Primary Gold Ltd

Toms Gully Underground Project

Further Information to the Environmental Impact Statement December 2019

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Response to Questions from Addendum by the NTEPA August 2019

1. Introduction

In August 2019 the NTEPA requested further information from Primary Gold Limited (Primary) in regard to the Addendum to the Supplement Environmental Impact Statement Toms Gully Underground Project submitted in July 2019.

Below is a table showing the questions from the NTEPA called "Attachment A – Request for Further Information on the Addendum to the supplement – Toms Gully.pdf"

ENVIRONMENTAL IMPACT STATEMENT – REQUEST FOR FURTHER INFORMATION

PRIMARY GOLD LIMITED – TOMS GULLY UNDERGROUND PROJECT – AUGUST 2019

Factor and Topic	Comment	Further Information Required
Proposal Description	It is essential for the Proponent to clearly and comprehensively articulate the Proposal, including alterations, that is to be assessed. Table 1 of the notification of alterations to the Proposal (December 2018) provides an outline of the changes to the Proposal since the Supplement was submitted in 2018. Section 2 and Table 2-1 of the Addendum provide a high level description of the key changes made to the Proposal since the Supplement. The tables in the notification and in the Addendum are in different terms. In addition, Section 5.2 of the Addendum outlines the necessity to review changes across three separate documents (the Draft EIS, the Supplement and the Addendum). This has the potential to create a lack of clarity for regulators, decision makers and stakeholders.	Provide a full outline of the current Proposal including amendments to the water management system and closure plans to address significant impacts arising from the alterations. If referencing earlier documents comprising the EIS, the response must clearly describe any details that differ from those documents. If you have any queries or require further guidance, please contact DENR officers.
Inland water environmental quality: Potential release of mine-affected water after closure	The Draft EIS and Supplement indicate that the pit contains legacy mine affected water and currently operates as sink for groundwater (including contaminated seepage) and surface water runoff. Alterations to the Proposal include the deposition of tailings and waste rock in the pit. This has the potential to affect: • whether the pit will remain a sink • the extent of freeboard during wet seasons • consequent risk of over topping without active water management Inland water quality during all phases of the Proposal, including after operations and after closure, is a key factor for potential significant impacts. Management of mine affected water from legacy AMD seepage, the pit lake, the underground mine and surface runoff is a critical part of the Proposal that will influence the potential for significant impacts to offsite water quality. The NT EPA considers that protection of the environmental, recreational and agricultural values of the Mary River catchment is an overarching environmental objective.	Demonstrate a post-closure long-term water-balance management strategy that addresses the risks of overtopping, seepage (and extent) and/or unauthorised, uncontrolled or passive discharge to the environment. Demonstrate post-closure strategy meets industry standard closure objectives. Provide water balance schematics, including volumes, for post-closure; for an average rainfall year and a very wet year.

<table>
<tr><th>Factor and Topic</th><th>Comment</th><th>Further Information Required</th></tr>
<tr><td></td><td>During life of mine active water management is proposed variously through pumping of pit water, underground mine water and other mine affected water to the water treatment plant and storage in the WSD and then release via Lake Bazzamundi or Oxbow Wetlands as relevant. The Addendum is not clear about impacts from the Proposal (as altered) during after closure when water management will be passive.

The Addendum indicates that after closure there will be a significant chance of mine-affected water being released to the environment in any wet season, assuming no active water management. This would be from three sources:

<table>
<tr><th>Source</th><th>Likelihood of release</th><th>Water quality</th></tr>
<tr><td>Pit lake</td><td>Potential for wet season spills after about 5 years post-mining, in very wet seasons (Fig 5-12 Appendix O), towards Mount Bundey Creek</td><td>Uncertain. Pit water geochemical modelling (Appendix D) indicated:
• worst-case scenario of high acidity acidic pH=2.3 (which could be treated with lime)
• AMD-generating material may be in the oxic layer and may continue to react</td></tr>
<tr><td>Oxide WRD runoff via drainage bund</td><td>90% annual probability of discharge (via the wetlands oxbow)</td><td rowspan="2">Future water quality will depend on rehabilitation of the Oxide WRD (if any) and the ROM pad (as per Mine Closure Plan). Current runoff contains contaminants (during wet season flows). While the oxbow wetland acts as a passive water treatment, measured water quality in Mount Bundey Creek has been poor in recent years.</td></tr>
<tr><td>ROM pad runoff via stormwater pond</td><td>34% annual probability of discharge (via the wetlands oxbow)</td></tr>
</table>
Additionally, the Addendum did not provide an assessment of the zone of influence around the pit, given that some mixing of waters will occur between the pit and surrounding groundwater. As the water level of the pit lake will be about 4m above the</td><td></td></tr>
</table>

<table>
<tr><th>Factor and Topic</th><th>Comment</th><th>Further Information Required</th></tr>
<tr><td></td><td>level of Mount Bundey Creek, it is possible that some seepage may occur towards Mound Bundey Creek. This could be a pathway for contaminants entering the creek.

The NT EPA's expectation in previous assessments is that legacy costs potentially borne by the community and government must be accounted for in mine planning and closure, and be avoided.

The Australian Government Leading Practice Sustainable Development Program for the Mining Industry series of handbooks (2016) for mine closure and mine rehabilitation have four general rehabilitation objectives (and that these should be seen as minimum objectives, and more site-specific rehabilitation objectives should be developed for each defined land use):
1. safe to humans, domestic livestock and wildlife
2. non-polluting
3. stable
4. able to sustain an agreed post-mining land use</td><td></td></tr>
<tr><td>Inland Water Environmental Quality and Terrestrial Environmental Quality:

Boxcut waste rock</td><td>The Addendum states that the waste rock may be placed on the existing waste rock dumps (WRDs) (p. 9). The NT EPA considers that this may reduce infiltration to these WRDs and thereby limit the production of AMD and its seepage/runoff to the environment.

As the boxcut will be excavated in the first year of the Proposal, the NT EPA considers the Proponent should know where the waste rock will be placed. It is unclear where the waste rock would be placed, the method of placement, and how this would help limit infiltration. It is also unclear what volume of material would be required to cover both WRDs (combined footprint of 54ha), and if 0.66Mt of boxcut material is sufficient for coverage. Are there priority areas where it should be placed?</td><td>Provide details on how/where boxcut waste rock will be placed on the existing WRDs, how it will help limit infiltration and reduce the generation/release of AMD from each of the WRDs.</td></tr>
</table>

2. Response to Question 1

"*Provide a full outline of the current Proposal including amendments to the water management system and closure plans to address significant impacts arising from the alterations.*

If referencing earlier documents comprising the EIS, the response must clearly describe any details that differ from those documents.

If you have any queries or require further guidance, please contact DENR officers. Primary Gold Limited, the proponent, seeks to reopen the Toms Gully Mine in the Northern Territory."

Toms Gully Mine (MLN 1058, MLN29812 and MLN29814) is 21km south east of the township of Marrakai. Access is via the Arnhem Highway to the Tom's Gully Mine turn-off and then via an established haul road one kilometre to the mine.

The current Proposal referred to in questions 1 is the "Addendum to the Supplement to the EIS for Toms Gully" (Addendum).

The Proposal or Addendum includes the following key activities:

- construction of a Boxcut and decline to access the underground ore body
- construction of a new 1GL water supply dam (WSD)
- clearing 76ha of native vegetation for the WSD, Boxcut, borrow pits and associated access tracks
- placement of all (new and historical) tailings sub aqueously and waste rock via a stacker into the existing pit lake
- establishment of a standalone water treatment plant (WTP)
- upgrade and recommissioning of the existing process plant
- underground mining
- processing of ore

Table 1 below shows the key components as shown in the Toms Gully Underground Project - Section 14A Notification December 2018 associated with Toms Gully and the subsequent Addendum to the Supplement to the EIS.

Table 1 - Key components of the current proposal

	Component	Size/capacity
Whole of Proposal	Total area of mineral leases (MLN1058, MLN29812, MLN29814)	924ha
	Total area of disturbance (existing and proposed	196ha
	Life of mine	5 years
	Operational workforce	104 workers
	Closure period	10 years
Mining	Ore to be extracted	0.90Mt
	Waste rock to be extracted from underground	0.85Mt
	Waste rock to be extracted from the Boxcut	0.66Mt
Processing	Gold to be extracted	315,000oz
	New tailings generated – to be placed in pit lake	0.90Mt
	Existing tailings – to be placed in pit lake	0.25Mt – TSF1 0.13Mt – TSF2
Proposed new Infrastructure (maximum)	Water storage dam (for treated water)	16ha 1GL
	Boxcut for new access to underground	2ha
	Borrow pits and associated access tracks required for dam embankments	58ha

Tailings

The existing tailings contained in TSF1 and TSF2 will be removed and placed into the pit within 18 months of the Boxcut excavation starting.

A small dredge will pump the existing tails to the pit as a slurry. Some of the tails maybe reprocessed through the Process Plant if the gold grade and recovery is suitable. All tails will go into the pit regardless if processed or not.

New tails from the Process Plant will be pumped straight into the pit for the duration of the life of the mine.

Additional lime/caustic will be added to the new tailings to keep the pH of the pit water at 8.5 to assist the removal of dissolved heavy metals in the pit water.

The pit water will still have a pH of 8.5 when the processing is completed and the mine is prepared for closure.

Mining and processing

Mining will be conducted by use of conventional Jumbo development drills, underground loaders and underground trucks. The mining method will be "Room and Pillar". This is detailed in the Addendum in Section "2.1 New Decline and Retention as a Barrier Pillar"

Processing will be by use of crushing, grinding, flotation and Carbon in leach (CIL) extraction process.

Disposal of waste and tailings

The underground waste and the new tailings from the process plant will be deposited into the Toms Gully pit.

The underground waste will be trucked to the south side of the pit edge. A front end loader will place the waste onto a stacker conveyor belt that will convey the waste towards the middle of the pit.

The tailings from the plant will be placed into the bottom of the pit via a floating head pipe arrangement as detailed in the Addendum section "2 Revised Project Description" and section "2.2 Use of Existing Toms Gully Pit for tailings and Waste Rock Disposal". The tailings from the existing TSF's will be pumped to the same floating head arrangement.

The Boxcut waste will not be placed in the pit, as testing of the waste has shown it to be nearly 100% non-acid producing. The waste will be placed on the existing waste dumps as detailed below in Section 3 of this document. Any acid producing Boxcut waste will be put into the pit via the stacker.

Water Management

In the Addendum it was proposed to treat water for the underground workings and any water displace above the 15m AHD in the pit. The treated water is to be pumped to a new WSD. Water is to be to be released from the WSD into Mt Bundey creek and Lake Bazzamundi in the wet season.

Since the Addendum was submitted in July 2019, Global Aquatica the supplier of the "BioAqua" treatment plant has gone out of business.

The former Technical Director of Global Aquatica approached Primary Gold to convey that the technology Global Aquatica had is able to be provided by his new company called WaterX.

Similar technology to "BioAqua" is now renamed the "Brutus" process. This process is the same as detailed in Appendix O of the Addendum.

As per the Addendum there is an alternate to the BioAqua process. It has been decided to use a Reverse Osmoses (RO) plant as the alternative.

From Toms Gully Underground Project EIS Addendum to the Supplement – Primary Golds Limited 20190715.pdf page 61 states:

"Stage 2; treatment of water for disposal or reuse. Water treated during this stage will be produced by displacement from the pit, from underground dewatering and/or excess water from around the site. This water will be either discharged to Mt Bundey Creek or Lake Bazzamundi, passed to a third party or used around the site. It is intended to use the Bioaqua process to achieve the:

• Site Specific Trigger Values derived by the CSIRO (Appendix F, EIS Supplement and Appendix U in this Addendum) for direct discharge to Mt Bundey Creek during the wet and dry season; or

• Water quality parameters associated with the water supplied to a third party as detailed in Comment 6 (Second Request for Information – October 2018) of this document.

It is proposed to use the BioAqua water treatment process, however if the treatment option doesn't achieved the desired water quality due to an inability to treat the water (this will be assessed by the onsite trial) (Trigger Point 1) or failure to treat the anticipated volumes due to limited scalability (this will be assessed at the operational plant design) (Trigger Point 2) then the proposed contingency planning can be detailed as follows;

As the majority of water to be treated is from the open pit (in-situ treated) and underground dewatering (groundwater). The stage 2 water treatment process will be dealing with water having a more neutral pH and reduced metal loads while the sulfates remain elevated. To meet the Site Specific Trigger Values (SSTVs) for aquatic ecological protection and water quality supply parameters (i.e. water supplied to a third party) the aim is to reduce the residual metal and sulfate levels to meet the desire levels. If the Bioaqua process is unsuitable for water treatment then the modified/better water quality allows for the use of either sulfate reducing bioreactor, active ion exchange or reverse osmosis to achieve the desire water quality. These three options have been used at various mining sites. The selection of the stage 2 contingency water treatment option will be a function of the ability to achieve desired water quality, availability of reagents/membranes, ability to dispose of waste products, energy input, infrastructure requirements and overall cost effectiveness.

The contingency treatment option would be located in the existing site for the proposed Bioaqua treatment plant thus potentially using existing and proposed infrastructure. Additionally, sulfate that is removed as part of the secondary process as detailed above is unlikely to be converted from a sulfate to sulfur form. This sulfate waste sludge is proposed to be removed from site."

Primary Gold has a preference to use the "Brutus " technology, as it converts all impurities into products that can be sold, such as sulphur from sulphates in the mine water. The scalability of the "Brutus" process requires testing. Primary Gold is willing to set up a "Brutus" test plant. If the test plant shows that it is economically scalable, then the "Brutus" process will be used. If it is not; then conventual RO treatment will be used and the "Brutus" test plant will be used to treat the brine from the RO plant. This treatment of the brine negates having to transport the sulfide waste mentioned in the paragraph above.

Primary Gold has investigated the RO as a backup alternative to the "Brutus" treatment process. RO uses known technology to treat up to 3 ML/day water from the underground mine and pit displacement water. After testing by the Brisbane based company Enviroconcepts Pty Ltd, they have proposed an economically viable RO plant operation to clean up the mine water.

The brine produced by RO is estimated to be $1m^3$ per hour or 24,000 L/day (0.024 ML/day). This is less than 1% of the original mine water input of $127m^3$ per hour .

Figure 1 below shows the schematic of the RO process proposed for Toms Gully.

Figure 1 - Schematic of Toms Gully RO water treatment alternative

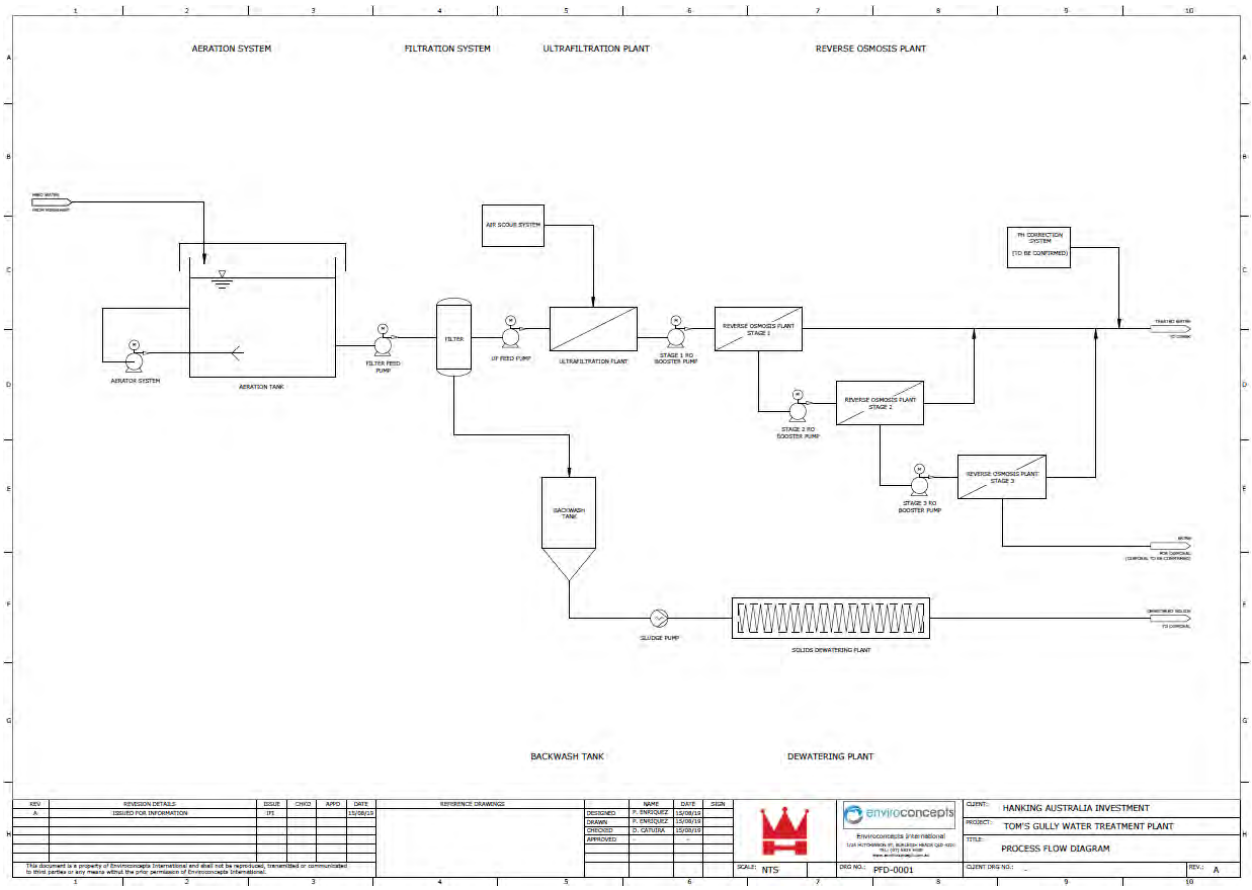
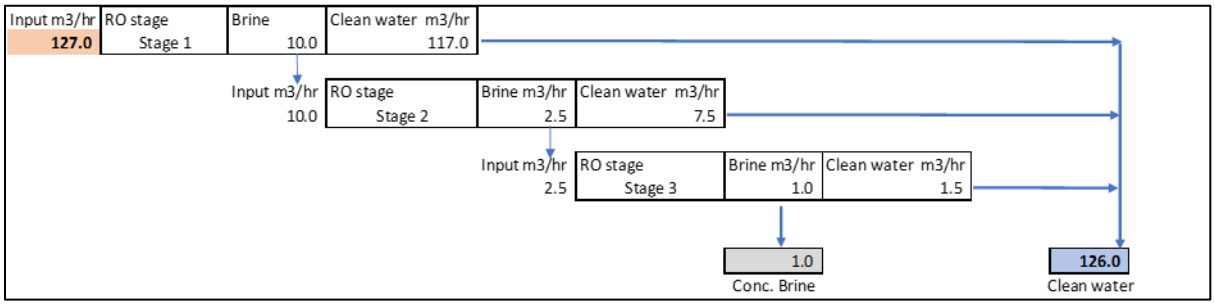


Figure 2 below shows the simplistic diagram of the water quantities of both treated water and brine.

Figure 2 - Quantities of treated water and brine at each stage of RO treatment as per Enviroconcepts estimate



The brine will be treated by the "Brutus" treatment plant.

In summary:

- Primary Gold intends to persevere with the original bacterial leach based treatment process that was called "BioAqua", but use a new company called WaterX with their equivalent process called "Brutus".
- Primary Gold has already engaged a RO supplier company called Enviroconcepts to test site water and quote for a RO plant to treat the water at Toms Gully if the "Brutus" process method cannot be scaled up to treat quantities as expected. Brine produced will be treated by the "Brutus" process as the test plant will be able to handle the expected Brine output.
- There is no major deviation from the water treatment stated in Addendum, except a new supplier of the bacterial leach water treatment process has been substituted.

As an addition to water management stated in the Addendum Primary will construct earthworks around the Toms Gully pit to minimise any unnecessary runoff into the pit. This will minimise the possibility of the pit over topping in extreme rainfall seasons.

Construction

The mine will be restarted over a period of 12 months.

During this time:

- Lime /caustic will be introduced into the pit to neutralise the pit water to a pH of 8.5.
- The existing process plant will be refurbished and made ready to start ore processing
- 78 Ha of vegetation will be cleared to provide an area for a new WSD, borrow pits and tracks
- A 1 GL water dam will be constructed west of the existing Sulfide WSD
- A water treatment plant will be constructed and commissioned during the first 12 months.
- A Boxcut and portal will be constructed

- A decline will be excavated from the portal
- The first ore drives (tunnels in the orebody) will be started towards the end of the 12 months

Energy and transport

The power for the mine will come from the NT state power grid. Backup generators will be onsite in case of power outages.

The mine is only one km from the Arnhem Highway and all transport will be motor vehicle, truck of light vehicle. No aircraft will be used to access the site.

Workforce

It is expected 104 personnel will be required to work at the mine. This includes underground, process plant, maintenance, administration and contractors.

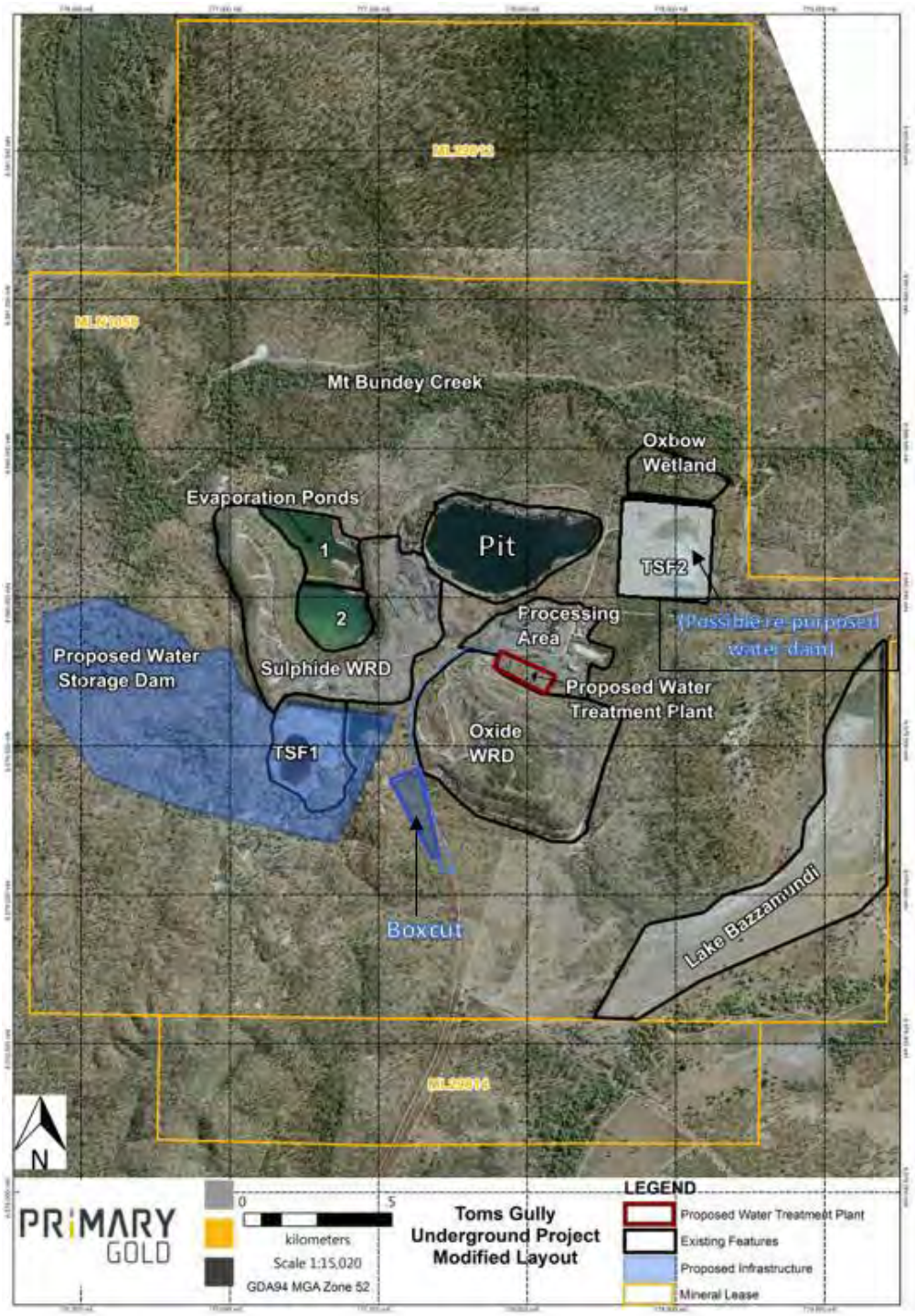
Rehabilitation and closure

The mine will be rehabilitated once all mining and processing is complete.

To clarify the rehabilitation of the two existing tailings dams.

- Existing waste dumps will be capped to reduce AMD. Earthworks will be constructed to minimise runoff from the top of the Sulfide waste dump running into Toms Gully Pit.
- Within 18 months of the Boxcut starting the existing tailings in the TSF's will be removed by a small dredge and pumped into Toms Gully Pit as the final destination.
- TSF1 will be rehabilitated soon after tailings removal with the walls of the dam spread over the area the tails where situated. The flatten dam will have topsoil spread over the area and ripped to encourage re-growth.
- The empty TSF2 may be kept intact to possibly use it as a short term water storage facility as part of the water treatment process. This is indicated in the Addendum Water from underground will be stored in the dam and treated with caustic/lime to bring the pH up to 7 or better prior to being sent to the rest of the treatment plant. Once underground mining is finished the TSF2 walls will be flattened and spread over the dam area. Topsoil will be placed on the flatten walls and ripped to encourage re-growth. See the Addendum, Section 2 Revised Project Description point 8 and section 2.3 regarding use of the TSF2 as a water storage dam.

Figure 3 – Location of Main Infrastructure at Toms Gully including Boxcut



The Closure plan in Appendix B in the Addendum has been updated to match the above summary. It is attached as "Appendix B1 – Mine Closure Plan – Toms Gully EIS Addendum to the Supplement 05122019"

3. Response to Question 2

"*Demonstrate a post-closure long-term water-balance management strategy that addresses the risks of overtopping, seepage (and extent) and/or unauthorised, uncontrolled or passive discharge to the environment.*

Demonstrate post-closure strategy meets industry standard closure objectives.

Provide water balance schematics, including volumes, for post-closure; for an average rainfall year and a very wet year."

Primary intends to treat the water in the Toms Gully Pit insitu so the pH will be 8.5 in the first year of operations. Initially the water will be treated with caustic soda or lime to elevate the pH to 8.5 so dissolved metals will participate out of the water and be deposited in the silts at the bottom of the pit.

New and old tailings will be placed into the pit and will settle to the bottom of the pit with the metals. While new tailings are being placed into the pit, the water will be monitored to ensure the pH stays at 8.5 by adding additional lime to the tailings discharge.

Primary will cap the Oxide and Sulfide waste dumps within four months of starting operations to reduce AMD water flowing from the two WRDs.

Currently AMD runoff from the Sulfide waste dump flows into the Pit continually sustaining acid and other contaminates in the pit water. Capping of the waste dumps will greatly reduce or eliminate the AMD into the pit and environment.

After capping the Sulfide waste dump, construction of bunds and drains will be done to limit the rainwater flow entering the pit. Drainage from the Sulfide waste dump and the processing area will be diverted to the natural drainage paths to Mt Bundey Creek.

Over topping of the pit will be avoided by diverting excess runoff into the pit. Any water in the pit be at 8.5 pH at the end of the mine life. Heavy metals in the pit water will drop out and be encapsulated in the tailings at the bottom of the pit.

As Primary intend to start a nearby mine called Rustlers Roost before the closure of Toms Gully, Primary will be able to monitor and treat the water in Toms Gully pit for at least five years after Toms Gully closure.

As the Boxcut waste has been now deemed suitable to cap the existing waste dumps, it will not be required to be placed into the pit.

This will lower the total height the deposited tailings and waste will occupy in the pit by 4m to 5 m.

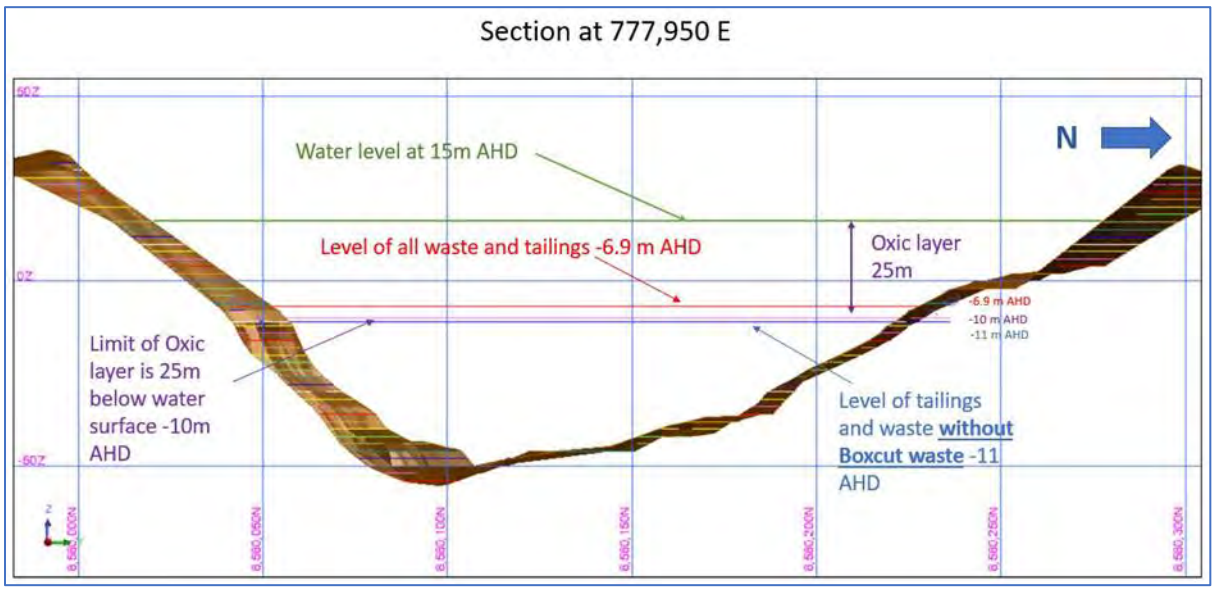
This lowering of height of deposited tailings and waste in the pit will now ensure the tailings and waste are below the 25m water Oxic layer by at least 1m. See Figure 4 below.

In addition to the Boxcut material not being placed into the pit. Primary intend to leave some of the underground waste underground in mined out areas of the mine after the ore is extracted. As this is dependent on the local geotechnical safety conditions of the area and scheduling of material movement at the time of mining the amount of waste left underground will range from 50,000 tonnes to 200,000 tonnes (potentially 0.3m to 1.2m less height, that is -10.7mAHD to -9.8mAHD total height). This reduction in height has not been accounted for and is an upside.

Stored underground waste will reduce the quantities of waste that would be placed into the pit and reducing the height of the combined waste and tailings in the pit. The level of the combined waste and tailings would be even lower than the aforementioned one metre below the Oxic layer.

Leaving waste underground is desirable for both economic and environmental reasons. Leaving waste underground would be actively pursued where possible by Primary Gold.

Figure 4 - Cross section showing waste and tailings deposit levels for all material and without Boxcut waste



Treatment and water level monitoring of the pit will occur while processing is in the finishing months after UG mining stops. Then for another 4 to 5 years water treatment (pH mainly) can occur in Toms Gully pit if necessary while Rustlers Roost is being mined. Thus the water in the Toms Gully pit will be monitored for at least 5 years after closure.

Due to the level of the deposited waste and tailings in the pit (no Boxcut placed into the pit), it is unlikely that further oxidation of these submerged materials will occur in the future.

The 25m water cover should be enough to stop oxidation of the tailings and fresh waste material. Even if the water cover was less than 25m - minimal oxidation would occur. In GHD document " Appendix D –

Pit Water Geochemical Modelling Report – Toms Gully EIS Addendum to the Suppliment.pdf" is states in Section "**2 Literature review"** that one to five metres of water cover is effective in minimising sulfide oxidation.

"…In determining the minimum depth of subaqueous disposal required to minimise sulfide oxidation, the key variables are wave activity and the sediment properties of the mine tailings relating to entrainment (Mine Environment Neutral Drainage (MEND) 1998). A review of case histories by MEND (1998) found that subaqueous disposal depths of between one and five metres below the water surface in constructed impoundments had been effective in minimising sulfide oxidation. While dissolved oxygen (DO) concentrations in water at such depths may still be significant, and even supersaturated (depending on submerged photosynthetic activity), this oxygen is preferentially used for the bacterial oxidation of organic matter in sediments (where there is sufficient organic matter present) (Rescan Environmental Services 1989). In most lake sediments, the organic carbon content is usually sufficient to establish anoxic conditions at sediment depths ranging from a few millimetres to one decimetre (Rescan Environmental Services 1989). When complimented by stoichiometrically balanced concentrations of sulfate and metals, sulfate reducing bacteria sequester metals as sulfides, thereby reducing the pool of potential environmental contaminants. This is a natural phenomenon that is found in reducing environments such as peat-bogs and estuarine or lacustrine backswamps.

Actual measurements of DO concentrations in sediment pore water, reported by Campbell and Price (2018), indicate that oxygen can penetrate up to 10 cm depths in sandy sediments, but in silts the oxic-anoxic interface is rarely deeper than one centimetre. Campbell and Price (2018) state that a minimum depth of water cover of one metre is usually sufficient to establish anoxic conditions in sediments overlying sub aqueously disposed tailings…."

Reducing runoff into the Pit

Earthworks will be constructed to minimise runoff into the pit. This will minimise the possibility of water overtopping of the pit in extreme rainfall seasons. The earthworks will be a combination of bunds and trenches.

Currently water in the pit comes from rainfall, runoff from the higher regions around the pit rim, overflow water pumped from the tailing's dams/evaporation ponds and water from the top of the Sulfide waste dump. The pit is currently acting as a sink for runoffs from the AMD sources around the mine. Figure 5 below shows the water flow directions of water from the Sulfide waste dump and process area into the Toms Gully pit.

Figure 5 – Water Flow into Toms Gully Pit

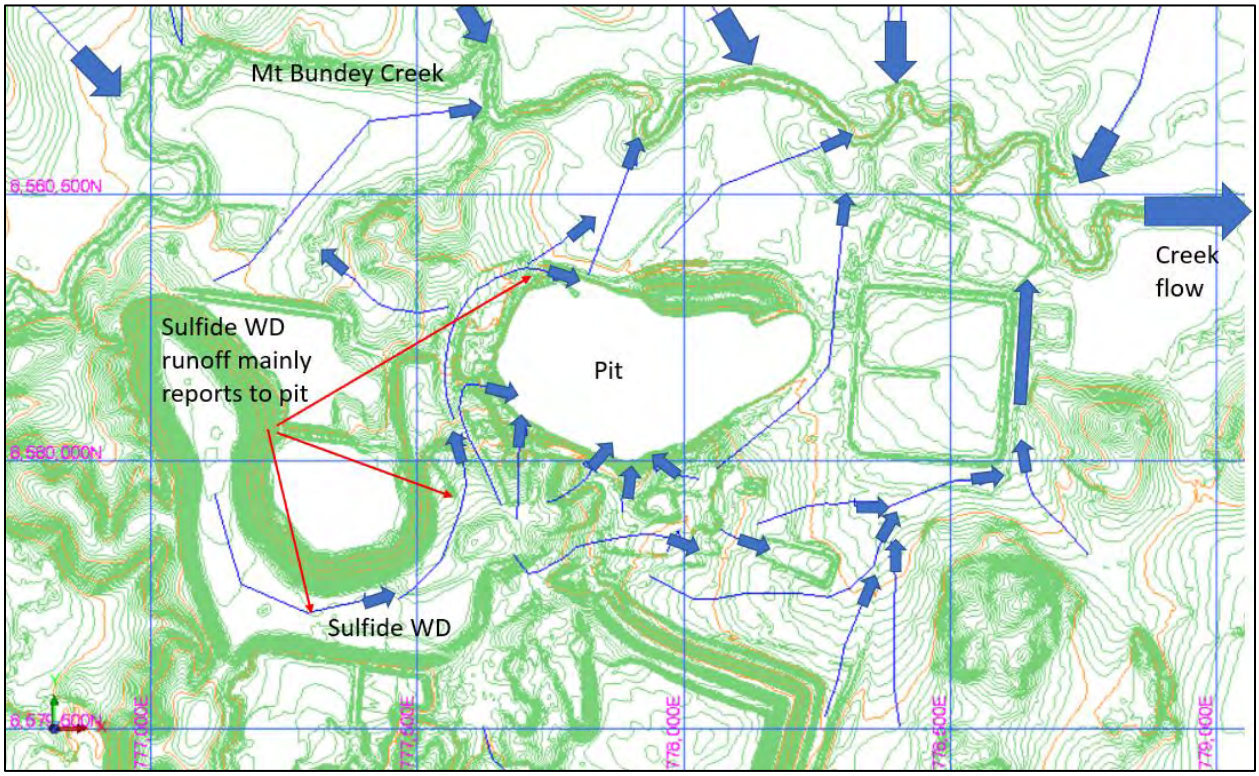
Currently rain and runoff sources are:

- Direct rain into the pit itself.
- Catchment around the pit edge.
- Top of Sulfide waste dump.
- Pumped water from TSF1, TSF2, Evaporation ponds 1 and 2 and Plant stormwater dam as required.

Water in the Pit is rising approximately 0.9 m per year at present. Most of this rise can be attributed to extra runoff from the Sulfide waste dump and Mill hard stand. Once the runoff from these areas are redirected; the Pit will behave as a sink as predicted by GHD in their report in Appendix C – Groundwater Modelling – Toms Gully Supplement.pdf.

See the Figure 6 below current runoff water. The rainwater on top of the Sulfide waste dump runs off the dump straight into the pit. This water is contaminated by the sulfides on the dump surface.

Figure 6 - Current Major Runoff Flow Directions



Consequently the pit is filling up faster due to these extra runoff sources.

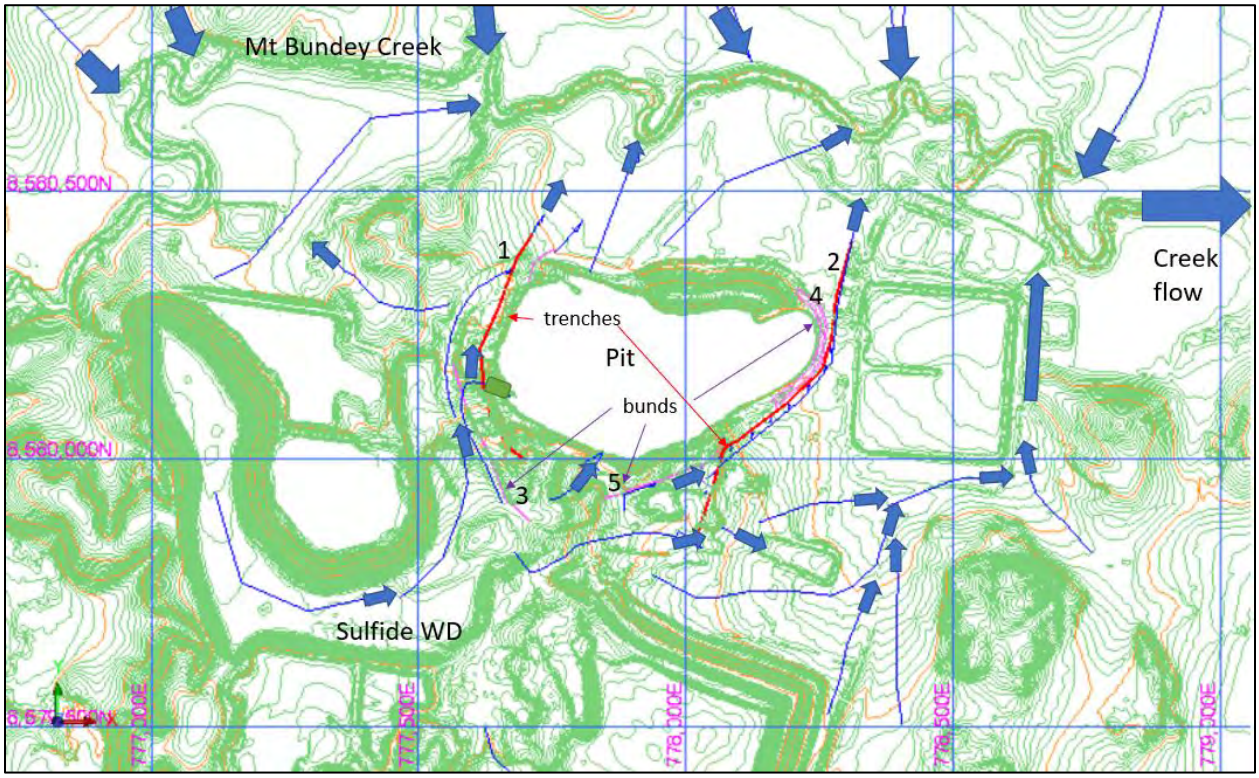
To ensure the pit does not over top after closure the following is required:

- Cap the Sulfide dump with non AMD material from the Boxcut and compact this material to seal the AMD rock from rainwater. If this is done early in the mine life the clean dump rain water runoff can be diverted straight into the Mt Bundey Creek instead of the pit.
- Create earthworks to divert runoff water from the top of the Sulfide waste dump flowing into the pit. (see figure below for location of trenches and water diversion bunds.
- Remove the two TSF's so pumping to the pit is no longer required.
- Remove the ROM and any surface sulfide rocks (old hardstand material) from the process plant area so clean surface soil is exposed and runoff is non AMD.
- Fill in the storm water dam or fill in with non AMD material.

Earth works proposed are as follows (numbers relate to numbers on Figure 7):

1. Western trench to divert water flow from the Sulfide waste dump and to prevent flow into the pit ramp (and pit)
2. Eastern trench to divert water from the process plant area and ensure it flows past the pit to the creek.
3. Water diversion bund to prevent water flowing into the pit from a number of small gullies.
4. A compacted bund to heighten the low section of the pit on the east side by 3m to the 22m AHD. This will give more capacity in the pit when high rainfall occurs. Approx. 2.5m, more capacity or 340ML.
5. Like in Point 3 above, a bund to block flow from the process plant area down a small gully into pit.

Figure 7 - Major Runoff Flow Directions After Earthworks to Divert Flow From Toms Gully Pit



Rainfall and evaporation rates at or near Toms Gully

The nearest government weather station to Toms Gully with sufficient data is Middle Point.

Table 2 below shows the rainfall from Middle Point.

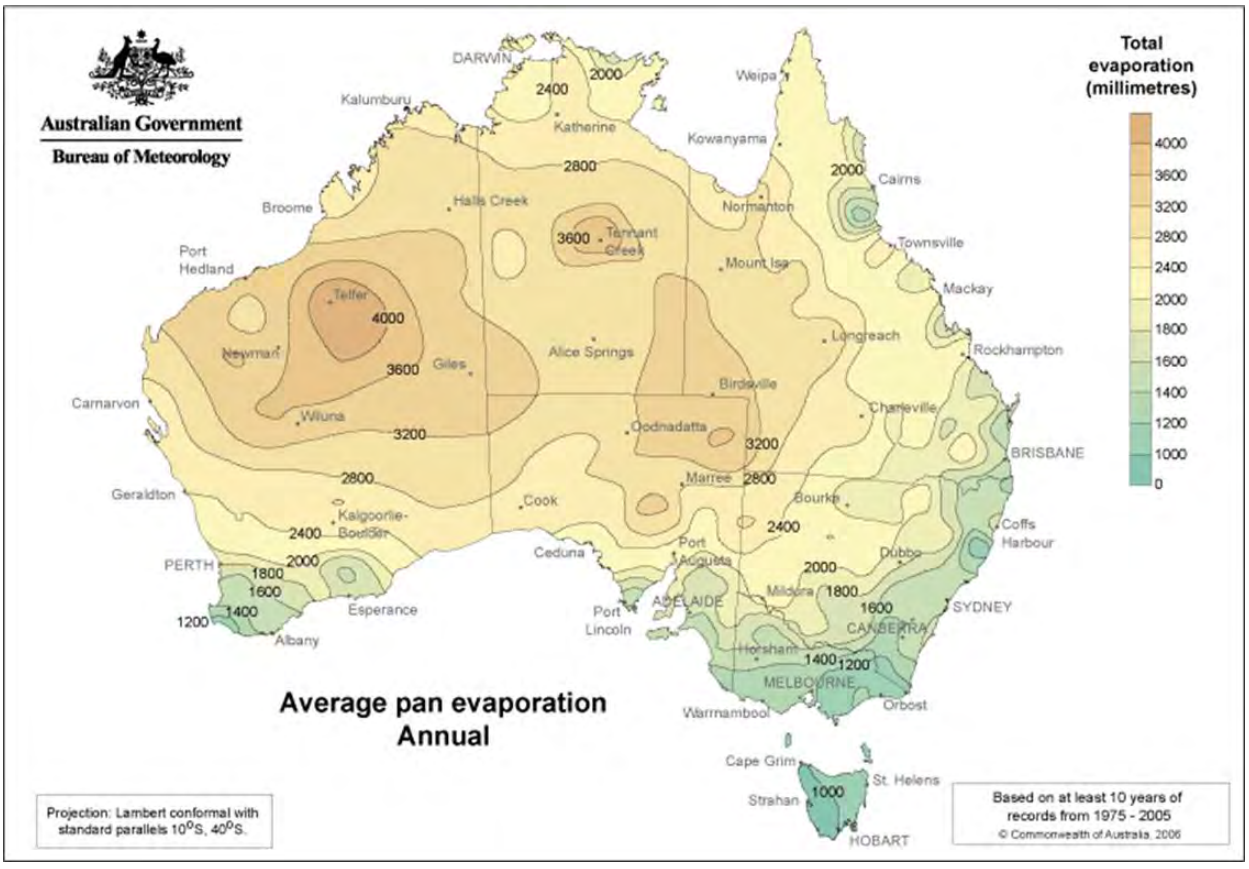
Table 2 - Rainfall Statistics from Middle Point

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	285.5	290.6	243.6	98.7	21.4	0.6	0.3	0.8	16.1	45.8	123.1	235.3	1393.9
Lowest	47.2	52.4	69.8	4	0	0	0	0	0	0	48.2	80.6	836.4
5th %ile	77.1	85.7	90.9	18.3	0	0	0	0	0	2.2	58.2	91.8	985.2
10th %ile	110.4	93.3	118.5	22.5	0	0	0	0	0	4.7	63.2	97.7	1045.2
Median	325.8	285.7	199	55.6	8	0	0	0	10.8	35.4	117.3	227.5	1374.5
90th %ile	383.6	542	416.4	232	76.8	1.8	0.4	3.6	38.6	81.7	198.2	376	1751.7
95th %ile	387.5	571	471.7	314	93.6	3.9	1.5	5.8	39.6	112.4	214.3	416.3	1854.2
Highest	399.2	727.4	584.2	405.6	103.6	4.4	4.4	6.2	42	240.4	261.4	456.6	1934.8

Average annual rainfall is 1,394mm, the highest is 1,935mm.

Figure 8 shows the average evaporation in Australia.

Figure 8 - BOM Evaporation Average Data



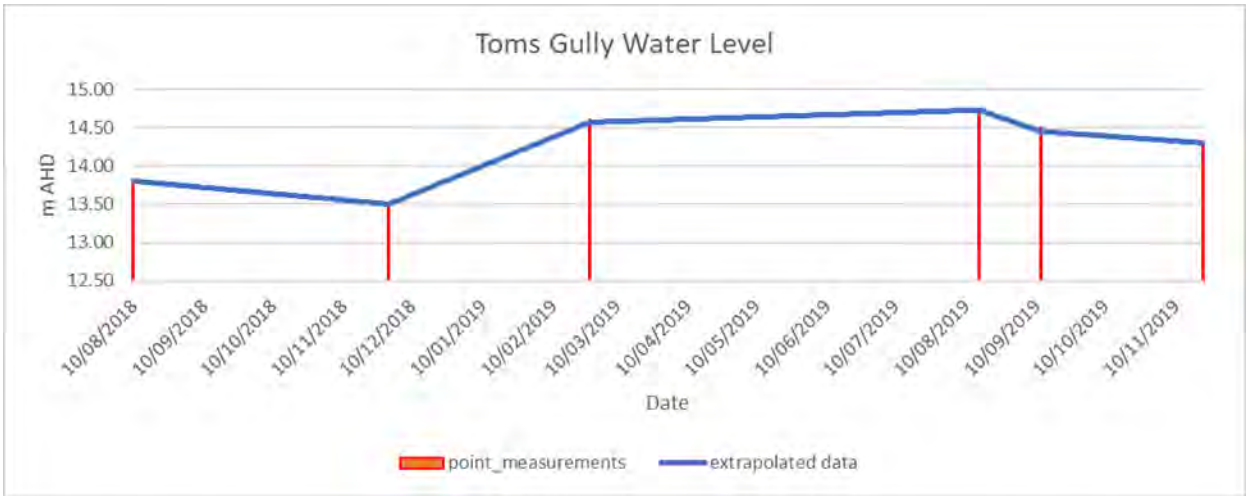
Toms Gully's average evaporation is 2,400 mm per year.

Class A pan evaporation figures can be used to estimate evaporation from a dam by using a factor of 0.67 (sourced from agriculture.vic.gov.au). Thus factorised evaporation is 1,608 mm per year from a dam (or pit).

Toms Gully recent water levels

Figure 9 below shows the pit water levels after since Hanking acquired Primary Gold in June 2018.

Figure 9 – Toms Gully Water level for the last 16 months 10 August 2018 to 22 November 2019



The above Figure 9 shows a rise in pit water level of approximately 0.9 m per year with all the additional runoffs going into the pit.

The surface area of the pit at 15m AHD is 130,514 m2; volume contained is 130.5 ML per one metre increment.

Industry standard closure objectives

Post mining land uses and objectives

- Process area hardstand material and ROM pad are removed. The natural ground is exposed so vegetation can re-grow. This will allow future cattle grazing.
- Waste dumps are capped to seal the Sulphide waste and stop AMD being emitted from the existing dumps. Future grazing will be possible once vegetation re-establishes itself.
- Remove existing TSF's and put all new tailings and waste into the Toms Gully Pit under 25m of water cover.
- Water drainage earthworks are made around the pit to prevent excessive runoff contributing to the filling the pit. Clean runoff will be returned as much as possible to pre mining runoff channels into Mt Bundey Creek.

- Improve the pH of the existing Pit water, reduce the heavy metal content in by water by improving the pH by Caustic/Lime addition.

The revised closure plan attached as "Appendix B1 Mine Closure Plan – Toms Gully Addendum to the Supplement 0512019.pdf" elaborates on the sustainable closure.

Erosion after closure

Toms Gully erosion is similar to what occurs in the surrounding natural environment.

With reference to Executive Summary, landform stability, page ii in Appendix 2 "MAIN REPORT Supplementary to the Tom's Gully Closure Report"

The effects of erosion by the mining of Toms Gully is negligible. New mining is underground focused, having very little effect on surface water flows especially after mining is finished.

The report in Appendix 2 states the following:

"…The mine site straddles the common catchment boundary of Mt Bundy Ck and Coulter Ck, and therefore was separated into two catchments for the stability analysis: Mt Bundey Ck Catchment (MBCC) and the Coulter Ck Catchment (CCC). Site stability was assessed using the RUSLE and CAESAR-LisFlood erosion models. Soil samples were collected from the mine and undisturbed surface material types. Laboratory analyses was conducted to determine input values for the erosion models.

RUSLE long-term erosion rates ranges from 0.24 t/ha/y to 7.7 t/ha/y and 21.14 t/ha/y for steep-sloped oxide material. These compare reasonably well with regional values.

Three-dimensional results for the 1%AEP and 0.1%AEP events show erosion occurring on the oxide cover, however, there are no significant signs of erosional instability and erosion features on the site are similar to the natural surrounds…"

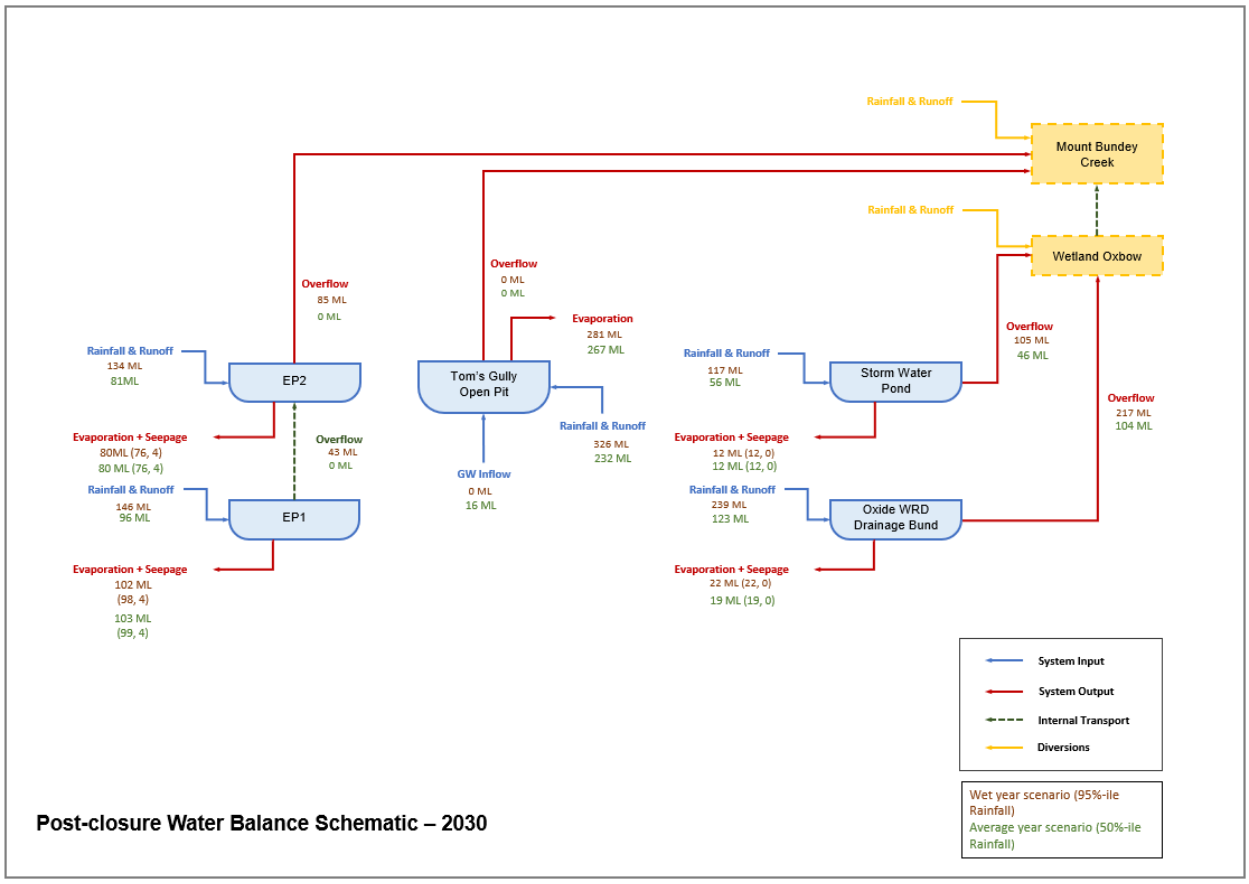
See Appendix 2, Section 7 for further details.

Water balance after closure

Appendix 3, Section C.3 "Short term water balance" shows a set of schematic water balance diagrams.

As an example Figure 10 below shows the 2030 schematic water balance diagram for both dry and wet seasons.

Figure 10 - Water Balance Diagram for 2030



In a wet year scenario the evaporation ponds may overflow. As the Sulfide waste dump has been sealed and the bottom of the evaporation ponds are also re-sealed (first year of operations) this water would be mainly rainwater. Toms Gully pit does not overflow at any time.

The storm water pond and the Oxide waste dump bund will overflow in both the wet and dry scenarios. The Oxide waste dump has been sealed in the first year of operations and the process area has been cleaned up at closure so overflow will be rain water.

Toms Gully Pit Water level estimate and potential overtopping after closure

Toms Gully Pit does not overflow even in a 1,000 year rainfall event. The water level rises to 16.8m AHD in the wettest year, see Figure 12 below.

The natural lowest point of the pit is at 19m AHD. Primary will build a bund at the west and east side of the pit to a height of 22.5m AHD. This creates a free board of 5.7 m even in the wettest year.

A hypothetical scenario was used to determine the effects of contaminated water on Mt Bundey Creek if it did overflow. In the hypothetical scenario water contamination at the measuring point SWTG2 is does exceed SSTV's for Aluminium, Cadmium, Cobalt, Copper, Lead, Nickel, Uranium, Zinc, Calcium and Magnesium. Further downstream the SSTV's are not exceeded. See Appendix 2, Section 6.3 and 6.4 for further details.

Figure 11 below shows the 1000 year dry climate scenario water level estimate for Toms Gully.

Figure 11 - 1000 year dry climate scenario water level estimate for Toms Gully.

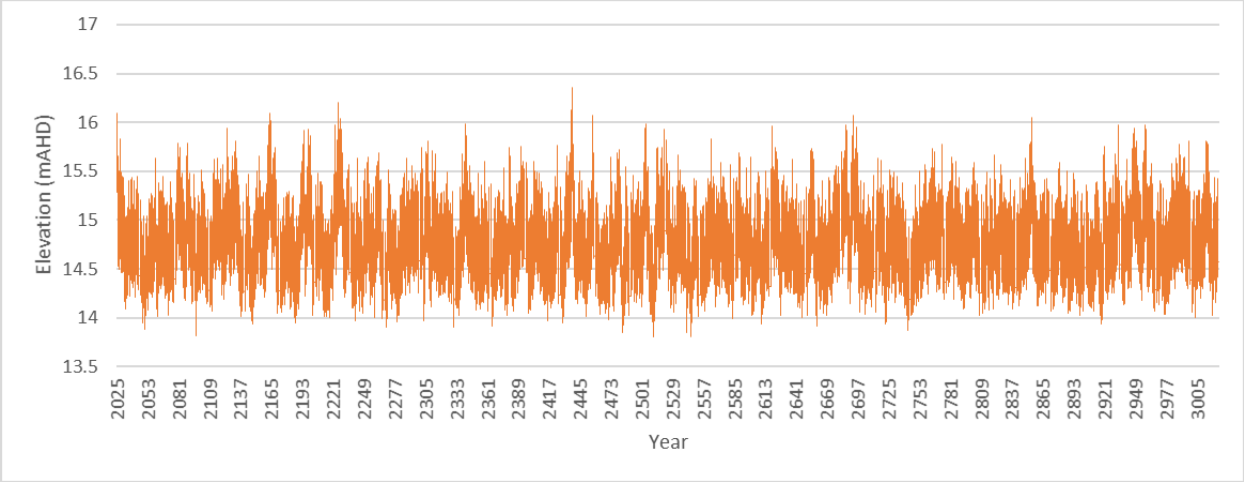
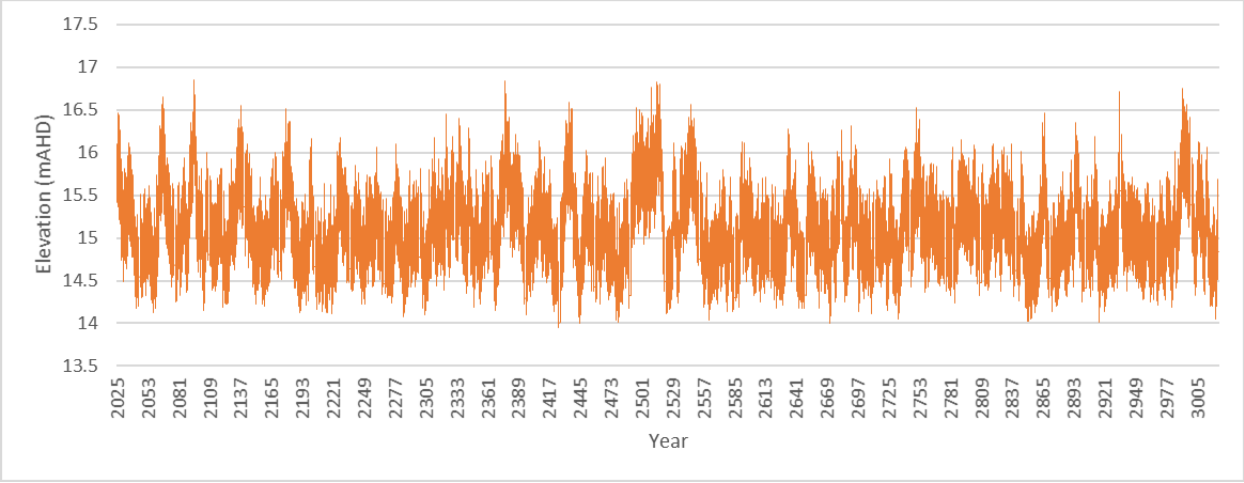


Figure 12 below shows the 1000 year wet climate scenario water level estimate for Toms Gully.

Figure 12 - 1000 year wet climate scenario water level estimate for Toms Gully.



The Appendix 1 below called “TOMS GULLY GROUND WATER BETWEEN THE PIT AND MT BUNDEY CREEK” discusses the ground water around Toms Gully Pit. The ground water in nearby measuring bores did not shown a significant increase in either ground water levels and contamination as the pit started to flood in 2010 until recent times. The pit appears to be a sink as detailed in Appendix C.

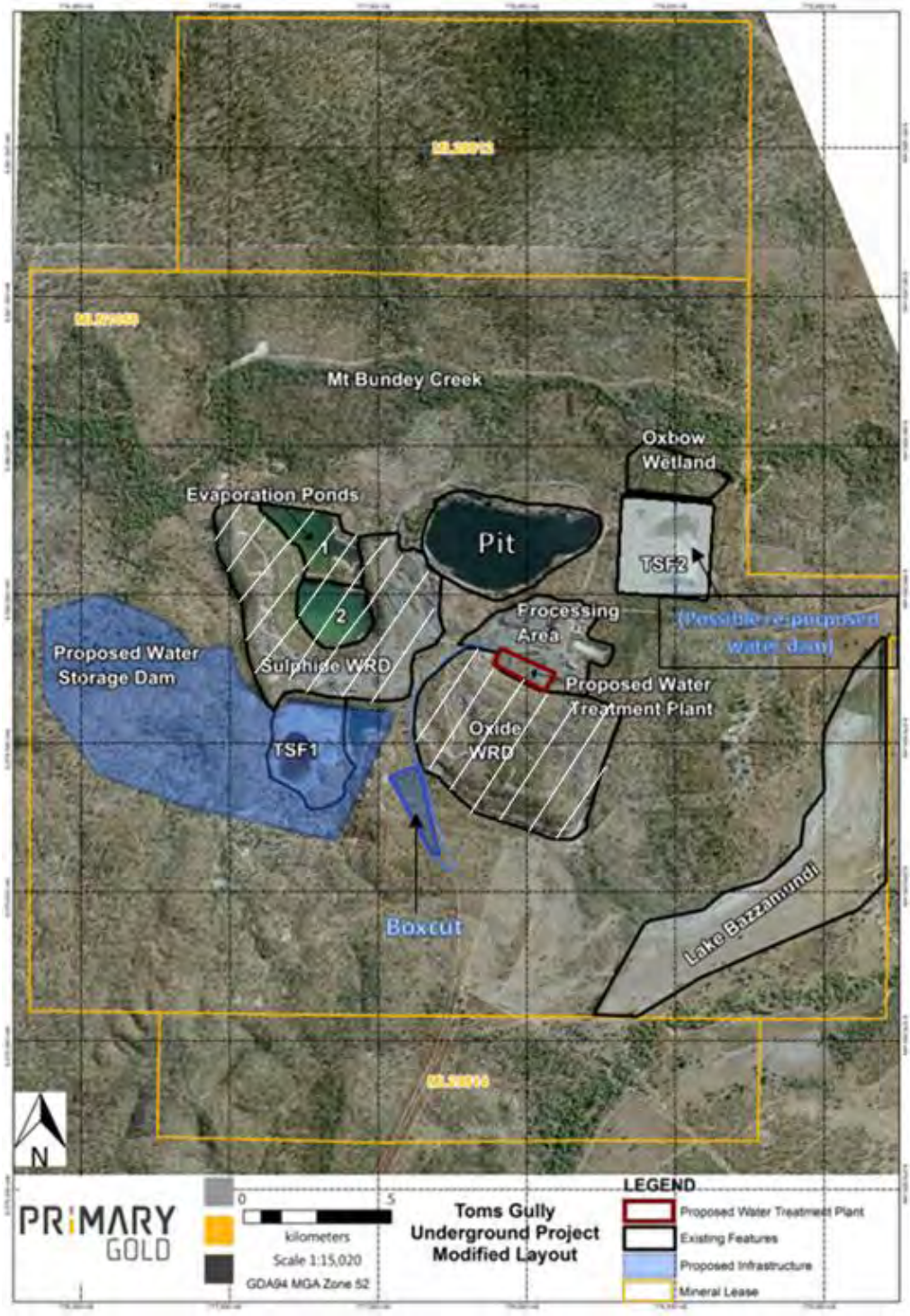
4. Response to Question 3

"*Provide details on how/where waste rock will be placed on existing WRD's, how it will help limit infiltration and reduce the generation/release of AMD from each of the WRDs.*"

Boxcut waste capping of Toms Gully's waste dumps will provide the main limiting action to prevent water infiltration to the WRDs. This capping will occur within the first four months of the Boxcut excavation beginning. The start of Boxcut excavations is the point defining the re-start of mining operations.

Figure 13 - below shows the location of major infrastructure at Toms Gully. The white lined areas are the extent of the capping on the waste dumps.

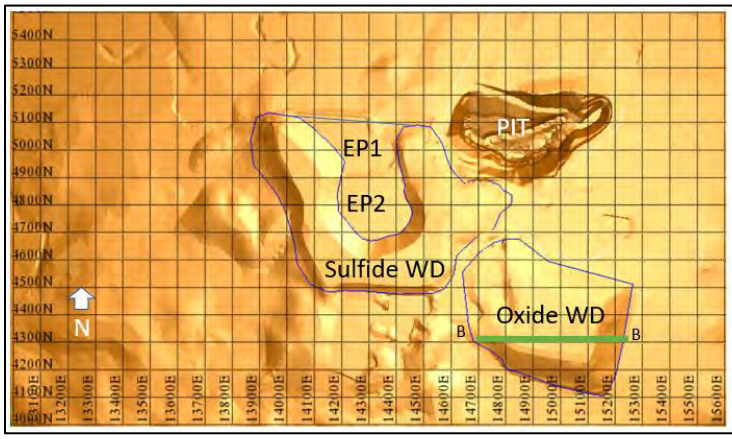
Figure 13 – Location Plan Showing the Existing Waste Dumps



It is planned to cover the whole of both dumps and the base of the evaporation ponds with the material from the Boxcut. The reason for covering the sides of the dumps is that rain water can also infiltrate the unprotected sides as easily as the top of the dump. Compaction of the top of the WRDs is done to further reduce water infiltration into the dumps. The evaporation ponds will be pumped dry and the contaminated base material will be dugout and placed into Toms Gully pit before placing the Boxcut capping material into it.

The Figure 14 below shows the two existing waste dumps and the calculated areas, and the calculated average thickness of waste that 660,000 tonnes Boxcut material would cap. The evaporations ponds are included in the area for the Sulfide Dump

Figure 14 – Location of the Existing Waste Dumps and Environmental Ponds and Calculated Area and Waste Cover Thickness Estimate



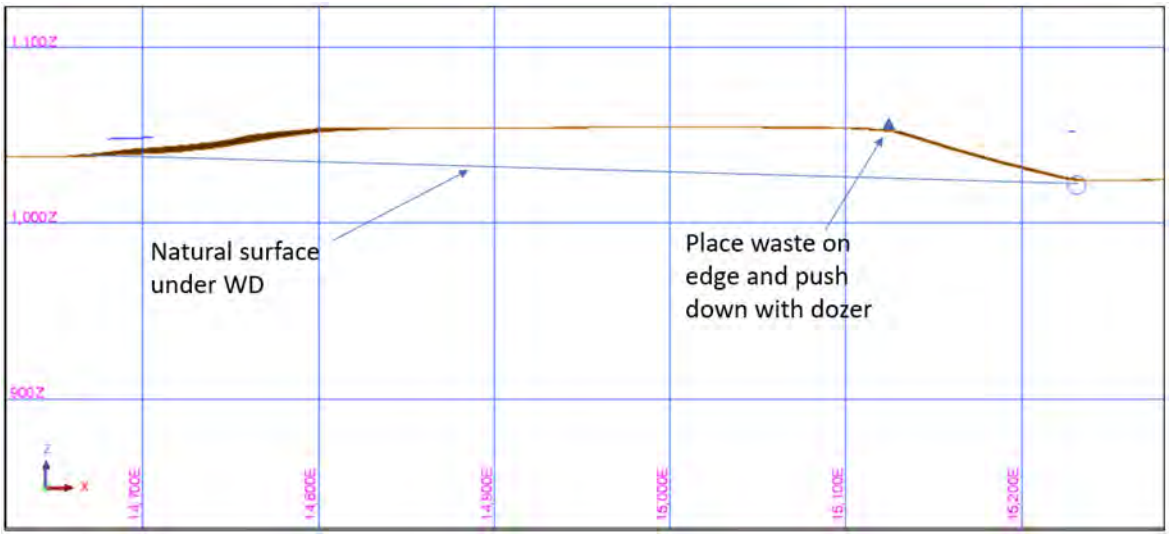
Item	Quanity	unit
Sulphide WD	388,447	m2
Oxide WD	243,693	m2
Total area measured	**632,140**	**m2**
Boxcut waste	660,000	tonnes
Specific gravity	2.3	t/m3
Bank cubic m of waste	286,957	bcm
Swell factor	20	%
Loose cubic m placed	**344,348**	**lcm**
Average thickness over dumps	**0.54**	**m**

The priority areas for the capping if quantities of Boxcut material is limited are the top of the Sulfide waste dump and the western side of the oxide waste dump where there appears to be sulfide rock on the surface. Otherwise the sequence of capping is detailed below.

Methodology for capping the waste dumps is as follows:

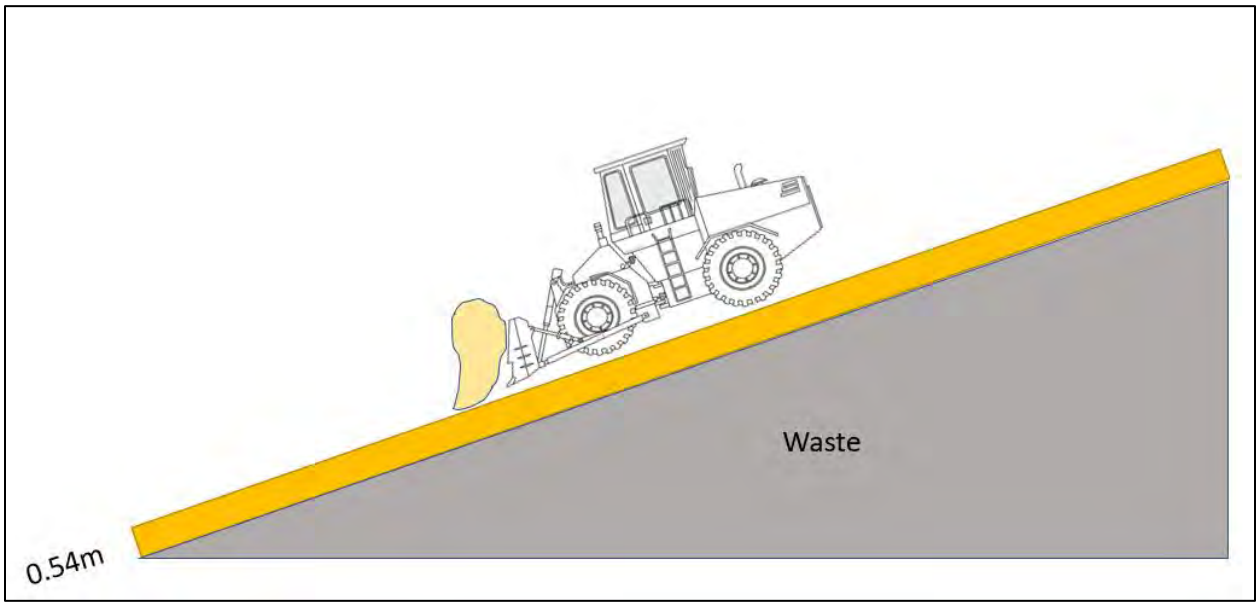
1. Clear any existing plant cover on the waste dumps.
2. Excavate the Boxcut and place the material into mining off-road trucks.
3. Haul the material in the trucks to the top of the Sulfide waste dump firstly.
4. Unload the material at the edge of the dump at the top of the dump (as an example see Figure 15 below Oxide dump - section B-B as shown in Figure 14 above)

Figure 15 - Section B-B Showing Cross Section Through Oxide Waste Dump



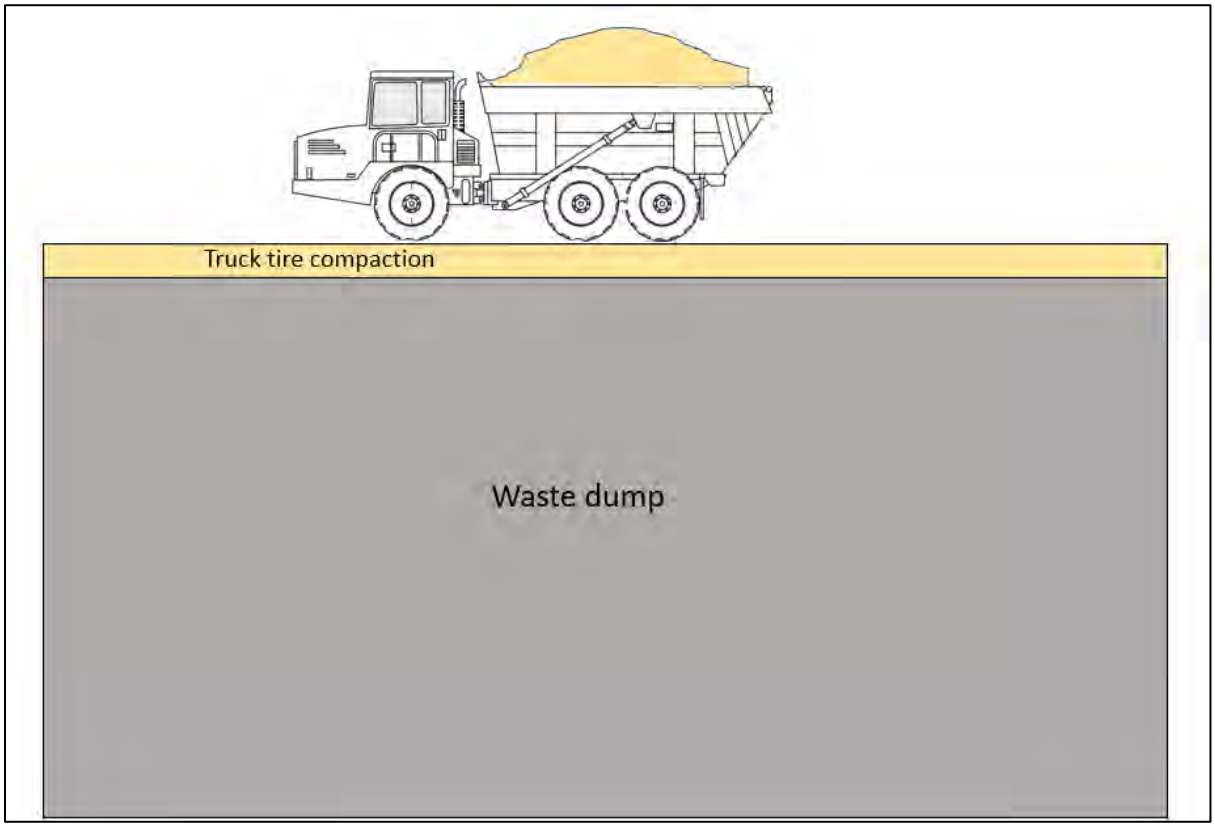
5. The material at the edge of the Sulfide dump is pushed down by a Dozer until a nominal thickness of 0.54m is attained. Dozer track rolling will contribute to compaction of the side of the waste dumps. Use of a Compactor would be unsafe on the slopes of the waste dump. Thus dozer compaction will be done only.

Figure 16 - Placement of Boxcut Material on the Sides of a Waste Dump (not to scale)



6. After the edge of the Sulfide dump are covered the same method (points 1 to 5) would be repeated on the Oxide waste dump.
7. Once both of the two dump edges are covered to 0.54m nominal thickness the Boxcut waste material will be dumped on top of the Sulfide waste dump.
8. The waste material will be dumped in piles and pushed over to form a layer of waste to a nominal thickness of 0.54m. The top of the dumps will have a 1 in 200 grade (2%) to assist drainage of rain water off the water dump to reduce seepage into the dump. The top of the Sulfide dump will be firstly compacted by the truck tyres while trucks are driving over the spread out Boxcut material. See Figure 17 below.

Figure 17 – Truck Compaction of Driving Surface Prior to Compaction by Sheepsfoot Compactor (not to scale)

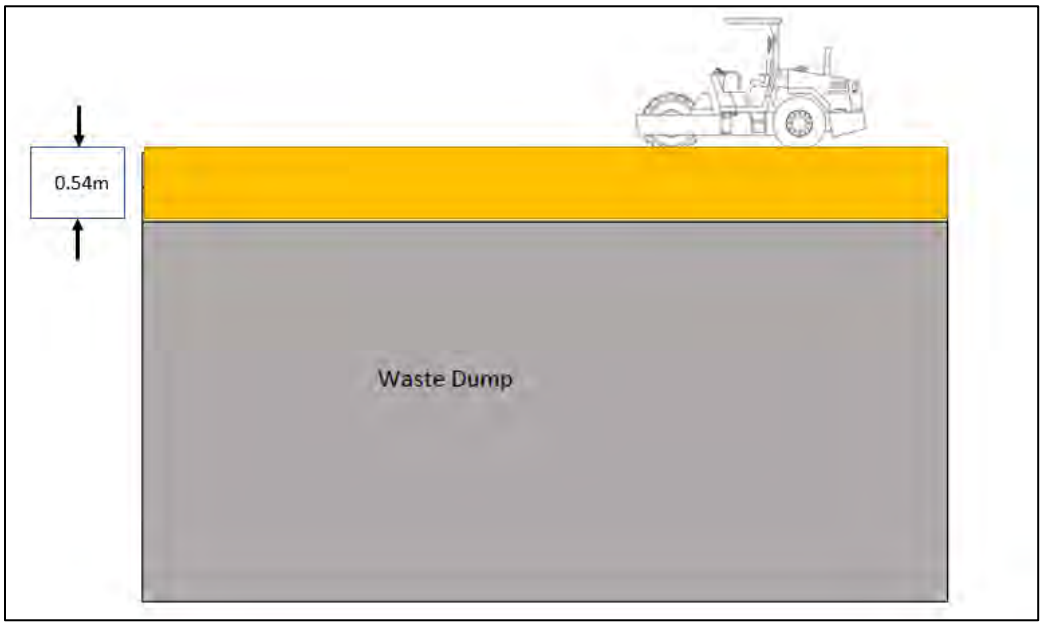


9. Once the top of the Sulfide waste dump is covered to a nominal thickness of 0.54m; a sheep's foot compactor will run over the layer to compact the layer to prevent water penetration. A minimum number of three passes by the Compactor will be competed.
10. While the Sulfide dump is being compacted the Oxide waste dump will have a layer of waste material being delivered and spread to nominal thickness of 0.54m. Once Oxide dump is covered, the Compactor will work on the top of the Oxide dump.

11. Compaction will prevent water from infiltrating the top of the waste dumps and producing acid containing water that will leak outside the dump.
12. Drain the Evaporation ponds, EP1 and EP2. Clean out built-up contaminated soil in the base of the ponds.
13. Dispose of the contaminated soil into Toms Gully Pit similar the tailings and underground waste rock.
14. Fill the ponds with 0.54m nominal thickness of Boxcut oxide material and compact to seal.

Figure 18 below shows a schematic diagram of the compaction of the Boxcut oxide material.

Figure 18 – Compaction of the Top of a Waste Dump Layer (not to scale)



Moisture content of the top surface of the deposited Boxcut material will be kept at about 11-15% moisture for optimum compaction. Field tests will be done to determine is sufficient moisture is present.

Boxcut material will be accessed daily by a geologist to identify any AMD material is present and send that AMD material to the open pit. Only Non-AMD material will be used to cap the waste dumps.

APPENDIX 1

TOMS GULLY GROUND WATER BETWEEN THE PIT AND MT BUNDEY CREEK

Response to specific comment in Question 2 regarding the ground water zone of influence around the Pit and Mt Bundey Creek

Appendix 1 - Toms Gully Groundwater Between the Pit and Mt Bundey Creek

1.0 Introduction

This Appendix 1 is mainly concerned with the zone of influence of the ground water around Toms Gully pit, in particular to the fact the water level in the pit will be higher than the bottom of the Mt Bundey Creek at times until water from the Sulfide waste dump is diverted from entering the pit.

2.0 Summary

- Toms Gully Pit is an evaporative sink according to GHD report Appendix C – Groundwater Modelling – Toms Gully Supplement.pdf March 2018 (from Addendum to the Supplement).
- G9 is a bore in between the pit and Mt Bundey Creek. Ground water SWL in G9 bore has not varied significantly since 2010 when the mine shut.
- Pit water level does not appear to affect the SWL of G9. Ground water flow comes from the east of the pit to G9.
- Main contamination is due to the Sulfide waste dump, which when capped will be decreased considerably.
- Once TSF1 and TSF2 are removed, this other source of contamination will not affect the Mt Bundey Creek.

3.0 Current Mt Bundey pH and EC Measurements

Currently Toms Gully has legacy contamination from previous mining. The main sources of contamination comes from:

- Sulfide Waste Dump
- TSF1 and TSF2
- Runoff from the process plant hard stand and
- Toms Gully Pit

The current situation of contaminate discharge into Mt Bundey Creek and Coulter Creek is shown in a recent independent report by GHD which an aquatic ecology report is titled "4322623_PROP_AquaticEcologyMonitoring2019_Rev0.pdf". This report is in Appendix 4.

Figure 1 below shows Mt Bundey and Coulter creeks level of flow at the end of the wet season April 2019 when sampling was conducted. The creeks are still flowing.

Figure 1- Location of Ecology Survey Sampling Points - April 2019

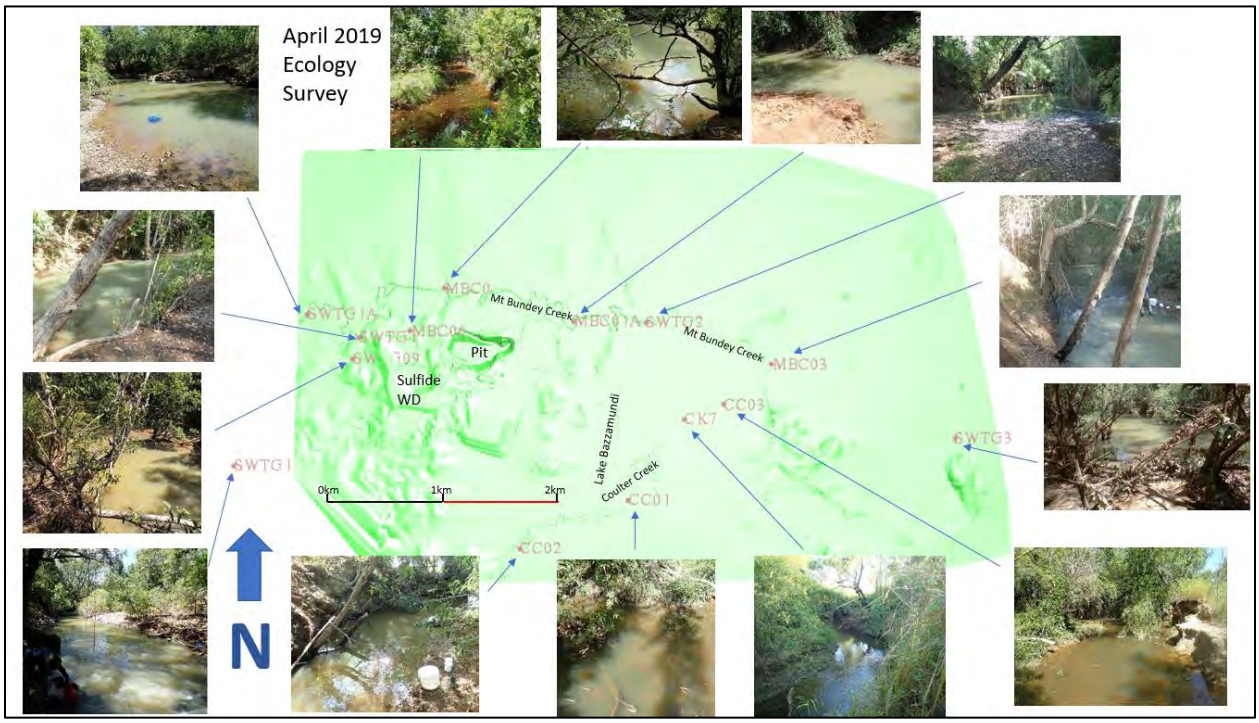


Table 1 below shows the results from the Ecology Report for the sampled points.

Table 1- Results of surface water quality from Aquatic Ecology Report

Site	Date	Time	Temp (°C)	pH	EC (µS/cm)	DO (% sat.)	DO (mg/L)	Turbidity (NTU)
SSTV	NA	NA	NA	5.8-8.0	41	85-120	NA	87
Control								
SWTG1C	15/4/19	8:37	27.8	7.1	39	80.1	6.79	21.1
SWTG1A	15/4/19	10:35	28.0	7.1	46	84.3	7.57	23.5
Adjacent								
SWTG09	16/4/19	14:40	28.2	7.0	47	60.6	5.87	19.4
SWTG1	17/4/19	7:40	27.0	7.6	71	78.3	7.51	19.1
MBC06	17/4/19	16:05	28.2	7.0	4286	51.3	2.56	57.1
MBC01A	16/4/19	14:05	28.9	7.1	105	74.2	7.17	59.1
Downstream								
SWTG2	17/4/19	15:20	28.8	6.7	83	79.5	7.25	17.3
MBC03	18/4/19	8:30	27.3	6.7	82	77.5	7.42	17.8
Reference								
CC02	19/4/19	8.39	27.6	7.1	152	89.2	7.21	10.4
CC01	18/4/19	13:55	28.6	7.3	134	78.1	7.97	12.9
CK7	19/4/19	7:30	27.0	7.1	130	88.9	7.58	5.1
CC03	18/4/19	10:45	27.8	7.2	128	82.3	8.05	10.8

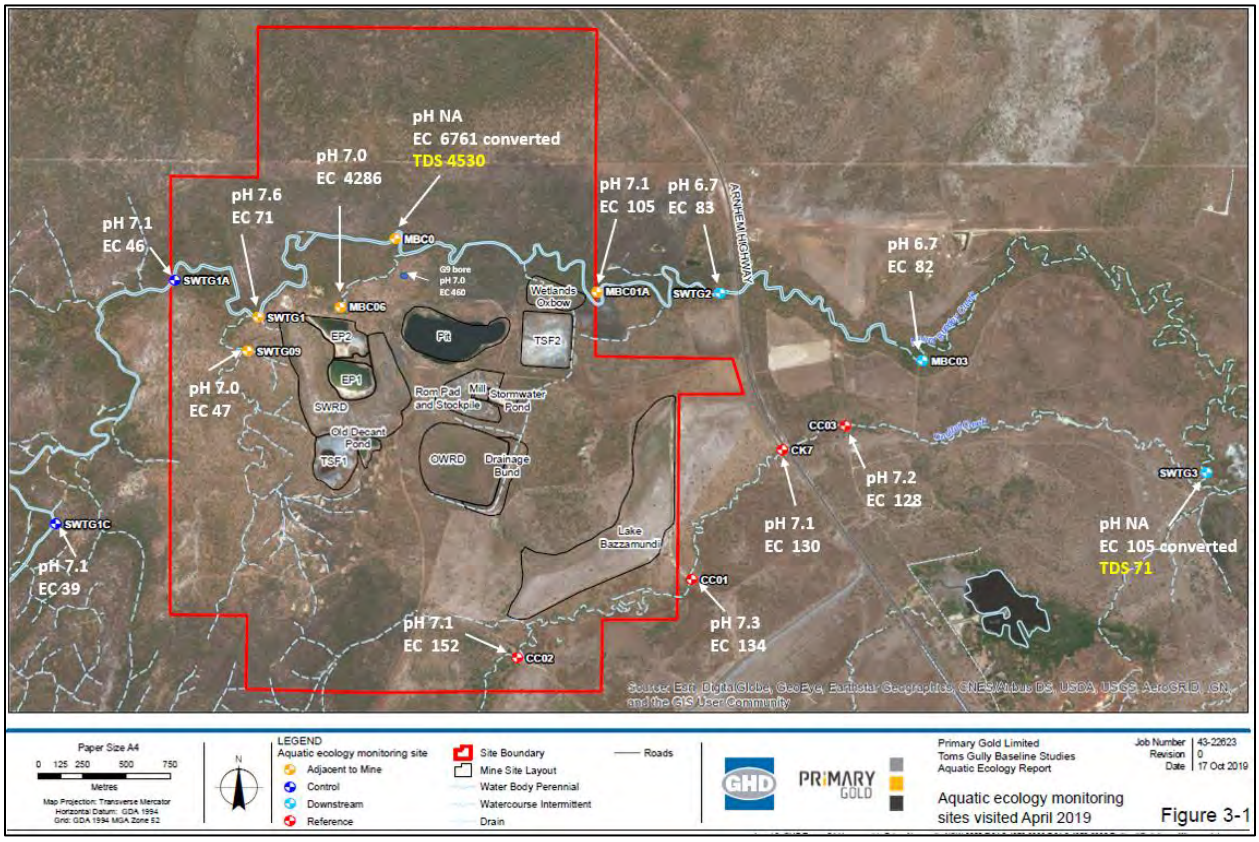
The above table shows results of the surface water sampling done by GHD in April 2019. The main contaminants or deficiencies are the high EC values and low dissolved oxygen measurements especially near the Sulfide waste dump sample point MBC06. This is in a mixing zone between the Sulfide waste dump and the Toms Gully oxbow section of the Mt Bundey Creek.

The pH of the sampled points is within site specific target values.

Capping of the Sulfide waste dump, removal of TSF1 and TSF2 would reduce the sources of salinity and other contaminations considerably.

Figure 2 below shows the sample points with pH and EC measurements.

Figure 2 - Location of Sampling Points with pH and EC Measurements



Observations from the Aquatic Report are shown below.

- Water leaving the mine tenements to the east have raised EC values approximately double the Target values (MBCO1A, SWTG2 and MBC03). Once removal of TSF's and capping of the Sulphide waste dump these values would reduce considerably.
- Water entering the mine tenements at the west of the mine are already close to the target values for EC (41 µs/cm). This creates a challenge to keep the EC vales down as it passes through the mixing zone between the Sulfide waste dump and the oxbow area if the creek. Waste dump capping, TSF1 and TSF2 removal is important to remove the sources of contamination.
- Coulter Creek has a higher EC reading than Mt Bundey Creek at the upstream entrance to the mine tenements and exit from the mine tenements. This indicates that there is no measurable contamination to Coulter Creek from existing mine infrastructure with average rainfalls. Either natural salinity sources exist upstream in Coulter Creek or possible contamination from the

Boral Quarry that is further south of Toms Gully Tenements. The flow from Coulter Creek joins with the Mt Bundey creek and raises the contamination level flowing in the combined creek flow with outside contaminants.

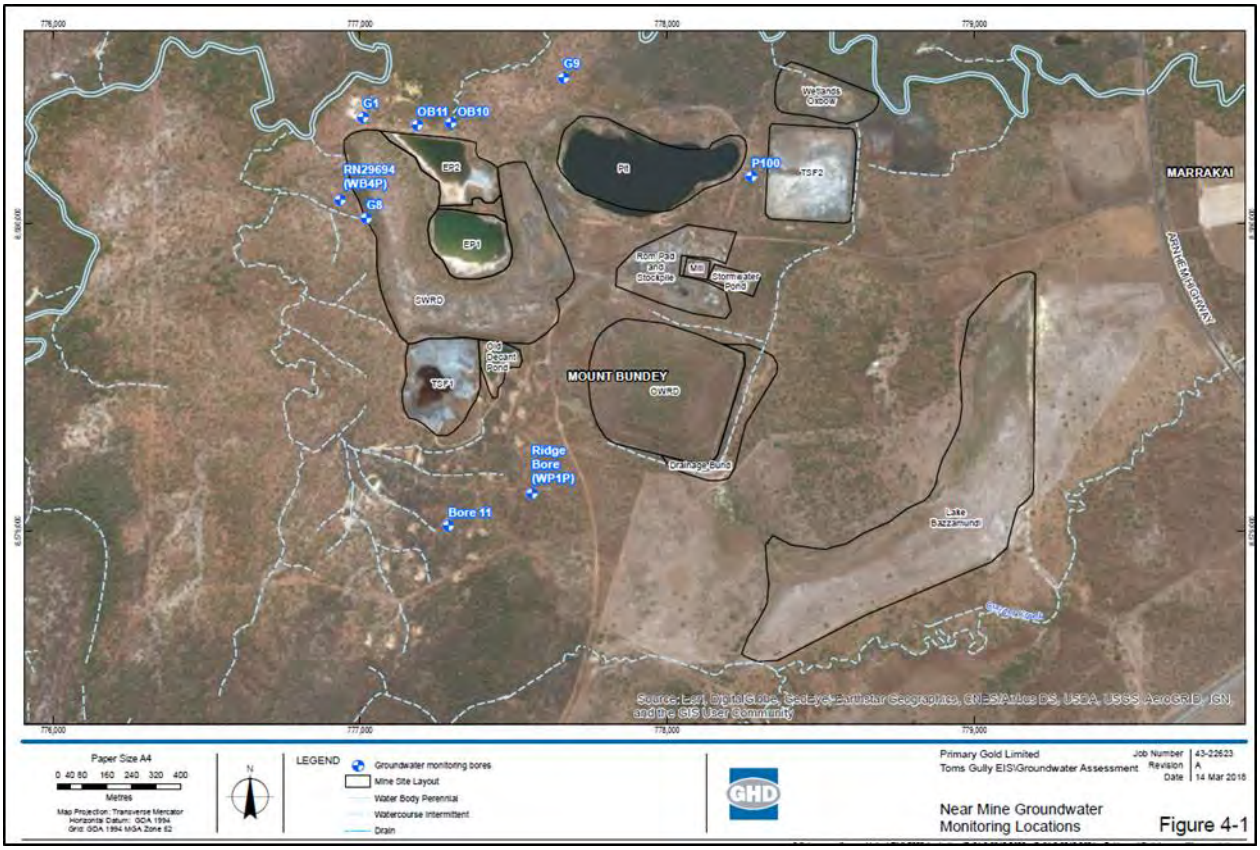
Bores G9 and P100 that are close to Toms Gully Pit

There are two monitoring bores close to Toms Gully Pit that have been monitored over a period of years.

Standing water levels and contaminate records have been kept. These records show that the standing water levels in both bores have not changed much from when the pit was empty. This indicates that ground water is coming from other locations and the pit water levels do not affect the general water levels significantly around these bores.

The water in the pit does not appear to be affecting the pH, EC values and SWL in the groundwater surrounding the bores. Figure 3 below shows the location of the two bores.

Figure 3 - Location of Monitoring Bores Around Toms Gully Pit



Bore G9

The ground water bore G9 has a lower EC reading near the sample point MBC0 than the surface water measurements in Mt Bundey Creek and also the Toms Gully Pit. This indicates that there is not a significant flow of water from the pit into the ground water in G9 bore.

Table 2 below shows the standing water level (SWL), pH and EC measurements of the Toms Gully Pit and Bore G9.

Table 2 - Relationship Between Pit Water Level and Bore G9 Groundwater North of the Pit

Days	Date	pH	EC	G9 Depth below surface of 22m AHD	SWL		Date	pit SWL approx match	est
0	2/11/2010	7.0	375	14.5	7.5		15/03/2010	-70.00	-70.0
31	3/12/2010	6.5	372	14.5	7.5				-58.5
84	25/01/2011	6.5	356	9.0	13.0				-47.0
385	22/11/2011	7.0	228	14.4	7.6				-35.5
454	30/01/2012	7.1	944	7.6	14.4				-24.0
542	27/04/2012	6.1	379	10.0	12.0		6/05/2012	-12.54	-12.5
659	22/08/2012	7.1	889	13.1	8.9				-10.2
883	3/04/2013	5.1	91	8.0	14.0				-7.9
1,150	26/12/2013	6.4	247	11.0	11.0		7/08/2013	-5.64	-5.6
1,206	20/02/2014	5.4	35	6.0	16.0				-3.2
1,256	11/04/2014	6.2	73	9.0	13.0				-0.8
1,496	7/12/2014	6.1	285	11.0	11.0				1.6
1,564	13/02/2015	7.1	233	10.0	12.0				4.0
1,592	13/03/2015	7.3	34	13.0	9.0				6.4
1,620	10/04/2015	8.6	223	12.0	10.0		22/10/2015	8.84	8.8
2,017	11/05/2016	6.7	143	7.9	14.1				10.1
2,131	2/09/2016	na	na	12.0	10.0				11.3
2,340	30/03/2017	7.1	340	na	na				12.6
2,797	30/06/2018	7.0	460	8.2	13.8		13/08/2018	13.80	13.8

It has taken approximately nine years for Toms Gully Pit to fill up with water since mining stopped in 2010. The first two years water flowed in to the pit relatively quickly. Mainly due to the incremental volume of the pit per metre is significantly smaller in the lower depths of the pit than the wider upper regions of the pit. The pit has filled up slower once the pit wall slopes flattened out.

