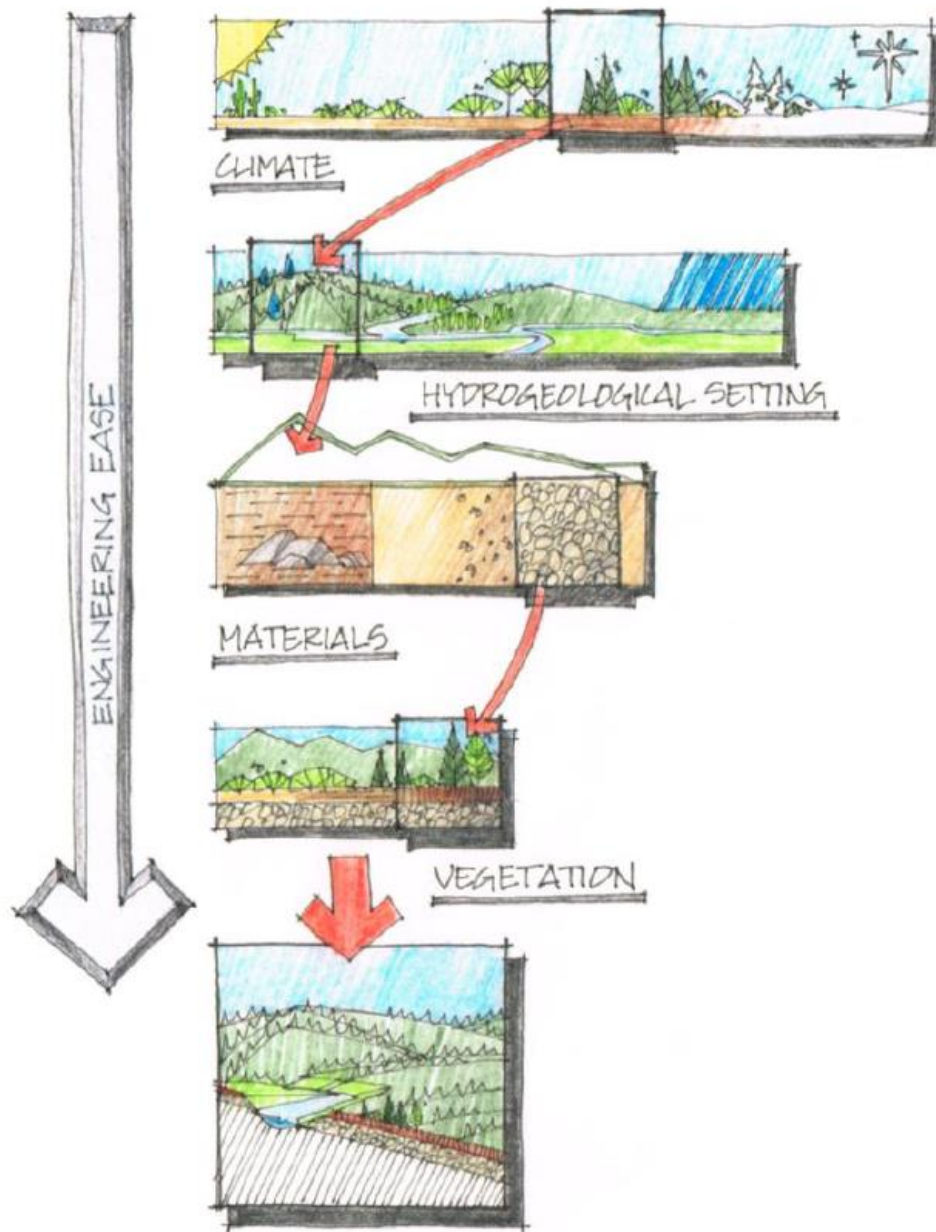


Figure 4.1: Cover system design framework displaying four filters.

INAP, 2017

4.1.1 Climate

A climate database is required as input for numerical models. This section describes the development of the climate database for the Yandan mine site and summarises the estimated climate conditions.

Based on the Köppen-Geiger climate classifications, Yandan is classified BSh, a local steppe or semi-arid climate. Rainfall in the region typically occurs during the November to March wet season, with between 75% and 80% of mean annual rain occurring during this period. Climatic data was obtained from the Scientific Information for Land Owners (SILO)

database, based on data from the Bureau of Meteorology (BOM), (Table 4.1). The daily dataset provides data for temperature, precipitation, relative humidity, solar radiation and potential evapotranspiration. This dataset was used to generate a 118-year period of climatic data for Yandan for the purposes of modelling seepage rates utilising site-specific conditions. The Yandan climate dataset begins 1 January 1900 and finishes 31 December 2018. The average annual rainfall during the 118-year period is 552 mm. A maximum recorded rainfall of 1,173 mm and minimum recorded rainfall of 169 mm indicate rainfall can be highly variable between years (Figure 4.2). The climate database indicates extended periods of wetting and drying can be experienced.

Table 4.1: Monthly and annual climate averages for the Yandan climate dataset.

Month	Maximum Air Temperature (°C)	Minimum Air Temperature (°C)	Maximum Relative Humidity (%)	Minimum Relative Humidity (%)	Rainfall (mm)	Potential Evapotranspiration (mm)
January	35	22	90	45	111	180
February	34	22	93	48	103	151
March	33	20	95	47	66	153
April	31	17	96	44	32	129
May	28	13	96	43	25	107
June	25	10	96	41	24	89
July	25	8	95	38	18	99
August	27	10	94	36	13	122
September	30	13	92	35	10	150
October	33	17	89	35	26	183
November	35	20	86	36	47	191
December	36	21	88	40	78	196
Annual Average	31	16	92	40	552	1,749

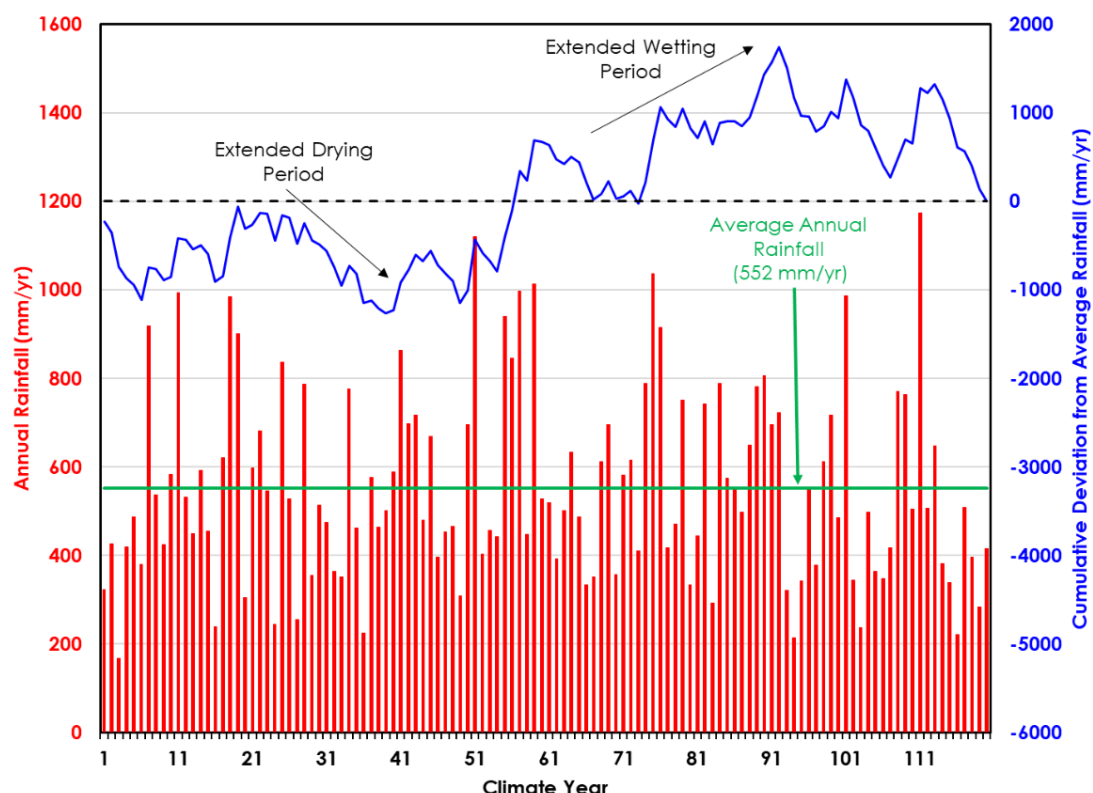


Figure 4.2: Annual rainfall and cumulative deviation from average rainfall for Yandan.

Based on GARD (2011), the cover system that best fits with the site's climate (Figure 4.3) utilises the store-and-release principle. Cover systems which utilise moisture store-and-release principles can be simple or complex, ranging from a single layer of earthen material to several layers of different materials. A store-and-release cover system aims to reduce NP to underlying waste material by increasing the available water storage capacity, while also limiting surface erosion of the material.

However, as discussed in Section 1 and Section 2.1 and owing to the presence of sulfidic tailings in Cell B, the DES have communicated to Straits Gold a requirement for a barrier layer to be incorporated into the Cell B cover system design. The conceptual store-and-release cover system design proposed in 2015 (Okane, 20105) was determined to not be robust enough and infiltration control in the form of a barrier layer would also be required.

Whilst the site's climate indicates a store-and-release cover system is appropriate, when plotted against the criteria provided in GARD (2011) (Figure 4.3), the site's climatic characteristics fall towards the outer edge of the suitable range for store-and-release covers systems and close to the transition point where infiltration control is recommended.

For these reasons the three alternative cover system designs all include a barrier layer.

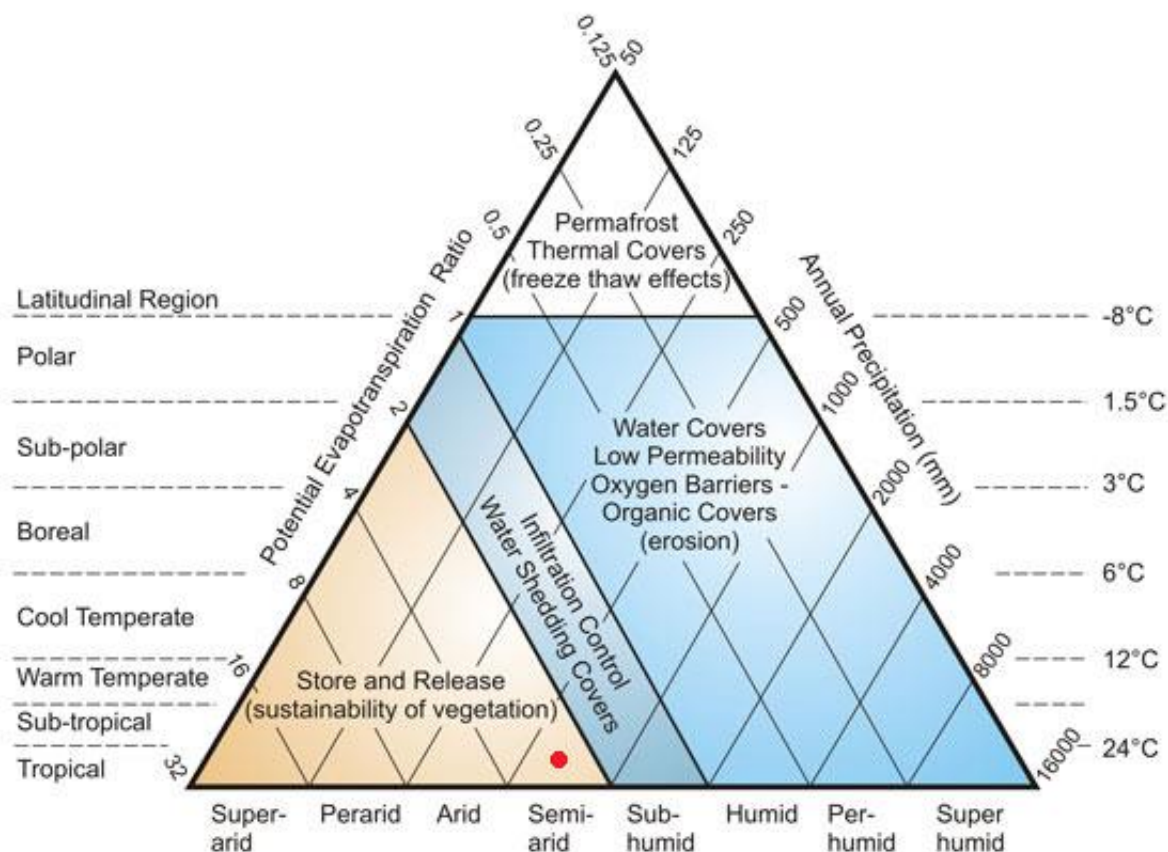


Figure 4.3: Cover systems and climate types. Red dot indicates approximate performance for Yandan.

GARD, 2011

4.1.2 Hydrogeological Setting

The regional hydrogeological setting focuses on several physical processes, including recharge, discharge rates, locations, volumes and rates of water movement, in addition to water flow pathways. The hydrogeological setting constrains the residence time and flux of water movement and while it can be altered, this requires substantial effort and expense, as such it is more advantageous to understand the hydrogeological setting prior to design and construction of any cover system design.

The hydrogeological setting can act as a passive treatment method or negatively impact remediation if the hydrogeology or associated chemistry is not fully understood. Although characterising the hydrogeological setting is important, changes will occur as the cover system matures and this must be anticipated.

The geological setting and landform geometry affect geotechnical stability and influences the overall NP mechanisms and rates. Therefore, consideration must be given to the shallow grades of a cover system constructed on Cell b as this impacts runoff, run-on, interflow, basal flow, seepage, evapotranspiration either directly or indirectly (INAP, 2017).

Groundwater in the area is of poor quality for stock watering and is considered unsuitable for irrigation and domestic use (GHD, 2008). Groundwater flow is towards the Sutor River, the water table is approximately 8 m below the riverbed at RL 158 m and there is no significant connection between groundwater and surface water in this area. Hence, the groundwater table is assumed to not influence any potential cover system performance, and as a result for modelling purposes the lower boundary within this study is simulated as a unit hydraulic gradient, further discussed in Section 5.2.4.

4.1.3 Materials

The material properties used to represent the cover system materials were key elements in the numerical modelling program. The behaviour of the soil cover system is largely influenced by material physical properties, including the PSD, permeability and water holding properties.

The physical properties used in the modelling were derived from laboratory testing of materials as part of a targeted materials characterisation program (as discussed in Section 3.1.2). The textural triangle, based on the PSD results, is shown in Figure 4.4.

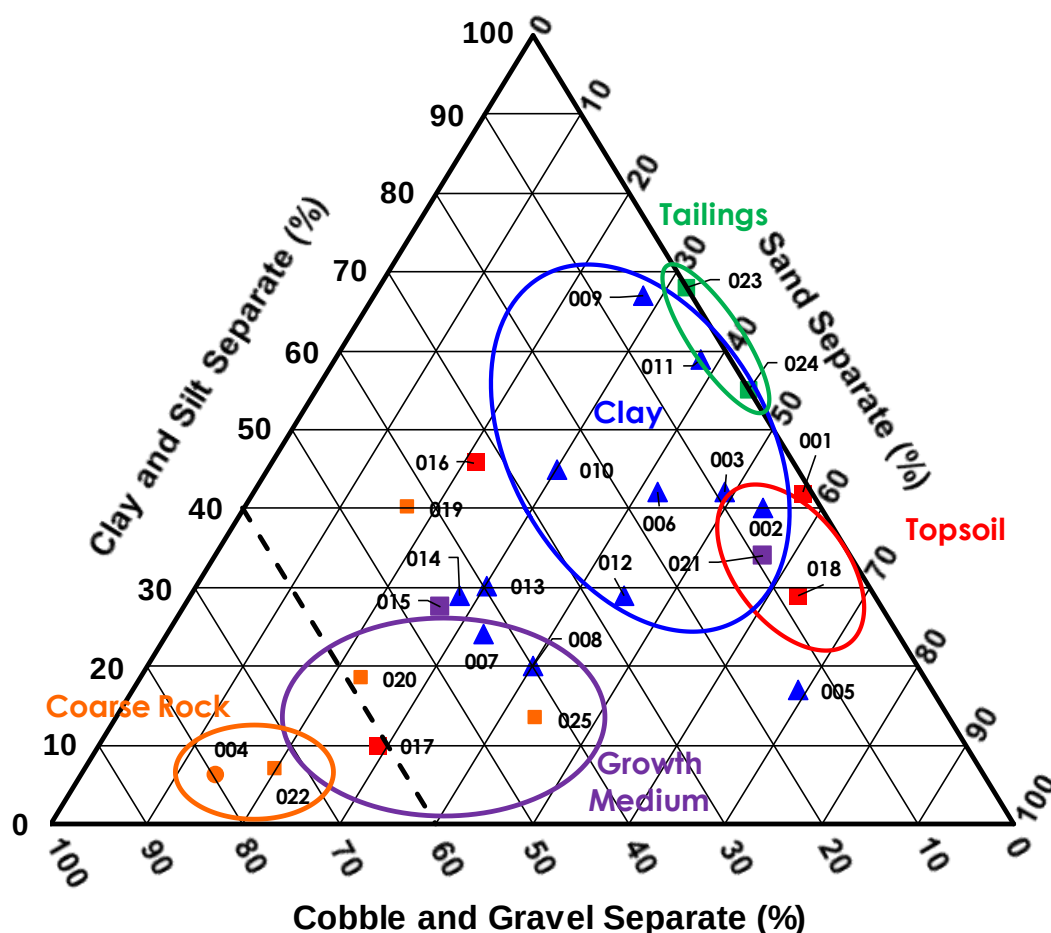


Figure 4.4: Textural triangle for potential Yandan cover system materials.

For the purposes of modelling the cover system, the materials were categorised into five zones on the textural triangle: coarse rock, growth medium, clay, topsoil and tailings. The growth medium and coarse rock were informed based on the gravel results. Further discussion on the specific textural zones is provided below:

- Coarse rock (orange circle): A consistent 70-80% cobble and gravel separate with 10% or less clay and silts, entirely grain supported. Indicates decreased water holding capacity due to the coarse texture of the material with decreased erodibility.
- Growth medium (purple circle): Comprises between 40-70% cobble and gravel separate and 20-50% sand fraction. It is predominately matrix supported with some fraction being grain supported. Matrix supported generally has increased erodibility over grain supported, with increased water holding capacity. Both growth medium and coarse rock are anticipated to contain some gravel.
- Clay (blue circle): A substantial range of between 30-70% clays and silts and is matrix supported. Typically used to form a barrier layer. The decreased coarse material would typically suggest increased erodibility and good water holding capacity.
- Topsoil (red circle): A mix of clays, silts and sands with almost no cobbles and gravel. While some samples were coarser, the selection highlighted are consistent and it has been assumed material will be taken from these locations.
- Tailings (green circle): Comprises no cobbles and gravel and a substantial portion of clays and silts mixed with 30-45% sands. The higher fines fraction indicates good water holding capacity. As the tailings will be below the other components of the cover system the high erosivity of this material is not of concern.

4.1.4 Vegetation

Yandan vegetation consists of persistent buffel grass pastures with the terrain characterised by undulating low hills and foot slopes with rocky outcrops (GHD, 2008). Towards the south-east of the site the terrain differs and can broadly be characterised by clay plains with some gilgai microrelief in low areas. The primary land use for the district is beef cattle grazing as much of the naturally occurring open forest and woodlands have been historically cleared for this purpose. However, due to the limitations imposed by the low fertility and degraded nature of the soil, low rainfall levels and high rainfall variability in the area, there is a low stock capacity. Natural vegetation communities on and adjacent to the site include (GHD, 2008):

- Blackwood (*Acacia argyrodendron*) and false sandalwood (*Eremophila mitchellii*);
- Brigalow (*Acacia harpophylla*) low forest with Dawson gum (*Eucalyptus cambageana*) emergent);

- Coolabah (*Eucalyptus microtheca*) woodlands with areas of brigalow (*Acacia harpophylla*), gidgee (*A. cambagei*) and Blackwood (*A. argyrodendron*); and
- Narrow leaf ironbark (*E. crebra*)/bloodwood (*E. dichromophora*) open woodland.

5 MODELLING PROGRAM

5.1 Model Description

The GeoStudio suite of modelling tools were used to model the behaviour of the Yandan cover system designs. The GeoStudio suite includes a fully coupled heat and mass transfer model capable of modelling saturated-unsaturated moisture conditions. Specifically, the VADOSE Bundle, capable of two-dimensional (2D) finite element modelling, in addition to one-dimensional (1D) modelling. It predicts suction in a given material profile in response to climatic forcing (such as evaporation) and lower boundary conditions (such as a water table). Based on these calculations, NP of water through a cover system and into the underlying material is predicted. A key feature of the software is the ability of the model to predict actual evapotranspiration based on potential evaporation and predicted suction, as opposed to the user being required to input these surface flux boundary conditions.

The CTRAN/W and SEEP/W modules of the GeoStudio suite were coupled to simulate the upward movement of saline pore water from the tailings into the cover system during periods of net upward flux across the cover material/tailings boundary. CTRAN/W accounts for both advective and diffusive transport. As such the modelling only requires minor modifications to the SEEP/W models built for the seepage assessment; mainly, applying salt concentration inputs to the tailings and cover system materials, and estimating diffusion coefficient curves for each material.

5.2 Modelling Inputs

The numerical modelling inputs can be divided into five categories: geometry, material properties, upper boundary conditions, lower boundary conditions, and initial conditions. Brief descriptions of these model inputs are presented in the following sections.

5.2.1 Geometry

All simulations were completed with a 1D column consisting of 99 nodes, representing a 7.1 m thick profile of cover system (ranging from 1.1 m to 3.1 m) overlying tailings material (4 m to 6 m). Figure 5.1 depicts the current base case cover system, as developed within the 2015 Okane project. This cover system comprises a store-and-release design of topsoil over coarse rock. As previously discussed, DES require a barrier layer unit be incorporated within the cover system to control infiltration and further limit potential NP reporting to the underlying tailings materials. As such, three alternative cover system designs have been proposed and addressed through numerical modelling:

- 1) *Base Case Cover System Design for Cell B (Zone 2)*: The store-and-release cover system originally designed by Okane in 2015. Not considered satisfactory by DES due to not incorporating a barrier layer. Included as a base case from which to assess the relative

performance of the alternative cover system configurations. The cover from the surface down comprises:

- Topsoil – 0.4 m;
- Coarse rock – 0.3 m; and
- Oxide tailings – 0.4 m.

2) *Double Capillary Break Cover System*: Most complex cover system suitable for Cell B. A capillary break unit is placed between the oxide tailings and the barrier layer to reduce potential for salt uptake from the tailings. A second capillary break unit is placed between the barrier layer and the growth medium to reduce potential for desiccation of the barrier layer from atmospheric forcings. The cover from the surface down comprises:

- Topsoil – 0.1 m;
- Growth medium/store-and-release - 1 m;
- Coarse rock – 0.3 m;
- Barrier layer – 0.3 m;
- Coarse rock – 0.3 m; and
- Oxide tailings – 0.4 m.

3) *Single Capillary Break Cover System – DES Min. Thickness*: Cover system unit thicknesses for this configuration comply with the minimum thickness prescribed in DES's Estimated Rehabilitation Cost (ERC) Calculator and includes both a barrier layer and a capillary break layer to reduce potential for salt uptake from the tailings. The cover from the surface down comprises:

- Topsoil – 0.15 m;
- Growth medium/store-and-release – 1.5 m;
- Barrier layer – 0.5 m;
- Coarse rock – 0.6 m;
- Working layer - +0.1 m (0.5 m separation between tailings and cover system); and
- Oxide tailings – 0.4 m.

4) *Single Capillary Break Cover System – Alternative Min. Thickness*: Same single capillary break cover system with barrier layer configuration as design 3. Unit thickness have been modified from those prescribed in DES's ERC Calculator based on results of the material characterisation program and Okane's experience. The cover from the surface down comprises:

- Topsoil – 0.1 m;
- Growth medium/store-and-release - 1 m; and
- LP layer – 0.3 m;
- Coarse rock – 0.3 m; and
- Oxide tailings – 0.4 m.

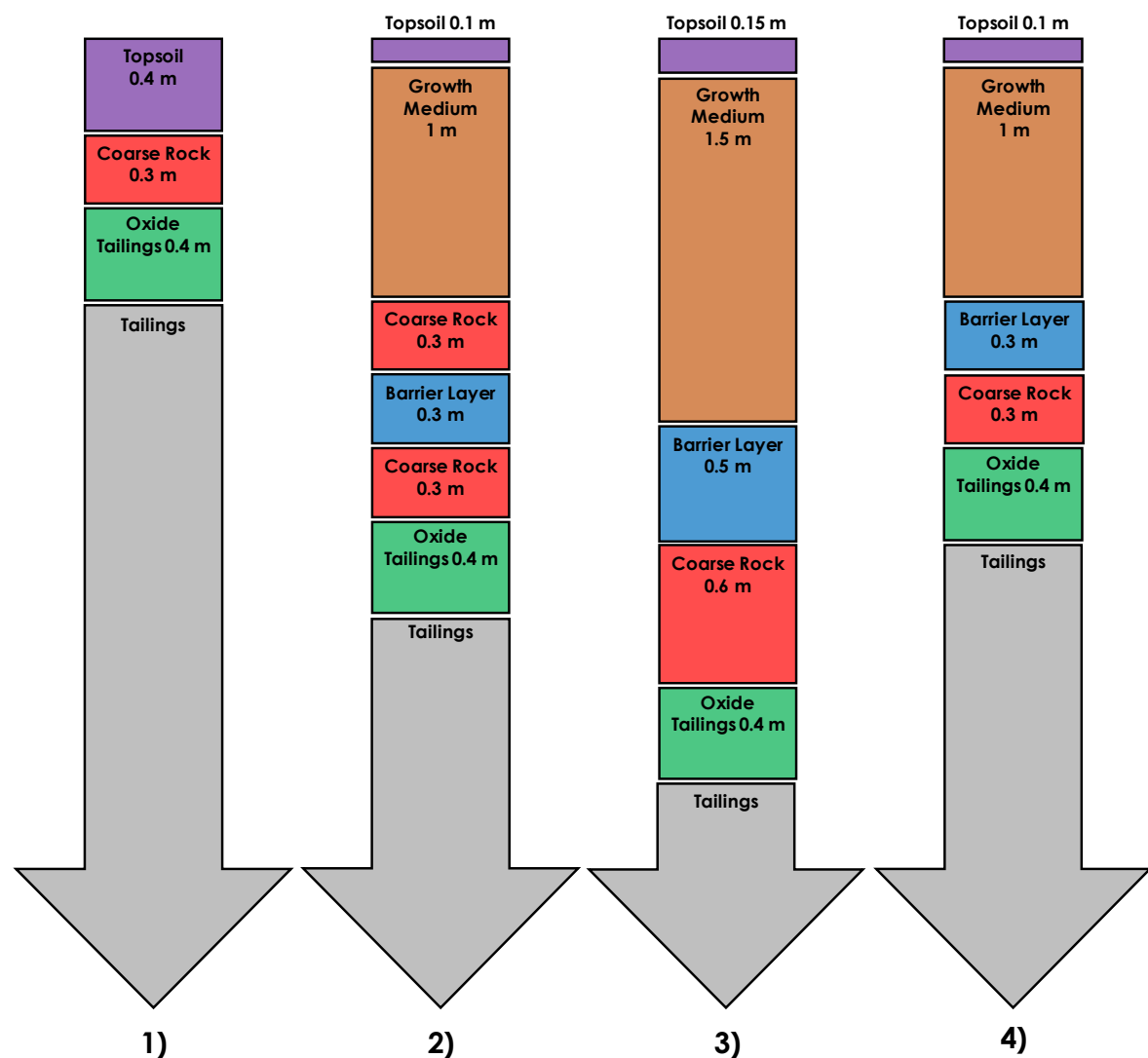


Figure 5.1: Cover system alternatives analysed in the modelling program; 1) Base Case Cover System Design, 2) Double Capillary Break, 3) Single Capillary Break – DES Min., 4) Single Capillary Break – Alternative Min.

5.2.2 Material Properties

The following section provides the hydraulic properties derived from the material characterisation program (discussed within Section 3.1.2), historical sampling and testing and Okane's experience with similar materials and cover system designs, as well as the mass transport material properties and source terms estimated for Yandan using the functions defined by Aachib *et al.* (2004).

5.2.2.1 Hydraulic Properties

SWCCs and saturated hydraulic conductivity (k_{sat}) estimates were developed based on testing conducted by the University of Queensland and PSD testing conducted by Trilab Pty Ltd. The term saturated hydraulic conductivity is used to describe the rate of water movement through the medium (or material) when saturated. The SWCC estimates are shown in Figure 5.2 and the estimated saturated hydraulic conductivities in Table 5.1.

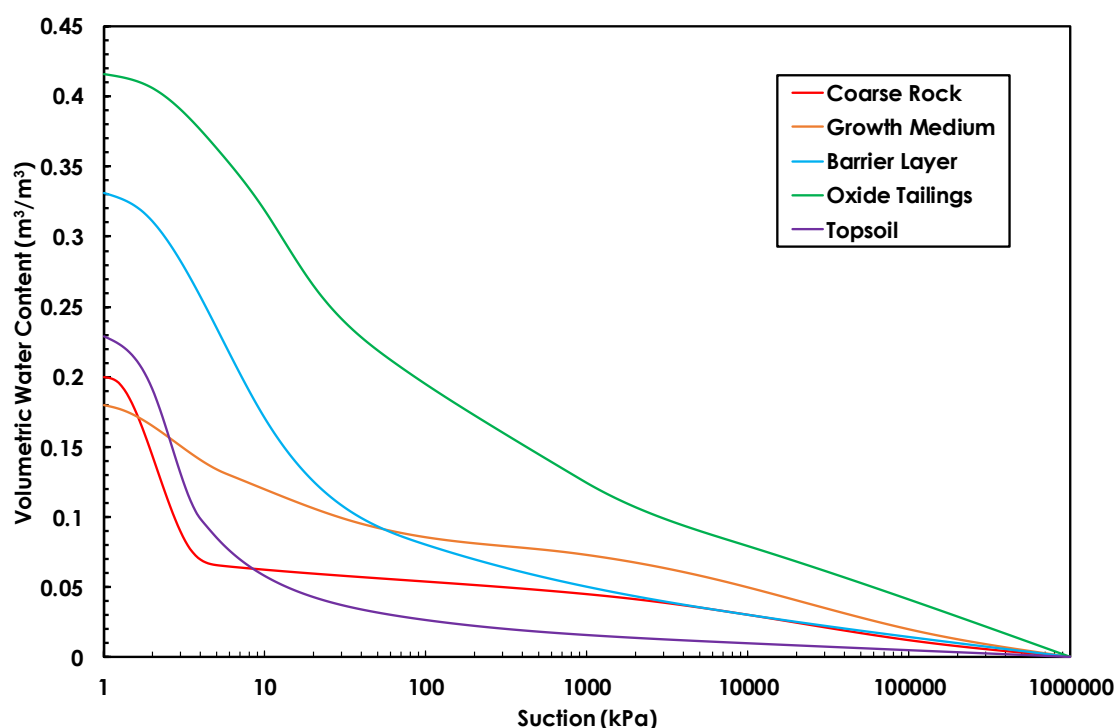


Figure 5.2: SWCC functions for the cover system materials used in the numerical modelling program.

Table 5.1: Estimated saturated hydraulic conductivity.

Material	Saturated hydraulic conductivity (m/s)
Coarse Rock	5×10^{-3}
Growth Medium	1×10^{-4}
Topsoil	5×10^{-6}
Oxide Tailings	1×10^{-7}
Barrier Layer	1×10^{-9}

5.2.2.2 Mass Transport Material Properties and Source Terms

The relationships between diffusion coefficient and volumetric water content were estimated for the materials using the functions defined by Aachib *et al.* (2004), shown in Figure 5.3. This method utilises a closed-form semi-empirical expression based on numerous test results and previously determined models proposed by Millington and Quirk (1961) and Millington and Shearer (1971). The free-water diffusion coefficient for NH_4 ($1.78 \times 10^{-9} \text{ m}^2/\text{s}$) was used in the model (Krom and Berner, 1980). The diffusion coefficient for NH_4 was used for the salt uptake modelling to represent a high estimate of diffusive mass transport from the waste rock. NH_4 has a relatively low molecular weight and, consequently, a relatively high diffusion coefficient. Salinity from the tailings was simulated with a constant concentration boundary applied to the entirety of the tailings material. The relative concentration throughout the profile into the cover system was tracked through time.

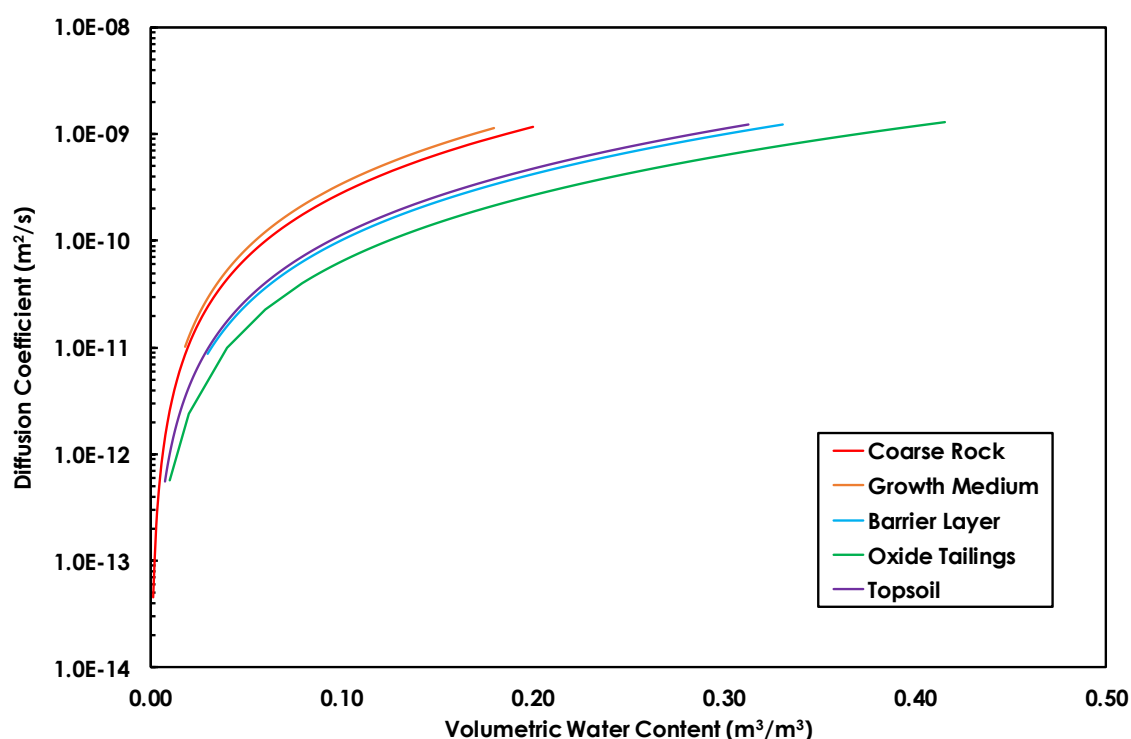


Figure 5.3: Estimated diffusion coefficients for the Yandan cover system materials.

5.2.3 Upper Boundary

5.2.3.1 Climate

A description of the long-term (118-year) climate database can be found in Section 4.1.1. This was applied using a Land-Climate Interaction (LCI) and Surface Energy Balance boundary (SEB) condition. The LCI boundary condition was used to simulate the water ingress from the top of the cover, computing the NP rates and water balance. The SEB boundary condition was used with air temperature, wind speed and net radiation values, which utilises the mass balance equation and is useful for including evaporation into the

simulation. Together both boundary conditions can be used to simulate Soil-Plant-Atmosphere transfers across the ground surface.

5.2.3.2 Vegetation

Vegetation establishment on the Cell B cover system is expected to be, at least during the initial stages, sparse and is not expected to provide high surface coverages. Jackson *et al.* (1996) estimated a typical root distribution based on a database of 250 root studies, subdivided into 11 biomes, using the following formula:

$$Y = 1 - \beta^d$$

Where Y is the cumulative root fraction from the soil surface to depth, d (cm), and β is the fitted "extinction coefficient", the results are shown in Figure 5.4. β is the only parameter estimated in the model and provides a simple numerical index rooting distribution. For a base case analysis, no vegetation was assumed within any of the numerical models. This approach allows any numerical modelling results to be conservative. However, additional modelling was undertaken which included established vegetation within the various cover system alternatives. Vegetation coverage was modelled at 28%. Observations recorded during the site visit indicate this is likely a conservative estimate. 28% coverage was considered reasonable for observations made of vegetation growth on Cell A, however greater vegetation coverage was observed on the areas immediately surrounding the TSF indicate vegetation coverage greater than 28% are achievable in this region. Jackson *et al.* (1996) recommend a β value of 0.972 for a 'Tropical grassland savanna' and this value was adopted for vegetation modelling purposes for Yandan. High β values (e.g. 0.98) correspond to a greater proportion of roots at depth and low β values (e.g. 0.92) imply a greater proportion of roots near the surface. Vegetation parameters used in the numerical modelling program representative of anticipated maximum vegetation establishment are summarised in Table 5.2. A rooting depth of 3.0 m was selected to represent the maximum value, however as shown in Figure 5.4, over 90% of cumulative root distribution occurs in the top 1 m of the cover system, with approximately 99% occurring within the top 2 m.

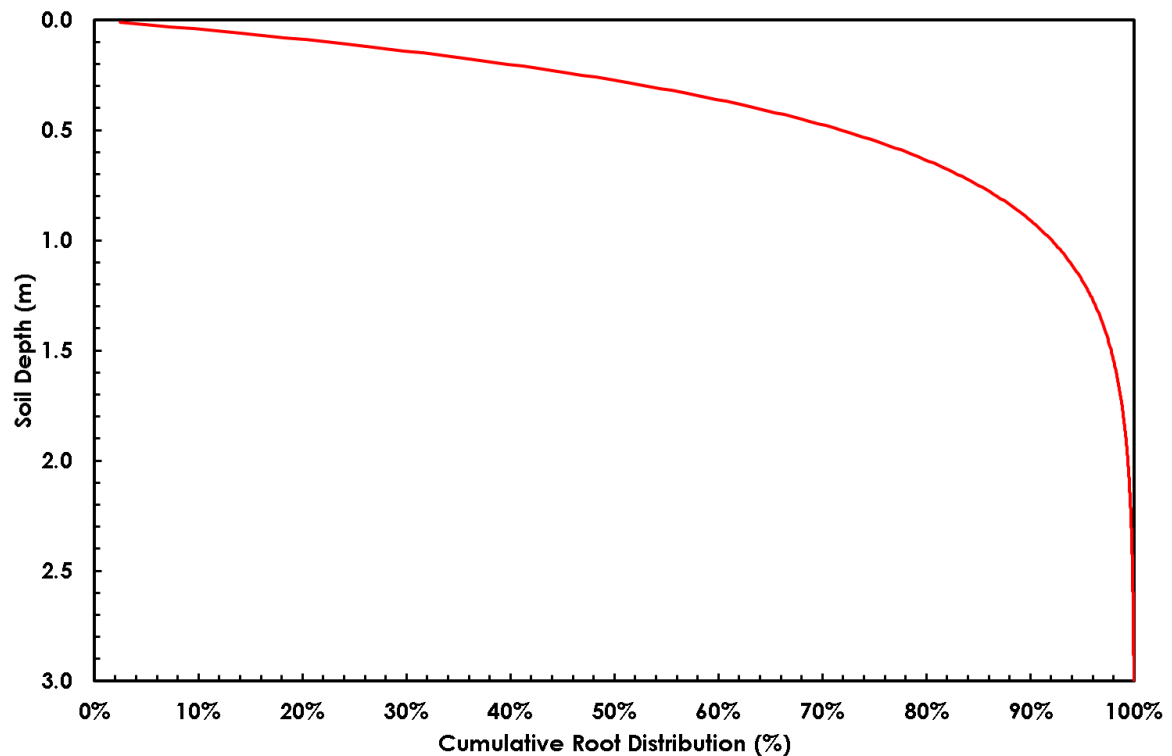


Figure 5.4: Cumulative root distribution for Yandan (not used in base case).

Table 5.2: Summary of vegetation parameters.

Model Parameters	Value
Root Depth (m)	3.0
Soil Cover Fraction	28%
Field Capacity (kPa)	10
Permanent Wilting Point (kPa)	1,500

In general, field capacity (FC) is defined as the water content of soil at a suction of 33 kPa, and the Plant Wilting Point (PWP) is defined as the minimum soil water required for a plant to resist wilting at a suction of 1,500 kPa. However, this range is generalised and does not account for differences in soil and plant characteristics. Based on the estimated properties for the topsoil and the anticipated vegetation, the FC and PWP for this project were defined at suctions of 10 kPa and 1,500 kPa, respectively.

5.2.4 Lower Boundary

The lower boundary of the models was simulated as a unit hydraulic gradient. A unit hydraulic gradient boundary condition assumes that at the lower boundary the suction (and as a result, water content and hydraulic conductivity) are constant with depth. For this situation, the total head equals the gravitational head, which results in a unit hydraulic gradient. In other words, it is assumed that the water table under the tailings is at sufficient depth that it does not influence the potential cover systems water balance.

5.2.5 Initial Conditions

Initial conditions were established by simulating the 1D model with the entire 118-year climate database and then using the resultant final conditions of that simulation as the initial conditions for the simulations presented in this report. Through this method initial conditions are more objective.

5.2.6 Model Limitations

The following limitations should be noted when interpreting the results for the cover system numerical modelling program.

- The model assumes movement of water in the unsaturated zone can be represented as Darcian flow in a porous media. The model does not account for any potential non-Darcian flow in macropores and/or cracks within the cover system. This is a key assumption because the model assumes that "flushing" of salt will result during infiltration events because it is assumed that all flow occurs as matrix flow. If macropores exist in the cover material, then infiltration through these macropores during rainfall events will bypass the matrix, and thus salt flushing may be much less than predicted by the model.
- The model assumes the cover system can be represented by various material types with homogenous material properties. The potential influence of local heterogeneity (within a given material type) was not investigated.
- The water movement within the cover systems is defined by the unsaturated hydraulic conductivity versus matric suction relationship. This relationship is extremely difficult to measure *in situ* in a field condition and consequently is derived by a theoretical algorithm based on the value input for k_{sat} . The theoretical relationship defines the hydraulic conductivity function over several orders of magnitude, while a single or half order of magnitude change can greatly affect the predicted NP results from a simulation.

The key advantage to the numerical modelling results summarised herein is the ability to enhance judgement. Hence, rather than a focus on the absolute results predicted, it is recommended that the modelling results be viewed as a tool to understand key processes and characteristics that will influence performance of the cover system and develop engineering decisions based on this understanding.

6 MODELLING RESULTS

Numerical modelling assessed the performance of the cover system design alternatives in three categories:

- 1) Net Percolation (NP) Assessment: each cover system alternative was simulated to determine the water balance.
- 2) Water Stored within cover system: defined as the volume of water that is stored within the growth medium and topsoil component of the cover system, helps determine which cover system alternatives best provide sufficient water for vegetation establishment and survival.
- 3) Salt Uptake Assessment: determines relative potential for salt uptake into the cover system based on the alternatives.

The alternatives, described in detail in Section 5.2.1, include:

- Base Case Cover System Design;
- Double Capillary Break Cover System;
- Single Capillary Break Cover System – DES Min. thickness; and
- Single Capillary Break Cover System – Alternative thickness.

6.1 NP Assessment

Simulations were completed to evaluate the NP performance of each potential cover system alternative. Results are provided in Table 6.1 for scenarios without vegetation and Table 6.2 for scenarios that included established vegetation. Exceedance probability results are shown in Figure 6.1 for scenarios without vegetation and Figure 6.2 for scenarios that included established vegetation. The results indicate:

- The introduction of established vegetation results in much higher ET and lower NP, particularly for the Base Case design as available water within the cover system is removed by vegetation;
- The double capillary break and single capillary break using the DES minimum thickness limited NP the greatest when compared to the Base Case design and single capillary break using the alternative thickness. However, the single capillary break using alternative thicknesses limits NP to within 1% of the double capillary break and single capillary break using DES thickness cover systems; and
- Without established vegetation the single capillary break cover system utilising alternative thicknesses limits NP the most. The reason for this would likely be due to the shallower depth of the barrier layer when compared to the double capillary break cover system and the single capillary break cover system using DES thicknesses (see Figure 5.1 in Section 5.2.1). A shallower barrier layer in the single capillary break system

with alternative thicknesses would hold moisture for longer within the zone where moisture cycling, as a result of evaporation can still reach and remove water from the system. Moisture in the double capillary break system and the single capillary break system with DES thicknesses could infiltrate past this zone and be out of reach of evaporation resulting in a larger proportion reporting as NP.

- The three alternative designs would be expected to perform much better than the Base Case during extreme wet periods. For example, under the modelled scenario with no established vegetation there is approximately 5% probability that in any given year NP through the single capillary break with alternative thicknesses would result in an INAP NP Classification of very high. This probability jumps to approximately 90% for the Base Case. Under the established vegetation scenario there is approximately 5% probability all three alternative designs would result in a classification of very high and 25% probability the Base Case would result in a classification of very high in any given year.

Table 6.1: Summary of simulated NP results for cover system alternatives as a percentage of average annual rainfall (552 mm/year).

Cover System	Description	E	NP	RO	INAP NP Classification ¹
1)	Base Case Design	44%	54%	2%	Very High
2)	Double Capillary Break	77%	7%	16%	Moderate
3)	Single Capillary Break – DES Min. thickness	76%	7%	17%	Moderate
4)	Single Capillary Break – Alternative thickness	76%	4%	20%	Low

INAP (2017) classification are: Very Low: < 1% of rainfall; Low: between 1% and 5% of rainfall; Moderate: between 5% and 10% of rainfall; High: between 10% and 20% of rainfall; and Very High: > 20% of rainfall.

Table 6.2: Summary of simulated NP results for cover system alternatives with vegetation as a percentage of average annual rainfall (552 mm/year).

Cover System	Description	ET	NP	RO	INAP NP Classification ¹
1)	Base Case Design	87%	8%	5%	Moderate
2)	Double Capillary Break	87%	2%	11%	Low
3)	Single Capillary Break – DES Min. thickness	87%	3%	10%	Low
4)	Single Capillary Break – Alternative thickness	84%	2%	14%	Low

INAP (2017) classification are: Very Low: < 1% of rainfall; Low: between 1% and 5% of rainfall; Moderate: between 5% and 10% of rainfall; High: between 10% and 20% of rainfall; and Very High: > 20% of rainfall.

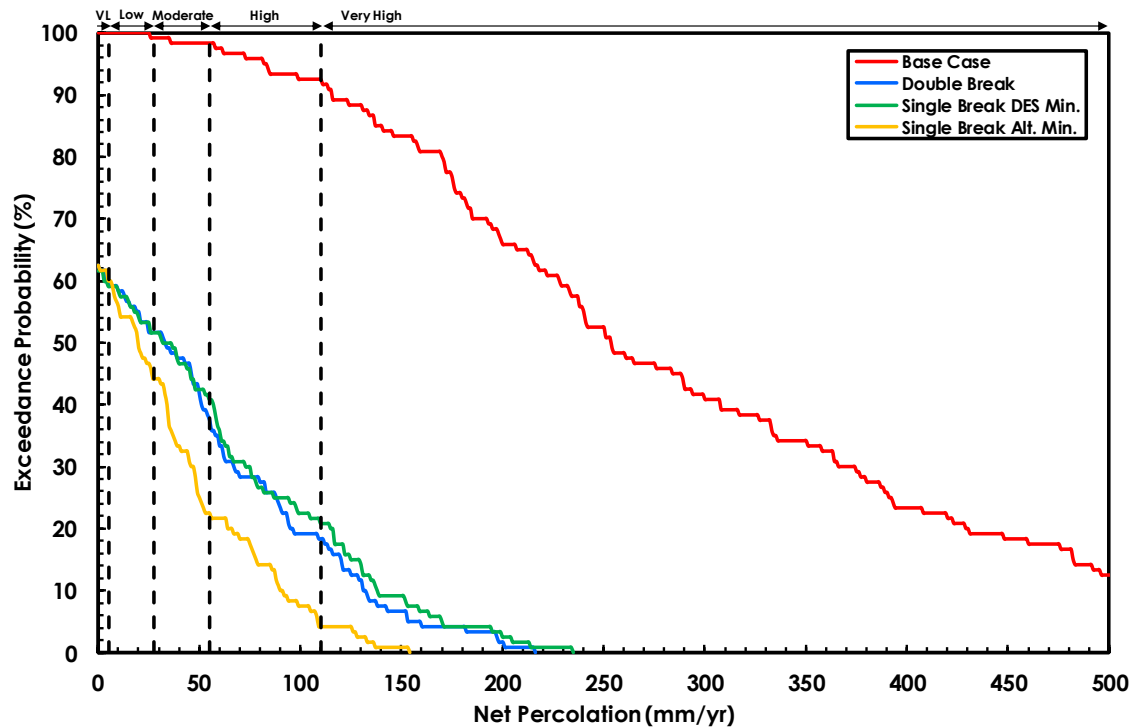


Figure 6.1: Exceedance probability chart for NP comparing cover system alternatives without vegetation modelled.

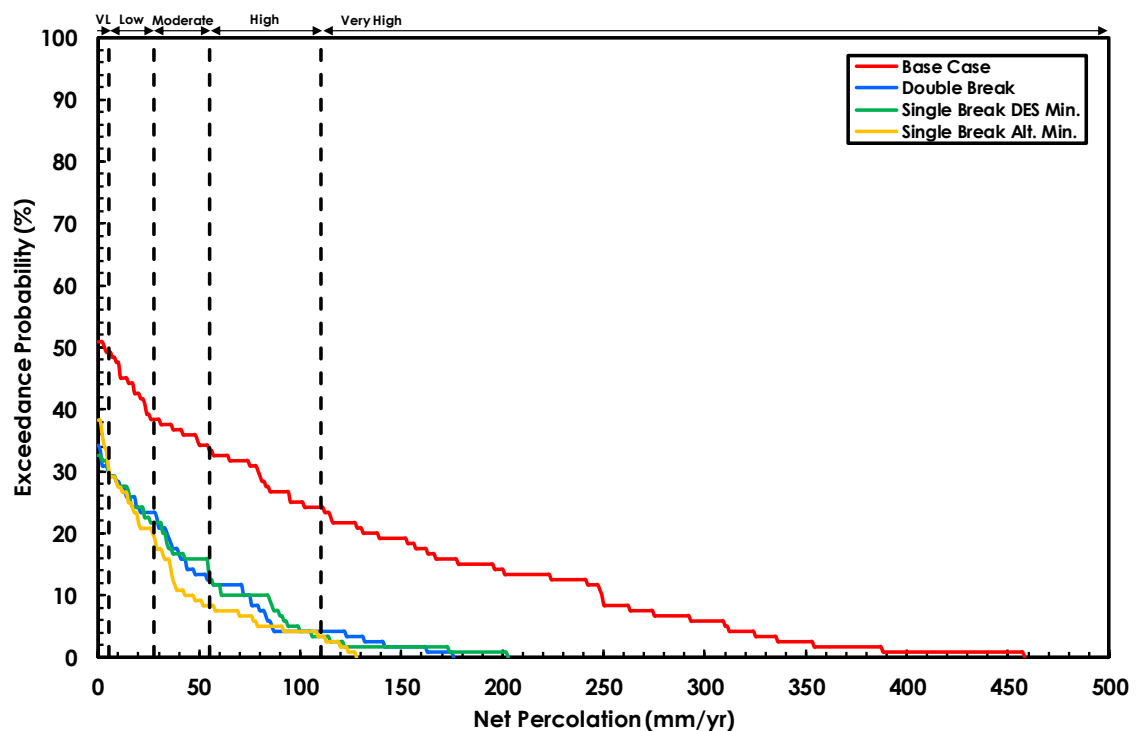


Figure 6.2: Exceedance probability chart for NP comparing cover system alternatives with vegetation modelled.

6.2 Water Storage

The volume of water stored within the upper section of a cover system provides a guide to the water that may be removed via evapotranspiration forces. The results displayed in

Table 6.3 and Figure 6.3 display the stored water (mm) per centimetre of topsoil and growth medium. Results indicate the Base Case design stores the least amount of water. This cover system design contains 0.4 m of topsoil with an absence of growth medium. The double capillary break and both the single capillary break with DES minimum thickness and alternative minimum thickness display a similar volume of water stored for each centimetre of topsoil and growth medium.

The performance of the Base Case design is to be expected due to the lack of impediment of downflow of the water. As a result, water is not stored within the upper portion of the cover system for similar durations as the other cover system designs and therefore is not available for uptake via evapotranspiration.

Table 6.3: Statistical analysis of water storage within the topsoil and growth medium for cover system design alternatives (mm/cm).

Cover System	Description	Average	Standard Deviation	Maximum	Minimum
1)	Base Case Design	0.19	0.24	2.39	-0.09
2)	Double Capillary Break	0.84	0.29	2.10	0.53
3)	Single Capillary Break – DES Min. thickness	0.85	0.27	2.03	0.60
4)	Single Capillary Break – Alternative thickness	0.85	0.28	1.96	0.57

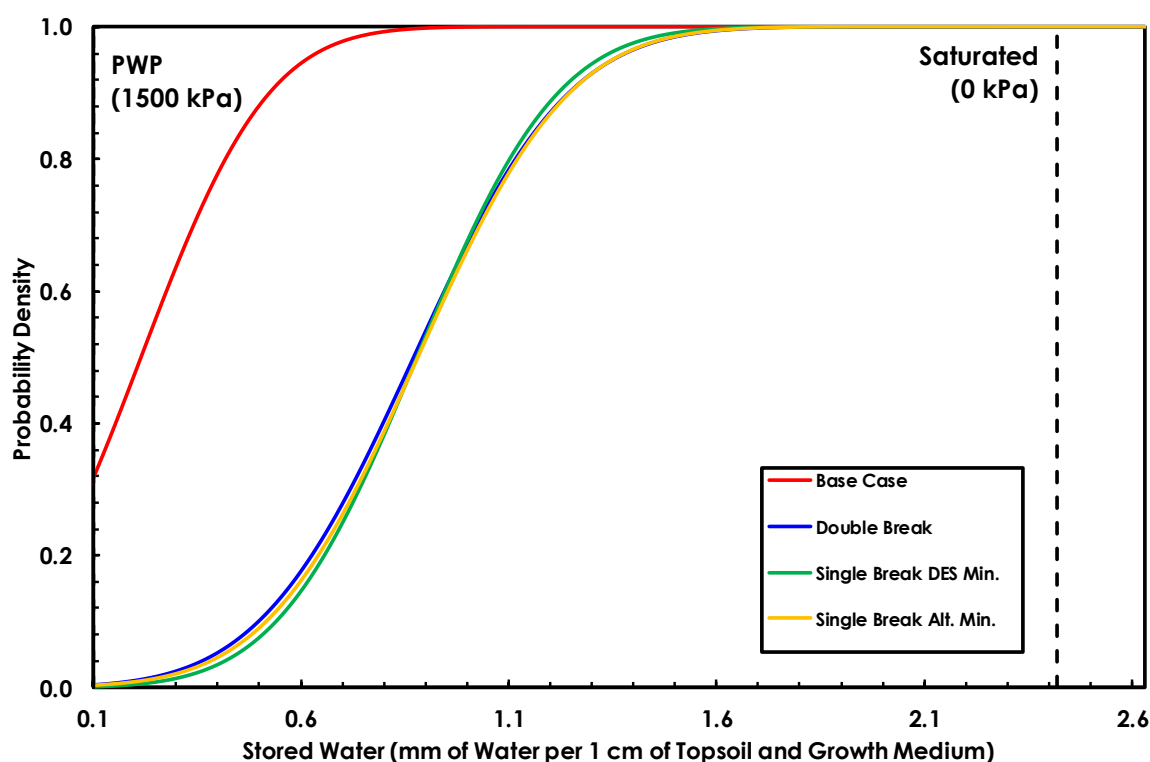


Figure 6.3: Cumulative normal distribution of water storage within topsoil and growth medium layers for each cover system alternative.

6.3 Salt Uptake Assessment

The four cover system alternatives were assessed for salt uptake. Figure 6.4 and Figure 6.5 present the anticipated EC values within the cover system profiles at the end of the simulations if the tailings had a surface EC value of 11.2 dS/m (Figure 6.4) and 5.19 dS/m (Figure 6.5). These values were the highest and the average EC values recorded during previous testing of the tailings (Dwyer, 2014). In situ testing during the site visit supported these values. An EC value of 5.8 dS/m was recorded for tailings tested from Test Pit 23 and are comparable with the average EC value recorded by Dwyer (2014). The following results represent both a conservative estimate by utilising the maximum recorded EC value, and a less conservative estimate by utilising the average recorded EC value. However, it should be noted that vegetation with tolerance to salinity will still grow in the maximum recorded EC range, should the salts be mobilised through upwards movement. The EC range presented corresponds to the soil salinity criteria developed by DERM (2011) (refer to Table 2.1). The salt uptake results indicate:

- For the Base Case design, adopting the maximum EC value results in the rooting zone (upper 3 m) being classified as having high, to very high salinity. Adopting the average EC values results in the rooting zone being classified as having moderate salinity;
- When the maximum EC value (Figure 6.4) is adopted, the single capillary break with DES minimum thicknesses is the only design capable of keeping salinity to very low levels within the rooting zone;
- When the average EC value (Figure 6.5) is used both single capillary break cover system designs and the double capillary break cover system design results in low and very low salinity within the rooting zone; and
- The key conclusion drawn from the salt uptake modelling is salt uptake within the growth medium reduces with an increase in cover system thickness, in particular during low rainfall climate years.

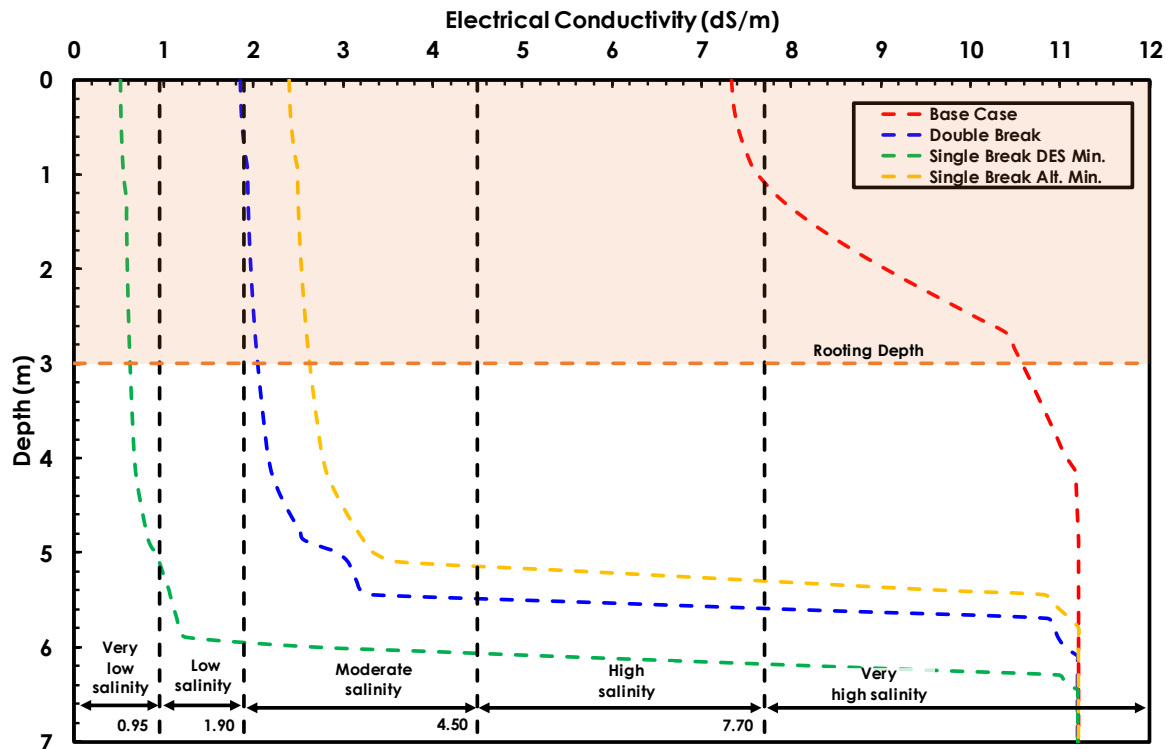


Figure 6.4: Anticipated electrical conductivity versus depth from the surface for the cover system alternatives assuming a tailings EC value of 11.2 dS/m.

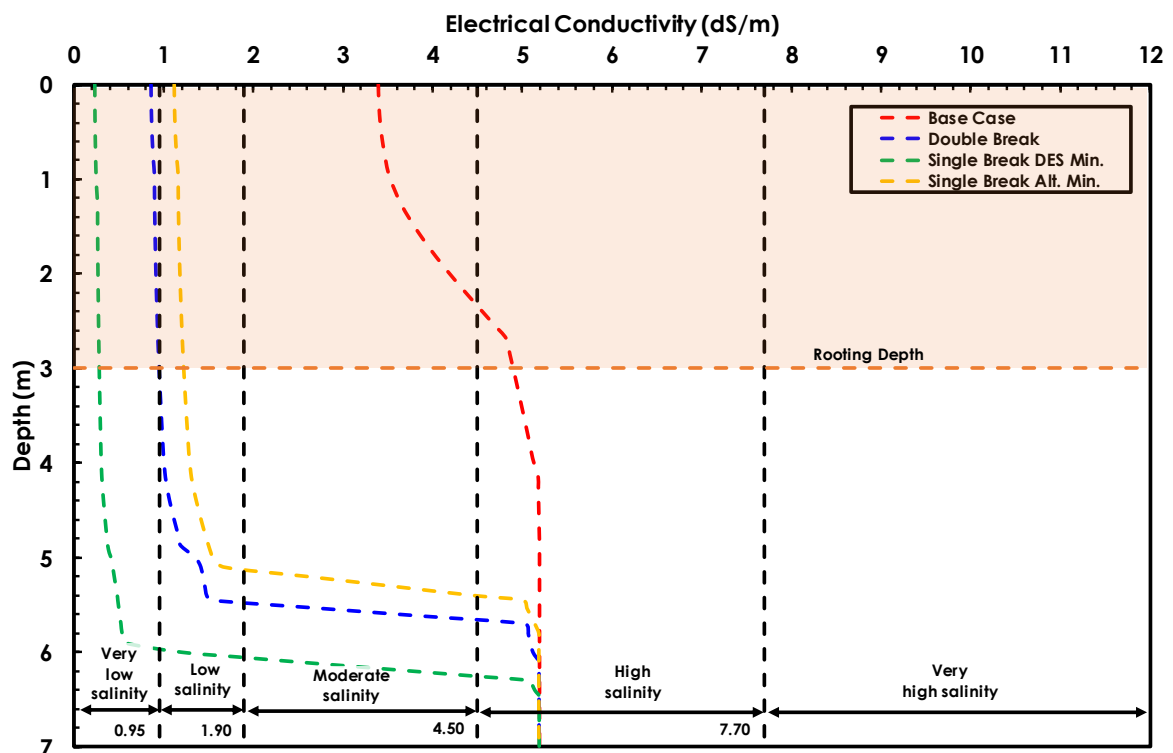


Figure 6.5: Anticipated electrical conductivity versus depth from the surface for the cover system alternatives assuming a tailings EC value of 5.19 dS/m.

7 COST BENEFIT COMPARISON

High-level cost estimates were developed to compare construction costs for each of the cover system alternatives considered in this study. The costing data utilised in this comparison was sourced from the DES Estimated Rehabilitation Cost (ERC) Calculator. Where the DES ERC Calculator was not able to provide adequate rates, alternative costings were sourced from previous works Okane had completed at an operational, open cut mine in North Queensland.

Key rates used in the cost benefit comparison are summarised in Table 7.1. These costings should only be used to assess the relative difference between alternative cover system designs in terms of NP performance. The comparison provides an indication of the cost burden associated with a performance improvement relative to the Base Case model. The costs are not to be considered complete costs for cover construction and budgeting purposes. The comparison only considers costs that are expected to vary between cover system designs. Costs considered common to all design alternatives, such as engineering design, haul road maintenance (grading, dust suppression, etc) and costs related to revegetation have been excluded.

Table 7.1: Key rates.

Task	Description ¹	Rate(\$/m ³)
Haulage & placement of Coarse Rock (gravel surrounding Cell B)	DES # 4.90 - Source local material, cart and spread to cap and/or cover (>200 m to <=500 m Rock) - small fleet	\$4.14
Haulage & placement of Coarse Rock (Heap Leach Pad)	DES # 4.94 - Source local material, cart and spread to cap and/or cover (>2000 m to <=2500 m Rock) - small fleet	\$5.57
Haulage & placement of Growth Medium (material surrounding TSF)	DES # 4.90 - Source local material, cart and spread to cap and/or cover (>200 m to <=500 m Rock) - small fleet	\$4.14
Haulage & placement of Clay (Upstream of WSD)	DES # 4.96 Source local material, cart and spread to cap and/or cover (>3000 m to <=4000 Rock) - small fleet	\$6.38
Haulage & placement of Topsoil (material surrounding TSF)	DES # 4.90 - Source local material, cart and spread to cap and/or cover (>200 m to <=500 m Rock) - small fleet	\$4.14
Haulage of Clay (offsite borrow)	DES – Miscellaneous Activities - Long distance carting of clay	\$0.22
Task	Description ²	Rate(\$/ha)
Compaction of <i>in situ</i> clay layer (3 passes per 0.3m of cover)	3 passes per 0.3m of material using 2 x 825H soil compactors	\$4,200

¹ Rates sourced from DES ERC Calculator.

² Rate sourced from operational open cut mine in North Queensland.

Table 7.2 summarises the estimated construction costs in total, and per square meter, for each cover system design. The Base Case design is the lowest cost design by a significant margin owing primarily to the smaller material volume requirement and, to a lesser extent, no requirement to construct a compacted clay barrier layer. Construction costs for the alternative cover designs are also driven largely by the volume of material required to be handled during construction, with the single capillary break with alternative layer thicknesses being the lowest cost design and the single capillary break using DES minimum thicknesses being the highest cost design.

Table 7.2: Estimated construction costs for cover system designs.

Cover System Design	Estimated Construction Cost (\$)	Estimated Construction Cost per m ² (\$)
Base Case	\$1,884,000	\$2.90
Double Capillary Break	\$6,092,000	\$9.37
Single Capillary Break – DES Min. thickness	\$8,402,000	\$12.93
Single Capillary Break – Alternative thickness	\$5,285,000	\$8.13

The alternative cover system designs investigated in this study include a barrier layer at the request of the DES in order to reduce NP through the cover system to a greater extent than would a simple store-and-release cover system, such as the Base Case. As discussed in Section 1 and Section 2.1, Okane understand the DES requested a low permeability layer be incorporated. A 'low permeability' is typically understood to be a layer with a saturated hydraulic conductivity of less than 1×10^{-9} m/s. Incorporating a geomembrane, such as HDPE, into the cover system design would provide the greatest confidence in achieving a level of permeability consistent with this interpretation. Table 7.3 summarises the percentage increase in costs that could be expected by incorporating a geomembrane into the three alternative cover system designs.

Table 7.3: Increase in costs related to incorporating a geomembrane into cover system designs.

Cover System Design	Estimated Construction Cost with Geomembrane (\$) ¹	% Increase in Cost
Double Capillary Break	\$13,583,000	123%
Single Capillary Break – DES Min. thickness	\$14,505,000	73%
Single Capillary Break – Alternative thickness	\$12,218,000	131%

¹ Rates for cost of geomembrane purchase and install sourced from DES ERC Calculator (\$13/m²).

Whilst a source of clay suitable for constructing the barrier layer has been identified onsite, and until a detailed material survey is completed to more accurately assess the volume available, there remains a risk this source will not be available in the quantities required. Table 7.4 provides an indication of the percentage increase in costs that could be expected should the offsite clay source be used as the sole borrow source for the barrier

layer. It should be noted this is a worst case scenario. It is much more likely all suitable onsite sources would be exhausted prior to sourcing clay from the offsite location and the volumes required would be less than those used to calculate the costs in Table 7.4.

Table 7.4: Additional estimated costs using clay from the offsite borrow source.

Cover System Design	Additional Estimated Construction Cost (\$)	% Increase in Cost
Double Capillary Break	\$3,500,000	57%
Single Capillary Break – DES Min. thickness	\$6,000,000	71%
Single Capillary Break – Alternative thickness	\$3,500,000	66%

Costs in relation to relative NP performance improvements were assessed against model results both excluding and including established vegetation. Figure 7.1 presents the percent increase in modelled cover performance and cost compared to the Base Case design without established vegetation and Figure 7.2 presents the percent increase in modelled cover performance and cost compared to the Base Case design with established vegetation.

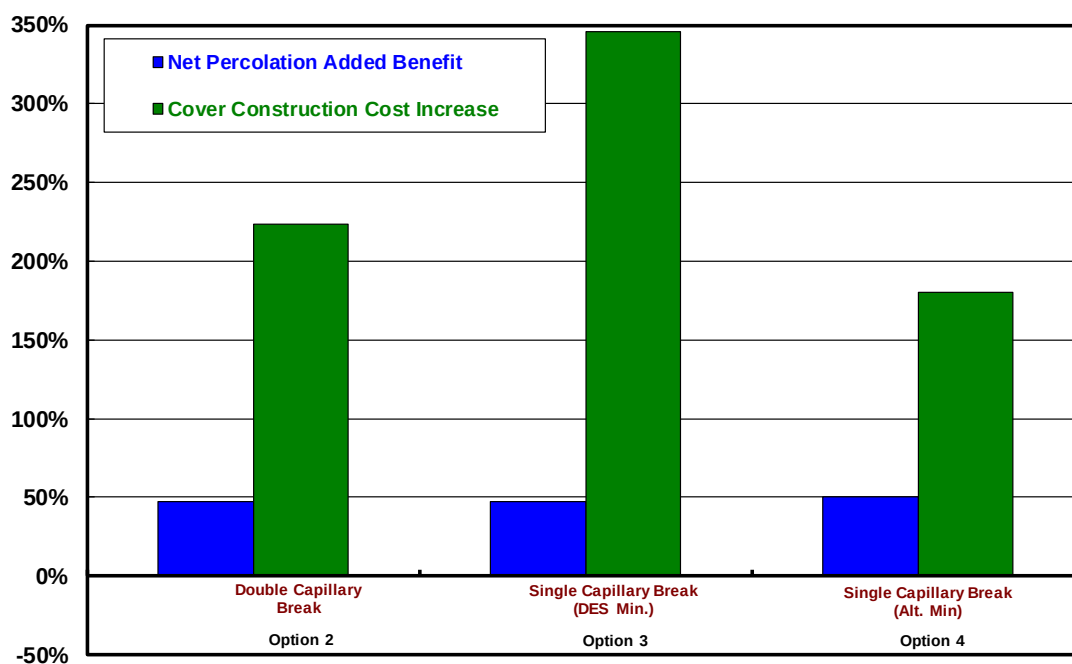


Figure 7.1: Percent increase in modelled cover performance and cost compared to the Base Case design without established vegetation.

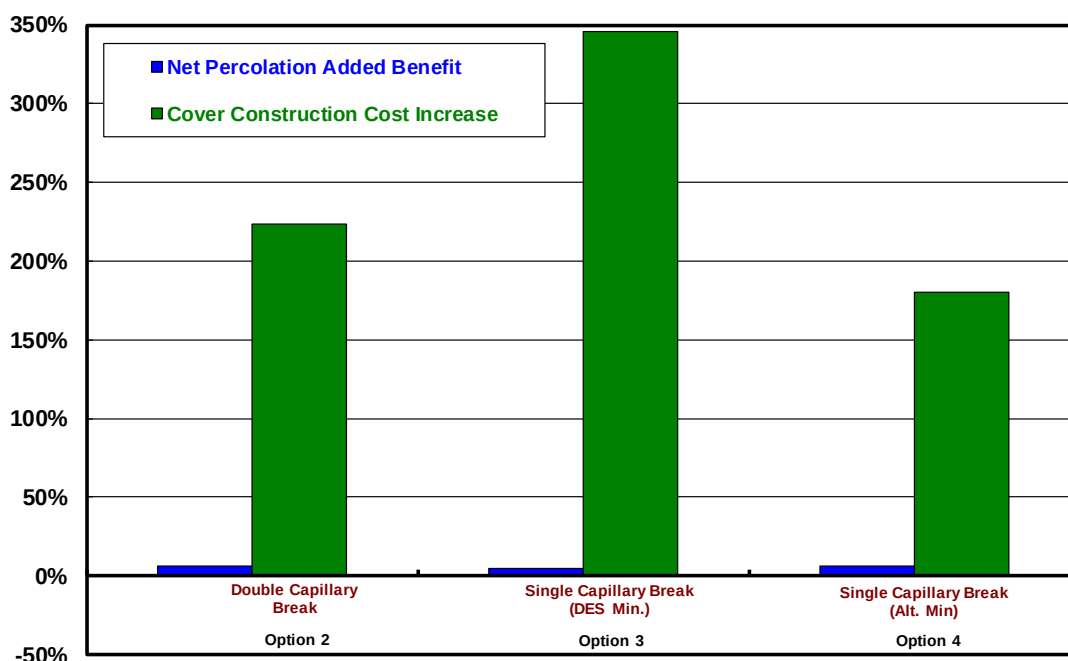


Figure 7.2: Percent increase in modelled cover performance and cost compared to the Base Case design with established vegetation.

When evaluating performance improvements against cost increases on a bare surface, the greatest performance improvement compared to the Base Case is provided by the single capillary break with alternative thickness design with a predicted improvement in NP of approximately 50%. The performance improvement from both the double capillary break and single capillary break with DES minimum thicknesses was modelled to be approximately 47% for both designs. When considering the cost of these performance improvements, the single capillary break with DES minimum thicknesses is the highest cost design and the single capillary break with alternative thicknesses is the lowest cost design. The 50% performance improvement achieved with the single capillary break with alternative thicknesses is estimated to cost at least 180% more than the Base Case. The 47% performance improvement achieved with the single capillary break with DES minimum thicknesses is expected to be accompanied by a cost increase in the order of 350% above the Base Case cost estimate.

When evaluating performance of the alternative designs in a scenario where 28% established vegetation coverage is assumed the costs remain the same, but the performance improvements are considerably reduced. The greatest performance improvement under these modelled conditions is achieved by both the single capillary break with alternative thicknesses and the double capillary break designs at 6% less NP than what is achieved with the Base Case design. The single capillary break with DES minimum thicknesses provides the least improvement, albeit only 1% less than the other alternatives.

Evaluation of modelled performance improvements versus high-level cost estimates for the three alternative cover system designs against the Base Case design indicates the single capillary break with alternative thicknesses design provides the greatest performance improvement at the lowest cost under both the bare surface model scenario and the 28% vegetation coverage model scenario. The improvements are in the order of approximately 50% under the bare surface scenario, but only 6% under a scenario that includes vegetation.

When assessing the relative performance improvements versus estimated construction costs provided by the alternative designs the following points should be considered:

- The DES has requested a barrier layer be incorporated in the cover system design and as such the current Base Case design is not considered suitable.
- A cover system will have a bare surface immediately following construction and would be expected to revegetate in the following years. Both the bare surface scenario and the vegetated scenario will occur at stages. Assessing the performance of a design under only one scenario would be misleading.
- The vegetated scenario assumed an established vegetation coverage of 28%. Based on observations during the site visit this is considered very achievable and potentially conservative.
- Modelled performance is based on average NP. The maximum NP that was predicted for the three alternative designs during the wettest periods was modelled as substantially less than the maximum NP expected through the Base Case design.
- The three alternative designs are less influenced by vegetation coverage than the Base Case design. In the event vegetation is adversely impacted, e.g. fire, the alternative designs will maintain a performance that cannot be matched by the Base Case design.

8 KEY FINDINGS AND RECOMMENDATIONS

The following key findings and recommendations are based on the results of the field sampling and material characterisation program:

- The clay borrow located upstream of the WSD was found to contain suitable material of good consistency capable of restricting hydraulic conductivity to an acceptable level for use within a barrier layer cover system unit. Similar results were found in the clay core of the HLP, upstream of the MWD and at the offsite clay borrow. The location upstream of the WSD looks to be the most promising source of clay material based on distance to the TSF and the potential volumes available. However, during detailed design and prior to construction, further investigatory work should be performed to more accurately determine available material volumes from this source and if it will satisfy construction volumes. Without considering shrink/swell/compaction factors, material volumes required for construction of a barrier layer are in the order of 195,000 m³ and 325,000 m³, depending on the cover system configuration chosen. The offsite clay borrow is expected to be capable of providing sufficient material of acceptable quality. However, this material is located approximately 45 km from the TSF by road. Material from the HLP embankment is limited in volume and the material upstream of the MWD should be investigated for contamination prior to being used in a cover system design.
- The TRWD embankment core and the MWD embankment core contain considerable oversize material that would likely make it unsuitable for a use in a barrier layer. This material may however be suitable for use as a source for a growth medium layer.
- The material adjacent to Cell A was found to be coarser than the material adjacent to Cell B and as such is more suitable for use in a coarse rock capillary break layer than as growth medium layer. Due to the finer nature of the material adjacent Cell B, this material is more suited for use as a growth medium. The physical properties of the heap leach pad waste rock are considered acceptable for use as a coarse rock capillary break layer. Should waste rock from the heap leach pad be used, a stringent quality control / quality assurance and testing program should be developed to provide evidence this material has not been contaminated by the leach process. High-level volume estimates suggest sufficient coarse rock material is available onsite to construction the capillary break layers.
- Several locations historically referred to as gravel, topsoil or gravel and topsoil mixes proved suitable for use as a growth medium layer of a cover system. However, when considering this layer will require the greatest volume of material, the high-level volume estimates of the areas investigated indicate additional sources may need to be identified to meet the volume requirements. Alternatively, blending with coarser material may also be an option.

- The topsoil borrow sources investigated were found to have suitable physical characteristics for use as a topsoil layer. Soil fertility testing of selected locations indicate that, whilst not particularly fertile, should not inhibit vegetation growth and establishment. High-level volume estimates suggest the topsoil sources investigated may not be sufficient to construct topsoil layers to the depths desired. Should topsoil inventories prove to be insufficient, options to address the shortfall could include blending with the gravel and topsoil mix areas or reducing the topsoil layer thickness.
- A more detailed material survey should be completed during detailed design works and prior to construction to ensure sufficient volumes of key materials will be available to meet the cover system design specification.

The following key findings and recommendations are based on the results of the numerical modelling program:

- Without established vegetation, modelling indicates NP will be limited to less than 7% of average annual rainfall for the double capillary break and DES minimum thickness single capillary break cover system alternatives. Based on the NP classifications adopted for Yandan (Section 2.2.1), these cover system designs provide a moderate NP system. The single capillary break with alternative layer thicknesses provided the greatest reduction in NP (4% of average annual rainfall) and was classified as a low NP system. Without established vegetation, the Base Case design only limited NP to approximately 54% of average annual rainfall and was classified as a very high NP system.
- The introduction of a, potentially conservative, 28% established vegetation coverage reduced NP for all three alternative cover system designs to low level NP systems. The introduction of established vegetation to the Base Case design reduced NP for this design from 54% to 8%, or from a very high to a moderate NP system.
- Whilst all three alternative cover system designs outperformed the base case design in terms of limiting NP, they also result in an increase in runoff. For example, for the non-vegetated scenario, 2% of average annual rainfall results in runoff for the base case. Runoff for the same scenario increases to 16%, 17% and 20% for the double capillary break, single capillary break with DES minimum thicknesses and single capillary break with alternative thicknesses respectively. Runoff would be considered clean and would not require containment. However, managing this runoff in a manner that will not result in erosion of the cover system or the ponding of water will require effective surface water management designs, construction and maintenance. It should be noted inadequate surface water management has previously been identified as key a reason behind the poor performance of earlier cover system trials on Cell B and isolated areas of Cell A (Okane, 2015).
- The double capillary break and both single capillary break designs can store more water within the cover system compared to the Base Case design. The increased

volume of water stored enables a potentially higher rate of moisture removal via evapotranspiration forces rather than infiltrating and as a result reduces NP. A greater water storage capacity will also delay the growth medium and topsoil reaching the PWP and reduce the time during which vegetation is subjected to water stress.

- The single capillary break with the DES minimum thicknesses performed the best in terms of limiting salt uptake into the root zone of the cover systems. This can be attributed to the greater overall cover thickness of this design. All three alternative cover system designs are expected to provide adequate control of salt uptake into the growth medium under both average and maximum likely tailings EC levels according to DERM (2011). Whilst the Base Case design results in moderate salinity levels at average tailings EC levels and is unlikely to significantly limit vegetation growth, at maximum tailings EC levels high to very high salinity levels are projected and would likely impact vegetation growth.

The following key findings and recommendations are based on the results of the cost benefit comparison:

- The single capillary break with alternative layer thicknesses to that prescribed by the DES provided the greatest relative performance improvement for the least cost. If a barrier layer must be incorporated into the cover system in order to receive DES support, this design should be adopted. However, the estimated construction costs for this design, and the other two alternative designs, were considerably higher than the Base Case design. A more detailed cost estimate should be developed for this design to fully appreciate the cost of this performance improvement over the Base Case.
- The single cover break with DES minimum layer thicknesses proved to provide the least performance improvement when compared to the Base Case design as well as being estimated as the highest cost design to construct.
- The improvements in modelled performance for all three alternative designs were substantially more under the bare surface modelled scenario than under the scenario modelled with conditions that included 28% vegetation coverage. Consideration should be given to the period of time during which the bare surface scenario would be most representative of expected conditions and the period of time during which at least 28% vegetation coverage would be most representative of expected conditions. Quantifying this risk would further inform the value of constructing a more costly cover system design.
- Performance comparisons are based on average modelled NP. Relative performance of the alternative designs may differ under the wetter extremes expected under closure timeframes. The performance of the alternative designs at the wet extremes, and the associated risk during these events, should be explored to further inform the value of constructing a more costly cover system design.

Based on the results and findings from the material characterisation program, numerical modelling and cost benefit comparison, Okane recommend Straits Gold adopt the single capillary break with alternative layer thicknesses design to address both the DES requirement for a cover system incorporating a barrier layer and the rehabilitation objectives defined in the Yandan Post Mine Land Use Plan (AARC, 2015) for Cell B of the TSF.

To further progress this conceptual cover system design towards detailed design, Okane recommend the following technical studies and investigations be considered:

- A detailed material survey should be completed to develop accurate material inventories. Material surveys will inform borrow locations and allow for cover system design refinements, if necessary. Accurate costings can be developed once borrow locations have been confirmed.
- If material surveys indicate additional clay sources are required to supplement clay from the borrow location upstream of the WSD, the clay material from the sampling location upstream of the MWD should be considered. If intending to use this material, it should be assessed for contamination from contact with process water. Existing samples of this material are stored onsite and could be shipped to a laboratory for analysis.
- Assess the suitability of the TRWD and MWD embankment material for use as a growth medium.
- Investigate the risk surrounding not being able to establish or maintain vegetation coverage of 28% or greater on the cover system. If the risk is high and establishing or maintaining 28% vegetation coverage for significant periods of time is likely to be difficult, this will further support adopting an alternative design which is less influenced by vegetation coverage than the Base Case.
- Develop more accurate cost estimates for construction of the single capillary break with alternative layer thicknesses option to fully understand the cost implications of adopting this design over the Base Case.
- Consider conducting a cover system trial to validate the preferred cover system alternative. In addition to validating the design and calibrating the existing numerical model, cover system trial objectives could be designed to investigate revegetation options with the view to selecting a revegetation species mix that will satisfy rehabilitation objectives, meet post mining land use goals and provide vegetation coverage greater than 28%.
- Integrate final cover system designs with an adequate surface water management system. A trade-off for limiting NP through the cover system with a barrier layer is the generation of increased runoff. Increased runoff can result in erosion damaging the

integrity of the cover system and increasing NP in addition to the potential to expose the underlying tailings. Runoff that cannot be effectively removed from the cover system can also result in areas of ponded water impacting vegetation growth and establishment. Removing runoff from the cover system in a manner that will limit erosion and the ponding of water on the cover will be critical to the success of a cover system for Cell B. Ineffective surface water management has previously been identified as a key factor leading to poor cover system performance on Cell A and on the previous cover system trials undertaken on Cell B.

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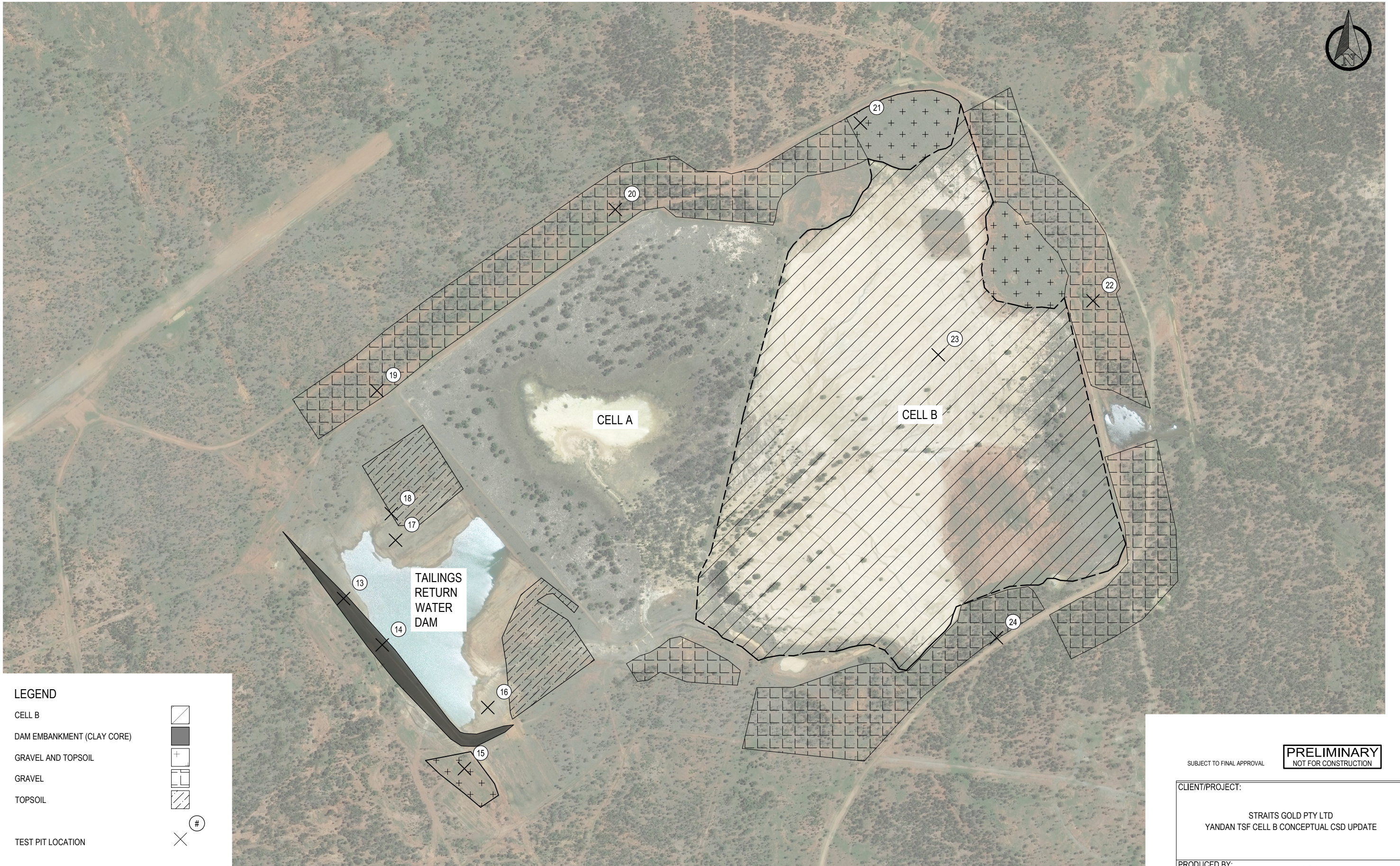
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Appendix A

Sampling Locations



LEGEND

CELL B

DAM EMBANKMENT (CLAY CORE)

GRAVEL AND TOPSOIL

GRAVEL

TOPSOIL

TEST PIT LOCATION

#

- NOTES:
1. ALL UNITS IN METERS U.N.O.

2. DO NOT SCALE.

3. AERIAL IMAGE PROVIDED BY STRAITS RESOURCES.

SUBJECT TO FINAL APPROVAL

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/PROJECT:

STRAITS GOLD PTY LTD
YANDAN TSF CELL B CONCEPTUAL CSD UPDATE

PRODUCED BY:


OKC PROJECT NO.: 956/007

TSF CELL B
MATERIAL LOCATIONS

DWG. NO.: 956-007-001 REV.: D

REFERENCE	DWG. NO.	DESCRIPTION	REVISIONS	NO.	DESCRIPTION	DRN. BY:	APPD. BY:	DATE	DRN. BY:	APPD. BY:	DATE	SCALE:	PAGE SIZE:	OKC RPT. NO.:
				A	ISSUED FOR CLIENT REVIEW	HSC	SL	06.13.19	H. COOPER		06.13.19			
				B	TEST PIT LOCATIONS ADDED	JMD	RB	07.29.19	A. OSBORN		06.13.19			
				C	UPDATED TITLEBLOCK	JMD	AO	12.05.19				AS SHOWN	A3	956-007-01
				D	UPDATED TITLEBLOCK	JMD	AO	12.10.19						



PROPOSED CLAY BORROW



LEGEND

- CLAY BORROW SOURCE
- ROADS
- TEST PIT LOCATION
-

- NOTES:
- 1. ALL UNITS IN METERS U.N.O.
 - 2. DO NOT SCALE.
 - 3. AERIAL IMAGE RESOURCED FROM GOOGLE.

SUBJECT TO FINAL APPROVAL

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/PROJECT:

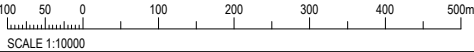
STRAITS GOLD PTY LTD
YANDAN TSF CELL B CONCEPTUAL CSD UPDATE



OKC PROJECT NO.: 956/007

PROPOSED CLAY BORROW

DWG. NO.: 956-007-002 REV.: C



REFERENCE	DWG. NO.	DESCRIPTION	REVISIONS	NO.	DESCRIPTION	DRN. BY:	APPD. BY:	DATE	DRN. BY:	APPD. BY:	DATE	SCALE:	PAGE SIZE:	OKC RPT. NO.:
				A	ISSUED FOR CLIENT REVIEW	HSC	SL	07.03.19	H. COOPER		07.03.19			
				B	TEST PIT LOCATIONS ADDED	JMD	RB	07.24.19	A. OSBORN		07.03.19			
				C	UPDATED TITLEBLOCK	JMD	AO	12.10.19	AS SHOWN	A3				956-007-01



LEGEND

DAM EMBANKMENT (CLAY CORE)

HEAP LEACH COARSE WASTE ROCK

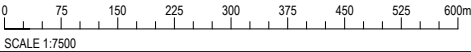
TEST PIT LOCATION

#

- NOTES:
1. ALL UNITS IN METERS U.N.O.

2. DO NOT SCALE.

3. AERIAL IMAGE PROVIDED BY STRAITS RESOURCES.



REFERENCE	DWG. NO.	DESCRIPTION	REVISIONS	NO.	DESCRIPTION	DRN. BY:	APPD. BY:	DATE	DRN. BY:	J. DAND	DATE:	07.08.19	ONSITE CLAY SOURCE AND HEAP LEACH LOCATION					
				A	ISSUED FOR CLIENT REVIEW	JMD	SL	07.09.19	APPD. BY:	S. LINES	DATE:	07.09.19						
				B	TEST PIT LOCATIONS ADDED	JMD	RB	07.24.19										
				C	UPDATED TITLEBLOCK	JMD	AO	12.10.19	SCALE:	AS SHOWN	PAGE SIZE:	A3	OKC RPT. NO.:	956-007-01	DWG. NO.:	956-007-003	REV.:	C

SUBJECT TO FINAL APPROVAL

PRELIMINARY
NOT FOR CONSTRUCTION

CLIENT/PROJECT:

STRAITS GOLD PTY LTD
YANDAN TSF CELL B CONCEPTUAL CSD UPDATE

PRODUCED BY:

OKC PROJECT NO.: 956/007

ONSITE CLAY SOURCE AND
HEAP LEACH LOCATION

REV.: C

Appendix B

Test Pit Logs

		TEST PIT LOG		TEST PIT # TP#1	SHEET 1/1
PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION				CLIENT AERIS RESOURCES	
DATE 17/07/2019		LOCATION OFFSITE CLAY BORROW SOURCE		SURFACE LEVEL 221 m	
EASTING 522472		NORTHING 7650127		PROJECT NUMBER 956-007	

RIG TELEHANDLER / SHOVEL	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA	SAMPLING AND TESTING				OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	TOPSOIL – light to dark brown silty sand topsoil, fine to medium grained sand, trace clay, some organic material.	BUCKET	YAN-001A	0.0-0.1	NA	Shovel sample scraped surface. Paste pH and EC testing completed.
			BUCKET	YAN-001B	0.0-0.1		
			BUCKET	YAN-001C	0.0-0.1		
			BUCKET	YAN-001D	0.0-0.1		
			BAG	YAN-001E	0.0-0.1		
			BAG	YAN-001 SWCC	0.0-0.1		
	0.1	Test pit discontinued at 0.1m					

PHOTO LOG	COMMENTS / LEGEND																								
	Paste pH Testing: <table border="1"> <thead> <tr> <th>Sample</th> <th>TP1</th> </tr> </thead> <tbody> <tr><td>Date</td><td>17/09/2019</td></tr> <tr><td>Time</td><td>10:29</td></tr> <tr><td>Temp (°C)</td><td>13.56</td></tr> <tr><td>SP Cond (µS/cm)</td><td>28</td></tr> <tr><td>Cond (µS/cm)</td><td>22</td></tr> <tr><td>TDS (g/L)</td><td>0.018</td></tr> <tr><td>DO Sat (%)</td><td>91</td></tr> <tr><td>DO (mg/L)</td><td>9.47</td></tr> <tr><td>pH</td><td>4.93</td></tr> <tr><td>pH (mV)</td><td>74.3</td></tr> <tr><td>ORP (mV)</td><td>162.8</td></tr> </tbody> </table>	Sample	TP1	Date	17/09/2019	Time	10:29	Temp (°C)	13.56	SP Cond (µS/cm)	28	Cond (µS/cm)	22	TDS (g/L)	0.018	DO Sat (%)	91	DO (mg/L)	9.47	pH	4.93	pH (mV)	74.3	ORP (mV)	162.8
Sample	TP1																								
Date	17/09/2019																								
Time	10:29																								
Temp (°C)	13.56																								
SP Cond (µS/cm)	28																								
Cond (µS/cm)	22																								
TDS (g/L)	0.018																								
DO Sat (%)	91																								
DO (mg/L)	9.47																								
pH	4.93																								
pH (mV)	74.3																								
ORP (mV)	162.8																								

		TEST PIT LOG		TEST PIT # TP#2	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 17/07/2019		LOCATION OFFSITE CLAY BORROW SOURCE		SURFACE LEVEL 221 m	
EASTING 522472		NORTHING 7650127		PROJECT NUMBER 956-007	

RIG TELEHANDLER / SHOVEL	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA	SAMPLING AND TESTING				OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	TOPSOIL – light to dark brown silty sand topsoil, fine to medium grained sand, trace clay, some organic material.				NA	Telehandler excavated test-pit, sampled by shovel.
	0.3	SANDY SILTY CLAY – Firm to stiff grey brown sandy silty clay, fine to medium grained sand, trace organic material, dry.	BUCKET BUCKET BUCKET BUCKET BAG BAG	YAN-002A YAN-002B YAN-002C YAN-002D YAN-002E YAN-002 SWCC	0.3-0.4 0.3-0.4 0.3-0.4 0.3-0.4 0.3-0.4 0.3-0.4		Paste pH and EC testing completed GP#1 completed at this location.
	0.4	Test pit discontinued at 0.1m					

PHOTO LOG	COMMENTS / LEGEND																								
	Paste pH Testing: <table border="1"> <tr> <th>Sample</th> <th>TP2</th> </tr> <tr> <td>Date</td> <td>17/09/2019</td> </tr> <tr> <td>Time</td> <td>10:39</td> </tr> <tr> <td>Temp (°C)</td> <td>14.06</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>15</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>12</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.01</td> </tr> <tr> <td>DO Sat (%)</td> <td>81.2</td> </tr> <tr> <td>DO (mg/L)</td> <td>8.36</td> </tr> <tr> <td>pH</td> <td>6.03</td> </tr> <tr> <td>pH (mV)</td> <td>13.7</td> </tr> <tr> <td>ORP (mV)</td> <td>162.2</td> </tr> </table>	Sample	TP2	Date	17/09/2019	Time	10:39	Temp (°C)	14.06	SP Cond (µS/cm)	15	Cond (µS/cm)	12	TDS (g/L)	0.01	DO Sat (%)	81.2	DO (mg/L)	8.36	pH	6.03	pH (mV)	13.7	ORP (mV)	162.2
	Sample	TP2																							
	Date	17/09/2019																							
	Time	10:39																							
	Temp (°C)	14.06																							
	SP Cond (µS/cm)	15																							
	Cond (µS/cm)	12																							
	TDS (g/L)	0.01																							
	DO Sat (%)	81.2																							
	DO (mg/L)	8.36																							
	pH	6.03																							
	pH (mV)	13.7																							
	ORP (mV)	162.2																							

		TEST PIT LOG		TEST PIT # TP#3	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 17/07/2019		LOCATION OFFSITE CLAY BORROW SOURCE		SURFACE LEVEL 219m	
EASTING 522452		NORTHING 7650100		PROJECT NUMBER 956-007	

RIG SHOVEL	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA	SAMPLING AND TESTING				OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	GRAVELLY CLAY – light brown / grey gravelly clay, fine to medium grained sand, fine to coarse grained gravel with some cobbles, crumbly (dry).	BUCKET	YAN-003A	0.2-0.3	NA	Shovel sample collected on dam embankment, in an erosion gully
			BUCKET	YAN-003B	0.2-0.3		
			BUCKET	YAN-003C	0.2-0.3		
			BUCKET	YAN-003D	0.2-0.3		
			BAG	YAN-003E	0.2-0.3		
			BAG	YAN-003 SWCC	0.2-0.3		
	0.3	Test pit discontinued at 0.3 m					Paste pH and EC testing completed

PHOTO LOG



COMMENTS / LEGEND

Paste pH Testing:

Sample	TP3
Date	18/09/2019
Time	19:39
Temp (°C)	17.52
SP Cond (µS/cm)	34
Cond (µS/cm)	29
TDS (g/L)	0.022
DO Sat (%)	88.3
DO (mg/L)	8.44
pH	6.56
pH (mV)	-15.2
ORP (mV)	98.5

		TEST PIT LOG		TEST PIT # TP#4	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 17/07/2019		LOCATION TOE OF HEAP LEACH PAD		SURFACE LEVEL 180 m	
EASTING 497399		NORTHING 7645374		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	SANDY GRAVEL – light brown / light grey, weathered at the surface (orange) gravel, some fine to medium grained sand, some cobbles and boulders, dry. Heap leach material.	BUCKET	YAN-004A	0.4-	NA	>115 mm fraction estimated at 15%, >100 mm fraction estimated at 40%.
			BUCKET	YAN-004B	0.5		
			BUCKET	YAN-004C	0.4-		
			BUCKET	YAN-004D	0.5		
			BAG	YAN-004E	0.4-		
			BAG	YAN-004	0.5		
	0.5	Test pit discontinued at 0.5 m		SWCC	0.4-		Test pit excavated into side of stockpile. Paste pH and EC testing completed.
					0.5		
					0.4-		
					0.5		

PHOTO LOG	COMMENTS / LEGEND																								
	Paste pH Testing: <table border="1"> <tr> <th>Sample</th> <th>TP4</th> </tr> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>19:41</td> </tr> <tr> <td>Temp (°C)</td> <td>14.93</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>30</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>24</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.02</td> </tr> <tr> <td>DO Sat (%)</td> <td>98.2</td> </tr> <tr> <td>DO (mg/L)</td> <td>9.92</td> </tr> <tr> <td>pH</td> <td>8.9</td> </tr> <tr> <td>pH (mV)</td> <td>-146.4</td> </tr> <tr> <td>ORP (mV)</td> <td>13</td> </tr> </table>	Sample	TP4	Date	18/09/2019	Time	19:41	Temp (°C)	14.93	SP Cond (µS/cm)	30	Cond (µS/cm)	24	TDS (g/L)	0.02	DO Sat (%)	98.2	DO (mg/L)	9.92	pH	8.9	pH (mV)	-146.4	ORP (mV)	13
Sample	TP4																								
Date	18/09/2019																								
Time	19:41																								
Temp (°C)	14.93																								
SP Cond (µS/cm)	30																								
Cond (µS/cm)	24																								
TDS (g/L)	0.02																								
DO Sat (%)	98.2																								
DO (mg/L)	9.92																								
pH	8.9																								
pH (mV)	-146.4																								
ORP (mV)	13																								

		TEST PIT LOG		TEST PIT # TP#5	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 17/07/2019		LOCATION HEAP LEACH POND EMBANKMENT		SURFACE LEVEL 179 m	
EASTING 498191		NORTHING 7644949		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA	SAMPLING AND TESTING					OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS	
	0.0	TOPSOIL – orange brown gravelly sand topsoil, fine to medium grained sand, some fine to coarse grained gravel, trace organic material.				NA	Test pit excavated into plateau of embankment. Paste pH and EC testing completed. GP#2 completed at this location.	
	0.05	SANDY SILTY CLAY – stiff to very stiff, grey brown mottled red silty clay, some fine to medium grained sand and gravel, some cobbles, trace organics.	BUCKET	YAN-005A	1.1-1.2			
			BUCKET	YAN-005B	1.1-1.2			
			BUCKET	YAN-005C	1.1-1.2			
			BUCKET	YAN-005D	1.1-1.2			
			BAG	YAN-005E	1.1-1.2			
			BAG	YAN-005 SWCC	1.1-1.2			
	1.2	Test pit discontinued at 1.2 m						

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1"> <tr> <th>Sample</th> <th>TP5</th> </tr> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>19:44</td> </tr> <tr> <td>Temp (°C)</td> <td>19.1</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>19</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>16</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.012</td> </tr> <tr> <td>DO Sat (%)</td> <td>80.2</td> </tr> <tr> <td>DO (mg/L)</td> <td>7.57</td> </tr> <tr> <td>pH</td> <td>7.98</td> </tr> <tr> <td>pH (mV)</td> <td>-95.8</td> </tr> <tr> <td>ORP (mV)</td> <td>78.3</td> </tr> </table>	Sample	TP5	Date	18/09/2019	Time	19:44	Temp (°C)	19.1	SP Cond (µS/cm)	19	Cond (µS/cm)	16	TDS (g/L)	0.012	DO Sat (%)	80.2	DO (mg/L)	7.57	pH	7.98	pH (mV)	-95.8	ORP (mV)	78.3
Sample	TP5																								
Date	18/09/2019																								
Time	19:44																								
Temp (°C)	19.1																								
SP Cond (µS/cm)	19																								
Cond (µS/cm)	16																								
TDS (g/L)	0.012																								
DO Sat (%)	80.2																								
DO (mg/L)	7.57																								
pH	7.98																								
pH (mV)	-95.8																								
ORP (mV)	78.3																								

		TEST PIT LOG		TEST PIT # TP#6	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 17/07/2019		LOCATION HEAP LEACH POND EMBANKMENT		SURFACE LEVEL 181 m	
EASTING 498104		NORTHING 7644883		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA	SAMPLING AND TESTING				OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	SANDY SILTY CLAY – stiff to very stiff red grey brown mottled red silty sandy clay mixed with silty sandy gravel matrix, some fine to coarse gravel, some fine to coarse cobbles, trace organics.	BAG	YAN-006F	0.9-1.0	NA	Test pit excavated into plateau of embankment. Paste pH and EC testing completed. Sample YAN-006F contains less clay and more gravel than sample E.
			BUCKET	YAN-006A	3.4-3.5		
			BUCKET	YAN-006B	3.4-3.5		
			BUCKET	YAN-006C	3.4-3.5		
			BUCKET	YAN-006D	3.4-3.5		
			BAG	YAN-006E	3.4-3.5		
			BAG	YAN-006 SWCC	3.4-3.5		
	3.5	Test pit discontinued at 3.5 m					

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1"> <tr> <th>Sample</th><th>TP6</th></tr> <tr> <td>Date</td><td>18/09/2019</td></tr> <tr> <td>Time</td><td>19:46</td></tr> <tr> <td>Temp (°C)</td><td>16.13</td></tr> <tr> <td>SP Cond (µS/cm)</td><td>13</td></tr> <tr> <td>Cond (µS/cm)</td><td>11</td></tr> <tr> <td>TDS (g/L)</td><td>0.08</td></tr> <tr> <td>DO Sat (%)</td><td>85.7</td></tr> <tr> <td>DO (mg/L)</td><td>8.43</td></tr> <tr> <td>pH</td><td>8.37</td></tr> <tr> <td>pH (mV)</td><td>-116.8</td></tr> <tr> <td>ORP (mV)</td><td>55.4</td></tr> </table>	Sample	TP6	Date	18/09/2019	Time	19:46	Temp (°C)	16.13	SP Cond (µS/cm)	13	Cond (µS/cm)	11	TDS (g/L)	0.08	DO Sat (%)	85.7	DO (mg/L)	8.43	pH	8.37	pH (mV)	-116.8	ORP (mV)	55.4
Sample	TP6																								
Date	18/09/2019																								
Time	19:46																								
Temp (°C)	16.13																								
SP Cond (µS/cm)	13																								
Cond (µS/cm)	11																								
TDS (g/L)	0.08																								
DO Sat (%)	85.7																								
DO (mg/L)	8.43																								
pH	8.37																								
pH (mV)	-116.8																								
ORP (mV)	55.4																								

		TEST PIT LOG		TEST PIT # TP#7	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 17/07/2019		LOCATION MINE WATER POND EMBANKMENT		SURFACE LEVEL 183 m	
EASTING 497846		NORTHING 7646133		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	SILTY CLAY – red brown mottled grey silty clay, firm, within a clayey sandy gravel matrix (less matrix than at TP#5 and TP#6), fine to medium grained sand, fine to coarse gravel.	BUCKET	YAN-007A	1.6-	NA	Test pit excavated into plateau of northern arm of embankment.
			BUCKET	YAN-007B	1.7		
			BUCKET	YAN-007C	1.6-		
			BUCKET	YAN-007D	1.7		
			BAG	YAN-007E	1.6-		
			BAG	YAN-007	1.7		
				SWCC	1.6-		
	1.7	Test pit discontinued at 1.7m			1.7		Higher clay content than at the Heap Leach Pond Embankment.
					1.6-		
					1.7		
					1.6-		
					1.7		
							Paste pH and EC testing completed.
							GP#3 completed at this location.

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1" style="width: 100%;"> <tr> <th>Sample</th> <th>TP7</th> </tr> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>19:48</td> </tr> <tr> <td>Temp (°C)</td> <td>19.04</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>106</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>94</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.069</td> </tr> <tr> <td>DO Sat (%)</td> <td>75.2</td> </tr> <tr> <td>DO (mg/L)</td> <td>6.97</td> </tr> <tr> <td>pH</td> <td>8.15</td> </tr> <tr> <td>pH (mV)</td> <td>-105.1</td> </tr> <tr> <td>ORP (mV)</td> <td>50.7</td> </tr> </table>	Sample	TP7	Date	18/09/2019	Time	19:48	Temp (°C)	19.04	SP Cond (µS/cm)	106	Cond (µS/cm)	94	TDS (g/L)	0.069	DO Sat (%)	75.2	DO (mg/L)	6.97	pH	8.15	pH (mV)	-105.1	ORP (mV)	50.7
Sample	TP7																								
Date	18/09/2019																								
Time	19:48																								
Temp (°C)	19.04																								
SP Cond (µS/cm)	106																								
Cond (µS/cm)	94																								
TDS (g/L)	0.069																								
DO Sat (%)	75.2																								
DO (mg/L)	6.97																								
pH	8.15																								
pH (mV)	-105.1																								
ORP (mV)	50.7																								

		TEST PIT LOG		TEST PIT # TP#8	SHEET 1/1
PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES			
DATE 17/07/2019		LOCATION MINE WATER POND EMBANKMENT		SURFACE LEVEL 181 m	
EASTING 497715		NORTHING 7645987		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	SANDY GRAVELLY CLAY – light grey brown mottled red sandy gravelly clay, stiff to very stiff, fine to medium grained sand, some fine to coarse gravel and cobbles. Clay within sandy gravel matrix (approx. 60% matrix and 40% clay), becoming moist with depth.	BUCKET	YAN-008A	2.9-	NA	Test pit excavated into plateau of northern arm of embankment. Higher clay content than at the Heap Leach Pond Embankment. Paste pH and EC testing completed. Sample F is the shallowest sample and contains more matrix, less clay. >100mm fraction estimated at 5%.
			BUCKET	YAN-008B	3.0		
			BUCKET	YAN-008C	2.9-		
			BUCKET	YAN-008D	3.0		
			BAG	YAN-008E	2.9-		
			BAG	YAN-008F	3.0		
				YAN-008 SWCC	2.9-		
	3.0	Test pit discontinued at 3.0 m			3.0		
					0.9–1		

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1"> <thead> <tr> <th>Sample</th> <th>TP8</th> </tr> </thead> <tbody> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>19:51</td> </tr> <tr> <td>Temp (°C)</td> <td>18.82</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>11</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>9</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.007</td> </tr> <tr> <td>DO Sat (%)</td> <td>73.6</td> </tr> <tr> <td>DO (mg/L)</td> <td>6.85</td> </tr> <tr> <td>pH</td> <td>8.45</td> </tr> <tr> <td>pH (mV)</td> <td>-122.1</td> </tr> <tr> <td>ORP (mV)</td> <td>46.9</td> </tr> </tbody> </table>	Sample	TP8	Date	18/09/2019	Time	19:51	Temp (°C)	18.82	SP Cond (µS/cm)	11	Cond (µS/cm)	9	TDS (g/L)	0.007	DO Sat (%)	73.6	DO (mg/L)	6.85	pH	8.45	pH (mV)	-122.1	ORP (mV)	46.9
Sample	TP8																								
Date	18/09/2019																								
Time	19:51																								
Temp (°C)	18.82																								
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DO Sat (%)	73.6																								
DO (mg/L)	6.85																								
pH	8.45																								
pH (mV)	-122.1																								
ORP (mV)	46.9																								

		TEST PIT LOG		TEST PIT # TP#9	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION MINE WATER POND CLAY BORROW		SURFACE LEVEL 183 m	
EASTING 498035		NORTHING 7645730		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	TOPSOIL – dark grey brown silty sand topsoil, fine to medium grained sand, trace fine to medium grained gravel, trace organics.	BAG	YAN-009F	0.0-0.1	NA	Good quality clay located here. Underlying basalt could be ripped and used for cover material. Paste pH and EC testing completed. GP#4 completed at this location.
	0.5	SILTY CLAY – dark red brown mottled grey silty clay, est. very stiff, moist, some silty sand matrix.	BUCKET BUCKET BUCKET BUCKET BAG BAG	YAN-009A YAN-009B YAN-009C YAN-009D YAN-009E YAN-009 SWCC	1.4-1.5 1.4-1.5 1.4-1.5 1.4-1.5 1.4-1.5 1.4-1.5		
	1.5	BASALT – grey brown basalt	BAG	YAN-009G	1.5–1.6		
	2.2	Test pit discontinued at 2.2 m.					

PHOTO LOG	COMMENTS / LEGEND																								
	Paste pH Testing: <table border="1"> <tr> <th>Sample</th> <th>TP9</th> </tr> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>19:53</td> </tr> <tr> <td>Temp (°C)</td> <td>18.49</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>251</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>220</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.163</td> </tr> <tr> <td>DO Sat (%)</td> <td>73.4</td> </tr> <tr> <td>DO (mg/L)</td> <td>6.88</td> </tr> <tr> <td>pH</td> <td>7.41</td> </tr> <tr> <td>pH (mV)</td> <td>-63.3</td> </tr> <tr> <td>ORP (mV)</td> <td>75.7</td> </tr> </table>	Sample	TP9	Date	18/09/2019	Time	19:53	Temp (°C)	18.49	SP Cond (µS/cm)	251	Cond (µS/cm)	220	TDS (g/L)	0.163	DO Sat (%)	73.4	DO (mg/L)	6.88	pH	7.41	pH (mV)	-63.3	ORP (mV)	75.7
Sample	TP9																								
Date	18/09/2019																								
Time	19:53																								
Temp (°C)	18.49																								
SP Cond (µS/cm)	251																								
Cond (µS/cm)	220																								
TDS (g/L)	0.163																								
DO Sat (%)	73.4																								
DO (mg/L)	6.88																								
pH	7.41																								
pH (mV)	-63.3																								
ORP (mV)	75.7																								

		TEST PIT LOG		TEST PIT # TP#9A	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION MINE WATER POND CLAY BORROW		SURFACE LEVEL 181 m	
EASTING 498036		NORTHING 7645791		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA	SAMPLE TYPE	SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION		SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	TOPSOIL – dark grey brown silty sand topsoil, fine to medium grained sand, trace fine to medium grained gravel, trace organics.	NA	NO SAMPLES COLLECTED	NA	NA	Clay similar to TP#9 but a larger amount. No samples collected here.
	0.5	SILTY CLAY – dark red brown mottled grey silty clay, est. very stiff, moist, some silty sand matrix.					
	2.1	BASALT – grey brown basalt					
	2.3	Test pit discontinued at 2.3 m.					

PHOTO LOG	COMMENTS / LEGEND
	

		TEST PIT LOG		TEST PIT # TP#9B	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION MINE WATER POND CLAY BORROW		SURFACE LEVEL 181 m	
EASTING 497968		NORTHING 7645782		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA	SAMPLE TYPE	SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION		SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	TOPSOIL – dark grey brown silty sand topsoil, fine to medium grained sand, trace fine to medium grained gravel, trace organics.	NA	NO SAMPLES COLLECTED	NA	NA	Clay similar to TP#9 but a much lower amount. Higher clay volumes found in gully. No samples collected here.
	0.3	SILTY CLAY – dark red brown mottled grey silty clay, est. very stiff, moist, some silty sand matrix.					
	0.5	BASALT – grey brown basalt					
	1.4	Test pit discontinued at 1.4 m.					

PHOTO LOG	COMMENTS / LEGEND
	

		TEST PIT LOG		TEST PIT # TP#10	SHEET 1/1
PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION				CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION ON-SITE CLAY BORROW		SURFACE LEVEL 175 m	
EASTING 498884		NORTHING 7646389		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	TOPSOIL – dark brown silty sand topsoil, fine to medium grained sand, trace fine to coarse gravel, some organics.	BAG	YAN-010F	0.0-0.1	NA	Low clay volume. Paste pH and EC testing completed. GP#5 completed at this location.
	0.2	SILTY SANDY CLAY – dark orange brown mottled red silty sandy clay, fine to medium grained sand, trace fine to medium grained gravel.	BUCKET	YAN-0010A	0.3-0.4		
			BUCKET	YAN-0010B	0.3-0.4		
			BUCKET	YAN-0010C	0.3-0.4		
			BUCKET	YAN-0010D	0.3-0.4		
			BAG	YAN-0010E	0.3-0.4		
			BAG	YAN-0010	0.3-0.4		
	0.4	BASALT – grey brown basalt, increasing hardness with depth.		SWCC			
	1.2	Test pit discontinued at 1.2 m.					

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1"> <tr> <th>Sample</th> <th>TP10</th> </tr> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>20:00</td> </tr> <tr> <td>Temp (°C)</td> <td>18.14</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>410</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>356</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.266</td> </tr> <tr> <td>DO Sat (%)</td> <td>78.6</td> </tr> <tr> <td>DO (mg/L)</td> <td>7.41</td> </tr> <tr> <td>pH</td> <td>9.04</td> </tr> <tr> <td>pH (mV)</td> <td>-155.1</td> </tr> <tr> <td>ORP (mV)</td> <td>52.2</td> </tr> </table>	Sample	TP10	Date	18/09/2019	Time	20:00	Temp (°C)	18.14	SP Cond (µS/cm)	410	Cond (µS/cm)	356	TDS (g/L)	0.266	DO Sat (%)	78.6	DO (mg/L)	7.41	pH	9.04	pH (mV)	-155.1	ORP (mV)	52.2
Sample	TP10																								
Date	18/09/2019																								
Time	20:00																								
Temp (°C)	18.14																								
SP Cond (µS/cm)	410																								
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DO (mg/L)	7.41																								
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pH (mV)	-155.1																								
ORP (mV)	52.2																								

		TEST PIT LOG		TEST PIT # TP#11	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION ON-SITE CLAY BORROW		SURFACE LEVEL 176 m	
EASTING 498777		NORTHING 7646386		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	TOPSOIL – dark brown silty sand topsoil, fine to medium grained sand, trace fine to coarse gravel, some organics.	BAG	YAN-011F	0.0-0.1	NA	Two distinct clay layers. Large volume of clay. Paste PH / EC testing completed here.
	0.2	SANDY SILTY CLAY – grey brown sandy silty clay, very stiff, dry, fine to medium grained sand, trace fine to coarse gravel.	BUCKET	YAN-0011A	2.3-2.4		
			BUCKET	YAN-0011B	2.3-2.4		
			BUCKET	YAN-0011C	2.3-2.4		
			BUCKET	YAN-0011D	2.3-2.4		
			BAG	YAN-0011E	2.3-2.4		
			BAG	YAN-0011 SWCC	2.3-2.4		
	2.5	SILTY SANDY CLAY – dark grey mottled light brown sandy silty clay, fine to medium grained sand, higher sand content, trace fine to coarse gravel.	BUCKET	YAN-0012A	3.9-4.0		
			BUCKET	YAN-0012B	3.9-4.0		
			BUCKET	YAN-0012C	3.9-4.0		
			BUCKET	YAN-0012D	3.9-4.0		
			BAG	YAN-0012E	3.9-4.0		
			BAG	YAN-0012 SWCC	3.9-4.0		
	4.0	Test pit discontinued at 4.0 m.					

PHOTO LOG	COMMENTS / LEGEND																																				
	Paste pH Testing: <table border="1"> <thead> <tr> <th>Sample</th> <th>TP11</th> <th>TP12</th> </tr> </thead> <tbody> <tr> <td>Date</td> <td>18/09</td> <td>18/09</td> </tr> <tr> <td>Time</td> <td>18:58</td> <td>20:03</td> </tr> <tr> <td>Temp (°C)</td> <td>18:21</td> <td>17.82</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>310</td> <td>32</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>270</td> <td>28</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.202</td> <td>0.021</td> </tr> <tr> <td>DO Sat (%)</td> <td>76.7</td> <td>73.9</td> </tr> <tr> <td>DO (mg/L)</td> <td>7.23</td> <td>7.02</td> </tr> <tr> <td>pH</td> <td>8.75</td> <td>9.17</td> </tr> <tr> <td>pH (mV)</td> <td>-138.9</td> <td>-162.7</td> </tr> <tr> <td>ORP (mV)</td> <td>57.2</td> <td>53.2</td> </tr> </tbody> </table>	Sample	TP11	TP12	Date	18/09	18/09	Time	18:58	20:03	Temp (°C)	18:21	17.82	SP Cond (µS/cm)	310	32	Cond (µS/cm)	270	28	TDS (g/L)	0.202	0.021	DO Sat (%)	76.7	73.9	DO (mg/L)	7.23	7.02	pH	8.75	9.17	pH (mV)	-138.9	-162.7	ORP (mV)	57.2	53.2
Sample	TP11	TP12																																			
Date	18/09	18/09																																			
Time	18:58	20:03																																			
Temp (°C)	18:21	17.82																																			
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TDS (g/L)	0.202	0.021																																			
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pH	8.75	9.17																																			
pH (mV)	-138.9	-162.7																																			
ORP (mV)	57.2	53.2																																			

		TEST PIT LOG		TEST PIT # TP#13	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION TAILINGS WATER DAM EMBANKMENT		SURFACE LEVEL 186 m	
EASTING 499303		NORTHING 7646818		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	GRAVELLEY SANDY CLAY – red brown gravelly clay, firm, fine to medium grained sand, fine to coarse grained gravel, some cobbles and few boulders, trace organic material.	BUCKET	YAN-0013A	1.9-2.0	NA	Sieve bucket used. >100mm fraction estimated at 10%.
			BUCKET	YAN-0013B	1.9-2.0		
			BUCKET	YAN-0013C	1.9-2.0		
			BUCKET	YAN-0013D	1.9-2.0		
			BAG	YAN-0013E	1.9-2.0		
			BAG	YAN-0013 SWCC	1.9-2.0		
	2.0	Test pit discontinued at 2.0 m.					Paste PH / EC testing completed here.

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1"> <tr> <td>Sample</td> <td>TP13</td> </tr> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>20:02</td> </tr> <tr> <td>Temp (°C)</td> <td>17</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>10</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>9</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.007</td> </tr> <tr> <td>DO Sat (%)</td> <td>77.9</td> </tr> <tr> <td>DO (mg/L)</td> <td>7.53</td> </tr> <tr> <td>pH</td> <td>7.67</td> </tr> <tr> <td>pH (mV)</td> <td>-77.9</td> </tr> <tr> <td>ORP (mV)</td> <td>68.5</td> </tr> </table>	Sample	TP13	Date	18/09/2019	Time	20:02	Temp (°C)	17	SP Cond (µS/cm)	10	Cond (µS/cm)	9	TDS (g/L)	0.007	DO Sat (%)	77.9	DO (mg/L)	7.53	pH	7.67	pH (mV)	-77.9	ORP (mV)	68.5
Sample	TP13																								
Date	18/09/2019																								
Time	20:02																								
Temp (°C)	17																								
SP Cond (µS/cm)	10																								
Cond (µS/cm)	9																								
TDS (g/L)	0.007																								
DO Sat (%)	77.9																								
DO (mg/L)	7.53																								
pH	7.67																								
pH (mV)	-77.9																								
ORP (mV)	68.5																								

		TEST PIT LOG		TEST PIT # TP#14	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION TAILINGS WATER DAM EMBANKMENT		SURFACE LEVEL 186 m	
EASTING 499384		NORTHING 7646721		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	GRAVELLEY SANDY CLAY – red brown gravelly clay, firm, fine to medium grained sand, fine to coarse grained gravel, some cobbles and few boulders, trace organic material.	BUCKET	YAN-0014A	1.7-1.8	NA	Sieve bucket used. >100mm fraction estimated at 10%.
			BUCKET	YAN-0014B	1.7-1.8		
			BUCKET	YAN-0014C	1.7-1.8		
			BUCKET	YAN-0014D	1.7-1.8		
			BAG	YAN-0014E	1.7-1.8		
			BAG	YAN-0014 SWCC	1.7-1.8		
	1.8	Test pit discontinued at 1.8 m.					Paste PH / EC testing completed here.

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1"> <tr> <td>Sample</td> <td>TP14</td> </tr> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>20:01</td> </tr> <tr> <td>Temp (°C)</td> <td>16.86</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>16</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>14</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.01</td> </tr> <tr> <td>DO Sat (%)</td> <td>80.2</td> </tr> <tr> <td>DO (mg/L)</td> <td>7.77</td> </tr> <tr> <td>pH</td> <td>7.73</td> </tr> <tr> <td>pH (mV)</td> <td>-81.2</td> </tr> <tr> <td>ORP (mV)</td> <td>75.7</td> </tr> </table>	Sample	TP14	Date	18/09/2019	Time	20:01	Temp (°C)	16.86	SP Cond (µS/cm)	16	Cond (µS/cm)	14	TDS (g/L)	0.01	DO Sat (%)	80.2	DO (mg/L)	7.77	pH	7.73	pH (mV)	-81.2	ORP (mV)	75.7
Sample	TP14																								
Date	18/09/2019																								
Time	20:01																								
Temp (°C)	16.86																								
SP Cond (µS/cm)	16																								
Cond (µS/cm)	14																								
TDS (g/L)	0.01																								
DO Sat (%)	80.2																								
DO (mg/L)	7.77																								
pH	7.73																								
pH (mV)	-81.2																								
ORP (mV)	75.7																								

		TEST PIT LOG		TEST PIT # TP#15	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION GRAVEL AND TOPSOIL BORROW SOURCE		SURFACE LEVEL 184 m	
EASTING 499556		NORTHING 7646462		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA	SAMPLING AND TESTING					OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS	
	0.0	GRAVELLEY SANDY TOPSOIL – orange brown gravelly sand topsoil, fine to coarse gravel, some cobbles, trace organics near the surface, dry.	BUCKET	YAN-0015A	1.1-1.2	NA	Sieve bucket used. >100mm fraction estimated at 15%. Paste PH / EC testing completed here.	
			BUCKET	YAN-0015B	1.1-1.2			
			BUCKET	YAN-0015C	1.1-1.2			
			BUCKET	YAN-0015D	1.1-1.2			
			BAG	YAN-0015E	1.1-1.2			
			BAG	YAN-0015 SWCC	1.1-1.2			
	1.2	Test pit discontinued at 1.2 m.						

PHOTO LOG	COMMENTS / LEGEND																								
	Paste pH Testing: <table border="1"> <tr><td>Sample</td><td>TP15</td></tr> <tr><td>Date</td><td>18/09/2019</td></tr> <tr><td>Time</td><td>20:07</td></tr> <tr><td>Temp (°C)</td><td>17.45</td></tr> <tr><td>SP Cond (µS/cm)</td><td>138</td></tr> <tr><td>Cond (µS/cm)</td><td>118</td></tr> <tr><td>TDS (g/L)</td><td>0.089</td></tr> <tr><td>DO Sat (%)</td><td>73</td></tr> <tr><td>DO (mg/L)</td><td>6.99</td></tr> <tr><td>pH</td><td>7</td></tr> <tr><td>pH (mV)</td><td>-40.3</td></tr> <tr><td>ORP (mV)</td><td>76.2</td></tr> </table>	Sample	TP15	Date	18/09/2019	Time	20:07	Temp (°C)	17.45	SP Cond (µS/cm)	138	Cond (µS/cm)	118	TDS (g/L)	0.089	DO Sat (%)	73	DO (mg/L)	6.99	pH	7	pH (mV)	-40.3	ORP (mV)	76.2
Sample	TP15																								
Date	18/09/2019																								
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Temp (°C)	17.45																								
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pH	7																								
pH (mV)	-40.3																								
ORP (mV)	76.2																								

		TEST PIT LOG		TEST PIT # TP#16	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION TOPSOIL BORROW SOURCE		SURFACE LEVEL 185 m	
EASTING 499605		NORTHING 7646590		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA	SAMPLING AND TESTING				OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	SANDY CLAY WITH SHALE/BASALT – fine to medium grained sand, dark grey brown sandy clay, fine to coarse grained gravel, considerable rock fragments.	BUCKET	YAN-0016A	0.3-0.4	NA	This area appears to have been stripped of topsoil, so available topsoil is minimal. Mostly clay and rock present. Rock < 100 mm. Paste PH / EC testing completed here.
			BUCKET	YAN-0016B	0.3-0.4		
			BUCKET	YAN-0016C	0.3-0.4		
			BUCKET	YAN-0016D	0.3-0.4		
			BAG	YAN-0016E	0.3-0.4		
			BAG	YAN-0016 SWCC	0.3-0.4		
	0.4	Test pit discontinued at 0.4 m.					

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1"> <tr><td>Sample</td><td>TP16</td></tr> <tr><td>Date</td><td>18/09/2019</td></tr> <tr><td>Time</td><td>20:06</td></tr> <tr><td>Temp (°C)</td><td>17.01</td></tr> <tr><td>SP Cond (µS/cm)</td><td>314</td></tr> <tr><td>Cond (µS/cm)</td><td>266</td></tr> <tr><td>TDS (g/L)</td><td>0.204</td></tr> <tr><td>DO Sat (%)</td><td>76.3</td></tr> <tr><td>DO (mg/L)</td><td>7.36</td></tr> <tr><td>pH</td><td>7.68</td></tr> <tr><td>pH (mV)</td><td>-78.7</td></tr> <tr><td>ORP (mV)</td><td>59.2</td></tr> </table>	Sample	TP16	Date	18/09/2019	Time	20:06	Temp (°C)	17.01	SP Cond (µS/cm)	314	Cond (µS/cm)	266	TDS (g/L)	0.204	DO Sat (%)	76.3	DO (mg/L)	7.36	pH	7.68	pH (mV)	-78.7	ORP (mV)	59.2
Sample	TP16																								
Date	18/09/2019																								
Time	20:06																								
Temp (°C)	17.01																								
SP Cond (µS/cm)	314																								
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pH	7.68																								
pH (mV)	-78.7																								
ORP (mV)	59.2																								

		TEST PIT LOG		TEST PIT # TP#17	SHEET 1/1
PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION				CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION TOPSOIL BORROW SOURCE		SURFACE LEVEL 184 m	
EASTING 499412		NORTHING 7646940		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA	SAMPLING AND TESTING				OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	SANDY CLAY WITH SHALE/BASALT – fine to medium grained sand, dark grey brown sandy clay, fine to coarse grained gravel, considerable rock fragments.	BUCKET	YAN-0017A	0.3-0.4	NA	This area appears to have been stripped of topsoil, so available topsoil is minimal. Mostly clay and rock present. Rock < 100 mm. Paste PH / EC testing completed here.
			BUCKET	YAN-0017B	0.3-0.4		
			BUCKET	YAN-0017C	0.3-0.4		
			BUCKET	YAN-0017D	0.3-0.4		
			BAG	YAN-0017E	0.3-0.4		
			BAG	YAN-0017 SWCC	0.3-0.4		
	0.4	Test pit discontinued at 0.4 m.					

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1"> <tr> <td>Sample</td> <td>TP16</td> </tr> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>20:06</td> </tr> <tr> <td>Temp (°C)</td> <td>17.01</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>314</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>266</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.204</td> </tr> <tr> <td>DO Sat (%)</td> <td>76.3</td> </tr> <tr> <td>DO (mg/L)</td> <td>7.36</td> </tr> <tr> <td>pH</td> <td>7.68</td> </tr> <tr> <td>pH (mV)</td> <td>-78.7</td> </tr> <tr> <td>ORP (mV)</td> <td>59.2</td> </tr> </table>	Sample	TP16	Date	18/09/2019	Time	20:06	Temp (°C)	17.01	SP Cond (µS/cm)	314	Cond (µS/cm)	266	TDS (g/L)	0.204	DO Sat (%)	76.3	DO (mg/L)	7.36	pH	7.68	pH (mV)	-78.7	ORP (mV)	59.2
Sample	TP16																								
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DO Sat (%)	76.3																								
DO (mg/L)	7.36																								
pH	7.68																								
pH (mV)	-78.7																								
ORP (mV)	59.2																								

		TEST PIT LOG		TEST PIT # TP#18	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION TOPSOIL BORROW SOURCE		SURFACE LEVEL 185 m	
EASTING 499382		NORTHING 7646961		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	SANDY CLAY TOPSOIL – orange brown sandy clay topsoil, fine to medium grained sand, trace fine to medium grained gravel, some organic material.	BUCKET	YAN-0018A	0.7-0.8	NA	This area has more topsoil than TP#15 and TP#16. >100 mm fraction estimated at 5%. Paste PH / EC testing completed here.
			BUCKET	YAN-0018B	0.7-0.8		
			BUCKET	YAN-0018C	0.7-0.8		
			BUCKET	YAN-0018D	0.7-0.8		
			BAG	YAN-0018E	0.7-0.8		
			BAG	YAN-0018 SWCC	0.7-0.8		
	0.8	Test pit discontinued at 0.8 m.					

PHOTO LOG	COMMENTS / LEGEND																								
	Paste pH Testing: <table border="1"> <tr> <td>Sample</td> <td>TP18</td> </tr> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>20:12</td> </tr> <tr> <td>Temp (°C)</td> <td>15.2</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>15</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>13</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.01</td> </tr> <tr> <td>DO Sat (%)</td> <td>79.2</td> </tr> <tr> <td>DO (mg/L)</td> <td>2.95</td> </tr> <tr> <td>pH</td> <td>7.74</td> </tr> <tr> <td>pH (mV)</td> <td>-81.7</td> </tr> <tr> <td>ORP (mV)</td> <td>83.6</td> </tr> </table>	Sample	TP18	Date	18/09/2019	Time	20:12	Temp (°C)	15.2	SP Cond (µS/cm)	15	Cond (µS/cm)	13	TDS (g/L)	0.01	DO Sat (%)	79.2	DO (mg/L)	2.95	pH	7.74	pH (mV)	-81.7	ORP (mV)	83.6
Sample	TP18																								
Date	18/09/2019																								
Time	20:12																								
Temp (°C)	15.2																								
SP Cond (µS/cm)	15																								
Cond (µS/cm)	13																								
TDS (g/L)	0.01																								
DO Sat (%)	79.2																								
DO (mg/L)	2.95																								
pH	7.74																								
pH (mV)	-81.7																								
ORP (mV)	83.6																								

		TEST PIT LOG		TEST PIT # TP#19	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 18/07/2019		LOCATION GRAVEL BORROW SOURCE		SURFACE LEVEL 196 m	
EASTING 499373		NORTHING 7647253		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	SILTY SAND TOPSOIL – orange brown sandy clay topsoil, fine to medium grained sand, trace fine to medium grained gravel, some organic material.	BUCKET	YAN-0019A	0.9-1.0	NA	This area has more topsoil than TP#15 and TP#16. >100 mm fraction estimated at 5%. Paste PH / EC testing completed here.
			BUCKET	YAN-0019B	0.9-1.0		
			BUCKET	YAN-0019C	0.9-1.0		
			BUCKET	YAN-0019D	0.9-1.0		
			BAG	YAN-0019E	0.9-1.0		
			BAG	YAN-0019 SWCC	0.9-1.0		
	0.2	GRAVEL – red grey gravel, angular, fine to coarse grained sand matrix.					
	1.0	Test pit discontinued at 1.0 m.					

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1"> <tr> <td>Sample</td> <td>TP19</td> </tr> <tr> <td>Date</td> <td>18/09/2019</td> </tr> <tr> <td>Time</td> <td>20:10</td> </tr> <tr> <td>Temp (°C)</td> <td>16.34</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>11</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>9</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.007</td> </tr> <tr> <td>DO Sat (%)</td> <td>7.45</td> </tr> <tr> <td>DO (mg/L)</td> <td>7.3</td> </tr> <tr> <td>pH</td> <td>6.56</td> </tr> <tr> <td>pH (mV)</td> <td>-15.3</td> </tr> <tr> <td>ORP (mV)</td> <td>56.7</td> </tr> </table>	Sample	TP19	Date	18/09/2019	Time	20:10	Temp (°C)	16.34	SP Cond (µS/cm)	11	Cond (µS/cm)	9	TDS (g/L)	0.007	DO Sat (%)	7.45	DO (mg/L)	7.3	pH	6.56	pH (mV)	-15.3	ORP (mV)	56.7
Sample	TP19																								
Date	18/09/2019																								
Time	20:10																								
Temp (°C)	16.34																								
SP Cond (µS/cm)	11																								
Cond (µS/cm)	9																								
TDS (g/L)	0.007																								
DO Sat (%)	7.45																								
DO (mg/L)	7.3																								
pH	6.56																								
pH (mV)	-15.3																								
ORP (mV)	56.7																								

		TEST PIT LOG		TEST PIT # TP#23	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 19/07/2019		LOCATION TSF CELL B		SURFACE LEVEL 196 m	
EASTING 500548		NORTHING 7647328		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	TAILINGS (ASSUMED OXIDE) – fine grained, light grey brown tailings with some discolouration.	BUCKET	YAN-0023A	1.0-1.1	NA	Layer boundaries between oxide and sulfide tailings not clearly defined.
			BUCKET	YAN-0023B	1.0-1.1		
			BUCKET	YAN-0023C	1.0-1.1		
			BUCKET	YAN-0023D	1.0-1.1		
			BAG	YAN-0023E	1.0-1.1		
			BAG	YAN-0023 SWCC	1.0-1.1		
	1.1	TAILINGS (ASSUMED SULFIDE) – fine grained, darker grey brown tailings with some discolouration.	BUCKET	YAN-0024A	1.9-2.0		GP#7 completed at this location.
			BUCKET	YAN-0024B	1.9-2.0		
			BUCKET	YAN-0024C	1.9-2.0		
			BUCKET	YAN-0024D	1.9-2.0		
			BAG	YAN-0024E	1.9-2.0		
			BAG	YAN-0024 SWCC	1.9-2.0		
	2.0	Test pit discontinued at 1.8 m.					Paste PH / EC testing completed on both samples here.

PHOTO LOG 	COMMENTS / LEGEND Paste pH Testing: <table border="1"> <thead> <tr> <th>Sample</th> <th>TP23 (oxide)</th> <th>TP23 (sulfide)</th> </tr> </thead> <tbody> <tr> <td>Date</td> <td>19/07/2019</td> <td>19/07/2019</td> </tr> <tr> <td>Time</td> <td>10:08</td> <td>10:12</td> </tr> <tr> <td>Temp (°C)</td> <td>15.33</td> <td>16.57</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>5813</td> <td>295</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>4744</td> <td>248</td> </tr> <tr> <td>TDS (g/L)</td> <td>3.778</td> <td>0.192</td> </tr> <tr> <td>DO Sat (%)</td> <td>90.7</td> <td>84.2</td> </tr> <tr> <td>DO (mg/L)</td> <td>8.9</td> <td>8.2</td> </tr> <tr> <td>pH</td> <td>3.59</td> <td>5.92</td> </tr> <tr> <td>pH (mV)</td> <td>150.3</td> <td>20.4</td> </tr> <tr> <td>ORP (mV)</td> <td>279.6</td> <td>249.2</td> </tr> </tbody> </table>	Sample	TP23 (oxide)	TP23 (sulfide)	Date	19/07/2019	19/07/2019	Time	10:08	10:12	Temp (°C)	15.33	16.57	SP Cond (µS/cm)	5813	295	Cond (µS/cm)	4744	248	TDS (g/L)	3.778	0.192	DO Sat (%)	90.7	84.2	DO (mg/L)	8.9	8.2	pH	3.59	5.92	pH (mV)	150.3	20.4	ORP (mV)	279.6	249.2
Sample	TP23 (oxide)	TP23 (sulfide)																																			
Date	19/07/2019	19/07/2019																																			
Time	10:08	10:12																																			
Temp (°C)	15.33	16.57																																			
SP Cond (µS/cm)	5813	295																																			
Cond (µS/cm)	4744	248																																			
TDS (g/L)	3.778	0.192																																			
DO Sat (%)	90.7	84.2																																			
DO (mg/L)	8.9	8.2																																			
pH	3.59	5.92																																			
pH (mV)	150.3	20.4																																			
ORP (mV)	279.6	249.2																																			

		TEST PIT LOG		TEST PIT # TP#24	SHEET 1/1
		PROJECT DESCRIPTION YANDAN MATERIAL CHARACTERISATION		CLIENT AERIS RESOURCES	
DATE 19/07/2019		LOCATION GRAVEL BORROW SOURCE		SURFACE LEVEL 198 m	
EASTING 500670		NORTHING 7646736		PROJECT NUMBER 956-007	

RIG 35 T EXCAVATOR	LOGGED BY RMB
OPERATOR CENTRAL HIGHLANDS PLANT HIRE	

LEVEL		STRATA		SAMPLING AND TESTING			OTHER
RL (m)	DEPTH (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE ID	DEPTH (m)	GW LEVEL	COMMENTS
	0.0	TOPSOIL – dark brown silty sand topsoil, fine to medium grained sand, some fine to medium grained gravel and some organic material.				NA	>100 mm fraction in the gravel estimated at 80%.
	0.2						
		GRAVEL – coarse gravel within a sandy matrix, larger angular and subangular gravel fractions compared to other gravel sources with higher >100mm fractions.	BUCKET	YAN-0025A	1.1-1.2		Paste PH / EC testing completed on both samples here.
			BUCKET	YAN-0025B	1.1-1.2		
			BUCKET	YAN-0025C	1.1-1.2		
			BUCKET	YAN-0025D	1.1-1.2		
			BAG	YAN-0025E	1.1-1.2		
			BAG	YAN-0025 SWCC	1.1-1.2		
	1.2	Test pit discontinued at 1.2 m due to refusal.					

PHOTO LOG	COMMENTS / LEGEND																								
	Paste pH Testing: <table border="1"> <tr> <th>Sample</th> <th>TP24</th> </tr> <tr> <td>Date</td> <td>19/07/2019</td> </tr> <tr> <td>Time</td> <td>10:16</td> </tr> <tr> <td>Temp (°C)</td> <td>17.86</td> </tr> <tr> <td>SP Cond (µS/cm)</td> <td>851</td> </tr> <tr> <td>Cond (µS/cm)</td> <td>735</td> </tr> <tr> <td>TDS (g/L)</td> <td>0.553</td> </tr> <tr> <td>DO Sat (%)</td> <td>79.5</td> </tr> <tr> <td>DO (mg/L)</td> <td>7.53</td> </tr> <tr> <td>pH</td> <td>7</td> </tr> <tr> <td>pH (mV)</td> <td>-40.2</td> </tr> <tr> <td>ORP (mV)</td> <td>241</td> </tr> </table>	Sample	TP24	Date	19/07/2019	Time	10:16	Temp (°C)	17.86	SP Cond (µS/cm)	851	Cond (µS/cm)	735	TDS (g/L)	0.553	DO Sat (%)	79.5	DO (mg/L)	7.53	pH	7	pH (mV)	-40.2	ORP (mV)	241
Sample	TP24																								
Date	19/07/2019																								
Time	10:16																								
Temp (°C)	17.86																								
SP Cond (µS/cm)	851																								
Cond (µS/cm)	735																								
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DO (mg/L)	7.53																								
pH	7																								
pH (mV)	-40.2																								
ORP (mV)	241																								

Appendix C

Laboratory Certificates of Analysis

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.1, 2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19070866-G
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	6256
		Report Date	15/08/2019

Project 0956-007 - Yandan Material Characterisation

Sample No.	19070866	19070851	19070852	19070859	19070858	19070856	19070857
Test Date	13/08/2019	13/08/2019	13/08/2019	13/08/2019	13/08/2019	13/08/2019	13/08/2019
Client ID	TP#20 - YAN-020A/B	TP#5 - YAN-005A/B	TP#6 - YAN-006A/B	TP#13 - YAN-013A/B	TP#12 - YAN-012A/B	TP#10 - YAN-010A/B	TP#11 - YAN-011A/B
Depth (m)	0.70	1.20	3.50	2.00	3.90	0.30	2.40
Moisture (%)	6.3	6.9	8.1	8.9	11.3	10.6	7.6
AS SIEVE SIZE (mm)	PERCENT PASSING						
150							
75	100						
63	99			100		100	
53	98	100	100	99	100	99	
37.5	89	99	99	96	99	94	
26.5	85	99	98	92	98	88	
19	82	98	98	90	96	84	
13.2	74	94	95	84	96	83	
9.5	68	92	92	80	88	80	100
6.7	59	89	88	74	80	77	99
4.75	54	86	84	70	74	75	97
2.36	44	79	75	62	66	72	96
1.18	38	71	66	54	53	69	94
0.600	36	65	60	49	45	67	93
0.425	35	62	58	47	41	66	91
0.300	34	60	55	45	38	65	89
0.150	29	54	48	40	33	56	74
0.075	24	47	42	35	29	45	59

NOTES/REMARKS:

Sample/s supplied by the client

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Accredited for compliance with ISO/IEC 17025 - Testing.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory

Authorised Signatory



C. Park



Laboratory No. 9926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.

Reference should be made to Trilab's "Standard Terms and Conditions of Business" for further details.

Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING



PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.1, 2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19070853-G
		Workorder No.	6256
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Report Date	20/08/2019

Project 0956-007 - Yandan Material Characterisation

Sample No.	19070853	19070849	19070850	19070854	19070855	19070847	19070848
Test Date	13/08/2019	19/08/2019	19/08/2019	19/08/2019	19/08/2019	19/08/2019	19/08/2019
Client ID	TP#7 - YAN-007A/B	TP#3- YAN-003A/B	TP#4 - YAN-004A/B	TP#8 - YAN-008A/B	TP#9 - YAN-009A/B	TP#1 - YAN-001A/B	TP#2 - YAN-002A/B
Depth (m)	1.70	0.30	0.50	3.00	1.50	0.10	0.40
Moisture (%)	9.0	3.6	7.3	8.5	16.2	3.0	4.1
AS SIEVE SIZE (mm)	PERCENT PASSING						
150							
75							
63			100				
53	100		99	100			
37.5	95		89	95			
26.5	90	100	77	88			
19	84	99	66	83	100		100
13.2	75	97	52	76	97		99
9.5	70	95	44	71	97		98
6.7	63	93	37	64	96	100	96
4.75	57	91	32	60	95	99	94
2.36	47	87	26	48	94	98	89
1.18	41	84	21	38	91	96	86
0.600	36	80	18	31	85	93	83
0.425	33	77	16	29	83	91	80
0.300	31	72	14	26	81	88	76
0.150	27	55	12	23	74	67	58
0.075	24	42	10	20	67	42	40

NOTES/REMARKS:

Sample/s supplied by the client

Page 1 of 1 REP01103

Accredited for compliance with ISO/IEC 17025 - Testing.
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Tested at Trilab Brisbane Laboratory

Authorised Signatory

C. Park



Laboratory No. 9926

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Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.1, 2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19070864-G
		Workorder No.	6256
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Report Date	20/08/2019

Project 0956-007 - Yandan Material Characterisation

Sample No.	19070864	19070870	19070869	19070865			
Test Date	19/08/2019	19/08/2019	19/08/2019	19/08/2019			
Client ID	TP#18 - YAN-018A/B	TP#24 - YAN-024A/B	TP#23 - YAN-023A/B	TP#19 - YAN-019A/B			
Depth (m)	0.80	2.00	2.00	1.00			
Moisture (%)	15.5	13.1	12.2	10.4			
AS SIEVE SIZE (mm)	PERCENT PASSING						
150							
75							
63				100			
53				98			
37.5				92			
26.5				86			
19	100			81			
13.2	95			73			
9.5	95			70			
6.7	94			64			
4.75	92			60			
2.36	89			54			
1.18	75			50			
0.600	59	100	100	47			
0.425	50	99	99	46			
0.300	43	97	98	46			
0.150	35	76	88	44			
0.075	29	55	68	42			

NOTES/REMARKS:

Sample/s supplied by the client

Page 1 of 1 REP01103

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C. Park



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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.1, 2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19070863-G
		Workorder No.	6256
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Report Date	20/08/2019

Project 0956-007 - Yandan Material Characterisation

Sample No.	19070863	19070871	19070868	19070867	19070861	19070862	19070860
Test Date	19/08/2019	19/08/2019	19/08/2019	19/08/2019	19/08/2019	19/08/2019	19/08/2019
Client ID	TP#17 - YAN-017A/B	TP#25 - YAN-025A/B	TP#22 - YAN-022A/B	TP#21 - YAN-021A/B	TP#15 - YAN-015A/B	TP#16 - YAN-016A/B	TP#14 - YAN-014A/B
Depth (m)	0.40	1.20	1.80	0.50	1.20	0.40	1.80
Moisture (%)	7.7	9.7	6.5	9.7	7.4	10.6	9.1
AS SIEVE SIZE (mm)	PERCENT PASSING						
150							
75							
63	100				100		
53	99	100	100	100	99		100
37.5	94	91	87	99	98		96
26.5	87	84	79	97	95		91
19	81	81	76	95	92	100	88
13.2	63	63	66	91	81	90	79
9.5	54	56	60	89	75	81	72
6.7	47	50	55	86	69	74	64
4.75	39	45	50	81	65	67	57
2.36	27	39	43	74	58	63	50
1.18	19	35	38	63	48	56	42
0.600	15	32	34	57	43	52	38
0.425	13	31	32	55	41	51	36
0.300	12	30	30	52	40	50	35
0.150	11	27	24	44	35	49	32
0.075	10	24	19	34	30	46	29

NOTES/REMARKS:

Sample/s supplied by the client

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

SOIL PARTICLE DENSITY TEST REPORT

Test Method: AS 1289 3.5.1

Client	O'Kane Consultants Pty Ltd	Report No.	19070866-SG
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006256
		Report Date	19/08/2019

Project 0956-007 - Yandan Material Characterisation

Sample No.	19070866	19070851	19070852	19070859	19070858	19070856	19070857
Test Date	14/08/2019	14/08/2019	14/08/2019	14/08/2019	14/08/2019	14/08/2019	14/08/2019
Client ID	TP#20 - YAN-020A/B	TP#5 - YAN-005A/B	TP#6 - YAN-006A/B	TP#13 - YAN-013A/B	TP#12 - YAN-012A/B	TP#10 - YAN-010A/B	TP#11 - YAN-011A/B
Depth (m)	0.70	1.20	3.50	2.00	3.90	0.30	2.40
Soil Particle Density (t/m³) (-2.36mm)	2.63	2.64	2.64	2.64	2.72	2.65	2.66

Sample No.	19070853	19070849	19070850	19070854	19070855	19070847	19070848
Test Date	14/08/2019	14/08/2019	14/08/2019	14/08/2019	14/08/2019	14/08/2019	14/08/2019
Client ID	TP#7 - YAN-007A/B	TP#3 - YAN-003A/B	TP#4 - YAN-004A/B	TP#8 - YAN-008A/B	TP#9 - YAN-009A/B	TP#1 - YAN-001A/B	TP#2 - YAN-002A/B
Depth (m)	1.70	0.30	0.50	3.00	1.50	0.10	0.40
Soil Particle Density (t/m³) (-2.36mm)	2.68	2.66	2.57	2.73	2.65	2.55	2.58

NOTES/REMARKS:

Sample/s supplied by the client

Page 1 of 1 REP04603

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

SOIL PARTICLE DENSITY TEST REPORT

Test Method: AS 1289 3.5.1

Client	O'Kane Consultants Pty Ltd	Report No.	19070863-SG
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006256
		Report Date	22/08/2019

Project 0956-007 - Yandan Material Characterisation

Sample No.	19070863	19070871	19070868	19070867	19070861	19070862	19070860
Test Date	19/08/2019	19/08/2019	19/08/2019	21/08/2019	21/08/2019	21/08/2019	21/08/2019
Client ID	TP#17 - YAN-017A/B	TP#25 - YAN-025A/B	TP#22 - YAN-022A/B	TP#21 - YAN-021A/B	TP#15 - YAN-015A/B	TP#16 - YAN-016A/B	TP#14 - YAN-014A/B
Depth (m)	0.40	1.20	1.80	0.50	1.20	0.40	1.80
Soil Particle Density (t/m³) (-2.36mm)	2.68	2.65	2.61	2.67	2.64	2.71	2.70

Sample No.	19070864	19070870	19070869	19070865			
Test Date	21/08/2019	21/08/2019	21/08/2019	21/08/2019			
Client ID	TP#18 - YAN-018A/B	TP#24 - YAN-024A/B	TP#23 - YAN-023A/B	TP#19 - YAN-019A/B	-	-	-
Depth (m)	0.80	2.00	2.00	1.00	-	-	-
Soil Particle Density (t/m³) (-2.36mm)	2.69	2.60	2.53	2.60			

NOTES/REMARKS:

Sample/s supplied by the client

Page 1 of 1 REP04603

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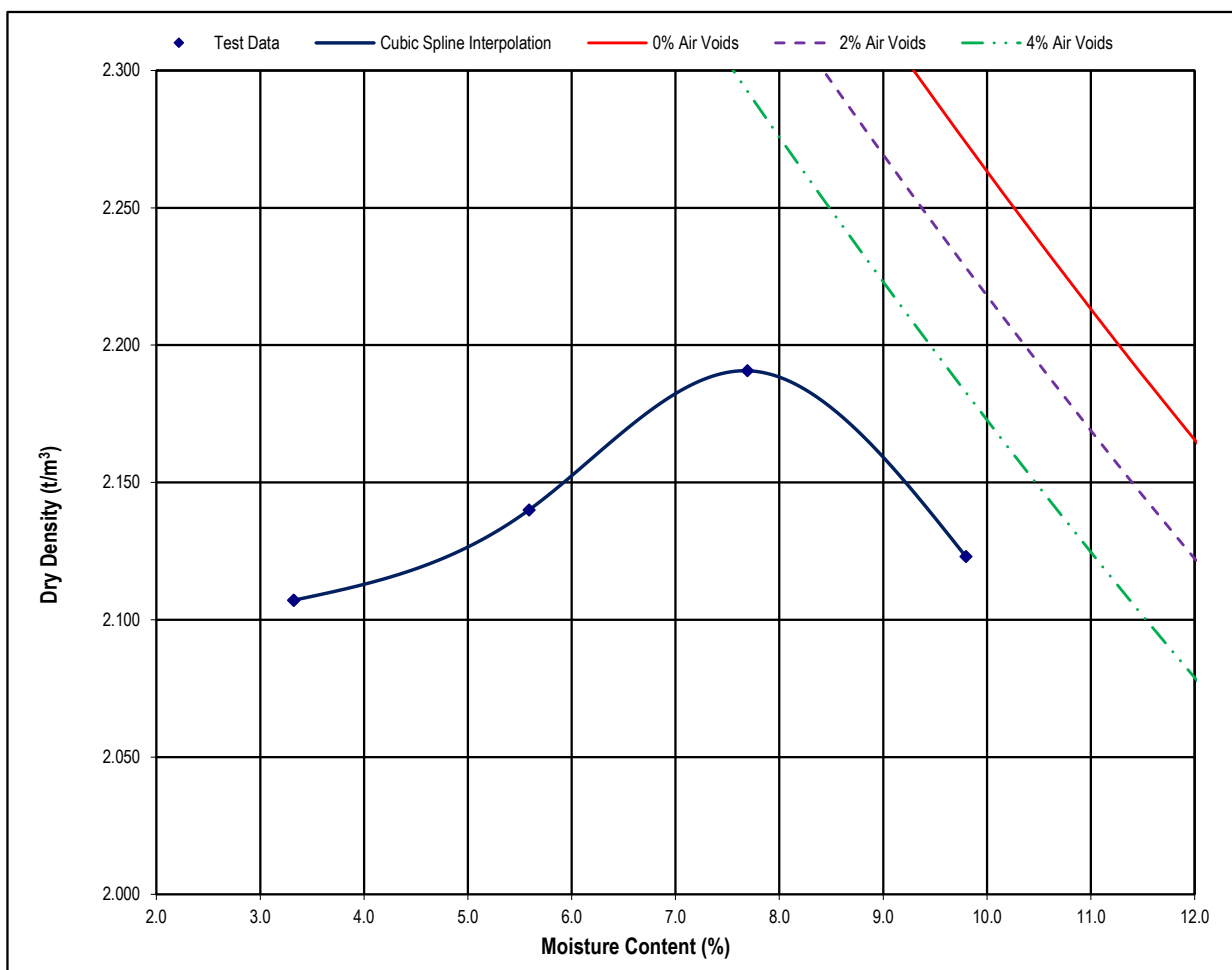
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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.2.1 (Modified) & AS 1289.2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081546-MDD
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	13/09/2019
		Report Date	17/09/2019
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#3- YAN-003A/B	Depth (m)	0.30



Maximum Dry Density (t/m³)	2.191	Optimum Moisture Content (%)	7.7
Moisture Content (%)	3.6	Percentage of Oversize/Sieve Size (mm)	1 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.93

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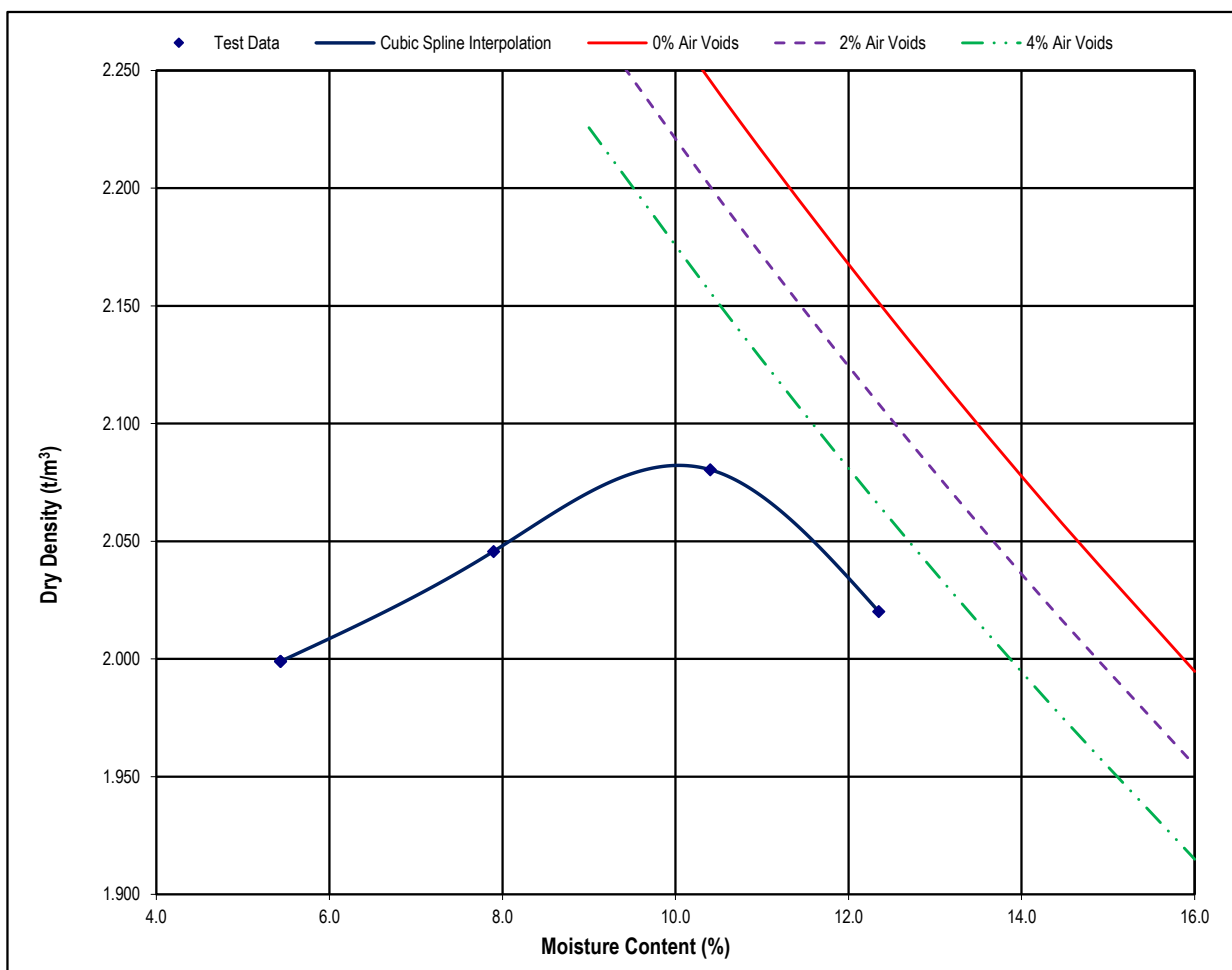
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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.2.1 (Modified) & AS 1289.2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081547-MDD
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	13/09/2019
		Report Date	17/09/2019
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#6 - YAN-006A/B	Depth (m)	3.50



Maximum Dry Density (t/m³)	2.082	Optimum Moisture Content (%)	10.0
Moisture Content (%)	8.1	Percentage of Oversize/Sieve Size (mm)	2 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.93

Page 1 of 1 REP01304

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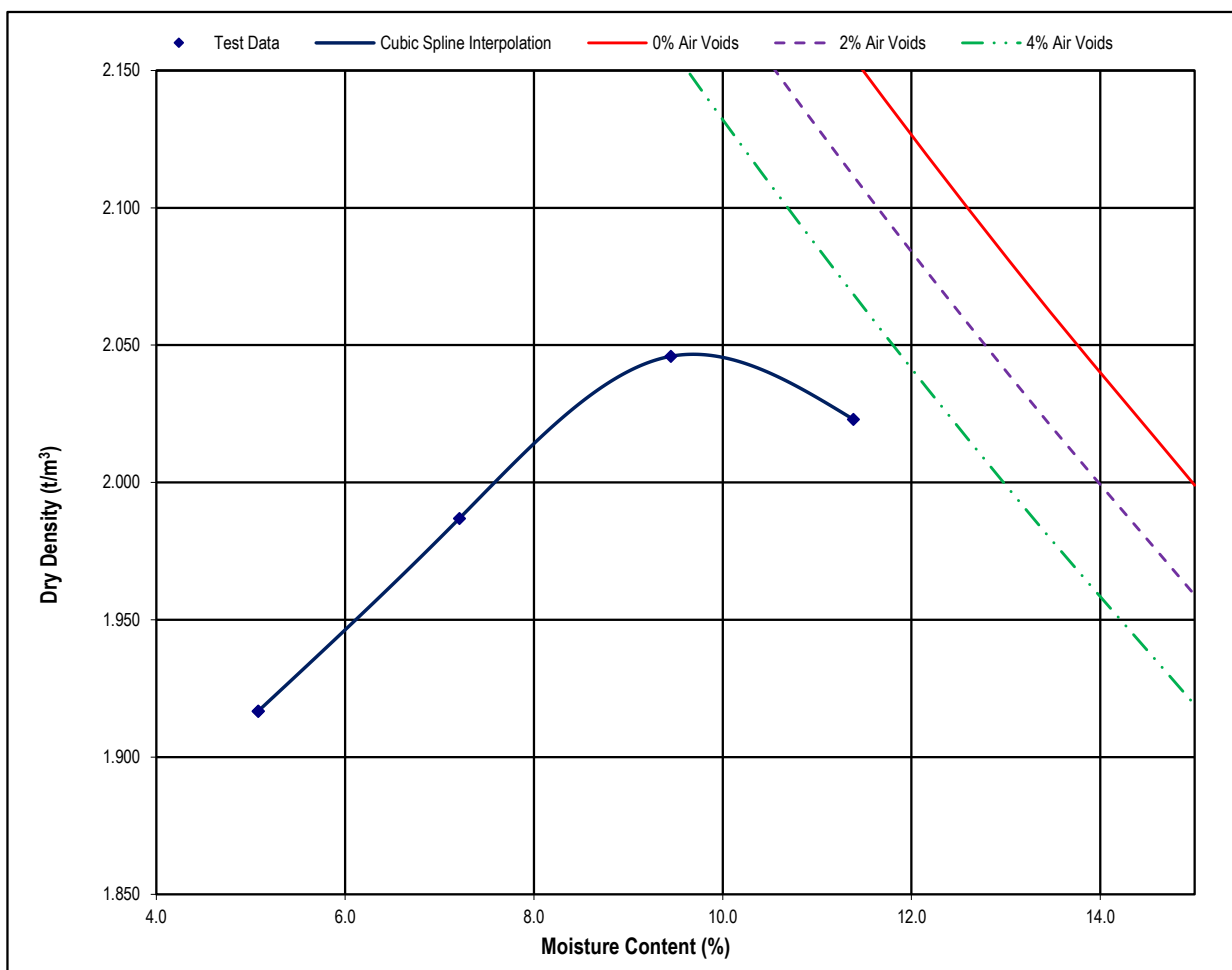
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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.2.1 (Modified) & AS 1289.2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081548-MDD
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	13/09/2019
		Report Date	17/09/2019
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#11 - YAN-011A/B	Depth (m)	2.40



Maximum Dry Density (t/m³)	2.047	Optimum Moisture Content (%)	9.7
Moisture Content (%)	7.6	Percentage of Oversize/Sieve Size (mm)	0 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.86

Page 1 of 1 REP01304

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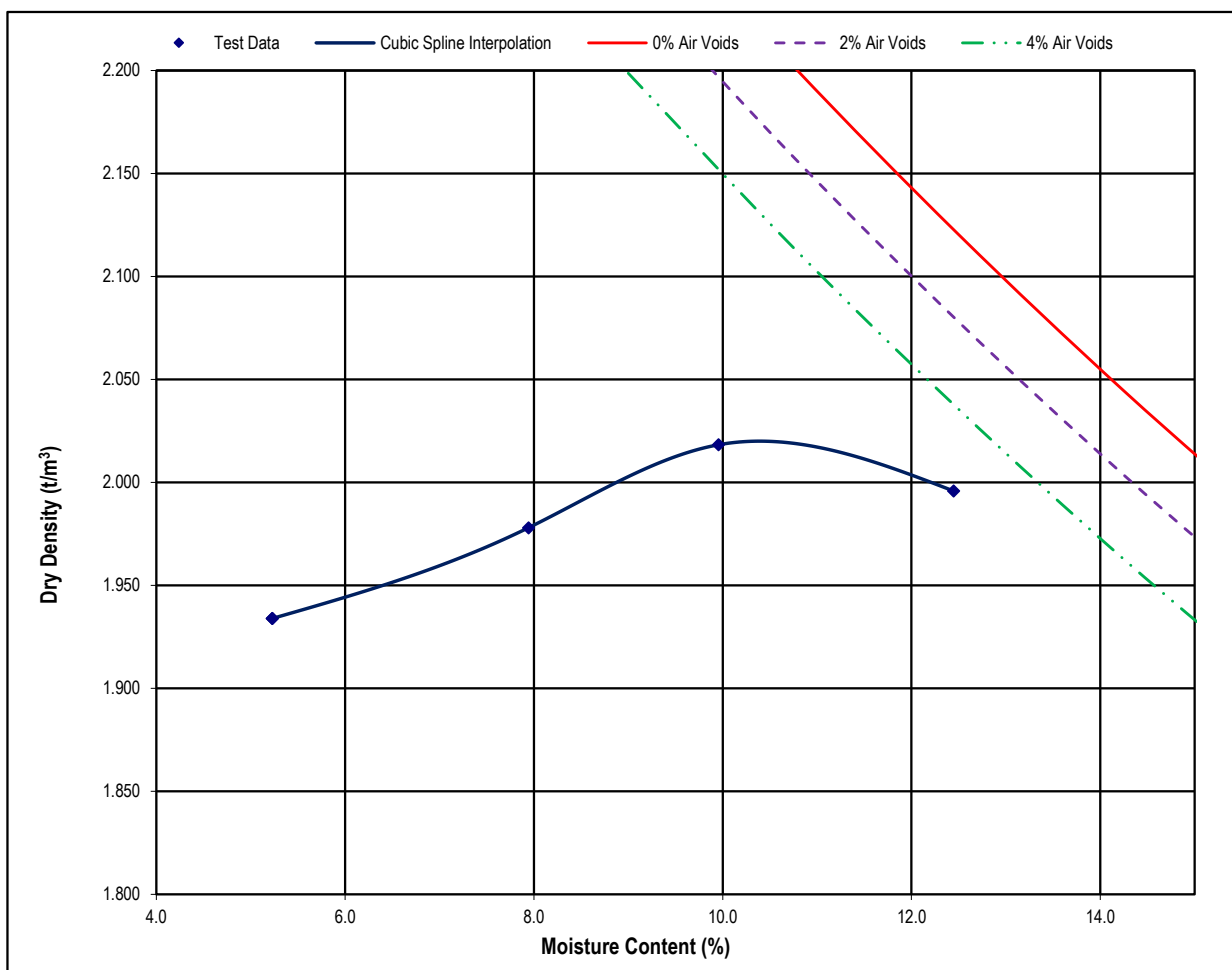
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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.2.1 (Modified) & AS 1289.2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081549-MDD
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	13/09/2019
		Report Date	17/09/2019
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#13 - YAN-013A/B	Depth (m)	2.00



Maximum Dry Density (t/m³)	2.020	Optimum Moisture Content (%)	10.4
Moisture Content (%)	8.9	Percentage of Oversize/Sieve Size (mm)	10 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.88

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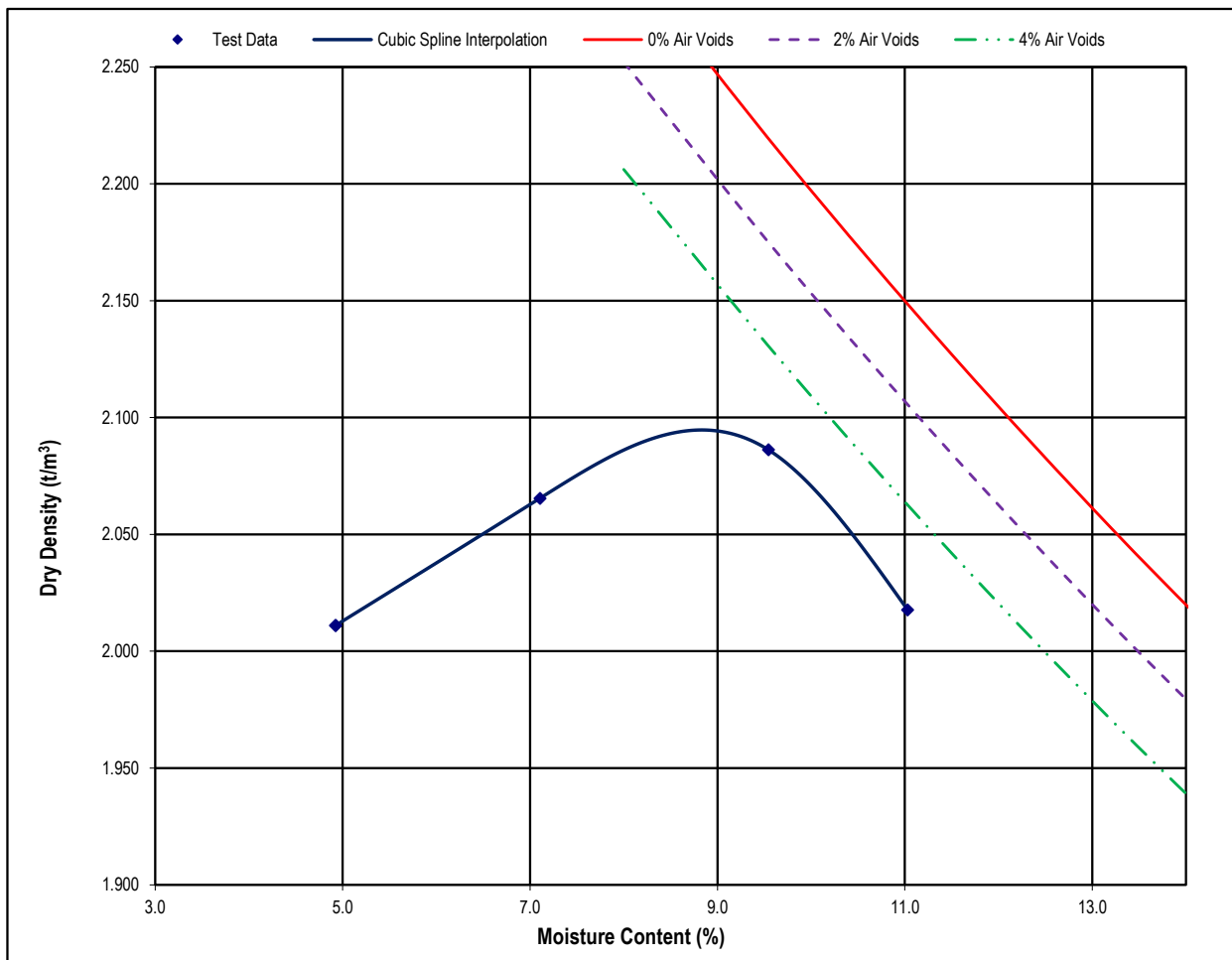
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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.2.1 (Modified) & AS 1289.2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081553-MDD
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	13/09/2019
		Report Date	17/09/2019
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#21 - YAN-021A/B	Depth (m)	0.50



Maximum Dry Density (t/m³)	2.095	Optimum Moisture Content (%)	8.8
Moisture Content (%)	9.7	Percentage of Oversize/Sieve Size (mm)	14 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.82

Page 1 of 1 REP01304

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

EMERSON CLASS NUMBER TEST REPORT

Test Method: AS 1289 3.8.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081545-EM
		Workorder No.	6403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	01/10/2019
		Report Date	03/10/2019
Project	0956-007 - Yandan Material Characterisation		

Sample No.	19081545	19081549	19081550	19081551	19081552	19081553	19081554
Client ID	TP#1 - YAN-001A/B	TP#13 - YAN-013A/B	TP#15 - YAN-015A/B	TP#18 - YAN-018A/B	TP#20 - YAN-020A/B	TP#21 - YAN-021A/B	TP#25 - YAN-025A/B
Depth (m)	0.10	2.00	1.20	0.80	0.70	0.50	1.20
Description	Sandy SILT - brown	Sandy CLAY - brown with gravel	Silty SAND - brown with gravel	Clayey SAND - brown with gravel	Silty Sandy GRAVEL - pale brown	Silty SAND - brown with gravel	Silty Sandy GRAVEL - pale brown
Emerson Class Number	3	4	2	4	5	4	4

Sample No.	-	-	-	-	-	-	-
Client ID	-	-	-	-	-	-	-
Depth (m)	-	-	-	-	-	-	-
Description	-	-	-	-	-	-	-
Emerson Class Number	-	-	-	-	-	-	-

Sample No.	-	-	-	-	-	-	-
Client ID	-	-	-	-	-	-	-
Depth (m)	-	-	-	-	-	-	-
Description	-	-	-	-	-	-	-
Emerson Class Number	-	-	-	-	-	-	-

NOTES/REMARKS:

Sample/s supplied by the client

Tested with Distilled water at 21.6°C

Page 1 of 1 REP00402

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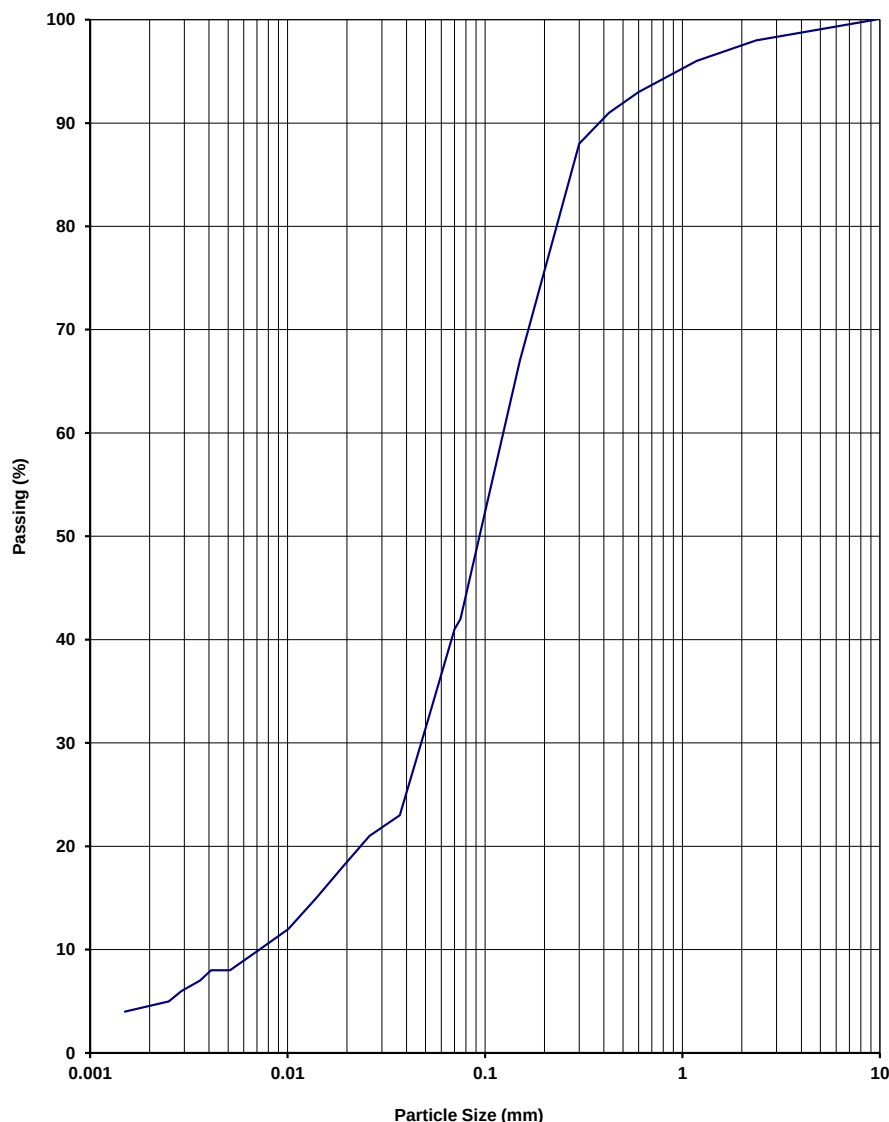
ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081545-G
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#1 - YAN-001A/B	Test Date	6/9/19-16/9/19
		Report Date	17/9/2019
Depth (m)	0.10		

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	
19.0	
13.2	
9.5	
6.7	100
4.75	99
2.36	98
1.18	96
0.600	93
0.425	91
0.300	88
0.150	67
0.075	42
0.07	41
0.051	32
0.037	23
0.026	21
0.019	18
0.014	15
0.0101	12
0.0072	10
0.0051	8
0.0041	8
0.0036	7
0.0029	6
0.0025	5
0.0015	4



NOTES/REMARKS:

-
Moisture Content 3% -2.36mm Soil Particle Density(t/m^3) 2.55
Sample/s supplied by the client

Page 1 of 1 REP03904

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ATTERBERG LIMITS TEST REPORT

Test Method: AS 1289 2.1.1, 3.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081546-AL
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Report Date	04/10/2019
Project	0956-007 - Yandan Material Characterisation		

Sample No.	19081546	19081547	19081548	19081549	19081551	19081553
Test Date	25/09/2019	25/09/2019	25/09/2019	25/09/2019	25/09/2019	25/09/2019
Client ID	TP#3- YAN-003A/B	TP#6 - YAN-006A/B	TP#11 - YAN-011A/B	TP#13 - YAN-013A/B	TP#18 - YAN-018A/B	TP#21 - YAN-021A/B
Depth (m)	0.30	3.50	2.40	2.00	0.80	0.50
Liquid Limit (%)	23	29	29	35	33	23
Plastic Limit (%)	12	14	13	17	21	14
Plasticity Index (%)	11	15	16	18	12	9
Linear Shrinkage (%)	4.5	8.5	9.0	9.5	8.0	4.0
Moisture Content (%)	3.6	8.1	7.6	8.9	15.5	9.7

Sample No.						
Test Date						
Client ID						
Depth (m)						
Liquid Limit (%)						
Plastic Limit (%)						
Plasticity Index (%)						
Linear Shrinkage (%)						
Moisture Content (%)						

NOTES/REMARKS: The samples were tested oven dried, dry sieved and in a 125-250mm mould.

Sample/s supplied by the client * Cracking occurred + Curling occurred Page 1 of 1 REP00102

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PERMEABILITY BY FALLING HEAD TEST REPORT

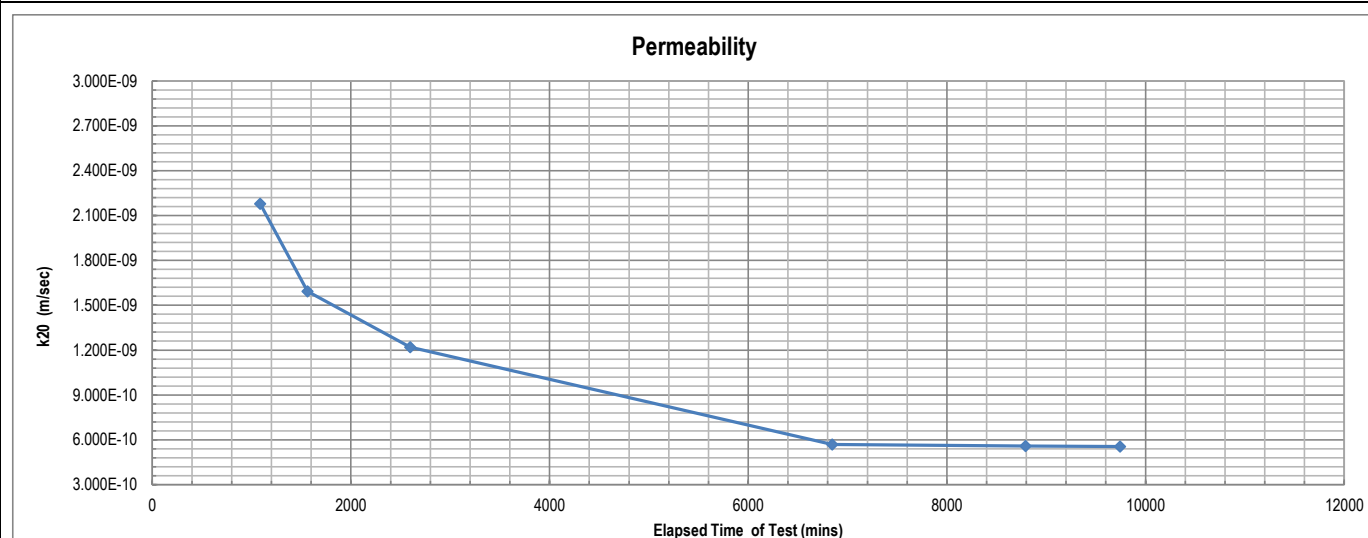
Test Method AS 1289 6.7.2, 5.2.1, KH2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client	O'Kane Consultants Pty Ltd	Report No.	19081546-FHPT
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation	Test Date	23/09/2019
Client ID	TP#3- YAN-003A/B	Report Date	8/10/2019
Description	SANDY SILTY CLAY-brown	Depth (m)	0.30
		Sample Type	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	AS1289.5.2.1 - Modified Compaction		
Maximum Dry Density (t/m ³)	2.19	Hydraulic Gradient	9.4
Optimum Moisture Content (%)	7.7	Surcharge (kPa)	2.9
Placement Moisture Content (%)	8.3	Head Pressure Applied (kPa)	10.79
Moisture Ratio (%)	107.5	Water Type	Deaerated
Placement Wet Density (t/m ³)	2.24	Percentage Material Retained/Sieve Size (mm)	0 % / 9.5 mm
Density Ratio (%)	94.6	Sample Height and Diameter (mm)	116.51 / 101.48 mm

PERMEABILITY $k_{(20)} = 5.6 \times 10^{-10}$ (m/sec)



Remarks: The above specimen was remoulded to a target of 95% of Modified Maximum Dry Density and at Optimum Moisture Content.

Sample/s supplied by client

Page: 1 of 1

REP06301

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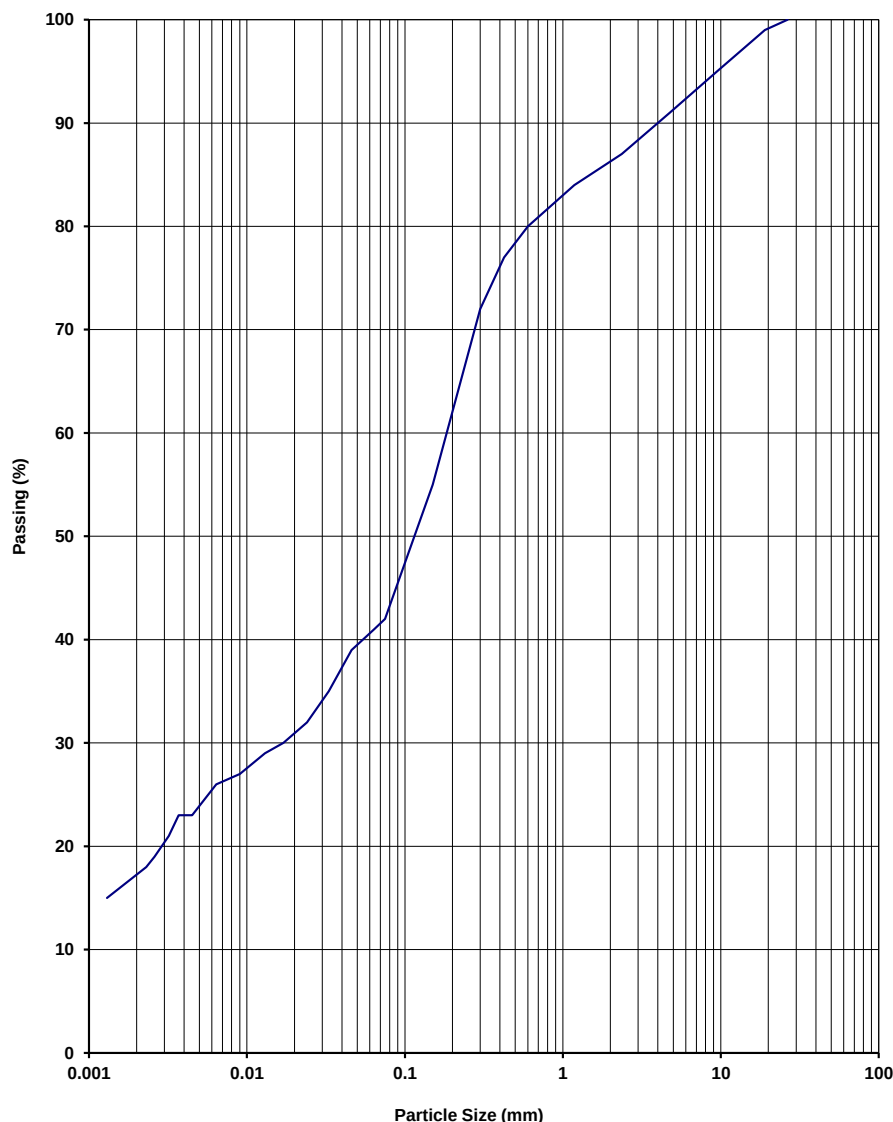
ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081546-G
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#3- YAN-003A/B	Test Date	6/9/19-16/9/19
		Report Date	17/9/2019
Depth (m)	0.30		

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	100
19.0	99
13.2	97
9.5	95
6.7	93
4.75	91
2.36	87
1.18	84
0.600	80
0.425	77
0.300	72
0.150	55
0.075	42
0.064	41
0.046	39
0.033	35
0.024	32
0.017	30
0.013	29
0.009	27
0.0064	26
0.0045	23
0.0037	23
0.0032	21
0.0026	19
0.0023	18
0.0013	15



NOTES/REMARKS:

-
Moisture Content 3.6% -2.36mm Soil Particle Density(t/m³) 2.66
Sample/s supplied by the client

Page 1 of 1 REP03904

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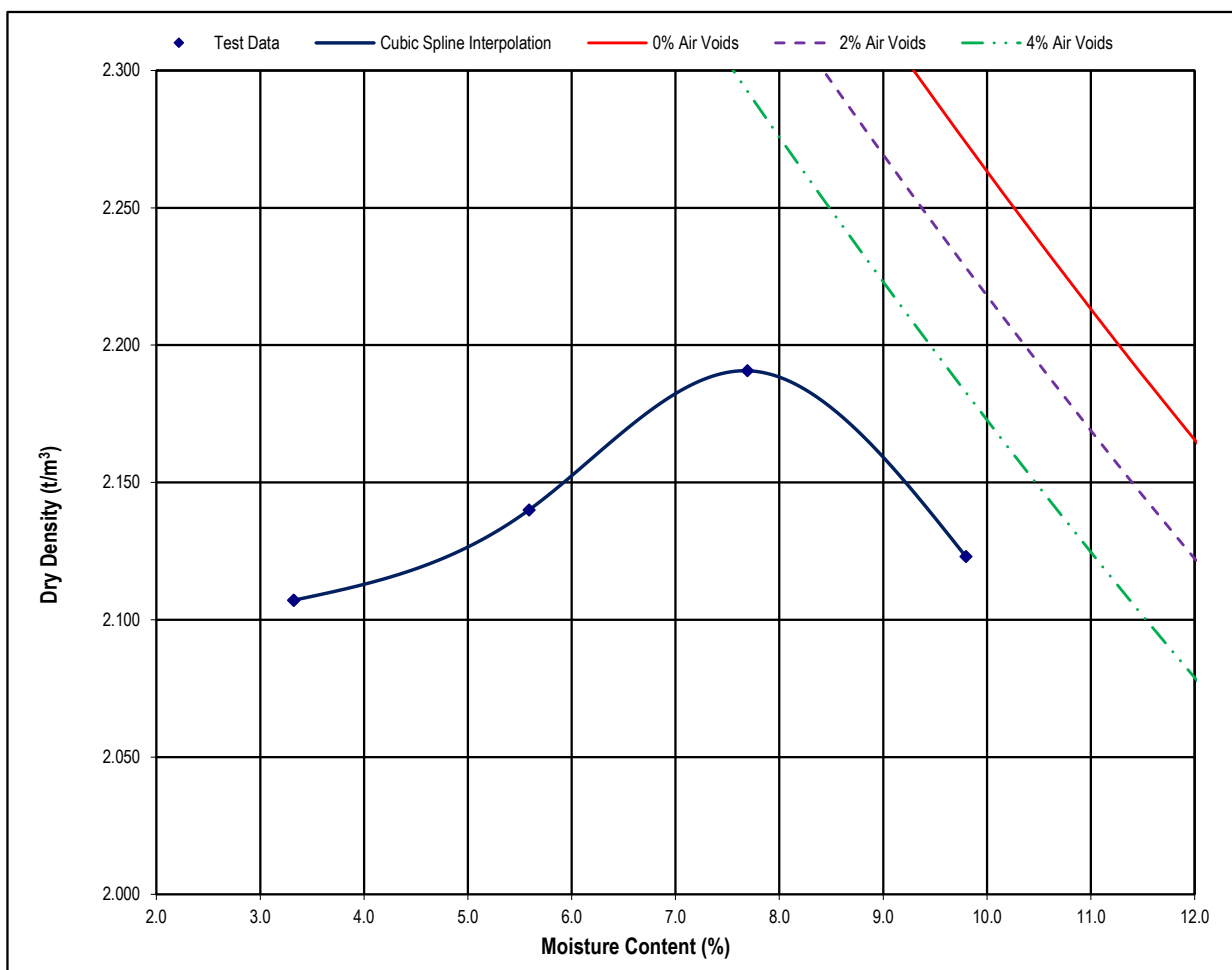
Laboratory No. 9926

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Trilab Pty Ltd ABN 25 065 630 506

MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.2.1 (Modified) & AS 1289.2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081546-MDD
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	13/09/2019
		Report Date	17/09/2019
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#3- YAN-003A/B	Depth (m)	0.30



Maximum Dry Density (t/m³)	2.191	Optimum Moisture Content (%)	7.7
Moisture Content (%)	3.6	Percentage of Oversize/Sieve Size (mm)	1 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.93

Page 1 of 1 REP01304

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PERMEABILITY BY FALLING HEAD TEST REPORT

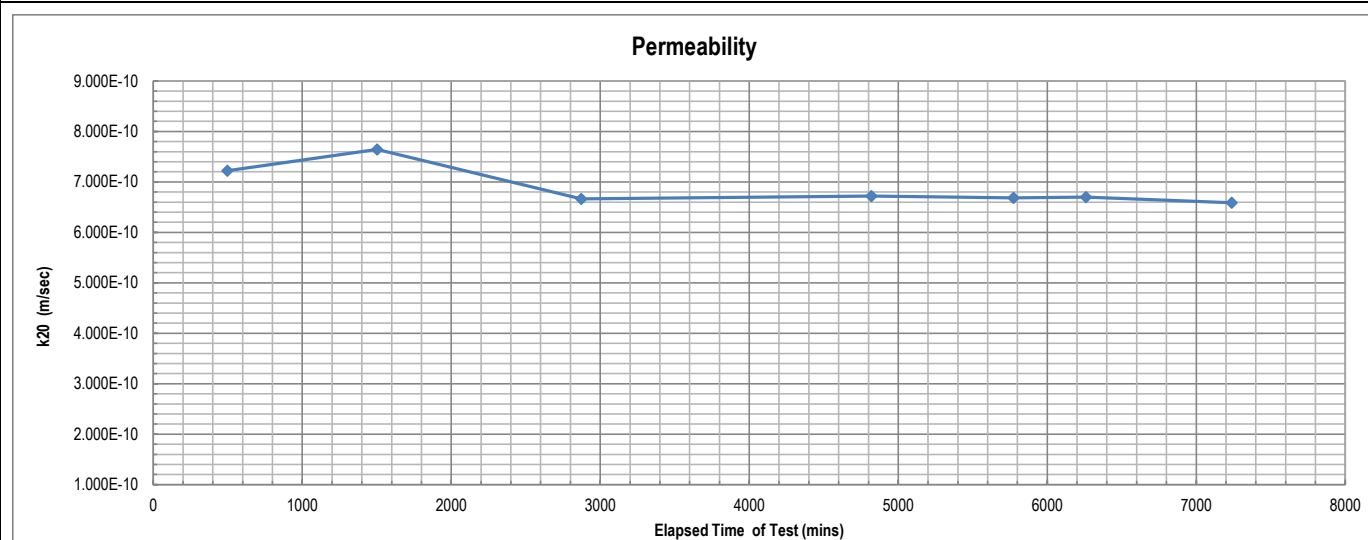
Test Method AS 1289 6.7.2, 5.2.1, KH2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client	O'Kane Consultants Pty Ltd	Report No.	19081547-FHPT
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation	Test Date	27/09/2019
Client ID	TP#6 - YAN-006A/B	Report Date	8/10/2019
Description	GRAVELLY CLAYEY SAND -pale brown	Depth (m)	3.50
		Sample Type	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	AS1289.5.2.1 - Modified Compaction		
Maximum Dry Density (t/m ³)	2.08	Hydraulic Gradient	9.5
Optimum Moisture Content (%)	10.0	Surcharge (kPa)	3.7
Placement Moisture Content (%)	10.5	Head Pressure Applied (kPa)	10.79
Moisture Ratio (%)	105.1	Water Type	Deaerated
Placement Wet Density (t/m ³)	2.17	Percentage Material Retained/Sieve Size (mm)	2 % /19 mm
Density Ratio (%)	94.5	Sample Height and Diameter (mm)	116.39 / 152.44 mm

PERMEABILITY $k_{(20)} = 6.6 \times 10^{-10}$ (m/sec)



Remarks: The above specimen was remoulded to a target of 95% of Modified Maximum Dry Density and at Optimum Moisture Content.

Sample/s supplied by client

Page: 1 of 1

REP06301

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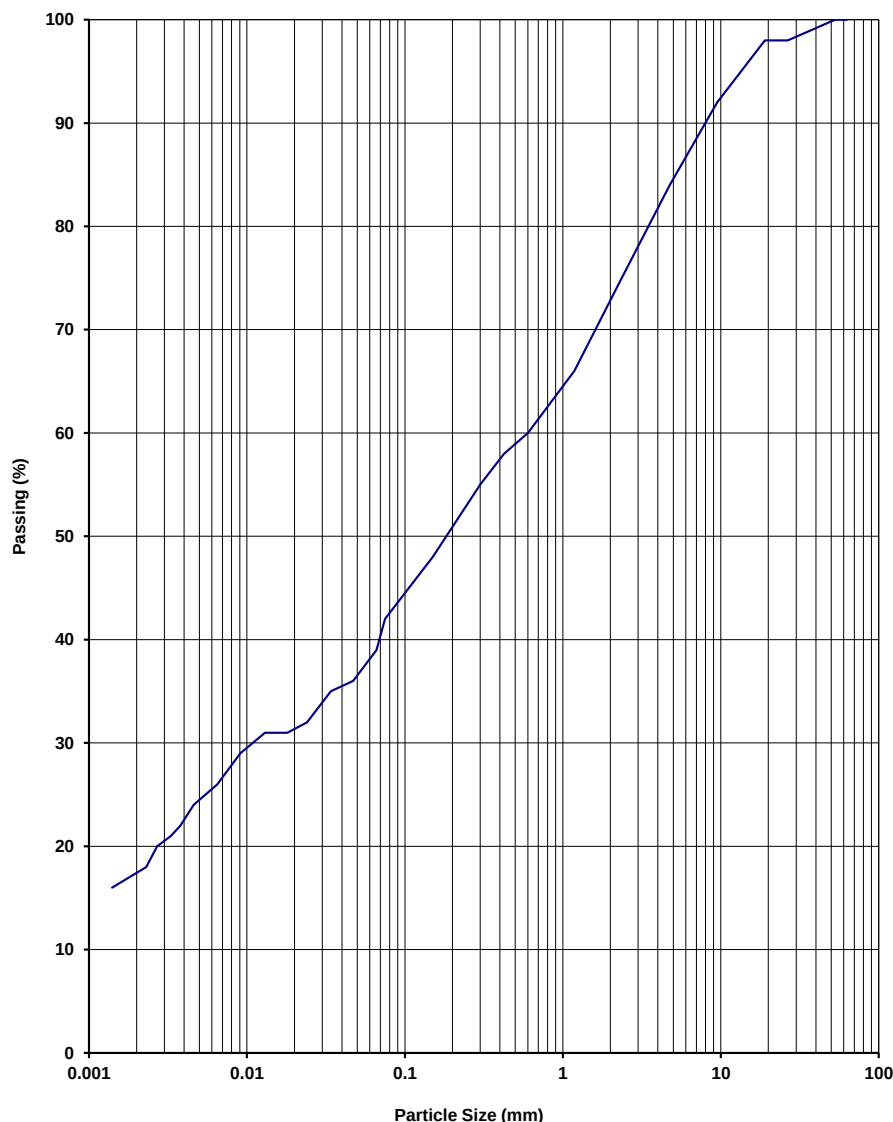
ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081547-G
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#6 - YAN-006A/B	Test Date	6/9/19-16/9/19
		Report Date	17/9/2019
Depth (m)	3.50		

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	100
37.5	99
26.5	98
19.0	98
13.2	95
9.5	92
6.7	88
4.75	84
2.36	75
1.18	66
0.600	60
0.425	58
0.300	55
0.150	48
0.075	42
0.066	39
0.047	36
0.034	35
0.024	32
0.018	31
0.013	31
0.0091	29
0.0065	26
0.0046	24
0.0038	22
0.0033	21
0.0027	20
0.0023	18
0.0014	16



NOTES/REMARKS:

-
Moisture Content 8.1% -2.36mm Soil Particle Density(t/m³) 2.64
Sample/s supplied by the client

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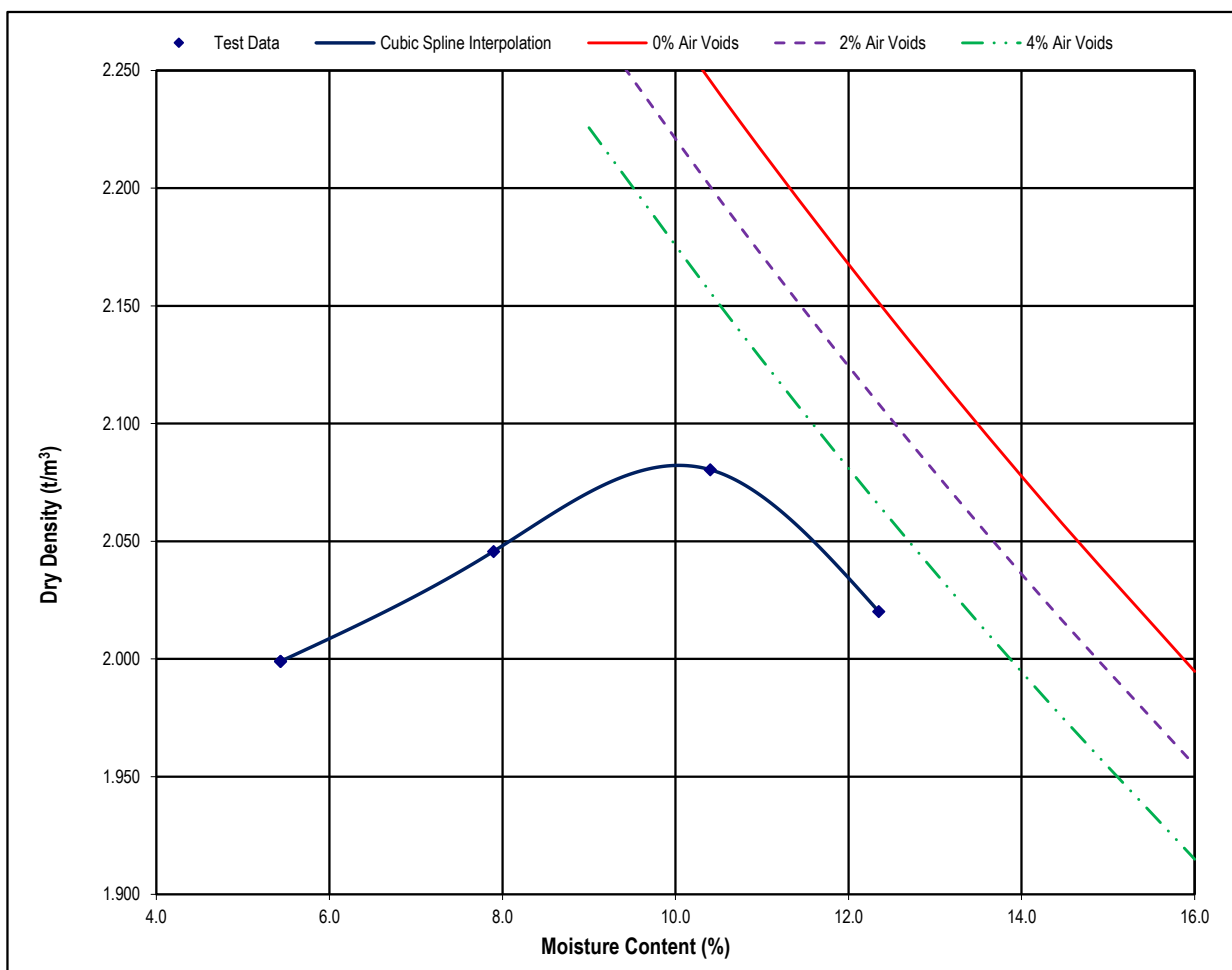
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MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.2.1 (Modified) & AS 1289.2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081547-MDD
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	13/09/2019
		Report Date	17/09/2019
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#6 - YAN-006A/B	Depth (m)	3.50



Maximum Dry Density (t/m³)	2.082	Optimum Moisture Content (%)	10.0
Moisture Content (%)	8.1	Percentage of Oversize/Sieve Size (mm)	2 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.93

Page 1 of 1 REP01304

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PERMEABILITY BY FALLING HEAD TEST REPORT

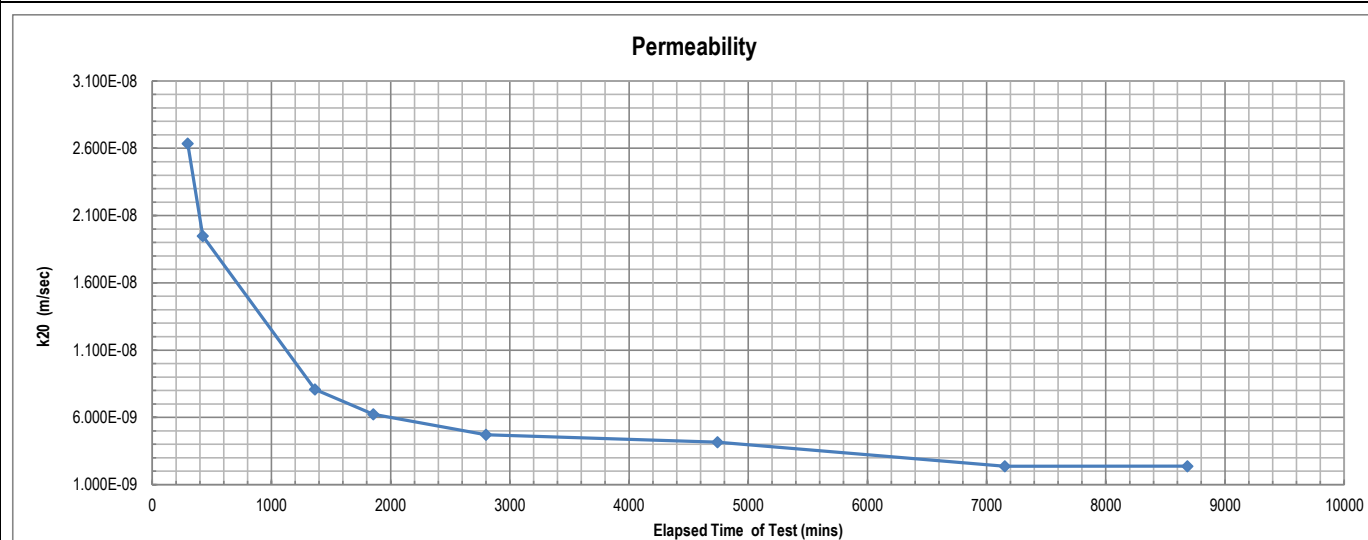
Test Method AS 1289 6.7.2, 5.1.1, KH2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client	O'Kane Consultants Pty Ltd	Report No.	19081548-FHPT
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation	Test Date	28/08/2019
Client ID	TP#11 - YAN-011A/B	Report Date	8/10/2019
Description	SANDY CLAY-brown	Depth (m)	2.40
		Sample Type	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	AS1289.5.1.1 - Standard Compaction		
Maximum Dry Density (t/m ³)	2.05	Hydraulic Gradient	9.5
Optimum Moisture Content (%)	9.7	Surcharge (kPa)	2.9
Placement Moisture Content (%)	9.7	Head Pressure Applied (kPa)	10.79
Moisture Ratio (%)	100.1	Water Type	Deaerated
Placement Wet Density (t/m ³)	2.13	Percentage Material Retained/Sieve Size (mm)	0 % / 9.5 mm
Density Ratio (%)	94.9	Sample Height and Diameter (mm)	116.21 / 101.52 mm

PERMEABILITY $k_{(20)} = 2.4 \times 10^{-09}$ (m/sec)



Remarks: The above specimen was remoulded to a target of 95% of Modified Maximum Dry Density and at Optimum Moisture Content.

Sample/s supplied by client

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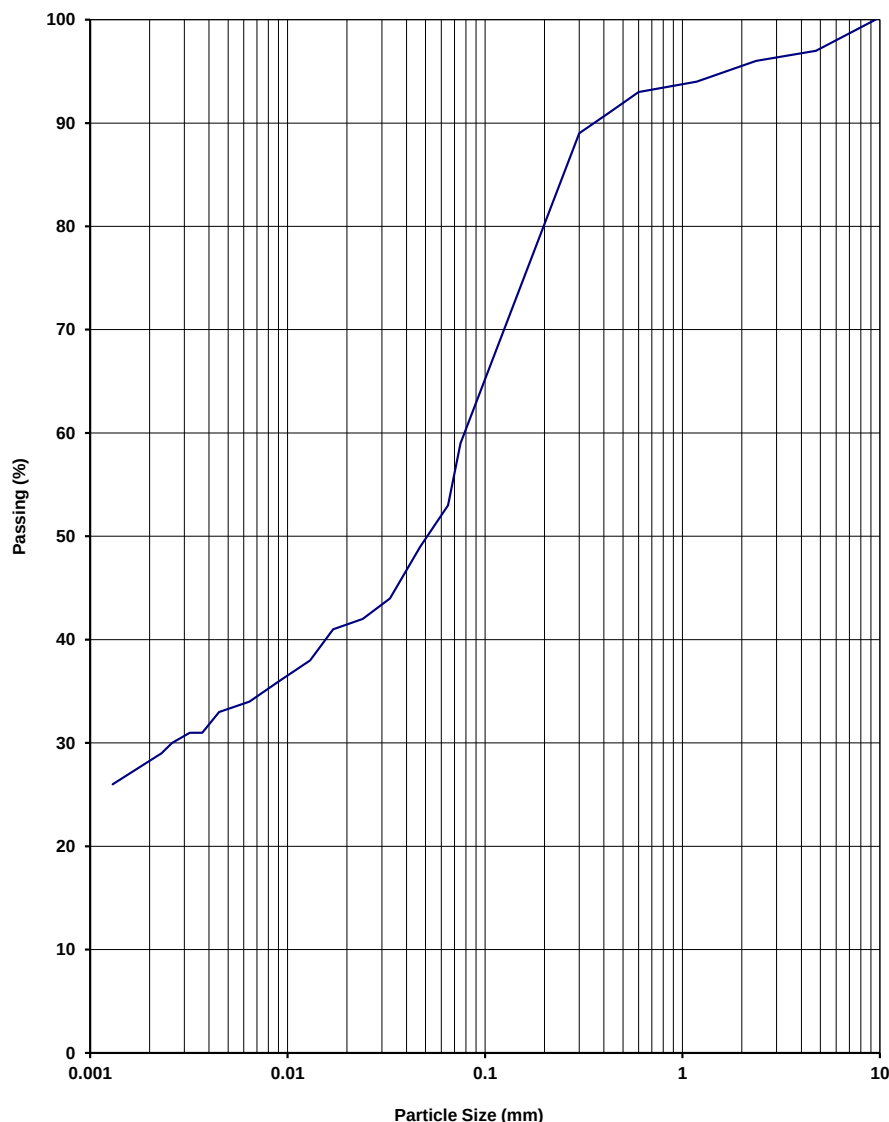
ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081548-G
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#11 - YAN-011A/B	Test Date	6/9/19-16/9/19
		Report Date	17/9/2019
		Depth (m)	2.40

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	
19.0	
13.2	
9.5	100
6.7	99
4.75	97
2.36	96
1.18	94
0.600	93
0.425	91
0.300	89
0.150	74
0.075	59
0.065	53
0.047	49
0.033	44
0.024	42
0.017	41
0.013	38
0.0091	36
0.0064	34
0.0045	33
0.0037	31
0.0032	31
0.0026	30
0.0023	29
0.0013	26



NOTES/REMARKS:

-
Moisture Content 7.6% -2.36mm Soil Particle Density(t/m³) 2.66
Sample/s supplied by the client

Page 1 of 1 REP03904

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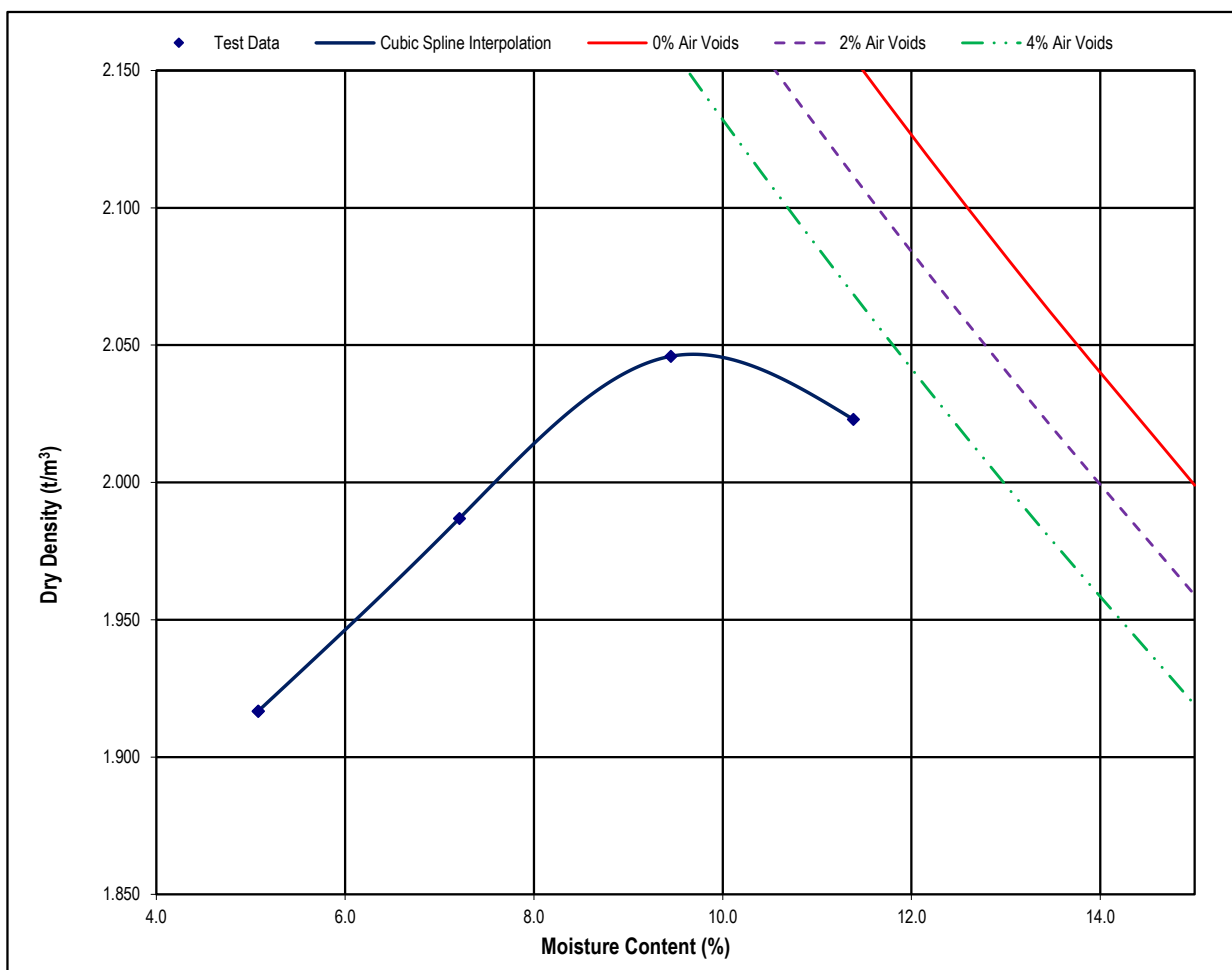
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MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.2.1 (Modified) & AS 1289.2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081548-MDD
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	13/09/2019
		Report Date	17/09/2019
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#11 - YAN-011A/B	Depth (m)	2.40



Maximum Dry Density (t/m³)	2.047	Optimum Moisture Content (%)	9.7
Moisture Content (%)	7.6	Percentage of Oversize/Sieve Size (mm)	0 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.86

Page 1 of 1 REP01304

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PERMEABILITY BY FALLING HEAD TEST REPORT

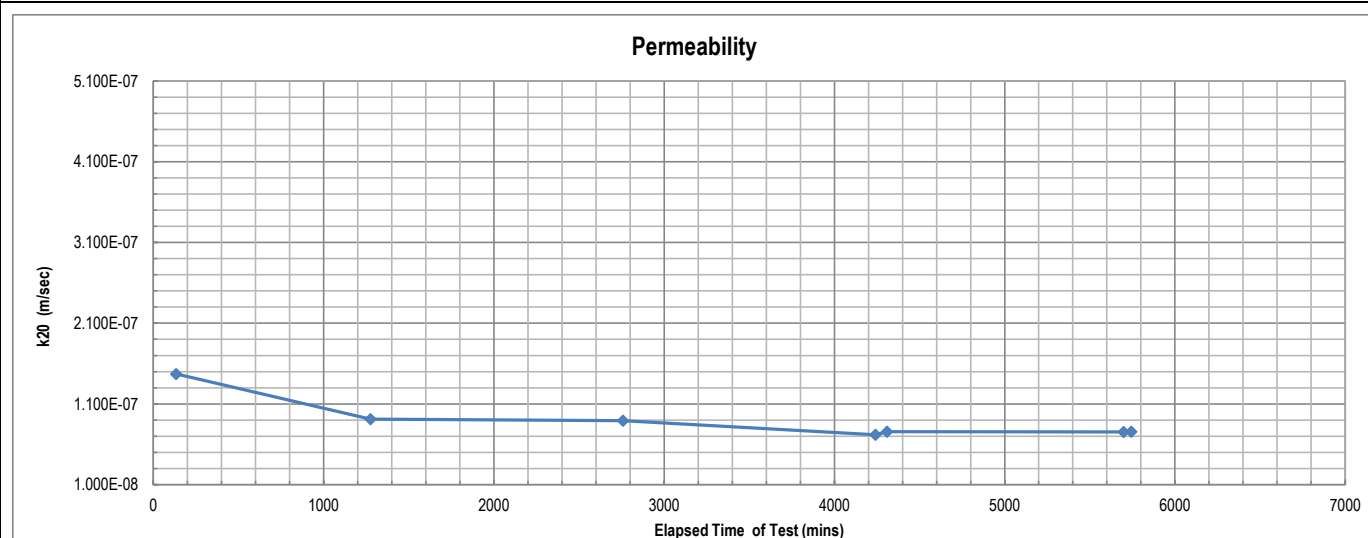
Test Method AS 1289 6.7.2, 5.2.1, KH2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client	O'Kane Consultants Pty Ltd	Report No.	19081549-FHPT
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation	Test Date	27/09/2019
Client ID	TP#13 - YAN-013A/B	Report Date	8/10/2019
Description	SANDY CLAY- brown	Depth (m)	2.00
		Sample Type	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	AS1289.5.2.1 - Modified Compaction		
Maximum Dry Density (t/m ³)	2.02	Hydraulic Gradient	9.4
Optimum Moisture Content (%)	10.4	Surcharge (kPa)	3.7
Placement Moisture Content (%)	10.2	Head Pressure Applied (kPa)	10.79
Moisture Ratio (%)	98.0	Water Type	Deaerated
Placement Wet Density (t/m ³)	1.89	Percentage Material Retained/Sieve Size (mm)	10 % /19 mm
Density Ratio (%)	85.1	Sample Height and Diameter (mm)	116.46 / 152.4 mm

PERMEABILITY $k_{(20)} = 7.6 \times 10^{-08}$ (m/sec)



Remarks: The above specimen was remoulded to a target of 85% of Modified Maximum Dry Density and at Optimum Moisture Content.

Sample/s supplied by client

Page: 1 of 1

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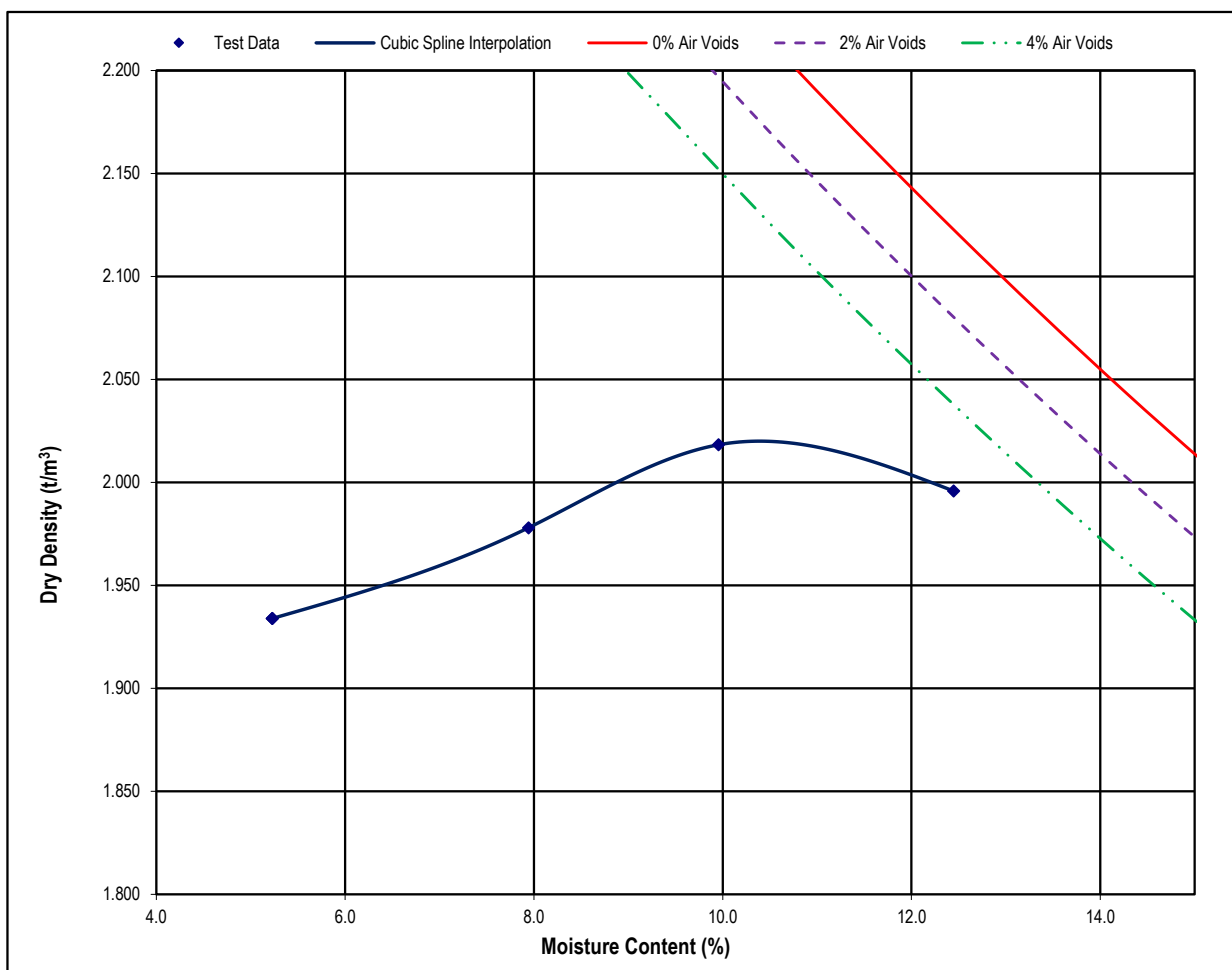
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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.2.1 (Modified) & AS 1289.2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081549-MDD
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	13/09/2019
		Report Date	17/09/2019
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#13 - YAN-013A/B	Depth (m)	2.00



Maximum Dry Density (t/m³)	2.020	Optimum Moisture Content (%)	10.4
Moisture Content (%)	8.9	Percentage of Oversize/Sieve Size (mm)	10 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.88

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PERMEABILITY BY CONSTANT HEAD TEST REPORT

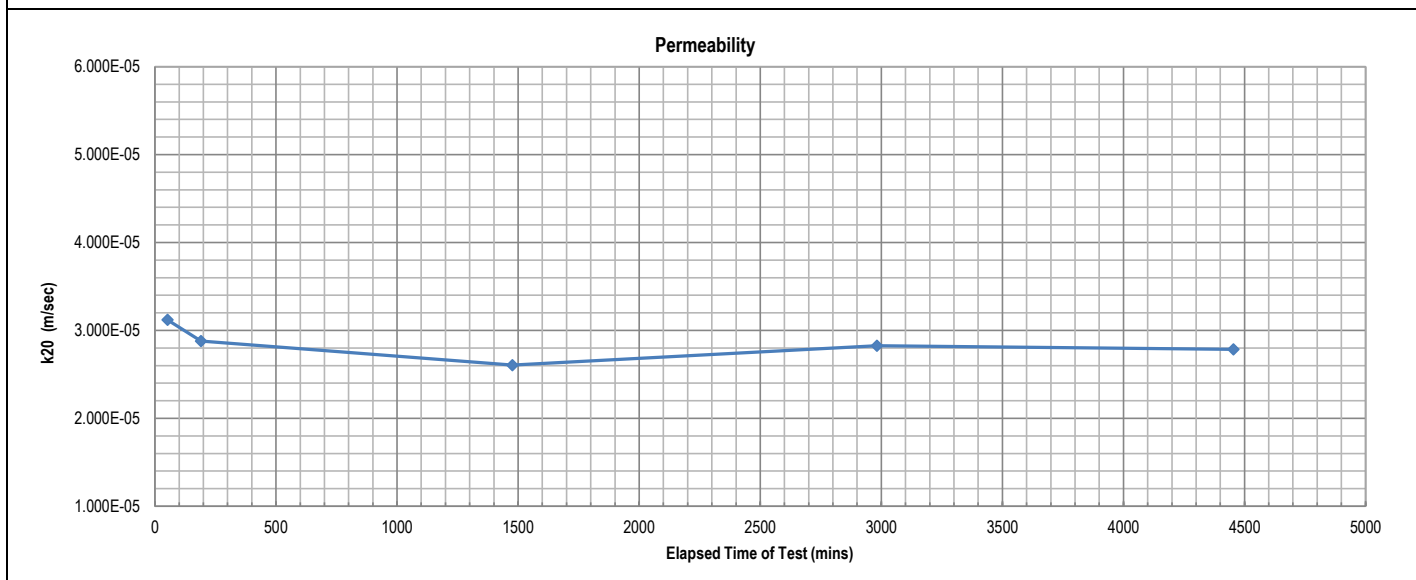
Test Method AS 1289 6.7.1, 5.1.1, KH2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client	O'Kane Consultants Pty Ltd	Report No.	19081551-CHP
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation	Test Date	16/09/2019
Client ID	TP#18 - YAN-018A/B	Report Date	25/09/2019
Description	CLAYEY SAND -brown with gravel	Depth (m)	0.80
		Sample Type	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	AS1289.5.1.1 - Standard Compaction		
Maximum Dry Density (t/m ³)	N/A	Hydraulic Gradient	0.9
Optimum Moisture Content (%)	N/A	Surcharge (kPa)	3.7
Placement Moisture Content (%)	15.5	Head Pressure Applied (kPa)	0.98
Moisture Ratio (%)	N/A	Water Type	Deaerated
Placement Wet Density (t/m ³)	1.76	Percentage Material Retained/Sieve Size (mm)	0 % / 19 mm
Density Ratio (%)	N/A	Sample Height and Diameter (mm)	116.39 / 152.44 mm

PERMEABILITY $k_{(20)} = 2.8 \times 10^{-05}$ (m/sec)



Remarks: The above specimen was remoulded as loose as possible at Field Moisture Content as advised by the client

Sample/s supplied by client

Page: 1 of 1

REP06401

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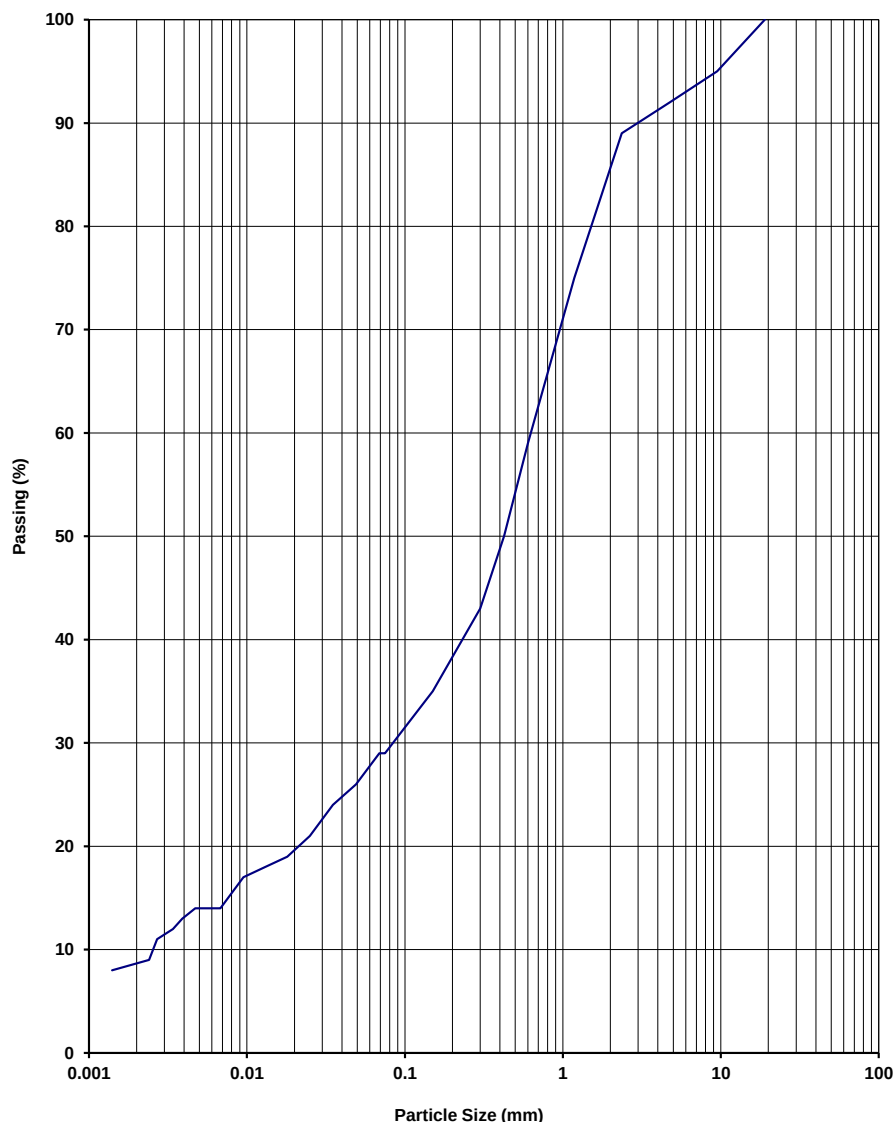
Trilab Pty Ltd ABN 25 065 630 506
ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081551-G
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#18 - YAN-018A/B	Test Date	6/9/19-16/9/19
		Report Date	17/9/2019
Depth (m)	0.80		

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	
19.0	100
13.2	95
9.5	95
6.7	94
4.75	92
2.36	89
1.18	75
0.600	59
0.425	50
0.300	43
0.150	35
0.075	29
0.069	29
0.049	26
0.035	24
0.025	21
0.018	19
0.013	18
0.0095	17
0.0068	14
0.0047	14
0.0039	13
0.0034	12
0.0027	11
0.0024	9
0.0014	8



NOTES/REMARKS:

-
Moisture Content 15.5% -2.36mm Soil Particle Density(t/m^3) 2.69
Sample/s supplied by the client

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PERMEABILITY BY FALLING HEAD TEST REPORT

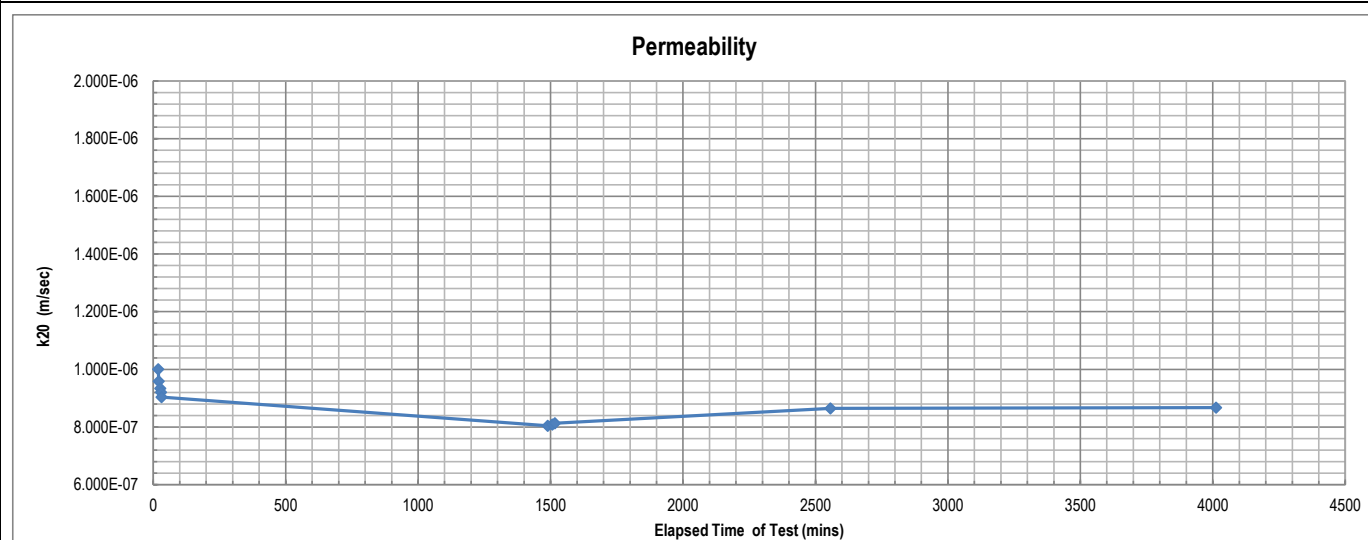
Test Method AS 1289 6.7.2, 5.1.1.1, KH2 (Based on K H Head (1988) Manual of Laboratory Testing, 10.7)

Client	O'Kane Consultants Pty Ltd	Report No.	19081553-FHPT
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Workorder No.	0006403
Project	0956-007 - Yandan Material Characterisation	Test Date	30/09/2019
Client ID	TP#21 - YAN-021A/B	Report Date	8/10/2019
Description	SILTY SAND -brown	Depth (m)	0.50
		Sample Type	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	AS1289.5.1.1 - Standard Compaction		
Maximum Dry Density (t/m ³)	2.10	Hydraulic Gradient	9.5
Optimum Moisture Content (%)	8.8	Surcharge (kPa)	3.7
Placement Moisture Content (%)	9.3	Head Pressure Applied (kPa)	10.79
Moisture Ratio (%)	106.1	Water Type	Deaerated
Placement Wet Density (t/m ³)	1.94	Percentage Material Retained/Sieve Size (mm)	14 % /19 mm
Density Ratio (%)	84.5	Sample Height and Diameter (mm)	116.24 / 152.44 mm

PERMEABILITY $k_{(20)} = 8.7 \times 10^{-07}$ (m/sec)



Remarks: The above specimen was remoulded to a target of 85% of Modified Maximum Dry Density and at Optimum Moisture Content.

Sample/s supplied by client

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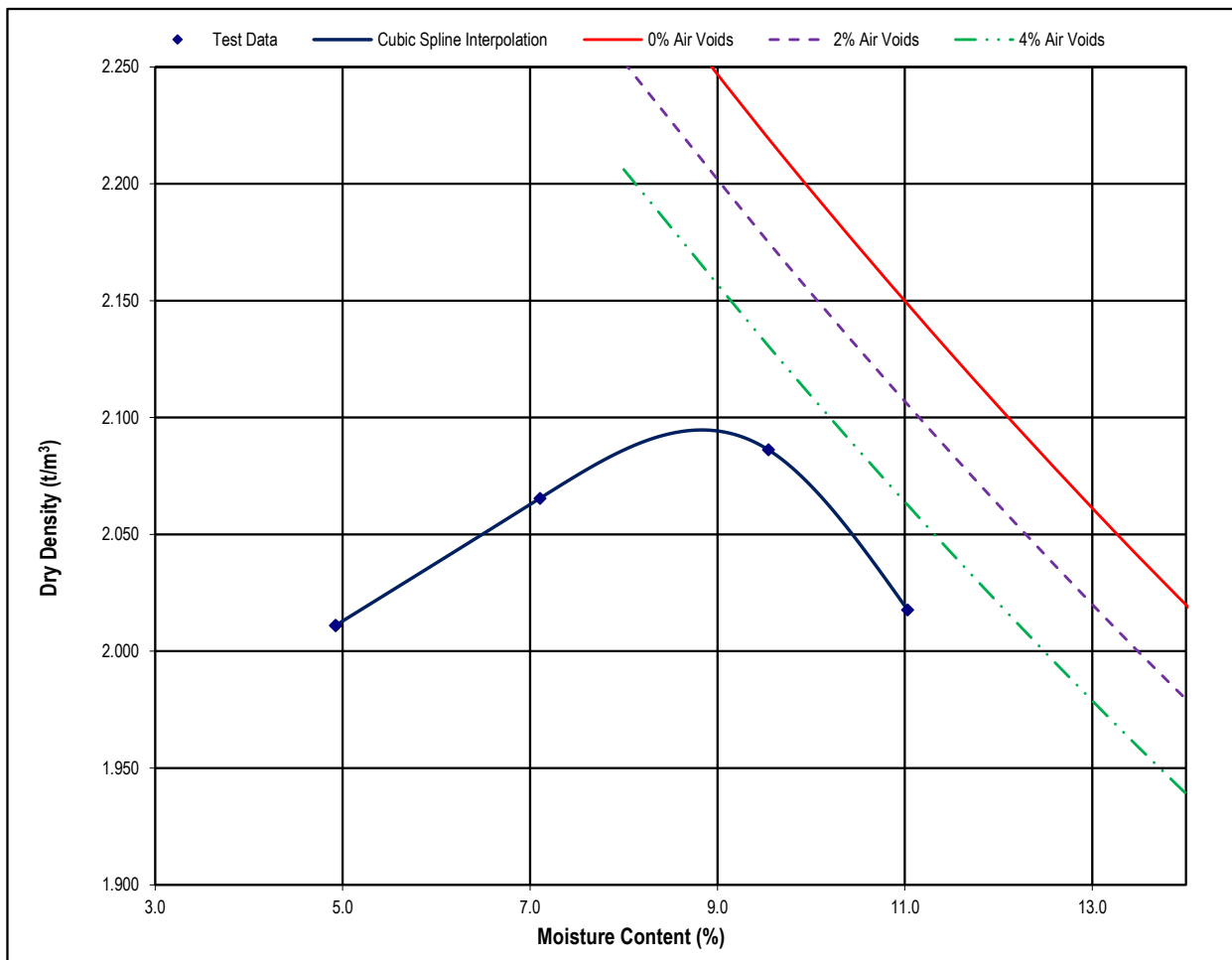
Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.2.1 (Modified) & AS 1289.2.1.1

Client	O'Kane Consultants Pty Ltd	Report No.	19081553-MDD
		Workorder No.	0006403
Address	202 Petrie Terrace, Petrie Terrace QLD 4074	Test Date	13/09/2019
		Report Date	17/09/2019
Project	0956-007 - Yandan Material Characterisation		
Client ID	TP#21 - YAN-021A/B	Depth (m)	0.50



Maximum Dry Density (t/m³)	2.095	Optimum Moisture Content (%)	8.8
Moisture Content (%)	9.7	Percentage of Oversize/Sieve Size (mm)	14 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.82

Page 1 of 1 REP01304

Accredited for compliance with ISO/IEC 17025 - Testing.
The results of the tests, calibrations, and/or measurements included in
this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory

Authorised Signatory



C. Park



Laboratory No. 9926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.
Reference should be made to Trilab's "Standard Terms and Conditions of Business" for further details.

Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

17/11/2014



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

School of Civil Engineering

GEOTECHNICAL LABORATORY - SOIL WATER CHARACTERISTIC CURVES

Client name	Scott Lines	Phone Number	
Company Name	Okane Consultants	Date	12/11/2019
Address	Unit 3, 202 Petrie Terrace, Petrie Terrace	Sample Name	TP#11 - OKC YAW 011 18/07/2018 - 0956-007
Email address	slines@okc-sk.com		

TEST RESULTS

Suction	Corrected Suction	Burette level*	Sample height	V _T	M _w	V _w	VWC	GMC
(kPa)	(kPa)	(mls)	(mm)	(mm ³)	(g)	(mm ³)	(%)	(%)
ua	u'=ua-uw	* Burette level here is the sum of the 2 tubes*scale adjustment						
0.1	0.10	4.21	31.22	99823.02	46.64	46640.8	46.72%	30.24%
10	9.095	10.67	31.22	99823.02	40.18	40182.4	40.25%	26.06%
20	18.845	14.18	31.22	99823.02	36.67	36672.4	36.74%	23.78%
40	38.595	17.69	31.22	99823.02	33.16	33162.4	33.22%	21.50%
80	78.375	20.78	31.22	99823.02	30.07	30073.6	30.13%	19.50%
160	158.125	24.29	31.22	99823.02	26.56	26563.6	26.61%	17.23%
320	317.895	27.52	31.22	99823.02	23.33	23334.4	23.38%	15.13%
500	497.785	29.06	31.22	99823.02	21.79	21790.0	21.83%	14.13%

Porous Plate Rating (bar)	5
Cell diameter (mm)	63.81

AFTER TEST CALCULATIONS

Tin Weight	97.55	g
Tin + Wet Soil	273.55	g
Tin + Dry Soil	251.76	g
M _T	176.00	g
M _S	154.21	g
M _w	21.79	g
w	14.130	%
γ _d	1.545	t/m3

Comments

- Sample soaked under water. MC reached was 25.5%
- The software used to obtain the fitted curve values is Soilvision. The equation used in this estimation is Fredlund and Xing
- The measured specific gravity of the composite sample is 2.6736 g/cm³. The test to obtain this value was Helium Pycnometer test
- Sample was placed on three layers each one compacted with a static load of approx. 20kPa

17/11/2014



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

School of Civil Engineering

GEOTECHNICAL LABORATORY - SOIL WATER CHARACTERISTIC CURVES

Client name	Scott Lines	Phone Number	
Company Name	Okane Consultants	Date	13/11/2019
Address	Unit 3, 202 Petrie Terrace, Petrie Terrace	Sample Name	TP#006 - OKC YAW 011 17/07/2018 -
Email address	slines@okc-sk.com		0956-007

TEST RESULTS

Suction	Corrected Suction	Burette level*	Sample height	V_T	M_w	V_w	VWC	GMC
(kPa)	(kPa)	(mls)	(mm)	(mm ³)	(g)	(mm ³)	(%)	(%)
ua	u'=ua-uw	* Burette level here is the sum of the 2 tubes*scale adjustment						
0.1	0.10	4.91	31.22	99823.02	44.94	44937.6	45.02%	28.52%
10	8.965	12.50	31.22	99823.02	37.36	37356.0	37.42%	23.71%
20	18.705	16.15	31.22	99823.02	33.71	33705.6	33.77%	21.39%
40	38.525	18.67	31.22	99823.02	31.18	31178.4	31.23%	19.79%
80	78.345	21.20	31.22	99823.02	28.65	28651.2	28.70%	18.18%
160	158.195	23.31	31.22	99823.02	26.55	26545.2	26.59%	16.85%
320	318.065	25.13	31.22	99823.02	24.72	24720.0	24.76%	15.69%

Porous Plate Rating (bar)	5
Cell diameter (mm)	63.81

AFTER TEST CALCULATIONS

Tin Weight	246.74	g
Tin + Wet Soil	429.02	g
Tin + Dry Soil	404.30	g
M_T	182.28	g
M_S	157.56	g
M_w	24.72	g
w	15.689	%
r_d	1.578	t/m3

Comments

- Sample soaked under water. MC reached was 25.5%
- The software used to obtain the fitted curve values is Soilvision. The equation used in this estimation is Fredlund and Xing
- The measured specific gravity of the composite sample is 2.7110 g/cm³. The test to obtain this value was Helium Pycnometer test
- Sample was placed on three layers each one compacted with a static load of approx. 20kPa

17/11/2014



THE UNIVERSITY
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AUSTRALIA

School of Civil Engineering

GEOTECHNICAL LABORATORY - SOIL WATER CHARACTERISTIC CURVES

Client name	Scott Lines	Phone Number	
Company Name	Okane Consultants	Date	4/10/2019
Address	Unit 3, 202 Petrie Terrace, Petrie Terrace	Sample Name	TP#3 - OKC - 0956-007
Email address	slines@okc-sk.com		

TEST RESULTS

Suction	Corrected Suction	Burette level*	Sample height	V _T	M _w	V _w	VWC	GMC
(kPa)	(kPa)	(mls)	(mm)	(mm ³)	(g)	(mm ³)	(%)	(%)
ua	u'=ua-uw	* Burette level here is the sum of the 2 tubes*scale adjustment						
0.1	0.10	6.04	31.22	98855.46	40.95	40946.0	41.42%	25.19%
10	9.095	10.67	31.22	98855.46	36.31	36312.8	36.73%	22.34%
20	18.855	14.04	31.22	98855.46	32.94	32943.2	33.32%	20.26%
40	38.645	16.99	31.22	98855.46	29.99	29994.8	30.34%	18.45%
80	78.455	19.66	31.22	98855.46	27.33	27327.2	27.64%	16.81%
160	158.305	21.76	31.22	98855.46	25.22	25221.2	25.51%	15.51%
320	318.165	23.73	31.22	98855.46	23.26	23255.6	23.52%	14.30%
500	498.025	25.69	31.22	98855.46	21.29	21290.0	21.54%	13.10%

Porous Plate Rating (bar)	5
Cell diameter (mm)	63.50

AFTER TEST CALCULATIONS

Tin Weight	185.31	g
Tin + Wet Soil	369.17	g
Tin + Dry Soil	347.88	g
M _T	183.86	g
M _S	162.57	g
M _w	21.29	g
w	13.096	%
Γ _d	1.645	t/m3

Comments

- Sample soaked under water. MC reached was 25.2%
- The software used to obtain the fitted curve values is Soilvision. The equation used in this estimation is Fredlund and Xing
- The measured specific gravity of the composite sample is 2.6795 g/cm³. The test to obtain this value was Helium Pycnometer test
- Sample was placed on three layers each one compacted with a static load of approx. 20kPa

CERTIFICATE OF ANALYSIS

Work Order : **EB1922743**
Client : **O'KANE CONSULTANTS PTY LTD**
Contact : **SCOTT LINES**
Address : **UNIT 2 202 Petrie Terrace,
PETRIE TERRACE QLD, AUSTRALIA 4000**
Telephone : **----**
Project : **956-007 Yandan**
Order number : **----**
C-O-C number : **----**
Sampler : **----**
Site : **----**
Quote number : **EN/222**
No. of samples received : **3**
No. of samples analysed : **3**

Page : 1 of 4
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 29-Aug-2019 15:50
Date Analysis Commenced : 30-Aug-2019
Issue Date : 06-Sep-2019 12:47



Accreditation No. 825
 Accredited for compliance with
 ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

Ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- ED006 (Exchangeable Cations on Alkaline Soils): Unable to calculate Magnesium/Potassium Ratio result as required Potassium and/or Magnesium results are less than the limit of reporting.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity ($H^+ + Al^{3+}$).



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	YAN-001	YAN-018	YAN-021	----	----
Client sampling date / time					17-Aug-2019 00:00	18-Aug-2019 00:00	18-Aug-2019 00:00	----	----
Compound	CAS Number	LOR	Unit		EB1922743-001	EB1922743-002	EB1922743-003	-----	-----
				Result	Result	Result	Result	----	----
EA002: pH 1:5 (Soils)									
pH Value	----	0.1	pH Unit		5.7	8.3	6.5	----	----
EA010: Conductivity (1:5)									
Electrical Conductivity @ 25°C	----	1	µS/cm		67	562	637	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		3.4	18.8	8.7	----	----
ED005: Exchange Acidity									
∅ Exchange Acidity	----	0.1	meq/100g		<0.1	----	----	----	----
∅ Exchangeable Aluminium	----	0.1	meq/100g		<0.1	----	----	----	----
ED006: Exchangeable Cations on Alkaline Soils									
∅ Exchangeable Calcium	----	0.2	meq/100g		----	12.0	----	----	----
∅ Exchangeable Magnesium	----	0.2	meq/100g		----	1.9	----	----	----
∅ Exchangeable Potassium	----	0.2	meq/100g		----	<0.2	----	----	----
∅ Exchangeable Sodium	----	0.2	meq/100g		----	1.5	----	----	----
∅ Cation Exchange Capacity	----	0.2	meq/100g		----	15.6	----	----	----
∅ Exchangeable Sodium Percent	----	0.2	%		----	9.7	----	----	----
∅ Calcium/Magnesium Ratio	----	0.2	-		----	6.3	----	----	----
ED007: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		2.9	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g		1.1	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g		0.2	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g		0.1	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g		4.3	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%		2.6	----	----	----	----
Calcium/Magnesium Ratio	----	0.1	-		2.6	----	----	----	----
Magnesium/Potassium Ratio	----	0.1	-		6.4	----	----	----	----
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		----	----	3.3	----	----
Exchangeable Magnesium	----	0.1	meq/100g		----	----	2.7	----	----
Exchangeable Potassium	----	0.1	meq/100g		----	----	0.2	----	----
Exchangeable Sodium	----	0.1	meq/100g		----	----	0.2	----	----
Cation Exchange Capacity	----	0.1	meq/100g		----	----	6.6	----	----
Exchangeable Sodium Percent	----	0.1	%		----	----	3.7	----	----
Calcium/Magnesium Ratio	----	0.1	-		----	----	1.2	----	----
Magnesium/Potassium Ratio	----	0.1	-		----	----	10.9	----	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	YAN-001	YAN-018	YAN-021	----	----
Client sampling date / time					17-Aug-2019 00:00	18-Aug-2019 00:00	18-Aug-2019 00:00	----	----
Compound	CAS Number	LOR	Unit		EB1922743-001	EB1922743-002	EB1922743-003	-----	-----
					Result	Result	Result	----	----
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.01	0.02	0.02	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		26.2	0.2	15.5	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		660	450	780	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		690	450	800	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		283	872	160	----	----
EP004: Organic Matter									
Organic Matter	----	0.5	%		1.4	0.5	1.2	----	----
Total Organic Carbon	----	0.5	%		0.8	<0.5	0.7	----	----



For further information contact:

O'Kane Consultants Pty Ltd

202 Petrie Terrace
Brisbane QLD 4000
Australia

Telephone: (07) 3367 8063

Facsimile: (07) 3367 8052

Web: www.okc-sk.com

8 October 2013
Project Number 111207

LRS Environmental Pty Ltd
PO Box 44
James Cook University
QLD 4818

Attention: Gil Fletcher – Managing Director

Dear Gil,

Subject: Geochemical Assessment of TSF Cell B cover materials, tailings and heap leach rocks at Yandan Gold Mine

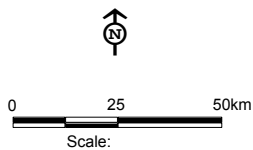
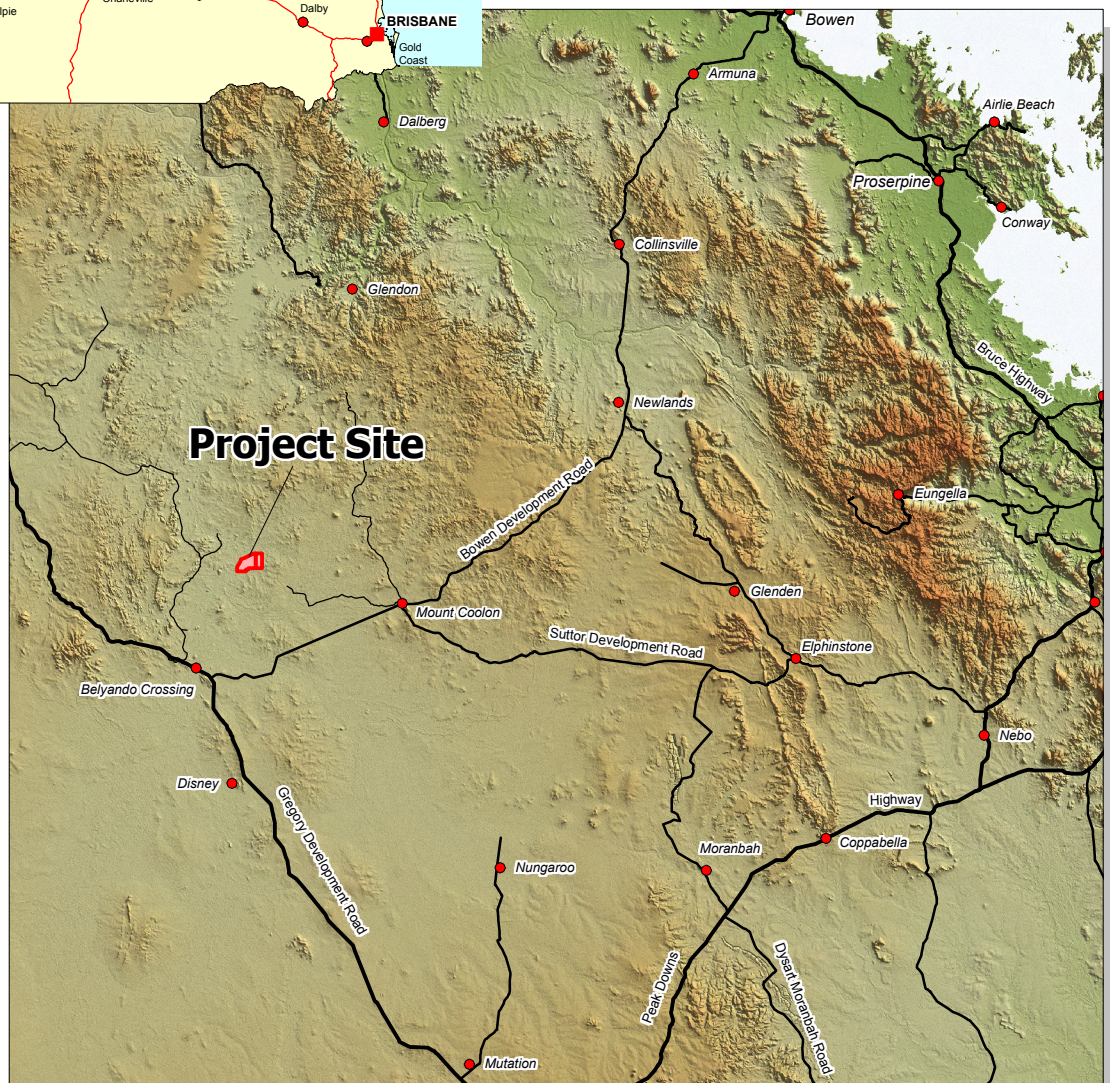
1.0 INTRODUCTION

RGS Environmental Pty Ltd (RGS) was commissioned by LRS Environmental Pty Ltd (LRS) on behalf of Straits Gold Pty Ltd to complete a geochemical assessment of Tailings Storage Facility (TSF) Cell B cover materials, underlying tailings and heap leach material from Yandan gold mine. The mine (now decommissioned) is located in the northern Drummond Basin of North Queensland, 230 km west of Mackay (**Figure 1**). The TSF is divided into two cells (Cells A and B) and Cell B has a trial rehabilitation cover system at the south eastern corner of the facility comprising oxidised waste rock material (**Figure 2**). RGS has been provided with representative samples of the TSF cover, tailings and heap leach materials for geochemical assessment.

2.0 SCOPE OF WORK

The RGS scope of work comprised:

1. Coordination of static geochemical tests for 32 TSF Cell B cover samples, 15 tailings samples and 6 heap leach rock samples supplied by LRS.
2. Completion of a kinetic geochemical test (kinetic leach column (KLC) test on a composite sample of heap leach rock.
3. Tabulation and interpretation of acquired static and kinetic geochemical test data against applied environmental guidelines.
4. Provision of a letter report (this report), which provides the geochemical test results and the RGS interpretation of the results.
5. Provision of preliminary recommendations for the management of selected mine materials with respect to potential Acid and Metalliferous Drainage (AMD) issues.



Source: This product incorporates data which is:
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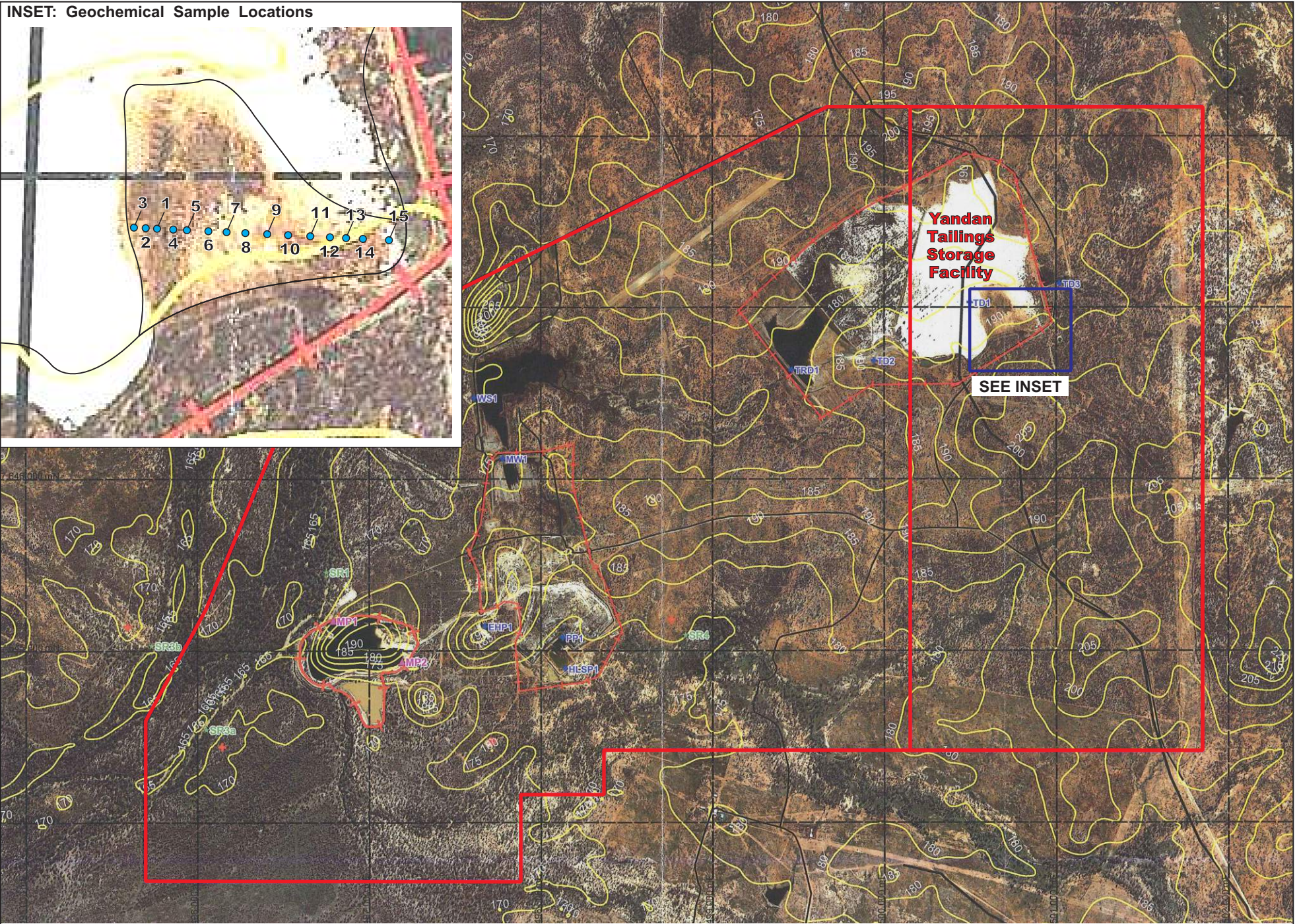
RGS Environmental Pty Ltd
18 Inglis Street, Grange, QLD 4051
Tel/Fax +61 7 3856 5591
Mobile 0431 620623
Email alan@rgsenv.com
File: 111207 001 A4
Date: 08/10/2013

LRS ENVIRONMENTAL PTY LTD

YANDAN PROJECT

Figure: 1
LOCATION MAP

INSET: Geochemical Sample Locations



Source: Client Supplied (September 2012)

3.0 METHODOLOGY

A brief explanation the parameters typically involved in undertaking a geochemical assessment of mine waste materials using static and kinetic geochemical tests is provided at **Attachment A**.

3.1 Sampling

A total of 32 TSF Cell B cover samples, 15 tailings samples and 6 heap leach rock samples were supplied to RGS by LRS in August 2012. The TSF Cell B cover and tailings samples were selected to represent cover and underlying tailings materials at the rehabilitation trial (**Figure 1**) and were obtained at selected intervals along a transect at the south eastern corner of TSF Cell B (**Figure 2**). The heap leach rock samples were taken to represent the range of heap leach rock types present at the mine site.

3.2 Laboratory Testing

Static Tests

The 53 samples received and viewed by RGS and then transferred to ALS in Brisbane for geochemical testing using standard methods and guidelines accepted in the mining industry (AMIRA, 2002; DITR, 2007; DME, 1995, Parker and Robertson, 1999; and INAP 2009). All samples were pulverised and tested for:

- pH (1:5 w:v),
- Electrical Conductivity (EC) (1:5 w:v).

The 6 heap leach rock samples were also tested for

- Total sulfur [LECO method];
- Acid Neutralising Capacity [AMIRA, 2002]
- Net Acid Producing Potential (NAPP).

This range of tests is called Acid-Base Account (ABA) tests and is a useful method for screening of samples prior to completing additional multi-element testing on a smaller number of composite samples.

The results of the initial geochemical tests were used to select a composite sample of heap leach rock material (comprising equal proportions of the 6 individual samples) for multi-element (total metal) testing. The composite heap leach rock sample was tested for:

- Total metals (Al, As, B, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Mo, N, Ni, Sb, Se, V, Zn) in solids [HCl and HNO₃ acid digest followed by ICP-AES and selected ICP-MS];
- Total chromium [HCl and HNO₃ acid digestion with ICP-AES analyses];
- Total mercury [FIMS method];
- Total cations (Ca, Mg, Na, K) and Exchangeable cations (Ca, Mg, Na, K);
- Cation Exchange Capacity (eCEC); and
- Exchangeable Sodium Percentage (ESP).

Kinetic Leach Column Tests

The intent of the kinetic leach column (KLC) program was to characterise the leachate from the composite heap leach rock sample when subjected to routine wetting and drying, simulating exposure to ‘atmospheric conditions’. The leachate collected from the column was analysed to determine various water quality parameters including concentration of soluble metals/metalloids, salts and nutrients. The KLC method generally followed the AMIRA (2002) guideline method. Some modifications were necessary, and justified, to suit the type of materials being analysed. The KLC set up used in this project is described and illustrated at **Attachment A**.

For the KLC test approximately 2,000 cm³ (1.562 kg) of crushed rock was loosely packed into a Buchner column, connected above a Buchner funnel. The base of the column (above the funnel) was lined with a filter membrane. The membrane acted to retain fine sediment from flushing into the collection bottle. The entire unit was supported on a shelf to allow a collection bottle to sit under the funnel and a heat lamp was mounted approximately 25 cm above the column and maintained a surface temperature of approximately 30-35°C.

The column was subjected to routine de-ionised water addition and subsequent heating using a heat lamp to simulate the effects of rainfall and sunshine on solids. During leaching events water was initially applied monthly for four leaching events and then quarterly for the final three leaching events (ie. a total leaching period of 12 months). The applied water was allowed to free-drain through the solid samples and was collected and analysed at ALS Brisbane (refer to list of analytes below). At leaching events 1,000 mL of deionised water was slowly added to the top surface of the sample.

The KLC tests commenced in September 2012 and continued until September 2013. Leachate from the composite sample was analysed for:

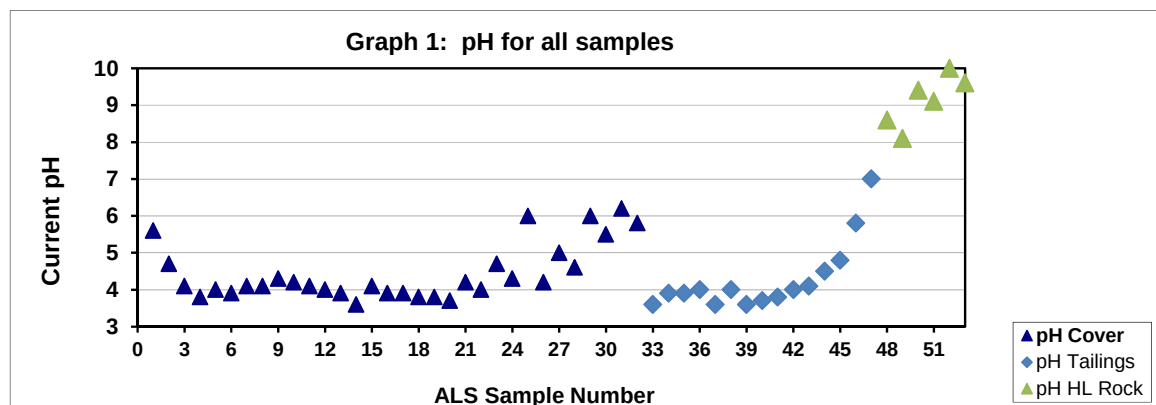
- pH and EC (at RGS sample collection and at ALS Brisbane);
- Alkalinity and acidity (titration as mgCaCO₃/L);
- Soluble metals and metalloids (25 elements) [ICP-AES];
- Soluble mercury [FIMS method];
- Soluble hexavalent chromium [discrete analyser];
- Soluble major cations [ICP-AES];
- Soluble sulfate [ICP-AES];
- Soluble chloride [discrete analyser].

The KLC tests were completed at the RGS Environmental in-house leaching laboratory. Analyses of collected leachates were undertaken at ALS Brisbane. The results for the static and KLC test programs are reported in **Section 4.0** and the laboratory results from ALS Brisbane on all samples are provided at **Attachment B**.

4.0 RESULTS AND DISCUSSION

4.1 pH and EC

- pH:** The pH values for the samples range from acidic to alkaline (3.6 to 10.0). The TSF cover material and tailings typically have reduced pH values with the majority less than pH 5. For the cover materials, there appears to be a strong correlation between sample pH and depth (see **Table 1**) and given that most of the tailings materials have a low pH value, this suggests migration of acidity from the tailings up through the one metre cover profile. In contrast, the pH values for heap leach rock are alkaline and range from 8.1 to 10 (Graph 1).



- EC:** The EC values for the samples range from 48 $\mu\text{S}/\text{cm}$ to 2,620 $\mu\text{S}/\text{cm}$. The TSF cover material and tailings typically have elevated EC values with the majority greater than 500 $\mu\text{S}/\text{cm}$. Again there appears to be a strong correlation between sample EC and depth for cover materials (see **Table 1**), which suggests migration of salts from the tailings up through the one metre cover profile. The few cover samples with relatively low EC values (< 500 $\mu\text{S}/\text{cm}$) are from the top surface of the cover. In contrast, the EC values for heap leach rock are all less than 500 $\mu\text{S}/\text{cm}$ (Graph 2).

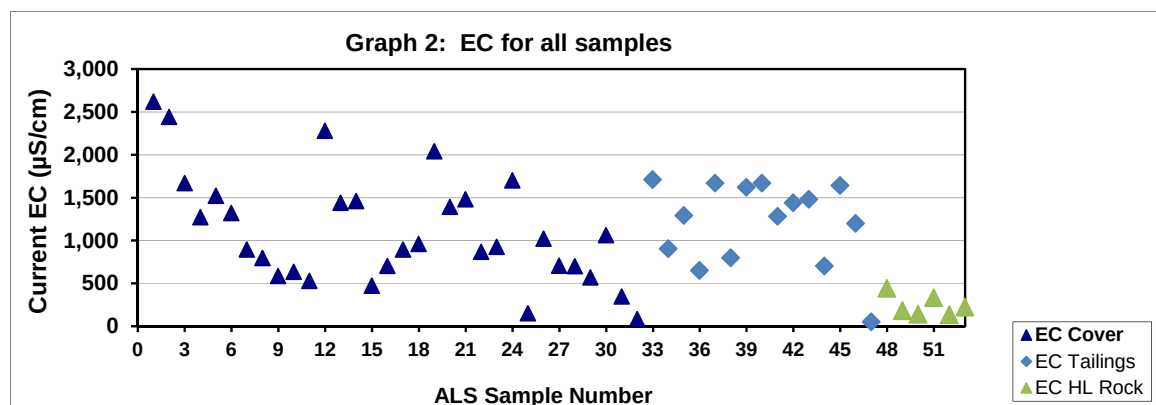


Table 1: Static Geochemical Results for Yandan Project

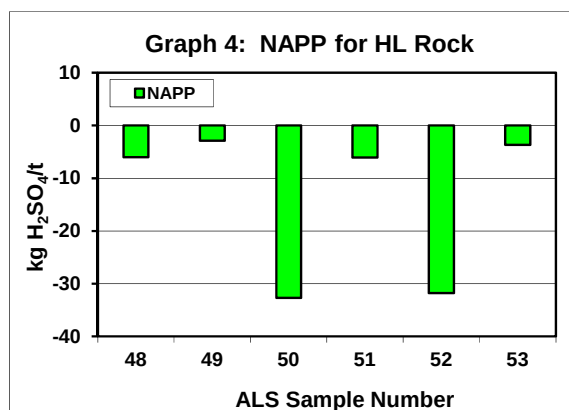
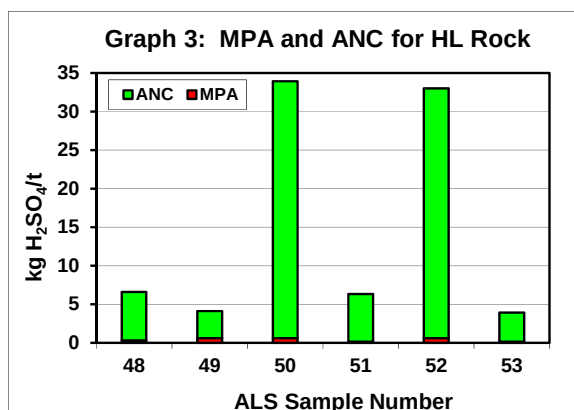
ALS Sample Number	Sample Type & Name/ID	Depth Interval (m)	Sample Location No.	pH ¹	EC ¹ (μS/cm)	Total Sulfur (%)	CRS ²	MPA ²	ANC ² (kg H ₂ SO ₄ /t)	NAPP ²	ANC:MPA Ratio	Classification
TSF CELL B COVER MATERIAL												
EB1221303001	TRT	0-250	1	5.6	2620							
EB1221303002	TRT	250-500	1	4.7	2440							
EB1221303003	TRT	500-750	1	4.1	1670							
EB1221303004	TRT	750-1000	1	3.8	1270							
EB1221303005	TRT	0-250	2	4.0	1520							
EB1221303006	TRT	250-500	2	3.9	1320							
EB1221303007	TRT	0-200	3	4.1	892							
EB1221303008	TRT	200-400	3	4.1	795							
EB1221303009	TRT	0-250	4	4.3	585							
EB1221303010	TRT	250-500	4	4.2	632							
EB1221303011	TRT	500-600	4	4.1	525							
EB1221303012	TRT	0-250	5	4.0	2280							
EB1221303013	TRT	250-500	5	3.9	1440							
EB1221303014	TRT	500-600	5	3.6	1460							
EB1221303015	TRT	0-250	6	4.1	473							
EB1221303016	TRT	250-500	6	3.9	701							
EB1221303017	TRT	0-250	7	3.9	892							
EB1221303018	TRT	250-500	7	3.8	960							
EB1221303019	TRT	0-150	8	3.8	2040							
EB1221303020	TRT	150-300	8	3.7	1390							
EB1221303021	TRT	0-150	9	4.2	1480							
EB1221303022	TRT	150-300	9	4.0	866							
EB1221303023	TRT	0-150	10	4.7	924							
EB1221303024	TRT	150-300	10	4.3	1700							
EB1221303025	TRT	0-250	11	6.0	149							
EB1221303026	TRT	250-500	11	4.2	1020							
EB1221303027	TRT	0-100	12	5.0	704							
EB1221303028	TRT	100-200	12	4.6	698							
EB1221303029	TRT	0-75	13	6.0	568							
EB1221303030	TRT	75-150	13	5.5	1060							
EB1221303031	TRT	0-75	14	6.2	343							
EB1221303032	TRT	0-10	15	5.8	81							
TSF CELL B TAILINGS												
EB1221303033	TRT	0-250	1 (T)	3.6	1710							
EB1221303034	TRT	0-250	2 (T)	3.9	905							
EB1221303035	TRT	0-250	3 (T)	3.9	1290							
EB1221303036	TRT	0-250	4 (T)	4.0	649							
EB1221303037	TRT	0-250	5 (T)	3.6	1670							
EB1221303038	TRT	0-250	6 (T)	4.0	796							
EB1221303039	TRT	0-250	7 (T)	3.6	1620							
EB1221303040	TRT	0-250	8 (T)	3.7	1670							
EB1221303041	TRT	0-250	9 (T)	3.8	1280							
EB1221303042	TRT	0-250	10 (T)	4.0	1440							
EB1221303043	TRT	0-250	11 (T)	4.1	1480							
EB1221303044	TRT	0-250	12 (T)	4.5	701							
EB1221303045	TRT	0-250	13 (T)	4.8	1640							
EB1221303046	TRT	0-250	14 (T)	5.8	1200							
EB1221303047	TRT	0-250	15 (T)	7.0	48							
HEAP LEACH ROCK												
EB1221303048	Heap Leach	-	1	8.6	440	0.01	N/A	0.31	6.3	-6.0	20.6	NAF (Barren)
EB1221303049	Heap Leach	-	2	8.1	181	0.02	N/A	0.61	3.5	-2.9	5.7	NAF (Barren)
EB1221303050	Heap Leach	-	3	9.4	140	0.02	N/A	0.61	33.3	-32.7	54.4	NAF (Barren)
EB1221303051	Heap Leach	-	4	9.1	332	0.005	N/A	0.15	6.2	-6.0	40.5	NAF (Barren)
EB1221303052	Heap Leach	-	5	10.0	131	0.02	N/A	0.61	32.4	-31.8	52.9	NAF (Barren)
EB1221303053	Heap Leach	-	6	9.6	221	0.005	N/A	0.15	3.8	-3.6	24.8	NAF (Barren)

Notes

1. Current pH, EC, Alkalinity and Acidity provided for 1:5 sample:water extracts
2. CRS = Chromium Reducible Sulfur; MPA = Maximum potential acidity; ANC = Acid neutralising capacity; and NAPP = Net acid producing potential.
3. Sample classification detail provided in report text.
4. TRT = Tailings Rehabilitation Trial.

4.2 Acid Base Account

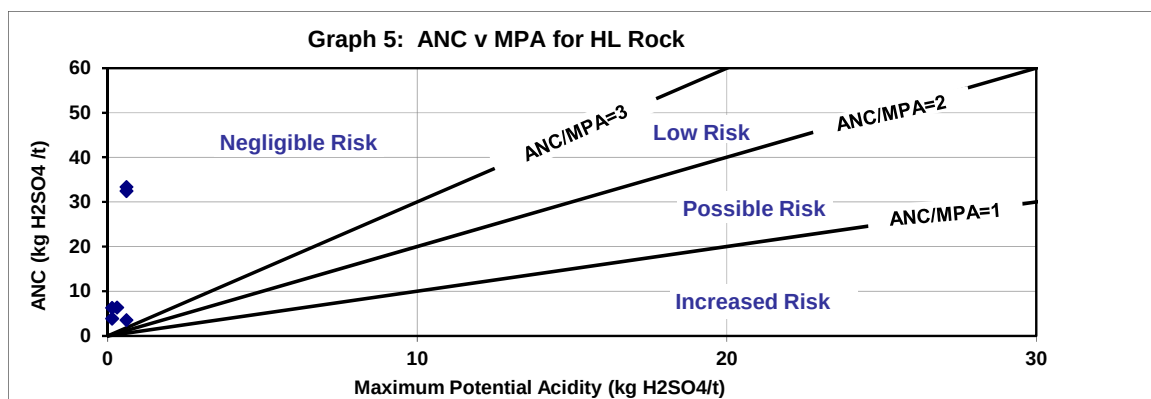
- **Total Sulfur:** The total sulfur contents of the Heap Leach Rock samples range from 0.005% to 0.02% and are typically very low. Mine waste samples with total sulfur content less than 0.1 % are essentially barren of sulfur, generally represent background concentrations, and have negligible capacity to generate acid¹.
- **MPA:** The maximum potential acidity (MPA) that could be generated from these samples through sulfide oxidation ranges from 0.15 to 0.61 kg H₂SO₄/t and is typically very low (**Graph 3**).
- **ANC:** The ANC of the samples ranges from 3.5 to 33.3 kg H₂SO₄/t and is typically moderate and far in excess of the MPA (**Graph 3**).
- **NAPP:** The calculated NAPP value for all of the samples is negative and ranges from -2.9 to -32.7 kg H₂SO₄/t (**Graph 4**). The NAPP is basically the balance between the capacity of a sample to generate acid (MPA) minus its capacity to neutralise acid (ANC).



Graph 5 shows a plot of ANC versus MPA for the Heap Leach Rock samples. The ANC/MPA ratio of the samples ranges from 5.7 to 54.4 and is typically elevated. ANC/MPA ratio lines have been plotted on the graph to illustrate the factor of safety associated with the samples. Generally those samples with an ANC/MPA ratio of greater than 2 are considered to have a low to negligible risk of acid generation and a high factor of safety in terms of potential for acid generation (DITR, 2007; INAP, 2009)². The results shown in **Graph 5** indicate that all of the Heap Leach Rock samples tested have a negligible risk acid generation and a high factor of safety.

¹ The average crustal abundance of sulfur is approximately 0.07 % (INAP, 2009).

² INAP considers that mine materials with an ANC/MPA ratio greater than 2 are likely to be NAF unless significant preferential exposure of sulphides along fracture planes occurs in combination with insufficiently reactive ANC.



4.3 Multi-Element Scans

Multi-element scans were carried out on a single composite sample made up from equal amounts of the six Heap Leach Rock samples, to identify any elements (particularly metals/metalloids) present at concentrations that may be of environmental concern with respect revegetation and groundwater and surface water quality. The assay result for each element was compared to median soil abundance and/or potentially relevant soil guideline criteria to determine any environmental concerns with these materials related to rehabilitation. Elements identified as enriched may not necessarily be a concern for revegetation, drainage water quality, or public health, but their significance was evaluated. Similarly, because an element is not enriched does not mean it will never be a concern, because under some conditions (*e.g.* low pH) the geochemical behaviour of common environmentally important elements such as Al, Cu, Cd, Fe and Zn increases significantly.

The multi-element results for the composite Heap Leach Rock rock sample are presented at **Table 2**. The results have been presented alongside:

- median crustal abundance and geochemical abundance index data (in order to provide a comparison against typical background concentrations) (Bowen, 1979); and
- NEPC health based investigation levels (in order to provide a comparison against metal concentrations, which may warrant further investigation) (NEPC, 1999a).

Geochemical Abundance Index

Total metal/metalloid concentrations in mine materials are relevant for revegetation activities or where the potential exists for human contact (*eg.* if the material was to be used off-site). In order to provide relevant context, the total metal concentration of each element reported in the waste rock samples has been compared to median crustal abundance for unmineralised soils (Bowen, 1979; INAP, 2009). The extent of enrichment is reported as the Geochemical Abundance Index (GAI), which relates the actual concentration with a median (or average) abundance on a log₁₀ scale. The GAI is expressed in integer increments from 0 to 6, where a GAI value of 0 indicates that the

element is present at a concentration less than, or similar to, the median crustal abundance; and a GAI value of 6 indicates approximately a 100-fold enrichment above median crustal abundance. As a general rule, a GAI of 3 or greater signifies enrichment that may warrant further examination.

Table 2 provides total metal/metalloid concentrations for the composite Heap Leach Rock sample. The relative enrichment of metals in the composite sample compared to median crustal abundance (the Geochemical Abundance Index - GAI) is also presented at **Table 2**. The results indicate that the composite sample has no significant element enrichment relative to median crustal abundance apart from antimony (Sb) and arsenic (As).

Australian Guidelines

The assay results for the composite Heap Leach Rock sample can also be compared to potentially relevant guideline criteria to determine any environmental concerns related to rehabilitation. There are no specific guidelines and/or regulatory criteria related to total metal/metalloid concentrations in these materials. In the absence of these and to provide relevant context, RGS has also compared the total metal/metalloid concentration in these materials to NEPC (1999a) background and health-based investigation levels (HIL (E)) for parks and recreational open spaces. The applicability of the NEPC (1999a) health based guideline values stems from the potential final land use of the mine following closure (*eg.* a return to low intensity grazing).

The composite sample has an arsenic concentration (67 mg/kg) that marginally exceeds the NEPC environmental guideline for this element (50 mg/kg) in background soils, but is much less than the HIL (E) guideline value (200 mg/kg). There is no NEPC background and/or HIL(E) guideline value for antimony. The remainder of the metals/metalloids tested are either present at a concentration well within the relevant NEPC guideline value or NEPC guideline values do not exist. Hence, heap leach materials represented by the composite sample should not present a significant risk to the environment with respect to total metal concentrations in solids and rehabilitation.

4.4 Exchangeable Cations and Sodicity

The exchangeable cation results presented in **Table 2** indicate that the effective Cation Exchange Capacity (eCEC) of the composite sample is 21.6 meq/100g, the exchangeable sodium percentage (ESP) is 0.3 %, and the calcium:magnesium ratio is 41.4. From a soil chemistry viewpoint, the materials represented by the composite heap leach sample rock sample are likely to be alkaline and will generally have relatively low salinity levels. The exchangeable cation and sodicity characteristics of the composite sample are also favourable and unlikely to result in any structural stability problems related to potential dispersion and erosion. Hence, materials represented by the composite sample are likely to be suitable for rehabilitation activities at the site.

Table 2: Multi-Element Results and Enrichment for Heap Leach Rock Composite - Yandan Project

Parameters	Detection Limit	NEPC ¹ Background and Health-Based Investigation Levels	Average Crustal Abundance ¹	Concentration	Geochemical Abundance Index (GAI)
Metals/Metalloids	All units mg/kg				No units
Aluminium (Al)	50	-	82,000	850	0
Antimony (Sb)	5	-	0.2	8	5
Arsenic (As)	5	50 (200)	1.5	67	5
Cadmium (Cd)	1	1 (40)	0.11	0.5	2
Calcium (Ca)	50	-	41,000	13000	0
Chromium (Cr) total *	2	(200)	100	4	0
Cobalt (Co)	2	40 (200)	20	1	0
Copper (Cu)	5	100 (2,000)	50	2.5	0
Iron (Fe)	50	-	41,000	9000	0
Lead (Pb)	5	200 (600)	14	2.5	0
Magnesium (Mg)	50	-	23,000	1080	0
Manganese (Mn)	5	850 (3,000)	950	45	0
Mercury (Hg)	0.1	0.03 (30)	0.05	0.05	0
Molybdenum (Mo)	2	-	1.5	1	0
Nickel (Ni)	2	500 (600)	80	2	0
Potassium (K)	50	-	21,000	590	0
Selenium (Se)	5	-	0.05	2.5	0
Sodium (Na)	50	-	23,000	60	0
Vanadium	5	500	160	2.5	0
Zinc (Zn)	5	300 (14,000)	75	6	0
Exchangeable Cations	All units in meq/100g (except ESP in %)				
Exch. Calcium	0.1	-	-	20.7	-
Exch. Magnesium	0.1	-	-	0.5	-
Exch. Potassium	0.1	-	-	0.3	-
Exch. Sodium	0.1	-	-	<0.1	-
Cation Exchange Capacity	0.1	-	-	21.6	-
Exchangeable Sodium Percentage (ESP)	0.1 %	-	-	0.3	-
Calcium/Magnesium Ratio	0.1 %	-	-	41.4	-

Notes < indicates less than the analytical detection limit. Shaded cells exceed applied guideline limit.

1. NEPC (1999). National Environmental Protection Council (NEPC). National Environmental Protection (Assessment of Site Contamination) Measure (NEPM). Guideline on investigation levels for soil and groundwater. Environmental Investigation Level with Health Investigation Level HIL(E); parks, recreation open space and playing fields shown in parenthesis of Site Contamination) Measure (NEPM). Guideline on investigation levels for soil and groundwater. Background and HIL(E); parks, recreation open space and playing fields.

* Guideline level for Cr(VI) = 200 mg/kg. Guideline level for Cr(III) = 24% of total Cr.

GAIs greater than or equal to 3 are highlighted.

1. Bowen H.J.M.(1979) Environmental Chemistry of the Elements, Academic Press, New York, p36-37.

4.5 Water Quality

In order to evaluate the likely initial water quality and solubility of metals/metalloids from heap leach materials, water extract (1:5 w/v sample:water) tests were completed for the composite heap leach rock sample and results are provided in **Table 3**.

The water extract has a neutral pH of 7.4 and a relatively low EC/salinity value of 551 $\mu\text{S}/\text{cm}$. The current total alkalinity of the water extract is 10 mg/L CaCO_3 , mainly due to the presence of bicarbonate. The dominant major soluble ions are potassium, bicarbonate, and sulfate although the concentration of all major soluble ions is relatively low. The soluble sulfate concentration is low (22 mg/L) and well below the applied water quality guideline criterion (1,000 mg/L; ANZECC, 2000).

There are no specific regulatory criteria for metal/metalloid concentrations in leachate from mine rock materials on mine sites in Queensland. As such, RGS has compared the multi-element results in water extracts from the composite heap leach rock sample with Australian guidelines to provide some context for discussion of test results (ANZECC, 2000; and NEPC, 1999b). The concentration of all trace metals/metalloids tested in the water extracts is low, predominantly below the laboratory limit of reporting, and below the applied water quality guideline criteria, where these exist. Hence, the risk of potential impact on the quality of surface and groundwater from heap leach rock materials at Yandan should be very low, although if this material is used for rehabilitation, this finding should be confirmed by the site water quality monitoring program.

Table 3: Multi-Element Results for Water Extracts from Heap Leach Rock Composite - Yandan Project

Parameters	Detection Limit	Guideline Levels ¹	Heap Leach Rock Composite
pH	0.1 pH unit	-	7.4
Electrical Conductivity	1 µS/cm	-	551
Total Alkalinity (mgCaCO ₃ /L)	0.2 mg/L	-	10
Bicarbonate Alkalinity (mgCaCO ₃ /L)	0.2 mg/L	-	10
Carbonate Alkalinity (mgCaCO ₃ /L)	0.2 mg/L	-	<0.2
Major Ions	All element concentrations in mg/L		
Calcium (Ca)	0.2	1,000	4
Magnesium (Mg)	0.2	-	1
Potassium (K)	0.2	-	15
Sodium (Na)	0.2	-	7
Chloride (Cl)	0.2	-	5
Sulfate (SO ₄)	0.2	1,000	22
Metals/Metalloids	All element concentrations in mg/L		
Aluminium (Al)	0.002	5	0.016
Antimony (Sb)	0.0002	-	0.0008
Arsenic (As)	0.0002	0.5	0.0134
Cadmium (Cd)	0.00002	0.01	<0.002
Chromium (Cr)	0.0002	1 / -	<0.002
Cobalt (Co)	0.0002	1	0.0012
Copper (Cu)	0.0002	1 / 0.5	0.0020
Iron (Fe)	0.01	-	<0.2
Lead (Pb)	0.0002	0.1	<0.002
Manganese (Mn)	0.0002	-	0.0004
Mercury (Hg)	0.00002	0.002	<0.002
Molybdenum (Mo)	0.0002	0.15	0.0014
Nickel (Ni)	0.0002	1	0.0002
Selenium (Se)	0.002	0.02	<0.002
Vanadium (V)	0.002	- / 0.1	<0.002
Zinc (Zn)	0.001	20	<0.002

Notes: < Indicates concentration less than the detection limit.

Shaded cells indicate values which exceed applied ANZECC/NEPC guideline values.

1. The first guideline level shown refers to ANZECC (2000) and the second to NEPC (1999). Where the two guidelines limits for a given element are in agreement, only one value is shown. A 'dash' represents no trigger value provided for this element.

a. ANZECC and ARMCA NZ, Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT (2000). Livestock drinking water (cattle).

b. NEPC (1999b). National Environment Protection Council (NEPC). National Environmental Protection (Assessment of Site Contamination) Measure (NEPM) Guideline on investigation levels for soil and groundwater. Groundwater Investigations Levels (Agricultural: Livestock).

4.6 Kinetic Leach Column (KLC) Tests

A KLC test program was completed from September 2012 to September 2013 for the composite heap leach rock sample using the methodology described in **Section 3.2** and **Attachment A**. The geochemical results obtained for the KLC test are presented at **Table 4** and **Figures KLC1a to KLC1d**. The results of the static and KLC test program available to date indicate that:

- Leachate from heap leach rock should be pH neutral (to slightly alkaline) and contain relatively low concentrations of soluble salts (**Figure KLC1a**).
- Heap leach rock will generate negligible acidity in leachate, much less than the inherent alkalinity value, leading to a positive net alkalinity value (**Figure KLC1b**);
- The dominant major ions in leachate from heap leach rock tend to be calcium, potassium, bicarbonate and sulfate. Overall, the concentration of major ions in leachate is relatively low.
- The concentrations of soluble calcium and magnesium in leachate from the KLC tests have been used to calculate the residual ANC in this material. The residual ANC appears to remain high (>99.3 %) after 12 months of leaching (**Figure KLC1c**);
- The concentration of soluble sulfate in leachate from the KLC tests has been used to calculate the residual sulfur content of the sample materials. The results indicate that about half of the sulfur content of the heap leach rock material remains (49.8 %) after 12 months of leaching;
- The molar ratio of soluble sulfate to calcium plus magnesium ($\text{SO}_4:\text{Ca}+\text{Mg}$) in KLC test leachate is elevated for the first two leach events indicating flushing of soluble sulfate salts from the column material. However, the sulfate to calcium plus magnesium molar ratio reduces significantly after the first two leach events indicating that soluble sulfate is being flushed from the heap leach rock at a slower rate than calcium and magnesium (**Figure KLC1c**); and
- The concentration of soluble trace metals/metalloids in KLC leachate from the heap leach rock sample is very low, typically below the laboratory limit of reporting, and well within the applied water quality guideline criteria (**Figure KLC1d**).

Table 4: KLC Test Results for Heap Leach Rock Composite Sample

Sample Weight (kg)	1.56	Total S (%)	0.01	ANC (kg H ₂ SO ₄ /t)	14.25			
pH(1:5)	8.7	CRS (%)	-	NAPP (kg H ₂ SO ₄ /t)	-13.8			
EC(1:5) (µS/cm)	241	MPA (kg H2SO4/t)	0.41	ANC:MPA ratio	34.9			
Date	21-Sep-12	19-Oct-12	20-Nov-12	21-Dec-12	19-Mar-13	20-Jun-13	20-Sep-13	
Leach Number	1	2	3	4	5	6	7	
Volume Collected (L)	0.682	0.776	0.839	0.788	0.765	0.714	0.799	
Cum. Volume (L)	0.68	1.46	2.30	3.09	3.85	4.56	5.36	
Pore Volumes	0.5	1.1	1.7	2.3	2.9	3.4	4.0	
pH	7.24	8.43	8.27	8.38	7.48	7.19	7.43	
EC (mS/cm)	558	110	66	78	59	244	74	
Acidity (mg/L)*	3	<1	<1	2	3	5	2	
Alkalinity (mg/L)*	52	27	22	24	19	58	43	
Net Alkalinity (mg/L)*	49	27	22	22	16	53	41	
Dissolved elements (mg/L)								Guideline Levels ¹
Aluminium (Al)	0.08	0.22	0.20	0.15	0.08	0.08	0.18	5
Arsenic (As)	0.067	0.025	0.02	0.016	0.011	0.082	0.022	0.5
Calcium (Ca)	19	8	7	7	5	14	8	1,000
Cadmium (Cd)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.01
Chloride (Cl)	26	2	<1	4	9	9	1	-
Cobalt (Co)	0.006	<0.001	<0.001	<0.001	<0.001	0.00	<0.001	1
Chromium (Cr)	<0.001	<0.001	0.005	0.002	<0.001	<0.001	<0.001	1 / -
Copper (Cu)	0.01	<0.001	0.001	<0.001	<0.001	0.004	0.001	1 / 0.5
Iron (Fe)	<0.05	0.08	0.15	<0.05	0.06	0.07	0.12	-
Mercury (Hg)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002
Potassium (K)	75	8	5	5	4	35	7	-
Magnesium (Mg)	3	<1	<1	<1	1	2	2	-
Manganese (Mn)	0.002	0.001	0.002	0.001	0.001	0.002	0.002	-
Molybdenum (Mo)	0.007	0.002	0.001	<0.001	<0.001	0.005	<0.001	0.15 / 0.01
Sodium (Na)	37	4	2	3	7	14	5	-
Nickel (Ni)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1
Lead (Pb)	<0.001	0.001	0.001	<0.001	<0.001	0.00	0.001	0.1
Sulphate (SO ₄)	108	137	12	9	8	39	5	1,000
Antimony (Sb)	0.004	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	-
Selenium (Se)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02
Vanadium (V)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	- / 0.1
Zinc (Zn)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	20
RESULTS**								
SO ₄ Release Rate	47	68	6	5	4	18	3	
Cumulative SO ₄ Release	47	115	122	126	130	148	151	
Ca Release Rate	8	4	4	4	2	6	4	
Cumulative Ca Release	8	12	16	20	22	28	33	
Mg Release Rate	1.3	0.2	0.3	0.3	0.5	0.9	1.0	
Cumulative Mg Release	1.3	1.6	1.8	2.1	2.6	3.5	4.5	
Residual ANC (%)	99.8	99.7	99.7	99.6	99.5	99.4	99.3	
Residual Sulfur (%)	84.3	61.5	59.4	57.9	56.6	50.6	49.8	
SO ₄ /(Ca+Mg) molar ratio	1.9	6.5	0.6	0.5	0.5	0.9	0.2	

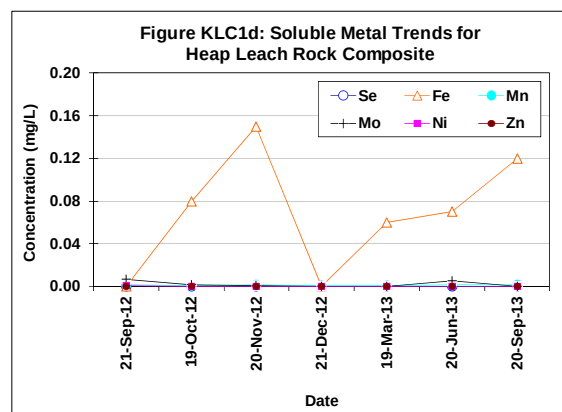
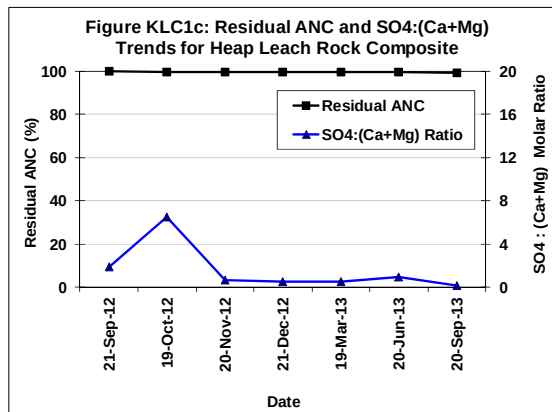
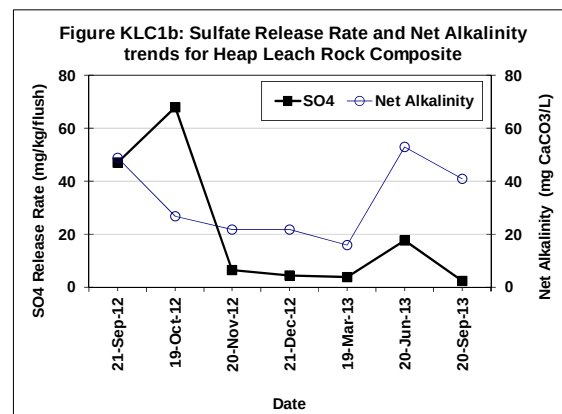
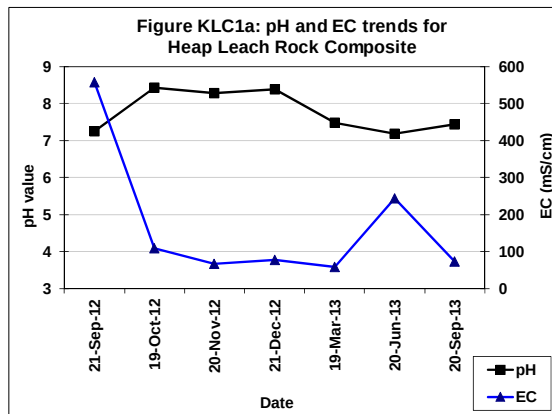
< indicates less than the analytical detection limit.

* Acidity and Alkalinity data calculated in mg CaCO₃/L

** SO₄, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur, SCR = Chromium Reducible Sulfur, MPA = Maximum Potential Acidity, ANC = Acid Neutralising Capacity, and NAPP = Net Acid Producing Potential

1. The first guideline level shown refers to ANZECC (2000) and the second to NEPC (1999). Where the two guidelines limits for a given element are in agreement, only one value is shown. A 'dash' represents no trigger value provided for this element.



5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

RGS has completed a geochemical assessment of representative samples of TSF Cell B cover and tailings materials and heap leach rock material from Yandan gold mine. The geochemical test results obtained to date indicate that:

- Cell B tailings materials have a reduced pH and elevated salinity value, and acidity and salts appear to be migrating from the tailings into the 1m cover at the tailings rehabilitation trial area, probably due to capillary rise effects. It is unlikely that a 1m cover will be sufficiently thick to prevent this capillary effect and this could impact upon the potential success of any rehabilitation efforts at the cover surface. It is possible that a thicker cover could assist to reduce or eliminate the rise of acid and salts from the tailings to the tailings cover surface; and
- The heap leach rock material appears to be geochemically benign and, on the basis of the samples provided and results received, is classified as NAF and therefore there is negligible risk of acid generation from these materials. This type of rock material should not present any significant risk to the environment with respect to total metal concentrations in solids and poses negligible risk of potential impact on the quality of surface and groundwater. In addition, heap leach rock is unlikely to have structural stability problems related to potential dispersion and erosion and may be suitable for rehabilitation activities at the site.

5.2 Recommendations

As a result of the findings of this geochemical assessment program it is recommended that Straits Resources considers:

- A site visit by RGS personnel to assess the status of the current TSF, collect and review available site information (*eg.* surface runoff and seepage quality monitoring data), and take representative samples of tailings materials;
- A static and kinetic geochemical test program on representative samples of tailings materials. A description of a typical geochemical assessment program for mine waste materials (*eg.* tailings) is provided at **Attachment A**;
- Preparation of a review report to include the findings of the site visit, an interpretation of the geochemical test program, conclusions and recommendations for potential management measures to mitigate the AMD currently being generated from the TSF; and
- An alternative method of covering/rehabilitating tailings at the TSF (such as a thicker cover) to reduce or eliminate the current upward migration of acidity and salts into the cover system.

6.0 REFERENCES

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AMIRA (2002). *ARD Test Handbook: Project 387A Prediction and Kinetic Control of Acid Mine Drainage*. Australian Minerals Industry Research Association, Ian Wark Research Institute and Environmental Geochemistry International Pty Ltd, May 2002.

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Parker G. and Robertson A. M. (1999). *Acid Drainage*. Occasional paper published by the Australian Minerals and Energy Environment Foundation (AMEEF), November, 1999, Melbourne, Victoria, Australia.

7.0 LIMITATIONS

RGS Environmental Pty Ltd (RGS) has prepared this report for the use of LRS Environmental Pty Ltd (LRS) and Straits Gold Pty Ltd. It is based on accepted consulting practices and standards and no other warranty is made as to the professional advice included in this report. This report was prepared from August 2012 to October 2013 and is based on the information and samples provided by LRS at the time of preparation. RGS disclaims responsibility for any changes that may have occurred after this time.

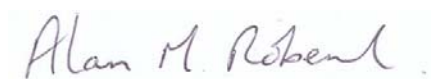
The sources of information and methodology used by RGS are outlined in this report and no independent verification of this information has been made. RGS assumes no responsibility for any inaccuracies or omissions, although no indication was found that any information contained in this report as provided to RGS was incorrect.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not provide legal advice, which can only be given by qualified legal practitioners.

If you have any questions regarding the information presented in this report, please contact the undersigned on 07 3856 5591 or 0431 620 623.

Yours sincerely,

RGS ENVIRONMENTAL PTY LTD



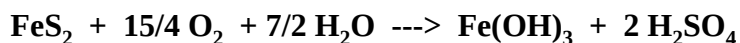
Dr. Alan Robertson
Principal Geochemist/Director

ATTACHMENT A

GEOCHEMICAL ASSESSMENT OF MINE WASTE MATERIALS

A1. ACID GENERATION AND PREDICTION

Acid generation is caused by the exposure of sulfide minerals, most commonly pyrite (FeS_2), to atmospheric oxygen and water. Sulfur assay results are used to calculate the maximum acid that could be generated by the sample by either directly determining the pyritic S content or assuming that all sulfur not present as sulfate occurs as pyrite. Pyrite reacts under oxidising conditions to generate acid according to the overall reaction:



According to this reaction, the maximum potential acidity (MPA) of a sample containing 1%S as pyrite would be 30.6 kg H_2SO_4 /t. The chemical components of the acid generation process consist of the above sulfide oxidation reaction and acid neutralization, which is mainly provided by inherent carbonates and to a lesser extent silicate materials. The amount and rate of acid generation is determined by the interaction and overall balance of the acid generation and neutralisation components.

Net Acid Producing Potential

The net acid producing potential (NAPP) is used as an indicator of materials that may be of concern with respect to acid generation. The NAPP calculation represents the balance between the maximum potential acidity (MPA) of a sample, which is derived from the sulfide sulfur content, and the acid neutralising capacity (ANC) of the material, which is determined experimentally. By convention, the NAPP result is expressed in units of kg H_2SO_4 /t sample. If the capacity of the solids to neutralise acid (ANC) exceeds their capacity to generate acid (MPA), then the NAPP of the material is negative. Conversely, if the MPA exceeds the ANC, the NAPP of the material is positive. A NAPP assessment involves a series of analytical tests that include:

Determination of pH and EC

pH and EC measured on 1:5 w/w water extract. This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

Total sulfur content, sulfate sulfur content, and Maximum Potential Acidity (MPA)

Total sulfur content is determined by the Leco high temperature combustion method. The total sulfur content is then used (in conjunction with the sulfate sulfur content) to calculate the MPA, which is based on the assumption that the entire sulfur content, minus the non-reactive sulfate sulfur content, is present as reactive pyrite. Direct determination of the pyritic sulfur content can provide a more accurate estimate of the MPA.

Acid neutralising capacity (ANC)

By addition of acid to a known weight of sample, then titration with NaOH to determine the amount of residual acid. The ANC measures the capacity of a sample to react with and neutralise acid. The ANC can be further evaluated by slow acid titration to a set end-point in the Acid Buffering Characteristic Curve (ABCC) test through calculation of the amount of acid consumed and evaluation of the resultant titration curve.

Net acid producing potential (NAPP)

Calculated from the MPA and ANC results. The NAPP represents the balance between a samples' inherent capacities to generate and neutralise acid. If the MPA is greater than the ANC then the NAPP is positive. If the MPA is less than the ANC then the sample then the NAPP is negative.

Net Acid Generation (NAG)

The net acid generation (NAG) test involves the addition of hydrogen peroxide to a sample of mine rock or process residue (tailings) to oxidise reactive sulfide, then measurement of pH and titration of any net acidity produced by the acid generation and neutralisation reactions occurring in the sample. A significant NAG result (*i.e.* final $\text{NAG}_{\text{pH}} < 4.5$) indicates that the sample is potentially acid forming (PAF) and the test provides a direct measure of the net amount of acid remaining in the sample after all acid generating and acid neutralising reactions have taken place. A $\text{NAG}_{\text{pH}} > 4.5$ indicates that the sample is non-acid forming (NAF). The NAG test provides a direct assessment of the potential for a material to produce acid after a period of exposure and weathering and is used to refine the results of the theoretical NAPP predictions. The NAG test can be used as a stand-alone test, but is recommended that this only be considered after site specific calibration work is carried out.

A2. ASSESSMENT OF ELEMENT ENRICHMENT AND SOLUBILITY

In mineralised areas it is common to find a suite of enriched elements that have resulted from natural geological processes. Multi-element scans are carried out to identify any elements that are present in a material (or readily leachable from a material) at concentrations that may be of environmental concern with respect to surface water quality, revegetation and public health. The samples are generally analysed for the following elements:

Major elements Al, Ca, Fe, K, Mg, Na and S.

Minor elements As, B, Cd, Co, Cr, Cu, F, Hg, Mn, Mo, Ni, Pb, Sb, Se and Zn.

The concentration of these elements in samples can be directly compared with relevant state or national environmental and health based concentration guideline criteria to

determine the level of significance. Water extracts are used to determine the immediate element solubilities under the existing sample pH conditions of the sample. The following tests are normally carried out:

Multi-element composition of solids. Multi-element composition of solid samples determined using a combination of ICP-mass spectroscopy (ICP-MS), ICP-optical emission spectroscopy (OES), and atomic absorption spectrometry (AAS).

Multi-element composition of water extracts (1:5 sample:deionised water). Multi-element composition of water extracts from solid samples determined using a combination of ICP-mass spectroscopy (ICP-MS), ICP-optical emission spectroscopy (OES), and atomic absorption spectrometry (AAS).

Under some conditions (*e.g.* low pH) the solubility and mobility of common environmentally important elements can increase significantly. If element mobility under initial pH conditions is deemed likely and/or subsequent low pH conditions may occur, kinetic leach column test work is generally undertaken on representative samples as described in **Section A3**.

A3. KINETIC LEACH COLUMN TESTS

Kinetic leach column tests can be used to provide information on the reaction kinetics of mine waste materials. The major objectives of kinetics tests are to:

- Provide time-dependent data on the kinetics and rate of acid generation and acid neutralising reactions under laboratory controlled (or onsite conditions);
- Investigate metal release and drainage/seepage quality; and
- Assess treatment options such as addition of alkaline materials.

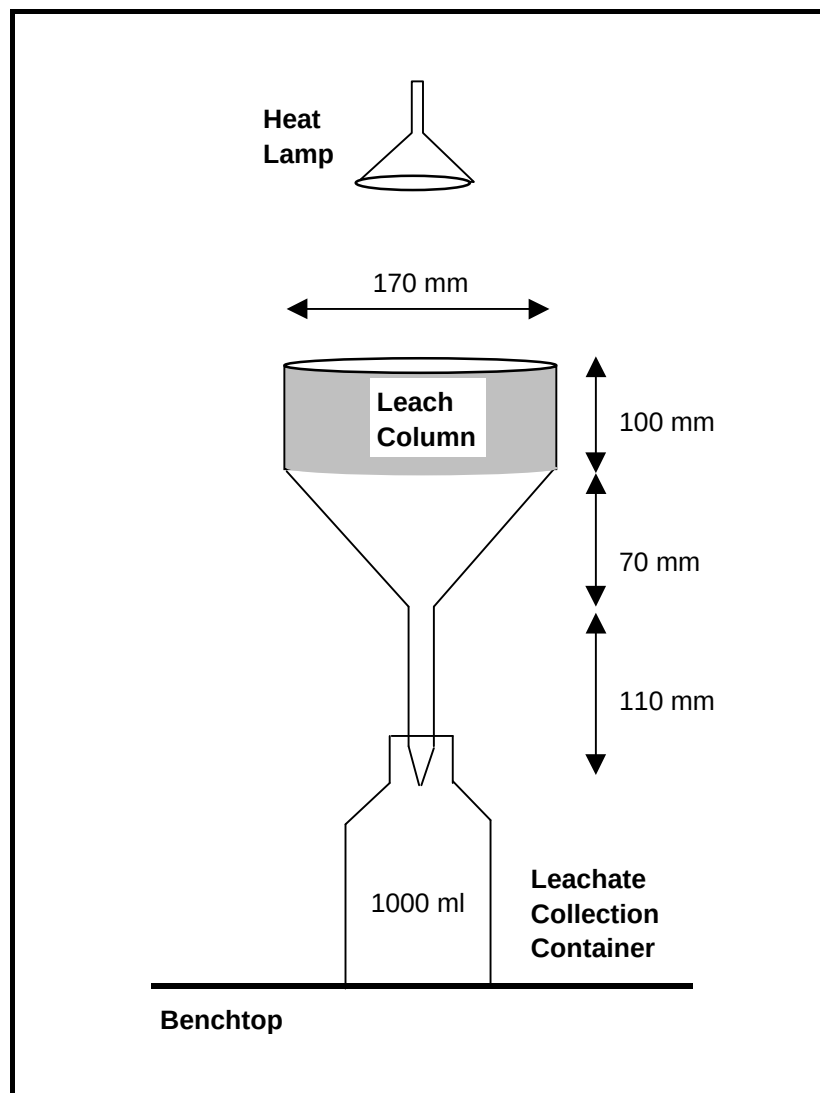
The kinetic tests simulate the weathering process that leads to acid and base generation and reaction under laboratory controlled or site conditions. The kinetic tests allow an assessment of the acid forming characteristics and indicate the rate of acid generation, over what period it will occur, and what management controls may be required.

In kinetic column leach tests, water is added to a sample and the mixture allowed to leach products and by-products of acid producing and consuming reactions. Samples of leachate are then collected and analysed. Intermittent water application is applied to simulate rainfall and heat lamps are used to simulate sunshine. These tests provide real-time information and may have to continue for months or years. Monitoring includes trends in pH, sulfate, acidity or alkalinity, and metals, for example. The pH of the collected leachate simulates the acid drainage process, acidity or alkalinity levels indicate the rate of acid production and acid neutralisation, and sulfate production can be related to the rate of sulfide oxidation. Metal concentration data provides an assessment of metal solubility and leaching behaviour.

Figure A1 shows the kinetic leach column set up used by RGS adapted from *AMIRA, 2002*. The columns are placed under heat lamps to allow the sample to dry between water additions to ensure adequate oxygen ingress into the sample material.

Approximately 2-3 kg of sample is generally used in the leach columns and depending on the physical nature of the material and particle size can be used on an as-received basis (*i.e.* no crushing as with process residues) or crushed to nominal 5-10 mm particle size (as with overburden). The sample in the column is initially leached with deionised water at a rate of about 500 ml/kg of sample and the initial leachate from the columns collected and analysed. Subsequent column leaching is carried out at a rate of about 500 ml/kg per month and again collected and analysed. The leaching rate can be varied to better simulate expected site conditions or satisfy test program data requirements. The column must be exposed to drying conditions in between watering events. The residual water content and air void content in the column can be determined by comparing the wet and dry column weights. A heat lamp is generally used above the sample during daylight hours to maintain the leach column surface temperature at about 30°C.

Figure A1
Kinetic Leach Column Setup



Reference:

AMIRA (2002). AMIRA International. *ARD Test Handbook. Project P387A Prediction & Kinetic Control of Acid Mine Drainage*. Ian Wark Institute and Environmental Geochemistry International Pty Ltd. May 2002, Melbourne, VIC.

ATTACHMENT B

ALS LABORATORY RESULTS

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1221303	Page	: 1 of 14
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
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Telephone	: +61 07 3856 5591	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3856 5591	Facsimile	: +61 7 3243 7218
Project	: 111207	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 13-AUG-2012
Sampler	: Gill Fletcher	Issue Date	: 28-AUG-2012
Site	: Yandan		
Quote number	: BN/413/12	No. of samples received	: 53
		No. of samples analysed	: 53

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited
Laboratory 825

Accredited for
compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Andrew Epps	Metals Production Chemist	Brisbane Inorganics
Andrew Epps	Metals Production Chemist	Stafford Minerals - AY
SATISH.TRIVEDI	2 IC Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

- **ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.**



Analytical Results

Sub-Matrix: **ROCK** (Matrix: **SOIL**)

Client sample ID

Client sampling date / time

				HL 1	HL 2	HL 3	HL 4	HL 5
				02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00
Compound	CAS Number	LOR	Unit	EB1221303-048	EB1221303-049	EB1221303-050	EB1221303-051	EB1221303-052
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.6	8.1	9.4	9.1	10.0
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-6.0	-2.9	-32.7	-6.2	-31.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	440	181	140	332	131
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	6.3	3.5	33.3	6.2	32.4
ANC as CaCO3	----	0.1	% CaCO3	0.6	0.4	3.4	0.6	3.3
Fizz Rating	----	0	Fizz Unit	0	0	2	0	2
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.01	0.02	0.02	<0.01	0.02



Analytical Results

Sub-Matrix: **ROCK** (Matrix: **SOIL**)

Client sample ID

				HL 6	----	----	----	----
				02-AUG-2012 15:00	----	----	----	----
				EB1221303-053	----	----	----	----
<i>Compound</i>	<i>CAS Number</i>	<i>LOR</i>	<i>Unit</i>					
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	9.6	----	----	----	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-3.8	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	221	----	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	3.8	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	0.4	----	----	----	----
Fizz Rating	----	0	Fizz Unit	0	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	----	----	----	----



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

				TRT 0-250 1	TRT 250-500 1	TRT 500-750 1	TRT 750-1000 1	TRT 0-250 2
Client sampling date / time				02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00
Compound	CAS Number	LOR	Unit	EB1221303-001	EB1221303-002	EB1221303-003	EB1221303-004	EB1221303-005
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.6	4.7	4.1	3.8	4.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	2620	2440	1670	1270	1520



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

				TRT 250-500 2	TRT 0-200 3	TRT 200-400 3	TRT 0-250 4	TRT 250-500 4
Client sampling date / time				02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00
Compound	CAS Number	LOR	Unit	EB1221303-006	EB1221303-007	EB1221303-008	EB1221303-009	EB1221303-010
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	3.9	4.1	4.1	4.3	4.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1320	892	795	585	632



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

				TRT 500-600 4	TRT 0-250 5	TRT 250-500 5	TRT 500-600 5	TRT 0-250 6
Client sampling date / time				02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00
Compound	CAS Number	LOR	Unit	EB1221303-011	EB1221303-012	EB1221303-013	EB1221303-014	EB1221303-015
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	4.1	4.0	3.9	3.6	4.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	525	2280	1440	1460	473



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

				TRT 250-500 6	TRT 0-250 7	TRT 250-500 7	TRT 0-150 8	TRT 150-300 8
Client sampling date / time				02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00
Compound	CAS Number	LOR	Unit	EB1221303-016	EB1221303-017	EB1221303-018	EB1221303-019	EB1221303-020
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	3.9	3.9	3.8	3.8	3.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	701	892	960	2040	1390



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

				TRT 0-150 9	TRT 150-300 9	TRT 0-150 10	TRT 150-300 10	TRT 0-250 11
Client sampling date / time				02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00
Compound	CAS Number	LOR	Unit	EB1221303-021	EB1221303-022	EB1221303-023	EB1221303-024	EB1221303-025
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	4.2	4.0	4.7	4.3	6.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1480	866	924	1700	149



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

				TRT 250-500 11	TRT 0-100 12	TRT 100-200 12	TRT 0-75 13	TRT 75-150 13
Client sampling date / time				02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00
Compound	CAS Number	LOR	Unit	EB1221303-026	EB1221303-027	EB1221303-028	EB1221303-029	EB1221303-030
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	4.2	5.0	4.6	6.0	5.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1020	704	698	568	1060



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

				TRT 0-75 14	TRT 0-10 15	TRT 0-250 1 (T)	TRT 0-250 2 (T)	TRT 0-250 3 (T)
Client sampling date / time				02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00
Compound	CAS Number	LOR	Unit	EB1221303-031	EB1221303-032	EB1221303-033	EB1221303-034	EB1221303-035
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.2	5.8	3.6	3.9	3.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	343	81	1710	905	1290



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

				TRT 0-250 4 (T)	TRT 0-250 5 (T)	TRT 0-250 6 (T)	TRT 0-250 7 (T)	TRT 0-250 8 (T)
Client sampling date / time				02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00
Compound	CAS Number	LOR	Unit	EB1221303-036	EB1221303-037	EB1221303-038	EB1221303-039	EB1221303-040
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	4.0	3.6	4.0	3.6	3.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	649	1670	796	1620	1670



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

				TRT 0-250 9 (T)	TRT 0-250 10 (T)	TRT 0-250 11 (T)	TRT 0-250 12 (T)	TRT 0-250 13 (T)
Client sampling date / time				02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00	02-AUG-2012 15:00
Compound	CAS Number	LOR	Unit	EB1221303-041	EB1221303-042	EB1221303-043	EB1221303-044	EB1221303-045
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	3.8	4.0	4.1	4.5	4.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1280	1440	1480	701	1640



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)

Client sample ID

				TRT 0-250 14 (T)	TRT 0-250 15 (T)	----	----	----
Client sampling date / time				02-AUG-2012 15:00	02-AUG-2012 15:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1221303-046	EB1221303-047	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.8	7.0	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	1200	48	----	----	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1225133	Page	: 1 of 3
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
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Telephone	: +61 07 3856 5591	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3856 5591	Facsimile	: +61 7 3243 7218
Project	: Yandan (111207)	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 21-SEP-2012
Sampler	: ----	Issue Date	: 28-SEP-2012
Site	: ----		
Quote number	: BN/413/12	No. of samples received	: 1
		No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics



General Comments

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- **EG005T (Total Metals): Sample EB1225062-001 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.**
- **EG005T (Total Metals): Sample EB1225133-001 (Heap Leach Composite 1) shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.**



Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)

Client sample ID

Client sampling date / time

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	Heap Leach Composite 1	----	----	----	----
				Client sampling date / time	21-SEP-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1225133-001	----	----	----	----	----
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1.0	%	11.9	----	----	----	----	----
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g	20.7	----	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	0.5	----	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	0.3	----	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	----	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	21.6	----	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	0.3	----	----	----	----	----
ED093T: Total Major Cations									
Sodium	7440-23-5	50	mg/kg	60	----	----	----	----	----
Potassium	7440-09-7	50	mg/kg	590	----	----	----	----	----
Calcium	7440-70-2	50	mg/kg	13000	----	----	----	----	----
Magnesium	7439-95-4	50	mg/kg	1080	----	----	----	----	----
EG005T: Total Metals by ICP-AES									
Aluminium	7429-90-5	50	mg/kg	850	----	----	----	----	----
Antimony	7440-36-0	5	mg/kg	8	----	----	----	----	----
Cobalt	7440-48-4	2	mg/kg	<2	----	----	----	----	----
Iron	7439-89-6	50	mg/kg	9000	----	----	----	----	----
Manganese	7439-96-5	5	mg/kg	45	----	----	----	----	----
Molybdenum	7439-98-7	2	mg/kg	<2	----	----	----	----	----
Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----	----
Vanadium	7440-62-2	5	mg/kg	<5	----	----	----	----	----
Arsenic	7440-38-2	5	mg/kg	67	----	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----	----
Chromium	7440-47-3	2	mg/kg	4	----	----	----	----	----
Copper	7440-50-8	5	mg/kg	<5	----	----	----	----	----
Lead	7439-92-1	5	mg/kg	<5	----	----	----	----	----
Nickel	7440-02-0	2	mg/kg	2	----	----	----	----	----
Zinc	7440-66-6	5	mg/kg	6	----	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg	<0.1	----	----	----	----	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1225112	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services
Address	: 18 INGLIS STREET GRANGE QLD, AUSTRALIA 4051	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3856 5591	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3856 5591	Facsimile	: +61 7 3243 7218
Project	: 111207-Yandan	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 21-SEP-2012
Sampler	: Mandie Matheson	Issue Date	: 27-SEP-2012
Site	: Yandan		
Quote number	: BN/413/12	No. of samples received	: 1
		No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



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Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics



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Analytical Results

Sub-Matrix: **LEACHATE (Matrix: WATER)**

Client sample ID

				Yandan - 1	----	----	----	----
				21-SEP-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1225112-001	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.38	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	551	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	52	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	52	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	3	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	108	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	26	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	19	----	----	----	----
Magnesium	7439-95-4	1	mg/L	3	----	----	----	----
Sodium	7440-23-5	1	mg/L	37	----	----	----	----
Potassium	7440-09-7	1	mg/L	75	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.08	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	0.004	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.067	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	0.010	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	0.006	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.002	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.007	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----



Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)

Client sample ID

Client sampling date / time

				Yandan - 1	----	----	----	----
				21-SEP-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1225112-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1227325	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services
Address	: 18 INGLIS STREET GRANGE QLD, AUSTRALIA 4051	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3856 5591	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3856 5591	Facsimile	: +61 7 3243 7218
Project	: 111207	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 19-OCT-2012
Sampler	: Mandie Matheson	Issue Date	: 25-OCT-2012
Site	: ----		
Quote number	: BN/413/12	No. of samples received	: 1
		No. of samples analysed	: 1

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Analytical Results

Sub-Matrix: **LEACHATE (Matrix: WATER)**

Client sample ID

Client sampling date / time

				Yandan - 1	----	----	----	----
				[19-OCT-2012]	----	----	----	----
<i>Compound</i>	<i>CAS Number</i>	<i>LOR</i>	<i>Unit</i>	EB1227325-001	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	9.01	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	92	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	8	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	18	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	27	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	137	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	2	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	8	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	4	----	----	----	----
Potassium	7440-09-7	1	mg/L	8	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.22	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.025	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.001	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.002	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----



Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)

Client sample ID

Client sampling date / time

				Yandan - 1	----	----	----	----
				[19-OCT-2012]	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1227325-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Iron	7439-89-6	0.05	mg/L	0.08	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1230208	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services
Address	: 18 INGLIS STREET GRANGE QLD, AUSTRALIA 4051	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3856 5591	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3856 5591	Facsimile	: +61 7 3243 7218
Project	: 111207 Yandan	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 20-NOV-2012
Sampler	: Mandie Matheson	Issue Date	: 27-NOV-2012
Site	: ----		
Quote number	: BN/413/12	No. of samples received	: 1
		No. of samples analysed	: 1

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Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics



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^ = This result is computed from individual analyte detections at or above the level of reporting



Analytical Results

Sub-Matrix: **LEACHATE (Matrix: WATER)**

Client sample ID

				Yandan - 1	----	----	----	----
				20-NOV-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1230208-001	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	9.09	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	67	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	6	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	16	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	22	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	12	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	<1	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	7	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	2	----	----	----	----
Potassium	7440-09-7	1	mg/L	5	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.20	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.020	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	0.005	----	----	----	----
Copper	7440-50-8	0.001	mg/L	0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.002	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----



Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	Yandan - 1	----	----	----	----
				Client sampling date / time	20-NOV-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1230208-001	----	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----	----
Iron	7439-89-6	0.05	mg/L	0.15	----	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1233394	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services
Address	: 18 INGLIS STREET GRANGE QLD, AUSTRALIA 4051	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3856 5591	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3856 5591	Facsimile	: +61 7 3243 7218
Project	: 111207 Yandan	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 21-DEC-2012
Sampler	: Mandie Matheson	Issue Date	: 04-JAN-2013
Site	: ----		
Quote number	: BN/413/12	No. of samples received	: 1
		No. of samples analysed	: 1

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Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics



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LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting



Analytical Results

Sub-Matrix: **LEACHATE (Matrix: WATER)**

Client sample ID

Yandan - 1

Client sampling date / time

21-DEC-2012 15:00

Compound	CAS Number	LOR	Unit	EB1233394-001	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.36	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	76	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	23	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	24	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	2	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	9	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	4	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	7	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	3	----	----	----	----
Potassium	7440-09-7	1	mg/L	5	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.15	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.016	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	0.002	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.001	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----



Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)

Client sample ID

Client sampling date / time

				Yandan - 1	----	----	----	----
				21-DEC-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1233394-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1306901	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services
Address	: 18 INGLIS STREET GRANGE QLD, AUSTRALIA 4051	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3856 5591	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3856 5591	Facsimile	: +61 7 3243 7218
Project	: 11207 Yandan	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 19-MAR-2013
Sampler	: Mandie Matheson	Issue Date	: 26-MAR-2013
Site	: ----		
Quote number	: BN/413/12	No. of samples received	: 1
		No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Jonathon Angell	Inorganic Coordinator	Brisbane Inorganics
Jonathon Angell	Inorganic Coordinator	Brisbane Inorganics
Jonathon Angell	Inorganic Coordinator	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics



General Comments

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LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting



Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)

Client sample ID

				Yandan - 1	----	----	----	----
				19-MAR-2013 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1306901-001	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.67	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	49	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L	19	----	----	----	----
Total Alkalinity as CaCO ₃	----	1	mg/L	19	----	----	----	----
ED038A: Acidity								
Acidity as CaCO ₃	----	1	mg/L	3	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA								
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L	8	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	9	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	5	----	----	----	----
Magnesium	7439-95-4	1	mg/L	1	----	----	----	----
Sodium	7440-23-5	1	mg/L	7	----	----	----	----
Potassium	7440-09-7	1	mg/L	4	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.08	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.011	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.001	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----



Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)

Client sample ID

Client sampling date / time

				Yandan - 1	----	----	----	----
				19-MAR-2013 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1306901-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Iron	7439-89-6	0.05	mg/L	0.06	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1314889	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services
Address	: 18 INGLIS STREET GRANGE QLD, AUSTRALIA 4051	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3856 5591	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3856 5591	Facsimile	: +61 7 3243 7218
Project	: 111207 YANDAN	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 20-JUN-2013
Sampler	: Mandie Matheson	Issue Date	: 28-JUN-2013
Site	: YANDAN		
Quote number	: BN/413/12	No. of samples received	: 1
		No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

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- General Comments
- Analytical Results



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Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics



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LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting



Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)

Client sample ID

				Yandan - 1	----	----	----	----
				20-JUN-2013 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1314889-001	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.81	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	236	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L	58	----	----	----	----
Total Alkalinity as CaCO ₃	----	1	mg/L	58	----	----	----	----
ED038A: Acidity								
Acidity as CaCO ₃	----	1	mg/L	5	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA								
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L	39	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	9	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	14	----	----	----	----
Magnesium	7439-95-4	1	mg/L	2	----	----	----	----
Sodium	7440-23-5	1	mg/L	14	----	----	----	----
Potassium	7440-09-7	1	mg/L	35	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.08	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	0.002	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.082	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	0.004	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	0.002	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	0.002	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.002	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.005	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----



Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	Yandan - 1	----	----	----	----
				Client sampling date / time	20-JUN-2013 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1314889-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	----	----	----	----
Iron	7439-89-6	0.05	mg/L		0.07	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	----	----	----	----

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: EB1323021	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services
Address	: 18 INGLIS STREET GRANGE QLD, AUSTRALIA 4051	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3856 5591	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3856 5591	Facsimile	: +61 7 3243 7218
Project	: 111207 Yandan	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 20-SEP-2013
Sampler	: Mandie Matheson	Issue Date	: 26-SEP-2013
Site	: ----		
Quote number	: BN/413/12	No. of samples received	: 1
		No. of samples analysed	: 1

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This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics



General Comments

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LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting



Analytical Results

Sub-Matrix: LIQUID (Matrix: WATER)

Client sample ID

				Yandan - 1	----	----	----	----
				20-SEP-2013 10:50	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1323021-001	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	8.62	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	72	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	4	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	39	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	43	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	2	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	5	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	1	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	8	----	----	----	----
Magnesium	7439-95-4	1	mg/L	2	----	----	----	----
Sodium	7440-23-5	1	mg/L	5	----	----	----	----
Potassium	7440-09-7	1	mg/L	7	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.18	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.022	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.002	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----



Analytical Results

Sub-Matrix: LIQUID (Matrix: WATER)				Client sample ID	Yandan - 1	----	----	----	----
				Client sampling date / time	20-SEP-2013 10:50	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1323021-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Vanadium	7440-62-2	0.01	mg/L		<0.01	----	----	----	----
Iron	7439-89-6	0.05	mg/L		0.12	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		0.99	----	----	----	----
Total Cations	----	0.01	meq/L		0.96	----	----	----	----

31 July 2015
Project Number 201434
Revision C – Final Report

Straits Gold Pty Ltd
Suite 1, Level 2, HQ South Tower
520 Wickham Street, Fortitude Valley
Queensland 4006 Australia

Attention: Mr Ian Sheppard – Chief Operating Officer

Yandan Oxide and Sulfide Tailings Assessment

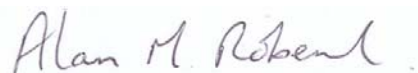
Dear Ian,

This letter report outlines the methods, results, findings, conclusions and recommendations of the geochemical assessment by RGS Environmental Pty Ltd (RGS) of 85 soil and oxide and sulfide tailings samples collected by Straits Gold Pty Ltd (Straits Gold) in October 2014.

We trust that this letter report fulfils your current requirements. Please contact Dr. Alan Robertson or Dr Greg Maddocks on 07 3344 1222 if you have any queries.

Yours sincerely,

RGS ENVIRONMENTAL PTY LTD



Dr. Alan Robertson
Principal Geochemist

1.0 INTRODUCTION

RGS Environmental Pty Ltd (RGS) was commissioned by Straits Gold Pty Ltd (Straits Gold) to complete a geochemical assessment of tailings from Cell B of the Yandan gold mine Tailings Storage Facility (TSF). The mine (now decommissioned) is located in the northern Drummond Basin of North Queensland, 230 km west of Mackay (**Figure 1-1**).



Figure 1-1: Site Location Map

1.1 Scope of Work

The RGS scope of work comprised:

- Coordination of static geochemical characterisation tests for 85 tailings samples.
- Completion of kinetic geochemical testing using kinetic leach columns (KLC) on both oxide and sulfide tailings.
- Tabulation and interpretation of static and kinetic geochemical test data.
- Provision of a letter report (this report), which provides the geochemical test results and the RGS interpretation of the results.
- Provision of recommendations for the management of selected mine materials with respect to potential Acid and Metalliferous Drainage (AMD) issues.

1.2 Purpose

The purpose of the testing program was to undertake static and kinetic testing on oxide and sulfide tailings samples to quantify the rate of acid production / consumption and the rate that major, minor and trace elements may be leached from free draining samples under laboratory conditions.

1.3 Objectives

The objectives included setting up small and large kinetic leach columns and testing them using a monthly leach cycling program. Leachate was collected from the columns each month and analysed for a range of chemical parameters to allow the rate of mineral dissolution to be quantified.

2.0 SAMPLING PROGRAM

Yandan TSF is divided into two cells (Cells A and B) and Cell B has a trial rehabilitation cover at the south eastern corner of the facility comprising oxidised waste rock material (**Figure 2-1**).

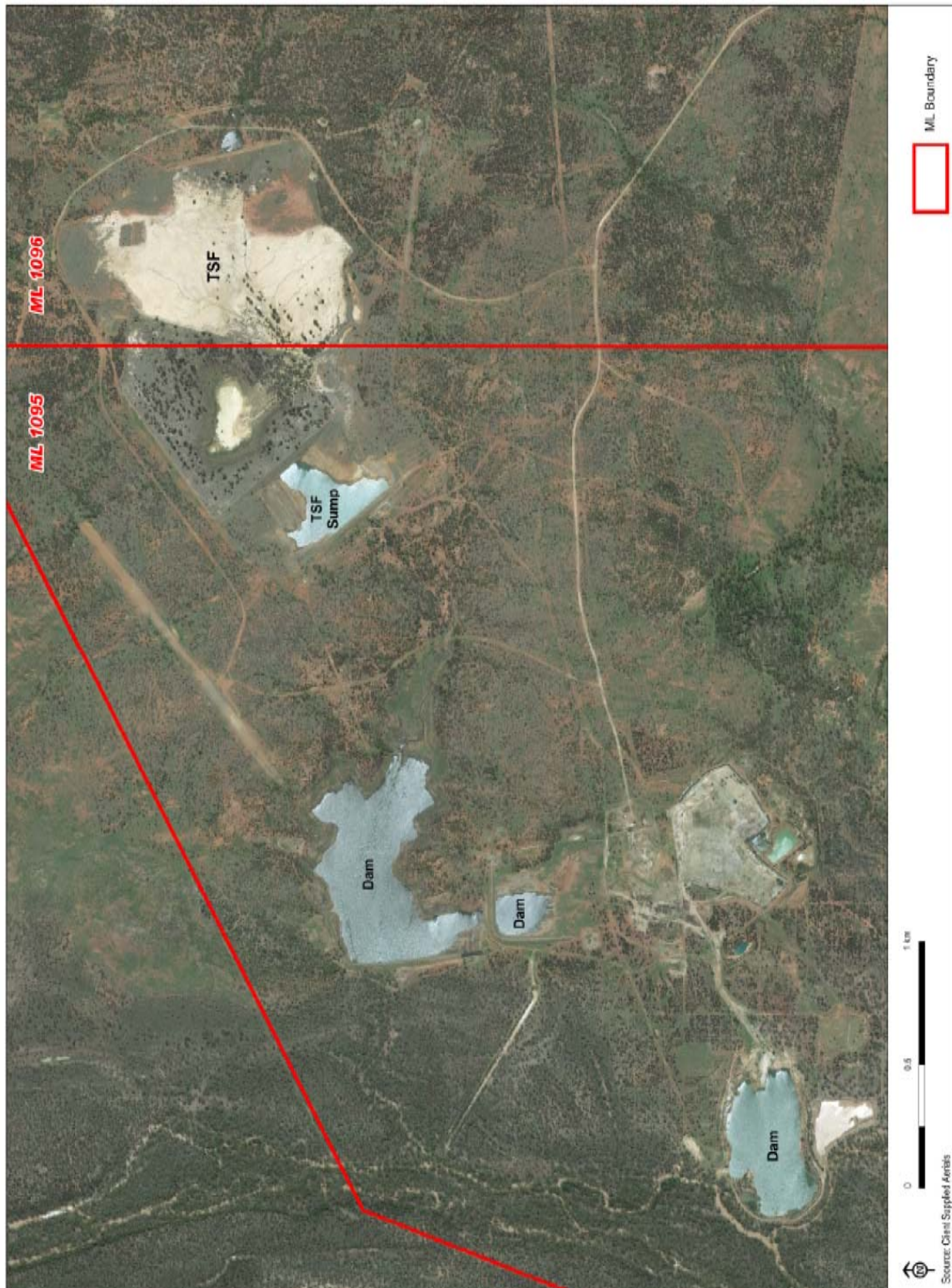


Figure 2-1: Site Layout

YANDAN TAILINGS ASSESSMENT

Straits Gold personnel collected 85 samples in Cell B using a tractor mounted auger to dig holes to up to 600mm depth from 7 to 9 October 2014. Samples of 1-2 kg weight were then collected from the wall of the augered hole within what was visually inferred to be oxide or sulfide tailings.

In the field, samples were described as soil, oxide tailings, sulfide tailings or a combination of oxide and sulfide tailings. The designation of tailings as being oxide or sulfide was based on Straits knowledge of the genesis of the ore processed at the operation and the depositional history of the tailings. Samples were placed into plastic bags and excess air was removed before the bags were sealed. The samples were sent to the RGS laboratory in Brisbane. Sample locations and depth are in **Table 2-1**. A map of the site including the location of the samples is provided in **Figure 2-2**.

Table 2-1: Tailings sample co-ordinates and sample interval information

Sample ID	Easting	Northing	Description
1	500223	7646721	0-100mm oxide (O)
2			100-300mm O
3			400-500 sulphide S
4	500244	7646749	0-500mm O
5			500-600mm S
6	500091	7646889	0-500mm O/S 50/50 Roots present (R)
7	500099	7646932	0-500mm O/S 50/50 R
8	500111	7646956	0-500mm O R to 200mm
9	500112	7647002	0-500mm O R to 100mm
10	500129	7647029	0-500mm O R to 50mm Oxide very hard
11	500136	7647055	0-500mm O/Minor S at 400-500mm
12	500149	7647096	0-500mm O R to 20mm
13	500155	7647138	0-500mm O R to 25mm
14	500169	7647178	0-500mm O Sandy R to 50mm
15	500217	7647170	0-500mm O 20mm crust
16	500204	7647124	0-500mm O Minor crust, R to 200mm
17	500191	7647077	0-500mm O R to 25mm
18	500187	7647042	0-500mm O R to 150mm
19	500187	7647014	0-500mm O R tp 150mm
20	500177	7646987	0-500mm O Minot S Sandy and dry R to 250mm
21	500170	7646954	0-500mm O R to 250mm
22	500157	7646912	0-100mm O R to 50mm
23			100-500mm 50/50 O/S trending to 10/90 O/S
24	500145	7646870	0-200mm O R to 50mm
25			200-500mm S
26	500191	7646890	0-200mm O R nil
27			200-500mm O/S 50/50 interlayered
28	500217	7646863	0-300mm O Some S at base R nil
29			300-500mm O/S mixed
30	500241	7646843	0-300mm O R nil
31			300-500mm O/S mixed
32	500264	7646820	0-500mm O/S mixed
33	500283	7646797	0-400mm O
34			400-500mm S
35	500306	7646778	0-300mm O
36			300-500mm S
37	500327	7646755	0-400mm O
38			400-500mm S
39	500349	7646733	0-500mm O Traces of S
40	500300	7646734	0-400mm O
41			400-500mm S

YANDAN TAILINGS ASSESSMENT

Sample ID	Easting	Northing	Description
42	500278	7646752	0-350mm O R nil
43			350-500mm S
44	500254	7646770	0-500mm O/S mixed R nil
45	500232	7646790	0-300mm O/S mixed
46	500211	7646810	0-300mm O
47			300-500mm S
48	500181	7646834	0-400mm O
49			400-500mm S
50	500160	7646857	0-500mm O to 100mm, O/S 100-400mm, S 400-500mm
51	500169	7646908	0-500mm O to 150mm, O/S 150-400mm, S 400-500mm
52	500186	7646945	0-300mm O
53			300-500mm O/S mixed
54	500227	7646919	0-400mm O
55			400-500mm O/S mixed
56	500262	7646949	0-300mm O
57			300-500mm S clear change
58	500292	7646981	0-100mm O, 400-500mm mixed
59	500322	7647019	0-100mm O, 100-500 O/S interlayered
60	500560	7647408	0-400mm O
61			400-500mm S
62	500600	7647471	0-300mm O
63			300-500mm S
64 Trial (T)	500597	7647542	0-100mm Topsoil
65 T			250-350mm Topsoil
66 T			350-450mm Tails
67 T	500577	7647560	0-100mm Topsoil
68 T			100-400mm O
69 T			400-500mm S
70 T	500578	7647602	0-100mm Topsoil
71 T			350-450mm Topsoil R to 250mm
72 T			450-550mm O
73	500563	7647830	400-500mm S Note reverse numbering for this hole
74			300mm Topsoil
75			0-100mm Topsoil
76 OR	500687	7646993	0-100mm Topsoil of a 600mm topsoil layer over S tailings
77 OR	500703	7646915	0-200 Topsoil Salty surface with no ground cover
78 OR			200-500mm S
79	500208	7646998	0-300mm O R to 300mm
80			300-500mm S
81	500271	7647266	0-300mm O
82			300-500mm S
83	500298	7647387	0-50mm O, 50-100mm S, 100-500mm O (combined sample)
84	500315	7647483	0-150mm S, 150-300mm O, 300-500mm S (combined sample)
85	500340	7647589	0-150mm O, 150-500 S/O 80/20

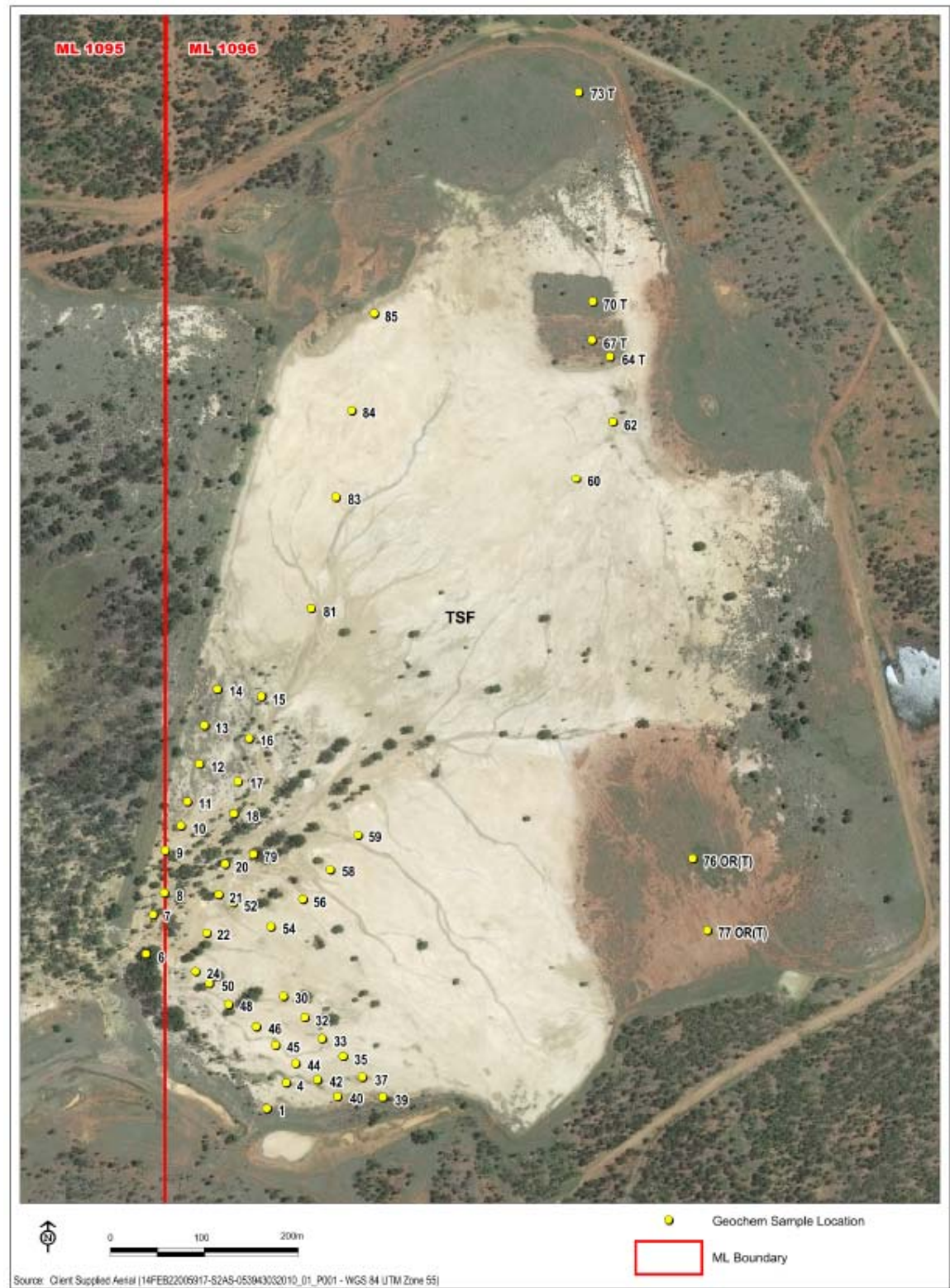


Figure 2-2: Sample Locations

3.0 STATIC TEST METHODS

3.1 Characterisation

Static geochemical tests provide a 'snapshot' of the geochemical characteristics of a sample at a single point in time. These tests were staged to screen a large number of samples before selecting either individual and/or composite samples for more detailed static test work. The Acid Base Account (ABA) was used as a screening procedure whereby the acid-neutralising and acid-generating characteristics of a material were assessed. The results of the screening assessment are discussed in **Section 5.0**.

The 85 samples received and viewed by RGS were transferred to ALS Laboratory in Brisbane for geochemical testing using standard methods and guidelines accepted in the mining industry (AMIRA, 2002; DITR, 2007; DME, 1995; and INAP 2009). All samples were pulverised and tested for:

- pH (1:5 w:v)
- Electrical Conductivity (EC) (1:5 w:v)
- Total sulfur [LECO high temperature method]
- Acid Neutralising Capacity [AMIRA, 2002]
- Net Acid Producing Potential (NAPP)

The results of the initial geochemical (screening) tests were used to select samples for supplementary testing including:

- Chromium reducible sulfur testing (Scr) [AS 4969.7-2008 method] (n=43)
- Net acid generating (NAG) analysis (n=26)
- Total metals (Al, As, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Mo, N, Ni, Sb, Se, V, Zn) in solids [HCl and HNO₃ acid digest followed by ICP-AES and selected ICP-MS] (n=13)
- Total mercury [FIMS method] (n=13)
- Total cations (Ca, Mg, Na, K) and Exchangeable cations (Ca, Mg, Na, K) (n=13)
- 1:5 (solid to water) water soluble metals (Al, As, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Mo, N, Ni, Sb, Se, V, Zn) by ICP-AES or ICP-MS (n=13)
- 1:5 (solid to water) water soluble metals (Ca²⁺, Mg²⁺, K⁺, Na⁺, Cl⁻, SO₄²⁻, pH, EC, alkalinity and acidity) (n=13)
- Cation Exchange Capacity (eCEC) (n=7)
- Exchangeable Sodium Percentage (ESP) (n=7).

4.0 KINETIC TEST METHODS

A description of the KLC test methodology for the standard and large cells including a schematic of the KLC test arrangement is provided in **Attachment A**. The larger columns were used to better represent conditions within the top 60 cm of the tailings as the solid to solute ratio is more indicative of actual conditions in the field.

4.1 Sample Classification

The field description of the samples as soil, oxide, sulfide or oxide/sulfide tailings by Straits personnel was based on site knowledge and visual identification of the samples during sample collection. These descriptions are retained within the tables in this report.

Composite samples of these materials were selected for KLC tests after the static screening test results became available.

Samples used for KLC tests were initially classified using the static screening test results as Potentially Acid Forming (PAF) and therefore classified as being sulfide tailings if they had;

- Total Sulfur (TS) > 0.3 %
- Net Acid Producing Potential (NAPP) > 10 kg H₂SO₄/tonne
- ANC/MPA ratio < 1 (where ANC = Acid Neutralising Capacity and MPA = Maximum Potential Acidity)

The sulfide tailings were then composited into a single sample for the KLC test program. The remainder of the samples were classified as being oxide tailings (based on static screening test results) or topsoil (based on field descriptions), and these samples were also composited into bulk samples for KLC testing.

4.2 Standard KLC Test Cells

The two samples used in standard KLC test cells included one composite oxide and one composite sulfide tailings sample (based on NAPP values derived from TS and ANC).

Approximately 2 kg of each selected sample was accurately weighed and used in the KLC tests. Heat lamps were used approximately 30 cm above the columns on a daily basis to increase surface temperature to approximately 35 °C and ensure that the KLC test materials dried and were subject to oxidising conditions between leaching events (essentially an assumed 'worst case' scenario for sulfide oxidation and potential acid/salt generation). Small columns were packed to achieve a bulk density of approximately 1.3 kg/m³

A solid:solute ratio of 2:1 was targeted in the standard cells (ie. a 2 kg sample received 1L of laboratory grade distilled water as part of the leaching process). Due to the KLC column diameter and the volume of water added, each leach cycle was equivalent to 50 to 60 mm of rain. During leaching, deionised water was slowly added to the top of each KLC sample, and allowed to free-drain through the solids. The two standard KLC tests commenced on 19 December 2014 and were operated under a monthly watering and leaching regime for a six month test period (ie. a total of seven leaching events) until June 2015.

All leachate samples collected from the leach events in the KLC tests were sent to ALS Brisbane laboratory and analysed for various parameters including:

- pH and EC [PC titrator]
- Alkalinity and Acidity [PC titrator]
- Soluble metals and metalloids (Al, As, Cd, Cr, Co, Cu, Fe, Mn, Mo, Ni, Pb, Sb, Se, V and Zn) [by ICP-MS]
- Dissolved mercury [FIMS method]

- Dissolved hexavalent chromium [discrete analyser]
- Major cations (Ca, Mg, K, Na) [by ICP-AES]
- Dissolved sulfate - turbidimetric [discrete analyser]
- Dissolved chloride and fluoride [discrete analyser and PC titrator]

4.3 Large KLC Test Cells

The “large” KLC test cell design (**Figure 4-1**) included approximately 20 kg of sample and a target solid:solute ratio of 10. Each leach cycle was equivalent to 65 mm of rain. The large cells were used to test three sample types including:

- Oxide Tailings
- Sulfide Tailings
- Oxide + Sulfide + Soil

Large columns were packed to achieve a bulk density of 1.3 kg/m³. An approximate configuration of the three large KLC samples is provided in **Figure 4-1**. A more detailed schematic of the large column design is provided in **Attachment A**. The three large KLC tests commenced on 19 December 2014 and were operated under a monthly watering and leaching regime for the six month test period (ie. a total of seven leaching events) until June 2015.

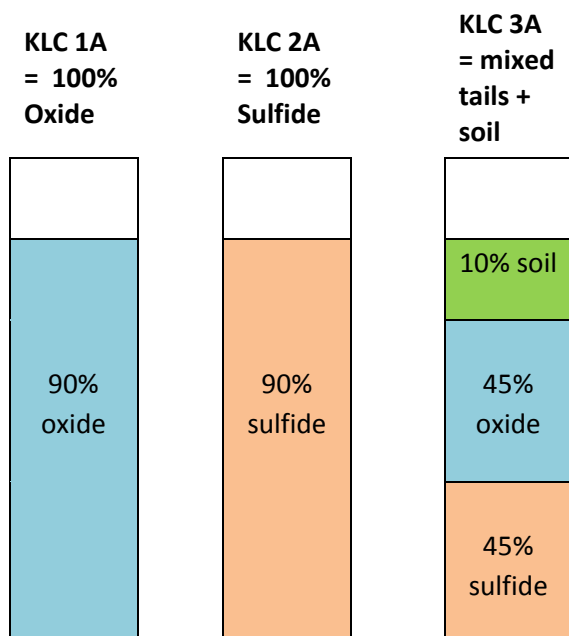


Figure 4-1: Large KLC Test Configuration

5.0 STATIC TEST RESULTS

5.1 Tailings Geochemistry

5.1.1 Total Sulfur (TS)

Total sulfur (TS) measurement includes all sulfur species (eg. organic S, sulfide S, sulfate minerals). The TS results indicate that the 85 samples.

- TS ranged from 0.02 to 0.53 %
- 18 samples had < 0.2 TS %
- 23 samples had > 0.2 and < 0.3 TS %
- 24 samples had > 0.3 and < 0.4 TS %
- 18 samples had > 0.4 and < 0.5 TS %
- 2 samples had > 0.5 and < 0.53% TS %

In general terms samples with > 0.2% TS may have some potential to generate acidity.

5.1.2 Sulfide Sulfur (SS)

TS is a standard method used to measure the maximum potential acidity (MPA) of a sample and assumes that all S is present as acid producing minerals such as Pyrite. As such TS can overestimate MPA and S speciation tests can be completed to verify the proportion of sulfide sulfur (SS) present in the TS mass. In the current work program, the chromium reducible sulfur (CRS) test method was used to measure reactive sulfide minerals on all 85 samples.

- 71 of the 85 samples had CRS % < 0.005 % verifying that the SS concentration is effectively zero
- Of the 14 samples that had measurable SS, the average percentage of SS in the TS mass was 4 %, as shown in **Figure 5-1**.

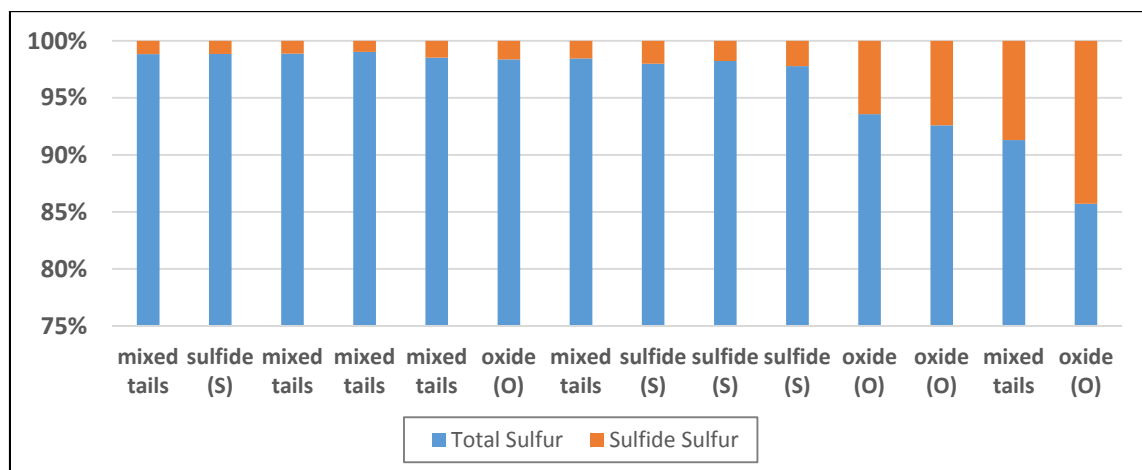


Figure 5-1: Sulfur Speciation Results for 14 Samples with Measurable Sulfide Sulfur

The CRS results have a significant bearing on the geochemical classification of the samples and this is discussed further in **Section 5.2.3**.

5.1.3 Acid Neutralising Capacity (ANC)

The ANC in the 85 samples was very low with a maximum value of 7 kg H₂SO₄/tonne; as a point of reference limestone (CaCO₃) theoretically has approximately 1,000 kg H₂SO₄/tonne of ANC per tonne of material.

5.1.4 Total Major, Minor and Trace Elements

Multi-element scans were carried out on 13 selected individual and composite samples of spoil to identify any elements (metals/metalloids) present in these materials at concentrations that may be of environmental concern with respect to materials handling, storage, and water quality.

The results were compared to guideline criteria to assess any concerns related to mine operation and final rehabilitation. To provide relevant context, RGS has compared the total metal/metalloid concentration in samples to National Environmental Protection Council (NEPC) Health-based Investigation Levels (HIL(C)) for soils in public open spaces (NEPC, 2013). Total (2 acid digest and analysis by ICP-AES or MS) elemental concentrations were measured on 4 soil and 9 tailings samples. The geochemical abundance index (GAI) method was used to evaluate elemental concentrations. The GAI quantifies an assay result for a particular element in terms of the average crustal abundance for that element. The index is based on a log (2) scale and is expressed in seven integer increments (0 to 6), which correspond to enrichment factors from 0 to over 96 times average crustal abundance, as shown in **Table 5-1**.

Table 5-1: Geochemical Abundance Index (GAI) values and Enrichment Factor

GAI	Enrichment factor	GAI	Enrichment factor
0	Less than 3-fold enrichment	4	24 – 48 fold enrichment
1	3 – 6 fold enrichment	5	48 – 96 fold enrichment
2	6 – 12 fold enrichment	6	Greater than 96 fold enrichment
3	12 – 24 fold enrichment		

As a general rule, a GAI greater than or equal to 3 indicates enrichment to a level that may warrant further investigation (INAP, 2009). This is the case with some environmentally important 'trace' elements, such as As, Cd, Cu and Zn, rather than with major rock-forming elements, such as Ca, Mg, K and Na. Elements identified as enriched may not necessarily be a concern for revegetation, drainage water quality or public health, but their significance should still be evaluated. Similarly, because an element is not enriched does not mean it will never be a concern, because under some conditions (eg. low pH) the solubility of common environmentally important elements such as Al, Cu, Cd, Fe and Zn increases significantly.

The multi-element data for the Yandan tailings samples show that none of the measured elements exceed health criteria for public open spaces (**Table 5-2**), although the GAI values were greater than or equal to 3 for arsenic in the both the oxide and sulfide tailings and mercury in the sulfide tailings only, as shown in **Table 5-3**.

The solubility of trace metals in water extracts and KLC tests for tailings materials are investigated in **Section 5.2.3**.

YANDAN TAILINGS ASSESSMENT

Table 5-2: Whole Rock Elemental Assays and Exchangeable Cations

	Material Type →		Soil				Oxide Tailings			SulfideTailings		Mixed Tailings - Sulfide + Oxide			
	Multi-Element Sample Number →		1	2	3	4	5	6	7	8	9	10	11	12	13
	ALS Laboratory ID →		EB1446063037	EB1446063040	EB1446063039	EB1446063036	EB1446063001	EB1446063033	EB1446063006	EB1446063042	EB1446063003	EB1446063032	EB1446063043	EB1446063005	EB1446063020
	RGS sample ID number →		2	5	6	7	10	16	31	52	55	68	70	74	81
	Client sample ID →		67 T	77 OR(T)	76 OR(T)	65 T	1	52	10	82	3	51	85	6	27
Parameters	Detection Limit	NEPC ¹ Health-Based Investigation Level (HIL-C)													
Major Cations	All units mg/kg														
Calcium (Ca)	50	-	1,360	1,510	1,350	1,580	390	1,260	1,230	2,520	2,140	1,040	1,080	1,170	1,430
Magnesium (Mg)	50	-	4,140	2,060	2,830	2,710	170	260	310	90	100	80	180	230	170
Potassium (K)	50	-	1,460	1,590	1,670	1,750	960	1,120	1,240	1,580	1,440	910	1,560	1,380	1,440
Sodium (Na)	50	-	750	670	1,210	510	710	980	550	580	340	560	1,140	710	580
Minor Elements	All units mg/kg														
Aluminium (Al)	50	-	12,000	10,900	10,200	10,100	2,600	3,110	2,780	2,150	2,130	1,650	2,210	3,370	2,740
Antimony (Sb)	5	-	<5	<5	<5	<5	18	19	10	18	10	10	11	16	11
Arsenic (As)	5	300	11	14	16	20	148	172	103	209	129	130	167	167	170
Barium (Ba)	10	-	240	160	160	160	140	150	190	110	130	120	100	150	160
Beryllium (Be)	1	90	2	3	1	2	<1	<1	1	<1	<1	<1	<1	1	<1
Boron (B)	50	20,000	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Cadmium (Cd)	1	90	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium (Cr) - hexavalent	2	300 **	45	47	53	50	58	45	51	45	50	24	68	56	40
Cobalt (Co)	2	300	22	18	26	20	4	6	4	2	<2	<2	5	5	4
Copper (Cu)	5	17,000	27	30	25	23	10	16	10	8	10	10	20	24	15
Iron (Fe)	50	-	34,000	45,500	41,400	29,700	13,500	14,800	10,100	11,100	8,090	9,960	11,500	13,400	12,400
Lead (Pb)	5	600	22	28	29	19	7	8	9	19	8	7	8	9	11
Manganese (Mn)	5	19,000	816	457	1,370	546	37	45	52	8	8	16	31	39	25
Mercury (Hg)	0.1	80	<0.1	<0.1	<0.1	<0.1	0	0	0	1	1	1	1	1	1
Molybdenum (Mo)	2	-	<2	<2	<2	<2	<2	<2	<2	3	<2	<2	2	<2	<2
Nickel (Ni)	2	1,200	34	35	45	31	8	9	9	3	3	3	8	9	6
Selenium (Se)	5	700	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Vanadium (V)	5	-	24	27	30	23	8	9	7	5	5	5	5	8	7
Zinc (Zn)	5	30,000	56	71	41	52	16	21	15	7	6	11	14	27	16
Exchangable Cations	All units meq/100g (except Exchangable Sodium Percentage (%))														
Exch. Calcium	0.1	-	3.4	1.9	3.5	3.0	1.0	1.6	1.7	-	-	-	-	-	-
Exch. Magnesium	0.1	-	2.2	0.3	2.1	0.5	0.4	0.2	0.3	-	-	-	-	-	-
Exch. Potassium	0.1	-	0.3	0.2	0.4	0.4	0.2	0.2	0.4	-	-	-	-	-	-
Exch. Sodium	0.1	-	0.1	<0.1	0.2	0.1	0.1	0.2	<0.1	-	-	-	-	-	-
Cation Exchange Capacity	0.1	-	5.9	2.5	6.2	4.0	1.8	2.1	2.5	-	-	-	-	-	-
Calcium:Magnesium Ratio	-	-	1.5	6.3	1.7	6.0	2.5	8.0	5.7	-	-	-	-	-	-
Exchangable Sodium Percentage	0.1%	-	1.7	0.9	2.9	1.8	6.2	5.7	2.8	-	-	-	-	-	-

Notes: < indicates less than the laboratory limit of reporting. Shaded cells exceed applied guideline limit.

** Guideline level for Cr(VI) = 300 mg/kg. Guideline level for Cr(III) = 24% of total Cr.

1. NEPC (2013). National Environmental Protection Council (NEPC). *National Environmental Protection (Assessment of Site Contamination) Measure (NEPM)*, Amendment of Schedule B1-B7 of 1999 version. *Guideline on Investigation Levels for Soil and Groundwater. Health-Based Investigation Level - HIL(C); public open spaces - recreational use.*

Table 5-3: Geochemical Abundance Indices

	Material Type →		Soil				Oxide Tailings			Sulfide Tailings		Mixed Tailings - Sulfide + Oxide			
	Multi-Element Sample Number →		1	2	3	4	5	6	7	8	9	10	11	12	13
	ALS Laboratory ID →		EB1446063037	EB1446063040	EB1446063039	EB1446063036	EB1446063001	EB1446063033	EB1446063006	EB1446063042	EB1446063003	EB1446063032	EB1446063043	EB1446063005	EB1446063020
	RGS sample ID number →		2	5	6	7	10	16	31	52	55	68	70	74	81
	Client sample ID →		67 T	77 OR(T)	76 OR(T)	65 T	1	52	10	82	3	51	85	6	27
Parameters	Detection Limit	Average Crustal Abundance ¹													
Major Elements	all units in mg/kg		Geochemical Abundance Index (GAI)												
Aluminium (Al)	50	71,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Calcium (Ca)	50	15,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Iron (Fe)	50	40,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Magnesium (Mg)	50	5,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Potassium (K)	50	14,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Sodium (Na)	50	5,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Minor Elements	all units in mg/kg		Geochemical Abundance Index (GAI)												
Antimony (Sb)	5	5	0	0	0	0	1	1	0	1	0	0	1	1	1
Arsenic (As)	5	6	0	1	1	1	4	4	4	5	4	4	4	4	4
Barium (Ba)	10	500	0	0	0	0	0	0	0	0	0	0	0	0	0
Beryllium (Be)	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Boron (B)	50	100	0	0	0	0	0	0	0	0	0	0	0	0	0
Cadmium (Cd)	1	0.35	0	0	0	0	0	0	0	0	0	0	0	0	0
Chromium (Cr) - hexavalent	2	70	0	0	0	0	0	0	0	0	0	0	0	0	0
Cobalt (Co)	2	8	1	1	1	1	0	0	0	0	0	0	0	0	0
Copper (Cu)	5	30	0	0	0	0	0	0	0	0	0	0	0	0	0
Lead (Pb)	5	35	0	0	0	0	0	0	0	0	0	0	0	0	0
Manganese (Mn)	5	1000	0	0	0	0	0	0	0	0	0	0	0	0	0
Mercury (Hg)	0.1	0.06	0	0	0	0	2	2	2	3	3	2	3	3	3
Molybdenum (Mo)	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Nickel (Ni)	2	50	0	0	0	0	0	0	0	0	0	0	0	0	0
Selenium (Se)	5	0.4	2	2	2	2	2	2	2	2	2	2	2	2	2
Vanadium (V)	5	90	0	0	0	0	0	0	0	0	0	0	0	0	0
Zinc (Zn)	5	90	0	0	0	0	0	0	0	0	0	0	0	0	0

Notes: GAI's greater than or equal to 3 are highlighted.

1. Average Crustal Abundance values sourced from the "GARD Guide", Chapter 5 (INAP, 2009).

1. When no GARD Guide value is available for particular element, then values are taken from Bowen H.J.M.(1979) Environmental Chemistry of the Elements, Academic Press, New York, p42-43.