The water level in a monitoring bore called G9, that is 140m north of the pit, has had a SWL of 11.4m AHD on average for most of the nine years the pit has been filling. The water level for G9 varies between 7.5m AHD and 16m AHD depending of rainfall and ground water flow from sources many kilometres from the pit area.

Figure 4 below shows the Toms Gully Pit SWL rise while filling against the cumulative volume filled by water in the pit.

Figure 4 – Toms Gully SWL and Cumulative Water Volume

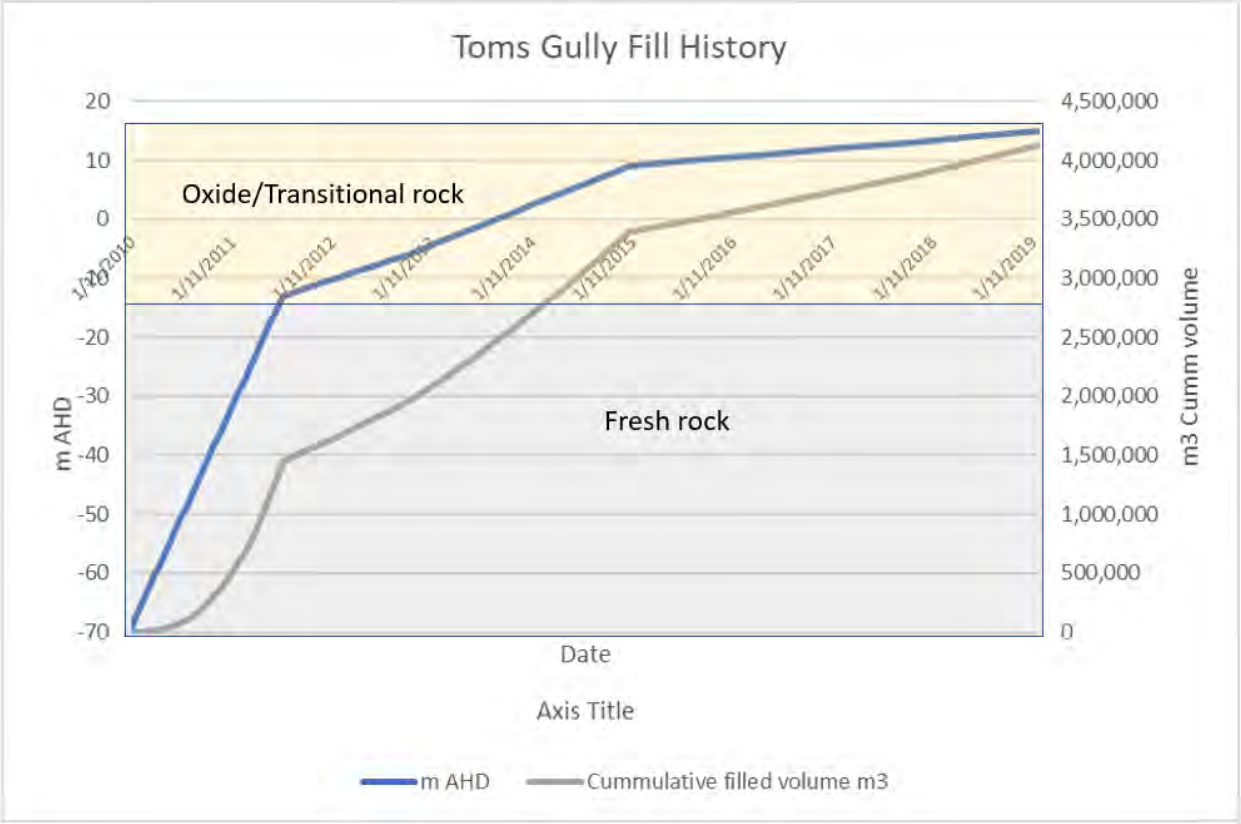


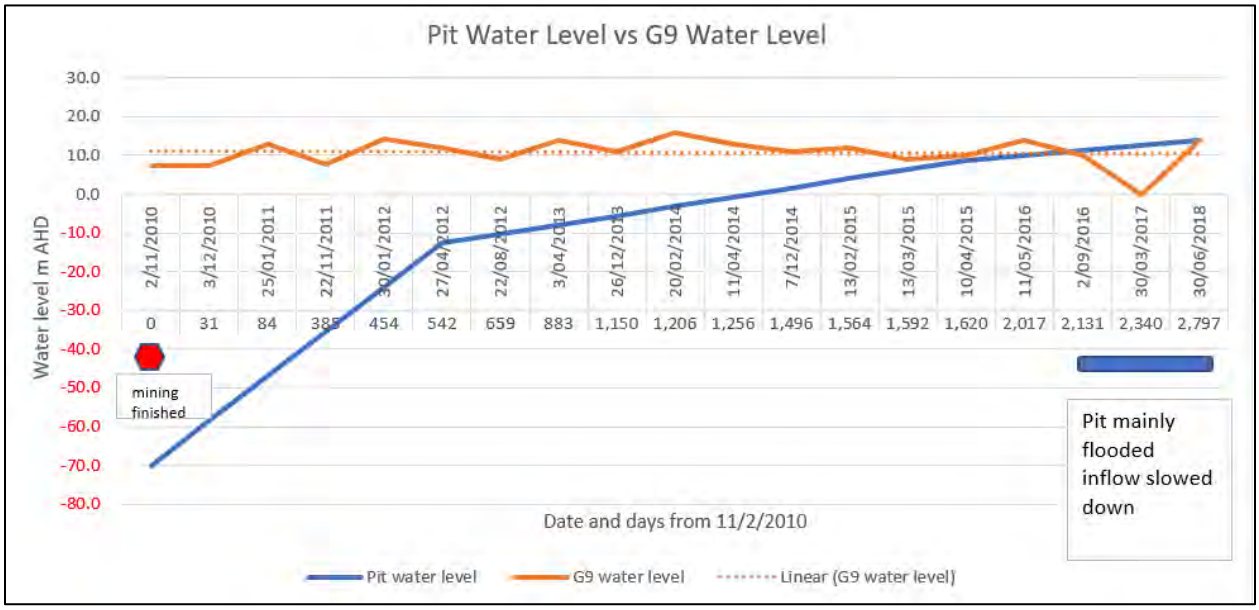
Figure 5 below shows the relationship between the SWL of G9 bore and the pit SWL.

It can be seen than the rise in the pit water level did not noticeably affect the water level in the G9 bore.

G9 bore is between the pit and Mt Bundey Creek and would respond to the pit being empty which it did not. It would rise if it was connected to the pit water level.

Current stormwater is pumped out of TSF1 and TSF2 water into the pit and direct runoff from the Sulfide waste dump is adding extra water into the pit. This is a temporary/artificial water input into the pit. Once the TSF1, TSF2 are removed and the Sulfide waste dump is capped. The runoff from the top of the Sulfide waste dump will be directed away from the pit – the water quality in the pit would be improved with less new contamination being added. Also the pit water level would stop rising above the natural water table.

Figure 5 – Rise in Toms Gully Water Level vs Bore G9 Water Level



Top of fresh material in the pit is -10m AHD. Transitional and oxide material are above the -10m AHD.

From the water monitoring records of G9 the:

- pH has stayed fairly constant, averaging 6.7
- EC us-cm has averaged 317 µs/cm.

Note when the pit water level was empty the EC measurement in G9 was 375 µs/cm. The highest EC reading in G9 was 944 µs/cm when the pit water levels were at -24m AHD or 46m below surface. Recent EC measurements in G9 is 460 µs/cm. This indicates the pit water is not greatly affecting the SWL in the bore as contaminated water was coming from another source before the water level in the pit rose to transitional or oxide surfaces in the pit.

Bore P100

P100 is a bore close to the eastern side of the pit (46m). There is an increase (27%) in EC values when pit water levels rose up to and above the oxide layer (-10m AHD) in the pit wall (2011 onwards).

When the pit was empty (-70m AHD) the EC values in Bore P100 were 1,000 µs/cm . As the water in the pit rose above the -10m AHD (bottom of transitional/oxide layer) the value rose to 1,271 µs/cm. The Pit EC values were 2,400 µs/cm at the time, thus a 271 µs/cm increase in bore P100 from a 2,400 µs/cm potential source shows a considerable amount of dilution is occurring in the 46m distance between pit and bore.

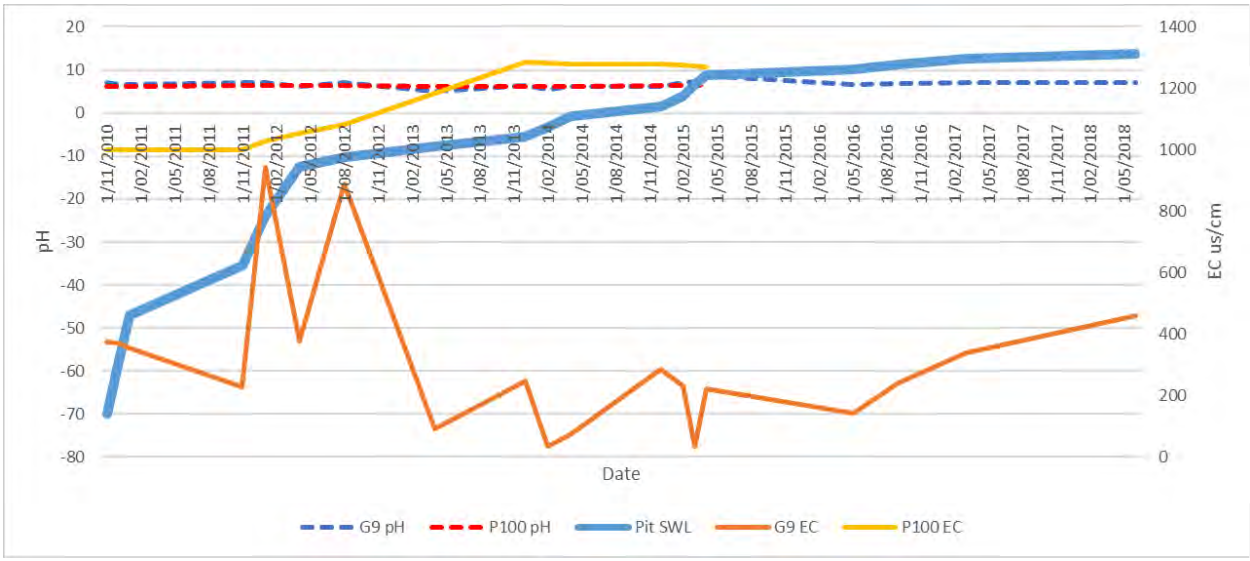
Table 3 below shows historical water quality data for Bores G9 and P100. P100 is 46m directly east of the pit.

Table 3 – Historical Water Quality Measurements of Bores G9 and P100

		Field		Alkalinity				Acidity	Inorganics	Major Ions						Metals									
		Electrical Conductivity (Field)	pH (Field)	Carbonate	Bicarbonate	Alkalinity (total) as CaCO3	Hardness as CaCO3	Hydroxide	Acidity (as CaCO3)	Total Suspended Solids	Calcium (Filtered)	Chloride	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Sulphate	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Cobalt (Filtered)	Copper (Filtered)	Iron (Filtered)	Lead (Filtered)	Manganese (Filtered)	Nickel (Filtered)	Zinc (Filtered)
		µS/cm	pH Units	mg/L	mg/L	mg/L	mg CaCO3/L	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	µg/L
ANZECC 2000 - Livestock Trigger		3000	6-8							5000	1000					1000	5000	500	10	1000	1000*	500		100		1000	20000
P100	22/11/2011	1001	6.29	<1	63	63		<1			90	14	56	7.4	28	380											
	30/01/2012	1081	6.27	<1	73	73		<1			100	15	60	8	31	450											
	30/01/2012	1081	6.27	<1	75	75		<1			96	15	60	7.8	31	440											
	22/08/2012	1285	6.13	<5	91	91		<5			110	14	62	8.3	31	460											
	22/08/2012	1286	6.13	<5	91	91		<5				14				460											
	1/09/2015	1271	6.53			81	642		36	10	138		72.5	8.9	35	598	4.3	56	0.36	<1	4.85	1.56	6300	0.12	1500	18.2	97.6
G9	3/12/2010	372	6.51	<0.1	160	160	160	<0.1	<2	27	48	7.4	9.2	2.8	4	8.2	23	5	0.3	<1	3	4	97	12	180	5	25
	2/11/2010	375.2	6.98	<0.1	150	150		<0.1			49	8.2	8.7	2.9	4.1	6.7											
	25/01/2011	356.2	6.5	<0.1	170	170	<5	<0.1	<2	150	46	7.7	7.7	2.8	4	11	16	5	0.3	<1	3	<1	84	18	240	10	25
	22/11/2011	228.3	7	<1	31	31		<1			8.7	4	2.1	1.3	1.1	3											
	30/01/2012	944	7.07	<1	180	180	470	<1	<2	55	92	8	59	2.9	6.2	280	<10	8	0.2	<1	22	<1	500	<1	1400	67	36
	27/04/2012	379	6.06	<5	25	25	97	<5	<2	<5	20	3	12	1.6	1.9	26	17	<1	0.3	<1	<1	2	<10	12	29	5	19
	22/08/2012	889	7.1	<5	190	190	440	<5	<5	13	88	6	53	2.9	6.1	190	12	6	0.2	<1	13	<1	180	<1	1000	54	24
	3/04/2013	90.7	5.06	<5	38	38	23	<5	<5	<5	4.6	4	2.7	1.6	1.1	34	48	1	2.2	<1	10	15	18	140	330	29	120
	26/12/2013	247	6.4	<5	12	12		<5			9.8	3	8.4	1.9	1.7	12											
	20/02/2014	34.5	5.4	<5	10	10		<5			1.6	2	0.5	1.4	1	1											
	11/04/2014	72.7	6.15	<5	25	25		<5			5.2	3	2.9	1.6	1.4	29											
	7/12/2014	285	6.1	<1	21	21		<1			10.5	4.5	5.9	1.9	1.7	26.6											
	13/02/2015	233	7.1			21	41.7		13	<10	8.4	4.8	5.1	2.1	1.6	24.3	3.5	3.45	0.74	<0.1	2.03	5.18	34	83.5	125	5.92	41.1
	13/03/2015	34.3	7.27			16	37.5		6	<10	7.6	4.6	4.5	2	1.5	22.5	6.4	3.5	0.72	<0.1	3.81	4.37	16	145	225	5.59	54.4
	10/04/2015	223	8.6			13	32.8		12	<10	6.5	4.4	4	1.5	1.3	18.9	4.9	3.6	0.8	<0.1	9.3	5.45	48	141	483	7.68	65.9
	1/09/2015	143.2	7.21			22	47.5		8	<10	9.9		5.6	2	2	24.7	5.4	7.65	0.72	0.1	5.7	1.96	854	238	299	9.42	69.3
	11/12/2015	112	7.1			13	42.6		3	<10	8.9	5.8	4.9	2.1	1.9	22.5	8.3	1.75	1.08	<0.1	4.62	3.94	104	305	235	8.21	99.3
	18/01/2016		6.64			28	62.8		7	20	13.2	5.2	7.3	2	2	31.1	5.1	3.15	0.94	<0.1	4.19	1.79	398	156	208	7.63	73.3
	11/05/2016	143	6.7			30	58.4		11	<10	12.6	4.9	6.5	1.7	1.9	26.5	2	0.8	0.38	<0.1	4.08	1.43	16	33.6	275	6.03	40.2
	2/09/2016					89	117		16	<10	30.1	6.2	10.2	2.3	2.9	31.3											
	11/01/2017	310	7.2			160	170			6	51	7	9.5	2.8	4	5	<10	6	<0.1	<1	<1	<1	320	<5	160	<1	2
	29/03/2017	340	7.1			150	160			<5	50	8	9.3	2.7	4	6	<10	5	<0.1	<1	<1	<1	20	<1	180	<1	2
	25/06/2017	320	7.1			160	170			<5	52	8	9.8	2.8	4.2	6	<10	5	<0.1	<1	<1	<1	540	<1	210	1	8
	10/09/2017	340	7.1			160	200			<5	63	8	10	2.7	4.3	4	<10	5	<0.1	<1	<1	<1	300	<1	150	<1	8

Figure 6 below shows that the pH in Bore G9 and P100 has not changed much as the water in the pit has risen to the top of the pit (sub 15m AHD).

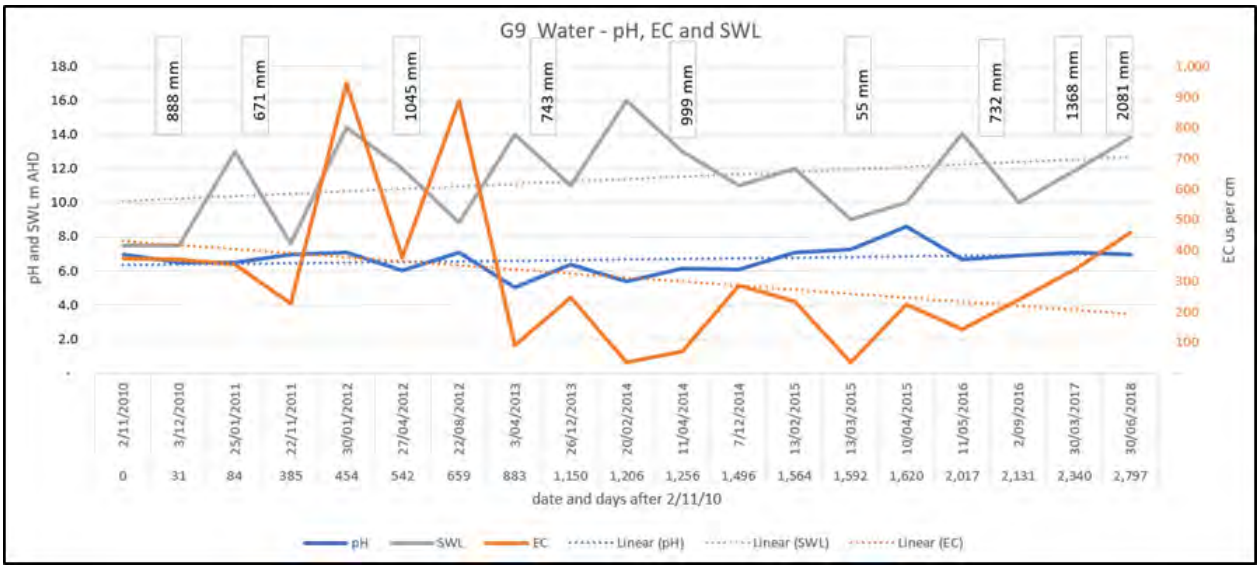
Figure 6 – pH and EC values in Bores G9 and P100



The EC value for G9 has not risen considerably as the pit water level has risen over the last nine years. EC reading spiked to 1,000 µs/cm in 2012 when the pit water was below the oxide levels in 2012 an assumption runoff from Sulfide waste dump may have contributed due to high rainfall in 2012. See Figure 6 below rainfall was 1,045mm in 2012.

Figure 7 below shows the relationship of heavy rains to EC values and to some extent the SWL in Bore G9.

Figure 7 – G9 SWL, pH and EC Values to Compare Pit water rise to Change in Contaminant Values



The pit has a low pH (3.3)and a high EC measurements (2,400 µs/cm). This low pH and high salinity is not shown in the bore G9 monitoring records even when the pit is full. Assumption is that ground water flows towards the pit from bore G9. That is, the pit is acting as a sink as per Appendix C.

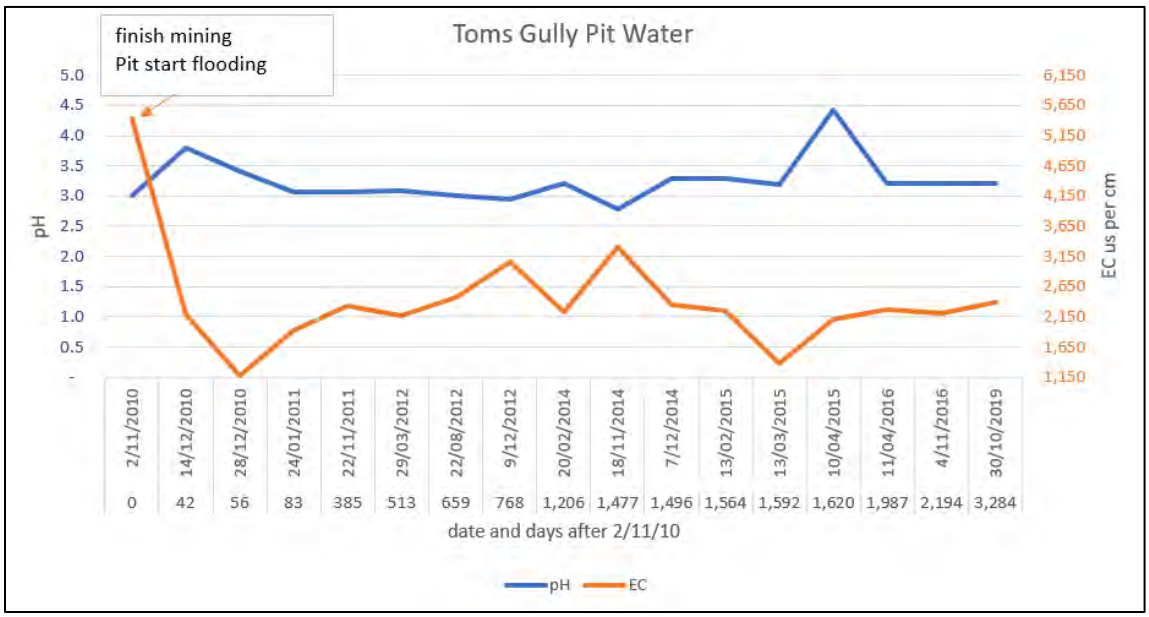
Toms Gully Pit Water

The Toms Gully Pit has filed up with water in the past nine years. The water quality is not very good due to contact with sulphide material in the pit walls as water rose and constant runoff from the Sulfide waste dump.

The pH and EC of the pit has stayed relatively constant during this time averaging pH 3.3 and EC of 2,400. The pit water has high levels of metal contaminates.

Figure 8 below shows the pH and EC measurements since the pit started flooding in 2010 until recently in October 2019.

Figure 8 - Toms Gully Water pH and EC Measurements



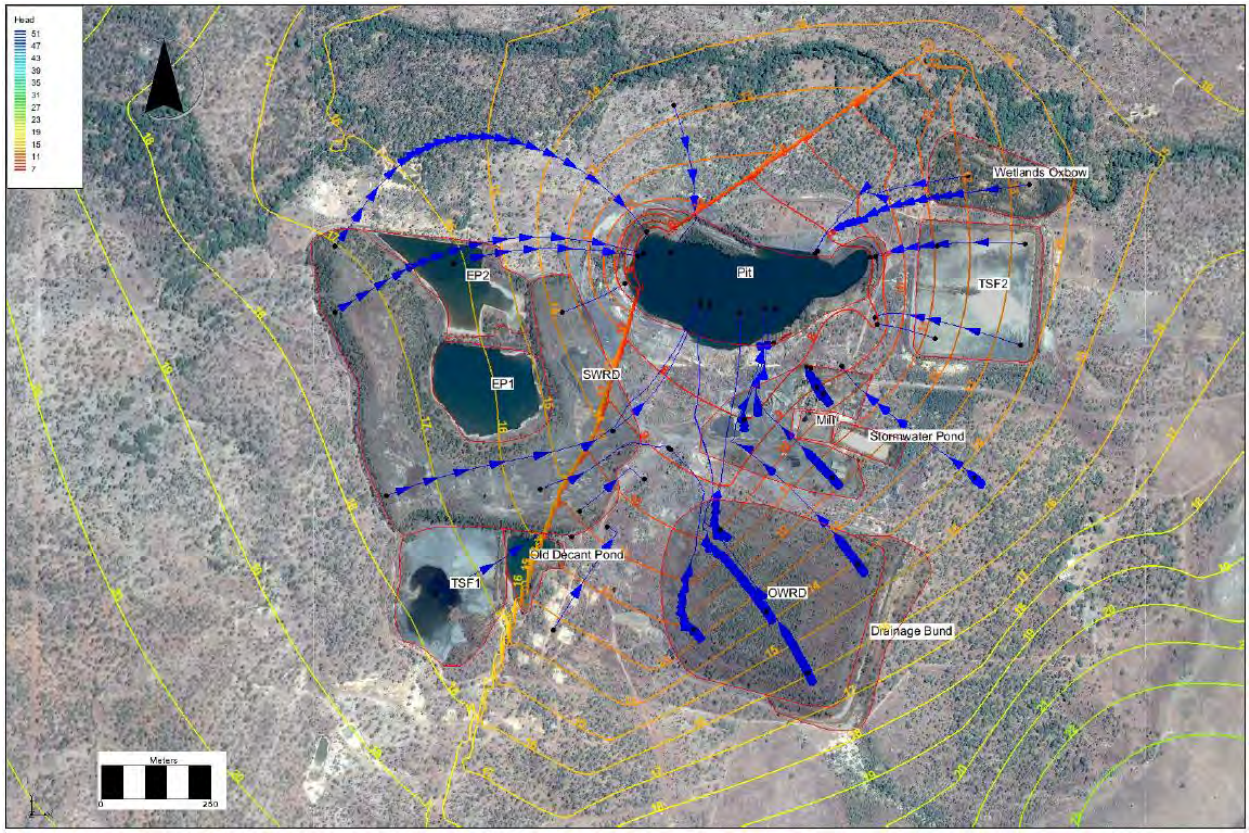
Primary Gold will treat the pit with lime or caustic to improve the pH to 8.5 once the operations start. This will improve the pH and allow heavy metals to drop into the bottom of the pit.

In Appendix C – Groundwater Modelling – Toms Gully Supplement.pdf in section 6.4 page 58. states "…the modelled heads indicate that the mine pit and connected underground workings remain a groundwater sink through evaporative losses from the pit surface…

This is likely to result in capture of groundwater contamination from the various site sources such as the TSFs and WRDs…"

Below in Figure 9 the ground water levels are shown from the modelling done in the GHD report shown in Appendix C.

Figure 9 - Particle tracking (arrow interval 10 years)



Extent of potential ground water subsurface seepage from Toms Gully pit

While additional water is pumped into the pit and captures the runoff from the Sulfide waste dump the water in the pit will rise above the natural water table. The following is an estimate of the surface expression that the water, may make if the additional water is not diverted or pumping outside sources continues.

The ground water flow from the pit is in a generally north-eastly direction.

The Figure 9 above indicates flow into the north east side of the pit. The Figure 9 also indicates the phreatic surface is 1 in 150 in the ground to the north east of the pit. It is assumed that 1 in 150 for the phreatic surface gradient would reasonable to use for sub surface water seepage out of the pit.

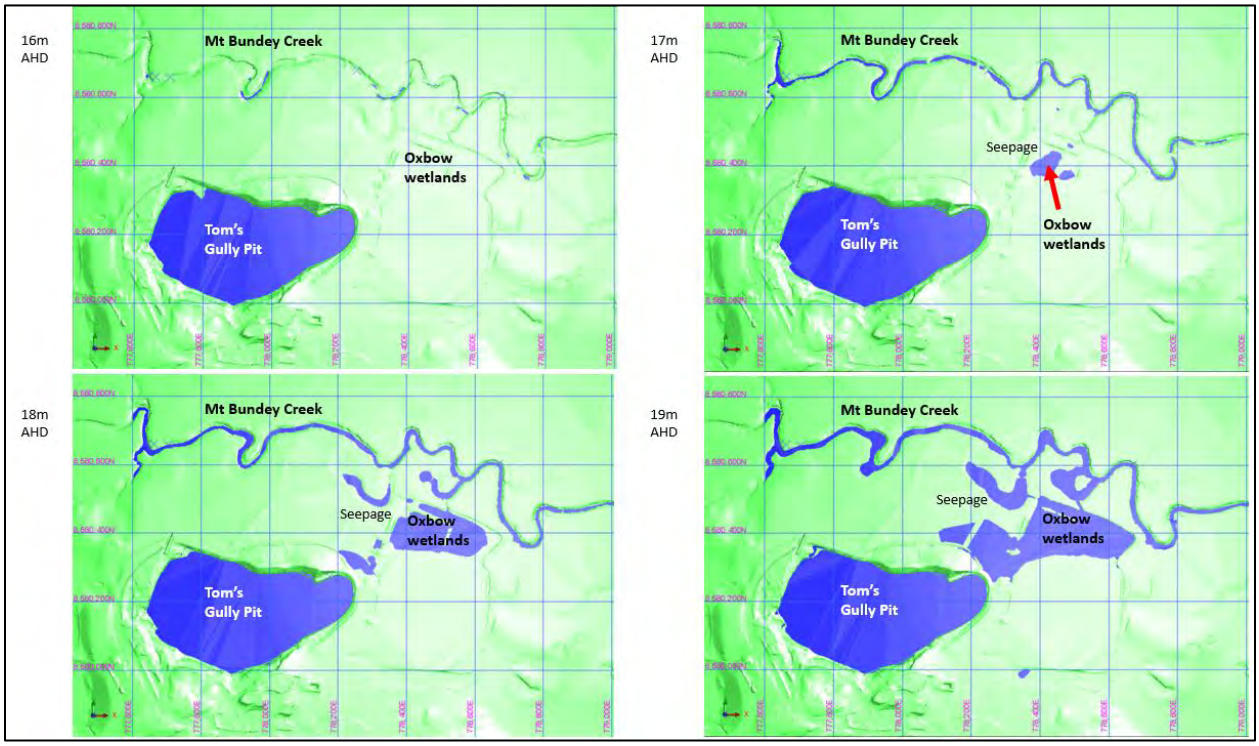
The localised groundwater flow from the pit water rising will flow into Oxbow wetlands. This is mainly due to the topography of the land. The Oxbow area is the lowest land between the pit and Mt Bundey Creek.

The Oxbow wetlands is already designed to be a passive treatment area. The area has surface water flow from the stormwater pond and the oxide waste dump (OWRD/WSD) see Figure 9 above for the locations.

The Figure 10 below shows the water level at 1 in 150 gradient for four pit water level scenarios (16m to 19 m AHD). The water will start to seep out of the Oxbow area when the water level gets to 17 m AHD. This is the estimated maximum level of water in the pit.

In the wet season, rainfall and runoff will dilute the water seeping into the Oxbow wetlands.

Figure 10 – Estimate of Local Groundwater Levels Due to Water Rising in the Pit



The water reporting to the Oxbow wetlands will be passively treated before running into Toms Gully Creek.

Figure 11 below shows the Oxbow wetlands in 2010 at the end of last mining activities in 2010.

Figure 11 – Picture of the Oxbow Wetlands in 2010

Table 4 below shows the Site Specific Trigger values from "Appendix U CSIRO review of site trigger values for Toms Gully Mine, NT.pdf". This has been previously presented as Primary Gold's Site Specific Trigger values previously in the Addendum to the Supplement documents in Appendix U on page 8.

Table 4 - Trigger values from Appendix U CSIRO review of site trigger values for Toms Gully Mine

Parameter	Trigger Value[a]	Trigger Value (90% species protection)	Final Proposed Trigger Values for the Discharge Point or Compliance Site SWTG2 after dilution
pH	6.9	-	5.8-8.0
EC, µS/cm	41	-	41
TSS, mg/L	54	-	54
Turbidity, NTU	87	-	87
Sulfate, mg/L	316[b]	210[b]	210
Al (pH>6.5), µg/L	295[c]	-	295[c]
As, µg/L	140	42	42
Cd, µg/L	0.8	0.4	0.4
Cr, µg/L	40	6	6
Cu, µg/L	2.5	1.8	1.8
Fe, µg/L	2700[d]	950[e]	2700[d]
Pb, µg/L	9.4	5.6	5.6
Mn, µg/L	3600	2500	2500
Ni, µg/L	17	13	13
Zn, µg/L	31	15	15
Total ammonia (pH 8), mg/L	2.3	1.4	1.4

[a] based on 80th percentile of reference site monitoring data for pH, EC, TSS and turbidity; based on 80% species protection for toxicants
[b] data for soft waters re-derived from Elphick et al. (2011) chronic toxicity study
[c] based on dissolved Al from background data
[d] based on total Fe from background data
[e] new ANZECC/ARMCANZ GV for total Fe (under review)

APPENDIX 2

Supplementary Information, Tom's Gully Underground Project Closure Plan

Inland water environmental quality: Potential release of mine-affected water after closure

Surface
Water &
Erosion
Solutions

Supplementary information, Tom's Gully Underground Project Closure Plan

Inland water environmental quality: Potential release of mine-affected water after closure

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December 2019

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1 Executive Summary

The NTEPA required the following supplementary information for the Primary Gold Limited – Tom's Gully Underground Project:

1. Demonstrate a post-closure long-term water-balance management strategy that addresses the risks (and extent) of overtopping, seepage, and/or unauthorised, uncontrolled or passive discharge to the environment.
2. Provide post-closure water balance schematics, including volumes, for an average rainfall year and a very wet year.
3. Demonstrate that the post-closure strategy meets industry standard closure objectives as follows:
    a. safe to humans, domestic livestock and wildlife,
    b. non-polluting,
    c. stable,
    d. able to sustain an agreed post-mining land use.

Long-Term Water-Balance Management Strategy

1000-year water balance simulations of the Tom's Gully mine site main pit under a dry climate (average rainfall) and wet climate (5% increase in average annual rainfall) showed there is no risk of overtopping the pit if the proposed passive water management strategies are implemented. The predicted freeboard level ranges from 5.1m to 8m for the dry climate scenario, and 5.6m to 8.2m for the wet climate scenario.

Short-Term Post-Closure Water Balance – average rainfall year & very wet year

Site-wide annual water balances from 2026 to 2030 for dry rainfall years (50th percentile annual rainfall) and very wet years (95th percentile annual rainfall) scenarios demonstrated that:

- There is no uncontrolled discharge from the main pit.
- Uncontrolled discharge occurs at EP1 after 3 years (up to 85ML in 2030).
- Uncontrolled discharge occurs at EP2 after 3 years (up to 45ML in 2030).

Post-Closure Strategies Meeting Industry Standards

Water Quality (non-polluting)

Water balance modelling showed that the pit is unlikely to overflow under a 1%AEP or 0.1%AEP event, however, water quality simulations were undertaken for the very unlikely hypothetical scenario where the main pit is full and about to overflow at the commencement of the event, and where there is no existing flow in the creek, or follow-up rainfall.

Contaminant dispersion and concentration was assessed for pit water constituents and compared with ANZECC 80% trigger values and site-specific trigger values at the monitoring point SGWT2. Possible exceedances were noted for the following constituents, for a 1%AEP event: Aluminium, Cadmium, Cobalt, Copper, Lead, Nickel, Uranium, Zinc, Calcium, and Magnesium.

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Risk to Humans, Livestock and Wildlife

Flood risk hazard was assessed using Velocity x Depth (VxD) maps. There is high risk should humans or livestock enter the floodplain adjacent to the creek channel or the creek channel, however, the area is on private property and is securely fenced so this is unlikely to occur. Flood risk on the mine site, while it does exist, is no greater than other nearby areas.

Landform Stability

The mine site straddles the common catchment boundary of Mt Bundy Ck and Coulter Ck, and therefore was separated into two catchments for the stability analysis: Mt Bundey Ck Catchment (MBCC) and the Coulter Ck Catchment (CCC). Site stability was assessed using the RUSLE erosion model and CAESAR-LisFlood landform evolution model. Soil samples were collected from the mine and undisturbed surface material types. Laboratory analyses was conducted to determine input values for the erosion models.

RUSLE long-term erosion rates ranges from 0.24 t/ha/y to 7.7 t/ha/y and 21.14 t/ha/y for steep-sloped oxide material. These compare reasonably well with regional values.

The CAESAR-Lisflood model was used to assess erosion and deposition on the mine landform from low frequency, high intensity rainfall events (1%AEP and 0.1%AEP), as well the long term stability over 100 years using a future wet climate scenario and a future dry climate scenario.

CAESAR-LisFlood simulations showed that the median (maximum) sediment concentrations were 14(30) mg/L (MBCC) and 5(26) mg/L (CCC) for the 1%AEP event, and 11(31) mg/L (MBCC) and 16(105) mg/L (CCC) for the 0.1%AEP event. These results compare favourably with regional suspended sediment concentrations median (maximum) values of 6(205) mg/L, indicating the mine suspended sediment loads are no larger than elsewhere for low frequency, high intensity events.

For the 100 years wet climate scenario, long-term erosion rate was 1.2 t/ha/y (MBCMC) and 1.9t/ha/y (CCC), and denudation rate was 0.04 mm/y (MBCC) and 0.07 mm/y (CCC). For the 100 years dry climate scenario, long-term erosion was 1.0 t/ha/y (MBCC) and 0.9 t/ha/y (CCC), and denudation rate was 0.04 mm/y (MBCC) and 0.03 mm/y (CCC). These values are well under the regional range of 3 to 8 t/ha/y long-term erosion rate and 0.2 to 0.25 mm/y denudation rate, indicating the mine will not erode any faster than the surrounding undisturbed areas.

Three-dimensional results for the 1%AEP and 0.1%AEP events show erosion occurring on the oxide cover, however, there are no significant signs of erosional instability and erosion features on the site are similar to the natural surrounds.

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2 Introduction

Following a review of the Environmental Impact Statement (EIS) for the Primary Gold Limited – Tom's Gully Underground Project (TGUP) conducted in August 2019, The Northern Territory Environment Protection Agency (NTEPA) has requested further information regarding post-closure water quality and the potential for future release of mine-affected water. The details are provided in Appendix I.

The specific areas for extra information are:

1. Demonstrate a post-closure long-term water-balance management strategy that addresses the risks (and extent) of overtopping, seepage, and/or unauthorised, uncontrolled or passive discharge to the environment.
2. Provide post-closure water balance schematics, including volumes, for an average rainfall year and a very wet year.
3. Demonstrate that the post-closure strategy meets industry standard closure objectives as follows:
    a. safe to humans, domestic livestock and wildlife,
    b. non-polluting,
    c. stable,
    d. able to sustain an agreed post-mining land use.

Full details of the current proposed closure strategies are provided in the Primary Gold Limited Tom's Gully Underground Project Mine Closure Plan 18 September 2015 and are not detailed further in this supplementary report.

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3 Site Description

The site is located at 77844mE and 8580645mN, GDA94/MGA zone 52. Full site details are provided in the Primary Gold Limited Toms Gully Underground Project Mine Closure Plan (18 September 2015).

Tom's Gully mine site straddles the catchment boundaries of the mid- to lower-reaches of Mt Bundey Ck and Coulter Ck (Figure 1).

Mt Bundey Ck rises near coordinates 776287mE and 8566158mN and the catchment is approximately 116.2 km^2 at the Arnhem Highway bridge (Photograph 1) including areas upstream of the mine site. The Coulter Ck catchment has an area of approximately 16.8km^2 including the area upstream of the mine site. The source of Coulter Ck is near coordinates 777747mE and 8572931mN.

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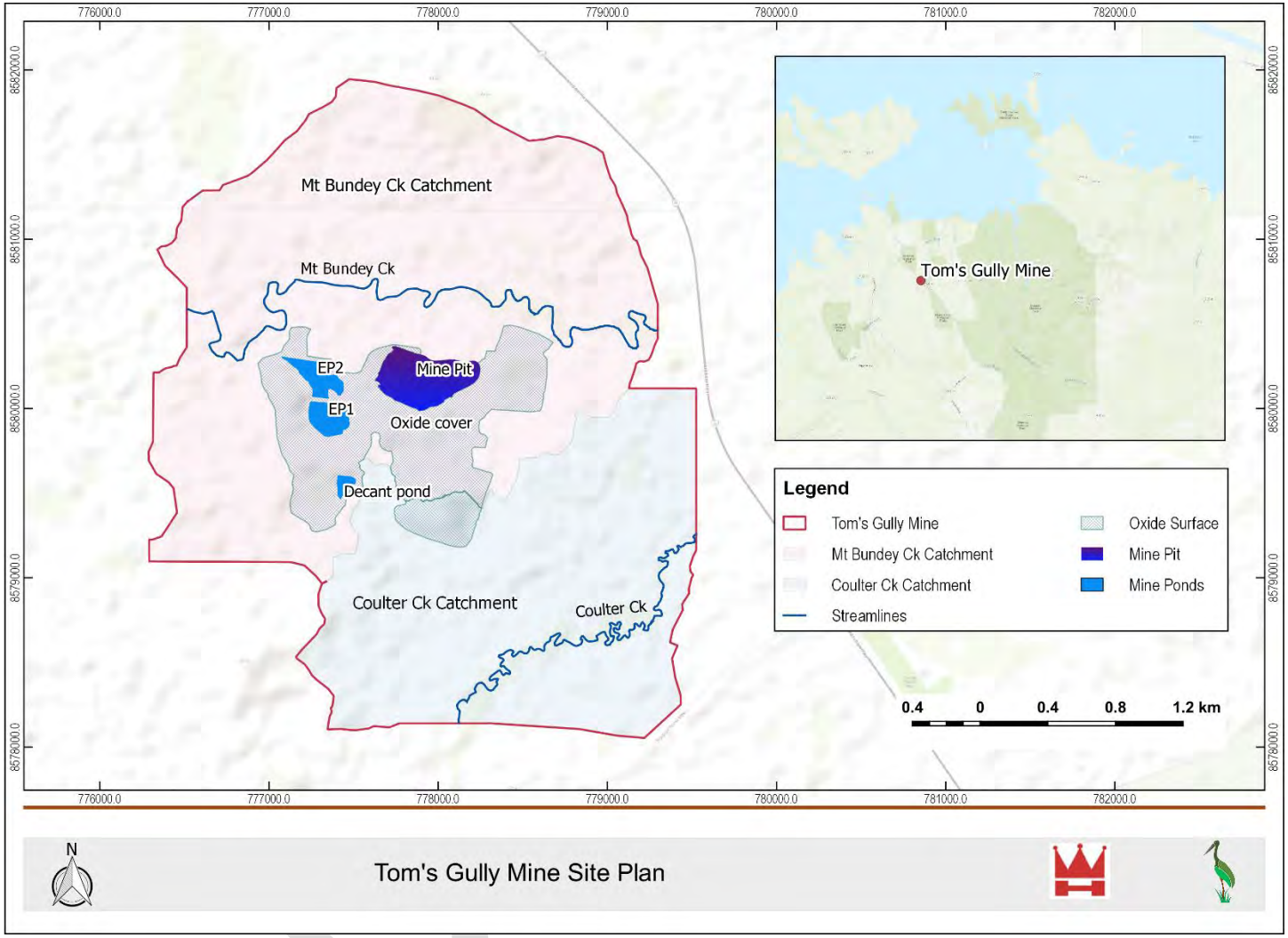

Figure 1. Tom's Gully Mine Site Plan

3.1 Site Investigation

A site visit, including soil sample collection, was conducted on 15 October 2019. Supplementary soil samples were also collected on 25 October 2019 for laboratory analysis (Appendix A).

The site appears generally stable, though some eroded areas were present. Five soil samples were taken for laboratory analysis to determine characteristics for input to the erosion models that were used in this study to assess site stability (Figure 2).

It is proposed that all unstable and eroded areas will be covered by oxide waste rock as part of the rehabilitation process.

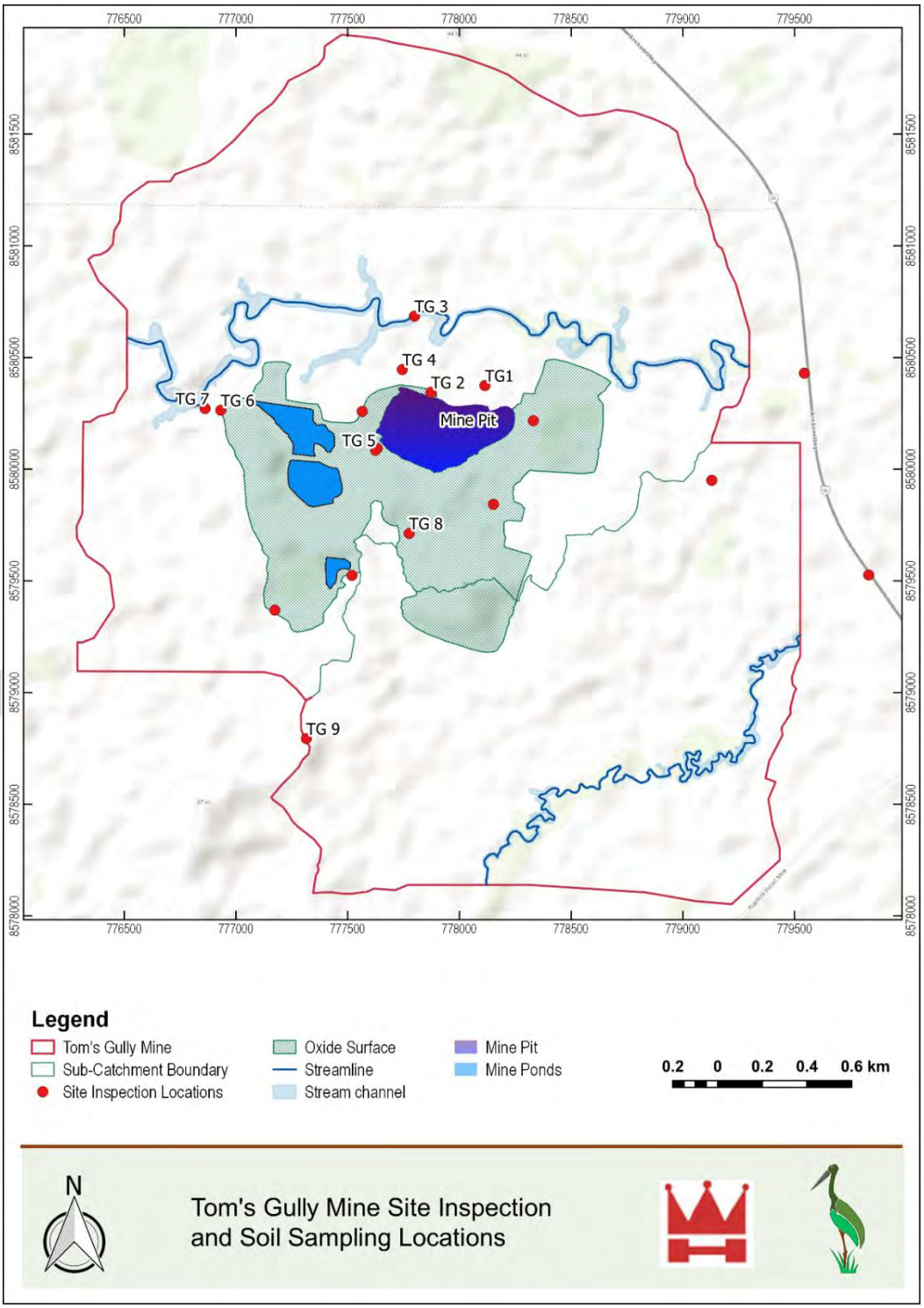

Figure 2. Soil sampling locations and site inspection plan

3.2 Soil Sample Sites

3.2.1 TG3 – Mount Bundey Creek

Soil Sample TG3 was collected from Mt Bundey Ck north of the site. Photograph 1 shows the well-defined stream channel of Mt Bundey Ck with about 3m high, silty banks held in place by riparian vegetation (Photograph 2). A soil sample was collected from the riverbed (Photograph 3), containing mainly coarse sand mixed with angular, flat pebbles and gravel. Ground cover primarily consists of leaf litter deposited from surrounding vegetation.

Photograph 1. Mt Bundey Ck Riverbed looking downstream showing some areas of bank collapse where vegetation has fallen into the stream bed

Photograph 2. Right bank showing silty layering bound with strong roots

Photograph 3. Soil Sample TG3 collected from the Mt Bundey Ck streambed

3.2.2 TG4 – Mount Bundey Creek Floodplain

Soil Sample TG4 was collected from the Mt Bundey Ck floodplain located between the creek and the mine site and represents the Creek Floodplain surface type (see Section 7.1). The natural ground shows minor signs of erosion with the absence of grassy vegetation and larger surface rocks are present (Photograph 4). As shown on Photograph 5, the soil mainly consists of fine materials deposited by overbank flow during flooding.

Photograph 4. Mount Bundey Ck Floodplain

Photograph 5. Soil Sample TG4 collected from the Mount Bundey Ck Floodplain

3.2.3 TG6 – Sulphide Waste Rock Dump (WRD)

Soil sample TG6 was taken from the Sulphide WRD area, representing the Sulphide Surface type. It has been rehabilitated and is similar in appearance to the surrounding natural areas, resembling open savanna woodlands consisting mostly of mature Eucalypt species with an understorey of immature wattle species and annual spear grasses (Photograph 6). The soil sample indicates hard competent surface rock with underlying fines (Photograph 7).

Photograph 6. Rehabilitated Sulphide WRD

Photograph 7. Soil Sample TG6 collected from the rehabilitated Sulphide WRD

3.2.4 TG 8 – Oxide Waste Rock Dump (WRD)

Soil Sample TG8 was collected from the Oxide WRD Area, representing the Oxide Surface type. The area is densely vegetated by mature wattle species and annual grasses (Photograph 8). The soil sample consists of fine, dry material which is covered by large surface rocks mostly >250m diameter or A-axis length (Photograph 9).

Photograph 8. Vegetation on Oxide Waste Rock Dump

Photograph 9. Soil Sample TG8 collected from the Oxide Waste Rock Dump

3.2.5 TG9 – Natural Ground

Soil Sample TG9 was taken from natural ground, representing the Koolpinyah Surface. The area consists of open savanna woodlands with mature Eucalypt species and an understory of immature Eucalypt and Pandanus species (Photograph 10). The soil sample contains larger pebbles as well as fine, clayey material (Photograph 11). The ground is widely covered with leaves and grasses.

Photograph 10. Natural Ground

Photograph 11. Soil Sample TG9 taken from natural ground

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4 Design Event simulation

4.1 RORBwin Hydrologic Modelling

RORBwin is a rainfall excess model which generates flow with the application of excess rainfall over defined sub-catchment areas. RORB was used to generate rainfall hyetographs for the 1%AEP and 0.1%AEP events in accordance with the Australian Rainfall & Runoff Guidelines 2019, which was used as input data to the HEC-HMS models and to CAESAR-LisFlood erosion modelling (Section 7). RORB was also used to generate discharge hydrographs at flow inlet locations used in the water quality modelling (Appendix B).

4.1.1 Catchment Analysis

Information available to create the RORBwin catchment model comprise:

- High-resolution 2.5m digital elevation model (DEM) purchased from the Northern Territory Government (NTG), covering the immediate study site and downstream flood plain areas, which was used for catchment and streamline delineation,
- Lower resolution GeoScience Australia 30m hydrologically corrected DEM, used for areas outside this coverage.
- 1m post-mining digital elevation model (DEM) created using Lidar data for detailed coverage of the mine site,
- GIS-based topographic information for defining waterways and waterbodies, and
- ESRI Satellite (ArcGIS/World Imagery) aerial photography accessed through Quantum GIS (QGIS).

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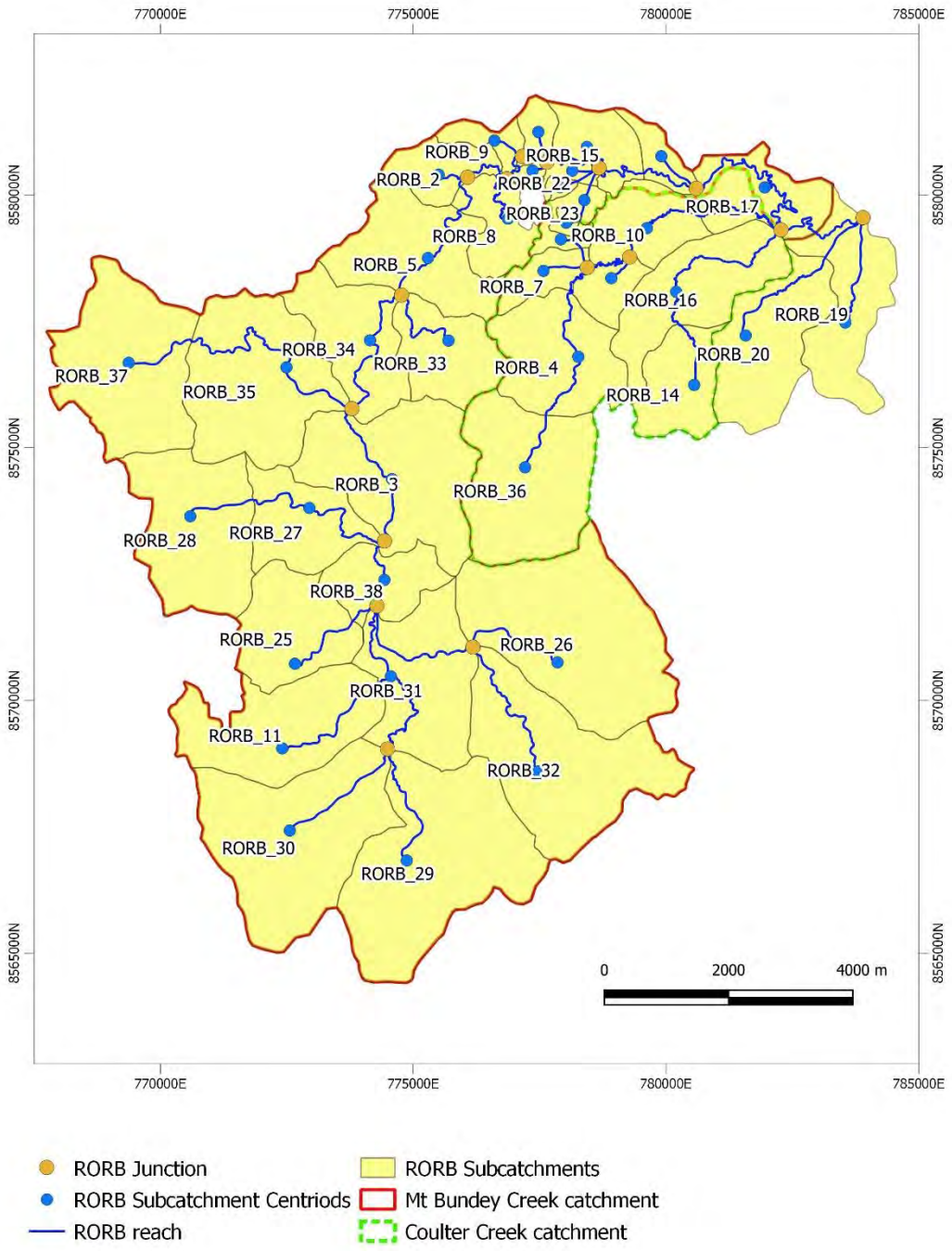

Figure 3. RORBwin sub-catchments covering Mt Bundey Ck and Coulter Ck

4.1.2 Design Rainfall Events

RORBwin was used to determine the hyetograph and hydrographs for 1%AEP and 0.1%AEP rainfall events.

The rainfall loss parameter values used in this study were initial loss (IL) 11 mm, and continuing loss (CL) 2.4 mm/h, which have previously been fitted for this region (Ball, et al., 2019)

Monte Carlo simulations, embedded in RORBwin and using the above parameter values and Bureau of Meteorology (BOM) Intensity-Frequency-Duration (IFD) curves, were run to determine the most probable rainfall and discharge for the 1%AEP and 0.1%AEP events. Refer to Appendix B for details.

5 Site water balance

5.1 Introduction

This section addresses the request for further information on the post-closure water balance of the site by:

- Demonstrating a post-closure long-term water-balance management strategy that addresses the risks of overtopping, seepage (and extent) and/or unauthorised, uncontrolled or passive discharge to the environment.
- Providing water balance schematics, including volumes, for both an average rainfall year and a very wet year.

The post-closure water balance assessment was completed using HEC-HMS modelling based on SILO long-term climate statistics.

5.2 Post closure surface water setting

Several mitigation measures have been proposed to improve post-closure passive water management, by reducing runoff catchment areas and increasing the storage capacity of the pit (Hanking 2019). The proposed diversion works will alter the surface runoff catchment draining on-site water storages. Figure 4 indicates the major runoff flow directions after the proposed earthworks to divert flow from Tom's Gully pit, which have been considered in the analysis. The post-closure surface catchments are illustrated in Figure 5.

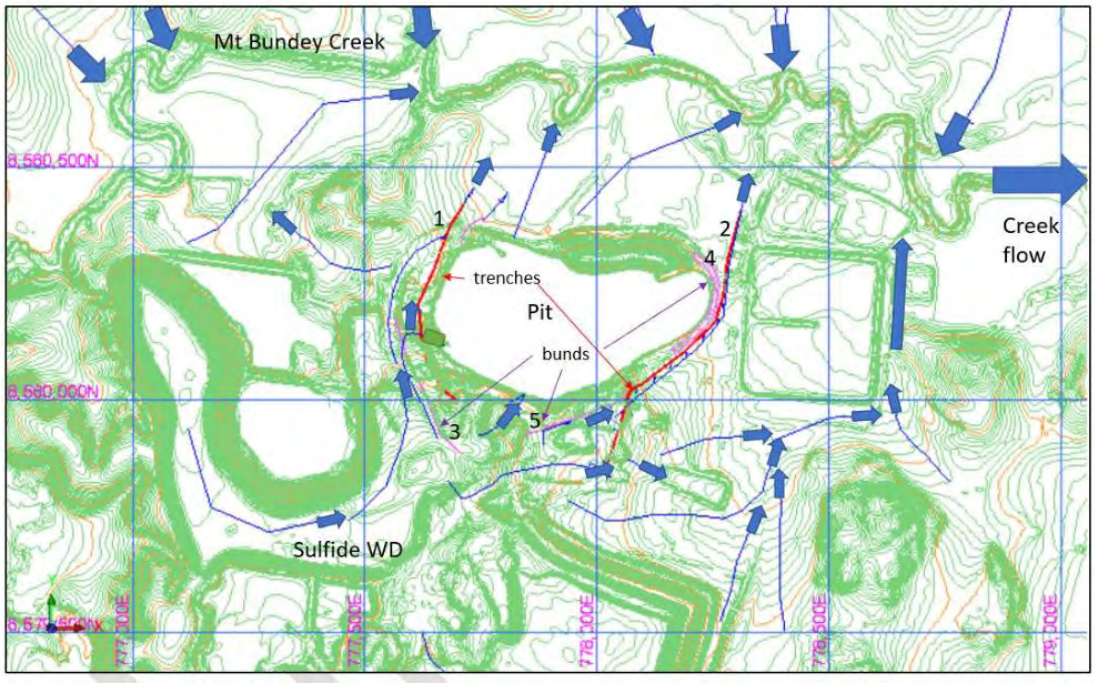

Figure 4. Major runoff flow directions after earthworks to divert flow from Tom's Gully pit (Hanking 2019).

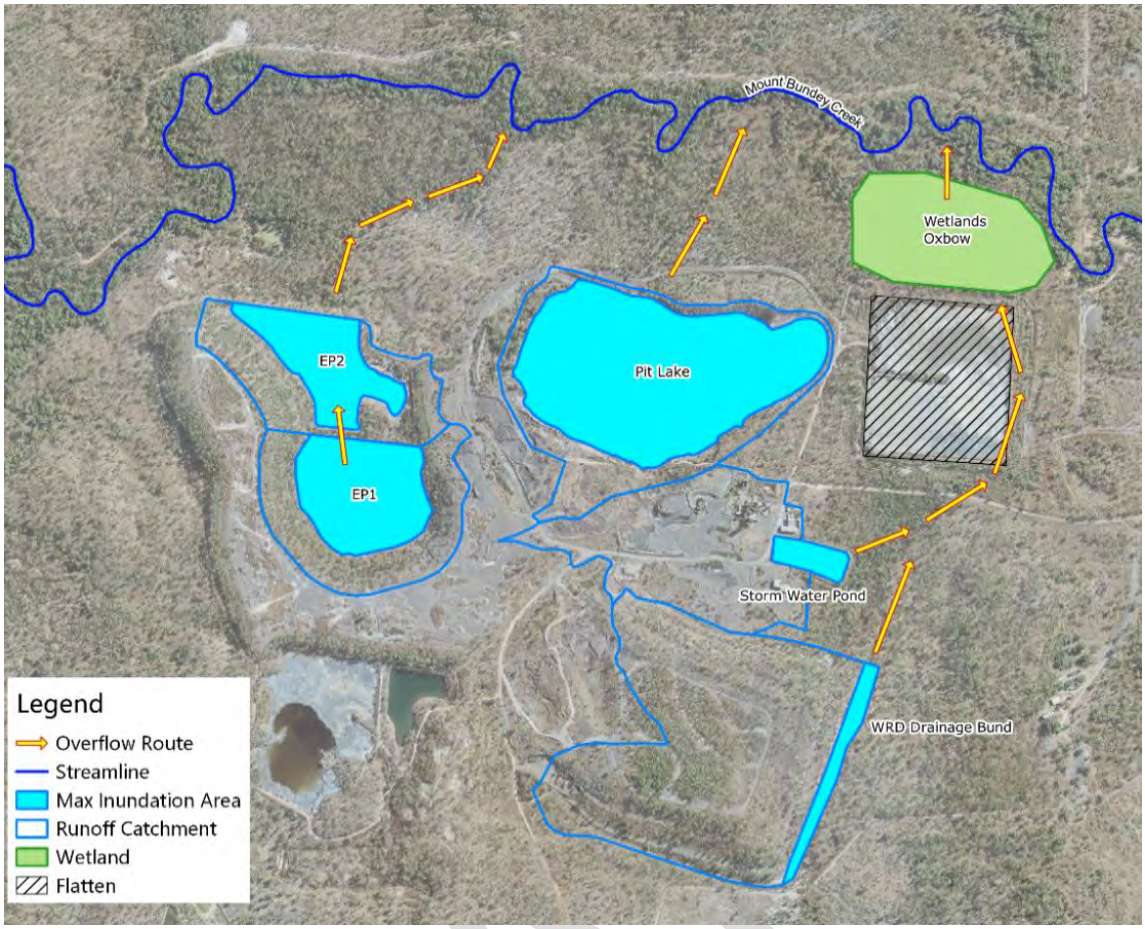

Figure 5. Post-closure catchments

Table 1 below summarises the mine site storage and catchment parameters adopted for the water balance models. EP1 and EP2 will be rehabilitated by being capped with oxide material, however, the depressions will still remain.

Table 1. Tom's Gully mine site storage and catchment parameters

Name	Storage capacity (ML)	Spillway level (m RL)	Catchment area (ha)	Maximum inundated area (ha)
EP1	346	27.0	10.3	4.8
EP2	354	24.5	8.7	3.7
Storm water pond	12.5	20.5	11.5	0.6
Pit lake	3588	22.0	19.7	14.0
WRD drainage bund	5	22.0	22.1	7.4

5.3 **Tom's** Gully Pit Post Closure Long-Term Water Balance

Previous assessment has indicated potential wet season spills of the Tom's Gully pit lake after about 5 years post-mining, assuming no active water management (GHD 2019). Refer to Appendix C.2 for details of model set-up.

A post-closure pit water balance model was developed using HEC-HMS and 1000-year simulations were conducted for dry climate scenario (average rainfall) and wet climate scenario (5% increase in average annual rainfall). The modelling comprises the following inputs:

- 1000-year continuous daily rainfall series were generated for each climate scenario based on SILO historical rainfall statistics at the site location.
- SILO monthly historical statistics of Morton Shallow Lake Evaporation Rate at the site location.
- Ground water inflow curve derived using an analytical method. The resulting inflow rates range from 0 to 5 ML/day depending on the elevation difference between pit water surface and long-term ground water table.

The predicted 1000-year post-closure pit water levels for different climate scenarios are presented in Figure 6 and Figure 7.

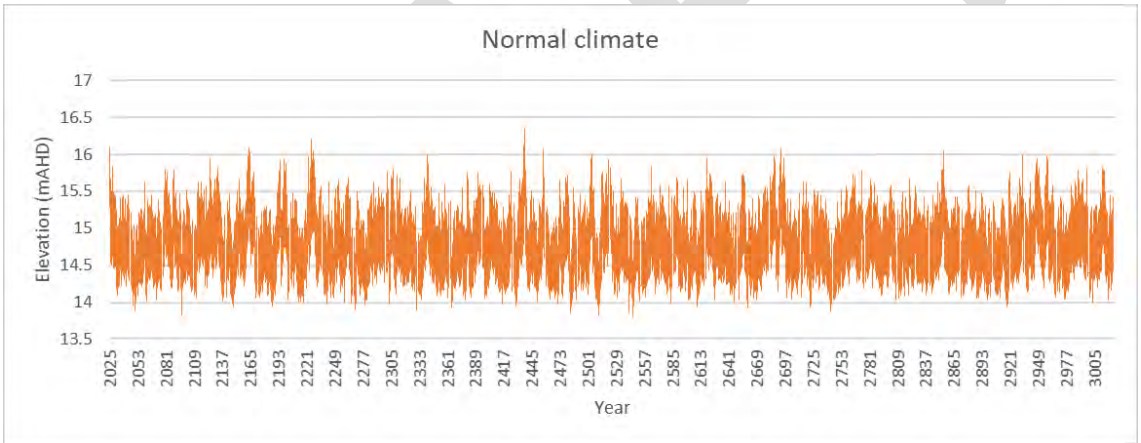

Figure 6. Predicted 1000-year pit water level for dry climate scenario

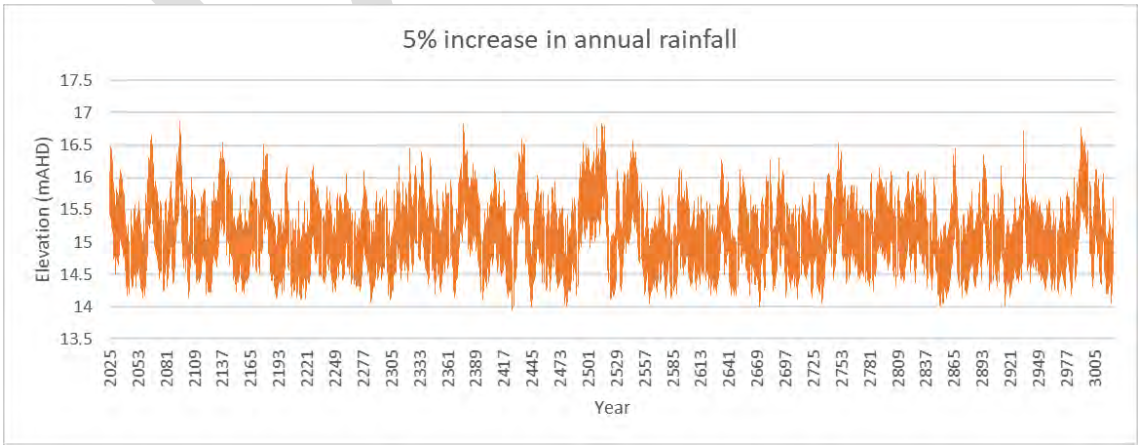

Figure 7. Predicted 1000-year pit water level for wet change scenario (5% increase in average annual rainfall)

The results show that the maximum storage capacity of 3588 ML and maximum water level of 22m are not exceeded at any point during the simulation, indicating that there is no risk of spills

if the proposed mitigation measures are implemented. The predicted freeboard for the pit ranges from 5.1m to 8.0m for the dry climate condition and 5.6 to 8.2 m for the wet climate scenario.

5.4 Mine Site Short-Term Post-Closure Water Balance

A site wide water balance schematic was developed to inform the post-closure water balance for a dry (average) rainfall year and a very wet year, incorporating the proposed prevention measures but assuming no additional active water management. The dry scenario assumed 50th percentile rainfall, and the very wet year assumes 95th percentile annual rainfall. The probability of occurrence of 5 successive very wet years occurring is less than 0.000031%, so this is a very conservative scenario. Water balance schematics are provided in Appendix C.3.

There is no uncontrolled discharge from the main pit under either climate scenario across the 5 simulation years (see Figure 10). However, uncontrolled discharge occurs at EP1 and EP2 after 3 years (21ML and 7ML in 2029, 85ML and 45ML in 2030) (see Figure 8 and Figure 9).

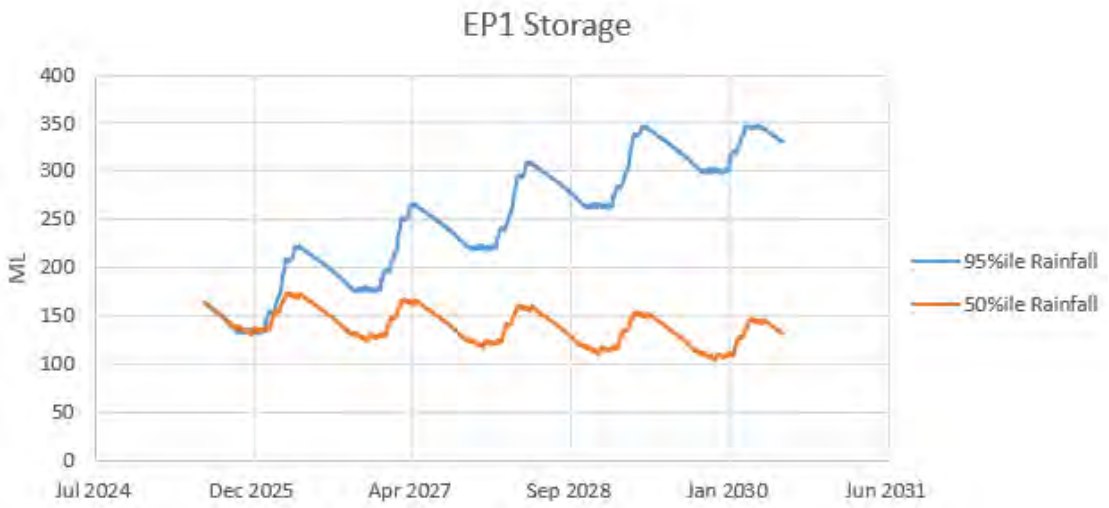

Figure 8. EP1 storage curve 2026 to 2030

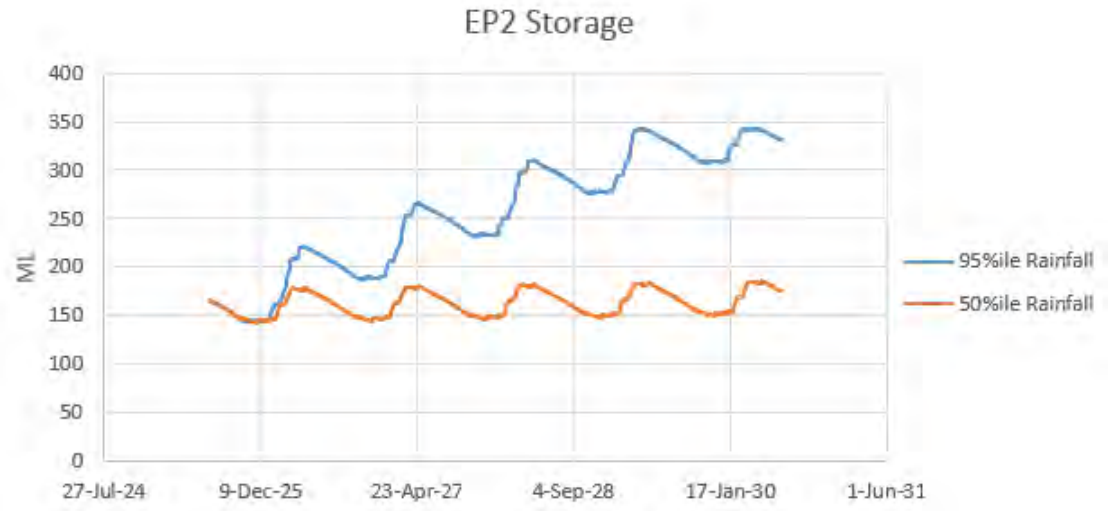

Figure 9. EP2 storage curve 2026 to 2030

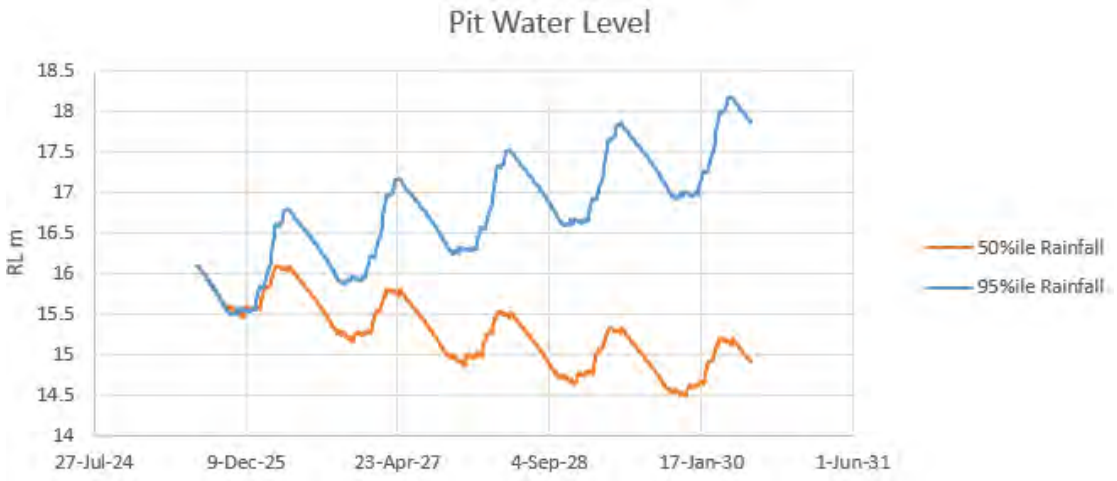

Figure 10. Main pit water level 2026 to 2030

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6 Water Quality Modelling

6.1 Introduction

This section assesses if the mine is non-polluting. The Resource Modelling Associates (RMA) model suite was used to assess constituent dispersion off-site as a result of a hypothetical release from the mine pit during a 1%AEP rainfall runoff event and 0.1%AEP rainfall runoff event. EP1 and EP2 were not included in the water quality model, as they will be covered with oxide material during rehabilitation to prevent movement of contaminants.

6.2 Model Setup

An irregular model mesh (Figure 11) was created from the available topographic data (Section 4.1.1), which comprises approximately 8700 elements and 20,000 nodes, with spatial resolutions ranging from 20m^2 to 20,000m^2. The model domain is divided into three element types, with different Manning's 'n' values, as follows 1) Koolpinyah surface, 'n' = 0.100; 2) Streams, 'n' = 0.060; and 3) Flood plain area, 'n' = 0.250.

The hydrodynamic simulations were run using 6 natural inflows (creeks and Mary River) (Figure 11) for a period of 400 hours, for a 1%AEP rainfall event. The discharge hydrographs were developed in RORB (Appendix B), except for the hydrograph representing input from the Mary River catchment, which was developed in HEC-HMS (Appendix D) based on initial RORBwin hydrologic modelling.

The impact of the post-closure flood events was simulated by applying the overflow of the open pit as inflow to the model. The inflow hydrographs for the pit were developed assuming the pit was already full at the time of the event. Water balance modelling (see Section 5.3 and 5.4) indicated that there was no uncontrolled discharge from the pit at any time during the simulation period of 5 successive very wet years, nor for the two 1000-year simulation under normal and 5% increase in rainfall conditions.

However, the pit was assumed to overflow during the simulation, to obtain a worst-case scenario input to the water quality model. In reality, overtopping of the pit is highly unlikely if the proposed mitigation measures to prevent spill-risk are put in place. Furthermore, it was assumed that there was no existing flow in the creeks, nor is there any follow-up rainfall. Therefore, these simulations can be considered to represent a worst-case hypothetical scenario.

The contaminant inputs from the pit are given in Appendix E.

0.1%AEP simulations were carried out for some constituents to assess the impact of that scenario occurring when the pit is full. Generally, this resulted in the constituents having lower downstream concentrations in comparison to the 1%AEP event. Where this was not the case, the higher concentrations were due to elevated upstream input concentrations, not due to the mine pit overflow. Therefore, the 0.1%AEP simulations were not carried out for all constituents.

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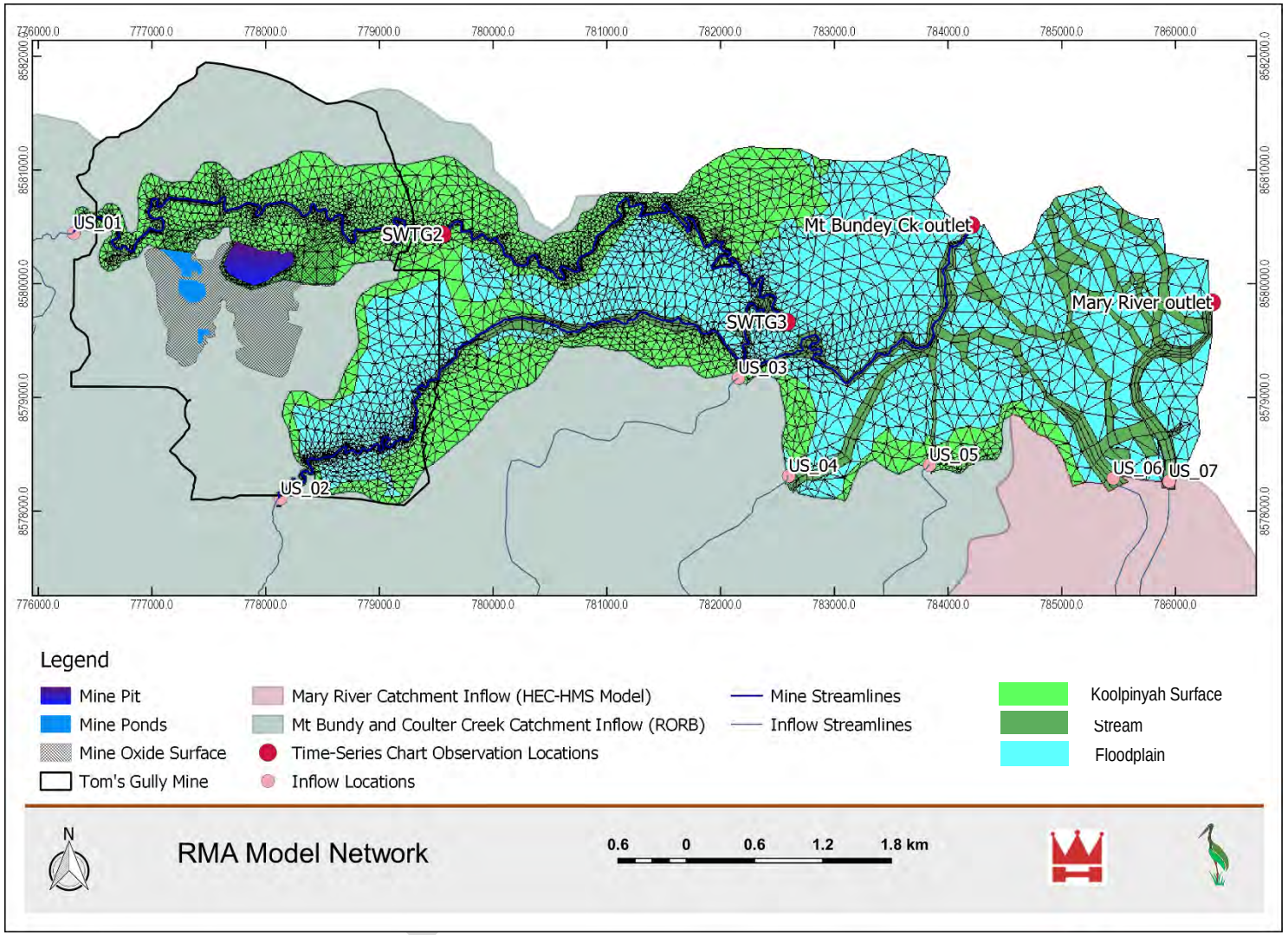

Figure 11. RMA model mesh for the Tom's Gully mine site

6.3 RMA Results

The RMA model results of the median concentration of each constituent were compared with ANZECC 80% trigger values (ATV) and site specific trigger values (SSTV) listed in Table 5-2 Surface Water Assessment Guideline Values, as recommended by ANZECC 2000, Section 7.4.4.

Where there were no trigger values provided, the downstream baseline concentration from samples taken at SWTG2 during site monitoring (Table 7-3, GHD 2015) were used to assess model results. Median simulated concentrations were compared against the median measured concentrations (MedOEV) from Table 7-3 (GHD 2015), and maximum simulated peak concentrations were compared against the maximum measured concentrations (MaxOEV).

Table 2 and Table 3 present the simulated maximum and median concentrations at SWTG2. Refer to Appendix E for detailed time series charts and concentration contour plots at the downstream outlet for each constituent, for SWTG2, SWTG3, Mt Bundey outlet, and Mary River outlet (Figure 11).

Table 2. RMA results for median and maximum concentrations at SWTG2 for 1%AEP and 0.1%AEP compared with ATV and SSTV (GHD, 2015)

Constituent	Median (1%AEP)	Max (1%AEP)	Median (0.1%AEP)	Max (0.1%AEP)	ATV	SSTV
pH	6.95	7.06*	7.05	7.35	6.0-8.0	5.8-8.0
Electrical Conductivity (µS/cm)	71.9	93.0	42.5	60.92*	250	250
Sulphate (mg/L)	24.99	36.29	8.30	23.22*	-	129
Aluminium-Dissolved (mg/L)	**0.60**	0.80	0.32	0.58	0.15	0.26
Arsenic-Dissolved (mg/L)*	-	-	-	-	0.14 (total)	0.14 (total)
Cadmium-Dissolved (mg/L)	**0.013**	0.019	**0.0038** (0.00027)	0.0125	0.0008	0.0008
Chromium-Dissolved (mg/L)	0.0129	0.0187	-	-	0.04	0.04
Cobalt-Dissolved (mg/L)	**0.0178**	0.0258	-	-	-	0.0014
Copper-Dissolved (mg/L)	**0.0174**	0.0251	**0.0061** (0.0019)	0.0160	0.0025	0.0025

Iron-Dissolved (mg/L)	0.244	0.265*	0.217	0.248**	-	0.30
Lead-Dissolved (mg/L)	**0.0131** (0.0019)	0.0189	-	-	0.0094	0.0094
Manganese-Dissolved (mg/L)	0.236	0.345	0.073	0.223	3.6	3.6
Nickel-Dissolved (mg/L)	**0.0345** (0.0039)	0.0505	0.011	0.033	0.017	0.017
Uranium-Dissolved (mg/L)	**0.0130**	0.0190	-	-	-	0.0005
Zinc-Dissolved (mg/L)	**0.139** (0.0144)	0.203	**0.043** (0.006)	0.130*	0.031	0.031

*Not simulated as the pit concentration is much lower than trigger values.

**The maximum spike is simulated to occur at Mt Bundey Ck or SWTG3 (see Appendix E for details), however, the SWTG2 value is listed here as the observed values were measured at SWTG2

Table 3. RMA results for median and maximum concentrations at SWTG2 for 1%AEP and 0.1%AEP compared with MedOEV and MaxOEV (GHD, 2015)

Constituent	Median expected value (1%AEP)	Max expected value (1%AEP)	Median expected value (0.1%AEP)	Max expected value (0.1%AEP)	MedOEV	MaxOEV
Calcium – Dissolved (mg/L)	**5.0** (1.3)	6.8	2.3	4.7*	3.4	121
Potassium – Dissolved (mg/L)	1.15	1.22*	1.05	1.14*	1.2	3.2
Magnesium – Dissolved (mg/L)	**3.83** (1.18)	5.23	1.79	3.61*	1.8	120
Sodium – Dissolved (mg/L)	2.93	3.12*	-	-	3.7	52.1

*The maximum spike is simulated to occur at Mt Bundey Ck or SWTG3 (see Appendix E for details), however, the SWTG2 value is listed here as the observed values were measured at SWTG2.

For several of the metal constituents, there are significant exceedances that could occur if the pit spills uncontrollably. However, as noted in the water balance section, the pit is unlikely to overflow at all even over a 1000-year wet climate scenario. For most of the constituents with exceedances, the high median concentration was due to the modelled concentration stabilising at a high level

after the event, which is due primarily to low flow conditions. These conditions cannot be modelled as effectively so the results are less reliable towards the tail end of the event, however, it may indicate there is the possibility some contaminants may settle in some locations due to low flow conditions after a large event with uncontrolled pit discharge. These should be flushed by subsequent events.

For constituents with this issue, the median across the period from Day 1 to Day 2 15:30 (within the event itself) was also calculated, to assess the effect of the skew caused by the high stabilised concentration at low flow conditions (shown in brackets below the median value in Table 2 and Table 3). Once this is removed, the median falls within the TV for all constituents except for Uranium, Aluminium, Cobalt and Cadmium. Constituents with potential exceedance issues are discussed in Section 6.4 below.

6.4 Potential Exceedances

Water quality modelling indicated that some constituents may exceed the TV (median concentration). Constituents for which there is a potential of contamination at Arnhem Highway Bridge (SWTG2) in the hypothetical case that pit overflow occurs are marked in bold in Table 2. Those are: Aluminium, Cadmium, Cobalt, Copper, Lead, Nickel, Uranium, Zinc, Calcium and Magnesium. A summary for those constituents is provided below, see Appendix E for details.

All exceedances are transitory as a spike in concentration moves through the system. They are a worst-case scenario in the highly unlikely event that the pit overflows. Simulations did not include a pre-burst in rainfall or follow up rainfall. The pre-burst would further dilute constituents that are in overflow and the follow up would further dilute and flush the system. Modelling indicates that the pit will not be a source of pollution to downstream surface water.

6.4.1 Aluminium

The SSTV of 0.26 mg/L is exceeded at SWTG2 during the 1%AEP (0.60 mg/L) and 0.1%AEP (0.315 mg/L) event when compared to median values. No exceedances occur further downstream.

6.4.2 Cadmium

At SWTG2, median values exceed the SSTV (0.0008 mg/L) during the 1%AEP (0.013 mg/L) and the 0.1%AEP (0.0038 mg/L) event. However, during the 0.1%AEP event the median concentration exceedance appears to be primarily due to low flow occurring after Day 2, as the median concentration during the storm event itself (Day 1 to Day 2 15:30) remained well below the TV at 0.00027 mg/L. The downstream locations indicated no exceedances.

6.4.3 Cobalt

Median cobalt concentrations (0.0178 mg/L) significantly exceed the SSTV (0.0014 mg/L) during the 1%AEP event at SWTG2. No exceedances were registered at any of the downstream locations during the event.

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6.4.4 Copper

During the 1%AEP and 0.1%AEP event, median copper concentrations (0.0174 mg/L and 0.0061 mg/L) significantly exceed SSTV (0.0025 mg/L) at SWTG2. However, similar to Cadmium for the 0.1%AEP event, median values (0.0019 mg/L) for both events fall below TV if only the period during the storm event is considered, and no exceedances occur at the downstream locations.

6.4.5 Lead

At SWTG2 the median concentration (0.013 mg/L) is above the SSTV (0.0094 mg/L) for the 1%AEP event. The SSTV is not exceeded at any of the downstream locations.

6.4.6 Nickel

The median Nickel concentration at SWTG2 (0.0345 mg/L) during the 1%AEP event is approximately double the TV (0.017 mg/L). However, discounting the low flow periods after the event, the median value (0.0039 mg/L) falls below the TV, indicating that the apparent exceedance may be due to the model being unable to handle the low flow conditions at the end of event. The simulation indicated no exceedances at SWTG2 during the 0.1%AEP event or at the downstream locations during both events.

At the time of peak concentration at SWTG2, the SSTV is temporarily exceeded on and off site around the pit and SWTG2 area for the 1%AEP event. For the 0.1%AEP event, the contamination is spread across larger portions of the model domain, including SWTG2 and areas near SWTG3 and Mt Bundey Ck outlet.

6.4.7 Uranium

The median concentration for Uranium significantly exceeds the SSTV (0.0005 mg/L) at SWTG2 (0.0130 mg/L) and SWTG3 (0.00731 mg/L) during the 1%AEP event. There were no indications of exceedances at the Mary River and Mt Bundey Ck outlet.

6.4.8 Zinc

For the 1%AEP and 0.1%AEP simulation the median concentration exceeds the TV (0.031 mg/L) for SWTG2 (0.139 mg/L and 0.043 mg/L), however, once the high concentration tail of the graph is discounted, the median concentration during the event drops to 0.0144 mg/L and 0.006 mg/L, which is below the TV. Median concentration did not exceed the SSTV at any of the downstream locations.

6.4.9 Calcium

Median calcium concentrations exceed the MedOEV (3.4 mg/L) for the 1%AEP simulation at SWTG2 (4.99 mg/L). If only the duration of the storm event is considered, median concentrations drop below the MedOEV to 1.3 mg/L, indicating that the high median concentration might be caused by low flows occurring after the storm. No exceedances occur at any of the downstream locations for the 1%AEP and the 0.1%AEP or for the 0.1%AEP at SWTG2 when compared to median calcium concentrations. MaxOEV are not reached at any of the locations.

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6.4.10 Magnesium

MedOEV (1.8 mg/L) are exceeded at SWTG2 during the 1%AEP simulation (3.83 mg/L), if the whole simulation period is considered. However, if only the period during the storm event is considered, median values drop below the MedOEV (1.18 mg/L). There are no exceedances for any of the other locations during the 1%AEP and 0.1%AEP for any of the downstream locations or at SWTG2 during the 0.1%AEP event. All concentrations remain below MaxOEV.

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7 Stability

The indicative completion criteria (ICC) closure objectives for the mine site are:

1) The site is stable (no mass movement, slumping)
2) No significant erosion, and
3) Complementary to surrounding land use.

Several gullies were observed during the site inspection, but these drain to internal water bodies and are proposed to be covered by an oxide layer. No mass slumping was observed.

Landform evolution modelling was used to assess the following with the aim to inform redesign of the post-closure landform, if necessary, to meet agreed ICC:

1. the amount of surface erosion on the mine landform,
2. gully incision rates, and
3. how stream sediment loads and sediment discharge may change off-site, and the rate at which erosion rates on the new landform return to background levels.

To assess stability a combination of two erosion models were used, the Revised Universal Soil Loss Equation (RUSLE) and CAESAR-LisFlood.

7.1 RUSLE

There is little erosion data available in the Tom's Gully region to calibrate the CAESAR-LisFlood model against, therefore, the RUSLE model was used to determine long-term erosion rates that long-term erosion values generated by CAESAR-LisFlood could be compared too.

RUSLE is an empirical model that is widely used to estimate average annual soil loss within a specified area. In this study, the RUSLE was used to predict long-term erosion rates of the four major surface types from which soil samples were taken during the site visits: Koolpinyah surface (TG9), Oxide Surface (TG8), Sulphide Surface (TG6) and Creek Floodplain (TG4) (Figure 2). Upper and lower average values were determined for all four surfaces, as well as maximum and minimum erosion rates for the oxide surface Table 4.

7.1.1 RUSLE Parameters

The RUSLE model requires the following input parameter values:

- R is the rainfall erosivity factor in (MJ mm) / (ha hr yr); determined based on average annual rainfall data from the Australian Bureau of Meteorology,
- K is the soil erodibility factor in (Mg ha h) / (ha MJ mm); based on soil particle size distribution (PSD) and organic matter (OM) (Appendix A),
- SL is the slope length factor; based on slope lengths and gradients from the DEM (±50m accuracy),
- C is the ground cover factor; determined from percentage grass cover noted during site visits, and
- P is the erosion control practice factor; 1.0 for a mostly undisturbed surface.

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7.1.2 Results

The RUSLE erosion rates across the post-mining landform are shown in Table 4. RUSLE is based on yearly average rainfall data, and hence no accountability for seasonal weather changes is given in the results. Erosion distribution across the mine site is shown in Figure 12.

Table 4. RUSLE parameter values for average slopes

Surface Type	Creek Floodplain		Sulphide Surface (information purposes only)		Oxide Surface (Average Slope)		Koolpinyah Surface		Oxide Surface (Max & Min Slopes)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
R (MJ mm) / (ha hr yr).	7996									
K	0.018		0.010		0.011		0.010		0.011	
SL	0.213	0.332	1.580	2.480	1.240	2.910	0.997	1.090	0.090	8.010
C	0.070		0.020		0.030		0.040		0.030	
P	1.0		1.0		1.0		1.0		1.0	
A (T/ha/yr)	2.14	3.34	2.53	3.97	3.27	7.68	3.19	3.49	0.24	21.14

Note: The pre-mining sulphide surface will be covered with oxide waste rock post-closure, therefore, the soil erodibility and ground cover factors for the post-mining oxide surface were assumed to be the same as the pre-mining oxide surface. The slope length factor for the post-mining oxide surface was determined by taking the area-weighted average of the pre-mining surfaces. The erosion rate for the sulphide surface presented in the table is provided solely for informative purposes.

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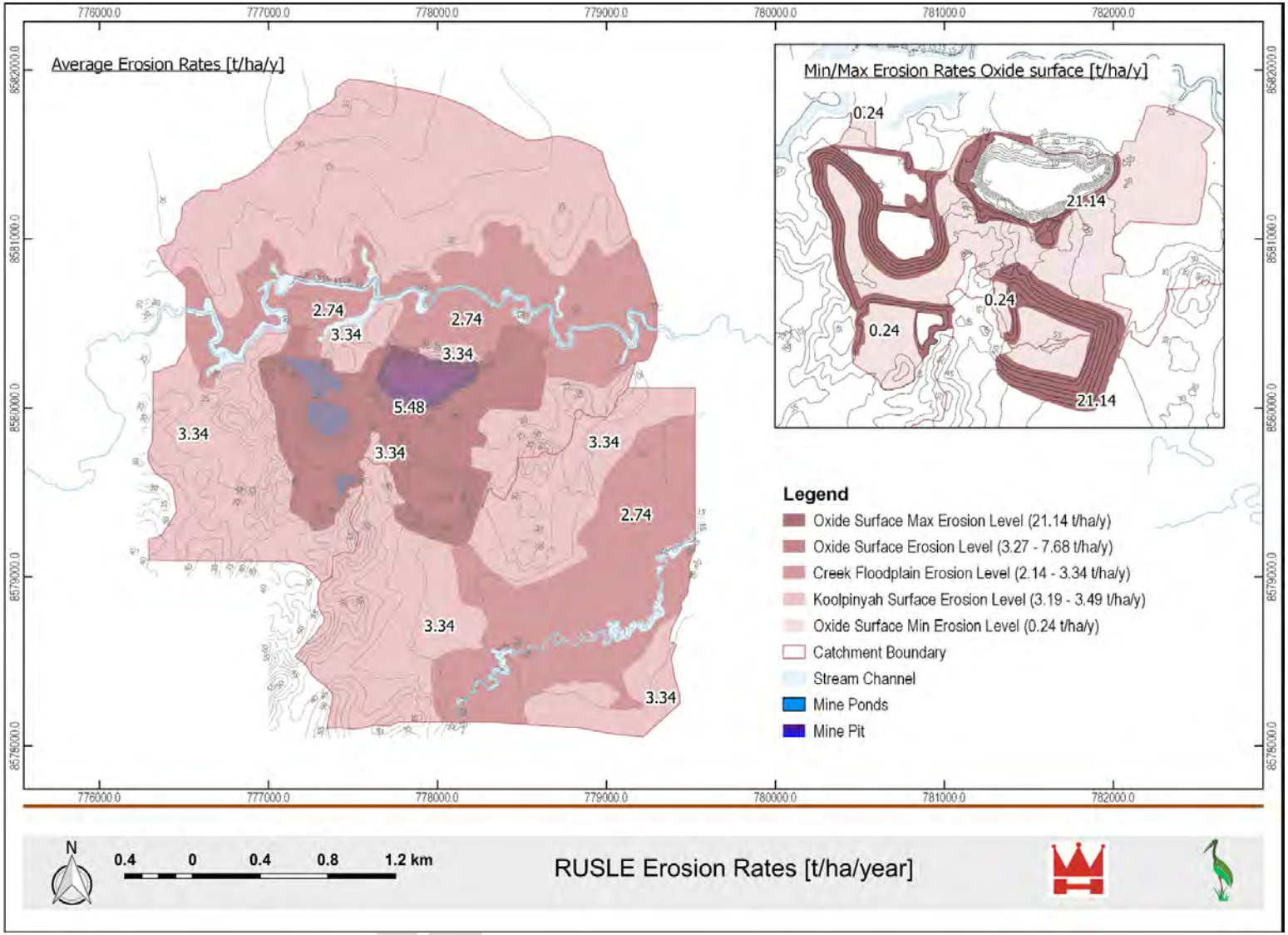

Figure 12. RUSLE erosion rates on the post-closure mine landform

Note: Lake Bazzamundi is treated as floodplain area, as site visits indicated that the soil accumulated in the Lake is very similar to the soil along the creek floodplain.

7.2 CAESAR-LisFlood

CAESAR-LisFlood (Coulthard, Macklin, & Kirkby, 2002) is a hydrogeomorphic model used to assess the effects of rainfall events and flow routing on landform stability. In this study, the model was applied to identify areas of erosion and deposition on and around the mine site following rainfall events by simulating changes in ground elevation and stream water level. Two scenarios were used:

1) **Short term, low frequency events:** 1%AEP and 0.1%AEP design storms to assess erosion response to low frequency high intensity events.
2) **Long term stability:** mine site was modelled across a 100-year rainfall period to assess long-term stability post-closure. Long-term effects of potential future climatic change on landscape morphology were considered by evaluating both a wet rainfall and dry rainfall future climate scenario.

7.2.1 Catchment delineation

The mine site is traversed by two creeks; Mt Bundey Ck and Coulter Ck. Therefore, the mine catchment was divided into two sub-catchments representing the lower reaches of the Mt Bundey Ck and Coulter Ck. Upstream, off-site contributions to the creeks were modelled by simulating rainfall runoff across the upper catchments of each creek (Figure 13).

The 1m resolution post-mining surface DEM was resampled to a 10m grid for the Mt Bundey Ck (MBCC) and Coulter Ck mine catchments (CCC). The Upper Mt Bundey Ck (UMBC) and Upper Coulter Ck (UCC) catchments covering the areas upstream of the mine site were modelled using a 50m and 20m grid, respectively, resampled from the Geoscience Australia 30m hydrologically-corrected DEM. The upper and lower catchments were simulated separately due to restrictions on processing power. Refer to Appendix F for details.

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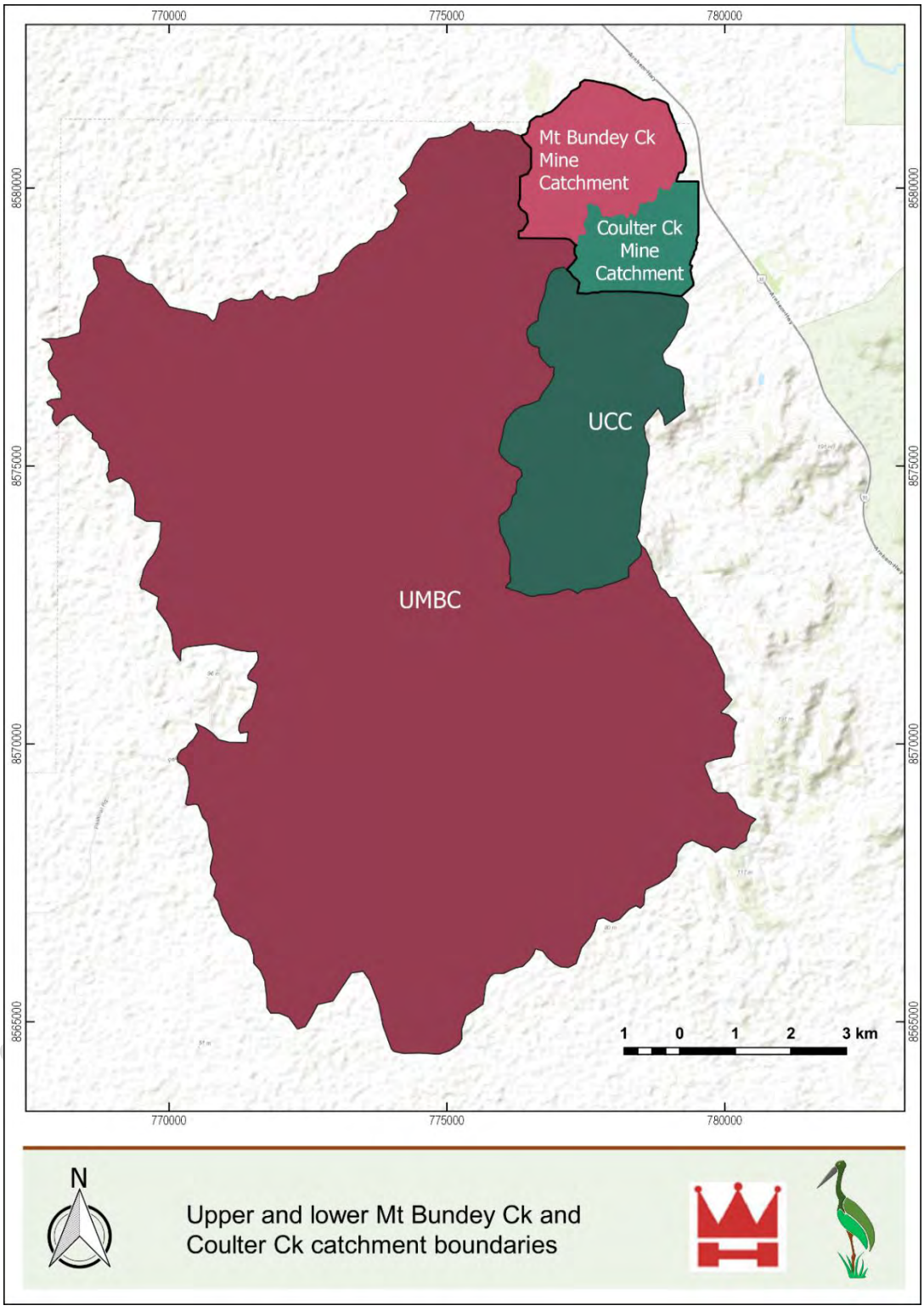

Figure 13. Upper and lower Mt Bundey Ck and Coulter Ck catchment boundaries

7.2.2 Calibration

A Multiple Lines of Evidence approach was used to calibrate the model based on published values from similar catchments, as no direct observed stream flow, sediment transport or stream flow data were available for the site. Three lines of evidence were chosen:

1) Long term erosion rate (t/ha/year),
2) Suspended sediment load (mg/l), and
3) Denudation rate (mm/year).

Published values for the region for these three calibration values are given in Table 5. Model parameters that were fitted during calibration were:

- **Hydrograph exponent, 'm':** determines the peakiness and duration of the hydrograph,
- **Manning's n:** level of surface roughness affecting flow velocity and flow path, and
- **Sediment Transport Equation (STE):** the choice of using either the Einstein or Wilcock and Crowe STE.

The CAESAR-LisFlood model was calibrated for the UMBC for the 100-year wet and dry rainfall scenarios, and the 1%AEP and 0.1% AEP events (peak suspended sediment only). UMBC calibration results were used to simulate erosion in the other catchments. The fitted model parameters obtained from the calibration were:

- **Manning's n:** 0.1 across the UMBC and UCC, refer to Appendix F for spatial distribution of Manning's n for each surface type across the Tom's Gully mine catchment.
- **Hydrograph exponent, m**: 0.01, reasonable results for all rainfall and catchments.
- **STE:** Einstein (1950) was most suitable approach for most catchments. Wilcock and Crowe (2003) was only used for the larger upstream Coulter Ck catchment, as the Einstein STE led to unrealistically high sediment deposition in the creek channel.

The fitted sediment loss, denudation rate and suspended sediment concentration (C) for the UMBC are given in Table 6. The results match the ranges of the regional studies (Table 5) and the model is considered well calibrated.

Table 5. CAESAR-LisFlood calibration parameters for the Tom's Gully region and fitted values using the RUSLE and CAESAR-LisFlood

Calibration Parameter	Value	Location	Source
Long-term erosion rate (T/ha/yr)	0.24 to 21.1	Tom's Gully Mine	7.1 RUSLE this study
	3 to 8	Tom's Gully region	Hau et al (2001)
	2.3 to 6.5	Daly R. basin	Smith & Hill (2011)
	0.04 to 0.66	Kakadu Region	Duggan (1994)
Denudation rate (mm/y)	0.02 to 0.26	Kakadu Region	Duggan (1994)
	0.023 to 0.04	Koolpinyah Surface NT	Nott (2003)
Wet Season monitoring 1998-2002. Suspended Sediment Concentration (mg/L)	Median = 6 Max = 205	Ngarradj Catchment, Jabiluka NT	Evans et al (2004)

Table 6. CAESAR-LisFlood simulation results for the UMBC using fitted parameter values for a 100-year wet scenario and a 100-year dry scenario

Calibration Parameter	Indicative Regional values	Value wet scenario	Value dry scenario	Sub-catchment
Long-term erosion rate (T/ha/y)	3 to 8	4.8	4.3	SC1
		6.0	5.3	SC3
Denudation rate (mm/y)	0.02 to 0.26	0.18	0.16	SC1
		0.23	0.2	SC3
Calibration Parameter	Indicative Regional values	1%AEP scenario	0.1%AEP scenario	Sub-catchment
Median (Max) Suspended Sediment Concentration* (mg/L)	6 (205)	135	147	SC1
		186	167	SC3
		170	202	SC9

Note: Suspended sediment is not directly comparable as the cited studies used a threshold suspended sediment fraction of <64μm, rather than <75μm in this study. Therefore, mg/L concentration from CAESAR-LisFlood is expected to be higher than the cited indicative values.

7.2.3 Modelling Scenarios

Using the calibrated parameters, four rainfall scenarios were run to assess site stability:

1) Short term:
   - 1%AEP rainfall event, and
   - 0.1%AEP rainfall event, and
2) Long term:
   - 100-year wet climate rainfall series, and
   - 100-year dry climate rainfall series.

Long term simulations were run using daily rainfall conditions and without upstream inputs, to isolate the effect of on-site rainfall runoff on long-term site erosion rates.

7.2.4 Sediment Loads and Erosion Rates

7.2.4.1 Sediment loads and discharge offsite

Simulation results are given in Table 7. For the 100-year scenarios, simulated long term erosion rates and denudation rates are toward the lower end of the indicative values. For the 1%AEP and 0.1%AEP events, the suspended sediment concentrations fall within the range of the indicative regional values.

Table 7. CAESAR-LisFlood results for the MBCMC and CCMC using fitted parameter values for rainfall events applied to the mine catchment only (no upstream input)

Calibration Value	Indicative Regional values	100-y wet scenario	100-y dry scenario	Mine catchment
Long-term erosion rate (t/ha/yr)	3 to 8	1.18	1.0	MBCMC
		1.88	0.91	CCMC
Denudation rate (mm/y)	0.02 to 0.26	0.04	0.04	MBCMC
		0.07	0.03	CCMC
Calibration Value	Indicative Regional values	1%AEP scenario	0.1%AEP scenario	Sub-catchment
Median (Max) Suspended Sediment* Concentration (mg/L)	6 (205)	14 (30)	11 (31)	MBCMC
		5 (26)	16 (105)	CCMC

7.2.4.2 Rate of return to background erosion levels

For this study the 100-year simulations show that sediment discharge rates for both the MBCC CCC never exceed the regional background rates for both the Wet (Figure 14 and Figure 16) and Dry (Figure 15 and Figure 17) climate scenarios, and for most years remains well below the expected range.

The low erosion rates are due to the fact that the oxide cover on the mine site consists of over approximately 40% competent angular rock fragments >250mm in size, which reduces the percentage of finer material available for erosion.

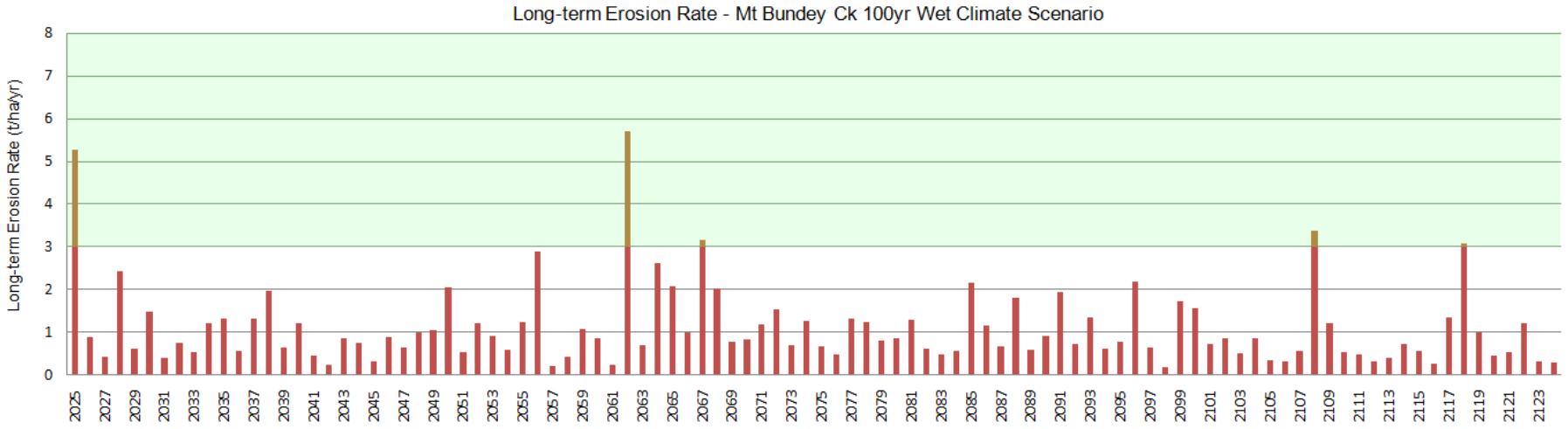

Figure 14. 100-year simulation time series for the Mt Bundey Ck mine catchment for a future wet climate scenario (regional range in background levels highlighted in green)

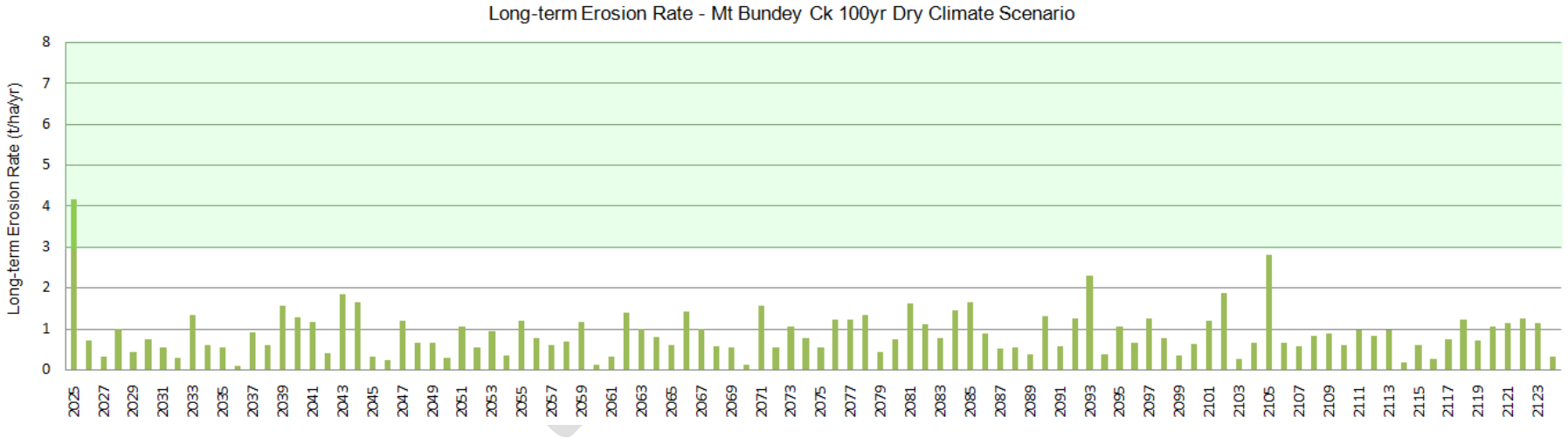

Figure 15. 100-year simulation time series for the Mt Bundey Ck mine catchment for a future dry climate scenario (regional range in background levels highlighted in green)

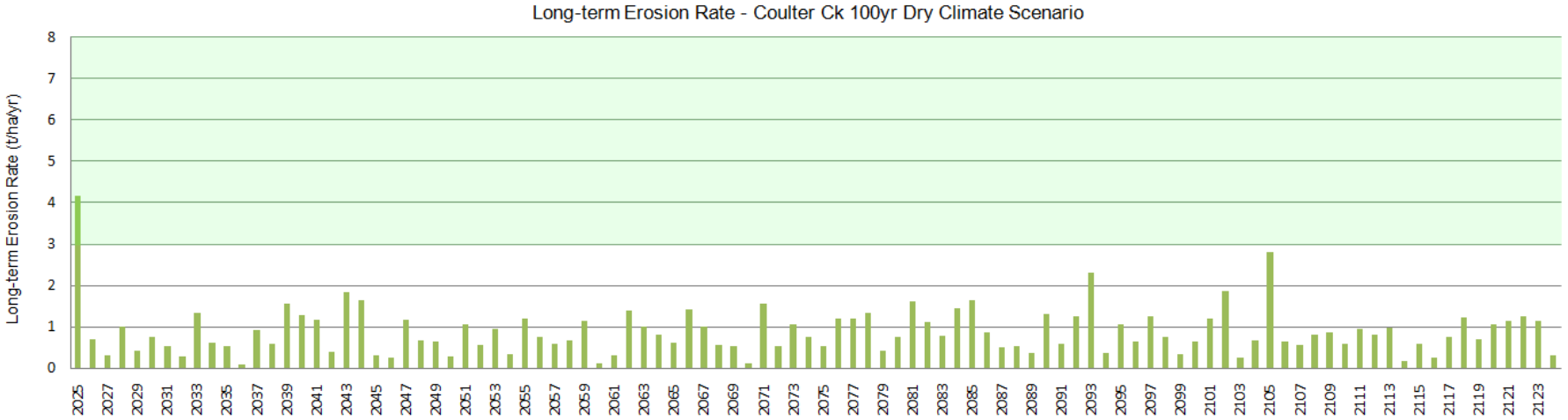

Figure 16. 100-year simulation time series for the Coulter Ck mine catchment for a future wet climate scenario (regional range in background levels highlighted in green)

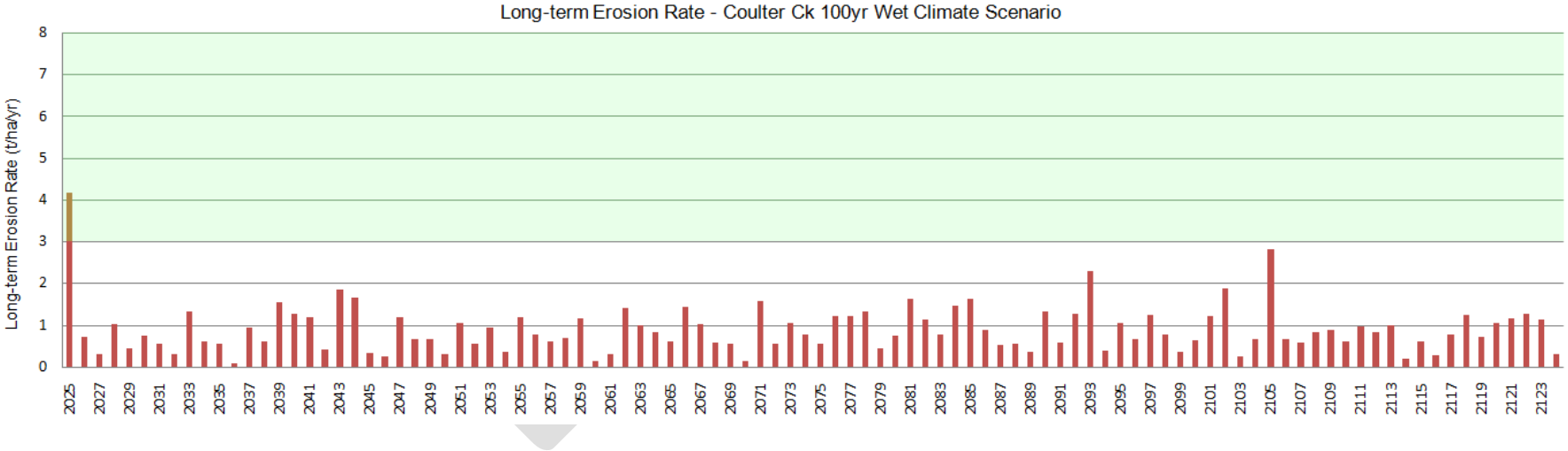

Figure 17. 100-year simulation time series for the Coulter Ck mine catchment for a future dry climate scenario (regional range in background levels highlighted in green)

7.2.5 Erosion and deposition – Mt Bundey Ck

7.2.5.1 Short term events

1%AEP

There does not appear to be any significant change to the erosion and deposition regime caused by the mine.

Minor erosion and deposition occurs along existing drainage and stream channels as part of the usual fluvial geomorphic process. Some deposition also occurs in the upper reaches of the creek, as well as scour in the lower reaches, minor erosion along the oxide cover east of TSF 2, and erosion along the right bank floodplain. However, erosion and deposition along the drainage channels within the mine site shows little difference from the channels on the Koolpinyah Surface.

Peak sediment concentration (C) at the outlet is 30mg/L, which falls within the range of observed values in the region (Table 5).

Refer to Appendix F for details of the simulation results.

0.1%AEP

Similarly, there does not appear to be a significant change in the flow regime under a 0.1%AEP event, as there is already natural high stream erosion caused by upstream flood waters.

The simulation shows higher erosion on the floodplain and higher overbank deposition near the western toe of the oxide cap near EP2, compared to the 1%AEP event. Up to 3m depth of erosion occurs in some locations where the creek banks collapse, and an anabranch appears to be developing on the left bank near the upstream inlet, however, this is caused by existing natural processes. There is only minor erosion on the oxide surface where the flow runs along the east of TSF 2, and some channel backfilling occurs where drainage channels converge with the main channel. Erosion and deposition in the drainage channels from the mine show little difference from the drainage channels on the Koolpinyah Surface.

Peak C at the domain outlet is 31mg/L. Refer to Appendix F for details of the simulation results. Figure 18 illustrates the erosion and deposition patterns for the 0.1%AEP scenario.

7.2.5.2 Long term (100 years)

Wet Climate Scenario

The results show that long term stability of the mine area is comparable to surrounding undisturbed areas. Long term soil loss was 1.2 t/ha/y and denudation rate was 0.04 mm/y. Both values fit within the range of values for the region (Table 5). illustrates the predicted erosion and deposition patterns. See Appendix F for details.

Dry Climate Scenario

The location of erosion and deposition was similar to the wet climate scenario. Long term sediment loss was 1 t/ha/y and denudation rate 0.036 mm/y, falling within the range of expected values for the region.

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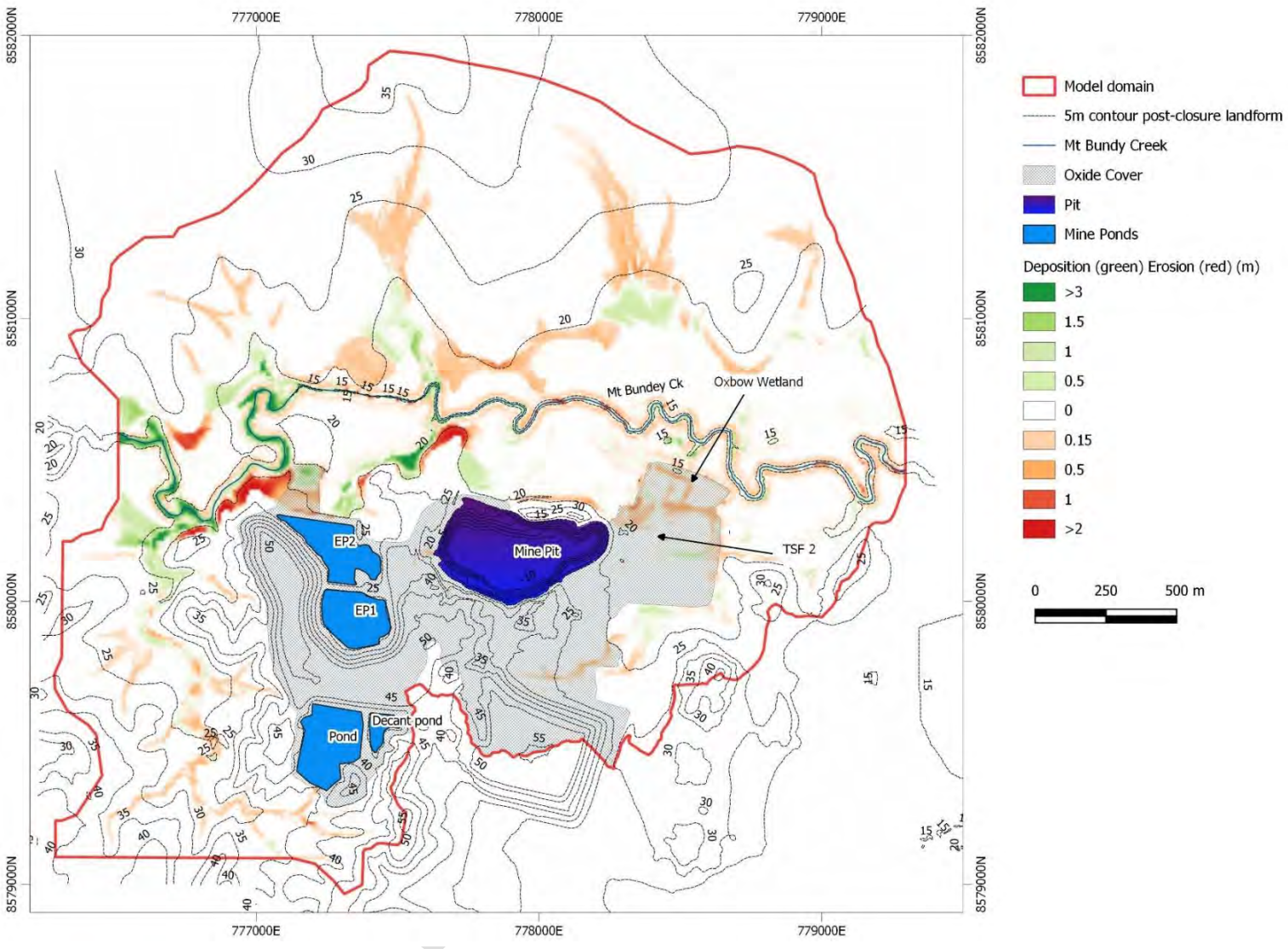

Figure 18. Erosion and deposition simulation for a 0.1%AEP rainfall event, Mt Bundey Ck (with UMBC inputs and rainfall runoff from the post-mine landform)

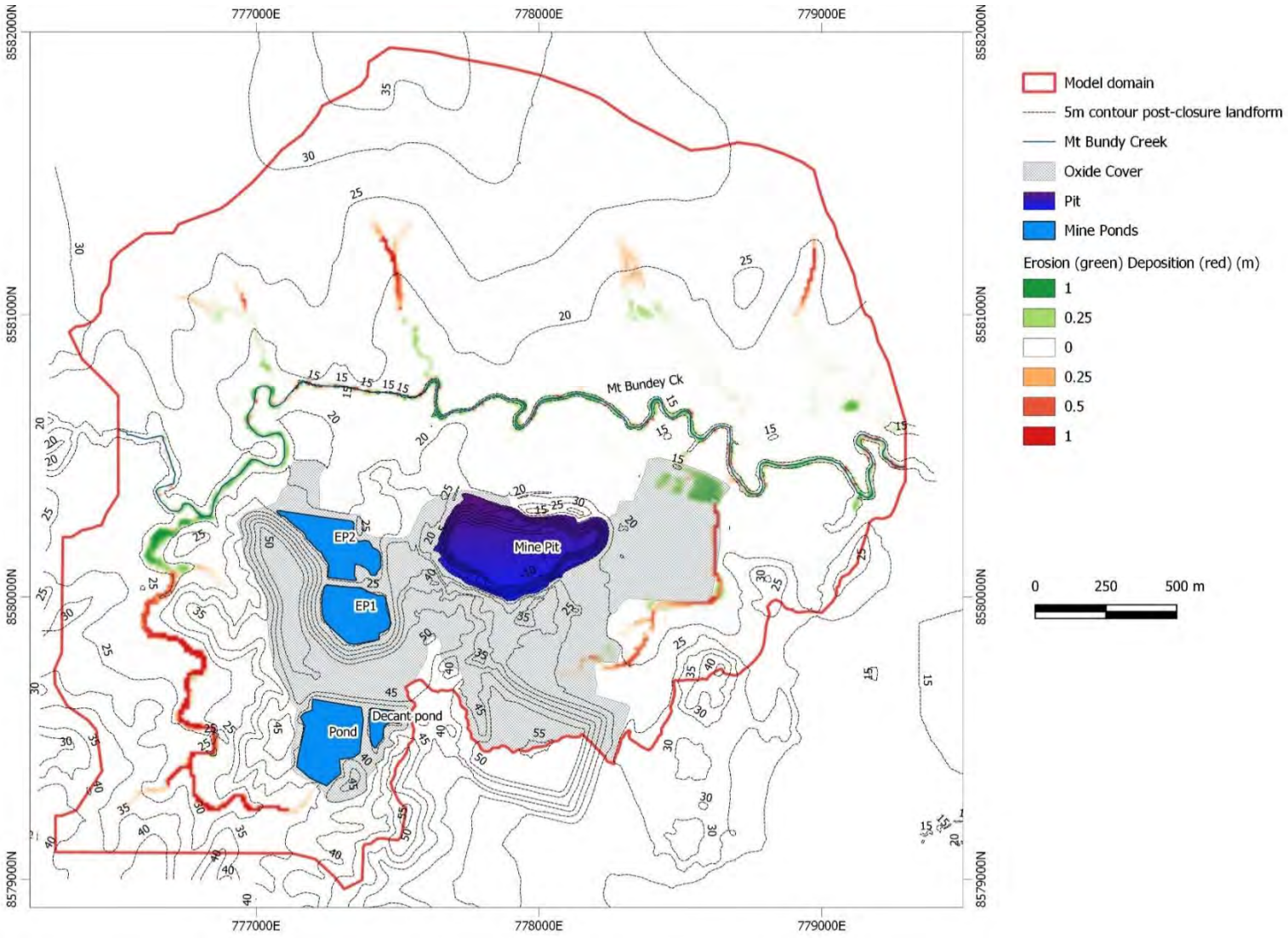

Figure 19. Mt Bundey Ck, erosion and deposition simulation for a for 100-year wet climate scenario with only rainfall applied.

7.2.6 Erosion and deposition – Coulter Ck

7.2.6.1 Short term events

1% AEP

The simulation demonstrates that most of the erosion occurring along the main Coulter Ck channel is caused by upstream inflows, which indicates that the mine site has only a limited effect on the erosion and deposition regime.

Precipitation on the mine site causes natural channels to form on the Koolpinyah Surface. These are natural processes that are unaffected by the mine site. Erosion occurs along natural drainage lines and along the boundary line of Lake Bazzamundi. There is also some erosion through the bund in one location. Some deposition occurs within the upper reaches of the Coulter Ck channel and within Lake Bazzamundi.

The peak C at the outlet is 38 mg/L for the simulation with only runoff from the mine site and 26 mg/L for the simulation with combined runoff from upstream inlets and the mine site.

0.1% AEP

Similar to the 1%AEP event, the mine site does not seem to have significant effect on the deposition and erosion regime within the catchment.

The 0.1%AEP simulation shows no significant change along the alignment of the eroded channels compared to the 1%AEP event. However, slightly higher erosion rates can be expected.

The peak C at the outlet is 18mg/L for the simulation with only runoff from the mine site and 105mg/L for the simulation with combined runoff from upstream inlets and the mine site, which falls within the range of observed values for this region.

Figure 20 shows the worst-case erosion scenario following a 0.1%AEP event with upstream input and rain on the mine site.

7.2.6.2 Long term (100 years)

Wet Climate Scenario

Similar to the MBCC, the results show that long term stability of the mine area is comparable to surrounding undisturbed areas. Natural precipitation runoff processes cause gullies to form on the natural Koolpinyah Surface, however, these processes are unaffected by the mine site. Long term soil loss was 1.88 t/ha/y and denudation rate was 0.07 mm/y. Both values fit within the range of values for the region (Table 5). Figure 21 illustrates the predicted erosion and deposition patterns. See Appendix F for details.

Dry Climate Scenario

The location of erosion and deposition is similar to the wet climate scenario with slightly less erosion and more deposition along channel lines. Long term sediment loss was 0.91 t/ha/y and denudation rate 0.03 mm/y, falling within the range of expected values for the region.

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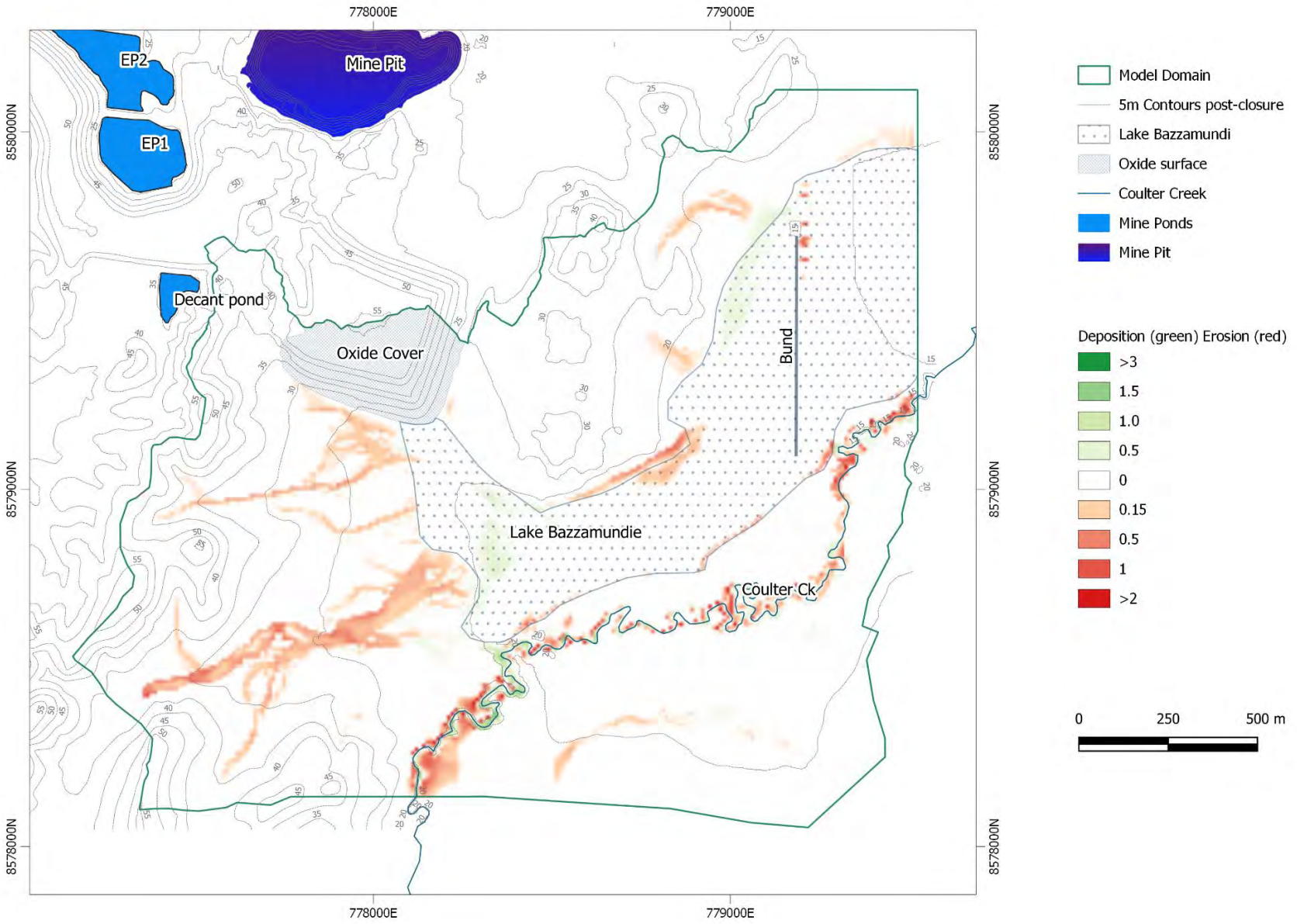

Figure 20. Erosion and deposition simulation for a 0.1%AEP rainfall event, Coulter Ck (with UMBC inputs and rainfall runoff from the post-mine landform)

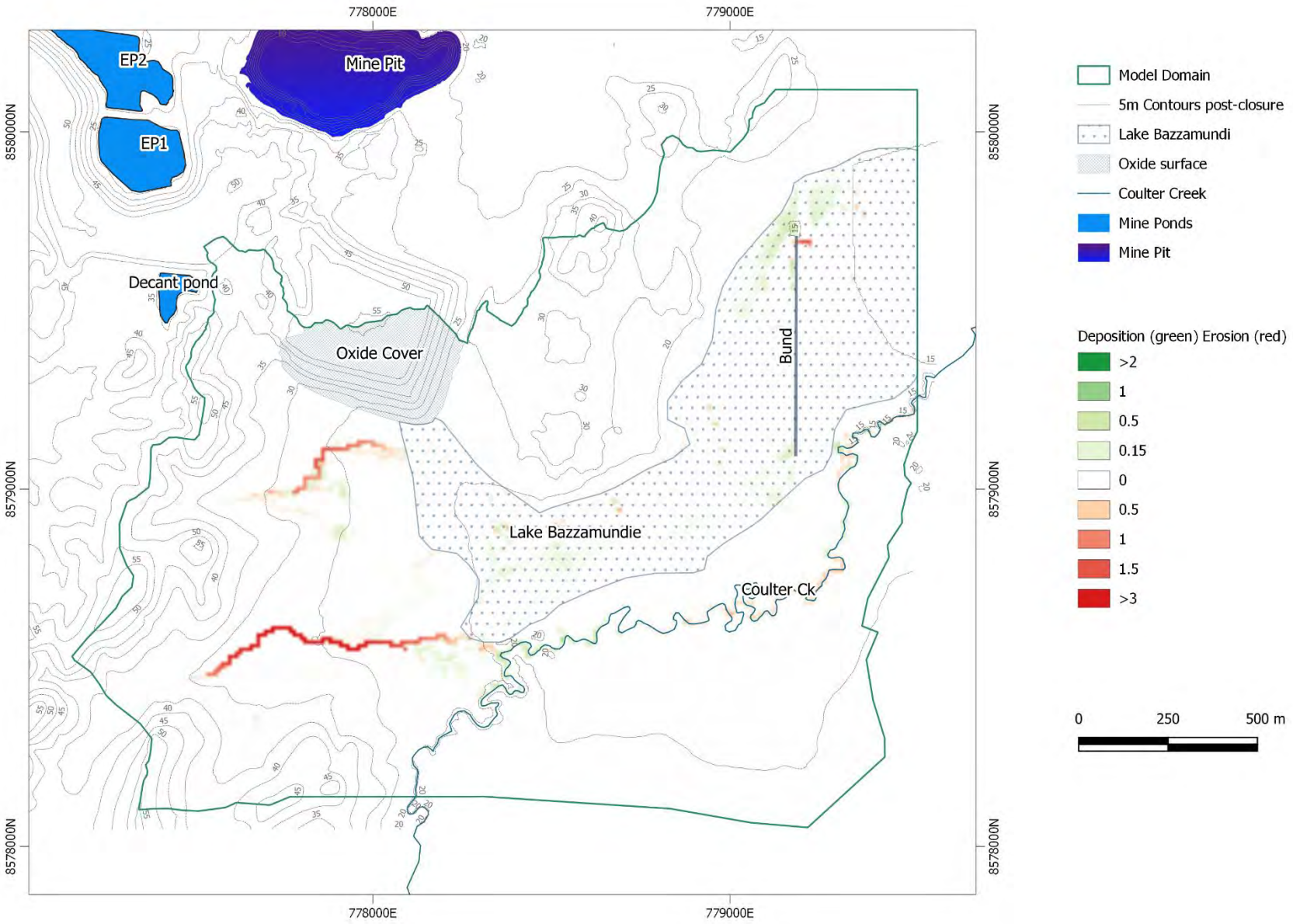

Figure 21. Coulter Ck erosion and deposition simulation for a for 100-year wet climate scenario with only rainfall applied.

7.2.7 Landform stability – Mt Bundey Ck

To assess landform stability, longitudinal sections were taken along the thalweg of the eroding channels resulting from the 100-year Wet and Dry scenarios, and the short-term high intensity 1%AEP and 0.1%AEP events (Figure 22).

The alignment of the Section A-A and C-C eroded channels changed for the 100 year climate scenario events, and are shown as a dashed red line in Figure 22.

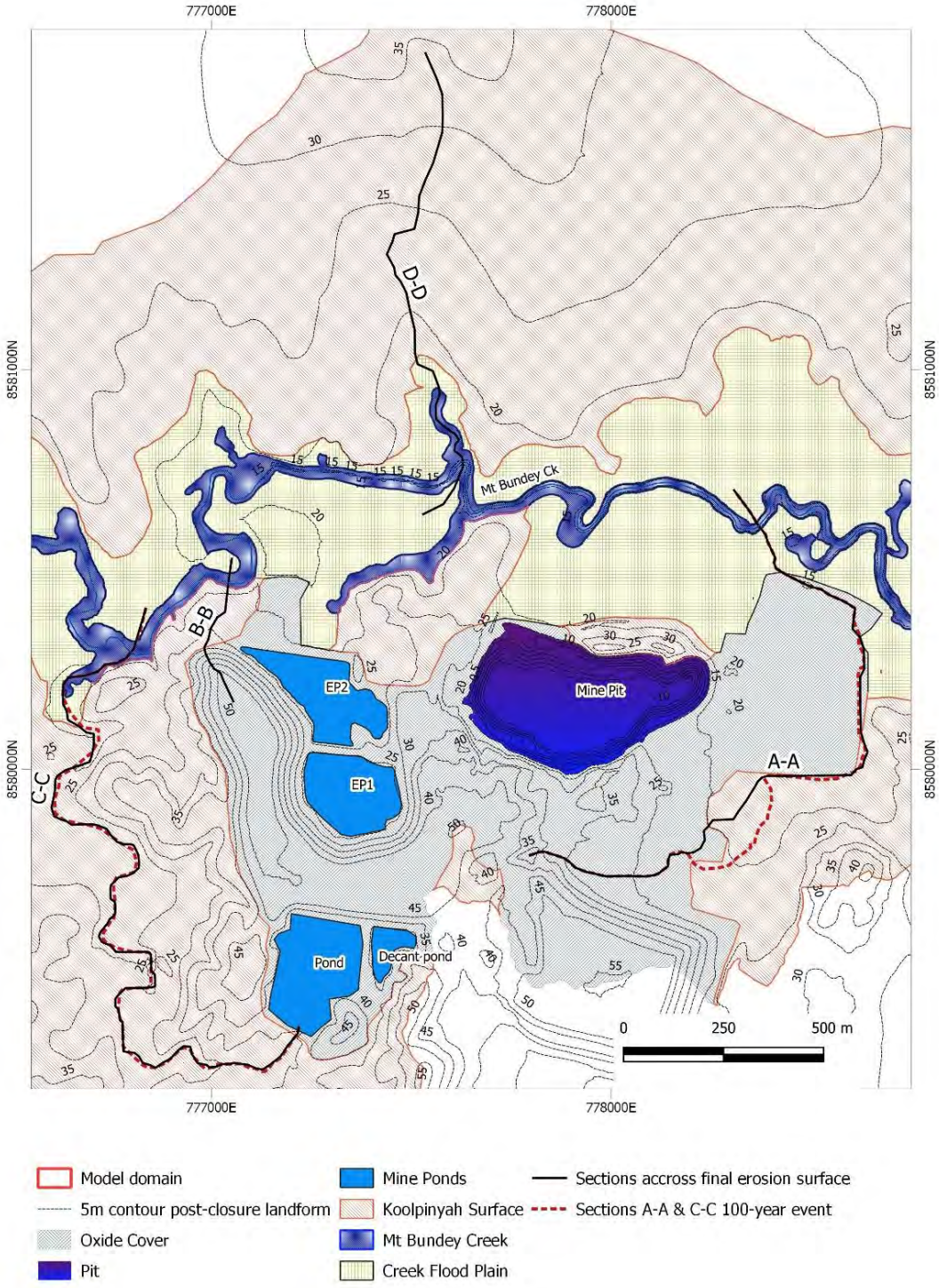

Figure 22. Longitudinal drainage line section locations to assess gully erosion for the MBCC.

7.2.7.1 Short term events

Most of the erosion and deposition occurs along the creek floodplain, transported by the flood waters from upstream of the mine site. Apart from minor erosion in drainage lines on the oxide cover, there is very little indication of site instability.

Refer to Appendix G for details.

7.2.7.2 Long term (100 year)

The sections demonstrated that the mine site and the oxide cover are no less stable than surrounding natural landforms, under both the Wet and Dry climate scenarios.

Section C-C showed the heaviest erosion but this channel is located on a natural surface that is actively eroding, and the oxide cover at the start of the channel does not appear to be affected. Section D-D also shows that the natural Koolpinyah Surface has higher levels of erosion than the oxide cover.

Refer to Appendix G for details.

7.2.8 Landform stability – Coulter Ck

Figure 23 shows the locations of the thalweg longitudinal sections for CCC.

7.2.8.1 Short term events

Most of the erosion and deposition occurs along the Coulter Creek channel and is mainly caused by upstream inflows. Small natural channels are forming as part of natural precipitation runoff processes across the Koolpinyah surface. There are no indications of site instability on the oxide cover. There are some minor signs of erosion along the boundary of Lake Bazzamundi and some erosion through the bund in one location, however, this does not appear to significantly affect the stability of the Lake surface.

Refer to Appendix G for details.

7.2.8.2 Long term (100 year)

The mine site appears to be stable for the 100 year Wet and Dry scenarios. Some gullies are forming across the natural Koolpinyah Surface, but the oxide cover shows no indications of instability. Apart from some erosion through the bund in one location, Lake Bazzamundi likewise appears to be mostly unaffected.

Refer to Appendix G for details.

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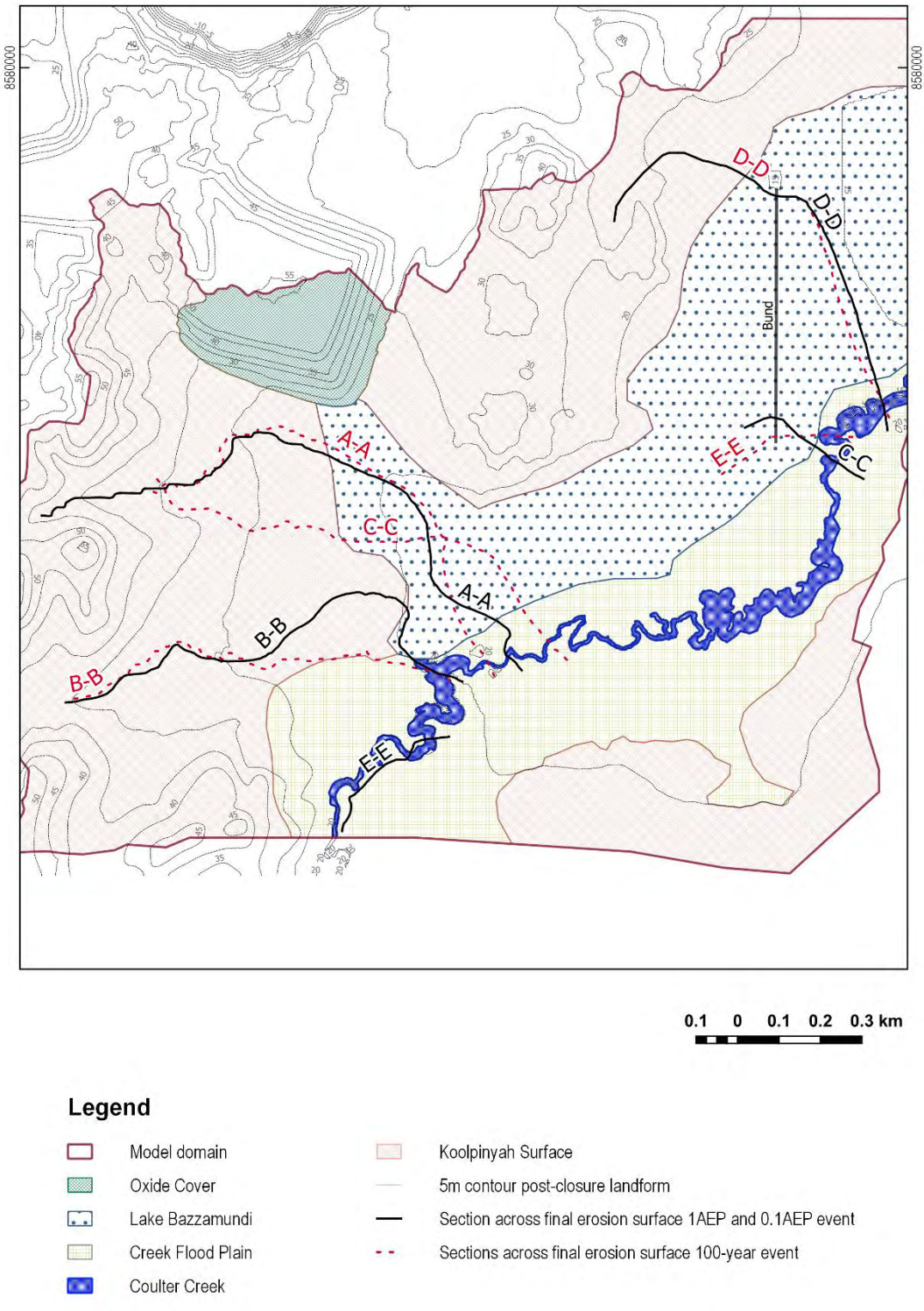

Figure 23. Longitudinal drainage line section locations to assess gully erosion for the AEP and 100-year events.

8 Flood hazard

This section investigates whether direct rainfall and runoff from the mine site increases the risk to people, livestock and wildlife during flood events.

There is little risk to humans as access to the site is through fences and locked gates. The broader area of the mine site is entered from the Arnhem Highway through fenced private property. There is a second fence and locked gate at the main entrance to the site, with a 4-strand barbed wire fence separating the mine from the southern right bank of lower Mt Bundey Ck. All remaining water bodies will be bunded. Wildlife would be familiar with flooding in the creek, therefore, the main safety risk lies with livestock (principally beef cattle).

CAESAR-LisFlood's hydraulic component (LisFlood) was used to simulate flood inundation extent, depth, and flood hazard (depth x velocity) (AIDR, 2017) for a 1%AEP rainfall event and a 0.1%AEP rainfall event. Simulations were run from the MBCC to the Arnhem Highway.

The analysis shows risk to humans or livestock due to flooding should they enter the flood plain or creek channel. However, due to fencing, this is unlikely. The runoff for the 0.1%AEP event only increases the width of the higher zones by 10m either side of the creek.

Figure 24 and Figure 25 show the worst-case flood hazard zones for the Mt Bundey Ck and Coulter Ck mine catchments, with both upstream input and mine rainfall runoff for the 0.1%AEP flood. Refer to Appendix H for the full set of flood hazard maps.

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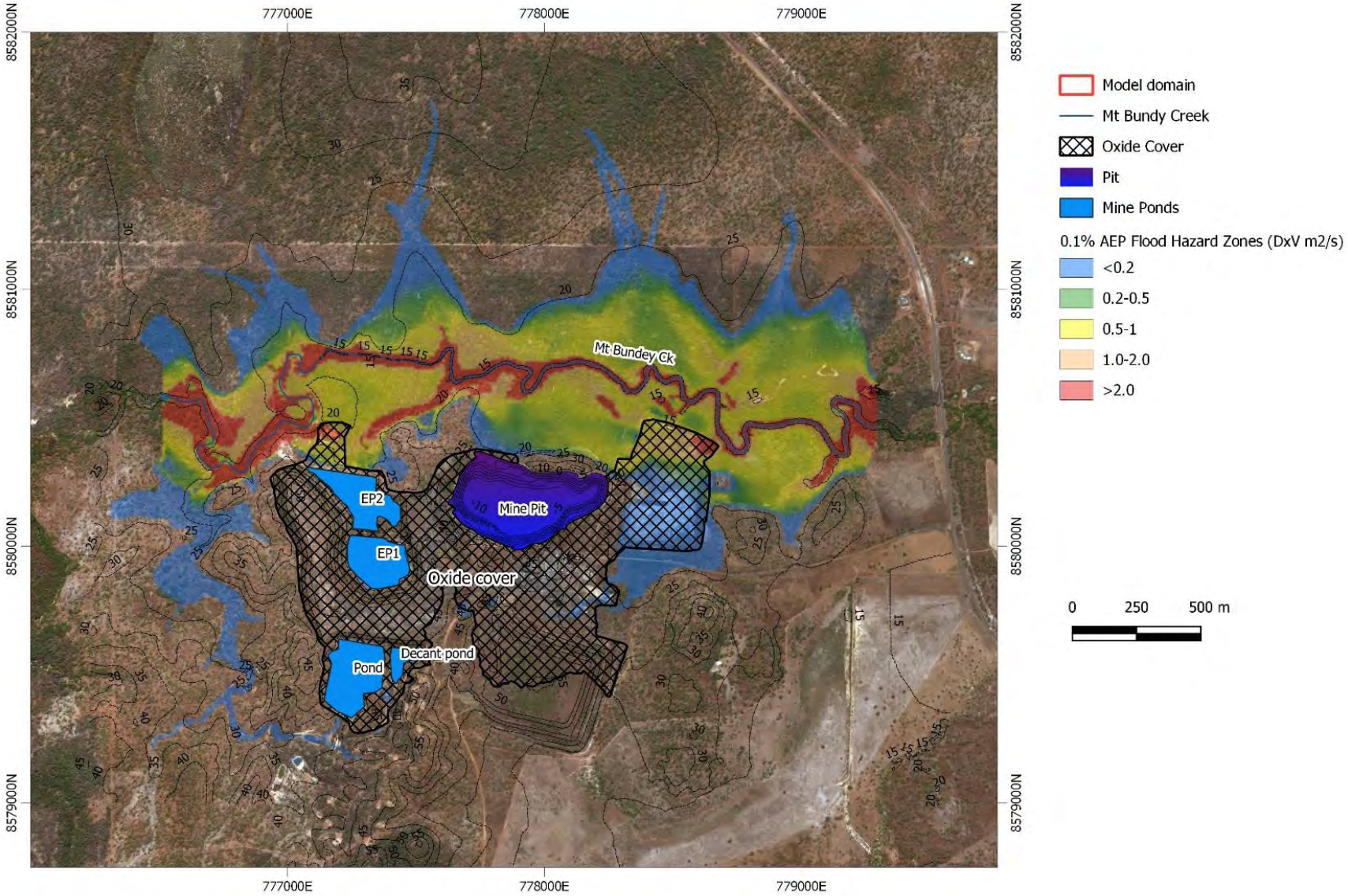

Figure 24. Flood hazard zones for Mt Bundey Ck mine catchment for 0.1%AEP rainfall event (flow from UMBC and mine area).

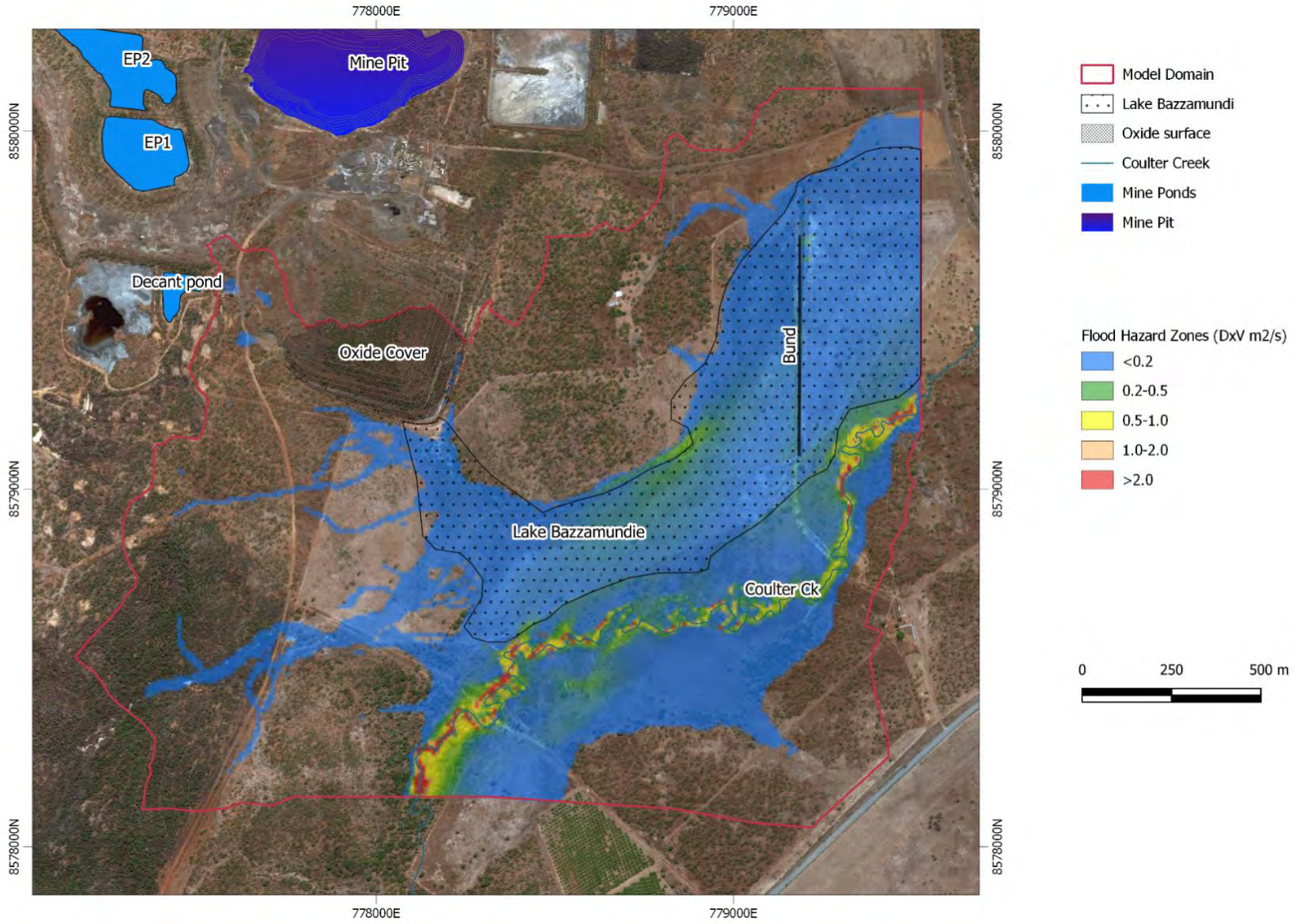

Figure 25. Flood hazard zones for Coulter Ck and Tom's Gully mine for 0.1%AEP rainfall event (flow from UCC and mine area).

9 References

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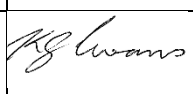
Draft	Ken Evans		Ken Evans		29/12/2019

APPENDIX 3

Supplementary Information, Tom's Gully Closure Plan

- Appendices

Inland water environmental quality: Potential release of mine-affected water after closure

Surface Water & Erosion Solutions

Supplementary information, Tom's Gully Closure Plan – Appendices

Inland water environmental quality: Potential release of mine-affected water after closure

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December 2019

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Appendix A. Laboratory Analysis Results

The results of the laboratory analysis of the soil samples are provided on the following pages.

Figure 1 to Figure 4 below present the particle size distributions for TG3, TG4, TG8, and TG9 corrected to account for the presence of rock fragments up to 250mm diameter, which was noted during the site investigation.

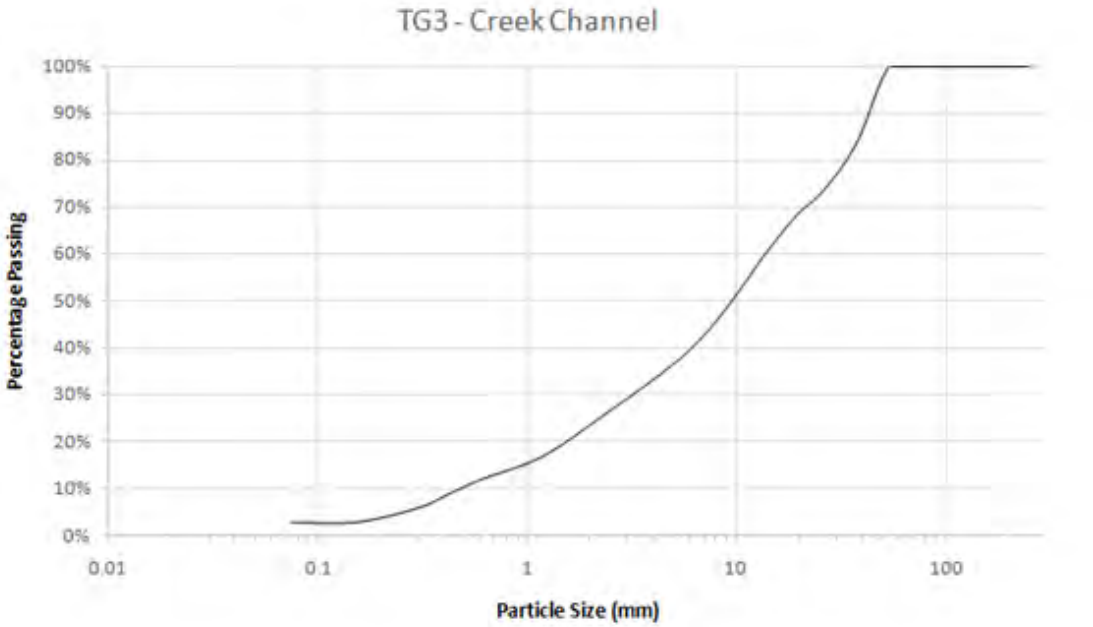

Figure 1. PSD for TG3 sample corrected to include 250mm fraction

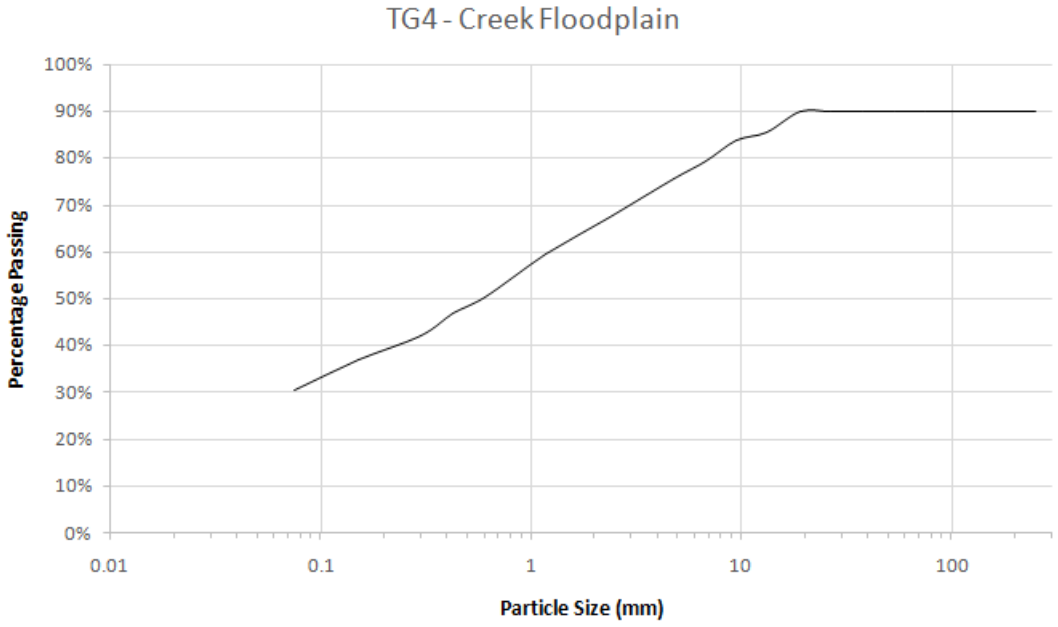

Figure 2. PSD for TG4 sample corrected to include 250mm fraction

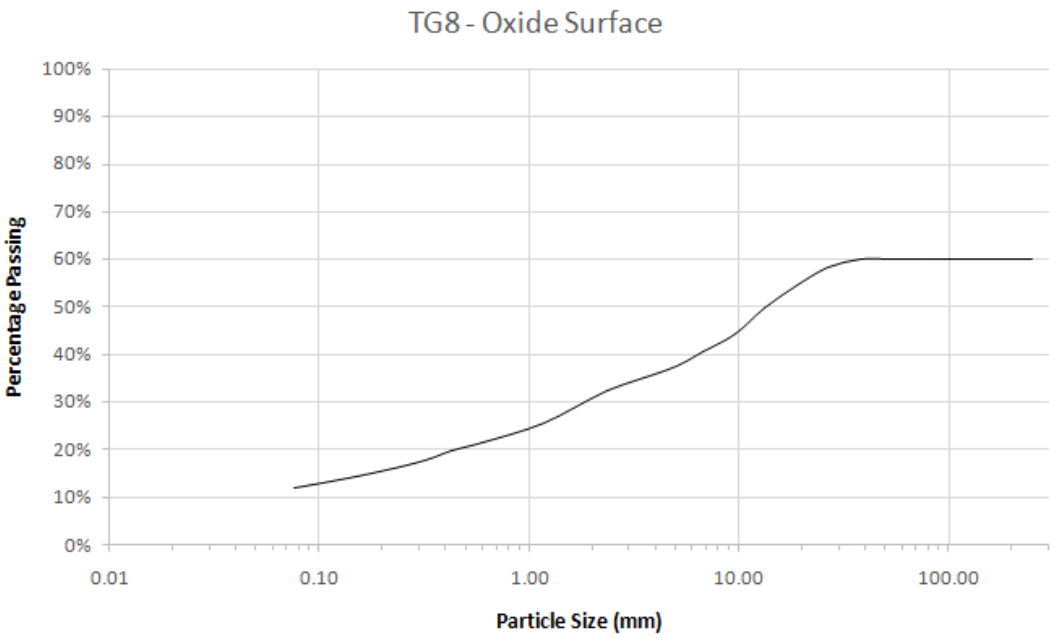

Figure 3. PSD for TG8 sample corrected to include 250mm fraction

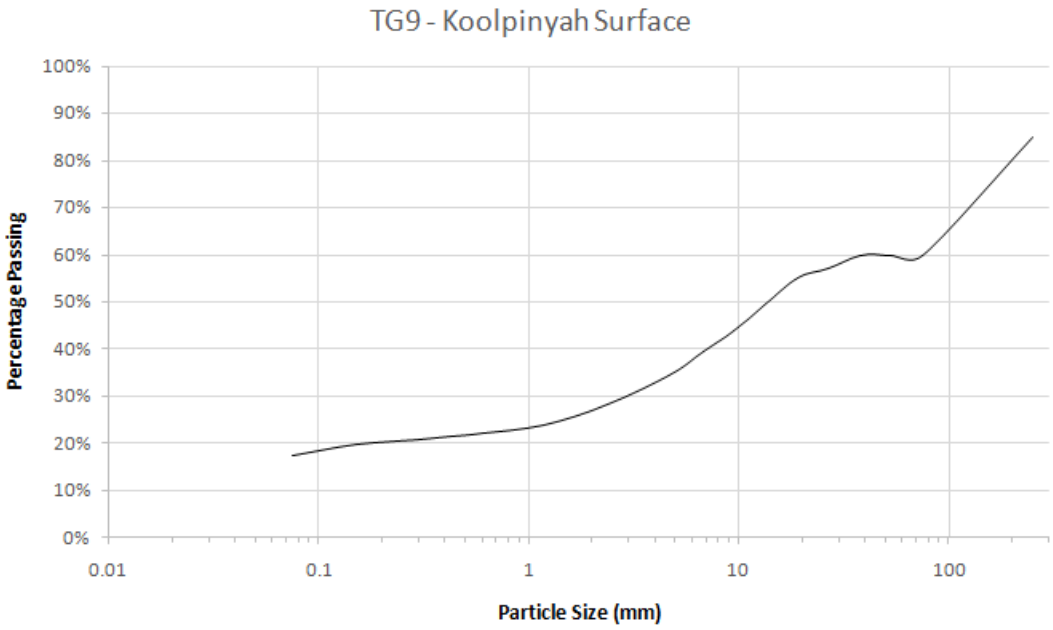

Figure 4. PSD for TG9 sample corrected to include 250mm fraction

Material Test Report

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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Aimee Cartwright
Laboratory Technician
NATA Accredited Laboratory Number: 828

Report Number: 677668.00-2
Issue Number: 1
Date Issued: 13/11/2019
Client: Hanking Australia Investment Pty Ltd
Level 26, 140 St Georges Terrace, Perth WA 6000
Contact: Ken Evans
Project Number: 677668.00
Project Name: Material Testing
Project Location: Not Supplied, Not Supplied
Work Request: 2206
Date Sampled: 25/10/2019
Dates Tested: 25/10/2019 - 07/11/2019
Sampling Method: Sampled by Client
The results apply to the sample as received

Moisture Content AS 1289 2.1.1

Sample Number	Sample Location	Moisture Content (%)	Material
DW-2206A	TG-3	4.6 %	Sandy GRAVEL with trace of Silt and Clay
DW-2206B	TG-4	0.9 %	Gravelly Silty SAND with Clay
DW-2206C	TG-6	1.6 %	Silty Sandy GRAVEL with trace Clay
DW-2206D	TG-8	0.5 %	Silty Sandy GRAVEL with trace Clay
DW-2206E	TG-9	2.8 %	Sandy Silty GRAVEL with Clay

This document shall not be reproduced except in full without approval of the laboratory.
Results relate only to the items tested/sampled.

Material Test Report

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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Clare Whelan
Lab Manager
NATA Accredited Laboratory Number: 828

Report Number: 677668.00-1
Issue Number: 2 - *This version supersedes all previous issues*
Reissue Reason: *Soil Discriptions Updated*
Date Issued: 13/11/2019
Client: Hanking Australia Investment Pty Ltd
Level 26, 140 St Georges Terrace, Perth WA 6000
Contact: Ken Evans - Principal Consultant
Project Number: 677668.00
Project Name: Material Testing
Project Location: Not Supplied, Not Supplied
Work Request: 2197
Sample Number: DW-2197A
Date Sampled: 21/10/2019
Dates Tested: 22/10/2019 - 29/10/2019
Sampling Method: Sampled by Client
The results apply to the sample as received
Remarks: Sample date not supplied. Entered date received in the lab.
Sample Location: **TG-3**
Material: Sandy GRAVEL with trace of Silt and Clay

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	**4 ***		
Soil Description	Sandy GRAVEL with trace of Silt and Clay		
Nature of Water	Demineralised water		
Temperature of Water (°C)	26		
* Mineral Present	Gypsum		

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Material Test Report

Douglas Partners
Geotechnics / Environment / Groundwater
Douglas Partners Pty Ltd
Darwin Laboratory
Unit 2/14 Caryota Circuit Coconut Grove NT 0810
Phone: (08) 8948 6800
Fax: (08) 8948 6899
Email: clare.whelan@douglaspartners.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Clare Whelan
Lab Manager
NATA Accredited Laboratory Number: 828

Report Number: **677668.00-1**
Issue Number: 2 - *This version supersedes all previous issues*
Reissue Reason: *Soil Discriptions Updated*
Date Issued: 13/11/2019
Client: Hanking Australia Investment Pty Ltd
Level 26, 140 St Georges Terrace, Perth WA 6000
Contact: Ken Evans - Principal Consultant
Project Number: 677668.00
Project Name: Material Testing
Project Location: Not Supplied, Not Supplied
Work Request: 2197
Sample Number: DW-2197B
Date Sampled: 21/10/2019
Dates Tested: 22/10/2019 - 29/10/2019
Sampling Method: Sampled by Client
The results apply to the sample as received
Remarks: Sample date not supplied. Entered date received in the lab.
Sample Location: **TG-4**
Material: Gravelly Silty SAND with Clay

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	4 *		
Soil Description	Gravelly Silty SAND with Clay		
Nature of Water	Demineralised water		
Temperature of Water (°C)	26		
* Mineral Present	Gypsum		

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Material Test Report

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Accredited for compliance with ISO/IEC 17025 - Testing

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Clare Whelan
Lab Manager
NATA Accredited Laboratory Number: 828

Report Number: **677668.00-1**
Issue Number: 2 - *This version supersedes all previous issues*
Reissue Reason: *Soil Discriptions Updated*
Date Issued: 13/11/2019
Client: Hanking Australia Investment Pty Ltd
Level 26, 140 St Georges Terrace, Perth WA 6000
Contact: Ken Evans - Principal Consultant
Project Number: 677668.00
Project Name: Material Testing
Project Location: Not Supplied, Not Supplied
Work Request: 2197
Sample Number: DW-2197C
Date Sampled: 21/10/2019
Dates Tested: 22/10/2019 - 29/10/2019
Sampling Method: Sampled by Client
The results apply to the sample as received
Remarks: Sample date not supplied. Entered date received in the lab.
Sample Location: **TG-5**
Material: Not Supplied

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	4 *		
Soil Description	Not Supplied		
Nature of Water	Demineralised water		
Temperature of Water (°C)	26		
* Mineral Present	Carbonate and Gypsum		

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Accredited for compliance with ISO/IEC 17025 - Testing

NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Clare Whelan
Lab Manager
NATA Accredited Laboratory Number: 828

Report Number: **677668.00-1**
Issue Number: 2 - *This version supersedes all previous issues*
Reissue Reason: *Soil Discriptions Updated*
Date Issued: 13/11/2019
Client: Hanking Australia Investment Pty Ltd
Level 26, 140 St Georges Terrace, Perth WA 6000
Contact: Ken Evans - Principal Consultant
Project Number: 677668.00
Project Name: Material Testing
Project Location: Not Supplied, Not Supplied
Work Request: 2197
Sample Number: DW-2197D
Date Sampled: 21/10/2019
Dates Tested: 22/10/2019 - 29/10/2019
Sampling Method: Sampled by Client
The results apply to the sample as received
Remarks: Sample date not supplied. Entered date received in the lab.
Sample Location: **TG-8**
Material: Silty Sandy GRAVEL with trace Clay

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	4 *		
Soil Description	Silty Sandy GRAVEL with trace Clay		
Nature of Water	Demineralised 2ater		
Temperature of Water (°C)	26		
* Mineral Present	Gypsum		

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Material Test Report

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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Clare Whelan
Lab Manager
NATA Accredited Laboratory Number: 828

Report Number: 677668.00-1
Issue Number: 2 - *This version supersedes all previous issues*
Reissue Reason: *Soil Discriptions Updated*
Date Issued: 13/11/2019
Client: Hanking Australia Investment Pty Ltd
Level 26, 140 St Georges Terrace, Perth WA 6000
Contact: Ken Evans - Principal Consultant
Project Number: 677668.00
Project Name: Material Testing
Project Location: Not Supplied, Not Supplied
Work Request: 2197
Sample Number: DW-2197E
Date Sampled: 21/10/2019
Dates Tested: 22/10/2019 - 29/10/2019
Sampling Method: Sampled by Client
The results apply to the sample as received
Remarks: Sample date not supplied. Entered date received in the lab.
Sample Location: TG-9
Material: Sandy Silty GRAVEL with Clay

Emerson Class Number of a Soil (AS 1289 3.8.1)		Min	Max
Emerson Class	4 *		
Soil Description	Sandy Silty GRAVEL with Clay		
Nature of Water	Demineralised water		
Temperature of Water (°C)	26		
* Mineral Present	Gypsum		

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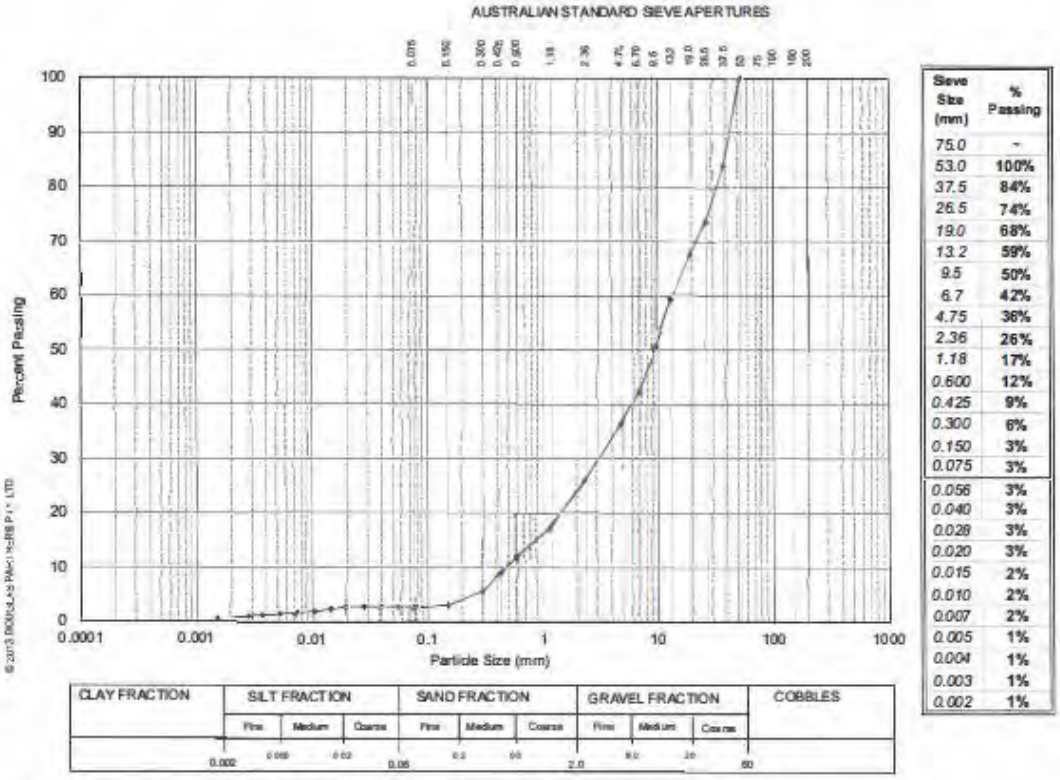
Results of Particle Size Distribution (Hydrometer)

Client :	Hanking Australia Investment Pty Ltd	**Project No. :**	677668
		Report No. :	BO19-0085
Project :	Material Testing	**Report Date :**	13.11.2019
Location :	Not Supplied	**Date Sampled:**	25.10.2019
Test Location:	TG-3	**Date of Test:**	12.11.2019
Depth / Layer:	-	**Page:**	1 of 1



Sieve Size (mm)	% Passing
75.0	-
53.0	100%
37.5	84%
26.5	74%
19.0	68%
13.2	59%
9.5	50%
6.7	42%
4.75	36%
2.36	26%
1.18	17%
0.600	12%
0.425	9%
0.300	6%
0.150	3%
0.075	3%
0.056	3%
0.040	3%
0.029	3%
0.020	3%
0.015	2%
0.010	2%
0.007	2%
0.005	1%
0.004	1%
0.003	1%
0.002	1%

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Description: Sandy GRAVEL with trace of Silt and Clay

Test Method(s): AS 1289.3.6.1, 3.6.3

Sampling Method(s): Sampled By Client

Loss in pretreatment: 0%

Remarks:

Type of Hydrometer: g/l

NATA Accredited Laboratory Number: 828

Tested: HW
Checked: AC

Aimee Cartwright
Laboratory Technician

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Geotechnics / Environment / Groundwater

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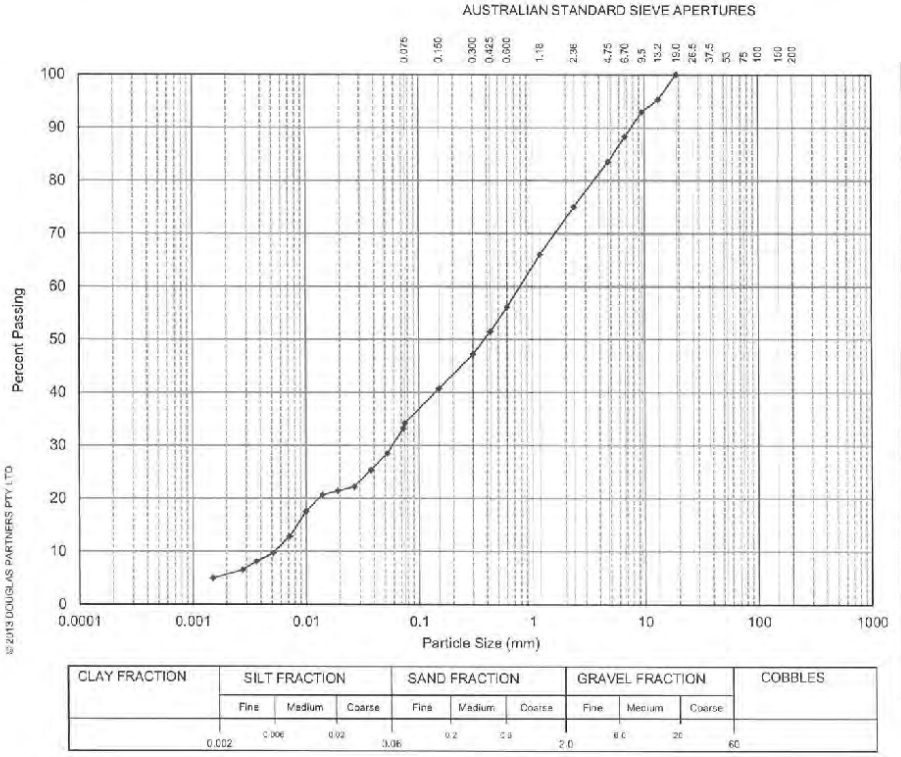
Results of Particle Size Distribution (Hydrometer)

Client :	Hanking Australia Investment Pty Ltd	**Project No. :**	677668
		Report No. :	BO19-0086
Project :	Material Testing	**Report Date :**	13.11.2019
Location :	Not Supplied	**Date Sampled:**	25.10.2019
Test Location:	TG-4	**Date of Test:**	12.11.2019
Depth / Layer:	-	**Page:**	1 of 1



Sieve Size (mm)	% Passing
75.0	-
53.0	-
37.5	-
26.5	-
19.0	100%
13.2	95%
9.5	93%
6.7	88%
4.75	84%
2.36	75%
1.18	66%
0.600	56%
0.425	52%
0.300	47%
0.150	41%
0.075	34%
0.052	29%
0.037	25%
0.027	22%
0.019	21%
0.014	21%
0.010	18%
0.007	13%
0.005	10%
0.004	8%
0.003	7%
0.002	5%

Description: Gravelly Silty SAND with Clay

Test Method(s): AS 1289.3.6.1, 3.6.3

Sampling Method(s): Sampled By Client

Loss in pretreatment: 0%

Remarks:

Type of Hydrometer: g/l

NATA Accredited Laboratory Number: 828

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Tested:	HW
Checked:	AC

Aimee Cartwright
Laboratory Technician

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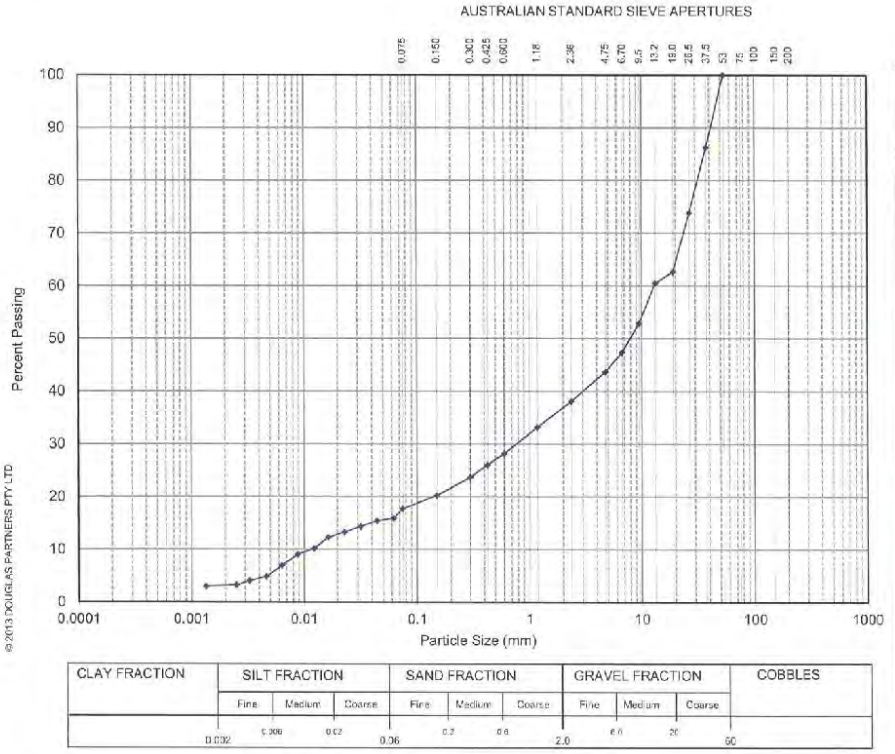
Results of Particle Size Distribution (Hydrometer)

Client :	Hanking Australia Investment Pty Ltd	**Project No. :**	677668
		Report No. :	BO19-0087
Project :	Material Testing	**Report Date :**	13.11.2019
Location :	Not Supplied	**Date Sampled:**	25.10.2019
Test Location:	TG-6	**Date of Test:**	12.11.2019
Depth / Layer:	-	**Page:**	1 of 1



Sieve Size (mm)	% Passing
75.0	~
53.0	100%
37.5	86%
26.5	74%
19.0	63%
13.2	61%
9.5	53%
6.7	47%
4.75	44%
2.36	38%
1.18	33%
0.600	28%
0.425	26%
0.300	24%
0.150	20%
0.075	18%
0.044	15%
0.032	14%
0.023	13%
0.016	12%
0.012	10%
0.009	9%
0.006	7%
0.005	5%
0.003	4%
0.002	3%
0.001	3%

Description: Silty Sandy GRAVEL with trace Clay

Test Method(s): AS 1289.3.6.1, 3.6.3

Sampling Method(s): Sampled By Client

Loss in pretreatment: 0%

Remarks:

Type of Hydrometer: g/l

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NATA Accredited Laboratory Number: 828

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Tested:	HW
Checked:	AC

Aimee Cartwright
Laboratory Technician

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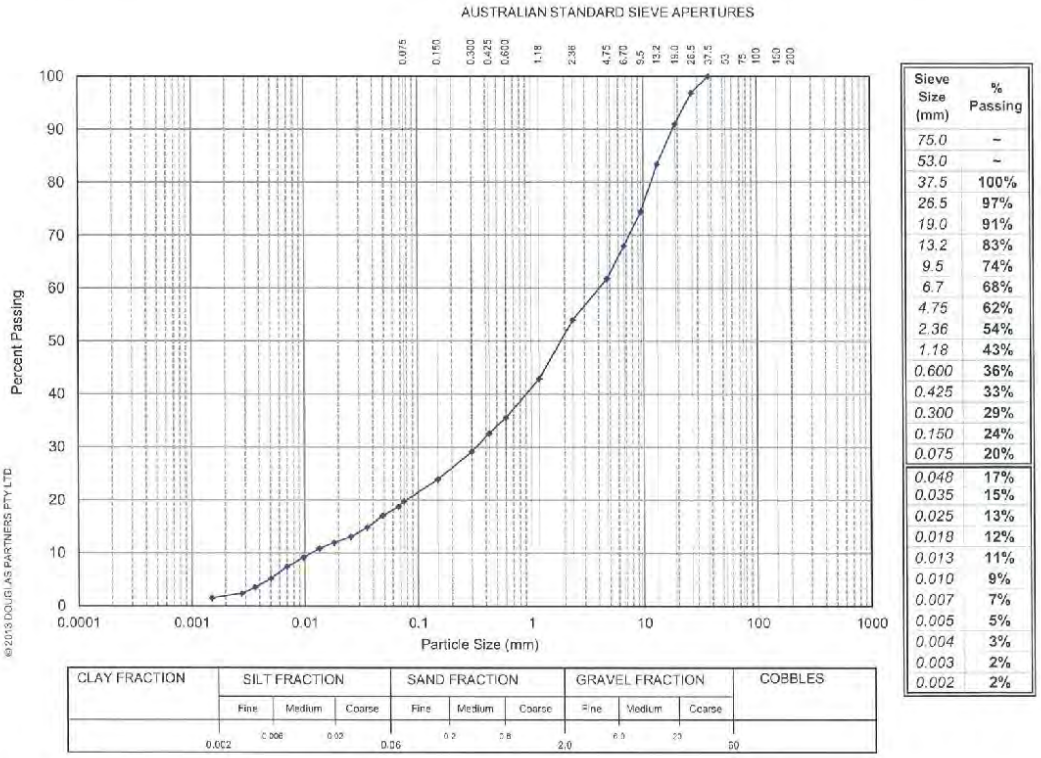
Results of Particle Size Distribution (Hydrometer)

Client :	Hanking Australia Investment Pty Ltd	**Project No. :**	677668
		Report No. :	BO19-0088
Project :	Material Testing	**Report Date :**	13.11.2019
Location :	Not Supplied	**Date Sampled:**	25.10.2019
Test Location:	TG-8	**Date of Test:**	12.11.2019
Depth / Layer:	-	**Page:**	1 of 1



Sieve Size (mm)	% Passing
75.0	-
53.0	-
37.5	100%
26.5	97%
19.0	91%
13.2	83%
9.5	74%
6.7	68%
4.75	62%
2.36	54%
1.18	43%
0.600	36%
0.425	33%
0.300	29%
0.150	24%
0.075	20%
0.048	17%
0.035	15%
0.025	13%
0.018	12%
0.013	11%
0.010	9%
0.007	7%
0.005	5%
0.004	3%
0.003	2%
0.002	2%

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Description: Silty Sandy GRAVEL with trace Clay

Test Method(s): AS 1289.3.6.1, 3.6.3

Sampling Method(s): Sampled By Client

Loss in pretreatment: 0%

Remarks:

Type of Hydrometer: g/l

FORM R64D REV 6 APRIL 2013

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NATA Accredited Laboratory Number: 828

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Tested: HW
Checked: AC

Aimee Cartwright
Laboratory Technician

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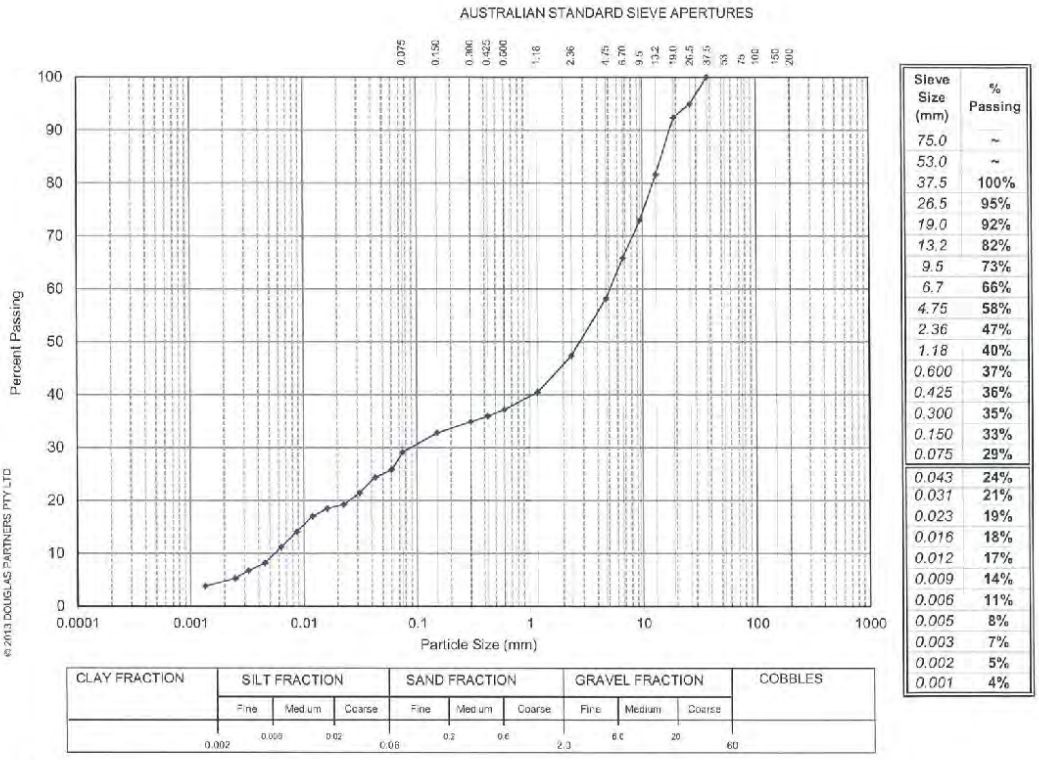
Results of Particle Size Distribution (Hydrometer)

Client :	Hanking Australia Investment Pty Ltd	**Project No. :**	677668
		Report No. :	BO19-0089
Project :	Material Testing	**Report Date :**	13.11.2019
Location :	Not Supplied	**Date Sampled:**	25.10.2019
Test Location:	TG-9	**Date of Test:**	12.11.2019
Depth / Layer:	-	**Page:**	1 of 1



Sieve Size (mm)	% Passing
75.0	~
53.0	~
37.5	100%
26.5	95%
19.0	92%
13.2	82%
9.5	73%
6.7	66%
4.75	58%
2.36	47%
1.18	40%
0.600	37%
0.425	36%
0.300	35%
0.150	33%
0.075	29%
0.043	24%
0.031	21%
0.023	19%
0.016	18%
0.012	17%
0.009	14%
0.006	11%
0.005	8%
0.003	7%
0.002	5%
0.001	4%

Description: Sandy Silty GRAVEL with Clay

Test Method(s): AS 1289.3.6.1, 3.6.3

Sampling Method(s): Sampled By Client

Loss in pretreatment: 0%

Remarks:

Type of Hydrometer: g/l

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NATA Accredited Laboratory Number: 828

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Tested: HW
Checked: AC

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Laboratory Technician

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lab@mpl.com.au
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DATA QUALITY ASSESSMENT SUMMARY

Report Details	
Envirolab Report Reference	**234883**
Client ID	Douglas Partners Pty Ltd - Coconut Grove
Project Reference	677668
Date Issued	29/10/2019

QC DATA

All laboratory QC data was within the Envirolab Group's specifications.

HOLDING TIME COMPLIANCE EVALUATION

All preservation / holding times (based on AS/ASPHA/ISO/NEPM/USEPA reference documents and standards) are compliant except:

Holding Time Exceedances

Analysis	Sample No	Date Sampled	Date Extracted	Date Analysed	Accepted
Miscellaneous Inorg - soil					
Electrical Conductivity (EC)	234883-1		25/10/2019	25/10/2019	#
pH	234883-1		25/10/2019	25/10/2019	#
Estimated Salinity* (calc)	234883-1		25/10/2019	25/10/2019	#
Total Organic Carbon(Walkley Black)	234883-1		25/10/2019	25/10/2019	#
Electrical Conductivity (EC)	234883-2		25/10/2019	25/10/2019	#
pH	234883-2		25/10/2019	25/10/2019	#
Estimated Salinity* (calc)	234883-2		25/10/2019	25/10/2019	#
Total Organic Carbon(Walkley Black)	234883-2		25/10/2019	25/10/2019	#
Electrical Conductivity (EC)	234883-3		25/10/2019	25/10/2019	#
pH	234883-3		25/10/2019	25/10/2019	#
Estimated Salinity* (calc)	234883-3		25/10/2019	25/10/2019	#
Total Organic Carbon(Walkley Black)	234883-3		25/10/2019	25/10/2019	#
Electrical Conductivity (EC)	234883-4		25/10/2019	25/10/2019	#
pH	234883-4		25/10/2019	25/10/2019	#
Estimated Salinity* (calc)	234883-4		25/10/2019	25/10/2019	#
Total Organic Carbon(Walkley Black)	234883-4		25/10/2019	25/10/2019	#
Electrical Conductivity (EC)	234883-5		25/10/2019	25/10/2019	#
pH	234883-5		25/10/2019	25/10/2019	#
Estimated Salinity* (calc)	234883-5		25/10/2019	25/10/2019	#
Total Organic Carbon(Walkley Black)	234883-5		25/10/2019	25/10/2019	#
ESP/CEC					
Cation Exchange Capacity	234883-1		25/10/2019	25/10/2019	#

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www.mpl.com.au

Holding Time Exceedances

Analysis	Sample No	Date Sampled	Date Extracted	Date Analysed	Accepted
Exchangeable Al	234883-1		25/10/2019	25/10/2019	#
Exchangeable Ca	234883-1		25/10/2019	25/10/2019	#
Exchangeable K	234883-1		25/10/2019	25/10/2019	#
Exchangeable Mg	234883-1		25/10/2019	25/10/2019	#
Exchangeable Na	234883-1		25/10/2019	25/10/2019	#
Aluminium	234883-1		25/10/2019	25/10/2019	#
Calcium	234883-1		25/10/2019	25/10/2019	#
Potassium	234883-1		25/10/2019	25/10/2019	#
Magnesium	234883-1		25/10/2019	25/10/2019	#
Sodium	234883-1		25/10/2019	25/10/2019	#
Cation Exchange Capacity	234883-2		25/10/2019	25/10/2019	#
Exchangeable Al	234883-2		25/10/2019	25/10/2019	#
Exchangeable Ca	234883-2		25/10/2019	25/10/2019	#
Exchangeable K	234883-2		25/10/2019	25/10/2019	#
Exchangeable Mg	234883-2		25/10/2019	25/10/2019	#
Exchangeable Na	234883-2		25/10/2019	25/10/2019	#
Aluminium	234883-2		25/10/2019	25/10/2019	#
Calcium	234883-2		25/10/2019	25/10/2019	#
Potassium	234883-2		25/10/2019	25/10/2019	#
Magnesium	234883-2		25/10/2019	25/10/2019	#
Sodium	234883-2		25/10/2019	25/10/2019	#
Cation Exchange Capacity	234883-3		25/10/2019	25/10/2019	#
Exchangeable Al	234883-3		25/10/2019	25/10/2019	#
Exchangeable Ca	234883-3		25/10/2019	25/10/2019	#
Exchangeable K	234883-3		25/10/2019	25/10/2019	#
Exchangeable Mg	234883-3		25/10/2019	25/10/2019	#
Exchangeable Na	234883-3		25/10/2019	25/10/2019	#
Aluminium	234883-3		25/10/2019	25/10/2019	#
Calcium	234883-3		25/10/2019	25/10/2019	#
Potassium	234883-3		25/10/2019	25/10/2019	#
Magnesium	234883-3		25/10/2019	25/10/2019	#
Sodium	234883-3		25/10/2019	25/10/2019	#
Cation Exchange Capacity	234883-4		25/10/2019	25/10/2019	#
Exchangeable Al	234883-4		25/10/2019	25/10/2019	#
Exchangeable Ca	234883-4		25/10/2019	25/10/2019	#
Exchangeable K	234883-4		25/10/2019	25/10/2019	#
Exchangeable Mg	234883-4		25/10/2019	25/10/2019	#

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lab@mpl.com.au
www.mpl.com.au

Holding Time Exceedances

Analysis	Sample No	Date Sampled	Date Extracted	Date Analysed	Accepted
Exchangeable Na	234883-4		25/10/2019	25/10/2019	#
Aluminium	234883-4		25/10/2019	25/10/2019	#
Calcium	234883-4		25/10/2019	25/10/2019	#
Potassium	234883-4		25/10/2019	25/10/2019	#
Magnesium	234883-4		25/10/2019	25/10/2019	#
Sodium	234883-4		25/10/2019	25/10/2019	#
Cation Exchange Capacity	234883-5		25/10/2019	25/10/2019	#
Exchangeable Al	234883-5		25/10/2019	25/10/2019	#
Exchangeable Ca	234883-5		25/10/2019	25/10/2019	#
Exchangeable K	234883-5		25/10/2019	25/10/2019	#
Exchangeable Mg	234883-5		25/10/2019	25/10/2019	#
Exchangeable Na	234883-5		25/10/2019	25/10/2019	#
Aluminium	234883-5		25/10/2019	25/10/2019	#
Calcium	234883-5		25/10/2019	25/10/2019	#
Potassium	234883-5		25/10/2019	25/10/2019	#
Magnesium	234883-5		25/10/2019	25/10/2019	#
Sodium	234883-5		25/10/2019	25/10/2019	#

Holding Table Comments

No Sample Dates were provided. Holding Times cannot be calculated.