5.1.5 Cation Exchange Capacity (CEC) and Exchangeable Sodium Percentage (ESP)

Cation exchange capacity (CEC) and the exchangeable sodium percentage (ESP) are parameters of relevance to rehabilitation materials. CEC is the capacity of the soil to hold and exchange cations. It provides a buffering effect to changes in pH, available nutrients, calcium levels and soil structural changes. As such it is a major controlling factor of soil structure, nutrient availability for plant growth, soil pH, and the soils reaction to fertilisers and other ameliorants. A low CEC means the soil has a low resistance to changes in soil chemistry (Hazleton and Murphy, 2007).

The five most abundant cations in soil are calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+) and aluminium (Al^{3+}), although exchangeable Al only becomes significant at pH levels less than 5.5.

The CEC was measured on seven samples (four soil and three oxide tailings) and ranged from 1.8 to 6.2 meq/100g (**Table 5-2**). The CEC value in the soil samples was generally higher than in the oxide tailings (average values of 4.7 and 2.1 meq/100g, respectively).

The average CEC values for the soil and oxide tailings samples are in the “very low” range as shown in **Table 6**. The CEC results suggest that from a revegetation viewpoint, some fertiliser addition may be required to soil to provide a reasonable growth medium for vegetation roots.

Soils with CEC values less than 3 meq/100g can be low in fertility and susceptible to soil acidification. Hence, direct vegetation of oxide tailings is not recommended without a topsoil cover as part of rehabilitation activities.

Table 5-4: Ratings for Effective Cation Exchange Capacity

CEC Rating	CEC meq/100g
Very Low	<6
Low	6-12
Moderate	12-25
High	25-40
Very High	>40

The ESP results for the seven soil and oxide tailings samples range from 0.9 to 6.2 % and are generally lower in the soil samples compared to the oxide tailings samples (average values of 1.8 versus 4.9, respectively). Generally samples with ESP values less than 6 are considered non-sodic and unlikely to be susceptible to dispersion and erosion. Samples with ESP values greater than 6 are considered moderately sodic and greater than 14 are considered strongly sodic and may be susceptible to dispersion and erosion (Isbell, 2002; and Northcote and Skene, 1972). The ESP results show that the soil and oxide tailings samples have relatively low sodicity values and materials represented by these samples are unlikely to be susceptible to significant dispersion and erosion.

The exchangeable Ca:Mg ratio is a key parameter of good (fertile and structurally stable) soils. If the exchangeable Ca:Mg ratio in mine waste materials is less than 4, then these materials may require some amelioration before the materials can be used as part of a revegetation growth layer (Hazleton and Murphy, 2010). The exchangeable cation results are provided in **Table 5-2** and indicate that the sample materials have exchangeable Ca:Mg ratios ranging from 1.5 to 8.0 (average 4.5). Hence, some soil and oxide tailings materials may require amelioration (such as gypsum or fertiliser addition) to provide a reasonable growth medium for vegetation roots.

5.2 Soluble Tailings Chemistry

A 1:5 (solid:solute) method was used to measure the pH, EC, and the concentration of major ions and trace metals/metalloids in water extracts. It should be recognised that direct comparison of geochemical data from 1:5 water extracts with guideline values can be misleading.

For the purpose of this study, guideline values are only provided for broad context and should not be interpreted as arbitrary 'maximum' values or 'trigger' values. Using sample pulps (ground to passing 75 μm) provides a very high surface area to solution ratio, which encourages mineral reaction and dissolution of the solid phase. As such, the results of screening tests on water extract solutions represent an assumed 'worst case' scenario for undiluted leachate from tailings or soil materials.

Actual runoff and/or seepage water quality from tailings emplacement areas would be better than the multi-element results due to the less optimum conditions for leaching, and the significant dilution from fresh rainfall runoff. Further to this, water storages on the site are susceptible to the effects of evapo-concentration and dilution from rain and the proportion of water that comes from different sources such as direct rainfall, seepage from the TSF, surface runoff from the TSF, runoff from the embankment or runoff from the catchment around the TSF. Nevertheless the 1:5 results allow a good qualitative assessment of the samples to be made within the site and with other sites.

5.2.1 pH and Acidity

pH is a measure of the hydrogen ion (H^+) and hydroxyl ion (OH^-) concentration in a water solution and is used to measure the acidity or alkalinity of a sample. The optimum soil pH for the majority of agronomic field, pasture, vegetable and fruit crops in Australia is pH 5 to 7, with most plants able to grow in soils at pH 5.5 to 6 (Hazleton and Murphy, 2007). In Australia, topsoil pH ranges from 4 to 10 (median 6.5); ~ 50% of agricultural soils have a $\text{pH} \leq 5.5$ (Caritat *et al.*, 2011).

Samples with a pH value of less than 5 can be considered to be acidic, regardless of sulfide concentrations, as they are able to leach mildly acid water. The pH results for the 85 soil and tailing samples are presented in **Figure 5-2**.

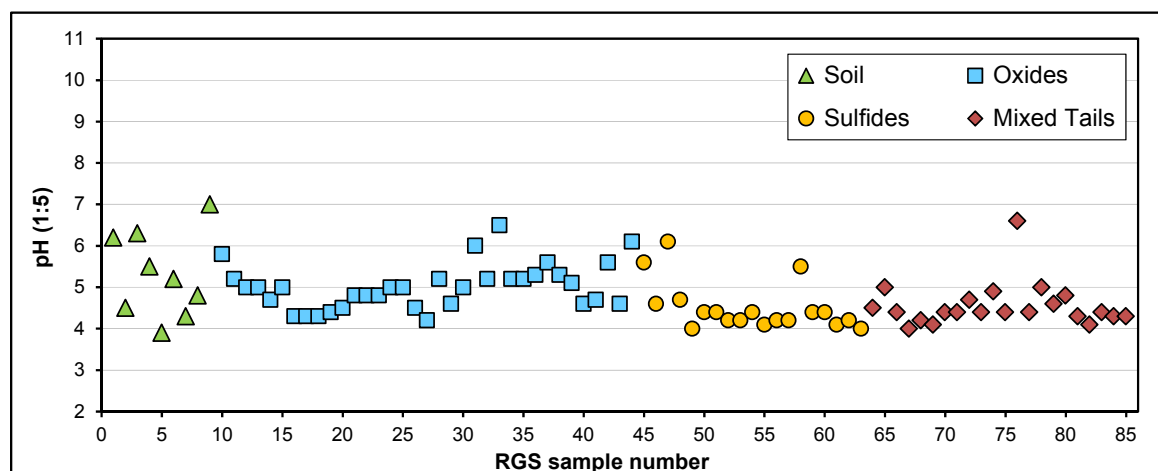


Figure 5-2: pH Results

Within the soil and tailings dataset;

- 1 sample is producing acidity and has a pH of < 4
- 54 samples are producing mild acidity and have a pH of > 4 and < 5
- 24 samples are producing negligible acidity and have a pH of > 5 and < 6, similar to the pH range found in the deionised water used in the water extract tests
- 6 samples are producing circum-neutral drainage and have a pH of > 6 and < 7

These pH results indicate that:

- 65 % of the samples produce mild acidity in contact with water
- there is no reactive ANC in the samples with a pH < 6 and hence no measured alkalinity (refer to **Table 5-5**)
- the tailings samples are generally not producing concentrated acidity in water extracts and the measured acidity in the 9 samples where acidity was tested ranged from 6 to 35 mg/L with an average value of 17 mg/L (refer to **Table 5-5**).

5.2.2 Salinity

Hazleton and Murphy (2007) define soils with an EC of < 2,000 $\mu\text{S}/\text{cm}$ as having negligible effects on agronomic plants, but that at EC values of 2,000 to 4,000 $\mu\text{S}/\text{cm}$, yields of sensitive crops can be affected. The Authors state that water extracts with an electrical conductivity (EC) of:

- < 700 $\mu\text{S}/\text{cm}$ are considered suitable for irrigation and drinking water (8 samples)
- 700 to 2,000 $\mu\text{S}/\text{cm}$ are considered suitable for irrigation water (67 samples)
- < 3,000 $\mu\text{S}/\text{cm}$ are considered to have slight to moderate salinity (10 samples)

The EC values for the soil and tailings range from 159 to 2,950 $\mu\text{S}/\text{cm}$ as shown in **Figure 5-3**. The average EC of the tailings and soil samples is 1,498 $\mu\text{S}/\text{cm}$ and 1,017 $\mu\text{S}/\text{cm}$, respectively.

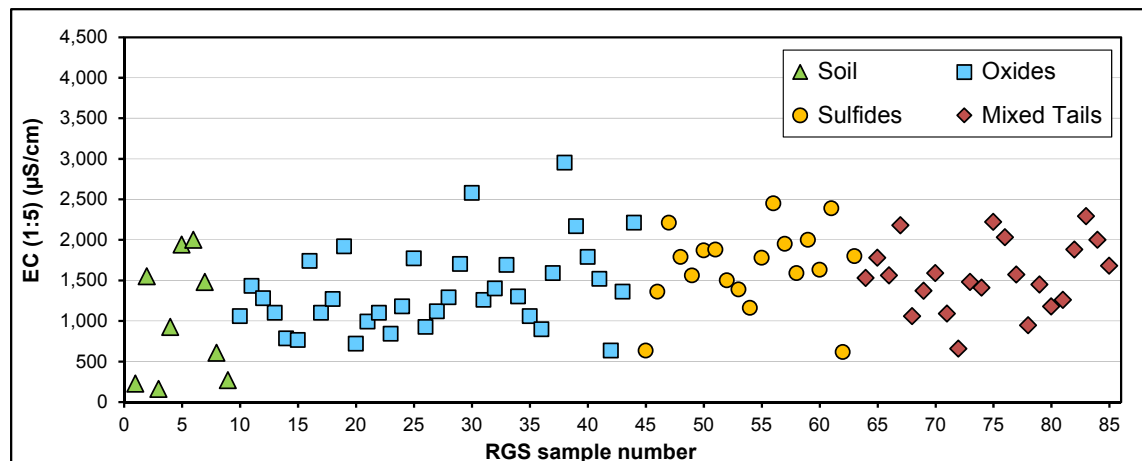


Figure 5-3: EC Results

The dominant major anion in the water extracts is sulfate (SO_4^{2-}) (**Table 5-5**) and there is a relationship between EC and TS as illustrated in **Figure 5-4**.

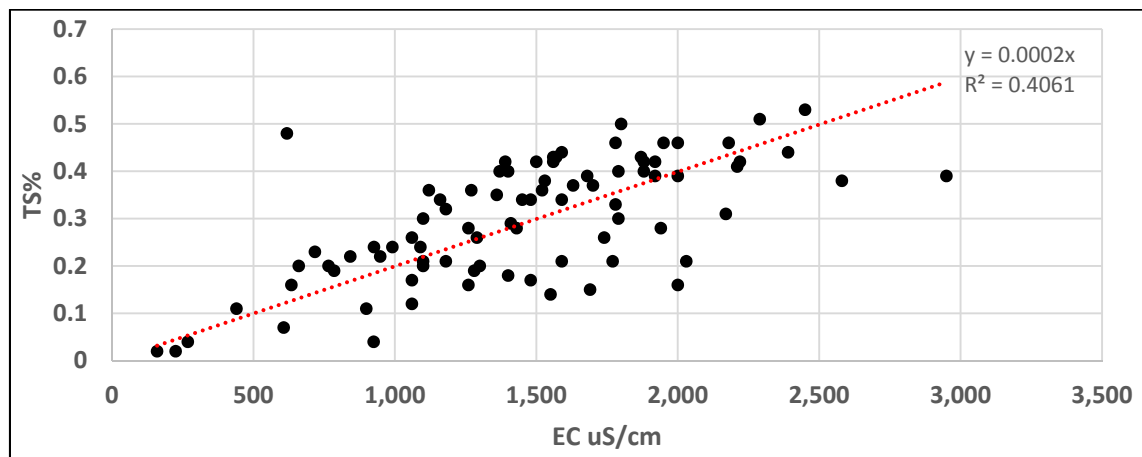


Figure 5-4: Correlation between TS and EC

5.2.3 Major Ions and Metals/Metalloids

RGS has compared the soluble major ion and metal/metalloid concentrations in water extracts from the 13 selected soil and tailings samples with Australian guidelines and relevant receiving water criteria and the results are presented in **Table 5-5**.

The concentrations of the major cations and anions in the water extracts are typically dominated by calcium and sulfate. For all but one sample (soil sample 77(OR)T), the sulfate concentration in the water extracts is below the livestock drinking water guideline for this anion (1,000 mg/L).

The concentration of most trace metals/metalloids tested in the water extracts is below the laboratory LoR and applied livestock drinking water guideline criteria in most samples (ANZECC & ARCANZ, 2000). The exceptions are aluminium and cadmium (one soil sample), iron (one sulfide tailings sample and one mixed oxide/sulfide tailings sample) and manganese (four soil samples, one oxide sample, and two mixed oxide/sulfide samples), which have concentrations in water extracts that can exceed the applied livestock drinking water guidelines values, where these exist.

The results indicate that dissolved metal/metalloid concentrations in initial surface runoff and seepage from soil and tailings materials are unlikely to significantly impact upon the quality of surface and groundwater resources at the TSF. Notwithstanding, it is recommended that the list of water quality monitoring parameters provided in **Table 5-5** be included in the water quality monitoring program at the site, from time to time.

Table 5-5: Tailings Water Extract Results

		Tailings Material Type →		Soil				Oxidic Tailings			Sulfidic Tailings		Mixed Tailings - Sulfide + Oxide			
		Multi-Element Sample Number →		1	2	3	4	5	6	7	8	9	10	11	12	13
		ALS Laboratory ID →		EB1446063037	EB1446063040	EB1446063039	EB1446063036	EB1446063001	EB1446063033	EB1446063006	EB1446063042	EB1446063003	EB1446063032	EB1446063043	EB1446063005	EB1446063020
		RGS sample ID number →		2	5	6	7	10	16	31	52	55	68	70	74	81
		Client sample ID →		67 T	77 OR(T)	76 OR(T)	65 T	1	52	10	82	3	51	85	6	27
Parameters	Detection Limit	Water Quality Guidelines:														
		Aquatic Ecosystems (freshwater) ¹	Livestock Drinking Water ²													
pH	0.01 pH unit	6 to 9	-	4.5	3.9	5.2	4.3	5.8	4.3	6.0	4.1	5.5	4.2	4.4	4.9	4.3
Electrical Conductivity	1 µS/cm	<1,000 [#]	3,580 [^]	1550	1940	2000	1480	1060	1740	1260	1780	1590	1060	1590	1410	1260
Carbonate Alkalinity (mgCaCO ₃ /L)	0.2 mg/L	-	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Bicarbonate Alkalinity (mgCaCO ₃ /L)	0.2 mg/L	-	-	<0.2	<0.2	1	<0.2	1	<0.2	3	<0.2	1	<0.2	<0.2	<0.2	<0.2
Total Alkalinity (mgCaCO ₃ /L)	0.2 mg/L	-	-	<0.2	<0.2	1	<0.2	1	<0.2	3	<0.2	1	<0.2	<0.2	<0.2	<0.2
Acidity (mgCaCO ₃ /L)	0.2 mg/L	-	-	17	240	10	46	12	17	6	12	8	19	35	13	29
Net Alkalinity (mgCaCO ₃ /L)	0.2 mg/L	-	-	-17	-240	-8	-46	-11	-17	-3	-12	-6	-19	-35	-13	-29
Major Ions		All units mg/L														
Calcium (Ca)	2	-	1,000	122	240	130	188	28	180	158	84	356	156	172	156	182
Magnesium (Mg)	2	-	-	74	42	92	28	8	20	22	6	8	6	24	20	12
Potassium (K)	2	-	-	14	14	22	26	16	10	44	16	30	4	18	14	12
Sodium (Na)	2	-	-	134	108	226	84	146	184	96	44	46	68	140	110	74
Chloride (Cl)	2	-	-	128	72	156	26	162	132	68	24	52	64	28	72	56
Fluoride (F)	0.2	-	2	<0.2	0.4	<0.2	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	<0.2	<0.2
Phosphate (PO ₄)	0.06	-	-	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	0.06
Sulfate (SO ₄)	2	-	1,000	704	1,104	968	788	196	722	614	302	928	476	754	584	588
Trace Metals/Metalloids		All units mg/L														
Aluminium (Al)	0.02	0.055	5	0.560	26.2	0.060	2.100	<0.02	0.420	<0.02	0.380	<0.02	0.960	1.880	0.460	1.280
Antimony (Sb)	0.002	-	-	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	0.004	0.008	0.004	0.014	0.004	0.004
Arsenic (As) - pentavalent	0.002	0.013 **	0.5	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.02	0.006	0.006	0.016	0.022	0.004	0.012
Barium (Ba)	0.002	-	-	0.034	0.048	0.034	0.044	<0.002	0.010	0.030	0.008	0.014	0.002	0.002	0.006	0.008
Beryllium (Be)	0.002	-	-	0.004	0.046	<0.02	0.008	<0.002	0.004	<0.002	<0.002	<0.002	0.004	0.008	0.004	0.004
Boron (B)	0.2	0.37	5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cadmium (Cd)	0.002	0.0002	0.01	0.004	0.014	0.002	0.006	<0.002	0.006	<0.002	<0.002	<0.002	0.002	0.008	0.004	0.004
Chromium (Cr) - total	0.002	0.001 (hex)*	1 (total)	<0.002	0.006	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002	0.004	<0.002	0.002
Cobalt (Co)	0.002	-	1	0.218	0.772	0.100	0.492	0.036	0.266	<0.002	0.060	0.022	0.072	0.328	0.208	0.172
Copper (Cu)	0.002	0.0014	1	0.006	0.018	0.004	0.006	<0.002	0.014	<0.002	0.008	<0.002	0.022	0.014	0.020	0.026
Iron (Fe)	0.2	-	1 (irrigation)	<0.2	<0.2	<0.2	<0.2	<0.2	0.4	<0.2	1.2	<0.2	0.2	1.6	0.4	0.8
Lead (Pb)	0.002	0.0034	0.1	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Manganese (Mn)	0.002	1.9	2 (irrigation)	15.5	22.6	23.6	15.8	1.176	3.340	0.726	1.204	0.296	1.350	3.900	2.900	1.802
Mercury (Hg)	0.0001	0.0006	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (Mo)	0.002	-	0.15	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.02	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nickel (Ni)	0.002	0.011	1	0.286	0.882	0.434	0.530	0.060	0.386	0.040	0.096	0.022	0.130	0.482	0.306	0.276
Selenium (Se)	0.02	0.011	0.020	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Vanadium (V)	0.02	-	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc (Zn)	0.01	0.008	20	0.540	2.260	0.110	0.564	0.104	0.926	<0.01	0.124	0.022	0.652	0.960	1.128	0.548

* Cr (VI) = hexavalent. ** 0.024 mg/L for trivalent Arsenic (III).

for still water bodies only, moving rivers at low flow rates should not exceed 2,200µS/cm

[^] calculated based on total dissolved solids (TDS) conversion rate of 0.67% of EC. TDS is an approximate measure of inorganic dissolved salts and should not exceed 2,400mg/L for livestock drinking water.

Notes: < indicates concentration less than the detection limit. Shaded cells indicate values which exceed applied guideline values.

1. ANZECC & ARMICANZ (2000). Trigger values for aquatic ecosystems (95% species protection level)

2. ANZECC & ARMICANZ (2000). Recommended guideline limits for Livestock Drinking Water.

1 + 2. both taken from the "Australian and New Zealand Guidelines for Fresh and Marine Water Quality", National Water Quality Management Strategy, 2000, compilation by ANZECC and ARMICANZ.

5.3 Material Classification Method

A standard Acid Base Account scheme is typically used for the classification of mine waste samples is described in **Table 5-6**. This type of classification scheme assumes that the samples are fresh and have not already weathered/oxidised to generate acidity. The terminology used in this standard scheme infers that mine waste samples have the potential to **produce** acidity from sulfide oxidation at some point in the future.

Table 5-6: Standard ABA Classification Criteria

Geochemical Classification	Sulfide Sulfur ¹ (%)	NAPP (kg H ₂ SO ₄ /t)	ANC:MPA Ratio
Barren ²	≤ 0.1	-	-
Acid Consuming	> 0.1	> -50	≥ 2
Non-Acid Forming	> 0.1	≤ 0 and -50	≥ 2
Potentially Acid Forming - Low Capacity	> 0.1	> 0 and ≤ +10	<2
Potentially Acid Forming-Moderate Capacity	> 0.1	> +10 and ≤ +50	<1
Potentially Acid Forming – High Capacity	> 0.1	> +50	<1

Notes:

1. If total sulfur or sulfide sulfur is less than or equal to 0.1 %, the NAPP and ANC: MPA ratio is not required for material classification as the sample is essentially barren of oxidisable sulfur.
2. A sample classified as NAF can be further described as 'barren' if the total sulfur and/or sulfide sulfur content is less than or equal to 0.1 per cent, as the sample essentially has negligible acid generating capacity from future sulfide oxidation.

In instances where mine waste materials have already weathered/oxidised, and the inherent ANC has been consumed through neutralisation processes, some of these materials may have already generated acidity. This acidity may have already leached from the mine waste material or could still be temporarily stored within the material matrix and/or within secondary minerals.

The strength of the acidity is a function of the soluble concentrations of the H⁺ (measured by the pH) and the acidity from the H⁺ ion and metals such as Al, Cu, Fe, Mn and Zn can be measured as titratable acidity (see **Table 5-5**). The static tests used in this study to characterise the samples included TS and SS, ANC and pH. NAG analyses were also completed for 26 selected samples and the results provide similar material classifications to those derived from ABA and pH data. The results from these analytical methods verify that many of the samples had slightly acidic pH values between 4 and 6 and that all samples had < 0.1% sulfide sulfur and very little or no ANC.

Due to the fact that all of the soil and tailings samples had already weathered/oxidised *in situ*, pH criteria were used by RGS to describe the samples in terms of their existing acidity (**Table 5-6**). The classification used in this report ranges from Inert (where the pH is 6 to 7) to Mild Acid Forming Potential (MAFP) where the pH is 3 to 4. Only one of the 85 soil and tailings samples had a pH value less than 4 (topsoil sample 76 OR(T) had a pH value of 3.9).

Table 5-7: pH Classification Criteria Existing Acid Forming Samples

Existing Acid Forming Potential (AFP) (Sulfide minerals have oxidised and acid neutralising capacity is consumed)		AFP Criteria
No Acid Forming Potential	Inert	pH 6 to 7
Low Acid Forming Potential	LAFP	pH 4 to 6
Mild Acid Forming Potential	MAFP	pH 3 to 4

The geochemical results and material classification for the 85 soil and tailings samples is provided at **Table 5-8**

5.4 Sample Classification

5.4.1 Acid Producing Potential

All 85 soil and tailings samples were classified as Barren using the standard Acid Base Account classification scheme. Essentially, 71 samples had < 0.005% sulfide sulfur and the balance of the samples had < 0.04% sulfide sulfur. The CRS analyses results verify that any sulfide minerals present in the tailings at the time of deposition have completely weathered/oxidised and that any future acid generation will come from actual acidity from within the material matrix (pore water) and/or from contained secondary minerals such as Jarosite.

5.4.2 Actual Acid Forming Potential

Of the 85 samples analysed 79 samples had a pH of 4 to 6 and are classified as having low acid forming potential (LAFP), 6 samples had a pH between 6 and 7 and are classified as being Inert, and one sample had a pH less than 4 and is classified as having Mild Acid Forming Potential (MAFP). The measured acidity of the samples was also quite low and ranged from 6 to 46 mg/L with an average measured acidity of 19 mg/L.

Based on the analyses all 76 tailings samples are classified as being Barren (with no potential to produce acid through sulfide oxidation) and being Inert and having LAFP (ie. dominated by pH values of 4 to 6). The 9 soil samples were also classified as Barren and were comprised of Inert (3 samples), LAFP (5 samples) and MAFP (1 sample), materials.

Table 5-8: Static Sample Classification

RGS No.	ALS Laboratory Number	Client Sample ID	GDA 94 Easting & Northing		Field Description	Moisture Content (%)	pH ¹	EC ¹ (µS/cm)	pH based Acid Forming Potential	Total S (%)	ANC ² (kg H ₂ SO ₄ /t)	NAPP (TS – ANC) (kg H ₂ SO ₄ /t)	NAG pH	NAG capacity @ pH 4.5 (kg H ₂ SO ₄ /t)	NAG capacity @ pH 7.0 (kg H ₂ SO ₄ /t)	CRS (%)	NAPP (CRS-ANC) (kg H ₂ SO ₄ /t)	NAPP (CRS-ANC) Sample Classification
1	EB1444979075	75 T	500563	7647830	topsoil	7.6	6.2	225	Inert	0.02	2.6	-2.0	--	--	--	0.003	2.5	Barren
2	EB1444979067	67 T	500577	7647560	topsoil	12.3	4.5	1,550	LAFP	0.14	1.5	2.8	6.2	<0.1	0.7	0.003	1.4	Barren
3	EB1444979070	70 T	500578	7647602	topsoil	4.8	6.3	159	Inert	0.02	5.2	-4.6	--	--	--	0.003	5.1	Barren
4	EB1444979064	64 T	500597	7647542	topsoil	5.5	5.5	925	LAFP	0.04	4.0	-2.8	--	--	--	0.003	3.9	Barren
5	EB1444979077	77 OR(T)	500703	7646915	topsoil	7.0	3.9	1,940	MAFP	0.28	0.3	8.3	3.3	1.0	5.7	0.003	0.2	Barren
6	EB1444979076	76 OR(T)	500687	7646993	topsoil + sulfide tails	6.9	5.2	2,000	LAFP	0.16	1.8	3.1	6.7	<0.1	0.6	0.003	1.7	Barren
7	EB1444979065	65 T	500597	7647542	topsoil	7.5	4.3	1,480	LAFP	0.17	0.8	4.4	5.7	<0.1	1.0	0.003	0.7	Barren
8	EB1444979074	74 T	500563	7647830	topsoil	14.0	4.8	607	LAFP	0.07	0.3	1.9	--	--	--	0.003	0.2	Barren
9	EB1444979071	71 T	500578	7647602	topsoil	7.0	7.0	268	Inert	0.04	6.9	-5.7	--	--	--	0.003	6.8	Barren
10	EB1444979001	1	500223	7646721	oxide (O)	6.0	5.8	1,060	LAFP	0.12	0.3	3.4	4.6	<0.1	2.9	0.003	0.2	Barren
11	EB1444979022	22	500157	7646912	oxide (O)	11.6	5.2	1,430	LAFP	0.28	0.6	8.0	--	--	--	0.003	0.5	Barren
12	EB1444979024	24	500145	7646870	oxide (O)	9.3	5.0	1,280	LAFP	0.19	0.3	5.6	--	--	--	0.003	0.2	Barren
13	EB1444979026	26	500191	7646890	oxide (O)	10.6	5.0	1,100	LAFP	0.20	0.3	5.9	4.2	0.6	3.4	0.003	0.2	Barren
14	EB1444979035	35	500306	7646778	oxide (O)	9.9	4.7	785	LAFP	0.19	0.3	5.6	--	--	--	0.003	0.2	Barren
15	EB1444979046	46	500211	7646810	oxide (O)	6.3	5.0	765	LAFP	0.20	0.3	5.9	--	--	--	0.003	0.2	Barren
16	EB1444979052	52	500186	7646945	oxide (O)	16.1	4.3	1,740	LAFP	0.26	0.3	7.7	4.1	0.6	2.6	0.003	0.2	Barren
17	EB1444979056	56	500262	7646949	oxide (O)	10.6	4.3	1,100	LAFP	0.30	0.3	8.9	--	--	--	0.003	0.2	Barren
18	EB1444979062	62	500600	7647471	oxide (O)	8.6	4.3	1,270	LAFP	0.36	0.3	10.8	--	--	--	0.003	0.2	Barren
19	EB1444979079	79	500208	7646998	oxide (O)	14.0	4.4	1,920	LAFP	0.39	0.3	11.7	--	--	--	0.003	0.2	Barren
20	EB1444979081	81	500271	7647266	oxide (O)	4.7	4.5	717	LAFP	0.23	0.3	6.8	--	--	--	0.003	0.2	Barren
21	EB1444979042	42	500278	7646752	oxide (O)	10.6	4.8	991	LAFP	0.24	0.3	7.1	4.0	0.6	2.2	0.003	0.2	Barren
22	EB1444979033	33	500283	7646797	oxide (O)	12.6	4.8	1,100	LAFP	0.21	0.3	6.2	--	--	--	0.003	0.2	Barren
23	EB1444979037	37	500327	7646755	oxide (O)	8.4	4.8	842	LAFP	0.22	0.3	6.5	--	--	--	0.003	0.2	Barren
24	EB1444979040	40	500300	7646734	oxide (O)	7.7	5.0	1,180	LAFP	0.21	0.3	6.2	4.2	0.4	1.8	0.003	0.2	Barren
25	EB1444979048	48	500181	7646834	oxide (O)	12.3	5.0	1,770	LAFP	0.21	0.3	6.2	--	--	--	0.003	0.2	Barren
26	EB1444979054	54	500227	7646919	oxide (O)	14.1	4.5	926	LAFP	0.24	0.3	7.1	3.8	0.8	2.3	0.040	-1.0	Barren
27	EB1444979060	60	500560	7647408	oxide (O)	7.3	4.2	1,120	LAFP	0.36	0.3	10.8	--	--	--	0.006	0.1	Barren
28	EB1444979004	4	500244	7646749	oxide (O)	10.7	5.2	1,290	LAFP	0.26	0.3	7.7	--	--	--	0.003	0.2	Barren
29	EB1444979008	8	500111	7646956	oxide (O)	10.4	4.6	1,700	LAFP	0.37	0.3	11.1	--	--	--	0.003	0.2	Barren
30	EB1444979009	9	500112	7647002	oxide (O)	11.3	5.0	2,580	LAFP	0.38	0.3	11.4	--	--	--	0.003	0.2	Barren
31	EB1444979010	10	500129	7647029	oxide (O)	11.6	6.0	1,260	LAFP	0.16	0.6	4.3	6.0	<0.1	1.2	0.011	0.3	Barren
32	EB1444979012	12	500149	7647096	oxide (O)	15.2	5.2	1,400	LAFP	0.18	0.3	5.3	--	--	--	0.003	0.2	Barren
33	EB1444979013	13	500155	7647138	oxide (O)	11.6	6.5	1,690	Inert	0.15	0.3	4.3	--	--	--	0.012	-0.1	Barren
34	EB1444979014	14	500169	7647178	oxide (O)	11.5	5.2	1,300	LAFP	0.20	0.3	5.9	--	--	--	0.003	0.2	Barren
35	EB1444979015	15	500217	7647170	oxide (O)	13.4	5.2	1,060	LAFP	0.17	0.3	4.9	--	--	--	0.003	0.2	Barren
36	EB1444979016	16	500204	7647124	oxide (O)	10.1	5.3	899	LAFP	0.11	0.3	3.1	--	--	--	0.003	0.2	Barren
37	EB1444979017	17	500191	7647077	oxide (O)	11.7	5.6	1,590	LAFP	0.21	0.3	6.2	--	--	--	0.003	0.2	Barren
38	EB1444979018	18	500187	7647042	oxide (O)	13.4	5.3	2,950	LAFP	0.39	0.3	11.7	--	--	--	0.003	0.2	Barren
39	EB1444979019	19	500187	7647014	oxide (O)	14.6	5.1	2,170	LAFP	0.31	0.3	9.2	--	--	--	0.003	0.2	Barren
40	EB1444979020	20	500177	7646987	oxide (O)	8.9	4.6	1,790	LAFP	0.30	0.9	8.3	4.4	<0.1	3.2	0.003	0.8	Barren
41	EB1444979021	21	500170	7646954	oxide (O)	9.4	4.7	1,520	LAFP	0.36	0.3	10.8	--	--	--	0.003	0.2	Barren
42	EB1444979002	2	500223	7646721	oxide (O)	6.6	5.6	634	LAFP	0.16	0.3	4.6	4.2	0.2	2.5	0.003	0.2	Barren
43	EB1444979068	68 T	500577	7647560	oxide (O)	11.2	4.6	1,360	LAFP	0.35	0.3	10.4	--	--	--	0.003	0.2	Barren
44	EB1444979072	72 T	500578	7647602	oxide (O)	10.4	6.1	2,210	Inert	0.41	1.7	10.8	--	--	--	0.003	1.6	Barren
45	EB1444979025	25	500145	7646870	sulfide (S)	10.7	4.7	1,790	LAFP	0.40	0.3	12.0	--	--	--	0.003	0.2	Barren
46	EB1444979078	78 OR(T)	500703	7646915	sulfide (S)	10.5	4.0	1,560	LAFP	0.43	0.3	12.9	--	--	--	0.003	0.2	Barren
47	EB1444979036	36	500306	7646778	sulfide (S)	12.5	4.4	1,870	LAFP	0.43	0.3	12.9	--	--	--	0.005	0.1	Barren
48	EB1444979047	47	500211	7646810	sulfide (S)	9.2	4.4	1,880	LAFP	0.40	0.3	12.0	--	--	--	0.003	0.2	Barren
49	EB1444979057	57	500262	7646949	sulfide (S)	9.6	4.2	1,500	LAFP	0.42	0.3	12.6	--	--	--	0.003	0.2	Barren
50	EB1444979063	63	500600	7647471	sulfide (S)	8.7	4.2	1,390	LAFP	0.42	0.3	12.6	--	--	--	0.003	0.2	Barren
51	EB1444979080	80	500208	7646998	sulfide (S)	11.3	4.4	1,160	LAFP	0.34	0.3	10.1	--	--	--	0.003	0.2	Barren
52	EB1444979082	82	500271	7647266	sulfide (S)	13.5	4.1	1,780	LAFP	0.46	0.3	13.8	4.2	0.2	2.3	0.003	0.2	Barren
53	EB1444979066	66 T	500597	7647542	sulfide (S)	12.0	4.2	2,450	LAFP	0.53	0.3	15.9	--	--	--	0.003	0.2	Barren
54	EB1444979043	43	500278	7646752	sulfide (S)	10.7	4.2	1,950	LAFP	0.46	0.3	13.8	--	--	--	0.003	0.2	Barren
55	EB1444979003	3	500223	7646721	sulfide (S)	5.5	5.5	1,590	LAFP	0.34	0.3	10.1	4.4	<0.1	1.7	0.007	0.0	Barren
56	EB1444979034	34	500283	7646797	sulfide (S)	14.5	4.4	2,000	LAFP	0.46	0.3	13.8	--	--	--	0.003	0.2	Barren
57	EB1444979038	38	500327	7646755	sulfide (S)	12.7	4.4	1,630	LAFP	0.37	0.3	11.1	--	--	--	0.003	0.2	Barren
58	EB1444979041	41	500300	7646734	sulfide (S)	17.8	4.1	2,390	LAFP	0.44	0.3	13.2	--	--	--	0.010	-0.1	Barren
59	EB1444979049	49	500181	7646834	sulfide (S)	13.7	4.2	618	LAFP	0.48	0.3	14.4	--	--	--	0.003	0.2	Barren

RGS No.	ALS Laboratory Number	Client Sample ID	GDA 94 Easting & Northing		Field Description	Moisture Content (%)	pH ¹	EC ¹ (µS/cm)	pH based Acid Forming Potential	Total S (%)	ANC ² (kg H ₂ SO ₄ /t)	NAPP (TS – ANC) (kg H ₂ SO ₄ /t)	NAG pH	NAG capacity @ pH 4.5 (kg H ₂ SO ₄ /t)	NAG capacity @ pH 7.0 (kg H ₂ SO ₄ /t)	CRS (%)	NAPP (CRS-ANC) (kg H ₂ SO ₄ /t)	NAPP (CRS-ANC) Sample Classification
60	EB1444979061	61	500560	7647408	sulfide (S)	11.5	4.0	1,800	LAFP	0.50	0.3	15.0	--	--	--	0.009	0.0	Barren
61	EB1444979069	69 T	500577	7647560	sulfide (S)	12.0	4.5	1,400	LAFP	0.40	0.3	12.0	--	--	--	0.003	0.2	Barren
62	EB1444979073	73 T	500563	7647830	sulfide (S)	8.0	5.8	440	LAFP	0.11	0.3	3.1	4.3	0.2	2.0	0.003	0.2	Barren
63	EB1444979005	5	500244	7646749	sulfide (S)	13.6	4.6	1,920	LAFP	0.42	0.3	12.6	--	--	--	0.003	0.2	Barren
64	EB1444979083	83	500298	7647387	mixed tails	5.6	4.5	1,530	LAFP	0.38	0.3	11.4	--	--	--	0.006	0.1	Barren
65	EB1444979050	50	500160	7646857	mixed tails	10.3	5.0	1,780	LAFP	0.33	0.3	9.8	4.5	<0.1	1.4	0.003	0.2	Barren
66	EB1444979058	58	500292	7646981	mixed tails	10.2	4.4	1,560	LAFP	0.42	0.3	12.6	--	--	--	0.003	0.2	Barren
67	EB1444979059	59	500322	7647019	mixed tails	12.3	4.0	2,180	LAFP	0.46	0.3	13.8	--	--	--	0.003	0.2	Barren
68	EB1444979051	51	500169	7646908	mixed tails	8.2	4.2	1,060	LAFP	0.26	0.3	7.7	3.6	1.1	2.4	0.003	0.2	Barren
69	EB1444979084	84	500315	7647483	mixed tails	6.3	4.1	1,370	LAFP	0.40	0.3	12.0	--	--	--	0.006	0.1	Barren
70	EB1444979085	85	500340	7647589	mixed tails	11.0	4.4	1,590	LAFP	0.44	0.3	13.2	4.3	0.2	1.6	0.005	0.1	Barren
71	EB1444979028	28	500217	7646863	mixed tails	13.6	4.4	1,090	LAFP	0.24	0.3	7.1	3.9	1.0	2.7	0.003	0.2	Barren
72	EB1444979030	30	500241	7646843	mixed tails	9.1	4.7	660	LAFP	0.20	0.3	5.9	3.9	0.9	2.2	0.003	0.2	Barren
73	EB1444979045	45	500232	7646790	mixed tails	8.5	4.4	1,480	LAFP	0.34	0.3	10.1	--	--	--	0.003	0.2	Barren
74	EB1444979006	6	500091	7646889	mixed tails	8.2	4.9	1,410	LAFP	0.29	0.3	8.6	4.6	<0.1	1.4	0.003	0.2	Barren
75	EB1444979007	7	500099	7646932	mixed tails	8.6	4.4	2,220	LAFP	0.42	0.3	12.6	--	--	--	0.003	0.2	Barren
76	EB1444979011	11	500136	7647055	mixed tails	12.4	6.6	2,030	Inert	0.21	0.6	5.8	6.2	<0.1	0.7	0.020	0.0	Barren
77	EB1444979032	32	500264	7646820	mixed tails	9.6	4.4	1,570	LAFP	0.43	0.3	12.9	--	--	--	0.003	0.2	Barren
78	EB1444979039	39	500349	7646733	mixed tails	12.2	5.0	948	LAFP	0.22	0.3	6.5	4.2	0.5	1.8	0.003	0.2	Barren
79	EB1444979044	44	500254	7646770	mixed tails	9.8	4.6	1,450	LAFP	0.34	0.3	10.1	--	--	--	0.003	0.2	Barren
80	EB1444979023	23	500157	7646912	mixed tails	13.2	4.8	1,180	LAFP	0.32	0.3	9.5	3.9	0.4	1.9	0.003	0.2	Barren
81	EB1444979027	27	500191	7646890	mixed tails	18.6	4.3	1,260	LAFP	0.28	0.3	8.3	4.3	0.5	4.0	0.003	0.2	Barren
82	EB1444979029	29	500217	7646863	mixed tails	13.7	4.1	1,880	LAFP	0.42	0.3	12.6	--	--	--	0.005	0.1	Barren
83	EB1444979031	31	500241	7646843	mixed tails	14.8	4.4	2,290	LAFP	0.51	0.3	15.3	--	--	--	0.005	0.1	Barren
84	EB1444979053	53	500186	7646945	mixed tails	18.2	4.3	2,000	LAFP	0.39	0.3	11.7	--	--	--	0.003	0.2	Barren
85	EB1444979055	55	500227	7646919	mixed tails	15.4	4.3	1,680	LAFP	0.39	0.3	11.7	--	--	--	0.003	0.2	Barren

Red numerical values are below the laboratory limit of reporting. In each case a value equal to half of the actual limit of reporting has been selected for resultant calculations.

6.0 KINETIC TEST RESULTS

Kinetic leach column (KLC) tests are used to (1) verify the static classification of a sample, (2) quantify the rate of sulfide oxidation and acid consumption and (3) assess the leachate chemistry over time.

As discussed in **Section 2.0** tailings samples were described in the field as being oxide or sulfide based on the type of the ore that was processed and visual observations. Samples were selected for kinetic testing based on (1) the field description of the tailings and (2) the NAPP classification using TS and ANC.

In order to obtain sufficient sample mass for the KLC testing oxide and sulfide samples classified using TS and ANC were composited into the two material types to provide two bulk oxide and sulfide tailings samples.

Five KLC tests commenced in December 2014 (two standard columns and three large columns) and were operated using the methodology described in **Section 4.0**. KLC test results are presented in **Attachment B** and verify that there are no significant differences in the leachate chemistry of the standard oxide or sulfide tailings KLC tests whereas there are differences in the large KLC tests (**Figure 6-1**) (ie. there are discernible differences in leachate chemistry between the oxide and sulfide tailings samples).

Overall the KLC test findings are summarised as follows:

- Initial sample:solute ratios were 2.3 and 2.7:1 for the standard columns and 11 to 22:1 in the large columns (now that the samples have been saturated, the leachate ratio of the small and large columns will be targeted as 2:1 and 10:1, respectively).
- Differences in the concentrations of the leachate from the standard and large columns is primarily due to the different sample:solute ratios.
- The standard oxide and sulfide columns do not show significant differences in leachate chemistry, although the sulfide column does have slightly lower pH and higher acidity.
- The large sulfide column has a notably higher concentration of acidity, metals and salts in the first four (monthly) leach cycles than the oxide and sulfide-oxide-soil columns.
- All columns show high initial solute concentrations in leachate that generally decreases with subsequent leach events due to the leaching of readily soluble ions being flushed from the cells – this is a common occurrence in KLC tests commonly referred to as a “first flush” response. Whilst the solute concentrations for the large oxide and sulfide tailings columns increase on the third leach event, the general concentration trends are down.

In the large cells:

- pH of leachate from all columns is between pH 4 and 5 apart from the large sulfide column, which has a leachate pH slightly less than 4.
- soluble concentrations of major, minor and trace elements are higher in leachate from the large sulfide and oxide columns compared to the large mixed column and the two standard columns.
- The concentrations of most elements in column leachate decreases significantly over time for the standard columns but remains persistently elevated for column leachate from the large oxide and sulfide columns with respect to aluminium, manganese and nickel.

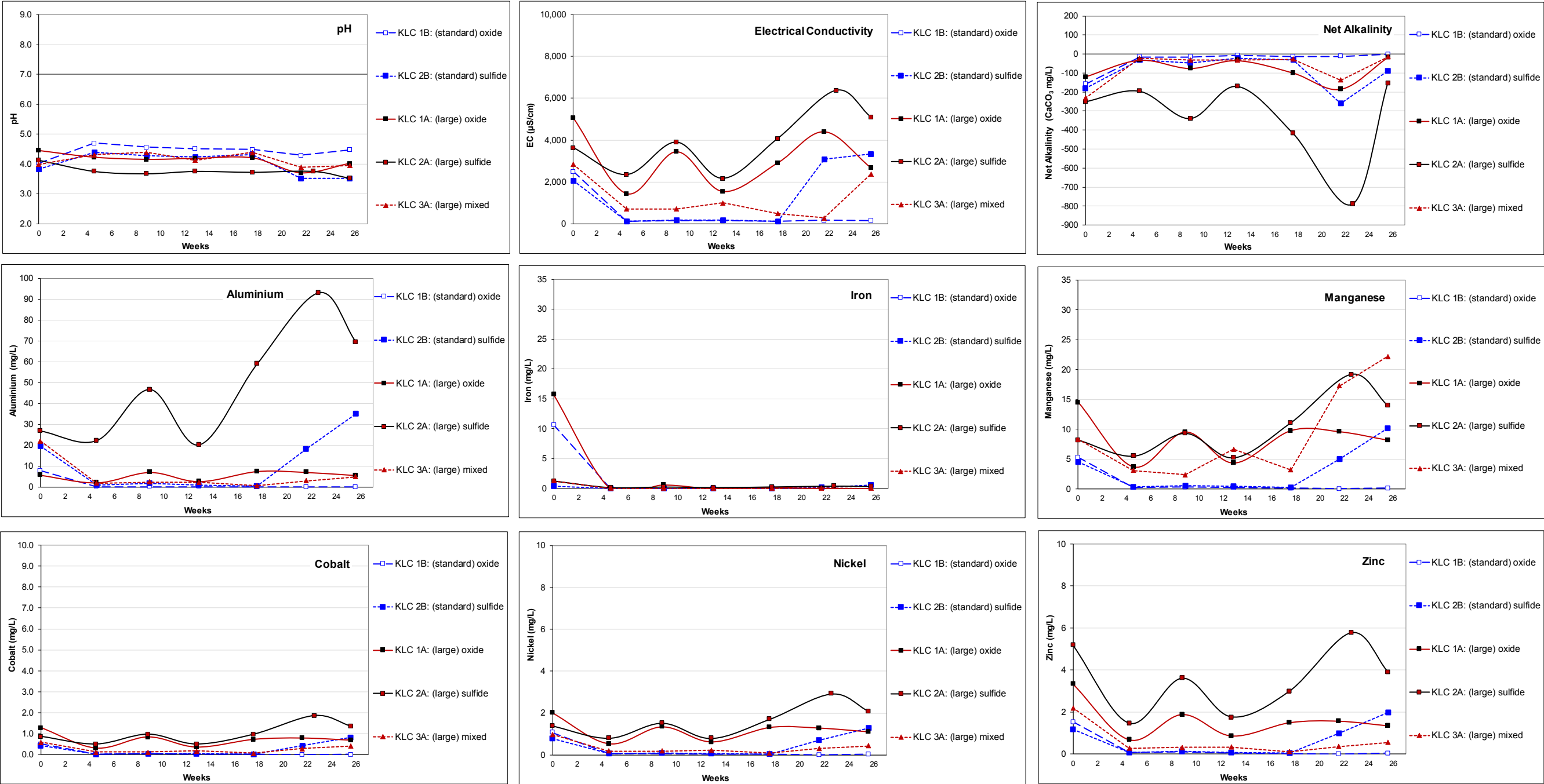


Figure 6-1: KLC Test Results

7.0 DISCUSSION

In this assessment, static geochemical tests have been used to quantify the Acid Base Account, measure the acid forming potential and geochemically classify soil and tailings samples. Static leach tests have been used to further evaluate the geochemistry of the sample materials and include measurement of the “total”, exchangeable and soluble concentrations of major ions and trace elements.

“Total” element concentrations have been used to determine whether elements are present in the sample materials at elevated concentrations compared to average crustal abundance and exchangeable cation data have been used to evaluate soil fertility and potential issues associated with sodicity. Soluble element concentrations have been used to infer potential solid/aqueous phase interactions and concentrations in surface runoff. Free draining KLC tests have been set up to provide an indication of the quality tailings pore water and any seepage.

7.1 Static Geochemistry

It has been assumed that the total sulfur concentration of 0.1 to 0.5 %TS in the 76 tailings samples (and nine soil samples) provides a reasonable representation of the initial sulfide sulfur concentration in both the oxide and sulfide tailings streams. The actual sulfide sulfur concentration of the tailings samples measured by CRS verifies that the samples have weathered/oxidised and the residual sulfide concentrations are now very low.

The oxidation of the acid producing sulfide minerals and generation of acidity has all but consumed the inherent acid consuming minerals in the tailings (there is essentially very little measureable ANC) and this has resulted in low to mild concentrations of acidity.

The absence, or very small proportion, of measured sulfide sulfur in the tailings samples verifies that since the initial placement of the tailings into the TSF, the sulfide minerals (to at least 600 mm depth) have undergone substantial or complete oxidation. As the samples oxidised, it is probable that the soluble ions precipitated in the unsaturated oxidation zones as secondary reaction products such as jarosite and schwermannite. These minerals can temporarily store acidity and metals or remove and immobilise contaminants through adsorption, co-precipitation, or structural incorporation, and can also slowly re-release both acidity and metals at pH values around pH 4. Due to their often poorly crystalline nature, schwermannite and jarosite particles continuously undergo transformation processes, which comprise dissolution/re-precipitation, solid-state recrystallization, and aggregation based crystal growth processes with release of their stored acidity (Li *et al.*, 2014). Whilst there is currently no mineralogical data to support the assumption that the source of the soluble major, minor and trace elements in the leachate from the kinetic leach cells is from the dissolution of minerals such as jarosite, it is reasonable to assume that this is the case as the vast majority of the sulfide minerals have oxidised and they are therefore no longer a source of acidity generation or metals.

The measured “total” element concentrations are generally low compared to average crustal abundance and applied health-based guideline criteria for public open spaces. Whilst the GAI values were elevated for arsenic in the both the oxide and sulfide tailings and mercury in the sulfide tailings, these elements were found to be sparingly soluble in the water extract and KLC tests on tailings materials.

The soluble and total elemental data suggest there has not been accumulation of soluble elements from the tailings into the trial soil cover through capillary action; if this had occurred the soluble concentrations of major ions (salts) would have been higher in the soil.

The multi-element data also indicate that the soil has not been adversely impacted by the accumulation of tailings through wind borne erosion processes; if this had occurred, the concentrations of the geochemical signature elements for tailings such as arsenic, mercury and antimony, for example, would have been higher in the soil.

The data suggest that depth of the soil cover (0.5 m depth) over the tailings is sufficient to not be affected by potential impacts from capillary rise of any acidity and salts in higher (and drier) topographical areas (ie in the northern and eastern areas of TSF Cell B). At the lower (and

wetter) topographical area towards the south-western side of TSF Cell B, a 1m cover depth may be more appropriate.

Anecdotal evidence from the aerial image provided in this report (**Figure 2-2**) suggests that the soluble concentrations of major ions and trace elements are not inducing chronic or acute eco-toxic effects as there is healthy vegetation growing on the tailings in drainage channels on the tailings in TSF Cell B; this suggests that the limiting factor to establishing vegetation may in fact be the availability of water; the drainage channels are likely to provide more water than the drier tailings beaches and thus more able to support vegetation.

7.2 Leach Tests, Rainfall, Surface Runoff and Seepage

Laboratory scale static and kinetic leach tests were used to assess the likely chemistry of the tailings under field conditions. The KLC cells are set up to be free draining so that adequate volumes of water can be collected and their primary application is to evaluate potential seepage quality under unsaturated freely oxidising conditions. However, there are significant differences between laboratory and field conditions such as the solid:solute ratio used, which is a function of rainfall and evaporation, soil moisture, the density and hydraulic conductivity of the tailings and the design of the TSF. On site, these factors contribute to differences in the proportion of rain that reports as runoff, water removed through evaporation/evapotranspiration, water that infiltrates into the tailings and reports to the water return dam, or water that drains to groundwater.

The climate in the region of the Yandan TSF is dominated by:

- long periods of little or no rain and irregular, short, but high intensity rainfall events, that can lead to a high proportion of runoff relative to infiltration; and
- occasional longer duration tropical depressions that may result in complete inundation and saturation of the tailings, and local or regional flooding.

Evaluation of rainfall data from the nearest available station (Moranbah) indicates that two weeks prior to the collection of the samples there was potentially 38 mm of rain at the site over two days. It is uncertain how this rainfall event contributed to the measured moisture in the samples, however it is considered unlikely that 38 mm of rain would be sufficient to wet the tailings to a depth of up to 600 mm if they had been completely dry prior to the rainfall event. It is therefore assumed that the tailings are not free draining and that they retain porewater in the 0 to 600 mm profile. The measured soil moisture in the tailings from surface to 500 mm depth was 4.7 to 18.6 % with an average of 10.7% and there were no readily discernible relationships between tailings depth and moisture.

To evaluate the effect of sample density on the permeability of the tailings, the tailings materials in the large columns were compacted to achieve a bulk density of 1.8 kg/m³ and this decreased permeability to a point where leachate could not be collected from the samples. Essentially, water remained at the top the tailings and did not penetrate significantly into the tailings mass. This required the large columns to be re-prepared with “loose” placement of the tailings and suggests that under field conditions where the tailings are consolidated, there is likely to be a significantly greater proportion of surface runoff compared to infiltration. A lower rate of infiltration would reduce the hydraulic gradient of pore water through the tailings towards the TSF sump and lead to low or even no seepage into groundwater.

In simplistic terms, this means that rainfall interaction with the tailings at TSF Cell B is generally restricted to surface tailings and results in a high proportion of surface runoff compared to infiltration. The action of disturbing and sampling the tailings and forcing water contact through re-disturbing and “loose” packing of tailings in order to get a leachate sample, has probably resulted in tailings/water interaction in the laboratory that will not occur in the field, even if the tailings mass remained uncovered.

7.2.1 Static Leach Tests and Surface Runoff

The 1:5 water extracts can be used to provide an indication of the chemistry of surface runoff from tailings. It is inferred that the extract results simulate water quality of “tailings on the tailings

beach” during a moderate rainfall event. A simplistic evaluation of the data suggests that surface runoff quality could exceed ANZECC aquatic ecosystem guidelines, but is likely to meet ANZECC stock water guidelines, other than for pH (**Table 5-5**). However, when tailings beach surface runoff mixes with runoff, direct rainfall and seepage from the TSF catchment the effect of dilution from these sources renders the water in the TSF return water dam suitable for consumption by grazing stock, and this quality may also meet aquatic ecosystem guidelines (**Table 7-1** and **Table 7-2**). It is also likely that during larger or more prolonged rainfall events, when the capacity of the TSF return water dam is exceeded and the water overflows, subsequent dilution results in aquatic ecosystem compliance in the freshwater dams down gradient of the TSF. The available surface water monitoring data for the TSF return water dam validates this assumption as measured water quality in the return water dam has neutral to alkaline pH with relatively low EC values that would make the water suitable for irrigation supply.

Given the elevated concentration of manganese in water extracts and KLC test leachate from some soil and tailings samples in the static and kinetic laboratory tests, it is recommended that this element also be included in the range of elements tests at the TSF return water dam.

Table 7-1: Yandan TSF Return Water Dam pH and EC data

Monitoring Site	Location Name	Month/year	Exact Date/Time* Sampled	Northing	Easting	pH	EC $\mu\text{S/cm}$
Tailings Runoff Dam	-	August 2011	30/08/2011	7646633	499456	6.90	960
Tailings Return Dam	TRD1	November 2011	24/11/11 07:00	7646637	499461	5.64	1,220
Tailings Return Dam	TRD1	May 2012	20/05/2012 9:35	7646637	499461	5.54	951
Tailings Return Dam	TRD1	October 2012	18/10/2012 13:00	7646637	499461	6.03	1,248
Tailings Return Dam	TRD1	April 2013	25/04/2013 14:20	7646637	499461	8.12	1,530
Tailings Return Dam	TRD1	October 2013	13/10/2013 14:10	7646637	499461	7.64	1,595
Tailings Return Dam	TRD1	May 2014	24/05/2014 10:15	7646637	499461	7.13	1,884

Table 7-2: Yandan TSF Return Water Dam Water Quality Data

Parameter	Tailings Return Dam - TRD1		
	April 2013	October 2013	May 2014
	ES1309755-030	EB1325140-031	EB1412585-020
	Value	Value	Value
pH	6.36	6.66	6.96
EC	1,590	1,930	3,020
Sulfate (SO_4)	471	728	928
Weak Acid Dissociable (WAD) Cyanide	<0.004	<0.004	<0.004
Metals (by ICP-MS)	Total	Total	Total
Aluminium (Al)	0.18	0.12	0.08
Arsenic (As)	0.002	0.002	0.001
Cadmium (Cd)	0.0006	0.0007	0.0002
Chromium (Cr)	<0.001	<0.001	<0.001
Copper (Cu)	0.003	0.002	0.002
Lead (Pb)	0.011	0.003	0.002
Nickel (Ni)	0.038	0.023	0.006
Zinc (Zn)	0.006	0.008	0.006

7.2.2 Kinetic Leach Tests and Tailings Porewater and Seepage

The KLC test results simulating potential tailings pore water or seepage quality from the tailings (under 100% permeability and following significant physical re-disturbance) verify that under these conditions, both “oxide” and “sulfide” tailings have the potential to produce mildly acidic drainage around pH 4-5. The measured acidity is dominated by acidity from aluminium, iron and manganese opposed to H^+ in sulfuric acid from sulfide oxidation.

The initial acidity level in the KLC test leachate samples was higher than for subsequent leaching events. These higher acidity concentrations probably resulted from the physical degradation of secondary minerals as the columns were set up. However, after the third leach event, the measured acidity in all the columns (apart from the large sulfide tailings column) decreased significantly and was generally consistent with the 1:5 static leach test results.

The initial major ion, trace element and acidity concentrations in the leachate from the KLC test samples are not considered to be indicative of *in situ* pore water chemistry, however longer term leachate data may be indicative once an equilibrium (relatively steady state) situation is reached. Essentially, during sample collection and preparation, the physical mixing of the samples can grossly affect the physical stability of minerals such as jarosite and increase their solubility. However, as the tailings return to, and reach, equilibrium after several leach events, the leachate chemistry is likely to be more indicative of oxidised tailings pore water under field conditions.

The solid:solute ratio is approximately 2:1 in the standard leach cells and 10:1 in the large leach cells. This can result in differences in the concentration and loads of major ions and trace elements in the leachate. The average volume of water added to the columns during each leach cycle is equivalent to 63 mm of rainfall and ranges from 49 to 77 mm.

8.0 CONCLUSIONS

Based on measured total sulfur data, the sulfide minerals and equivalent sulfide sulfur concentrations of the Yandan tailings were assumed to be in the order of 0.5% when originally placed into TSF Cell B. Since placement, the sulfide minerals have undergone substantial or complete oxidation. This means that in the tailings, to at least 600 mm depth, essentially no residual sulfide minerals are present.

The multi-element data for the soil and tailings samples indicate that metal/metalloid concentrations in solids are relatively low and/or are sparingly soluble under expected field conditions. The measured acidity in leachate from tailings is dominated by acidity from aluminium, iron and manganese as opposed to H^+ in sulfuric acid from sulfide oxidation and this is reflected in the quality of leachate from physically disturbed tailings materials.

The geochemical results indicate that secondary sulfide minerals (eg. jarosite) may be controlling solute chemistry. There are no significant differences between the small and large KLC tests except that the physical disturbance of the sulfide tailings in the large KLC tests may have adversely affected the physical stability of minerals such as jarosite and increase their solubility.

The soluble and total elemental data suggest there has not been an accumulation of soluble elements from the tailings into the trial soil cover through capillary action; if this had occurred the soluble concentrations of major ions (salts) would have been higher in the soil. The multi-element data also indicate that the soil has not been adversely impacted by the accumulation of tailings through wind borne erosion processes; if this had occurred, the concentrations of the geochemical signature elements for tailings would have been higher in soil.

Development of mitigation/rehabilitation methods for tailings, such as a cover system containing sulfide minerals, is typically undertaken to reduce the amount of:

- Oxygen ingress and subsequently sulfide mineral oxidation
- Rainwater and surface runoff that comes into contact with the tailings to ultimately control the amount of and quality of drainage.

There may be other objectives such as reducing dust from the materials, or providing a cover that will support vegetation. The sulfide mineral and total element content is relatively low in the Cell B tailings tested to date therefore (and assuming this occurs throughout the full depth of the TSF) the cover design objectives at Yandan should therefore be:

- to stop the tailings being blown from the TSF to adjoining land;
- provide a growth medium that is capable of supporting vegetation; and
- provide a stable soil surface that may include a coarse rock mulch to retain moisture from small rainfall events and protect the surface from erosion during large rainfall events.

Based on the results from this assessment it is considered unlikely that the tailings contain a sufficient mass of soluble ions (acid, salt and metals) to significantly affect the overlying soil due to the effects of capillary rise. This means that a capillary break in the cover system is unlikely to be required. The potential use if a capillary break for a TSF cover system is fundamentally questionable in any case due to potential for long term failure through differential settlement into the tailings mass and also migration of fines from the cover system into the capillary layer.

Compaction of the tailings at RGS laboratory demonstrates that the compacted Yandan tailings have very low permeability and for the initial large KLC tests, were found to be essentially impermeable. The cover system proposed for TSF Cell B could therefore utilise:

- mild grading of the current surface to smooth out any existing erosion and direct surface flow to a desired location ie. encouraging water to follow the geomorphic channels on the current surface of the TSF towards the spillway and then into the return water dam, or if water quality subsequently permits, directly to the environment;
- compaction of the regraded tailings beach profile to further decrease permeability; and
- placement of a 0.5m to 1 m deep soil cover over the tailings; a nominal minimal depth of 50 cm should be achieved in drier areas and 1m depth in wetter areas.

9.0 RECOMMENDATIONS

When the tailings materials from TSF Cell B are compacted they become virtually impermeable. In the field, the permeability of the tailings is likely to have a significant effect on the proportion of rainfall that reports as surface runoff versus infiltration.

To verify the assumptions in this report relating to runoff and infiltration RGS **recommends field permeability measurements** be undertaken using single ring or double ring infiltrometer tests. This should be done at:

- six tailings sites within Cell B
- three placed soil sited on Cell B
- three rehabilitated sites on Cell A
- three analogue soil sites outside the TSF.

At each site in-situ samples should be collected to measured specific gravity, bulk density porosity and initial soil moisture.

The test work completed in this study has verified that sulfide minerals in the top 600 mm of the TSF have undergone substantial or complete oxidation. The depth of the oxidation front into the tailings is currently unknown. To verify the depth of oxidation in the tailings profile **RGS recommends in-situ core sampling** of the tailings through the tailings profile in the deepest area of the TSF. Samples should ideally be collected from a single drill hole using push tube sampling methods to provide intact core samples. During sample retrieval pH, Eh, and EC would be measured on saturated tailings samples.

Event based water monitoring is recommended ie. collection of surface water samples prior to, during and directly after a major storm event. This could quantify surface water quality runoff from the tailings beach over a storm event and provide improve the understanding of whether water could be discharged directly to the environment. Routine sampling, on the other hand, defines water quality in the standing water bodies after the wet season, and at the end of the dry season to quantify the broader effects of dilution and evaporation.

Addition of alkaline material to acidic geological materials is a common approach to mitigate the impacts of AMD. RGS recommends adding agricultural lime (CaCO_3) to the surface of the small oxide and sulfide tailings samples to ascertain if the addition of alkalinity to the mildly acidic tailings would change the rate that metals (eg. Mn) or metalloids (eg. As) are released from the tailings if leachate chemistry is in fact dominated by secondary minerals such as jarosite that sorb metals and acid below pH 4 but can release them if the pH increases (refer to **Section 7.1**).

10.0 FORWARD WORKS COST ESTIMATE

RGS has obtained an approximate cost to drill one hole to 20 m using push tube methods; the cost estimate is \$7,000. The analytical cost would be approximately \$3,000 for 20 samples measured for CRS, TS, ANC, pH and EC.

RGS suggest that it would take approximately six days to complete field permeability testing (up to half a day per site). The main equipment requirements would include a tray back ute, a 1,000L intermediate small container (IBC) or small tank for holding water, a small generator and a pump. At each site the bulk density extracted using soil cores would also be measured.

Geochemical analyses should also be completed on surface samples at each site. The analytical cost would be approximately \$1,800 for 12 samples tested for CRS, TS, ANC, pH and EC.

11.0 REFERENCES

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12.0 LIMITATIONS AND SIGN-OFF

This report documents the work undertaken by RGS Environmental Pty Ltd (RGS).

This report should be read in full. While the findings presented in this report are based on information that RGS considers reliable unless stated otherwise, the accuracy and completeness of source information cannot be guaranteed, although RGS has taken reasonable steps to verify the accuracy of such source data. RGS has made no independent verification of this information beyond the agreed scope of works and RGS assumes no responsibility for any inaccuracies or omissions outside of RGS's direct control. Furthermore, the information compiled in this report addresses the specific needs of the Client, so may not address the needs of third parties using this report for their own purposes. Thus, RGS and their employees accept no liability for any losses or damage for any action taken or not taken on the basis of any part of the contents of this report. Those acting on information provided in this report do so entirely at their own risk.

This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Please contact Alan Robertson or Greg Maddocks at RGS if you have any questions regarding this report.

Telephone 07 3344 1222, 0431 620 623, alan@rgsenv.com

Yours sincerely,

RGS Environmental Pty Ltd



Dr. Alan Robertson
Principal Geochemist

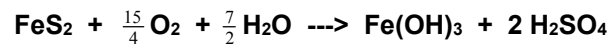
ATTACHMENT A

Geochemical Assessment Methodology for Mine Waste Materials

ATTACHMENT A

A1. Acid Generation and Prediction

Acid generation is caused by the exposure of sulfide minerals, most commonly pyrite (FeS_2), to atmospheric oxygen and water. Sulfur assay results are used to calculate the maximum amount of acid that could be generated by the sample, as a direct stoichiometric function of either the pyritic sulfur content, or by assuming that all sulfur not present as sulfate occurs as pyrite. Pyrite reacts under oxidising conditions to generate acid according to the following overall reaction:



According to this reaction, the maximum potential acidity (MPA) of a sample containing one per cent sulfur as pyrite would be 30.6 kg $\text{H}_2\text{SO}_4/\text{t}$; *ie.* 30.6 kg of acid generated per tonne of rock.

The chemical components of the acid generation process consist of the above sulfide oxidation reaction and acid neutralisation, which is mainly provided by inherent carbonates and to a lesser extent silicate materials. The amount and rate of acid generation is determined by the interaction and overall balance of the acid generation and neutralisation components.

Determination of pH and Electrical Conductivity

pH and electrical conductivity (EC) are measured (and reported) on 1:5 weight/weight water extract. This gives an indication of the inherent acidity and salinity of the mineral waste material when initially exposed in an emplacement area.

Total sulfur (S), chromium-reducible sulfur (S_{CR}) and Maximum Potential Acidity (MPA)

Total sulfur concentration is determined by the LECO high temperature combustion method. The total sulfur is typically used to calculate the Maximum Potential Acidity (MPA), which is based on the assumption that all sulfur is present as reactive pyrite.

A more accurate estimate of the MPA can be achieved by determining pyritic sulfur and other sulfide forms directly, such as using the chromium-reducible sulfur (S_{CR}) test. S_{CR} is determined by the reduction of inorganic sulfur in a hot acidic chromous chloride solution, where evolved H_2S is carried in nitrogen gas and trapped in a zinc acetate trapping solution as zinc sulfide. This solution is then titrated with iodine. For the Project, S_{CR} was used instead of total sulfur to determine MPA, where S_{CR} data was available.

Acid neutralising capacity (ANC)

The ANC measures the capacity of a sample to react with and neutralise acid by addition of acid to a known weight of sample, then titration with NaOH to determine the amount of residual acid. The ANC can be further evaluated by slow acid titration to a set end-point and then calculation of the amount of acid consumed and evaluation of the resultant titration curve, called an Acid Buffering Characteristic Curve (ABCC).

Net acid producing potential (NAPP)

The NAPP is calculated from the MPA and ANC results and represents the balance between the inherent capacity of a sample to generate acid (MPA) and neutralise acid (ANC). If the MPA is greater than the ANC (*ie.* a net excess of acidity) then the NAPP is positive. If the MPA is less than the ANC (*ie.* a net excess of alkalinity) then the NAPP is negative. A strongly positive NAPP result generally indicates that a sample is PAF, whereas a strongly negative NAPP generally indicates that a sample is NAF. The NAPP result is expressed in units of kg $\text{H}_2\text{SO}_4/\text{t}$ of sample.

Net acid generation (NAG)

The standard NAG tests can be used to confirm the acid forming nature for coal mine waste materials, but should generally be used with caution as it can generate incorrect results if the sample material contains a high concentration of sulfur or a significant amount of organic materials (ACARP, 2008). The sequential NAG or extended boil NAG test can address this issue, but are difficult to complete and acquired results can be difficult to interpret.

ATTACHMENT A

A2. Assessment of Element Enrichment and Solubility

In mineralised areas it is common to find a suite of enriched elements that have resulted from natural geological processes. Multi-element scans are carried out to identify any elements that are present in a material at concentrations that may be of environmental concern with respect to surface water quality and revegetation. The samples are typically analysed for the following elements, although the actual suite of elements tested is project specific:

Major elements Al, Ca, Fe, K, Mg, Na, Si, and S

Minor elements As, B, Cd, Co, Cr, Cu, F, Mn, Mo, Ni, P, Pb, Sb, Se, Zn

The assay result for each element is compared to either average background concentrations to evaluate any potential concerns related to rock emplacement or process residue facility operation and final rehabilitation, or compared to soil quality guidelines where applicable.

Elements identified as enriched may not necessarily be a concern for revegetation, drainage water quality, or public health but their significance should be evaluated. Similarly, because an element is not enriched does not mean it will never be a concern, because under some conditions (eg. low pH) the geochemical behaviour of common environmentally important elements such as Al, Cu, Cd, Fe and Zn increases significantly.

Water extracts or leaching tests can be used to determine the element solubilities under the existing pH conditions of the sample (eg. bottle leaching tests) or under changing conditions (eg. kinetic leach column tests). Where applicable, element concentrations in water extracts or leachates have been compared with applied water quality guidelines to determine their potential environmental significance.

A3. Kinetic Leach Column Tests

Kinetic leach column tests can be used to provide information on the reaction kinetics of mine waste materials. The major objectives of kinetics tests are to:

- Provide time-dependent data on the kinetics and rate of acid generation and acid neutralising reactions under laboratory controlled (or onsite conditions);
- Investigate metal release and drainage / seepage quality; and
- Assess treatment options such as addition of alkaline materials.

The kinetic tests simulate the weathering process that leads to acid and base generation and reaction under laboratory controlled or site conditions. The kinetic tests allow an assessment of the acid forming characteristics and indicate the rate of acid generation, over what period it will occur, and what management controls may be required.

In kinetic leach column tests, water is added to a sample and used to leach the products and by-products of acid producing and consuming reactions. Samples of leachate are then collected and analysed. Intermittent water application is applied to simulate rainfall and heat lamps are used to simulate sunshine. These tests provide real-time information and may have to continue for several months or years. Monitoring includes trends in pH, sulfate, acidity or alkalinity, and metals/metalloids, for example. The pH of the collected leachate simulates the acid drainage process, acidity or alkalinity levels indicate the rate of acid production and acid neutralisation, and sulfate production can be related to the rate of sulfide oxidation. Metal/metalloid concentration data provides an assessment of metal solubility and leaching behaviour.

Figure A1 shows the kinetic leach column set up used by RGS adapted from *AMIRA, 2002*. The columns are placed under heat lamps to allow the sample to dry between water additions to ensure adequate oxygen ingress into the sample material.

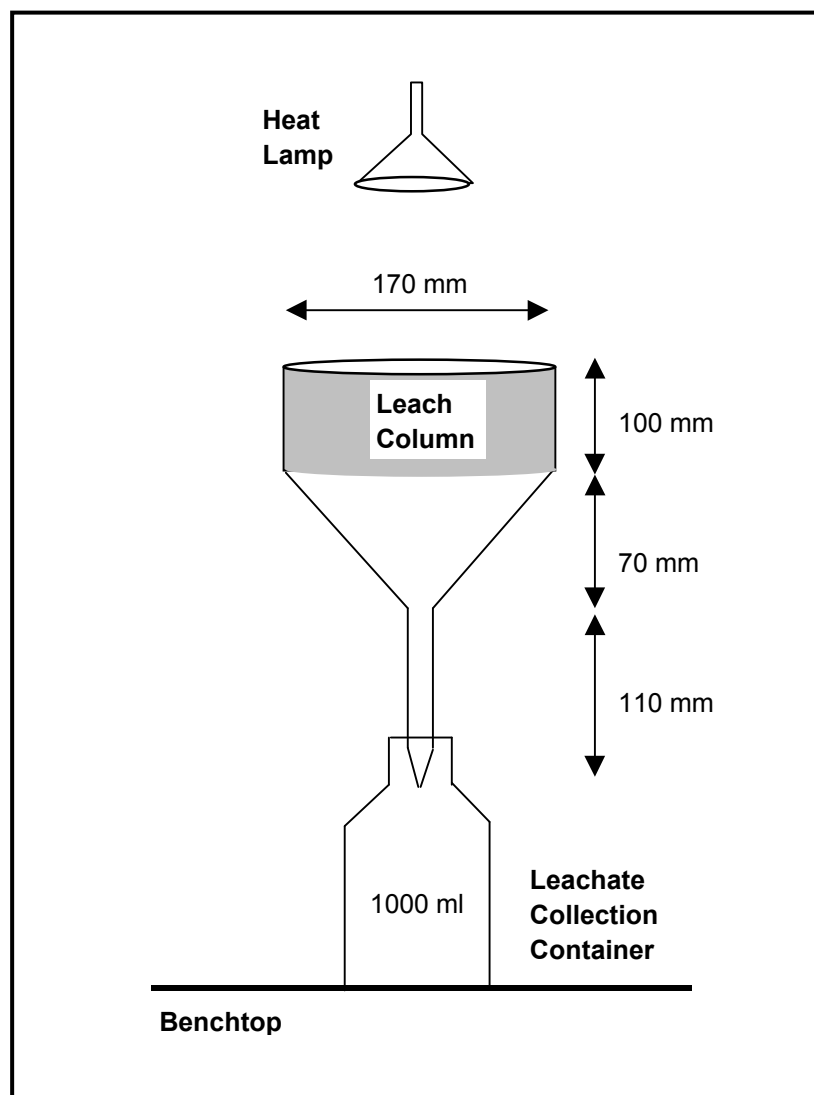
Approximately 2 kg of sample is generally used in the leach columns and depending on the physical nature of the material and particle size can be used on an as-received basis (*i.e.* no crushing as with fine rejects) or crushed to nominal 5 to 10 mm particle size (as with overburden).

ATTACHMENT A

The sample in the column is initially leached with deionised water at a rate of about 400 ml/kg of sample and the initial leachate from the columns collected and analysed. Subsequent column leaching is carried out at a rate of about 400 ml/kg per month and again collected and analysed. The leaching rate can be varied to better simulate expected site conditions or satisfy test program data requirements. The column must be exposed to drying conditions in between watering events. The residual water content and air void content in the column can be determined by comparing the wet and dry column weights. A heat lamp is generally used above the sample during daylight hours to maintain the leach column surface temperature at about 30°C.

Figure A2 shows the KLC set up used by RGS for the larger columns. No heat lamps were used for the larger KLC tests.

Figure A1
Kinetic Leach Column Setup



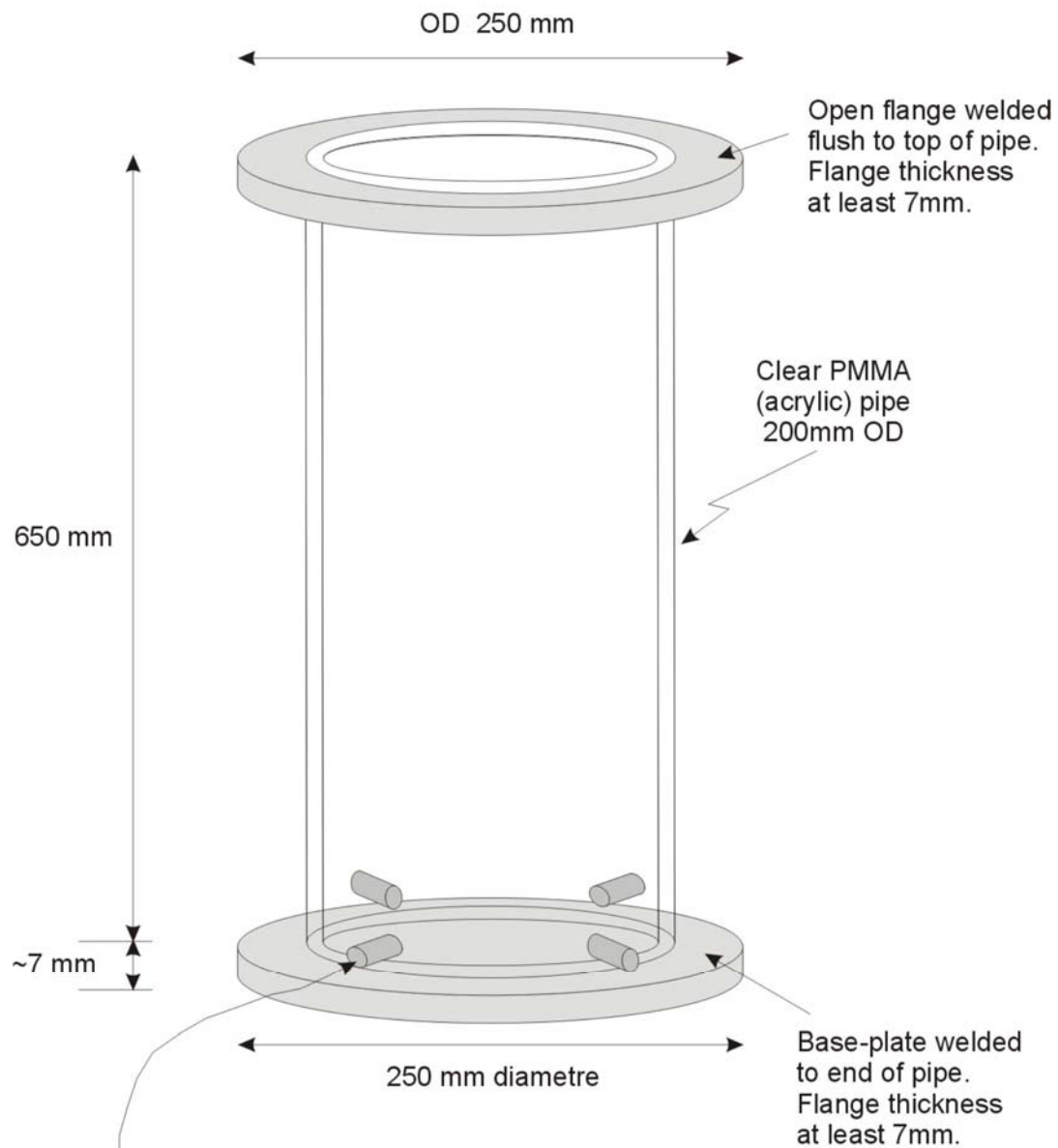
Reference:

AMIRA (2002). AMIRA International. *ARD Test Handbook. Project P387A Prediction & Kinetic Control of Acid Mine Drainage*. Ian Wark Institute and Environmental Geochemistry International Pty Ltd. May 2002, Melbourne, VIC.

ATTACHMENT A

Figure A2
Large Kinetic Leach Column Setup

3 columns. Each column as shown



- * 4 drain tubes, evenly spaced around bottom of pipe.
- * Each tube welded into pipe ~15mm up from base.
- * Each tube at least 10mm ID.
- * Each tube internally flush with inside wall of pipe.
- * Each tube protruding 15mm out from pipe.

ATTACHMENT B

Kinetic Leach Column Test Data

RGS-KLC # 1A : Yandan Straits Project (Oxide Tails)

KLC Test Results: Tailings comp (leachate = deionised water)

Weight (kg)	18.097	Total S (%)	0.251	ANC	0.27	NAG pH	4.03
pH (1:5)	4.71	Scr (%)	0.079	NAPP	2.14		
EC (µS/cm)	1,324	MPA	2.41	ANC:MPA	0.11	NAG capacity	0.58 kgH ₂ SO ₄ /t
Date	19-Dec-14	20-Jan-15	19-Feb-15	19-Mar-15	21-Apr-15	19-May-15	16-Jun-15
Week	0	5	9	13	18	22	26
Leach Number	1	2	3	4	5	6	7
ALS Laboratory Number	EB1448978	EB1511069	EB1513237	EB1515129	EB1517151	EB1519626	EB1521030
Volume Added (L)	4.0	2.0	1.8	1.8	1.8	1.8	1.8
Volume Collected (L)	1.125	1.656	1.681	1.438	1.071	0.541	1.286
Cum. Volume (L)	1.13	2.78	4.46	5.90	6.97	7.51	8.80
Solid:Solute Ratio-recovered	16.09	10.93	10.77	12.58	16.90	33.45	14.07
Solid:Solute Ratio-added	4.52	9.05	10.05	10.05	10.05	10.05	10.05
Pore Volumes	1.0	2.4	3.9	5.1	6.1	6.5	7.7
pH - RGS measurement	4.46	4.23	4.16	4.19	4.21	3.70	4.02
EC (µS/cm) - RGS record	5,070	1,439	3,450	1,539	2,910	4,410	2,690
Acidity (mg/L)*	123	32	76	34	100	187	18
Alkalinity (mg/L)*	2	<1	<1	<1	<1	<1	<1
Net Alkalinity (mg/L)*	-121	-32	-76	-34	-100	-187	-18
Dissolved elements (mg/L)	Guideline Limits #						
Calcium (Ca)	1,000	284	71	269	75	172	183
Magnesium (Mg)	-	101	21	56	22	52	40
Potassium (K)	-	35	8	19	7	14	11
Sodium (Na)	-	843	191	490	200	354	340
Chloride (Cl)	-	755	216	513	234	425	372
Sulfate (SO ₄)	1,000	1,330	432	1,190	451	1,100	922
Aluminium (Al)	5	5.70	2.10	7.08	2.66	7.53	5.59
Antimony (Sb)	-	0.006	<0.001	0.001	<0.001	0.003	0.003
Arsenic (As)	0.5	0.001	0.001	0.003	0.003	0.006	0.004
Cadmium (Cd)	0.01	0.0260	0.0054	0.0142	0.006	0.012	0.013
Chromium (Cr)	1	0.005	0.002	0.006	0.003	0.007	0.006
Cobalt (Co)	1	1.290	0.320	0.847	0.366	0.729	0.794
Copper (Cu)	1	0.158	0.044	0.11	0.051	0.091	0.086
Iron (Fe)	1#	15.7	<0.05	0.59	<0.05	0.17	<0.05
Lead (Pb)	0.1	<0.001	<0.001	0.003	<0.001	<0.001	0.002
Manganese (Mn)	2#	14.50	3.76	9.55	4.38	9.77	9.60
Molybdenum (Mo)	0.15	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel (Ni)	1	2.01	0.521	1.34	0.613	1.310	1.28
Selenium (Se)	0.02	<0.01	<0.01	0.01	<0.01	0.01	0.01
Vanadium (V)	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (Zn)	20	3.34	0.69	1.89	0.87	1.50	1.57
Calculations**							
SO ₄ Release Rate		83	40	111	36	65	56
Cumulative SO ₄ Release		83	122	233	269	334	390
Ca Release Rate		17.7	6.5	25.0	6.0	10.2	5.6
Cumulative Ca Release		17.7	24.2	49.1	55.1	65.3	70.9
Mg Release Rate		6.3	1.9	5.2	1.7	3.1	1.4
Cumulative Mg Release		6.3	8.2	13.4	15.2	18.2	19.6
Residual ANC (%)		74.6	65.9	35.5	27.4	13.6	6.5
Residual Sulfur (%)		98.9	98.4	96.9	96.4	95.6	94.8
SO ₄ /(Ca+Mg) molar ratio		1.23	1.71	1.37	1.69	1.78	2.97

< indicates less than the analytical detection limit. * Acidity and alkalinity data calculated in mg CaCO₃/L.

** SO₄, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

ANZECC & ARCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC # 2A : Yandan Straits Project (Sulfide Tails)

KLC Test Results: Tailings comp (leachate = deionised water)

Weight (kg)	18.763	Total S (%)	0.415	ANC	0.30	NAG pH	4.10
pH (1:5)	4.31	Scr (%)	0.393	NAPP	11.74		
EC (µS/cm)	1,721	MPA	12.04	ANC:MPA	0.02	NAG capacity	0.25 kgH ₂ SO ₄ /t
Date	19-Dec-14	20-Jan-15	19-Feb-15	19-Mar-15	21-Apr-15	26-May-15	16-Jun-15
Week	0	5	9	13	18	23	26
Leach Number	1	2	3	4	5	6	7
ALS Laboratory Number	EB1448978	EB1511069	EB1513237	EB1515129	EB1517151	EB1519626	EB1521030
Volume Added (L)	4.0	2.0	1.9	1.9	1.9	1.9	1.9
Volume Collected (L)	1.025	1.423	1.812	1.673	0.667	0.416	0.193
Cum. Volume (L)	1.03	2.45	4.26	5.93	6.60	7.02	7.21
Solid:Solute Ratio-recovered	18.31	13.19	10.35	11.22	28.13	45.10	97.22
Solid:Solute Ratio-added	4.69	9.38	9.88	9.88	9.88	9.88	9.88
Pore Volumes	0.9	2.1	3.7	5.2	5.7	6.1	6.3
pH - RGS measurement	4.13	3.76	3.68	3.76	3.73	3.76	3.53
EC (µS/cm) - RGS record	3,630	2,341	3,900	2,160	4,070	6,380	5,110
Acidity (mg/L)*	252	196	340	171	418	790	154
Alkalinity (mg/L)*	<1	<1	<1	<1	<1	<1	<1
Net Alkalinity (mg/L)*	-252	-196	-340	-171	-418	-790	-154
Dissolved elements (mg/L)	Guideline Limits #						
Calcium (Ca)	1,000	330	204	378	176	406	722
Magnesium (Mg)	-	73	32	65	29	67	106
Potassium (K)	-	9	4	8	4	6	11
Sodium (Na)	-	466	231	496	214	376	725
Chloride (Cl)	-	426	282	505	252	447	763
Sulfate (SO ₄)	1,000	1,100	954	1,680	806	2,060	3,820
Aluminium (Al)	5	26.80	22.30	46.70	20.20	59.00	93.00
Antimony (Sb)	-	0.057	0.013	0.028	0.017	0.035	0.064
Arsenic (As)	0.5	0.007	0.026	0.05	0.025	0.055	0.093
Cadmium (Cd)	0.01	0.0176	0.0094	0.018	0.0096	0.0176	0.0349
Chromium (Cr)	1	0.021	0.018	0.033	0.015	0.036	0.064
Cobalt (Co)	1	0.868	0.494	0.971	0.496	0.97	1.87
Copper (Cu)	1	0.280	0.168	0.352	0.167	0.317	0.633
Iron (Fe)	1#	1.22	0.13	0.22	0.13	0.23	0.37
Lead (Pb)	0.1	<0.001	0.001	0.005	0.15	0.031	0.026
Manganese (Mn)	2#	8.22	5.52	9.33	5.24	11.10	19.20
Molybdenum (Mo)	0.15	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel (Ni)	1	1.390	0.804	1.520	0.796	1.710	2.92
Selenium (Se)	0.02	<0.01	0.01	0.04	0.01	0.04	0.06
Vanadium (V)	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (Zn)	20	5.19	1.46	3.61	1.76	3.00	5.79
Calculations**							
SO ₄ Release Rate		60	72	162	72	73	85
Cumulative SO ₄ Release		60	132	295	367	440	524
Ca Release Rate		18.0	15.5	36.5	15.7	14.4	16.0
Cumulative Ca Release		18.0	33.5	70.0	85.7	100.1	116.1
Mg Release Rate		4.0	2.4	6.3	2.6	2.4	2.4
Cumulative Mg Release		4.0	6.4	12.7	15.3	17.7	20.0
Residual ANC (%)		79.9	64.1	25.8	9.6	0	0
Residual Sulfur (%)		99.5	98.9	97.6	97.1	96.5	95.8
SO ₄ /(Ca+Mg) molar ratio		1.02	1.55	1.44	1.50	1.66	1.78

< indicates less than the analytical detection limit. * Acidity and alkalinity data calculated in mg CaCO₃/L.

** SO₄, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

ANZECC & ARCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC # 3A : Yandan Straits Project (Mixed Tails)

KLC Test Results: Tailings comp (leachate = deionised water)

Weight (kg)		21.745	Total S (%)	0.310	ANC	0.51	NAG pH	4.05
pH (1:5)		4.47	Scr (%)	0.215	NAPP	6.06		
EC (µS/cm)		1,472	MPA	6.57	ANC:MPA	0.08	NAG capacity	22.7 kgH ₂ SO ₄ /t
Date		19-Dec-14	20-Jan-15	19-Feb-15	19-Mar-15	21-Apr-15	19-May-15	16-Jun-15
Week		0	5	9	13	18	22	26
Leach Number		1	2	3	4	5	6	7
ALS Laboratory Number		EB1448978	EB1511069	EB1513237	EB1515129	EB1517151	EB1519626	EB1521030
Volume Added (L)		4.0	2.0	2.3	2.2	2.2	2.2	2.2
Volume Collected (L)		0.989	1.764	2.064	1.969	1.747	1.510	1.848
Cum. Volume (L)		0.99	2.75	4.82	6.79	8.53	10.04	11.89
Solid:Solute Ratio-recovered		21.99	12.33	10.54	11.04	12.45	14.40	11.77
Solid:Solute Ratio-added		5.44	10.87	9.45	9.88	9.88	9.88	9.88
Pore Volumes		0.9	2.4	4.2	5.9	7.4	8.7	10.3
pH - RGS measurement		3.99	4.31	4.39	4.13	4.39	3.89	3.95
EC (µS/cm) - RGS record		2,840	712	710	1,002	490	281	2,373
Acidity (mg/L)*		232	23	33	33	28	137	15
Alkalinity (mg/L)*		<1	<1	<1	<1	<1	<1	<1
Net Alkalinity (mg/L)*		-232	-23	-33	-33	-28	-137	-15
Dissolved elements (mg/L)	Guideline Limits #							
Calcium (Ca)	1,000	195	32	34	49	17	82	132
Magnesium (Mg)	-	67	14	12	21	10	45	56
Potassium (K)	-	12	2	2	3	1	3	5
Sodium (Na)	-	377	80	76	107	41	171	244
Chloride (Cl)	-	397	88	83	132	54	418	311
Sulfate (SO ₄)	1,000	918	185	201	306	139	1,160	674
Aluminium (Al)	5	22.00	1.82	2.41	2.31	0.56	2.99	4.84
Antimony (Sb)	-	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic (As)	0.5	0.005	0.003	0.003	0.004	0.002	0.006	0.011
Cadmium (Cd)	0.01	0.0127	0.0020	0.0021	0.0025	0.0008	0.0032	0.0048
Chromium (Cr)	1	0.016	0.001	<0.001	0.001	<0.001	0.002	0.003
Cobalt (Co)	1	0.599	0.125	0.122	0.171	0.066	0.292	0.412
Copper (Cu)	1	0.176	0.021	0.026	0.028	0.01	0.03	0.046
Iron (Fe)	1#	1.28	<0.05	<0.05	<0.05	<0.05	0.06	<0.05
Lead (Pb)	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
Manganese (Mn)	2#	8.28	3.13	2.39	6.64	3.19	17.30	22.20
Molybdenum (Mo)	0.15	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel (Ni)	1	0.975	0.174	0.175	0.224	0.087	0.301	0.434
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium (V)	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (Zn)	20	2.19	0.28	0.32	0.34	0.12	0.36	0.56
Calculations**								
SO ₄ Release Rate		42	15	19	28	11	81	57
Cumulative SO ₄ Release		42	57	76	104	115	195	253
Ca Release Rate		8.9	2.6	3.2	4.4	1.4	5.7	11.2
Cumulative Ca Release		8.9	11.5	14.7	19.1	20.5	26.2	37.4
Mg Release Rate		3.0	1.1	1.1	1.9	0.8	3.1	4.8
Cumulative Mg Release		3.0	4.2	5.3	7.2	8.0	11.2	15.9
Residual ANC (%)		93.3	91.2	88.7	85.1	83.8	78.6	69.5
Residual Sulfur (%)		99.6	99.4	99.2	98.9	98.8	97.9	97.3
SO ₄ /(Ca+Mg) molar ratio		1.25	1.40	1.56	1.53	1.73	3.10	1.25

< indicates less than the analytical detection limit. * Acidity and alkalinity data calculated in mg CaCO₃/L.

** SO₄, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

ANZECC & ARCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC # 1B : Yandan Straits Project (Oxide Tails)

KLC Test Results: Tailings comp (leachate = deionised water)

Weight (kg)		1.733	Total S (%)	0.251	ANC	0.27	NAG pH	4.03
pH (1:5)		4.71	Scr (%)	0.079	NAPP	2.14		
EC (µS/cm)		1,324	MPA	2.41	ANC:MPA	0.11	NAG capacity	0.58 kgH ₂ SO ₄ /t
Date		19-Dec-14	20-Jan-15	19-Feb-15	19-Mar-15	21-Apr-15	19-May-15	16-Jun-15
Week		0	5	9	13	18	22	26
Leach Number		1	2	3	4	5	6	7
ALS Laboratory Number		EB1448978	EB1511069	EB1513237	EB1515129	EB1517151	EB1519626	EB1521030
Volume Added (L)		1.0	1.0	0.90	0.87	0.87	0.87	0.87
Volume Collected (L)		0.750	0.644	0.744	0.696	0.682	0.695	0.710
Cum. Volume (L)		0.75	1.39	2.14	2.83	3.52	4.21	4.92
Solid:Solute Ratio-recovered		2.31	2.69	2.33	2.49	2.54	2.49	2.44
Solid:Solute Ratio-added		1.73	1.73	1.93	1.99	1.99	1.99	1.99
Pore Volumes		0.7	1.2	1.9	2.5	3.1	3.7	4.3
pH - RGS measurement		4.03	4.70	4.56	4.52	4.49	4.29	4.48
EC (µS/cm) - RGS record		2,492	124	147	141	110	174	159
Acidity (mg/L)*		159	15	16	9	14	19	2
Alkalinity (mg/L)*		<1	<1	<1	1	<1	<1	<1
Net Alkalinity (mg/L)*		-159	-15	-16	-8	-14	-13	-2
Dissolved elements (mg/L)	Guideline Limits #							
Calcium (Ca)	1,000	192	16	15	12	11	129	8
Magnesium (Mg)	-	36	2	2	1	<1	9	<1
Potassium (K)	-	8	<1	<1	<1	<1	2	<1
Sodium (Na)	-	324	10	13	8	4	<1	6
Chloride (Cl)	-	305	6	11	4	3	7	4
Sulfate (SO ₄)	1,000	709	52	64	50	43	72	50
Aluminium (Al)	5	7.78	0.17	0.20	0.14	0.09	<0.01	0.10
Antimony (Sb)	-	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Arsenic (As)	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001
Cadmium (Cd)	0.01	0.0094	0.0004	0.0006	0.0004	0.0002	<0.0001	0.0002
Chromium (Cr)	1	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt (Co)	1	0.512	0.026	0.035	0.022	0.012	0.001	0.016
Copper (Cu)	1	0.22	0.005	0.006	0.006	0.004	<0.001	0.003
Iron (Fe)	1#	10.60	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead (Pb)	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese (Mn)	2#	5.31	0.27	0.35	0.24	0.14	0.07	0.17
Molybdenum (Mo)	0.15	<0.001	<0.001	<0.001	<0.001	<0.001	0.056	<0.001
Nickel (Ni)	1	1.060	0.050	0.066	0.042	0.027	0.003	0.03
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Vanadium (V)	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (Zn)	20	1.53	0.07	0.10	0.05	0.03	0.01	0.04
Calculations**								
SO ₄ Release Rate		307	19	27	20	17	29	20
Cumulative SO ₄ Release		307	326	354	374	391	420	440
Ca Release Rate		83.1	5.9	6.4	4.8	4.3	51.7	3.3
Cumulative Ca Release		83.1	89.0	95.5	100.3	104.6	156.4	159.6
Mg Release Rate		15.6	0.7	0.9	0.4	0.2	3.6	0.2
Cumulative Mg Release		15.6	16.3	17.2	17.6	17.8	21.4	21.6
Residual ANC (%)		1.4	0	0	0	0	0	0
Residual Sulfur (%)		95.9	95.7	95.3	95.0	94.8	94.4	94.1
SO ₄ /(Ca+Mg) molar ratio		1.18	1.12	1.46	1.53	1.52	0.21	2.36

< indicates less than the analytical detection limit. * Acidity and alkalinity data calculated in mg CaCO₃/L.

** SO₄, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

ANZECC & ARCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC # 2B : Yandan Straits Project (Sulfide Tails)

KLC Test Results: Tailings comp (leachate = deionised water)

Weight (kg)		2.134	Total S (%)	0.415	ANC	0.30	NAG pH	4.10
pH (1:5)		4.31	Scr (%)	0.393	NAPP	11.74		
EC (µS/cm)		1,721	MPA	12.04	ANC:MPA	0.02	NAG capacity	0.25 kgH ₂ SO ₄ /t
Date		19-Dec-14	20-Jan-15	19-Feb-15	19-Mar-15	21-Apr-15	19-May-15	16-Jun-15
Week		0	5	9	13	18	22	26
Leach Number		1	2	3	4	5	6	7
ALS Laboratory Number		EB1448978	EB1511069	EB1513237	EB1515129	EB1517151	EB1519626	EB1521030
Volume Added (L)		1.00	1.00	1.10	1.07	1.07	1.07	1.07
Volume Collected (L)		0.807	0.834	0.920	0.849	0.773	0.540	0.286
Cum. Volume (L)		0.81	1.64	2.56	3.41	4.18	4.72	5.01
Solid:Solute Ratio-recovered		2.64	2.56	2.32	2.51	2.76	3.95	7.46
Solid:Solute Ratio-added		2.13	2.13	1.94	1.99	1.99	1.99	1.99
Pore Volumes		0.7	1.4	2.2	3.0	3.6	4.1	4.4
pH - RGS measurement		3.84	4.40	4.27	4.23	4.32	3.52	3.52
EC (µS/cm) - RGS record		2,065	126	178	172	132	3,100	3,340
Acidity (mg/L)*		180	31	47	24	33	261	90
Alkalinity (mg/L)*		<1	<1	<1	<1	<1	<1	<1
Net Alkalinity (mg/L)*		-180	-31	-47	-24	-33	-261	-90
Dissolved elements (mg/L)	Guideline Limits #							
Calcium (Ca)	1,000	184	30	31	21	13	356	526
Magnesium (Mg)	-	35	2	4	2	2	30	62
Potassium (K)	-	4	<1	<1	<1	<1	2	4
Sodium (Na)	-	203	8	12	8	5	143	294
Chloride (Cl)	-	212	6	8	6	4	242	309
Sulfate (SO ₄)	1,000	785	91	118	79	60	2,030	2,060
Aluminium (Al)	5	19.50	0.90	1.77	0.89	0.47	18.10	35.10
Antimony (Sb)	-	0.002	<0.001	<0.001	<0.001	<0.001	0.002	0.004
Arsenic (As)	0.5	0.017	0.005	0.007	0.006	0.004	0.048	0.147
Cadmium (Cd)	0.01	0.0083	0.0005	0.0007	0.0005	0.0003	0.0074	0.016
Chromium (Cr)	1	0.02	<0.001	0.001	<0.001	<0.001	0.014	0.027
Cobalt (Co)	1	0.43	0.031	0.055	0.035	0.02	0.429	0.823
Copper (Cu)	1	0.213	0.008	0.014	0.012	0.006	0.107	0.18
Iron (Fe)	1#	0.40	<0.05	<0.05	<0.05	<0.05	0.15	0.56
Lead (Pb)	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
Manganese (Mn)	2#	4.58	0.34	0.60	0.42	0.25	5.04	10.20
Molybdenum (Mo)	0.15	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel (Ni)	1	0.772	0.053	0.092	0.062	0.038	0.693	1.27
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02
Vanadium (V)	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc (Zn)	20	1.17	0.07	0.12	0.08	0.05	0.99	1.98
Calculations**								
SO ₄ Release Rate		297	36	51	31	22	514	276
Cumulative SO ₄ Release		297	332	383	415	436	950	1226
Ca Release Rate		69.6	11.7	13.4	8.4	4.7	90.1	70.5
Cumulative Ca Release		69.6	81.3	94.7	103.0	107.7	197.8	268.3
Mg Release Rate		13.2	0.8	1.7	0.8	0.7	7.6	8.3
Cumulative Mg Release		13.2	14.0	15.7	16.5	17.3	24.9	33.2
Residual ANC (%)		25.5	14.8	1.6	0	0	0	0
Residual Sulfur (%)		97.6	97.3	96.9	96.7	96.5	92.4	90.1
SO ₄ /(Ca+Mg) molar ratio		1.36	1.14	1.31	1.36	1.54	2.09	1.37

< indicates less than the analytical detection limit. * Acidity and alkalinity data calculated in mg CaCO₃/L.

** SO₄, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

ANZECC & ARCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

ATTACHMENT C

ALS Certificates of Analysis

CERTIFICATE OF ANALYSIS

Work Order	: EB1444979	Page	: 1 of 19
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091	Address	: 2 Byth Street Stafford QLD Australia 4053
	SUNNYBANK SOUTH QLD, AUSTRALIA 4109		
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: Blanket Quote - L2	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 23-Oct-2014 19:30
C-O-C number	: ----	Date Analysis Commenced	: 27-Oct-2014
Sampler	: ALAN ROBERTSON	Issue Date	: 03-Nov-2014 10:47
Site	: ----		
Quote number	: ----	No. of samples received	: 85
		No. of samples analysed	: 85

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Satishkumar Trivedi	2 IC Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	1	2	3	4	5
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-001	EB1444979-002	EB1444979-003	EB1444979-004	EB1444979-005
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		5.8	5.6	5.5	5.2	4.6
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		3.7	4.9	10.4	8.0	12.8
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1060	634	1590	1290	1920
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		6.0	6.6	5.5	10.7	13.6
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.12	0.16	0.34	0.26	0.42



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	6	7	8	9	10
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-006	EB1444979-007	EB1444979-008	EB1444979-009	EB1444979-010
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		4.9	4.4	4.6	5.0	6.0
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		8.9	12.8	11.3	11.6	4.3
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1410	2220	1700	2580	1260
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	0.6
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		8.2	8.6	10.4	11.3	11.6
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.29	0.42	0.37	0.38	0.16



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	11	12	13	14	15
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-011	EB1444979-012	EB1444979-013	EB1444979-014	EB1444979-015
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		6.6	5.2	6.5	5.2	5.2
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		5.8	5.5	4.6	6.1	5.2
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		2030	1400	1690	1300	1060
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		0.6	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		12.4	15.2	11.6	11.5	13.4
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.21	0.18	0.15	0.20	0.17



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	16	17	18	19	20
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-016	EB1444979-017	EB1444979-018	EB1444979-019	EB1444979-020
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		5.3	5.6	5.3	5.1	4.6
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		3.4	6.4	11.9	9.5	8.3
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		899	1590	2950	2170	1790
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	0.9
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		10.1	11.7	13.4	14.6	8.9
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.11	0.21	0.39	0.31	0.30



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	21	22	23	24	25
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-021	EB1444979-022	EB1444979-023	EB1444979-024	EB1444979-025
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		4.7	5.2	4.8	5.0	4.7
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		11.0	8.0	9.8	5.8	12.2
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1520	1430	1180	1280	1790
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	0.6	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		9.4	11.6	13.2	9.3	10.7
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.36	0.28	0.32	0.19	0.40



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	26	27	28	29	30
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-026	EB1444979-027	EB1444979-028	EB1444979-029	EB1444979-030
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		5.0	4.3	4.4	4.1	4.7
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		6.1	8.6	7.3	12.8	6.1
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1100	1260	1090	1880	660
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		10.6	18.6	13.6	13.7	9.1
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.20	0.28	0.24	0.42	0.20



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	31	32	33	34	35
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-031	EB1444979-032	EB1444979-033	EB1444979-034	EB1444979-035
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		4.4	4.4	4.8	4.4	4.7
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		15.6	13.2	6.4	14.1	5.8
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		2290	1570	1100	2000	785
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		14.8	9.6	12.6	14.5	9.9
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.51	0.43	0.21	0.46	0.19



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	36	37	38	39	40
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-036	EB1444979-037	EB1444979-038	EB1444979-039	EB1444979-040
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		4.4	4.8	4.4	5.0	5.0
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		13.2	6.7	11.3	6.7	6.4
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1870	842	1630	948	1180
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		12.5	8.4	12.7	12.2	7.7
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.43	0.22	0.37	0.22	0.21



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	41	42	43	44	45
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-041	EB1444979-042	EB1444979-043	EB1444979-044	EB1444979-045
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		4.1	4.8	4.2	4.6	4.4
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		13.5	7.3	14.1	10.4	10.4
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		2390	991	1950	1450	1480
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		17.8	10.6	10.7	9.8	8.5
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.44	0.24	0.46	0.34	0.34



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	46	47	48	49	50
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-046	EB1444979-047	EB1444979-048	EB1444979-049	EB1444979-050
				Result	Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		5.0	4.4	5.0	4.2	5.0
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		6.1	12.2	6.4	14.7	10.1
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		765	1880	1770	618	1780
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		6.3	9.2	12.3	13.7	10.3
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.20	0.40	0.21	0.48	0.33



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	51	52	53	54	55
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-051	EB1444979-052	EB1444979-053	EB1444979-054	EB1444979-055
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		4.2	4.3	4.3	4.5	4.3
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		8.0	8.0	11.9	7.3	11.9
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1060	1740	2000	926	1680
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		8.2	16.1	18.2	14.1	15.4
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.26	0.26	0.39	0.24	0.39



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	56	57	58	59	60
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-056	EB1444979-057	EB1444979-058	EB1444979-059	EB1444979-060
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		4.3	4.2	4.4	4.0	4.2
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		9.2	12.8	12.8	14.1	11.0
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1100	1500	1560	2180	1120
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		10.6	9.6	10.2	12.3	7.3
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.30	0.42	0.42	0.46	0.36



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	61	62	63	64 T	65 T
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-061	EB1444979-062	EB1444979-063	EB1444979-064	EB1444979-065
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		4.0	4.3	4.2	5.5	4.3
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		15.3	11.0	12.8	-2.8	4.4
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		1800	1270	1390	925	1480
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	4.0	0.8
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	0.4	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		11.5	8.6	8.7	5.5	7.5
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.50	0.36	0.42	0.04	0.17



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	66 T	67 T	68 T	69 T	70 T
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-066	EB1444979-067	EB1444979-068	EB1444979-069	EB1444979-070
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		4.2	4.5	4.6	4.5	6.3
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		16.2	2.8	10.7	12.2	-4.6
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		2450	1550	1360	1400	159
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	1.5	<0.5	<0.5	5.2
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	0.2	<0.1	<0.1	0.5
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		12.0	12.3	11.2	12.0	4.8
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.53	0.14	0.35	0.40	0.02



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	71 T	72 T	73 T	74 T	75 T
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-071	EB1444979-072	EB1444979-073	EB1444979-074	EB1444979-075
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		7.0	6.1	5.8	4.8	6.2
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		-5.7	10.8	3.4	2.1	-2.0
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		268	2210	440	607	225
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		6.9	1.7	<0.5	<0.5	2.6
^ ANC as CaCO3	----	0.1	% CaCO3		0.7	0.2	<0.1	<0.1	0.3
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		7.0	10.4	8.0	14.0	7.6
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.04	0.41	0.11	0.07	0.02



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	76 T - OR	77 T - OR	78 T - OR	79	80
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-076	EB1444979-077	EB1444979-078	EB1444979-079	EB1444979-080
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		5.2	3.9	4.0	4.4	4.4
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		3.1	8.6	13.2	11.9	10.4
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		2000	1940	1560	1920	1160
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		1.8	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		0.2	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		6.9	7.0	10.5	14.0	11.3
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.16	0.28	0.43	0.39	0.34



Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	81	82	83	84	85
Client sampling date / time					[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]	[22-Oct-2014]
Compound	CAS Number	LOR	Unit		EB1444979-081	EB1444979-082	EB1444979-083	EB1444979-084	EB1444979-085
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		4.5	4.1	4.5	4.1	4.4
EA009: Nett Acid Production Potential									
^ Net Acid Production Potential	----	0.5	kg H2SO4/t		7.0	14.1	11.6	12.2	13.5
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		717	1780	1530	1370	1590
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		<0.5	<0.5	<0.5	<0.5	<0.5
^ ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit		0	0	0	0	0
EA055: Moisture Content									
^ Moisture Content (dried @ 103°C)	----	1	%		4.7	13.5	5.6	6.3	11.0
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		0.23	0.46	0.38	0.40	0.44



ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1446063	Page	: 1 of 29
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091	Address	: 2 Byth Street Stafford QLD Australia 4053
	SUNNYBANK SOUTH QLD, AUSTRALIA 4109		
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201434	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 10-Nov-2014 15:29
C-O-C number	: ----	Date Analysis Commenced	: 12-Nov-2014
Sampler	: ----	Issue Date	: 01-Dec-2014 18:45
Site	: ----		
Quote number	: ----	No. of samples received	: 43
		No. of samples analysed	: 43

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Greg Vogel	Laboratory Manager	Brisbane Inorganics
Satishkumar Trivedi	2 IC Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				1	2	3	4	6
				EB1444979001	EB1444979002	EB1444979003	EB1444979004	EB1444979006
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-001	EB1446063-002	EB1446063-003	EB1446063-004	EB1446063-005
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	4.6	4.2	4.4	----	4.6
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	0.2	<0.1	----	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	2.9	2.5	1.7	----	1.4
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	0.007	<0.005	<0.005
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	1.0	----	----	----	----
^ Exchangeable Magnesium	----	0.1	meq/100g	0.4	----	----	----	----
^ Exchangeable Potassium	----	0.1	meq/100g	0.2	----	----	----	----
^ Exchangeable Sodium	----	0.1	meq/100g	0.1	----	----	----	----
^ Cation Exchange Capacity	----	0.1	meq/100g	1.8	----	----	----	----
^ Exchangeable Sodium Percent	----	0.1	%	6.2	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	5	----	7	----	<5
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	5	----	7	----	<5
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<5	----	<5	----	<5
ED038A: Acidity								
Acidity	----	1	mg/kg	60	----	38	----	67
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	980	----	4640	----	2920
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	810	----	260	----	360
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	140	----	1780	----	780
Magnesium	7439-95-4	10	mg/kg	40	----	40	----	100
Sodium	7440-23-5	10	mg/kg	730	----	230	----	550
Potassium	7440-09-7	10	mg/kg	80	----	150	----	70
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	710	----	340	----	710
Potassium	7440-09-7	50	mg/kg	960	----	1440	----	1380
Calcium	7440-70-2	50	mg/kg	390	----	2140	----	1170
Magnesium	7439-95-4	50	mg/kg	170	----	100	----	230
EG005S : Soluble Metals by ICPAES								
Boron	7440-42-8	1	mg/kg	<1	----	<1	----	<1



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				1 EB1444979001	2 EB1444979002	3 EB1444979003	4 EB1444979004	6 EB1444979006
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-001	EB1446063-002	EB1446063-003	EB1446063-004	EB1446063-005
				Result	Result	Result	Result	Result
EG005S : Soluble Metals by ICPAES - Continued								
Iron	7439-89-6	1	mg/kg	<1	----	<1	----	2
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	2600	----	2130	----	3370
Antimony	7440-36-0	5	mg/kg	18	----	10	----	16
Arsenic	7440-38-2	5	mg/kg	148	----	129	----	167
Barium	7440-39-3	10	mg/kg	140	----	130	----	150
Beryllium	7440-41-7	1	mg/kg	<1	----	<1	----	1
Boron	7440-42-8	50	mg/kg	<50	----	<50	----	<50
Cadmium	7440-43-9	1	mg/kg	<1	----	<1	----	<1
Chromium	7440-47-3	2	mg/kg	58	----	50	----	56
Cobalt	7440-48-4	2	mg/kg	4	----	<2	----	5
Copper	7440-50-8	5	mg/kg	10	----	10	----	24
Iron	7439-89-6	50	mg/kg	13500	----	8090	----	13400
Lead	7439-92-1	5	mg/kg	7	----	8	----	9
Manganese	7439-96-5	5	mg/kg	37	----	8	----	39
Molybdenum	7439-98-7	2	mg/kg	<2	----	<2	----	<2
Nickel	7440-02-0	2	mg/kg	8	----	3	----	9
Selenium	7782-49-2	5	mg/kg	<5	----	<5	----	<5
Vanadium	7440-62-2	5	mg/kg	8	----	5	----	8
Zinc	7440-66-6	5	mg/kg	16	----	6	----	27
EG020S: Soluble Metals by ICPMS								
Arsenic	7440-38-2	0.01	mg/kg	<0.01	----	0.03	----	0.02
Selenium	7782-49-2	0.1	mg/kg	<0.1	----	<0.1	----	<0.1
Silver	7440-22-4	0.01	mg/kg	<0.01	----	<0.01	----	<0.01
Barium	7440-39-3	0.01	mg/kg	0.11	----	0.07	----	0.03
Beryllium	7440-41-7	0.01	mg/kg	<0.01	----	<0.01	----	0.02
Cadmium	7440-43-9	0.01	mg/kg	<0.01	----	<0.01	----	0.02
Cobalt	7440-48-4	0.01	mg/kg	0.18	----	0.11	----	1.04
Chromium	7440-47-3	0.01	mg/kg	<0.01	----	<0.01	----	<0.01
Thorium	7440-29-1	0.01	mg/kg	<0.01	----	<0.01	----	<0.01
Copper	7440-50-8	0.01	mg/kg	<0.01	----	<0.01	----	0.10
Manganese	7439-96-5	0.01	mg/kg	5.88	----	1.48	----	14.5
Molybdenum	7439-98-7	0.01	mg/kg	<0.01	----	<0.01	----	<0.01
Nickel	7440-02-0	0.01	mg/kg	0.30	----	0.11	----	1.53
Lead	7439-92-1	0.01	mg/kg	<0.01	----	<0.01	----	<0.01



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				1 EB1444979001	2 EB1444979002	3 EB1444979003	4 EB1444979004	6 EB1444979006
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-001	EB1446063-002	EB1446063-003	EB1446063-004	EB1446063-005
				Result	Result	Result	Result	Result
EG020S: Soluble Metals by ICPMS - Continued								
Antimony	7440-36-0	0.01	mg/kg	<0.01	----	0.04	----	0.02
Uranium	7440-61-1	0.01	mg/kg	<0.01	----	<0.01	----	<0.01
Zinc	7440-66-6	0.05	mg/kg	0.52	----	0.11	----	5.64
Vanadium	7440-62-2	0.1	mg/kg	<0.1	----	<0.1	----	<0.1
Aluminium	7429-90-5	0.1	mg/kg	<0.1	----	<0.1	----	2.3
EG035S: Soluble Mercury by FIMS								
Mercury	7439-97-6	0.0005	mg/kg	<0.0005	----	<0.0005	----	<0.0005
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	0.4	----	0.7	----	0.6
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	<1	----	<1	----	<1
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	<0.1	----	<0.1	----	<0.1



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				10 EB1444979010	11 EB1444979011	12 EB1444979012	13 EB1444979013	14 EB1444979014
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-006	EB1446063-007	EB1446063-008	EB1446063-009	EB1446063-010
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.0	6.2	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	1.2	0.7	----	----	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.011	0.020	<0.005	0.012	<0.005
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	1.7	----	----	----	----
^ Exchangeable Magnesium	----	0.1	meq/100g	0.3	----	----	----	----
^ Exchangeable Potassium	----	0.1	meq/100g	0.4	----	----	----	----
^ Exchangeable Sodium	----	0.1	meq/100g	<0.1	----	----	----	----
^ Cation Exchange Capacity	----	0.1	meq/100g	2.5	----	----	----	----
^ Exchangeable Sodium Percent	----	0.1	%	2.8	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	15	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	15	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<5	----	----	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	29	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	3070	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	340	----	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	790	----	----	----	----
Magnesium	7439-95-4	10	mg/kg	110	----	----	----	----
Sodium	7440-23-5	10	mg/kg	480	----	----	----	----
Potassium	7440-09-7	10	mg/kg	220	----	----	----	----
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	550	----	----	----	----
Potassium	7440-09-7	50	mg/kg	1240	----	----	----	----
Calcium	7440-70-2	50	mg/kg	1230	----	----	----	----
Magnesium	7439-95-4	50	mg/kg	310	----	----	----	----
EG005S : Soluble Metals by ICPAES								
Boron	7440-42-8	1	mg/kg	<1	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				10 EB1444979010	11 EB1444979011	12 EB1444979012	13 EB1444979013	14 EB1444979014
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-006	EB1446063-007	EB1446063-008	EB1446063-009	EB1446063-010
				Result	Result	Result	Result	Result
EG005S : Soluble Metals by ICPAES - Continued								
Iron	7439-89-6	1	mg/kg	<1	----	----	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	2780	----	----	----	----
Antimony	7440-36-0	5	mg/kg	10	----	----	----	----
Arsenic	7440-38-2	5	mg/kg	103	----	----	----	----
Barium	7440-39-3	10	mg/kg	190	----	----	----	----
Beryllium	7440-41-7	1	mg/kg	1	----	----	----	----
Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg	51	----	----	----	----
Cobalt	7440-48-4	2	mg/kg	4	----	----	----	----
Copper	7440-50-8	5	mg/kg	10	----	----	----	----
Iron	7439-89-6	50	mg/kg	10100	----	----	----	----
Lead	7439-92-1	5	mg/kg	9	----	----	----	----
Manganese	7439-96-5	5	mg/kg	52	----	----	----	----
Molybdenum	7439-98-7	2	mg/kg	<2	----	----	----	----
Nickel	7440-02-0	2	mg/kg	9	----	----	----	----
Selenium	7782-49-2	5	mg/kg	<5	----	----	----	----
Vanadium	7440-62-2	5	mg/kg	7	----	----	----	----
Zinc	7440-66-6	5	mg/kg	15	----	----	----	----
EG020S: Soluble Metals by ICPMS								
Arsenic	7440-38-2	0.01	mg/kg	<0.01	----	----	----	----
Selenium	7782-49-2	0.1	mg/kg	<0.1	----	----	----	----
Silver	7440-22-4	0.01	mg/kg	<0.01	----	----	----	----
Barium	7440-39-3	0.01	mg/kg	0.15	----	----	----	----
Beryllium	7440-41-7	0.01	mg/kg	<0.01	----	----	----	----
Cadmium	7440-43-9	0.01	mg/kg	<0.01	----	----	----	----
Cobalt	7440-48-4	0.01	mg/kg	0.06	----	----	----	----
Chromium	7440-47-3	0.01	mg/kg	<0.01	----	----	----	----
Thorium	7440-29-1	0.01	mg/kg	<0.01	----	----	----	----
Copper	7440-50-8	0.01	mg/kg	<0.01	----	----	----	----
Manganese	7439-96-5	0.01	mg/kg	3.63	----	----	----	----
Molybdenum	7439-98-7	0.01	mg/kg	<0.01	----	----	----	----
Nickel	7440-02-0	0.01	mg/kg	0.20	----	----	----	----
Lead	7439-92-1	0.01	mg/kg	<0.01	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				10 EB1444979010	11 EB1444979011	12 EB1444979012	13 EB1444979013	14 EB1444979014
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-006	EB1446063-007	EB1446063-008	EB1446063-009	EB1446063-010
				Result	Result	Result	Result	Result
EG020S: Soluble Metals by ICPMS - Continued								
Antimony	7440-36-0	0.01	mg/kg	0.01	----	----	----	----
Uranium	7440-61-1	0.01	mg/kg	<0.01	----	----	----	----
Zinc	7440-66-6	0.05	mg/kg	<0.05	----	----	----	----
Vanadium	7440-62-2	0.1	mg/kg	<0.1	----	----	----	----
Aluminium	7429-90-5	0.1	mg/kg	<0.1	----	----	----	----
EG035S: Soluble Mercury by FIMS								
Mercury	7439-97-6	0.0005	mg/kg	<0.0005	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	0.4	----	----	----	----
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	<1	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	<0.1	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				15 EB1444979015	16 EB1444979016	17 EB1444979017	19 EB1444979019	20 EB1444979020
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-011	EB1446063-012	EB1446063-013	EB1446063-014	EB1446063-015
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	----	----	----	----	4.4
NAG (pH 4.5)	----	0.1	kg H2SO4/t	----	----	----	----	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	----	----	----	----	3.2
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	<0.005	<0.005
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	----
^ Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	----	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	----	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	----	----	----	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	----	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	----	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	----	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	----	----	----	----	----
Magnesium	7439-95-4	10	mg/kg	----	----	----	----	----
Sodium	7440-23-5	10	mg/kg	----	----	----	----	----
Potassium	7440-09-7	10	mg/kg	----	----	----	----	----
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	----	----	----	----	----
Potassium	7440-09-7	50	mg/kg	----	----	----	----	----
Calcium	7440-70-2	50	mg/kg	----	----	----	----	----
Magnesium	7439-95-4	50	mg/kg	----	----	----	----	----
EG005S : Soluble Metals by ICPAES								
Boron	7440-42-8	1	mg/kg	----	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				15 EB1444979015	16 EB1444979016	17 EB1444979017	19 EB1444979019	20 EB1444979020
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-011	EB1446063-012	EB1446063-013	EB1446063-014	EB1446063-015
				Result	Result	Result	Result	Result
EG005S : Soluble Metals by ICPAES - Continued								
Iron	7439-89-6	1	mg/kg	----	----	----	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	----	----	----	----
Antimony	7440-36-0	5	mg/kg	----	----	----	----	----
Arsenic	7440-38-2	5	mg/kg	----	----	----	----	----
Barium	7440-39-3	10	mg/kg	----	----	----	----	----
Beryllium	7440-41-7	1	mg/kg	----	----	----	----	----
Boron	7440-42-8	50	mg/kg	----	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	----	----	----	----	----
Chromium	7440-47-3	2	mg/kg	----	----	----	----	----
Cobalt	7440-48-4	2	mg/kg	----	----	----	----	----
Copper	7440-50-8	5	mg/kg	----	----	----	----	----
Iron	7439-89-6	50	mg/kg	----	----	----	----	----
Lead	7439-92-1	5	mg/kg	----	----	----	----	----
Manganese	7439-96-5	5	mg/kg	----	----	----	----	----
Molybdenum	7439-98-7	2	mg/kg	----	----	----	----	----
Nickel	7440-02-0	2	mg/kg	----	----	----	----	----
Selenium	7782-49-2	5	mg/kg	----	----	----	----	----
Vanadium	7440-62-2	5	mg/kg	----	----	----	----	----
Zinc	7440-66-6	5	mg/kg	----	----	----	----	----
EG020S: Soluble Metals by ICPMS								
Arsenic	7440-38-2	0.01	mg/kg	----	----	----	----	----
Selenium	7782-49-2	0.1	mg/kg	----	----	----	----	----
Silver	7440-22-4	0.01	mg/kg	----	----	----	----	----
Barium	7440-39-3	0.01	mg/kg	----	----	----	----	----
Beryllium	7440-41-7	0.01	mg/kg	----	----	----	----	----
Cadmium	7440-43-9	0.01	mg/kg	----	----	----	----	----
Cobalt	7440-48-4	0.01	mg/kg	----	----	----	----	----
Chromium	7440-47-3	0.01	mg/kg	----	----	----	----	----
Thorium	7440-29-1	0.01	mg/kg	----	----	----	----	----
Copper	7440-50-8	0.01	mg/kg	----	----	----	----	----
Manganese	7439-96-5	0.01	mg/kg	----	----	----	----	----
Molybdenum	7439-98-7	0.01	mg/kg	----	----	----	----	----
Nickel	7440-02-0	0.01	mg/kg	----	----	----	----	----
Lead	7439-92-1	0.01	mg/kg	----	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				15 EB1444979015	16 EB1444979016	17 EB1444979017	19 EB1444979019	20 EB1444979020
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-011	EB1446063-012	EB1446063-013	EB1446063-014	EB1446063-015
				Result	Result	Result	Result	Result
EG020S: Soluble Metals by ICPMS - Continued								
Antimony	7440-36-0	0.01	mg/kg	----	----	----	----	----
Uranium	7440-61-1	0.01	mg/kg	----	----	----	----	----
Zinc	7440-66-6	0.05	mg/kg	----	----	----	----	----
Vanadium	7440-62-2	0.1	mg/kg	----	----	----	----	----
Aluminium	7429-90-5	0.1	mg/kg	----	----	----	----	----
EG035S: Soluble Mercury by FIMS								
Mercury	7439-97-6	0.0005	mg/kg	----	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	----	----	----	----	----
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	----	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	----	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				22 EB1444979022	23 EB1444979023	24 EB1444979024	26 EB1444979026	27 EB1444979027
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-016	EB1446063-017	EB1446063-018	EB1446063-019	EB1446063-020
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	----	3.9	----	4.2	4.3
NAG (pH 4.5)	----	0.1	kg H2SO4/t	----	0.4	----	0.6	0.5
NAG (pH 7.0)	----	0.1	kg H2SO4/t	----	1.9	----	3.4	4.0
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	<0.005	<0.005
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	----
^ Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	----	----	----	----	<5
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	----	----	----	----	<5
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	----	----	----	----	<5
ED038A: Acidity								
Acidity	----	1	mg/kg	----	----	----	----	144
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	----	----	----	----	2940
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	----	----	----	280
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	----	----	----	----	910
Magnesium	7439-95-4	10	mg/kg	----	----	----	----	60
Sodium	7440-23-5	10	mg/kg	----	----	----	----	370
Potassium	7440-09-7	10	mg/kg	----	----	----	----	60
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	----	----	----	----	580
Potassium	7440-09-7	50	mg/kg	----	----	----	----	1440
Calcium	7440-70-2	50	mg/kg	----	----	----	----	1430
Magnesium	7439-95-4	50	mg/kg	----	----	----	----	170
EG005S : Soluble Metals by ICPAES								
Boron	7440-42-8	1	mg/kg	----	----	----	----	<1