Certain analyses have had their recommended technical holding times elongated by filtering and/or freezing on receipt at the laboratory (e.g. BOD, chlorophyll/Pheophytin, nutrients and acid sulphate soil tests).

COMPLIANCE TO QC FREQUENCY (NEPM)

Internal laboratory QC rate complies with NEPM requirements (LCS/MB/MS 1 in 20, Duplicates 1 in 10 samples). Note, samples are batched together with other sample consignments in order to assign QC sample frequency.

QC Evaluation

Duplicate(s) was performed as per NEPM frequency	✓
Laboratory Control Sample(s) were analysed with the samples received	✓
A Method Blank was performed with the samples received	✓
Matrix spike(s) was performed as per NEPM frequency	✓

Refer to Certificate of Analysis for all Quality Control data.

Envirolab Services (WA) Pty Ltd trading as MPL Laboratories
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lab@mpl.com.au
www.mpl.com.au

CERTIFICATE OF ANALYSIS 234883

Client Details

Client	Douglas Partners Pty Ltd - Coconut Grove
Attention	Clare Whelan
Address	2/14 Caryota Court, COCONUT GROVE, NT, 0810

Sample Details

Your Reference	**677668**
Number of Samples	5 Soil
Date samples received	23/10/2019
Date completed instructions received	23/10/2019

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	29/10/2019
Date of Issue	29/10/2019

NATA Accreditation Number 2901. This document shall not be reproduced except in full.

Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Heram Halim, Operations Manager

Authorised By

Michael Kubiak, Laboratory Manager

Client Reference: 677668

Miscellaneous Inorg - soil						
Our Reference		234883-1	234883-2	234883-3	234883-4	234883-5
Your Reference	UNITS	TG-3	TG-4	TG-5	TG-8	TG-9
Type of sample		Soil	Soil	Soil	Soil	Soil
Date prepared	-	25/10/2019	25/10/2019	25/10/2019	25/10/2019	25/10/2019
Date analysed	-	25/10/2019	25/10/2019	25/10/2019	25/10/2019	25/10/2019
pH	pH Units	7.3	4.4	7.6	5.4	5.8
Electrical Conductivity (EC)	µS/cm	8.7	96	370	21	74
Estimated Salinity* (calc)	mg/kg	30	330	1,300	72	250
Total Organic Carbon (Walkley Black)	mg/kg	4,600	19,000	12,000	13,000	31,000

Client Reference: 677668

ESP/CEC						
Our Reference	UNITS	234883-1	234883-2	234883-3	234883-4	234883-5
Your Reference		TG-3	TG-4	TG-5	TG-8	TG-9
Type of sample		Soil	Soil	Soil	Soil	Soil
Date digested	-	25/10/2019	25/10/2019	25/10/2019	25/10/2019	25/10/2019
Date analysed	-	25/10/2019	25/10/2019	25/10/2019	25/10/2019	25/10/2019
Calcium	mg/kg	130	190	2,200	130	350
Potassium	mg/kg	<50	55	<50	54	67
Magnesium	mg/kg	<50	96	88	67	160
Sodium	mg/kg	<50	<50	<50	<50	<50
Aluminium	mg/kg	<10	<10	<10	<10	<10
Exchangeable Ca	meq/100g	0.6	1	11	0.6	1.7
Exchangeable K	meq/100g	<0.13	0.1	<0.13	0.1	0.2
Exchangeable Mg	meq/100g	<0.41	0.8	0.7	0.5	1.3
Exchangeable Na	meq/100g	<0.22	<0.22	<0.22	<0.22	<0.22
Exchangeable Al	meq/100g	<0.07	<0.07	<0.07	<0.07	<0.07
Cation Exchange Capacity	meq/100g	<1	2	12	1	3

Client Reference: 677668

Method ID	Methodology Summary
INORG-001	pH - Measured using pH meter and electrode base on APHA latest edition, Method 4500-H+. Please note that the results for water analyses may be indicative only, as analysis can be completed outside of the APHA recommended holding times. Soils are reported from a 1:5 water extract unless otherwise specified.
INORG-002	Conductivity and Salinity - measured using a conductivity cell at 25°C based on APHA latest edition Method 2510. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-036	Total Organic Carbon or Matter - A titrimetric method that measures the oxidisable organic content of soils.
METALS-009	Determination of exchangeable cations and cation exchange capacity in soils using 1M Ammonium Chloride exchange and ICP-AES analytical finish.
METALS-009	Determination of exchangeable cations and cation exchange capacity in soils using 1M Ammonium Chloride exchange and ICP-AES analytical finish.
METALS-020	Determination of various metals by ICP-AES.

Client Reference: 677668

QUALITY CONTROL: Miscellaneous Inorg - soil						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	234883-2
Date prepared	-			25/10/2019	1	25/10/2019	25/10/2019		25/10/2019	25/10/2019
Date analysed	-			25/10/2019	1	25/10/2019	25/10/2019		25/10/2019	25/10/2019
pH	pH Units		INORG-001		1	7.3			102	
Electrical Conductivity (EC)	µS/cm	1	INORG-002	<1	1	8.7			107	
Total Organic Carbon (Walkley Black)	mg/kg	1000	INORG-036	<1000	1	4600	5000	8	100	77

Client Reference: 677668

QUALITY CONTROL: ESP/CEC						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	234883-4
Date digested	-			25/10/2019					25/10/2019	25/10/2019
Date analysed	-			25/10/2019					25/10/2019	25/10/2019
Calcium	mg/kg	50	METALS-020	<50					103	103
Potassium	mg/kg	50	METALS-020	<50					99	108
Magnesium	mg/kg	50	METALS-020	<50					102	103
Sodium	mg/kg	50	METALS-020	<50					99	103
Aluminium	mg/kg	10	METALS-020	<10					99	117

Client Reference: 677668

Result Definitions	
NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Client Reference: 677668

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from "2018 TLVs and BEIs", as published by ACGIH (where available).

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Appendix B. RORB results

B.1 Rainfall hyetograph

The RORBwin model was used to determine the hyetographs for the 1%AEP and 0.1%AEP rainfall events in accordance with ARR 2019 (Figure 5).

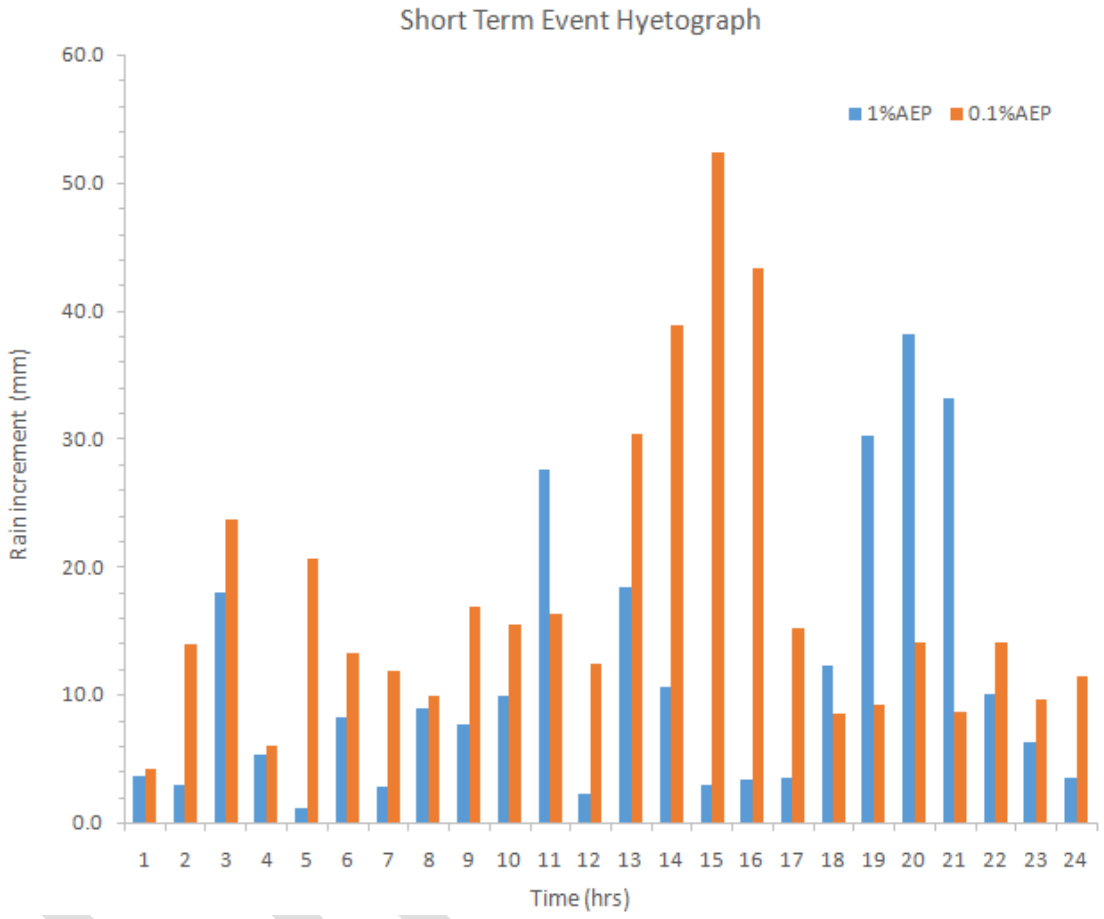

Figure 5. Hyetographs for 1%AEP and 0.1%AEP rainfall events

B.2 Simulated mine pit overflow discharge

Discharge hydrographs for the overflow from the mine pits were also produced for assessment of the impact of pit overflow on downstream water quality. Overflow hydrographs for the EP2 pit (Figure 6) and the main mine pit (Figure 7) were generated for the 1%AEP and 0.1%AEP events.

The simulation for the main mine pit was undertaken assuming the pit was already full when the event occurred, to assess the worst-case scenario for the water quality modelling.

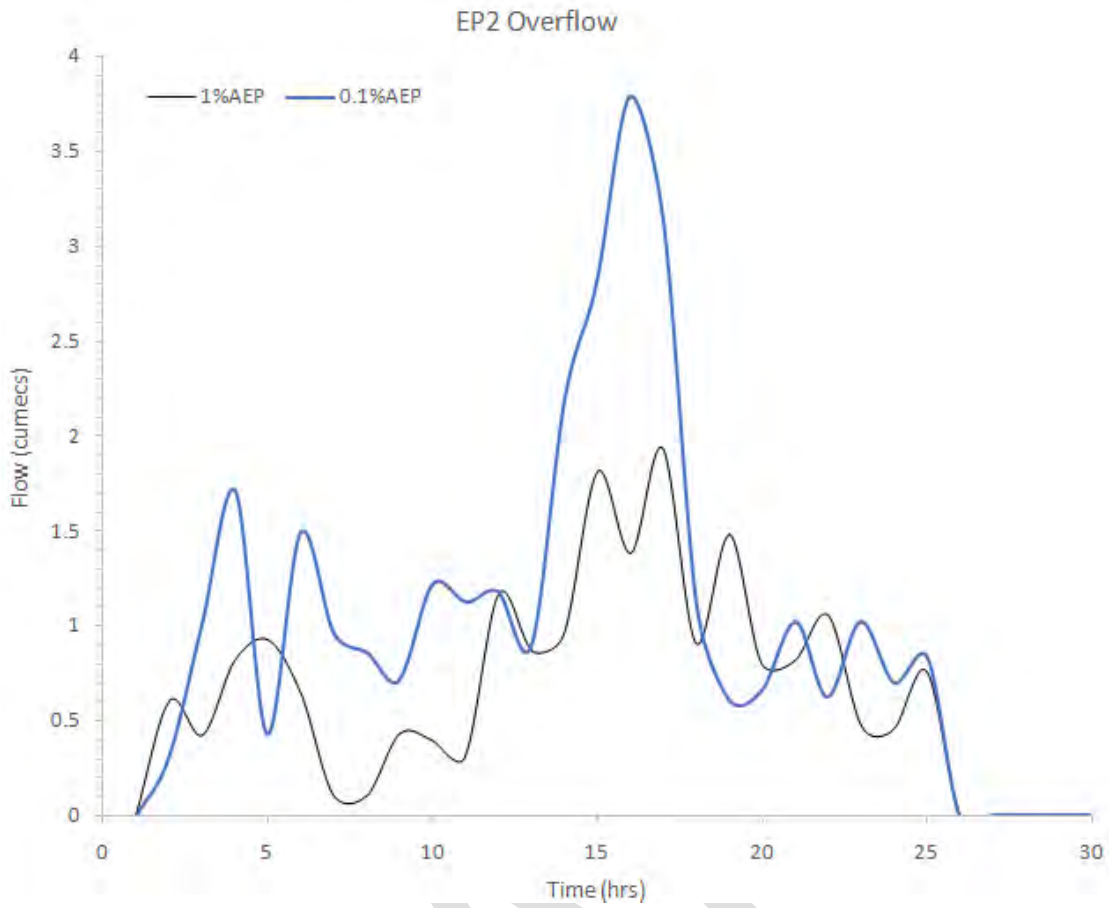

Figure 6. EP2 pit overflow discharge hydrograph for 1% and 0.1%AEP events

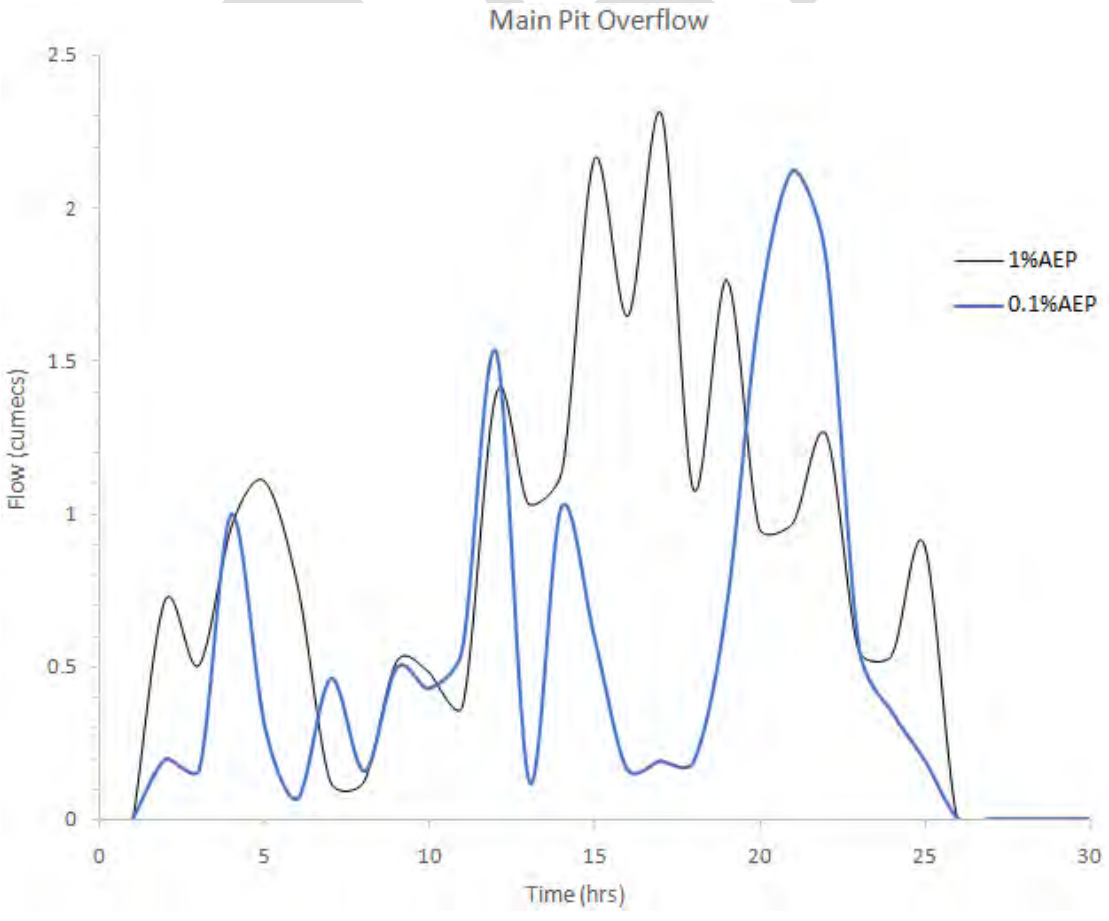

Figure 7. Main mine pit overflow discharge hydrograph for 1% and 0.1%AEP events

B.3 Inflow hydrographs

Discharge hydrographs were produced to simulate upstream flow from the Coulter Ck and Mt Bundey Ck upper catchments, which were used as inputs to the RMA water quality model, for both the 1%AEP (Figure 9 and Figure 10) and 0.1%AEP (Figure 11 and Figure 12) events.

The locations of each of the inlets is shown in Figure 8 below.

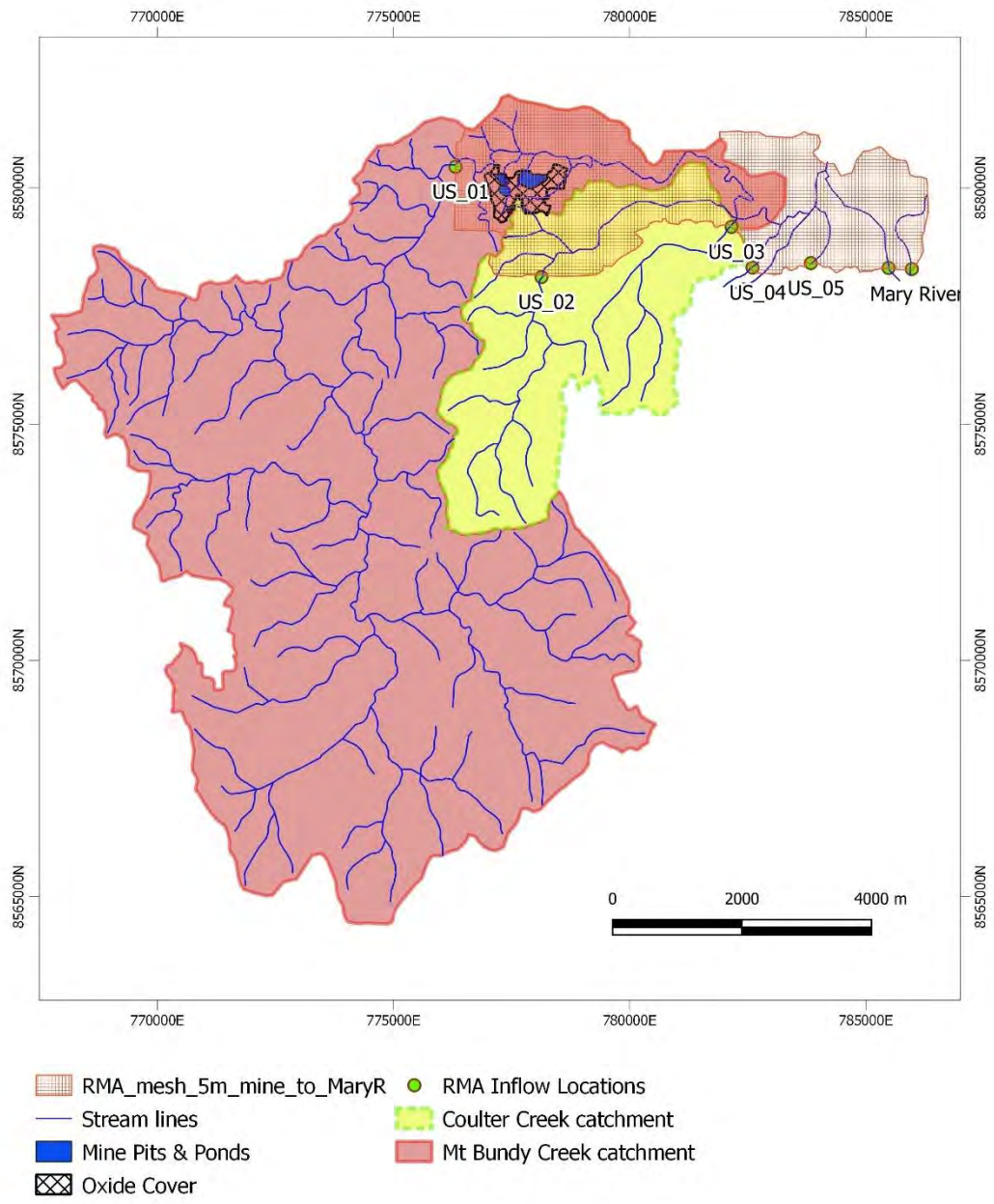

Figure 8. Input location for the RMA model. Hydrographic inputs were derived using RORBwin.

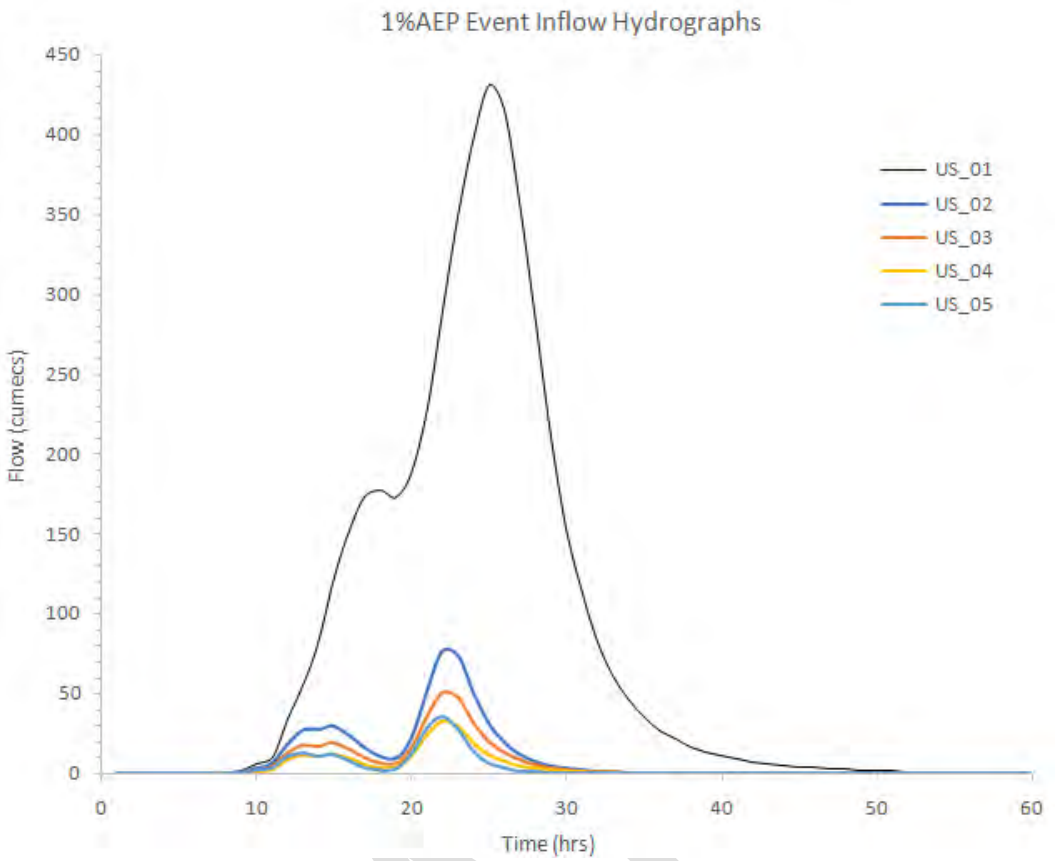

Figure 9. Hydrograph at RMA model inlets for 1%AEP event

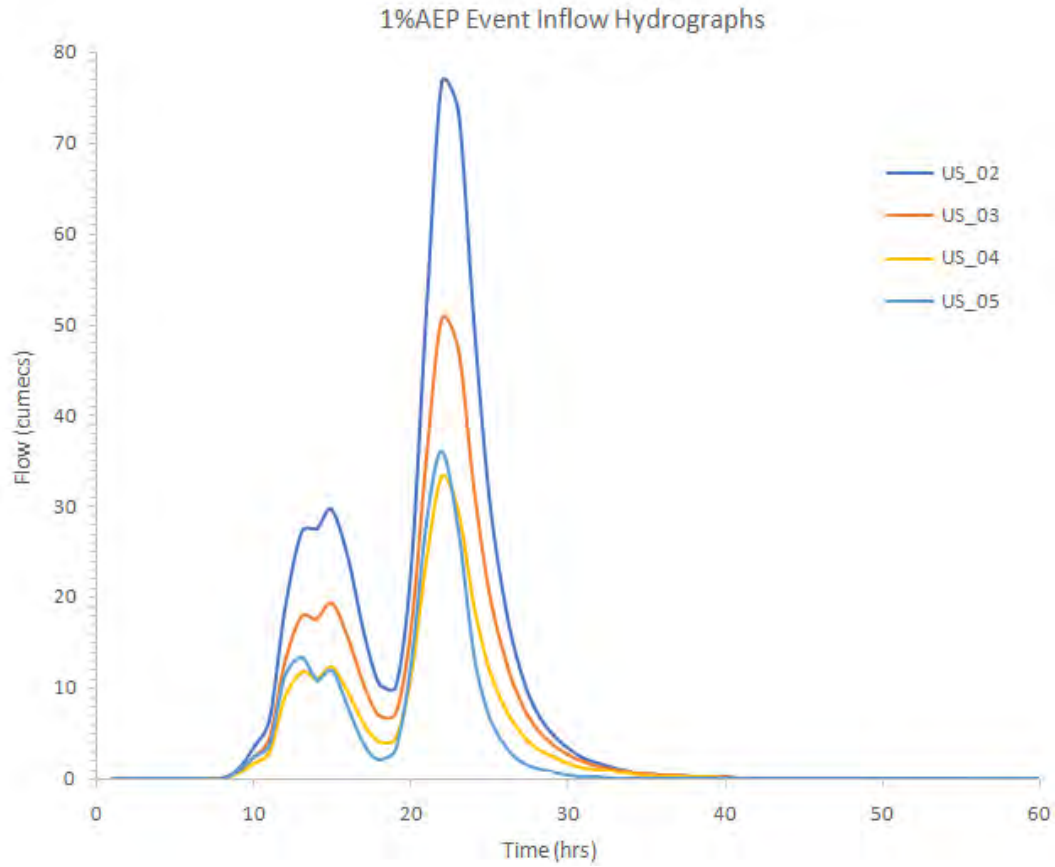

Figure 10. Hydrograph at RMA model inlets US_02 to US_05 for 1%AEP event

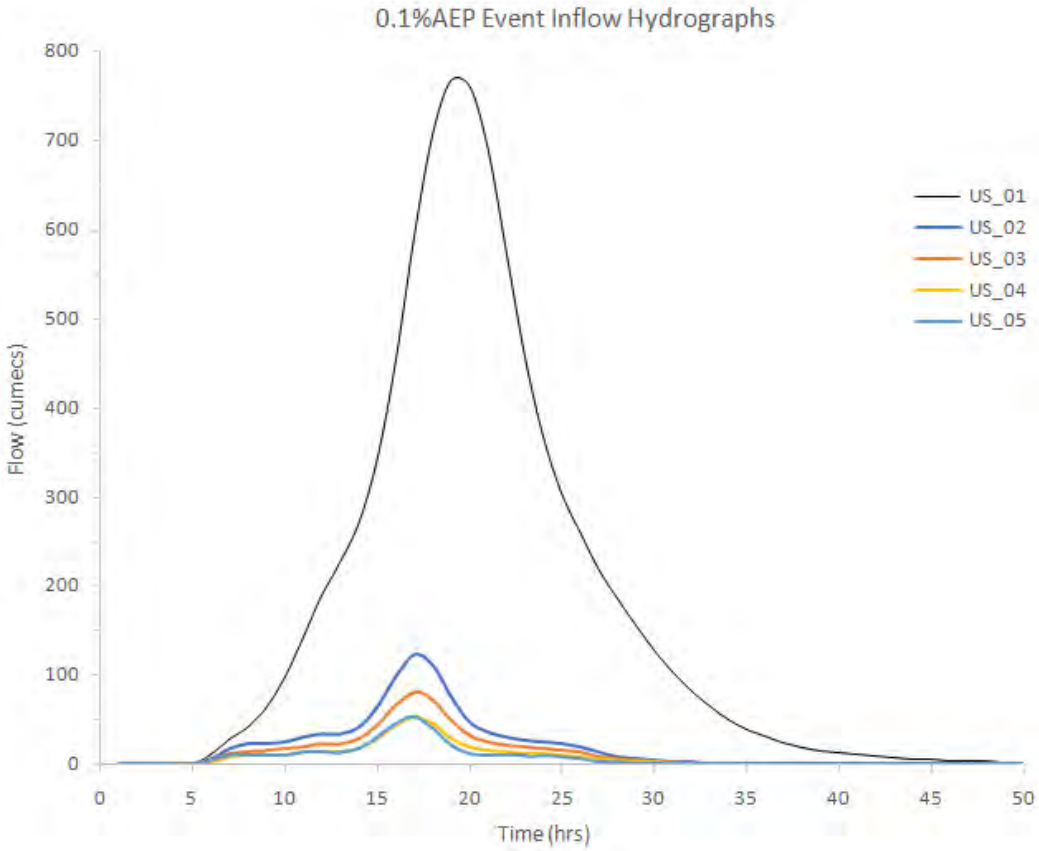

Figure 11. Discharge hydrograph at RMA model inlets for 0.1%AEP event

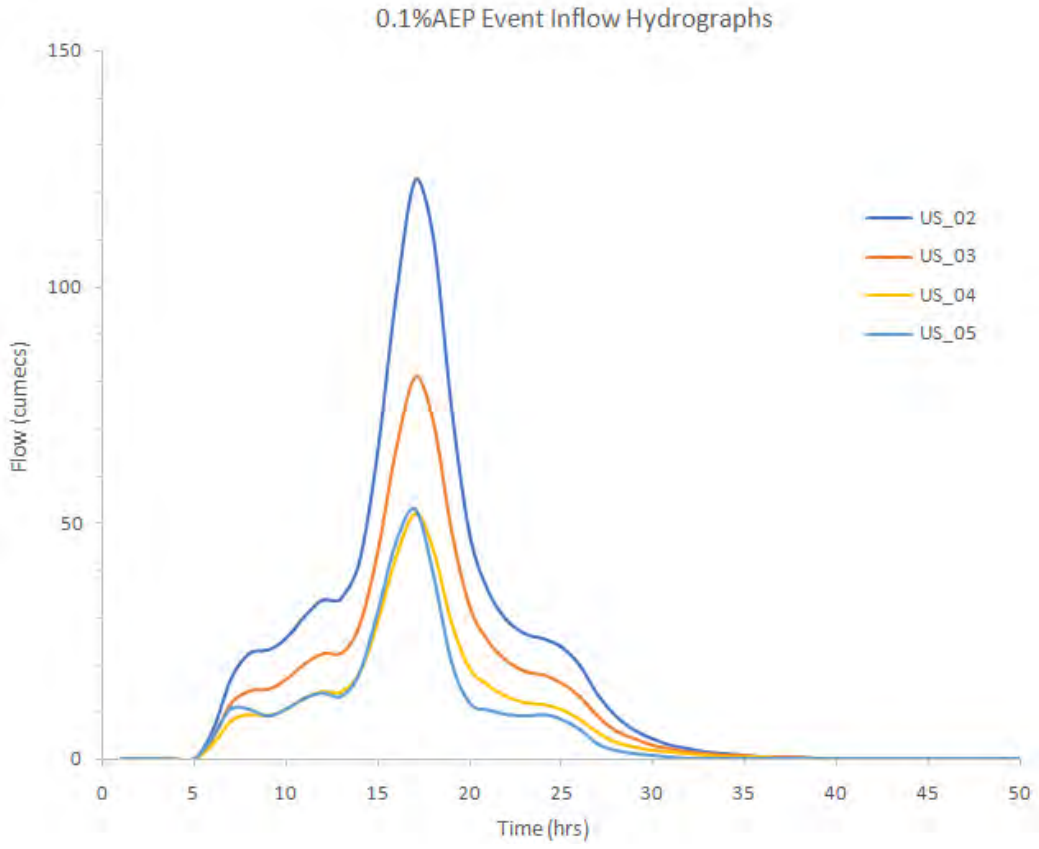

Figure 12. Hydrographs at RMA model inlets US_02 to US_05 for 0.1%AEP event

Appendix C. HEC-HMS Water Balance

C.1 Introduction

This section summarises the assessment of the proposed post-closure water management of the Tom's Gully mine. The assessment includes the flowing:

- Long-term water balance of the Tom's Gully pit lake to inform of the potential risks of overtopping or uncontrolled discharge to the environment.
- Provide annual short-term water balance schematics of the post-closure mine site water management, including volumes, for dry and wet rainfall scenarios.

C.2 Long-term water balance modelling

A post-closure pit water balance model was developed using HEC-HMS to simulate changes in water storage based on inflows and outflows. 1000-year simulations were conducted for a dry climate scenario (average annual rainfall) and wet climate scenario (5% increase in average annual rainfall).

Major sources of water inflow to the pit lake include; direct precipitation on the lake surface, surface runoff from the pit catchment, and horizontal or vertical groundwater inflow from bed rock or alluvium. Major losses from the pit lake are evaporation and seepage.

C2.1 Model setup

The HEC-HMS hydrological model simulates the complete hydrologic processes of dendritic watershed systems. The HEC-HMS model for the pit lake uses an elevation-area relationship, developed based on the post-closure bathymetry of the pit lake. Figure 13 below presents the model layout.

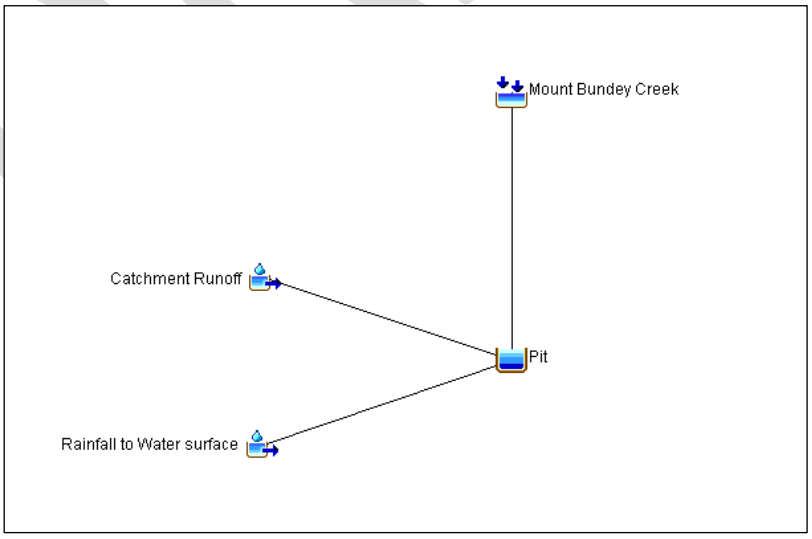

Figure 13. Long-term HEC-HMS water balance model layout

C2.2 Climate data input

The 1000-year continuous daily rainfall series were generated by the WGEN weather simulator. WGEN is a stochastic weather generator which uses monthly and annual statistics to generate

daily time series of precipitation, minimum temperature, maximum temperature, and solar radiation (Richardson and Wright 1984). In the absence of on-site observation data, long-term daily climate data from 1957 to 2019 was sourced from the SILO Australian climate online database. The monthly average Morton Shallow Lake Evaporation Rate from SILO was adopted for the water balance modelling.

C2.3 Ground water inflow

The ground water inflow to the pit was predicted using Maximov's analytical equation based on the hydraulic head and permeability of the surrounding geologic units (Maximov, 1967).

Previous studies indicate the hydraulic conductivity is 0.2m/day for the fractured siltstone around the pit, and the long-term (stabilised) groundwater table level is at 15m RL (AGE 2015). An inflow-elevation relationship was derived based on the above assumptions. The resulting inflow rates range from 0 to 5 ML/day depending on the elevation difference between pit water surface and the long-term ground water table.

C2.4 Simulation results

The predicted 1000-year post-closure pit storages for the two climate scenarios are presented in Figure 14 and Figure 15.

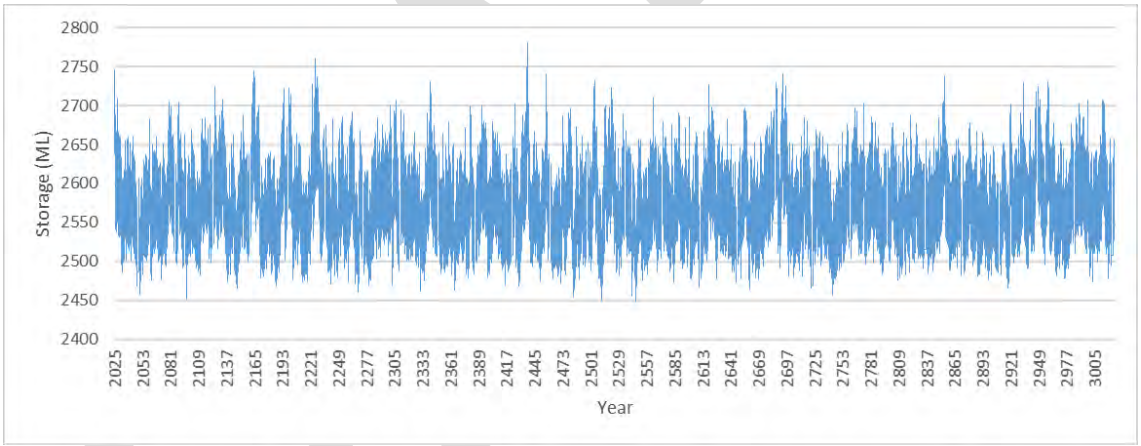

Figure 14. Predicted 1000-year pit storage for dry climate scenario

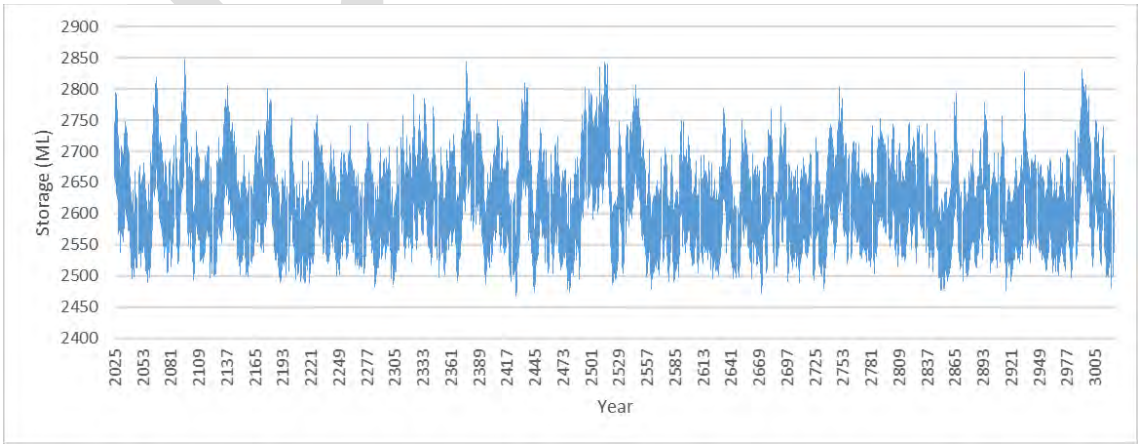

Figure 15. Predicted 1000-year pit storage wet change scenario (5% increase in average annual rainfall)

Simulated time series for the water levels in the main pits for the two climate scenarios are presented in Figure 16 and Figure 17.

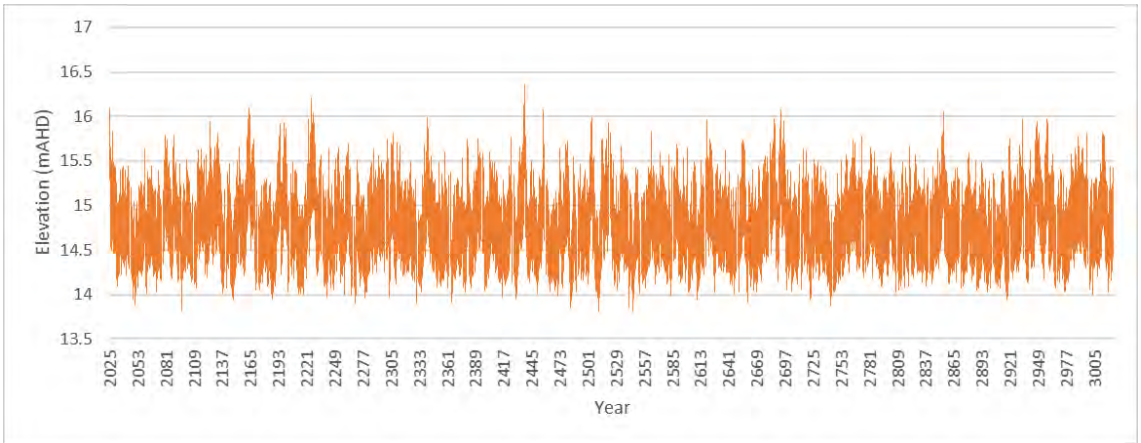

Figure 16. Predicted 1000-year pit water level for dry climate scenario

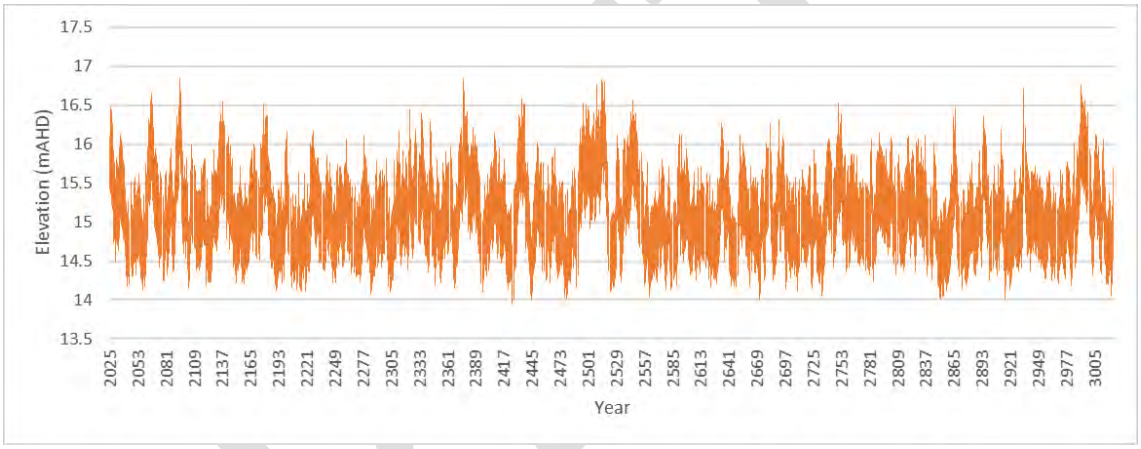

Figure 17. Predicted 1000-year pit water level for wet change scenario (5% increase in average annual rainfall)

The maximum storage capacity of 3588 ML and maximum water level of 22m are not exceeded at any point during the simulation, indicating that there is no risk of spills if the proposed mitigation measures are implemented. The predicted freeboard for the pit ranges from 5.1m to 8.0m for the dry climate condition, and 5.6m to 8.2 m for the wet climate scenario.

C.3 Short-term water balance

C3.1 Model set-up

A short-term water balance model was created using HEC-HMS to provide water balance schematics for the post-closure mine site water management. The HEC-HMS model was developed in accordance with the post-closure surface setting described above. The model layout is presented in Figure 18 below.

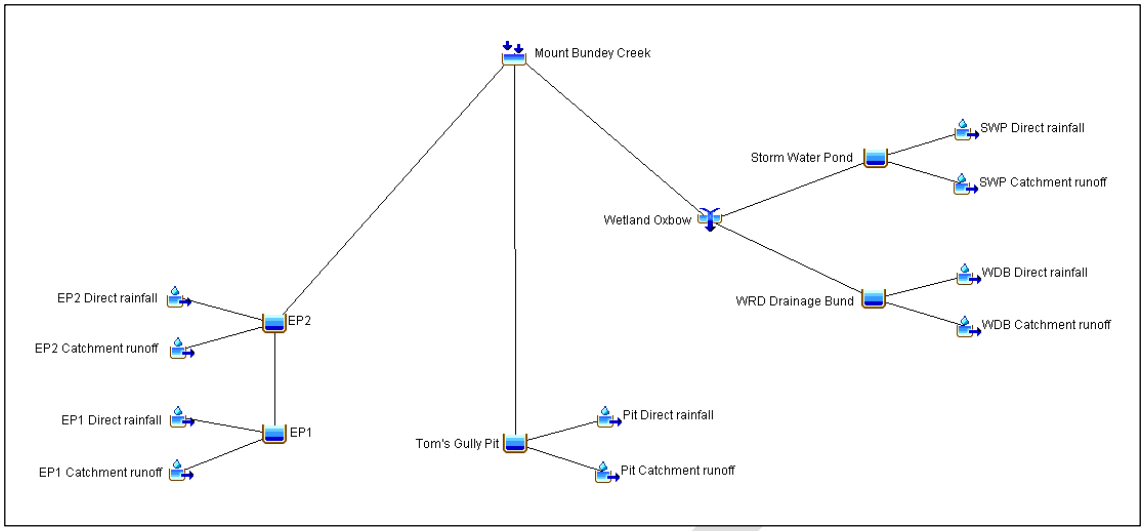

Figure 18. Short term water balance model layout

C3.2 Simulation results

The following figures (Figure 19 to Figure 23) show the resulting annual water balance schematics for the post-closure catchments for the period between 2026 to 2030.

DRAFT

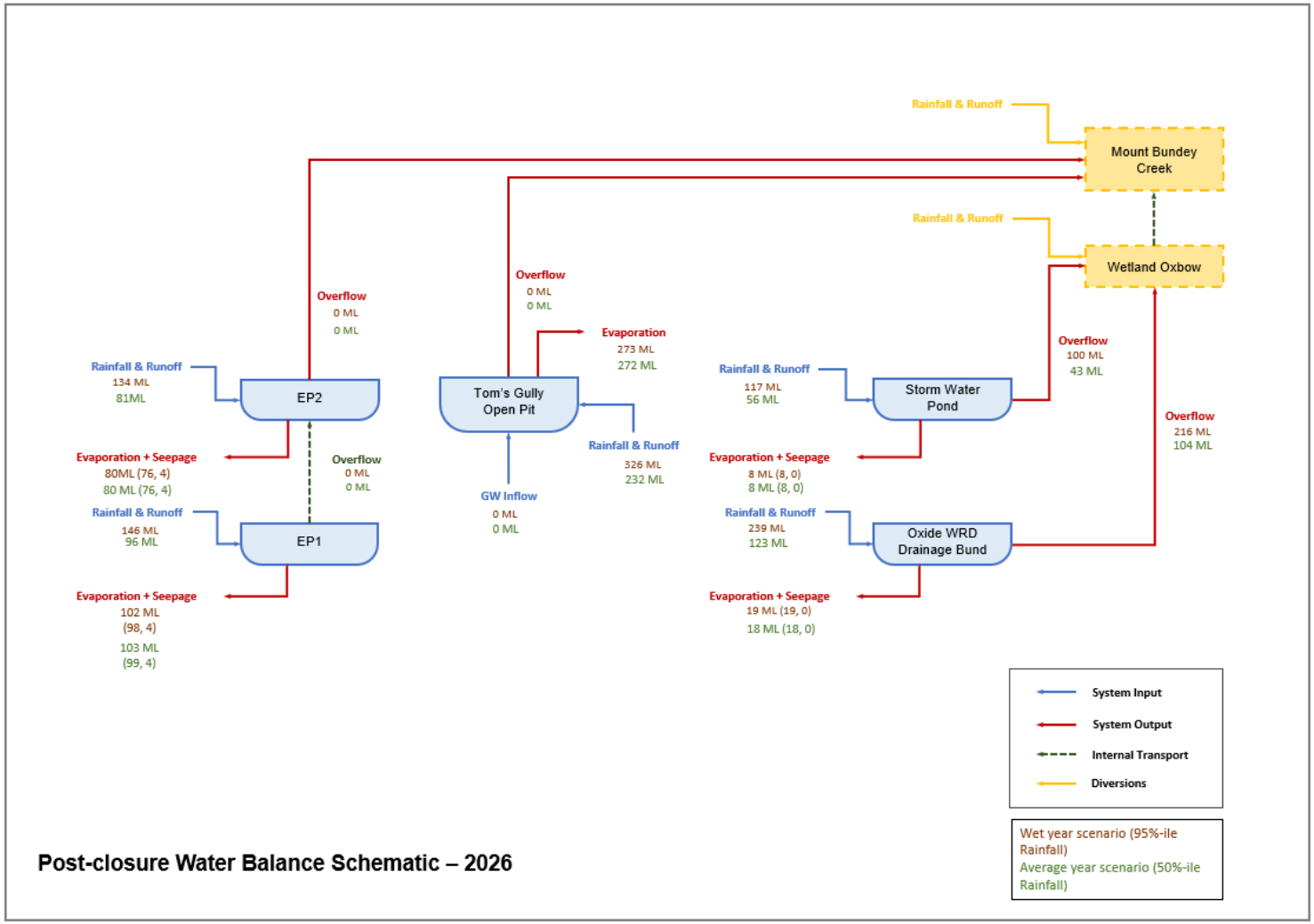

Figure 19. Post Closure Water Balance Schematic for a wet and dry year scenario 2026

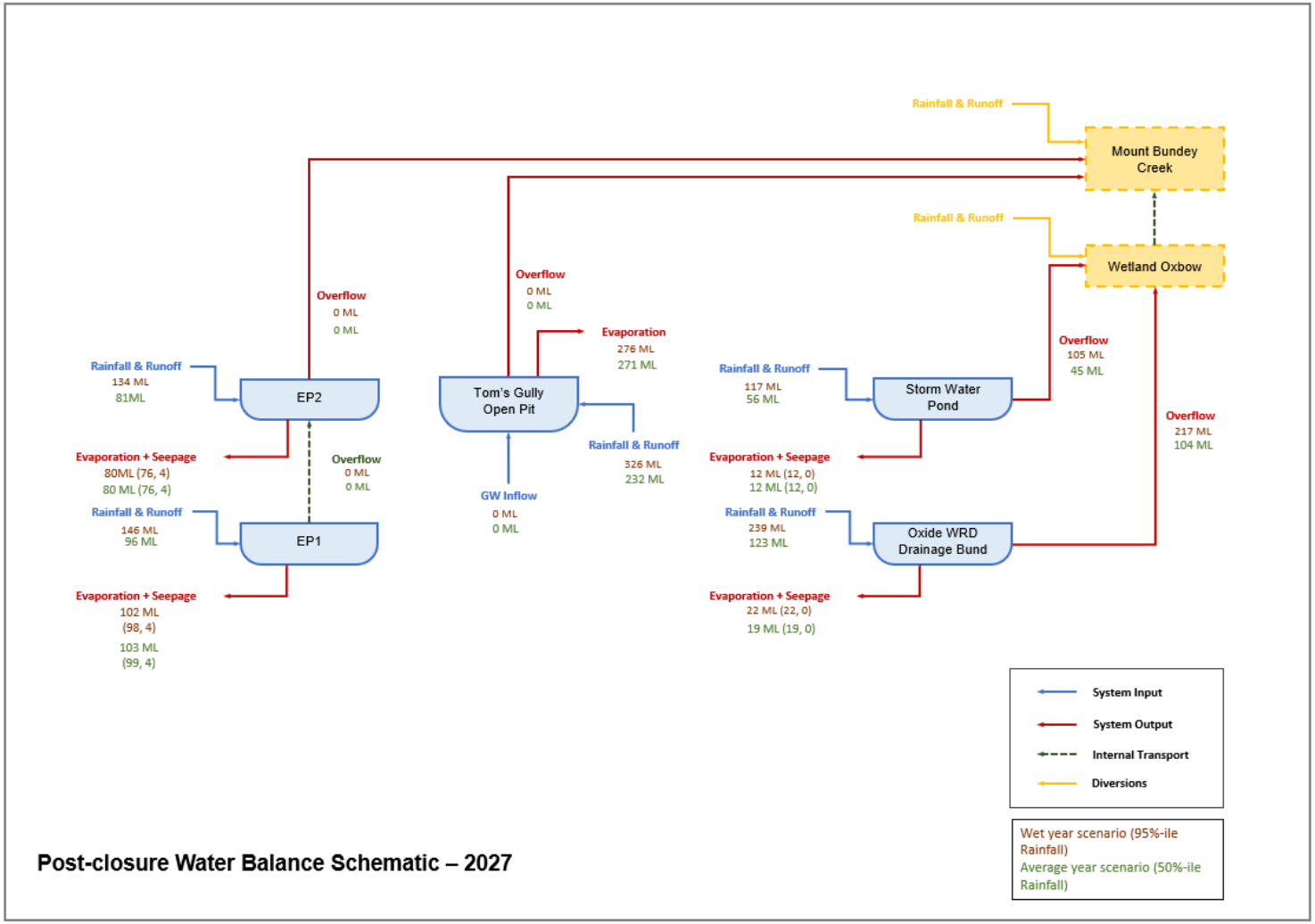

Figure 20. Post Closure Water Balance Schematic for a wet and dry year scenario 2027

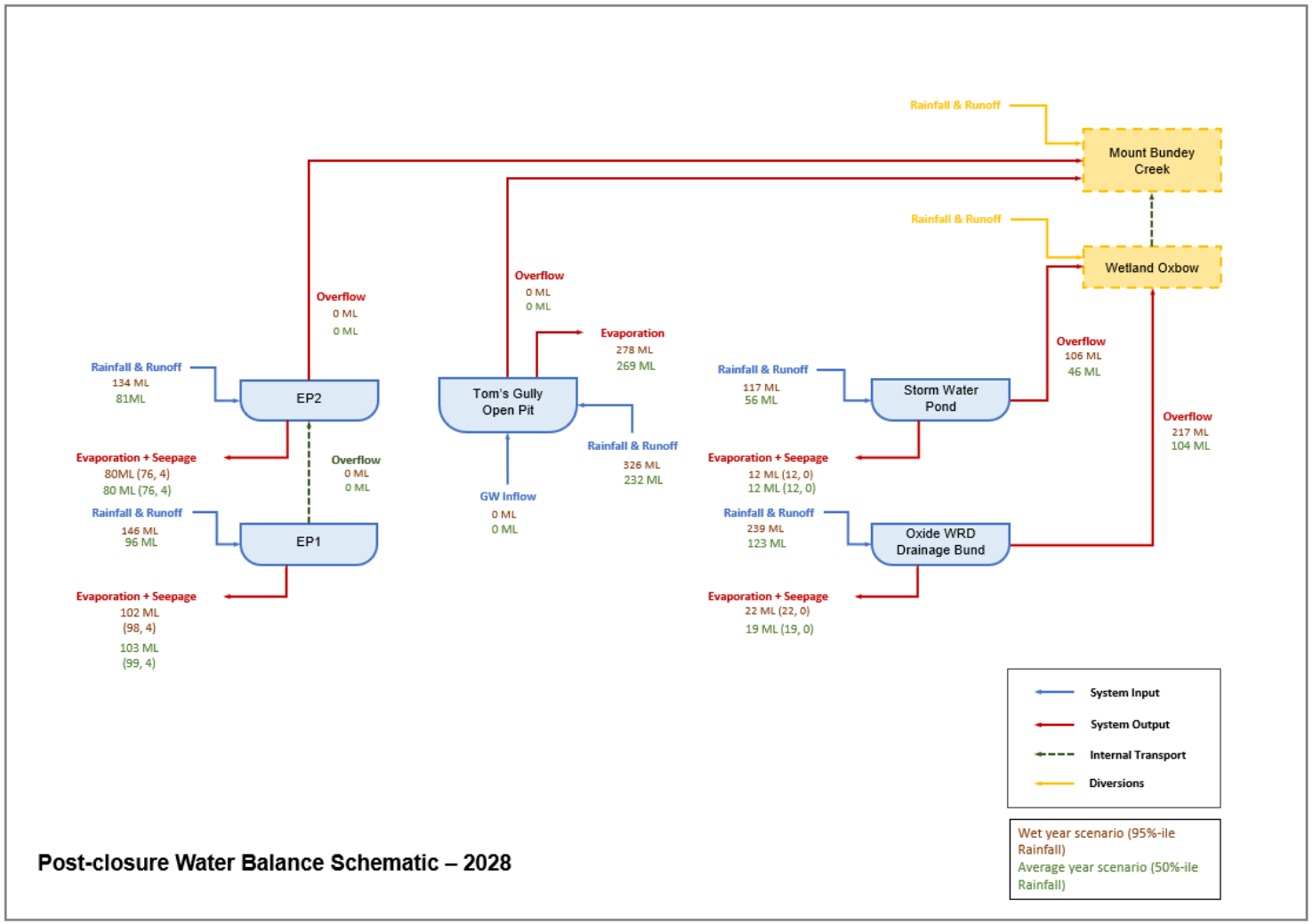

Figure 21. Post Closure Water Balance Schematic for a wet and dry year scenario 2028

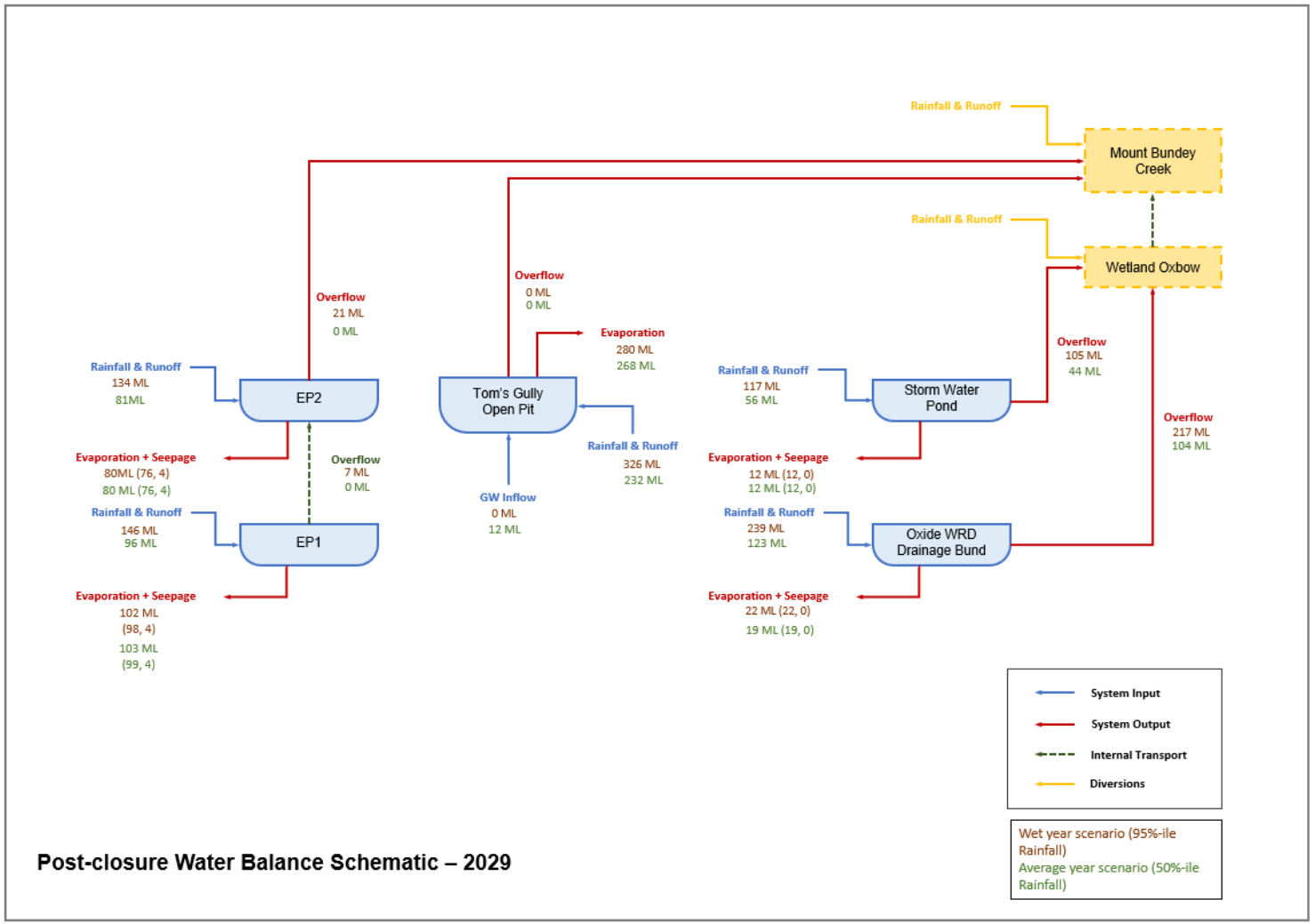

Figure 22. Post Closure Water Balance Schematic for a wet and dry year scenario 2029

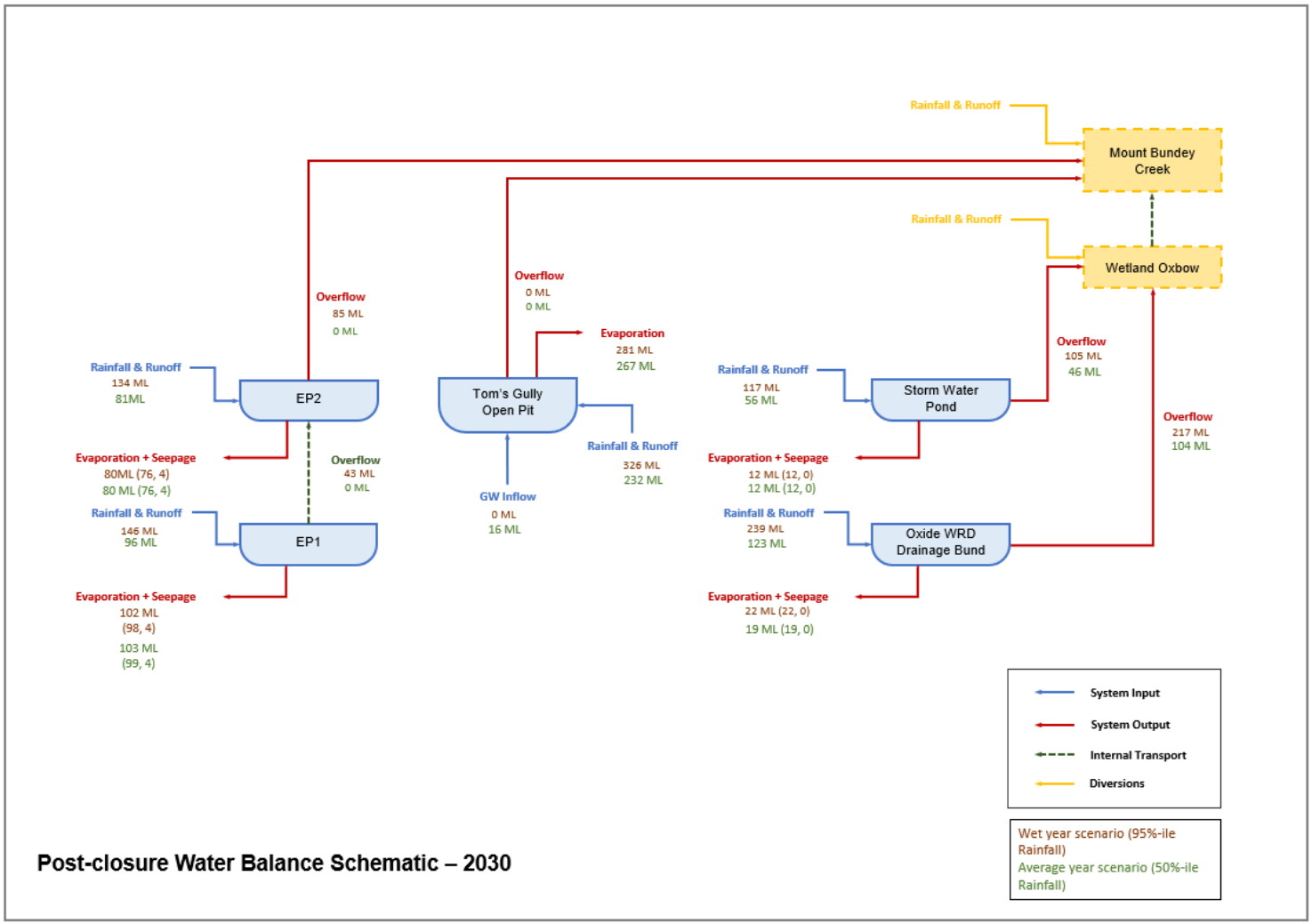

Figure 23. Post Closure Water Balance Schematic for a wet and dry year scenario 2030

Appendix D. Mary River HEC-HMS

The Mary River catchment, (Figure 24; total area of 5821.65 km^2,) was divided into 16 sub-catchments. The model was calibrated against stream flow data from gauging station G8180035 located 7.7 km upstream of the Tom's Gully Catchment southern boundary.

D.1 Input precipitation

Precipitation data was obtained from three rainfall gauging stations: G8180035, G8180069, and G8200052 (Figure 24).

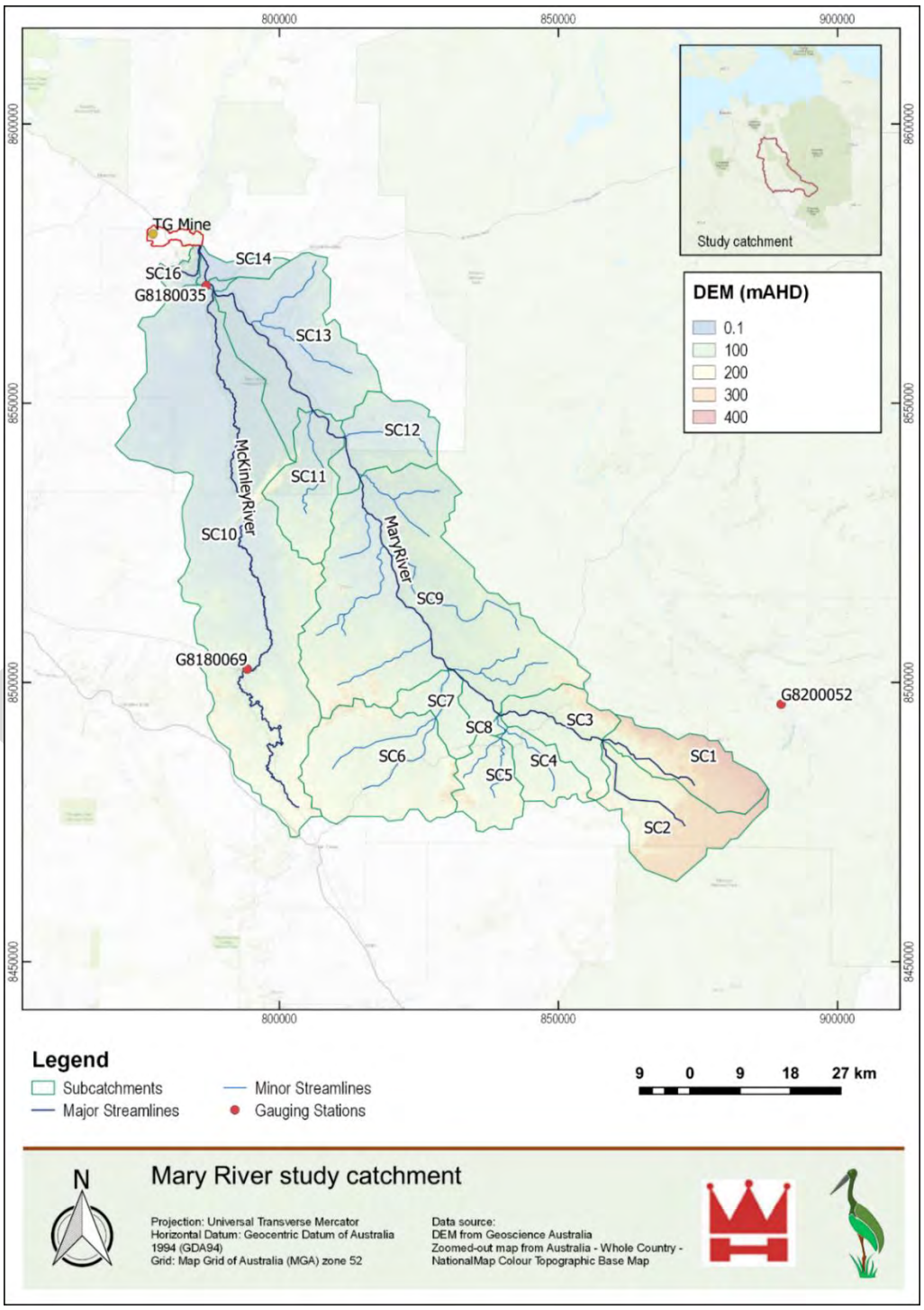

Figure 24. Mary River Catchment Gauging stations

A gauge model was used to transfer the input precipitation time-series data for the three historical calibration and validation events into a meteorological model. The gauge model accounts for the differing influence of each rain gauge in each sub-catchment. The weighted depth of rainfall in each sub-catchment was determined using Voronoi polygons (Table 1). The domain of each gauging station is illustrated in Figure 25.

Table 1.Rain gauge areas and weighted areas

Subcatchment	Rain gauge – Area (km^2)			Rain gauge - Weighted Area		
	G8180035	G8180069	G8200052	G8180035	G8180069	G8200052
1	-	-	237.87	-	-	1.000
2	-	-	320.87	-	-	1.000
3	-	9.62	197.27	-	0.047	0.953
4	-	3.90	120.06	-	0.031	0.969
5	-	133.07	26.60	-	0.833	0.167
6	-	481.72	-	-	1.000	-
7	-	115.35	-	-	1.000	-
8	-	12.69	-	-	1.000	-
9	-	1211.08	117.21	-	0.912	0.088
10	671.02	1062.43	-	0.387	0.613	-
11	79.10	157.83	-	0.334	0.666	-
12	176.43	44.16	-	0.800	0.200	-
13	544.10	-	-	1.000	-	-
14	55.02	-	-	1.000	-	-
15	7.32	-	-	1.000	-	-
16	37.14	-	-	1.000	-	-

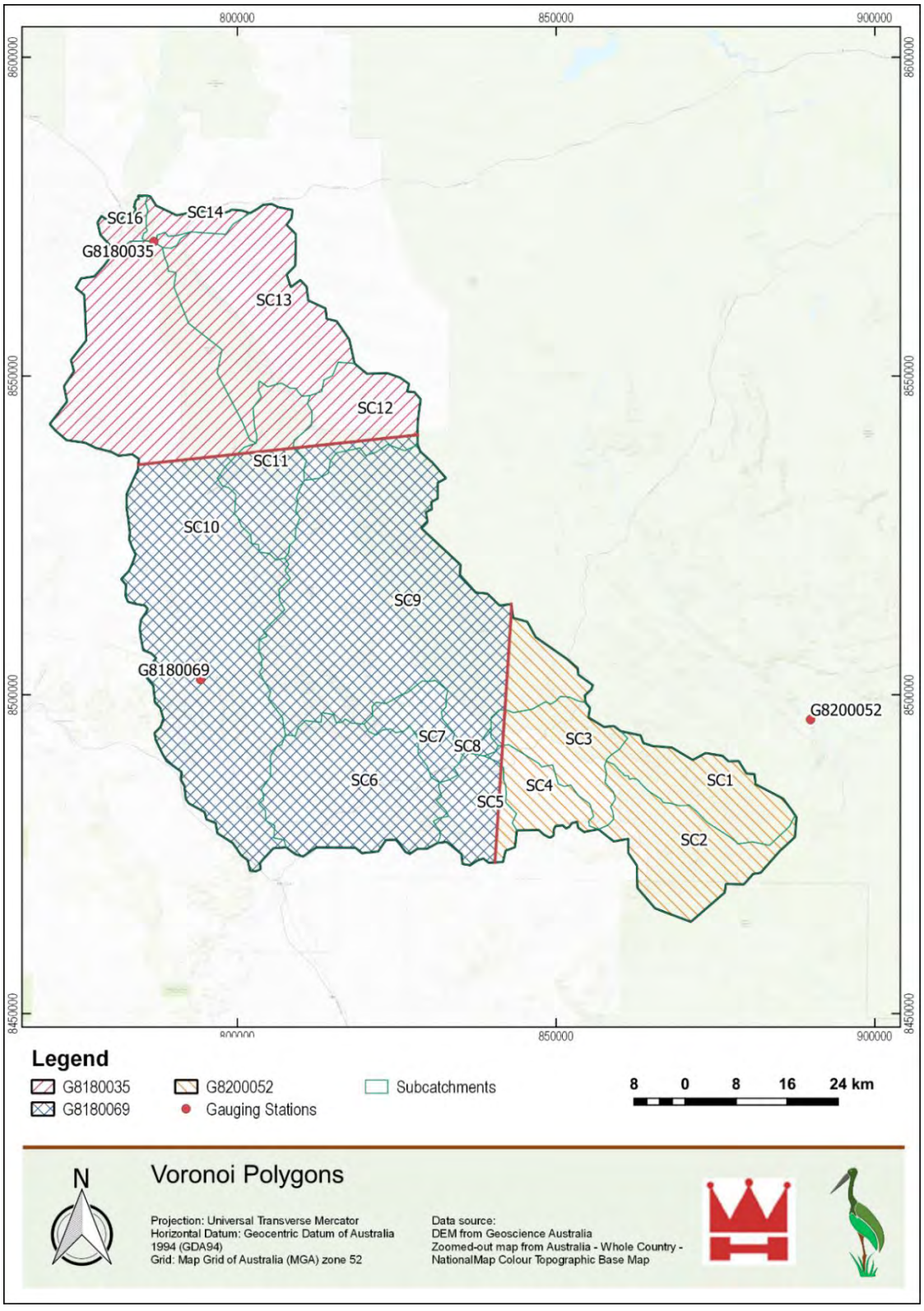

Figure 25. Voronoi polygons determining the influence of each gauging station within the Mary River catchment

D.2 Catchment Parameters

Table 2 lists all relevant physical properties of the Mary River sub-reaches and their Transform method lag time parameters, while Table 3 lists the Routing method parameters.

Table 2. Physical properties and Transform method parameters of the Mary River sub-catchments

Subcatch-ment	Area km²	Longest reach within the catchment		Evapo-transpiration (mm/day)	Transform method	
		Length (km)	Slope (m/km)		Time of Conc (hr)	Storage Coefficient (hr)
1	237.87	20.41	6.89	8.0	8.03	12.04
2	320.87	24.89	4.49	8.0	10.35	15.52
3	206.89	21.77	1.64	8.0	11.57	17.36
4	123.96	16.35	2.32	8.0	8.53	12.79
5	159.67	13.70	4.18	8.0	6.20	9.29
6	481.72	21.73	2.58	8.0	9.69	14.54
7	115.35	10.40	1.74	8.0	5.79	8.69
8	12.69	4.00	1.80	8.0	2.76	4.14
9	1328.11	56.02	1.04	8.0	27.10	40.65
10	1733.45	136.93	1.19	8.0	62.68	94.03
11	236.91	22.88	2.99	8.0	10.64	15.96
12	220.59	18.58	2.02	8.0	9.41	14.12
13	544.10	32.19	0.42	8.0	20.44	30.66
14	55.02	7.40	0.41	8.0	5.91	8.87
15	7.32	1.96	0.84	8.0	1.66	2.50
16	37.14	12.49	3.01	8.0	6.98	10.47

Table 3. Physical properties and Routing method lag time parameters of the Mary River sub-reaches

Reach		Catchment	Lag Time (min)
Number	Stream Name		
1	Mary River	3	2176.94
2	O'Neill Ck	4	137.95
3	Bowerbird Ck	8	400.39
4	Mary River	9	1343.71
5	-	7	1040.21
6	Mary River	9	4259.19
7	Mary River	12	747.02
8	Mary River	11	896.10
9	Mary River	13	3219.90
10	Mary River	15	196.24
11	Mary River	14	740.55

D.3 Design Flood Events

The calibrated hydrology model was used to determine the 1%AEP and 0.1%AEP discharge at the inlet to the water quality model, using hyetographs obtained from RORBwin modelling. To account for low infiltration, IL was conservatively set to 5mm and in-channel losses to zero.

The inflow into the Tom's Gully Mine catchment consists of the Mary River and a small left-bank anabranch in sub-catchment 16. The discharge was determined separately for both outlets.

D.4 Calibration and validation details

The HEC-HMS model was calibrated against a hydrograph recorded at G8180035 for a historical rainfall event, then validated against two other historical events:

- **Calibration Run:** 8 November 1995 00:00 to 24 November 1995 00:00
- **Validation Run 1:** 07 November 1989 12:00 to 02 December 1989 13:00
- **Validation Run 2:** 15 January 1986 to 30 January 1986 00:00

The calibration and validation rainfall events were selected based on the completeness of the data available. Details of model calibration are provided in Appendix D.

The fitted parameter values are listed in Table 4. The loss and base flow parameters were used throughout the entire catchment.

Table 4. Calibrated parameter values

Loss model parameter			Base flow model parameter			Routing loss model parameter	
IL (mm)	CL ($mmhr^{-1}$)	Impervious (%)	Initial discharge (m^3s^{-1})	Recession constant	Ratio to peak	Loss (m^3s^{-1})	Fraction
200	2.6	3.0	0.00	0.60	0.05	0.8	0.25

There was a close correlation between the predicted discharges and the observed hydrographs for all three rainfall events, particularly in the match between observed and predicted data for total volume and peak discharge. Although there was a minor under-prediction of the lag time for Calibration Run 1 and Validation Run 1 and a slightly higher over-prediction for Validation Run 2, and the predicted discharge curves also exhibited greater peakiness compared to the historical data, these differences were not deemed significant.

The model parameters were the same for all runs, except for IL and Routing Loss in validation run 2 which was set to 85mm and 0mm respectively, to account for a difference in soil moisture (event occurred later in the wet season when moisture content would be higher due to previous rainfall). Table 5 shows the input parameter values for the two validation runs.

Table 5. Validated parameter values

Validation run	Loss model parameter			Base flow model parameter			Routing loss model parameter	
	IL (mm)	CL ($mmhr^{-1}$)	Impervious (%)	Initial discharge (m^3s^{-1})	Recession constant	Ratio to peak	Loss (m3/s)	Fraction
1	200	2.6	3.0	0.00	0.60	0.05	0.8	0.25
2	85	2.6	3	0	0.6	0.05	0	0

Figure 26 to Figure 28 show the fitted and observed hydrographs for the calibration and two validation events.

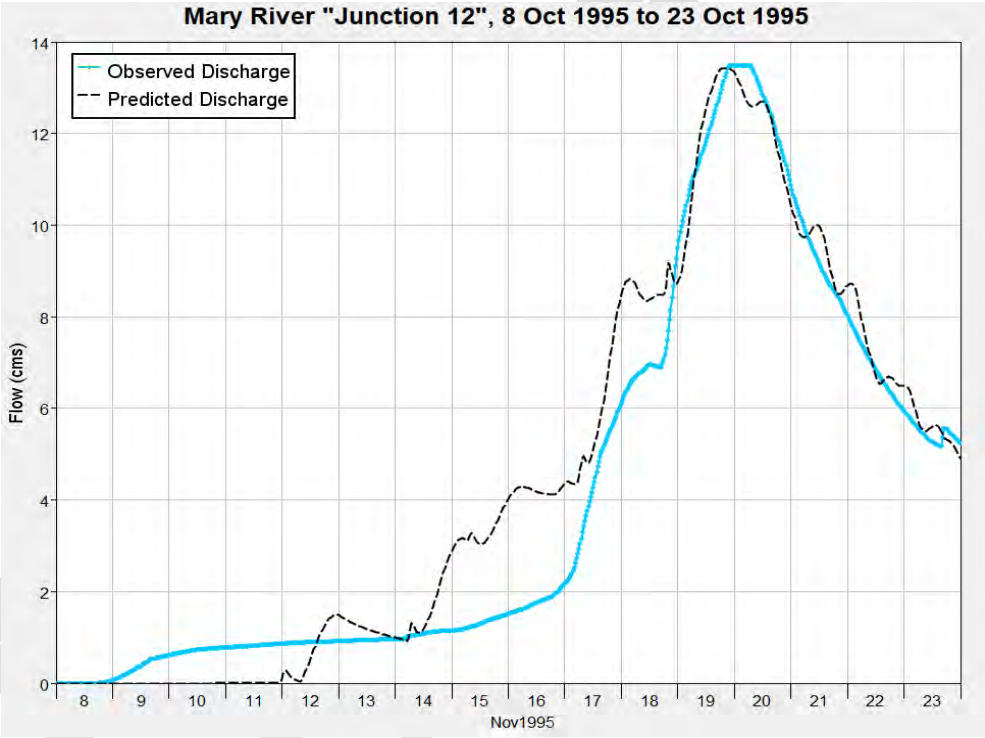

Figure 26. Fitted and observed hydrographs for the Calibration Run

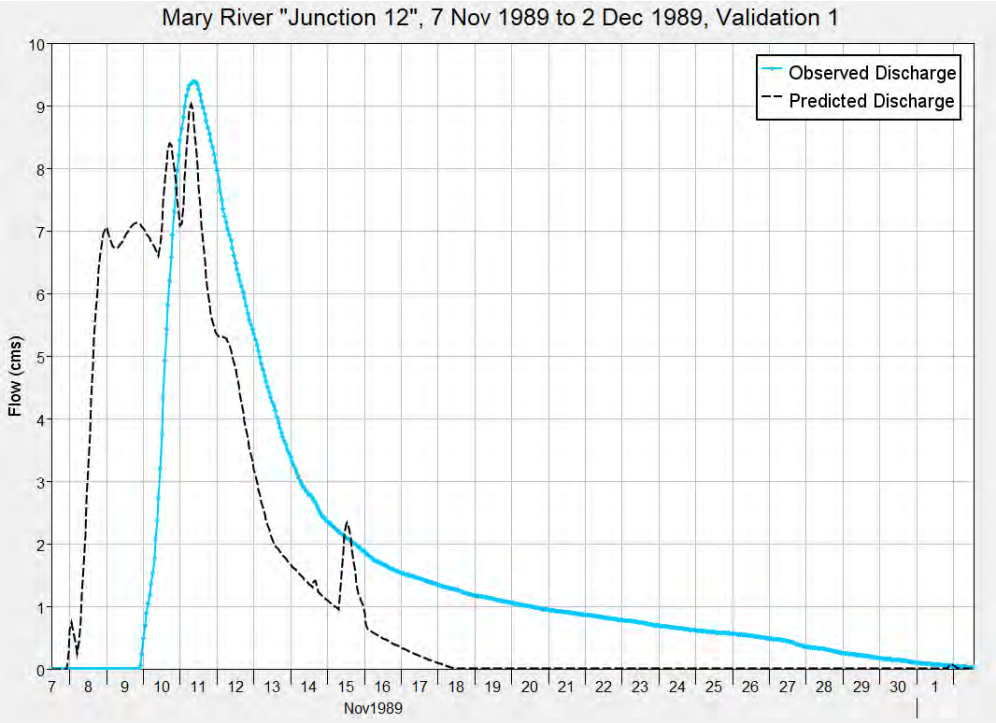

Figure 27. Fitted and observed hydrographs for Validation Run 1

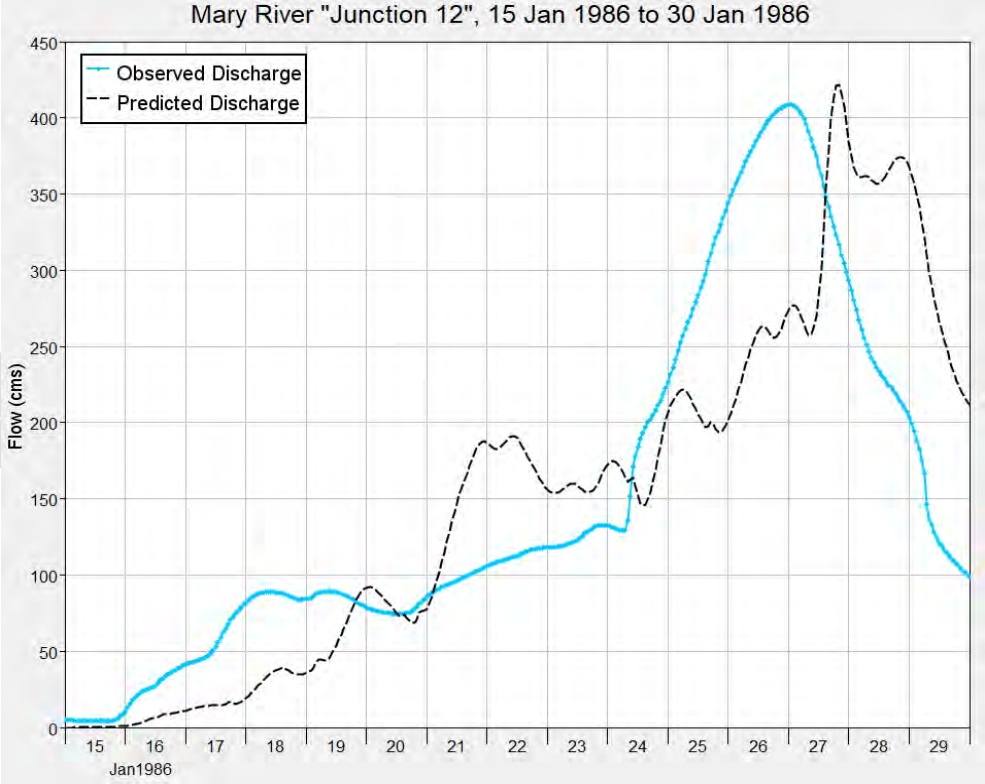

Figure 28. Fitted and observed hydrographs for Validation Run 2

D.5 Output hydrographs

The resulting hydrographs for the 1%AEP and 0.1%AEP design storms are provided in the figures below.

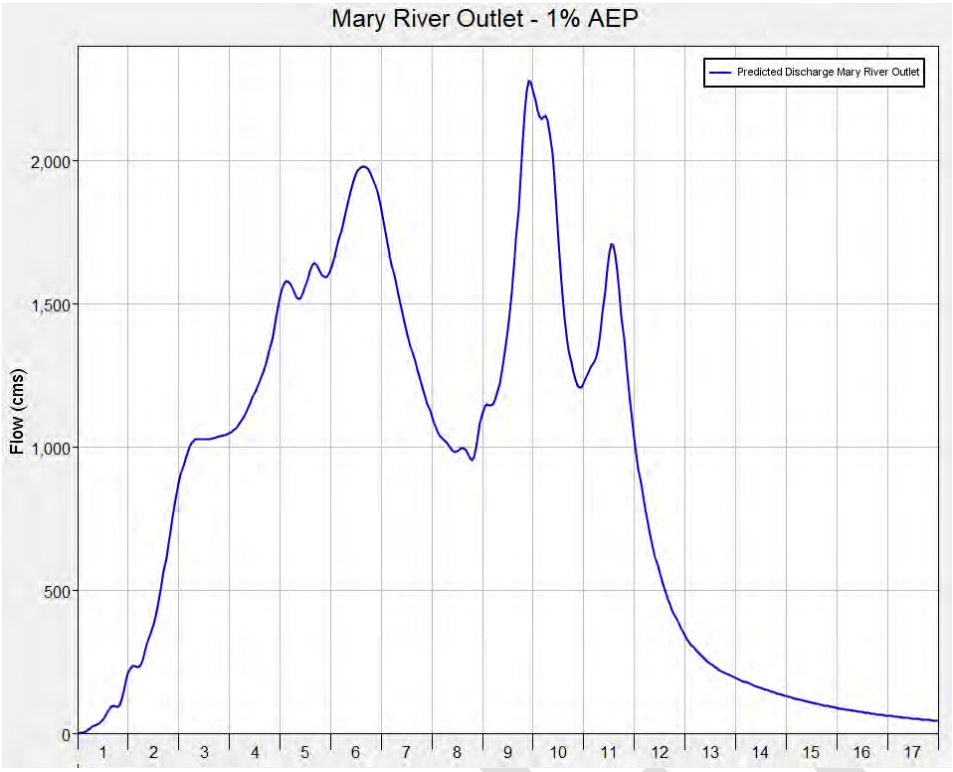

Figure 29. Hydrograph at the Mary River Outlet for a 1%AEP

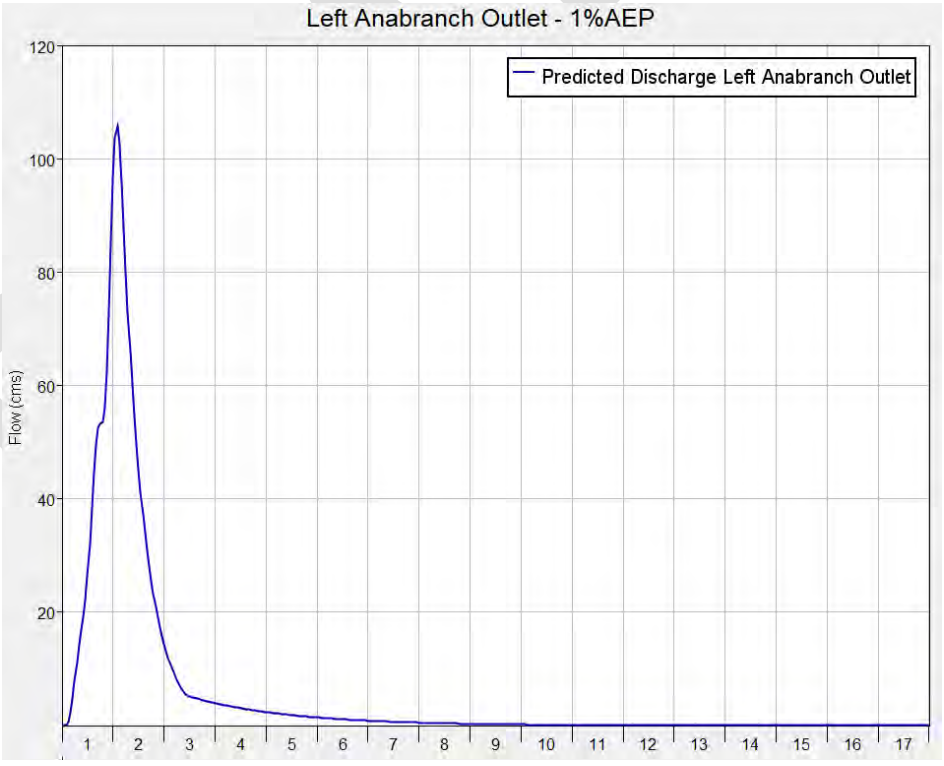

Figure 30. Hydrograph at the Left Anabranch Outlet for a 1%AEP

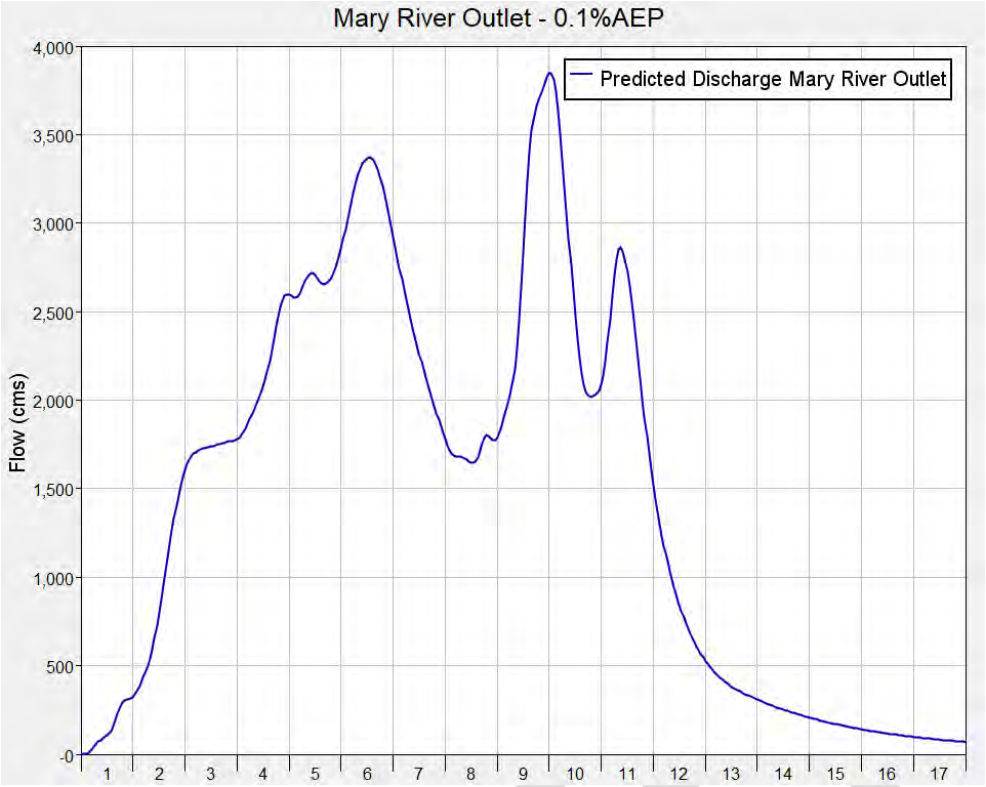

Figure 31. Hydrograph at the Mary River Outlet for a 0.1%AEP

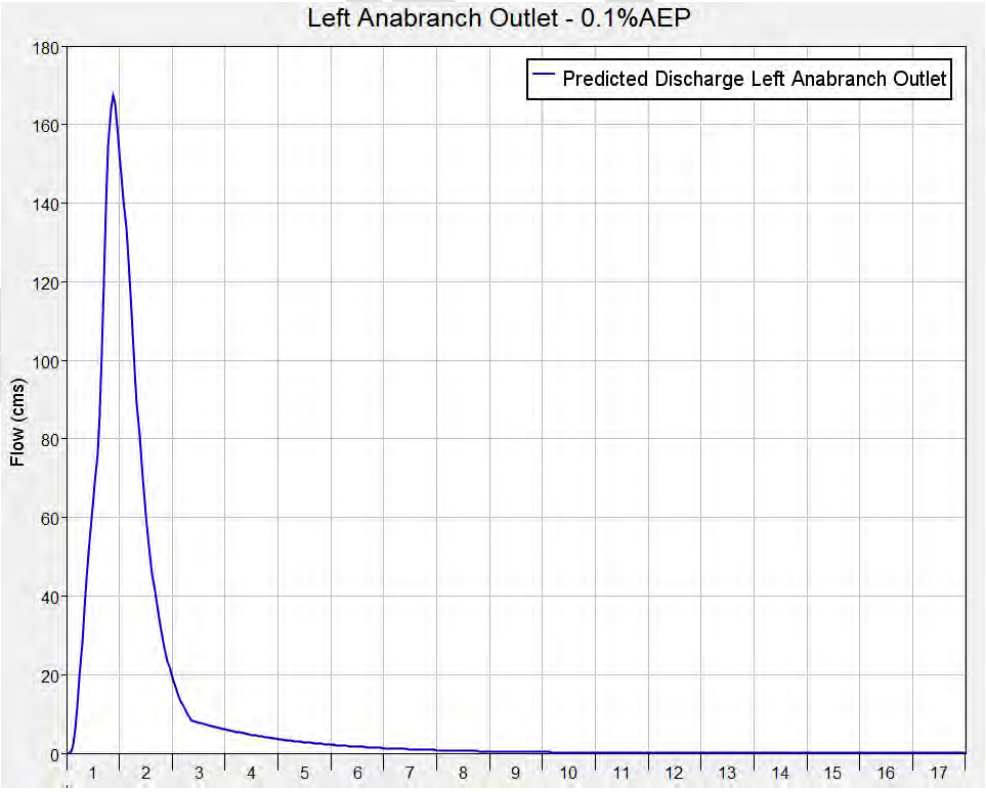

Figure 32. Hydrograph at the Left Anabranch Outlet for a 0.1%AEP

Appendix E. RMA Modelling

Hypothetical water releases from the Pit were simulated for a 1%AEP event and 0.1%AEP event to assess if the site would be non-polluting during an uncontrolled release post-closure. For the simulations it was assumed that the Pit was full at the time of release. The constituent levels in the hypothetical pit release are given in Table 6 below. The results are provided in Sections E.1 to E.19. Results were compared to ANZECC 80% trigger values (ATV) and site specific trigger values (SSTV) (Table 5-2, GHD 2015), or, where no trigger values were available, to median and maximum observed existing values (MedOEV and MaxOEV) previously measured at SWTG2 monitoring location (Table 7-3, GHD 2015).

Constituent dispersal was modelled for the 1%AEP hypothetical worst-case scenario where the pit was assumed to be overflowing at the time of the event. A 0.1%AEP event was also simulated for some of the constituents to assess what would happen in the very unlikely case that an event like this occurs when the pit is at the point of overflowing.

This was not carried out for all constituents, as the results of preliminary modelling showed that the concentrations were generally lower in all cases for the 0.1%AEP event, with the exception of some constituents where the higher concentrations were related to other upstream inputs, rather than the mine pit overflow itself.