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				22 EB1444979022	23 EB1444979023	24 EB1444979024	26 EB1444979026	27 EB1444979027
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-016	EB1446063-017	EB1446063-018	EB1446063-019	EB1446063-020
				Result	Result	Result	Result	Result
EG005S : Soluble Metals by ICPAES - Continued								
Iron	7439-89-6	1	mg/kg	----	----	----	----	4
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	----	----	----	2740
Antimony	7440-36-0	5	mg/kg	----	----	----	----	11
Arsenic	7440-38-2	5	mg/kg	----	----	----	----	170
Barium	7440-39-3	10	mg/kg	----	----	----	----	160
Beryllium	7440-41-7	1	mg/kg	----	----	----	----	<1
Boron	7440-42-8	50	mg/kg	----	----	----	----	<50
Cadmium	7440-43-9	1	mg/kg	----	----	----	----	<1
Chromium	7440-47-3	2	mg/kg	----	----	----	----	40
Cobalt	7440-48-4	2	mg/kg	----	----	----	----	4
Copper	7440-50-8	5	mg/kg	----	----	----	----	15
Iron	7439-89-6	50	mg/kg	----	----	----	----	12400
Lead	7439-92-1	5	mg/kg	----	----	----	----	11
Manganese	7439-96-5	5	mg/kg	----	----	----	----	25
Molybdenum	7439-98-7	2	mg/kg	----	----	----	----	<2
Nickel	7440-02-0	2	mg/kg	----	----	----	----	6
Selenium	7782-49-2	5	mg/kg	----	----	----	----	<5
Vanadium	7440-62-2	5	mg/kg	----	----	----	----	7
Zinc	7440-66-6	5	mg/kg	----	----	----	----	16
EG020S: Soluble Metals by ICPMS								
Arsenic	7440-38-2	0.01	mg/kg	----	----	----	----	0.06
Selenium	7782-49-2	0.1	mg/kg	----	----	----	----	<0.1
Silver	7440-22-4	0.01	mg/kg	----	----	----	----	<0.01
Barium	7440-39-3	0.01	mg/kg	----	----	----	----	0.04
Beryllium	7440-41-7	0.01	mg/kg	----	----	----	----	0.02
Cadmium	7440-43-9	0.01	mg/kg	----	----	----	----	0.02
Cobalt	7440-48-4	0.01	mg/kg	----	----	----	----	0.86
Chromium	7440-47-3	0.01	mg/kg	----	----	----	----	0.01
Thorium	7440-29-1	0.01	mg/kg	----	----	----	----	<0.01
Copper	7440-50-8	0.01	mg/kg	----	----	----	----	0.13
Manganese	7439-96-5	0.01	mg/kg	----	----	----	----	9.01
Molybdenum	7439-98-7	0.01	mg/kg	----	----	----	----	<0.01
Nickel	7440-02-0	0.01	mg/kg	----	----	----	----	1.38
Lead	7439-92-1	0.01	mg/kg	----	----	----	----	<0.01



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				22 EB1444979022	23 EB1444979023	24 EB1444979024	26 EB1444979026	27 EB1444979027
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-016	EB1446063-017	EB1446063-018	EB1446063-019	EB1446063-020
				Result	Result	Result	Result	Result
EG020S: Soluble Metals by ICPMS - Continued								
Antimony	7440-36-0	0.01	mg/kg	----	----	----	----	0.02
Uranium	7440-61-1	0.01	mg/kg	----	----	----	----	<0.01
Zinc	7440-66-6	0.05	mg/kg	----	----	----	----	2.74
Vanadium	7440-62-2	0.1	mg/kg	----	----	----	----	<0.1
Aluminium	7429-90-5	0.1	mg/kg	----	----	----	----	6.4
EG035S: Soluble Mercury by FIMS								
Mercury	7439-97-6	0.0005	mg/kg	----	----	----	----	<0.0005
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	----	----	----	----	0.7
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	----	----	----	----	<1
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	----	----	----	----	0.1



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				28 EB1444979028	30 EB1444979030	33 EB1444979033	35 EB1444979035	37 EB1444979037
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-021	EB1446063-022	EB1446063-023	EB1446063-024	EB1446063-025
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	3.9	3.9	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	1.0	0.9	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	2.7	2.2	----	----	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	<0.005	<0.005
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	----
^ Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	----	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	----	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	----	----	----	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	----	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	----	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	----	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	----	----	----	----	----
Magnesium	7439-95-4	10	mg/kg	----	----	----	----	----
Sodium	7440-23-5	10	mg/kg	----	----	----	----	----
Potassium	7440-09-7	10	mg/kg	----	----	----	----	----
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	----	----	----	----	----
Potassium	7440-09-7	50	mg/kg	----	----	----	----	----
Calcium	7440-70-2	50	mg/kg	----	----	----	----	----
Magnesium	7439-95-4	50	mg/kg	----	----	----	----	----
EG005S : Soluble Metals by ICPAES								
Boron	7440-42-8	1	mg/kg	----	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				28 EB1444979028	30 EB1444979030	33 EB1444979033	35 EB1444979035	37 EB1444979037
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-021	EB1446063-022	EB1446063-023	EB1446063-024	EB1446063-025
				Result	Result	Result	Result	Result
EG005S : Soluble Metals by ICPAES - Continued								
Iron	7439-89-6	1	mg/kg	----	----	----	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	----	----	----	----
Antimony	7440-36-0	5	mg/kg	----	----	----	----	----
Arsenic	7440-38-2	5	mg/kg	----	----	----	----	----
Barium	7440-39-3	10	mg/kg	----	----	----	----	----
Beryllium	7440-41-7	1	mg/kg	----	----	----	----	----
Boron	7440-42-8	50	mg/kg	----	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	----	----	----	----	----
Chromium	7440-47-3	2	mg/kg	----	----	----	----	----
Cobalt	7440-48-4	2	mg/kg	----	----	----	----	----
Copper	7440-50-8	5	mg/kg	----	----	----	----	----
Iron	7439-89-6	50	mg/kg	----	----	----	----	----
Lead	7439-92-1	5	mg/kg	----	----	----	----	----
Manganese	7439-96-5	5	mg/kg	----	----	----	----	----
Molybdenum	7439-98-7	2	mg/kg	----	----	----	----	----
Nickel	7440-02-0	2	mg/kg	----	----	----	----	----
Selenium	7782-49-2	5	mg/kg	----	----	----	----	----
Vanadium	7440-62-2	5	mg/kg	----	----	----	----	----
Zinc	7440-66-6	5	mg/kg	----	----	----	----	----
EG020S: Soluble Metals by ICPMS								
Arsenic	7440-38-2	0.01	mg/kg	----	----	----	----	----
Selenium	7782-49-2	0.1	mg/kg	----	----	----	----	----
Silver	7440-22-4	0.01	mg/kg	----	----	----	----	----
Barium	7440-39-3	0.01	mg/kg	----	----	----	----	----
Beryllium	7440-41-7	0.01	mg/kg	----	----	----	----	----
Cadmium	7440-43-9	0.01	mg/kg	----	----	----	----	----
Cobalt	7440-48-4	0.01	mg/kg	----	----	----	----	----
Chromium	7440-47-3	0.01	mg/kg	----	----	----	----	----
Thorium	7440-29-1	0.01	mg/kg	----	----	----	----	----
Copper	7440-50-8	0.01	mg/kg	----	----	----	----	----
Manganese	7439-96-5	0.01	mg/kg	----	----	----	----	----
Molybdenum	7439-98-7	0.01	mg/kg	----	----	----	----	----
Nickel	7440-02-0	0.01	mg/kg	----	----	----	----	----
Lead	7439-92-1	0.01	mg/kg	----	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				28 EB1444979028	30 EB1444979030	33 EB1444979033	35 EB1444979035	37 EB1444979037
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-021	EB1446063-022	EB1446063-023	EB1446063-024	EB1446063-025
				Result	Result	Result	Result	Result
EG020S: Soluble Metals by ICPMS - Continued								
Antimony	7440-36-0	0.01	mg/kg	----	----	----	----	----
Uranium	7440-61-1	0.01	mg/kg	----	----	----	----	----
Zinc	7440-66-6	0.05	mg/kg	----	----	----	----	----
Vanadium	7440-62-2	0.1	mg/kg	----	----	----	----	----
Aluminium	7429-90-5	0.1	mg/kg	----	----	----	----	----
EG035S: Soluble Mercury by FIMS								
Mercury	7439-97-6	0.0005	mg/kg	----	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	----	----	----	----	----
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	----	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	----	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				39 EB1444979039	40 EB1444979040	42 EB1444979042	46 EB1444979046	48 EB1444979048
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-026	EB1446063-027	EB1446063-028	EB1446063-029	EB1446063-030
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	4.2	4.2	4.0	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	0.5	0.4	0.6	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	1.8	1.8	2.2	----	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	<0.005	<0.005
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	----
^ Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	----	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	----	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	----	----	----	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	----	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	----	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	----	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	----	----	----	----	----
Magnesium	7439-95-4	10	mg/kg	----	----	----	----	----
Sodium	7440-23-5	10	mg/kg	----	----	----	----	----
Potassium	7440-09-7	10	mg/kg	----	----	----	----	----
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	----	----	----	----	----
Potassium	7440-09-7	50	mg/kg	----	----	----	----	----
Calcium	7440-70-2	50	mg/kg	----	----	----	----	----
Magnesium	7439-95-4	50	mg/kg	----	----	----	----	----
EG005S : Soluble Metals by ICPAES								
Boron	7440-42-8	1	mg/kg	----	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				39 EB1444979039	40 EB1444979040	42 EB1444979042	46 EB1444979046	48 EB1444979048
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-026	EB1446063-027	EB1446063-028	EB1446063-029	EB1446063-030
				Result	Result	Result	Result	Result
EG005S : Soluble Metals by ICPAES - Continued								
Iron	7439-89-6	1	mg/kg	----	----	----	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	----	----	----	----
Antimony	7440-36-0	5	mg/kg	----	----	----	----	----
Arsenic	7440-38-2	5	mg/kg	----	----	----	----	----
Barium	7440-39-3	10	mg/kg	----	----	----	----	----
Beryllium	7440-41-7	1	mg/kg	----	----	----	----	----
Boron	7440-42-8	50	mg/kg	----	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	----	----	----	----	----
Chromium	7440-47-3	2	mg/kg	----	----	----	----	----
Cobalt	7440-48-4	2	mg/kg	----	----	----	----	----
Copper	7440-50-8	5	mg/kg	----	----	----	----	----
Iron	7439-89-6	50	mg/kg	----	----	----	----	----
Lead	7439-92-1	5	mg/kg	----	----	----	----	----
Manganese	7439-96-5	5	mg/kg	----	----	----	----	----
Molybdenum	7439-98-7	2	mg/kg	----	----	----	----	----
Nickel	7440-02-0	2	mg/kg	----	----	----	----	----
Selenium	7782-49-2	5	mg/kg	----	----	----	----	----
Vanadium	7440-62-2	5	mg/kg	----	----	----	----	----
Zinc	7440-66-6	5	mg/kg	----	----	----	----	----
EG020S: Soluble Metals by ICPMS								
Arsenic	7440-38-2	0.01	mg/kg	----	----	----	----	----
Selenium	7782-49-2	0.1	mg/kg	----	----	----	----	----
Silver	7440-22-4	0.01	mg/kg	----	----	----	----	----
Barium	7440-39-3	0.01	mg/kg	----	----	----	----	----
Beryllium	7440-41-7	0.01	mg/kg	----	----	----	----	----
Cadmium	7440-43-9	0.01	mg/kg	----	----	----	----	----
Cobalt	7440-48-4	0.01	mg/kg	----	----	----	----	----
Chromium	7440-47-3	0.01	mg/kg	----	----	----	----	----
Thorium	7440-29-1	0.01	mg/kg	----	----	----	----	----
Copper	7440-50-8	0.01	mg/kg	----	----	----	----	----
Manganese	7439-96-5	0.01	mg/kg	----	----	----	----	----
Molybdenum	7439-98-7	0.01	mg/kg	----	----	----	----	----
Nickel	7440-02-0	0.01	mg/kg	----	----	----	----	----
Lead	7439-92-1	0.01	mg/kg	----	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				39 EB1444979039	40 EB1444979040	42 EB1444979042	46 EB1444979046	48 EB1444979048
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-026	EB1446063-027	EB1446063-028	EB1446063-029	EB1446063-030
				Result	Result	Result	Result	Result
EG020S: Soluble Metals by ICPMS - Continued								
Antimony	7440-36-0	0.01	mg/kg	----	----	----	----	----
Uranium	7440-61-1	0.01	mg/kg	----	----	----	----	----
Zinc	7440-66-6	0.05	mg/kg	----	----	----	----	----
Vanadium	7440-62-2	0.1	mg/kg	----	----	----	----	----
Aluminium	7429-90-5	0.1	mg/kg	----	----	----	----	----
EG035S: Soluble Mercury by FIMS								
Mercury	7439-97-6	0.0005	mg/kg	----	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	----	----	----	----	----
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	----	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	----	----	----	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				50 EB1444979050	51 EB1444979051	52 EB1444979052	54 EB1444979054	56 EB1444979056
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-031	EB1446063-032	EB1446063-033	EB1446063-034	EB1446063-035
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	4.5	3.6	4.1	3.8	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	1.1	0.6	0.8	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	1.4	2.4	2.6	2.3	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	0.040	<0.005
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	----	----	1.6	----	----
^ Exchangeable Magnesium	----	0.1	meq/100g	----	----	0.2	----	----
^ Exchangeable Potassium	----	0.1	meq/100g	----	----	0.2	----	----
^ Exchangeable Sodium	----	0.1	meq/100g	----	----	0.2	----	----
^ Cation Exchange Capacity	----	0.1	meq/100g	----	----	2.1	----	----
^ Exchangeable Sodium Percent	----	0.1	%	----	----	5.7	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	----	<5	<5	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	----	<5	<5	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	----	<5	<5	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	----	96	86	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	----	2380	3610	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	320	660	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	----	780	900	----	----
Magnesium	7439-95-4	10	mg/kg	----	30	100	----	----
Sodium	7440-23-5	10	mg/kg	----	340	920	----	----
Potassium	7440-09-7	10	mg/kg	----	20	50	----	----
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	----	560	980	----	----
Potassium	7440-09-7	50	mg/kg	----	910	1120	----	----
Calcium	7440-70-2	50	mg/kg	----	1040	1260	----	----
Magnesium	7439-95-4	50	mg/kg	----	80	260	----	----
EG005S : Soluble Metals by ICPAES								
Boron	7440-42-8	1	mg/kg	----	<1	<1	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				50 EB1444979050	51 EB1444979051	52 EB1444979052	54 EB1444979054	56 EB1444979056
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-031	EB1446063-032	EB1446063-033	EB1446063-034	EB1446063-035
				Result	Result	Result	Result	Result
EG005S : Soluble Metals by ICPAES - Continued								
Iron	7439-89-6	1	mg/kg	----	1	2	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	----	1650	3110	----	----
Antimony	7440-36-0	5	mg/kg	----	10	19	----	----
Arsenic	7440-38-2	5	mg/kg	----	130	172	----	----
Barium	7440-39-3	10	mg/kg	----	120	150	----	----
Beryllium	7440-41-7	1	mg/kg	----	<1	<1	----	----
Boron	7440-42-8	50	mg/kg	----	<50	<50	----	----
Cadmium	7440-43-9	1	mg/kg	----	<1	<1	----	----
Chromium	7440-47-3	2	mg/kg	----	24	45	----	----
Cobalt	7440-48-4	2	mg/kg	----	<2	6	----	----
Copper	7440-50-8	5	mg/kg	----	10	16	----	----
Iron	7439-89-6	50	mg/kg	----	9960	14800	----	----
Lead	7439-92-1	5	mg/kg	----	7	8	----	----
Manganese	7439-96-5	5	mg/kg	----	16	45	----	----
Molybdenum	7439-98-7	2	mg/kg	----	<2	<2	----	----
Nickel	7440-02-0	2	mg/kg	----	3	9	----	----
Selenium	7782-49-2	5	mg/kg	----	<5	<5	----	----
Vanadium	7440-62-2	5	mg/kg	----	5	9	----	----
Zinc	7440-66-6	5	mg/kg	----	11	21	----	----
EG020S: Soluble Metals by ICPMS								
Arsenic	7440-38-2	0.01	mg/kg	----	0.08	<0.01	----	----
Selenium	7782-49-2	0.1	mg/kg	----	<0.1	<0.1	----	----
Silver	7440-22-4	0.01	mg/kg	----	<0.01	<0.01	----	----
Barium	7440-39-3	0.01	mg/kg	----	0.01	0.05	----	----
Beryllium	7440-41-7	0.01	mg/kg	----	0.02	0.02	----	----
Cadmium	7440-43-9	0.01	mg/kg	----	0.01	0.03	----	----
Cobalt	7440-48-4	0.01	mg/kg	----	0.36	1.33	----	----
Chromium	7440-47-3	0.01	mg/kg	----	0.01	<0.01	----	----
Thorium	7440-29-1	0.01	mg/kg	----	<0.01	<0.01	----	----
Copper	7440-50-8	0.01	mg/kg	----	0.11	0.07	----	----
Manganese	7439-96-5	0.01	mg/kg	----	6.75	16.7	----	----
Molybdenum	7439-98-7	0.01	mg/kg	----	<0.01	<0.01	----	----
Nickel	7440-02-0	0.01	mg/kg	----	0.65	1.93	----	----
Lead	7439-92-1	0.01	mg/kg	----	<0.01	<0.01	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				50 EB1444979050	51 EB1444979051	52 EB1444979052	54 EB1444979054	56 EB1444979056
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-031	EB1446063-032	EB1446063-033	EB1446063-034	EB1446063-035
				Result	Result	Result	Result	Result
EG020S: Soluble Metals by ICPMS - Continued								
Antimony	7440-36-0	0.01	mg/kg	----	0.02	<0.01	----	----
Uranium	7440-61-1	0.01	mg/kg	----	<0.01	0.02	----	----
Zinc	7440-66-6	0.05	mg/kg	----	3.26	4.63	----	----
Vanadium	7440-62-2	0.1	mg/kg	----	<0.1	<0.1	----	----
Aluminium	7429-90-5	0.1	mg/kg	----	4.8	2.1	----	----
EG035S: Soluble Mercury by FIMS								
Mercury	7439-97-6	0.0005	mg/kg	----	<0.0005	<0.0005	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	----	0.5	0.4	----	----
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	----	<1	<1	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	----	<0.1	<0.1	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				65 T EB1444979065	67 T EB1444979067	73 T EB1444979073	76 OR(T) EB1444979076	77 OR(T) EB1444979077
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-036	EB1446063-037	EB1446063-038	EB1446063-039	EB1446063-040
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	5.7	6.2	4.3	6.7	3.3
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	0.2	<0.1	1.0
NAG (pH 7.0)	----	0.1	kg H2SO4/t	1.0	0.7	2.0	0.6	5.7
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	<0.005	<0.005
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	3.0	3.4	----	3.5	1.9
^ Exchangeable Magnesium	----	0.1	meq/100g	0.5	2.2	----	2.1	0.3
^ Exchangeable Potassium	----	0.1	meq/100g	0.4	0.3	----	0.4	0.2
^ Exchangeable Sodium	----	0.1	meq/100g	0.1	0.1	----	0.2	<0.1
^ Cation Exchange Capacity	----	0.1	meq/100g	4.0	5.9	----	6.2	2.5
^ Exchangeable Sodium Percent	----	0.1	%	1.8	1.7	----	2.9	0.9
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	<5	<5	----	7	<5
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	<5	<5	----	7	<5
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	<5	<5	----	<5	<5
ED038A: Acidity								
Acidity	----	1	mg/kg	230	86	----	48	1200
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	3940	3520	----	4840	5520
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	130	640	----	780	360
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	940	610	----	650	1200
Magnesium	7439-95-4	10	mg/kg	140	370	----	460	210
Sodium	7440-23-5	10	mg/kg	420	670	----	1130	540
Potassium	7440-09-7	10	mg/kg	130	70	----	110	70
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	510	750	----	1210	670
Potassium	7440-09-7	50	mg/kg	1750	1460	----	1670	1590
Calcium	7440-70-2	50	mg/kg	1580	1360	----	1350	1510
Magnesium	7439-95-4	50	mg/kg	2710	4140	----	2830	2060
EG005S : Soluble Metals by ICPAES								
Boron	7440-42-8	1	mg/kg	<1	<1	----	<1	<1



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				65 T EB1444979065	67 T EB1444979067	73 T EB1444979073	76 OR(T) EB1444979076	77 OR(T) EB1444979077
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-036	EB1446063-037	EB1446063-038	EB1446063-039	EB1446063-040
				Result	Result	Result	Result	Result
EG005S : Soluble Metals by ICPAES - Continued								
Iron	7439-89-6	1	mg/kg	<1	<1	----	<1	<1
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	10100	12000	----	10200	10900
Antimony	7440-36-0	5	mg/kg	<5	<5	----	<5	<5
Arsenic	7440-38-2	5	mg/kg	20	11	----	16	14
Barium	7440-39-3	10	mg/kg	160	240	----	160	160
Beryllium	7440-41-7	1	mg/kg	2	2	----	1	3
Boron	7440-42-8	50	mg/kg	<50	<50	----	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	----	<1	<1
Chromium	7440-47-3	2	mg/kg	50	45	----	53	47
Cobalt	7440-48-4	2	mg/kg	20	22	----	26	18
Copper	7440-50-8	5	mg/kg	23	27	----	25	30
Iron	7439-89-6	50	mg/kg	29700	34000	----	41400	45500
Lead	7439-92-1	5	mg/kg	19	22	----	29	28
Manganese	7439-96-5	5	mg/kg	546	816	----	1370	457
Molybdenum	7439-98-7	2	mg/kg	<2	<2	----	<2	<2
Nickel	7440-02-0	2	mg/kg	31	34	----	45	35
Selenium	7782-49-2	5	mg/kg	<5	<5	----	<5	<5
Vanadium	7440-62-2	5	mg/kg	23	24	----	30	27
Zinc	7440-66-6	5	mg/kg	52	56	----	41	71
EG020S: Soluble Metals by ICPMS								
Arsenic	7440-38-2	0.01	mg/kg	<0.01	<0.01	----	<0.01	0.01
Selenium	7782-49-2	0.1	mg/kg	<0.1	<0.1	----	<0.1	<0.1
Silver	7440-22-4	0.01	mg/kg	<0.01	<0.01	----	<0.01	<0.01
Barium	7440-39-3	0.01	mg/kg	0.22	0.17	----	0.17	0.24
Beryllium	7440-41-7	0.01	mg/kg	0.04	0.02	----	<0.01	0.23
Cadmium	7440-43-9	0.01	mg/kg	0.03	0.02	----	0.01	0.07
Cobalt	7440-48-4	0.01	mg/kg	2.46	1.09	----	0.50	3.86
Chromium	7440-47-3	0.01	mg/kg	<0.01	<0.01	----	<0.01	0.03
Thorium	7440-29-1	0.01	mg/kg	<0.01	<0.01	----	<0.01	<0.01
Copper	7440-50-8	0.01	mg/kg	0.03	0.03	----	0.02	0.09
Manganese	7439-96-5	0.01	mg/kg	78.9	77.4	----	118	113
Molybdenum	7439-98-7	0.01	mg/kg	<0.01	<0.01	----	<0.01	<0.01
Nickel	7440-02-0	0.01	mg/kg	2.65	1.43	----	2.17	4.41
Lead	7439-92-1	0.01	mg/kg	<0.01	<0.01	----	<0.01	0.01



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				65 T EB1444979065	67 T EB1444979067	73 T EB1444979073	76 OR(T) EB1444979076	77 OR(T) EB1444979077
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]
Compound	CAS Number	LOR	Unit	EB1446063-036	EB1446063-037	EB1446063-038	EB1446063-039	EB1446063-040
				Result	Result	Result	Result	Result
EG020S: Soluble Metals by ICPMS - Continued								
Antimony	7440-36-0	0.01	mg/kg	<0.01	<0.01	----	<0.01	<0.01
Uranium	7440-61-1	0.01	mg/kg	<0.01	<0.01	----	<0.01	0.02
Zinc	7440-66-6	0.05	mg/kg	2.82	2.70	----	0.55	11.3
Vanadium	7440-62-2	0.1	mg/kg	<0.1	<0.1	----	<0.1	<0.1
Aluminium	7429-90-5	0.1	mg/kg	10.5	2.8	----	0.3	131
EG035S: Soluble Mercury by FIMS								
Mercury	7439-97-6	0.0005	mg/kg	<0.0005	<0.0005	----	<0.0005	<0.0005
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	----	<0.1	<0.1
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	2	<1	----	<1	2
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	<0.1	<0.1	----	<0.1	<0.1



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				81 EB1444979081	82 EB1444979082	85 EB1444979085	----	----
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	----	----
Compound	CAS Number	LOR	Unit	EB1446063-041	EB1446063-042	EB1446063-043	-----	-----
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	----	4.2	4.3	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	----	0.2	0.2	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	----	2.3	1.6	----	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	0.005	----	----
ED008: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	----
^ Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	----
^ Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	----
ED037: Alkalinity								
Total Alkalinity as CaCO3	----	1	mg/kg	----	<5	<5	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/kg	----	<5	<5	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/kg	----	<5	<5	----	----
ED038A: Acidity								
Acidity	----	1	mg/kg	----	58	173	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	----	1510	3770	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	----	120	140	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	----	420	860	----	----
Magnesium	7439-95-4	10	mg/kg	----	30	120	----	----
Sodium	7440-23-5	10	mg/kg	----	220	700	----	----
Potassium	7440-09-7	10	mg/kg	----	80	90	----	----
ED093T: Total Major Cations								
Sodium	7440-23-5	50	mg/kg	----	580	1140	----	----
Potassium	7440-09-7	50	mg/kg	----	1580	1560	----	----
Calcium	7440-70-2	50	mg/kg	----	2520	1080	----	----
Magnesium	7439-95-4	50	mg/kg	----	90	180	----	----
EG005S : Soluble Metals by ICPAES								
Boron	7440-42-8	1	mg/kg	----	<1	<1	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				81 EB1444979081	82 EB1444979082	85 EB1444979085	----	----
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	----	----
Compound	CAS Number	LOR	Unit	EB1446063-041	EB1446063-042	EB1446063-043	-----	-----
				Result	Result	Result	Result	Result

EG005S : Soluble Metals by ICPAES - Continued

Iron	7439-89-6	1	mg/kg	----	6	8	----	----
------	-----------	---	-------	------	---	---	------	------

EG005T: Total Metals by ICP-AES

Aluminium	7429-90-5	50	mg/kg	----	2150	2210	----	----
Antimony	7440-36-0	5	mg/kg	----	18	11	----	----
Arsenic	7440-38-2	5	mg/kg	----	209	167	----	----
Barium	7440-39-3	10	mg/kg	----	110	100	----	----
Beryllium	7440-41-7	1	mg/kg	----	<1	<1	----	----
Boron	7440-42-8	50	mg/kg	----	<50	<50	----	----
Cadmium	7440-43-9	1	mg/kg	----	<1	<1	----	----
Chromium	7440-47-3	2	mg/kg	----	45	68	----	----
Cobalt	7440-48-4	2	mg/kg	----	2	5	----	----
Copper	7440-50-8	5	mg/kg	----	8	20	----	----
Iron	7439-89-6	50	mg/kg	----	11100	11500	----	----
Lead	7439-92-1	5	mg/kg	----	19	8	----	----
Manganese	7439-96-5	5	mg/kg	----	8	31	----	----
Molybdenum	7439-98-7	2	mg/kg	----	3	2	----	----
Nickel	7440-02-0	2	mg/kg	----	3	8	----	----
Selenium	7782-49-2	5	mg/kg	----	<5	<5	----	----
Vanadium	7440-62-2	5	mg/kg	----	5	5	----	----
Zinc	7440-66-6	5	mg/kg	----	7	14	----	----

EG020S: Soluble Metals by ICPMS

Arsenic	7440-38-2	0.01	mg/kg	----	0.03	0.11	----	----
Selenium	7782-49-2	0.1	mg/kg	----	<0.1	<0.1	----	----
Silver	7440-22-4	0.01	mg/kg	----	<0.01	<0.01	----	----
Barium	7440-39-3	0.01	mg/kg	----	0.04	0.01	----	----
Beryllium	7440-41-7	0.01	mg/kg	----	<0.01	0.04	----	----
Cadmium	7440-43-9	0.01	mg/kg	----	<0.01	0.04	----	----
Cobalt	7440-48-4	0.01	mg/kg	----	0.30	1.64	----	----
Chromium	7440-47-3	0.01	mg/kg	----	<0.01	0.02	----	----
Thorium	7440-29-1	0.01	mg/kg	----	<0.01	<0.01	----	----
Copper	7440-50-8	0.01	mg/kg	----	0.04	0.07	----	----
Manganese	7439-96-5	0.01	mg/kg	----	6.02	19.5	----	----
Molybdenum	7439-98-7	0.01	mg/kg	----	<0.01	<0.01	----	----
Nickel	7440-02-0	0.01	mg/kg	----	0.48	2.41	----	----
Lead	7439-92-1	0.01	mg/kg	----	<0.01	<0.01	----	----



Analytical Results

Sub-Matrix: PULP
 (Matrix: SOIL)

Client sample ID

				81 EB1444979081	82 EB1444979082	85 EB1444979085	----	----
Client sampling date / time				[23-Oct-2014]	[23-Oct-2014]	[23-Oct-2014]	----	----
Compound	CAS Number	LOR	Unit	EB1446063-041	EB1446063-042	EB1446063-043	-----	-----
				Result	Result	Result	Result	Result
EG020S: Soluble Metals by ICPMS - Continued								
Antimony	7440-36-0	0.01	mg/kg	----	0.02	0.07	----	----
Uranium	7440-61-1	0.01	mg/kg	----	<0.01	0.02	----	----
Zinc	7440-66-6	0.05	mg/kg	----	0.62	4.80	----	----
Vanadium	7440-62-2	0.1	mg/kg	----	<0.1	<0.1	----	----
Aluminium	7429-90-5	0.1	mg/kg	----	1.9	9.4	----	----
EG035S: Soluble Mercury by FIMS								
Mercury	7439-97-6	0.0005	mg/kg	----	<0.0005	<0.0005	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	----	0.7	0.9	----	----
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	----	<1	2	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.1	mg/kg	----	<0.1	<0.1	----	----

CERTIFICATE OF ANALYSIS

Work Order	: EB1512512	Page	: 1 of 11
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091	Address	: 2 Byth Street Stafford QLD Australia 4053
	SUNNYBANK SOUTH QLD, AUSTRALIA 4109		
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201434 (Yandan)	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 09-Feb-2015 15:40
C-O-C number	: ----	Date Analysis Commenced	: 11-Feb-2015
Sampler	: ----	Issue Date	: 17-Feb-2015 13:29
Site	: ----		
Quote number	: ----	No. of samples received	: 42
		No. of samples analysed	: 42

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				5	7	8	9	18
				EB1444979005	EB1444979007	EB1444979008	EB1444979009	EB1444979018
Client sampling date / time				[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1512512-001	EB1512512-002	EB1512512-003	EB1512512-004	EB1512512-005
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	<0.005	<0.005



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				21 EB1444979021	25 EB1444979025	29 EB1444979029	31 EB1444979031	32 EB1444979032
Client sampling date / time				[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1512512-006	EB1512512-007	EB1512512-008	EB1512512-009	EB1512512-010
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	0.005	0.005	<0.005



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				34 EB1444979034	36 EB1444979036	38 EB1444979038	41 EB1444979041	43 EB1444979043
Client sampling date / time				[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1512512-011	EB1512512-012	EB1512512-013	EB1512512-014	EB1512512-015
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	0.005	<0.005	0.010	<0.005



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				44 EB1444979044	45 EB1444979045	47 EB1444979047	49 EB1444979049	53 EB1444979053
Client sampling date / time				[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1512512-016	EB1512512-017	EB1512512-018	EB1512512-019	EB1512512-020
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	<0.005	<0.005



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				55 EB1444979055	57 EB1444979057	58 EB1444979058	59 EB1444979059	60 EB1444979060
Client sampling date / time				[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1512512-021	EB1512512-022	EB1512512-023	EB1512512-024	EB1512512-025
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	<0.005	0.006



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				61 EB1444979061	62 EB1444979062	63 EB1444979063	64 T EB1444979064	66 T EB1444979066
Client sampling date / time				[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1512512-026	EB1512512-027	EB1512512-028	EB1512512-029	EB1512512-030
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.009	<0.005	<0.005	<0.005	<0.005



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				68 T EB1444979068	69 T EB1444979069	70 T EB1444979070	71 T EB1444979071	72 T EB1444979072
Client sampling date / time				[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1512512-031	EB1512512-032	EB1512512-033	EB1512512-034	EB1512512-035
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	<0.005	<0.005



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				74 T EB1444979074	75 T EB1444979075	78 OR(T) EB1444979078	79 EB1444979079	80 EB1444979080
Client sampling date / time				[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]	[22-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1512512-036	EB1512512-037	EB1512512-038	EB1512512-039	EB1512512-040
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	<0.005	<0.005	<0.005	<0.005	<0.005

Page : 11 of 11
 Work Order : EB1512512
 Client : RGS ENVIRONMENTAL PTY LTD
 Project : 201434 (Yandan)



Analytical Results

Sub-Matrix: **SOIL**
 (Matrix: **SOIL**)

Client sample ID

				83 EB1444979083	84 EB1444979084	----	----	----
Client sampling date / time				[22-Dec-2014]	[22-Dec-2014]	----	----	----
Compound	CAS Number	LOR	Unit	EB1512512-041	EB1512512-042	-----	-----	-----
				Result	Result	Result	Result	Result
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.006	0.006	----	----	----



Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1448978	Page	: 1 of 5
Amendment	: 1		
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201434 Yandan Straits	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 19-Dec-2014 17:40
C-O-C number	: ----	Date Analysis Commenced	: 23-Dec-2014
Sampler	: MANDIE MATHESON	Issue Date	: 06-Feb-2015 15:40
Site	: ----		
Quote number	: ----	No. of samples received	: 7
		No. of samples analysed	: 7

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Peter Keyte	Newcastle Manager	Newcastle - Inorganics



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

- **EA150H: Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1 2006 was not requested by the client. Typical sediment SPD values used for calculations and consequently NATA endorsement does not apply to hydrometer results.**



Analytical Results

Sub-Matrix: SOIL
 (Matrix: SOIL)

Client sample ID

				Yandan-1(A/B)-oxide tails	Yandan-2(A/B)-sulfide tails	----	----	----
Client sampling date / time				[19-Dec-2014]	[19-Dec-2014]	----	----	----
Compound	CAS Number	LOR	Unit	EB1448978-006	EB1448978-007	-----	-----	-----
				Result	Result	Result	Result	Result
EA150: Particle Sizing								
+75µm	----	1	%	39	35	----	----	----
+150µm	----	1	%	16	14	----	----	----
+300µm	----	1	%	3	3	----	----	----
+425µm	----	1	%	<1	1	----	----	----
+600µm	----	1	%	<1	<1	----	----	----
+1180µm	----	1	%	<1	<1	----	----	----
+2.36mm	----	1	%	<1	<1	----	----	----
+4.75mm	----	1	%	<1	<1	----	----	----
+9.5mm	----	1	%	<1	<1	----	----	----
+19.0mm	----	1	%	<1	<1	----	----	----
+37.5mm	----	1	%	<1	<1	----	----	----
+75.0mm	----	1	%	<1	<1	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	16	16	----	----	----
Silt (2-60 µm)	----	1	%	40	45	----	----	----
Sand (0.06-2.00 mm)	----	1	%	44	39	----	----	----
Gravel (>2mm)	----	1	%	<1	<1	----	----	----
Cobbles (>6cm)	----	1	%	<1	<1	----	----	----



Analytical Results

Sub-Matrix: WATER
 (Matrix: WATER)

Client sample ID

				Yandan-KLC (1A) -oxide	Yandan-KLC (2A) -sulfide	Yandan-KLC (3)-Mixed Tails	Yandan-KLC (1B) -oxide	Yandan-KLC (2B) -sulfide
Client sampling date / time				[18-Dec-2014]	[18-Dec-2014]	[18-Dec-2014]	[18-Dec-2014]	[18-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1448978-001	EB1448978-002	EB1448978-003	EB1448978-004	EB1448978-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	4.64	4.14	4.06	4.00	3.81
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	5280	3740	3040	2510	2100
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L	2	<1	<1	<1	<1
Total Alkalinity as CaCO ₃	----	1	mg/L	2	<1	<1	<1	<1
ED038A: Acidity								
Acidity as CaCO ₃	----	1	mg/L	123	252	232	159	180
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA								
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L	1330	1100	918	709	785
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	755	426	397	305	212
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	284	330	195	192	184
Magnesium	7439-95-4	1	mg/L	101	73	67	36	35
Sodium	7440-23-5	1	mg/L	843	466	377	324	203
Potassium	7440-09-7	1	mg/L	35	9	12	8	4
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	5.70	26.8	22.0	7.78	19.5
Antimony	7440-36-0	0.001	mg/L	0.006	0.057	0.002	<0.001	0.002
Arsenic	7440-38-2	0.001	mg/L	0.001	0.007	0.005	<0.001	0.017
Cadmium	7440-43-9	0.0001	mg/L	0.0260	0.0176	0.0127	0.0094	0.0083
Chromium	7440-47-3	0.001	mg/L	0.005	0.021	0.016	0.008	0.020
Copper	7440-50-8	0.001	mg/L	0.158	0.280	0.176	0.220	0.213
Cobalt	7440-48-4	0.001	mg/L	1.29	0.868	0.599	0.512	0.430
Nickel	7440-02-0	0.001	mg/L	2.01	1.39	0.975	1.06	0.772
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	3.34	5.19	2.19	1.53	1.17
Manganese	7439-96-5	0.001	mg/L	14.5	8.22	8.28	5.31	4.58
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: **WATER**
 (Matrix: **WATER**)

Client sample ID

				Yandan-KLC (1A) -oxide	Yandan-KLC (2A) -sulfide	Yandan-KLC (3)-Mixed Tails	Yandan-KLC (1B) -oxide	Yandan-KLC (2B) -sulfide
Client sampling date / time				[18-Dec-2014]	[18-Dec-2014]	[18-Dec-2014]	[18-Dec-2014]	[18-Dec-2014]
Compound	CAS Number	LOR	Unit	EB1448978-001	EB1448978-002	EB1448978-003	EB1448978-004	EB1448978-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Iron	7439-89-6	0.05	mg/L	15.7	1.22	1.28	10.6	0.40

CERTIFICATE OF ANALYSIS

Work Order	: EB1511069	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091	Address	: 2 Byth Street Stafford QLD Australia 4053
	SUNNYBANK SOUTH QLD, AUSTRALIA 4109		
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201434 Yandan Straits	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 20-Jan-2015 19:05
C-O-C number	: ----	Date Analysis Commenced	: 21-Jan-2015
Sampler	: MANDIE MATHESON	Issue Date	: 29-Jan-2015 17:09
Site	: ----		
Quote number	: ----	No. of samples received	: 5
		No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.



Analytical Results

Sub-Matrix: LEACHATE
 (Matrix: WATER)

Client sample ID

				Yandan - KLC (1A) - oxide	Yandan - KLC (2A) - sulfide	Yandan - KLC (3A) - mixed tails	Yandan - KLC (1B) - oxide	Yandan - KLC (2B) - sulfide
Client sampling date / time				[20-Jan-2015]	[20-Jan-2015]	[20-Jan-2015]	[20-Jan-2015]	[20-Jan-2015]
Compound	CAS Number	LOR	Unit	EB1511069-001	EB1511069-002	EB1511069-003	EB1511069-004	EB1511069-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	4.23	3.65	4.27	4.75	4.22
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1450	2340	718	172	244
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L	<1	<1	<1	<1	<1
Total Alkalinity as CaCO ₃	----	1	mg/L	<1	<1	<1	<1	<1
ED038A: Acidity								
Acidity as CaCO ₃	----	1	mg/L	32	196	23	15	31
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA								
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L	432	954	185	52	91
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	216	282	88	6	6
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	71	204	32	16	30
Magnesium	7439-95-4	1	mg/L	21	32	14	2	2
Sodium	7440-23-5	1	mg/L	191	231	80	10	8
Potassium	7440-09-7	1	mg/L	8	4	2	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	2.10	22.3	1.82	0.17	0.90
Antimony	7440-36-0	0.001	mg/L	<0.001	0.013	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.001	0.026	0.003	<0.001	0.005
Cadmium	7440-43-9	0.0001	mg/L	0.0054	0.0094	0.0020	0.0004	0.0005
Chromium	7440-47-3	0.001	mg/L	0.002	0.018	0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.044	0.168	0.021	0.005	0.008
Cobalt	7440-48-4	0.001	mg/L	0.320	0.494	0.125	0.026	0.031
Nickel	7440-02-0	0.001	mg/L	0.521	0.804	0.174	0.050	0.053
Lead	7439-92-1	0.001	mg/L	<0.001	0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.686	1.46	0.276	0.073	0.071
Manganese	7439-96-5	0.001	mg/L	3.76	5.52	3.13	0.273	0.337
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	0.01	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: **LEACHATE**
 (Matrix: **WATER**)

Client sample ID

				Yandan - KLC (1A) - oxide	Yandan - KLC (2A) - sulfide	Yandan - KLC (3A) - mixed tails	Yandan - KLC (1B) - oxide	Yandan - KLC (2B) - sulfide
Client sampling date / time				[20-Jan-2015]	[20-Jan-2015]	[20-Jan-2015]	[20-Jan-2015]	[20-Jan-2015]
Compound	CAS Number	LOR	Unit	EB1511069-001	EB1511069-002	EB1511069-003	EB1511069-004	EB1511069-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Iron	7439-89-6	0.05	mg/L	<0.05	0.13	<0.05	<0.05	<0.05



Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1513237	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201434 Yandan Straits	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 19-Feb-2015 20:00
C-O-C number	: ----	Date Analysis Commenced	: 20-Feb-2015
Sampler	: MANDIE MATHESON	Issue Date	: 02-Mar-2015 11:46
Site	: ----		
Quote number	: ----	No. of samples received	: 5
		No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories

Position

Accreditation Category

Kim McCabe

Senior Inorganic Chemist

Brisbane Inorganics



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.



Analytical Results

Sub-Matrix: LEACHATE
 (Matrix: WATER)

Client sample ID

				Yandan - KLC (1A) - oxide	Yandan - KLC (2A) - sulfide	Yandan - KLC (3A) - mixed tails	Yandan - KLC (1B) - oxide	Yandan - KLC (2B) - sulfide
Client sampling date / time				[19-Feb-2015]	[19-Feb-2015]	[19-Feb-2015]	[19-Feb-2015]	[19-Feb-2015]
Compound	CAS Number	LOR	Unit	EB1513237-001	EB1513237-002	EB1513237-003	EB1513237-004	EB1513237-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	4.18	3.69	4.39	4.63	4.26
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	3520	4010	706	187	308
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L	<1	<1	<1	<1	<1
Total Alkalinity as CaCO ₃	----	1	mg/L	<1	<1	<1	<1	<1
ED038A: Acidity								
Acidity as CaCO ₃	----	1	mg/L	76	340	33	16	47
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA								
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L	1190	1680	201	64	118
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	513	505	83	11	8
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	269	378	34	15	31
Magnesium	7439-95-4	1	mg/L	56	65	12	2	4
Sodium	7440-23-5	1	mg/L	490	496	76	13	12
Potassium	7440-09-7	1	mg/L	19	8	2	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	7.08	46.7	2.41	0.20	1.77
Antimony	7440-36-0	0.001	mg/L	0.001	0.028	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.003	0.050	0.003	<0.001	0.007
Cadmium	7440-43-9	0.0001	mg/L	0.0142	0.0180	0.0021	0.0006	0.0007
Chromium	7440-47-3	0.001	mg/L	0.006	0.033	<0.001	<0.001	0.001
Copper	7440-50-8	0.001	mg/L	0.110	0.352	0.026	0.006	0.014
Cobalt	7440-48-4	0.001	mg/L	0.847	0.971	0.122	0.035	0.055
Nickel	7440-02-0	0.001	mg/L	1.34	1.52	0.175	0.066	0.092
Lead	7439-92-1	0.001	mg/L	0.003	0.005	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	1.89	3.61	0.323	0.097	0.120
Manganese	7439-96-5	0.001	mg/L	9.55	9.33	2.39	0.352	0.596
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	0.01	0.04	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: **LEACHATE**
 (Matrix: **WATER**)

Client sample ID

				Yandan - KLC (1A) - oxide	Yandan - KLC (2A) - sulfide	Yandan - KLC (3A) - mixed tails	Yandan - KLC (1B) - oxide	Yandan - KLC (2B) - sulfide
Client sampling date / time				[19-Feb-2015]	[19-Feb-2015]	[19-Feb-2015]	[19-Feb-2015]	[19-Feb-2015]
Compound	CAS Number	LOR	Unit	EB1513237-001	EB1513237-002	EB1513237-003	EB1513237-004	EB1513237-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Iron	7439-89-6	0.05	mg/L	0.59	0.22	<0.05	<0.05	<0.05



Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1515129	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201434 Yandan Straits	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 19-Mar-2015 18:45
C-O-C number	: ----	Date Analysis Commenced	: 20-Mar-2015
Sampler	: MANDIE MATHESON	Issue Date	: 25-Mar-2015 13:29
Site	: ----		
Quote number	: ----	No. of samples received	: 5
		No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

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Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories

Position

Accreditation Category

Kim McCabe

Senior Inorganic Chemist

Brisbane Inorganics



General Comments

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
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Analytical Results

Sub-Matrix: LEACHATE
 (Matrix: WATER)

Client sample ID

				Yandan - KLC (1A) - oxide	Yandan - KLC (2A) - sulfide	Yandan - KLC (3A) - mixed tails	Yandan - KLC (1B) - oxide	Yandan - KLC (2B) - sulfide
Client sampling date / time				[19-Mar-2015]	[19-Mar-2015]	[19-Mar-2015]	[19-Mar-2015]	[19-Mar-2015]
Compound	CAS Number	LOR	Unit	EB1515129-001	EB1515129-002	EB1515129-003	EB1515129-004	EB1515129-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	4.26	3.80	4.29	4.83	4.43
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	1620	2240	1060	144	215
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L	<1	<1	<1	1	<1
Total Alkalinity as CaCO ₃	----	1	mg/L	<1	<1	<1	1	<1
ED038A: Acidity								
Acidity as CaCO ₃	----	1	mg/L	34	171	33	9	24
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA								
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L	451	806	306	50	79
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	234	252	132	4	6
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	75	176	49	12	21
Magnesium	7439-95-4	1	mg/L	22	29	21	1	2
Sodium	7440-23-5	1	mg/L	200	214	107	8	8
Potassium	7440-09-7	1	mg/L	7	4	3	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	2.66	20.2	2.31	0.14	0.89
Antimony	7440-36-0	0.001	mg/L	<0.001	0.017	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.003	0.025	0.004	<0.001	0.006
Cadmium	7440-43-9	0.0001	mg/L	0.0060	0.0096	0.0025	0.0004	0.0005
Chromium	7440-47-3	0.001	mg/L	0.003	0.015	0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.051	0.167	0.028	0.006	0.012
Cobalt	7440-48-4	0.001	mg/L	0.366	0.496	0.171	0.022	0.035
Nickel	7440-02-0	0.001	mg/L	0.613	0.796	0.224	0.042	0.062
Lead	7439-92-1	0.001	mg/L	<0.001	0.150	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	0.869	1.76	0.335	0.054	0.077
Manganese	7439-96-5	0.001	mg/L	4.38	5.24	6.64	0.235	0.418
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	0.01	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: **LEACHATE**
 (Matrix: **WATER**)

Client sample ID

				Yandan - KLC (1A) - oxide	Yandan - KLC (2A) - sulfide	Yandan - KLC (3A) - mixed tails	Yandan - KLC (1B) - oxide	Yandan - KLC (2B) - sulfide
Client sampling date / time				[19-Mar-2015]	[19-Mar-2015]	[19-Mar-2015]	[19-Mar-2015]	[19-Mar-2015]
Compound	CAS Number	LOR	Unit	EB1515129-001	EB1515129-002	EB1515129-003	EB1515129-004	EB1515129-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Iron	7439-89-6	0.05	mg/L	<0.05	0.13	<0.05	<0.05	<0.05



Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1517151	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: carsten.emrich@alsenviro.com
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7123
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201434 Yandan Straits	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 21-Apr-2015 16:30
C-O-C number	: ----	Date Analysis Commenced	: 22-Apr-2015
Sampler	: MANDIE MATHESON	Issue Date	: 27-Apr-2015 14:46
Site	: ----		
Quote number	: ----	No. of samples received	: 5
		No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
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Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories

Position

Accreditation Category

Kim McCabe

Senior Inorganic Chemist

Brisbane Inorganics



General Comments

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.



Analytical Results

Sub-Matrix: LEACHATE
 (Matrix: WATER)

Client sample ID

				Yandan - KLC (1A) - oxide	Yandan - KLC (2A) - sulfide	Yandan - KLC (3A) - mixed tails	Yandan - KLC (1B) - oxide	Yandan - KLC (2B) - sulfide
Client sampling date / time				[21-Apr-2015]	[21-Apr-2015]	[21-Apr-2015]	[21-Apr-2015]	[21-Apr-2015]
Compound	CAS Number	LOR	Unit	EB1517151-001	EB1517151-002	EB1517151-003	EB1517151-004	EB1517151-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	4.30	3.75	4.56	4.74	4.45
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	3040	4200	504	121	166
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L	<1	<1	<1	<1	<1
Total Alkalinity as CaCO ₃	----	1	mg/L	<1	<1	<1	<1	<1
ED038A: Acidity								
Acidity as CaCO ₃	----	1	mg/L	100	418	28	14	33
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA								
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L	1100	2060	139	43	60
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	425	447	54	3	4
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	172	406	17	11	13
Magnesium	7439-95-4	1	mg/L	52	67	10	<1	2
Sodium	7440-23-5	1	mg/L	354	376	41	4	5
Potassium	7440-09-7	1	mg/L	14	6	1	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	7.53	59.0	0.56	0.09	0.47
Antimony	7440-36-0	0.001	mg/L	0.003	0.035	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.006	0.055	0.002	<0.001	0.004
Cadmium	7440-43-9	0.0001	mg/L	0.0120	0.0176	0.0008	0.0002	0.0003
Chromium	7440-47-3	0.001	mg/L	0.007	0.036	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.091	0.317	0.010	0.004	0.006
Cobalt	7440-48-4	0.001	mg/L	0.729	0.970	0.066	0.012	0.020
Nickel	7440-02-0	0.001	mg/L	1.31	1.71	0.087	0.027	0.038
Lead	7439-92-1	0.001	mg/L	<0.001	0.031	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	1.50	3.00	0.116	0.032	0.047
Manganese	7439-96-5	0.001	mg/L	9.77	11.1	3.19	0.135	0.250
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	0.01	0.04	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: **LEACHATE**
 (Matrix: **WATER**)

Client sample ID

				Yandan - KLC (1A) - oxide	Yandan - KLC (2A) - sulfide	Yandan - KLC (3A) - mixed tails	Yandan - KLC (1B) - oxide	Yandan - KLC (2B) - sulfide
Client sampling date / time				[21-Apr-2015]	[21-Apr-2015]	[21-Apr-2015]	[21-Apr-2015]	[21-Apr-2015]
Compound	CAS Number	LOR	Unit	EB1517151-001	EB1517151-002	EB1517151-003	EB1517151-004	EB1517151-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Iron	7439-89-6	0.05	mg/L	0.17	0.23	<0.05	<0.05	<0.05



ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: EB1519626	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: carsten.emrich@alsenviro.com
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7123
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201434 Yandan Straits	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 26-May-2015 14:45
C-O-C number	: ----	Date Analysis Commenced	: 27-May-2015
Sampler	: VERONICA CANALES	Issue Date	: 01-Jun-2015 14:39
Site	: ----		
Quote number	: ----	No. of samples received	: 5
		No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



WORLD RECOGNISED
ACCREDITATION

NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories

Position

Accreditation Category

Kim McCabe

Senior Inorganic Chemist

Brisbane Inorganics



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.



Analytical Results

Sub-Matrix: LEACHATE
 (Matrix: WATER)

Client sample ID

				Yandan - KLC (1A) - oxide	Yandan - KLC (2A) - sulfide	Yandan - KLC (3A) - mixed tails	Yandan - KLC (1B) - oxide	Yandan - KLC (2B) - sulfide
Client sampling date / time				[19-May-2015]	[26-May-2015]	[19-May-2015]	[19-May-2015]	[19-May-2015]
Compound	CAS Number	LOR	Unit	EB1519626-001	EB1519626-002	EB1519626-003	EB1519626-004	EB1519626-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	4.13	3.67	4.09	4.72	3.67
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	4530	6840	2900	184	3340
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L	<1	<1	<1	<1	<1
Total Alkalinity as CaCO ₃	----	1	mg/L	<1	<1	<1	<1	<1
ED038A: Acidity								
Acidity as CaCO ₃	----	1	mg/L	187	790	137	19	261
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA								
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L	1880	3820	1160	72	2030
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	642	763	418	7	242
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	188	722	82	129	356
Magnesium	7439-95-4	1	mg/L	46	106	45	9	30
Sodium	7440-23-5	1	mg/L	368	725	171	<1	143
Potassium	7440-09-7	1	mg/L	11	11	3	2	2
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	7.06	93.0	2.99	<0.01	18.1
Antimony	7440-36-0	0.001	mg/L	0.003	0.064	<0.001	0.001	0.002
Arsenic	7440-38-2	0.001	mg/L	0.004	0.093	0.006	0.005	0.048
Cadmium	7440-43-9	0.0001	mg/L	0.0130	0.0349	0.0032	<0.0001	0.0074
Chromium	7440-47-3	0.001	mg/L	0.006	0.064	0.002	<0.001	0.014
Copper	7440-50-8	0.001	mg/L	0.086	0.633	0.030	<0.001	0.107
Cobalt	7440-48-4	0.001	mg/L	0.794	1.87	0.292	0.001	0.429
Nickel	7440-02-0	0.001	mg/L	1.28	2.92	0.301	0.003	0.693
Lead	7439-92-1	0.001	mg/L	0.002	0.026	0.002	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	1.57	5.79	0.355	0.006	0.993
Manganese	7439-96-5	0.001	mg/L	9.60	19.2	17.3	0.069	5.04
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	<0.001	0.056	<0.001
Selenium	7782-49-2	0.01	mg/L	0.01	0.06	<0.01	0.01	0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: **LEACHATE**
 (Matrix: **WATER**)

Client sample ID

				Yandan - KLC (1A) - oxide	Yandan - KLC (2A) - sulfide	Yandan - KLC (3A) - mixed tails	Yandan - KLC (1B) - oxide	Yandan - KLC (2B) - sulfide
Client sampling date / time				[19-May-2015]	[26-May-2015]	[19-May-2015]	[19-May-2015]	[19-May-2015]
Compound	CAS Number	LOR	Unit	EB1519626-001	EB1519626-002	EB1519626-003	EB1519626-004	EB1519626-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Iron	7439-89-6	0.05	mg/L	<0.05	0.37	0.06	<0.05	0.15

CERTIFICATE OF ANALYSIS

Work Order	: EB1521030	Page	: 1 of 4
Client	: RGS ENVIRONMENTAL PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091	Address	: 2 Byth Street Stafford QLD Australia 4053
	SUNNYBANK SOUTH QLD, AUSTRALIA 4109		
E-mail	: alan@rgsenv.com	E-mail	: carsten.emrich@alsenviro.com
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7123
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201434 Yandan Straits	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 16-Jun-2015 15:40
C-O-C number	: ----	Date Analysis Commenced	: 17-Jun-2015
Sampler	: VERONICA CANALES	Issue Date	: 23-Jun-2015 14:11
Site	: ----		
Quote number	: ----	No. of samples received	: 5
		No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results



NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.



Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	KLC 1A	KLC 2A	KLC 3A	KLC 1B	KLC 2B
Client sampling date / time					[16-Jun-2015]	[16-Jun-2015]	[16-Jun-2015]	[16-Jun-2015]	[16-Jun-2015]
Compound	CAS Number	LOR	Unit		EB1521030-001	EB1521030-002	EB1521030-003	EB1521030-004	EB1521030-005
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		4.15	3.60	4.10	4.76	3.59
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		2900	5350	2400	144	3980
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO ₃	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO ₃	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO ₃	71-52-3	1	mg/L		<1	<1	<1	<1	<1
Total Alkalinity as CaCO ₃	----	1	mg/L		<1	<1	<1	<1	<1
ED038A: Acidity									
Acidity as CaCO ₃	----	1	mg/L		18	154	15	2	90
ED041G: Sulfate (Turbidimetric) as SO₄ 2- by DA									
Sulfate as SO ₄ - Turbidimetric	14808-79-8	1	mg/L		922	2500	674	50	2060
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		372	519	311	4	309
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		183	520	132	8	526
Magnesium	7439-95-4	1	mg/L		40	78	56	<1	62
Sodium	7440-23-5	1	mg/L		340	528	244	6	294
Potassium	7440-09-7	1	mg/L		11	8	5	<1	4
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		5.59	69.4	4.84	0.10	35.1
Antimony	7440-36-0	0.001	mg/L		0.002	0.037	<0.001	<0.001	0.004
Arsenic	7440-38-2	0.001	mg/L		0.006	0.087	0.011	<0.001	0.147
Cadmium	7440-43-9	0.0001	mg/L		0.0116	0.0266	0.0048	0.0002	0.0160
Chromium	7440-47-3	0.001	mg/L		0.005	0.047	0.003	<0.001	0.027
Copper	7440-50-8	0.001	mg/L		0.064	0.453	0.046	0.003	0.180
Cobalt	7440-48-4	0.001	mg/L		0.691	1.36	0.412	0.016	0.823
Nickel	7440-02-0	0.001	mg/L		1.10	2.08	0.434	0.030	1.27
Lead	7439-92-1	0.001	mg/L		<0.001	0.006	<0.001	<0.001	0.003
Zinc	7440-66-6	0.005	mg/L		1.35	3.90	0.558	0.040	1.98
Manganese	7439-96-5	0.001	mg/L		8.19	14.0	22.2	0.165	10.2
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L		<0.01	0.05	<0.01	<0.01	0.02
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01



Analytical Results

Sub-Matrix: **LEACHATE**
 (Matrix: **WATER**)

Client sample ID

				KLC 1A	KLC 2A	KLC 3A	KLC 1B	KLC 2B
Client sampling date / time				[16-Jun-2015]	[16-Jun-2015]	[16-Jun-2015]	[16-Jun-2015]	[16-Jun-2015]
Compound	CAS Number	LOR	Unit	EB1521030-001	EB1521030-002	EB1521030-003	EB1521030-004	EB1521030-005
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Iron	7439-89-6	0.05	mg/L	<0.05	0.30	<0.05	<0.05	0.56



**LEADERS IN MINING
GEOCHEMISTRY**

01 August 2021
Project Number 2021068

From: RGS Environmental Consultants Pty Ltd
To: AARC Environmental Solutions Pty Ltd
Attention: Kate Jeffrey – Environmental Scientist
Content: Yandan Tailings Storage Facility: Technical Memorandum

1.0 Introduction

RGS Environmental Consultants Pty Ltd (RGS) has been requested by AARC Environmental Solutions Pty Ltd (AARC) on behalf of GBM Resources Limited (GBM) to provide a response to specific information gaps cited by the Regulator regarding the 'risk level' associated with Cell B of the Tailings Storage Facility (TSF) at Yandan Gold Mine. It is understood that GBM has applied to the Department of Environment and Science (DES) for an Estimated Rehabilitation Cost (ERC) decision for the environmental authority (EA EPML00771913 – Yandan Gold Mine and that DES has subsequently completed an initial assessment and determined the application is invalid¹.

RGS has previously completed a geochemical assessment of oxide and sulfide tailing materials stored at TSF Cell B and in order to provide a qualified response, has relied upon information and findings associated with the RGS technical report² as well as the findings of an independent review of the risk level and appropriate capping strategy for TSF Cell B³.

This technical memorandum provides a response to specific information gaps cited by DES regarding the 'risk level' associated with the Tailings Storage Facility (TSF) at Yandan Gold Mine shown in **Figure 1**.

2.0 Information Gaps

The specific information gaps cited by DES which RGS has been requested to address are:

1. *The combined volume of waste material was provided for both TSF Cell A and B, however individual volumes are required to assist in consideration of whether representative sampling was undertaken in accordance with the recognised guideline Queensland Department of Mines and Energy (1995) Assessment and management of acid drainage - Technical guidelines for the environmental management of exploration and mining in Queensland (DME 1995 Guideline).*
2. *The supporting document indicates that the proposal for a low-risk capping methodology is supported by a report prepared by RGS Environmental Pty Ltd (RGS Report), which provides a geochemical assessment of the tailings based off 85 samples collected to a maximum depth of 600mm in Cell B. The embankments are known to be 4.5m on the Eastern Perimeter wall and 1.0m at the Northern Perimeter Embankment, indicating that the 600mm samples were unlikely to intercept the deepest area of the TSF. the department considers that the sampling effort (a total of 85 samples on Cell B) is not considered to have been undertaken in accordance with the recognised DME 1995 Guideline and therefore the assumptions made by the applicant cannot be relied upon.*
3. *The RGS Report provides several recommendations for TSF Cell B in Section 9.0 of the document, notably the advice to the EA holder to verify the depth of oxidation in the tailings profile by undertaking in-situ core sampling of the tailings through the tailings profile in the deepest area of the TSF. Please provide an assessment and demonstrate consideration and implementation of the recommendations in Section 9 of the RGS Report.*

¹ DES (2021). Invalid Application Notice. Department of Environment and Science. 23 June.

² RGS (2015). Yandan Oxide and Sulfide Tailings Assessment. Report prepared by RGS Environmental Pty Ltd for Straits Gold Pty Ltd. 31 July.

³ Williams (2021). Independent Desktop Review of Risk Level and Appropriate Capping Strategy for TSF Cell B at Yandan Gold Mine. 2 June.



Figure 1: Yandan TSF (Source: Williams, 2021)

3.0 RGS Responses

The RGS responses to specific information gaps detailed in Section 2.0 are as follows:

1. The combined amount of tailings materials stored at Cell A and Cell B at the TSF was described (at closure) in the 2005 Plan of Operations⁴ as 7,500,000 tonnes (t). The original Environmental Management Overview Strategy (EMOS⁵) predicted that 2,111,850 t of tailings would report to Cell A. Given an *in situ* bulk density of 1.38 t/m³, this equates to approximately 2,900,000 t of tailings in Cell A and approximately 4,600,000 t of tailings in Cell B.

The Draft Technical Guidelines for Assessment and Management of Acid Drainage in Queensland (DME 1995 Guidelines)⁶, whilst useful, is currently not a discoverable document on the DES website. Notwithstanding, the DME 1995 Guidelines provide a sampling rate of 80 samples per 10,000,000 t of waste material. Given that the number of tailings samples from Cell B provided to RGS for geochemical assay was 85 and the amount of tailings materials in Cell B is approximately 4,600,000 t the number of samples is greater than required by the cited guidelines. The relevant sampling locations are provided in **Figure 2**.

⁴ Straits (2005). *Plan of Operations Yandan Gold Mine*. Straits Exploration (Australia) Pty Ltd. 1 November

⁵ Ross Mining N.I. (1992). *Yandan Gold Deposit Environmental Overview Strategy*. December.

⁶ DME 1995. *Draft Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland*. Assessment and Management of Acid Drainage. Department of Minerals and Energy, Brisbane, Queensland.

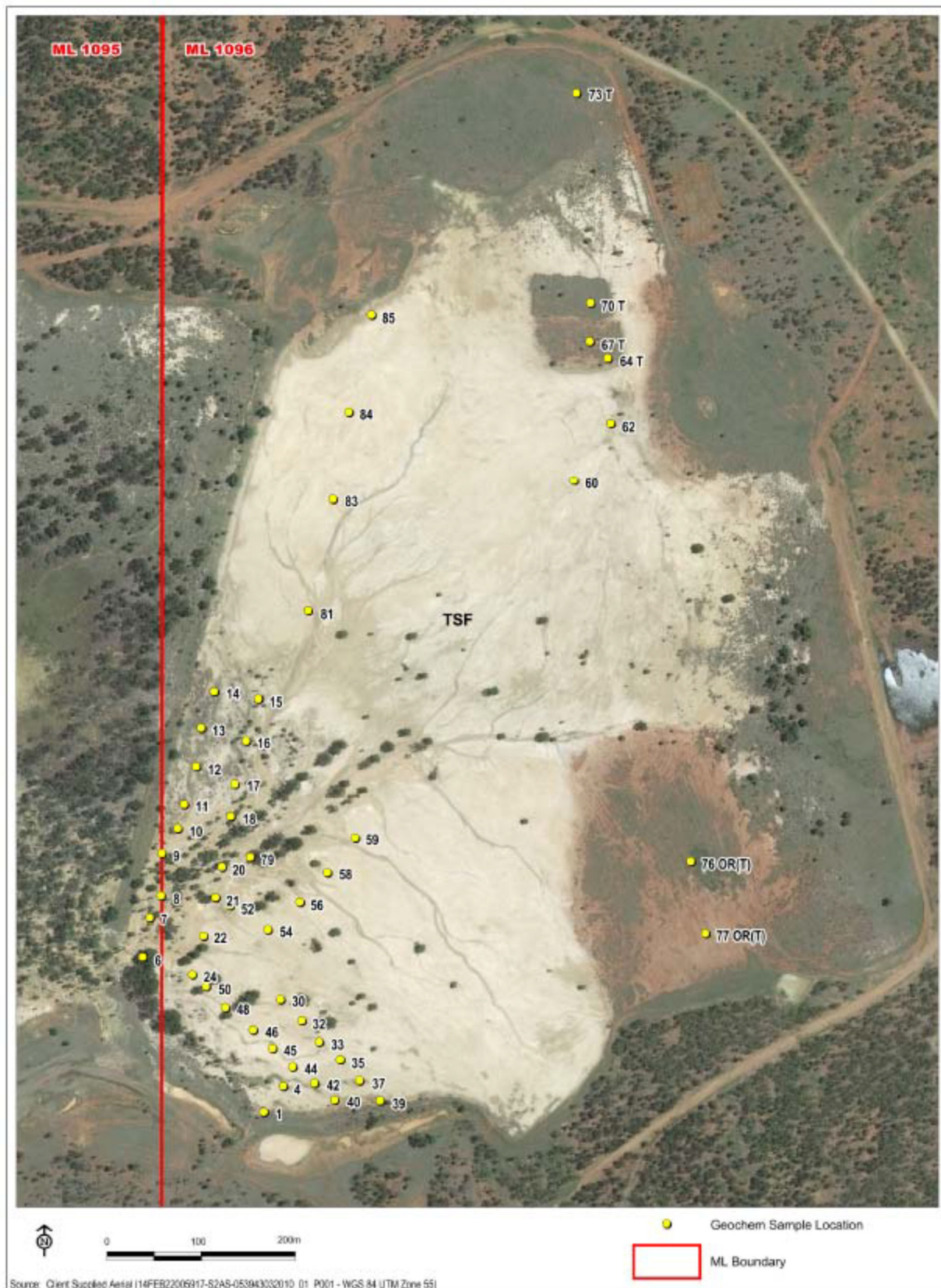


Figure 2: Sampling Locations at TSF Cell B (Source: RGS, 2015)

2. The low risk capping methodology for TSF Cell B is supported by RGS on the basis of the findings of the geochemistry assessment² and the independent review of the risk level and appropriate capping strategy³. The geochemistry assessment found that since placement, the sulfide minerals (e.g., pyrite) in the tailings, to at least 600 mm depth, have oxidized and that no residual sulfide minerals remain. Secondary sulfide minerals (e.g., jarosite) are likely to be controlling solute chemistry and capillary rise of solutes (e.g., acidity, salts and metals) into the trial soil cover is not apparent.

The original EMOS⁵ estimated that sulfide ore is was likely to represent less than 15 % of the total mined ore on site. Tailings from the oxide and sulfide ore were generally placed within 'layers', with sulfide ore only mined in the latter stages of the pit. As such deposition of sulfide ore is limited to the upper portion of TSF Cell B, with this underlain in most areas by oxide tailings.

On the basis of the geochemical nature of the tailings materials, RGS suggested that the cover design objectives at TSF Cell B should be to stop wind blown movement of tailings, provide a growth medium that is capable of supporting vegetation and provide a stable soil surface that may include coarse rock mulch to retain moisture from small rain events and protect the surface from erosion during large rainfall events. The use of a capillary break in the cover system is not required and is fundamentally questionable due to the potential for long term failure through differential settlement into the tailings mass and also migration of fines from the cover system into the capillary layer.

RGS advocated mild grading of the tailings surface to encourage rainwater to flow in a controlled direction, compaction of the tailings surface to further decrease permeability and placement of a 0.5 to 1.0 m deep spoil cover over the tailings with a nominal 0.5 m depth in drier areas and a 1.0 m depth in wetter areas.

RGS went on to recommend that a forward test work program be completed on the Cell B tailings materials including field permeability measurements; specific gravity, bulk density, porosity and initial soil moisture on collected samples; in situ push tube core tailings sampling and geochemical testing through the tailings profile in the deepest area of the TSF; event based water volume/quality monitoring; and investigation of the effect of addition of alkaline material.

3. The RGS 2015 report and recommendations acknowledge the fact that the tailings samples provided to RGS for geochemical assay down to 600 mm depth do not intercept the deepest area of the TSF. **Figure 3** shows the depth of tailings within TSF Cell B and illustrates that the tailings depths across the facility range from approximately 1 to 10 m.

Whilst the deeper tailings may contain some residual sulfide minerals, it is unlikely that the sulfide minerals content would be more variable and/or significantly higher than that of the total sulfur values found for the tailings samples collected from up to 600 mm depth (up to 0.53 %S). In addition, interaction of rainwater and runoff with these materials is unlikely given the low permeability of the near-surface tailings and is even less likely when a cover system has been placed due to its "store and release" function. It is noted that the water quality monitoring data from the TSF return water dam provided in the RGS 2015 report showed that this is likely to be the case as in 2013/2014 water quality met applied livestock drinking water quality guidelines and generally met applied freshwater aquatic ecosystem guidelines⁷.

Notwithstanding, it is understood that GBM will consider the recommendations in the RGS 2015 report with respect to additional sampling and testing and implement these, where appropriate.

⁷ ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines. (Superseed ANZECC and ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT (2000).

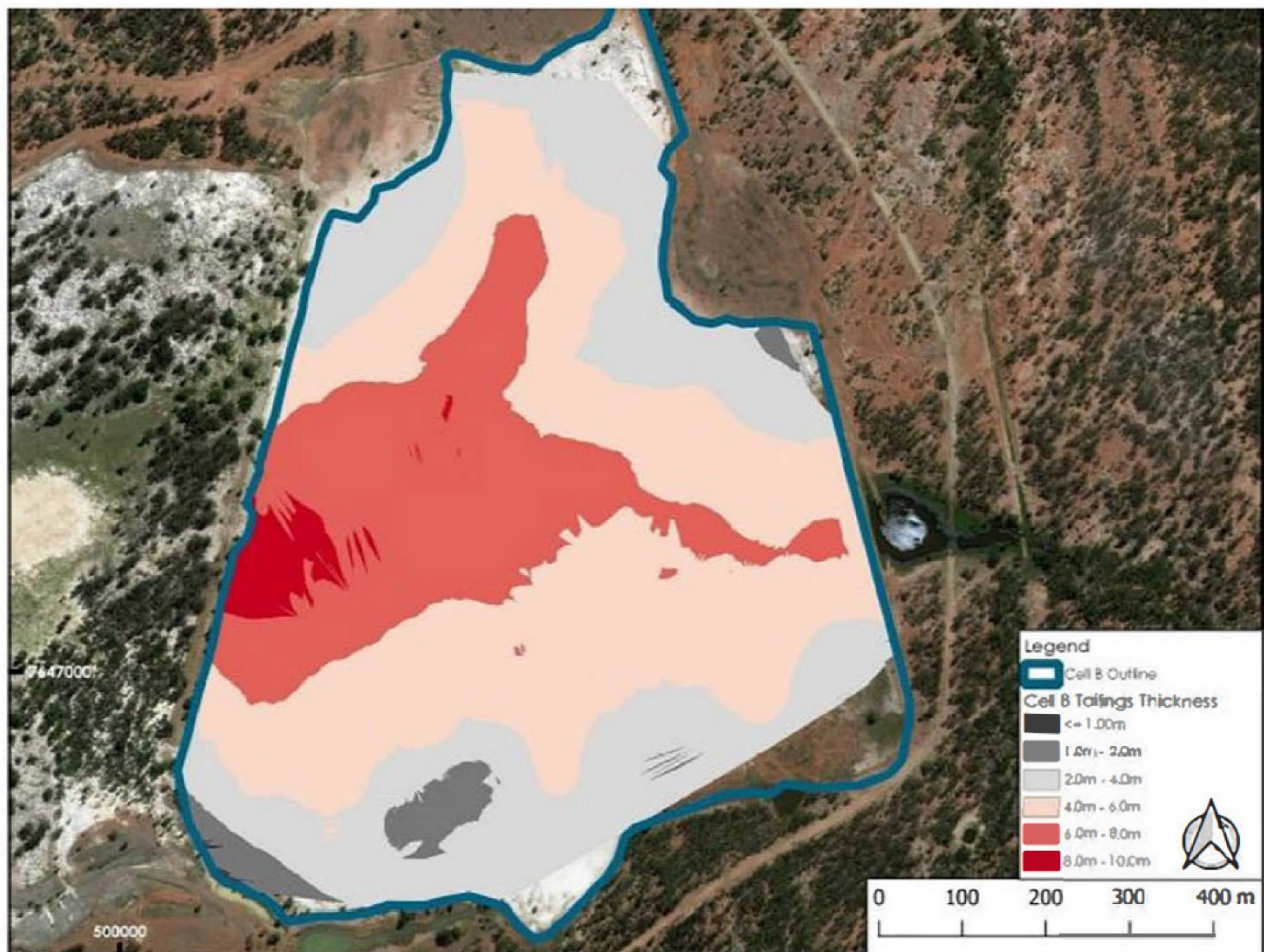


Figure 3: Depth of Tailings within TSF Cell B (Source: AARC, 2021)

4.0 Independent Review

The independent review of the risk level and appropriate capping strategy for TSF Cell B³ (Williams 2021) found that based on the available information, TSF Cell B satisfies Table 6-1 of the ERC Users Guide (2009) for a Low Risk Category and recommended a grass covered 400 to 600 mm gravelly topsoil cover system. These findings were based on the RGS 2015 Geochemistry Report results in that the sulfide minerals in TSF Cell B have completely oxidised to at least 600 mm depth, and revegetation of the trial 400 to 600 mm of gravelly topsoil placed on Cell B tailings is achieving similar success to reference sites, with similar minor erosion over a seven year period. The available information therefore does not support a High Risk Category as considered by DES.

In line with RGS, Williams (2021) went on to recommend consideration of compaction of the surface tailings to form a low permeability layer to enhance the “store and release” function of a revegetated gravelly topsoil layer on TSF Cell B. This would better hold-up moisture to be available to support revegetation, limit net percolation and seepage, and limit potential salt uptake into the cover.

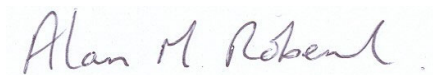
A capillary break coupled to a thicker cover system was not advocated by the author and was expected to be counter productive in that net percolation into underlying tailings could actually increase with deep drainage passing beyond the rooting zone of the proposed grass cover.

5.0 Closing

Please contact Alan Robertson on 07 3344 1222 (office) or 0431 620 623 (mobile) if you require further information.

Yours sincerely,

RGS ENVIRONMENTAL CONSULTANTS PTY LTD

A handwritten signature in blue ink that reads 'Alan M. Robertson'.

Dr. Alan M. Robertson
Principal Geochemist/Director

RGGS



MINE WASTE AND
WATER MANAGEMENT

28 MARCH
2022



21°18' S
146°58' E

Water performance of Yandan Mine landscape at closure

March 2022

GBM RESOURCES LIMITED



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GBM Resources

Water performance of Yandan mine landscape

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1 Introduction

1.1 Location & project background

The Yandan mine project lays in the Central Highlands region of Queensland within the Charters Towers, Bowen and Clermont mining districts. The site is very central to Queensland – laying approximately 230 kilometres west of Mackay & south of Townsville in the Whitsunday Shire, 220km north of Moranbah, and 40km west of the regional town of Mount Coolon (Figure 1). The lease area is currently held by GBM Resources.

Yandan mine operated between 1993 to 1999 extracting gold hosted in hydrothermal & volcanic complex via three (3) open pits and a heap leach pad, with processing & tailings storage onsite. The project is currently in care & maintenance, though is subject to active exploration by GBM Resources. The site lays within the Burdekin River catchment within the Brigalow Biozone (Queensland Government 2021b).

1.2 Context & purpose

As part of implementation of Queensland state environment reforms Yandan is required to undertake technical review & post-mining land use outcomes to inform submission & approval of a Progressive Rehabilitation & Closure Plan (PRCP).

This program of work is to provide technical evaluation of water performance for the Yandan mine landscape against closure requirements, inform post-mining land uses (PMLUs) & risk assessment relating to any non-use management areas (NUMAs).

1.3 Scope

This study provides description, analysis & findings of water-related risk areas as landform fates & permanent landscape, including an assessment of the current situation, how the water systems work across the project with the mix of materials, hydrology & landforms, & scenarios of future states. In detail, scope includes:

- Overview of Yandan site framework: including operations summary, monitoring network & regulatory environment, planned rehabilitation outcomes & status.
- Description of the project water setting: landscape, surface water, geology, materials characterisation, climate, flooding (including PMF), climate change expectations, groundwater and regional water values.
- Characterisation & analysis of Yandan mine landforms & domains: analysis of current state of water quality & movement, including surface water & catchments, groundwater levels & water quality to identify trends & processes underway.
- Construction & assessment of pit void water balance and fate modelling.
- Recommended water completion criteria.
- Key findings & water-related risk assessment.

Scope of the study also included a 2-day site visit to Yandan understand the site & landforms to inform assessment through observations & review.



Figure 1 - Location of Yandan mine project



1.4 Rehabilitation fates & key questions for water performance at closure

Table 1 - Planned rehabilitation outcomes & key questions for study

Landform	Rehabilitation fate	Land-use	Closure questions
Heap Leach Pad (16.9 ha)	Cover system for low risk - gravel layer at a minimum of 0.5 m thickness & topsoil	Low hill	Water system response to landform (quality & quality). Final landform design needs, risk & appropriate cover for water performance stability. Potential water-related impacts & required monitoring to completion criteria.
HL Stormwater Pond (1.59ha)	Dam wall removed & area rehabilitated.	Low hill	Leakage & potential groundwater containment. Indication of landform surface water drainage.
Pregnant Pond (0.16 ha)	Dam wall removed & area rehabilitated.	Low hill	
Barren Pond (0.18 ha)	Dam wall removed & area rehabilitated.	Low hill	
Tailings Cell A (4.5 ha)	Repair of existing rehabilitation & regrading of surface (low risk cover)	Open pasture	Water system response to landform (quality & quality). Final landform design needs, risk & appropriate cover for water performance stability. Potential water-related impacts & required monitoring to completion criteria.
Tailings Cell B (70.8 ha)	Cover system for low risk: - Rock cover of 1.0 m; and - Growth media of 0.15 m.	Open pasture	
Tailings Water Return Dam (18.37ha)	Dam wall removed & area rehabilitated.	Open pasture	Leakage & potential groundwater containment. Indication of landform surface water drainage.
East Hill Pit (0.5 ha)	Partially backfilled with concrete from infrastructure area, and sediment from water storage structures.	Lake	Water system response as a landform/pit lake (quality & quality). Water level stability to cover fresh rock. Water quality stability & risk as pit lake. Fate of pit wall bund.
Main Pit (17.8 ha)	Maintain water cover & connectivity with two spillways. Query whether bund wall required longer term.	Lake	
South Pit (3.1 ha)	No major works required.	Open pasture	Not required – rehabilitated & fully infilled. Water risk is low & stable.
Water Storage / Raw Water Dam (35.2 ha)	Maintain, will remain.	Lake	Not required – water risk is low & stable.
Mine Water Dam (14.17 ha)	Dam wall removed & area rehabilitated.	Open pasture	Not required – water risk is low & stable.
All of site			Flooding profile for landforms & potential risk as permanent landforms. Responses of pit voids to climate change or rare rainfall events. Receiving environment stability & risk – surface water & groundwater.



2 Overview of Yandan mine site & project

2.1 Background of the site

Yandan as a project commenced development in 1988 & operated between 1993 to 1999. The project extracted gold from a series of three (3) pits of varying size, creating 2 pit voids & the third now refilled, a tailings landform, heap leach pad, & supporting dam infrastructure. Notably processing methods used cyanide in leach (CIL) in milling & leaching processes.

Current Yandan lease area is ~2,500 hectares, though mine-related disturbance is only a portion of the total lease. A general layout map of Yandan site with landforms, features & water sampling network is provided in Figure 2.

Mined ore sources at Yandan are described as two major sources: oxide (weathered or altered) ore & sulphide (fresh rock) ore. Notably, sulphide ore is applied as a mining term to signify fresh rock ore in comparison to oxide & differing hydrothermal alteration. In fresh rock, sulphides are not weathered or altered (hence the presence of sulphides), whereas oxide rock is leached, weathered, or hydrothermally altered where fresh sulphides minerals are removed.

Mining applied processes of milling/cyanide in leach of oxide & fresh (sulphides) ore, & low-grade ore leaching via the leach pad. Both methods applied large volumes of lime or limestone to lift pH & increase mobility of gold. As a result, both the tailings & the heap leach pad can be expected to yield water higher in alkalinity.

In the time since 1998, much of the surface infrastructure used during active mining has been removed from Yandan site, leaving remnant landforms able to be reactivated in the event of discovery, or to be prepared for final closure fate. Table 2 provides a summary of current landforms, related infrastructure with a description of construction & nature.

2.2 Monitoring network & framework

Yandan mine is currently permitted for Environment Authority under EPML00771913 (Appendix A).

The broader monitoring program includes regional sites as upstream & downstream reference sites on the Suttor River, Yandan Creek & local drainage lines, plus groundwater bores surrounding landforms and surface water storages.

Details of the current monitoring network, including compliance monitoring sites are listed in:

- Table 3 lists receiving environment sites & purpose.
- Table 4 lists surface water storage & ponding sampling locations as available.
- Table 5 lists groundwater monitoring by domain & depth.

Eight (8) new groundwater wells were drilled in late 2020 at Yandan as replacement wells for compliance, with two wells retired. There is limited information available for historical wells & review of network may be required as several appeared in disrepair on inspection & during sampling.

There are currently no production wells on site for water use or points of groundwater extraction. Raw water is sourced via mine water dam or the water supply dam.



Table 2 - Summary of Yandan landforms & current state

Landform	Features included	Description
Main pit	Pit void (currently a pit lake) berm wall to control water reaching the pit, borrow pit on southern side which hosts throughflow of Yandan Creek. Oxide & sulphide zones mined.	Main pit to maximum depth of 60m & surface area of ~ 22 hectares. Pit is open at two engineered “spillways” at 169mAHD which allows flow in & flow out of the pit during periods of higher rainfall & creek flow to refresh the pit. The pit wall and constructed pit berm around the perimeter of the pit contains the pit unless in high flow: diverts additional surface water catchment flow around the pit to the creek, & with the pit wall is able to contain water within the pit whilst the pit drains. Pit lake has an obligation to remain above fresh (sulphide) rock & maintain a minimum 160mAHD water level. Borrow pit is 3-4m depth maximum, captures flow down Yandan Creek (undisturbed catchment) which flows to Suttor River & to eastern pit intake at 169mAHD.
East pit	Narrow pit void with flow & safety restriction berm. Oxide & sulphides zones mined.	East pit is 0.9ha surface area as a narrow entrance pit & appears to be to depth of at least 20m (184mAHD at surface to water surface at 168mRL) from surface to water surface. Historical knowledge of the complete pit void is currently unknown. A partial pit lake, water will spill only if water levels exceed 184mAHD. Obligation to keep pit lake levels above 160m AHD.
South pit	Filled in pit void to surface & above: only oxide ore mined.	
Heap leach pad	Leaching stockpile, perimeter water capture drain, leach pond, process pond & levee banks. Contains oxide materials.	Surface area of 17.5 hectares, ranging up to 38m high from 212mAHD to 174mAHD. Situated at the highest elevation of the site wrapped across the top of a low hill. Constructed from low grade oxide materials, interbedded with limestone to lift pH to liberate gold through cyanide leaching. Likely to be unlined or prepared ground. Leach & process pond lay on downgradient side of leach pad, ponds were originally lined but are currently in disrepair. Perimeter drain contains a large amount of sediment & is likely to be only partially effective.
Tailings	Tailings landform & embankment & landform, containment dam (borrow pit), spillway & additional borrow pits around perimeter. Contains oxide & sulphides materials.	Low lying & gradient landform wrapped across the landscape in broad pad like form wrapped across landscape with minimal gradient change. Tailings embankment is generally 1-5m around most of the perimeter, extending to 12m height at highest point at the lower embankment (179mAHD to 191mAHD). Two cells: Cell A (western & partly rehabilitated) contains predominantly oxide tailings, Cell B contains a mix of oxide & fresher rock (sulphide) tailings, which is not rehabilitated. Cell A appears to be to form a surface pond, with an overflow to the returns dram. Cell B has no formed drainage but flows to Cell A. Materials in the tailings dam may be enriched in alkalinity given the amount of lime applied in CIL processing. Series of shallow & small borrow pits around the perimeter of the tailings embankment(s). Tailings containment (or returns dam) has a 9m dam wall for a storage capacity estimate of 1,035ML.
Water storage dam(s)	Raw water dam (water supply dam) – wall height of 7.5m, capacity of 1300m. Downstream of tailings & tailings containment dam. Mine water (or process water dam) – wall height of 8m, currently raw water, full capacity 450ML. Diversion drain from Suttor River not in use.	



Table 3 - Receiving environment sites & purpose

Site	MPID	Status	Role	Description	East	North
REMP1	SR3a	Reference	Compliance	Upstream of project site on Suttor River	496050	7644545
REMP2	SR3b	Reference	Compliance	Eastern side of the Tailings dams, along Sandy Creek	501308	7647055
REMP3	SR4	Reference	Compliance	East of REMP7, upstream on Yandan Creek	499214	7645089
REMP4	SR1	Impact	Compliance	Downstream of release point (REMP6) on Suttor River	496750	7645460
REMP5	SR2	Impact	Compliance	Downstream of site & release point on Suttor River	496820	7646759
REMP6	MP1	Impact	Compliance	West Main Pit Dam Spillway Overflow on Suttor River	496790	7645177
REMP7	MP2	Impact	Compliance	East Main Pit Dam Spillway Overflow on Suttor River	497191	7644940

Table 4 - Surface water & storages monitoring locations

SiteID	Site area	Frequency	Northing	Easting
HLPP1	HL Pregnant Pond	Regular	7645013	498090
HLSP1	HL Stormwater	Regular	7644897	498141
TRD1	Tailings Return Dam	Regular	7646643	499476
MW1	Mine Water Dam	Regular	7646108	497791
EHP1	East Hill Pit	Regular	7645142	497674
WS1	Water Storage Dam	Regular	7646481	497641
TD Cell A	Tailings Dam Cell A	As possible	7647146	499717
TD Cell B	Tailings Dam Cell B	As possible	7646668	500289
GIL6	Below Water Supply Dam	As possible	7646511	497593
TDP1	Pond Near Cell B of TSF	As possible	7647130	500950
TDP2	Pond Near Cell B of TSF	As possible	7647157	501071



Table 5 - Groundwater monitoring bores & purpose

	Site area	Bore purpose	Aquifer	Depth	East	North	mAHD
RB1D	Reference	Reference	Siltstone	30m	500400	7645740	193
RB1S	Reference	Reference	Siltstone	10m	500400	7645740	193
RB2D	Reference	Due diligence	Siltstone	30m	498940	7646310	174
RB2S	Reference	Due diligence	Siltstone	10m	498940	7646310	174
HL1	Heap Leach	Compliance	Unknown (historical)	~18m	498095	7644871	172
HL3	Heap Leach	Compliance	Unknown (historical)	~18m	498285	7644838	172
HL4	Heap Leach	Compliance	Unknown (historical)	~17m	497914	7644965	177
HL5	Heap Leach	Compliance	Unknown (historical)	~24m	498359	7645104	177
HL6	Heap Leach	Compliance	Unknown (historical)	~25m	498322	7645359	180
HL7	Heap Leach	Compliance	Unknown (historical)	~25m	498145	7645428	179
SH3	South Hill pit	Compliance	Unknown (historical)	~19m	497421	7644571	169
TD3	Tailings	Compliance	Unknown (historical)	~15m	499334	7646725	179
TD4	Tailings	Compliance	Unknown (historical)	~16m	499617	7647435	188
TD5	Tailings	Compliance	Unknown (historical)	~16m	500549	7647883	192
TD6	Tailings	(Retired)	Unknown (historical)	Unknown	499436	7646581	178
TD6D	Tailings	Compliance	Siltstone	30m	501010	7647150	188
TD6S	Tailings	Compliance	Siltstone	10m	501010	7647150	188
TD7	Tailings	(Retired)	Unknown (historical)	Unknown	500549	7647883	192
TD7D	Tailings	Compliance	Siltstone	30m	499436	7646581	178
TD7S	Tailings	Compliance	Siltstone	10m	499436	7646581	178
WSB1	Water supply dam	Water supply	Unknown (historical)	~24m	497598	7646464	169
WSB2	Water supply dam	Water supply	Unknown (historical)	~24m	497588	7646599	169

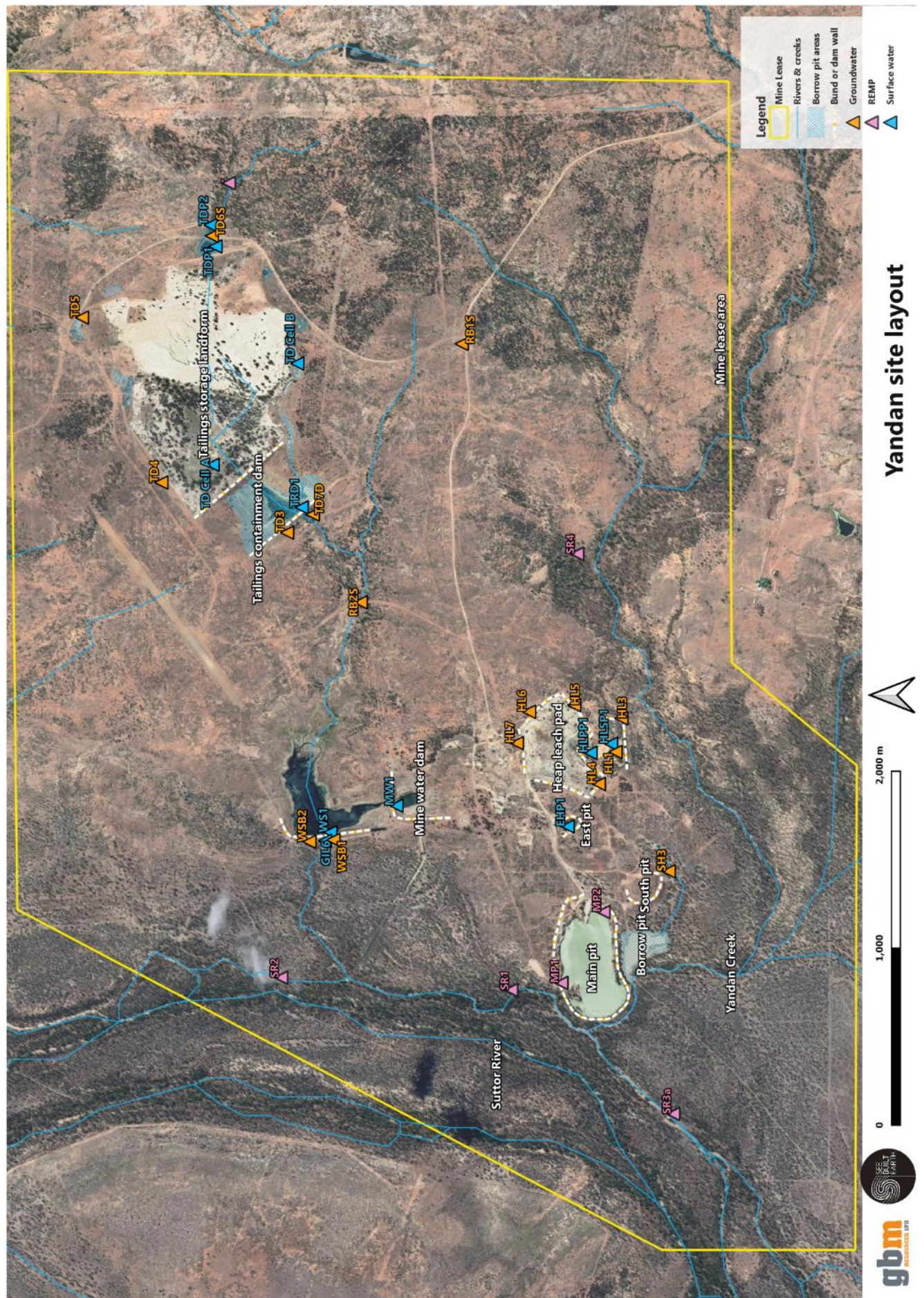


Figure 2 - Overview of Yandan site, monitoring locations & landscape



3 Water systems setting

3.1 Landscape

3.1.1 Regional

Yandan sits within the broad valley of the Burdekin catchment on the Suttor River, 50km upstream of the Burdekin dam. Topography of the area generally consists of broad valleys & relatively low gradient areas, with isolated low elevation hills formed through rocky outcrop.

Drainage lines are low gradient, forming broad, predominantly ephemeral & generally alluvial rich drainage lines. Soils range from black & sandy soils across river alluvial areas through to poorly developed & rocky soils from volcanics & meta-sediments on slopes & near absent on hilltops.

Vegetation zone is eucalypt woodland to grasslands as part of the Brigalow BioZone (Queensland Government 2021). However, the broad region is extensively cleared for agricultural purposes, as dryland & stock farming, but with occasional irrigation areas. There are a number of other historical gold mines both upstream & downstream of the site.

3.1.2 Yandan site

Yandan site is a gently undulating site, rising from adjacent to the Suttor River at around 168mAHD to 191mAHD at the tailings area in the east over 3 kilometers (Figure 3). There are three (3) small hills on the site, rising generally 5-10m, but up to 30m from the broad depression where the Suttor River flows. The highest elevation on the site is 212mAHD as the top of the heap leach pad. Mount Coolon township lays at ~230mAHD.

Grass is developed across much of the site, with few trees. In previous mining areas (including infrastructure) the site remains disturbed but is predominantly stable, with infrastructure & landforms in place for more than 20 years.



Figure 3 - View north over Yandan project site from top of heap leach pad

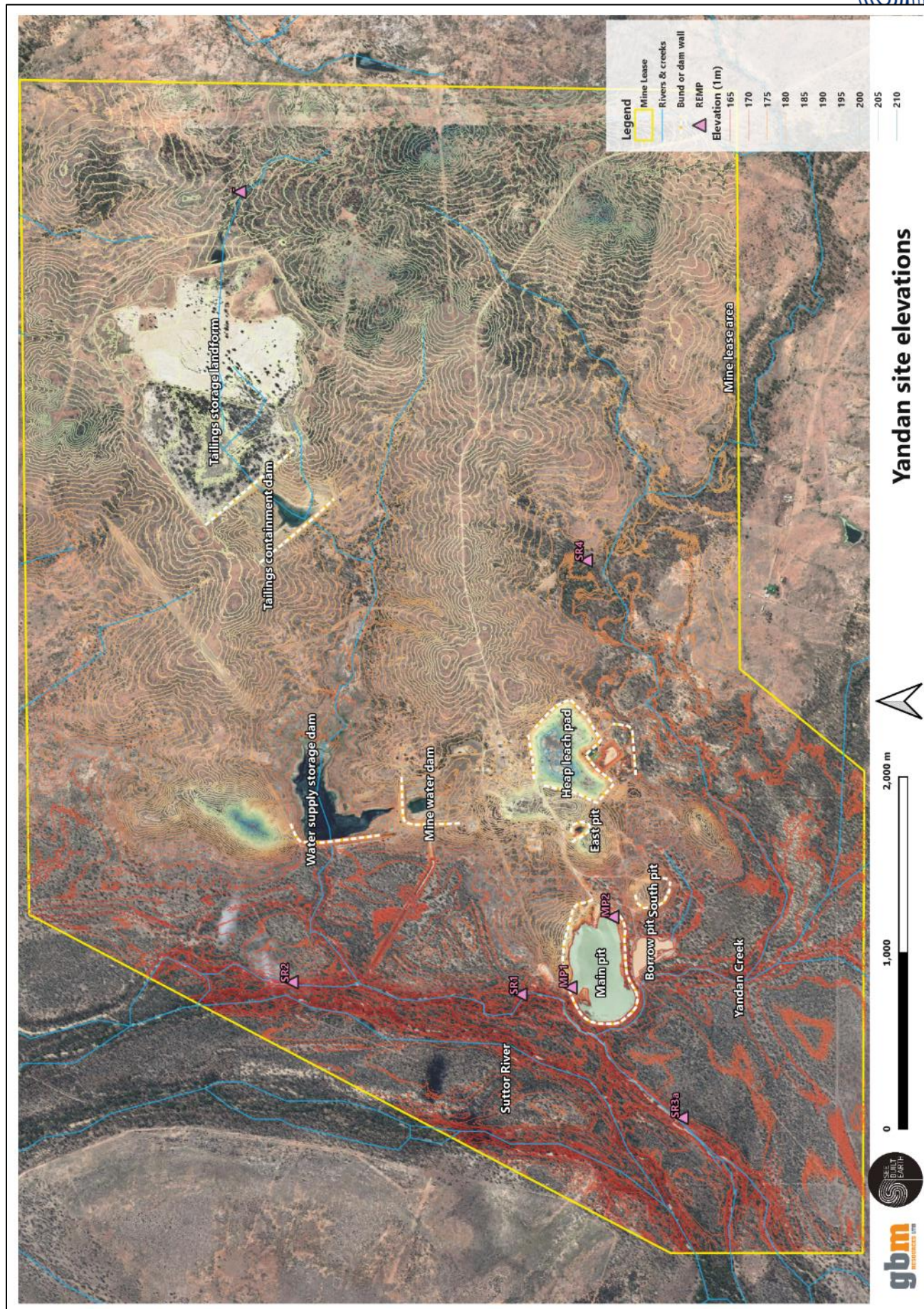


Figure 4 – Contours & elevation of Yandan site & landscape



3.2 Surface water

3.2.1 Regional

Yandan sits within the Burdekin River catchment in the mid-reaches of the catchment supplying Burdekin dam & downstream of the township of Mount Coolon on the Suttor River, just after the confluence of the Suttor River, Police Creek & Belyando River (Figure 6).

The Suttor River is a wide, ephemeral braided river, flowing after rainfall over wet seasons in wide & low energy flow as observed during the site visit for the project (Figure 5). Most local creeks & rivers around the project site are ephemeral, flowing only after rainfall & acting as losing streams (not fed by groundwater), & forming water holes during drier seasons.

There are two relevant gauging sites upstream & downstream of Yandan which track flow, water levels & quality since the 1970's:

- Belyando near Gregory Highway (Mount Douglas) (120301A/B upstream) with records since
- St Anns Station (120303A downstream).

Flow records for both stations are provided in Figure 7, showing the seasonal nature of flow & the capacity of the system to convey large volumes of water. Notably, there is a step up in flow volumes/rates at St Anns from flow measured at Mt Douglas given St Anns lays further down the catchment. Figure 8 shows river heights over the same record: with an interpolated base of river at 163mAHD, the Suttor River regularly rises 5-8m in flood to around at 168-170mAHD.

Both gauges also provide an electrical conductivity (uS/cm) record measured only during flow events (Figure 9, Figure 10) showing salinity generally remaining below 500 uS/cm over the past 20 years with the exception of short-term higher salinity experienced during the major regional flooding event in 2011. Comparison of upstream & downstream salinity would suggest an additional salt load entered the river during this significant event, similar to occurrences across the Queensland region for this event. A Yandan downstream receiving environment (SR1) sample collected during this time placed electrical conductivity at ~1,200uS/cm.



Figure 5 -Suttor River approximately 50km upstream of Yandan

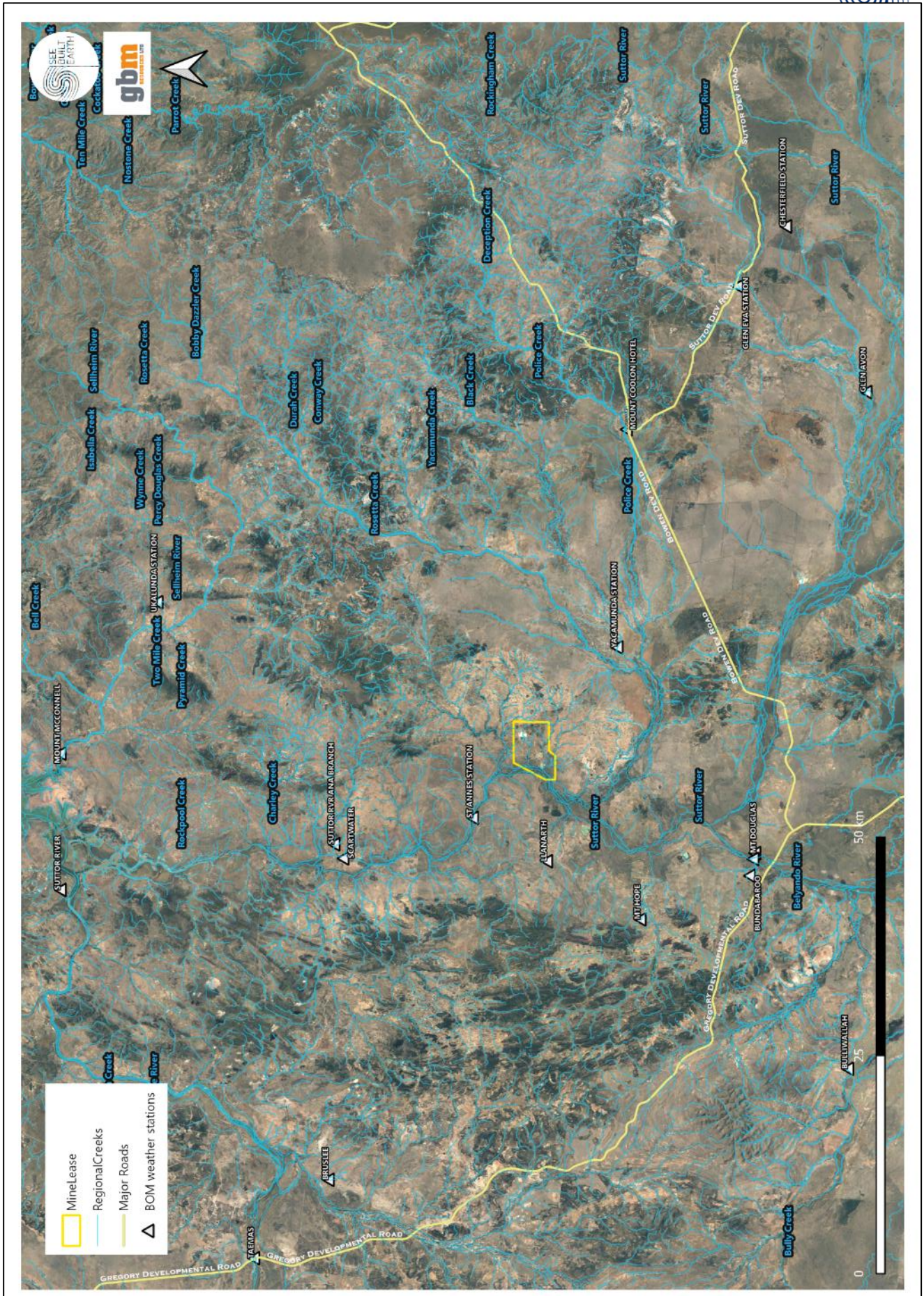
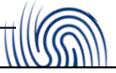


Figure 6 - Regional surface water setting of Yandan

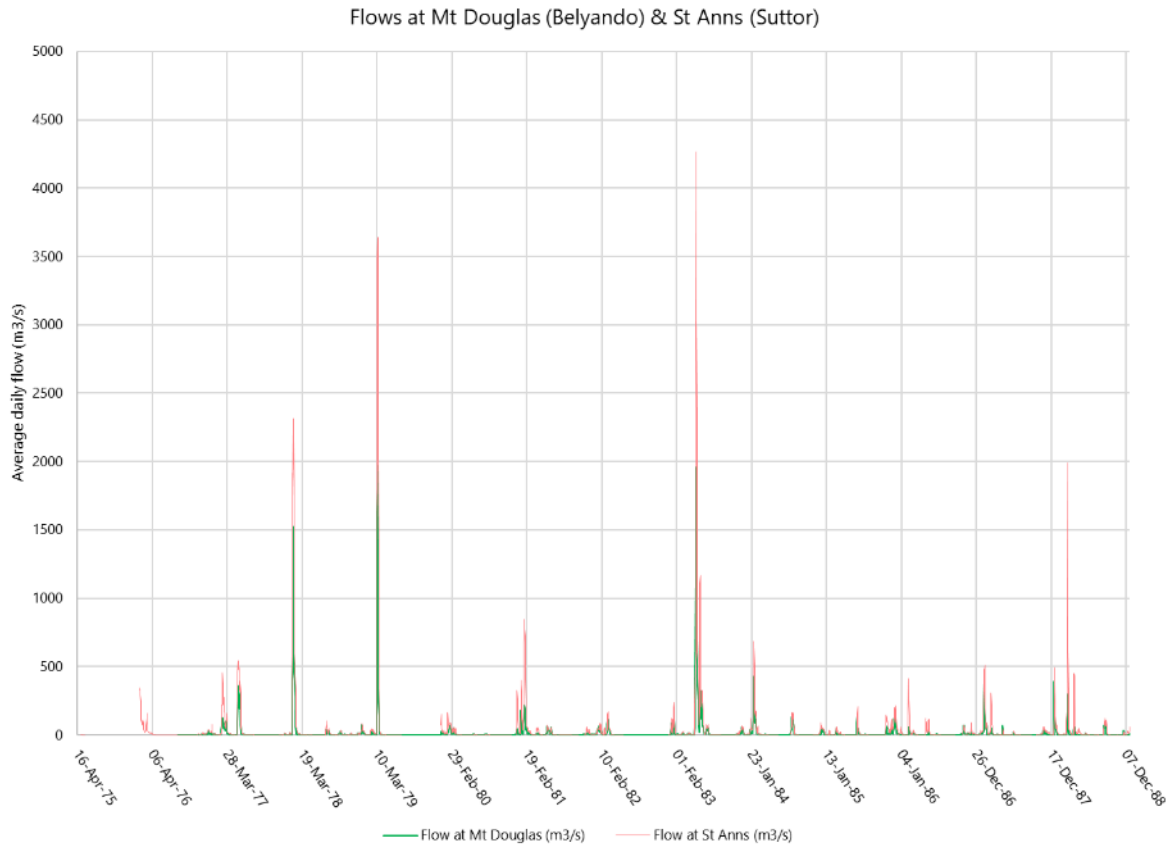


Figure 7 - Average daily flows at regional river gauging stations

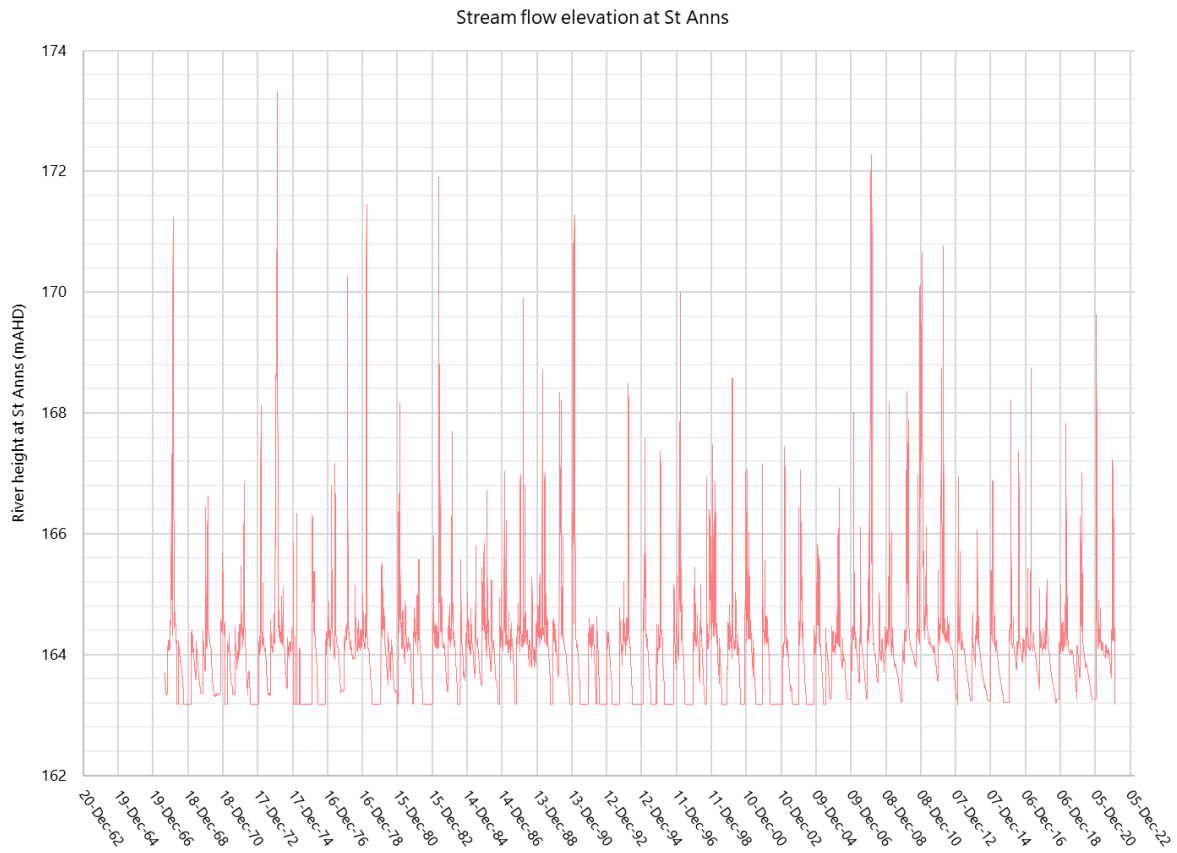


Figure 8 – River heights at St Anns Station

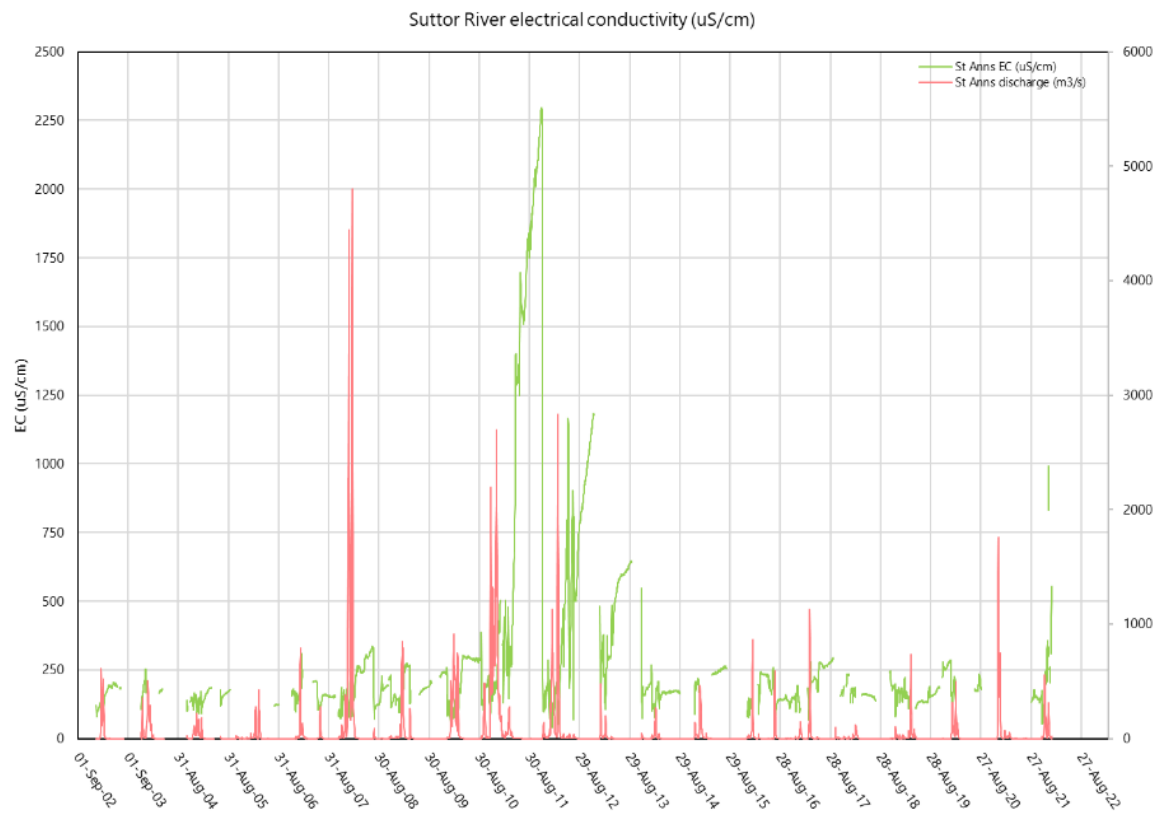


Figure 9 - St Anns Suttor River flow & conductivity

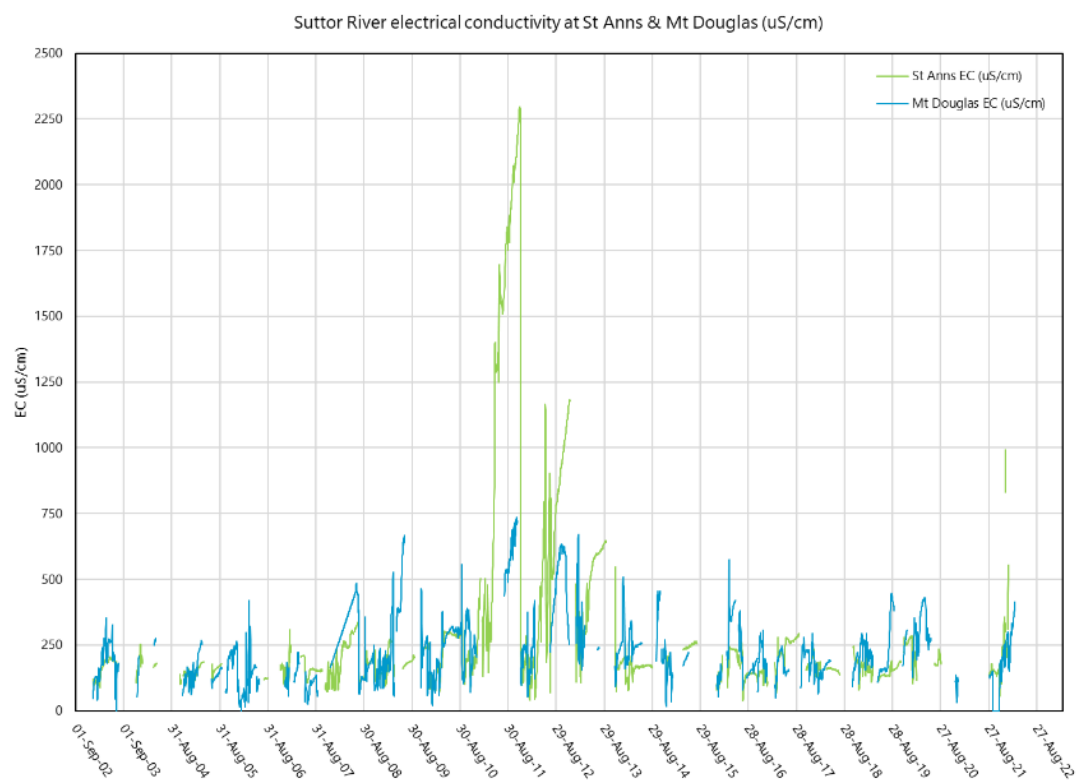


Figure 10 - Suttor River electrical conductivity since 2002



3.2.2 Yandan site

Drainage of the current Yandan site is formed through a combination of natural topography & mining landforms. Drainage direction is generally east to west with topography, with some bund walls creating flow diversions or containment. The project area sits close to the top of a small sub-catchment draining to the Suttor River (Figure 12).

Figure 13 shows site catchments with marked up flow directions & nature of catchment (green – undisturbed catchment, yellow – potentially mine impacted). Details of catchments are detailed in Table 6, with a map of catchments & flow directions across the site in Figure 13. Monitoring locations for site storages & water ponds are shown, along with receiving environment. Notably several sampling sites are borrow pits or ponded areas, near to Main Pit & also around the tailings storage. Further information relating to surface water of Yandan site is provided in the domain assessment.

The Suttor River runs along the western extent, flowing north towards Burdekin Dam 50km to the north. The Suttor River runs close to the periphery of Main Pit, & Main pit has two spillways which enable hydraulic connections between the pit lake & river flow from the Suttor or Yandan Creek when water level exceeds 169mAHD. Yandan Creek enters the project area from the south & is diverted around Main Pit before joining the Suttor River. Conditions are generally dry, with drainage lines only flowing after rainfall.

The pit is required to maintain a minimum water level of 160mAHD to minimise water quality impacts. Views of the Suttor River near the discharge point are shown in Figure 11.

Table 6 - Summary of surface water catchments

Code	Description	Area m ²	Area ha	Status
B-01	Borrow pit catchment (Yandan Creek)	60,537,540	6,054	Undisturbed
B-WS	Borrow pit water surface	26,258	2.6	Undisturbed
E-01	Catchment reporting to East Pit	28,827	2.9	Mine impacted
E-Pit	East pit direct area	9,048	0.9	Mine impacted
E-WS	Water surface of East pit	1,190	0.1	Mine impacted
L-02	Leach pad stormwater area	53,560	5.4	Mine impacted
L-Dam	Leach pad stormwater pond	16,344	1.6	Mine impacted
L-Pad	Leach pad direct catchment	174,152	17.4	Mine impacted
L-Pond	Leach pad ponds	3,990	0.4	Mine impacted
M-01	Catchment reporting to Main Pit	224,625	11.3	Mine impacted
M-Pit	Main pit area	63,049	21.9	Mine impacted
M-WS	Main pit water surface	156,207	15.6	Mine impacted
S-Pit	South pit direct area (rehabilitated)	29,567	3.0	Undisturbed
T-01	Catchment reporting to tailings storage	919,825	92.0	Undisturbed
T-02	Catchment reporting to tailings storage	260,723	26.1	Undisturbed
T-03	Catchment reporting to tailings storage	282,502	28.3	Undisturbed
T-CellA	Cell A of tailings storage	426,307	42.6	Mine impacted
T-CellB	Cell A of tailings storage	726,984	72.7	Mine impacted
T-Dam	Tailings dam water catchment	36,689	3.7	Mine impacted
WS-01	Catchment reporting to water supply dam	3,257,776	325.8	Undisturbed
WS-Dam	Water supply dam surface	410,325	41.0	Undisturbed
MW-01	Mine water dam catchment	42,336	4.2	Undisturbed



Figure 11 - View of Suttor River near discharge zone of Main Pit

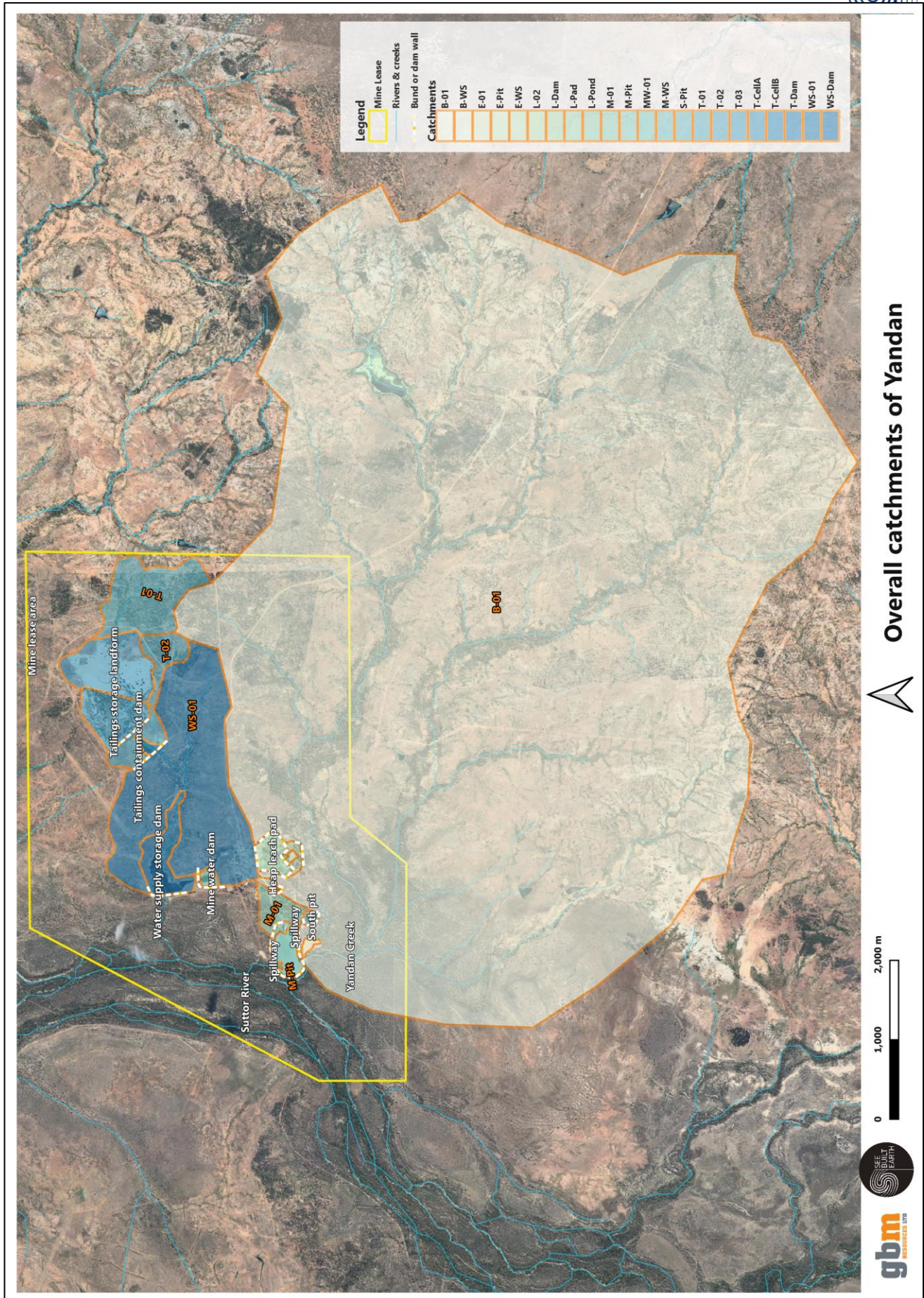


Figure 12 – Broader surface water catchments of Yandan site



3.3 Geology

3.3.1 Regional

Regional geology of Yandan lays in the broad basin of the Drummond Basin, consisting of volcanics & sediments of Middle Devonian to Lower Carboniferous age (Carver & Chenoweth 2003). The Drummond Basin forms a broad valley, extensively overlain with alluvial deposits around the Suttor River.

Volcanic rocks generally occur as hills or rocky areas as more resistant to erosion. Where altered through hydrothermal activity such as associated with gold, weathering can be more extensive. Common volcanic rocks are dacite, andesite, ignimbrite & sinter. Sedimentary rocks of the Drummond Group occur as siltstone, limestone & sandstone.

Peaks around the area are often the Suttor Formation: sandstones units which are Tertiary in age & have been eroded & incised to form the modern landscape.

3.3.2 Yandan site

Yandan mine is situated on the Anakie High consisting of volcanics, sandstones & siltstones at the base of the Drummond Trough. The Anakie High abuts the alluvium of the Suttor River & St Anns Formation, likely via a structural contact. Ukalunda Formation of siltstones lays to the east, with sandstone & limestone, also likely via a fault contact.

Gold extraction accesses low-sulphidation epithermal gold deposits from surface which occur as hydrothermal veins & zones, with a hydrothermal alteration including a porous boiling zone. Mineralisation occurs as oxide in the altered & weathered zone, or in fresh rock lenses & veins at depth as sulphides (Figure 14).

Oxide & fresh rock are both present & are loosely termed oxide & sulphides as different ore types, however the overall system is low-sulphidation. Oxide ores are formed through hydrothermal alteration of rocks & then subsequent leaching through fluids or rainfall which oxidises sulphur to form changed minerals & often more porous materials, whereas fresh rock mineralisation occurs at depth & tend to be highly silicified, crystalline, brittle & low porosity.

Faults occur across the site, particularly around mineralised zones, with the most important being the Yandan East fault to the east of mineralised areas. Structural trends follow north/south & north-east/southwest orientations.

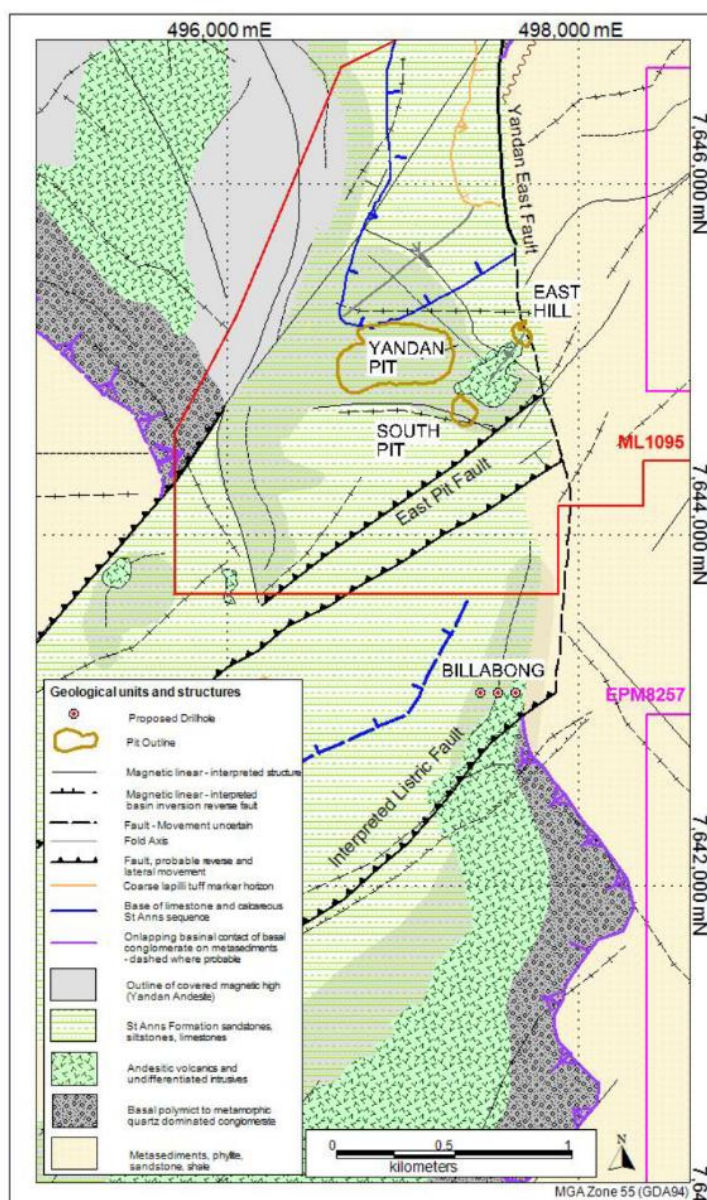


Figure 14 - Geology of Yandan site



3.4 Materials geochemistry characterisation (ARD/AMD)

3.4.1 Tailings & leach pad

Geochemical assessment of host materials at Yandan is informed by four (4) main studies:

- Tailings rehabilitation studies – 26 samples Dwyer (internal), circa 1999 for Ross Mining.
- Heap leach assessment – 20 samples - EGI 2002 for Warralie Mines.
- Combined heap leach & Cell B tailings – 6 samples - RGS 2013 for Straits Resources.
- Oxide & tailings assessment – 85 samples – RGS 2015 for Straits Resources.

Outcomes from each study are presented into an ARD classification matrix in Figure 15.

Heap leach pad characterisation as low-grade oxide materials is expected to be:

- Non-acid forming but may generate saline runoff & seepage.
- Likely to increase calcium, sulphate, chloride & sodium runoff given the extent of lime addition through the heap leach.
- Enriched & metals of interest are arsenic, mercury, antimony, silver, lead & selenium. Mercury is not anticipated to be mobile.

Review of heap leach materials in 2002 & 2013 characterised heap leach materials as benign.

Tailings (particularly sulphide tailings) has changed in characterisation in the twenty (20) years since tailings construction. Initial assessment in 1999 indicated:

- Tailings as oxide materials are uncertain, but do not have a clear ARD signature.
- Potential for saline drainage.
- Enriched elements of interest of arsenic, copper, zinc, manganese, chromium, antimony & cobalt with changing profiles across oxide & sulphides zones (Figure 16).
- Tailings as fresh materials is higher in sulphur (Figure 17) has a low marker to potentially acid forming, but when combined with oxide tailings (such as in Cell B) reduces.

However, subsequent review in 2015 of 76 tailings samples found nearly all were essentially now either low acid forming potential (LAFP) to inert. The study concluded that there was an absence of sulphides mineralisation remaining given leaching over the past 20 years (Figure 17) with complete oxidation & precipitation of sulphate minerals such as jarosite ($\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$), & no longer qualified as potentially acid forming (RGS 2013, 2015).

3.4.2 Main pit

Yandan main pit exists as a pit lake since 1999, designed as a water cover closure outcome to encapsulate both fresh sulphides ore in pit walls & waste rock deposited into the pit prior to filling with water.

Figure 18 shows a map of where & what materials were placed in the pit prior to filling (SRK 1999), with a backfill cover of lime layers to offset short term acidity until the cover could be established.

To ensure coverage of materials & not expose pit walls or materials to oxidation, pit lake water levels are required to remain above 160mAHD to maintain water cover & control oxidation.



Acid base accounting - all known samples

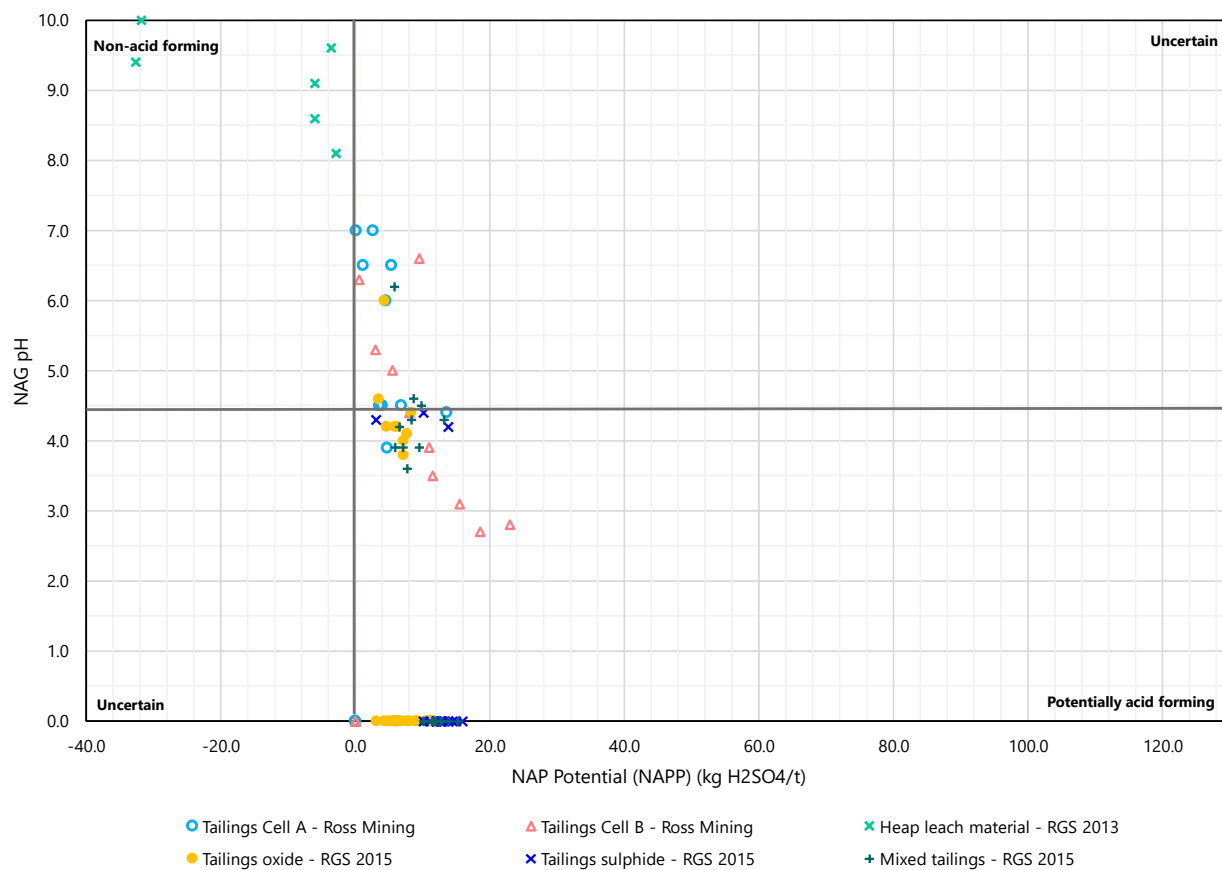


Figure 15 – Acid base accounting matrix for all known tailings & leach samples

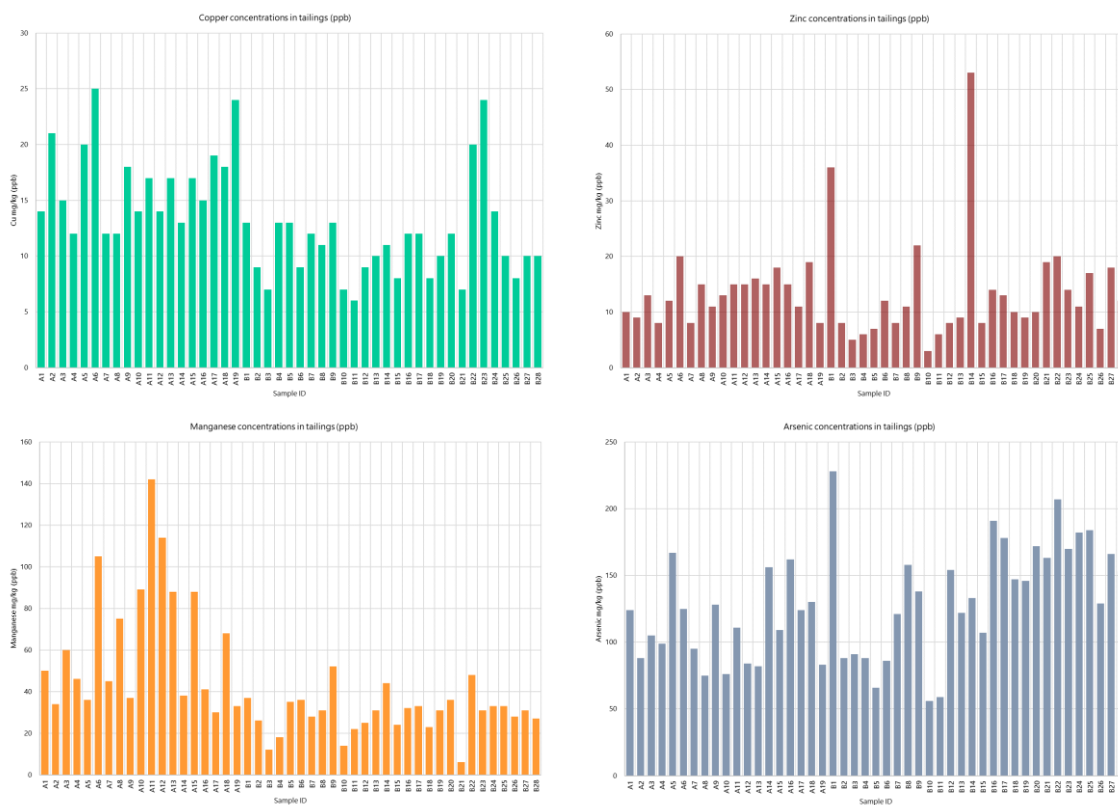


Figure 16 – Key metals concentration distribution (ppb) in tailings from Dwyer (1999)

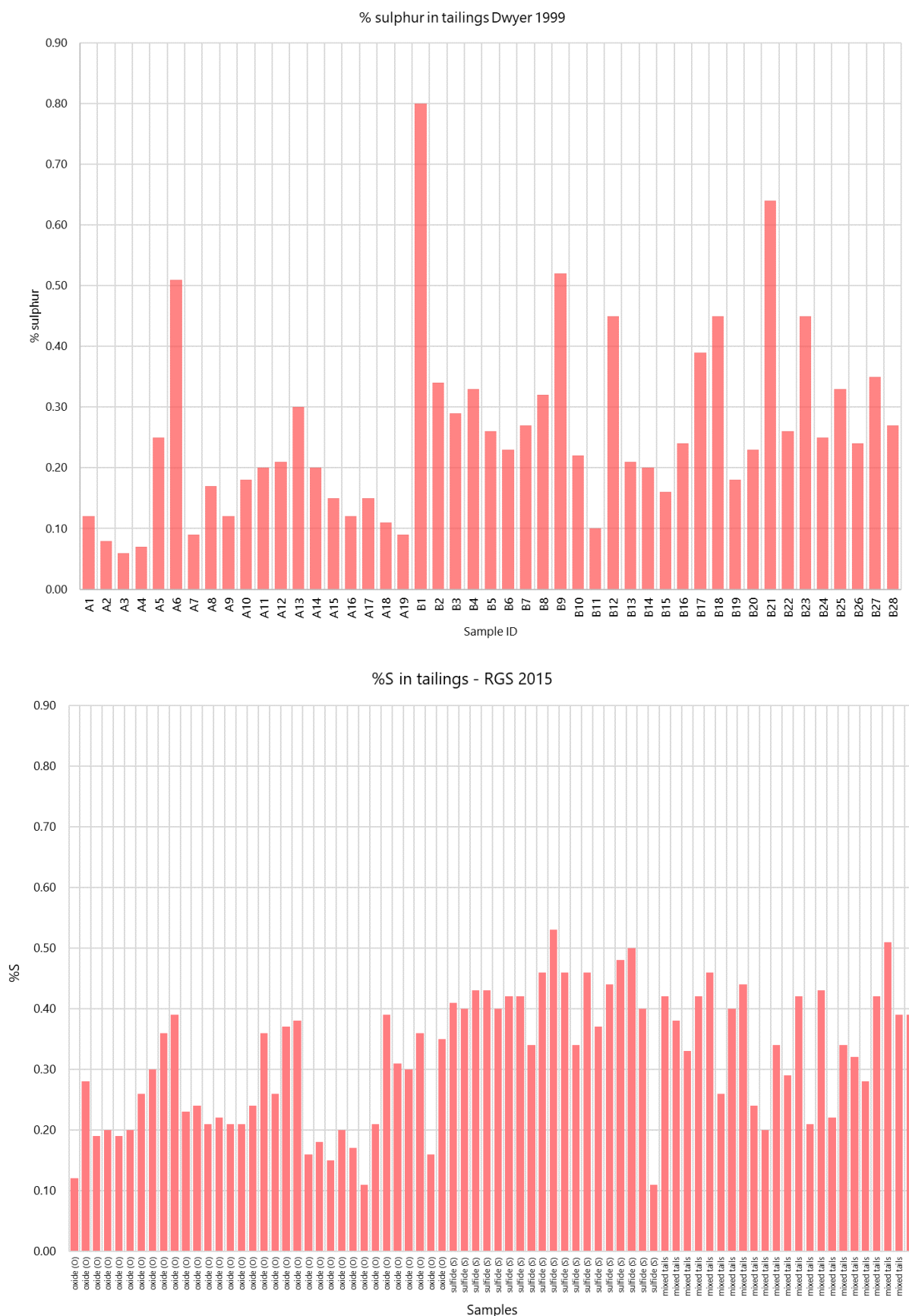


Figure 17 - % sulphur in tailings changes over time

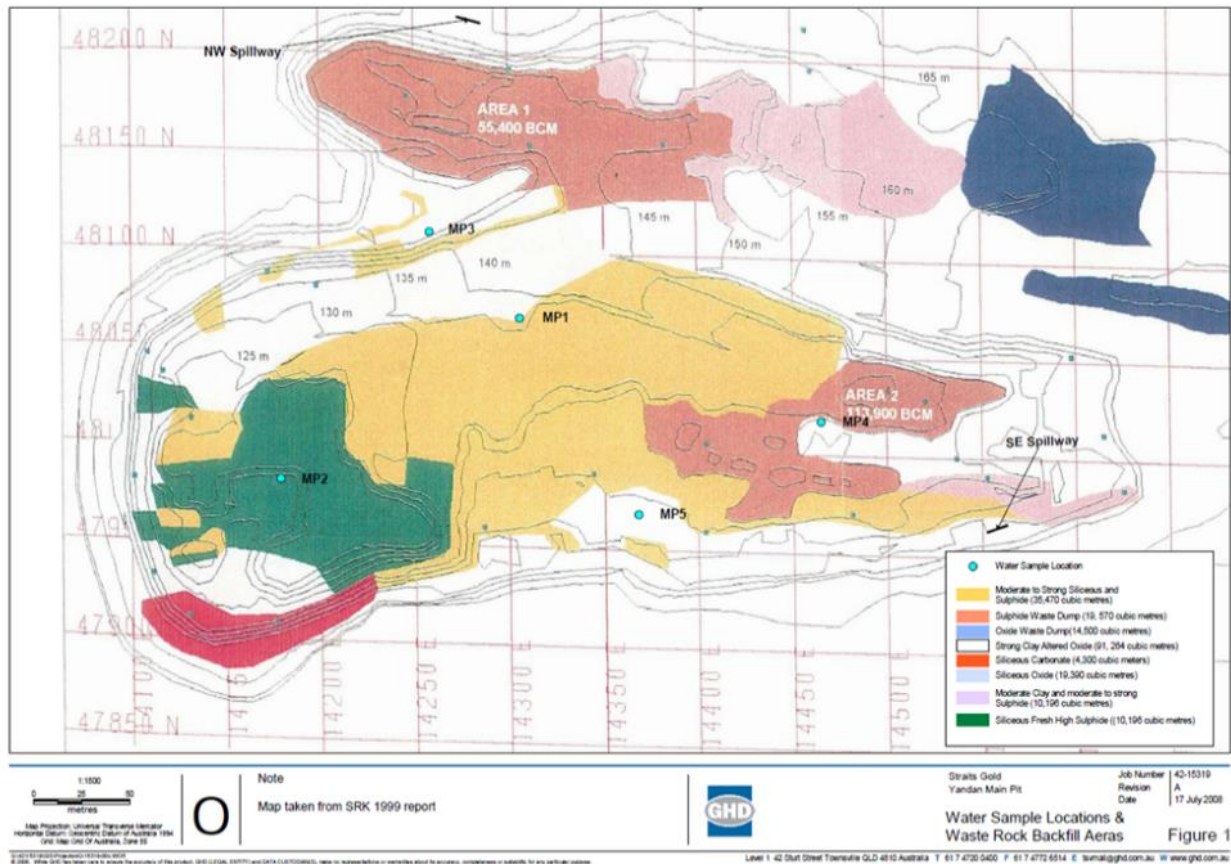


Figure 18 - View of reactive materials stored & in wall rock of Main pit



3.5 Climate

3.5.1 Rainfall

The central highlands of Queensland sits in a sub-tropical to semi-arid savannah climate, with hot, dry to wet summers & mild, dry winters. The area frequently experiences extended dry periods, interrupted by tropical wet season rainfall, characterised by downpours or larger tropical low systems crossing the coast. When rain does occur, it can be intense & highly localised, capable of depositing large depths of rain & varying significantly across the landscape.

Specific rainfall data is not available for Yandan site area, however good records are available at Mount Douglas (50km south) & St Anns (10km north) as Bureau of Meteorology sites (locations in Figure 19).

Since 1900, rainfall predominantly varies between 400-800mm/year, though can range from as low as 200mm/year & or up to 1,100mm/year associated with cyclones & tropical lows into Mackay. Dry conditions prevail – with an average of 315 days without rain per year: rainfall occurs of annual rainfall occurs in just a few events each year. Figure 20 plots daily & seasonal cumulative rainfall (July to June) for the past 20 years.

Rainfall also varies over time: a residual rainfall chart (deviation from average) in Figure 21 shows the seasonal cycle of rain, with broader cycles of wetter & drier periods over the record, with clear capacity for extreme wets events & severe dries. Since 2012, the region has experienced drought conditions & the last two years average rainfall. Since Yandan was mined, the region has undergone a drier period, then a wetter period & since 2012 another wet period except since 2012.

3.5.2 Evaporation & wind

Daily rates of evaporation & average wind speeds for the project are adapted from pan evaporation measured at the closest regional station available: Moranbah Water Treatment plant, Twin Hills & Collinsville Post office. Table 7 summarises average daily evaporation by month for each station.

Evaporation ranges from ~3mm/day over the cooler winter period, through to ~8.0mm/day in November-December, in demonstration of the heat capacity in summer, particularly in the absence of seasonal rains. Average annual potential evaporation equates to approximately 2,094mm. Wind speeds (Table 8) range around 5kph to 9.6kph across a year.

Table 7- Evaporation rates for the Mount Coolon area

Station	Dir	J	F	M	A	M	J	J	A	S	O	N	D	Average/day	Total/year
MoranbahWater Treatment	SE	8	7.4	6.8	5.7	4.3	3.5	3.7	4.9	6.6	8	8.5	8.5	6.3mm	2,306mm
Twin Hills	SW	7.5	6.5	6.1	5.2	3.6	2.9	3.1	4.2	6.1	7.9	8.6	8.7	5.9mm	2,140mm
Collinsville Post Office	NE	6.2	5.7	5.2	4.4	3.5	2.9	3.2	4.1	5.3	6.5	6.9	6.9	5.1mm	1,840mm
Average/month		7.2	6.5	6.0	5.1	3.8	3.1	3.3	4.4	6.0	7.5	8.0	8.0	5.8mm	2,094mm

Table 8 - Temperature & wind speeds at Moranbah Water Treatment Plant

Station	J	F	M	A	M	J	J	A	S	O	N	D	Average annual
9am temperature (°C)	26.4	25.8	24.7	22.1	18.9	15.4	14.7	16.6	20.6	24.0	25.3	26.4	21.7
9am wind (km/h)	7.5	7.7	8.1	7.6	6.2	5.5	5.3	6.6	7.7	8.4	8.4	8.4	7.3
3pm temperature (°C)	32.7	31.9	31.2	28.6	25.8	22.9	22.9	24.6	28.3	31.4	32.2	33.0	28.8
3pm wind (km/h)	8.8	9.6	9.4	8.7	6.9	6.6	7.0	7.7	8.3	8.4	8.9	8.8	8.3

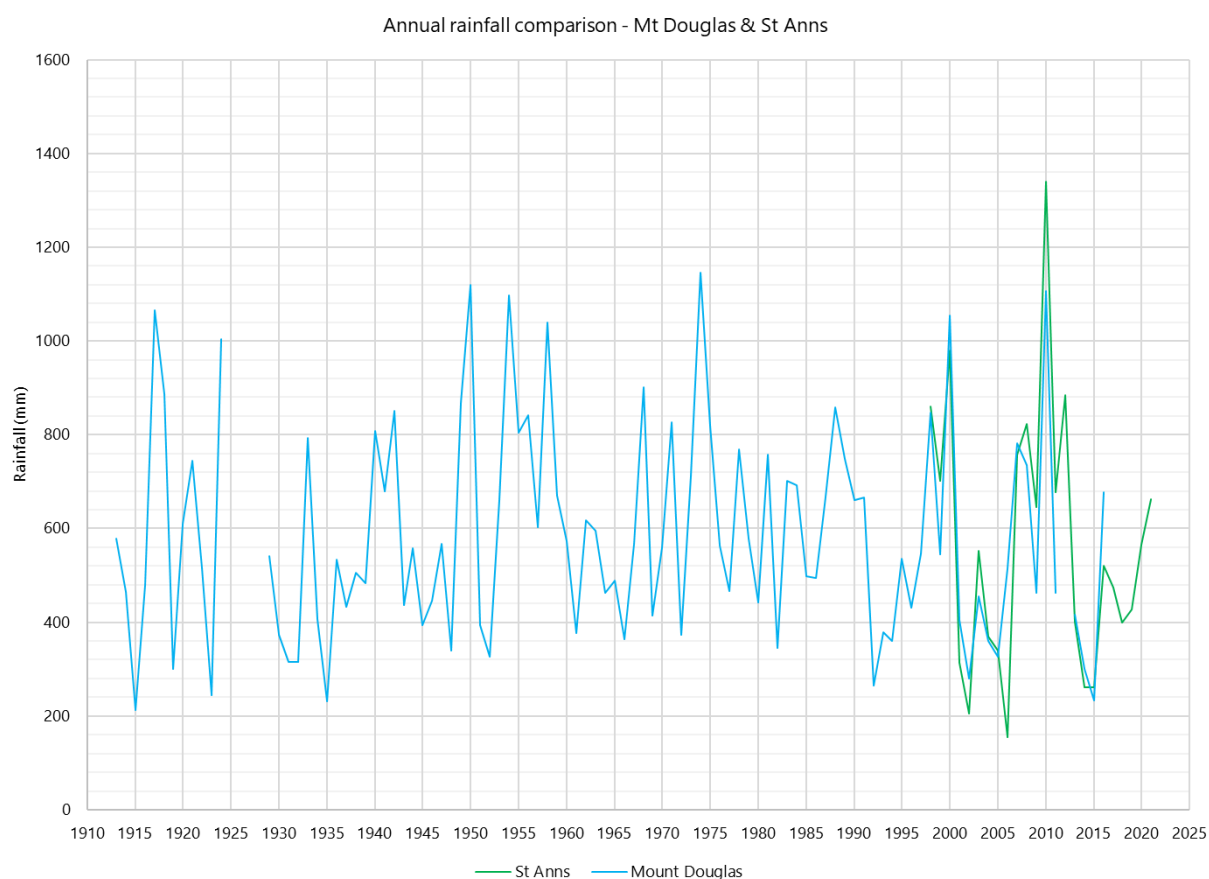


Figure 19 - Annual rainfalls of local stations

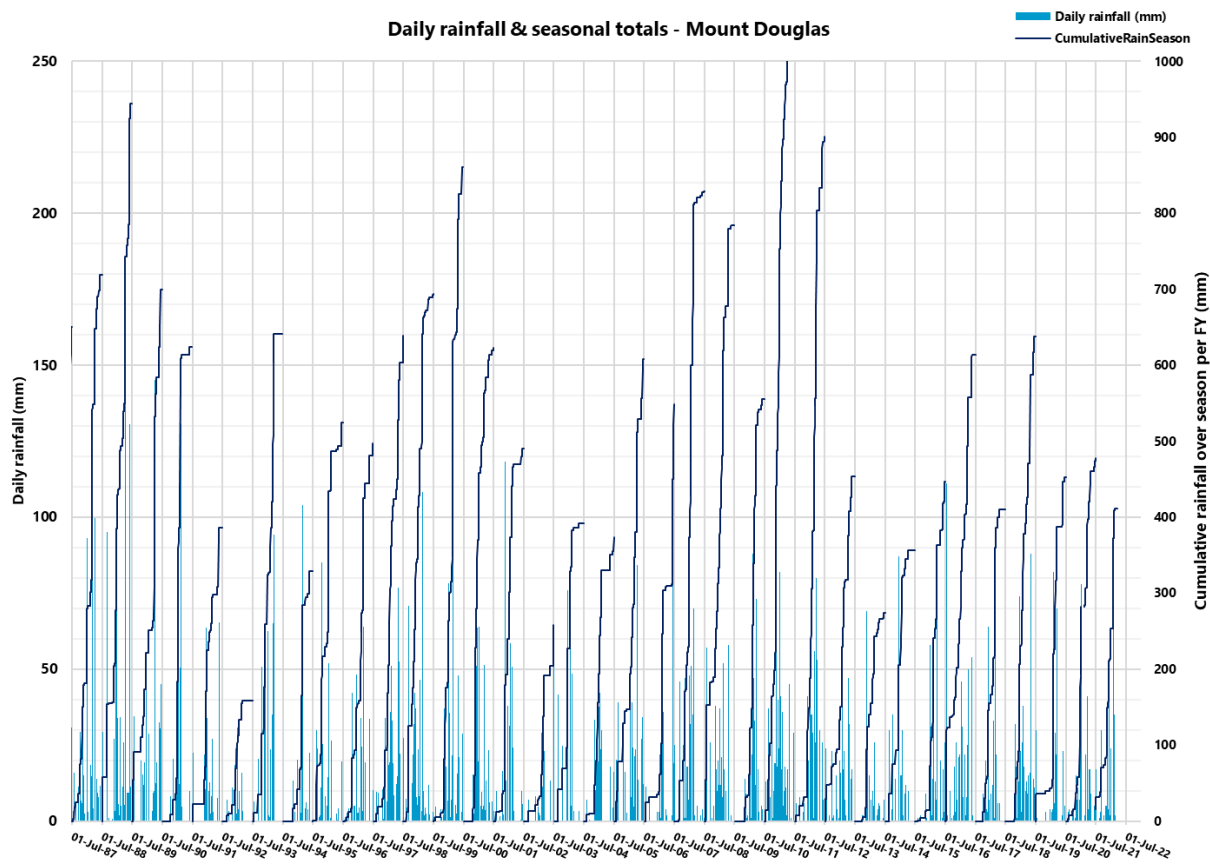


Figure 20- Seasonal annual rainfall in region 1987-2021

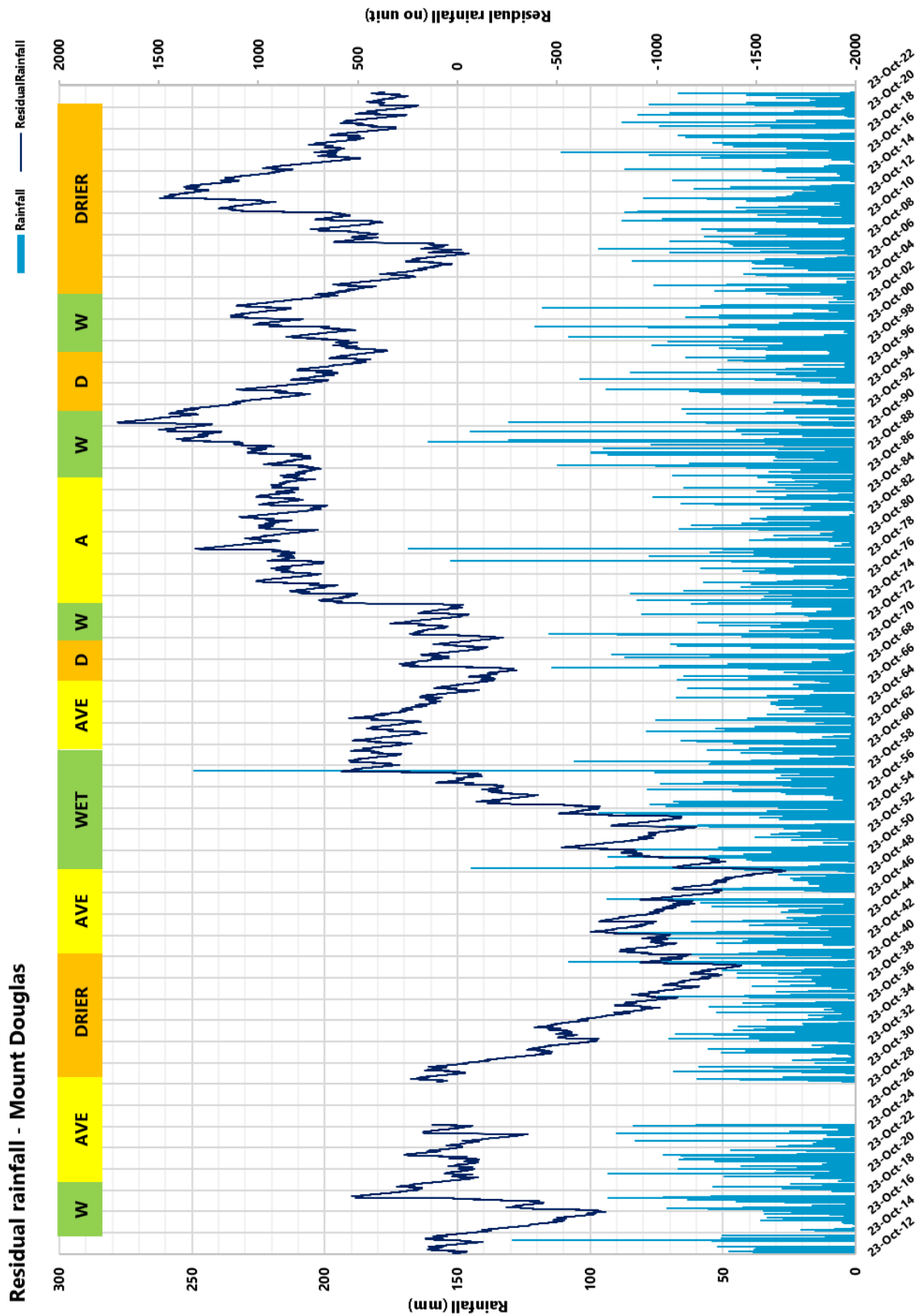
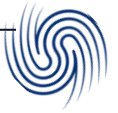


Figure 21 - Residual rainfall of Mount Douglas rainfall station



3.5.3 Design rainfall (Annual Exceedance Probability AEP)

Guidance on design rainfall for Yandan site is provided by Bureau of Meteorology Australia. Design rainfall refers to the statistical profile of rainfall event intensity & duration for a site, or Annual Exceedance Probability (AEP), & is useful in planning for significant rain events & design of water infrastructure such as drainages, spillway capacities & pipelines.

Annual Exceedance Probability (AEP) profiles indicate the probability an event will occur – as defined by a depth of rainfall over a time frame. For Yandan, the 1% AEP event over 24 hours is 241mm, & the 10% AEP event over 24 hours is 142mm or over 72 hours is 191mm.

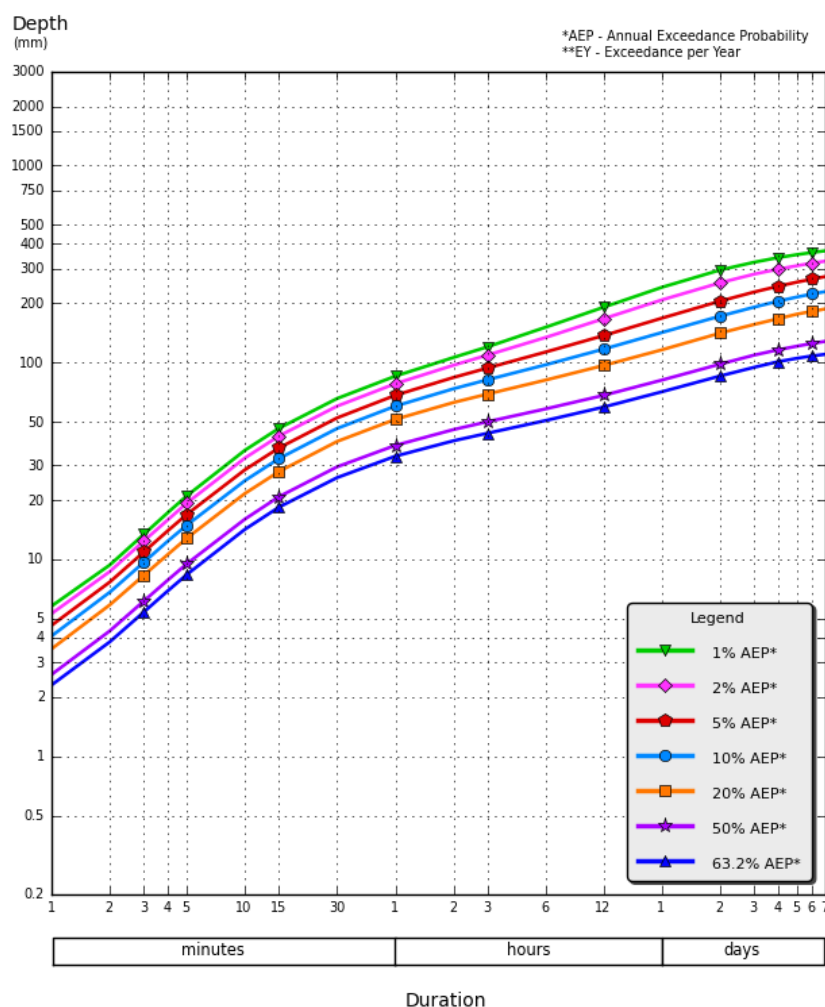


Figure 22 - Rainfall intensity frequency durations

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Table 9 - AEP (design rainfall) table of duration & rainfall depth

Annual Exceedance Probability (AEP)														
Duration	63.20%	50%	20%	10%	5%	2%	1%	63.20%	50%	20%	10%	5%	2%	1%
5 min	8.36	9.48	12.8	14.9	16.9	19.3	21	24 hour	71	81.4	116	142	168	208
10 min	14.2	16	21.6	25.1	28.5	32.7	35.8	48 hour	85.4	98.1	141	172	205	254
30 min	26	29.5	39.7	46.2	52.3	60	65.6	72 hour	94.5	109	156	191	228	281
1 hour	33.4	37.9	51.4	60	68.1	78	85.2	96 hour	101	116	167	205	244	298
2 hour	40	45.6	62.6	73.5	83.9	96.8	106	120 hour	105	121	176	215	256	310
6 hour	50.7	58.1	81.4	97.3	113	134	151	144 hour	108	125	182	223	265	320
12 hour	59.4	68.1	96.6	117	137	167	191	168 hour	110	128	187	229	273	327



3.6 Calculation of Probable Maximum Flood event (PMF)

Probable maximum flood (PMF) event is calculated using the Generalised Short Duration Method (BOM 2003). Applied variables are shown in Table 10, with reference table in Appendix B.

PMF event for Yandan is calculated at 1,233mm over 6 hours.

Table 10 - Variables determined as applied in PMF calculation

Zone	GTSMR coastal zone
Duration limit	6 hours (1,000km ²) (Yandan & are 1.3km ² & 1.5km ² respectively)
Terrain factor	Rough (Dr) – due to waste rock & other
Elevation adjustment factor (EAF)	1 (200mAHD, below 1500mAHD)
Moisture adjustment factor (MAF) based on location	0.85
Point value	1450

Calculation

$$\begin{aligned}
 \text{PMF} &= (S \times D_s) (R \times D_r) \times \text{MAF} \times \text{EAF} \\
 &= 1450\text{mm in 6 hours} \times 0.85 \\
 \text{PMF} &= 1,233\text{mm in 6 hours}
 \end{aligned}$$

3.7 Flooding

3.7.1 Extents by exceedance probability

Regional flood extents as published by Queensland Spatial Services for the Burdekin Basin for a 1% annual exceedance probability (AEP) event & extreme event (PMF) are shown in Figure 25, & demonstrate the large extents of significant rainfall & flooding events are for the region.

At Yandan scale, flooding was considered from project design: with WMC (1998) following construction of all major infrastructure above 180mAHD. Flood extents for Yandan are shown in Figure 26, both as base model output & aligned contours of:

- 1% AEP event – 179mAHD
- PMF event – 187mAHD

The heap leach pad lays above the 1% AEP flood extent, & the tailings facility lays above the PMF flood extent for the site. Note with the top of the heap leach pad elevation peak at 212mRL, the leach pad will not be fully submerged but may have partial flooding through the base. East pit lays above a 1% AEP event, & Main pit is submerged in both events & will be in direct connection with the river.

3.7.2 Reference elevations for pit flooding & connection

Estimation of flood duration for Main pit can be based from St Anns river gauge downstream. AECOMM (2020) calculated reference levels of St Ann gauge river levels to Main pit as follows:

- At 3.8m river height, or flow elevation of 165.8m AHD at St Anns river gauge, flow to Main pit is established at 169.05mAHD at Yandan. This equates to when flows exceed 500m³/s.



3.7.3 Flow durations

Flow durations developed from St Anns gauge & confirmed with BOM analysis tools are shown in Figure 27.

Conversion of river height where hydraulic connection from the river to the pit matches 3.8m depth at the gauge to a flow rate of 500m³/s at St Anns. The equivalent flow rate averages around 10% AEP, or once in every 10 years, but with variable rainfall & flow over the record, varies from 5% AEP to up 25% AEP.

Based on AECOM (2020) records, the pit & river have connected (either through inflow or releases) 6 times since installed (2000, 2001, 2003, 2004, 2007, 2011) over 22 years, which would support an AEP based on past climate of 25%. A view of Main Pit & Suttor River in flood from 2000.



Figure 24 - View of Main pit during flood in 2020

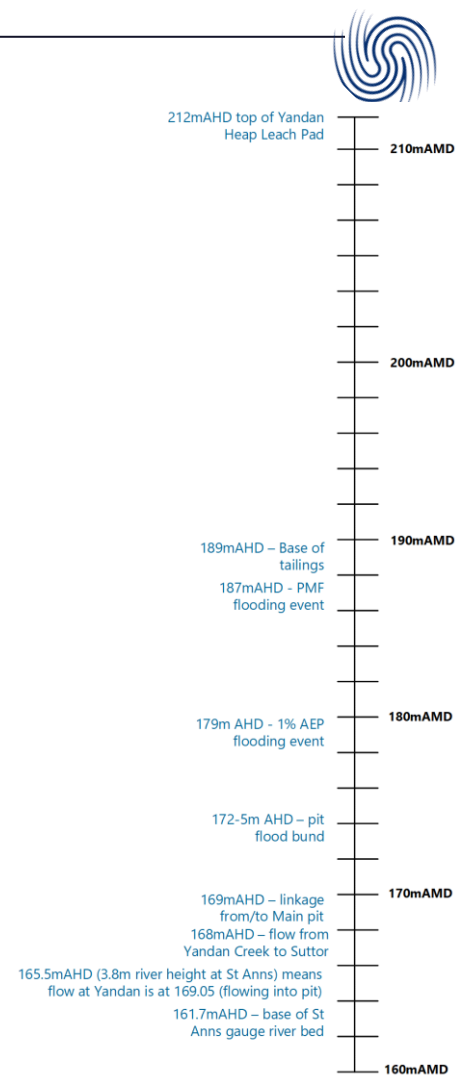


Figure 23 - Reference elevations for Yandan river & flood system

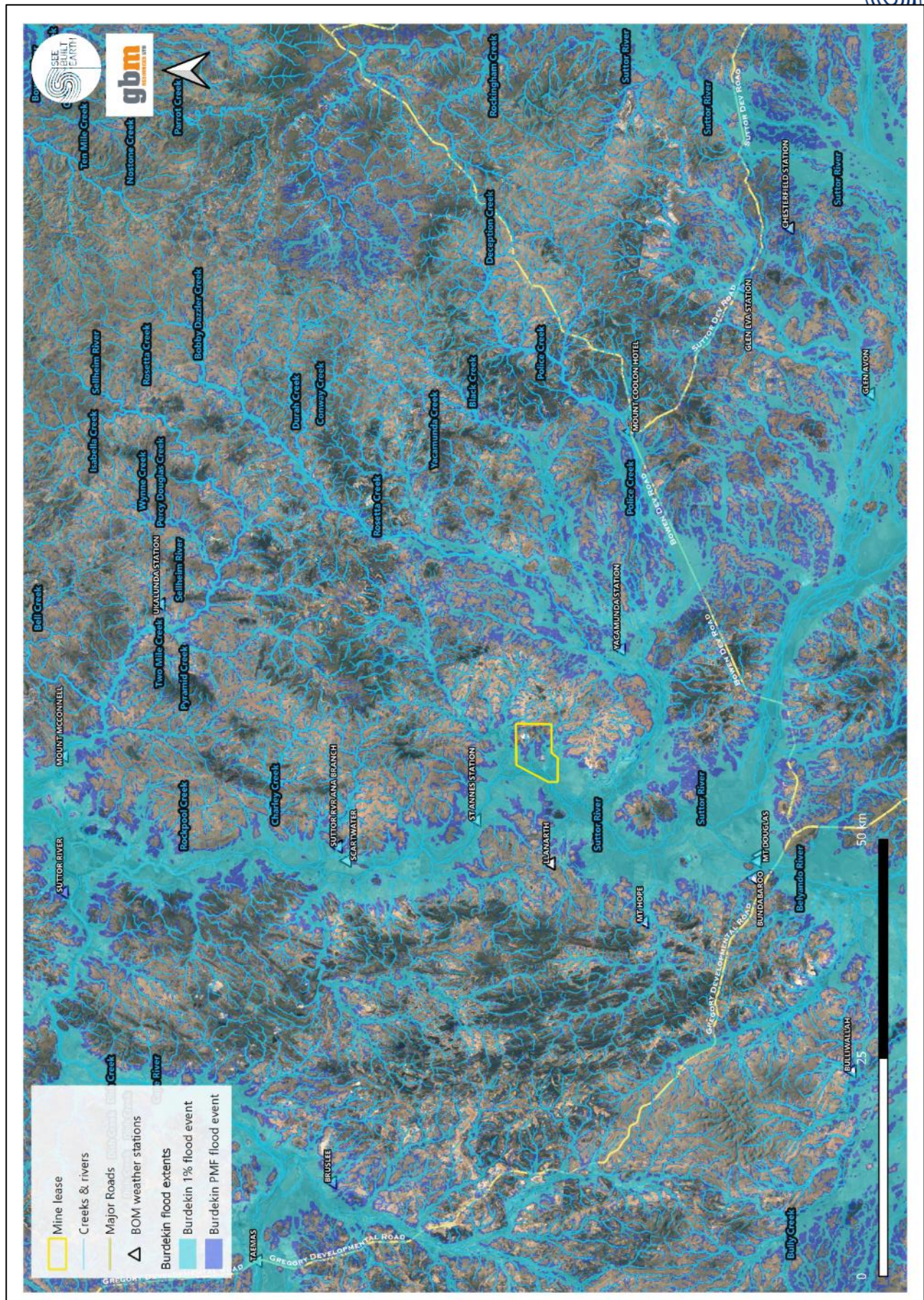


Figure 25 - Regional flooding profiles – 1% AEP & PMF events

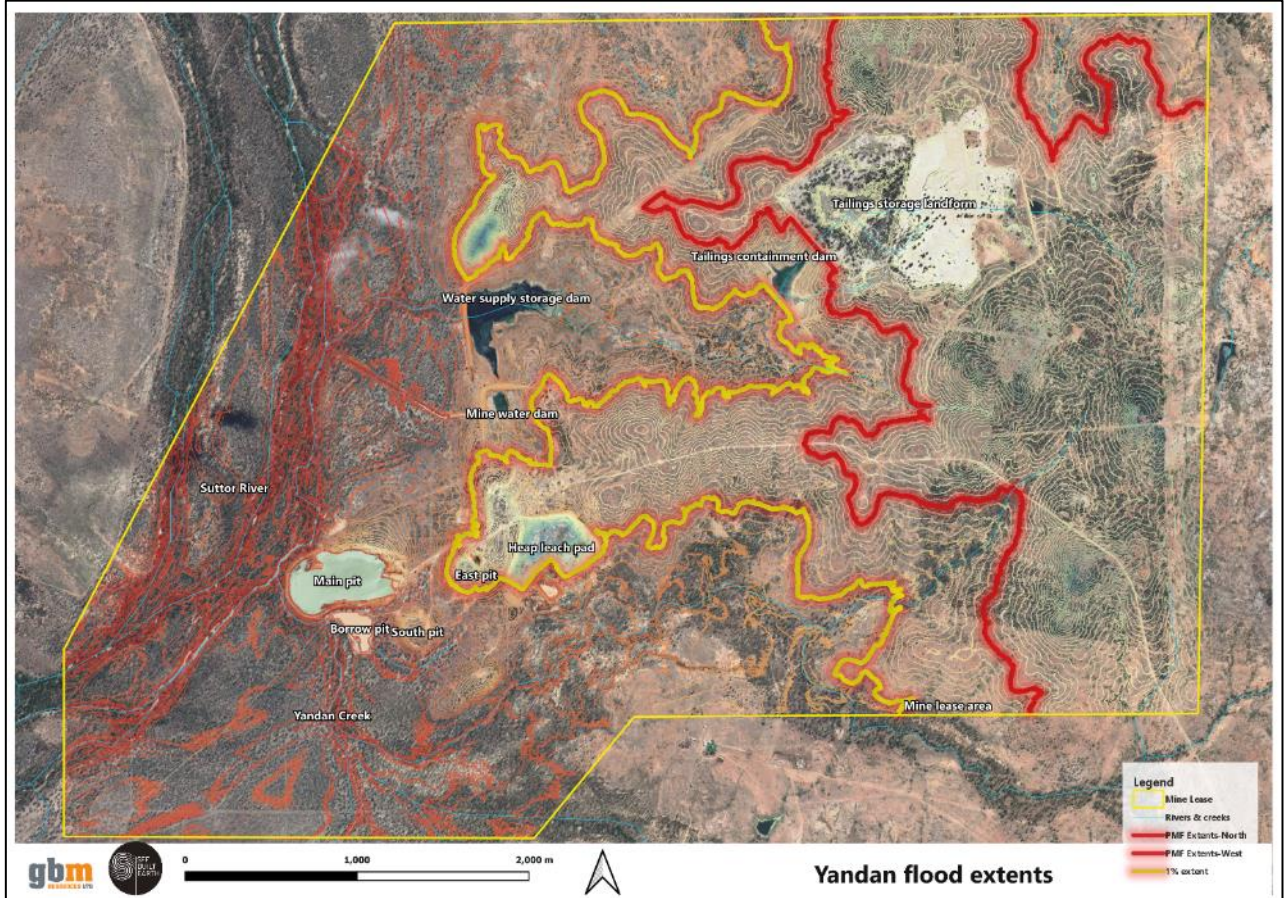
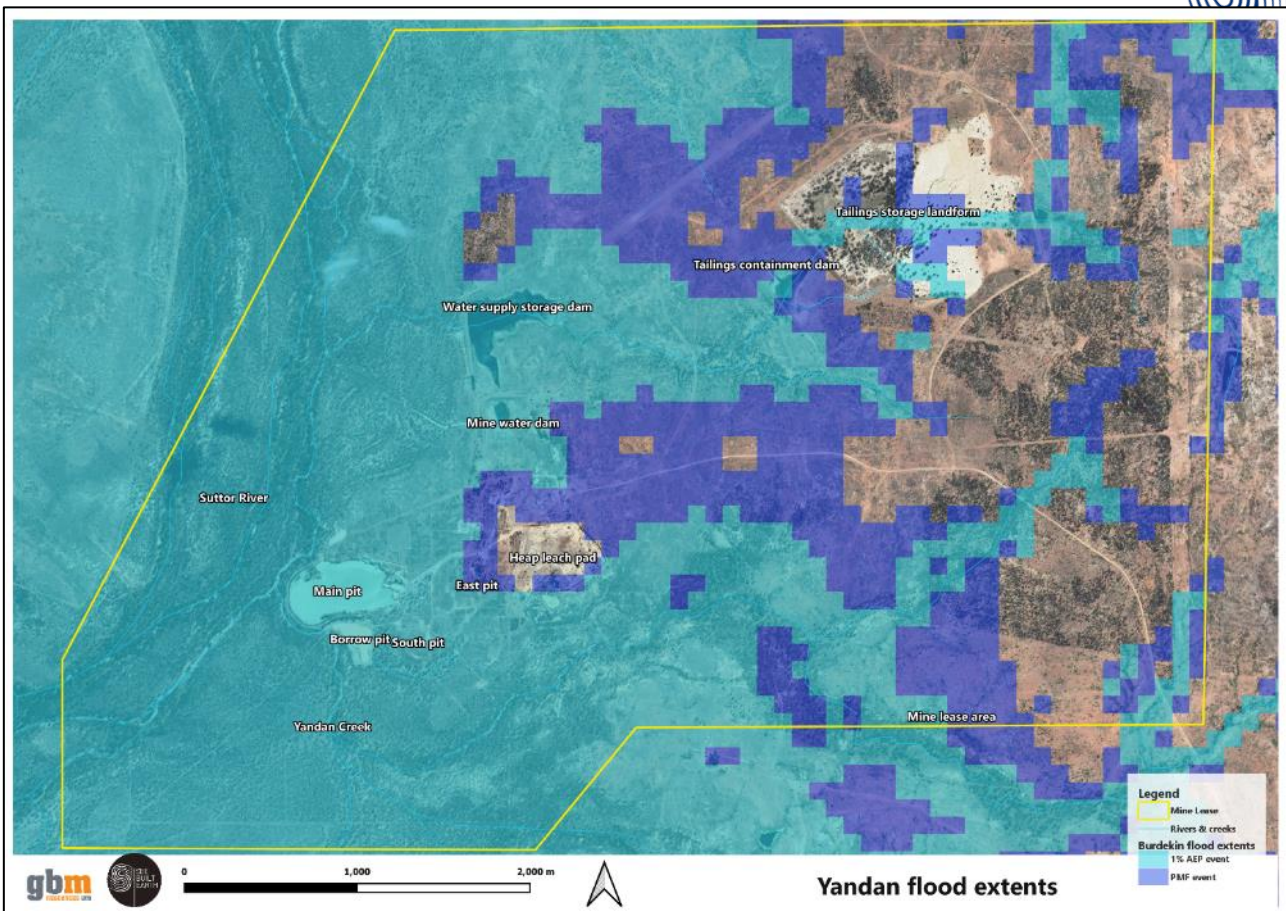


Figure 26 - Flooding extents for Yandan site

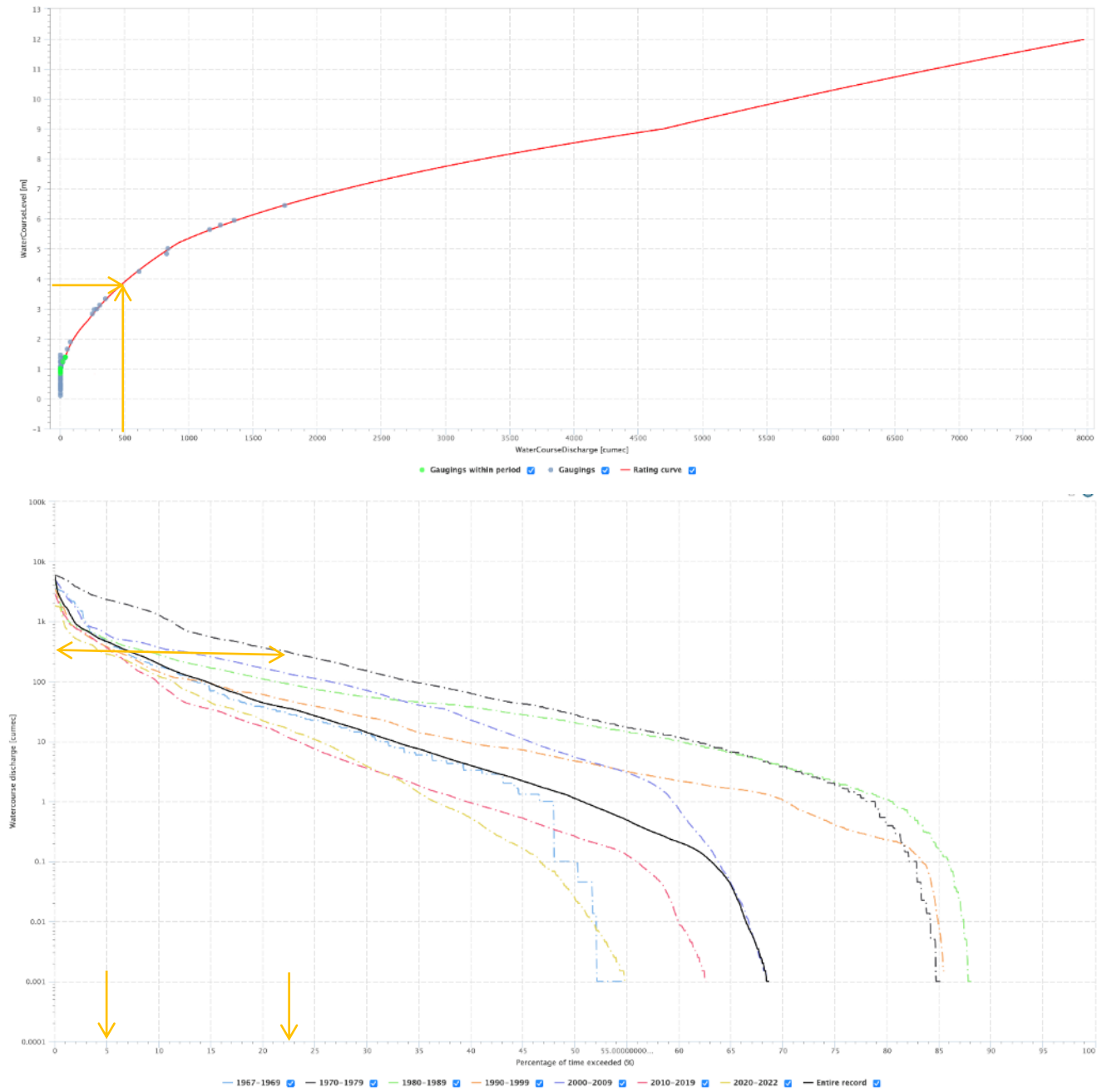


Figure 27 - River gauging & flood duration curve for St Anns river gauge



3.8 Climate change expectations

Climate change model scenarios are compiled & available from the Future Climate Dashboard (Queensland Government 2021a) at time series snapshots of 2030, 2050, 2070, 2090. The resource brings together scenarios predicted by 12 major climate models & provides a magnitude change ranked by probability (percentiles) of changes to daily precipitation & evaporation (pan) rates.

Model outcomes per season & time snapshot from 2030 to 2090 are shown in Figure 28 (Queensland Government 2021a). Expected median rainfall suggests rates will continue but will have potential to vary much more widely over time, particularly after 2050. However, evaporation rates will continually increase, with median rates up 1.8mm/day in 2090 (increase of ~30%), but at least 0.7mm/day & at most 3.6mm/day.

Regional changes in 2090 are shown in Figure 29 & Figure 30 (Yandan project area highlighted).

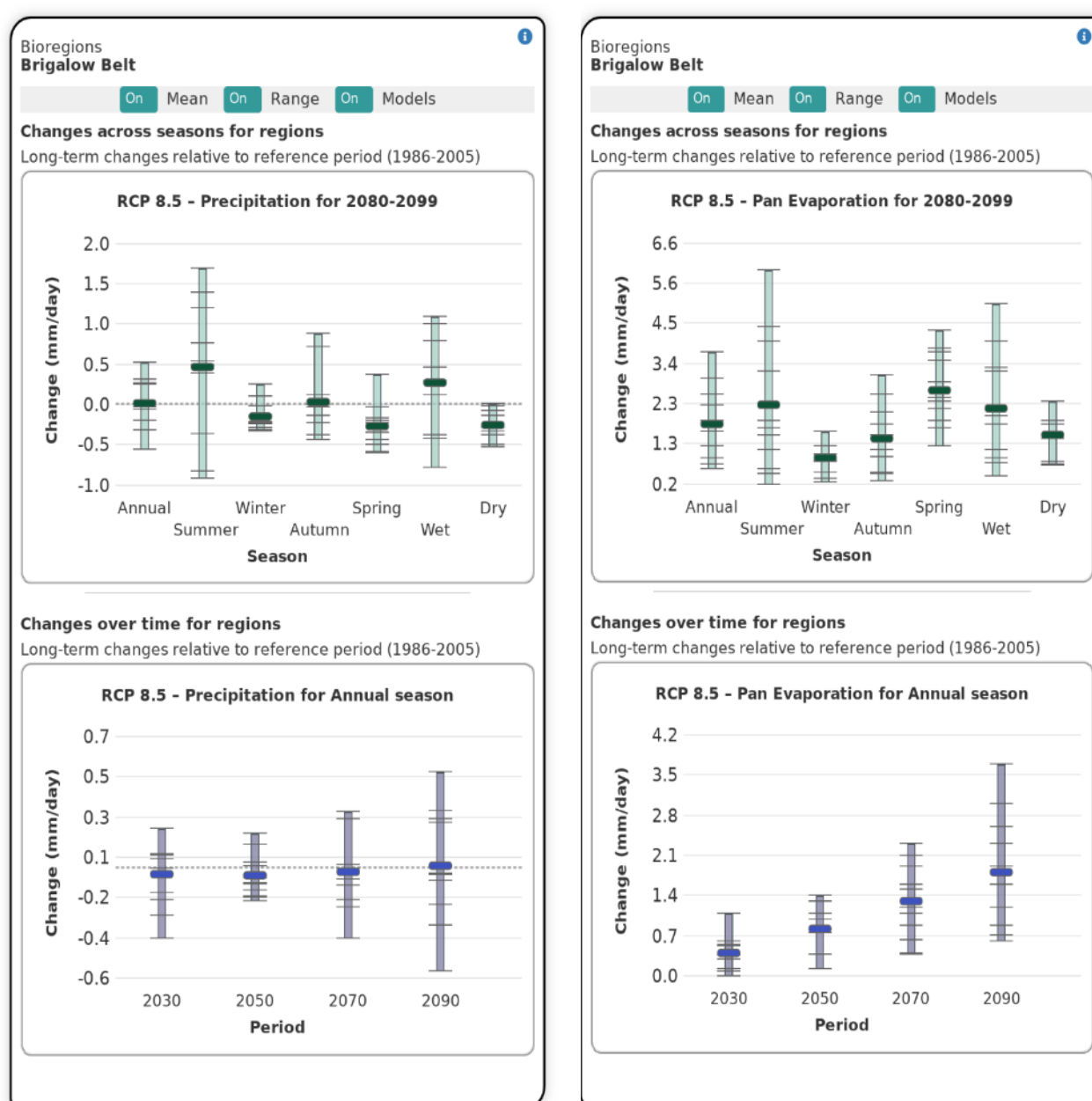


Figure 28 - Climate change scenario predicted changes for major water balance

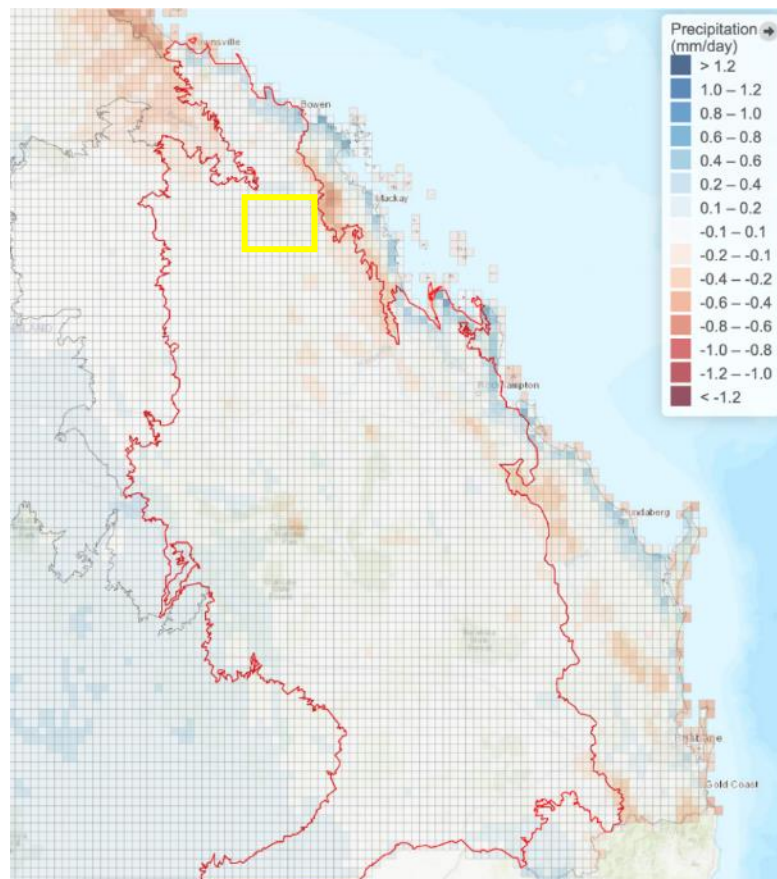


Figure 29 - 2090 median precipitation changes across region

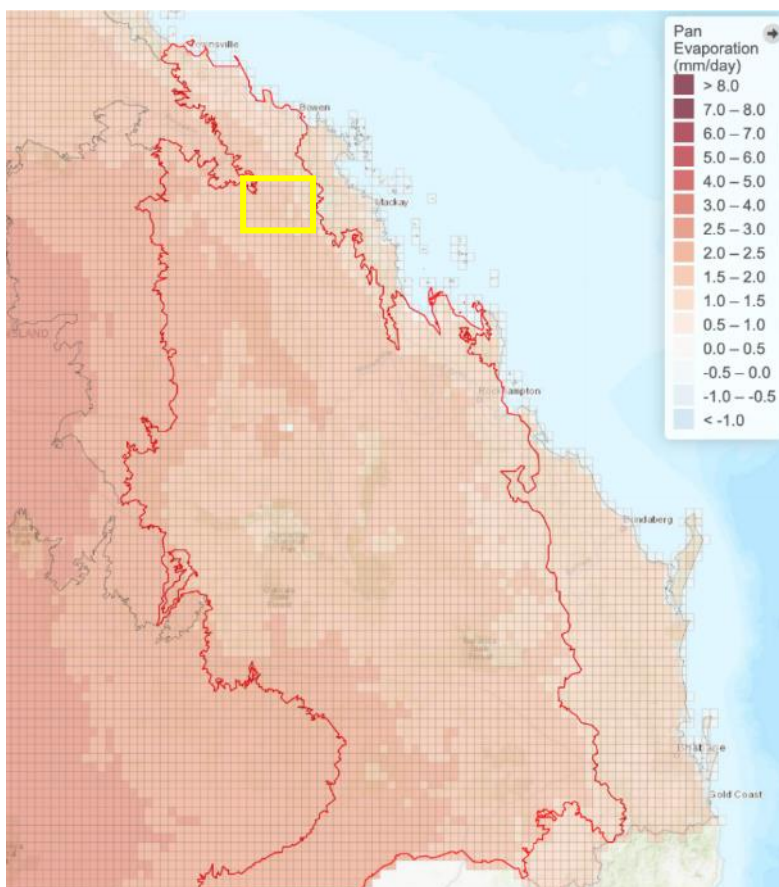


Figure 30 - 2090 median evaporation changes across region



3.9 Hydrogeology & groundwater

Aquifers of the Yandan project area occur as (Forbes 1988):

1. East of the mining area – low to very low permeability siltstones, sandstones & metamorphics, with limited groundwater occurrence.
2. Through the central area, a limited extent fracture hosted aquifer associated with the Yandan Fault.
3. West of the Yandan Fault in the mineralised zone, a porous unit associated with mineralisation & is likely the boiling zone of the epithermal mineralised system.
4. Alluvial aquifer as part of the Suttor River alluvium, reaching up to 30m depth.

The boiling zone & Yandan Faults appears to be relatively conductive, with pre-project dewatering (Forbes 1988, WMC 1998) studies suggesting dewatering demand rates of up to 5,000m³/d to keep Main pit dry, & pump test finding the fault & (what would appear to be) the boiling zone yielding draining storativity & transmissivities of 50-1,000m²/d. The study notes an expectation of finding connection to alluvial aquifers, but which was not identified at the time. It is not known of actual dewatering rates experienced during mining.

Groundwater is also described as flowing from east to west with topography, but with strong changes of hydraulic head changes between wells, indicating structural control & compartmentalisation with volcanic intrusions or contacts in geology & potential hydraulic separation.

Recent water level results for regional wells RB1D, RB2D, & SH3 support a westward flow (Figure 31 & Figure 32), moving from 177.7mAHD at RB1D in the east, to 168.4mAHD westward & to 162.5mAHD at SH3 close to main pit.

A groundwater surface of Yandan using February 2022 groundwater levels confirms groundwater flow direction in Figure 33, with groundwater levels dropping towards towards Yandan Creek. Note RB series are only recently installed, & the exclusion of levels from HL4, HL6 & TD5 bores given likely integrity issues.

Pre-mining groundwater quality is described as moderately saline with total dissolved salts (TDS) between 4,000 to 15,000mg/l.

3.10 Regional water values

3.10.1 Other water users

With rainfall between 200-1,100mm/year against an evaporation capacity of 2,094mm/year, the Yandan site & region is currently a strongly water negative balance site (as with much of the Central Highlands region).

Groundwater is not well developed in the area, with state registered showing only a few bores within Yandan for the region (Figure 34). An upstream neighbour appears to be running a very large irrigation operation, with a significant dam storage & cultivated field.

3.10.2 Presence of RAMSAR wetlands, GDE's or water values

Review of published RAMSAR wetlands (WetlandsMap, 2022) indicate there are no recorded sites in the region (Figure 35). There are also no occurrences of artesian or groundwater mounds in the area.

The Suttor River & Yandan Creek are mapped as wetlands & potential terrestrial river GDE's.

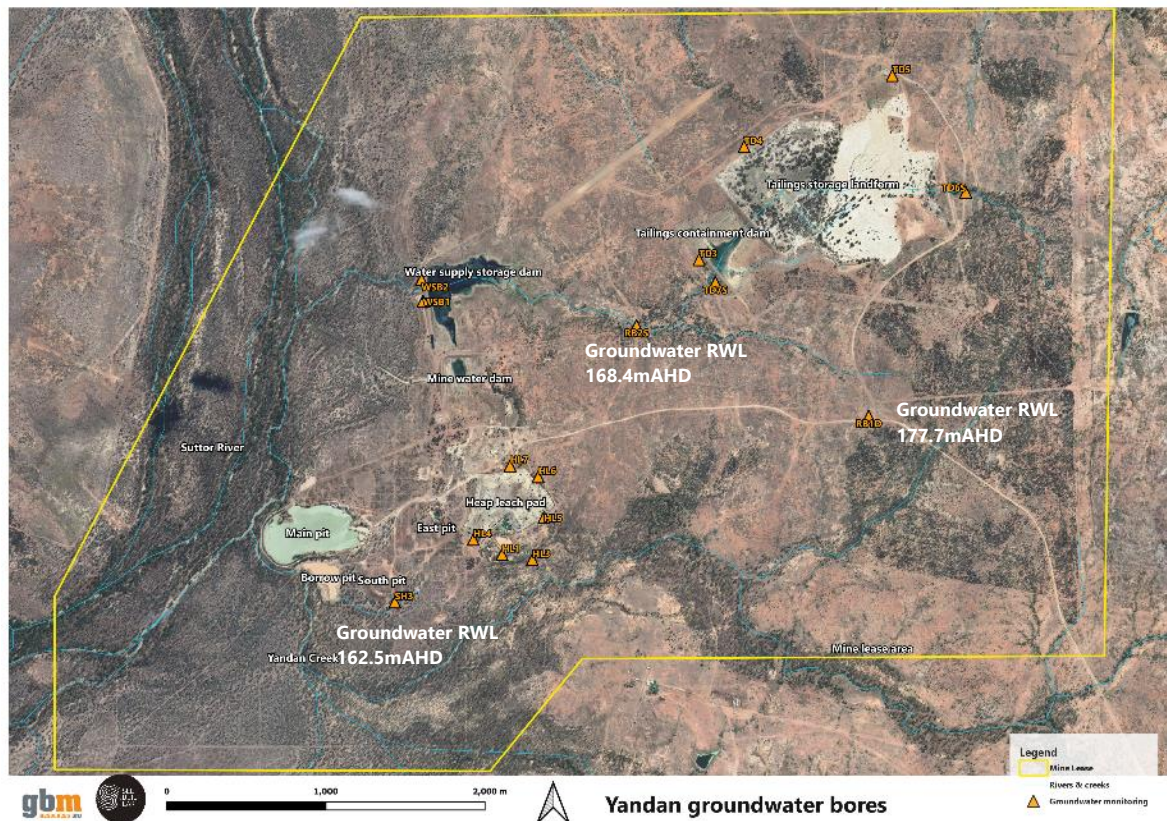


Figure 31 - Yandan groundwater bores & Feb-2022 groundwater relative levels for regional wells

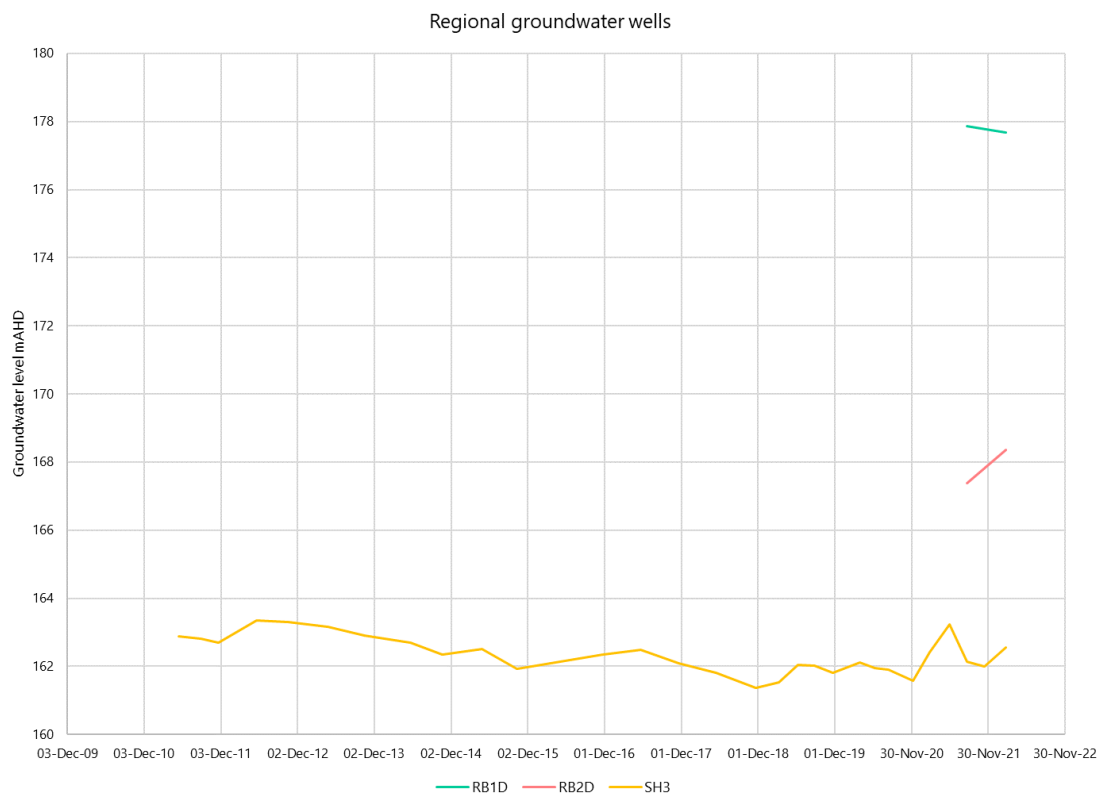


Figure 32-Relative water levels of regional groundwater wells (RB series recently installed)

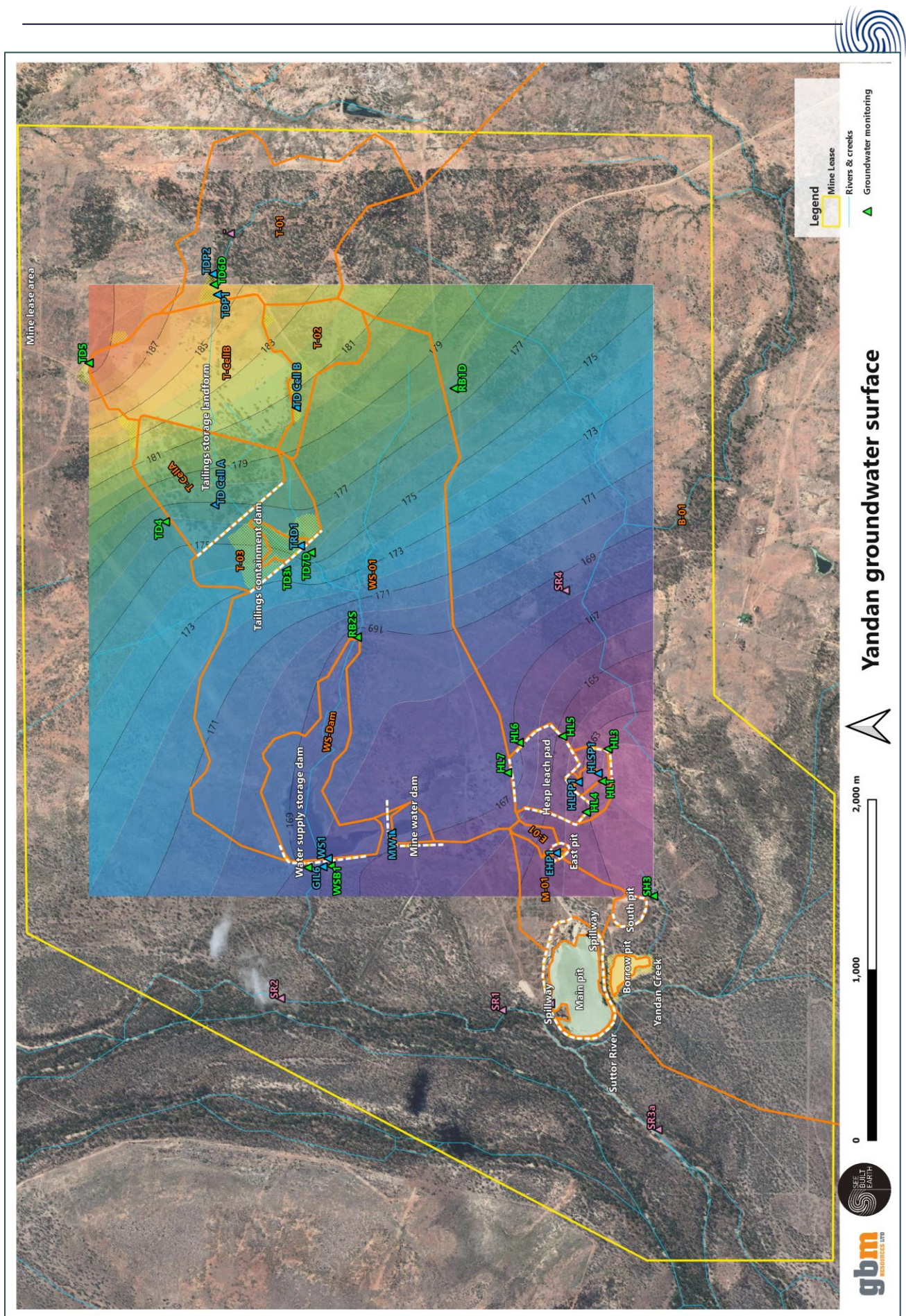


Figure 33 – Yandan groundwater surface



Figure 34 - State registered well locations & nearby water users

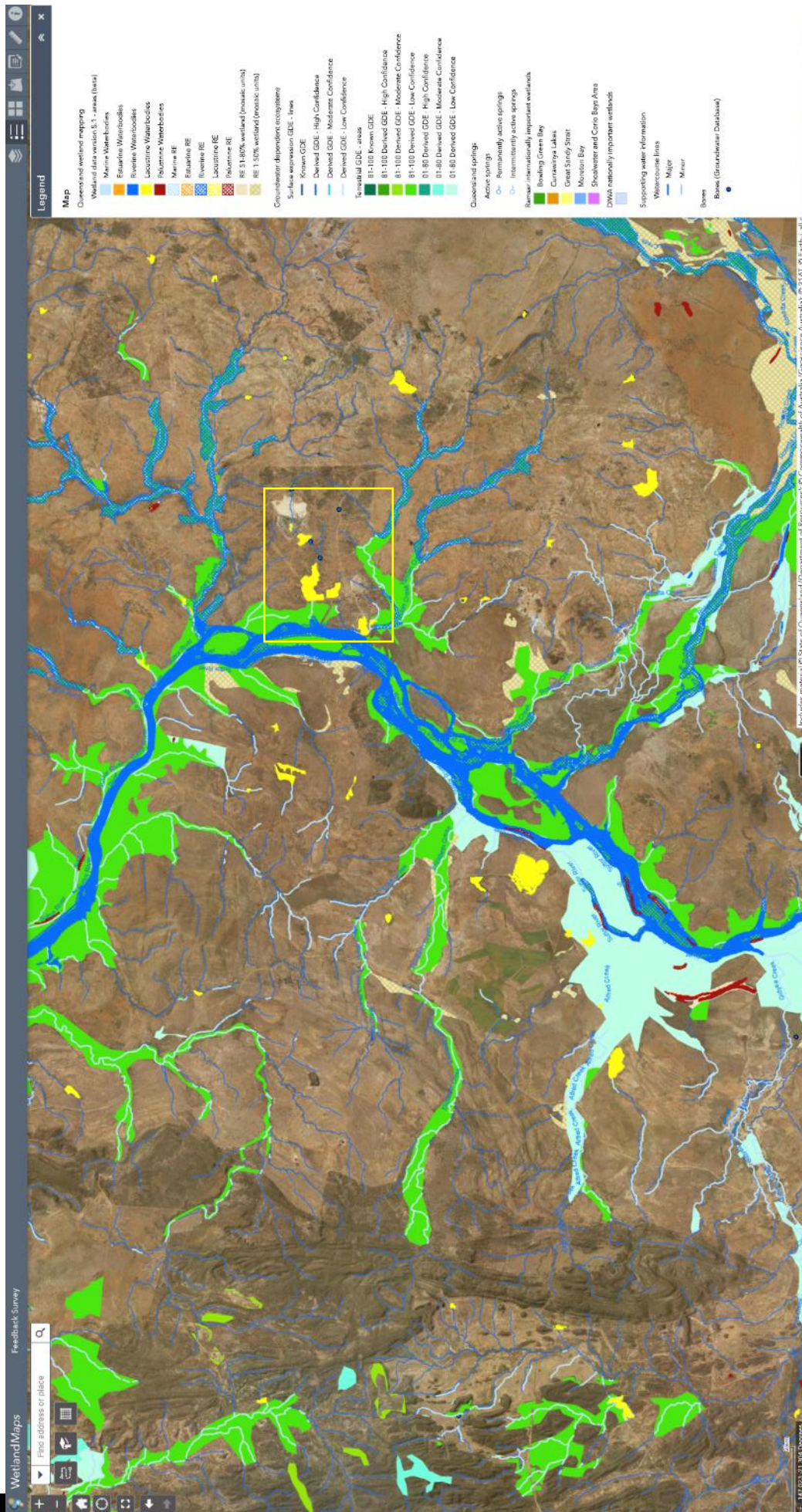


Figure 35 – Wetland & GDE map



4 Site landforms & domain characterisation

4.1 Overview

Piper plots of all groundwater & surface water sample sites from February 2022 sampling (following rainfall) are shown in Figure 36 & Figure 37 as a overview snapshot of water quality types across Yandan site. In groundwater, water tends to be sodium/potassium in cations, with bicarbonate or sulphate anions, with no clear populations between areas. This would indicate different processes underway. Similarly in surface water, storage waters plots as consistently of mixed types without clear populations, though remain sodium/potassium dominant, along with carbonate/sulphate.

Populations of water become more pronounced with detailed cation/anion analysis (Figure 38):

- Log Cl to Log Na chart identifies populations of increased sodium
 - Increased sodium - surface water storages in east hill pit, heap leach ponds with bores of TD6D&S with TD4 to identify the likely group of most impacted waters.
 - Remainder of groundwater bores for tailings & heap leach.
 - Fresher water & regional groundwater as the lowest sodium.
- Ca:Mg to Na:Cl shows groupings of surface water storage & groundwater, separated into levels of impact: TD4 & TD6D at the tailings dams are most affected in groundwater; East Hill pit & heap leach ponds most affected in surface water storages.
- Ca:Mg to pH shows clear:
 - Close grouping of groundwater populations migrating to fresher surface water storage sources.
 - Altered surface water storage populations, including most impacted surface waters of East Hill pit, tailings return dam (note after rainfall) & heap leach ponds.

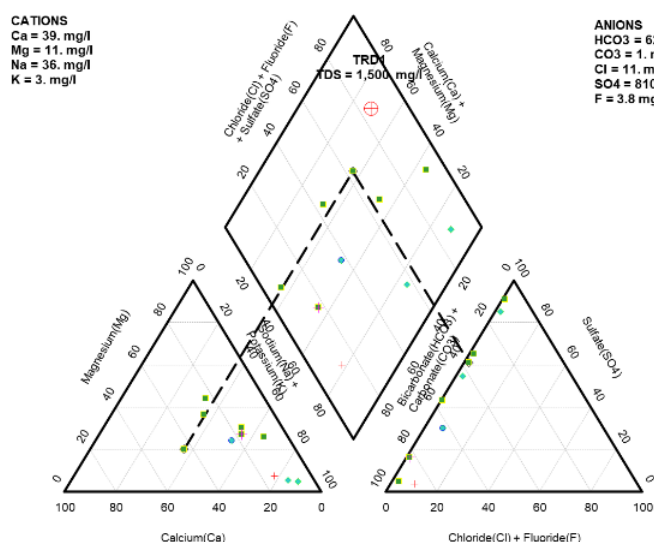


Figure 36 - Piper plot of groundwater water quality

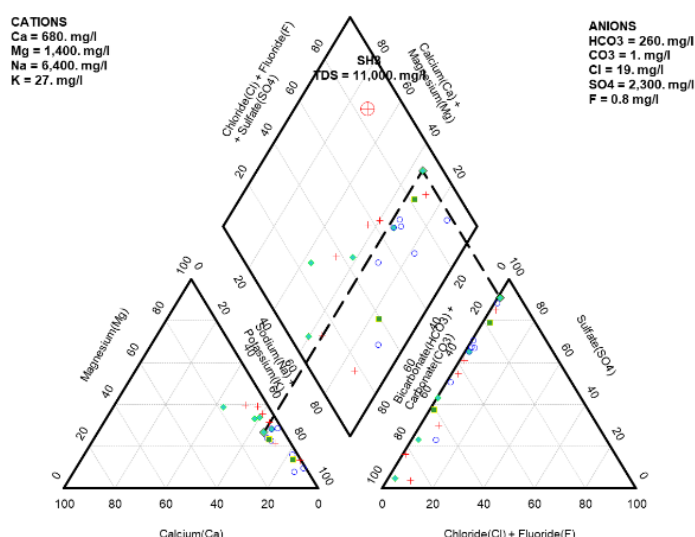


Figure 37 - Piper plot of water storages & bodies water

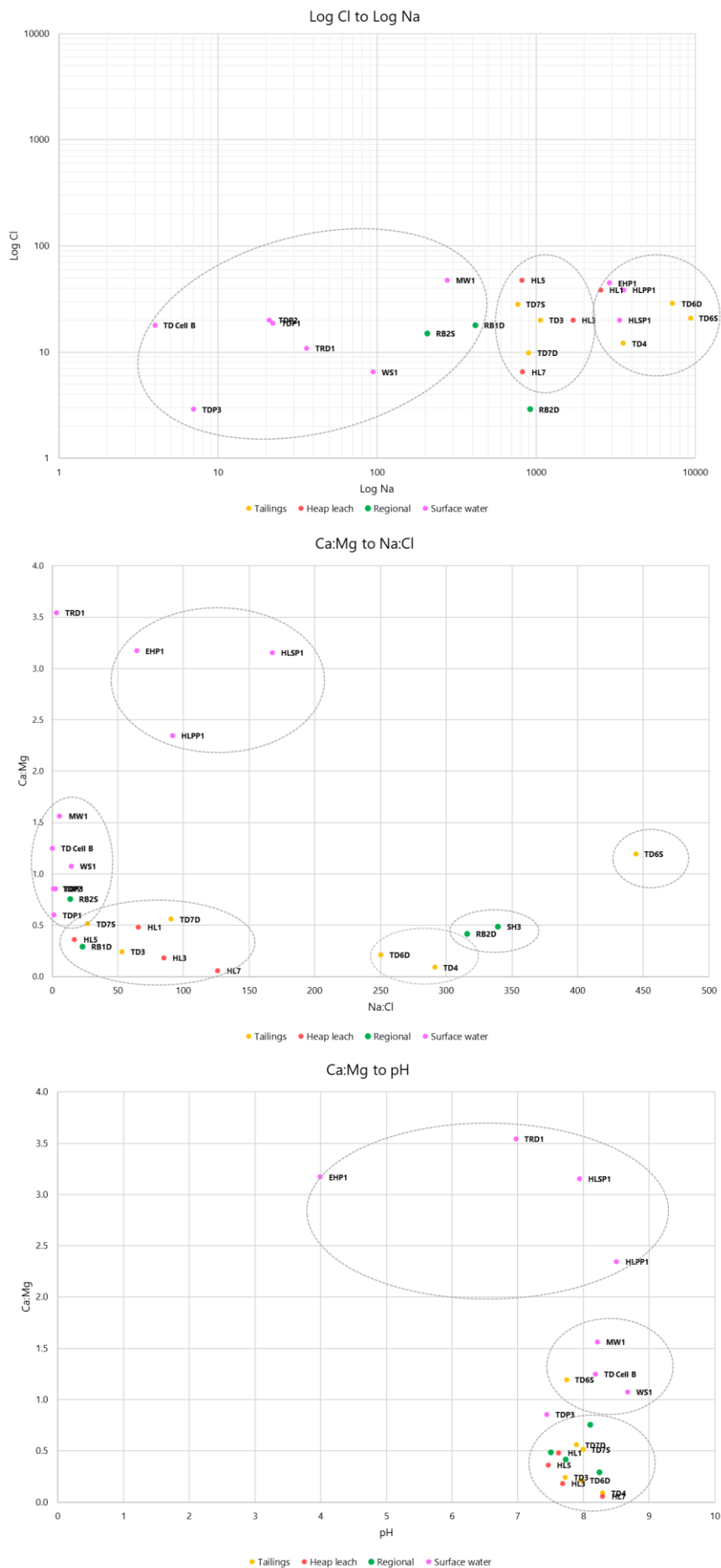


Figure 38 - Geochemical populations of groundwater & surface storages (Feb 22 sampling)



4.2 Tailings landform

4.2.1 Description & observations

Yandan tailings is stored in a broad & low relief 115ha landform (Figure 39) which begins as a low 1-3m embankment from the top of catchment & wraps over the landscape in a platform to a 12m earthen embankment downstream (Figure 40 & Figure 41). The landform sits above maximum flooding elevations of current PMF & consists of two cells: Cell A & Cell B.

Cell A is classed as rehabilitated (Figure 42) & Cell B is yet to be rehabilitated (Figure 43). The surface of the facility is very low gradient (flat): rainfall flows across the surface of Cell B to a broad depression area in Cell A where it ponds & likely seeps into the tailings storage below (Figure 44). When Cell A when pond capacity is exceeded, excess water flows over the spillway on the south side when the pond fills. Spillway flow is directly contained by the tailings return dam (containment dam).

Around the perimeter of the landform, there are several borrow pits directly adjacent to tailings embankment, presumably for use of material in construction (Figure 45 & Figure 46). With rainfall, these borrow pits are acting as places for additional ponding & actively store water given the low relative level to tailings & ground surface: it is likely the ponds are a mix of tailings seepage water & rainfall. On the eastern side, the landform is not quite at the top of catchment & has a small drainage line above which has a retaining structure as a dam wall with an access road, & a storage lays beneath (TDP).

Inspection of the tailings surface identified several areas of internal erosion & small voids observed into the tailings (Figure 47), likely associated with either differential settling & increased flow with the lack of drainage, taking advantage of decomposed tree roots which when removed leave a preferential pathway for water flow. Ripple marks from over-surface flow from rainfall is also present.

Monitoring consists of several groundwater wells of historical & recent construction around the perimeter of the landform, generally located close to tailings embankments & some within borrow pit areas, with background wells up-gradient & two wells downstream of the containment dam. Underlying geology is predominantly siltstone. Surface water quality is monitored where possible, both upstream & downstream in the containment dam, & at other locations as available.

4.2.2 Water responses

Groundwater elevations over time are shown in Figure 48 in relative water level (mAHD). The wells show a clear response to rainfall, declining in drier times since 2012, stabilising in 2020 & then rising for 2021 wet season. This may be in response to direct rainfall, or from increased water storage within the facility given the lack of drainage & their close location to embankments. Note TD5 on the north side of the facility appears to have lost surface integrity is connected to surface (matching reduction in salinity), as well as being sited in a borrow pit pond.

Groundwater flow direction follows the landscape as expected: with highest elevations at TD6S/D to TD4 & then TD3 downstream of the containment dam. Note TD7D/S indicates a high elevation & suggests the well may be potentially monitoring the containment dam wall potentiometric surface rather than groundwater. Both TD6D/S & TD7D/S are monitoring a similar aquifer given the similar responses & generally can not be regarded as nested bores, though show variation in salinity due to density settling in the bore water column.

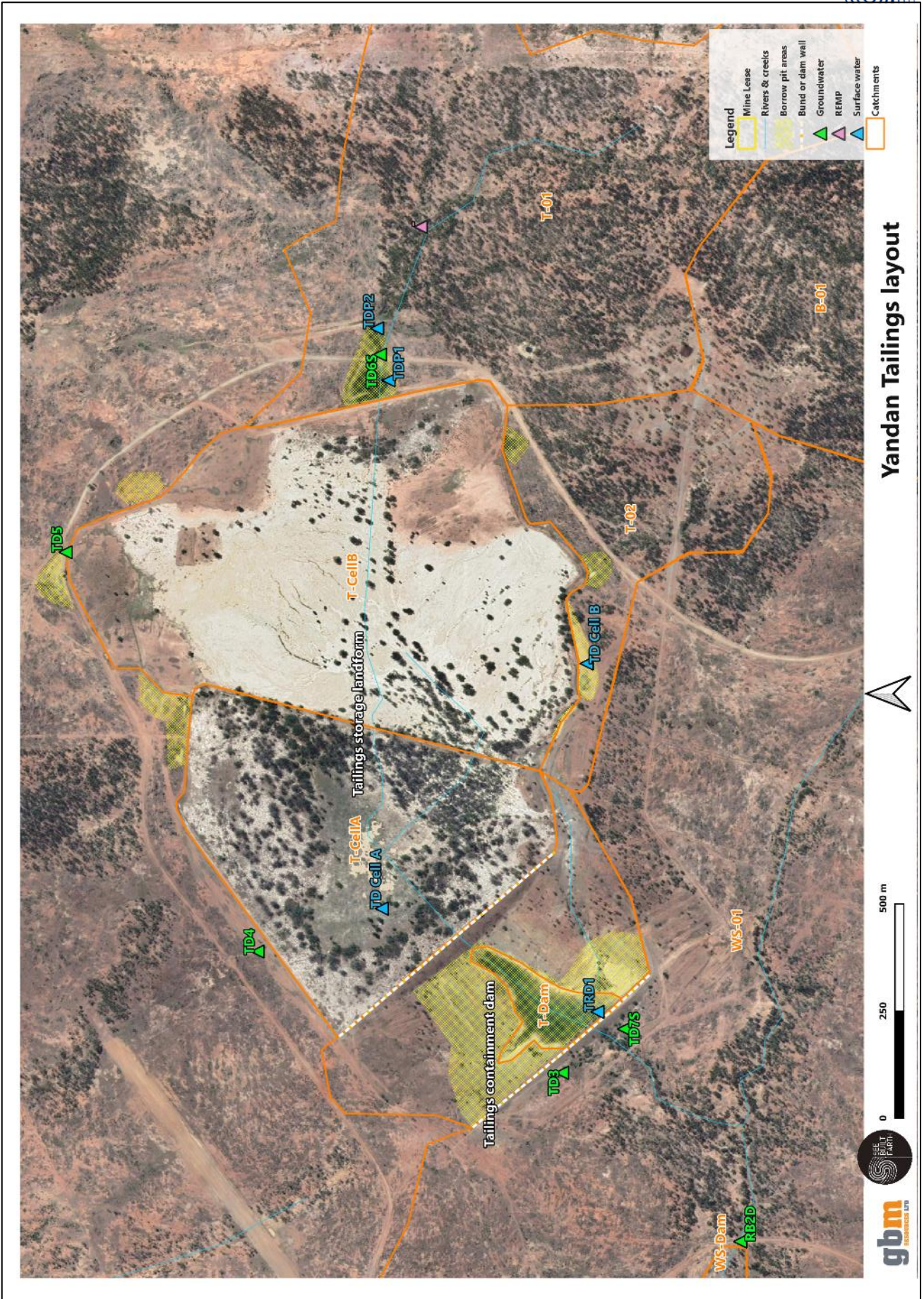


Figure 39 - Map of Tailings Storage domain



Figure 40 - View of low relief tailings landform at top of catchment



Figure 41 - View from downstream of facility looking at downstream embankment from containment dam



Figure 42 - Views of surface of Cell A (rehabilitated)



Figure 43 - Views of surface of Cell B tailings



Figure 44 - View of broad depression & ponding area on Cell A



Figure 45 - South borrow pit ponding against embankment (TD Cell B)



Figure 46 - North borrow pit ponding against embankment (TD5)



Figure 47 - Views of differential settling & internal erosion visible on the tailings surface

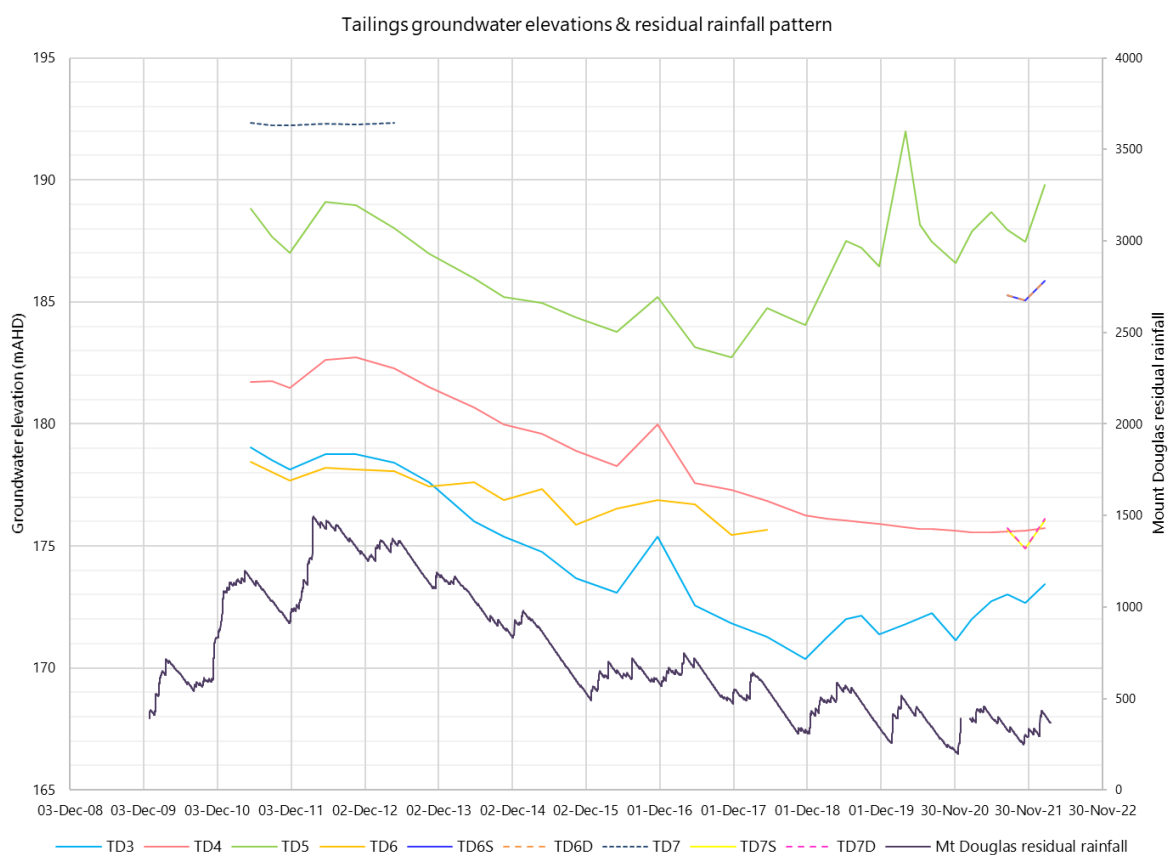
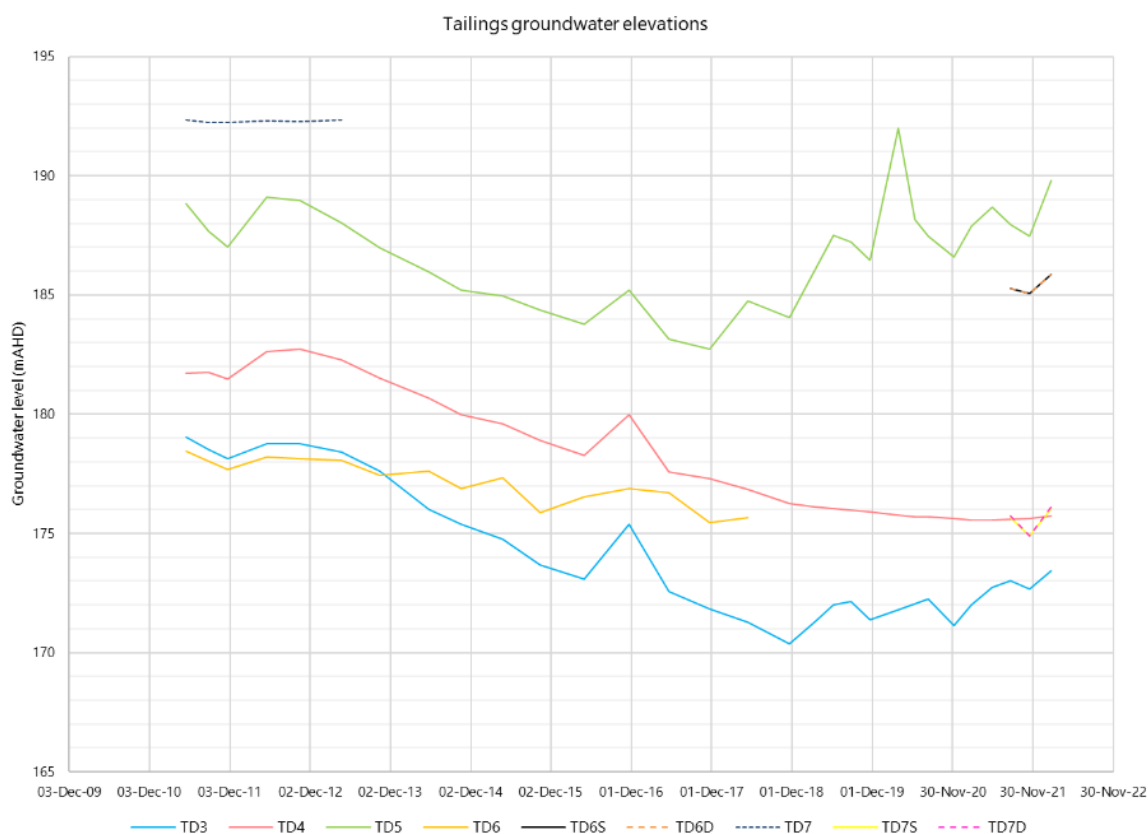


Figure 48 - Tailings groundwater elevations over time & with residual rainfall



4.2.3 Water quality & containment

Materials characterisation identified salinity, sulphate, mercury, arsenic, copper, zinc, manganese, chromium, antimony & cobalt as potential water quality threats associated with tailings materials. Review of monitoring records since 2011 across groundwater & surface water results for water quality, trends & likely drivers is provided below & summarised in Table 11, with charts in Figure 49, Figure 50 & Figure 51 to demonstrate key parameters & trends. Key observations include:

- Overall, pH is stable, though has increasing alkalinity in surface water after rainfall approaching pH 10 which is driven by rainfall.
- Groundwater has elevated salinity at northern wells: TD4 which is the closest to the ponding area on Cell A & adjacent to the facility itself, plus the eastern upgradient wells, & TD6S/D, though both wells are installed well below relative elevations of the tailings facility. Notably for salinity - both downstream wells show no sign of changed salinity down gradient, indicating containment is maintained. Salinity is less in both upstream & downstream dams.
- Sulphate is relatively stable in groundwater at <1,000mg/l, but is relatively higher for upstream groundwater by early indications (new wells). The tailings return dam periodically experiences peaks of higher sulphate in clear association with rainfall patterns. Most monitoring records as "dry" conditions show a much lower sulphate level, but following rainfall (with lag time), a peak reports. Whether this peak is via infiltration, or loss of dilution over the dry season is uncertain given 6-month sampling frequencies.
- In metals: mobility in groundwater is limited to arsenic at TD4 which is elevated & on an increasing trend. TD4 is closest to the ponding area of Cell A & situated directly next to the facility, & it is likely TD4 is monitoring water in direct contact with tailings. All other metals are generally not detected, with some gaps to address in monitoring parameters. In surface water, several metals appear to peak associated with rainfall (like sulphate) – including arsenic, cadmium (Figure 51), copper, nickel & zinc. Further work is needed to identify mechanisms.

4.2.4 Findings

- Tailings impacts are characterised by low-risk saline drainage, not acid rock processes (either pH or sulphate). Sulphate may be elevated; however levels have been stable for some time & likely indicates production of sulphate has reduced.
- Primary metals of interest (mobile) are arsenic, cadmium, copper, nickel, zinc (mobile at neutral to alkaline pH).
- Downgradient wells demonstrate containment of potential impacts is effective: in surface water, the tailings return dam (TRD) is capturing surface water runoff. Whilst there may be some quality concerns for perimeter monitoring wells, these impacts are likely to be limited by topography & geology & will require further investigation.
- The current form of the tailings facility captures & stores water on the facility, which maximises infiltration & percolation of water through stored tailings: a design & function which must be avoided.
- Groundwater wells on the perimeter are generally located in borrow pits & near the facility & are likely monitoring direct tailings water. Likewise, TD6S/D as upgradient wells are further away, but are at a much lower relative level & will be in a direct area of the potentiometric surface (Figure 52).



Table 11 - Summary of water quality trends for surface water & groundwater for tailings

Parameter	Groundwater	Surface storage
pH	Stable & within normal ranges	Varies with rainfall for both TRD1/3 (dam downgradient) & TDP (dam upgradient), approaching pH 10
Salinity (EC)	Elevated in TD4 to 25,000EC (north Cell A), TD5 (prior to breakdown) at 15,000EC (north Cell B), TD6S/D (upstream) at 35,000, & stable downgradient at 1,000EC at TD3 & TD7D/S well within background.	<5,000EC for all sites, TRD1 varies with rainfall, likely through dilution with freshwater.
Sulphate	All relatively stable at 1,000mg/l or less, except for TD6S/D (upgradient) at 1,400mg/l.	Peaks at TRD1 after rainfall, <5,000mg/l. Either dilution or pulse driven through rainfall. (not tested at TDP)
Arsenic	All stable to not detected except for TD4, which is on an increasing trend.	Peaks at <u>low levels</u> associated with rainfall or lack of rainfall.
Antimony	Not currently monitored	Not tested.
Cadmium	Not detected to around detection	Peaks associated with rainfall above compliance.
Chromium	Not detected to around detection	Single sampling event (not detected)
Cobalt	Not currently monitored	Not currently monitored.
Copper	Not detected to around detection	Peaks at <u>low levels</u> associated with rainfall.
Cyanide	Not detected	Not detected
Lead	Not detected to around detection	Not detected to around detection
Manganese	Single sampling event	Single sampling event
Mercury	Not detected	Not detected
Molybdenum	Not detected to around detection	Not currently monitored
Nickel	Single sampling event	Peaks at <u>low levels</u> associated with rainfall.
Selenium	Not detected to around detection	Not currently monitored.
Zinc	Not detected to around detection	Peaks at <u>low levels</u> associated with rainfall.