Table 6. Pit Overflow Inlet Concentrations

Constituent	TGM – Pit
Aluminium-Dissolved (mg/L)	14
Arsenic-Dissolved (mg/L)	0.005
Bicarbonate HCO3 as CaCO3 (mg/L)	<5
Carbonate CO32- as CaCO3 (mg/L)	<5
Cadmium-Dissolved (mg/L)	0.43
Calcium – Dissolved (mg/L)	126
Chloride (mg/L)	3.4
Chromium-Dissolved (mg/L)	0.4
Cobalt-Dissolved (mg/L)	0.56
Copper-Dissolved (mg/L)	0.53
Electrical Conductivity (µS/cm)	1,320
Hardness as CaCO3 (mg/L)	720
Hydroxide OH- as CaCO3 (mg/L)	<5

Ionic Balance (%)	-6.1
Iron-Dissolved (mg/L)	1.42
Lead-Dissolved (mg/L)	0.4
Magnesium – Dissolved (mg/L)	96
Manganese-Dissolved (mg/L)	7.6
Nickel-Dissolved (mg/L)	1.12
pH	7.9
Potassium – Dissolved (mg/L)	5.2
Total Suspended Solids (mg/L)	7
Sodium – Dissolved (mg/L)	13.6
Sulphate (mg/L)	780
Turbidity (NTU)	0.7
Total Alkalinity as CaCO3 (mg/L)	<5
Uranium-Dissolved (mg/L)	0.42
Zinc-Dissolved (mg/L)	4.48

Time series plots for the constituents and water quality contour maps were used to assess dispersion. The recession component of the time series graphs, for some constituents, under low flow conditions are indicated with a dotted line, as there is a possibility that the model cannot simulate the recession conditions as well as higher flow conditions.

E.1. pH

E.1.1. Time Series

Maximum pH occurs at Day 3, 04:15hrs for the 1%AEP event at SWTG3 (7.24), and at Day 6, 19:15hrs at SWTG2 (7.35) for the 0.1%AEP event. Minimum pH occurs at day 6, 9:00 at Mary River Outlet (6.81) for the 1%AEP event and at day 2, 11:00 at Mt Bundey Ck outlet (6.78) for the 0.1%AEP. pH lies within the maximum and minimum trigger values during the whole simulation period at all the locations for both the 1%AEP and 0.1%AEP event.

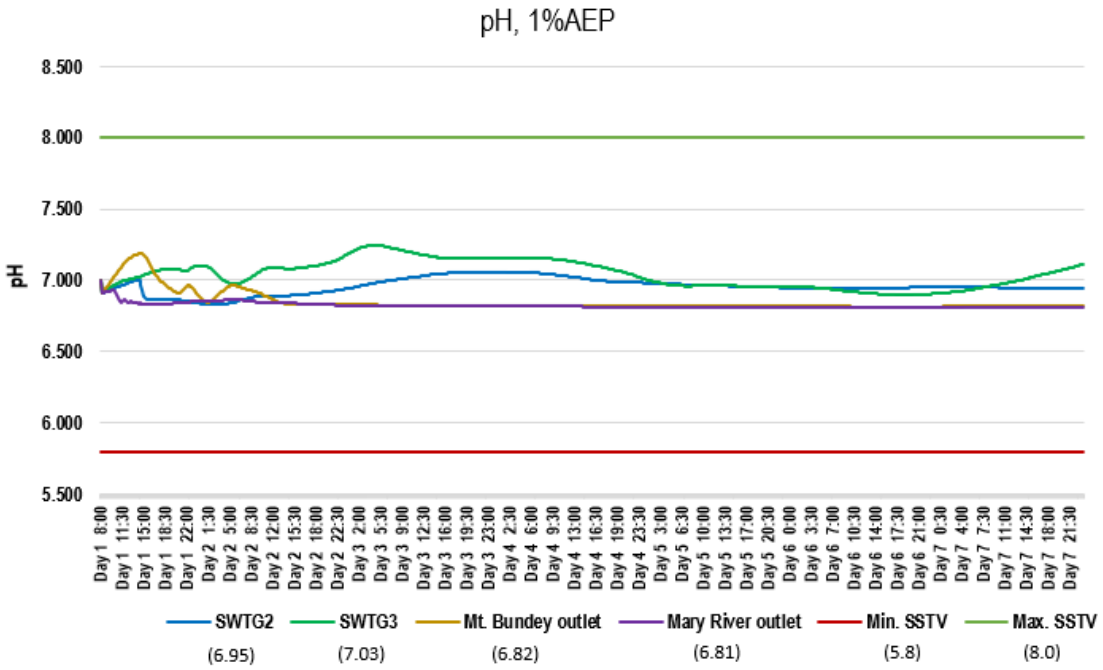

Figure 33. 1%AEP time series for pH plume (median values noted in legend)

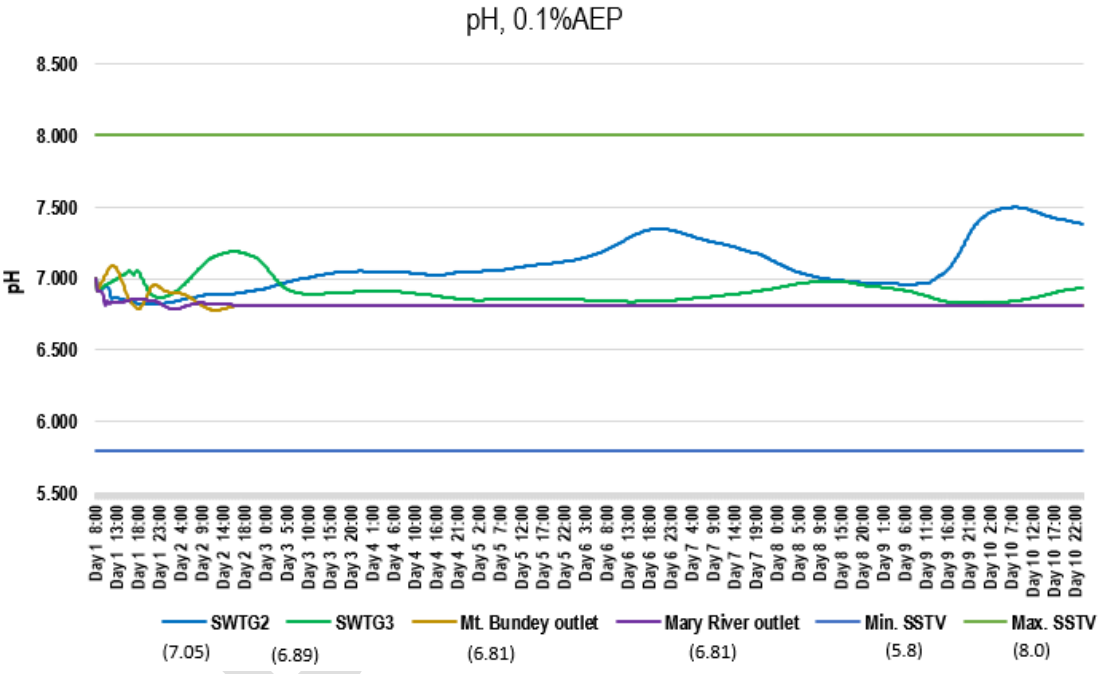

Figure 34. 0.1%AEP time series for pH plume (median values noted in legend)

E.1.2. Contour plot at peak concentration at SWTG2

At the time of peak concentration at SWTG2, the pH remains within the upper and lower TV everywhere within the entire model domain for the 1%AEP and 0.1%AEP event.

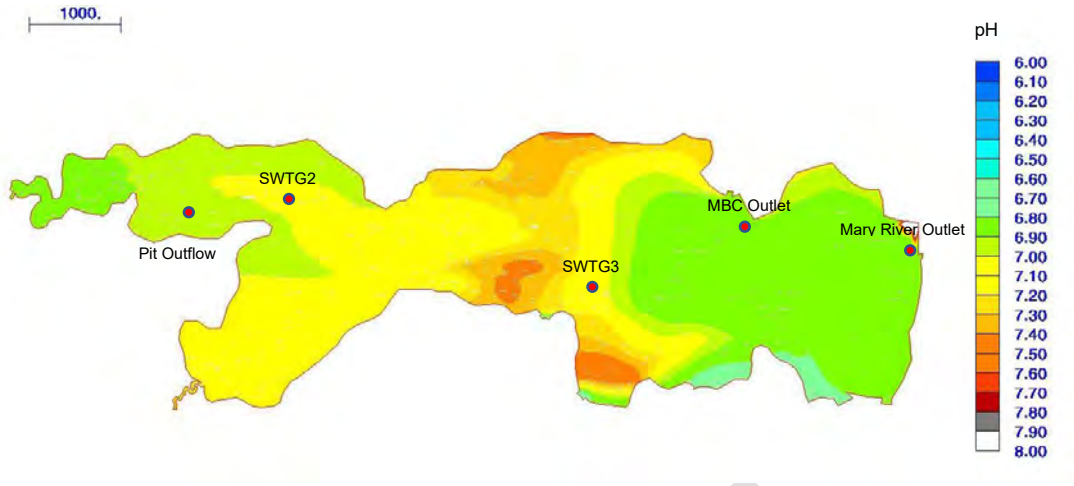

Figure 35. Contour plot pH at peak concentration at SWTG2, 1%AEP, Day 4 05:30

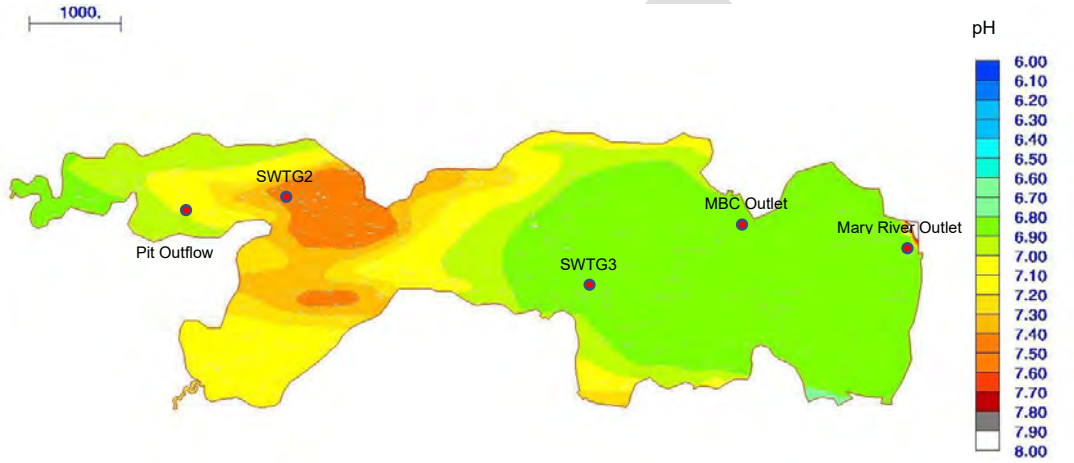

Figure 36. Contour plot pH at peak concentration at SWTG2, 0.1%AEP, Day 10 08:15

E.2. Electrical Conductivity

E.2.1. Time Series

Electrical conductivity (EC) stayed well within the TV limits for the 0.1%AEP and the 0.1%AEP.

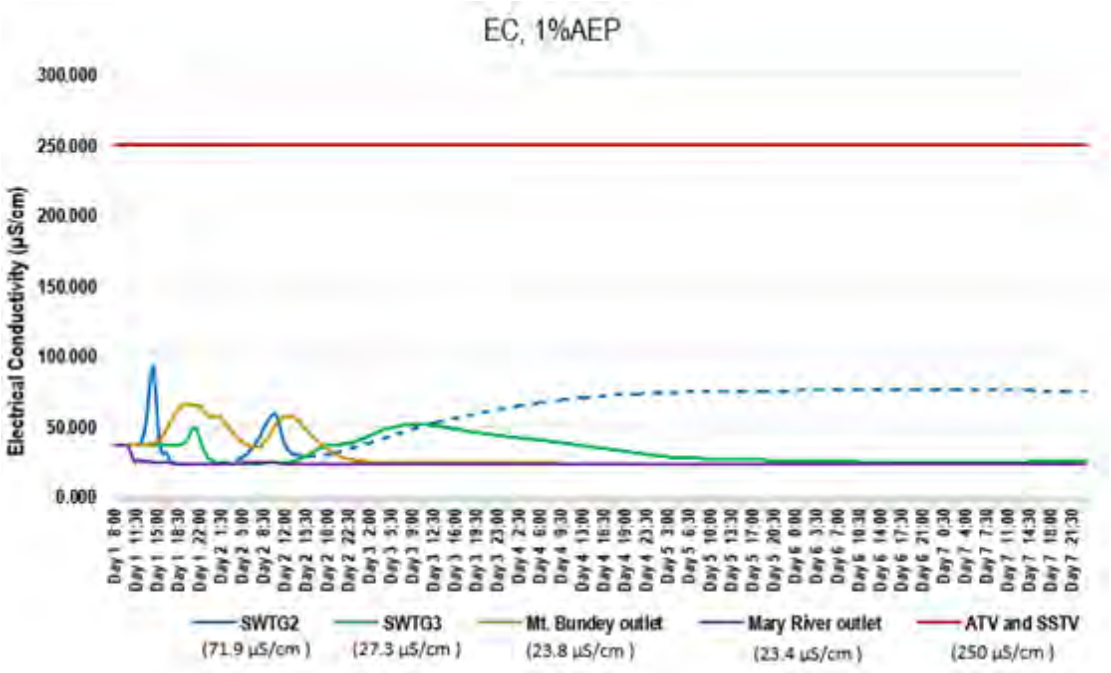

Figure 37. 1%AEP time series for Electrical Conductivity. The dashed blue line indicates uncertainty in this part of the time series.

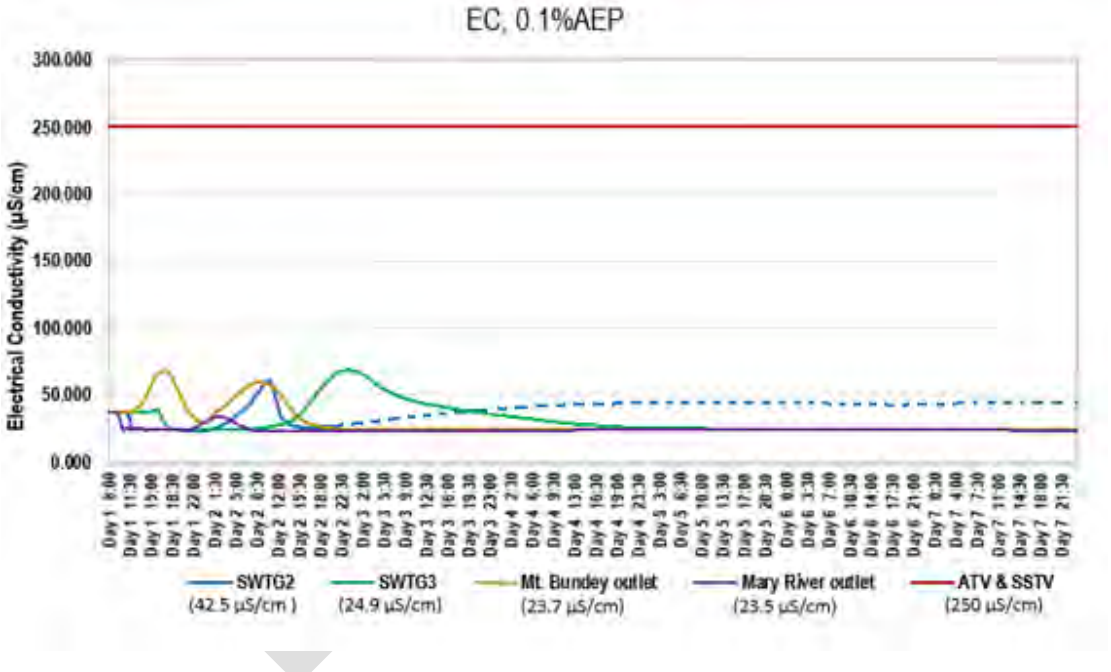

Figure 38. 0.1%AEP time series for Electrical Conductivity. The dashed blue line indicates uncertainty in this part of the time series.

E.2.2 Contour plot at peak concentration at SWTG2

TV are not exceeded at any location for the 1%AEP event at the time of peak concentration at SWTG2, however, a temporary exceedance occurs during the 0.1%AEP exceedance just south of Arnhem Highway Bridge (SWTG2) at that time.

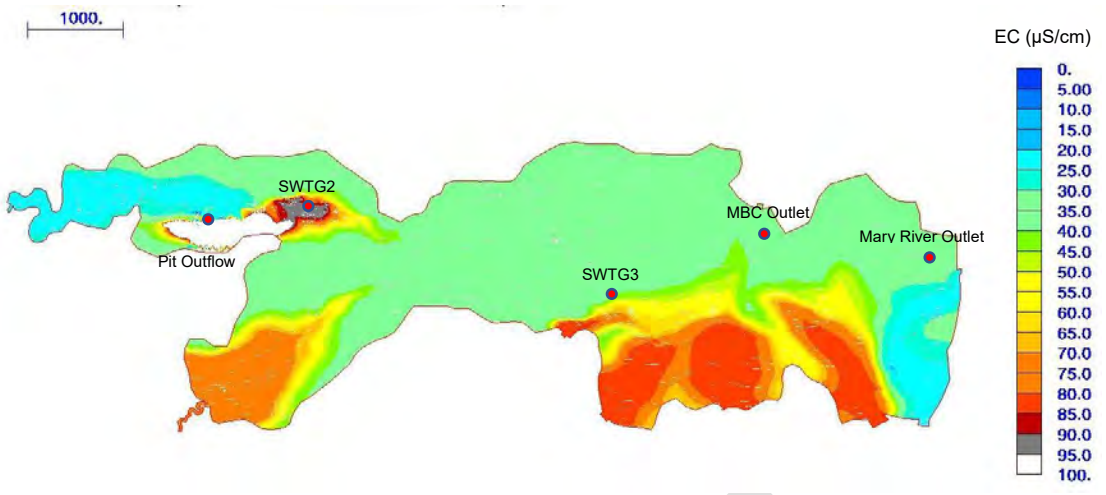

Figure 39. Contour plot EC at peak concentration at SWTG2, 1%AEP, Day 1, 14:15

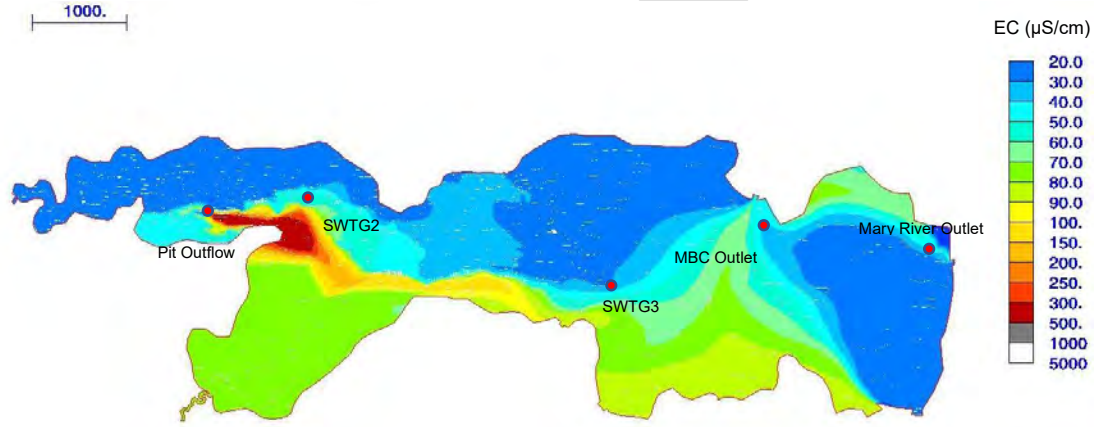

Figure 40. Contour plot EC at peak concentration at SWTG2, 0.1%AEP, Day 2, 10:30

E.3. Calcium

E.3.1. Time Series

Dissolved Calcium concentrations peak at Day 1, 14:15 for the 1%AEP event (6.84 mg/L) at SWTG2, and at Day 2, 22:45 at SWTG3 for the 0.1%AEP event (5.02 mg/L).

Calcium exceeds MedOEV (3.4 mg/L) at SWTG2 with a value of 4.99 mg/L for the 1%AEP event, but stays below MedOEV at all of the other locations. The median value at SWTG2 during the storm event (day 1 8:00 to day 2 15:30) lies well below the MedOEV with 1.3 mg/L. This indicates that the median concentration exceedance at SWTG2 is primarily due to the concentration stabilising to a very high value after Day 3, which is caused by low flows occurring approximately after Day 2, making it difficult for the contaminant to be transported. The model also has difficulty handling low flow conditions. It is expected that the contaminant will be flushed during the next rainfall creek flow event.

During the 0.1%AEP event peak concentrations spike higher than the MedOEV at SWTG2, STWG3 and MT Bundey Ck Outlet, but median values stay below MaxOEV at all three locations.

MaxOEV are not exceeded at any point during the simulation period for both events.

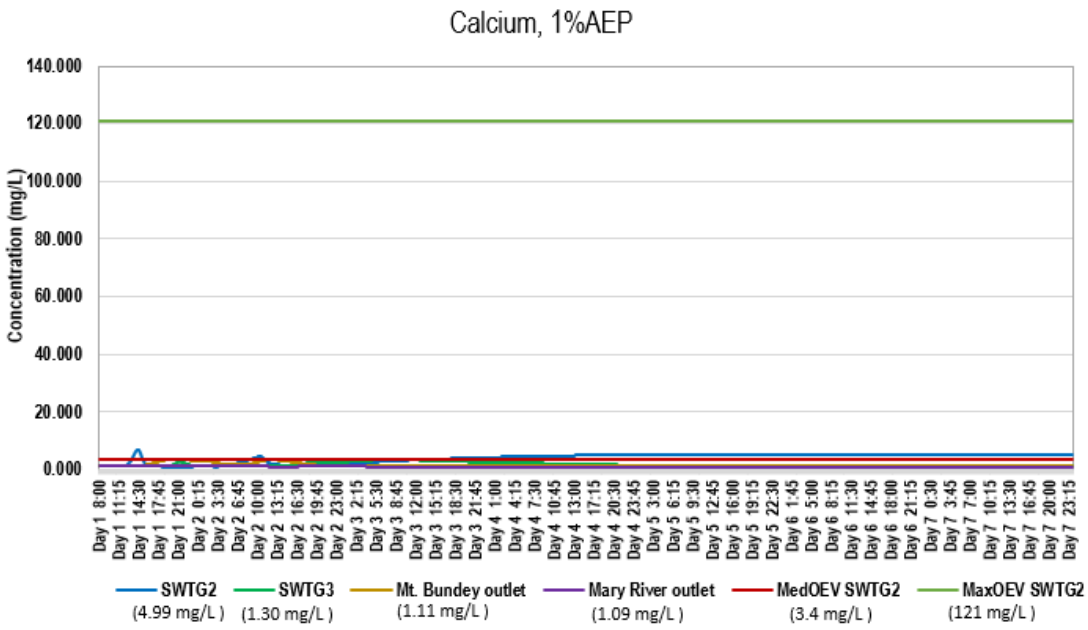

Figure 41. 1%AEP time series for Calcium plume with MaxOEV (median values noted in legend)

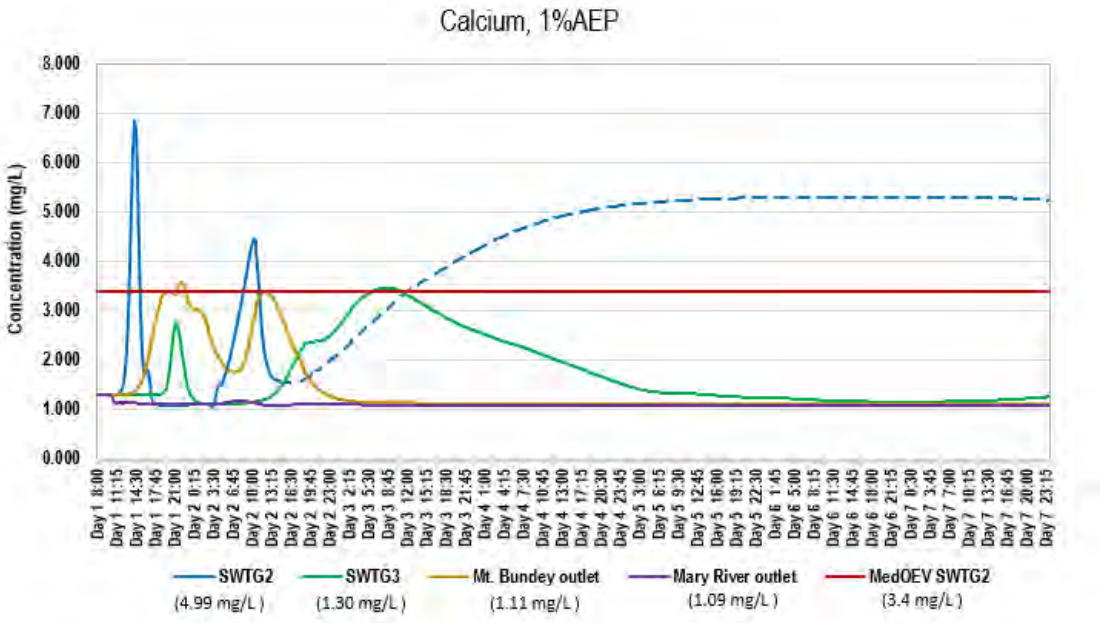

Figure 42. 1%AEP time series for Calcium plume without MaxOEV (median values noted in legend). The dashed blue line indicates uncertainty in this part of the time series.

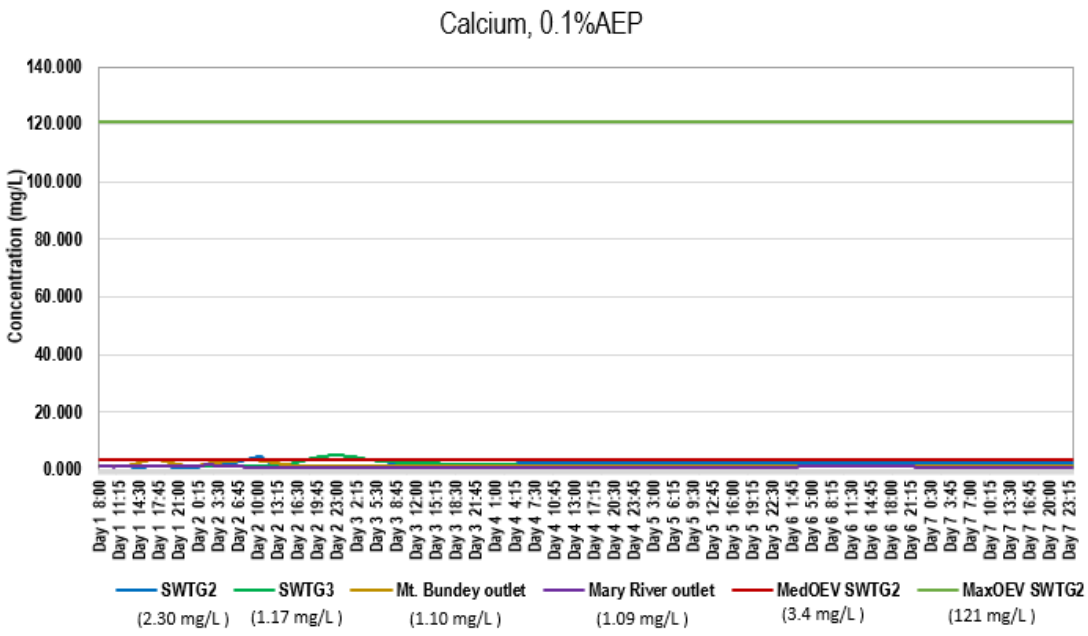

Figure 43. 0.1%AEP time series for Calcium plume with MaxOEV (median values noted in legend)

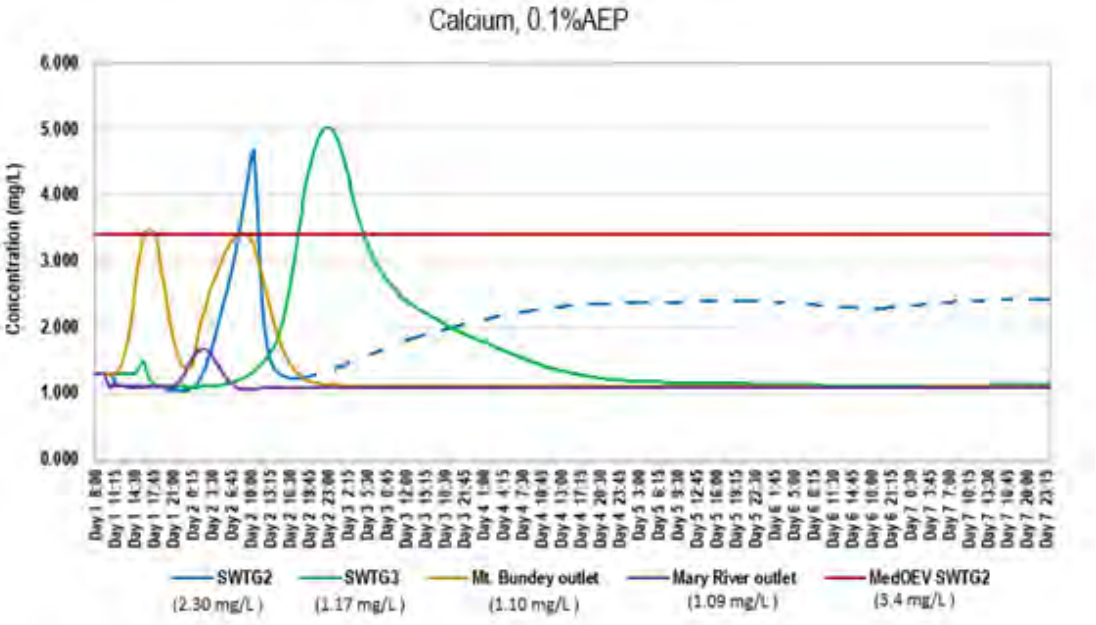

Figure 44. 0.1%AEP time series for Calcium plume without MaxOEV (median values noted in legend). The dashed blue line indicates uncertainty in this part of the time series.

E.3.2 Contour plot at peak concentration at SWTG2

At the time of maximum concentration at SWTG2, there is a temporary exceedance of the MaxOEV within the immediate vicinity of the pit for the 1%AEP event. MedOEV are temporarily exceeded around the pit and SWTG2 and along the upstream inputs US_02 to US_06 at that time.

During the 0.1%AEP event at the time of peak concentration at SWTG2, temporary exceedances of the MedOEV can be observed across large portions of the model domain. No exceedance of the MaxOEV was registered at that time.

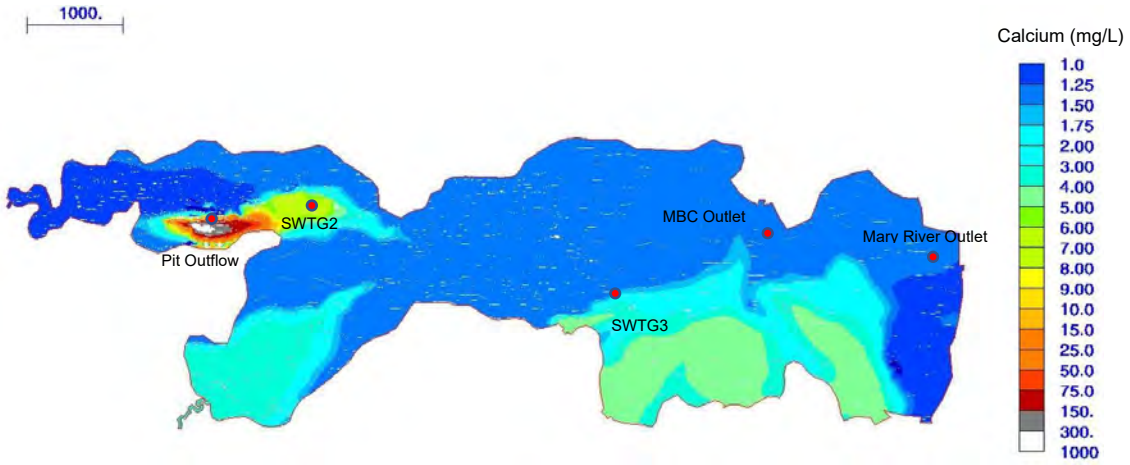

Figure 45. Contour plot Calcium at peak concentration at SWTG2, 1%AEP, Day 1 14:15

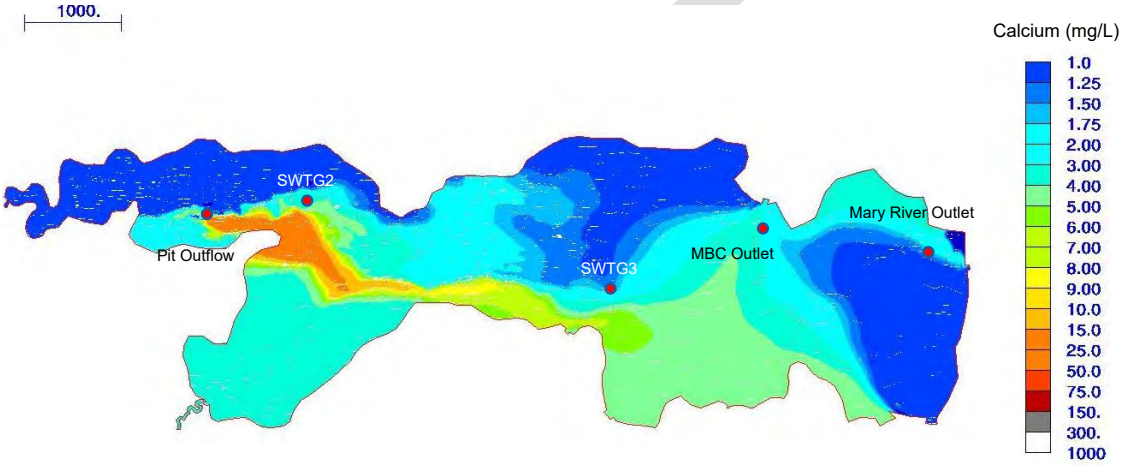

Figure 46. Contour plot Calcium at peak concentration at SWTG2, 0.1%AEP, Day 2 10:30

E.4. Potassium

E.4.1. Time Series

Maximum Potassium concentrations occur at Day 1, 22:15 for the 1%AEP event at the Mt Bundey Ck Outlet (1.3 mg/L), which slightly exceed the MedOEV but falls well short of the MaxOEV.

Likewise, for the 0.1%AEP event, the MaxOEV is not exceeded at any point, and the median concentrations do not exceed the MedOEV, though the maximum peaks for MBC outlet and SWTG3 spike briefly over the MedOEV.

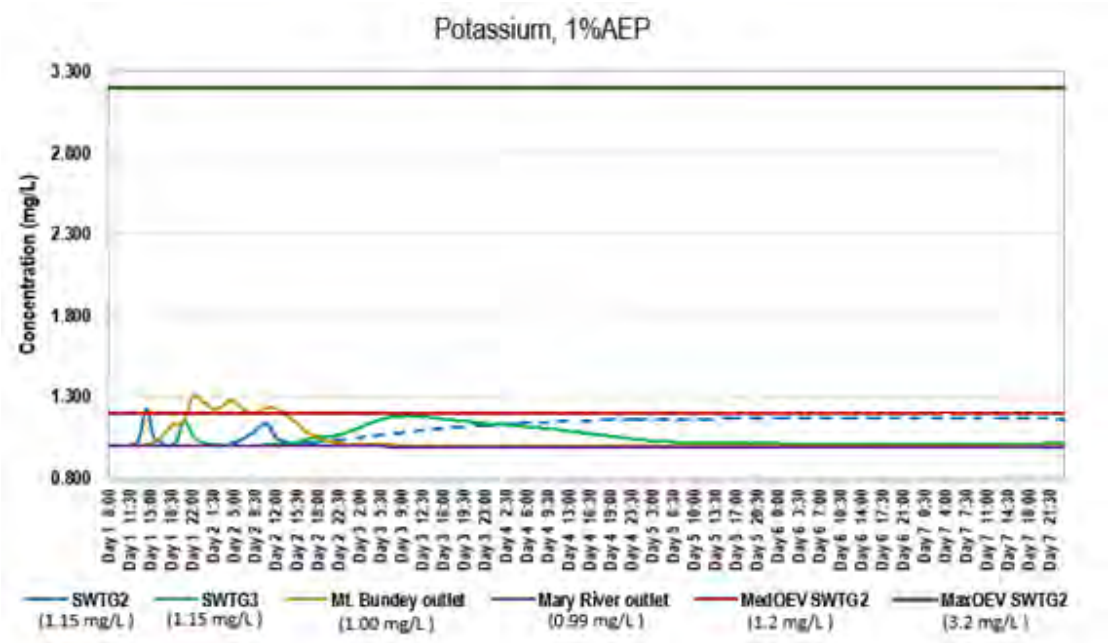

Figure 47. 1%AEP time series for Potassium plume (median values noted in legend). The dashed blue line indicates uncertainty in this part of the time series.

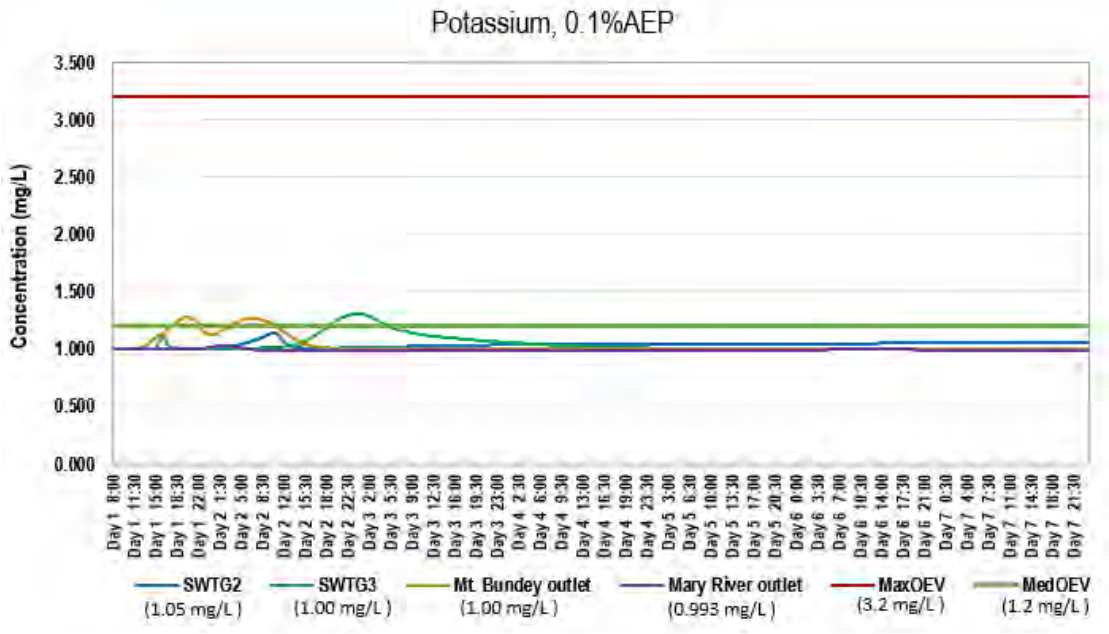

Figure 48. 0.1%AEP time series for Potassium plume (median values noted in legend)

E.4.2 Contour plot at peak concentration at SWTG2

For 1%AEP at the time of SWTG2 peak concentration, there is a temporary exceedance of MaxOEV within the immediate vicinity of the pit and a potential temporary minor exceedance along the Coulter Ck upstream inlet (US_02). MedOEV are potentially temporarily exceeded by a minor amount across large portions of the model domain at that time.

For the 0.1%AEP there is a potential of a temporary minor exceedance of MaxOEV along larger portions of the Coulter Ck upstream inlet at the time of peak concentration at SWTG2. The Coulter Ck upstream exceeds is not due to pit overflow. Similar to the 1%AEP event, there is the potential for MedOEV to be slightly exceeded across large areas of the model domain, at this time.

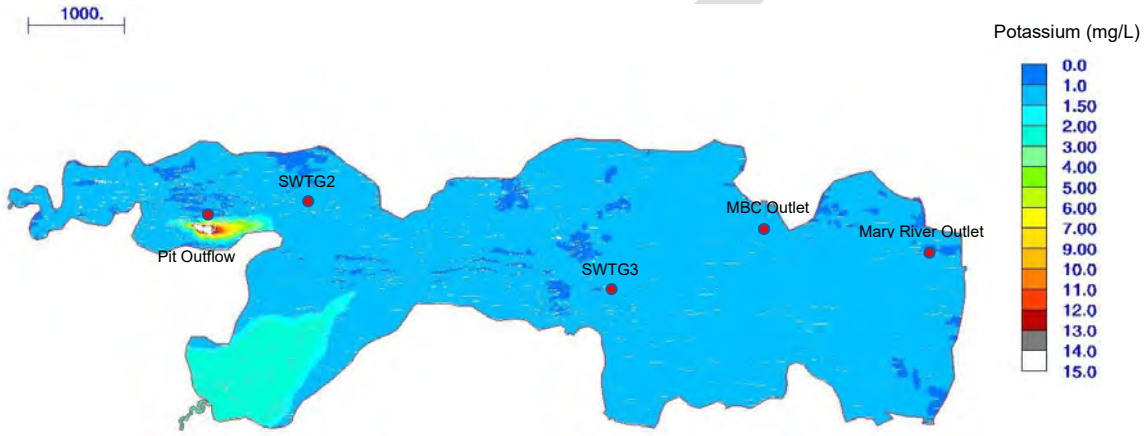

Figure 49. Contour plot Potassium at peak concentration at SWTG2, 1%AEP, Day 1 14:15

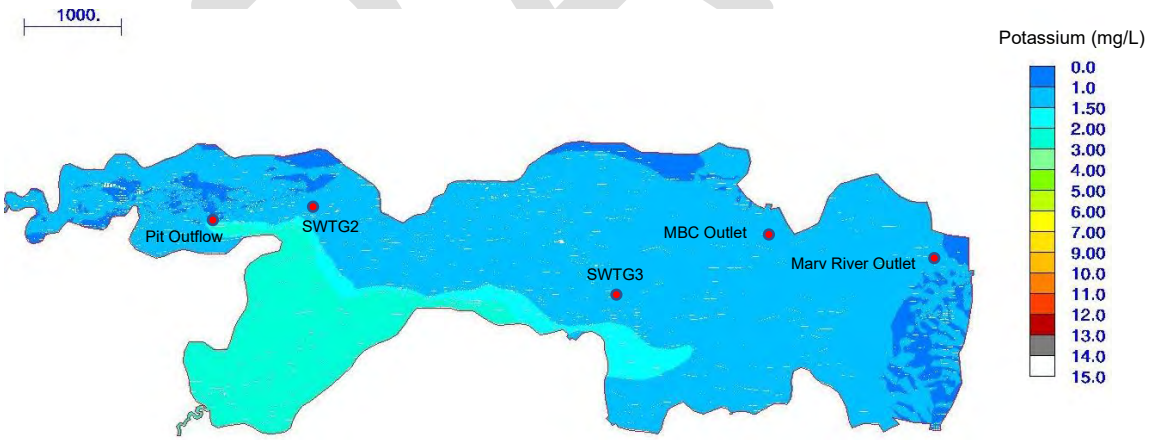

Figure 50. Contour plot Potassium at peak concentration at SWTG2, 0.1%AEP, Day 2 10:30

E.5. Magnesium

E.5.1. Time Series

Maximum dissolved Magnesium concentration spikes at Day 1, 14:15 for the 1%AEP event (5.23 mg/L) at SWTG2. The MedOEV of 1.8 mg/L is exceeded for the 1%AEP at SWTG2 (3.83 mg/L), but median values during the event do not exceed MedOEV (1.18 mg/L). The MedOEV are not exceeded at any of the other locations. Concentrations at all locations remain well below the MaxOEV of 120 mg/L.

During the 0.1%AEP event, the MedOEV is not exceeded by the median concentrations at any of the locations. Although the maximum concentration peaks spike over the MedOEV for SWTG2, SWTG3, and MBC outlet, they remain well below the MaxOEV limit.

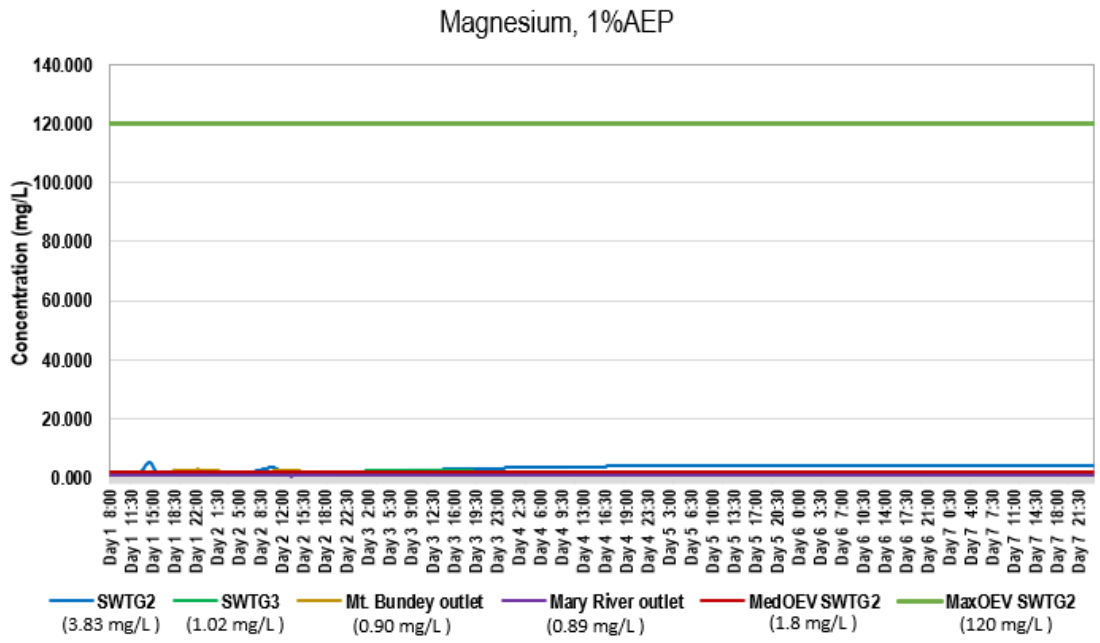

Figure 51. 1%AEP time series for Magnesium plume with MaxOEV (median values noted in legend)

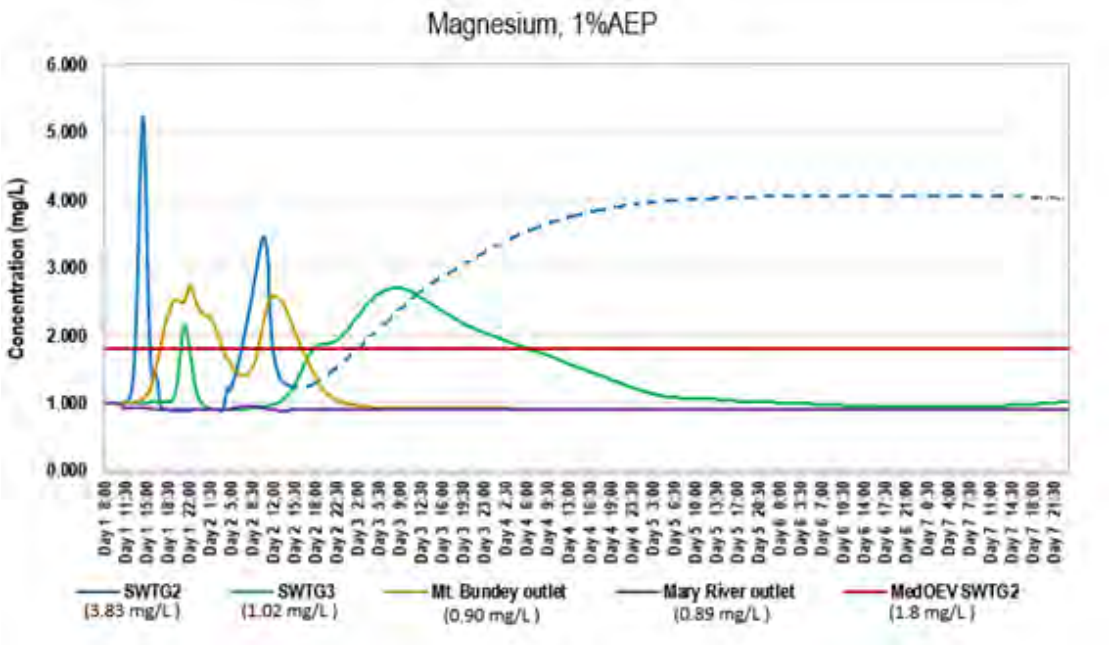

Figure 52. 1%AEP time series for Magnesium plume with MedOEV (median values noted in legend). The dashed blue line indicates uncertainty in this part of the time series.

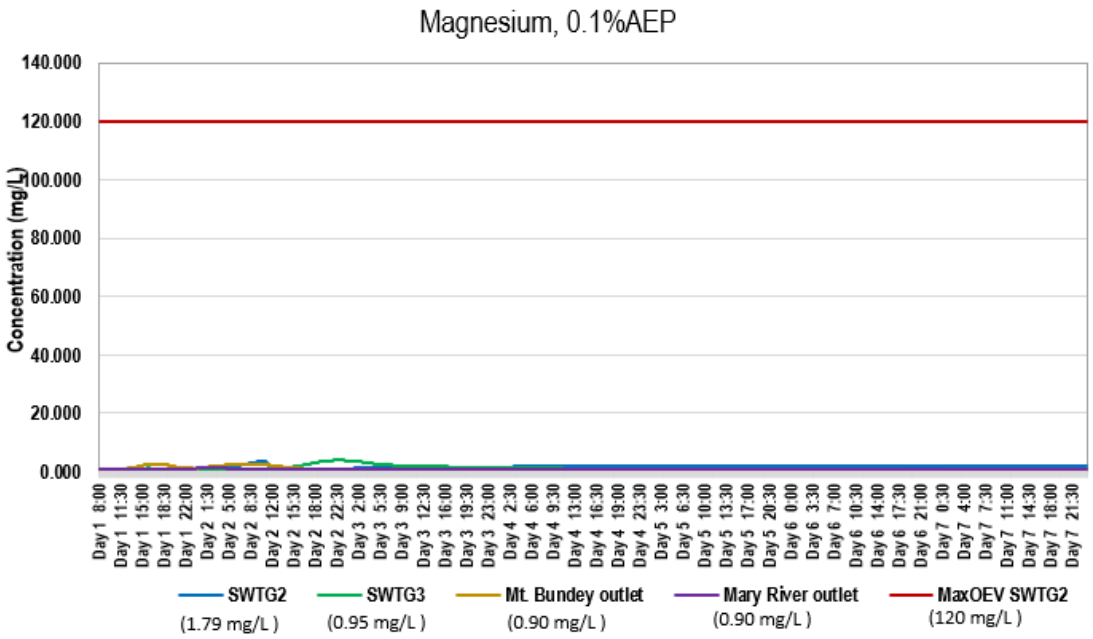

Figure 53. 0.1%AEP time series for Magnesium plume with MaxOEV (median values noted in legend)

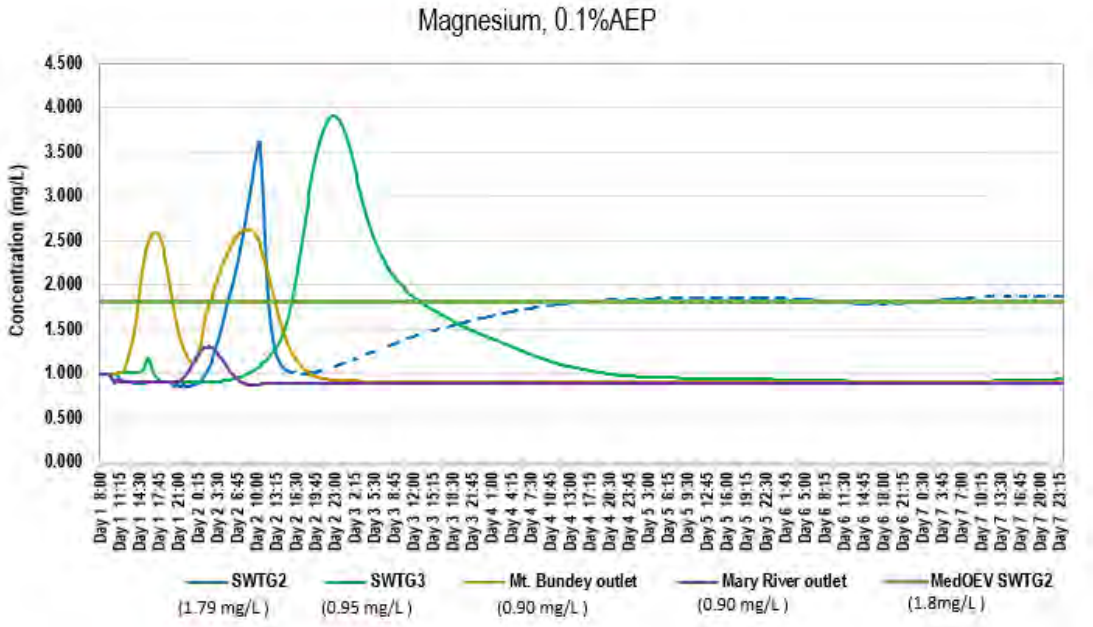

Figure 54. 0.1%AEP time series for Magnesium plume with MedOEV (median values noted in legend). The dashed blue line indicates uncertainty in this part of the time series.

E.5.2. Contour plot at peak concentration at SWTG2

At the time of maximum concentration at SWTG2 there is a small exceedance of MaxOEV within the immediate vicinity of the pit for the 1%AEP. MedOEV are temporarily exceeded around the pit and SWTG2, and along the upstream inlets US_02 to US_05, for the 1%AEP and across large portions of the model including SWTG2 for the 0.1%AEP at that time.

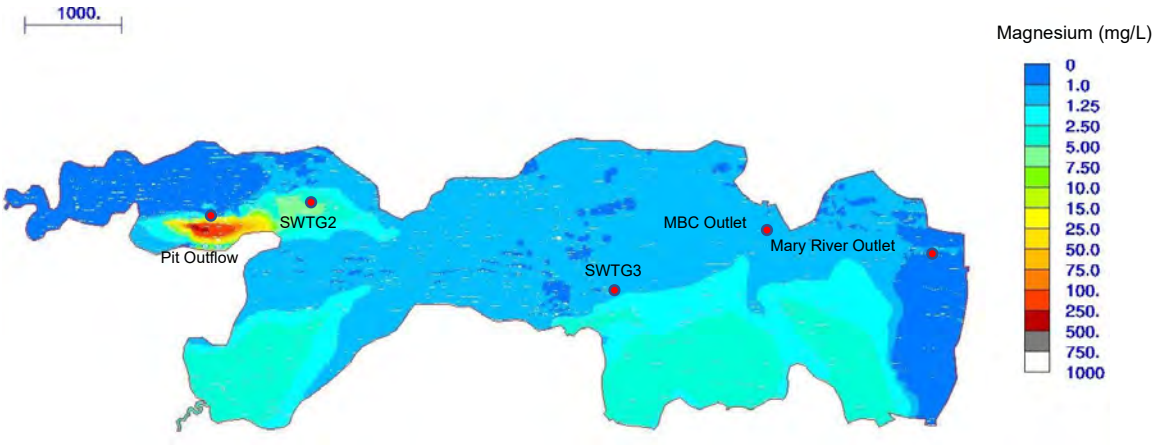

Figure 55. Contour plot at peak concentration at SWTG2 for dissolved Magnesium, 1%AEP, Day 1 14:15

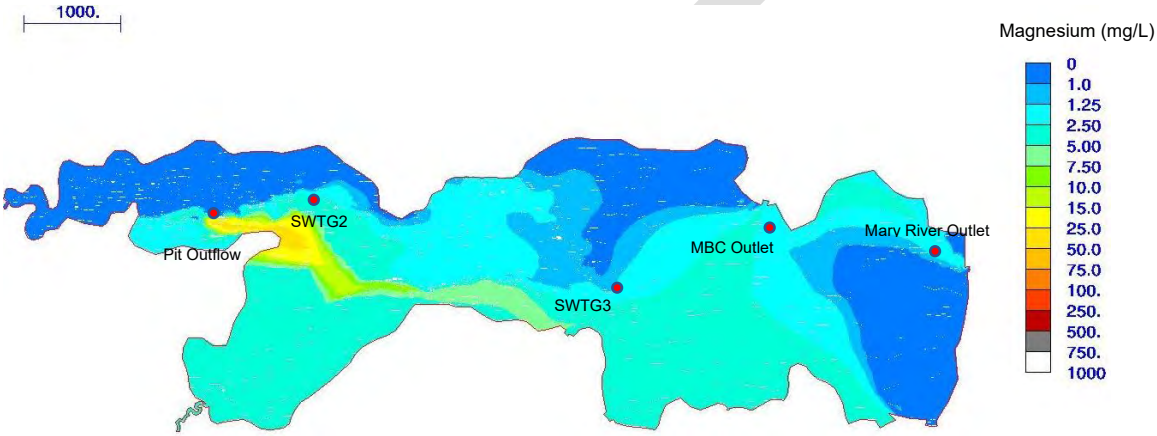

Figure 56. Contour plot at peak concentration at SWTG2 for dissolved Magnesium, 0.1%AEP, Day 2 10:30

E.6. Sodium

E.6.1. Time Series

Sodium concentrations spike at day 1 20:00 (3.44 mg/L) at the Mt Bundey Ck Outlet for the 1%AEP event. MaxOEV and MedOEV are not exceeded at any point during the simulations at any of the locations.

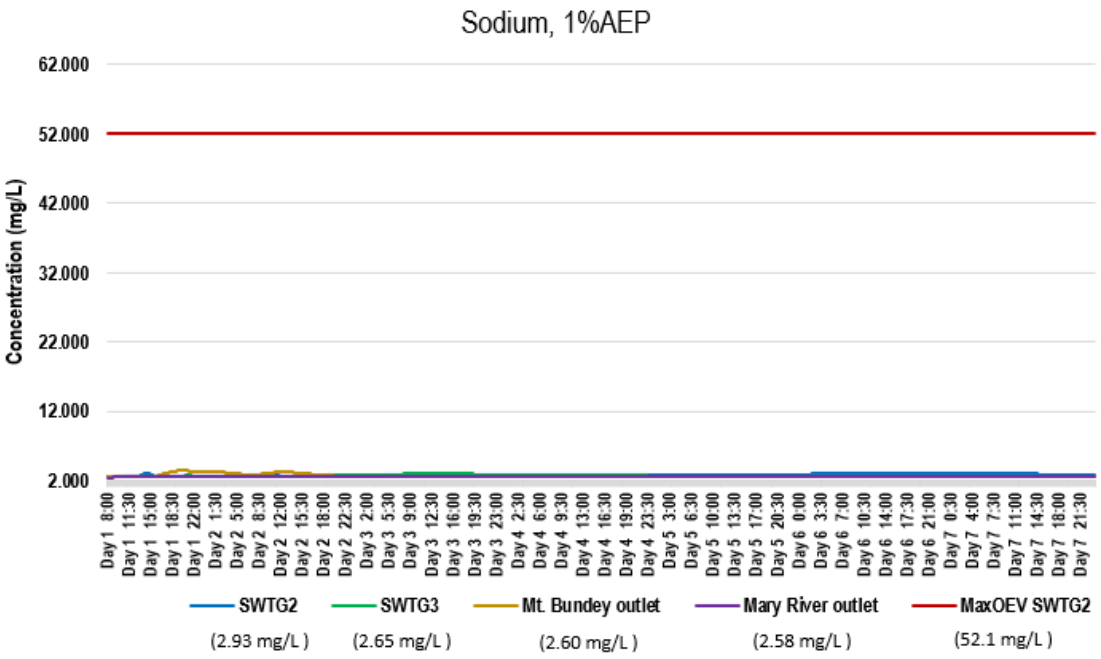

Figure 57. 1%AEP time series for Sodium plume with MaxOEV (median values noted in legend)

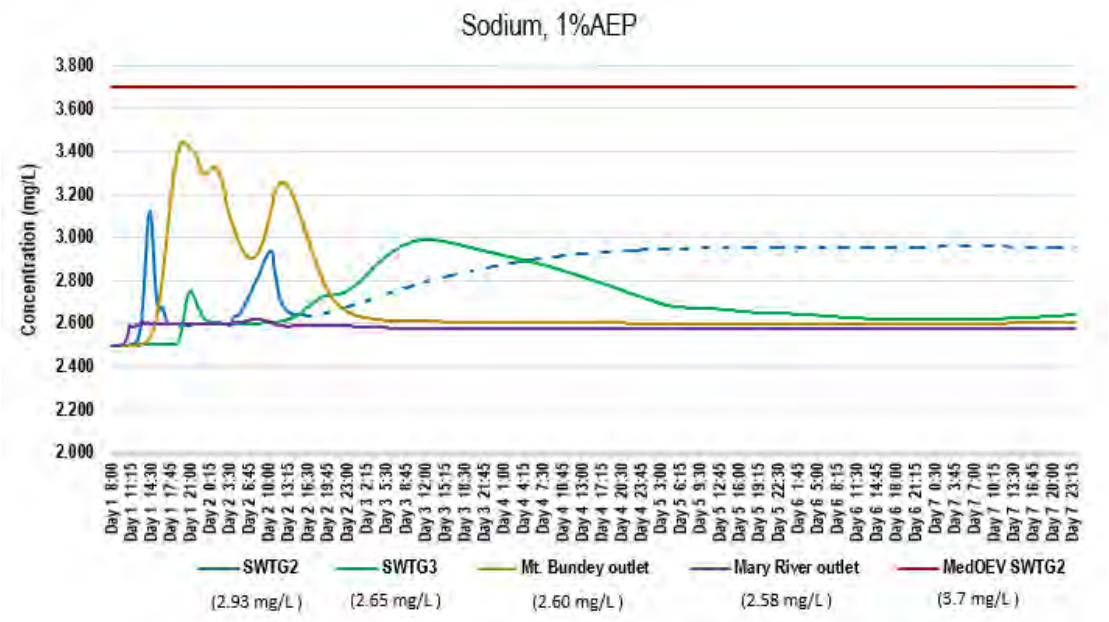

Figure 58. 1%AEP time series for Sodium plume with MedOEV (median values noted in legend)

E.6.2. Contour plot at peak concentration at SWTG2

At the time of maximum concentration at SWTG2 MedOEV are temporarily exceeded within the vicinity of the pit and along upstream inputs US_02 to US_05 for the 1%AEP. No exceedance of MaxOEV values occurs anywhere within the model domain at that time.

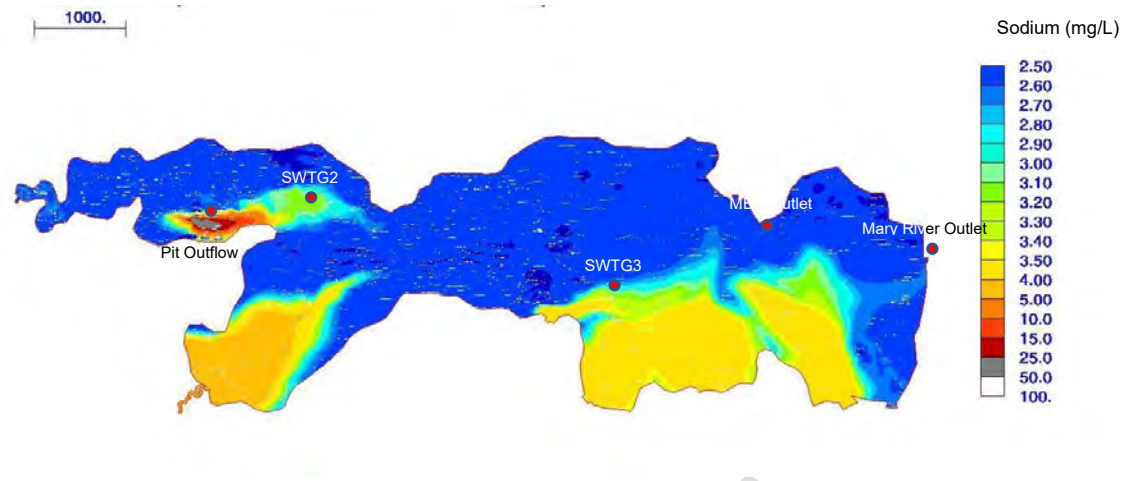

Figure 59. Contour plot at peak concentration at SWTG2 for dissolved Sodium, 1%AEP, Day 1 14:30

E.7. Sulphate

E.7.1. Time Series

Maximum Sulphate concentrations occur at Day 1 14:15 at SWTG2 for the 1%AEP event (36.29 mg/L), and at Day 2 22:45 at SWTG3 for the 0.1%AEP event (24.62 mg/L). For the 1%AEP and 0.1%AEP event Sulphate concentrations remain well below the SSTV of 129 mg/L at all locations, so there is no risk of contamination should pit overflow occur.

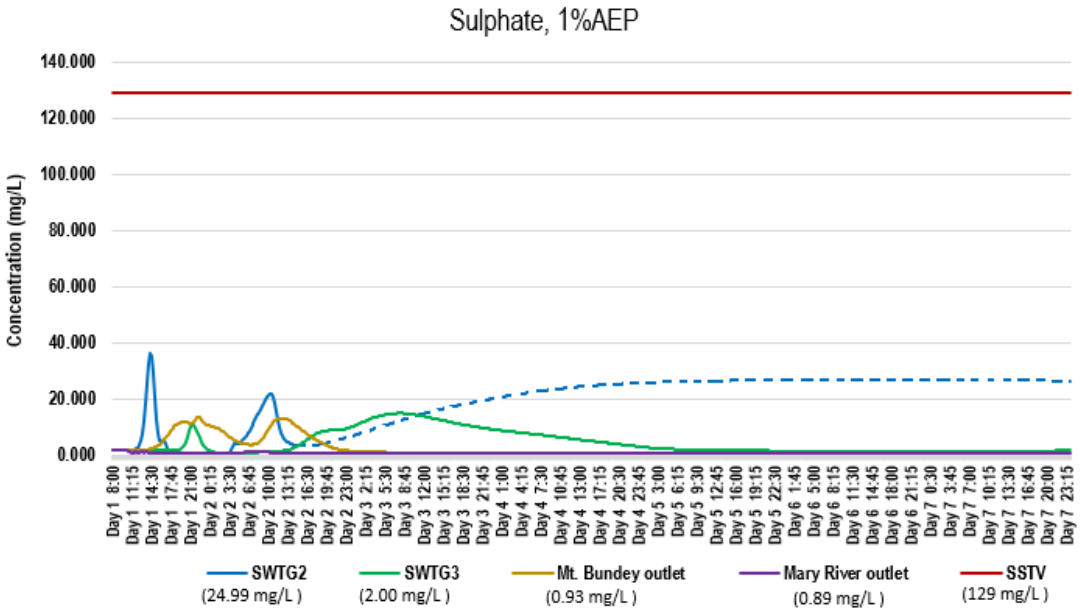

Figure 60. 1%AEP time series for Sulphate plume (median values noted in legend)

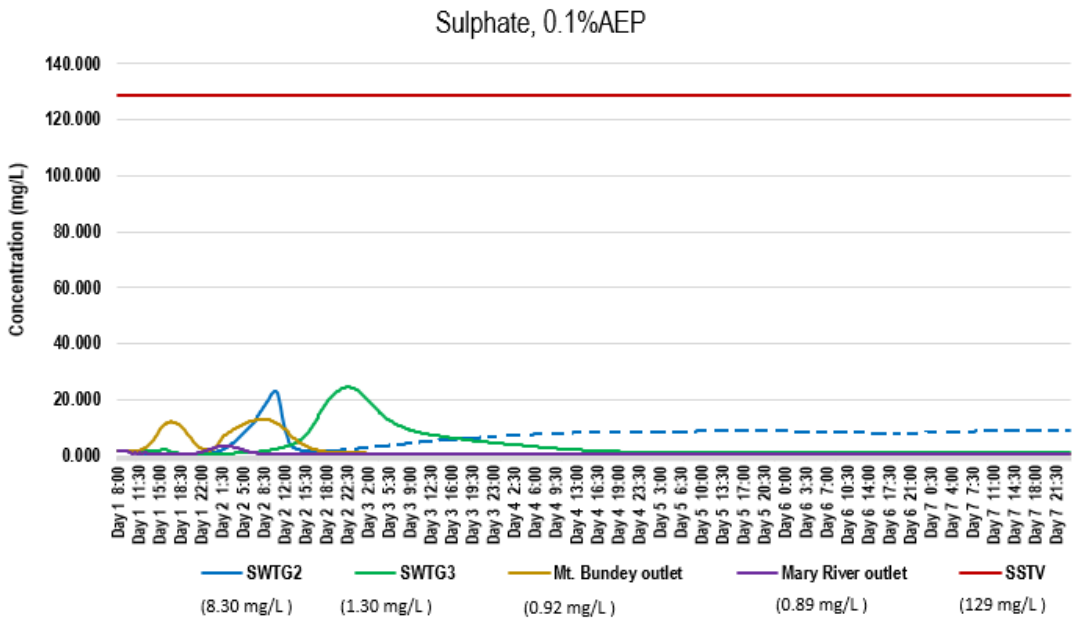

Figure 61. 0.1%AEP time series for Sulphate plume (median values noted in legend)

E.7.2. Contour plot at peak concentration at SWTG2

At the time of maximum concentration at SWTG2, SSTV are temporarily exceeded within the immediate vicinity of the pit for the 1%AEP. There is a potential for temporary minor exceedance south of SWTG2 for the 0.1%AEP event at the time of peak concentration at SWTG2.

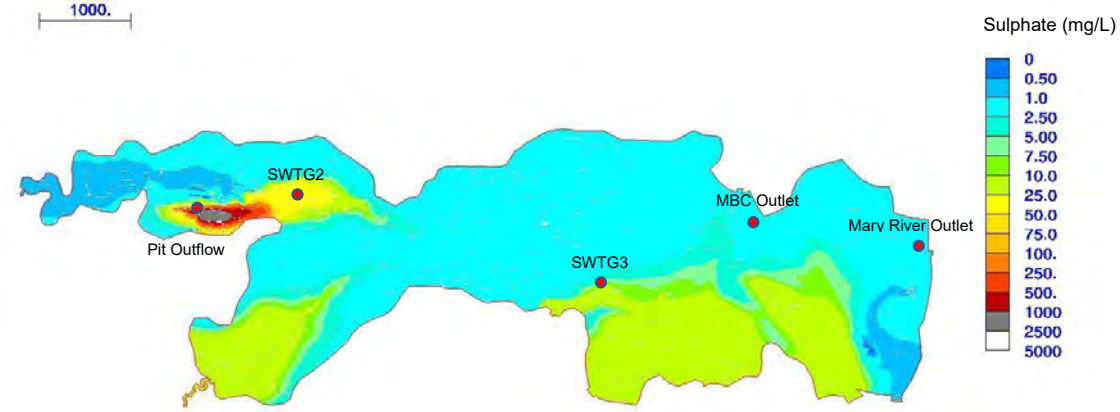

Figure 62. Contour plot at peak concentration at SWTG2 for Sulphate, 1%AEP, Day 1 14:15

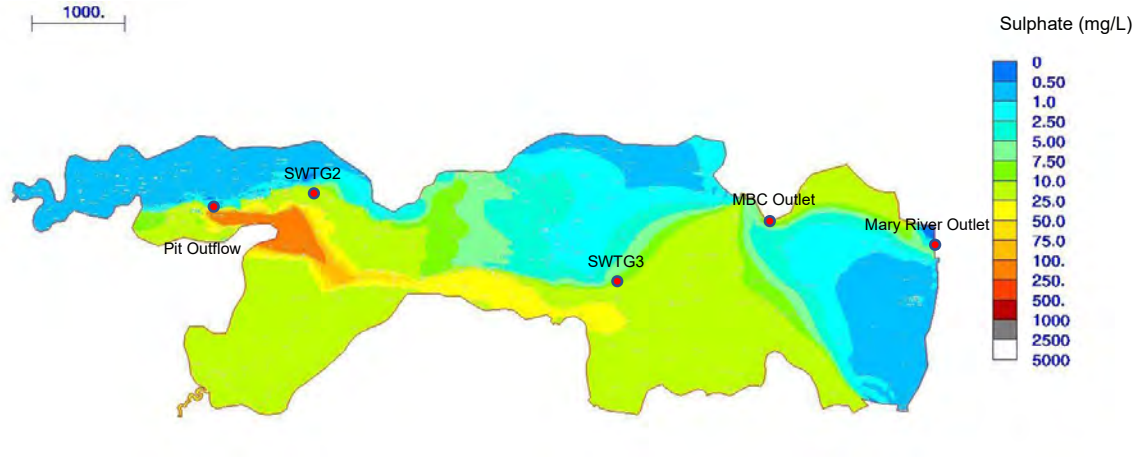

Figure 63. Contour plot at peak concentration at SWTG2 for Sulphate, 0.1%AEP, Day 2 10:30

E.8. Aluminium

E.8.1. Time Series

Maximum dissolved Aluminium levels occur at Day 1 14:15 for the 1%AEP event (0.800 mg/L) at SWTG2 and at Day 2 10:30 for the 0.1%AEP event at SWTG2 (0.580 mg/L). The ATV is always exceeded at all four locations. This is due to the high initial concentration of Aluminium, which exceeds the ATV prior to pit overflow. However, SSTV is only exceeded at SWTG2 when compared to the median value (0.60 mg/L for 1%AEP, 0.32 mg/L for 0.1%AEP).

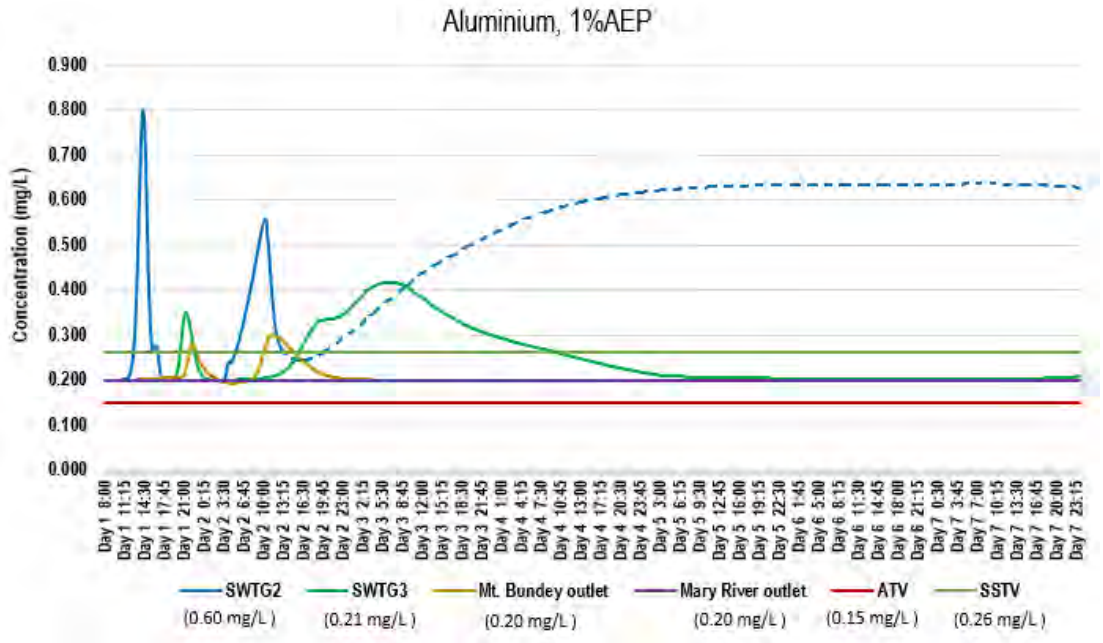

Figure 64. 1%AEP time series for Aluminium plume

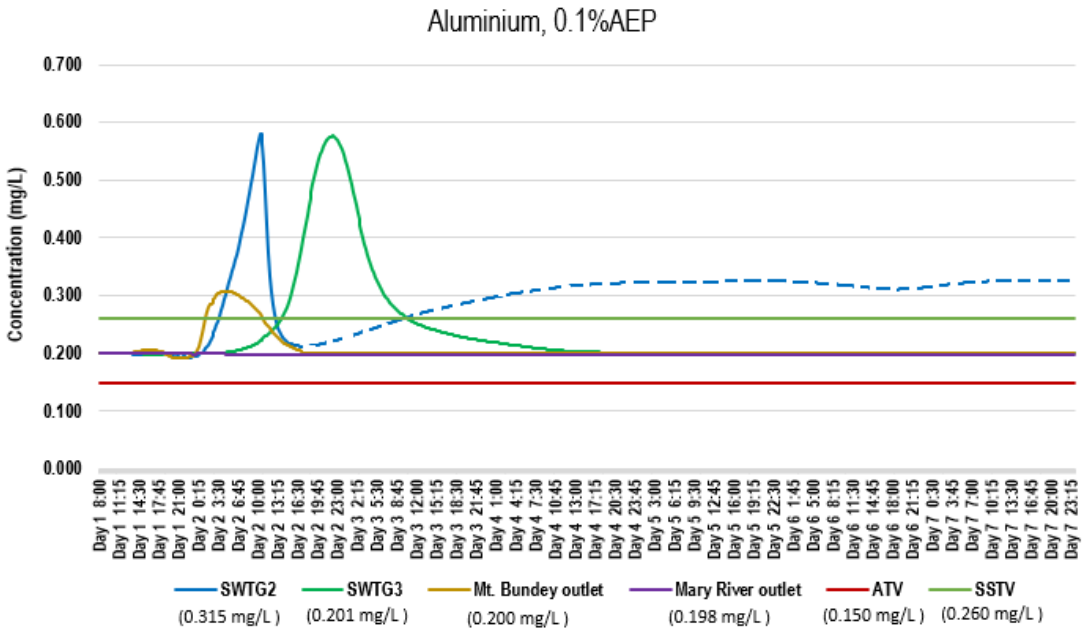

Figure 65. 0.1%AEP time series for Aluminium plume

E.8.2. Contour plot at peak concentration at SWTG2

There is a temporary exceedance of SSTV around the pit and SWTG2, and a potential of slight exceedance of SSTV across the model domain for the time of peak concentration at SWTG2 for the 1%AEP event. For the 0.1%AEP event there is a temporary exceedance along the plume stretching from the pit along the southern model boundary past SWTG3 at that time. There is also a potential of slight temporary exceedance of the SSTV across large portions of the model domain.

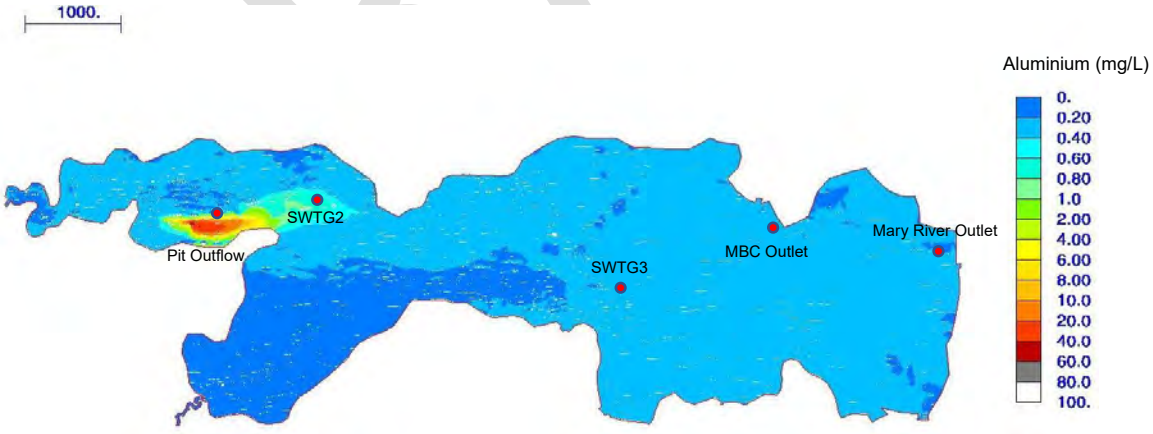

Figure 66. Contour plot at peak concentration at SWTG2 for Aluminium, 1%AEP, Day 1 14:15

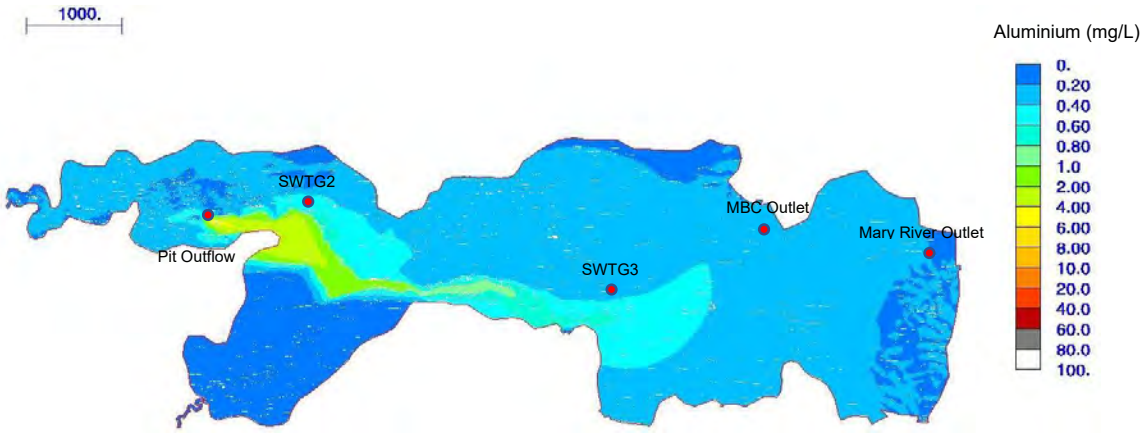

Figure 67. Contour plot at peak concentration at SWTG2 for Aluminium, 0.1%AEP, Day 2 10:30

E.9. Arsenic

Simulation was not run, as the concentration in the pit overflow (0.005 mg/L) is so much lower than the TV (0.14 mg/L) as to be insignificant.

E.10. Cadmium

E.10.1. Time Series

Dissolved cadmium concentration spikes at Day 1 14:15 at SWTG2 (0.0192 mg/L) for the 1%AEP event and at Day 2 10:30 at SWTG2 (0.0125 mg/L) for the 0.1%AEP event. After Day 2, concentrations stabilize at a level of approximately 0.14 mg/L for the 1%AEP and at 0.004 mg/L for the 0.1%AEP, due to low discharge flow.

Median and maximum concentrations exceed TV at SWTG2 with 0.013 mg/L and 0.019 mg/L compared to a TV of 0.0008 mg/L for the 1%AEP event. The maximum peaks spike higher than TV at SWTG3 (0.007 mg/L) and Mt Bundey Ck Outlet (0.003 mg/L), however, median values at those locations stay below TV. Concentrations at the Mary River Outlet never exceed the TV.

For the 0.1%AEP event median (0.0038 mg/L) and maximum (0.0125 mg/L) values also exceed TV at SWTG2. However, during the flood event median values (0.00027 mg/L) stay below TV. Spikes at Mt Bundey Ck outlet (0.00386 mg/L) and SWTG3 (0.0123 mg/L) also are above TV, however, median values remain below TV, similar to the 1%AEP event.

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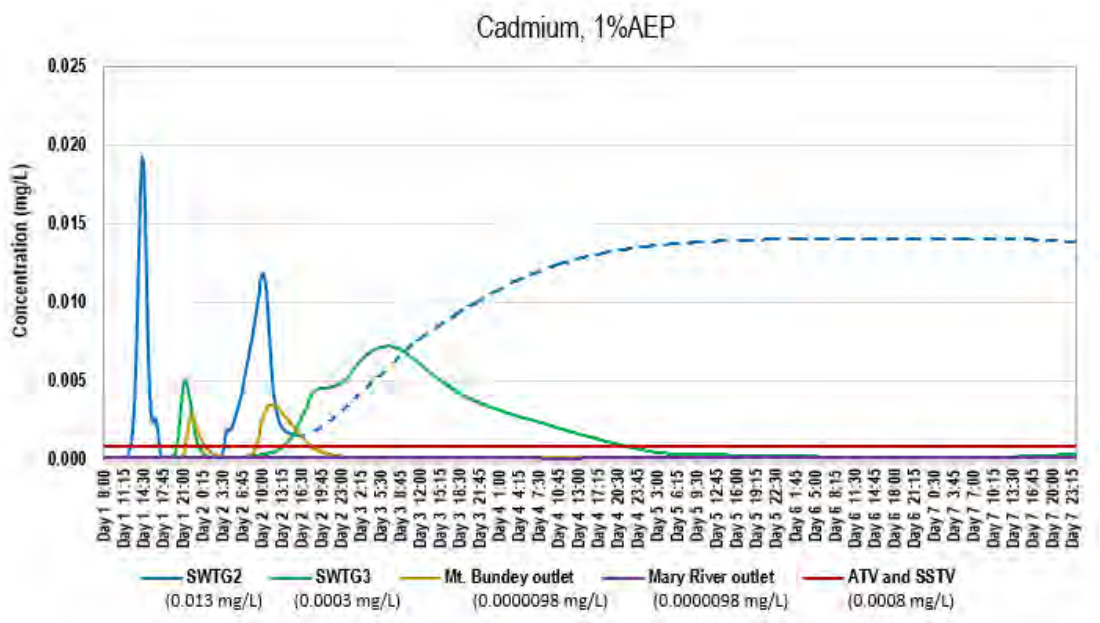

Figure 68. 1%AEP time series for Cadmium plume (median values noted in legend)

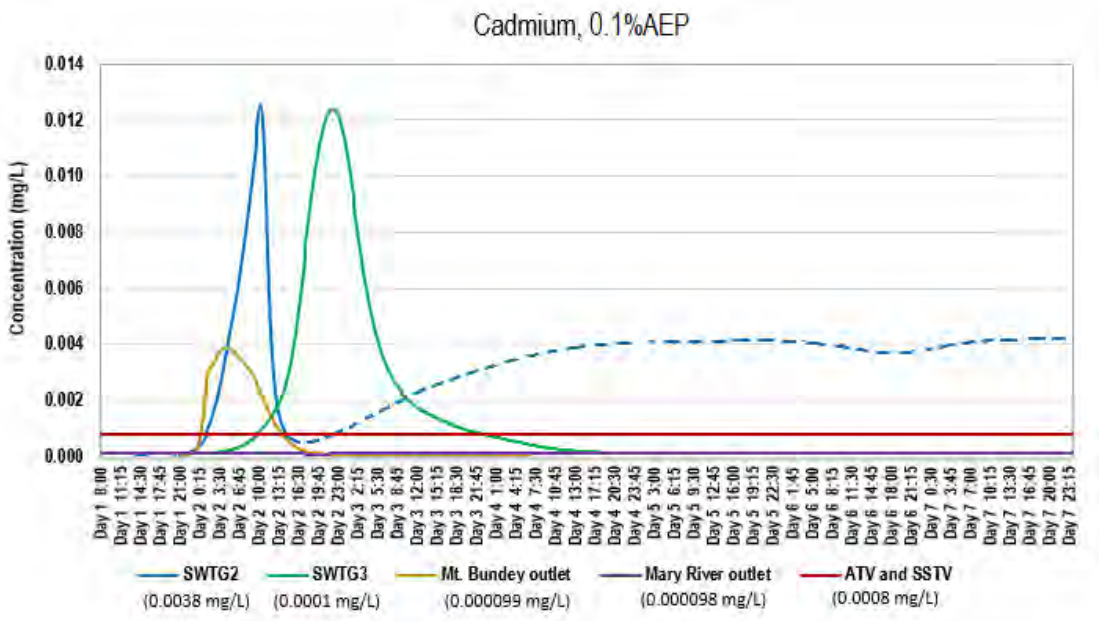

Figure 69. 0.1%AEP time series for Cadmium plume (median values noted in legend)

E.10.2. Contour plot at peak concentration at SWTG2

For the 1%AEP event, the SSTV is temporarily exceeded within the disturbed mine area and partially across the Mt Bundey Ck floodplain, extending beyond SWTG2 at the time of maximum concentration. For the 0.1%AEP event, significant exceedances occur at that time across large portions of the model domain, extending from the pit down beyond SWTG3 and then to Mt Bundey Ck outlet.

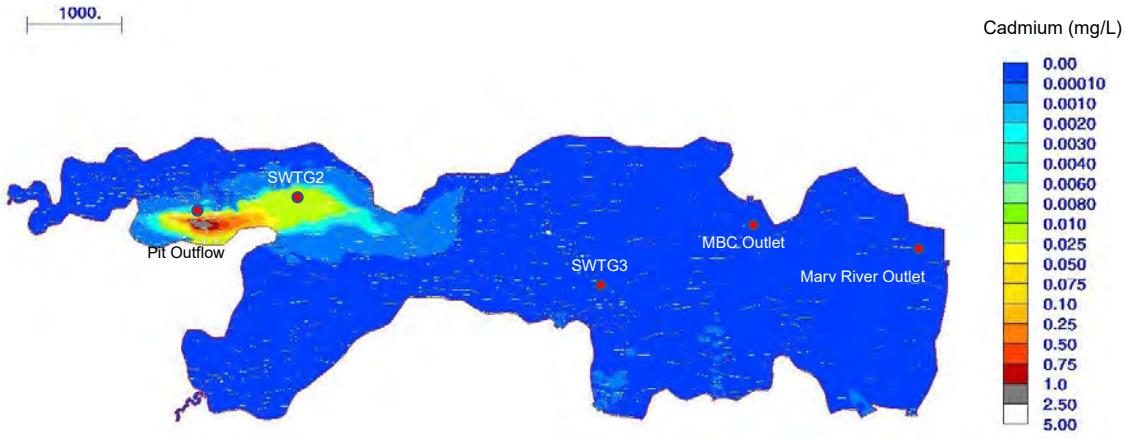

Figure 70. Contour plot at peak concentration at SWTG2 for Cadmium, 1%AEP, Day 1 14:15

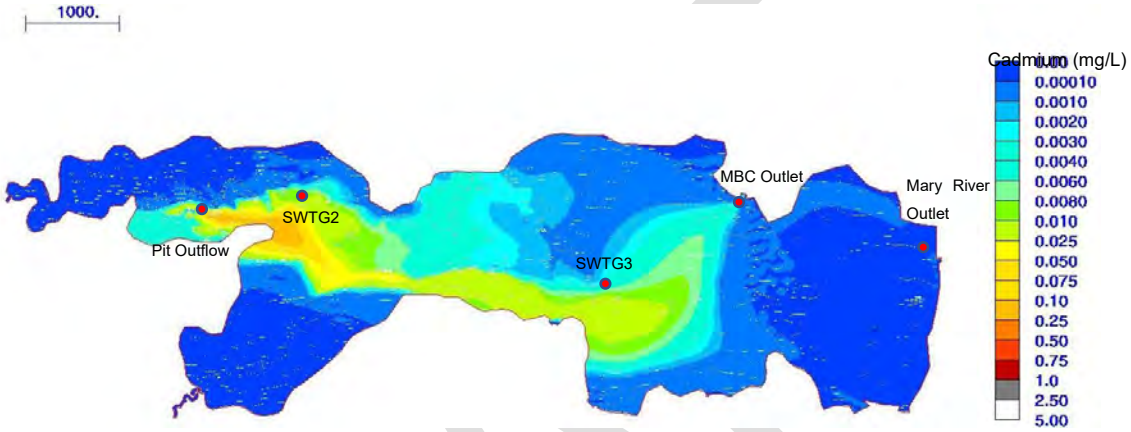

Figure 71. Contour plot at peak concentration at SWTG2 for Cadmium, 0.1%AEP, Day 2 10:30

E.11. Chromium

E.11.1. Time Series

Maximum dissolved chromium concentration occurs at day 1 14:15 for the 1% AEP event at SWTG2. Trigger values (0.04 mg/L) are not exceeded at any point during the simulation period at any of the four locations.

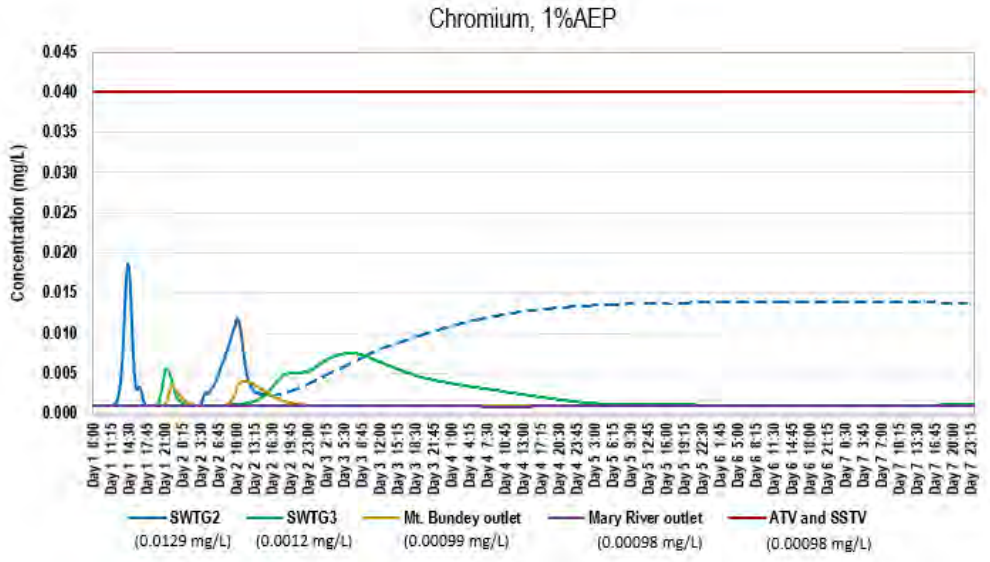

Figure 72. 1%AEP time series for Chromium plume (median values noted in legend)

E.11.2. Contour plot at peak concentration at SWTG2

The SSTV are temporarily but significantly exceeded around the pit and partially off-site around the location of SWTG2, at the time of maximum concentration during the 1%AEP event.

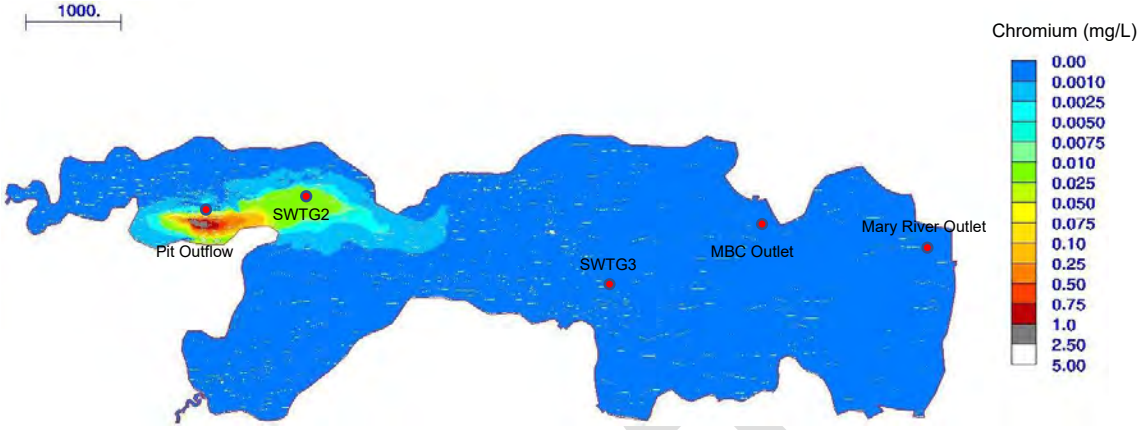

Figure 73. Contour plot at peak concentration at SWTG2 for Chromium, 1%AEP, Day 1 14:15

E.12. Cobalt

E.12.1. Time Series

Maximum dissolved Cobalt concentration spikes over the TV (0.0014 mg/L) at SWTG2 at Day 1 14:15 for the 1%AEP event (0.0258 mg/L). Median Cobalt concentration (0.0178 mg/L) at SWTG2 significantly exceeds the TV for the 1%AEP.

Peak Cobalt concentrations at SWTG3 (0.010 mg/L, Day 3 7:15) and Mt Bundey Ck (0.0053 mg/L, Day 2 11:00) outlet also significantly exceed TV, however, median values stay below TV, therefore overall exceedances are acceptable for these locations.

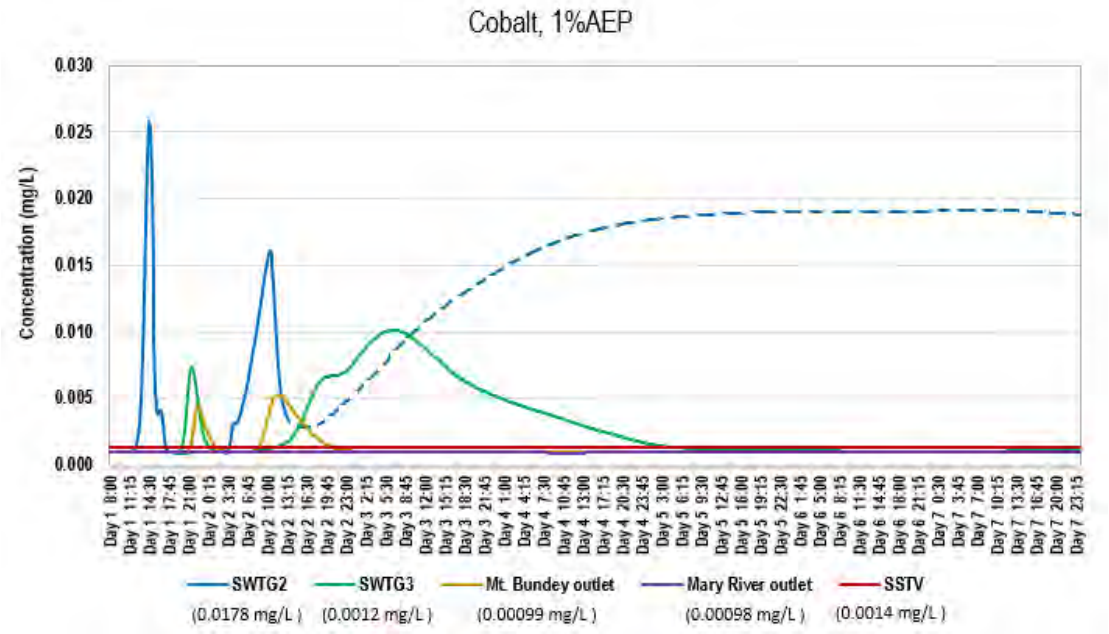

Figure 74. 1%AEP time series for Cobalt plume

E.12.2. Contour plot at peak concentration at SWTG2

Significant SSTV exceedance occurs temporarily for the 1%AEP event within the vicinity of the pit, extending off-site beyond SWTG2 at the time of peak concentration at SWTG2.

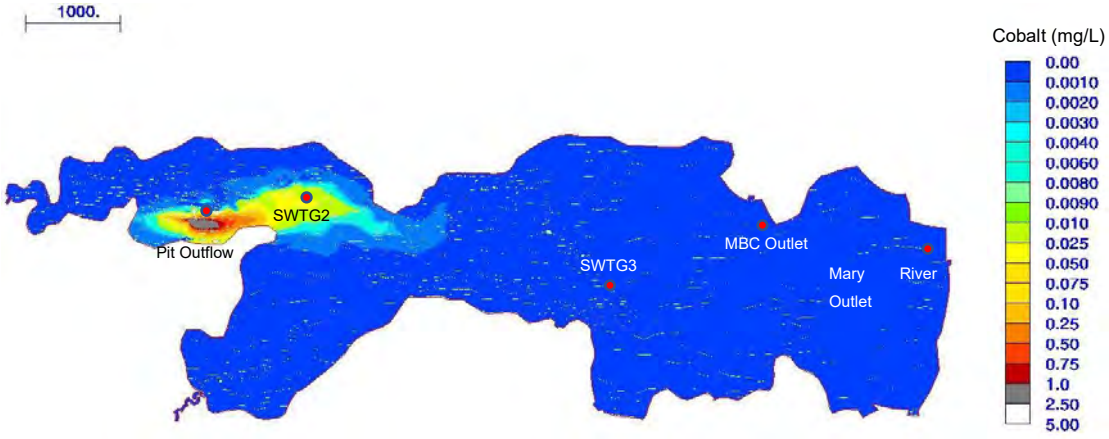

Figure 75. Contour plot at peak concentration at SWTG2 for Cobalt, 1%AEP, Day 1 14:15

E.13. Copper

E.13.1. Time Series

Peak copper concentrations spike above TV (0.0025 mg/L) at SWTG2 (0.0251 mg/L, day 1 14:15), SWTG3 (0.0097 mg/L, day 3 6:45) and Mt Bundey Ck outlet (0.0057 mg/L, day 2 11:45) for the 1%AEP event. However, compared to the median values only SWTG2 (0.0174 mg/L) exceeds TV.

Similarly, for the 0.1%AEP maximum copper concentrations exceed TV at SWTG2 (0.016 mg/L, day 2 10:15), SWTG3 (0.016 mg/L, day 2 22:15) and MT Bundey Ck outlet (0.0058 mg/L, day 2 5:15), but median values only exceed TV at SWTG2 (0.0061 mg/L). However, if only the period during the event (Day 1 to Day 2 15:30), is considered, the median concentration is only 0.0019 mg/L, which is within the TV limit.

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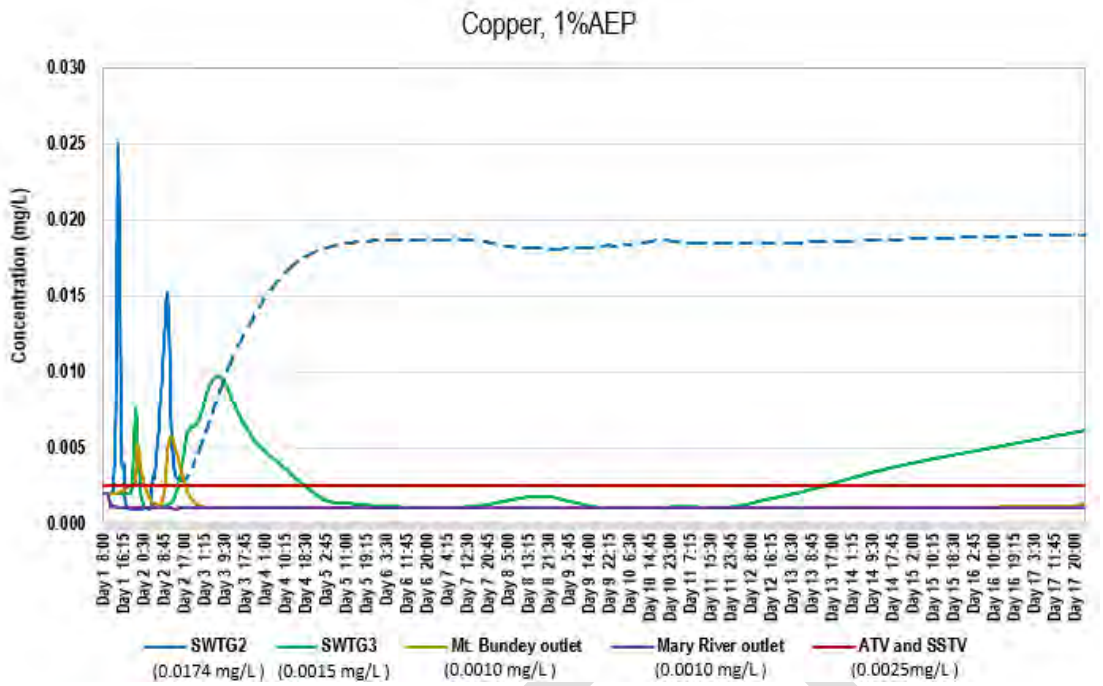

Figure 76. 1%AEP time series for Copper plume (median value in legend)

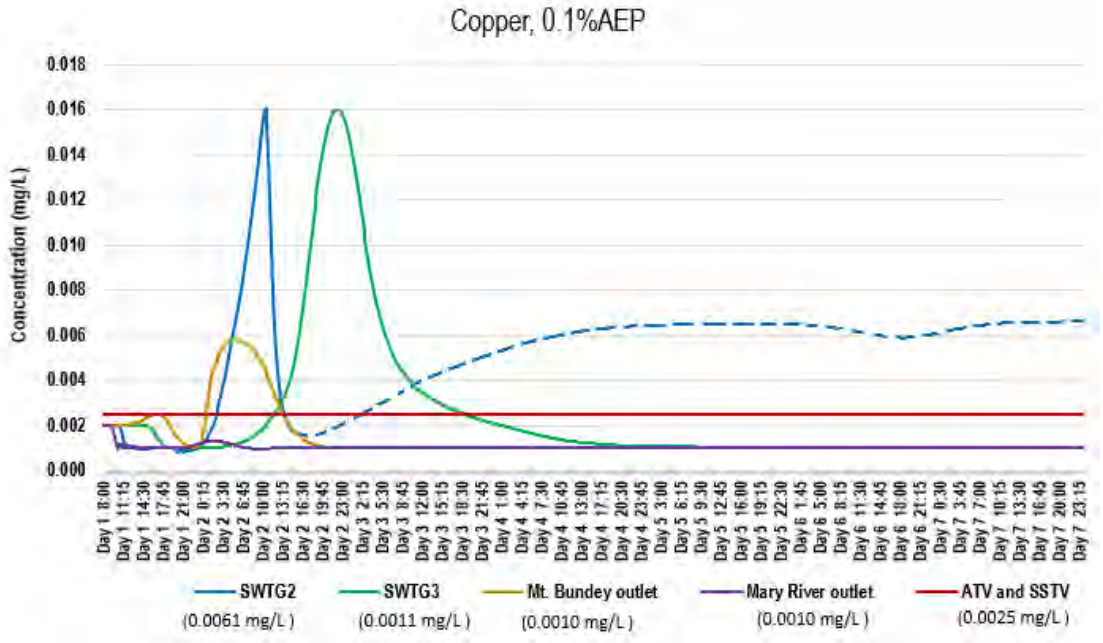

Figure 77. 0.1%AEP time series for Copper plume (median values in legend)

E.13.2. Contour plot at peak concentration at SWTG2

At the time of peak concentration at SWTG2 a significant temporary exceedance of the SSTV occurs around the pit and SWTG2, and a small exceedance occurs along the upstream inputs of US_03 to US_05, for the 1%AEP event. For the 0.1%AEP event, the SSTV is exceeded across a large portion of the model domain stretching from the pit past SWTG2, SWTG3 and the Mt Bundey Ck outlet at that time.

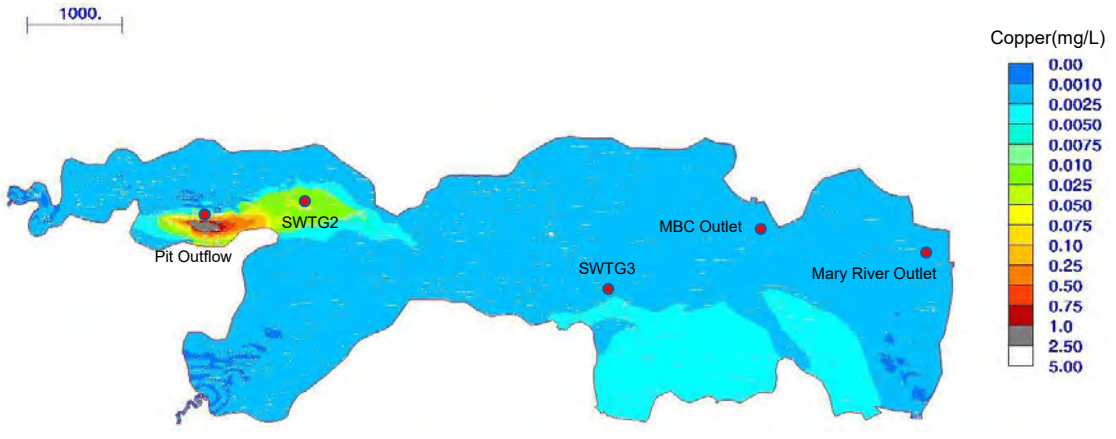

Figure 78. Contour plot at peak concentration at SWTG2 for Copper, 1%AEP, Day 1 14:15

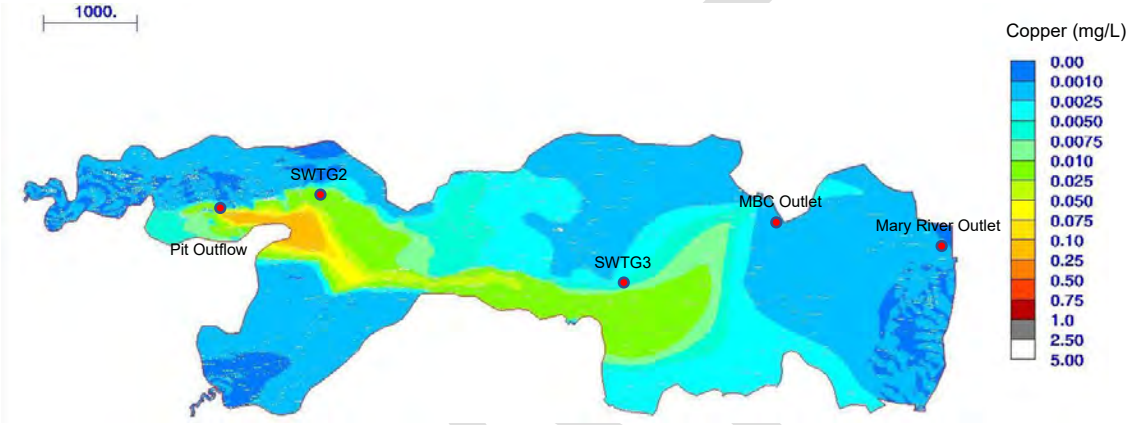

Figure 79. Contour plot at peak concentration at SWTG2 for Copper, 0.1%AEP, Day 2 10:30

E.14. Iron

E.14.1. Time Series

The maximum iron concentration at SWTG2 remains below the trigger level for the 1%AEP event, however, the concentration at Mt. Bundey outlet spikes over the trigger level during Day 1 (peak 0.48 mg/L, 21:45), and at SWTG3 during Day 3 (peak 0.31 mg/L, 14:30). However, the median concentrations do not exceed the SSTV, therefore, overall the exceedances are acceptable.

For the 0.1%AEP event, only SWTG3 and Mt. Bundey Ck outlet exceed the SSTV for the maximum peaks (0.382 mg/L at Day 3 2:30 for SWTG3, 0.495 mg/L at Day 1 17:30 for Mt Bundey Ck). The median concentrations for all locations are well below the SSTV.

The relatively high spike in iron concentration at MBC outlet is due to the existing high iron concentration at the inlet from Coulter Ck (1.1 mg), which is comparable to the concentration from the pit overflow (1.42 mg/L), and significantly higher than other natural inputs (e.g. Mt Bundey Ck US_01 inlet 0.21 mg/L).

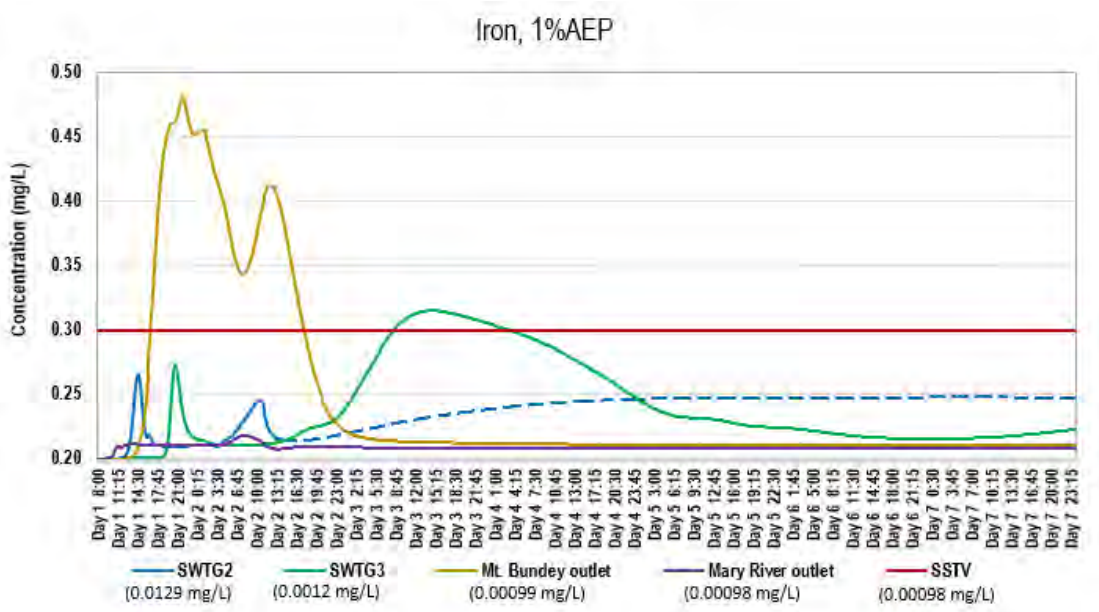

Figure 80. 1%AEP time series for Iron plume (median values noted in legend)

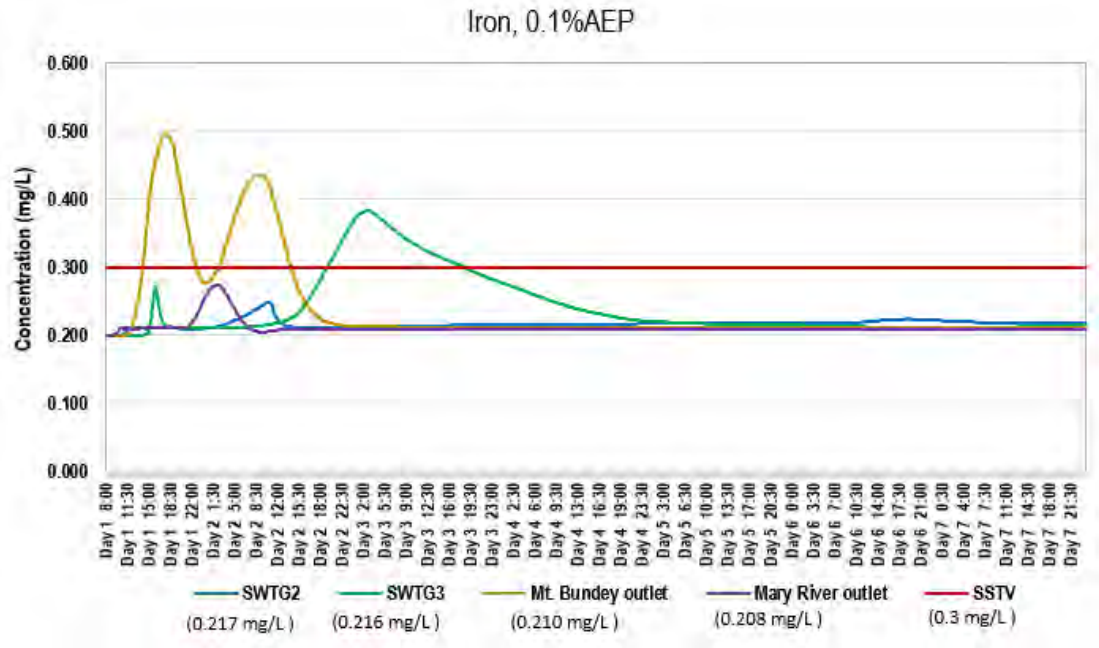

Figure 81. 0.1%AEP time series for Iron plume (median values noted in legend)

E.14.2. Contour plot at peak concentration at SWTG2

At the time of peak concentration at SWTG2, the SSTV is temporarily but significantly exceeded in the vicinity of the pit and along Coulter Ck upstream input (US_02) for the 1%AEP event. Exceedance also occurs along the inlets US_03 to US_05 at that time.

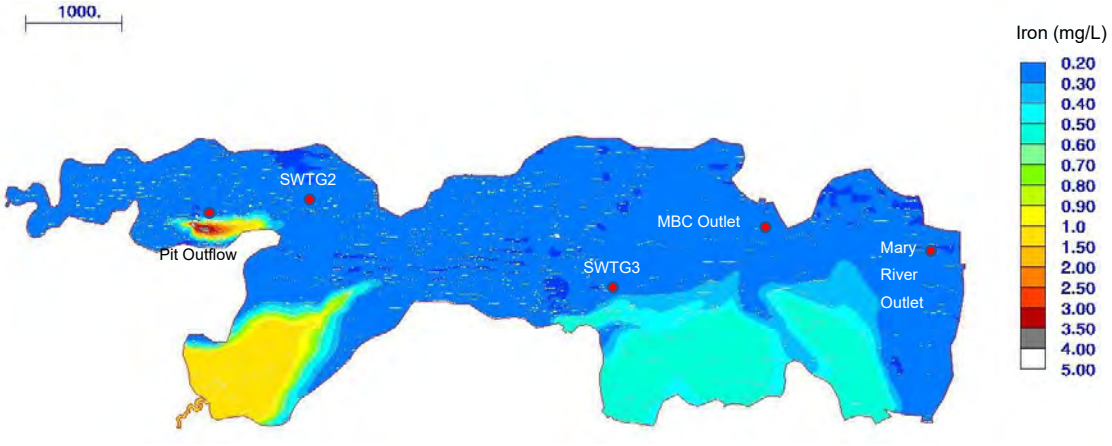

Figure 82. Contour plot at peak concentration at SWTG2 for Iron, 1%AEP, Day 1 14:30

E.15. Lead

E.15.1. Time Series

Both the median (13.08 µg/L) and maximum lead concentration for SWTG2 (18.9 µg/L, Day 1 14:15) exceed the TV. Once again, the high median concentration is due to the concentration stabilising at a high level caused by low flows.

Considering only the period during the event (Day 1 to Day 2 15:30), before the low flows occur, the median concentration is only 0.0019 mg/L, which is within the TV limit. This suggests that the high value may be due to the model not being able to handle the low flow conditions effectively.

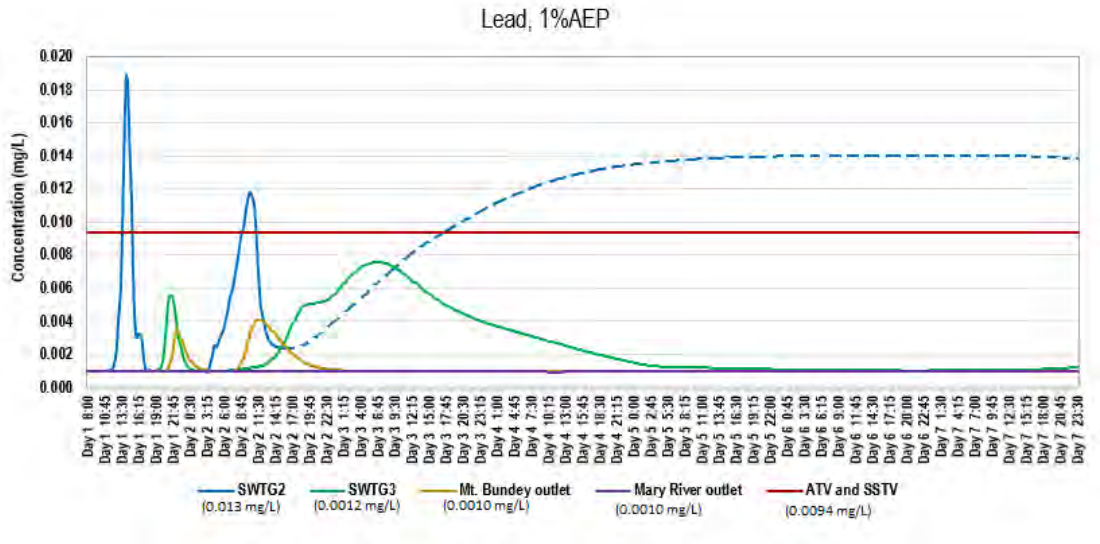

Figure 83. 1%AEP time series for Lead plume

E.15.2. Contour plot at peak concentration at SWTG2

The SSTV is temporarily exceeded around the pit and Mt Bundey Ck floodplain, extending partially off-site beyond SWTG2 at the time of maximum concentration for the 1%AEP event.

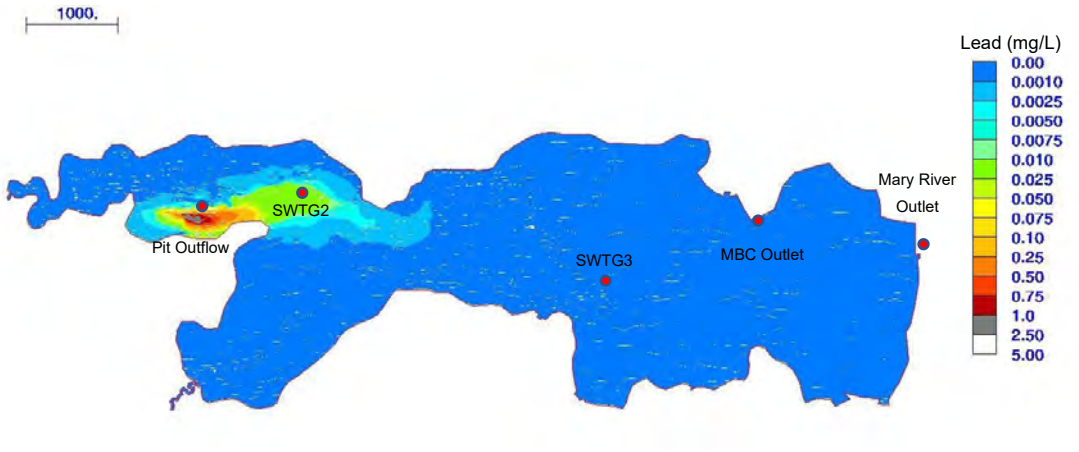

Figure 84. Contour plot at peak concentration at SWTG2 for dissolved Lead, 1%AEP, Day 1 14:15

E.16. Manganese

E.16.1. Time Series

Trigger levels are not exceeded at any location by either the maximum peaks or median concentration, for either the 1%AEP or 0.1%AEP event.

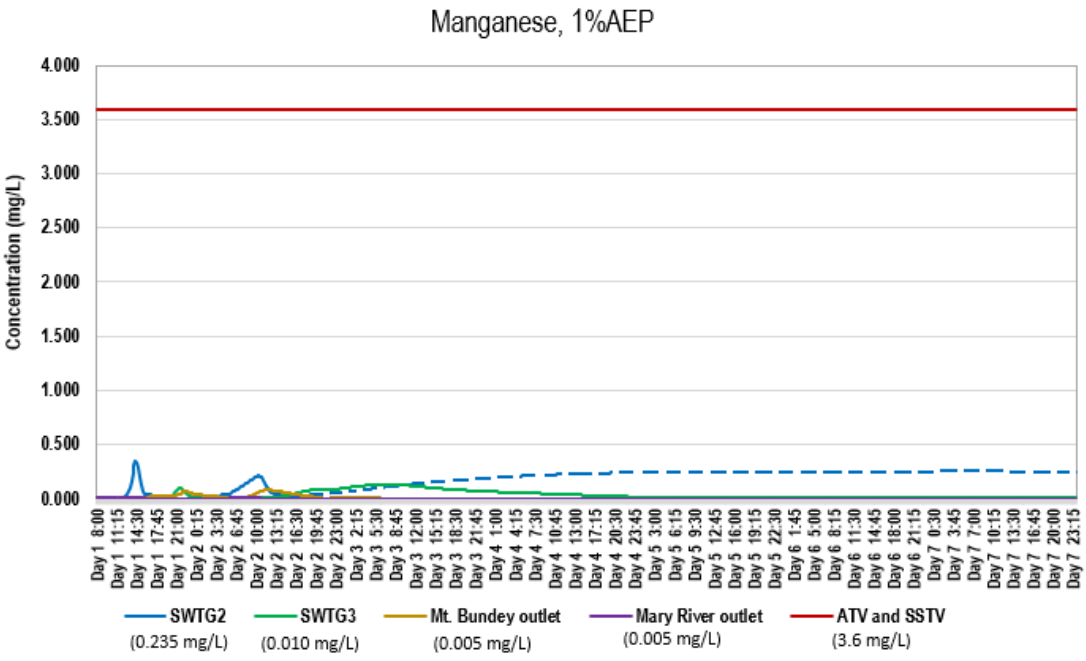

Figure 85. 1%AEP time series for Manganese plume. The dashed blue line indicates uncertainty in this part of the time series.

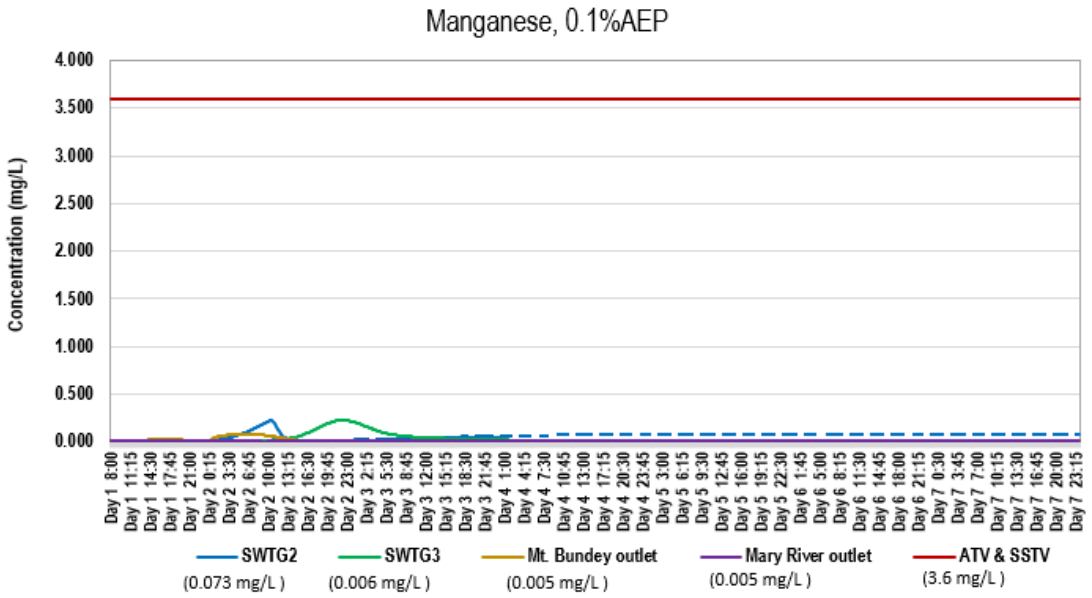

Figure 86. 0.1%AEP time series for Manganese plume

E.16.2. Contour plot at peak concentration at SWTG2

At the time of peak concentration at SWTG2, a temporary exceedance of the SSTV occurs within the immediate vicinity of the pit for the 1%AEP event. There is no exceedance for the 0.1%AEP event at that time of maximum concentration at SWTG2.

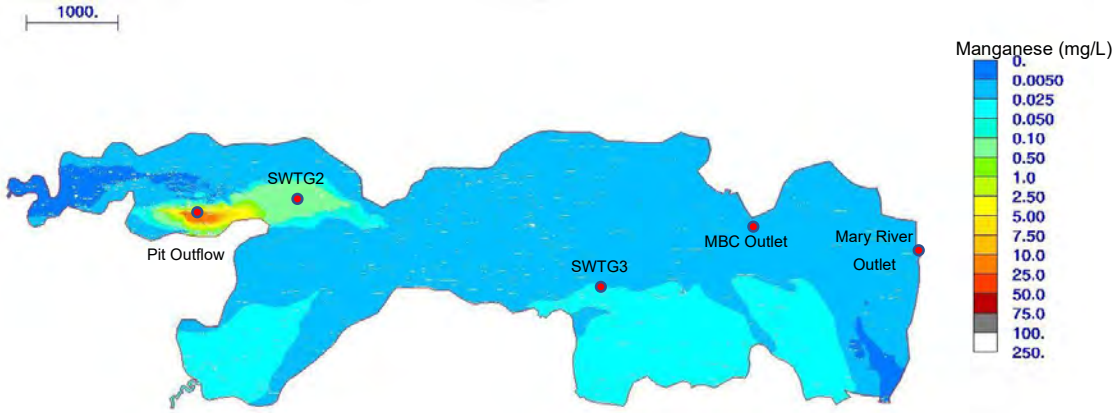

Figure 87. Contour plot at peak concentration at SWTG2 for Manganese, 1%AEP, Day 1 14:15

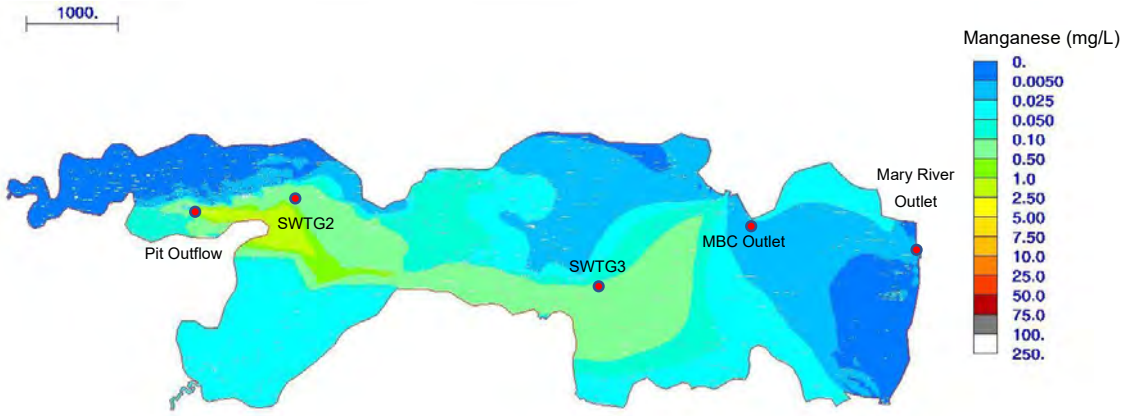

Figure 88. Contour plot at peak concentration at SWTG2 for Manganese, 0.1%AEP, Day 2 10:30

E.17.1 Nickel

E.17.1. Time Series

The median concentration for Nickel exceeds the TV (0.017 mg/L) for SWTG2 (0.0345 mg/L), and the maximum peak also spikes over the TV for both SWTG2 (0.0505 mg/L, Day 1 14:15) and SWTG3 (0.0193 mg/L, Day 3 6:45).

The high median concentration is primarily due to the tail end of the graph, which is caused by low flows that are unable to transport the contaminant. Once the low flow periods are discounted (model does not handle low flows well), the median concentration during the event (Day 1 to Day 2 15:30) is only 0.0039 mg/L, which is below the TV.

The median concentrations for the 0.1%AEP event do not exceed the TV limits, although the maximum peak exceeds briefly for SWTG2 (0.033 mg/L, Day 2 10:30) and SWTG3 (0.033 mg/L, Day 2 22:15).

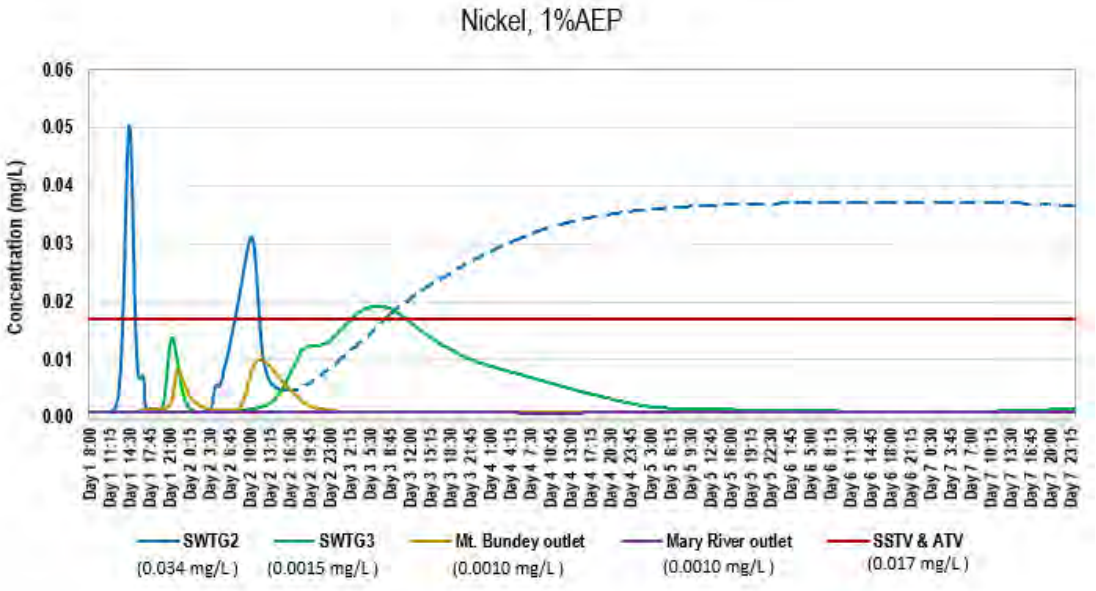

Figure 89. 1%AEP time series for Nickel plume. The dashed blue line indicates uncertainty in this part of the time series.

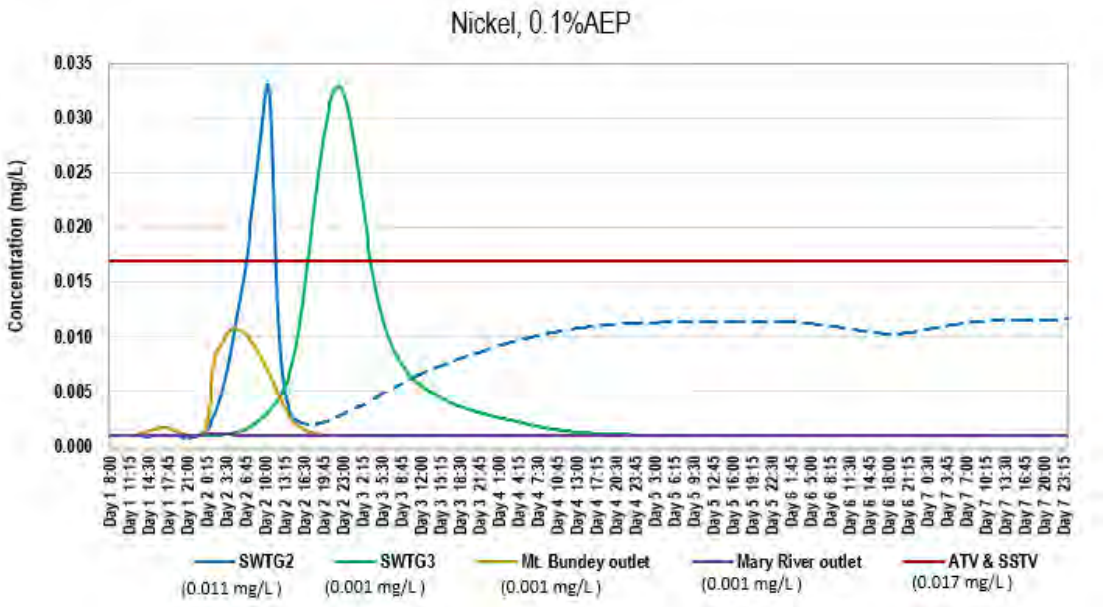

Figure 90. 0.1%AEP time series for Nickel plume. The dashed blue line indicates uncertainty in this part of the time series.

E.17.2. Contour plot at peak concentration at SWTG2

The SSTV for Nickel is exceeded temporarily on and off site within the plume around the pit and SWTG2 at the time of peak concentration at SWTG2 for the 1%AEP event.

For the 0.1%AEP event the SSTV is temporarily exceeded across large portions of the model domain especially within the plume extending from the pit towards SWTG3 and the Mt Bundey Ck outlet, including exceedances occurring south of SWTG2, at that point in time.

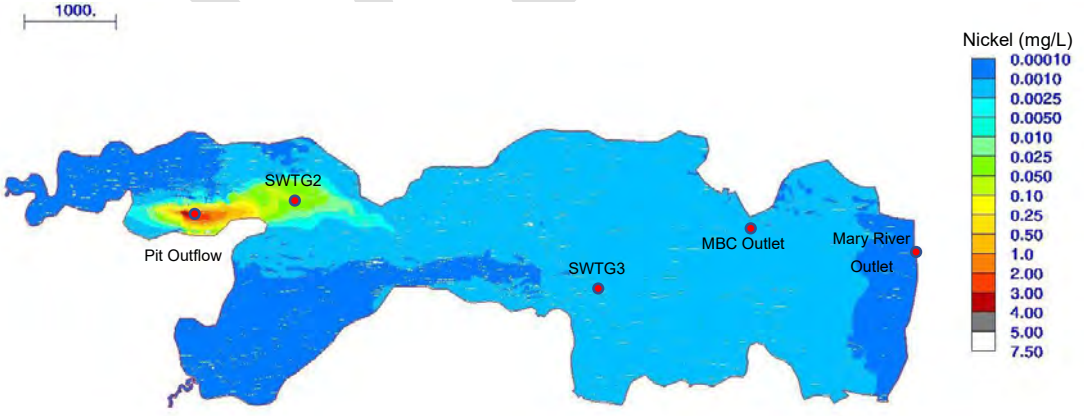

Figure 91. Contour plot at peak concentration at SWTG2 for dissolved Nickel, 1%AEP, Day 1 14:15

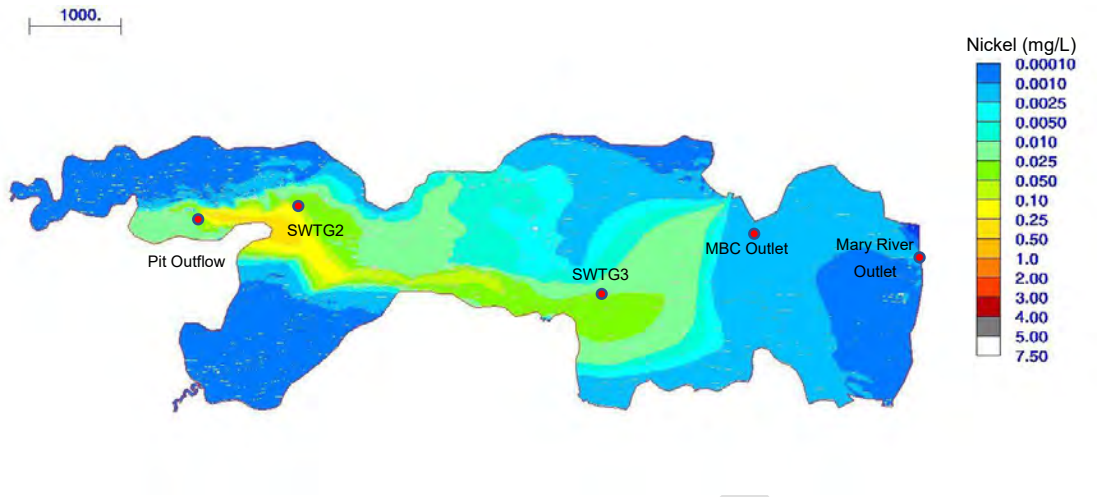

Figure 92. Contour plot at peak concentration at SWTG2 for dissolved Nickel, 0.1%AEP, Day 2 10:30

E.18. Uranium

E.18.1. Time Series

The median concentration for Uranium significantly exceeds the TV (0.0005 mg/L) for SWTG2 (0.0130 mg/L) and SWTG3 (0.000682 mg/L). The maximum peaks also exceed the TV, for SWTG2 (0.0190 mg/L, Day 14:15), SWTG3 (0.00731 mg/L, Day 3 6:45), and Mt. Bundey Ck outlet (0.00371 mg/L, Day 2 11:30).

This indicates there is the potential for significant exceedance of this constituent, if the pit ever overflows with uncontrolled discharge. However, as noted earlier, the water balance modelling showed that the pit is unlikely to overflow even during wet climate scenarios, across 1000 years of simulation.

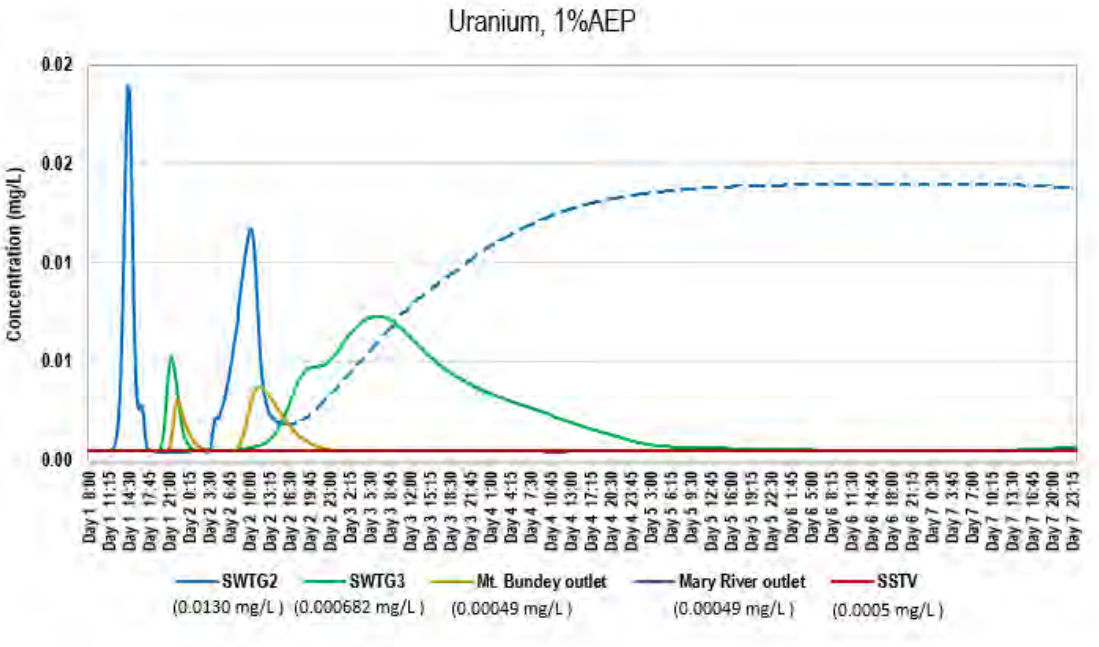

Figure 93. 1%AEP time series for Uranium plume. The dashed blue line indicates uncertainty in this part of the time series.

E.18.2. Contour plot at peak concentration at SWTG2

At the time of peak concentration at SWTG2, there are significant exceedances of the SSTV surrounding the pit and SWTG2 for the 1%AEP.

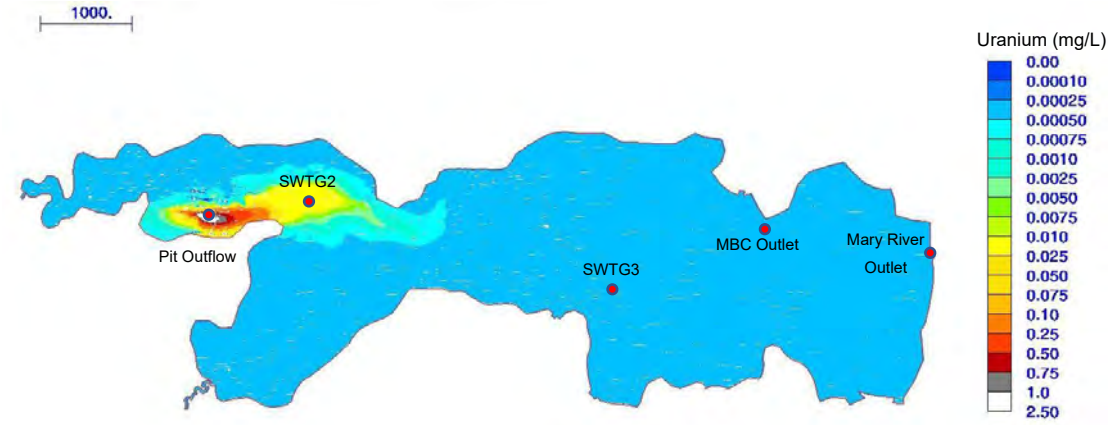

Figure 94. Contour plot at peak concentration at SWTG2 for dissolved Uranium, 1%AEP, Day 1 14:15

E.19. Zinc

E.19.1. Time Series

For the 1%AEP event the median concentration exceeds the TV (0.031 mg/L) for SWTG2 (0.139 mg/L), however, once the high concentration tail of the graph is discounted (model does not handle low flows well), the median concentration during the event drops to 0.0144 mg/L, which is below the TV. Similarly, for the 0.1%AEP event the median concentration at SWTG2 (0.043 mg/L) slightly exceeds the TV if the whole simulation period is considered. However, during the event the median concentration (0.006 mg/L) falls below TV (median concentration considering only up to Day 2 15:30, before the low flow).

The maximum peak at SWTG2, SWTG3, and Mt Bundey Ck outlet all also significantly exceeded the TV for the 1%AEP (SWTG2: 0.203 mg/L, Day 1 14:15; SWTG3: 0.0834 mg/L, Day 3, 9:00; Mt Bundey Ck outlet: 0.114 mg/L, Day 1, 20:00) and the 0.1%AEP event (SWTG2: 0.130 mg/L, Day 2, 23:00; SWTG3: 0.136 mg/L, Day 3, 9:00; Mt Bundey Ck outlet: 0.0116 mg/L, Day 1 16:30).

The higher peak Zinc concentrations at Mt Bundey Ck outlet and SWTG3 during the 0.1%AEP event (compared to the 1%AEP event) are caused by higher Zinc concentrations from natural upstream inlets (US_03 to US_06) during the higher flood event.

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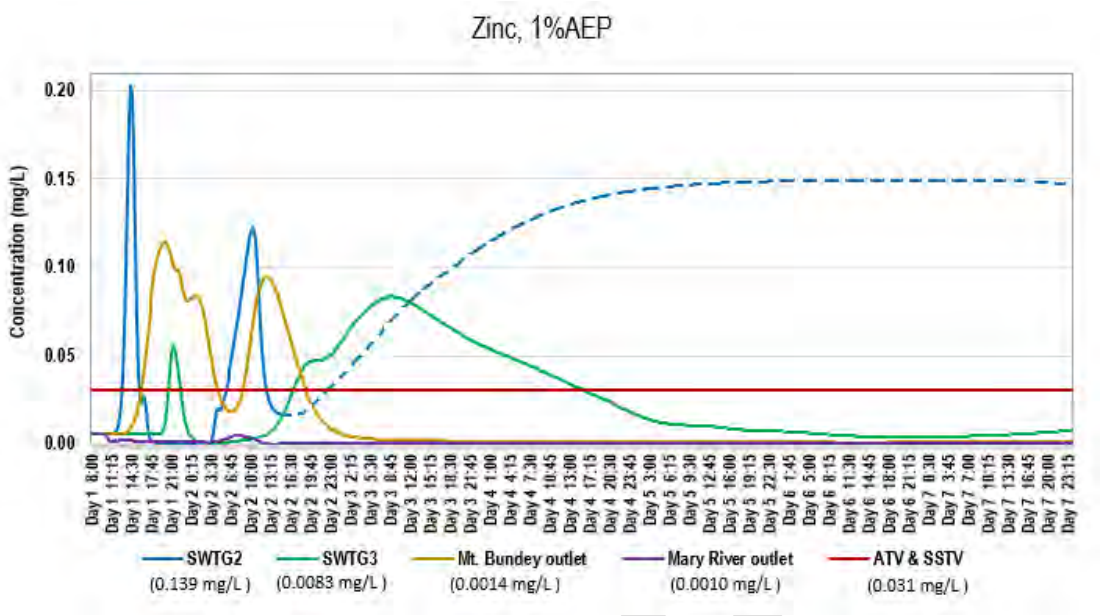

Figure 95. 1%AEP time series for Zinc plume. The dashed blue line indicates uncertainty in this part of the time series.

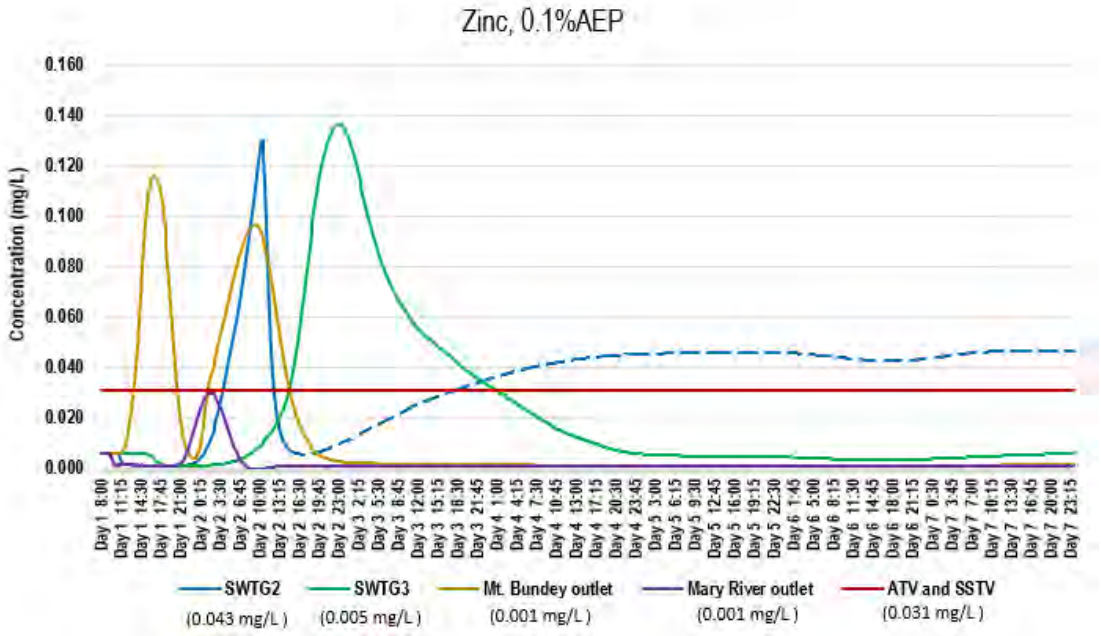

Figure 96. 0.1%AEP time series for Zinc plume. The dashed blue line indicates uncertainty in this part of the time series.

E.19.2. Contour plot at peak concentration at SWTG2

For the 1%AEP event, exceedances occur in the area surrounding the pit and SWTG2 and along the inlets US_03 to US_05 extending towards the Mt Bundey Ck outlet at the time of maximum concentration at SWTG2.

For the 0.1%AEP event, temporary exceedances occur across large areas of the model domain extending from the pit towards Mt Bundey and Mary River outlets at the time of maximum concentration at SWTG2.

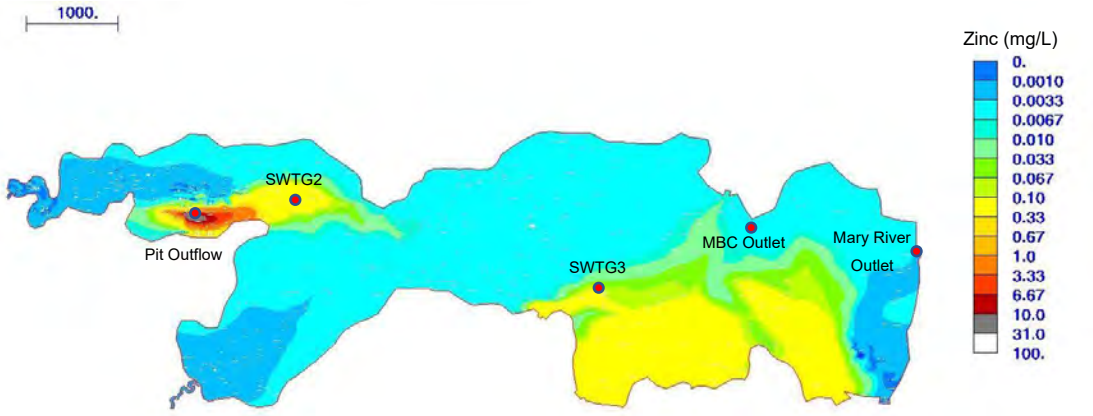

Figure 97. Contour plot at peak concentration at SWTG2 for Zinc, 1%AEP, Day 1 14:15

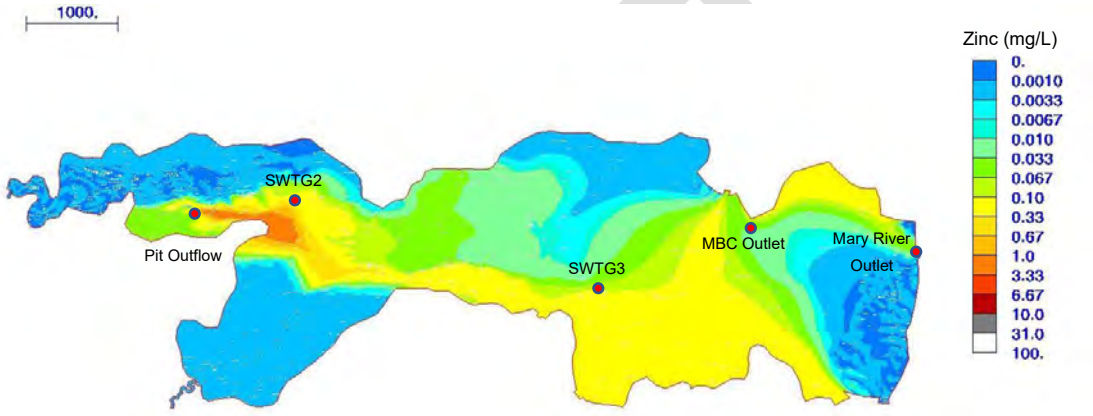

Figure 98. Contour plot at peak concentration at SWTG2 for Zinc, 0.1%AEP, Day 2 10:30

Appendix F. CAESAR-LisFlood Modelling

F.1. Catchment setup

Due to the size of the catchments, the Mt Bundey Ck mine catchment, Coulter Ck mine catchment, and upper Mt Bundey and upper Coulter Ck catchments were simulated separately to conserve processing power. Each of these catchments were also split into component subcatchments. Refer to Figure 99 and Figure 100 for the subcatchment plans for the Mt Bundey Ck and Coulter Ck upper and lower catchments.

F.2. Model Setup and Simulation

Due to the size of the catchments, a cascading subcatchment approach was taken during the modelling. The parameter values fitted during the calibration process were used in the final scenarios.

It was assumed that the UMBC and UCC catchments consisted of Koolpinyah surface with uniform Mannings' n everywhere, except for UMBC SC9 where different Mannings' n values were assigned to the creek channel and floodplain (Creek channel n=0.06, Creek floodplain n=0.12, Koolpinyah Surface n=0.1). However, different Mannings' n values were assigned across the Mt Bundey Ck and Coulter Ck mine catchments to provide better resolution and account for the different surface types that will be present on the site post-closure. Refer to Figure 101 for the spatial distribution of Mannings' n assigned across the mine site.

Each simulation was separated to consider both the combined effects of mine site runoff and upstream inputs from the UMBC and UCC, as well as the effect of only the runoff generated on-site to isolate the effect of the mine site landforms.

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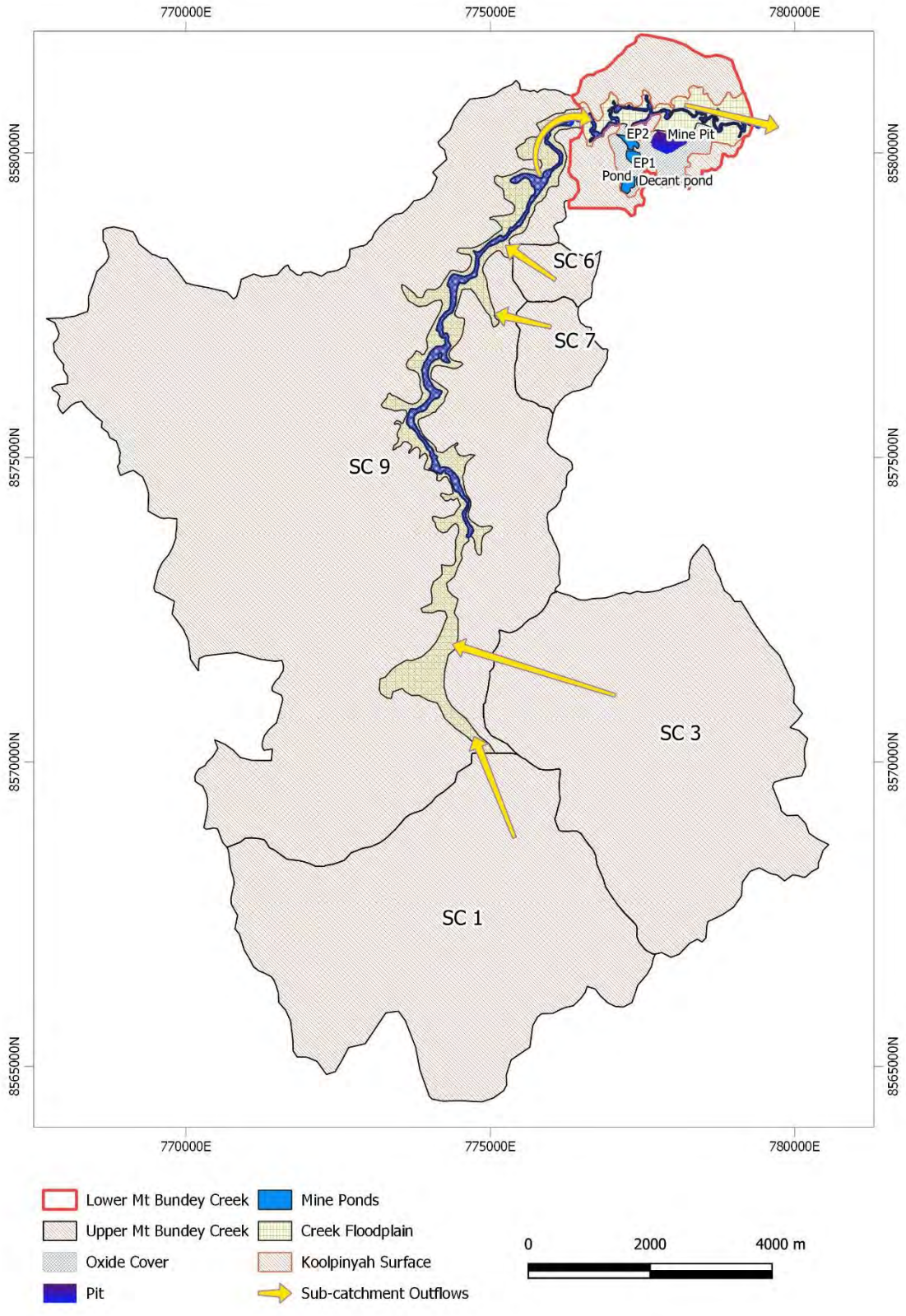

Figure 99. Mt Bundey Creek upper (upstream) and lower (mine site) catchments including subcatchments

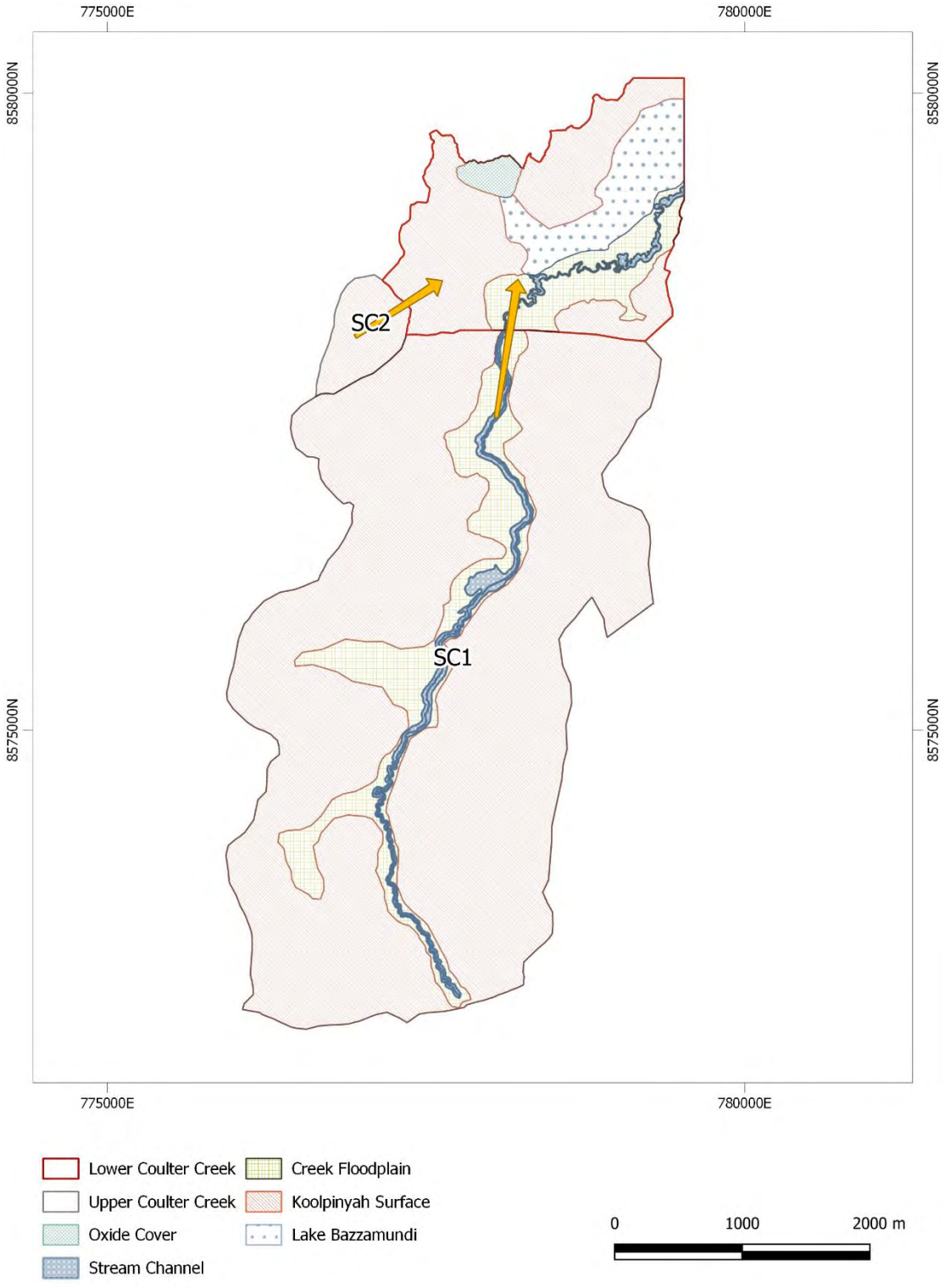

Figure 100. Coulter Creek upper (upstream) and lower (mine site) catchments including subcatchments

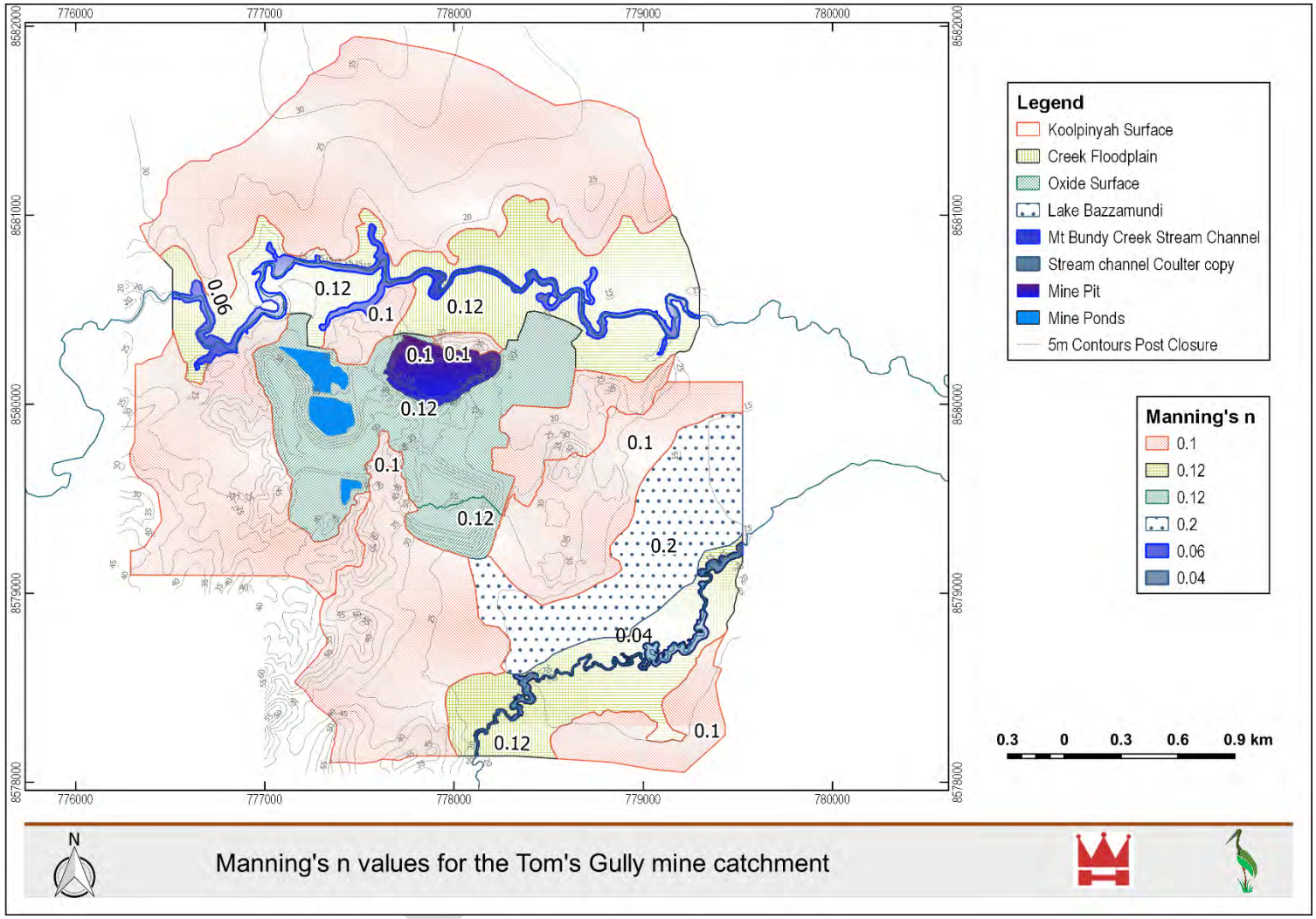

Figure 101. Manning's n values spatial distribution for Tom's Gully Mine Site catchment

F.3. Erosion and water depth

F.3.1. 1%AEP – Mt Bundey Ck

The simulation with just the mine site runoff shows minor erosion occurring along the existing drainage lines (Figure 102), and on the Koolpinyah Surface north of Mt Bundey Creek within the existing stream channels. Minor deposition occurs at the confluence of drainage channels, both on the disturbed mine surfaces and on the undisturbed Koolpinyah Surface. This is a usual fluvial geomorphic process. Peak sediment concentration (C) at the outlet is 30mg/L, which falls within the range of observed values in the region.

There is only minor flooding occurring downstream during peak discharges; some overbank flow and oxbow wetland inundation. Channelised flow occurs along the eastern toe of the oxide cover in the TSF 2 area (Figure 103).

The simulation with combined runoff from the mine site and inflows from the UMBC shows some deposition in the upper reaches of the creek and scour in the lower reaches (Figure 104). There are higher levels of erosion on the right bank (RB) floodplain, and minor erosion on the mine site where flow drains along the oxide cover, east of TSF 2. Erosion and deposition in the drainage channels from the mine show little difference from the drainage channels on the Koolpinyah Surface. Peak C at the domain outlet is still 30mg/L.

For peak discharges (Figure 105), the oxbow wetland is inundated both from overbank flow and flow from the oxide cover. The toe of the oxide cover near EP2 is inundated and deposition occurs as well as minor sheet erosion.

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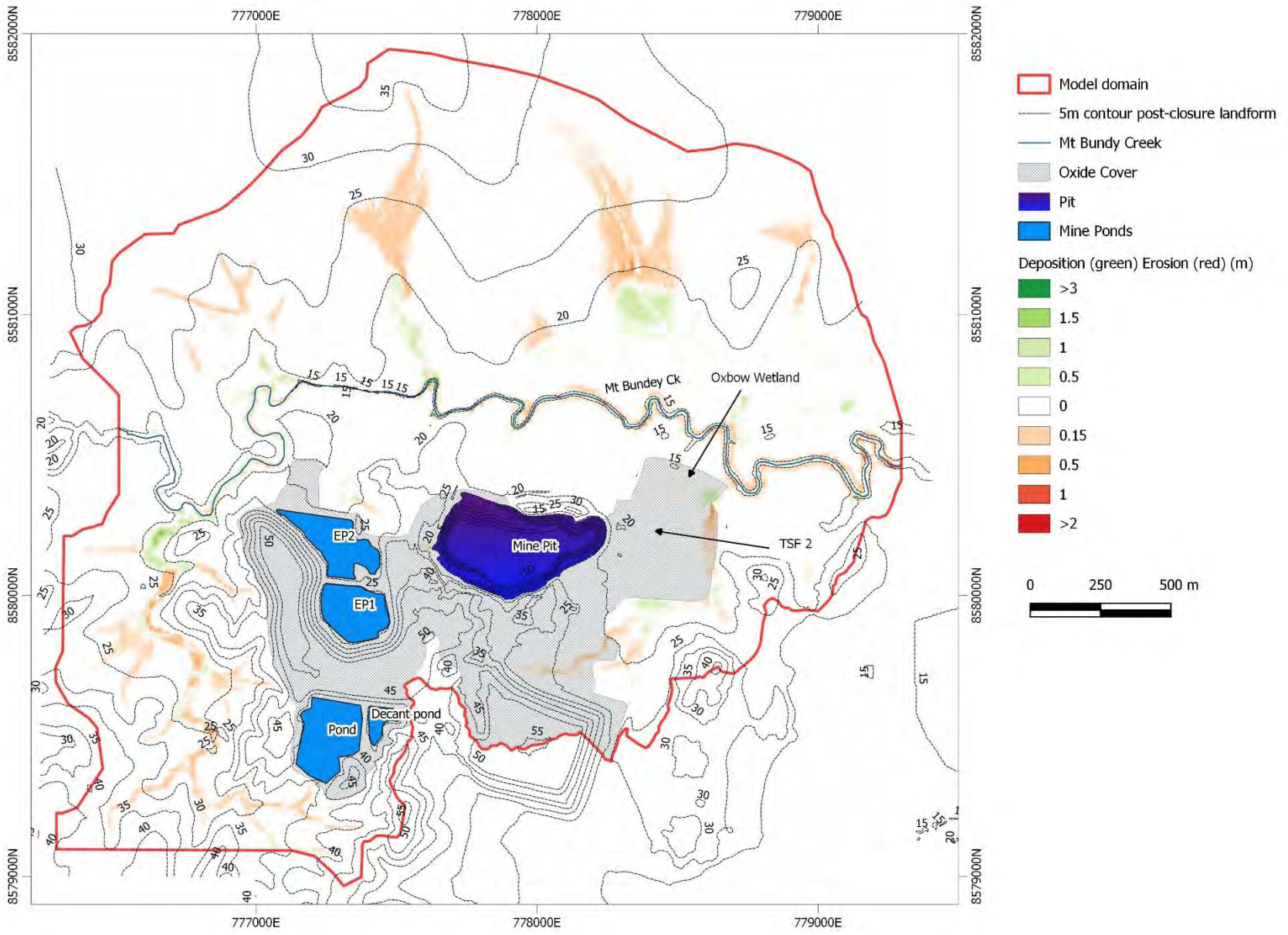

Figure 102. Erosion and deposition simulation for a 1%AEP rainfall event, Mt Bundey Ck (no UMBC inputs, only rainfall runoff from the post-mine landform)

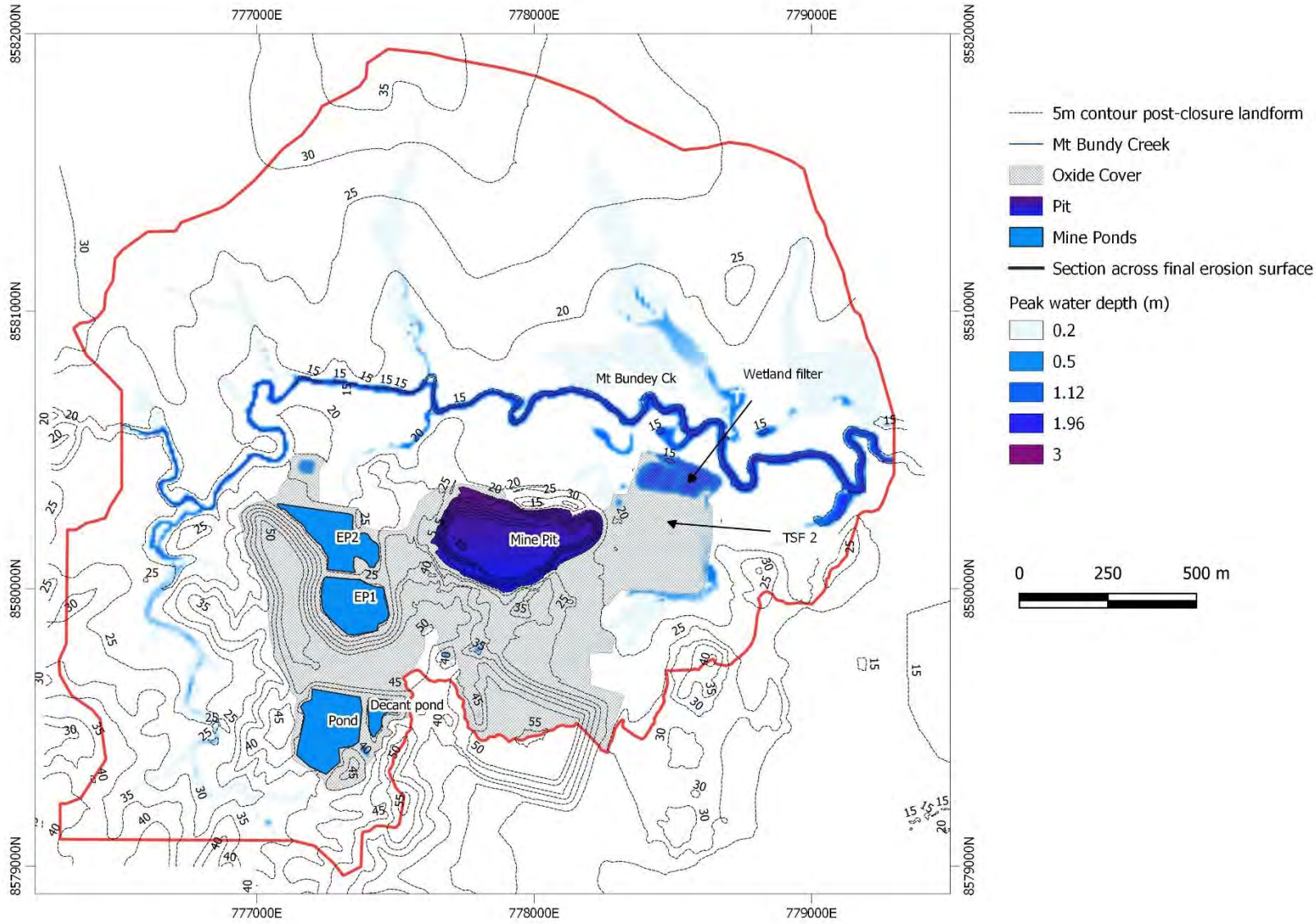

Figure 103. Water depth at peak discharge for a 1%AEP rainfall event, Mt Bundey Ck (no UMBC inputs, only rainfall runoff from the post-mine landform).

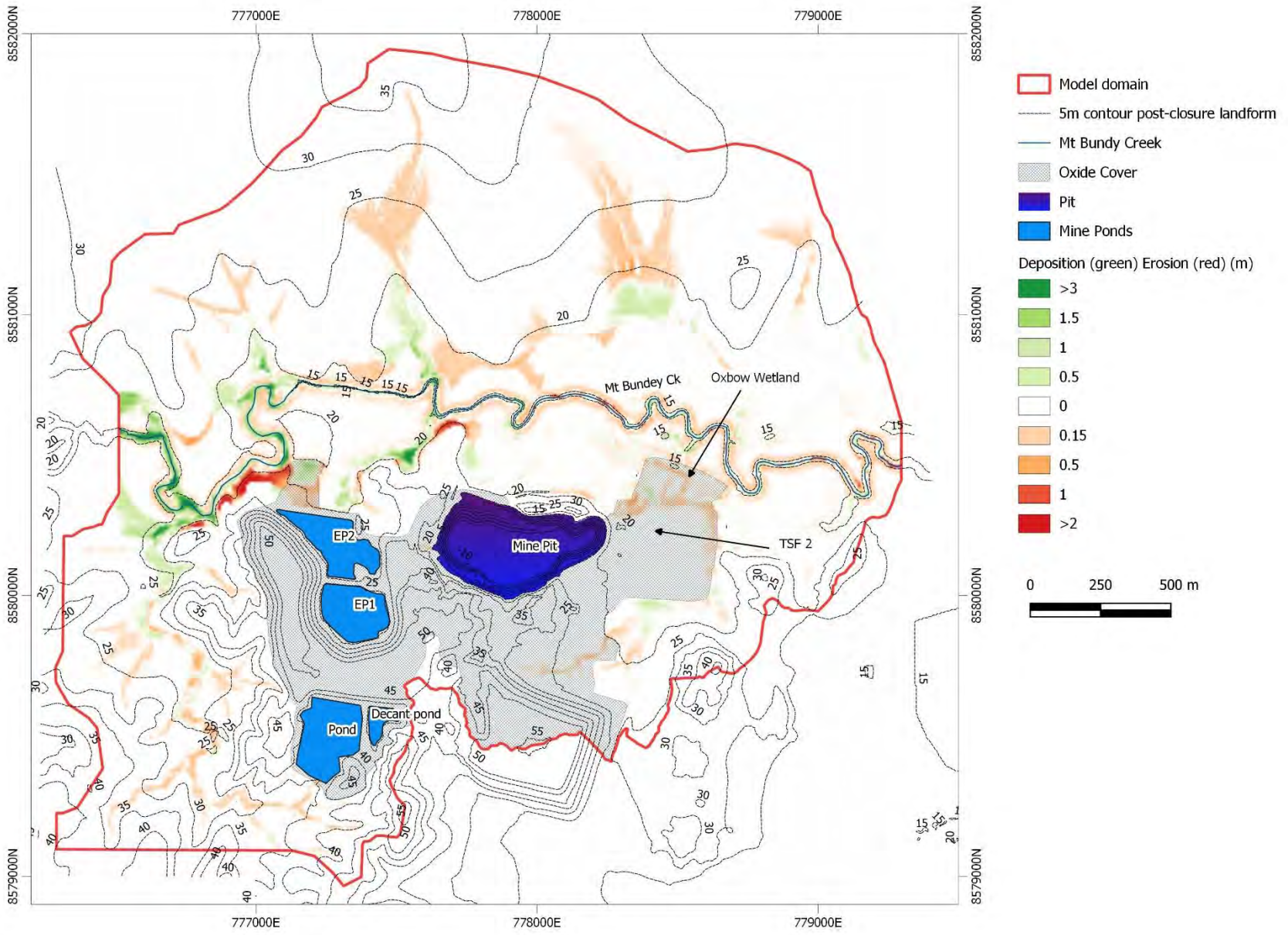

Figure 104. Erosion and deposition simulation for a 1%AEP rainfall event, Mt Bundey Ck (with UMBC inputs and rainfall runoff from the post-mine landform).

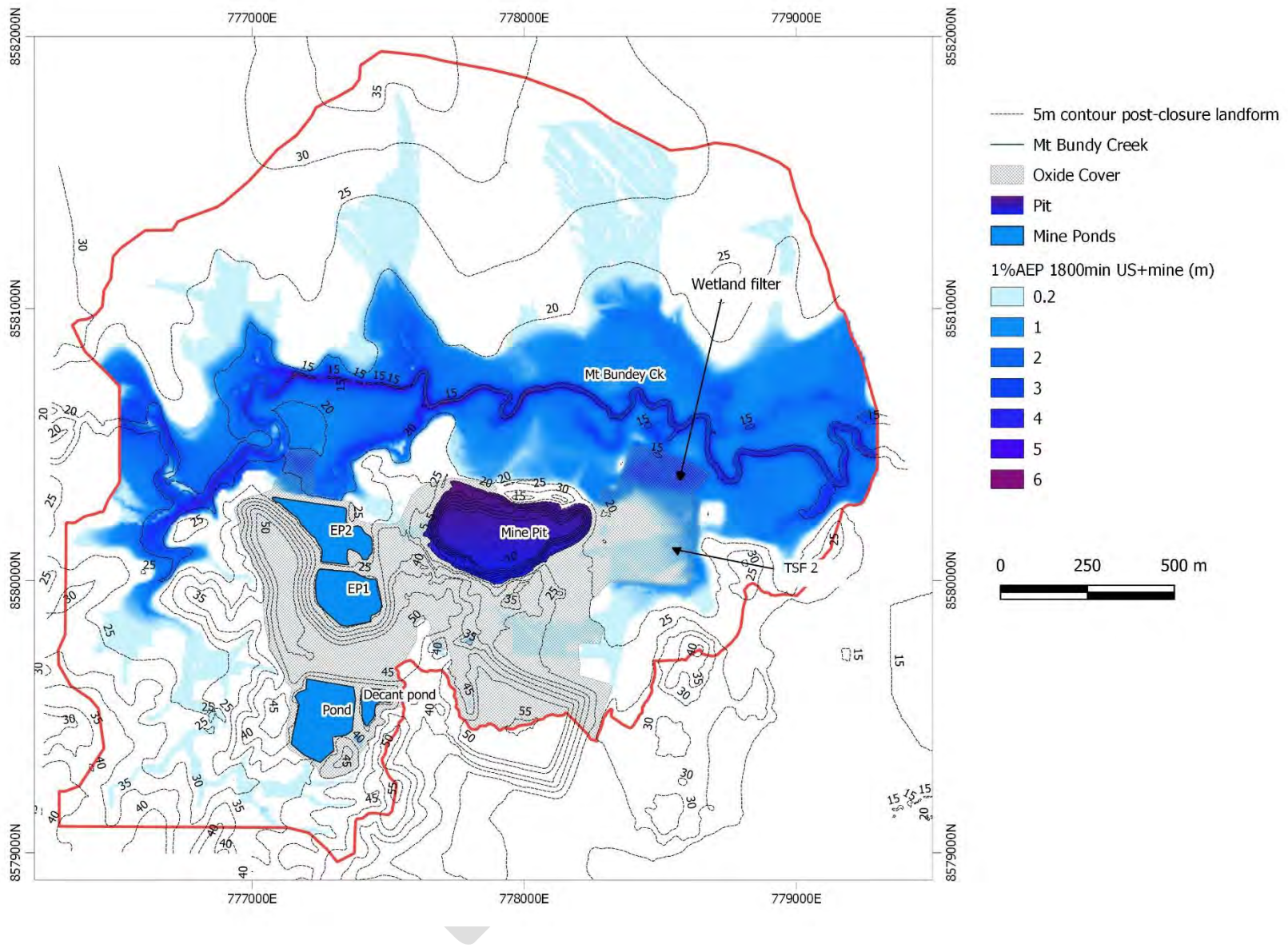

Figure 105. Water depth at peak discharge for a 1%AEP rainfall event, Mt Bundey Ck (with UMBC discharge and mine rainfall runoff).

F.3.2. 0.1%AEP – Mt Bundey Ck

The simulation with only the runoff from the mine site showed only minor erosion occurring in existing drainage lines (Figure 106) similar to the 1%AEP event. Peak C was slightly higher than the 1%AEP event at 31mg/L, however, it still falls within the range of observed values in the region. Flooding during peak discharges is slightly higher than the 1%AEP event but otherwise is similar in inundation extent (Figure 107).

The simulation combining runoff from both the mine site and the UMBC inflows shows deposition in the upper reaches of the creek and scour in the lower reaches (Figure 108), with higher erosion on the RB floodplain and overbank deposition near the western toe of the oxide cap near EP2. Up to 3m depth of erosion occurs in some locations where the creek banks collapse. On the left bank near the upstream inlet there is also high erosion and the model may be simulating a developing anabranch. This is a sinuous active stream, so bank failure, scour, and lateral movement of the channel are expected. This behaviour is likely due to the large upstream discharges, which suddenly change direction and reduce speed at a sharp 90° bend. There is only minor erosion on the mine site where flow drains along the oxide cover and runs to the east of TSF 2, and some channel backfilling occurs where drainage channels converge with the main channel. Erosion and deposition in the drainage channels from the mine show little difference from the drainage channels on the Koolpinyah Surface.

Peak C at the domain outlet is 31mg/L.

For peak discharges (Figure 109), inundation is extensive on both sides of the main channel. The oxbow wetland is inundated both from overbank flow as well as overland flow from the oxide cover, and the creek floodplain is inundated to the oxide cover near EP2.

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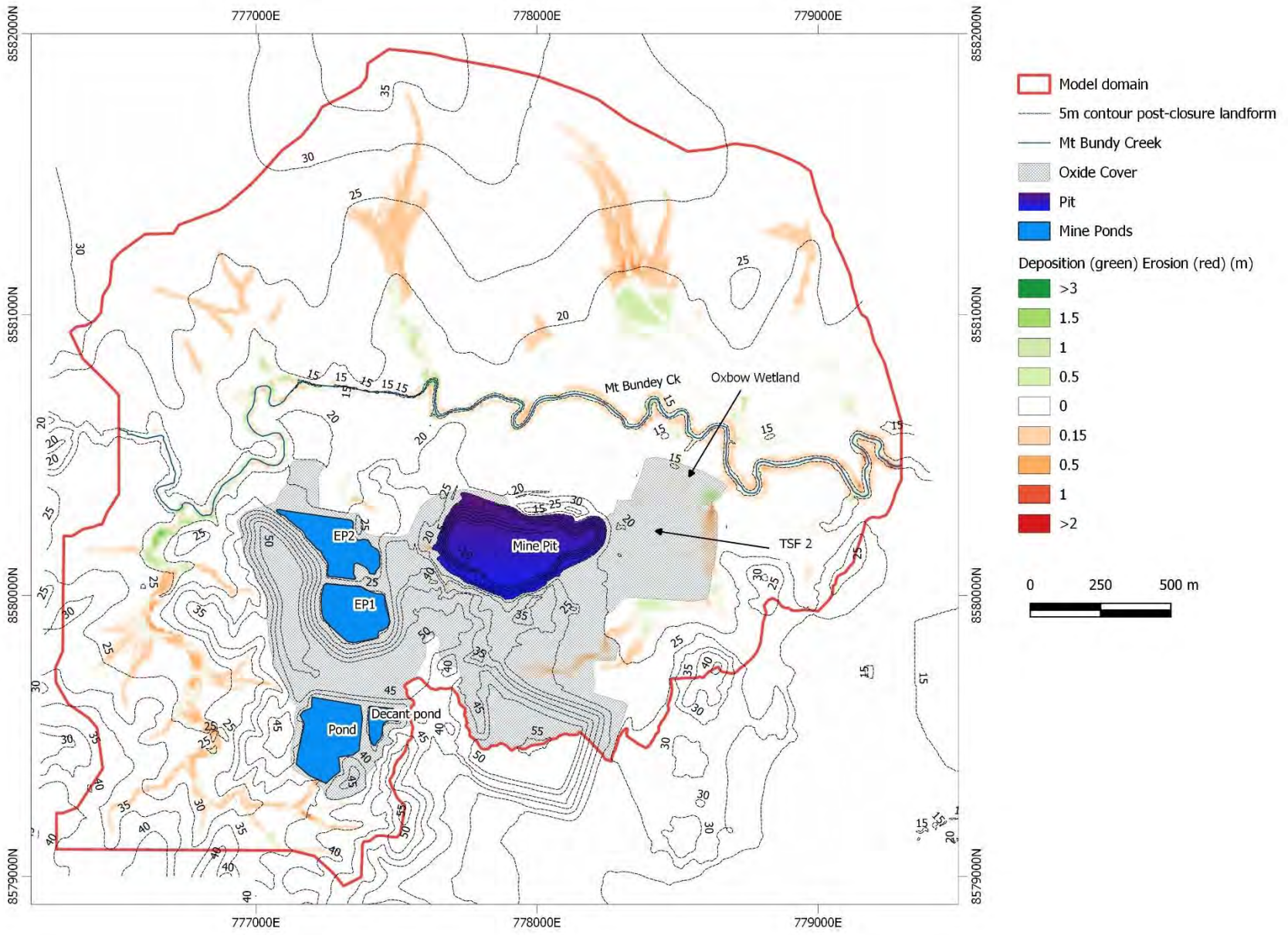

Figure 106. Erosion and deposition simulation for a 0.1%AEP rainfall event, Mt Bundey Ck, (no UMBC inputs and only rainfall runoff from the post-mine landform)

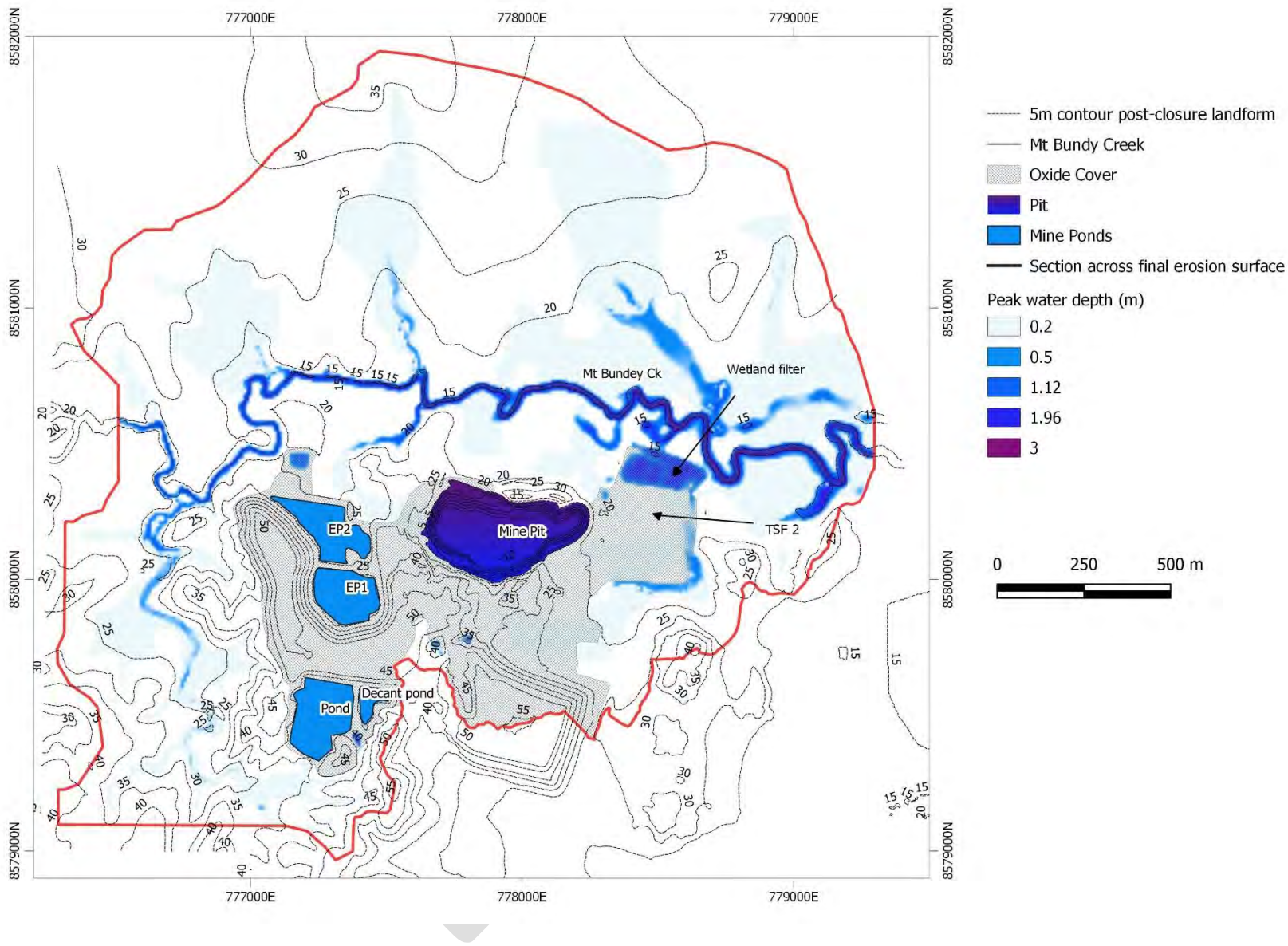

Figure 107. Water depth at peak discharge for a 0.1%AEP rainfall event, Mt Bundey Ck (no UMBC discharge and mine rainfall runoff)

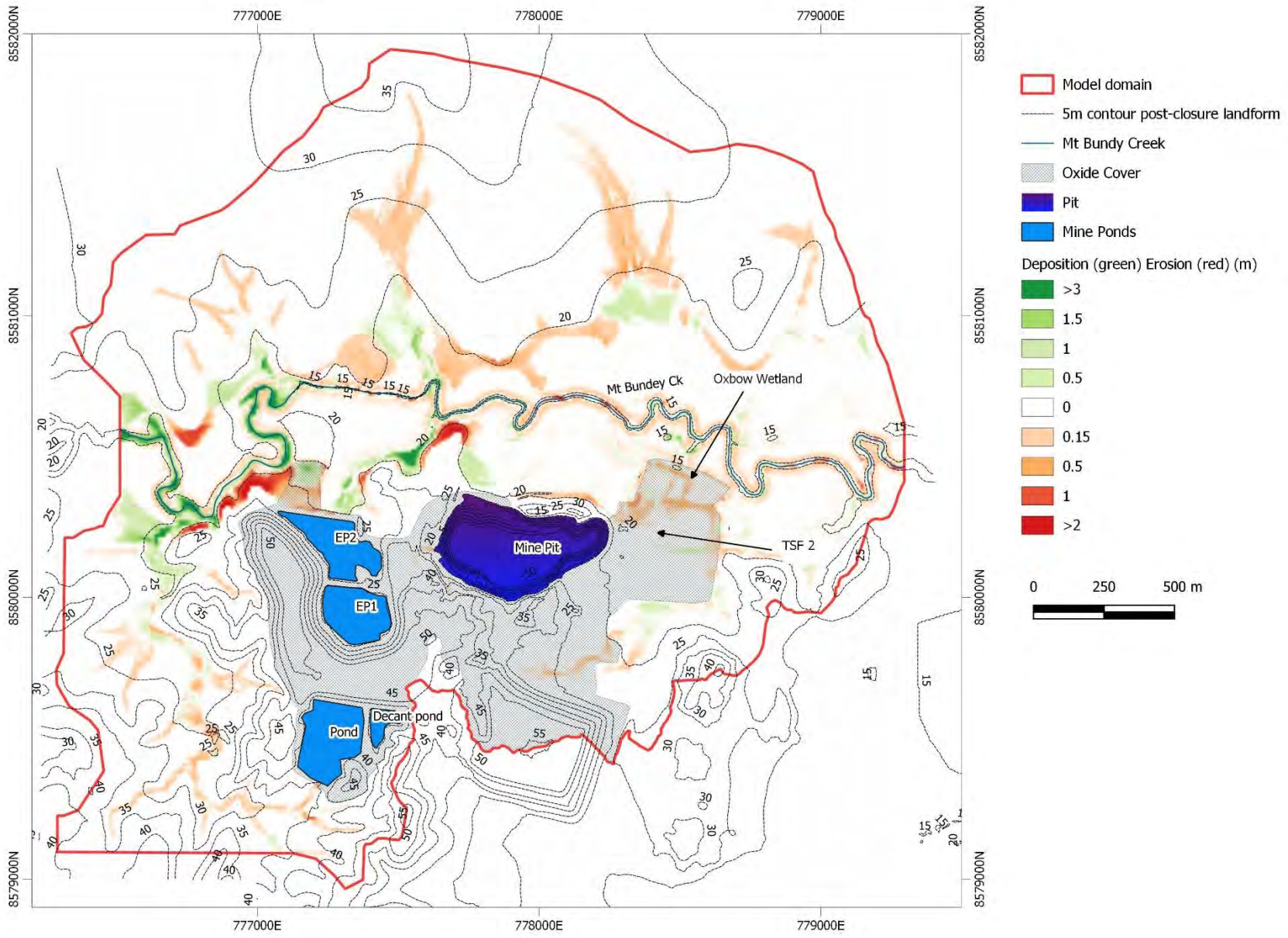

Figure 108. Erosion and deposition simulation for a 0.1%AEP rainfall event, Mt Bundey Ck (with UMBC inputs and rainfall runoff from the post-mine landform)

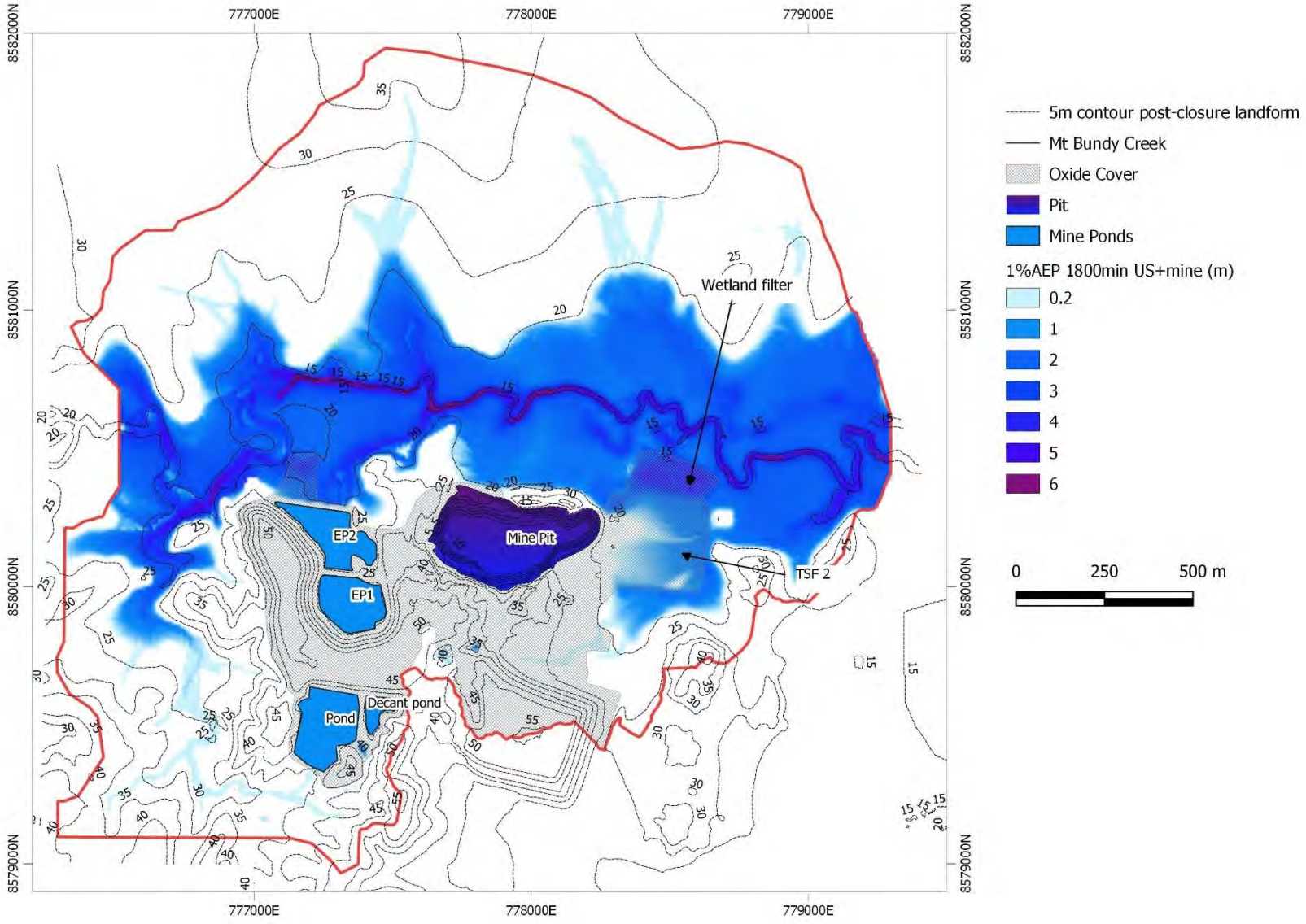

Figure 109. Water depth for a 0.1%AEP rainfall event, Mt Bundey Ck (with UMBC discharge and mine rainfall runoff)

F.3.3. Long term – Mt Bundey Ck

Wet Climate Scenario

Most of the erosion occurred in existing drainage channels on both sides of the creek (Figure 110). Deposition (green) occurs along the streambed mixed with areas of scour and erosion. Long term soil loss was 1.2 t/ha/yr and denudation rate was 0.04mm/yr.