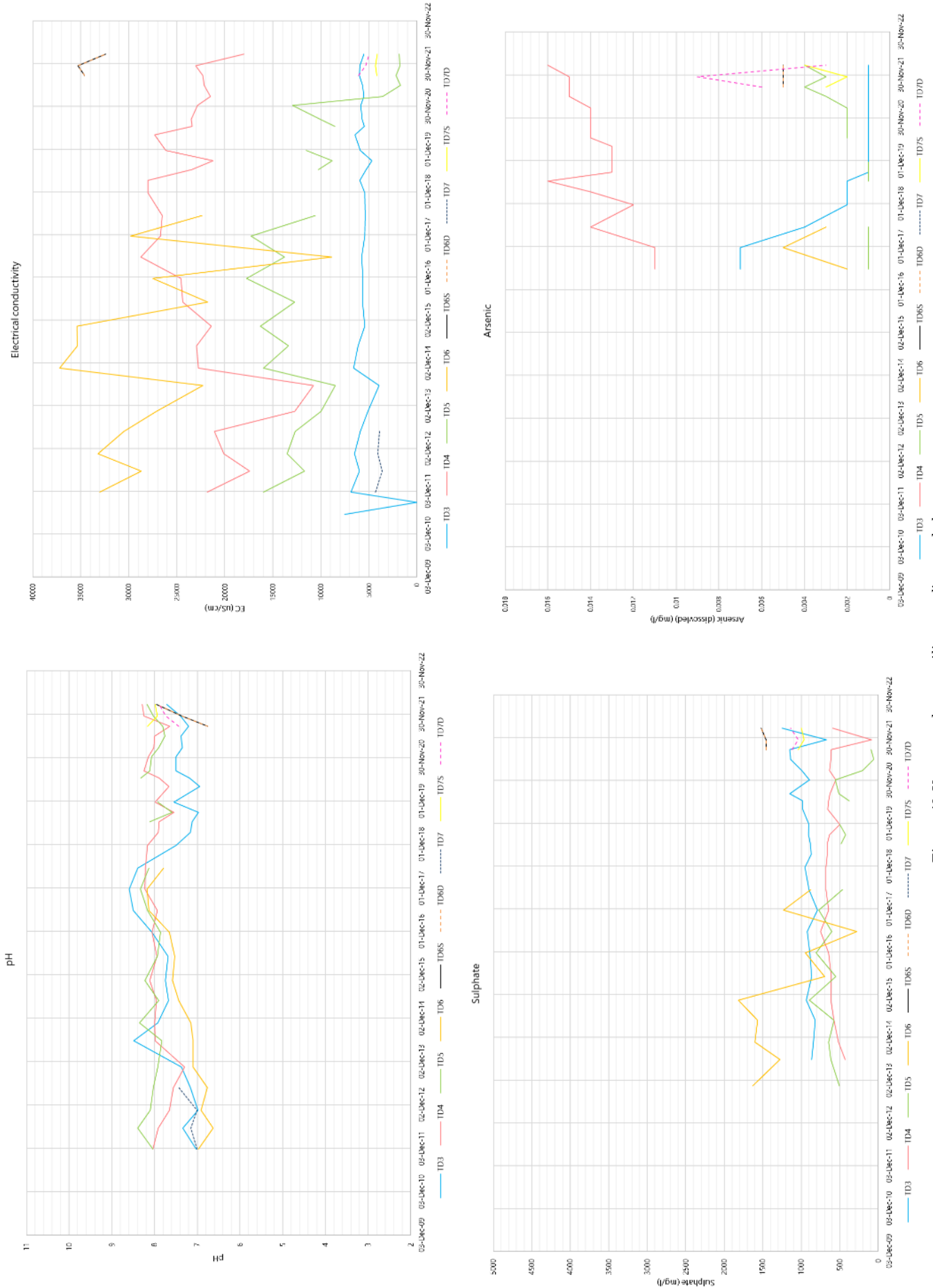


Figure 49-Key groundwater tailings quality trend charts

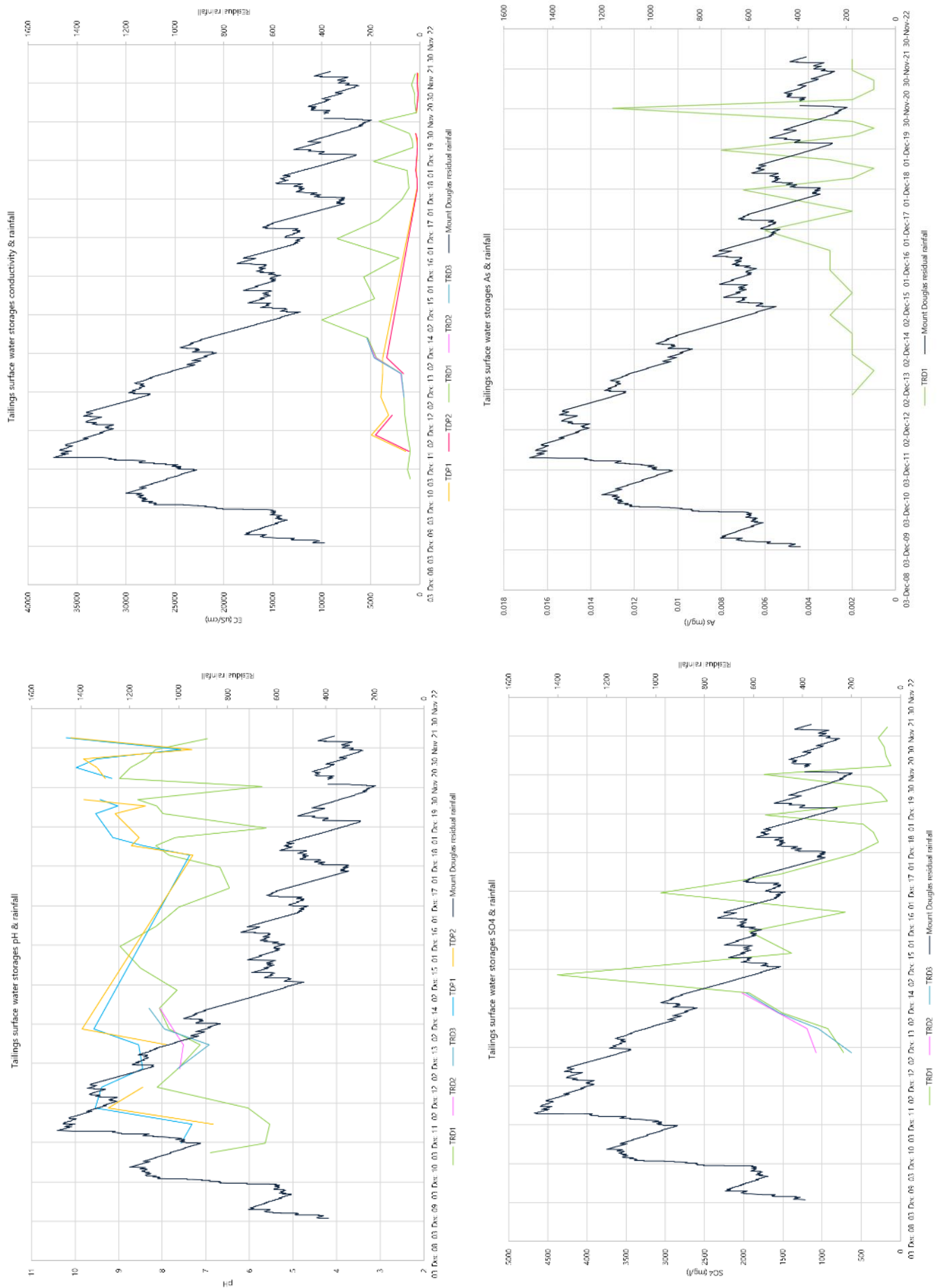


Figure 50-Key surface water tailings quality trend charts

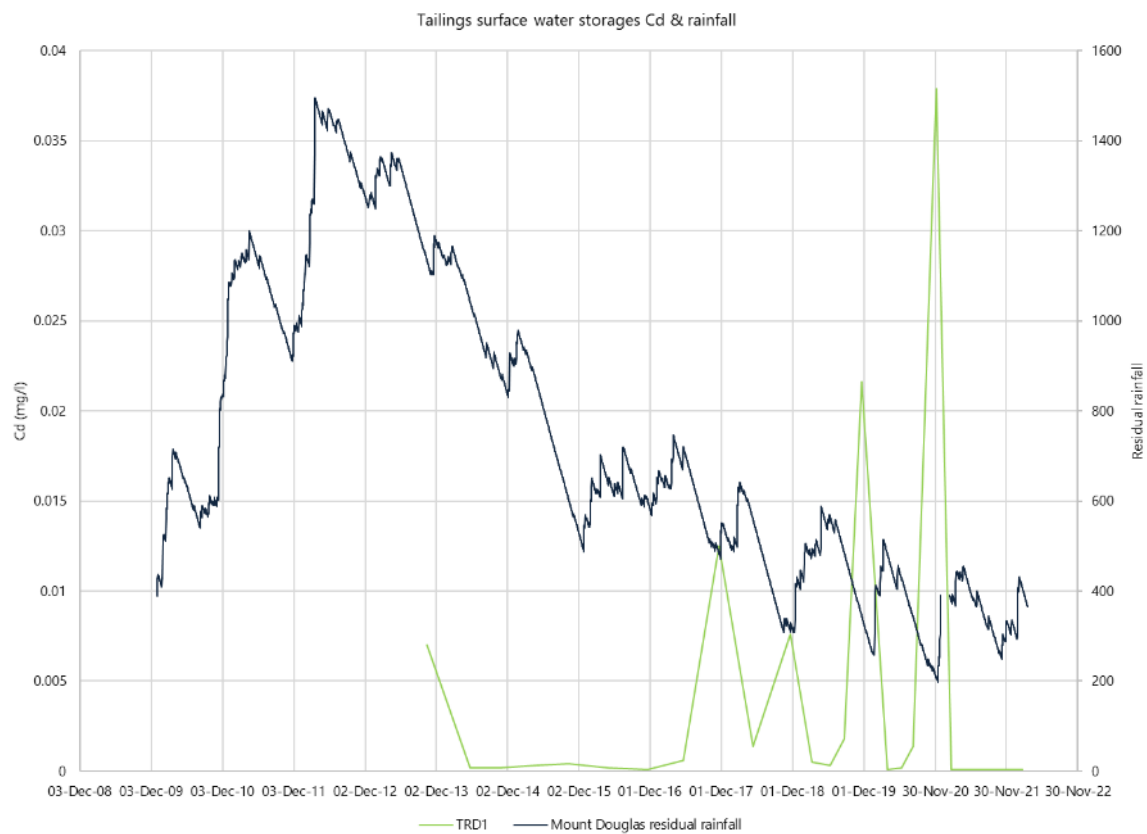


Figure 51 - Surface water cadmium peaks

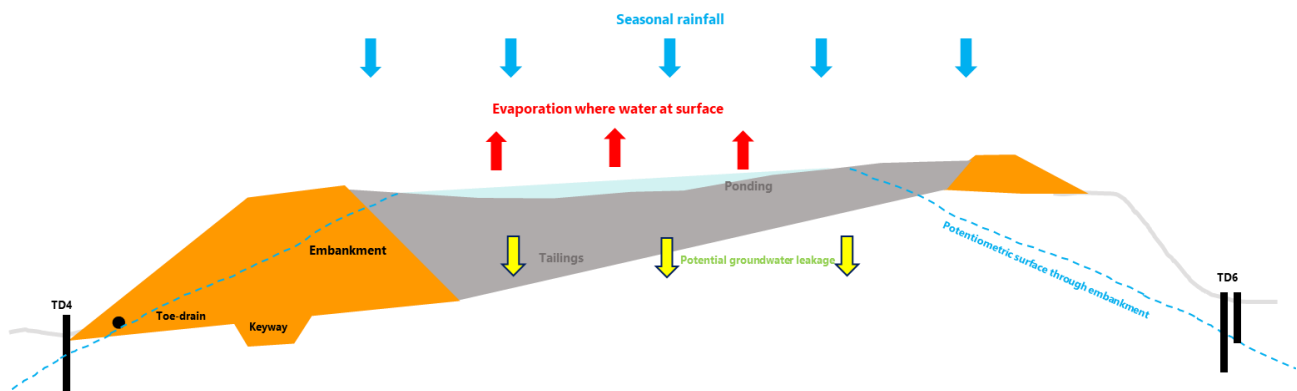


Figure 52 - Schematic of tailings & monitoring locations



4.3 Heap leach landform

4.3.1 Description & observations

The legacy Yandan heap leach is a 25m high, 17.4 hectare landform, constructed at the top of a small hill upgradient from Main pit (Figure 53 & Figure 54). Construction at the top of the hill & to the south side enabled the heap leach to remain above the 1% AEP flood levels & to direct water flow downgradient towards containment ponds. At 212mAHD, the top of the heap leach landform is the highest point across the site. During operation, the leaching process involved application of lime within the facility, & cyanide to liberate the fine gold. The process of leaching is based on infiltration through a landform: spraying a low cyanide concentration water across the leach pad, which percolates through the landform & is captured as a leachate for processing & gold recovery.

The heap leach drains from north to south, & consists of the constructed landform of low grade oxide rock, a perimeter capture drain (Figure 55), a remnant leach collection pond area, and stormwater capture dam (Figure 56). A bund wall lays further to the south as secondary protection from overland flow. Groundwater monitored by six (6) shallow monitoring wells around the perimeter & near to the leach ponds, plus a downgradient well, HL3. The site is likely to lay on geology of volcanics & siltstone.

Inspection of the heap leach landform & surrounding infrastructure indicated a broadly sound structure: degradation of the perimeter drain through sediment fill has occurred in multiple locations & would not function well as a containment drain. The lining of the leach pond is also ripped & would no longer be acting as containment (Figure 56). HL1 close to the embankment of the leach pond & is likely in connection with the water storage.

4.3.2 Water responses

Review of groundwater levels of the heap leach area indicates a broad trend of groundwater decline, consistent with draining of the landform since leaching operations stopped (Figure 57). The exception is HL4 on the southwest extent showing a rise: with no clear linkage to rainfall or water, this rise is unexplainable & may indicate a loss of well integrity. HL6 is also beginning to show signs of loss of integrity, as indicated by groundwater surface construction.

4.3.3 Water quality & containment

Materials classification identified heap leach as non-acid forming, but likely saline drainage, with potential to increase calcium, sulphate, chloride & sodium loading given the extent of lime addition through the heap leach. Metals of interest are arsenic, mercury, antimony, silver, lead & selenium.

Review of monitoring records since 2011 across groundwater & surface water results for water quality, trends & likely drivers is provided below & summarised in Table 11, with charts in Figure 58, to demonstrate key parameters & trends. Key observations include:

- Overall, pH is stable & within normal ranges.
- Groundwater has elevated salinity in HL1 & HL3 near to the leach pad pond & stormwater pond, which lifted around 2012/13 at a similar time to a strong reduction in rainfall, & has stayed higher since at around 15,000EC. Conductivity is also high in both surface water ponds at around 20,000EC.



- Sulphate in groundwater is generally <1,000mg/l, with the exception of HL1 adjacent to the leach pond, which is in decline since 2012 & currently around 2,500mg/l. Both ponds record sulphate levels of ~5,000mg/l, which has reduced to date & is currently stable.
- In metals: mobility in groundwater is limited to arsenic at HL6 on the north eastern extent which seems localised, but which is on a decreasing trend. Arsenic & selenium is also present at elevated levels at the leach pond but is currently stable suggesting the process has ceased.

4.3.4 Findings

- Heap leach impacts are characterised by low-risk saline drainage, not acid rock processes. Sulphate may be elevated; however levels are stable & likely indicates the rate of sulphate production has reduced.
- The landform is actively draining post operations & groundwater quality is likely to improve over time. The current form of the heap leach actively sheds water effectively, though sedimentation of the perimeter drains may not keep all surface runoff water within the heap leach catchment during periods of rainfall.
- Leakage from the leach ponds is likely contributing to elevated conductivity & sulphate in groundwater of HL1, with quality likely relating to remnant quality from within & around the ponds acquired during operation.
- Primary metals of interest (ie. mobile) are arsenic, & potentially copper & zinc.
- Downgradient well HL3 shows elevated salinity, but with limited other potential contaminants indicates lower risk of impact.

Table 12 - Summary of water quality trends for heap leach surface water & groundwater

Parameter	Groundwater	Surface storage
pH	Stable & within normal ranges	Stable & within normal ranges
Salinity (EC)	HL1 & HL3 at 15,000EC	Generally around 20,000EC
Sulphate	HL1 around 2,500mg/l, others <1,000mg/l	Generally around 5,000mg/l
Arsenic	Stable except for HL6	Leach ponds elevated.
Aluminium	Not detected to around detection	Not detected to around detection.
Cadmium	Not detected to around detection	Single sampling event.
Chromium	Single sampling event	Not currently monitored.
Cobalt	Not currently monitored	Not currently monitored.
Copper	Not detected to around detection	Not detected to around detection
Cyanide	Not detected	Not detected
Lead	Not detected to around detection	Not detected to around detection
Manganese	Single sampling event	Single sampling event
Mercury	Not detected	Not detected
Molybdenum	Not detected to around detection	Single sampling event
Nickel	Single sampling event	Not detected to around detection
Selenium	Not detected to around detection, varies.	Not currently monitored.
Zinc	Not detected to around detection	Not detected to around detection.

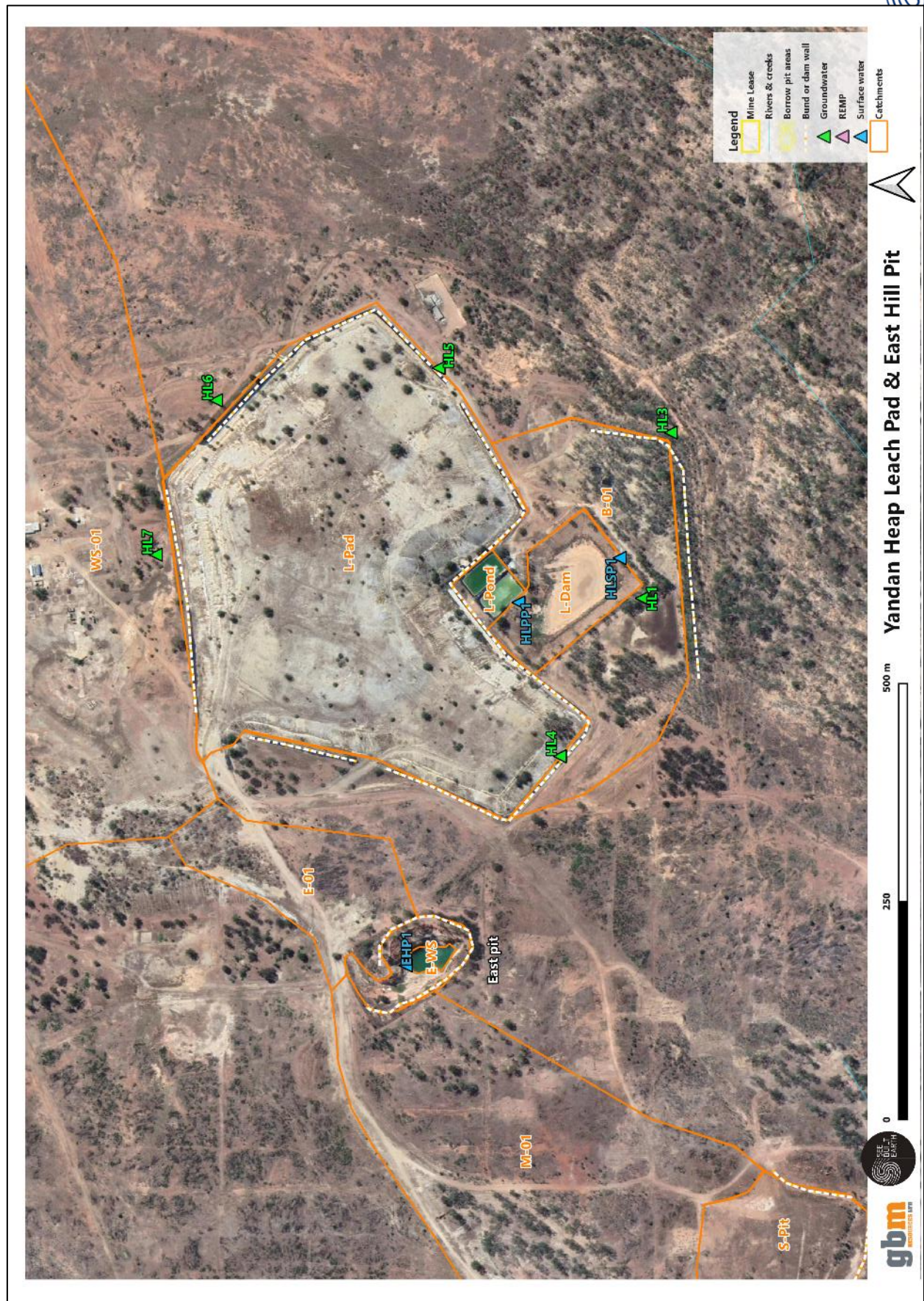


Figure 53 – Map of Heap Leach Landform



Figure 54 - View of heap leach pad (distance & nearby wall)



Figure 55 - Views of leach pad drainage with some erosion & minor wall slumping



Figure 56 - View of leach ponds & stormwater

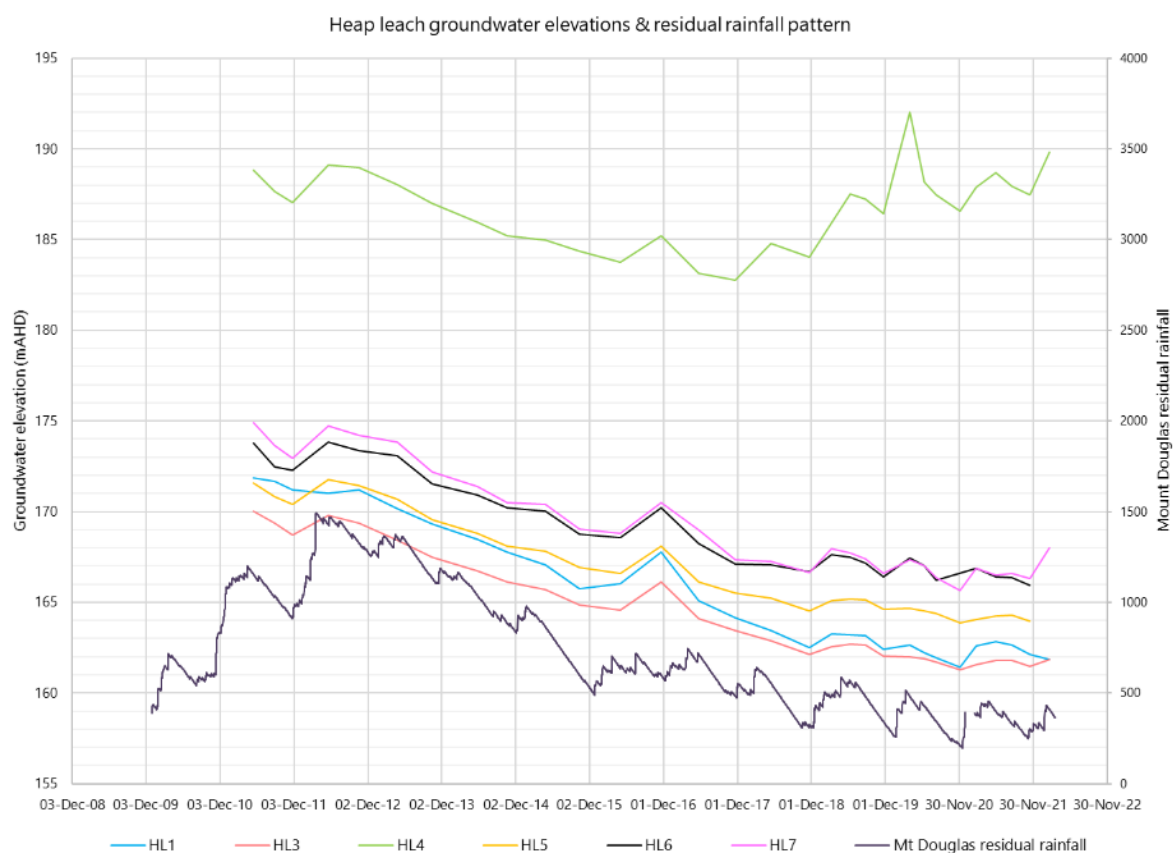
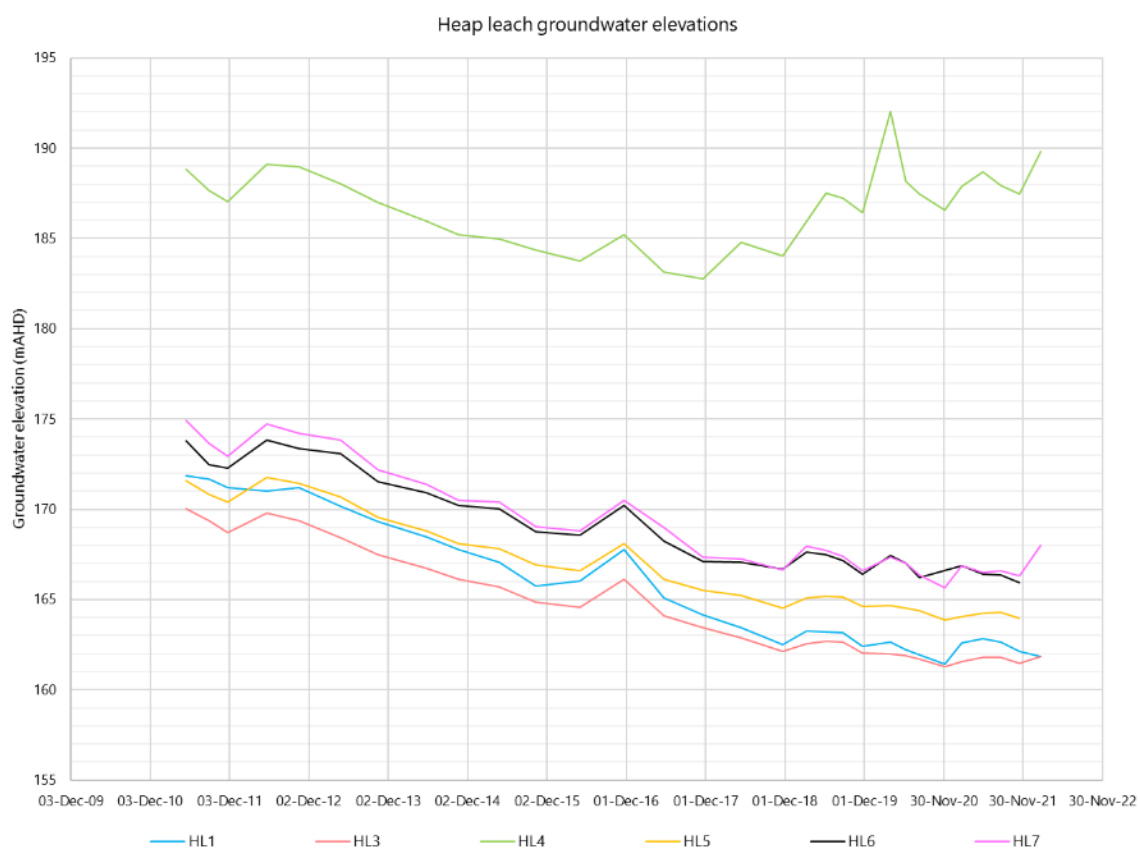


Figure 57 - Groundwater elevations of heap leach groundwater with residual rainfall

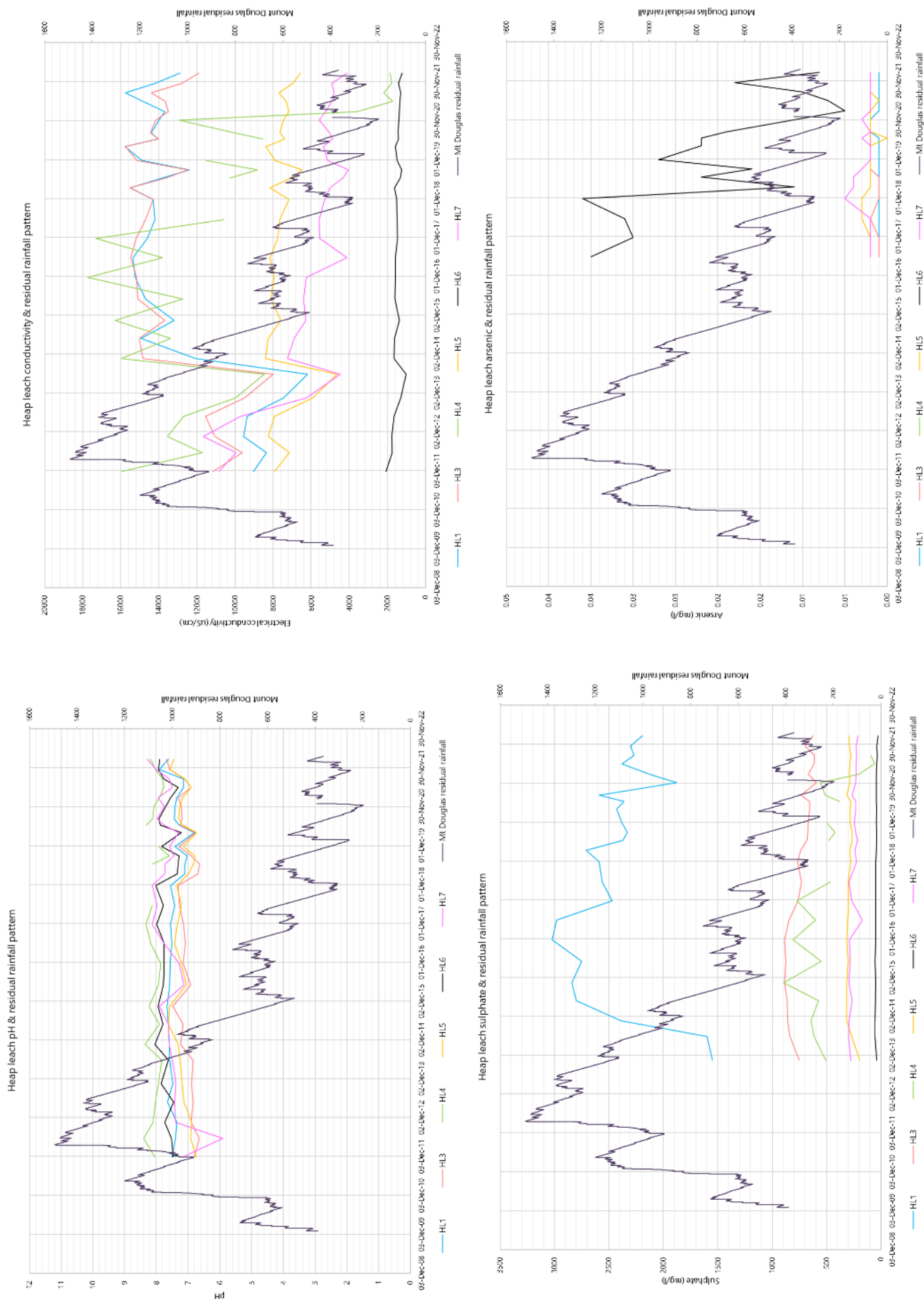


Figure 58 - Key water groundwater quality trends for heap leach

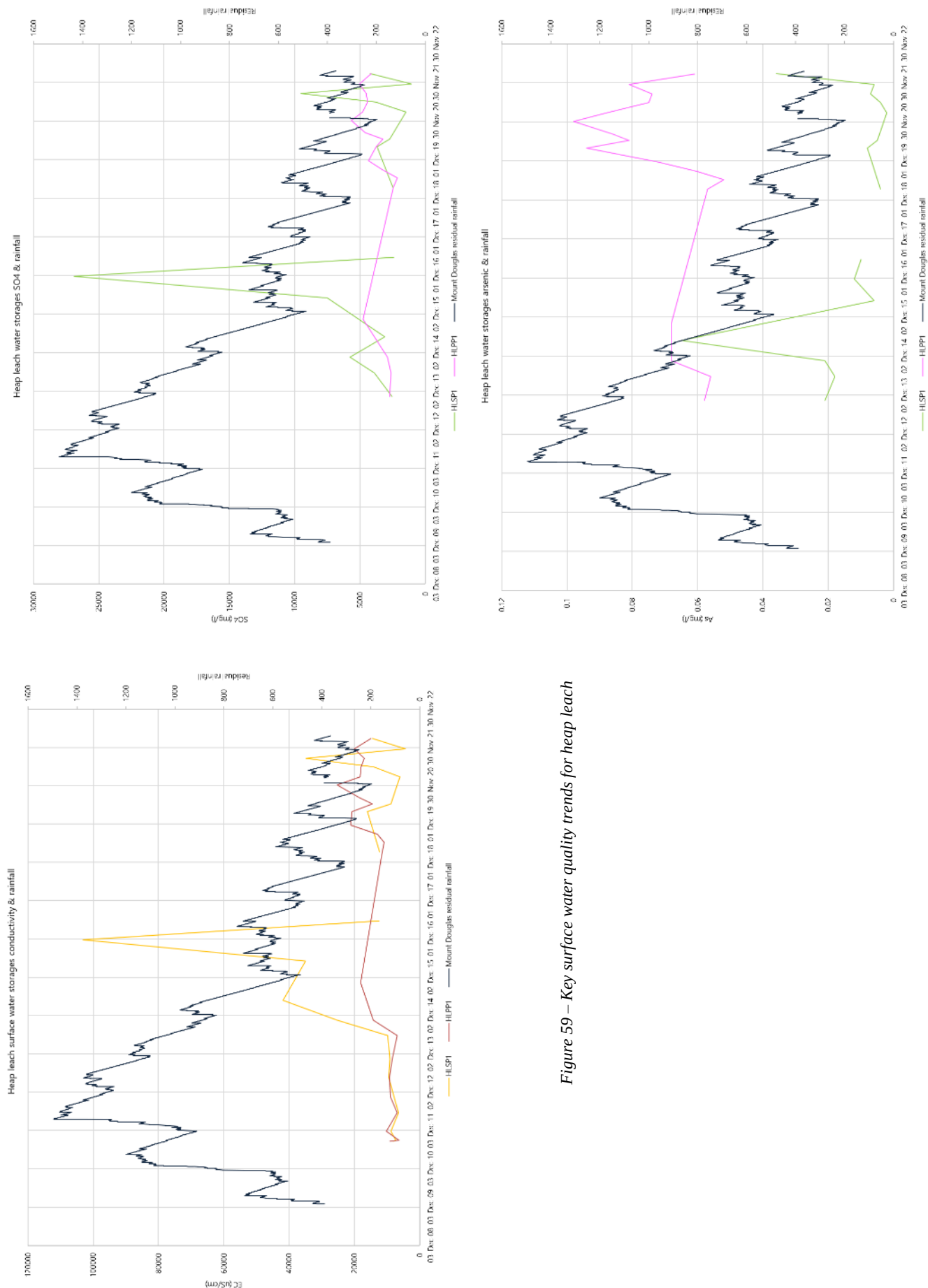


Figure 59 – Key surface water quality trends for heap leach



4.4 Main pit void

4.4.1 Description & observations

Main pit is a 22ha historical mine void formed during open pit mining which has operated since 1999 as a water cover legacy landform (Figure 60, Figure 61). To be successful, water cover requires water levels to always remain above 160mAHD to cover waste rock placed into the pit base at closure to avoid oxygen exposure & potential acid rock drainage. At full capacity, the pit is estimated to hold up to 6.8 gigalitres of water based on historical mine shells. Based on historical studies of dewatering (Forbes 1988), there is strong potential for groundwater connection to Main Pit with an estimated demand of 5,000m³/d to maintain dry operations within the pit. It not clear if this is sourced from a fault or from a porous boiling zone unit. Notably the pit is defined as being hydraulically separate to the alluvial aquifer of the Suttor River.

The pit is located close to the Suttor river & lays within the flood plain: when river levels or pit water level reach 169mAHD, the pit & river connect & flow in/out via excavated spillways (Figure 62) on the north west & the south east of the pit (@ 169mAHD). Design of the pit void & spillways was extensively developed throughout 1999-2000 for hydraulic design, positioning/height of the spillways & achieving water cover: R&D Environmental 1999; Chapman & Dwyer 1999; SRK Consulting 1999a; SRK Consulting 1999b & HLA EnviroSciences 2001. There are two ways for water to enter the pit (via surface flow): from the Suttor River when at level >169mAHD, or from Yandan Creek (south) where the borrow pit constructed to the south fills & flows to the pit.

To manage water levels within the pit & limit interactions unless in appropriate flood for flow mixing, there are two primary bunds around pit:

- Along the northern catchment of the pit (a relatively clean catchment): to divert flow around the pit & to the Suttor River without interaction with pit waters. This is required to ensure water levels do not increase dramatically due to flow from the catchment without ensuring flow in the Suttor River to enable mixing & protect receiving environment health through water quality.
- Along the western extent (between the pit & the Suttor River) to hold a short head of water within the pit & manage flow by the constructed spillways.

Catchments that directly report include the pit itself & drainage area shown in Figure 60.

On inspection, the pit lake & surrounding infrastructure appeared stable with robust design (including spillways) with some maintenance required on the western bund. Further information on the pit void is developed in the void water balance section.

4.4.2 Water responses

As part of regular water quality monitoring of the Main Pit, a water level by depth is recorded by sampling teams. Review of the water levels recorded shows reads likely lack precision (Figure 63): with different reads & responses between MP1 & MP2 of the same elevation surface, & limited indication of rainfall response. This reduces the confidence of these recorded pit water levels to indicative only.



4.4.3 Water quality & receiving environment

Water quality of Main Pit (including at depth) has been monitored since 2011 & is neutral pH (Figure 65), consistent temperature (Figure 66), low salinity (<350EC uS/cm, Figure 67), and low sulphate(<100mg/l). As a water body, it is lower in dissolved oxygen than for a healthy lake environment (Figure 68), & like other parts of the site, elevated arsenic occurs (Figure 69) with trace copper & zinc (though at trace levels).

Minimal mixing will be required with site or river water to meet receiving environment requirements: releases have been monitored in two spill events of 2011 & 2017 with samples taken at release points & SR1 downstream, with results fully compliant & no impact to environment health (Figure 64). A summary of water quality within the pit & receiving environment is provided in Table 13.

4.4.4 Findings

- The water cover of Main Pit is successful to design in managing risk of materials exposure & maintaining a pit lake which is relatively self-sustaining, consistent water quality & stable.
- Water quality is stable over time & at depth, with no observable signs of ARD or water quality issues, except for elevated arsenic & lower rates of dissolved oxygen than required to sustain healthy plant life. The pit is contained except for times of higher water flow in the Suttor River (>500m³/s) with more than adequate levels of mixing to achieve water quality objectives.
- The water profile shows water mixing is excellent throughout the water column with no thermocline or zoning – quality is consistent at depth & across the lake. Times of inflow from Suttor River increase dissolved oxygen throughout the pit lake.
- Average recurrence interval of hydraulic connection between pit & Suttor River/Yandan Creek is 5-15 years, or an average of 10 years as a natural refresh of water & part of the flood plain activity: receiving water quality is stable & meets water health objectives.
- Groundwater inflow into the pit lake is likely: historical records suggest strong groundwater inflow (separate to alluvial aquifers) & water level appears to be relatively constant.

Table 13 - Summary of water quality trends of Main Pit in-pit water & receiving environment

Parameter	Pit water	Receiving environment
pH	Stable & average	Stable & within normal ranges
Temperature	Stable & average	
Sulphate	<100mg/l	<50mg/l
Electrical conductivity (EC)	<350 uS/cm	1300 & <200 uS/cm
Dissolved oxygen (DO)	10mg/l	N/A
Arsenic	Elevated <0.07mg/l	Around detection limits to not detected.
Cadmium	Not detected to around detection	Around detection limits to not detected.
Copper	Elevated to trace levels at times	Around detection limits to not detected.
Lead	Not detected to around detection	Not detected.
Mercury	Not detected	Not detected
Molybdenum	Not detected to around detection	Not detected.
Selenium	Not detected to around detection	Not detected.



Zinc

Elevated to trace levels at times

Around detection limits to not detected.

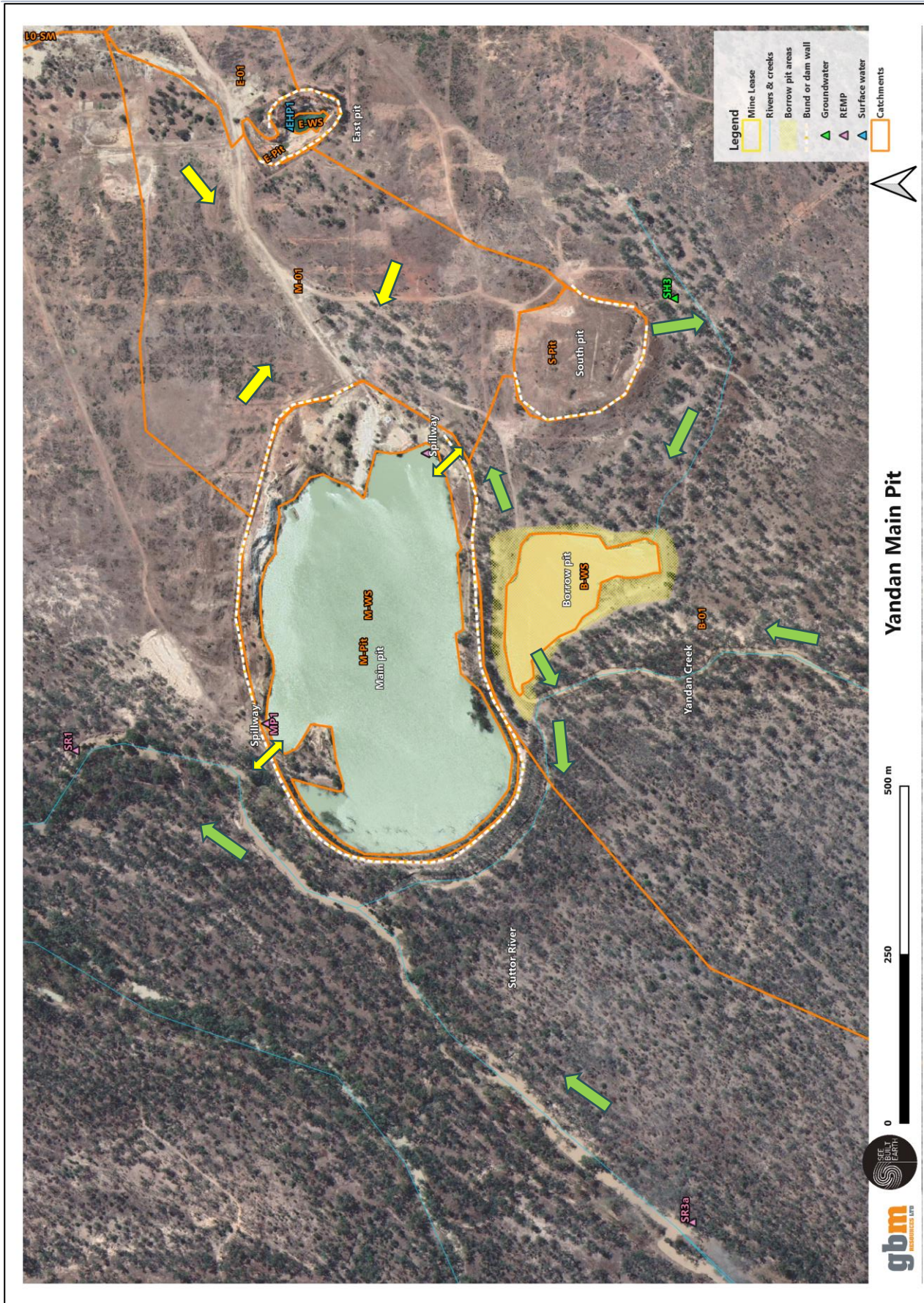


Figure 60 – Map of Main Pit Landform



Figure 61 - Views of Main Pit



Figure 62 - Views of spillways at south east & north west ends of Main pit



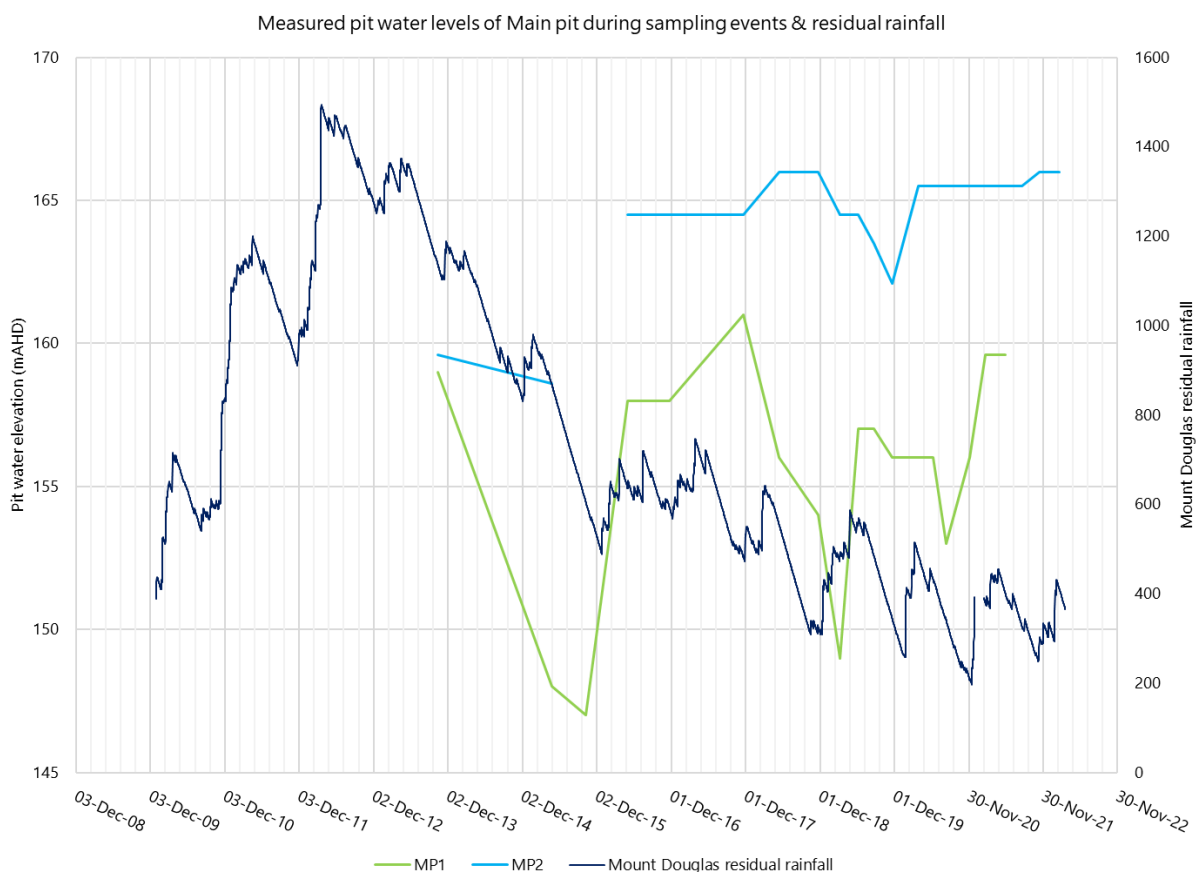


Figure 63 - Pit water level elevations as measured during sampling events (wide range of error)

Yandan Gold Mine Discharge Monitoring Database		Parameter			Total Metals										Dissolved Metals									
			pH	EC	Sulphate	Arsenic	Cadmium	Copper	Lead	Mercury	Molybdenum	Selenium	Zinc	Aluminium	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	Nickel	Zinc	Hardness	
		Unit	pH Units	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	
EA LIMITS		Release Limits (If Limit is exceeded, check against 95th Percentile of Reference Data):	6-9	1000	1000	0.5	0.01	0.5	0.1	0.002	0.05	0.02	20											
		Trigger Levels (If Trigger is exceeded, check against 80th Percentile of Reference Data):	6-7.5	250	0										55	13	0.2	1.4	3.4	0.6	11	11	8	N/A
Sample No.	Sample Date	Site ID.																						
EB1707881	10-04-17	MP1	7.38	113	7	0.008	<0.0001	0.003	0.004	<0.0001	<0.001	<0.01	0.01	not taken										
EB1707881	10-04-17	MP2	7.39	151	10	0.028	<0.0001	0.003	0.003	<0.0001	<0.001	<0.01	0.008	not taken										

Release Monitoring Points (Compliance Points & Reference Points)			Total Metals										Dissolved Metals									
Parameter			pH	EC	Sulphate	Hardness	Aluminium	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	Nickel	Zinc							
Unit			pH Units	µs/cm	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L							
EA Limits			6 - 7.5																			
EA Release Contaminant Trigger Levels			(or 20th percentile of reference of 6.0, whichever is lower. 80th percentile of reference or 7.5, whichever is higher)																			
				250 (or 80th percentile of reference or 250, whichever is higher)																		
					80th percentile or reference	NA	55	13	0.2	1.4	3.4	0.6	11	11	8							
Sample Date	Sample Time	EA Monitoring Point																				
	18-May-11	SR1	8.32	1330																		
EB1117232003	23-Aug-11	SR1	8.05	1620																		
EB1707881	10-Apr-17	SR1	7.37	152																		
	10-Apr-17	SR3a	7.36	152																		

Dissolved Metals									
Aluminium	Arsenic	Cadmium	Copper	Lead	Mercury	Selenium	Nickel	Zinc	
µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	
55	13	0.2	1.4	3.4	0.6	11	11	8	
(or 80th percentile of reference or 55, whichever is higher)	(or 80th percentile of reference or 13, whichever is higher)	(or 80th percentile of reference or 0.2, whichever is higher)	(or 80th percentile of reference or 1.4, whichever is higher)	(or 80th percentile of reference or 3.4, whichever is higher)	(or 80th percentile of reference or 0.6, whichever is higher)	(or 80th percentile of reference or 11, whichever is higher)	(or 80th percentile of reference or 11, whichever is higher)	(or 80th percentile of reference or 8, whichever is higher)	
980	2	<0.1	4	1	<0.1	<10	3	38	
950			4					55	

Figure 64 - Release point & receiving environment sampling from 2011 & 2017 release events

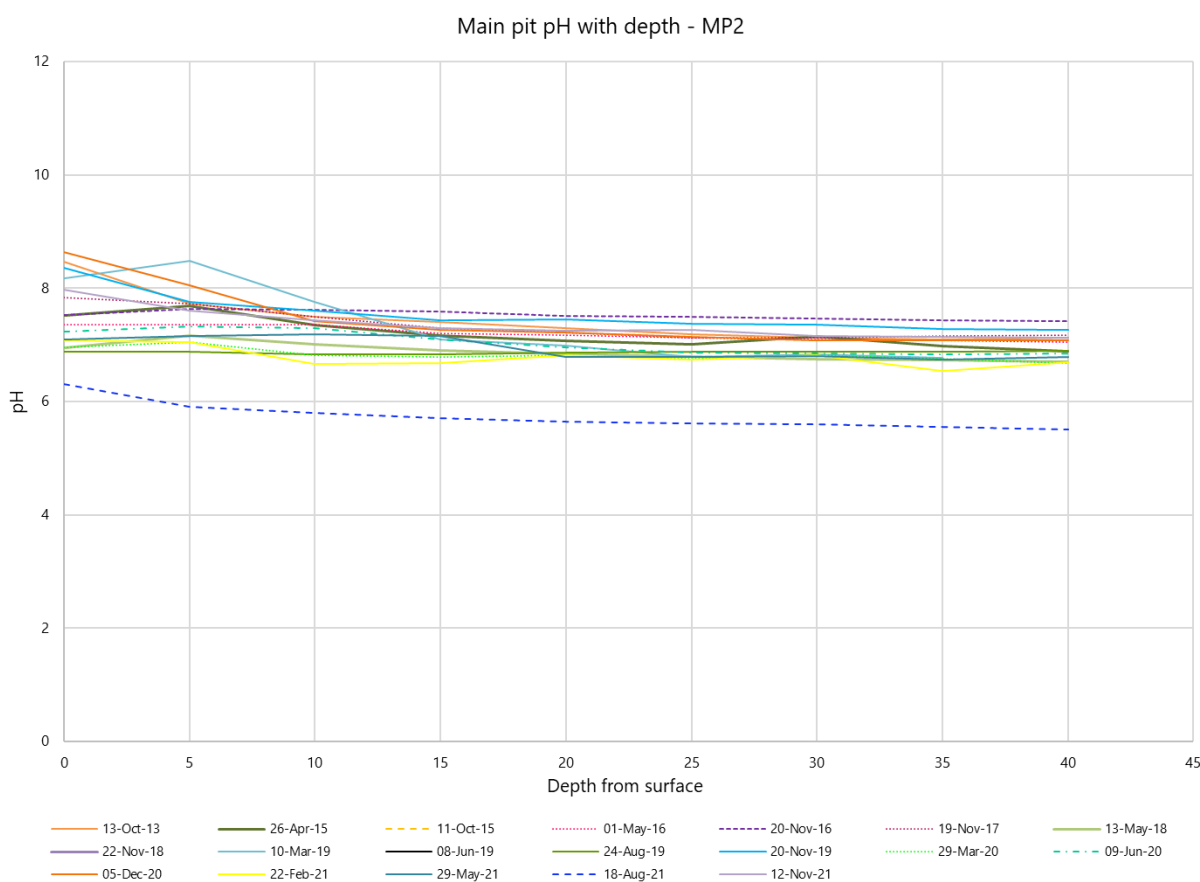
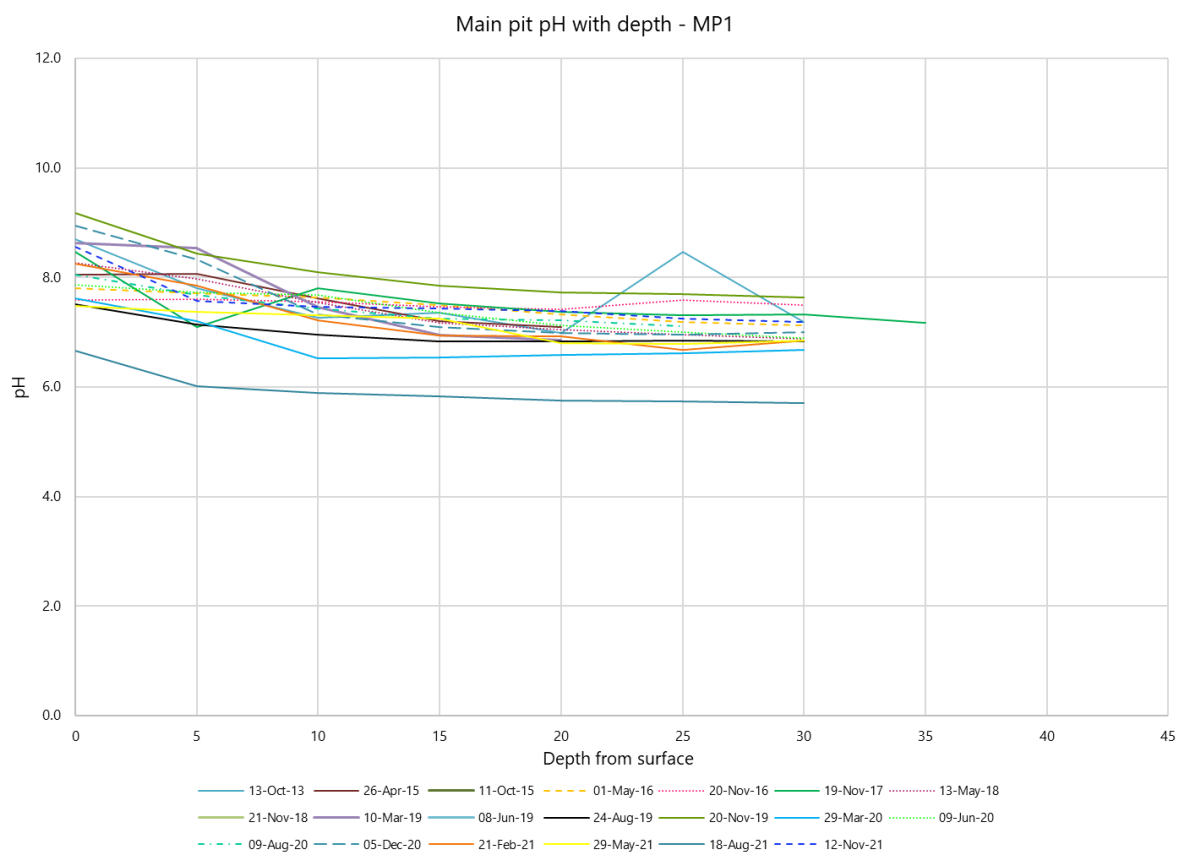
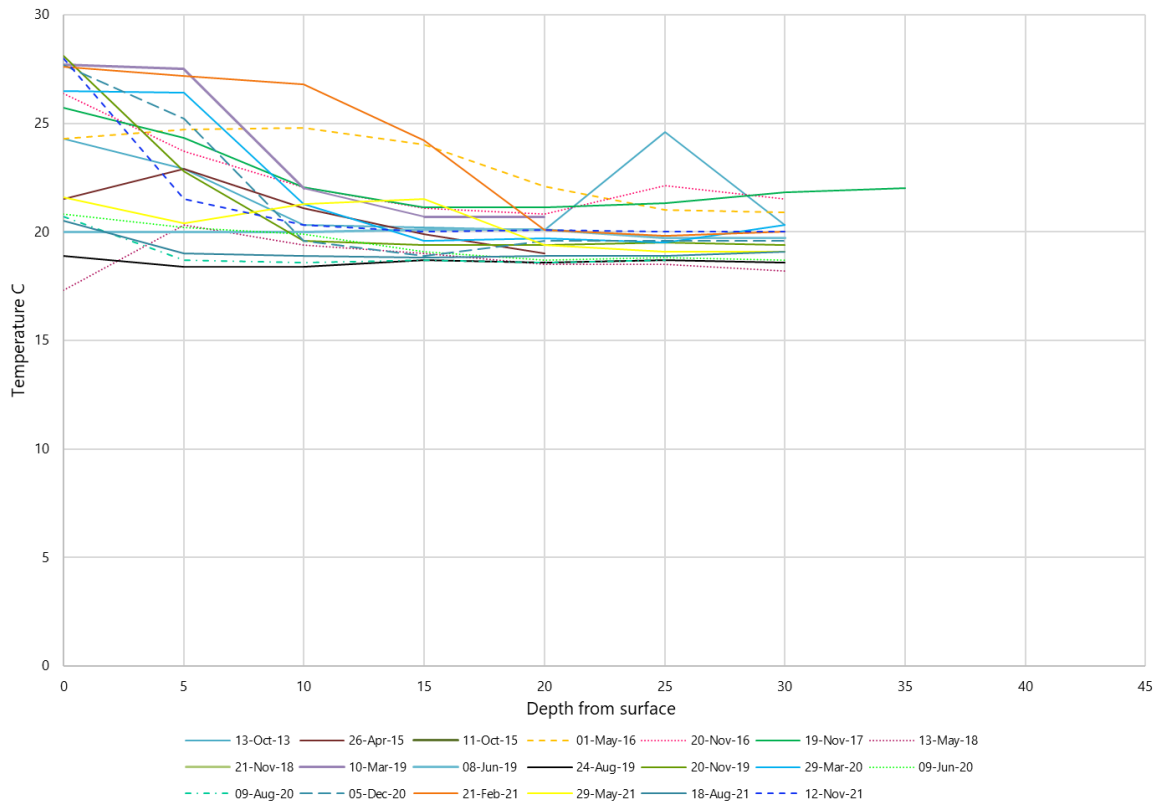


Figure 65 - pH at depth within Main pit



Main pit temperature with depth - MP1



Main pit temperature with depth - MP2

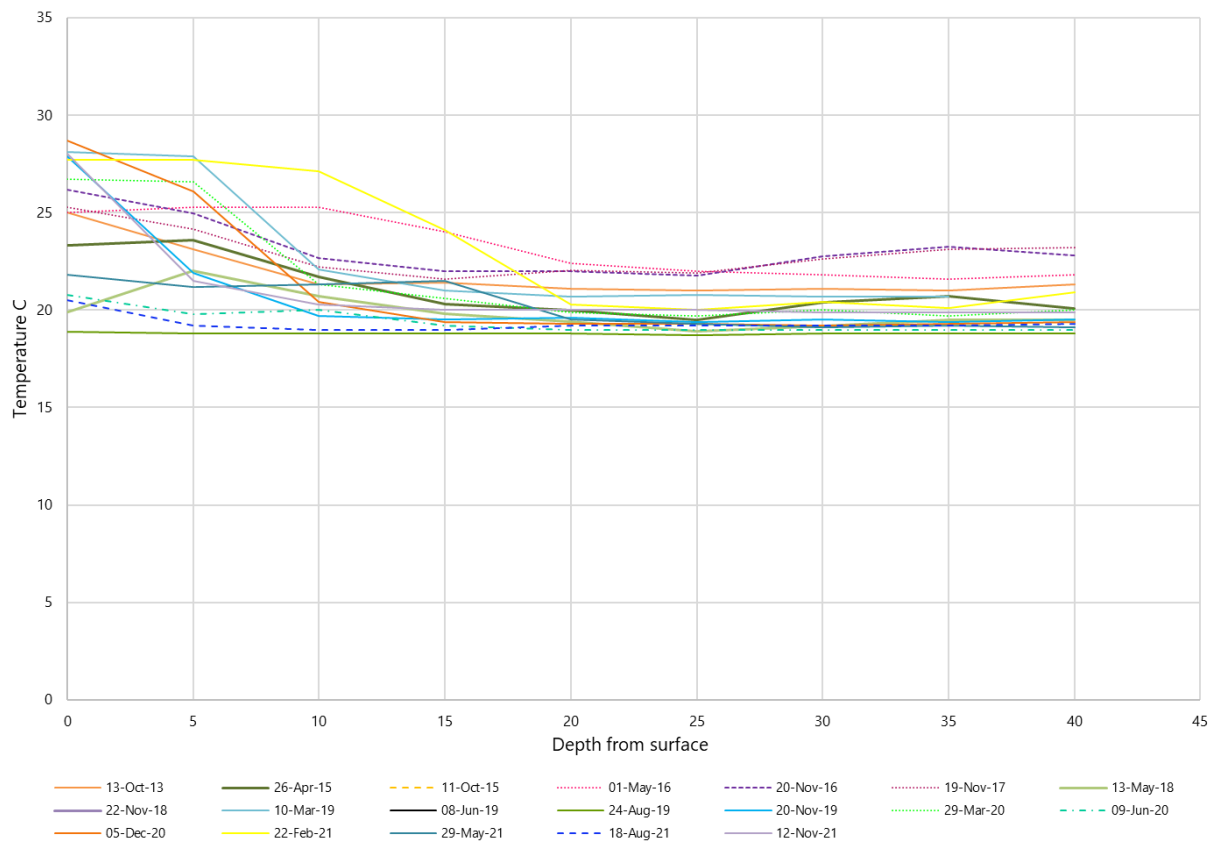
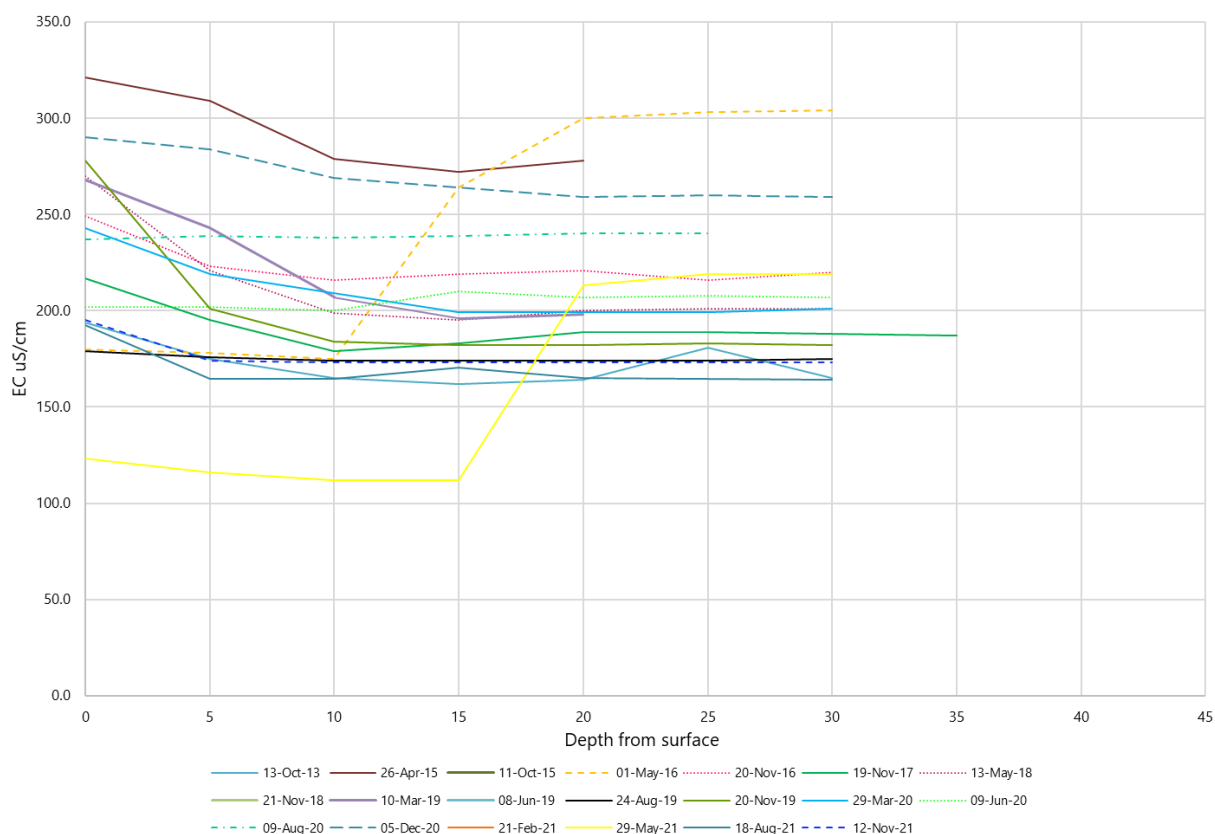


Figure 66 - Temperature at depth within main pit



Main pit conductivity with depth - MP1



Main pit conductivity with depth - MP2

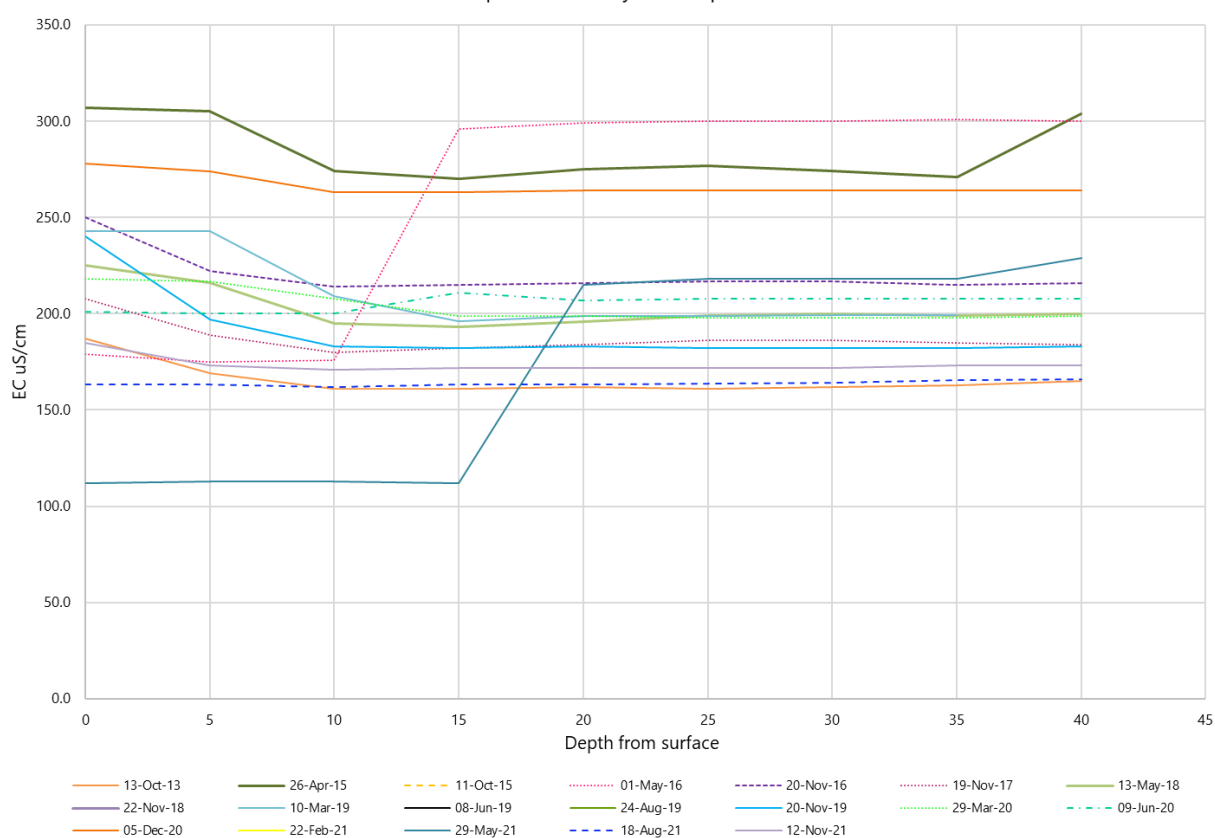


Figure 67 - Electrical conductivity at depth within Main pit

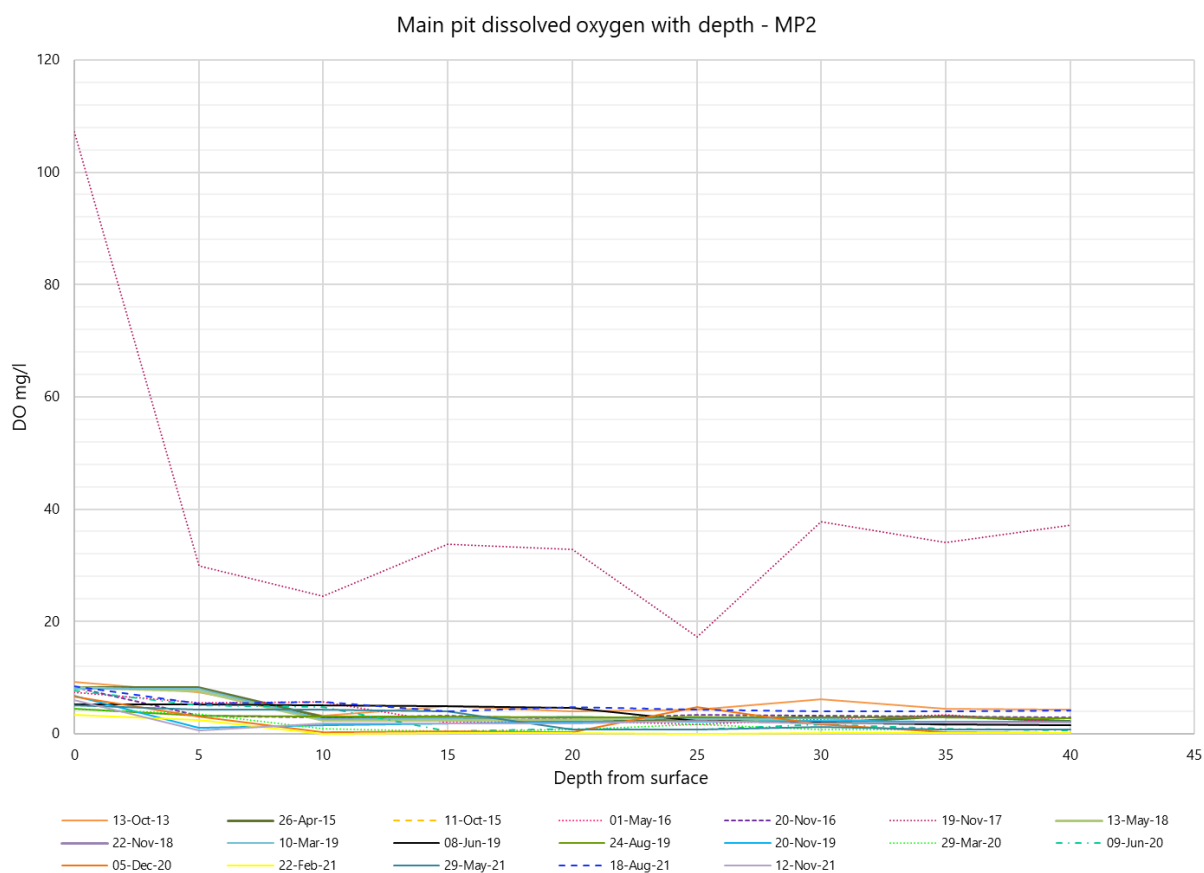
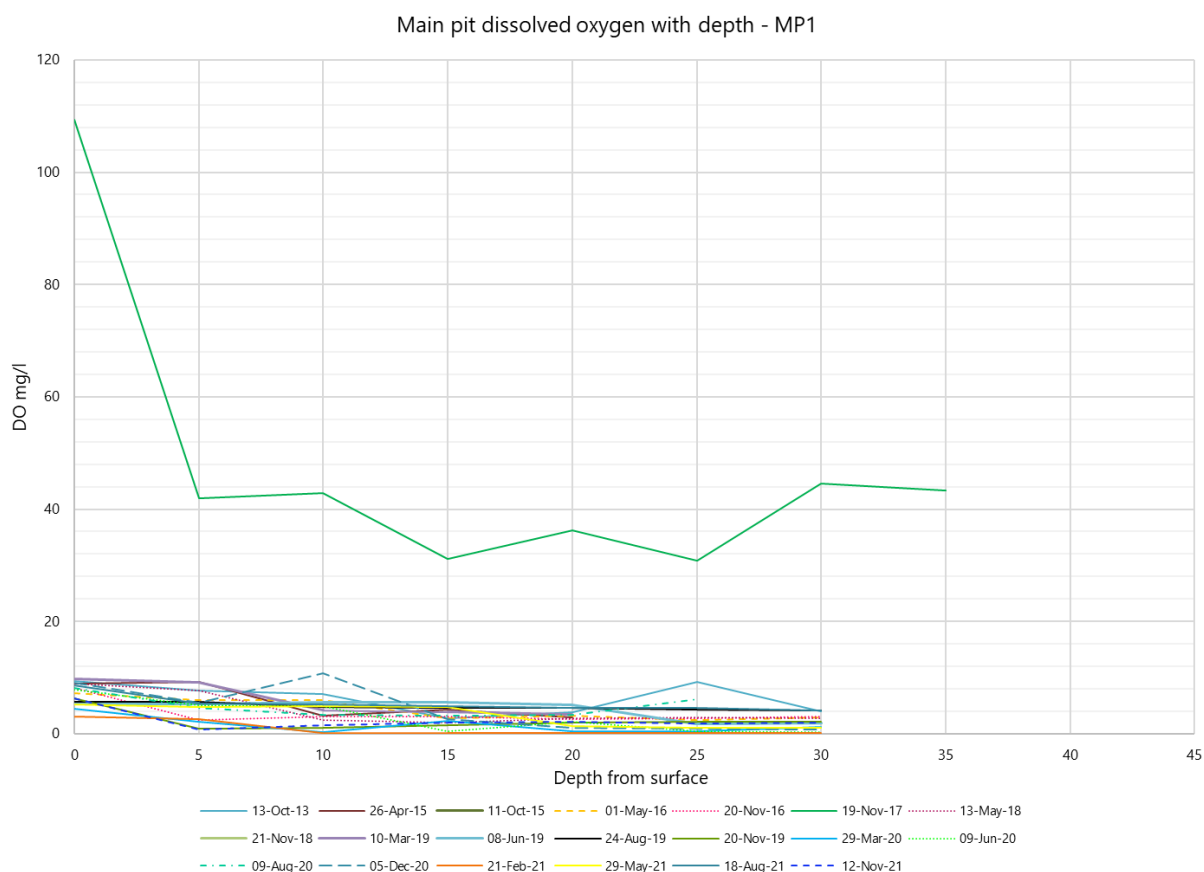


Figure 68 - Dissolved oxygen at depth within Main Pit

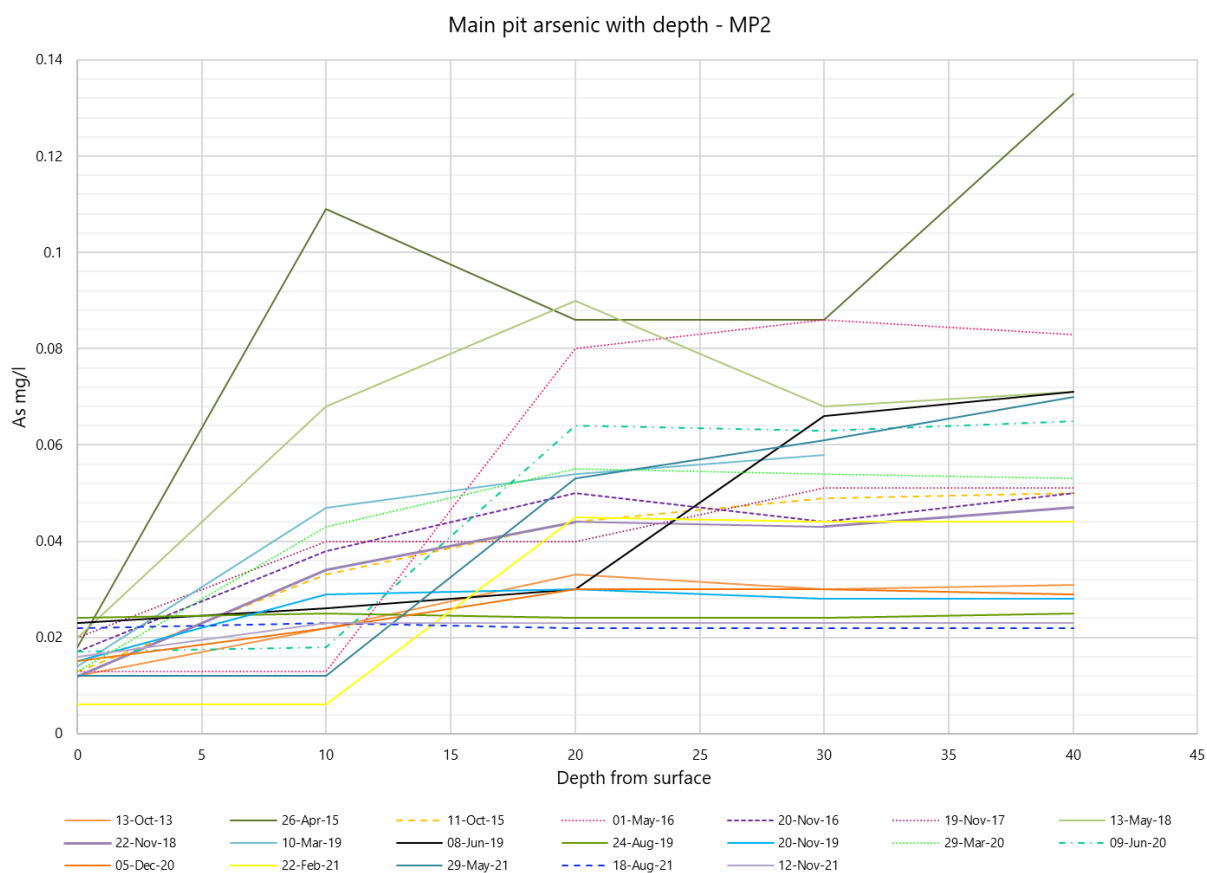
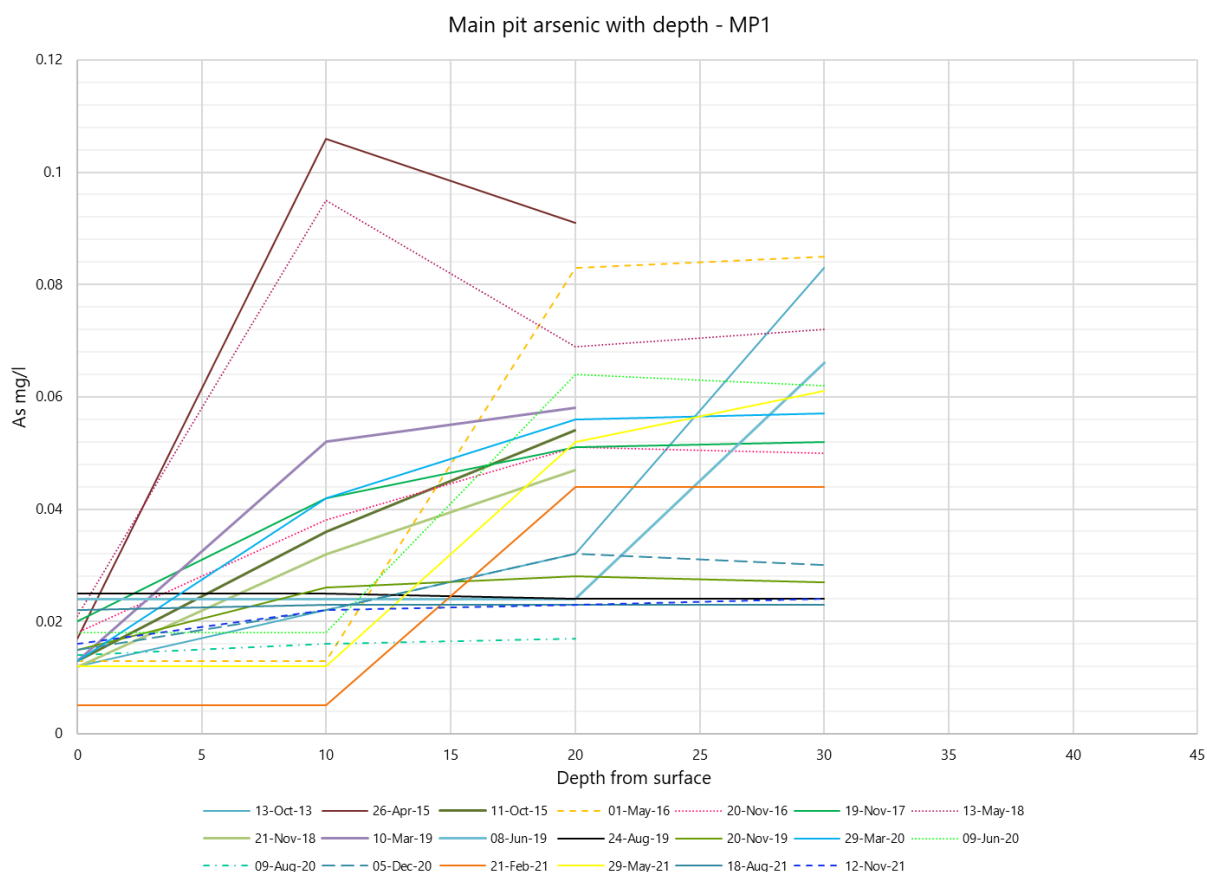


Figure 69 – Arsenic at depth within Main Pit



4.5 East pit void

4.5.1 Description & observations

East Hill pit is a small, limited surface footprint pit of only 0.9 hectares area, 60m width & a limited catchment from part of a road (Figure 70) between the Heap Leach Pad & Main pit. The pit has limited access, with 20m of exposed pit walls above a pit lake.

4.5.2 Water responses

No water level measurements are available for East Hill Pit lake, however water remains at low levels within the pit. Relative water levels plot above site groundwater levels (168mAHD versus 163mAHD) which suggest hydraulic separate from site groundwater or different aquifers. Water balance assessments (Section 5) also suggest there is no groundwater contribution, though there is potential for connection to the Main pit lake through faulting.

4.5.3 Water quality & containment

East Hill Pit has hosted acidic water of around pH 4 since 2011 & is stable (Figure 71). Over that time, electrical conductivity & sulphate have increased & now sit around 20,000 uS/cm & 5,000 mg/l respectively. Materials characterisation metals expected to be mobile are mobile at East Hill pit: with elevated arsenic, copper, nickel & zinc. No mercury or cyanide is detected.

4.5.4 Findings

East Hill pit is a low-lying pit lake, with reactive materials & acidic water quality with increasing salts & metals. The pit appears contained at low levels & is unlikely to be connected to groundwater unless through faulting to the Main Pit.

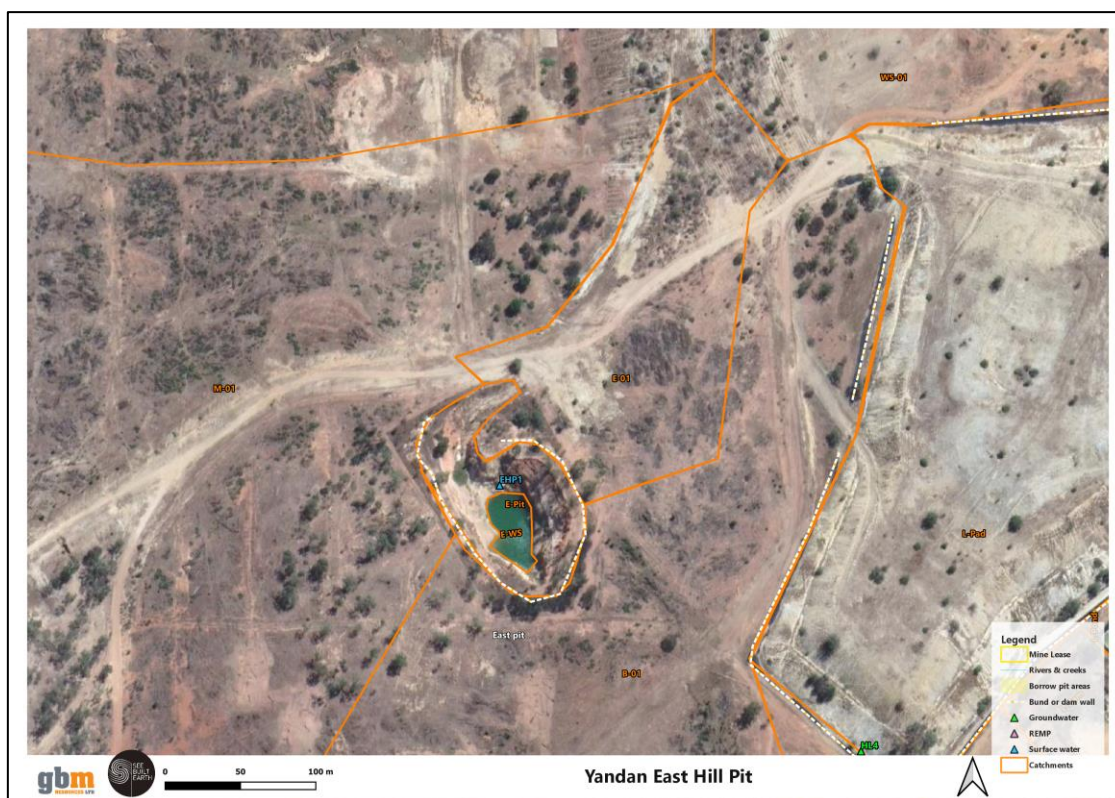


Figure 70 - Map of East Hill Pit

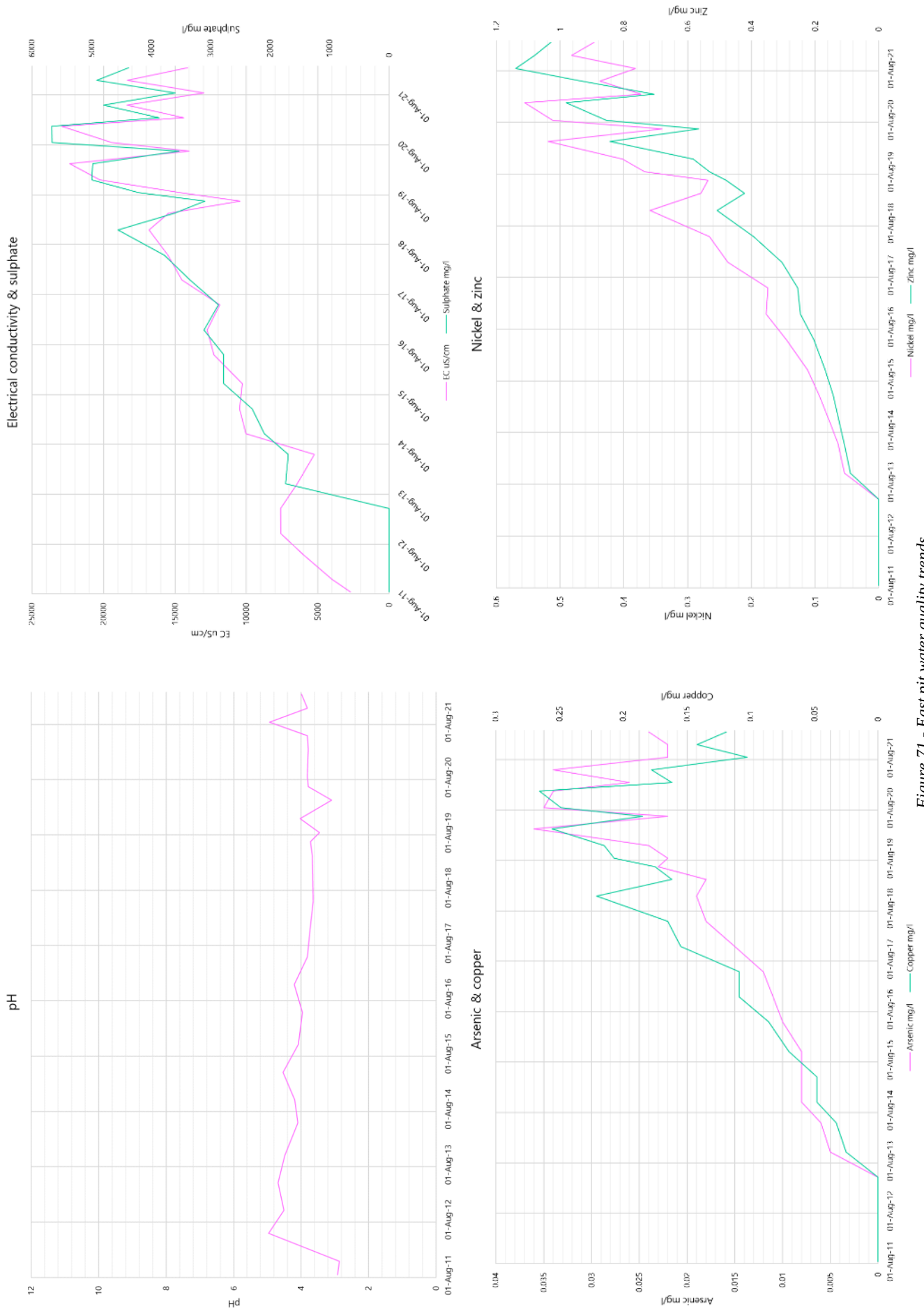


Figure 71 - East pit water quality trends



5 Pit voids fates - water balances & quality outcomes

5.1 Approach

The selected method for water system simulation at Yandan is a void mass balance: a transparent, & practical approach which is a good fit to the pit void systems. The selection of method is based on the dominance of the key driving forces of rainfall, evaporation (& evaporation surface) in pit lake levels, & the ability to include groundwater & river inflow/outflow to directly inform closure states of the pits. The model is analytical, & assesses a range of rainfall conditions over a 108-year timeframe, with a catchment based approach applying runoff factors common to Rational Method to solve for overall flow volumes. To capture rainfall variation, a 108-year rainfall record from 1913 to 2021 is applied, which is explored further in variations to simulate climate change scenarios at time steps through to 2090. Simulations are developed as a base case to which variations for State forecasts climate change are applied.

The water balance builds from available data & applied logics of a historical pit void as a conceptual model, including knowable pit geometry as storage curves & elevations, then water system interactions of rainfall & evaporation in the region, catchments reporting & nature, & looks to simulate a model response which reflects observed or recorded behaviour of the pit lake. Yandan Main pit as a pit lake has been in commission since 2000, & since (20 years) the pit has not dried or dropped below minimum levels, & has taken in flood waters up to 6 times. Vegetation & setting around the pit lake suggests a level of consistency in water levels when not in flood. For East Hill pit: the pit has never overflowed & has limited exposure to sunshine given the narrow pit crest.

Each pit has a character of design which enables informed assumptions to guide the water balance where data is limited & setup a useful model. The intent of modelling pit void fates is to simulate how a pit void (& catchments) will react over the longer term in water level & to gain insight as to other potential sources of the water balance such as potential groundwater inflow or loss. The approach is structured & objective. following a calibration & reasoning process to ensure relevance, transparency & credibility for each pit void in the landscape.

5.2 Pit geometry & storage curves

Pit geometry was developed with the following process:

- For Yandan, last known survey of the pit was used. To create the void model, pit shapes were sliced at 0.5m RL intervals in 3D software Vulcan, & void space estimated through applying a 0.5m unit to the surface area by elevation. The cumulative volumes of each slice through the pit from deepest to top of the pit provides the void storage curve.
- For East Hill pit, with no mining survey available an estimation of storage curve was calculated using surface area LiDAR elevation contours as unit widths (1m), & extrapolation for pit wall curve for extra pit below the water surface at 168mAHD to 166mAHD.

Each pit is very different in size & dimensions:

- Main pit extends from ~110mAHD up to 169mAHD to spill level at 59m depth, for a total void capacity of 6,800 megaliters at fill supply capacity.
- East Hill pit runs between 166mAHD at base of pit to 184mAHD at the top of the pit to spill level & contains only 45 megaliters of void capacity.

Slices & volumes used in each void model are available in Appendix D.



Main pit storage curve

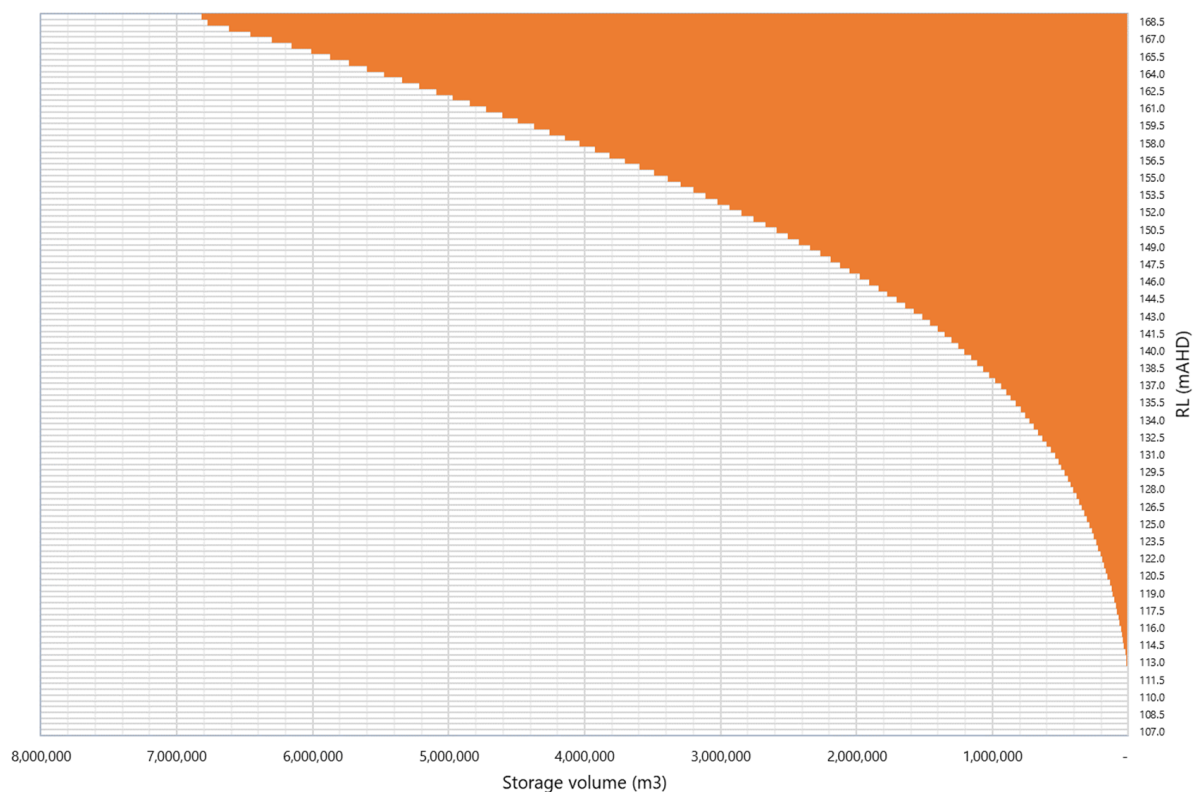


Figure 72 - Main pit void storage curve

East Hill pit storage curve

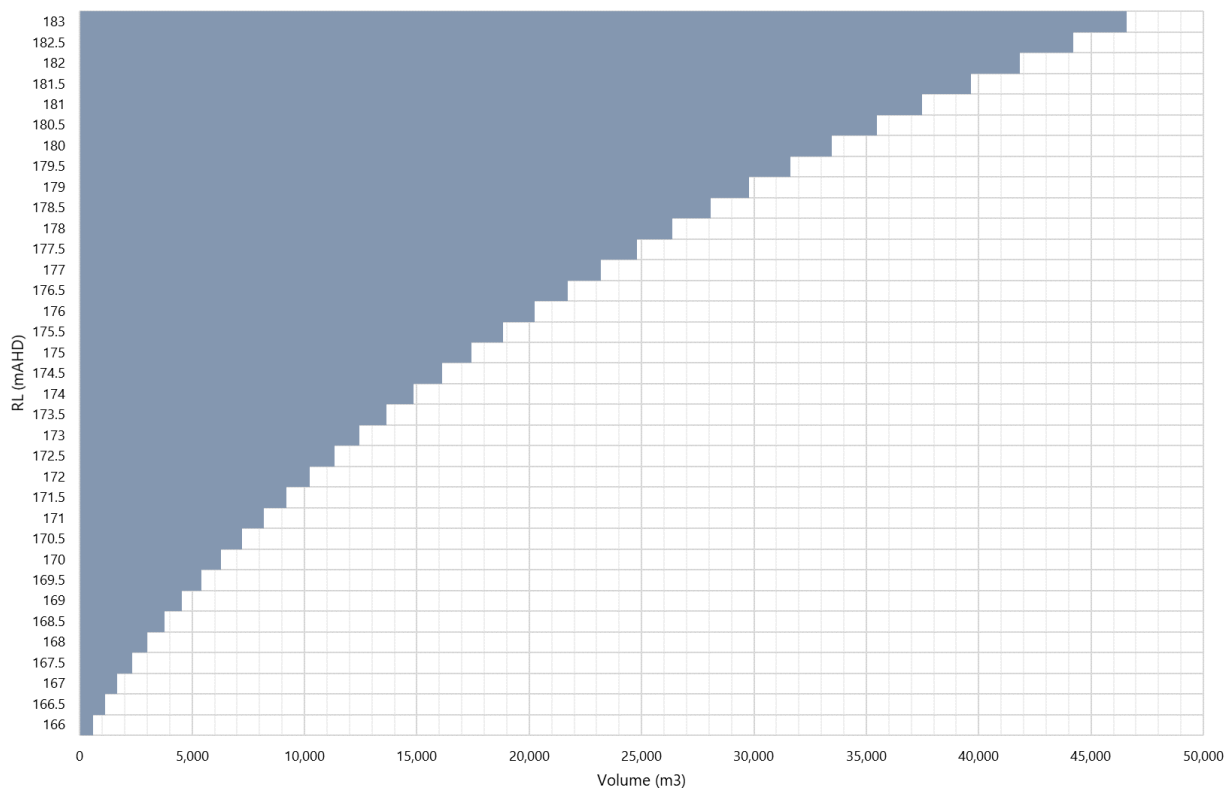


Figure 73 - East Hill pit void storage curve



5.3 Conceptual model

Both Main pit & East Hill pit lay within volcanic geology, which is fault bounded, variable from porous to crystalline & highly compartmentalized. Pumping tests as part of impact studies for the original project around Main Pit (Forbes 1988) encountered flow boundaries & estimated up to 5ML/day of dewatering per day, identifying two possible groundwater sources: either the Yandan Fault, or a porous “boiling zone” alteration horizon formed as part of hydrothermal activity. The study calculated transmissivities (conductivity over the width of a unit) of 60-200m²/d, & identified no connection with the alluvial aquifer to groundwater. Like many ephemeral drainages, the Suttor River is likely to be a losing river system, where water recharges into alluvial aquifers rather than being permanently groundwater fed as part of a natural system.

Inside the fault boundaries, both pits are comprised of altered andesite & sinter, with shears & silicified veining hosting the mineralisation. Oxidised zones are likely be more porous/conductive than fresh, crystalline rock, & there is likely to a change in hydraulic conductivity between the types of materials which is depth & fault dependent. The conductivity of crystalline rock is low given the lack of porosity (examples in Figure 74), & suggests much of the transmissivity observed in early pumping tests is primarily through the boiling zone unit, or the Yandan Fault. Faults are more capable of conveying volumes of water, as is porous & altered rocks such as a boiling zone unit.

Crystalline Rocks	
Material	Hydraulic Conductivity (m/sec)
Permeable basalt	4×10^{-7} to 2×10^{-2}
Fractured igneous and metamorphic rock	8×10^{-9} to 3×10^{-4}
Weathered granite	3.3×10^{-6} to 5.2×10^{-5}
Weathered gabbro	5.5×10^{-7} to 3.8×10^{-6}
Basalt	2×10^{-11} to 4.2×10^{-7}
Unfractured igneous and metamorphic rock	3×10^{-14} to 2×10^{-10}

Figure 74 - Typical conductivity values of crystalline rocks (Domenico & Schwartz 1990)

Unfortunately, the locations of pump tested wells have since been lost from reporting & the spatial dynamics of the work is not known to gain greater insight into unit & fault occurrences. However, we can assume Main pit to be connected to groundwater & that there will be a groundwater inflow component rather than loss to groundwater, & it is likely to be around current pit water levels as potentiometric equilibrium is likely to be reached after 20 years (aligned with the apparent consistency of pit water level at Main pit).

At East Hill pit, there is limited information to determine if groundwater is a factor: what is known is that water levels are low in the East Hill pit & sulphides are exposed leading to the observed water quality degradation in the pit over time. There may be signs of a potential hydraulic link between the pits: LiDAR imagery in 2021 identified similar water elevations for both pits at 168mAHD.

Linkage is possible, most likely through faulting: East Hill pit is higher in elevation, but water level is near to the base of the pit, whereas Main pit is lower elevation but has a greater water depth. If so, a level of groundwater leakage from East Hill pit may occur via the fracture, but would be towards Main pit discharge only, & be protected from environment harm.

Risk of groundwater transmission away from the pits is considered low as a conceptual model as:



- Main Pit is likely a gaining pit & be the lowest groundwater level in the landscape & will act as a groundwater sink given unconfined/open to air & position next to the Suttor River. Groundwater will flow towards Main Pit.
- East Pit is either hydraulically separate to Main pit, or may be connected through a discrete structures/or discrete boiling zone which is able to host water, where the rest of the crystalline rock will not. If connected, water will only flow towards Main pit when the hydraulic gradient between the pits allows it to (East Hill pit lake would need to have elevation greater than Main Pit pit lake water elevation), & if so, would be captured as a small volume contribution into a much larger volume pit lake (order of magnitude difference even at full supply level), & be measured by the water quality observations of the Main pit over the past 20 years.
- There is no known connection to alluvial aquifers, with pump tests in 1988 identifying no response from alluvial areas & a fault bounded geology, & evidence Suttor River is a losing stream into almost 30m of alluvials below current stream bed.

In surface water & pit lake interactions, three other key factors for Main Pit conceptual model are:

- Requirement for the pit lake to remain above 160mAHD to maintain water cover.
- Hydraulic separation of the pit lake to the river through the western bund wall.
- Interaction with the Suttor River & Yandan Creek at flood heights of 169.05mAHD (spillway at 169mAHD), with observed periodic flood events in the order of 5-15 year AEP. Size & magnitude of flows can be estimated from a known relationship of flows at St Anns gauge & relative elevations where inflow from the Suttor River or Yandan Creek occurs at flow rates of >500m³/s.

Risk of pit water quality impacting surface water quality is considered very low as:

- Main pit
 - Engineering controls restricting interaction of pit water except in flood conditions.
 - Main pit lake water quality is very good except for arsenic levels, & which will be adequately addressed with dilution from flood waters mixing as part of discharge.
 - Lack of groundwater hydraulic connection to alluvial aquifers.
- East Hill pit
 - Catchment for pit is very small & likelihood of spill is negligible except in rare flooding events where inflow may come from external sources.
 - East Hill pit is not hydraulically connected to any drainage lines.

Schematics of conceptual models for each pit are shown in Figure 75 & Figure 76.

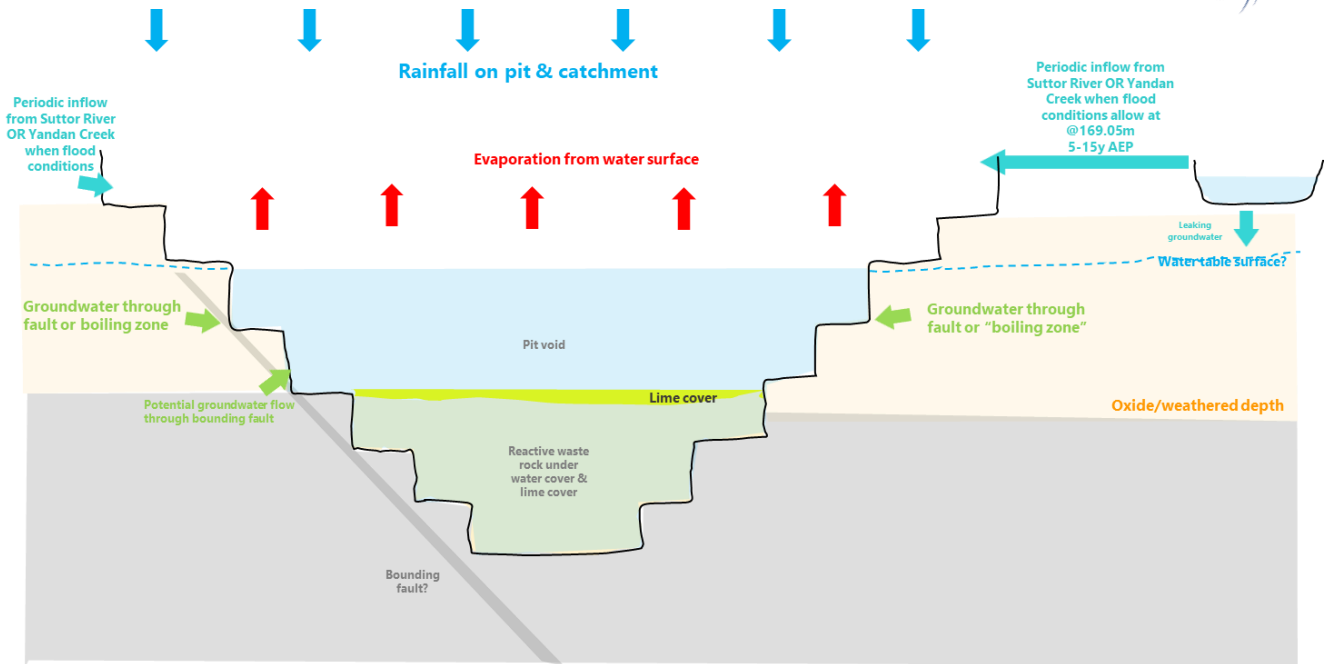


Figure 75 - Conceptual model for Main pit lake

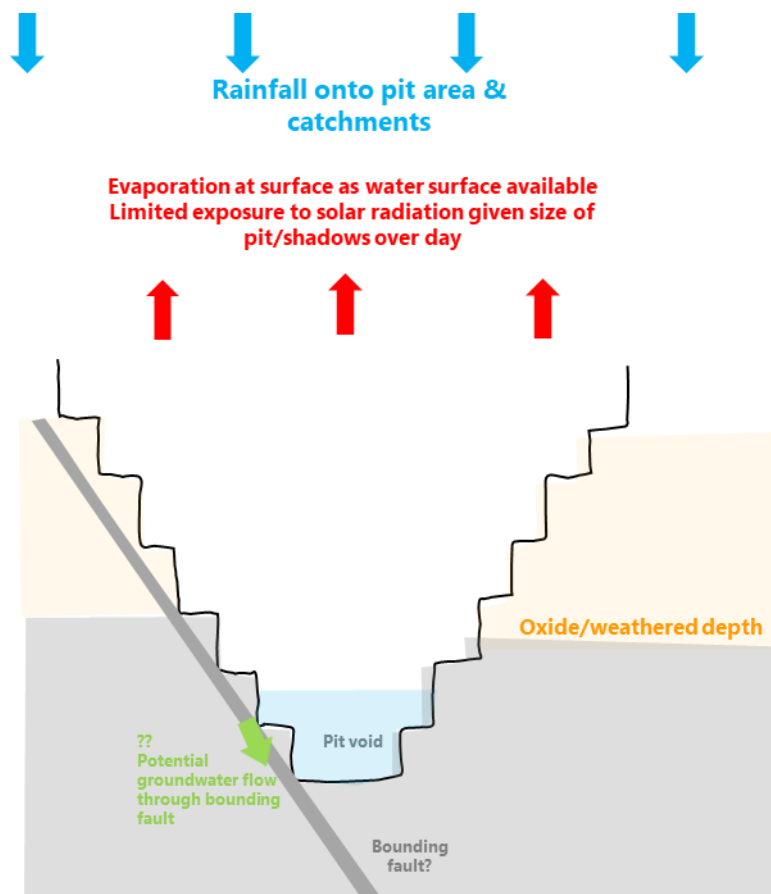


Figure 76 - Conceptual model for East Hill pit



5.4 Water balance construction

5.4.1 Structure

The void mass balance applies a time step application of mass flow change, creating a rolling change in storage or flows over the period of the water balance:

- *Initial starting volume + mass inflows/gains – mass outflows/losses = Δ (change) in storage (including overflow if storage capacity is reached or dry to zero if reached)*

A map of components possible in each day step in the void mass balance model is outlined in Figure 77, which are configured to be in alignment with the conceptual model.

Mechanics of the water balance are:

Pit void profiles are referenced to a table, where elevation, mine RL, volume & pond surface area (water surface) are cross referenced to each other, enabling mapping of geometry & volume parameters.

Water inputs (mass inflows) are built up for sources of gains:

- Rainfall & runoff factors with initial losses & runoff factors, potential groundwater gain, stormwater river inflow when flows exist, potential other sources. Rainfall is the primary source for Yandan site: loss & runoff factors are adjusted to be reasonable for catchment, landscape/infrastructure, soils, or types of events.
- Stormwater inflow as a major source of event-based inflow for Main pit, applied based on flows recorded at St Anns gauge above 500m³/s (condition for elevation to allow inflow), & a relative factor of 5% of greater than 500m³/s flows. Storm inflow is considered a normal event as part of managing quality & quantity in the pit, particularly mixing & increased dissolved oxygen, but is also a factor of available storage capacity in the pit at the time which is dependent on scenario.

Water outputs (mass outflows) are built up for sources of loss:

- Evaporation based on water surface & changes for rain, groundwater leakage & pumping. Evaporation is the primary driver of loss for Yandan, factored by whether the day is wet or not & then rated by how similar the pond will behave to pan evaporation rates. With ongoing solar radiation & shallow depths, it is expected pit lakes have a slightly higher evaporation rate given the lack of “refill” adapting quality with high evaporation conditions. Evaporation is applied by average BOM monthly rates. Evaporation rates vary based on average BOM daily rates by month & water surface from rolling water storage volume/elevations surface area.

For objectivity & rigour, conservative rates & settings are applied as to water related risk outcomes & also applied consistently across the life of the model (unless clear differences are required), such as river flood event inflow. Starting levels are set to actual levels taken at time of the LiDAR as start of model (168mAHD).

5.4.2 Scenarios

Scenarios assessed include:

- Base case – which is used to set rates & settings for balance then applied across all scenarios.
- Climate change scenarios based on 50th percentile - 2030, 2050, 2070, 2090
- Climate change scenarios for extreme wet & dry (90th/10th percentile) – 2090
- PMF event.

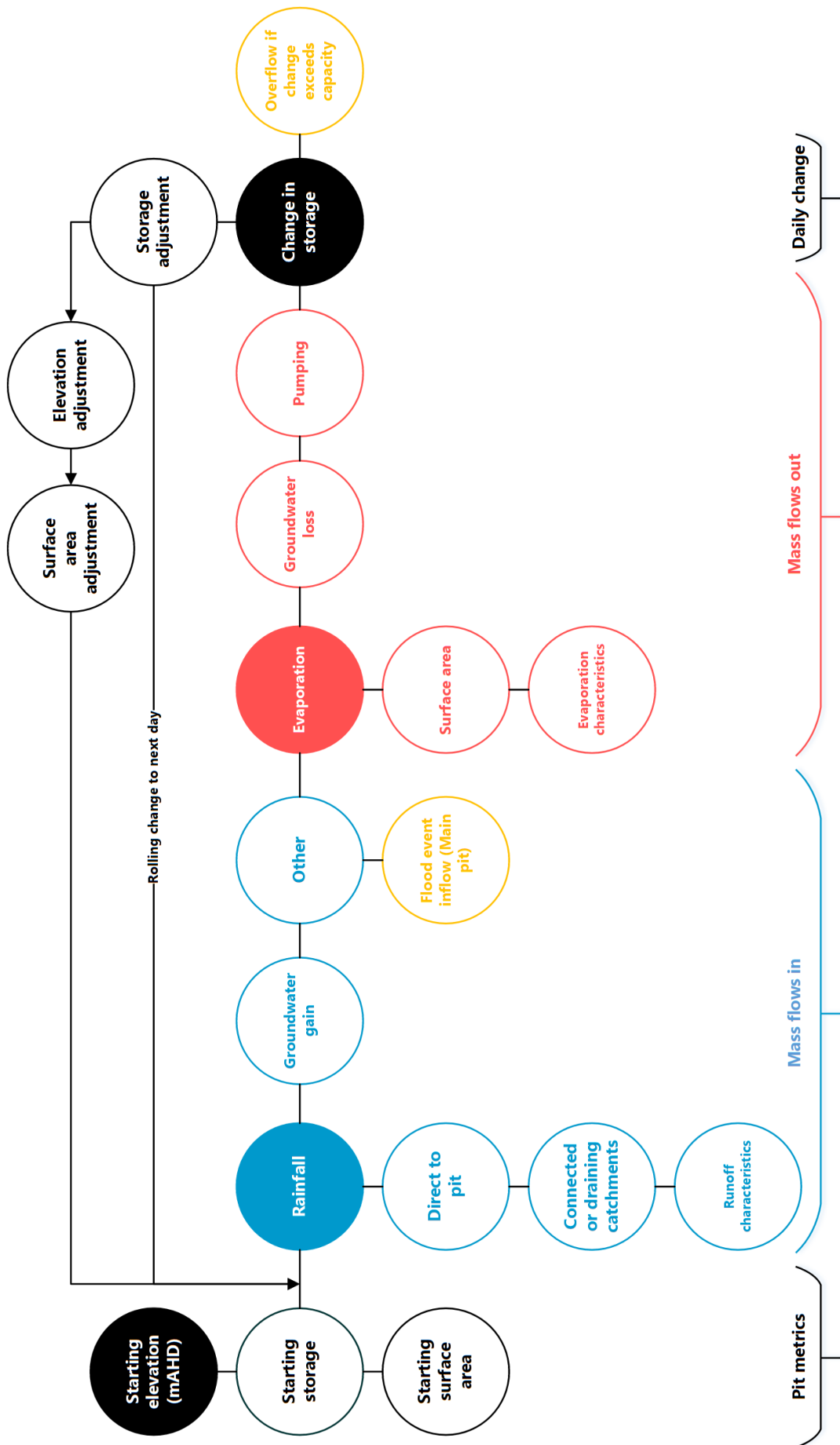


Figure 77 - Schematic of water balance logics

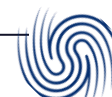


Table 14 – Main pit water balance model settings & parameters

#	Parameter	Comments
0	Model period, time step & starting setup	108 years: 1 July 1913 through to 31 December 2021 - Daily time step, calibrated via achieving relative stability & close in proximity to pit water level reads (used as a guide) in base case - Starting water levels: 168mAHD (based off LiDAR survey in 2016)
1	Rainfall	Mount Douglas station, up to 31 December 2021. Large break in record (18 months) replaced by St Anns gauge rainfall record for same period.
2	Evaporation	- Average of three regional stations as in Table 7 - Rainfall limit above which daily evaporation does not occur: 10mm - Pan factor applied: 1.1 based on long term exposure of pit lake, except 2090 dry scenario which has 1.2 pan factor
3	Catchments & runoff factors	- Main pit catchments reporting as in Table 6 & Figure 13. - M-WS - 0mm initial loss before runoff, 100% reporting - M-Pit (pit catchment not water surface) – 5mm initial loss, 95% runoff factor - M-01 (reporting catchment) – 15mm initial loss, 70% runoff factor
4	Groundwater	“Balance” achieved via inferring the mass flow discrepancy between rainfall & evaporation to manage roughly stable conditions (same RL/volume from start to finish) – 14l/s (1.2 ML/d)
5	Water movement	None
6	River inflow	- Applied over 9 days of “average” actual event in 1981 from St Anns for only drying events of 2070, 2090, 2090 dry - Applied each 10 years to mimic AEP - Volume of >500m³/s extracted, rate of 5% of excess flow available for pit
7	Pit bottom & spill	- Base ~110mAHD, spill 169mAHD - Storage capacity - 6,800,000m³

Table 15 – East Hill pit water balance model settings & parameters

#	Parameter	Comments
0	Model period, time step & starting setup	108 years: 1 July 1913 through to 31 December 2021 - Daily time step, calibrated via achieving relative stability & close in proximity to pit water level reads (used as a guide) in base case - Starting water levels: 168mAHD (based off LiDAR survey in 2016)
1	Rainfall	Mount Douglas station, up to 31 December 2021. Large break in record (18 months) replaced by St Anns gauge rainfall record for same period.
2	Evaporation	- Average of three regional stations as in Table 7 - Rainfall limit above which daily evaporation does not occur: 10mm - Pan factor applied: 1.1 based on long term exposure of pit lake, except 2090 dry scenario which has 1.2 pan factor
3	Catchments & runoff factors	- Main pit catchments reporting as in Table 6 & Figure 13 - E-WS - 0mm initial loss before runoff, 90% reporting - E-Pit (pit catchment not water surface) – 25mm initial loss, 70% runoff - E-01 (reporting catchment) – 30mm initial loss, 40% runoff factor
4	Groundwater	None
5	Water movement	None
6	River inflow	None
7	Pit bottom & spill	- Base ~166mAHD, spill 184mAHD - Storage capacity – 45,000m³



5.4.3 Calibration

The key control in construction of a model reflective of pit lake systems is to set ranges of parameters based on the framework & known dynamics of the system: physical space, measured applicable rates, & honour observations of the system: groundwater contributions at Main pit, variable rainfall, geometry of voids/water surfaces & catchments.

In setting the framework of the system based on known observations, the broad performance of the model is shaped, & the major dynamics represent a reasonable simulation. The knowledge of both pits forming pit lakes since 2000 & have neither completely dried nor overflowed as boundaries, plus records of six flooding inflow events since provides outlying boundaries. And as closed pits, there is no extraction or pumping.

Calibration stages involved setting up base parameters as a starting point, & adjusting parameter within reasonable ranges for initial loss, rainfall limits on evaporation occurring per day, runoff factors & evaporation rates to fit for purpose & gain a relative stability in the system (not drying or overflowing). Over 108 years, minor tweaks of settings plays out to show if the system is aligned.

For each pit, where the system indicated an ongoing loss or ongoing gain because of rainfall/evaporation differentials & resulting in an unstable system (ie dries or overflows in the model), groundwater gain or river inflow was adjusted into the mass flow as a constant to achieve relative stability in a conservative way. To ensure integrity & objectivity as a system model, factors are applied consistently across the length of the model based on parameters set: there is no adjustment of parameters over time to assess overall performance & fate.

The construction & calibration achieved a reasonable fit & profile for each pit: including alignment of model predictions to recent elevation reads & gradients, with commonality applied between both where appropriate.

5.5 Model outcomes

5.5.1 Base case

Base case outcomes achieved relative stability of pit lakes consistent with observations over past 20 years (Figure 78). Note storage & elevation are shown on different sides of the chart.

Main pit is shown independent of river inflow & with 14l/s (or 1.2MI/d) groundwater contribution, which is within reasonable scale limits with active mining dewatering rates of 5MI/d with mining drawdown. Note:

- Minimum pit water storage levels remain above 160mAHD.
- Elevation variation is minimal given baseflow contribution.
- Elevation generally aligned with in-pit monitoring (MP2) & scale of model variations.
- Low risk of spilling from the pit without river inflow which ensures mixing with stormwater for water quality outcomes.

East Hill pit, with a very limited catchment reporting & a lack of groundwater inflow demonstrates strong variation in water level (also factor of size of pool with rainfall/evaporation) & water level elevation remains low within the pit. Risk of spilling is almost negligible: by water balance the only means the pit may fill is through flooding in a potential PMF event, with flood waters entering the pit from above.

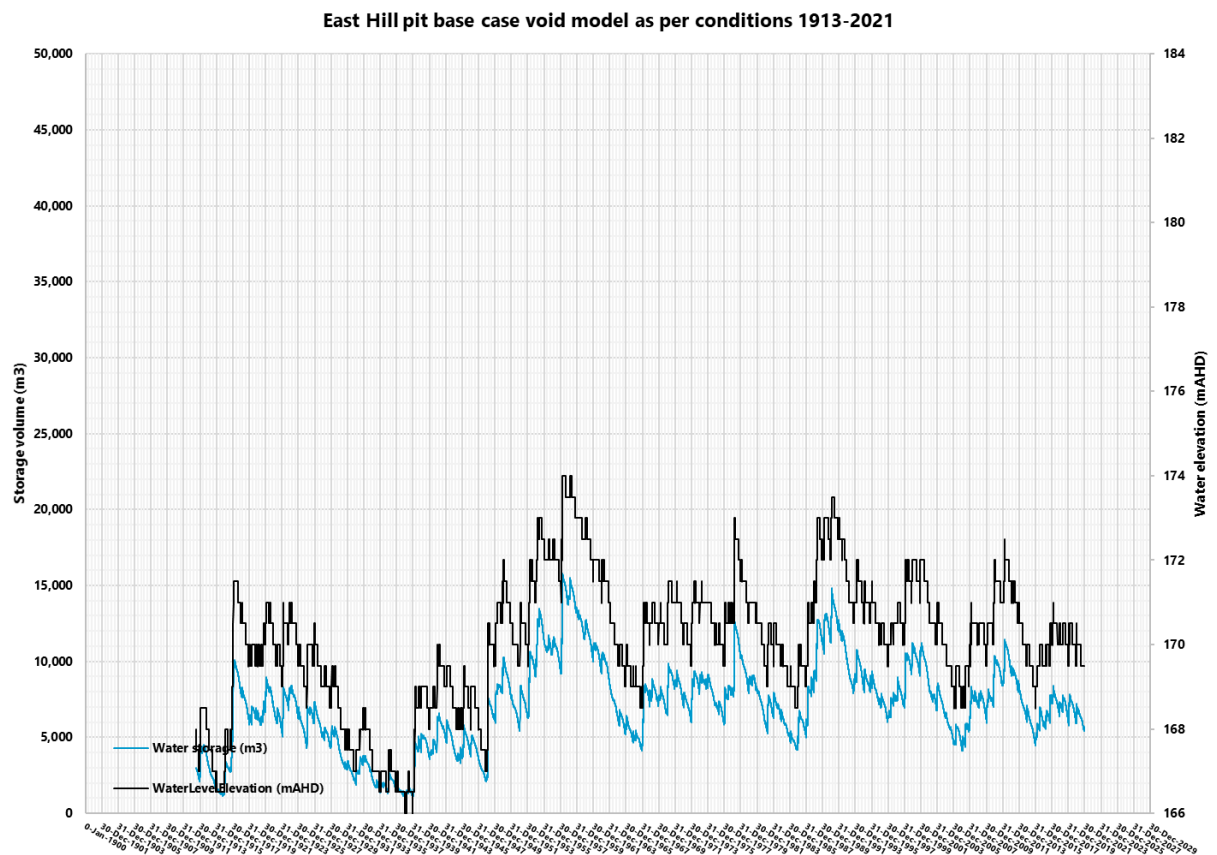
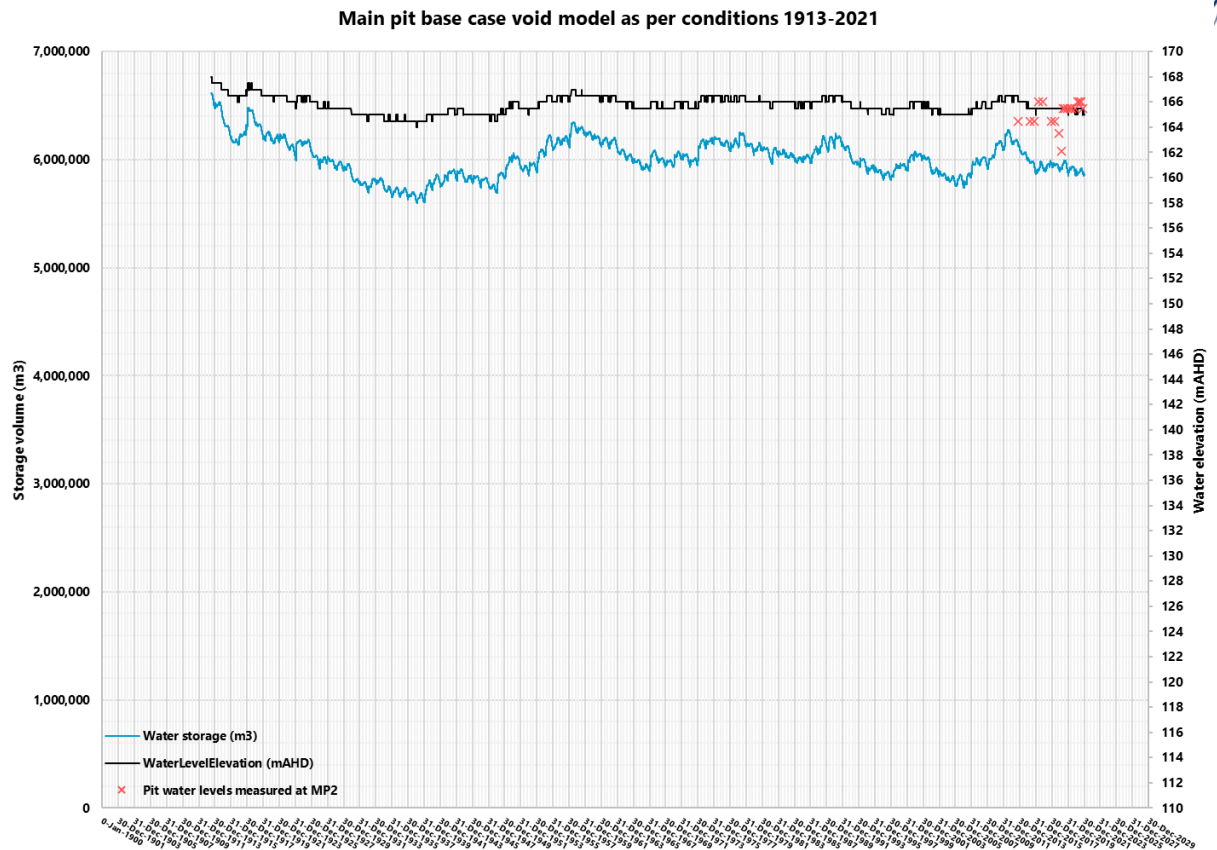


Figure 78 - Base case void model outcomes & profiles



5.6 Void response under PMF

To assess if a PMF event is likely to result in pit water release, application of PMF rainfall rates of 1232.5mm in 6 hours have been applied to both water balance models of Yandan.