Dry Climate Scenario

The simulations indicate that the landform has similar erosion rates to surrounding undisturbed land. The location of erosion and deposition (Figure 111) was similar to the wet climate scenario. Long term sediment loss was 1 t/ha/yr and denudation rate 0.036 mm/yr, falling within the range of expected values for the region.

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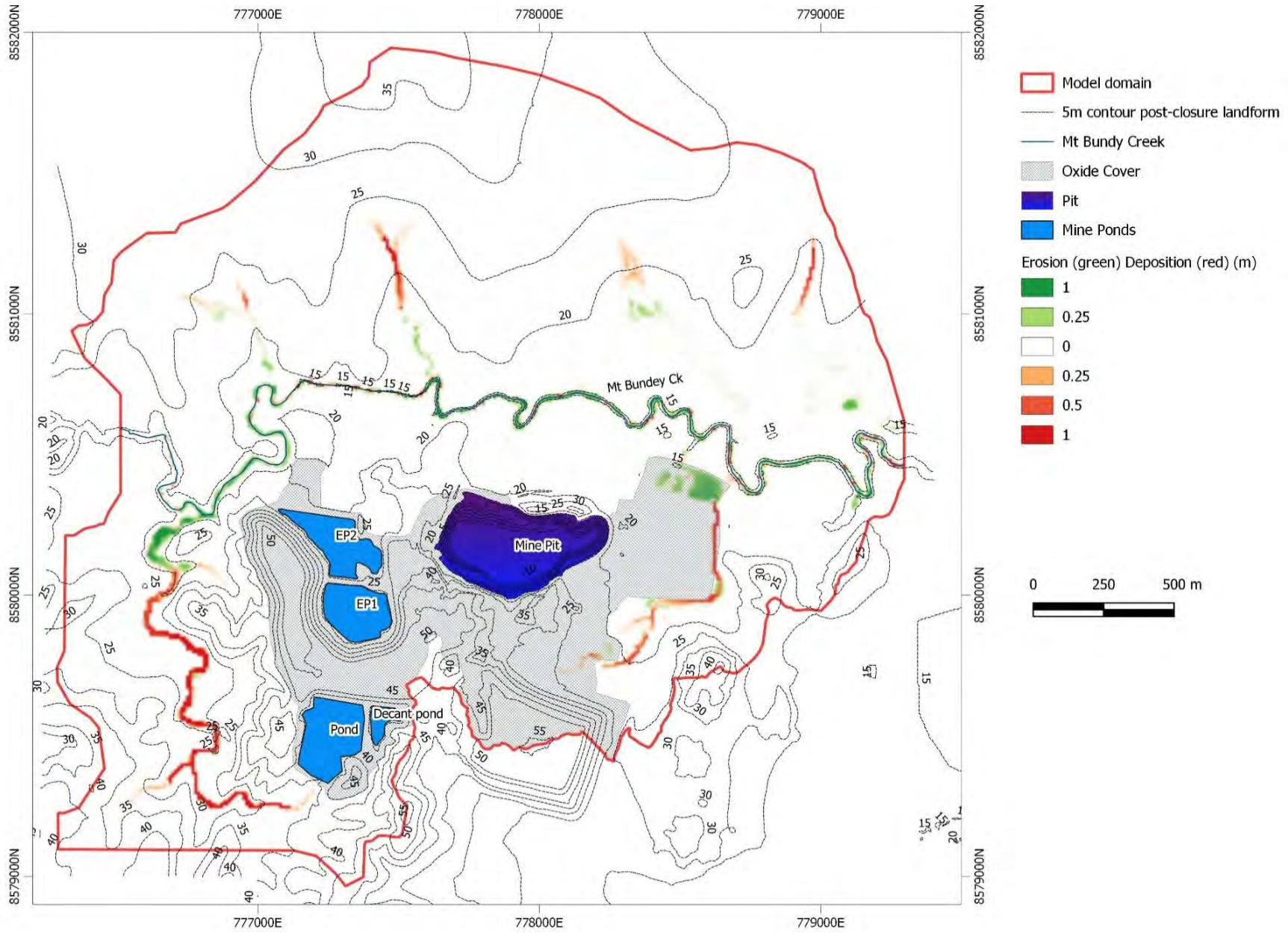

Figure 110 Erosion and deposition simulation for a for 100-year wet climate scenario with only rainfall applied

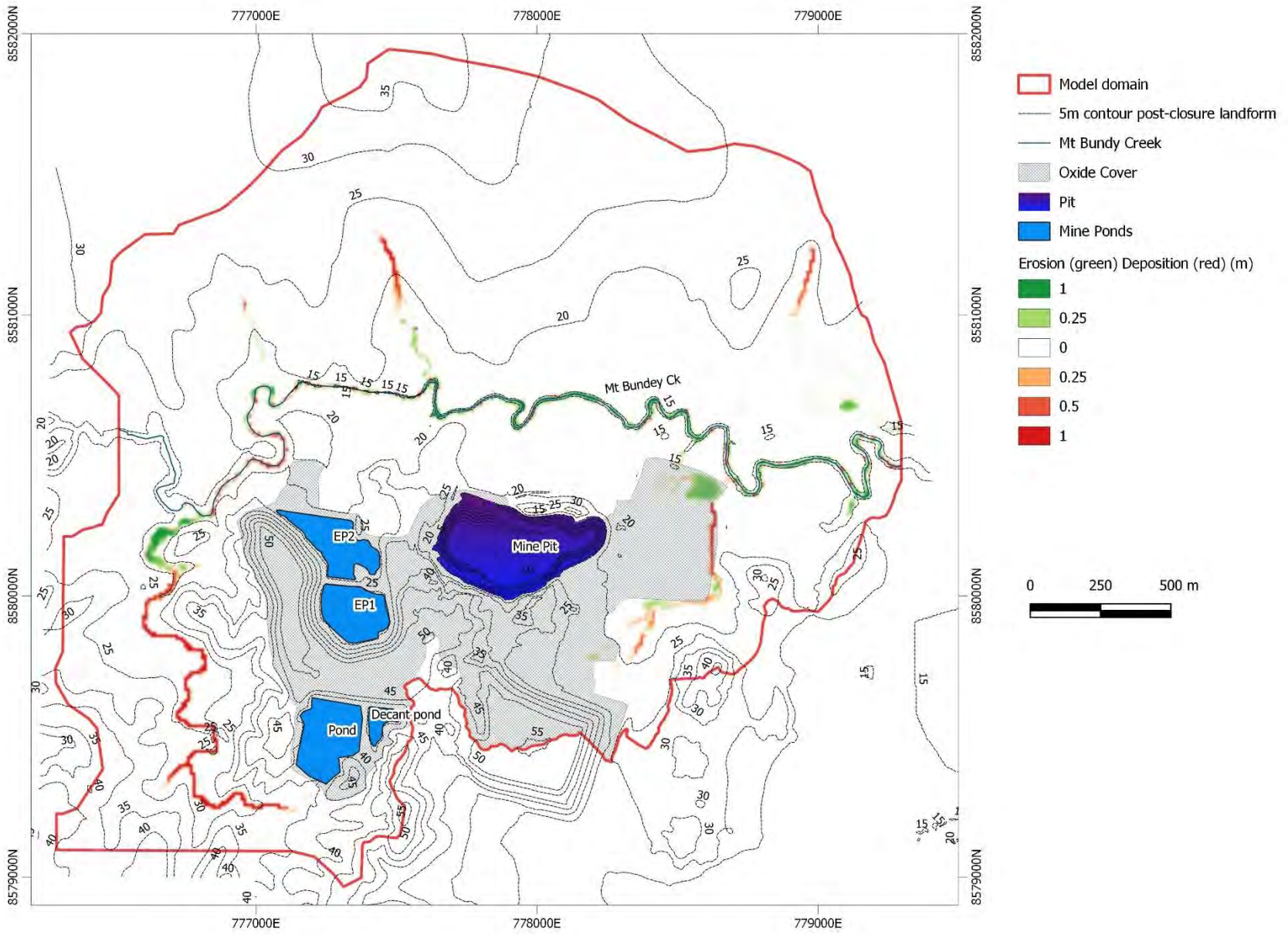

Figure 111. Erosion and deposition simulation for a for 100-year dry climate scenario with only rainfall applied

F.3.4. 1%AEP – Coulter Ck

The simulation with only the mine site runoff (Figure 112) showed minor erosion exceeding 0.3m occurring along the eastern catchment outlet of the existing Coulter Creek (CC) drainage line, as well as within existing natural stream channels exceeding 0.25m on the Koolpinyah surface, west and north of Lake Bazzamundi. The northern end of the bund has eroded through in one location. Minor deposition occurs around the boundaries of Lake Bazzamundi.

Peak C at the outlet is 38 mg/L, which is similar to the peak C at the Mt Bundey outlet, and falls within the range of observed values for this region.

During peak discharges (Figure 113), there is some overbank flow along Coulter Ck, and inundation of Lake Bazzamundi, although the water level does not overtop the bund. There is, however, some outflow from Lake Bazzamundi through the eroded channel in the bund.

The simulation with combined runoff from the upstream inflows and the mine site (Figure 114) has erosion along the natural channel lines of up to approximately 0.4m, and within the creek floodplain and creek channel, with erosion depth exceeding 0.6m in the lower reaches. High deposition within the upper CC reaches causes minor shift in drainage channel alignment, forming new channels with depths exceeding 1.9m, however, this is due to the upstream inputs, not runoff from the mine site itself. Some deposition also occurs within Lake Bazzamundi. Peak C at the outlet is 26 mg/L. For peak discharges (Figure 115), the extent of inundation for Lake Bazzamundi and Coulter Creek riparian zone is greater, and the water level overtops the bund in Lake Bazzamundi.

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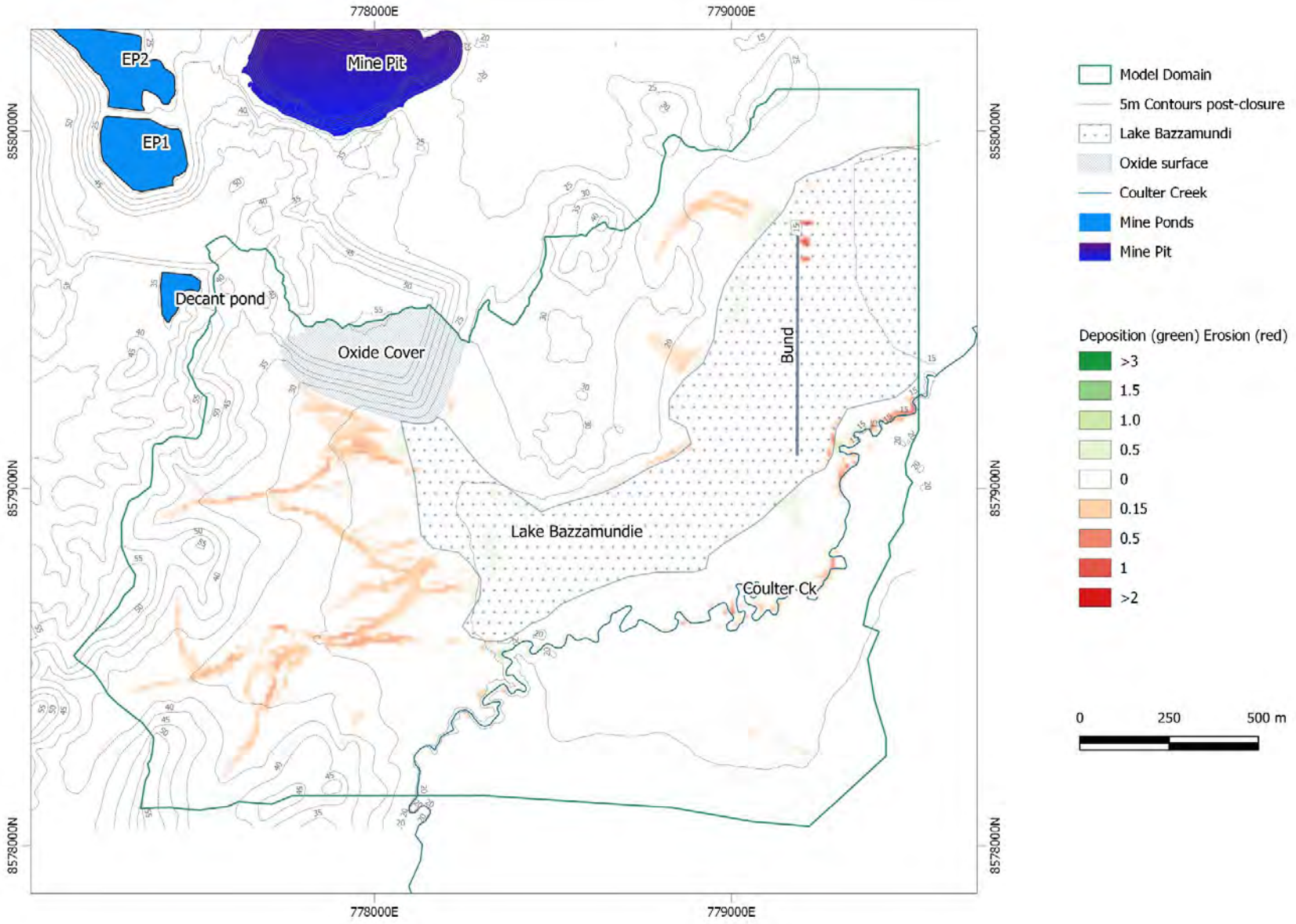

Figure 112. Erosion and deposition simulation for a 1%AEP rainfall event, Coulter Ck, (no UMBC inputs and only rainfall runoff from the post-mine landform)

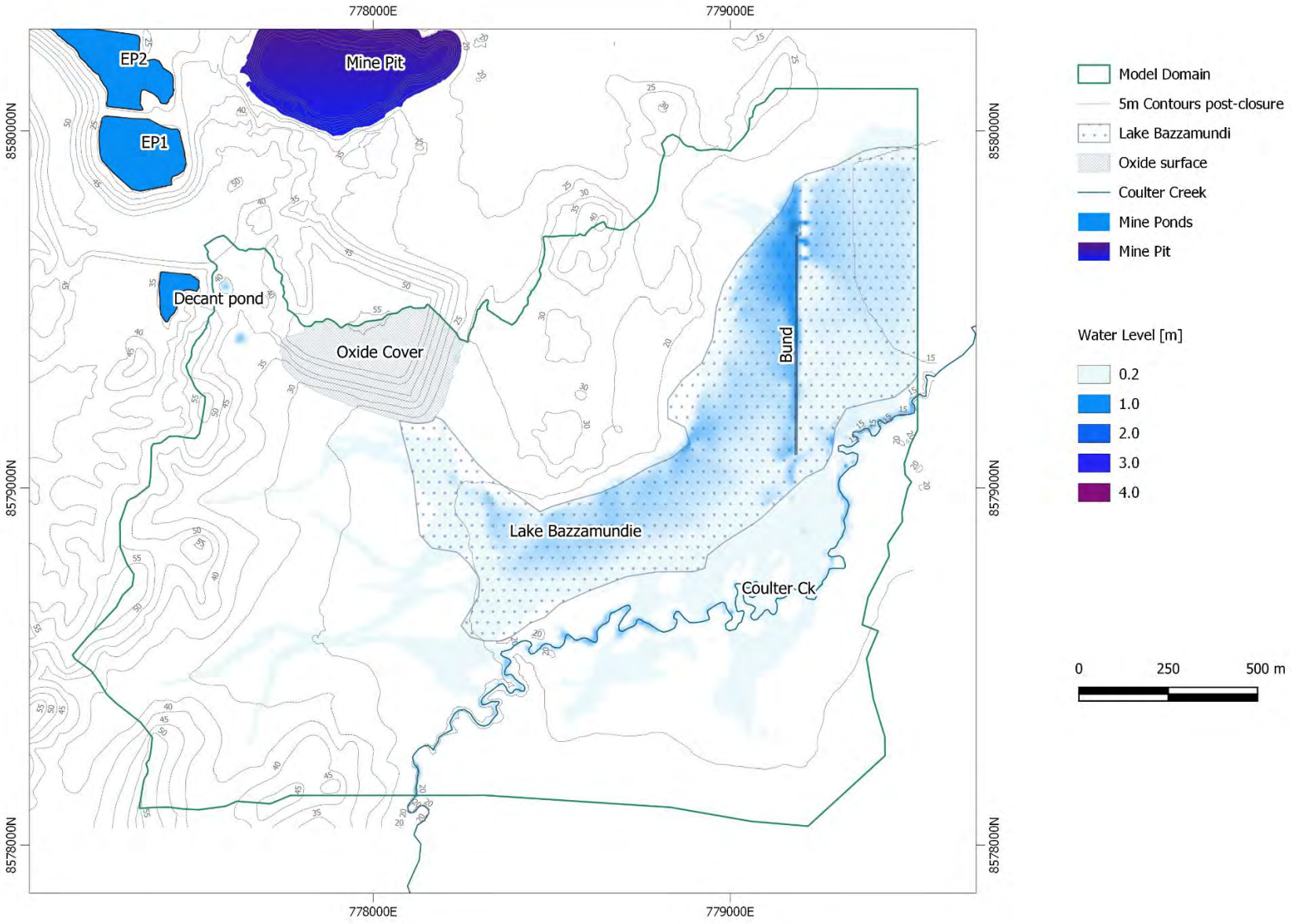

Figure 113. Water depth at peak discharge for a 1%AEP rainfall event, Coulter Ck (no UMBC inputs, only rainfall runoff from the post-mine landform)

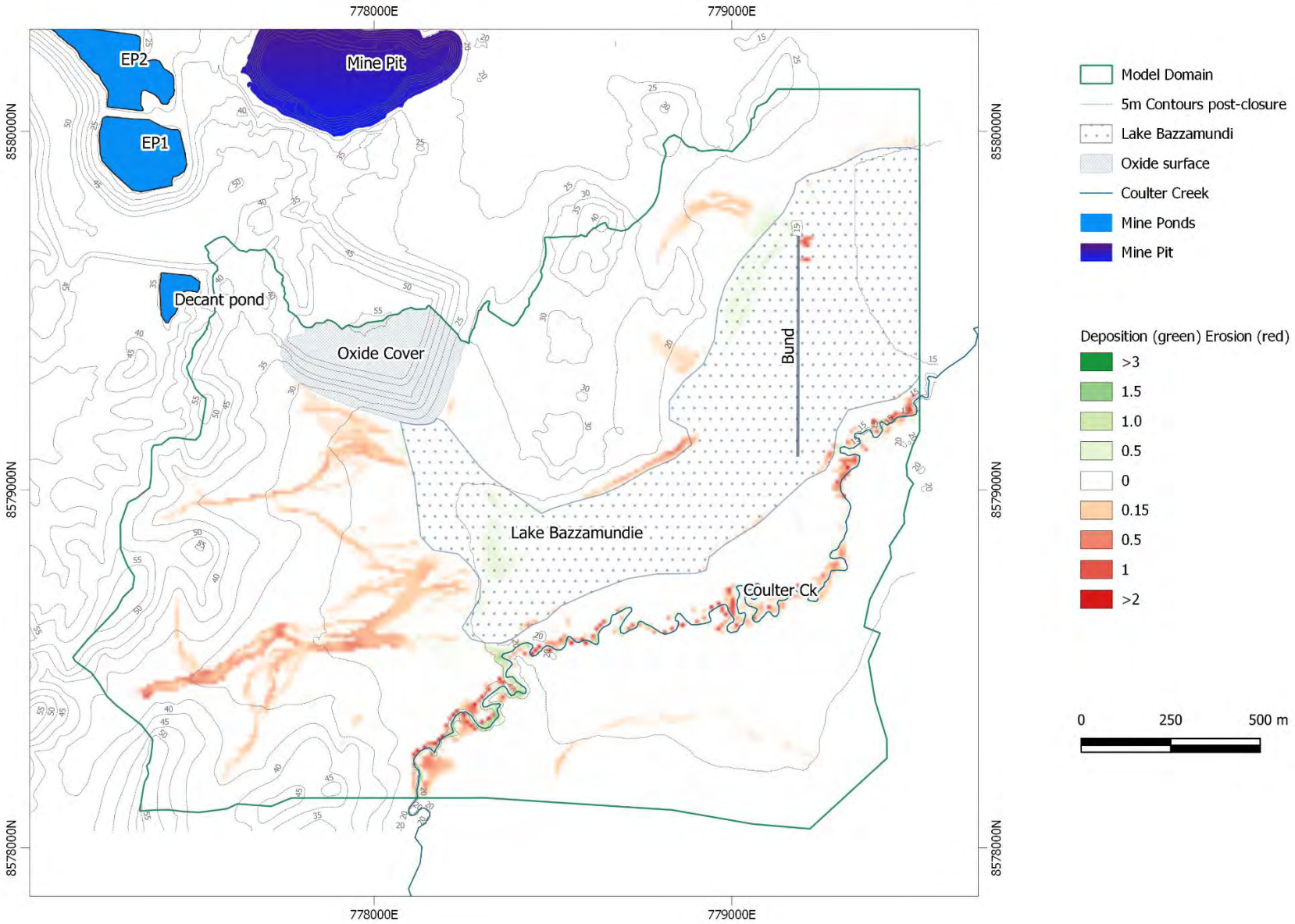

Figure 114. Erosion and deposition simulation for a 1%AEP rainfall event, Coulter Ck (with UMBC inputs and rainfall runoff from the post-mine landform)

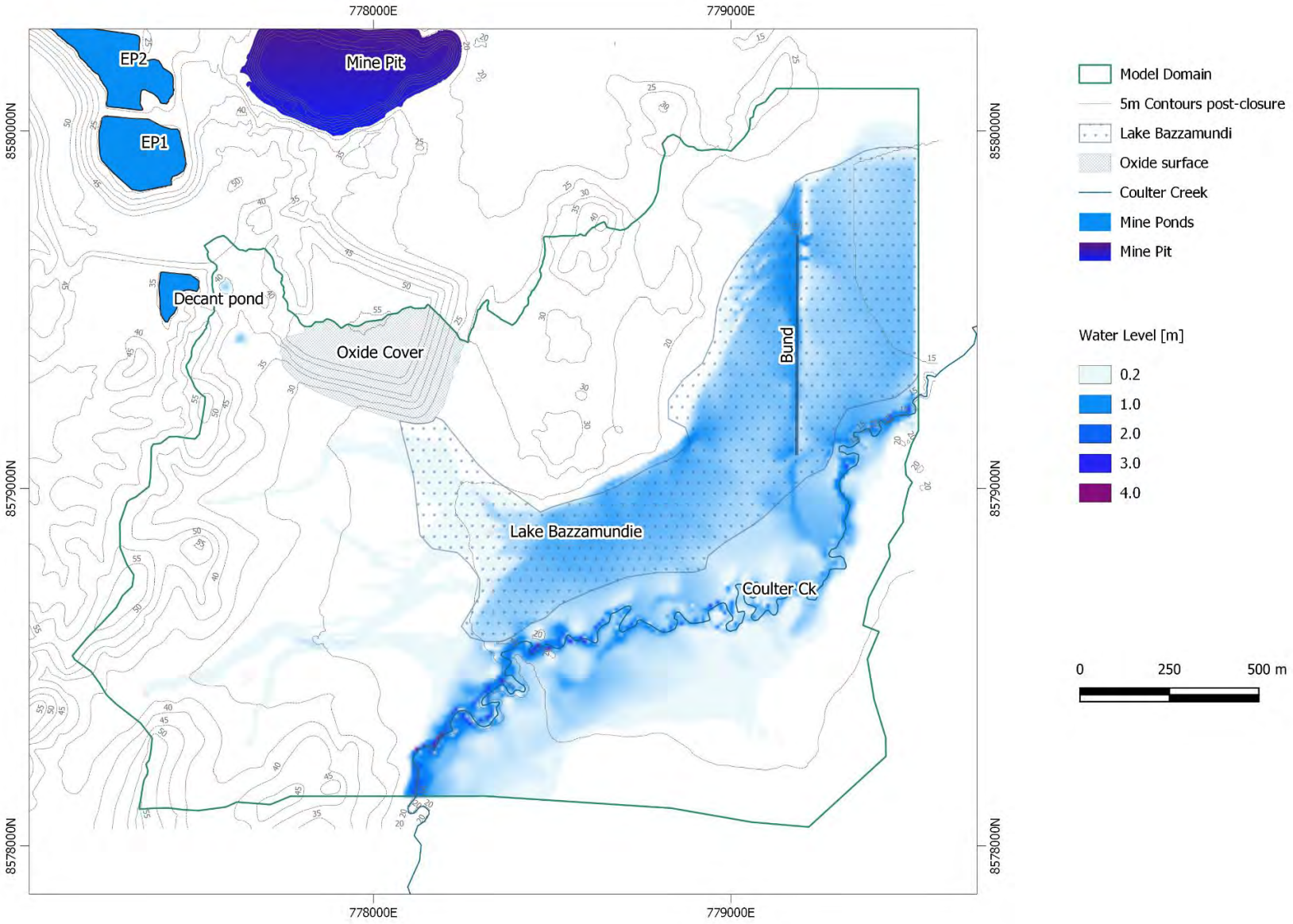

Figure 115. Water depth at peak discharge for a 1%AEP rainfall event, Coulter Ck (with UMBC discharge and mine rainfall runoff)

F.3.5. 0.1%AEP – Coulter Ck

The simulation with only the runoff from the mine site shows no significant change along the alignment of the eroded channels compared to the 1%AEP event, but erosion depths are slightly higher (0.4m) (Figure 116). Peak C along the channel outlet is 18 mg/L. Inundation extents during peak discharges are very similar to the 1%AEP event but the flood levels are slightly higher (Figure 117).

The simulation combining runoff from both the mine site and UCC inflows shows higher erosion along the right bank Coulter Ck floodplain near the southern catchment inlet and along the northern boundary of Lake Bazzamundi (Figure 118). There is higher deposition within Lake Bazzamundi especially near the northern and western boundary lines. Otherwise, erosion and deposition occurs in similar areas as for the 1%AEP event, but with slightly higher erosion depths, exceeding 3.5m in some locations along the creek-line.

The peak C is higher than the 1%AEP event at 105 mg/L, however, it still falls within the range of observed values in the region.

Flood depths during peak discharge are slightly higher than for the 1%AEP event, but with similar inundation extent (Figure 119).

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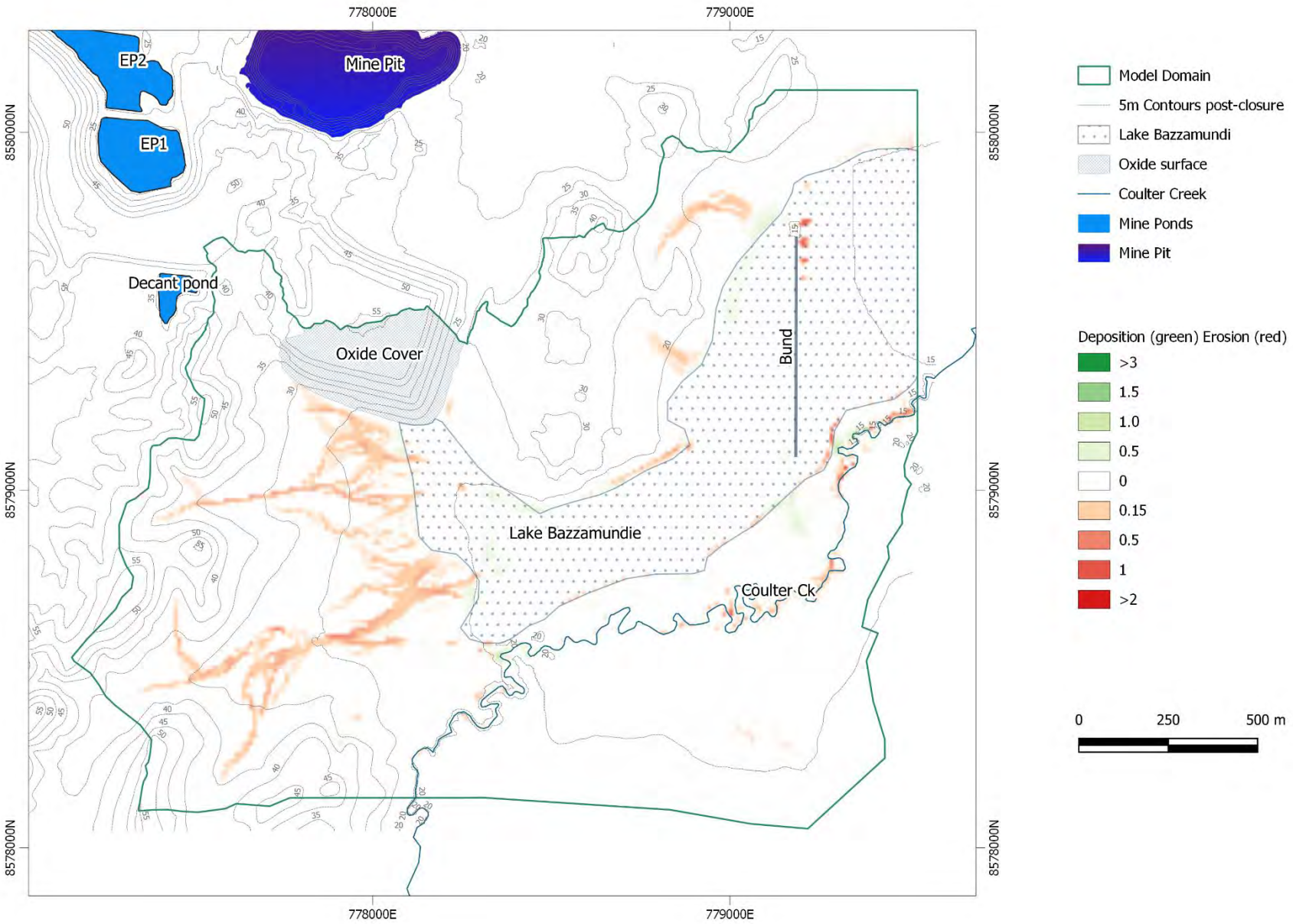

Figure 116. Erosion and deposition simulation for a 0.1%AEP rainfall event, Coulter Ck, (no UMBC inputs and only rainfall runoff from the post-mine landform)

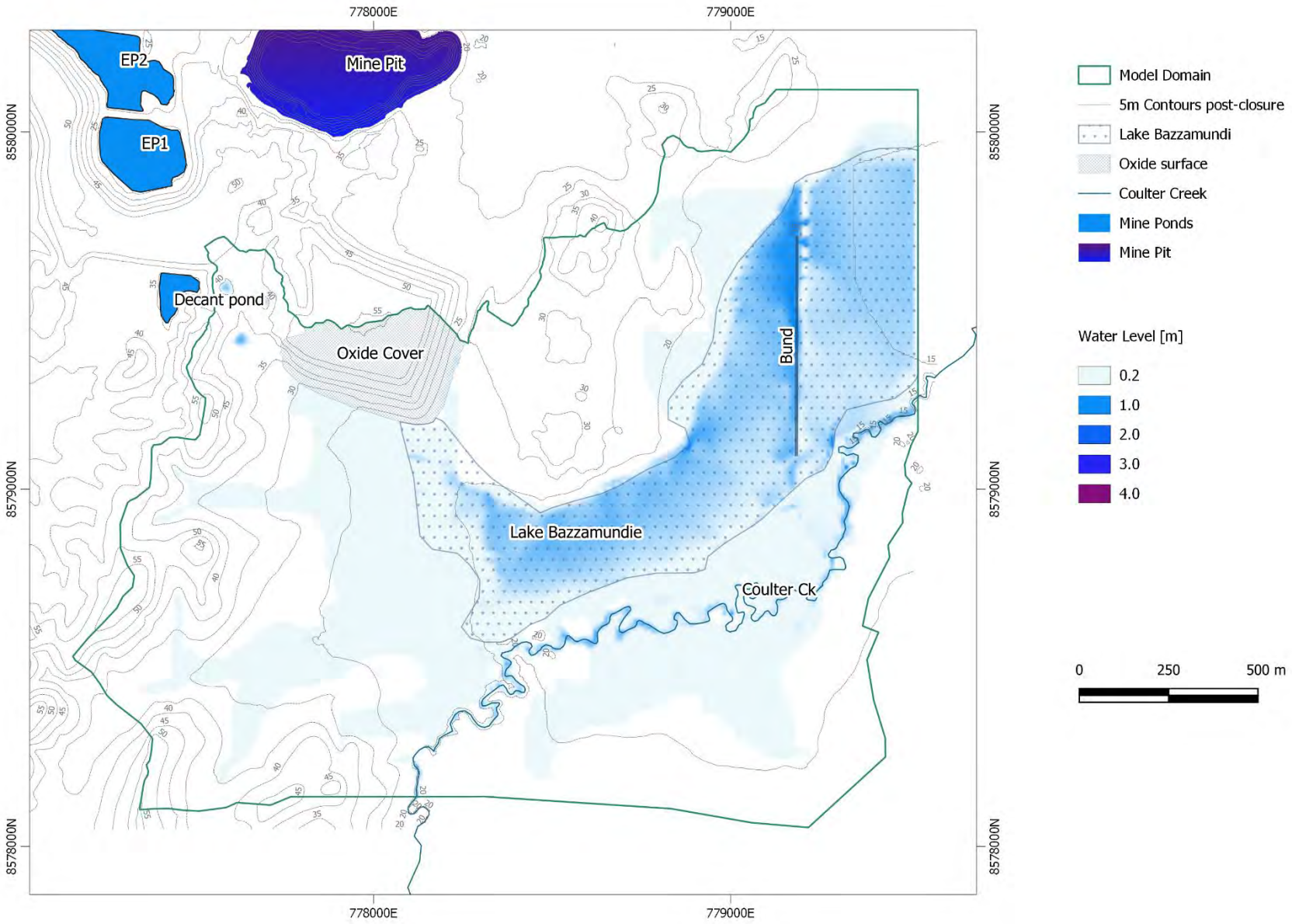

Figure 117. Water depth at peak discharge for a 0.1%AEP rainfall event, Coulter Ck (no UMBC inputs, only rainfall runoff from the post-mine landform).

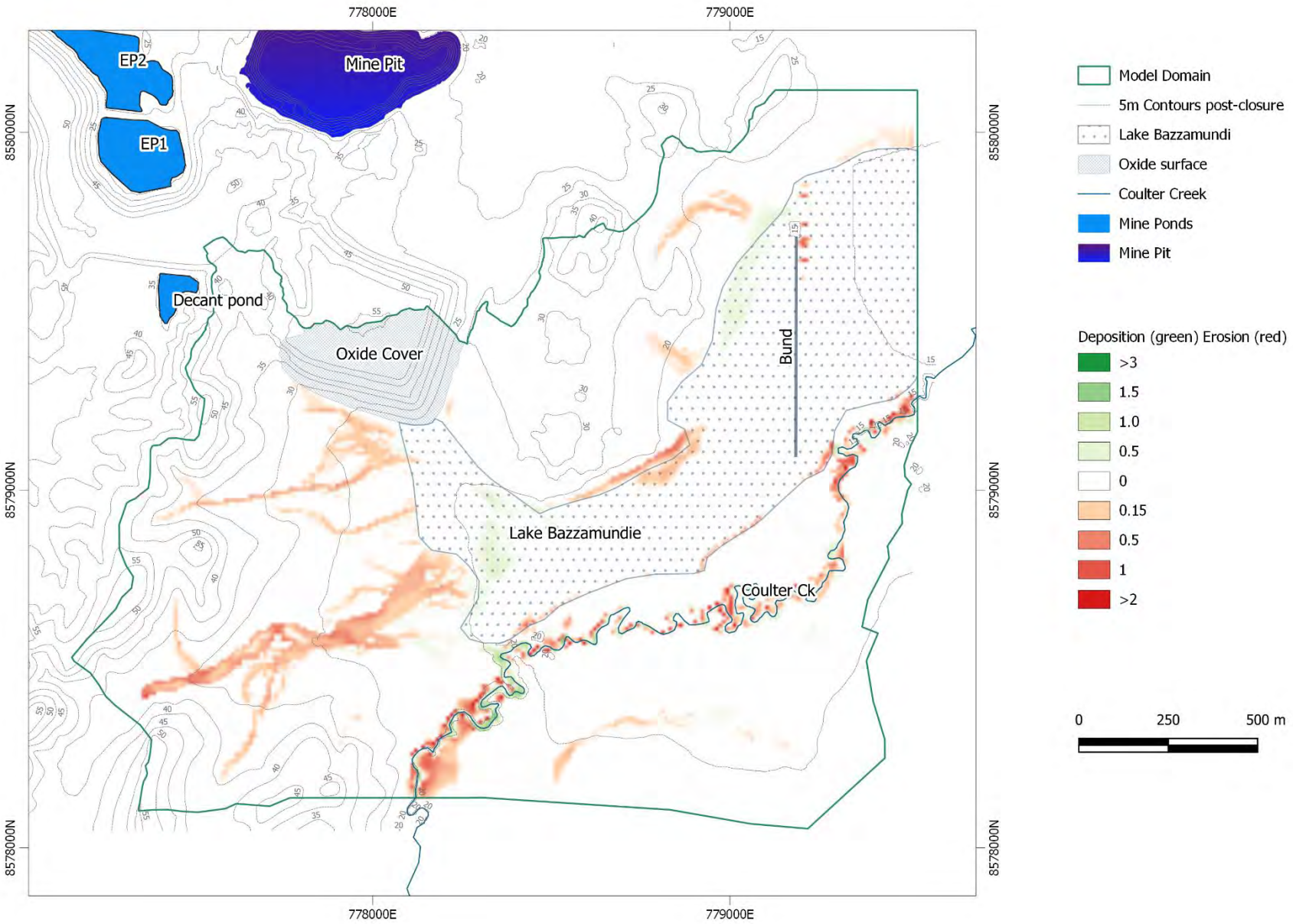

Figure 118. Erosion and deposition simulation for a 0.1%AEP rainfall event, Coulter Ck (with UMBC inputs and rainfall runoff from the post-mine landform)

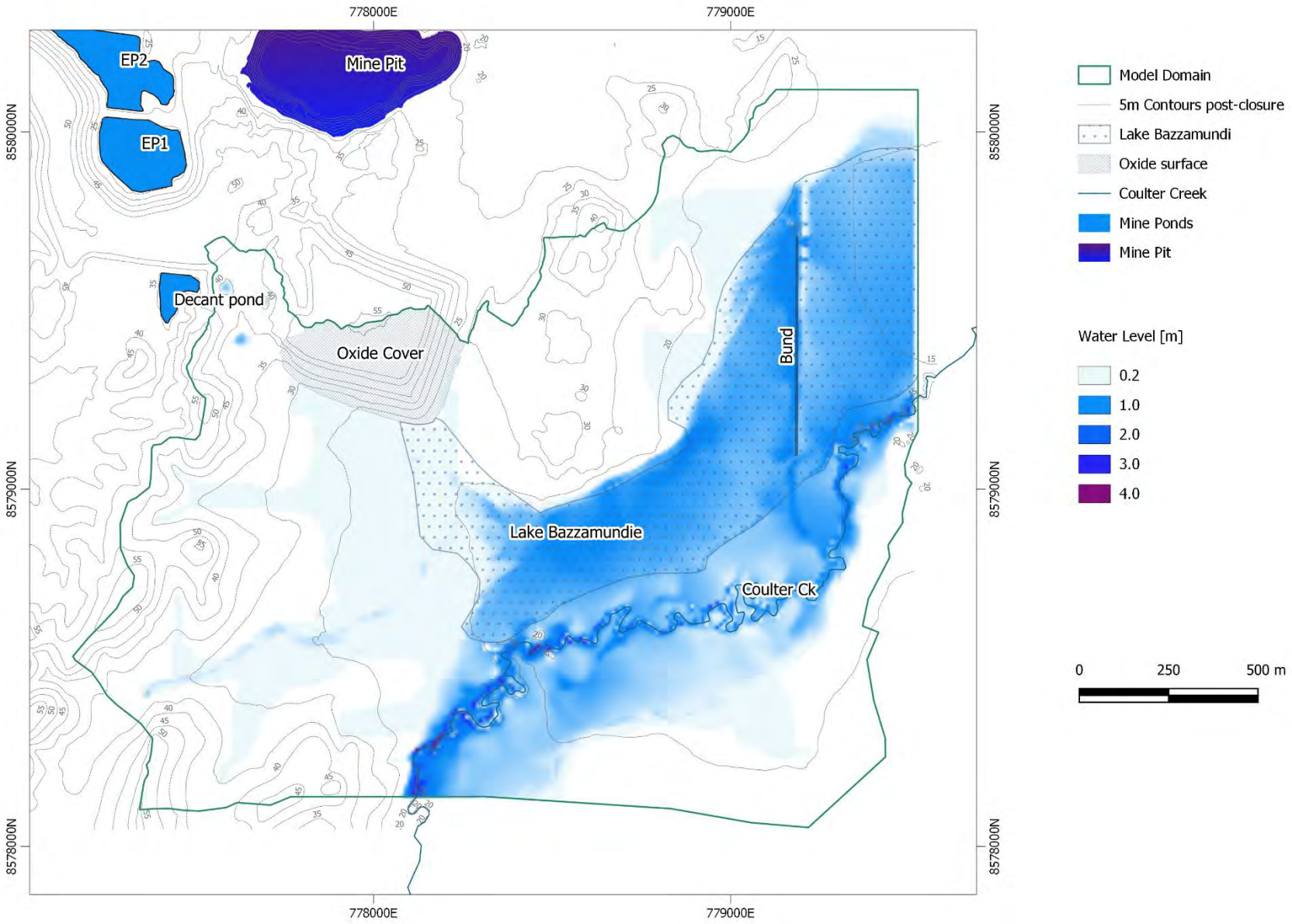

Figure 119. Water depth at peak discharge for a 0.1%AEP rainfall event, Coulter Ck (with UMBC discharge and mine rainfall runoff)

F.3.6. Long-term – Coulter Ck

Wet Climate Scenario

Erosion occurs along two existing natural channels on the western side of Lake Bazzamundi, leading into Coulter Creek and Lake Bazzamundi with erosion depths exceeding 3m. Little erosion occurs in the Coulter Creek drainage channel. The northern end of the bund has eroded through in one location, while deposition occurs within the lake and along Coulter Creek channel. Minor backfilling also occurs where the natural drainage channels converge with the Coulter Creek main channel. These are natural processes that are unaffected by the mine site.

Long term soil loss was 1.88 t/ha/yr and the denudation rate was 0.07mm/yr. Both values fit within the range of values for this region.

Dry Climate Scenario

This scenario has less in-channel erosion than the Wet climate scenario especially in the northern half of the catchment. Higher deposition occurs along the main CC channel and within the natural channels on the western side of Lake Bazzamundi.

Long term sediment loss was 0.91 t/ha/yr and denudation rate was 0.03 mm/yr, falling within the range of expected values for this region.

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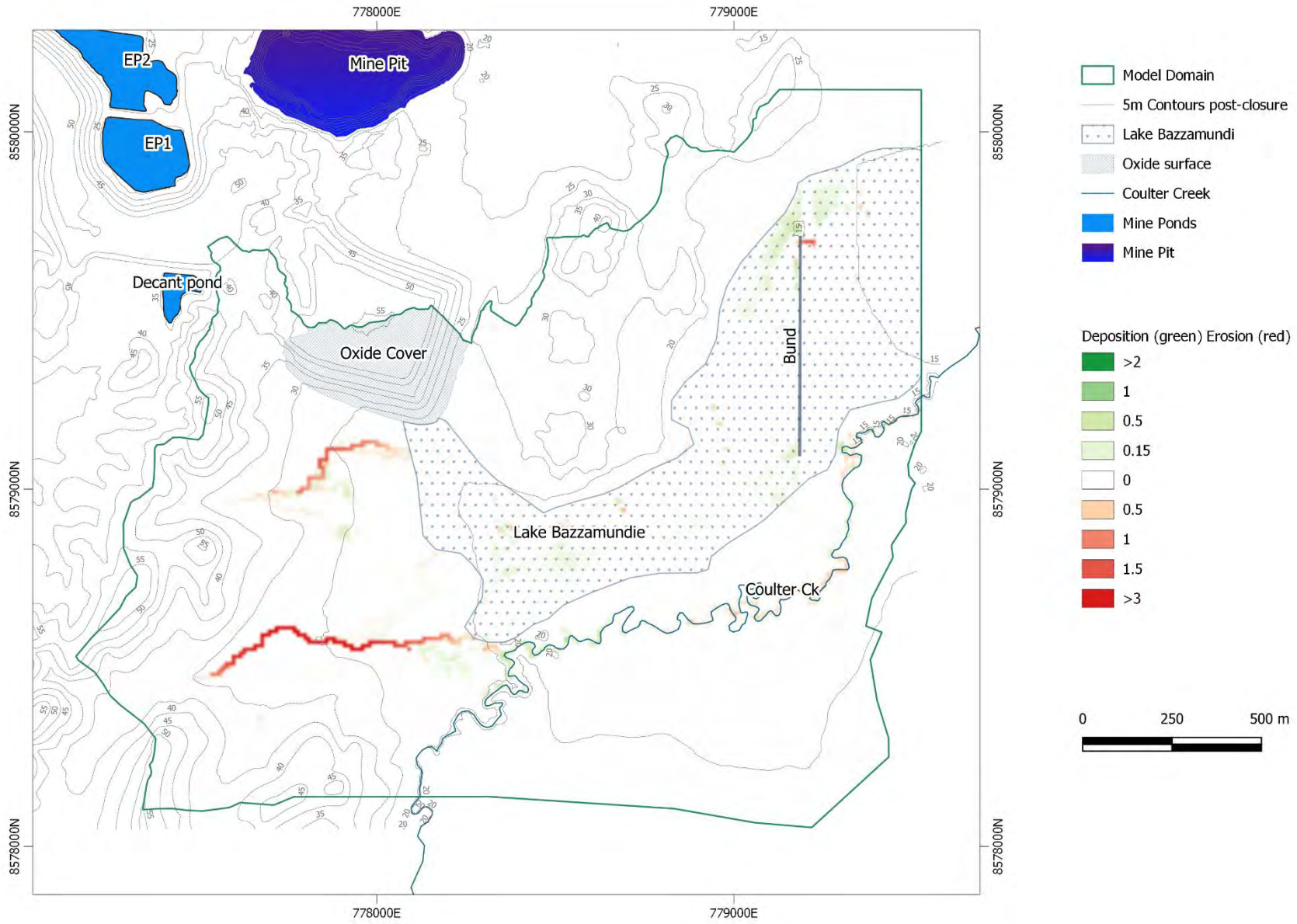

Figure 120. Erosion and deposition simulation for a for 100-year wet climate scenario with only rainfall applied

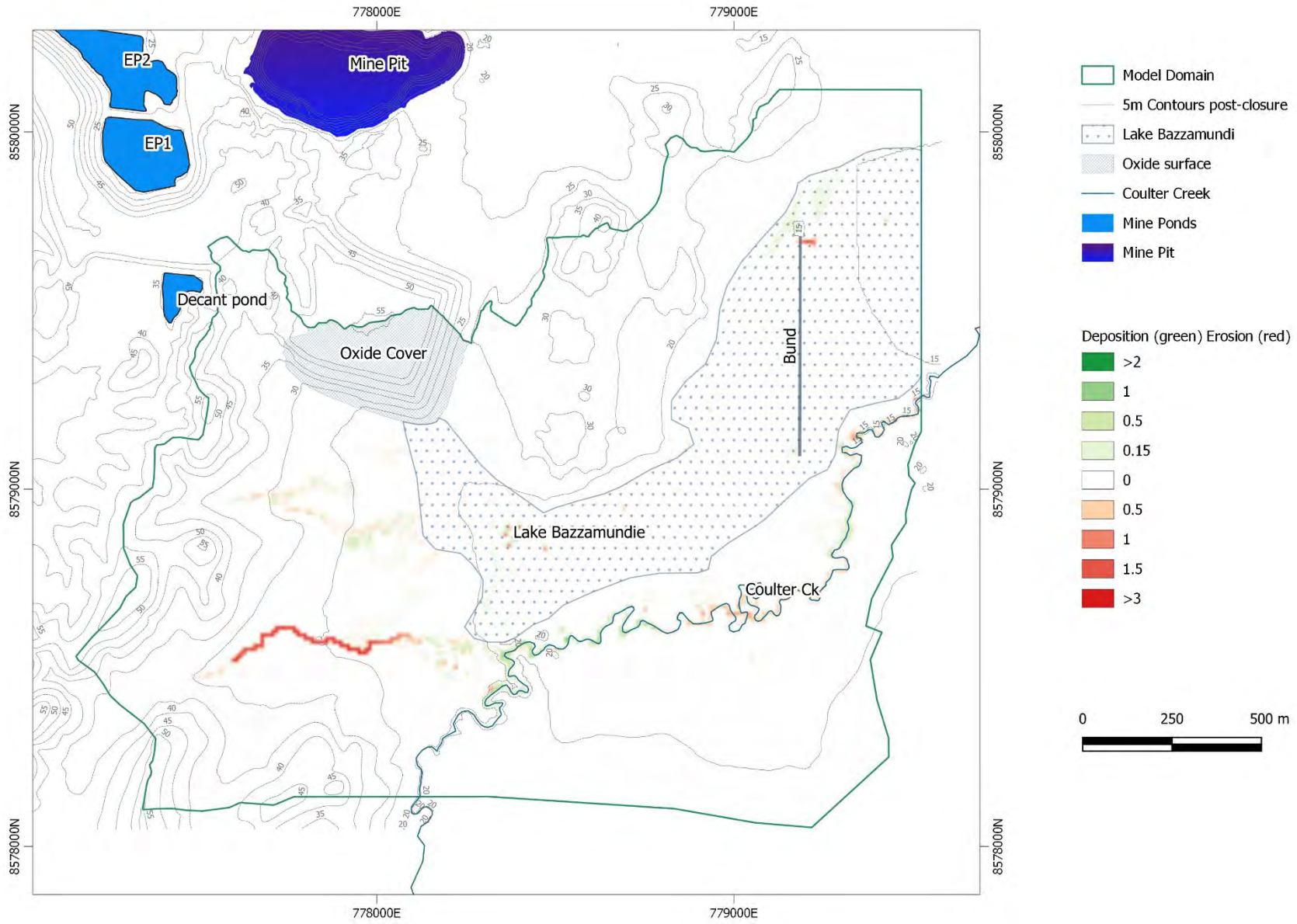

Figure 121. Erosion and deposition simulation for a for 100-year dry climate scenario with only rainfall applied.

Appendix G. Landform Stability

A series of longitudinal sections along eroded channel thalwegs are provided showing the expected severity of landform erosion across the mine site under each of the scenarios modelled in CAESAR-LisFlood.

G1. Mt Bundey Ck mine catchment

G1.1 Long term stability

The following figures show the expected difference in surface levels along the eroded channel thalwegs after 100 years, for the two wet and dry climate scenarios.

Section A-A (Figure 122)

Erosion occurs from the mid-slope to the toe and then along the eastern edge of the oxide cover over TSF 2. Approximately 1m of deposition occurs in the oxbow wetland, but there is little change to the main creek channel. The 100-year Wet climate scenarios has both greater erosion and deposition than the 100-year Dry climate scenario.

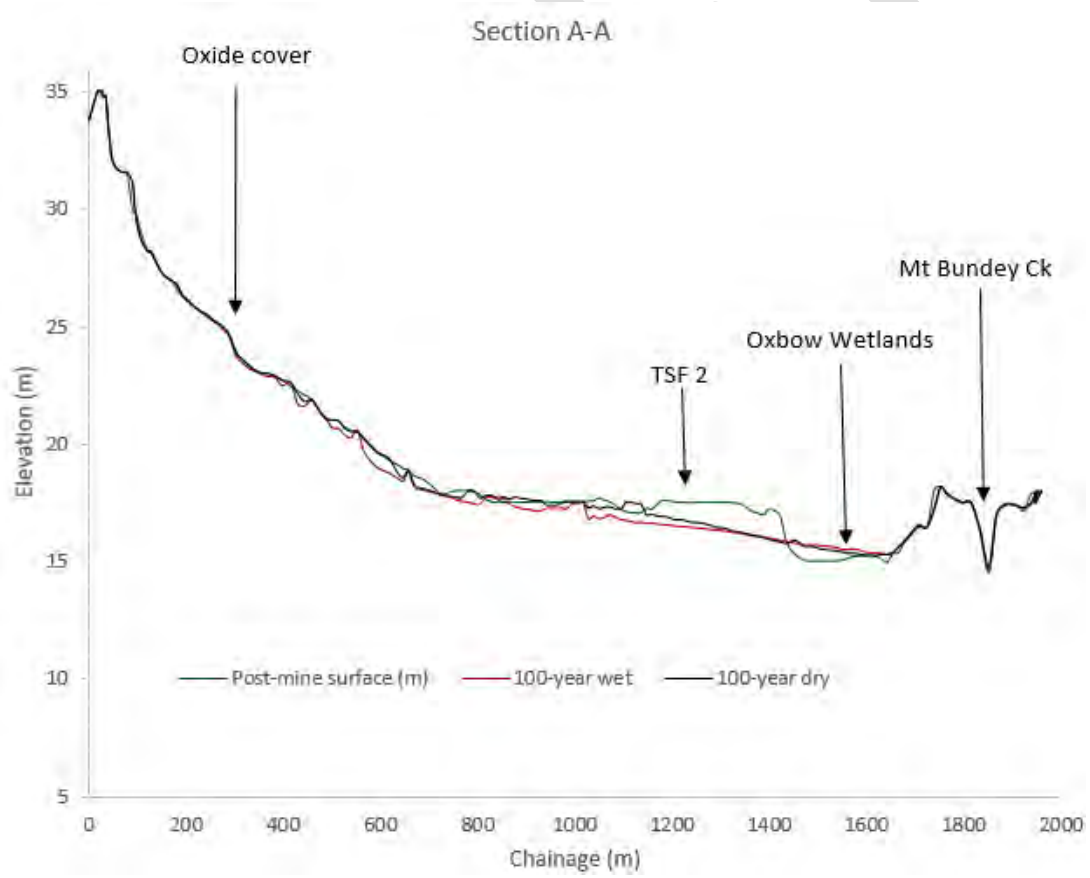

Figure 122. Simulated erosion along Section A-A over 100 year Wet and Dry scenarios

Section B-B (Figure 123)

Erosion occurs where water flows from the upper flat area to the batter slope, while deposition occurs on the upper slope. There is no change to the riparian zone and creek floodplain. Minor scour occurs in the creek channel, but in this area the direction of flow in the creek is at 90° to the section so it is likely the scour is caused by creek flow.

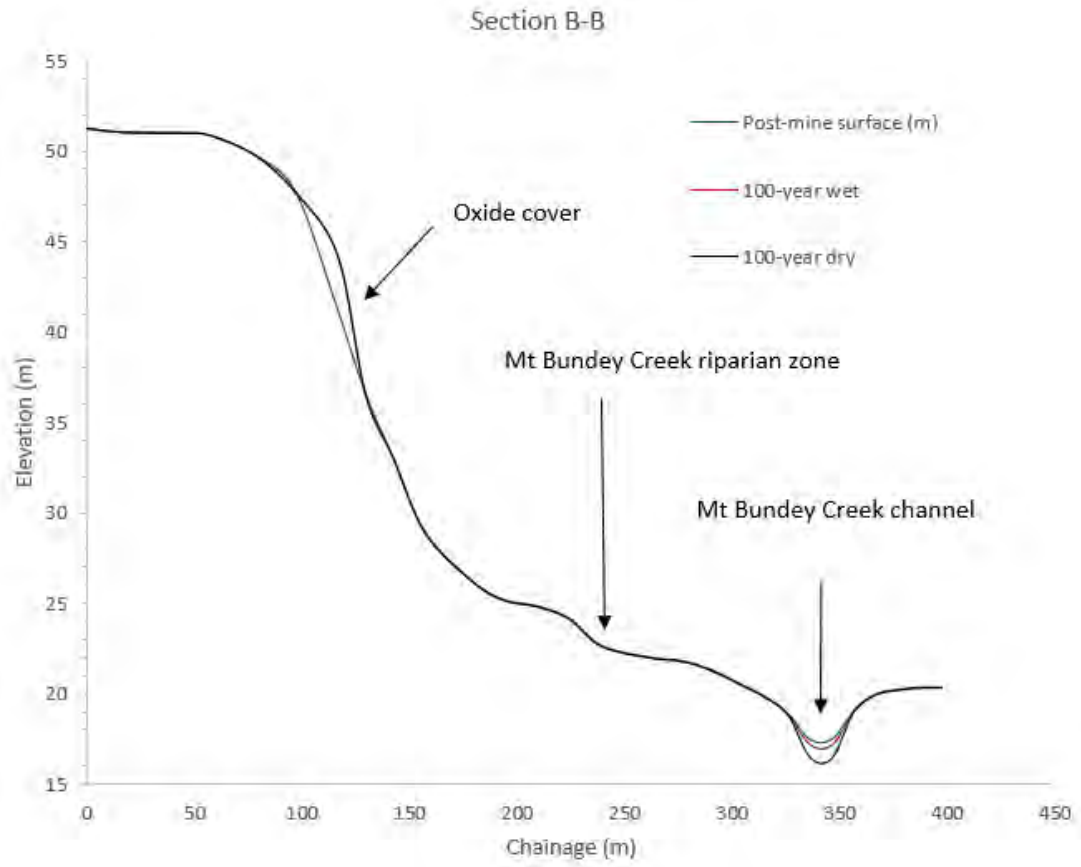

Figure 123. Simulated erosion along Section B-B over 100 year Wet and Dry scenarios

Section C-C(w) (Figure 124) and Section C-C(d) (Figure 125)

In this drainage line the Wet scenario and Dry scenario drainage channel had different thalwegs. This is a natural drainage channel in the Koolpinyah Surface and for the Wet scenario, scour occurs to about 3m depth. For the Dry scenario it scours to about 2.5m depth mid-channel. This is a natural process.

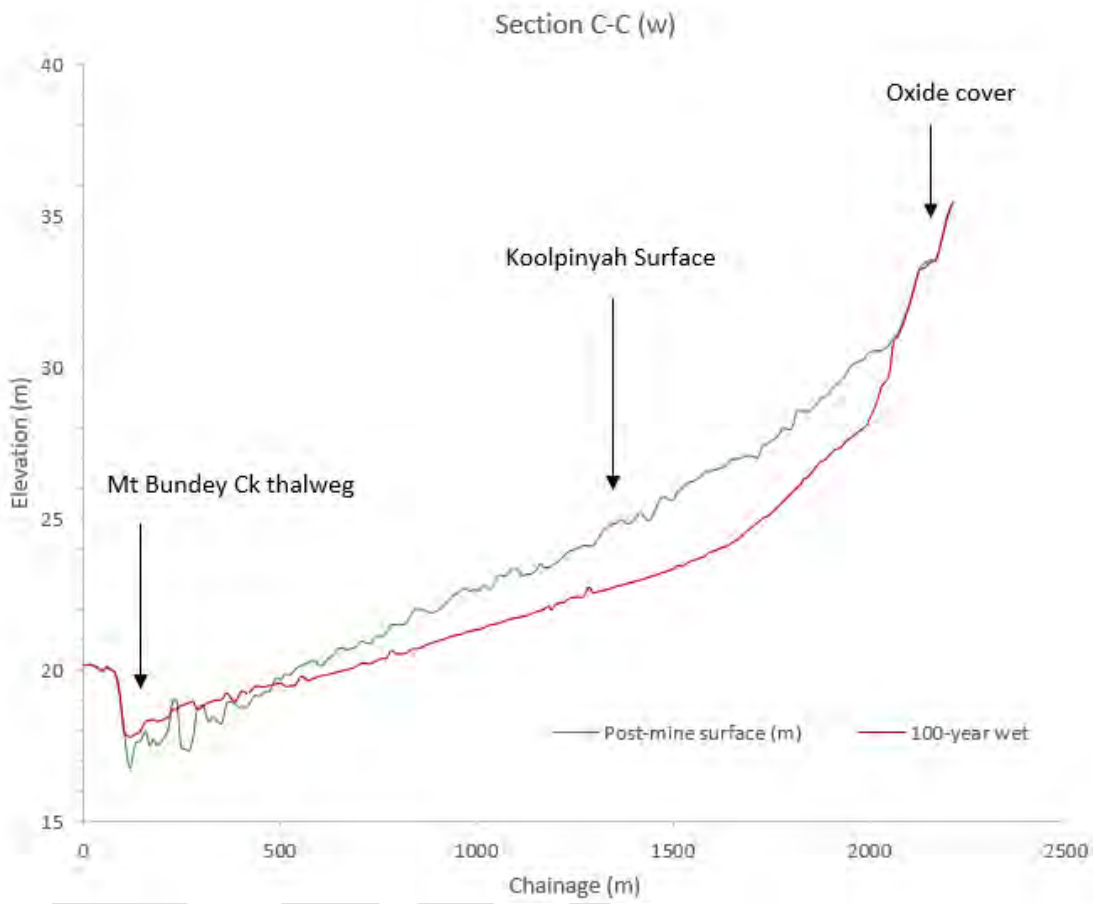

Figure 124. Simulated erosion along Section C-C(w) for the 100-year Wet scenario

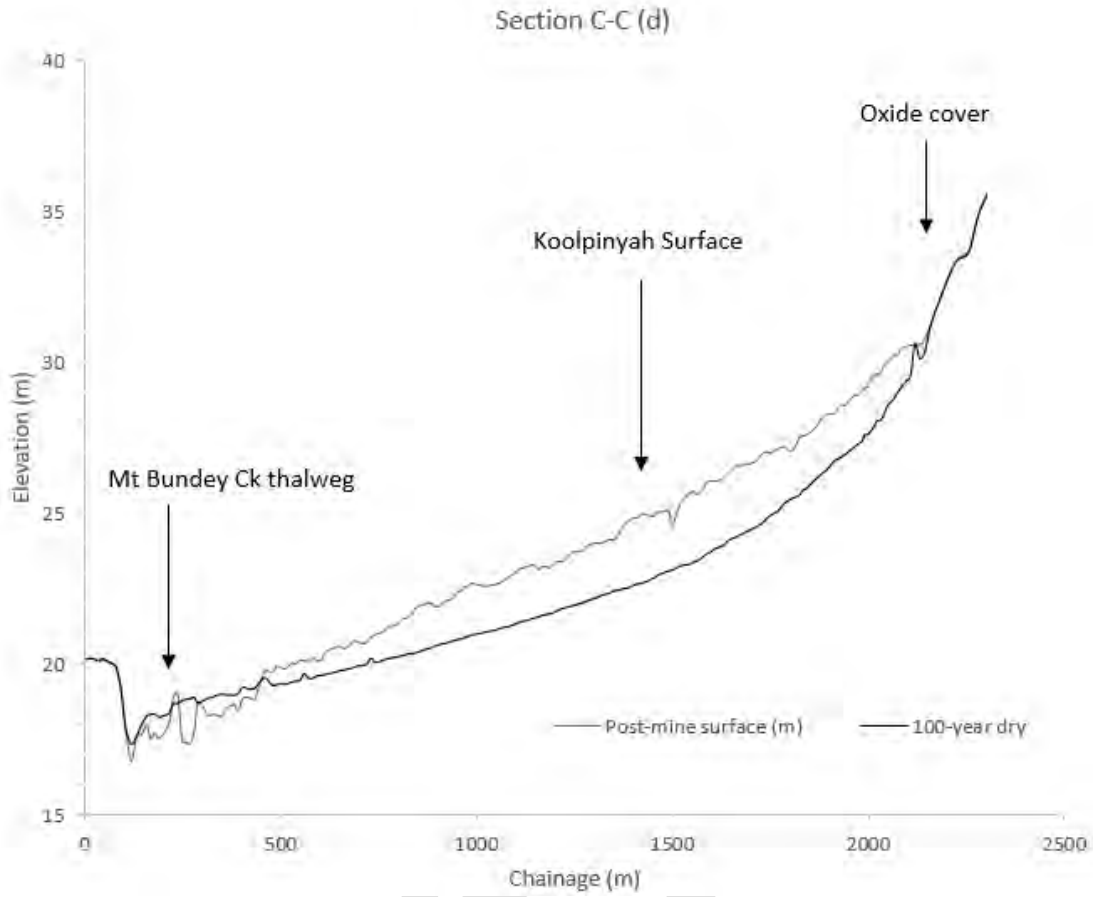

Figure 125. Simulated erosion along Section C-C(d) for the 100-year Dry scenario

Section D-D (Figure 126)

This section is in a natural channel on the northern side of Mt Bundey Creek, which flows south and debouches to the main Mt Bundey Creek channel. Gully head-cut is developing about 650m upstream of the Mt Bundey Creek channel, however, this is a natural geomorphic process in this region. Head-cut to the same extent was not observed in sections A-A or B-B. Section C-C may have evolved through this stage in the simulated 100-year period.

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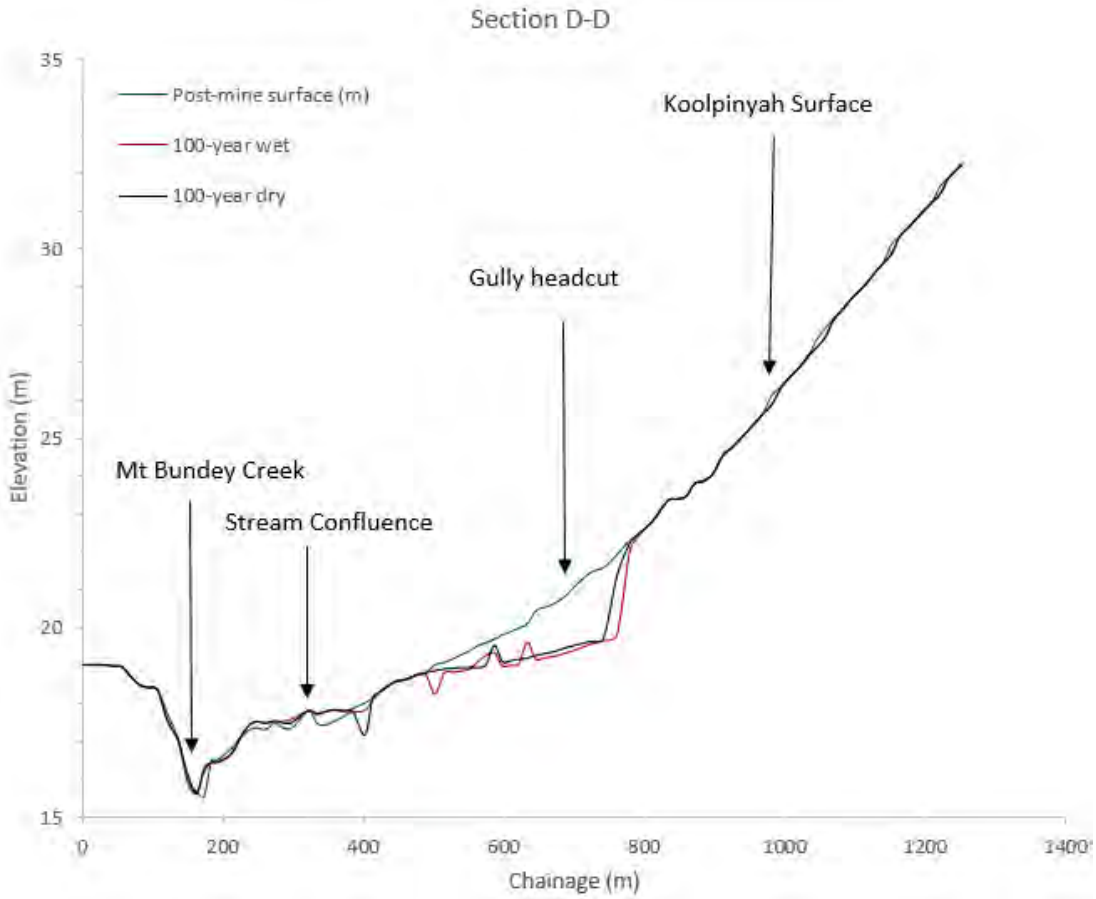

Figure 126. Simulated erosion along Section D-D over 100 year Wet and Dry scenarios

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G1.2 Short term stability

The following figures show the expected difference in surface levels along the channel thalwegs after a 1%AEP and 0.1%AEP storm event, considering both the flows from upstream catchments and the runoff directly generated on the site.

Section A-A (Figure 127)

Erosion occurs from the mid-slope of the oxide cover, and deposition occurs at the toe of the slope to depth of about 0.5m. The profiles after the 1%AEP and 0.1%AEP are reasonably similar. There is deposition and erosion along TFS 2 and scour in the oxbow wetland. The erosion and deposition in this area is probably caused by the overbank flow of the flood wave as it moves through the system inundating the creek floodplain. Scour is also present in the creek channel. No deep gullying has occurred.

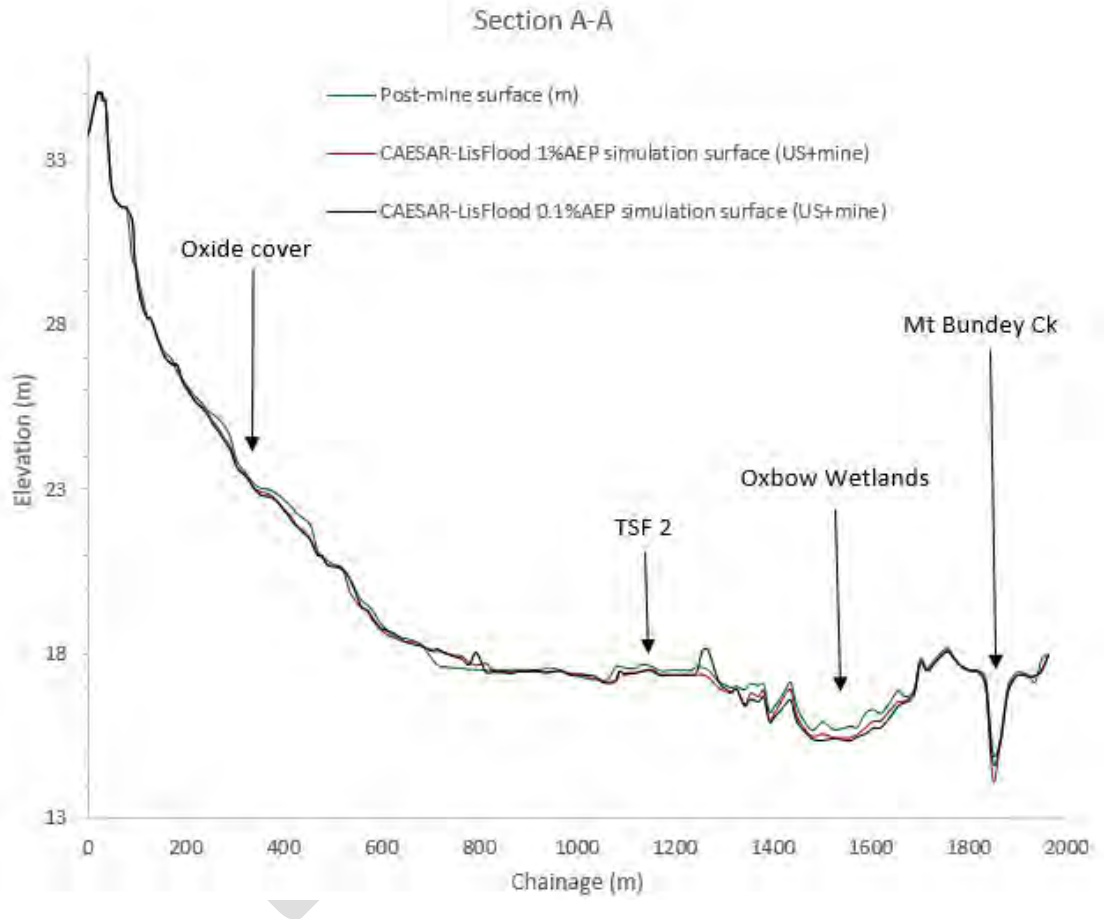

Figure 127. Simulated erosion along Section A-A after 1%AEP and 0.1% storm event

Section B-B (Figure 128)

Considerable erosion occurs along the riparian zone for the 1%AEP and even more for the 0.1%AEP. Overbank flow velocities in this area ranged from 1.5 to 1.9 m/s with water depth up to 5m for the 0.1%AEP event. There was also deposition along the left bank of the channel.

This a major flood and since the simulations assumed uniform rain over the whole upstream catchment, large volumes of water are moving through the system. There are no indications of scour on the toe of the oxide cover, although the lower area north of EP2 does become inundated.

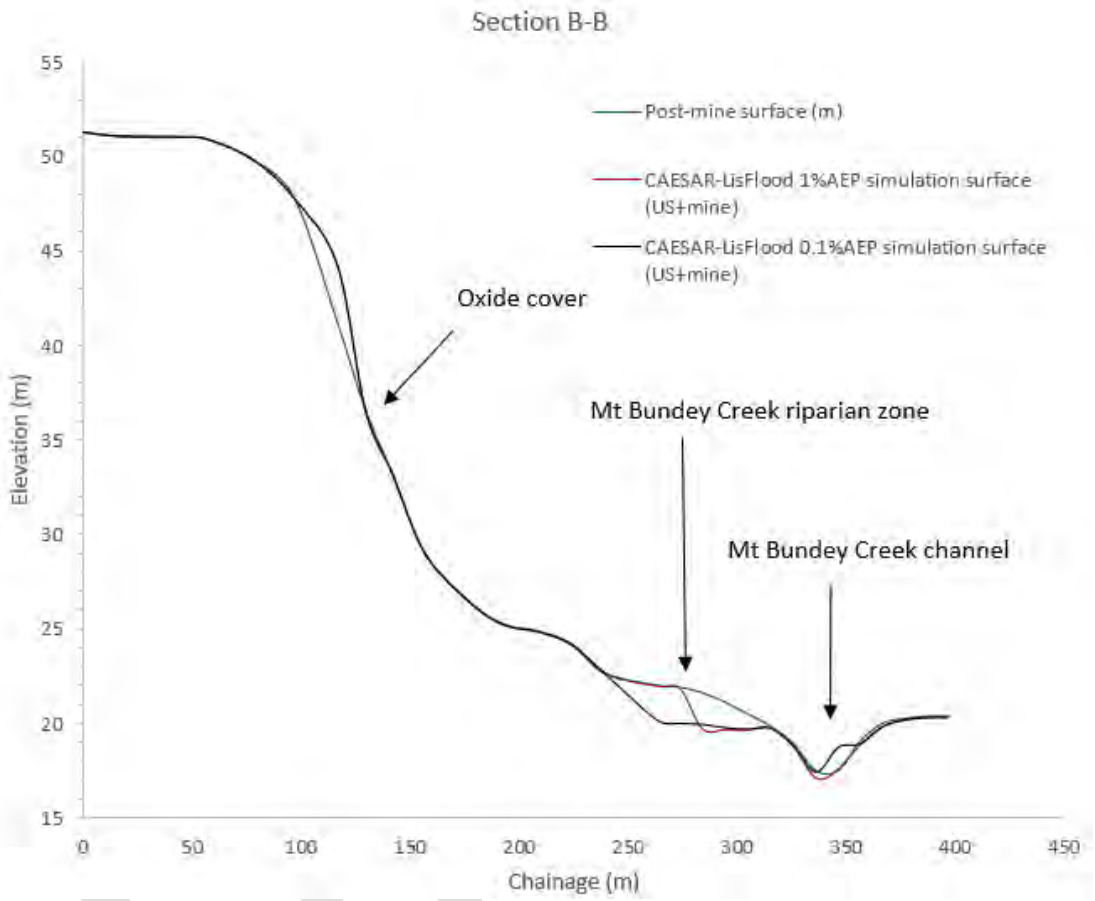

Figure 128. Simulated erosion along Section B-B after 1%AEP and 0.1% storm event

Section C-C (Figure 129)

This section is along a natural drainage channel in the Koolpinyah Surface. Heavy deposition occurs at the confluence with Mt Bundey Creek, with the channel backfilling due to the interaction with the dominant flow in the creek. The simulation was also run with only the runoff from the mine catchment itself (no upstream input), which showed considerably less deposition even under the 0.1%AEP event. This demonstrates that the deposition and backfilling is due to the UMBC upstream inputs. Erosion along the thalweg is not excessive.

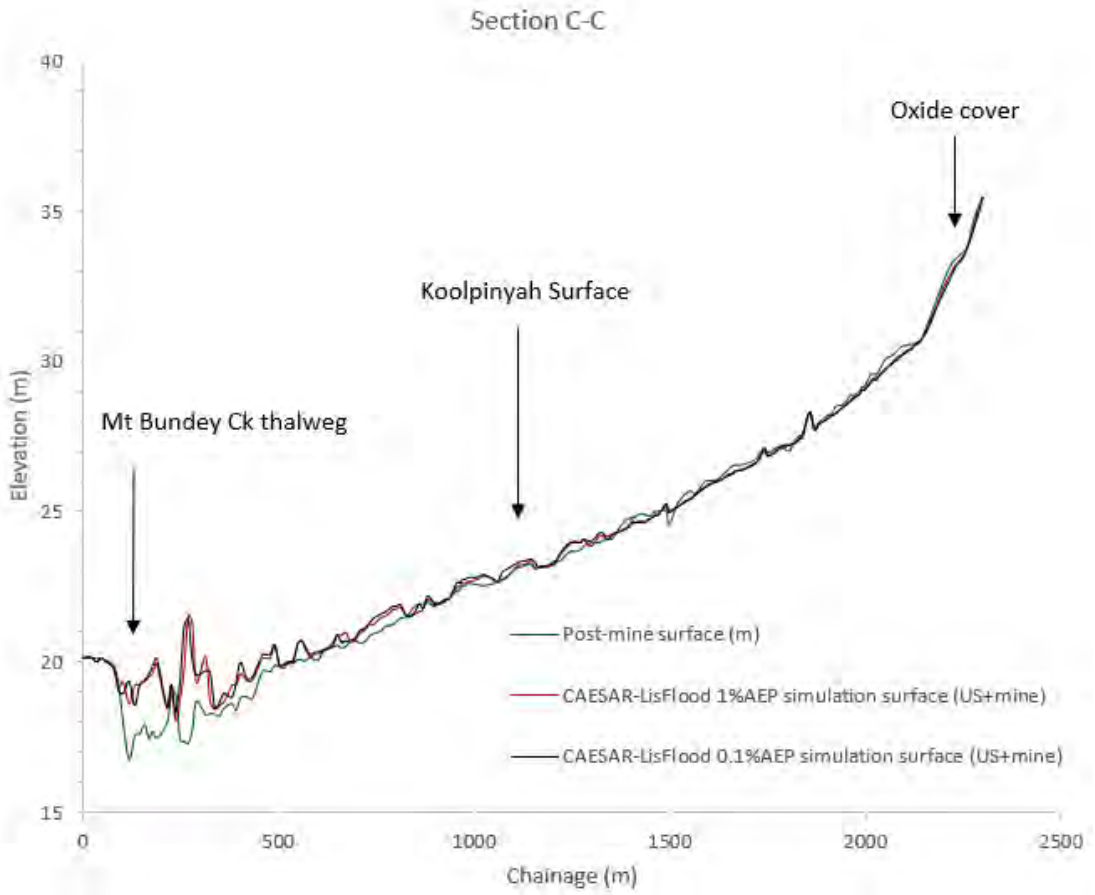

Figure 129. Simulated erosion along Section C-C after 1%AEP and 0.1% storm event

Section D-D (Figure 130)

This natural channel behaves similarly to Section C-C. There is up to 0.5m of erosion along the thalweg and deposition in the main channel and backfilling in the drainage channel. This is due to upstream inputs. For the scenario without UMBC inputs, the section shows much reduced deposition levels.

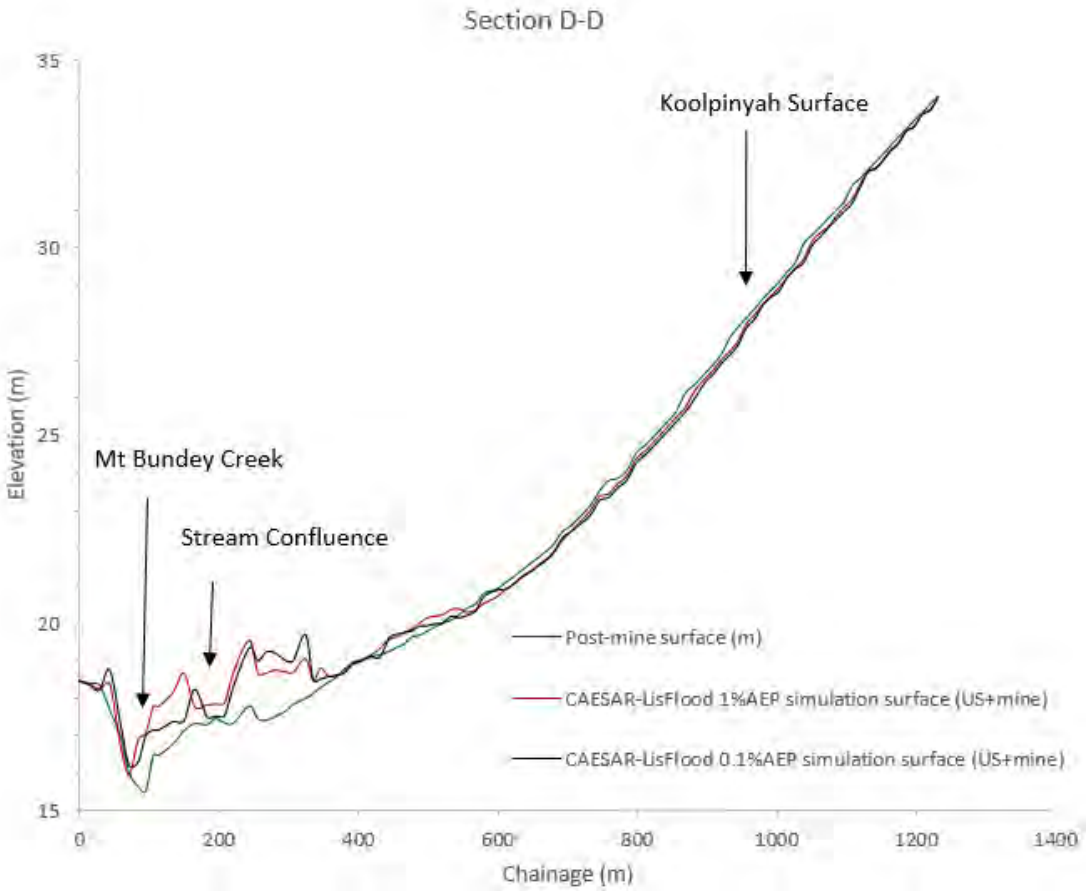

Figure 130. Simulated erosion along Section D-D after 1%AEP and 0.1% storm event

G2. Coulter Ck mine catchment

G2.1 Long term stability

The following figures show the expected difference in surface levels along the eroded channel thalwegs after 100 years, for the two wet and dry climate scenarios.

Section A-A (Figure 131)

Erosion occurs from the mid-slope to the end of Koolpinyah surface for the Wet climate scenario and then in a small area at the toe in the middle of Lake Bazzamundi. No erosion occurs along the Koolpinyah surface for the Dry climate scenario. There is some small deposition in the CC channel.

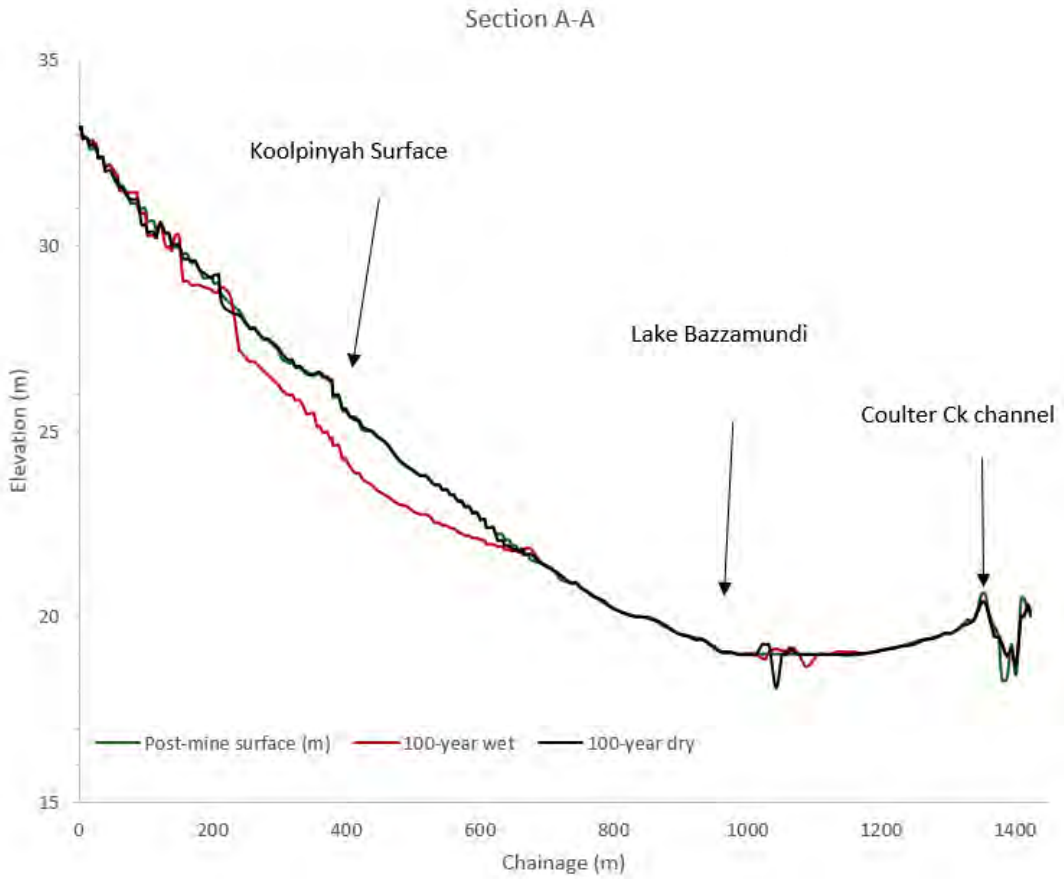

Figure 131. Simulated erosion along Section A-A over 100 year Wet and Dry scenarios for Coulter Creek

Section B-B (Figure 132)

High scour of up to 3m for the Wet scenario and up to 2m for the Dry scenario occurs along the natural channel on the Koolpinyah surface on the upper and mid slope. There is some deposition caused by backfilling of the channel where the natural channel converges with CC. High deposition occurs in the CC channel. The Wet climate scenario has higher erosion than the Dry climate scenario, while deposition is greater for the Dry climate scenario.

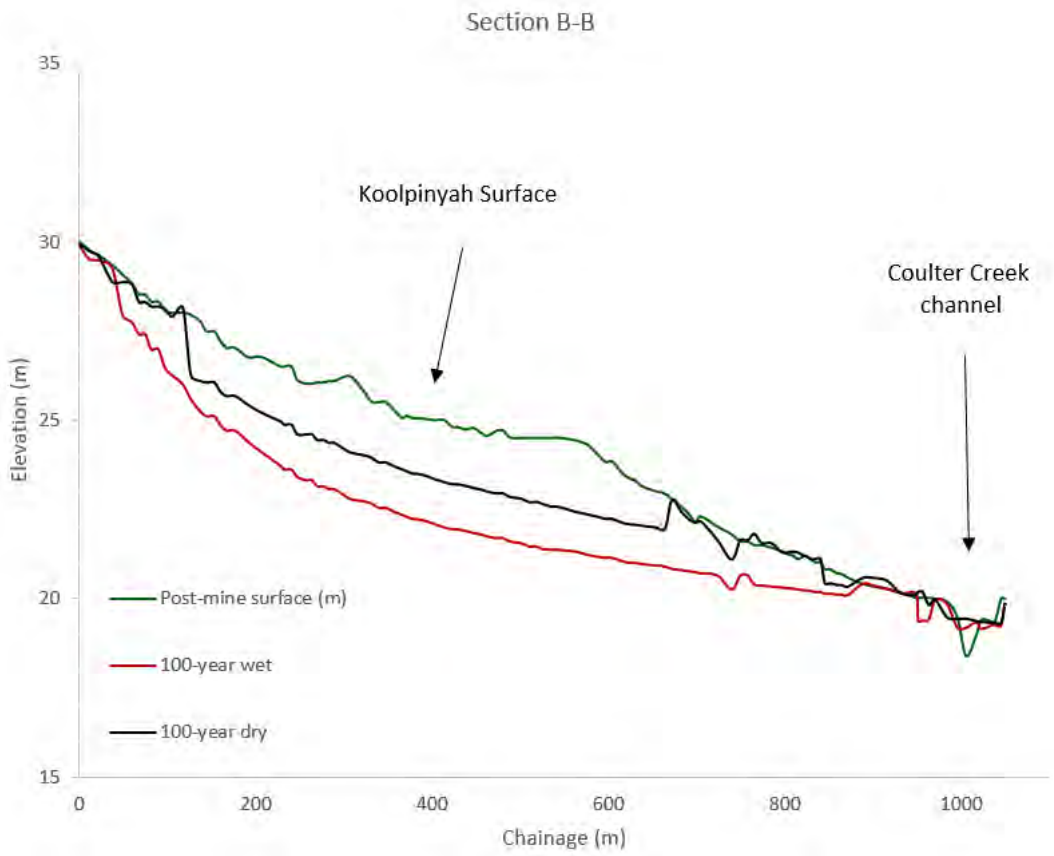

Figure 132. Simulated erosion along Section B-B over 100 year Wet and Dry scenarios for Coulter Creek

Section C-C (Figure 133)

Very little erosion and deposition occurs on the Koolpinyah surface and there is no change to the Creek Floodplain and Lake Bazzamundi, except for some erosion at an isolated location in the middle of Lake Bazzamundi. High deposition occurs along the CC channel, filling up over half of the channel depth.

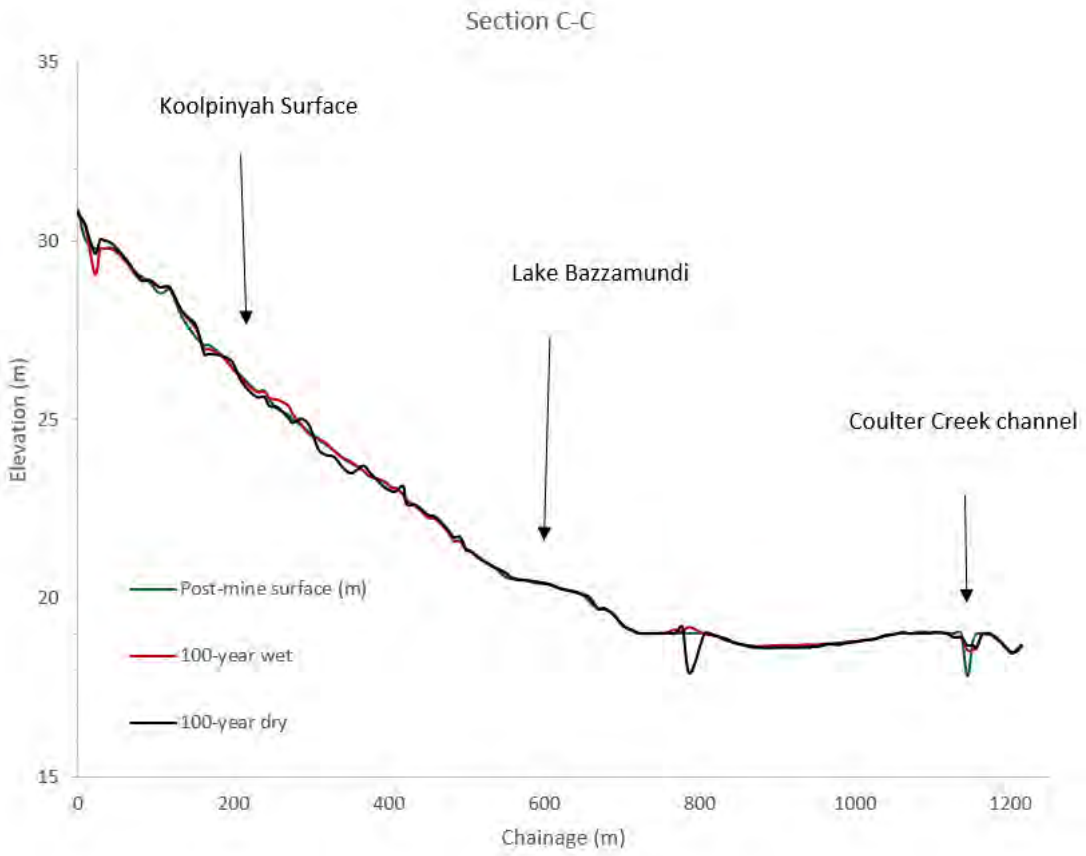

Figure 133. Simulated erosion along Section C-C over 100 year Wet and Dry scenarios for Coulter Creek

Section D-D (Figure 134)

The bund has eroded through and water flow has caused a 1.5m deep channel to form in that location. There is no change to the Lake Bazzamundi surface, however, scour occurs within the creek channel to about 0.35m depth.