Outcomes are plotted with overall volume capacity of the pit based on pit void storage curves, & base of pit to spill elevation as each axis in Figure 79, with metrics in Table 16.

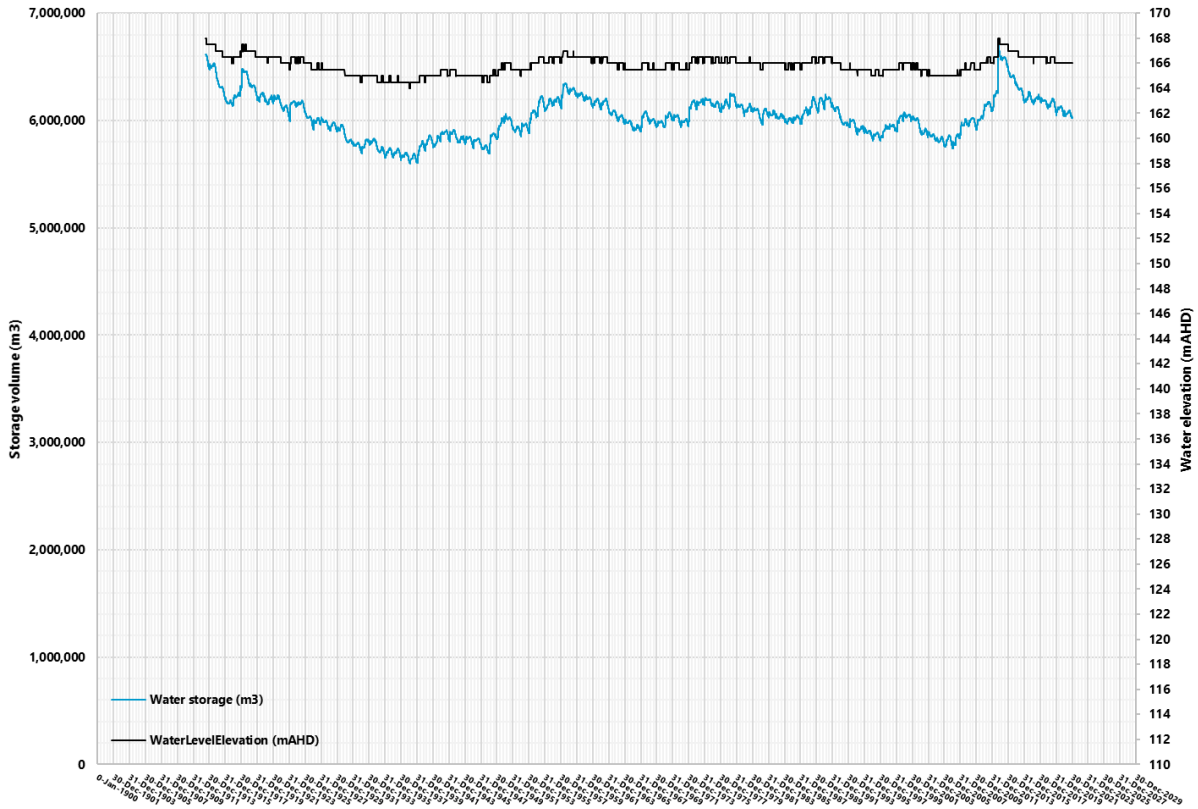
Simulations indicate both pits have a substantial capacity to absorb major or extreme rainfall events with low risk of spilling in a range of conditions. Note, in a PMF event the catchment will be hosting dramatically increased volumes of freshwater as well as clear hydraulic connection between Main pit & Yandan Creek/Suttor River for mixing of any potential impacted water. Likewise, East Hill pit may run close to filling in a PMF event, but with rapid fill will achieve substantial mixing as part of regional flooding of the area.

Table 16 - Metrics of PMF event on pit lake storage

PMF – 1232.5mm in 6 hours - applied date 10 September 2012 (high water level point)						
	Relative current storage (m3)	Change in storage (m3)	Change in void water height (m)	Outcome for pit volume	Potential increase in groundwater flow	Return to historical levels
Main Pit	285,497	458,880	2.5m	Contained within storage	Unlikely given large scale flooding across region, plus flooding from Yandan Creek & Suttor River	Falls rapidly under evaporation ~10-15 years
East Hill Pit	10,499	21,818	7.5m	Contained within storage	Unlikely given large scale flooding across region.	Falls rapidly under evaporation ~10-15 years



Main pit base case void model as per conditions 1913-2021 - PMF



East Hill pit base case void model as per conditions 1913-2021 - PMF

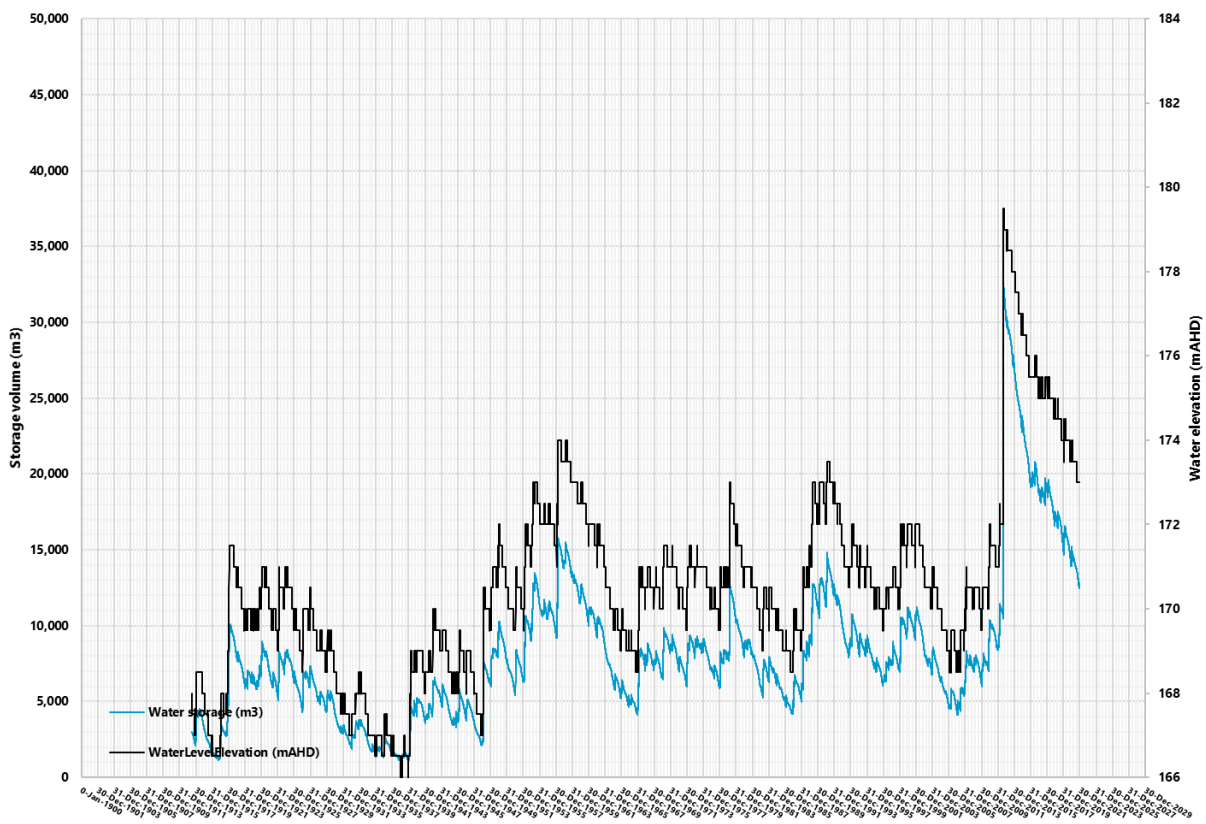


Figure 79 - View of PMF event into Main & East Hill pit: standard (top), increased runoff rates(bottom)



5.7 Void responses under climate change

5.7.1 Approach

As pits are proposed as remaining legacy landforms, an assessment of changing climate is required to review for potential impacts & implications of changing rainfall & evaporation to the pit void & lake.

Scenarios & changes apply parameters provided by the Queensland Government Future Climate (2021a) for the Mount Coolon region. Model scenarios of assess changes in evaporation & rainfall rates, with the following cases selected for scenarios:

50th percentile (mean) changes for rain & evaporation at: 2030, 2050, 2070, 2090

As a measure of potential extremes bounds, 90th/10th percentile scenarios in 2090:

- Wetter/lower evaporation.
- Drier/higher evaporation.

Table 17 presents the summary of expected changes suggested by climate change models as applied into the void water model. In application of the changes into the model:

Evaporation - updated tables by month were developed applying the average daily change (available in Appendix G).

Rainfall - change to annual rainfall depth was allocated to rainfall days as recorded over the record, as a ratio of the total weight of rainfall for the year (ie. Weighted increase to recorded rainfall events relative to their significance to simulate events).

In terms of changes to the system: in average scenarios, it is anticipated evaporation will increase in the order of 20% across a given year, & rainfall will reduce by 5-10%. Bounding scenarios indicate evaporation may increase by up to 35-50%, & rainfall either increase or decrease by 25%.

For drier scenarios (2050, 2070, 2090 & 2090 dry), an allowance for flood inflow is also modelled: applying an "average" Suttor River flooding event over 9 days of >500m³/s flow each 10 years as an average recurrence interval & allowing for 5% of the available flow above 500m³/s to be available as inflow to Main pit. The approach discounts additional flow which may come from Yandan Creek flow which would likely offer additional inflow. Values applied are provided in Table 18. Flows are applied every 10 years on 1-9 January from 1920 through to 2021.

5.7.2 Outcomes

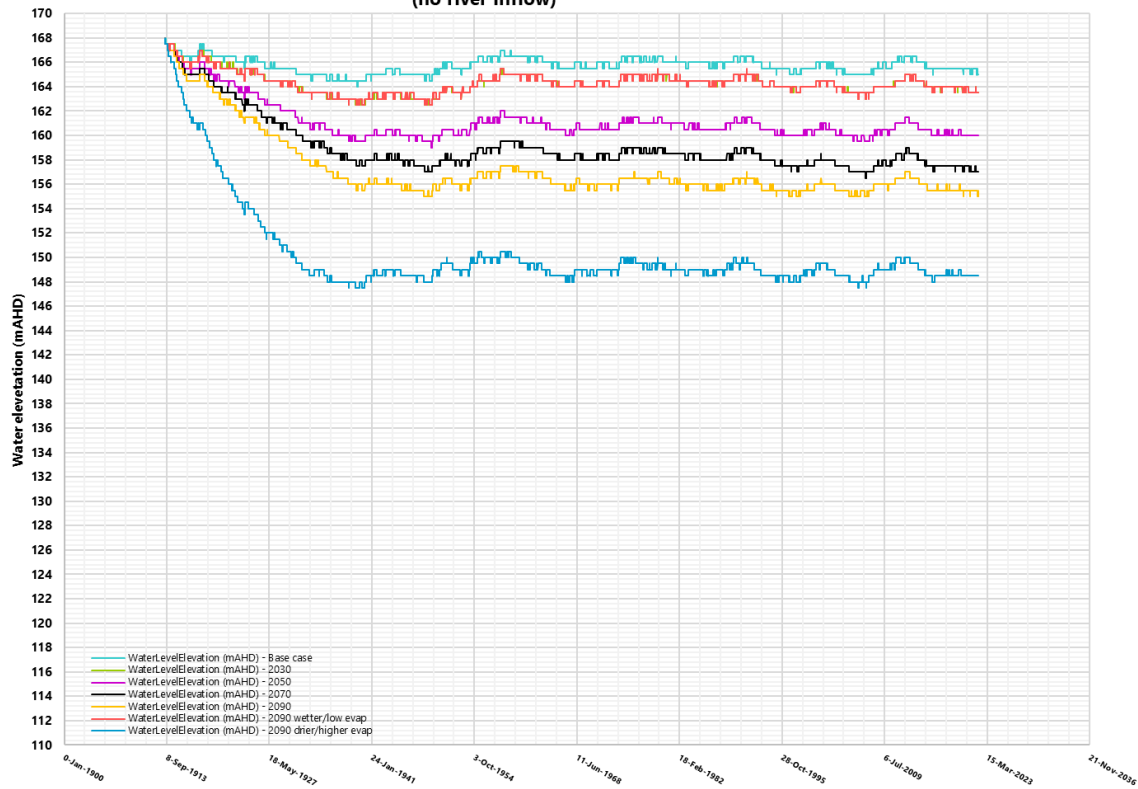
Figure 80 & Figure 80 presents outcomes of pit lake elevations comparison across the range of climate change scenarios.

In Main pit, climate change scenarios to 2050 & 2090 wet maintain minimum water elevation in storage above 160mAHD. For 2070, 2090 & 2090 dry however – drop below 160mAHD without additional river inflow from flooding events. However, with application of an average flow event every 10 years pit water levels are more generally maintained except in the 2090 extreme dry scenario. Scenario 2090 extreme wet is also contained unless a flood event occurs & allowing mixing.

In East Hill pit, climate scenarios of 2070, 2090 & 2090 extreme dry each result in a relatively dry pit which supports containment. Scenarios 2030, 2050 & 2090 extreme wet maintain water level within the pit & are contained, although 2050 may have periods of wet & dry for pit storage.



Main pit - 108 year base case pit water levels through climate change scenarios
(no river inflow)



Main pit - 108 year base case pit water levels through climate change scenarios
(river inflow)

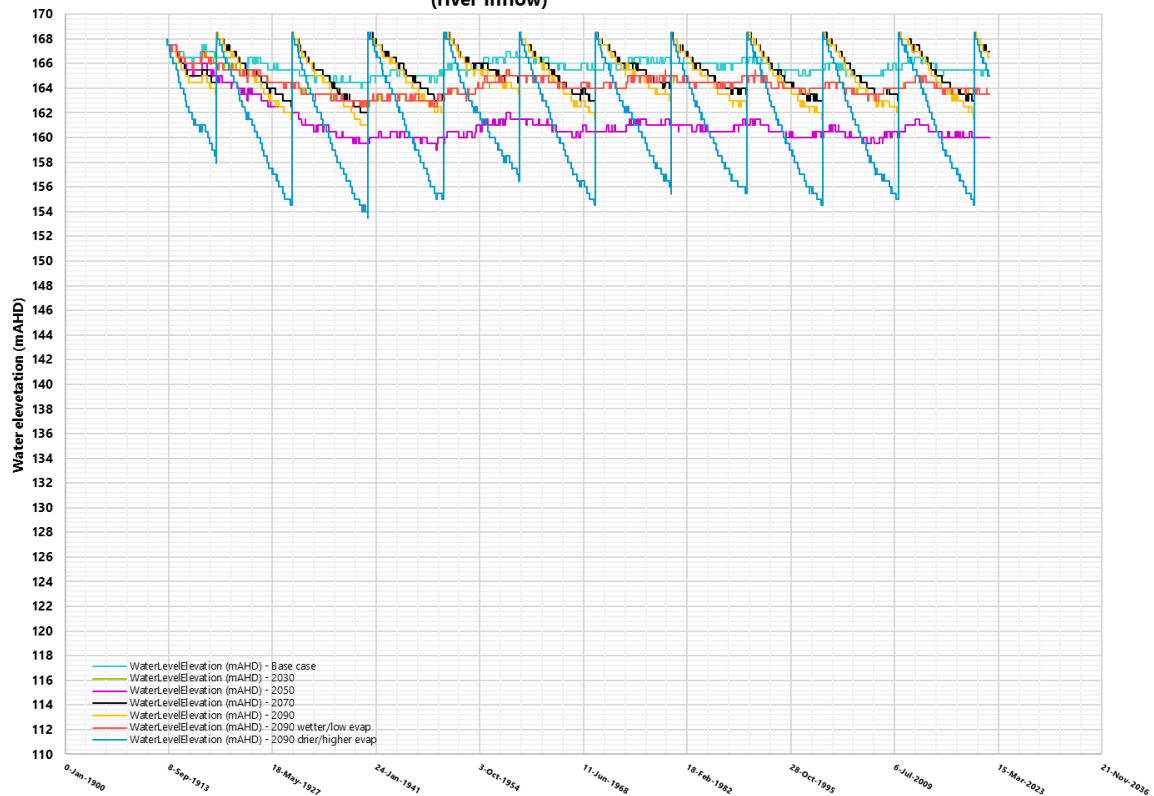


Figure 80 - Main pit void model under climate change scenarios – without & with river inflow



East Hill pit - 108 year base case pit water levels through climate change scenarios

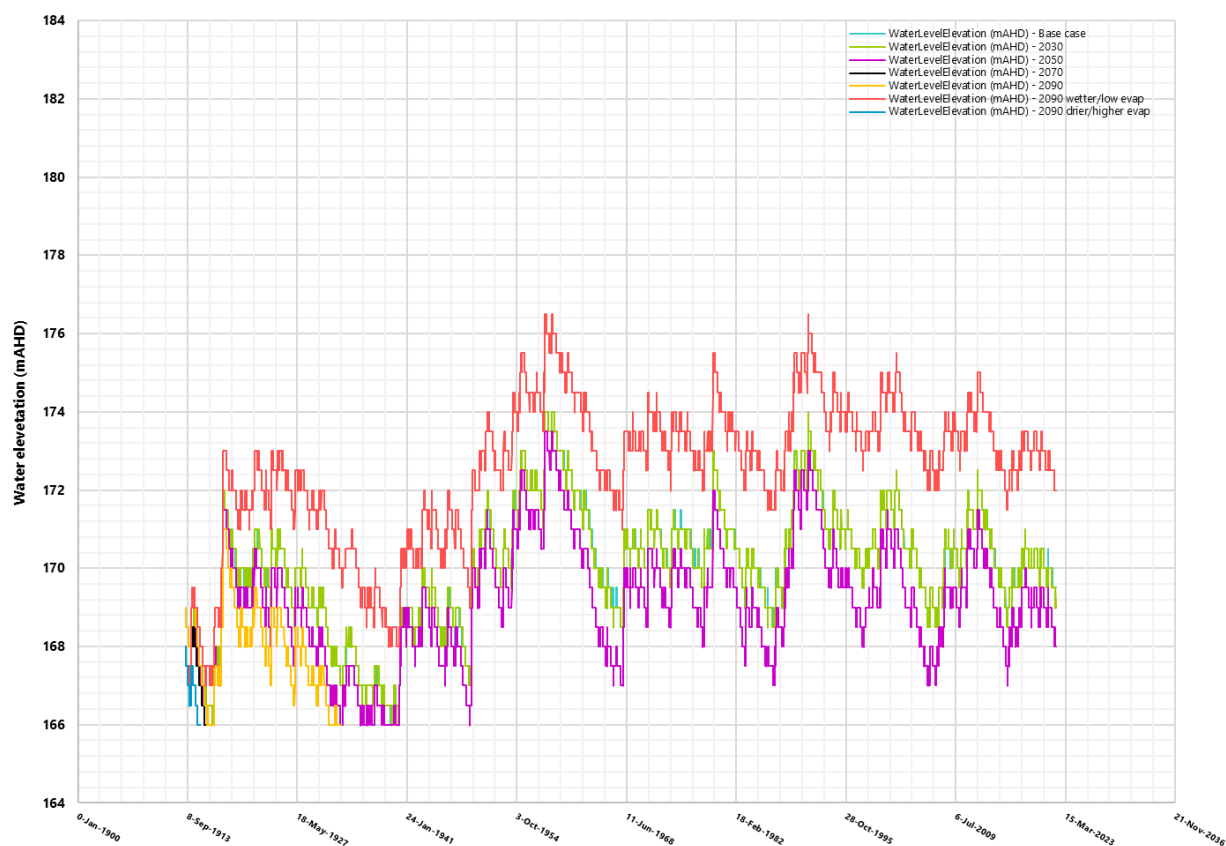


Figure 81 –East Hill void model outcomes under climate change scenarios

Table 17 - Summary of climate change values

Climate time frame	Selected probability profile	Rainfall (mm/y)	Evaporation (mm/d)
2030	50 th percentile (mean)	18.2	0.36
2050	50 th percentile (mean)	-29.2	0.8
2070	50 th percentile (mean)	-21.9	1.2
2090	50 th percentile (mean)	-10.96	1.6
2090 Wet	90 th /10 th percentile (upper bound)	116.9	0.7
2090 Dry	90 th /10 th percentile (lower bound)	-113.2	3.0

Table 18 - Summary of values from 1981 flood applied to simulate flooding inflow every 10 years AEP

Minimum flooding flow			500	m3/s
Date	Average flow recorded m3/s	Available flow > flood m3/s	m3/s to m3/d	5% of available flow
05-02-81	640.1	140.1	12,108,096	605,405
06-02-81	674.7	174.7	15,097,795	754,890
07-02-81	707.8	207.8	17,951,846	897,592
08-02-81	779.7	279.7	24,169,104	1,208,455
09-02-81	846.1	346.1	29,906,064	1,495,303
10-02-81	772.2	272.2	23,522,054	1,176,103
11-02-81	721.1	221.1	19,100,794	955,040
12-02-81	654.1	154.1	13,312,858	665,643
13-02-81	551.2	51.2	4,426,618	221,331



5.8 Potential for pit water stratification

Pit lake stratification describes a condition where vertical layering of the water column of a pit lake, based on physical or chemical factors, such as temperature or salinity, respectively. Stratification can influence the state of safety & health of the pit lake, for example, in oxygenation of water, or if gases are produced.

Key conditions in the potential for pit water stratification include (Jewell 2009):

Stability variables – wind & temperature, or formation of pit lake thermocline thickness as factor of effective pit length. Exposure to wind ripples the surface, changes in temperature over a year each contribute to the turnover of water in a water column.

Density gradients – density gradients of water between the base of pit & surface of pit must be large enough for when freshwater runoff enters the lake, the freshwater remains separate.

Water balances - Permanent stratification requires a positive water balance, where rainfall & runoff is greater than evaporation, as evaporation also creates mixing through changes of water heights, differential rates of evaporation, & density changes.

In evaluation of potential pit water stratification of Main & East Hill pits, formation of pit water stratification is unlikely based on the following factors:

- Main pit:
 - Monitoring results at depth show complete mixing of the water column across all parameters (Figure 65 to Figure 69).
 - River inflow results in increased oxygenation & mixing.
 - Groundwater inflow creating movement & mixing.
 - Wind is present throughout the year across the pit lake surface, & there are strong temperature differentials throughout the year, creating conditions conducive to mixing & oxygenation of the water column.
- East Hill pit:
 - Minimal water storage is in the pit (often only a few meters) which is not conducive to development of thermoclines or development of density gradients.



6 Recommendations for path forward

Landform	Recommendations
Tailings	Establish water shedding cover design for the final landform as a priority. Water flow must be managed & shed across the surface of the facility and must not be allowed to pool on the surface. Reducing percolation through managed drainage is the primary way to reduce risk for Yandan tailings storage. Regrade borrow pits to remove ponding around perimeter of facility. Construction of updated groundwater well network at a setback distance from the facility to monitor groundwater outside of the direct influence of the tailings on north, south & eastern sides of the facility. These wells should be considered life of mine wells for closure criteria monitoring. Update monitoring program to be consistent across all metals of interest. Consider technical investigation to mechanism & timings to explain how peaks of metals are occurring in surface water storages.
Heap leach	Rehabilitate leach ponds as soon as practical, removing material from the area & regrading. The stormwater pond can be maintained until final landform closure. Maintenance of existing drain or bunding to direct water to managed stormwater storage as practical. Check of HL4 integrity, installation of additional wells downgradient of HL1 & HL3 to provide closure monitoring.
Main pit void & receiving environment	Maintain water cover post-closure with existing bunding, particularly western sections. Increase groundwater knowledge: installation of groundwater wells around the mine domain to obtain groundwater information to assist hydrogeology and water balance modelling, including identification of where boiling zone unit occurs. Installation of logging equipment to capture water level measurement of pit water & groundwater. Review if diversion of Yandan Creek requires further engineering for longer term. Update & review of water balance modelling in 3-5 years for final position & long purpose of bund. Review potential of sustainable options to improve dissolved oxygen or reduce arsenic concentrations.
East pit void	If pit is to be left as a NUMA, recommend bunding across road access way to limit inflow in flooding conditions. Increase groundwater knowledge: installation of 2-3 wells around East pit void to obtain groundwater information to assist hydrogeology and water balance modelling, including if boiling zone unit or Yandan fault occurs. Installation of logging equipment to capture water level measurement of pit water & groundwater. Review options to fill or partially fill East Hill pit to reduce exposure to materials or change nature of the pit given poor water quality.



7 Findings & water-related risk

Table 19 - Summary of water-related risk

Landform	Rehabilitation fate	Land-use	Closure questions	Water risk outcomes
All of site			Flooding profile for landforms & potential risk as permanent landforms.	The site lays in a frequent flood area given the Suttor River wide valley, & which the Main Pit water cover relies on. Pit voids are stable under climate & PMF (rare) rainfall events for quality & level for water performance. Receiving environment quality & quantity is stable during flooding & release events & supports environment health. Flooding is considered for the site as the site infrastructures is designed above 1% AEP flooding events generally, with tailings laying above expected PMF flooding levels.
Heap Leach Pad (16.9 ha)	Cover system for low risk - gravel layer at a minimum of 0.5 m thickness & topsoil	Low hill	Water system response to landform (quality & quality). Final landform design needs, risk & appropriate cover for water performance stability. Potential water-related impacts & required monitoring to completion criteria.	Yandan heap leach is characterised by low-risk saline drainage. Sulphate & salinity are elevated around leach ponds; however levels are stable & likely indicates the rate of sulphate production has ceased or reduced. The landform is actively draining post operations & groundwater levels are declining to stabilising. The current form of the heap leach actively sheds water effectively, though sedimentation of the perimeter drains may not keep all surface runoff water within the heap leach catchment during periods of rainfall.
HL Stormwater Pond (1.59ha)	Dam wall removed & area rehabilitated.	Low hill	Leakage & potential groundwater containment. Indication of landform surface water drainage.	Groundwater quality is likely to improve over time. Primary metals of interest are arsenic, & potentially copper & zinc.
Pregnant Pond (0.16 ha)	Dam wall removed & area rehabilitated.	Low hill		Downgradient well HL3 shows elevated salinity but limited other potential contaminants as an indicator of overall contained risk & impact. An additional well downgradient of HL3 is recommended.
Barren Pond (0.18 ha)	Dam wall removed & area rehabilitated.	Low hill		Leakage from the leach ponds is likely contributing to elevated conductivity & sulphate in groundwater near to HL1, with quality likely relating to remnant quality from within & around the ponds acquired during operation. Removal of HL ponds is recommended.



Landform	Rehabilitation fate	Land-use	Closure questions	Water risk outcomes
Tailings Cell A (4.5 ha)	Repair of existing rehabilitation & regrading of surface (low risk cover)	Open pasture	Water system response to landform (quality & quantity). Final landform design needs, risk & appropriate cover for water performance stability. Potential water-related impacts & required monitoring to completion criteria.	Tailings impacts are characterised by low-risk saline drainage, with evidence of acid rock processes (either pH or sulphate). Sulphate & salinity are elevated; however, levels have been stable for some time & likely indicates production of sulphate has ceased or reduced.
Tailings Cell B (70.8 ha)	Cover system for low risk: - Rock cover of 1.0 m; and - Growth media of 0.15 m.	Open pasture		Whilst there may be some quality concerns for perimeter monitoring wells, these impacts are likely to be limited by topography & geology for water movement. Downgradient wells demonstrate containment of potential impacts is effective: in surface water, the tailings return dam (TRD) is effectively capturing runoff via the spillway. Groundwater wells on the perimeter are generally located in borrow pits & near the facility & are likely monitoring direct tailings water – further wells are recommended away from the dam potentiometric surface as indicative groundwater quality. Likewise, TD6S/D as upgradient wells are further away, but are at a much lower relative level & will be in a direct area of the potentiometric surface. It is recommended to rehabilitate borrow pits to ensure drainage.
Tailings Water Return Dam (18.37 ha)	Dam wall removed & area rehabilitated.	Open pasture	Leakage & potential groundwater containment. Indication of landform surface water drainage.	The current low gradient & depression form of the surface of the tailings facility allows ponding to occur on the facility, which maximises infiltration & percolation of water through stored tailings: a design & function which must be avoided for containment. Infiltration is likely exacerbating groundwater & surface water quality given the increased rates of infiltration & percolation through tailings material. A change to a water shedding facility is strongly recommended with a suitable low-risk tailings cover based on materials characterisation & water quality performance. Primary metals of interest (mobile) are arsenic, cadmium, copper, nickel & zinc (mobile at neutral to alkaline pH). Flushes of metals & salts are related to rainfall events, bringing peaks to shallow groundwater bores & returns dam alike as rainfall flushes through the facility.



Landform	Rehabilitation fate	Land-use	Closure questions	Water risk outcomes
Main Pit (17.8 ha)	Maintain water cover & connectivity with two spillways. Query whether bund wall required longer term.	Lake	Water system response as a landform/pit lake (quality & quality). Water level stability to cover fresh rock. Water quality stability & risk as pit lake. Fate of pit wall bund. Responses of pit voids to climate change or rare rainfall events. Receiving environment stability & risk – surface water & groundwater.	The water cover of Main Pit is successful & stable to design in managing risk of materials exposure & maintaining a pit lake which is relatively self-sustaining. Flooding events & releases are an expected & normal part of pit operation to maintain water levels & freshening of water, with floods every 5-15 years. Receiving waters monitoring shows during releases, water quality targets are achieved, both in sampling events & ongoing salinity via St Anns over the past 20 years. In alignment with detailed studies for pit flooding design, the pit is unlikely to spill without flooding flow from Suttor River or Yandan Creek with adequate surface water for mixing (with excess flow rates of 500m³/s or more). Water quality within the pit is stable over time & at depth, with no observable signs of ARD or water quality issues except for elevated arsenic & lower rates of dissolved oxygen. Times of inflow from Suttor River increase dissolved oxygen throughout the pit lake. The water profile shows water mixing is excellent throughout the water column with no thermocline or zoning – quality is consistent at depth & across the lake. Further works for closure might consider how dissolved oxygen could be increased. Pit water levels remain above minimum levels of 160mAHD in all climate change scenarios when regular inflow into the pit is considered in the water balance. The pit is also likely groundwater gaining from either a fault or a porous zone which requires further investigation. It is recommended to continue with current bunds to manage catchments & contain pit water unless Suttor River is in flood & review in several years.
East Hill Pit (0.5 ha)	Partially backfilled with concrete from infrastructure area, and sediment from	Lake	Water system response as a landform/pit lake (quality & quality). Water level stability to cover fresh rock. Water	East Hill pit is a low lying pit lake, with reactive materials & acidic water quality with increasing salts & metals. The pit is contained however at low levels & is unlikely to be connected to groundwater (confirmed through water balance) though may have some level of connection to Main Pit via a



Landform	Rehabilitation fate	Land-use	Closure questions	Water risk outcomes
	water storage structures.		quality stability & risk as pit lake. Fate of pit wall bund. Responses of pit voids to climate change or rare rainfall events. Receiving environment stability & risk – surface water & groundwater.	structural fault dependent on relative levels. A limited groundwater investigation is recommended to confirm groundwater nature. The site groundwater is highly compartmentalised with hydraulic boundaries between volcanic areas of the pits & other formations. Water quality is acidic & increasing in metals: however exposure to receiving environment is limited & volume of water is limited given the size of the pit & rainfall over time. The pit does not spill in PMF or in climate change scenarios, but maybe susceptible to inflow at PMF flood conditions from surface. An access bund across the lowest point on the north access road is recommended as a final fate.



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Schedule C - Water

General

(C1-1) Contaminants that will, or have the potential to cause environmental harm, must not be released directly or indirectly to any waters except as permitted under the conditions of this environmental authority.

(C1-2) The release of contaminants directly or indirectly to waters must not:

- (a) produce any visible discolouration of receiving waters; or
- (b) produce any slick or other visible or odorous evidence of oil, grease or petrochemicals nor contain visible floating oil, grease, scum, litter or other objectionable matter.

(C1-3) All determinations of water quality must be:

- (a) performed by a person or body possessing appropriate experience and qualifications to perform the required measurements;
- (b) made in accordance with methods prescribed in the latest edition of the latest edition of the Administering Authority's monitoring and sampling manual;
- (c) collected from the monitoring locations identified within this environmental authority, within 2 hours of each other where possible;
- (d) carried out on representative samples; and
- (e) for laboratory determinations, carried out in a laboratory accredited (e.g. NATA) for the method of analysis being used.

Contaminant Release to Waters

(C2-1) The release of contaminants to waters must only occur from the release points specified in Schedule C - Table 1 (Contaminant Release Points) and depicted in Schedule J - Figure 1.

Schedule C - Table 1 (Contaminant Release Points)

Release Point	Easting GDA94	Northing GDA94	Description of Release Point	Monitoring Point	Receiving Waters Description
MP1	496790	7645177	Northwest Main Pit Dam Spillway Overflow	Dam Spillway	Suttor River
MP2	497191	7644940	Southeast Main Pit Dam Spillway Overflow	Dam Spillway	Suttor River

(C2-2) The release of contaminants to waters from the release points must be monitored at the locations specified in Schedule C - Table 1 (Contaminant Release Points) for each quality characteristic and at the frequency specified in Schedule C - Table 2 (Contaminant Release Limits).



Schedule C - Table 2 (Contaminant Release Limits)

Parameter	Units	Limit type	Limit	Monitoring Frequency
pH	pH Unit	Range	6 – 9	A first flush sample at commencement of release A sample within 48 hours of the commencement of release Weekly sampling thereafter until the release ceases
EC	µS/cm	Maximum	1000 ² or 95th percentile ³ of reference, whichever is higher	
Sulfate	mg/L	Maximum	1000 ¹ or 95th percentile ³ of reference, whichever is higher	
Arsenic	mg/L	Maximum	0.5 ¹ or 95th percentile ³ of reference, whichever is higher	
Cadmium	mg/L	Maximum	0.01 ¹ or 95th percentile ³ of reference, whichever is higher	
Copper	mg/L	Maximum	0.5 ¹ or 95th percentile ³ of reference, whichever is higher	
Lead	mg/L	Maximum	0.1 ¹ or 95th percentile ³ of reference, whichever is higher	
Mercury	mg/L	Maximum	0.002 ¹ or 95th percentile ³ of reference, whichever is higher	
Molybdenum	mg/L	Maximum	0.05 ¹ or 95th percentile ³ of reference, whichever is higher	
Selenium	mg/L	Maximum	0.02 ¹ or 95th percentile ³ of reference, whichever is higher	
Zinc	mg/L	Maximum	20 ¹ or 95th percentile ³ of reference, whichever is higher	

1. Measured as a total unfiltered concentration and based on ANZECC (2000) stock water quality guidelines
2. DERM Scientific services, 2009
3. Where the 95th percentile of reference is exceeded and the reference site also exceeds the value during the same event, the value of the reference for the same event applies.

(C2-3) Waters potentially affected by the release of contaminants must be monitored at the locations specified in Schedule C - Table 3 (Release Monitoring Points) for each quality characteristic and at the frequency specified in Schedule C - Table 4 (Release Contaminant Trigger Levels).

Schedule C - Table 3 (Release Monitoring Points)

Monitoring Point	Easting GDA94	Northing GDA94	Description of Monitoring Point
Compliance Points			
SR1	496750	7645460	Monitoring point in the Suttor River at Suttor River causeway approximately 150 meters downstream of the MP1 contaminant release point
SR2	496820	7646759	Monitoring point in the Suttor River approximately 1.7 kilometres downstream of MP1 contaminant release point
Reference Points			
SR3a	496050	7644545	Monitoring point in Suttor River upstream of the main pit on the western side
SR3b	495734	7645032	Monitoring point in the Suttor River upstream of the main pit on the western side. (Alternative monitoring point to SR3a to be used when access to SR3a is restricted due to flood waters)
SR4	498842	7645095	Monitoring point upstream of the main pit in Yandan Creek branch on the eastern side of the Suttor River

Schedule C - Table 4 (Release Contaminant Trigger Levels)

Quality Characteristic	Unit	Trigger Levels	Monitoring Frequency
pH	pH Unit	20 th percentile ^{2,5} of reference or 6.0 ⁴ , whichever is lower. 80 th percentile ^{2,5} of reference or 7.5 ⁴ , whichever is higher	A first flush sample at commencement of release
EC	µS/cm	80 th percentile ^{2,5} of reference or 250 ⁴ , whichever is higher	
Sulphate	µg/L	80 th percentile ^{2,5} of reference	
Aluminium	µg/L	80 th percentile ^{3,5} of reference or 55 ⁴ , whichever is higher	
Arsenic	µg/L	80 th percentile ^{3,5} of reference or 13 ^{4,6} , whichever is higher	
Cadmium	µg/L	80 th percentile ^{3,5} of reference or 0.2 ⁴ , whichever is higher	A sample within 48 hours of the commencement of release
Copper	µg/L	80 th percentile ^{3,5} of reference or 1.4 ⁴ , whichever is higher	
Lead	µg/L	80 th percentile ^{3,5} of reference or 3.4 ⁴ , whichever is higher	
Mercury	µg/L	80 th percentile ^{3,5} of reference or 0.6 ⁴ , whichever is higher	Weekly sampling thereafter until the release ceases
Selenium	µg/L	80 th percentile ^{3,5} of reference or 11 ⁴ , whichever is higher	
Nickel	µg/L	80 th percentile ^{3,5} of reference or 11 ⁴ , whichever is higher	
Zinc	µg/L	80 th percentile ^{3,5} of reference or 8 ⁴ , whichever is higher	
Hardness ⁷	mg/L	N/A	

1. All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered). Trigger levels for metal/metalloids apply if dissolved results exceed trigger.
2. An interim trigger value can be derived from ≥ 8 but ≤ 17 consecutive reference site samples, derived using the methodology described in the Queensland Water Quality Guidelines (2009).
3. For toxicants, trigger values are based on the 80th percentile of at least 10 and no more than 24 consecutive reference site samples, derived using the methodology described in the Queensland Water Quality Guidelines (2009).
4. Default trigger values from ANZECC (2000)
5. 20th, 80th and 95th percentiles are calculated using ANZECC (2000) methodology (section 7.4.4.1)

Residual Void Outcome

- (F7-1) Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself, and subject to any other condition within this environmental authority.

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- (F7-2) Mining voids must be managed during the operation and decommissioning phases to maximise the potential post mine beneficial uses, by consideration of the following:
- (a) limiting sulphide exposures in void walls; and
 - (b) capping of sulphide exposures in void base; and
 - (c) limiting period of exposure of sulphides in void walls and base to oxidising conditions; and
 - (d) managing catchment into the void; and
 - (e) geo-technical stability of final void.
- (F7-3) Decommissioning strategies for the final voids must be updated with each update of the Plan of Operations.





Main Pit Water Cover

- (C4-1) The depth of water in the main pit must be measured quarterly in order to ensure water depth within the pit is maintained greater than 160m AHD.
- (C4-2) Water in the main pit must be monitored quarterly for the parameters and depth intervals defined in Schedule C – Table 7 (Main pit water quality parameters).

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Schedule C - Table 7 (Main pit water quality parameters)

Parameter	Units	Depth intervals
pH		5m and 10m
Temperature	°C	5m and 10m
Electrical Conductivity	uS/cm	5m and 10m
Salinity	Ppm	5m and 10m
Dissolved Oxygen	DO	5m and 10m
Oxidation Reduction Potential	mV / Eh	5m and 10m
Total Dissolved Solids	mg/L	10m
Sulfate	mg/L	10m
Arsenic	mg/L	10m
Cadmium	mg/L	10m
Copper	mg/L	10m
Lead	mg/L	10m
Mercury	mg/L	10m
Molybdenum	mg/L	10m
Selenium	mg/L	10m
Zinc	mg/L	10m





Groundwater

- (C7-1) Within 12 months of the date of approval of this environmental authority, the holder of the environmental authority must establish suitable reference bores for the establishment of background groundwater quality. Reference sites must:
- (a) be selected in accordance with the ANZECC & ARMCANZ 2000 methodology
 - (b) be from the same bio-geographic and climatic region; and
 - (c) have similar geology, soil types and topography; and
 - (d) not be so close to the test sites that any disturbance at the test site also results in a change at the reference site.
- (C7-2) Groundwater quality and level must be monitored at the locations and frequencies defined in Schedule C - Table 10 (Groundwater Monitoring Locations and Frequency) & Schedule J - Figure 3 for quality characteristics identified in Schedule C - Table 11 (Groundwater Contaminant and Trigger Limits).
- (C7-3) If quality characteristics of groundwater from compliance bores identified in Schedule C - Table 10 (Groundwater Monitoring Locations and Frequency) exceed any of the trigger levels stated in Schedule C - Table 11 (Groundwater Contaminant and Trigger Limits), the holder of this environmental authority must compare the compliance monitoring bore results to the reference bore results and:
- (a) if the level of contaminants at the compliance monitoring bore does not exceed the reference bore results, then no action is to be taken; and

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- (b) if the level of contaminants at the compliance monitoring bore is greater than the reference bore results, complete an investigation in accordance with the ANZECC & ARMCANZ 2000, into the potential for environmental harm and provide a written report to the administering authority within 3 months, 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 this condition, no further reporting is required for subsequent trigger events for that quality characteristic within the three month investigation period.

- (C7-4) Monitoring of groundwater from compliance bores identified in Schedule C - Table 10 (Groundwater Monitoring Locations and Frequency), must not exceed any of the limits defined in Schedule C - Table 11 (Groundwater Contaminant and Trigger Limits).
- (C7-5) Groundwater monitoring bores must be constructed and operated in accordance with methods prescribed in the latest edition of the Agriculture and Resource Management Council of Australia and New Zealand manual titled *Minimum Construction Requirements for Water Bores in Australia*.
- (C7-6) Annual groundwater monitoring reports analysing groundwater chemistry and hydro-geological status of all groundwater bores and groundwater conditions must be prepared and submitted to the administering authority with each annual return.

Schedule C - Table 10 (Groundwater Monitoring Locations and Frequency)

Monitoring Point	Easting (GDA94)	Northing (GDA94)	Surface RL ¹ (m)	Monitoring Frequency
Compliance Bores				
Yandan – Tailings Dam (TD) South Bore 3	499333	7646724	To be advised ³	Quarterly
Yandan – TD West Bore 4	499616	7647434	To be advised ³	Quarterly
Yandan – TD North Bore 5	500548	7647882	To be advised ³	Quarterly
Yandan – TD East Bore 6	500941	7647110	To be advised ³	Quarterly
Yandan – TD South Bore 7	499440	7646580	To be advised ³	Quarterly
Yandan – South Hill pit bore 3	497420	7644570	To be advised ³	Quarterly
Yandan – Heap Leach west bore 1	498094	7644870	To be advised ³	Quarterly
Yandan – Heap Leach west bore 3	498284	7644837	To be advised ³	Quarterly
Yandan – Heap Leach west bore 4	497913	7644964	To be advised ³	Quarterly
Yandan – Heap Leach east bore 5	498308	7645064	To be advised ³	Quarterly
Yandan – Heap Leach north bore 6	498321	7645358	To be advised ³	Quarterly
Yandan – Heap Leach north bore 7	498144	7645427	To be advised ³	Quarterly
Reference Bores²				
To be determined within 12 months of the date of approval of this licence, in accordance with condition C7-1				

¹ RL measurement to be taken from top of bore casing and measured to nearest 0.05m

² Reference sites must:

- (a) be from the same bio-geographic and climatic region; and
- (b) have similar geology, soil types and topography; and
- (c) not be so close to the test sites that any disturbance at the test site also results in a change at the reference site

³ within three months of the date of approval of this environmental authority



Schedule C - Table 11 (Groundwater Contaminant and Trigger Limits)

Parameter	Units	Limit type	Contaminant limit	Trigger Level
pH		Range	6 – 8.5 ³	6.0 – 7.5
Sulfate	mg/L	Maximum	1000 ⁵	The 80% percentile of the background reference
Arsenic	mg/L	Maximum	0.5 ¹	0.013 ^{2,4} or the 80% percentile of the background reference
Cadmium	mg/L	Maximum	0.5 ¹	0.0002 ⁴ or the 80% percentile of the background reference
Copper	mg/L	Maximum	0.5 ¹	0.0014 ⁴ or the 80% percentile of the background reference
Lead	mg/L	Maximum	0.1 ¹	0.0034 ⁴ or the 80% percentile of the background reference
Mercury	mg/L	Maximum	0.1 ¹	0.0006 ⁴ or the 80% percentile of the background reference
Molybdenum	mg/L	Maximum	0.05 ¹	The 80% percentile of the background reference
Selenium	mg/L	Maximum	0.02 ¹	0.011 ⁴ or the 80% percentile of the background reference
Zinc	mg/L	Maximum	20 ¹	0.008 ⁴ or the 80% percentile of the background reference
WAD Cyanide	mg/L	Maximum	0.2	0.007 ⁴ or the 80% percentile of the background reference

1. All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered).
2. If arsenic (soluble) exceeds 13ug/L then speciation to As(III) and As(V) must be conducted. The As(III) and As(V) levels must not exceed the 80th percentile of reference site samples or the respective trigger level: As(III) – 24ug/L; As(V) – 13ug/L.
3. Based on ANZECC (2000) primary industries guidelines
4. Default trigger values from ANZECC 2000 for aquatic ecosystems
5. Based on ANZECC (2000) Livestock Drinking Water Guidelines

Receiving Environment Monitoring Program (REMP)

(C8-1) A REMP must be developed and implemented within 3 months of the date of approval of this environmental authority to monitor and record the effects of the release of contaminants on the receiving environment periodically and whilst contaminants are being discharged from the site, with the aims of identifying and describing the extent of any adverse impacts to local environmental values, and monitoring any changes in the receiving water. A copy of the REMP must be provided to the administering authority prior to its implementation and due consideration given to any comments made on the REMP by the administering authority.

For the purposes of the REMP, the receiving environment is the waters of the Sutor River and connected waterways within 2 kilometres downstream of the release.

(C8-2) The REMP must address (but not necessarily be limited to) the following:

- (a) Description of potentially affected receiving waters including key communities and background water quality characteristics based on accurate and reliable monitoring data that takes into consideration any temporal variation (e.g. seasonality);
- (b) Description of applicable environmental values and water quality objectives to be achieved (i.e. as scheduled pursuant to the Environmental Protection (Water) Policy 2009);
- (c) Any relevant reports prepared by other governmental or professional research organisations that relate to the receiving environment within which the REMP is proposed;
- (d) Water quality targets within the receiving environment to be achieved, and clarification of contaminant concentrations or level indicating adverse environmental impacts during the REMP;
- (e) Monitoring for any potential adverse environmental impacts caused by the release;



Residual Void Outcome

- (F7-1) Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself, and subject to any other condition within this environmental authority.

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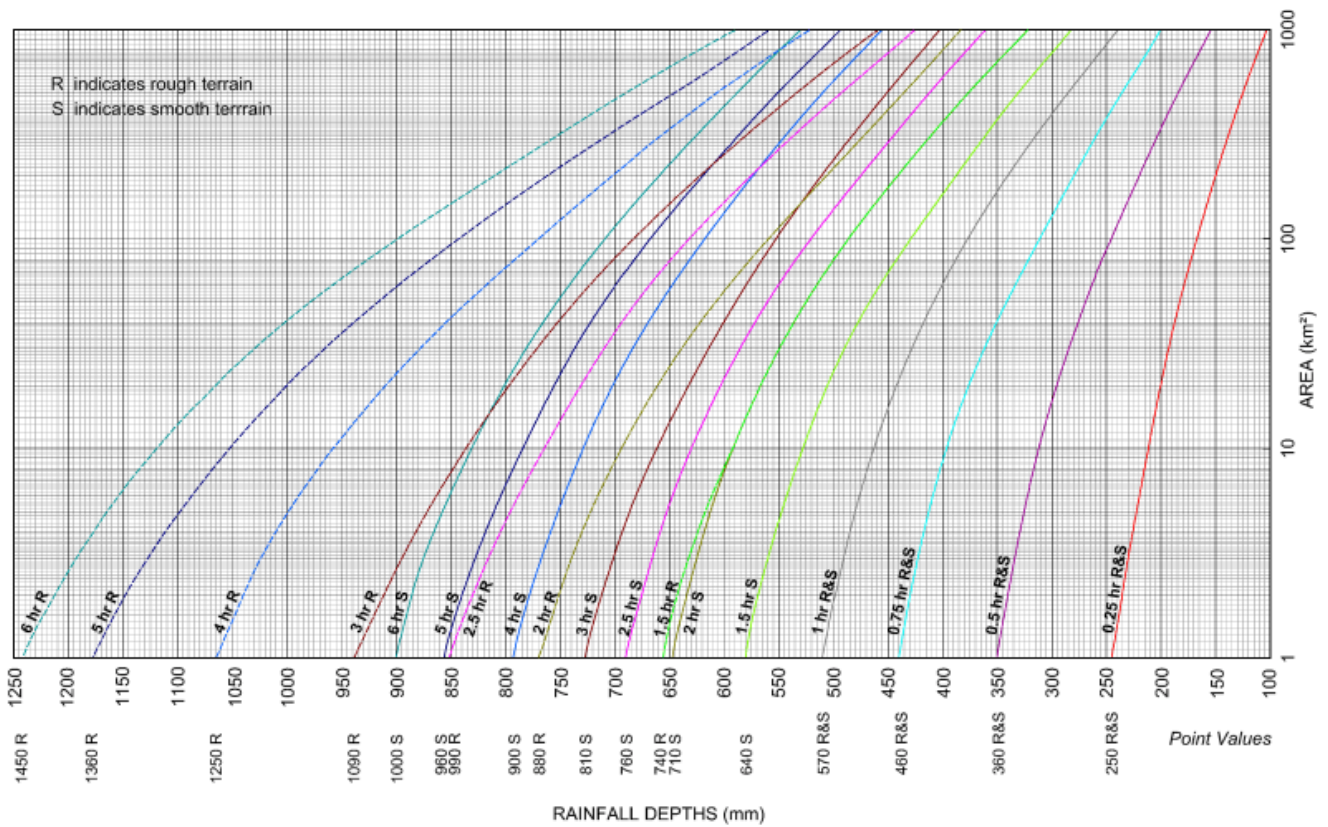
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- (F7-2) Mining voids must be managed during the operation and decommissioning phases to maximise the potential post mine beneficial uses, by consideration of the following:
- (a) limiting sulphide exposures in void walls; and
 - (b) capping of sulphide exposures in void base; and
 - (c) limiting period of exposure of sulphides in void walls and base to oxidising conditions; and
 - (d) managing catchment into the void; and
 - (e) geo-technical stability of final void.
- (F7-3) Decommissioning strategies for the final voids must be updated with each update of the Plan of Operations.





Appendix B – PMF reference event table for GSDM method (BOM 2003)



Depth-Duration-Area Curves of Short Duration Rainfall





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Appendix D – Void slice tables for Main Pit & East Hill Pit

Main pit

RL	Surface area m2	Cumulative volume m3	Cumulative m3	Surface area m2	RL
107.0	353	177	177	353	107.0
107.5	921	461	637	921	107.5
108.0	1,228	614	1,251	1,228	108.0
108.5	1,337	668	1,920	1,337	108.5
109.0	1,477	739	2,658	1,477	109.0
109.5	1,609	805	3,463	1,609	109.5
110.0	1,742	871	4,334	1,742	110.0
110.5	1,978	989	5,323	1,978	110.5
111.0	2,152	1,076	6,399	2,152	111.0
111.5	2,349	1,175	7,573	2,349	111.5
112.0	2,587	1,293	8,867	2,587	112.0
112.5	2,948	1,474	10,341	2,948	112.5
113.0	4,386	2,193	12,534	4,386	113.0
113.5	10,701	5,350	17,884	10,701	113.5
114.0	14,046	7,023	24,908	14,046	114.0
114.5	14,484	7,242	32,150	14,484	114.5
115.0	15,016	7,508	39,657	15,016	115.0
115.5	15,656	7,828	47,486	15,656	115.5
116.0	16,364	8,182	55,668	16,364	116.0
116.5	17,067	8,534	64,201	17,067	116.5
117.0	17,868	8,934	73,136	17,868	117.0
117.5	18,644	9,322	82,457	18,644	117.5
118.0	19,392	9,696	92,153	19,392	118.0
118.5	20,540	10,270	102,423	20,540	118.5
119.0	22,056	11,028	113,451	22,056	119.0
119.5	24,512	12,256	125,707	24,512	119.5
120.0	25,169	12,584	138,292	25,169	120.0
120.5	25,799	12,900	151,191	25,799	120.5
121.0	26,412	13,206	164,397	26,412	121.0
121.5	27,111	13,555	177,952	27,111	121.5
122.0	27,887	13,944	191,896	27,887	122.0
122.5	29,020	14,510	206,406	29,020	122.5
123.0	30,155	15,077	221,483	30,155	123.0
123.5	30,850	15,425	236,908	30,850	123.5
124.0	31,612	15,806	252,714	31,612	124.0
124.5	32,337	16,169	268,883	32,337	124.5
125.0	33,339	16,669	285,552	33,339	125.0
125.5	36,906	18,453	304,005	36,906	125.5
126.0	38,180	19,090	323,095	38,180	126.0
126.5	38,957	19,478	342,573	38,957	126.5
127.0	39,768	19,884	362,457	39,768	127.0
127.5	40,590	20,295	382,752	40,590	127.5
128.0	41,462	20,731	403,483	41,462	128.0
128.5	42,568	21,284	424,767	42,568	128.5
129.0	43,739	21,870	446,637	43,739	129.0
129.5	44,821	22,410	469,047	44,821	129.5
130.0	46,033	23,017	492,064	46,033	130.0
130.5	47,560	23,780	515,844	47,560	130.5
131.0	51,702	25,851	541,695	51,702	131.0
131.5	57,865	28,933	570,628	57,865	131.5
132.0	59,702	29,851	600,479	59,702	132.0
132.5	60,910	30,455	630,934	60,910	132.5
133.0	62,087	31,043	661,977	62,087	133.0
133.5	63,262	31,631	693,609	63,262	133.5
134.0	64,580	32,290	725,898	64,580	134.0
134.5	66,453	33,226	759,125	66,453	134.5
135.0	68,020	34,010	793,135	68,020	135.0
135.5	69,517	34,758	827,893	69,517	135.5
136.0	71,142	35,571	863,464	71,142	136.0
136.5	73,118	36,559	900,023	73,118	136.5

136.5	73,118	36,559	900,023	73,118	136.5
137.0	77,205	38,603	938,626	77,205	137.0
137.5	82,847	41,424	980,049	82,847	137.5
138.0	86,169	43,085	1,023,134	86,169	138.0
138.5	88,289	44,145	1,067,279	88,289	138.5
139.0	90,004	45,002	1,112,281	90,004	139.0
139.5	91,843	45,922	1,158,203	91,843	139.5
140.0	93,951	46,975	1,205,178	93,951	140.0
140.5	96,603	48,302	1,253,479	96,603	140.5
141.0	98,608	49,304	1,302,783	98,608	141.0
141.5	100,356	50,178	1,352,961	100,356	141.5
142.0	102,336	51,168	1,404,129	102,336	142.0
142.5	106,011	53,006	1,457,135	106,011	142.5
143.0	113,028	56,514	1,513,649	113,028	143.0
143.5	124,575	62,287	1,575,936	124,575	143.5
144.0	128,748	64,374	1,640,310	128,748	144.0
144.5	131,372	65,686	1,705,996	131,372	144.5
145.0	133,275	66,638	1,772,634	133,275	145.0
145.5	135,542	67,771	1,840,405	135,542	145.5
146.0	137,682	68,841	1,909,246	137,682	146.0
146.5	139,483	69,741	1,978,987	139,483	146.5
147.0	141,020	70,510	2,049,497	141,020	147.0
147.5	142,553	71,277	2,120,774	142,553	147.5
148.0	144,167	72,083	2,192,857	144,167	148.0
148.5	146,059	73,030	2,265,887	146,059	148.5
149.0	151,878	75,939	2,341,826	151,878	149.0
149.5	160,218	80,109	2,421,935	160,218	149.5
150.0	165,068	82,534	2,504,469	165,068	150.0
150.5	167,194	83,597	2,588,066	167,194	150.5
151.0	169,232	84,616	2,672,682	169,232	151.0
151.5	170,797	85,399	2,758,080	170,797	151.5
152.0	173,408	86,704	2,844,784	173,408	152.0
152.5	175,351	87,675	2,932,459	175,351	152.5
153.0	177,100	88,550	3,021,010	177,100	153.0
153.5	178,646	89,323	3,110,333	178,646	153.5
154.0	180,178	90,089	3,200,422	180,178	154.0
154.5	181,918	90,959	3,291,381	181,918	154.5
155.0	191,894	95,947	3,387,328	191,894	155.0
155.5	207,124	103,562	3,490,890	207,124	155.5
156.0	213,563	106,781	3,597,671	213,563	156.0
156.5	215,449	107,725	3,705,396	215,449	156.5
157.0	217,357	108,679	3,814,074	217,357	157.0
157.5	219,832	109,916	3,923,990	219,832	157.5
158.0	221,776	110,888	4,034,878	221,776	158.0
158.5	224,491	112,245	4,147,123	224,491	158.5
159.0	226,134	113,067	4,260,190	226,134	159.0
159.5	227,746	113,873	4,374,063	227,746	159.5
160.0	229,374	114,687	4,488,750	229,374	160.0
160.5	231,641	115,821	4,604,571	231,641	160.5
161.0	235,939	117,969	4,722,540	235,939	161.0
161.5	245,924	122,962	4,845,502	245,924	161.5
162.0	246,823	123,412	4,968,914	246,823	162.0
162.5	248,720	124,360	5,093,274	248,720	162.5
163.0	250,611	125,305	5,218,579	250,611	163.0
163.5	252,575	126,287	5,344,866	252,575	163.5
164.0	256,614	128,307	5,473,173	256,614	164.0
164.5	259,896	129,948	5,603,121	259,896	164.5
165.0	263,328	131,664	5,734,785	263,328	165.0
165.5	272,793	136,397	5,871,182	272,793	165.5
166.0	278,146	139,073	6,010,255	278,146	166.0
166.5	285,497	142,748	6,153,003	285,497	166.5
167.0	294,573	147,286	6,300,290	294,573	167.0
167.5	309,961	154,981	6,455,270	309,961	167.5
168.0	317,116	158,558	6,613,828	317,116	168.0
168.5	322,475	161,237	6,775,066	322,475	168.5
169.0	80,669	40,334	6,815,400	80,669	169.0



East Hill pit

RL	Surface area m2	Cumulative volume m3	Cumulative m3	Surface area m2	RL
166.0	600.0	600.0	600	600	166.0
166.5	825.0	825.0	1125.0	825.0	166.5
167.0	1050.0	1050.0	1,650	1,050	167.0
167.5	1196.3	1196.3	2321.3	1196.3	167.5
168.0	1342.6	1342.6	2,993	1,343	168.0
168.5	1444.4	1444.4	3765.7	1444.4	168.5
169.0	1546.2	1546.2	4,539	1,546	169.0
169.5	1643.6	1643.6	5409.3	1643.6	169.5
170.0	1740.9	1740.9	6,280	1,741	170.0
170.5	1817.0	1817.0	7226.2	1817.0	170.5
171.0	1893.0	1893.0	8,173	1,893	171.0
171.5	1971.9	1971.9	9198.1	1971.9	171.5
172.0	2050.8	2050.8	10,224	2,051	172.0
172.5	2137.5	2137.5	11335.7	2137.5	172.5
173.0	2224.2	2224.2	12,448	2,224	173.0
173.5	2306.9	2306.9	13642.6	2306.9	173.5
174.0	2389.6	2389.6	14,837	2,390	174.0
174.5	2493.7	2493.7	16136.3	2493.7	174.5
175.0	2597.8	2597.8	17,435	2,598	175.0
175.5	2694.3	2694.3	18830.6	2694.3	175.5
176.0	2790.8	2790.8	20,226	2,791	176.0
176.5	2877.5	2877.5	21708.1	2877.5	176.5
177.0	2964.2	2964.2	23,190	2,964	177.0
177.5	3069.5	3069.5	24777.6	3069.5	177.5
178.0	3174.8	3174.8	26,365	3,175	178.0
178.5	3290.2	3290.2	28067.8	3290.2	178.5
179.0	3405.6	3405.6	29,771	3,406	179.0
179.5	3547.8	3547.8	31615.6	3547.8	179.5
180.0	3690.1	3690.1	33,461	3,690	180.0
180.5	3846.0	3846.0	35461.6	3846.0	180.5
181.0	4001.8	4001.8	37,462	4,002	181.0
181.5	4180.1	4180.1	39641.7	4180.1	181.5
182.0	4358.5	4358.5	41,821	4,358	182.0
182.5	4557.2	4557.2	44199.0	4557.2	182.5
183.0	4756.0	4756.0	46,577	4,756	183.0





Appendix E – Evaporation across climate change scenarios

Station		StationID	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	AnnualAverage	Years
MoranbahWaterTreatment	SE	34038	8	7.4	6.8	5.7	4.3	3.5	3.7	4.9	6.6	8	8.5	8.5	6.3	1986-2012
TwinHills	SW	36047	7.5	6.5	6.1	5.2	3.6	2.9	3.1	4.2	6.1	7.9	8.6	8.7	5.9	1967-1985
CollinsvillePostOffice	NE	33013	6.2	5.7	5.2	4.4	3.5	2.9	3.2	4.1	5.3	6.5	6.9	6.9	5.1	1967-2017
Average			7.2	6.5	6.0	5.1	3.8	3.1	3.3	4.4	6.0	7.5	8.0	8.0	5.8	
2030		0.36														
Station		StationID	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	AnnualAverage	Years
MoranbahWaterTreatment	SE	34038	8.36	7.76	7.16	6.06	4.66	3.86	4.06	5.26	6.96	8.36	8.86	8.86	6.69	
TwinHills	SW	36047	7.86	6.86	6.46	5.56	3.96	3.26	3.46	4.56	6.46	8.26	8.96	9.06	6.23	
CollinsvillePostOffice	NE	33013	6.56	6.06	5.56	4.76	3.86	3.26	3.56	4.46	5.66	6.86	7.26	7.26	5.43	
Average			7.6	6.9	6.4	5.5	4.2	3.5	3.7	4.8	6.4	7.8	8.4	8.4	6.1	
2050		0.82														
Station		StationID	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	AnnualAverage	Years
MoranbahWaterTreatment	SE	34038	8.82	8.22	7.62	6.52	5.12	4.32	4.52	5.72	7.42	8.82	9.32	9.32	7.15	
TwinHills	SW	36047	8.32	7.32	6.92	6.02	4.42	3.72	3.92	5.02	6.92	8.72	9.42	9.52	6.69	
CollinsvillePostOffice	NE	33013	7.02	6.52	6.02	5.22	4.32	3.72	4.02	4.92	6.12	7.32	7.72	7.72	5.89	
Average			8.1	7.4	6.9	5.9	4.6	3.9	4.2	5.2	6.8	8.3	8.8	8.9	6.6	
2070		1.2														
Station		StationID	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	AnnualAverage	Years
MoranbahWaterTreatment	SE	34038	9.2	8.6	8	6.9	5.5	4.7	4.9	6.1	7.8	9.2	9.7	9.7	7.53	
TwinHills	SW	36047	8.7	7.7	7.3	6.4	4.8	4.1	4.3	5.4	7.3	9.1	9.8	9.9	7.07	
CollinsvillePostOffice	NE	33013	7.4	6.9	6.4	5.6	4.7	4.1	4.4	5.3	6.5	7.7	8.1	8.1	6.27	
Average			8.4	7.7	7.2	6.3	5.0	4.3	4.5	5.6	7.2	8.7	9.2	9.2	7.0	
2090		1.6														
Station		StationID	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	AnnualAverage	Years
MoranbahWaterTreatment	SE	34038	9.6	9	8.4	7.3	5.9	5.1	5.3	6.5	8.2	9.6	10.1	10.1	7.93	
TwinHills	SW	36047	9.1	8.1	7.7	6.8	5.2	4.5	4.7	5.8	7.7	9.5	10.2	10.3	7.47	
CollinsvillePostOffice	NE	33013	7.8	7.3	6.8	6	5.1	4.5	4.8	5.7	6.9	8.1	8.5	8.5	6.67	
Average			8.8	8.1	7.6	6.7	5.4	4.7	4.9	6.0	7.6	9.1	9.6	9.6	7.4	
2090 Wetter/Low Evap		0.72														
Station		StationID	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	AnnualAverage	Years
MoranbahWaterTreatment	SE	34038	8.72	8.12	7.52	6.42	5.02	4.22	4.42	5.62	7.32	8.72	9.22	9.22	7.05	
TwinHills	SW	36047	8.22	7.22	6.82	5.92	4.32	3.62	3.82	4.92	6.82	8.62	9.32	9.42	6.59	
CollinsvillePostOffice	NE	33013	6.92	6.42	5.92	5.12	4.22	3.62	3.92	4.82	6.02	7.22	7.62	7.62	5.79	
Average			8.0	7.3	6.8	5.8	4.5	3.8	4.1	5.1	6.7	8.2	8.7	8.8	6.5	
2090 Drier/higher evap		3														
Station		StationID	1 Jan	2 Feb	3 Mar	4 Apr	5 May	6 Jun	7 Jul	8 Aug	9 Sep	10 Oct	11 Nov	12 Dec	AnnualAverage	Years
MoranbahWaterTreatment	SE	34038	11	10.4	9.8	8.7	7.3	6.5	6.7	7.9	9.6	11	11.5	11.5	9.33	
TwinHills	SW	36047	10.5	9.5	9.1	8.2	6.6	5.9	6.1	7.2	9.1	10.9	11.6	11.7	8.87	
CollinsvillePostOffice	NE	33013	9.2	8.7	8.2	7.4	6.5	5.9	6.2	7.1	8.3	9.5	9.9	9.9	8.07	
Average			10.2	9.5	9.0	8.1	6.8	6.1	6.3	7.4	9.0	10.5	11.0	11.0	8.8	

INDEPENDENT DESKTOP REVIEW OF RISK LEVEL AND APPROPRIATE CAPPING STRATEGY FOR TSF CELL B AT YANDAN GOLD MINE



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EXECUTIVE SUMMARY

Dr David Williams was commissioned by Mr Peter Rohner of GBM Resources Ltd, to carry out an Independent Desktop Review of the risk level and appropriate capping strategy for TSF Cell B at Yandan Gold Mine in Central Queensland.

Based on the available information, TSF Cell B satisfies Table 6-1 in the ERC User Guide (2009) for a Low Risk Category, and grass on a 400 to 600 mm gravelly topsoil cover is recommended. This is supported by the sulfide minerals in the Cell B tailings having completely oxidised to at least 600 mm depth, and revegetation of the trial 400 to 600 mm of gravelly topsoil placed on the Cell B tailings achieving similar success to reference sites, with similar minor erosion, over a 7-year period. The available information does not support a High Risk Category as considered by the Queensland Department of Environment and Science (DES).

Consideration could be given to compacting the surface tailings to form a low permeability layer to enhance the store and release function of a revegetated gravelly topsoil cover on TSF Cell B. This would better hold-up moisture to be available to support revegetation, limit net percolation and seepage, and limit potential salt uptake into the cover. Surface salinity is most likely related to evaporative concentration in ponded surface water rather than to uptake from the tailings.

O'Kane did not consider a revegetated gravelly topsoil cover, as has been demonstrated to be successful on TSF Cell B tailings. O'Kane considered a deficient and limited thickness store and release cover design, with a capillary break (or drain), and with no low permeability layer to hold-up rainfall infiltration, limit net percolation and limit salt uptake. O'Kane focussed on much thicker cover system designs incorporating capillary break(s) of unspecified coarse rock and a low permeability layer of compacted clay.

O'Kane's inclusion of a capillary break in their Base Case and an upper capillary break in their Case 2 is counter-productive, since they would act as a drain to increase net percolation into the underlying tailings. Capillary breaks need to exclude fines to be effective and are considered prone to failure in the longer-term due to settlement and fines migration. Further, given the absence of residual sulfide minerals in the upper Cell B tailings and their low permeability, a capillary break is not needed.

Excessive thickness of the combined topsoil and growth medium in some of the O'Kane cover system designs would lead to deep drainage beyond the rooting zone of the proposed grass cover.

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1 INTRODUCTION

Dr David Williams was commissioned by Mr Peter Rohner of GBM Resources Ltd, to carry out an Independent Desktop Review of the risk level and appropriate capping strategy for TSF Cell B at Yandan Gold Mine (Yandan) in Central Queensland. Reference was made to:

- Information on the mineralogy of the ore and hence the tailings in Cell B.
- RGS Letter Report R001-C on Yandan Cell B Soil, Oxide and Sulfide Tailings Assessment, dated 31 July 2015.
- Monitoring of ongoing capping trials on Cell B from 2014 to 2021, including an AARC Yandan Gold Mine Rehabilitation Monitoring Report, dated 22 January 2021.
- Report by O'Kane Consultants Pty Ltd (O'Kane) on Yandan Gold Mine TSF Cell B Conceptual Cover System Design Update, dated 1 December 2019.
- Various correspondence from meetings with the Queensland Department of Environment and Science (DES).

2 REVIEW OF RISK AND APPROPRIATE CAPPING

Review comments are highlighted in ***bold italics***.

2.1 Background

The Yandan orebody comprises generally very fine-grained gold within two-stage bleaching around the ore of quartz, illite, K-feldspar and pyrite, overprinted by intense kaolin alteration. The composition of the ore suggests clay-dominated tailings.

The Yandan TSF comprises two cells. Cell A was revegetated directly on tailings and was considered in Straits Gold's Rehabilitation Review in 2013 to have been largely effective in terms of revegetation and surface drainage, apart from limited central ponding and lack of revegetation (see Figure 1, Figure 2.2 in the O'Kane Report). ***No comment is offered in the O'Kane Report, although the bare patch in the middle of Cell A may be related to consolidation of the tailings producing a low spot prone to ponding. Salinity at this location is most likely related to evaporative concentration rather than to uptake from the tailings.***



Figure 1 Revegetated TSF Cell A and largely unvegetated Cell B

2.2 Geochemical Assessment of Soil and Cell B Tailings

RGS sampled 85 soil, oxide tailings, sulfidic tailings and mixed tailings to a depth of 600 mm, at the locations shown in Figure 2 (Figure 2-2 in the RGS Report). ***Note the partial revegetation seen directly on the tailings in Figure 2.*** The measured soil 1(solids):5(deionised water) paste pH varied from 3.9 to 7.0, the oxide tailings paste pH varied from 4.1 to 6.5, the sulfidic tailings paste pH varied from 4.0 to 6.1, and the mixed tailings paste pH varied from 4.0 to 6.6. There was no measured alkalinity. The tailings samples did not generally produce acidity, with only nine tailings samples producing acidity ranging from 6 to 35 mg/L, averaging 17 mg/L.

The soil 1(solids):5(deionised water) paste electrical conductivity (EC) varied from 100 to 2,000 $\mu\text{S}/\text{cm}$, the oxide tailings paste EC varied from 600 to 2,950 $\mu\text{S}/\text{cm}$, the sulfidic tailings paste EC varied from 600 to 2,400 $\mu\text{S}/\text{cm}$, and the mixed tailings paste EC varied from 650 to 2,350 $\mu\text{S}/\text{cm}$. ***It is noted that the paste EC is not a true measure of the EC of the pore water, which can only be determined by extracting pore water. For relatively dry samples, producing a paste results in crystallised salts being dissolved, which over-estimates the salinity of the pore water (Indrawan et al. 2012¹).*** The dominant anion is sulfate and the majority of the samples produced water with an EC suitable for irrigation purposes.

All 85 samples were classified as “barren” (containing essentially no residual sulfide minerals) based on the Acid Base Accounting. The sulfide minerals present in the tailings were completely oxidised to a depth of 600 mm, and any future very low acid forming potential would come from the pore water or secondary minerals such as Jarosite. Metals, such as aluminium, iron and manganese, were low compared with average crustal abundance, and other metals, such as arsenic and mercury, were sparingly soluble. RGS suggested that any residual acid generation could be mitigated by adding alkaline minerals such as lime, provided that elevating the pH did not cause the release of metals from secondary minerals such as Jarosite.

RGS considered that the revegetation of the Cell B tailings, apart from along drainage lines (as seen in Figure 2), is likely limited by the availability of water. The tailings in Cell B were considered by RGS to have low permeability, particularly if compacted, limiting deep drainage. There was no apparent accumulation of soluble salts in the trial cover on Cell B due to capillary action, obviating the need for a capillary break in the cover system, which in any case is prone to failure over time due to settlement and fines migration. Further, there was no accumulation of tailings in the surface soils due to wind erosion. RGS recommended a soil cover 0.5 to 1.0 m thick.

¹ Indrawan, I.G.B., Williams, D.J. and Scheuermann, A. (2012). Determination of the true electrical conductivity of a saline clay. *Proceedings of Eleventh Australia-New Zealand Conference on Geomechanics, Melbourne, Australia, 15-18 July 2012*, 92-95.

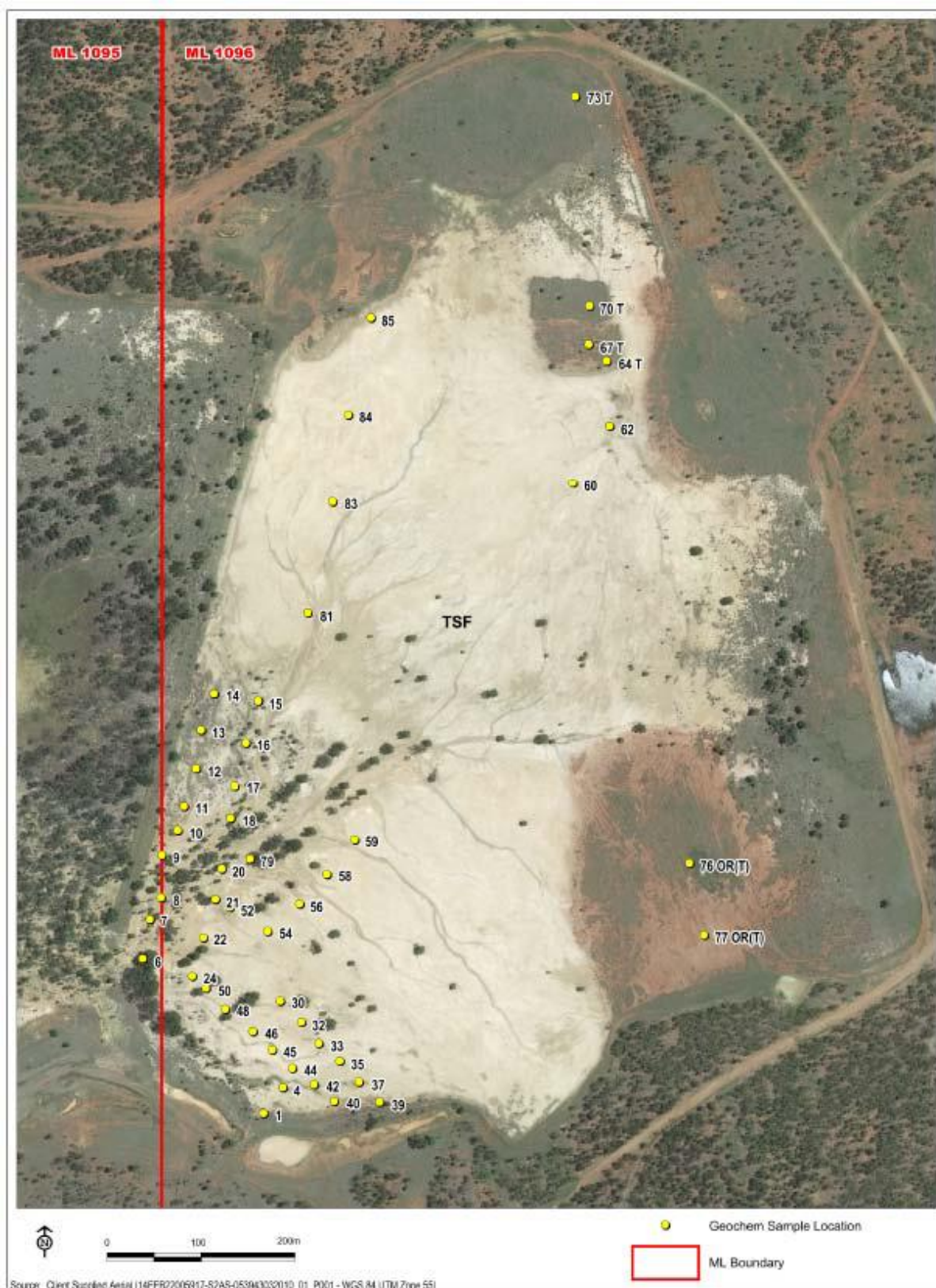


Figure 2 RGS sample locations on TFS Cell B

2.3 Monitoring of Ongoing Capping Trials on Cell B

AARC reported in 2021 on rehabilitation monitoring as summarised in Table 1 and 2 (from Tables 1 and 2 of AARC Report, and a supplied spreadsheet for revegetation towards the end of the dry season on 24-26 August 2020), with the rehabilitation sites shown in Figure 3 (Figure 2 in the AARC Report). The revegetation was dominated by grasses, with some forbs (flowering plants) and occasional shrubs. It is clear from Table 2 that direct revegetation of Cell A oxide tailings, and revegetation of 400 to 600 mm of gravelly topsoil on Cell B sulfide tailings that had completely oxidised to a depth of at least 600 mm depth, achieved similar success to the reference sites. Revegetation of thin topsoil on Cell B tailings was somewhat less successful compared with the reference site. Vegetation cover on all sites is greener, and tends to be taller and at a higher percentage, during and following the wet season. Erosion of the reference sites and revegetated covers was generally minor.

Table 1 Rehabilitation monitoring

NUMBER	DATES	SEASON
1	8-9 October 2014	Pre-wet
2	25-26 March 2015	Wet
3	10-11 June 2015	Post-wet
4	13-14 August 2015	Dry
5	17-18 May 2016	Post-wet
6	22-22 July 2017	Post-wet
7	28-29 May 2018	Post-wet
8	25-26 February 2019	Post-wet
9	24-26 August 2020	Dry

Table 2 Revegetation at end of dry season on 19 September 2020

SITES	YEAR ESTABLISHED	% COVER AUG 20
Reference (R1 to R3)	2014	20, 24 & 71
Cell A directly on oxide tailings (A1 & A2)	2014	42 & 39
Cell B 300 mm topsoil (B1 & B2)	2014	18 & 12
Cell B 450 mm topsoil (B3 & B4)	2014	28 & 23
Cell B 400 to 600 mm gravelly topsoil (B5 & B6)	2014	31 & 57

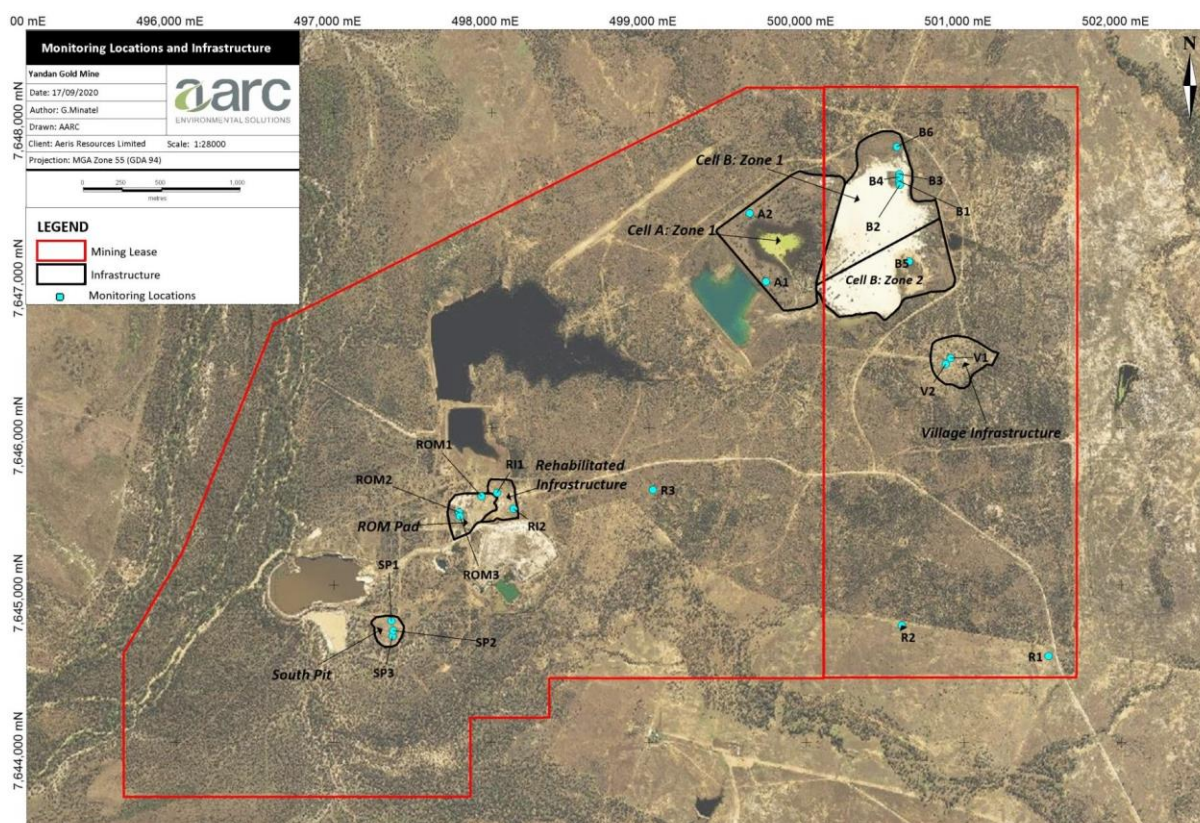


Figure 3 Locations of rehabilitation monitoring sites

2.4 Assessment of Risk Category for TSF Cell B

According to the ERC User Guide (2019)², the key entry for review by the DES is the Risk Category selected by the User, which should reflect the risk that TSF Cell B poses to the environment. Table 6-1 in the ERC User Guide (2019) provides Risk Category characteristics to inform the selection of the Risk Category. For TSFs, these are reproduced in Table 3.

On the basis of the available information, TSF Cell B has the following characteristics:

- ***Sulfide minerals in the tailings are completely oxidised to a depth of at least 600 mm.***
- ***Metals, such as aluminium, iron and manganese, are low compared with average crustal abundance, and other metals, such as arsenic and mercury, are sparingly soluble; hence salinity is low.***
- ***The tailings support traffic.***
- ***The TSF embankments are <15 m high.***

² DES. (2019). User Guide for Estimated Rehabilitation Cost Calculator for Mining. Operational Support, Department of Environment and Science, State of Queensland. (https://environment.des.qld.gov.au/_data/assets/pdf_file/0029/89615/rs-gl-user-guide-erc-calculator-mining.pdf).

- *The compacted tailings are of low permeability; that is, suitable as a low permeability layer to hold-up rainfall infiltration, limit net percolation into the underlying tailings and hence limit seepage to the environment, and limit potential uptake of salts into the cover.*
- *Revegetation of 400 to 600 mm of gravelly topsoil placed on the Cell B tailings achieved similar success to reference sites, with similar minor erosion, over a 7-year period.*

On this basis, TSF Cell B satisfies Table 6-1 in the ERC User Guide (2009) for a Low Risk Category, for which a revegetated cover is required. DES considers the TSF Cell B to be High Risk due to the presence of sulfidic tailings, which is inconsistent with the available information, including the successful revegetation of 400 to 600 mm of gravelly topsoil placed on the Cell B tailings.

Table 3 Risk Category characteristics for TSFs

RISK CATEGORY	CHARACTERISTICS FOR TSFS
High	Potentially acid forming (PAF) material Other highly reactive materials including (ARD/AMD/NMD) Poor consolidation and low shear strength tailings Requiring composite liners (e.g., HDPE) Embankments >30 m high Observed contaminated seepage capable of causing environmental harm
Medium	Moderately reactive materials (ARD/AMD/NMD) Hypersaline tailings that could impact on the proposed end land use objectives for the facility Low strength consolidated tailings Embankments 15 to 30 m high
Low	Low reactive materials (ARD/AMD/NMD) Moderate to low salinity Moderate strength consolidated tailings Embankments <15 m high
Very Low	Zero reactive materials (ARD/AMD/NMD) Low salinity Moderate strength consolidated tailings Embankments <15 m high

2.5 TSF Cell B Cover System Design by O’Kane

A store and release cover system was originally proposed by O’Kane as a conceptual cover system design for Cell B in 2015, but without a “low permeability layer”. **The selection of a store and release cover system is consistent with the GARD Guide (2011), as shown in Figure 4 (Figure 4.3 in the O’Kane Report).** All covers have some “store and release” function, including direct revegetation of inert tailings underlain by low permeability tailings, as was largely successfully applied to Cell A. The vital components of a store and release cover are an underlying low permeability layer to “hold-up” rainfall infiltration, limit net percolation into the underlying tailings, and limit potential uptake of salts into the cover, and a growth medium to sustain revegetation. Where it is desirable to limit rainfall runoff and erosion, the upper surface may be hummocked.

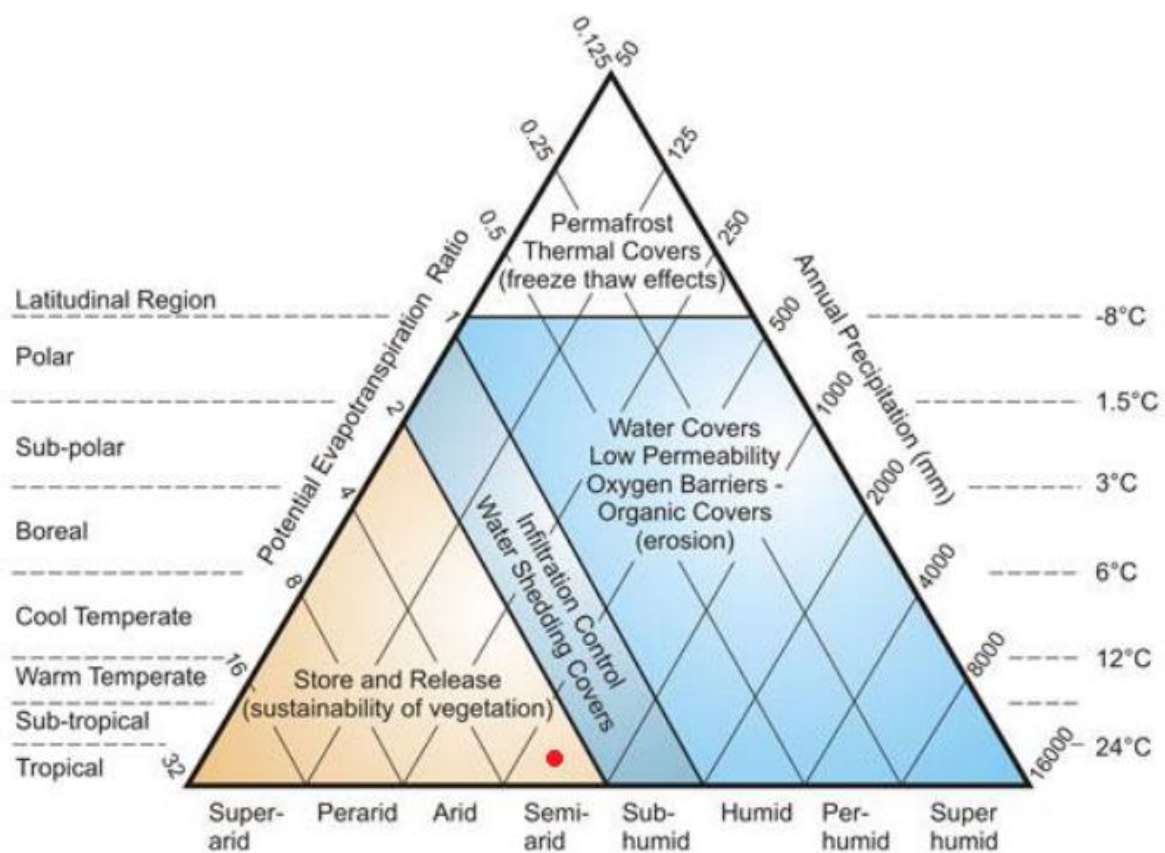


Figure 4 Recommended cover system for Yandan TSF Cell B (indicated by red dot)

DES required a cover on Cell B that limits the potential for acid and metalliferous drainage (AMD), through a low permeability layer over the sulfidic tailings. **In fact the upper 600 mm depth of tailings, at least, are oxidised. DES did not require a capillary break layer.**

Subsequently, DES was prepared to consider an alternative capping design (Case 4 in Figure 5), supported by the results of a trial cover established on representative tailings. The alternative cover system design and trial would need to be certified by a suitably qualified, independent, third party reviewer. There is no mention of the need for cover trials in the ERC User Guide (2019).

The objectives of the cover system are to ensure clean surface runoff and limit surface erosion, limit potential salt uptake into the cover, limit net percolation into the sulfide tailings and the seepage of AMD, and support future cattle grazing while avoiding deep-rooted trees.

2.5.1 Cover System Designs Considered by O’Kane

O’Kane assessed the suitability of available cover materials, including Topsoil, Growth Medium, Coarse Rock, and Clay from an offsite borrow location. O’Kane considered four cover system designs:

1. The previously proposed store-and-release cover system design;
2. Incorporating a double capillary break to the DES default thickness;
3. Incorporating a single capillary break to the DES default thickness; and
4. Incorporating an alternative single capillary break thickness.

The cover system designs are compared in Figure 5 (Figure 5.1 in the O’Kane Report). ***It is noted that O’Kane did not include among their cover system designs a store and release cover with an underlying low permeability layer, as is normally required to hold-up rainfall infiltration and limit net percolation and salt uptake. This is despite all of the other three designs incorporating a low permeability (Barrier) layer. Their Base Case included a capillary break (of Coarse Rock), which is essentially a “drain” in the absence of an overlying low permeability layer. It is further noted that the thickness of the Base Case is much less than that of the other designs considered, with the Growth Medium absent. These deficiencies make comparisons between the cover system designs somewhat meaningless, and the results biased against a store and release cover system. It is also not clear how O’Kane determined the representative dimension of the “variable” thickness of Oxide Tailings to be 0.4 m, given that RGS found oxidised tailings to at least 0.6 m depth, nor the rationale for the variable thickness of Topsoil between the alternative cover system designs. Further, the O’Kane Report did not consider compacted tailings as a possible low permeability layer, as suggested by RGS (see Section 2.2).***

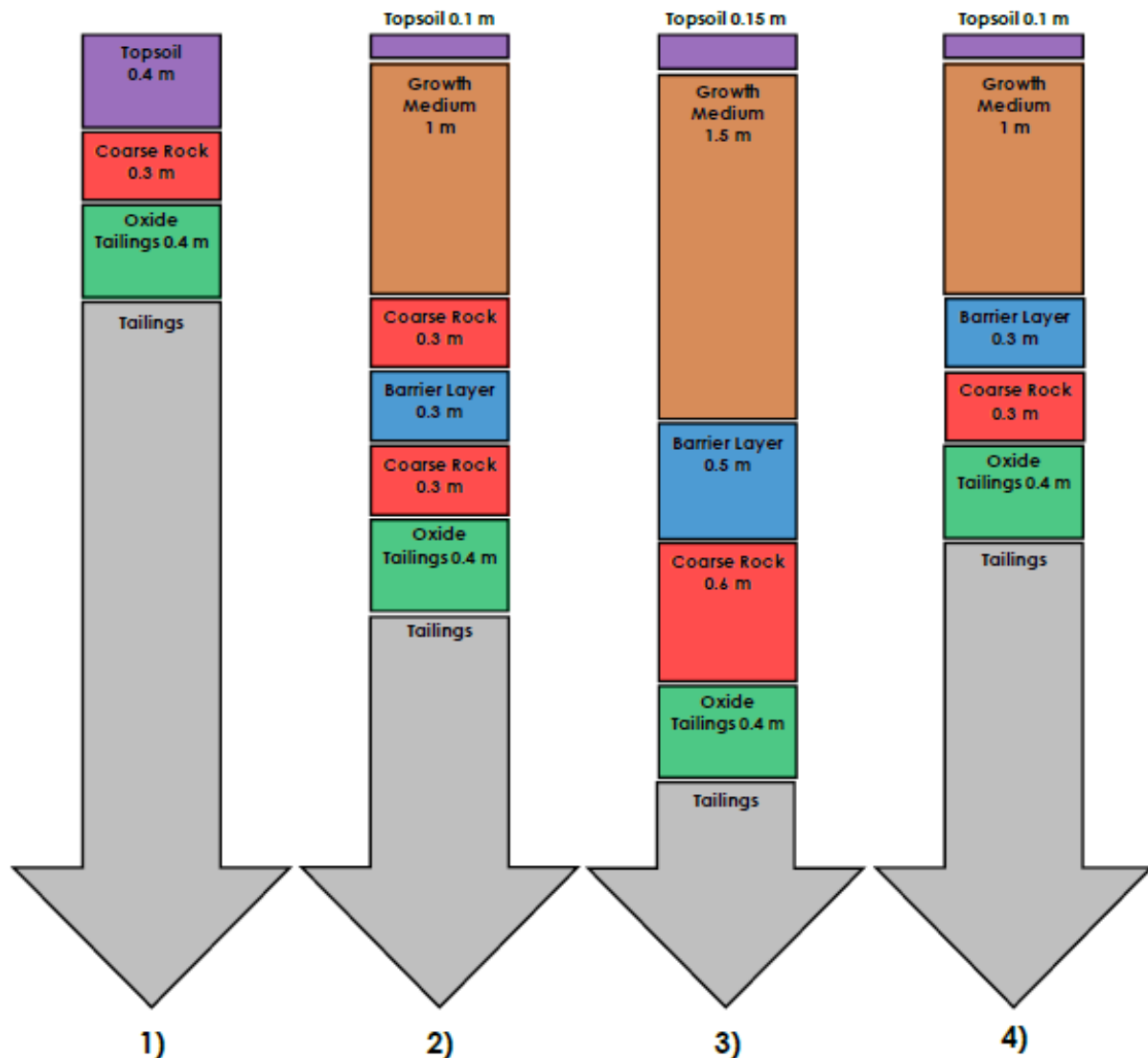


Figure 5 Four cover system designs considered by O’Kane

2.5.2 Available Cover Materials and Their Geotechnical Parameters

The available cover materials identified by O’Kane include Topsoil, Growth Medium, Coarse Rock, and Clay from an offsite borrow location, plus the Oxide Tailings. **Figure 3.16 of the O’Kane Report indicates a laboratory-measured Air Entry Value (AEV) for the Compacted Clay (Barrier Layer) of about 8 kPa. Figure 5.2 in the O’Kane Report indicates that all of the cover materials were presumed to have a similar, low AEV of 1 to 3 kPa, which is more representative of Coarse Rock. The Topsoil, Growth Medium and Coarse Rock all have a very much higher inferred dry density (ρ_{dry}) than would be expected, averaging about 2.1 t/m³ (for a very low porosity n of about 0.2 and a very low saturated gravimetric moisture content w_{sat} of about 9%). These materials would be placed loose in practice, Topsoil and Growth Medium being intended to promote and sustain revegetation, and the Coarse Rock (capillary break) being loose by virtue of its lack of fines.**

Figure 3.16 of the O’Kane Report indicates for the Compacted Clay a low ρ_{dry} of about 1.54 t/m^3 (for n of about 0.42 and w_{sat} of about 27%). Figure 5.2 of the O’Kane Report presumes for the Compacted Clay a more reasonable ρ_{dry} of about 1.78 t/m^3 (for n of about 0.33 and w_{sat} of about 19%). The Modified maximum dry densities were much higher, ranging from 2.05 to 2.22 t/m^3 , at very much lower optimum gravimetric moisture contents ranging from 10 to 7%, which are considered unrepresentative of field conditions.

The Oxide Tailings were presumed to have a ρ_{dry} of only about 1.57 t/m^3 (for n of 0.42 and a high w_{sat} of 27%), which could be increased though compaction.

The saturated hydraulic conductivity (k_{sat}) values adopted by O’Kane are reproduced in Table 4 (Table 5.1 in the O’Kane Report). **Presumably the Sulfidic Tailings are presumed to have the same k_{sat} as the Oxide Tailings.**

Table 4 Saturated hydraulic conductivity values adopted by O’Kane

MATERIAL	SATURATED HYDRAULIC CONDUCTIVITY (m/s)
Topsoil	5×10^{-6}
Growth Medium	1×10^{-4}
Coarse Rock	5×10^{-3}
Low Permeability (Barrier) Layer	1×10^{-9}
Oxide Tailings	1×10^{-7}

The k_{sat} of the low permeability (barrier) layer is apparently presumed by O’Kane to be $1 \times 10^{-9} \text{ m/s}$ (up to 32 mm/year for a constant supply of water at unit hydraulic gradient). This is higher than that obtained in the laboratory, but lower than that obtained in the field. Under the climatic conditions of Central Queensland, rainfall may fall on perhaps 10% of the days of the year, and the low permeability layer would be unsaturated for most of the year, for which an unsaturated hydraulic conductivity of perhaps two orders of magnitude lower than the saturated value may apply, giving an average hydraulic conductivity of the order of $1 \times 10^{-10} \text{ m/s}$ (up to 3 mm/year). The k_{sat} of the Oxide Tailings is apparently presumed to be $1 \times 10^{-7} \text{ m/s}$, and may average $1 \times 10^{-8} \text{ m/s}$ (up to 315 mm/year). The estimated saturated hydraulic conductivities of the other materials appear reasonable, and it is noted that the Coarse Rock is presumed to be free-draining.

Figure 5.3 in the O’Kane Report indicates that all materials have the same saturated diffusion coefficient of $1.78 \times 10^{-9} \text{ m}^2/\text{s}$, giving a conservative (high) uptake of salts from the tailings. It would expected that the coarser-grained the material, the greater the saturated diffusion coefficient.

O'Kane adopted a conservative vegetation coverage of 28%, ***which is low compared with measured dry season coverage***. Further, O'Kane adopted a root penetration depth of 3.0 m, with the majority of the roots within the top 1.0 m depth, ***irrespective of the variable depth of the combined Topsoil and Growth Medium in the different cover system designs. This is not rational. Grass roots are relatively shallow, and would also not be expected to penetrate the Oxide Tailings, given that it is acidic (measured at 3.6, much lower than that of the Sulfidic Tailings measured at 5.9).***

2.5.4 Numerical Modelling by O'Kane

The one-dimensional (***vertical***) numerical modelling carried out by O'Kane assessed net percolation (NP) of rainfall, water storage in the cover available for revegetation, and salt uptake into the cover. O'Kane adopted a unit hydraulic gradient at the lower boundary of the model (***presumably at 3 m depth, but this is not made clear***), presuming that the water table within the tailings does not influence the water balance of the cover systems. ***However, the intention of the low permeability (Barrier) layer is to hold-up or perch water, so that the hydraulic gradient at the lower boundary will vary and could be much higher than unity following rainfall infiltration events.***

From the results of the numerical modelling, O'Kane concluded:

- The Base Case design predicted NP of approximately 54% of average annual rainfall, without revegetation.
- The double and single capillary breaks to the DES default thickness predicted a moderate reduction in NP, without revegetation.
- The alternative single capillary break thickness predicted the greatest reduction in NP (of 4% of average annual rainfall), without revegetation.
- Incorporating capillary breaks served to increase the storage of water in the cover system.
- With revegetation, low NP was predicted for all alternatives, including the Base Case.
- Incorporating a single capillary break to the DES default thickness was predicted to best limit salt uptake into the cover, although all capillary break alternatives were predicted to limit salt uptake, and the Base Case to a lesser degree.
- Rainfall runoff was predicted to increase from the Base Case (2% of average annual rainfall) to Cases 3 to 4 (16 to 20% of average annual rainfall).

The slope of the cover surface is not given by O'Kane, and no explanation is offered for the variation in rainfall runoff between the different cover system designs, which should be similar for the same slope. It could be that the slope is that of the tailings beach (presumably about 1%). A store and release cover is normally meant to contain runoff.

2.5.5 Comments on Effectiveness of O'Kane Cover System Designs

Dr Williams offers the following comments on the four O'Kane cover system designs and their likely effectiveness in sustaining grasses and limiting net percolation into the tailings:

- **Base Case 1:**
 - *The k_{sat} of the Topsoil is 50% higher than that of the bare Oxide Tailings, and hence will allow 50% greater rainfall infiltration, and reduce evaporation.*
 - *The free-draining capillary break (Coarse Rock) underlying the Topsoil will accept all of the infiltrated rainfall until it is saturated, filling a porosity of about 0.3; that is, 90 mm of rainfall.*
 - *The Oxide Tailings is sufficiently permeable to percolate all of the rainfall infiltration into the cover.*
 - *Hence, the Base Case cover system is far less effective in limiting net percolation of rainfall into the tailings than no cover.*
- **Case 2:**
 - *The 0.1 m of Topsoil and 1 m of Growth Medium will essentially allow all rainfall to infiltrate the cover and wet up the underlying capillary break (Coarse Rock).*
 - *This will make water largely unavailable to shallow-rooted grasses.*
 - *Wetting-up of the upper capillary break (Coarse Rock) will maintain a head of water above the low permeability (Barrier) layer, encouraging net percolation into the lower capillary break (Coarse Rock) and tailings below.*
- **Case 3:**
 - *The 0.1 m of Topsoil and 1.5 m of Growth Medium will essentially allow all rainfall to infiltrate the cover to the low permeability (Barrier) layer.*
 - *This will make water largely unavailable to shallow-rooted grasses.*
 - *It will also maintain a head of water above the low permeability layer, encouraging net percolation into the capillary break (Coarse Rock) and tailings below.*
- **Case 4:**
 - *The 0.1 m of Topsoil and 1 m of Growth Medium will essentially allow all rainfall to infiltrate the cover and wet up the underlying low permeability (Barrier) layer.*
 - *This will make water largely unavailable to shallow-rooted grasses.*
 - *It will also maintain a head of water above the low permeability (Barrier) layer, encouraging net percolation into the capillary break (Coarse Rock) and tailings below.*

No specification for the capillary break material is given in the O’Kane Report apart from the descriptor “Coarse Rock”. The function of a capillary break is to limit capillary rise from below, which requires the exclusion of fines that would lead to capillary rise. Coarse Rock would need to be washed to exclude fines. Placing fine-grained growth materials above a capillary break leads to the inevitable transport of fines with rainfall infiltration into the capillary break, rendering it ineffective. Further, placing a free-draining layer at the base of the growth materials serves no useful purpose and is likely to be detrimental, as described above. A capillary break would best be placed directly above the saline tailings, and beneath a low permeability layer. However, there remains a potential for fines from the low permeability layer to migrate into the capillary break. An effective low permeability layer will limit both downward and upward flow, removing the need for a capillary break, which is difficult to get right and to sustain.

No comment is made in the O’Kane Report about whether the cover system designs will limit oxygen ingress into the tailings, and hence limit the oxidation of the Sulfidic Tailings. However, due to the dry seasonal climate of Central Queensland, the covers will be relatively dry for much of the year and oxygen ingress is unlikely to be limited.

2.5.6 Construction Costs Estimated by O’Kane

The estimated construction costs for all three designs incorporating capillary breaks were considerably higher than those estimated for the Base Case, with the alternative single capillary break thickness the least costly of these. The O’Kane Report recommended a cover design incorporating the alternative single capillary break thickness as the most cost-effective. **A store and release cover with an underlying low permeability (Barrier) layer should also be assessed for cost-effectiveness, along with direct revegetation as a base case, and a revegetated gravelly topsoil cover.**

3 CONCLUSIONS AND RECOMMENDATIONS

Based on the available information, TSF Cell B satisfies Table 6-1 in the ERC User Guide (2009) for a Low Risk Category, and grasses on a 400 to 600 mm gravelly topsoil cover is recommended. This is supported by the sulfide minerals in the Cell B tailings having completely oxidised to at least 600 mm depth, and revegetation of the trial 400 to 600 mm of gravelly topsoil placed on the Cell B tailings achieving similar success to reference sites, with similar minor erosion, over a 7-year period. The available information does not support a High Risk Category as considered by DES.

Consideration could be given to compacting the surface tailings to form a low permeability layer to enhance the store and release function of a revegetated gravelly topsoil cover on TSF Cell B. This would better hold-up moisture to be available to support revegetation, limit net percolation and seepage, and limit potential salt uptake into the cover. Surface salinity is most likely related to evaporative concentration in ponded surface water rather than to uptake from the tailings.

O'Kane did not consider a revegetated gravelly topsoil cover, as has been demonstrated to be successful on TSF Cell B tailings. O'Kane considered a deficient and limited thickness store and release cover design, with a capillary break (or drain), and with no low permeability layer to hold-up rainfall infiltration, limit net percolation and limit salt uptake. O'Kane focussed on much thicker cover system designs incorporating capillary break(s) of unspecified coarse rock and a low permeability layer of compacted clay.

O'Kane's inclusion of a capillary break in their Base Case and an upper capillary break in their Case 2 is counter-productive, since they would act as a drain to increase net percolation into the underlying tailings. Capillary breaks need to exclude fines to be effective and are considered prone to failure in the longer-term due to settlement and fines migration. Further, given the absence of residual sulfide minerals in the upper Cell B tailings and their low permeability, a capillary break is not needed. Excessive thickness of the combined topsoil and growth medium in some of the O'Kane cover system designs would lead to deep drainage beyond the rooting zone of the proposed grass cover.

APPENDIX A – Curriculum Vitae

Professor David J Williams

BE (Hons I), PhD, FIEAust, MAusIMM, CPEng, RPEQ

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Professor David Williams is a Chartered and Registered Professional Engineer with over 40 years of experience. His discipline area is Geotechnical Engineering, and he is internationally recognised for his expertise and experience in mine waste management and mine closure. He is particularly recognised for his expertise in tailings dams, and the closure and rehabilitation of tailings dams and waste rock dumps, including the design of covers. He carries out high-level reviews of and provides expert advice and opinion on tailings dam designs, tailings and waste rock facility closure, and the closure and rehabilitation of open pits.

He authored in 2016 the Tailings Management Handbook, as part of the Commonwealth Leading practice sustainable development program for the mining industry. He is on the Working Party for the Australian National Committee for Large Dams Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure published in 2012, with an Addendum on Static Liquefaction published in 2019, and commissioned to write updates.

QUALIFICATIONS

1979	PhD, Soil Mechanics	University of Cambridge, England
1975	BE (Hons I), Civil Engineering	Monash University, Australia

AWARDS/DISTINCTIONS/FELLOWSHIPS

1996	Japan Society for the Promotion of Science Fellow
1995	The University of Queensland Collaborative Research Travel Grant
1995	Australian Minerals and Energy Environment Foundation (AMEEF) Travelling Scholarship
1993	Australian Research Fellow (Industry)
1992	AMEEF Environmental Excellence Award (Individual)
1990	Masuda Fellow for Collaborative Research in Japan, Jan-Feb
1989	The University of Queensland Collaborative Research Travel Grant

MEMBERSHIPS

From 2015	Member, Australasian Institute of Mining and Metallurgy
From 2015	Registered Professional Engineer of Queensland (RPEQ)
1986-1987	Member, National Committee, Australian Geomechanics Society
2007-2008	
From 1984	Member, Queensland Committee, Australian Geomechanics Society, Chair in 1986
From 1980	Member, Australian Geomechanics Society
From 1980	Member then Fellow, Institution of Engineers, Australia

EMPLOYMENT HISTORY

2007 – Present	Professor of Geotechnical Engineering Founder and Director of Geotechnical Engineering Centre Manager of the Large Open Pit Project School of Civil Engineering The University of Queensland
1994 – 2007	Associate Professor of Geomechanics Department of Civil Engineering The University of Queensland
1990 – 1994	Senior Lecturer in Geomechanics Department of Civil Engineering The University of Queensland
1983 – 1989	Lecturer in Geomechanics Department of Civil Engineering The University of Queensland
1980 – 1983	Geotechnical Engineer Melbourne and Brisbane Golder Associates Pty Ltd
1979 – 1980	Engineer Country Roads Board (CRB) of Victoria
1976 – 1979	Research Student University of Cambridge, England
1972 – 1976	Engineer, Cadet Engineer, CRB, Victoria

SUMMARY OF CONSULTING COMMISSIONS

Board and Expert Panel Memberships

- Member of the Independent Technical Review Board for the Ranger Mine Pit 3 Capping of Tailings from 2020
- Independent Member of the Alcoa Impoundments Lead Team from 2020
- Chair of Independent Technical Review Board for Minera Escondida-BHP, Chile from 2019
- Geotechnical Advisor to Aguamarina, Chile from 2019
- Member of Expert Panel commissioned to investigate the technical causes of the failure of Tailings Dam I at the Córrego de Feijão Mine in the State of Minas Gerais, Brazil on 25 January 2019
- Member of Independent Technical Review Board for Rio Tinto Alcan Yarwun Residue Management Area Embankment Raise Designs from 2016
- Member of Independent Technical Review Panel of Life-of-Mine Tailings Storage Facility at Glencore's McArthur River Mine, Northern Territory, Australia from 2015
- Member of Northern Territory EPA Board, from 2012 to 2014

Peer Reviews of Major Projects

- Sole Independent Expert Geotechnical Reviewer for Unity Mining Limited from 2016
- Sole Independent Expert Geotechnical Reviewer for Bluestone Mines Tasmania JV Pty Ltd from 2015
- Sole Reviewer of Proposed Integrated Waste Landform Design for Central Eyre Iron Project in 2015
- Sole Independent Expert Geotechnical Reviewer for Rio Tinto Alcan Gove Residue Disposal Area from 2015
- Sole Independent Expert Geotechnical Reviewer and Annual Dam Inspections for QAL Residue Disposal Area and Ash Dams from 2013
- Sole Independent Expert Geotechnical Reviewer for Rio Tinto Alcan Yarwun Residue Management Area from 2013
- Led International Peer Review for the South Deposit TSF at Savage River Mine in Tasmania in 2012/13
- Sole Independent Expert Geotechnical Reviewer for Rio Tinto Alcan Weipa Tailings Storage Facilities in 2012 and 2014
- Peer Review of Harvey Creek Non-Erodable Waste Rock Dump Design for Ok Tedi Mining Limited in 2010/11
- Member of Expert Peer Review Team for Rio Tinto Alcan Weipa Tailings Storage Facilities from 2009
- Member of the International Technical Advisory Group reporting to the South Australian Government on Rehabilitation of Brukunga Pyrite Mine from 2007

- Led International Peer Reviews for the Savage River Rehabilitation Project in Tasmania in 2002, 2005, 2009 and 2013
- Led International Peer Review on handling acid generating waste rock dumping and dump closure strategies at Cadia Hill Gold Mine in New South Wales in 2002/3
- Member of the Peer Review Team for Stage 2 of the Stuart Oil Shale Project at Gladstone in Queensland in 2004
- Peer Reviewer of the rehabilitation of the San Manuel Copper Mine tailings facility in Arizona, USA in 2004
- Member of the 2005 Peer Review Team that reviewed future red mud disposal, containment and rehabilitation at QAL at Gladstone in Queensland in 2005
- Geotechnical Reviewer of the breach of the co-disposal dam at Burton Coal in Queensland in 2005
- Peer Reviewer of the conceptual closure plan for Worsley Alumina red mud storage in Western Australia in 2005
- Peer Reviewer for waste rock dump covers for Century Mine in North Queensland from 2007
- During 2006, David was an Expert Advisor to the EIS team for the Olympic Dam Expansion Project in South Australia, providing expert input on disposal, hydrology and closure issues for both waste rock and tailings

Expert Witness

- Expert witness through Corrs Chambers Westgarth Lawyers, in relation to coal washery rejects used as filling for residential sub-division purposes
- Expert witness through McCullough Robertson Lawyers, in relation to the failure of a concrete arch reclaim tunnel beneath a coal stockpile
- Expert witness in relation to professional misconduct cases brought by the Queensland Professional Engineers Registration Board
- Numerous expert witness commissions related to residential and commercial building footing failures and slope instability

Consultancies

Professor David John Williams is widely sought for his expert input, in particular to mine waste disposal and mine site rehabilitation and remediation at operating mines throughout Australia and overseas. In Australia, he has consulted on numerous coal mines throughout Queensland and New South Wales; on Red Dome Gold Mine closure, Kidston closure, Osborne waste disposal, Ivanhoe Cloncurry mine closure, Phosphate Hill gypsum disposal, QERL processed waste storage facility closure, and Century Zinc Mine waste rock dumping in Queensland; Cadia Hill Gold Mine waste rock dumping and dump closure in New South Wales; Mt Morgans Gold Mine co-disposal, WMC Resources' nickel operations tailings closure and Minara heap leaching in Western Australia; waste disposal issues at the Ballarat East and Heathcote gold mines in Victoria; and a review of ARD treatments at Savage River Mine in Tasmania. Overseas he has consulted on tailings depositional design and

water balance for the Kori Kollo Mine in Bolivia, a review of co-disposal of tailings and waste rock at Porgera Gold Mine and the closure of Misima Gold Mine in PNG, waste disposal design for the Goro Nickel project in New Caledonia, and advice on co-disposal for the Martabe Project in Indonesia.

David has been involved in material characterisation testing and the design of numerous mine waste covers throughout Australia, and the design, installation and monitoring of lysimeters and mine waste covers at Kidston Gold Mines, WMC Resources' Mt Keith Nickel Operations, QERL's Stuart Oil Shale Project, a large-scale trial waste rock dump at Cadia Hill Gold Mine, and a large-scale trial tailings cell at Jubilee Nickel Mine.

David has been invited to visit numerous mining regions and individual mines throughout Australia, and in Canada, the USA, Brazil, South Africa, UK, China, Chile, PNG, New Caledonia, Spain and Mozambique.

MAJOR RESEARCH ACHIEVEMENTS

From 1989, Professor Williams carried out research under NERDDC and ACARP Projects on the characterisation of the deposit formed on the pumped co-disposal of combined washery wastes, which has since been adopted at numerous coal mines in Australia and Indonesia.

From 1996, David developed the store/release cover system suited to seasonally dry climates, for application to covering acid generating rock dumps at Kidston Gold Mine in north Queensland, and has had a long-term involvement in researching and monitoring this cover system, as evidenced by his numerous papers on his research on this topic. The store/release cover system on the tops of the Kidston rock dumps has been shown to limit percolation to less than 1% of rainfall, and to support a sustainable vegetation cover comparable to that occurring along water courses in the area. He was also involved in the development of a rehabilitation strategy for the side slopes of the rock dumps at Kidston designed to maximise geotechnical and erosional stability while promoting vegetation, and analysed the wetting up by rainfall infiltration and subsequent drain-down of and seepage from the rock dumps. Store/release covers have now been adopted at numerous mine sites in dry climates worldwide.

From 1999 to 2001, David led ACARP Project C8039 to develop a risk assessment and cost-effectiveness analysis for the rehabilitation of Bowen Basin coal mine spoil. The results of the project were reported in a Literature Review and Commentary and Project Final Report, plus a spreadsheet-based risk assessment and cost-effectiveness analysis, available at: www.uq.edu.au/civil/. In 2006, David undertook a closure study for Xstrata's new Rolleston Coal Project in the Bowen Basin Coalfields.

David has since 2000 been involved in the closure design for the waste rock dump at Cadia Hill Gold Mine in New South Wales, including studies on the use of mixtures of benign trafficked rock and tailings as an alternative cover material, to overcome the shortage of suitable natural materials. In 2002/3, he led an international peer review of the rock dumping operation and closure plan. In 2004, David was successful in an ARC Linkage grant application with Cadia totalling over \$ 700,000 over 3 years, which has led to the construction of a 15 m high, world-class, demonstration, instrumented rock dump covering 7,000 m². The instrumentation includes a full weather station, 24 lysimeters at the base of the dump to monitor seepage, lysimeters on the top surface to monitor rainfall infiltration and three store/release trial covers constructed using natural and mine waste materials. To date it has shown that about 70% of the rainfall

incident on the traffic-compacted top of the dump infiltrates, with the majority going into storage within the dump during the first year, and only small amounts percolating to the base of the dump. The behaviour of the cover trials has to date been dominated by the moisture state at which they were constructed. Monitoring of the instrumented rock dump is expected to continue for at least 10 years.

From 2000 to 2003, David was a principal researcher into the physical and geochemical nature of acid generating waste rock dumps in Southern Carolina, USA (Rio Tinto's Ridgeway Mine) and Sudbury, Canada (Inco's Whistle Dump), sampled as they were being excavated and moved to a pit.

From 2001 to 2005, David led an ARC Spirt research project with industry partner WMC Resources focussed on an assessment of the long-term seepage and runoff from mine tailings storage facilities, to facilitate lease surrender. This included the monitoring of trial covers on tailings over the duration of the project and large-scale laboratory column testing and numerical analyses. Natural salt pan and rocky slope analogues under the same climatic and similar geochemical conditions were also studied to point to sustainable approaches for rehabilitating the tailings storage facilities.

From 2010, David has led three ACARP Projects, C19022, C20047 and C25040, investigating the settlement and stability of high coal mine spoil, the behaviour of problematic clay-rich coal mine tailings, and the behaviour of "mud" derived from spoil on wetting-up.

David has been sponsored by mining companies and consultants to visit numerous mining regions and mine sites worldwide, both to impart and extend his knowledge. Since 2000, he has developed a relationship with the International Network for Acid Prevention (INAP), and has contributed to INAP-sponsored research and development projects and workshops involving mine sites in the USA, Canada, Australia and PNG.

Research funding has totalled over \$10 million, including funding from ARC, ARC-SPIRT, ARC Linkage, NERDDC, ACARP-AMIRA, ACARP, MIM CRA-ATD, Kidston Gold Mines, BHP Coal and WMC Resources, Cadia Holdings, Jubilee Mines NL.

PUBLICATIONS

Professor Williams has over 300 refereed publications, including five book chapters, over 100 refereed journal articles and over 200 refereed conference publications, plus numerous research and consulting reports. About two-thirds of these publications are in the mine waste field.