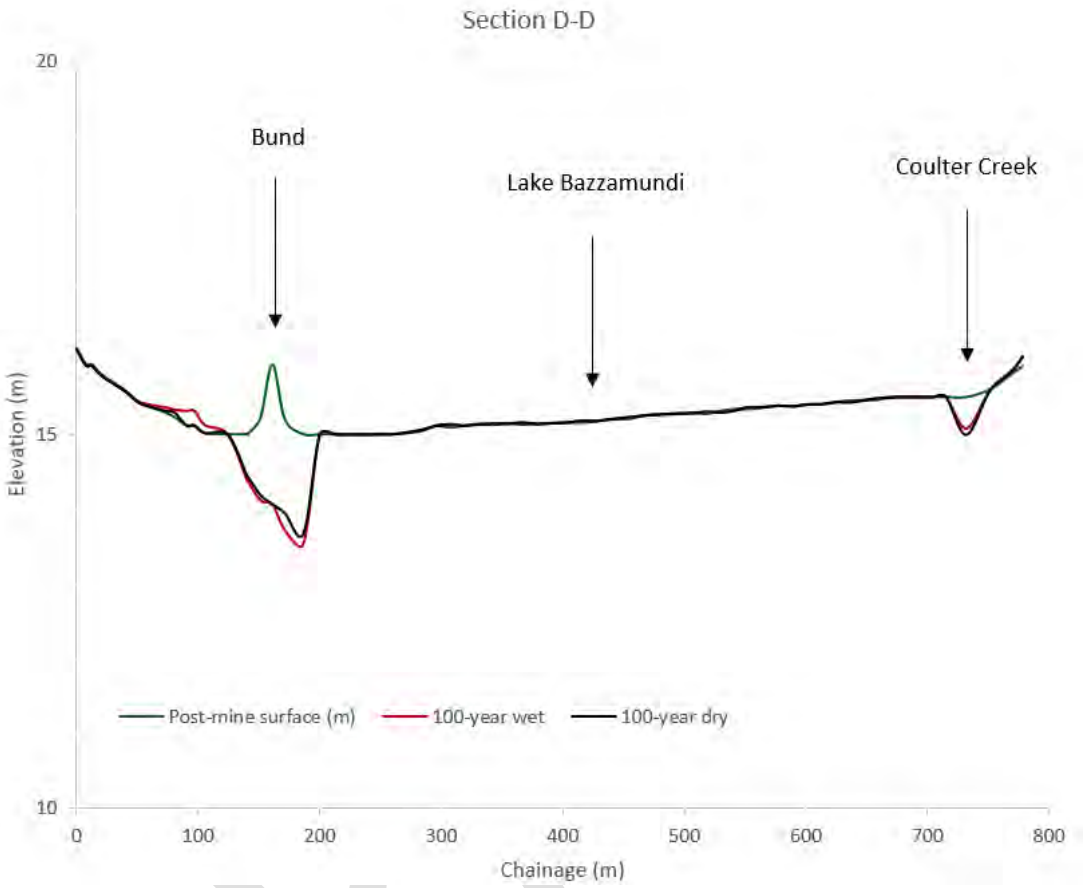

Figure 134. Simulated erosion along Section D-D over 100 year Wet and Dry scenarios for Coulter Creek

Section E-E (Figure 135)

Deposition exceeding 0.35m occurs right before and on the bund in Lake Bazzamundi. There is no change to the Lake Bazzamundi surface before and after the bund. High deposition occurs along the CC channel causing a minor shift in channel alignment to the right bank side.

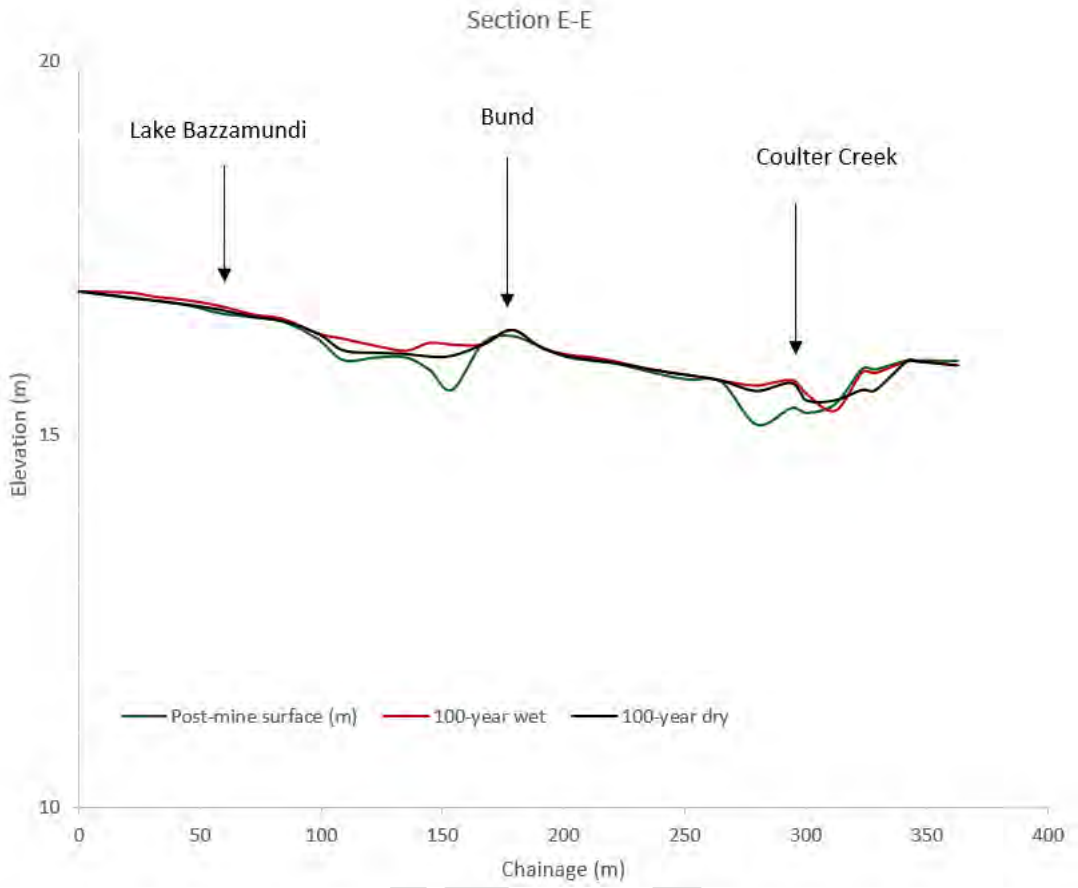

Figure 135. Simulated erosion along Section E-E over 100 year Wet and Dry scenarios for Coulter Creek

G2.2 Short term stability

The sections below show the expected differences in surface levels after a 1%AEP and 0.1%AEP storm event, taking into account both the flows from upstream catchments and the runoff directly generated on the site.

Section A-A (Figure 136)

Some erosion occurs along natural channel lines on Koolpinyah Surface with depths of up to 0.4m. There is some 0.5m high deposition in the middle of Lake Bazzamundi at the toe of the slope. Minor scour is present in the CC channel. The profiles after the 1%AEP and 0.1%AEP events are very similar, but slightly higher erosion occurs for the 0.1% AEP event.

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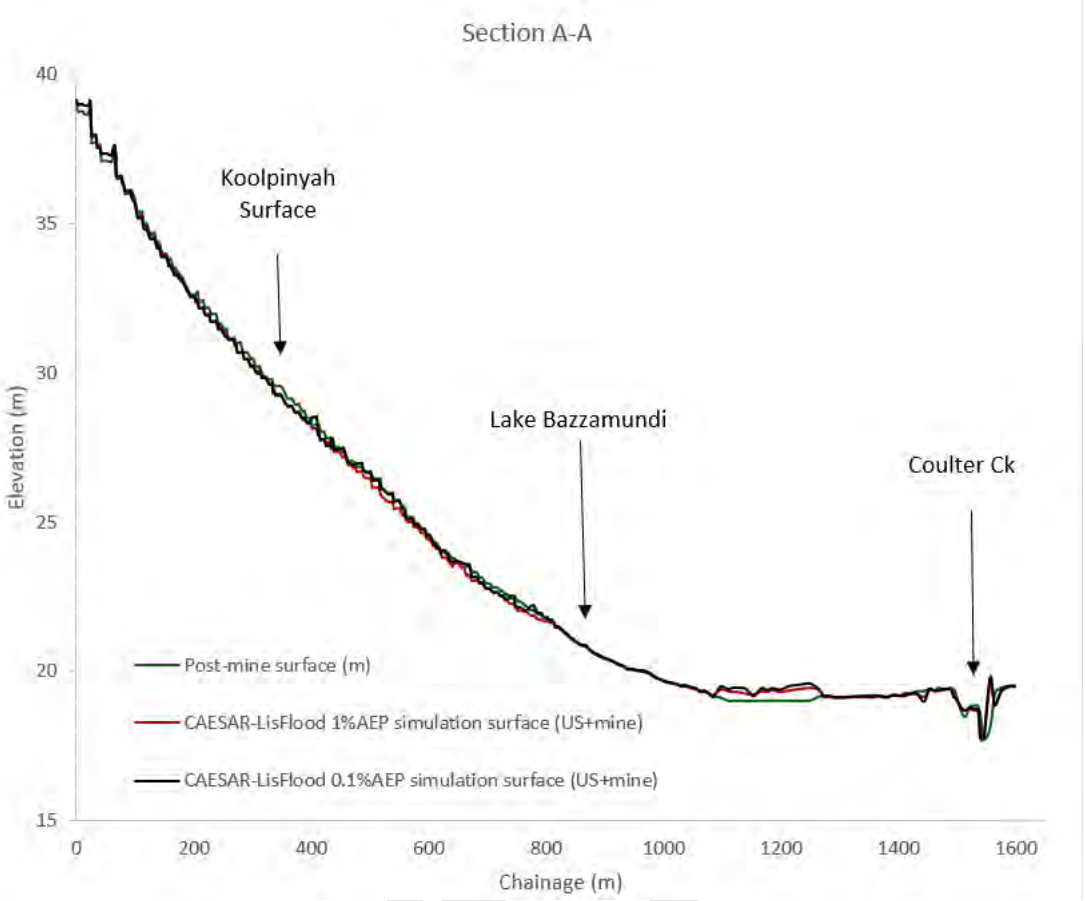

Figure 136. Simulated erosion along Section A-A after 1%AEP and 0.1% storm event for Coulter Creek

Section B-B (Figure 137)

Erosion occurs along natural drainage line on the Koolpinyah Surface and Lake Bazzamundi. The floodplain surface remains mostly unchanged. There is significant sedimentation along the Coulter Creek channel causing the channel alignment to shift towards the right bank side. This sedimentation is caused by backfilling due to flow interaction at the convergence between the drainage line and the Coulter Creek channel.

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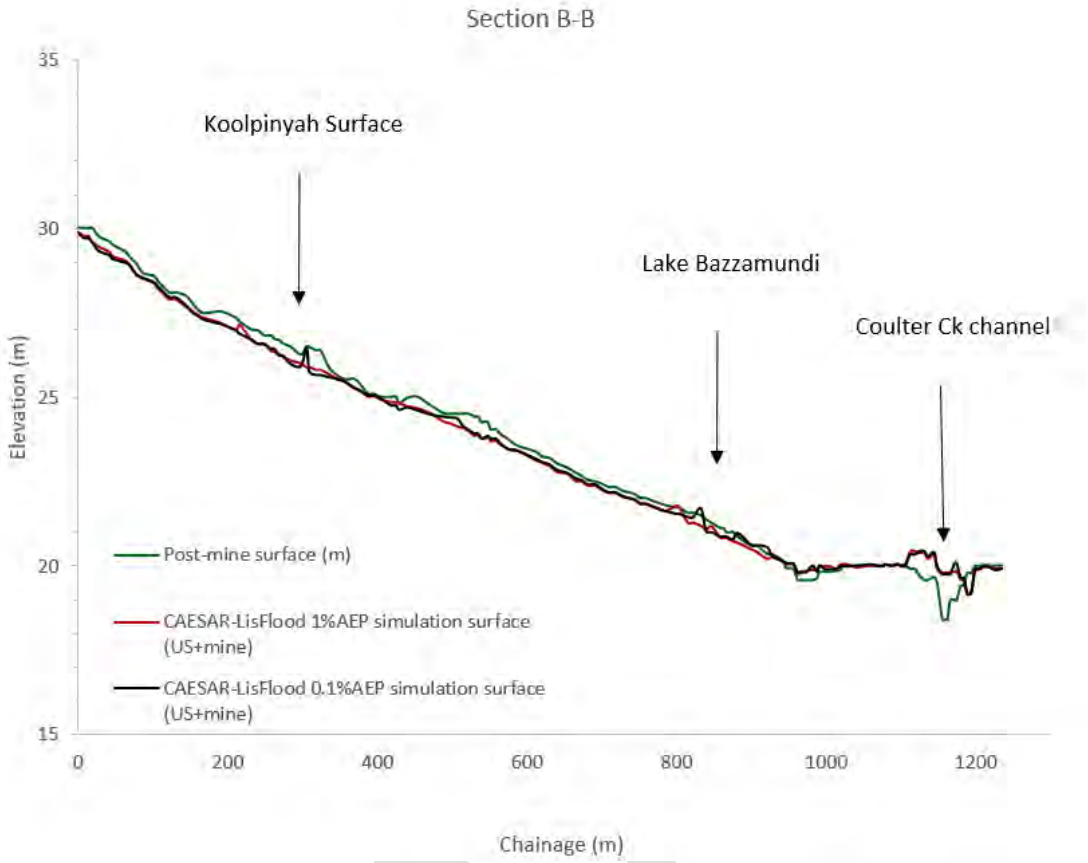

Figure 137. Simulated erosion along Section B-B after 1%AEP and 0.1% storm event for Coulter Creek

Section C-C (Figure 138)

The Lake Bazzamundi surface remains mostly unchanged with only little erosion occurring along the bund. Higher erosion occurs along the boundary line of Lake Bazzamundi with up to 0.5m depth. There is scour present in the Coulter Creek channel, causing the channel to widen and deepen significantly.

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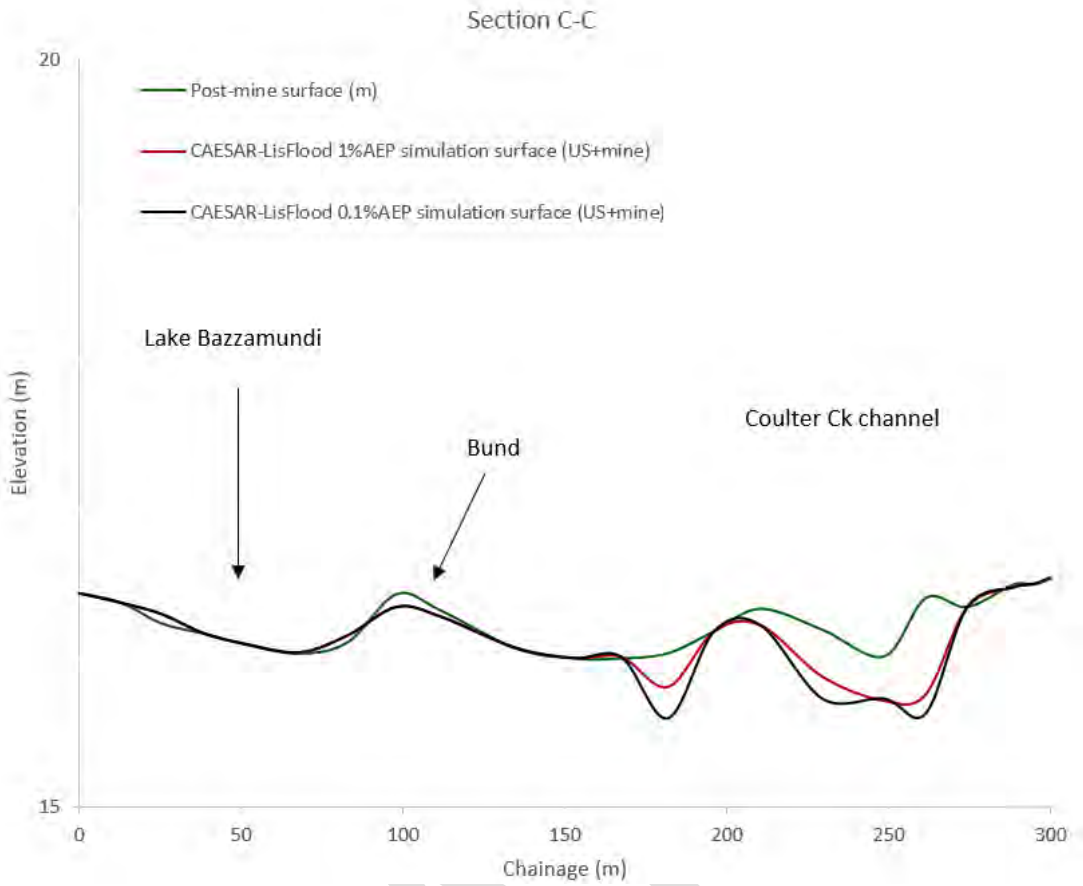

Figure 138. Simulated erosion along Section C-C after 1%AEP and 0.1% storm event for Coulter Creek

Section D-D (Figure 139)

Little erosion occurs along a natural drainage channel on Koolpinyah surface There is up to 0.55m high deposition from the boundary line of Lake Bazzamundi to the bund and over 0.8m deep erosion through the bund in that location. The channel has been scoured along the left bank causing the thalweg to be moved towards the left and the channel to deepen by over 0.4m.

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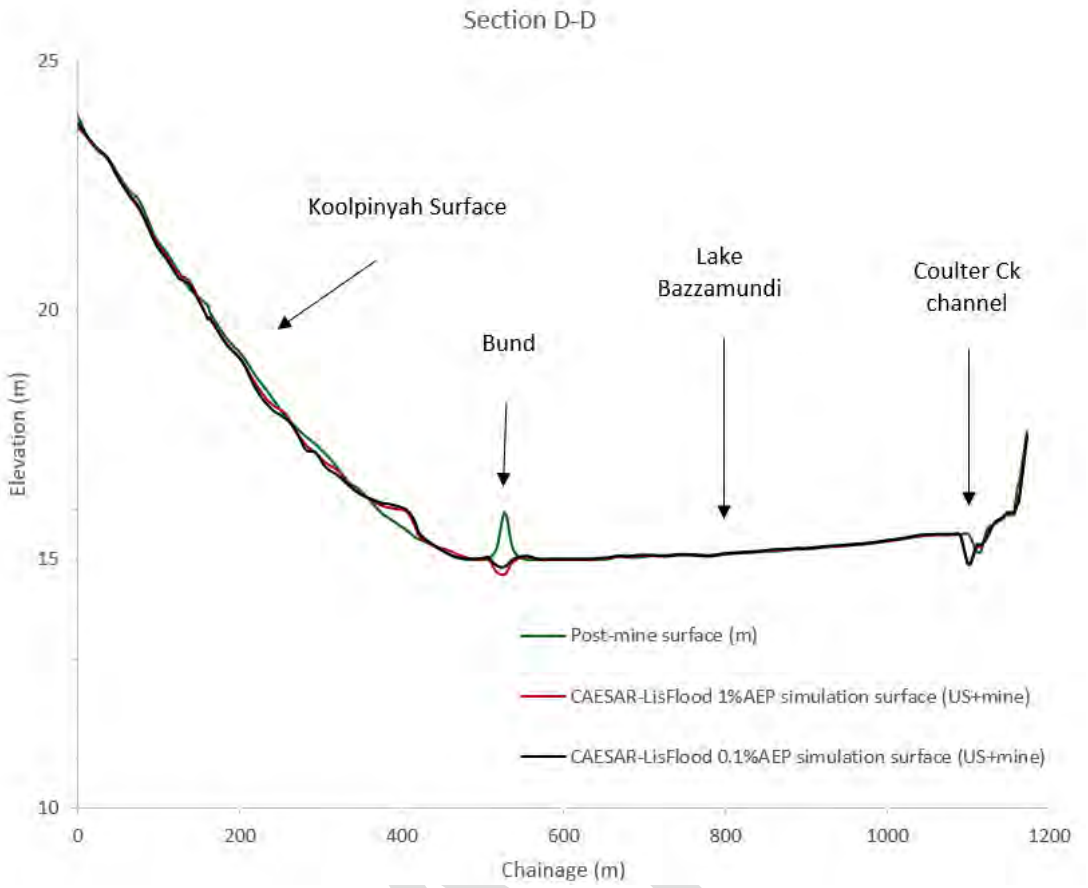

Figure 139. Simulated erosion along Section D-D after 1%AEP and 0.1% storm event for Coulter Creek

Section E-E (Figure 140)

Upstream inflow causes high erosion depth along the floodplain, which can exceed 1m in some locations. Where Section E-E intersects the Coulter Creek channel the first time there is high deposition along the left bank of Coulter Creek and high erosion along the right bank. This causes the channel to deepen and narrow and shift towards the right side. At the second intersection of Section E-E with the Coulter Creek channel there is minor erosion along the left bank for the 1%AEP event and high deposition for the 0.1%AEP event. There is also a second, smaller channel forming directly next to the main Coulter Creek channel.

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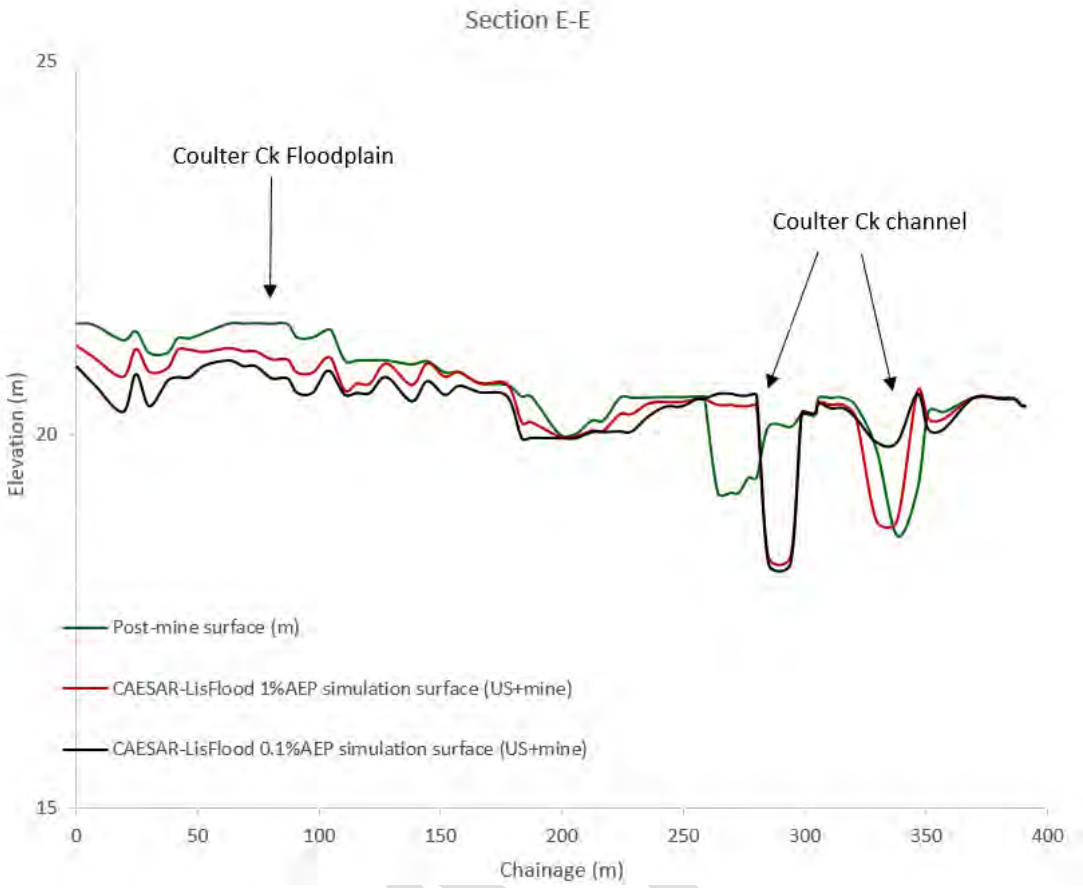

Figure 140. Simulated erosion along Section E-E after 1%AEP and 0.1% storm event for Coulter Creek

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Appendix H. Flood hazard maps

Figure 141 shows flood hazard zones for Mt Bundey Creek flows combined with the mine rainfall runoff for the 1%AEP flood. High risk zones exist in the creek channel for up to a maximum of about 150m either side of the channel.

shows the flood hazard zones for Mt Bundey Creek with upstream input and mine rainfall runoff for the 0.1%AEP flood.

Figure 143 shows the flood hazard zones for Mt Bundey Creek with no mine inputs (only upstream input) for the 0.1%AEP flood. High risk flood hazard zones extend about 250m either side of the creek, demonstrating that the biggest contributor to the high flood risk comes from the upstream catchment, rather than the mine site itself.

Figure 144 shows flood hazard zones for Coulter Creek flows combined with the mine rainfall runoff for the 1%AEP flood.

Figure 145 shows the flood hazard zones for Coulter Creek with upstream input and mine rainfall runoff for the 0.1%AEP flood.

Figure 146 shows the flood hazard zones for Coulter Creek with no mine inputs (only upstream input) for the 0.1%AEP flood.

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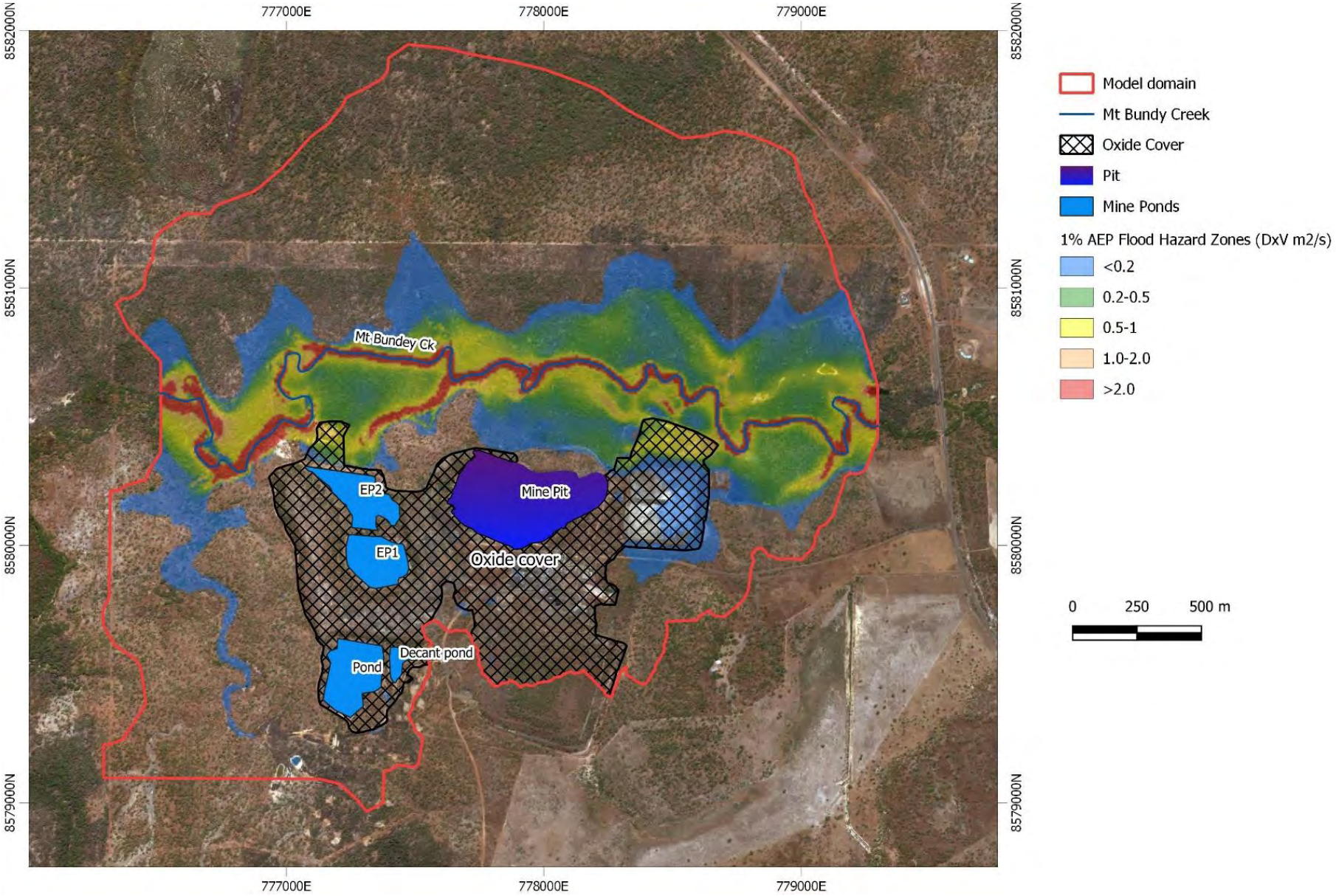

Figure 141. Flood hazard zones for Mt Bundey Creek mine catchment for a 1%AEP rainfall event (flow from UMBC and mine area)

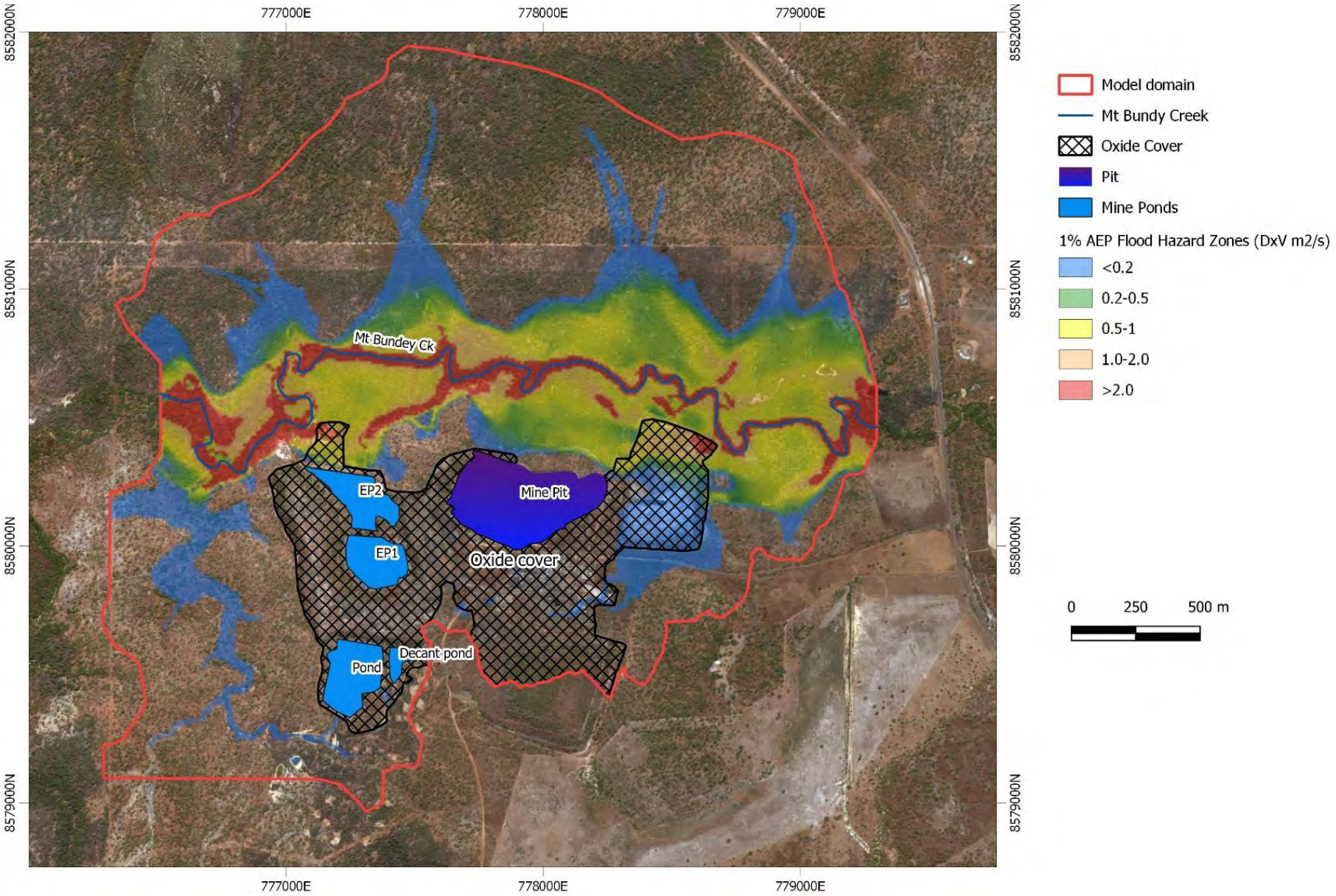

Figure 142. Flood hazard zones for Mt Bundey Creek mine catchment for 0.1%AEP rainfall event (flow from UMBC and mine area)

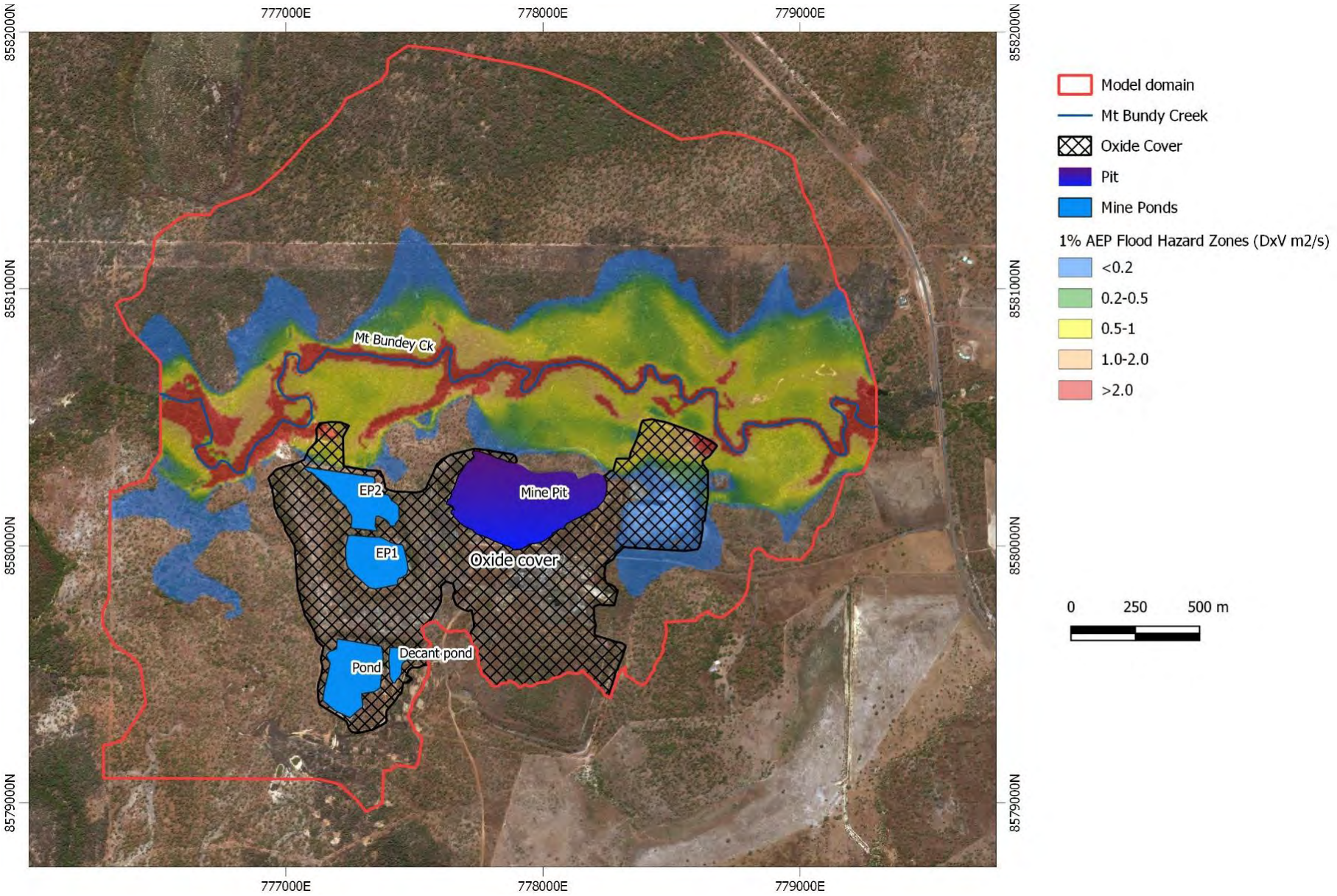

Figure 143. Flood hazard zones for Mt Bundey Creek mine catchment for 0.1%AEP rainfall event (flow from UMBC only)

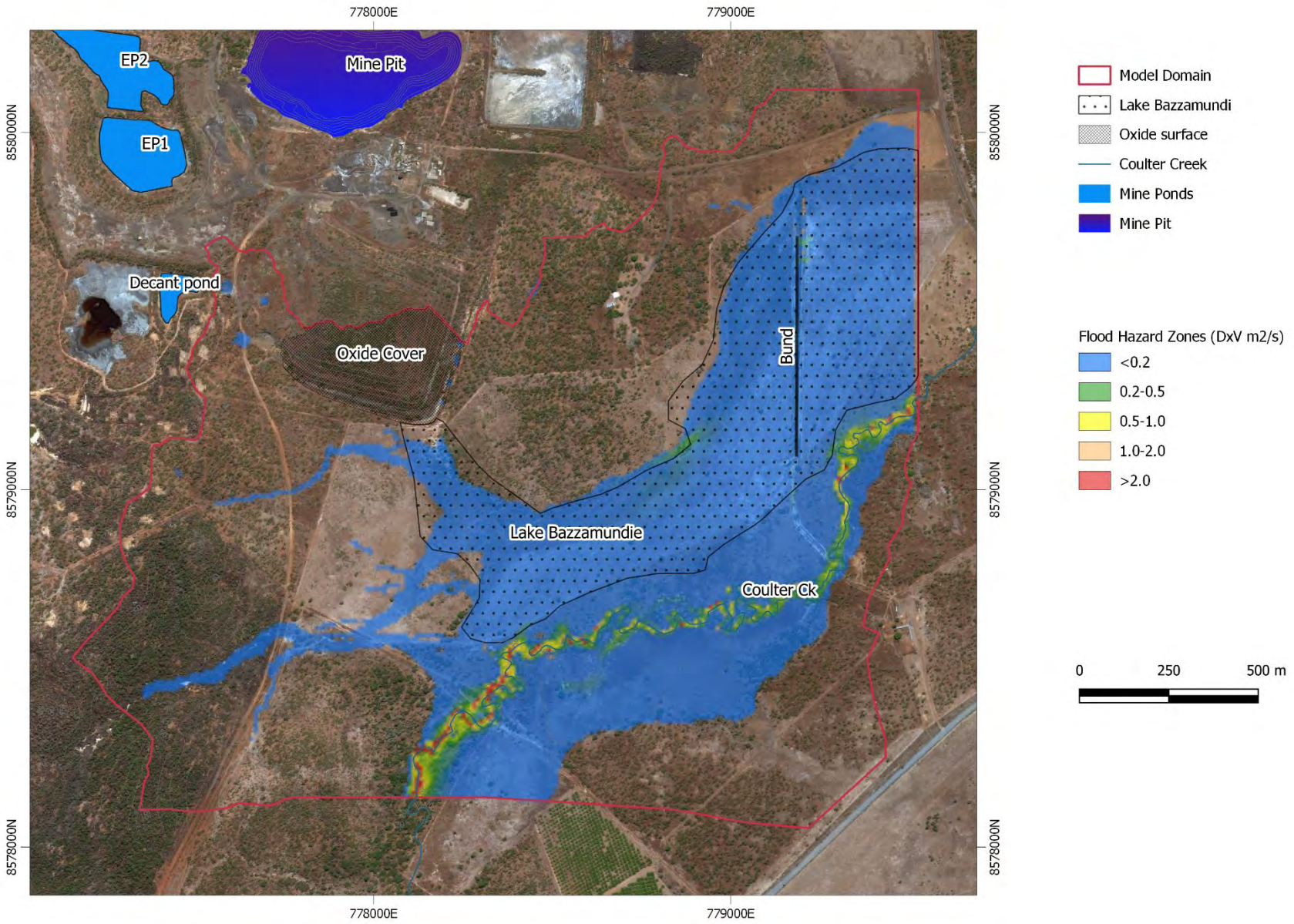

Figure 144. Flood hazard zones for Coulter Creek mine catchment for a 1%AEP rainfall event (flow from UCC and mine area)

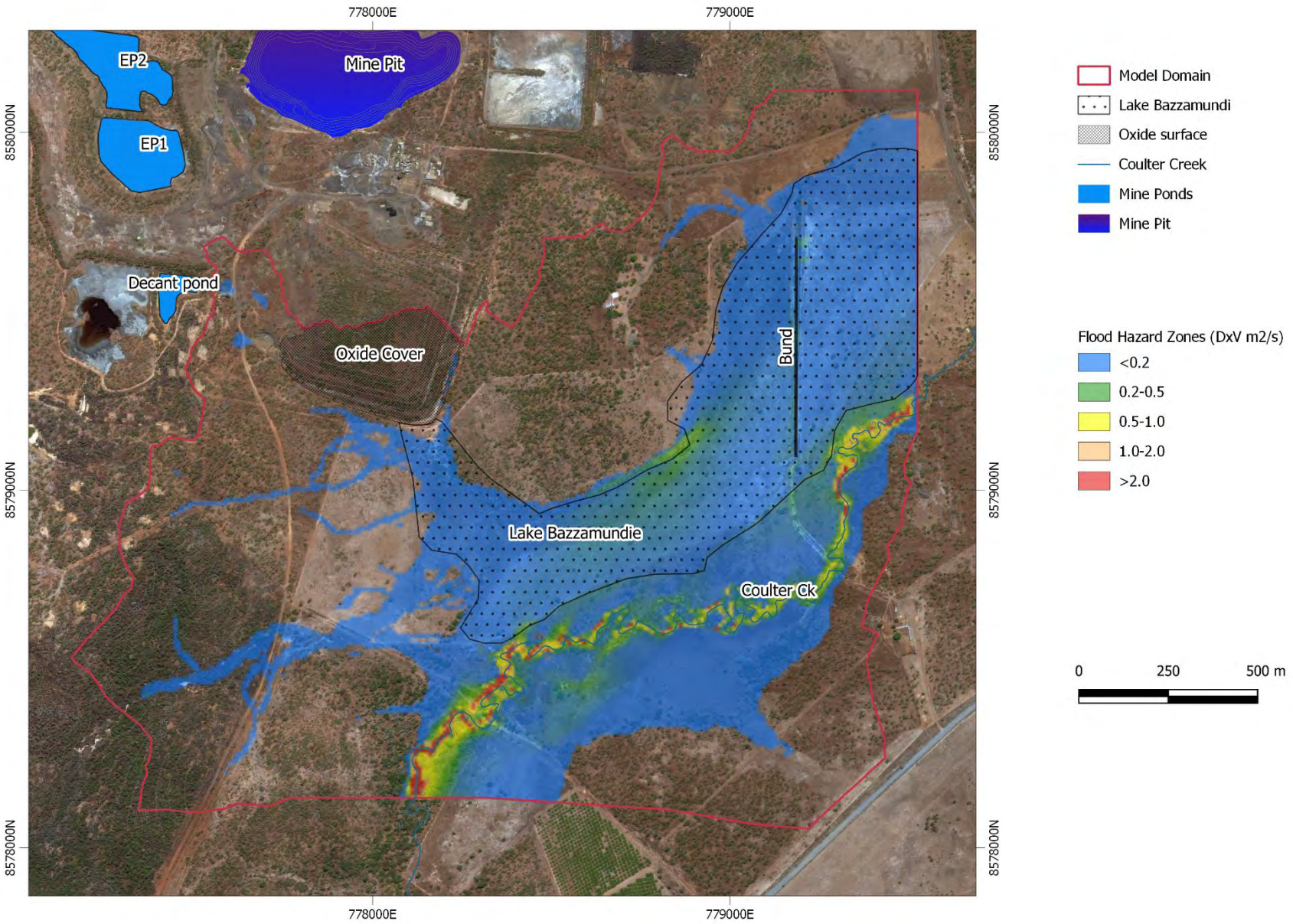

Figure 145. Flood hazard zones for Coulter Creek mine catchment for 0.1%AEP rainfall event (flow from UCC and mine area)

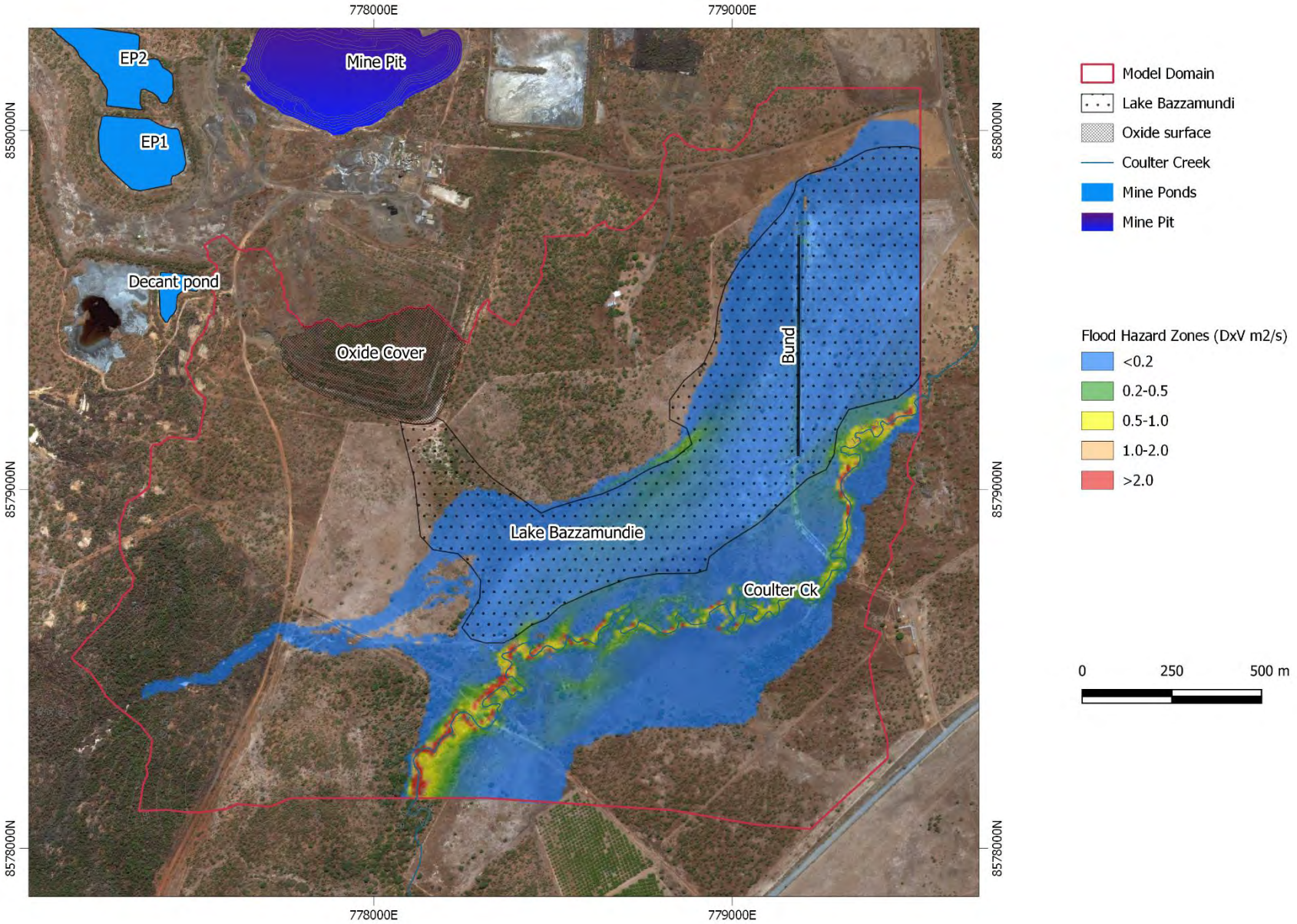

Figure 146. Flood hazard zones for Coulter Creek mine catchment for 0.1%AEP rainfall event with flow from UCC only

Appendix I. EPA response to Draft EIS

Inland water environmental quality: Potential release of mine-affected water after closure

The Draft EIS and Supplement indicate that the pit currently operates as sink for groundwater (including contaminated seepage) and surface water runoff. Alterations to the proposal include the deposition of tailings and waste rock in the pit, which may affect:

- whether the pit will remain a sink
- the extent of freeboard during wet seasons
- consequent risk of over topping without active water management

Management of mine affected water during all phases of the Proposal, including post-closure, is a key factor influencing the potential for significant impacts to offsite water quality to occur. The NT EPA considers that protection of the environmental, recreational and agricultural values of the Mary River catchment is an overarching environmental objective.

During the life of the mine, active water management is proposed through pumping of pit water, underground mine water and other mine affected water to the water treatment plant and storage in the WSD, followed by release via Lake Bazzamundi or Oxbow Wetlands as relevant. The Addendum is not clear about impacts from the Proposal (as altered) during after closure when water management will be passive.

The Addendum indicates that after closure there will be a significant chance of mine- affected water being released to the environment in any wet season, assuming no active water management. This would be from three sources as listed below.

Table 7. Potential sources of contamination

Source	Likelihood of release	Water quality
Pit lake	Potential for wet season spills after about 5 years post-mining, in very wet seasons (Fig 5-12 Appendix O), towards Mount Bundey Creek	Uncertain. Pit water geochemical modelling (Appendix D) indicated: worst-case scenario of high acidity acidic pH=2.3 (which could be treated with lime) AMD-generating material may be in the oxide layer and may continue to react
Oxide WRD runoff via drainage bund	90% annual probability of discharge (via the Oxbow Wetlands)	Runoff currently contains contaminants (during wet season flows). While the Oxbow Wetlands acts as a passive water treatment, measured water quality in Mount Bundey Creek has been poor in recent years.

		Future water quality will depend on rehabilitation of the Oxide WRD (if any) and the ROM pad (as per Mine Closure Plan).
ROM pad runoff via stormwater pond	34% annual probability of discharge (via the Oxbow Wetlands)	

Additionally, the Addendum did not provide an assessment of the zone of influence around the pit, given that some mixing is expected to occur with the surrounding groundwater. As the water level of the pit lake will be about 4m above Mt Bundey Ck, it is possible that some seepage may occur, providing a pathway for potential contamination of Mt Bundey Ck.

The NT EPA's expectation is that legacy costs potentially borne by the community and government must be accounted for in mine planning and closure, and avoided as far as possible.

The Australian Government Leading Practice Sustainable Development Program for the Mining Industry's series of handbooks (2016) on mine closure and rehabilitation have four general rehabilitation objectives:

1. safe to humans, domestic livestock and wildlife
2. non-polluting
3. stable, and
4. able to sustain an agreed post-mining land use.

These should be seen as minimum objectives, and more site-specific rehabilitation objectives should be developed for each defined land use.

DRAFT

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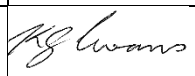
Description	Author	Checked by	Approved for Issue		
			Name	Signature	Date
Draft	Ken Evans	Ken Evans	Ken Evans		27/12/2019

APPENDIX 4

Primary Gold Limited

Toms Gully EIS - Baseline Studies

Aquatic ecology report 2019

October 2019

Executive summary

In situ water quality results from the April 2019 aquatic ecology survey indicated that electrical conductivity (EC) was elevated above the site-specific trigger value (SSTV) at the majority of sites in the study area in 2019, though results were lower than those observed in 2018. The highest EC was observed at aquatic ecology monitoring site MBC06 with a value more than 100 times higher than the SSTV. As identified in 2018, it is likely that this elevated EC at MBC06, along with highly elevated concentrations of sulfate, calcium and magnesium, when compared with results from all other sites, are due to seepage from a nearby groundwater bore.

Water at MBC06 had the highest concentrations of dissolved arsenic, cobalt, manganese, nickel and uranium of all the sites assessed, with cobalt and nickel concentrations exceeding the SSTVs. This provides further evidence that this site is being influenced by groundwater seepage.

Concentrations of dissolved aluminium exceeded the SSTV at adjacent surface water monitoring sites SWTG09 and SWTG1 and downstream sites MBC01A, SWTG2 and SWTG3, with the highest concentration observed at MBC01A. Dissolved aluminium concentrations were below the SSTV at all control and reference sites, indicating possible contributions of aluminium to Mount Bundey Creek from overland flows from Toms Gully Mine. However, the potential impacts appear to be largely localised with furthest downstream sites MBC03 and SWTG3, containing comparatively reduced concentrations of metals apart from aluminium. As such, any impacts on aquatic ecosystems due to water quality are likely to be localised.

Sediment quality in the study area was generally good in 2019, with only cadmium at MBC06 found in concentrations above the default guideline value (DGV), indicating the potential for toxicity to aquatic biota at this location.

The macroinvertebrate community was in good condition at most sites in the study area based on the results of AUSRIVAS modelling and other macroinvertebrate metrics. The exception was MBC06 which exhibited poor macroinvertebrate community condition, likely due to the poor water and sediment quality observed.

Three sightings of Mertens' Water Monitors (Varanus mertensi) were recorded in 2019 at two sites, including one site upstream of Toms Gully Mine, and one site far downstream. No monitors were observed at any site adjacent to the mine or immediately downstream.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.4 and the assumptions and qualifications contained throughout the report.

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1. Introduction

1.1 Background

Toms Gully Mine, located near Marrakai in the Northern Territory, has been in operation intermittently since 1988. The Toms Gully resource was discovered in 1986 by the Carpentaria Exploration Company. Following its discovery, the project area has operated under the ownership of several companies. Most recently, the site was operate by Crocodile Gold until 2010; then after a period of care and maintenance, it was divested to Primary Gold Limited (Primary).

Primary, the current lease owner, proposes to recommence underground mining and ore processing at the Toms Gully Mine.

An aquatic ecology monitoring program conducted in 2015, 2017 and 2018 gathered data on water quality, macroinvertebrate and fish communities, and habitat information for Mount Bundey and Coulter Creeks. This report builds upon the data that has already been collected during those sampling events.

1.2 Scope

The scope of work for this study included:

- An aquatic ecology survey carried out in April 2019 to characterise the existing aquatic health and condition of the receiving environment, including:
  - Macroinvertebrate sampling and aquatic habitat assessment carried out in accordance with the NT AUSRIVAS Darwin-Daly Region Manual (Lamche 2007), with the inclusion of replicate sampling
  - Fish sampling
  - Water and sediment quality sampling and analysis at each site where aquatic ecology monitoring takes place.
- A study design that incorporates locations upstream, within and downstream of the Toms Gully Mine Lease (ML), and as a minimum, assessment of Primary sites SWTG1A (control site) and SWTG2 (potential impact site downstream of Toms Gully Mine).
- Monitoring for the presence of the Mertens' Water Monitor (*Varanus mertensi*) and Mitchell's Water Monitor (*Varanus mitchelli*) downstream of the Toms Gully Mine site.

This report presents the results of the above monitoring conducted in April 2019, as well as an historical analysis of macroinvertebrate results from previous studies in 2015, 2017 and 2018.

1.3 Assumptions

Some data used as part of this report was gathered from external sources, and has not been verified by GHD. Climate data gathered from the Bureau of Meteorology was assumed to be validated and correct at the time it was accessed.

1.4 Limitations

This report has been prepared by GHD for Primary Gold Limited and may only be used and relied on by Primary Gold Limited for the purpose agreed between GHD and the Primary Gold Limited as set out in section 1.2 of this report.

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The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Study area

2.1 Climate

The area in which Toms Gully Mine is located has a tropical monsoonal climate with a pronounced wet season from October to April.

Rainfall data was sourced from the Bureau of Meteorology Point Stuart Wilderness Lodge station (station number 14263) (BOM 2018), the nearest active rainfall station to Toms Gully Mine. Rainfall data for May 2018 to April 2019 is displayed in Figure 2-1 and includes a comparison to long-term monthly median results from data recorded between 1957 and 2019. Rainfall exceeded the long-term median during three of the seven wet season months prior to April sampling.

Watercourses in the study area are ephemeral and cease to flow during the late dry season, but have regular flows during the wet season. Semi-permanent waterholes exist in the area. These are likely to be ecologically important and serve as a refuge for fish and aquatic reptiles during the dry season, as well as being water sources for terrestrial fauna.

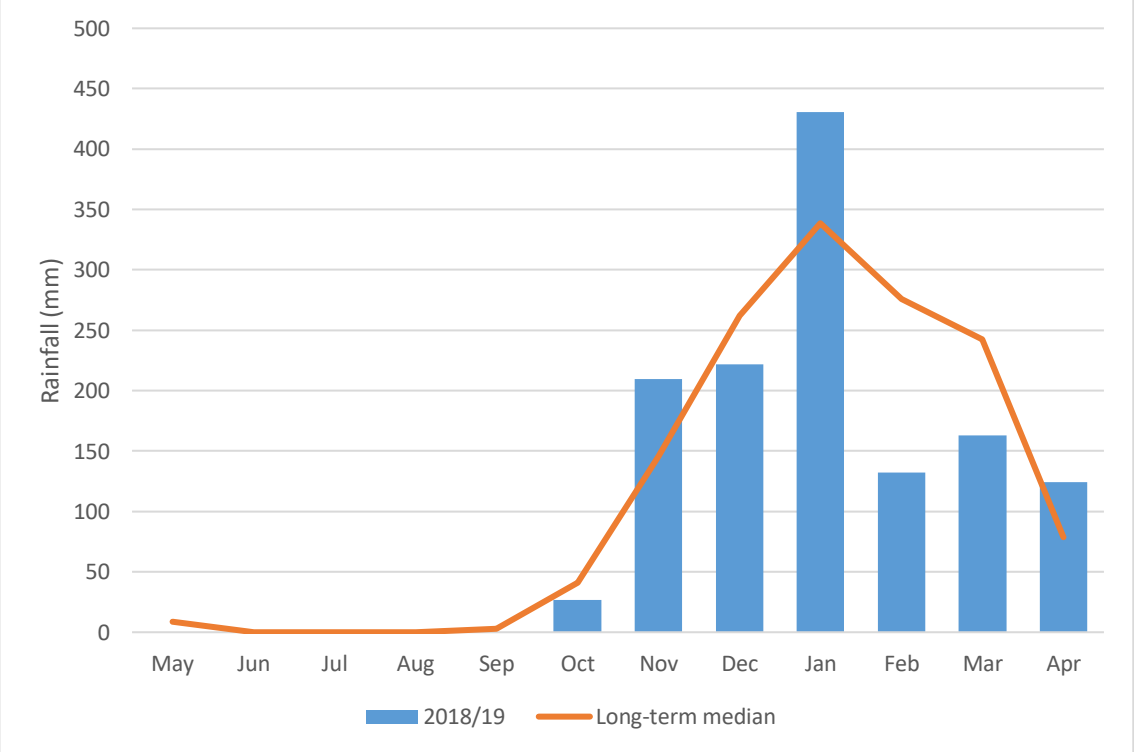


Figure 2-1 Monthly rainfall at Point Stuart Wilderness Lodge weather station (14263) 2018/19, with comparison to long-term median results

2.2 Waterways in the project area

The Toms Gully Mine site is located within the Mount Bundey Creek catchment, which comprises a series of small ridges and dissected hills that are drained by small, steep rivulets converging into Mount Bundey Creek. The majority of the catchment upstream of the project area consists of outcropping rock with thin soil cover and shallow alluvium drainage lines. The total catchment area upstream from the mine is approximately 117 km^2. Toms Gully mine site is situated at approximately 40 m AHD and, is therefore considered to be a lowland river for assessment against water quality guidelines. For the purpose of AUSRIVAS assessment, the site is located within the Darwin-Daly Catchment.

Mount Bundey Creek flows west to east along the northern section of the project area. The creek is approximately 30 km long with 13 km of the creek upstream of the mine site. It has several tributaries upstream of the project area. Downstream from the mine site it drains into Hardies Creek, and then the Mary River.

Coulter Creek is a tributary of Mount Bundey Creek and flows southwest to east (to the south of the project area). Coulter Creek flows into Mount Bundey Creek downstream of the project area, and compliance monitoring site SWTG2, and therefore, is not influenced by Toms Gully Mine.

3. Methodology

3.1 Survey timing

Sampling was undertaken between 15 and 20 April 2019. Rainfall during April was higher than median levels (Figure 2-1), resulting in higher water levels across all sites than during previous monitoring events.

A crocodile spotter was present for all field surveys to reduce the risk of crocodile attack.

3.2 Survey sites

3.2.1 Aquatic ecology survey

Aquatic ecology sampling was undertaken at 14 sites in April 2019 as outlined in Table 3-1 and Figure 3-1. On Mount Bundey Creek, 10 sites were sampled, consisting of two control sites upstream of the mine (including new site SWTG1C), five sites adjacent to the mine, and three sites downstream of the mine. Four sites were sampled on the reference system Coulter Creek. There is no direct discharge from the mine site into Coulter Creek.

Table 3-1 Aquatic ecology monitoring site details for sites visited in April 2019. Coordinates in zone 52L.

Site	Easting	Northing	Location	Site Type
Mount Bundey Creek Catchment				
SWTG1C	775674	8579115	Mount Bundey Creek approximately 2.5 km upstream of SWTG1A.	Control
SWTG1A	776351	8580503	Mount Bundey Creek upstream of mine at lease boundary.	Control
SWTG09	776766	8580098	Tributary adjacent to EP1 and EP2, approximately 200 m upstream of the confluence with Mount Bundey Creek.	Adjacent to Mine
SWTG1	776825	8580290	Mount Bundey Creek at confluence of tributary adjacent to EP1 and EP2	Adjacent to Mine
MBC0	777606	8580736	Mount Bundey Creek upstream of tributary draining EP1 and EP2	Adjacent to Mine
MBC06	777293	8580350	Mount Bundey Creek downstream on tributary draining EP1 and EP2	Adjacent to Mine
MBC01A	778787	8580437	Mount Bundey Creek downstream of wetland oxbow and Toms Gully Mine Tailings Dam 2 (TSF2). Located 700 m downstream of previously monitored site MBC01.	Adjacent to Mine
SWTG2	779453	8580428	Compliance monitoring point at Arnhem Highway Crossing	Downstream
MBC03	780604	8580044	Mount Bundey Creek approximately 1.8 km downstream of SWTG2.	Downstream
SWTG3	782278	8579366	300 m upstream of confluence between Mount Bundey Creek and Coulter Creek	Downstream
Coulter Creek Catchment (Reference sites)				
CC02	778299	8578355	Coulter Creek. Approx. 2 km upstream from CK7	Reference
CC01	779293	8578801	Coulter Creek approximately 1 km upstream from CK7	Reference

Site	Easting	Northing	Location	Site Type
CK7	779807	8579538	Coulter Creek. Existing monitoring site located at highway crossing	Reference
CC03	780166	8579675	Coulter Creek approximately 750 m downstream of CK7	Reference

3.2.2 Water monitor survey

Remote cameras were set up in six locations along Mount Bundey Creek (Table 3-2; Figure 3-2) in order to monitor the presence of Mitchell's and Mertens' Water Monitors. Where possible, cameras were set up in locations close to aquatic ecology sites where habitat was considered favourable for their presence. One camera was located upstream of Toms Gully Mine, and the remaining five were located downstream.

Table 3-2 Remote camera locations

Camera Code	Easting	Northing	Associated aquatic ecology site
M1	778691	8580427	MBC01
M3	776351	8580503	SWTG1A (control site)
M4	780126	8580212	Not applicable.
M5	779453	8580428	SWTG2
M7	778787	8580437	MBC01A
M8	782278	8579366	SWTG3

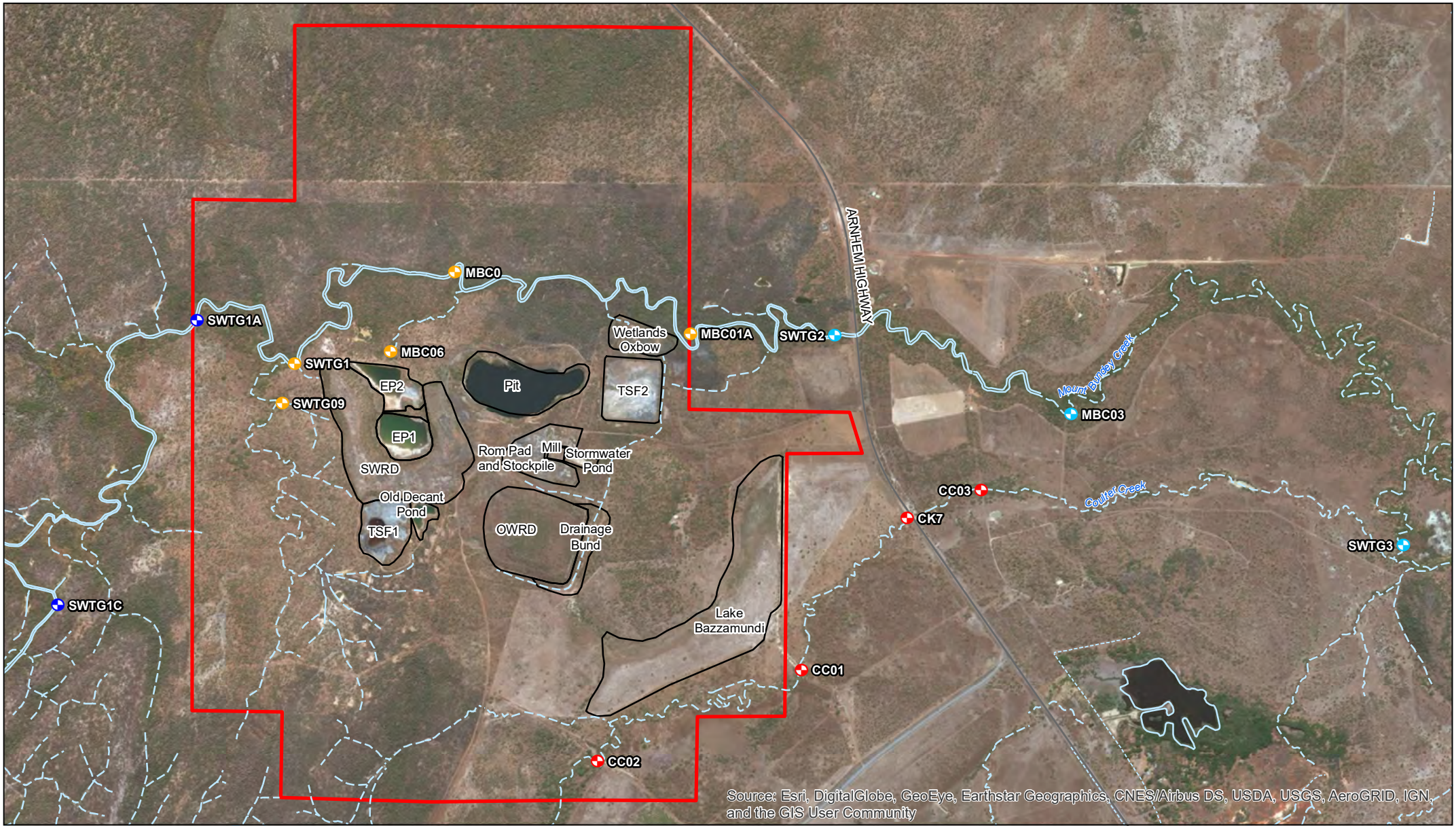
3.3 Habitat assessment

Information about site habitat conditions were recorded at each site following the criteria listed in the Northern Territory AUSRIVAS Darwin-Daly field sheets (Lamche 2007). Habitat assessment at each site included the whole reach (100 m section of the river), the habitats sampled, and the surrounding terrestrial environment. This included information on:

- Site description, including field estimates of stream width, bank height and riparian width
- Characteristics of macroinvertebrate habitat
- Riparian vegetation characteristics (types, % cover, exotic species, erosion, land use)
- Water and sediment quality observations (clarity, odour, oils, foam/scum, plume) and
- A sketch of each site.

The information recorded was used to help interpret trends in the biological data and to provide input data for the Darwin-Daly AUSRIVAS model.

Photos were taken of upstream and downstream sections of the sampled stream reach, as well as bank habitat and other key habitat features to further characterise the habitat conditions at each site. These serve as a pictorial record of site conditions that can be tracked over time using photos taken from the same points.



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Metres

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Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

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LEGEND

Aquatic ecology monitoring site
- Adjacent to Mine
- Control
- Downstream
- Reference

- Site Boundary
- Mine Site Layout
- Water Body Perennial
- Watercourse Intermittent
- Drain
- Roads

Primary Gold Limited
Toms Gully Baseline Studies
Aquatic Ecology Report

Job Number	43-22623
Revision	0
Date	17 Oct 2019

Aquatic ecology monitoring sites visited April 2019

Figure 3-1

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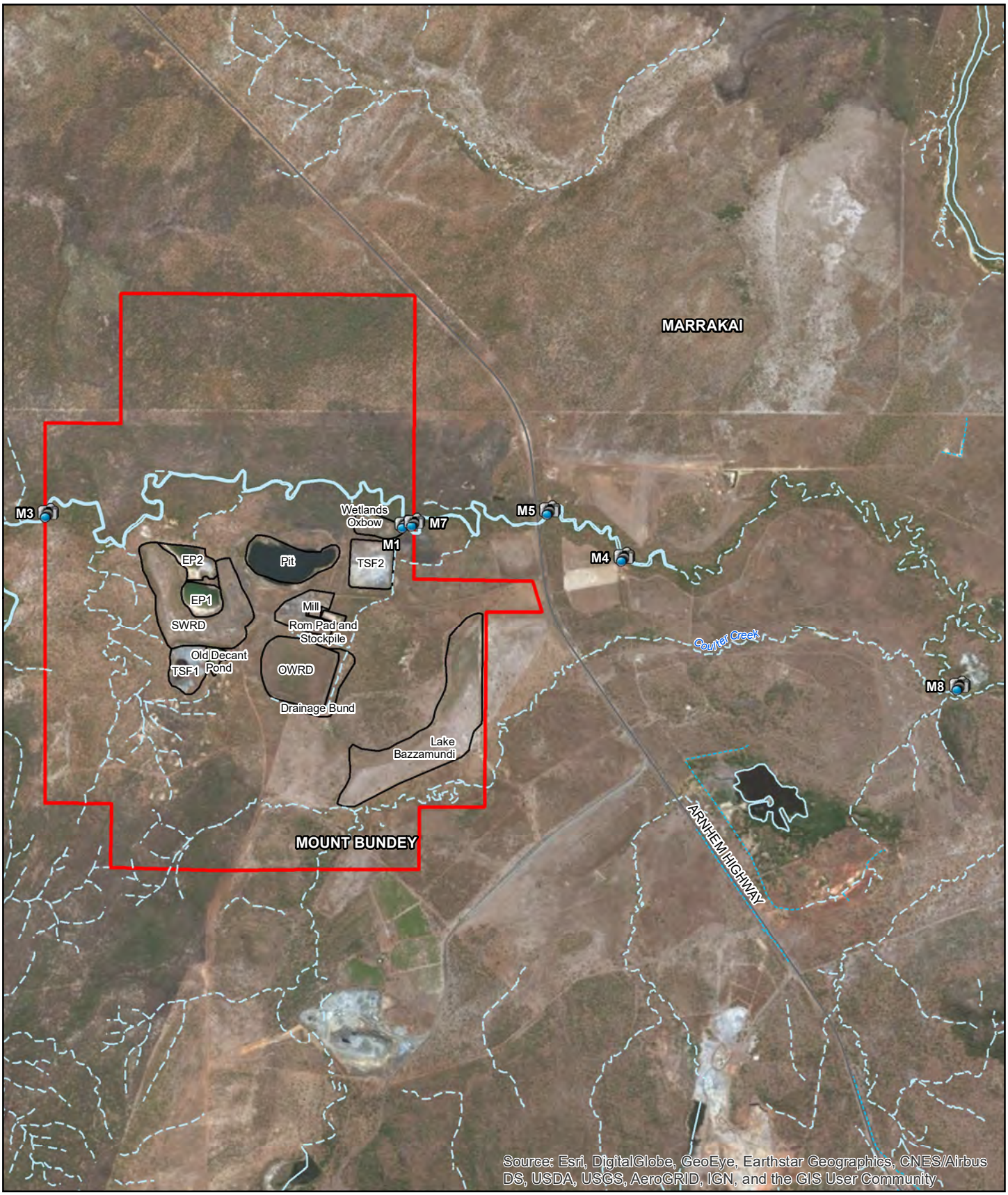

LEGEND

- Site Boundary
- Mine Site Layout
- Remote camera location
- Roads
- Water Body Perennial
- Watercourse Intermittent
- Drain

Paper Size A4

0 250 500 750 1,000 1,250

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

N

Primary Gold Limited
Toms Gully Baseline Studies
Aquatic Ecology Report

Location of remote cameras used in April 2019 survey

Job Number	43-22623
Revision	0
Date	17 Oct 2019

Figure 3-2

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Data source: Commonwealth of Australia (Geoscience Australia): DTDB, 2015. ESRI: Imagery, 2017. Created by: tmorton, fmackay, pkiem

3.4 Water quality

3.4.1 *In situ* water quality

In situ physical and chemical parameters were measured at each site using an Aquaread multi-parameter water quality meter. The water quality meter was calibrated in accordance with the manufacturer's specifications, and used in accordance with operating protocols defined in the GHD Quality Systems manual.

The Aquaread Water Quality meter was used to measure pH, electrical conductivity (EC) (µS/cm), water temperature (°C), dissolved oxygen (DO) concentrations (% saturation and mg/L) and turbidity (NTU).

3.4.2 Grab samples

One surface water grab sample was collected at each site prior to the collection of fish and macroinvertebrate samples. Water requiring analysis of dissolved metals was field filtered using a dedicated high volume 45 µm filter prior to collection in the sample bottle. Water samples were analysed for the parameters in Table 3-3. Laboratory certificates of analysis are presented in Appendix A.

Table 3-3 Laboratory water quality analytical schedule

Suite	Analytes
Physico-chemical	Total dissolved solids (TDS), total suspended solids (TSS), turbidity
Major anions	Alkalinity, chloride, sulfate
Major cations	Calcium, magnesium, sodium, potassium
Metals (dissolved and total)	Aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, uranium, zinc
Cyanide	Free cyanide, weak acid dissociable (WAD) cyanide, total cyanide

3.4.3 Data analysis

Water quality results were compared against the Site Specific Trigger Values (SSTVs) derived for Toms Gully Mine by Stauber and Batley (2018).

3.5 Sediment quality

Sediment samples were collected in accordance with the sediment-water interface hand corer methods as outlined in the Sediment Quality Assessment (Simpson and Batley 2016) guide. Sediment samples were collected at each of the monitoring sites using a plastic trowel. A minimum of two samples were collected from each site and homogenised to produce one composite sediment sample.

The sediment samples were analysed for the parameters presented in Table 3-4 by a NATA accredited laboratory. The laboratory certificate of analysis is presented in Appendix A.

Table 3-4 Laboratory sediment quality analytical schedule

Lab Analyses	Analytes
1M HCl extractable metals	Aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, uranium, zinc.
Total recoverable metals	Mercury
Cyanide	Free cyanide, weak acid dissociable (WAD) cyanide, total cyanide
Other parameters	Particle size distribution (PSD), total organic carbon (TOC), moisture content.

3.5.1 Data analysis

Sediment quality results from each survey site were compared to the revised toxicant default guideline values (DGVs) sediment quality guidelines for metals and metalloids, as outlined in ANZG (2018). The sediment DGVs represent the thresholds above which biological effects are possible. GV-high values are the thresholds above which there is a high probability of biological effects (ANZG 2018).

3.6 Macroinvertebrates

3.6.1 Sampling methods

Macroinvertebrate sampling and processing followed procedures outlined in the Northern Territory AUSRIVAS manual for the Darwin-Daly region (Lamche 2007). Sampling involved one field team member scraping submerged root matter associated with the lower bank to agitate and remove macroinvertebrates into the water column, while the other field team member swept a dip net through the water column downstream of the edge habitat, to collect the dislodged animals. Areas of riffle or fast flowing habitat, Pandanus roots and severe bank undercuts were avoided when collecting edge habitat samples.

Once collected, the samples were washed through 10 mm and 250 µm mesh sieves. The course mesh sieve was examined for large, conspicuous taxa, and these were placed in the labelled sample container. The sample collected in the fine mesh sieve was also placed in the labelled sample container and filled with 70% ethanol. All samples were processed and macroinvertebrates identified by Aquatic Ecology Services.

3.6.2 Laboratory processing

In addition to the field sieving outlined in 3.6.1, samples were washed through a series of sieves (10 mm, 500 µm and 250 µm mesh sizes) in the laboratory. Any large, conspicuous taxa identified in the 10 mm mesh sieve were added to the contents of the large mesh fraction retained in the field. The contents of the 500 µm mesh sieve were retained for macroinvertebrate identification and enumeration, while the 250 µm fraction was retained as sample residue for quality assurance purposes. The contents of the 500 µm mesh fraction was poured into a Marchant sub-sampler (Marchant, 1989) and extractions made randomly from cells (aliquots) in this apparatus. These extractions were placed under a microscope and the taxa identified and counted. This process continued until either all aliquots were examined, or a total of 200 individuals had been counted and identified. The number of aliquots required to be processed to obtain a minimum 200 individual sub-sample was recorded in order to be able to calculate abundance. Leica MZ9.5 stereo-dissection microscopes with planachromat objectives and a zoom capability between 6.3x and 60x were used to examine specimens.

Taxa were identified to family level where possible, with the exception of key taxa identified in Lamche (2007) as either requiring identification to sub-family level (e.g. Chironomidae) or only to order level (e.g. Acarina). All taxa have been identified using the keys specified in Hawking (2000). Following identification, taxa counts were recorded in Microsoft Excel and samples preserved. Raw macroinvertebrate data are presented in Appendix B.

3.6.3 Data analysis

A number of indices can be used to assess and/or quantify the influence of anthropogenic activities on macroinvertebrate communities. Responses to contaminants or changes in flow can result in anything from changes in abundance and diversity through to changes in community composition such as the loss or reduction of sensitive taxa. As such, a multiple lines of evidence approach has been adopted with regards to interpreting macroinvertebrate community data, with multiple indices calculated.

Univariate analyses

Table 3-5 provides a summary of the univariate macroinvertebrate indices assessed as part of this study and, where relevant, a description of how to interpret results relating to those indices. Lamche (2007) cautions against the use of the SIGNAL-2 index for assessing the status of Northern Territory macroinvertebrate communities. This measure is however, considered appropriate for this study as the number of pollution-sensitive versus pollution-tolerant families does provide some insight into the condition of the macroinvertebrate community.

Table 3-5 Macroinvertebrate indices used as part of this assessment

Macroinvertebrate Index	Description
Taxa richness	The total number of taxa present at each site is a direct measure of diversity. It assumes that a high number of taxa within a site indicate that the various water quality, habitat and food requirements of taxa have been met (though this could also occur through anthropogenic effects that increase food or habitat supply). A negative environmental impact would normally result in the loss of taxa and a decline in taxa richness at a site.
PET richness	PET Richness was calculated as the total number of families from three orders of macroinvertebrates; Ephemeroptera (mayflies); Plecoptera (stoneflies); and Trichoptera (caddisflies). These orders tend to include taxa that are sensitive to disturbance (though some have moderate tolerances to pollution). Therefore, higher numbers of PET taxa are generally taken to indicate a lower level of disturbance.
SIGNAL-2	SIGNAL-2 is a biotic index that allocates a value to each macroinvertebrate family based upon their sensitivity to pollution. A macroinvertebrate family with a value of 10 indicates high pollution sensitivity whilst a value of 1 indicates high pollution tolerance (Chessman 1995). SIGNAL-2 represents the average pollution sensitivity of taxa in a sample. Higher SIGNAL-2 scores generally indicate a higher proportion of pollution-sensitive taxa in a sample. However, high SIGNAL-2 scores can sometimes be observed when there is a small number of taxa collected (i.e. low taxa richness). For this reason, SIGNAL-2 must be assessed in combination with other macroinvertebrate indices.

Macroinvertebrate Index	Description
AUSRIVAS OE50 and bandings	Under the AUSRIVAS model, the expected (E) fauna from reference sites with similar sets of predictor variables (physical and chemical characteristics which cannot be influenced due to human activities e.g. altitude) are compared to the fauna observed (O) during monitoring and the ratio derived is then used to indicate the condition of the macroinvertebrate community. The critical metric in the AUSRIVAS model is the OE50, which is calculated from the O and E measures for macroinvertebrates with a predicted probability greater than 50% of occurring at the site based on habitat variables recorded. The OE50 ratio can range from 0, when none of the expected taxa are found at a site, to >1, when either all the expected taxa are found in a sample or when more families are found in a sample than predicted by the model. The scores derived from the model can be placed in bands delineated by the Monitoring River Health Initiative, which allows assessment of the level of environmental health at a site, as shown in Table 3-6.

Table 3-6 AUSRIVAS OE50 scores and bands for the Darwin-Daly Model.

Band Label	OE50 Upper Limit	Band Name	Band Description
Band X	>1.18	More biologically diverse than reference sites	More families found than expected. Potential biodiversity "hot-spot" or mild organic enrichment. Continuous irrigation flow in a normally intermittent stream.
Band A	1.18	Reference condition	Expected number of families within the range found at 80% of the reference sites.
Band B	0.81	Significantly impaired	Potential impact either on water and/or habitat quality resulting in a loss of families.
Band C	0.44	Severely impaired	Many fewer families than expected. Loss of families from substantial impairment of expected biota caused by water and/or habitat quality.
Band D	0.07	Extremely impaired	Few of the expected families and only the hardy, pollution tolerant families remain. Severe impairment.

For this study, macroinvertebrate data was assessed using the NT AUSRIVAS Darwin-Daly Early (dry season) Family level Edge habitat model. The habitat variables required to run this model are latitude, longitude, RIP500 (amount of square kilometres of rainforest within a 500 m radius of a given site) and average steam width. RIP500 data has been estimated using vegetation classification GIS data obtained from DLRM.

Multivariate analysis

A non-metric Multi-Dimensional Scaling (NMDS) analysis was conducted to identify temporal and spatial trends in macroinvertebrate community composition. This multivariate analysis was performed in PRIMER 7 (Clarke and Gorley 2015) statistical analysis software.

Non-metric MDS or ordination provides a graphical representation of the relative similarity of entities (i.e. samples) based on their attributes (i.e. macroinvertebrate community composition) within a reduced dimensional space. The more similar samples are to each other, the closer they are located within the ordination space. The non-metric MDS ordination was performed on Bray-Curtis similarity coefficients which are suitable for biological data (Bray and Curtis 1957). The 2-dimensional ordination has been displayed as this is more easily interpreted than the 3-dimensional plot.

The stress level is a measure of the distortion produced by compressing multi-dimensional data into a reduced set of dimensions and would increase as the number of axes (i.e. dimensions) is reduced. If the stress is over 0.2, the MDS plot must be interpreted with caution.

An Analysis Of Similarities test (ANOSIM) was performed on the macroinvertebrate similarity matrix to test whether macroinvertebrate communities were statistically different between site types and between sampling events. This method permutes the observed data and tests the between group similarity observed under this “random” data set. These values are then compared to the observed similarity and the significance of the test based on whether higher or equal similarity was experienced under the permuted datasets. Interpretation of this technique is based on significance ($p<5\%$) and strength of the relationship, denoted as R.

3.7 Fish surveys

Electrofishing was attempted at SWTG1, but the turbidity of the water made it difficult to see stunned fish. Electrofishing was not conducted at any other site in 2019 due to fast flowing streams, turbid water and high water levels. Bait trapping was employed at all aquatic ecology sites except SWTG3 and SWTG09. Bait trapping involved setting five rectangular box traps (2 mm mesh size) for approximately four hours at each site. Each trap was baited and deployed close to representative physical habitat structure (e.g. rocks, snags, roots, macrophytes, etc) to maximise the likelihood of catching fish and freshwater prawns.

3.8 Water monitors

All remote cameras were set up with guidance from Gillespie *et al*. (2015). Cameras were attached to trees approximately 0.5 m from the ground, with a bait placed in front of the camera. Cameras were positioned where possible to include areas likely to be used for basking by water monitors, such as banks close to the water and logs. The cameras remained operational between 10 May and 21 August 2018. The camera located upstream (Figure 3-2) of Toms Gully Mine was set up to check for the presence of water monitors outside of the influence of the mine.

3.9 Quality assurance

In accordance with GHD's Quality Assurance (QA) protocol, duplicate water and sediment samples were collected at the same time as the collection of the primary samples during April 2019. The collection of duplicate water and sediment samples allows for the assessment of the potential level of uncertainty associated with natural variability, sampling method, preservation, or laboratory analysis. The results of the duplicate samples are presented in Appendix C for water quality and Appendix D for sediment quality. There were some small differences in the results between the primary sample and the duplicate sample for both water and sediment. However, the variance was within the laboratories acceptable limits.

Two macroinvertebrate samples were reanalysed by a different GHD taxonomist to check the accuracy of identification, the results of which are presented in Appendix E. The percentage of families identified correctly was 100% for both QA samples.

3.10 Summary of sampling tasks

Due to water availability and site characteristics, not all sites were subject to the full spectrum of sampling as described in Sections 3.1 to 3.8. Table 3-7 summarises the sampling tasks carried out at each site.

Table 3-7 Summary of sampling carried out at each site in April 2019

Site	Macroinvertebrate sampling	Fish sampling	Habitat assessment	Water quality	Remote camera
SWTG1A	✓	✓	✓	✓	✓ (M3)
SWTG1C	✓	✓	✓	✓	
SWTG1	✓	✓	✓	✓	
SWTG2	✓	✓	✓	✓	✓(M5)
SWTG3	✓		✓	✓	✓(M8)
SWTG09	✓		✓	✓	
MBC01A	✓	✓	✓	✓	✓(M7)
MBC03		✓	✓	✓	
MBC06	✓	✓	✓	✓	
MBC0	✓		✓	✓	
CC01	✓	✓	✓	✓	
CC02	✓	✓	✓	✓	
CC03	✓	✓	✓	✓	
CK7	✓	✓	✓	✓	
M1					✓
M4					✓

4. Results and discussion

4.1 Site conditions

A description of habitat characteristics associated with monitoring sites sampled in April 2019 are presented in Table 4-1, along with site photographs taken at the time of sampling. At the time of sampling, the water was flowing at the majority of sites and water levels were high compared to previous sampling events.

Left and right banks, as referenced in Table 4-1 is determined when facing downstream.

Table 4-1 Habitat descriptions for sites sampled in April 2019

Site/habitat description	
Control	
SWTG1C	
The site was made up of a series of pools connected by riffles. Flow was strong on the right bank, which was steep and made up of bedrock, exposed roots and clay. The right bank was gentle, and the substrate was cobbles and bedrock. The creek did not span the entire channel, and was confined to the right bank. Vegetation in the riparian zone was growing close to the bank and providing shade to the entire creek. The right side of the channel had trees growing in it, denoting that flow did not increase into this section of the channel often. The substrate was mostly cobbles, but some sand pockets were located on the left side of the creek, where flow was gentle.	
Edge 1 sample:	Left bank. Backwater with submerged woody habitat (SWH) and undercuts. Small pockets of sand and detritus.
Edge 2 sample:	Left bank. Cobbles and leaf packs in a backwater downstream. Exposed roots from Callistemons. Not much sand. Periphyton covering cobbles.
SWTG1A	
Sampling location was moved 100 m downstream due to depth and water clarity. The site was characterised by a wide, shallow pool with gentle flow. Downstream was a stock crossing and deeper pool. The upstream pool was lined by riparian vegetation which was overhanging, and shaded edges. The left bank was steep, and a mixture of consolidated clay and gravel with sections of bedrock, while the right bank was a gentle slope and consisted of cobbles and pebbles. Flow was observably faster along the left bank. Some SWH and undercut roots were present on the left bank, creating a backwater. The riparian zone was ~30 m wide on both sides, and the pool sampled was around 8 m wide and 30 cm deep.	
Edge 1 sample:	Sampled left bank around SWH and some of right bank in sunny areas.

Site/habitat description	
Edge 2 sample:	Sampled right bank in shallow areas, some trailing veg and leaf packs.

Adjacent

SWTG09

The site was a series of isolated pools separated by bedrock located on a tributary of Mount Bundey Creek. The pools had vertical banks that were undercut along almost the entire area of all pools. Each end of the pools were lined with bedrock and cobbles. Trees lined the site, but the riparian zone was discontinuous. Shade was high, as the creek was narrow (2 m wide) and the canopy was enclosed in some areas. SWH was present in some larger pools, and fine detritus was common. Cattle had been accessing the site, and areas beyond the riparian zone had been disturbed by pigs. Debris on banks indicated that high flow had occurred at some point prior to sampling.

Edge 1 sample:	Overhanging trees, exposed roots and an undercut bank. Some cobbles and leaf packs sampled, lots of fine detritus.
Edge 2 sample:	Overhanging trees, exposed roots and an undercut bank. Some cobbles and leaf packs sampled, lots of fine detritus

SWTG1

The site is made up of two large, deep pools, connected by a shallow run. The substrate of both pools is made up of sand and gravel, and the connecting run has substrate made up of pebbles, cobbles and sand. SWH was found through the extent of the reach and the right bank was undercut, exposing roots from riparian vegetation. Banks were approximately 3.5 m high and were very steep. Riparian vegetation was thick, extending at least 20 m from each bank. Riparian vegetation was overhanging and shaded most of the creek. Large trees lined the banks, with their roots exposed, creating good habitat for larger fish.

Edge 1 sample:	Sand, gravel and clay. Exposed roots and SWH sampled
Edge 2 sample:	Undercut bank and roots sampled as well as a cobble lined backwater.

MBC0

The site was almost completely inundated with water. Given the height of banks observed in previous years, water was estimated to be at least 3 m deep. No sampling was undertaken due to safety risks associated with depth, flow and potential presence of crocodiles.

Site/habitat description	
MBC06	
The site is located on a small tributary of Mount Bundey Creek draining away from EP2. The site was made up of a single isolated pool winding along the creek for around 25 m, with an average width of 2 m. The substrate was a mixture of bedrock, cobbles, silt and clay, with small amounts of SWH and leaf packs. An oil slick was observed on the surface. When sampling macroinvertebrates, an anoxic odour was released from sediment. Towards EP2, water was observed seeping from the ground close to a groundwater bore, which was oxidising and iron floc was present. There was no surface water connection to the pool. The riparian zone was narrow, and did not persist for more than 5 m from the water.	
Edge 1 sample:	Undercut banks and exposed roots. Lots of detritus and sticks.
Edge 2 sample:	Backwater with detritus, on right bank, lots of iron floc and silt. Small section of exposed roots.
MBC01A	
MBC01 was relocated 700 m downstream based on a recommendation in 2018 report (GHD 2018a). The site is made up of two pools intersected by a cattle crossing. The upstream pool is deep, and has very steep clay banks. The downstream pool is shallow, with SWH and undercut banks. Both banks in the downstream pool are steep, and the riparian zone along the entire site is dense and continuous, except for the path leading to the cattle crossing on both sides. The substrate of the downstream pool is mostly sand, with some bedrock. Detritus was present in backwaters.	
Edge 1 sample:	Backwater with SWH and leaf packs. Some exposed roots.
Edge 2 sample:	Along right bank, undercut with fine exposed roots, some algae and fine detritus.
Downstream	
SWTG2	
The site is made up of a series of pools connected by runs upstream of a stock crossing. Downstream of the crossing, the site was a wide, shallow pool. Substrate along the entire reach was a mixture of cobbles, pebbles and sand, with clay banks. Continuous riparian vegetation was observed at the site, except through the causeway path, resulting in heavy deposition of detritus and SWH within the creek. Exposed roots were common in deeper pools. Trailing vegetation (parra grass and riparian overhang) was common along the length of the site.	
Edge 1 sample:	Undercut bank and trailing vegetation from overhanging trees. Backwater sections with some detritus. Lots of sand a pebbles.
Edge 2 sample:	Trailing vegetation and sandy gentle sloped edge.

Site/habitat description	
MBC03	
The site is located on a bend and was characterised by a long shallow run connecting deep pools at either end of the reach. The majority of the run was 0.2 m deep and 3 m wide with some deeper sections adjacent to banks. SWH and leaf packs were found through the reach. Substrate was made up mainly of sand and gravel with some silty deposits in deeper areas. The creek was highly shaded and the riparian zone extended for 20 m on the right bank and >30 m on the left bank. The right bank was very steep and 3.5 m high, whereas the left bank was a gentle slope reaching a similar height. Undercut banks and exposed fine roots were common on both sides of the creek.	
Edge 1 sample:	Undercut bank and exposed roots. Log jam with leaf packs.
Edge 2 sample:	Undercut bank and sandy shallow backwater.
SWTG3	
Remote camera set up and WQ sample taken, but no macros or fish. The site is located downstream of the Coulter Creek confluence, and is the furthest downstream site on Mount Bundey Creek. At the time of sampling, the water level at the site was well above the water mark. Water flow and turbidity were high, and it was deemed to be unsafe to undertake biological sampling. There did not appear to be any changes in the riparian zone from 2018.	
Reference	
CC02	
This is the furthest upstream site on Coulter Creek, and is intersected by a ford made of boulders, cobbles and clay. Upstream of the ford was a large, deep pool containing SWH. The pool was considered unsafe to enter. Downstream of the ford was a series of pools connected by shallow runs that was 2 m wide for the majority of the reach. The creek was shaded by a dense, 5 m wide, native riparian strip on both banks. Beyond the riparian zone was cleared and the land used for grazing. An oil slick was observed directly downstream of the ford. Macroinvertebrate sampling was undertaken downstream of the ford.	
Edge 1 sample:	SWH, undercut banks and leaf packs. Some exposed roots. Sandy.
Edge 2 sample:	Trailing veg, some bamboo. Stick and leaf jams. Sandy.

Site/habitat description	
CC01	
The site is normally a set of isolated pools, but was flowing during sampling. The site is located close to Mount Bundey Creek Station cattle yards, with a ford intersecting the creek. The reach extended from the ford downstream. The site was characterised by a meandering run with some deeper pools. Shading was lower in the downstream parts of the creek, with large patches of filamentous algae observed. Banks were eroded close to areas where cattle had been accessing the creek. A representative from Mount Bundey Creek Station advised that cattle were regularly herded through this section of the creek and over the ford. The upstream section of the reach was shaded and had a riparian strip around 5 m wide. Exposed roots and SWH were common.	
Edge 1 sample:	Exposed fine roots and undercut banks. Some detritus.
Edge 2 sample:	Lots of filamentous algae and thick and deep detritus packs. Anoxic.
CK7	
The site is an existing water quality monitoring point for Tom's Gully Mine, located on the downstream side of the crossing of Coulter Creek with the Arnhem Highway. The site was made up of a series of deep pools connected by shallow runs. Steep, eroded banks were covered by pasture grasses, and some sparse riparian trees. The substrate was mostly bedrock, with gravel, sand and clay present in areas of low flow. Evidence of cattle and pig access to the creek from both banks was observed. Some undercut banks and exposed roots and shade were present in the deeper pools. Archerfish observed in deep pools.	
Edge 1 sample:	Backwater areas with trailing grass. Lots of bedrock substrate, but also leaf packs and sticks. Not much shade.
Edge 2 sample:	Leaf packs, exposed roots and gravel sampled in shallower pools. Shady.
CC03	
Site in previous years of sampling has been a set of isolated pools, but was a connected flowing creek in 2019. The site is located approximately 1.7 km downstream of the Arnhem Highway and is a pool 50 m in length, upstream and downstream of the pool was a shallow run. The pool has a moderate amount of shade, and its banks were heavily eroded with discontinuous riparian vegetation mixed with pasture grasses. The substrate was mostly bedrock, with some deposition of clay and silt in the downstream end of the pool.	
Edge 1 sample:	Backwater with SWH and leaf packs. Some exposed roots.
Edge 2 sample:	Along right bank, undercut with fine exposed roots, fine detritus.

4.2 Water quality

4.2.1 *In situ* water quality

Table 4-2 presents the *in situ* water quality results for April 2019.

pH values were within SSTV limits at all sites, but were very slightly acidic at downstream sites in Mount Bundey Creek, and most alkaline at adjacent site SWTG1.

EC was above the SSTV at all sites except control site SWTG1C. These results may indicate influences from the mine area via overland flows and/or seepages.

Water at MBC06 was very saline compared to all other sites, with EC more than 100 times the SSTV. Seepage from a nearby groundwater bore is thought to be causing higher EC at MBC06 which has only been evident at the site since 2018 (GHD 2017; GHD 2018a). Seepage from the ground close to a groundwater bore was observed during the 2019 field survey. EC at sites downstream of MBC06 was slightly higher than observed at sites upstream of MBC06 on Mount Bundey Creek, but decreased with distance downstream. EC results were slightly lower at all sites in 2019 compared with results from 2018 (GHD 2018a); likely due to dilution. DO concentrations were low (below the lower SSTV) at all sites except Coulter Creek sites CC02 and CK7. The lowest DO saturation was recorded at MBC06, and was slightly lower and adjacent and downstream sites than at control sites. DO results at all sites except MBC06 were higher in 2019 than 2018. This is likely to be due to the increased flow at all sites in 2019 compared to 2018.

Turbidity was below the SSTV at all sites and lower in Coulter Creek than in Mount Bundey Creek.

Table 4-2 *In situ* water quality results, April 2019

Site	Date	Time	Temp (°C)	pH	EC (µS/cm)	DO (% sat.)	DO (mg/L)	Turbidity (NTU)
SSTV	NA	NA	NA	5.8-8.0	41	85-120	NA	87
Control								
SWTG1C	15/4/19	8:37	27.8	7.1	39	80.1	6.79	21.1
SWTG1A	15/4/19	10:35	28.0	7.1	46	84.3	7.57	23.5
Adjacent								
SWTG09	16/4/19	14:40	28.2	7.0	47	60.6	5.87	19.4
SWTG1	17/4/19	7:40	27.0	7.6	71	78.3	7.51	19.1
MBC06	17/4/19	16:05	28.2	7.0	4286	51.3	2.56	57.1
MBC01A	16/4/19	14:05	28.9	7.1	105	74.2	7.17	59.1
Downstream								
SWTG2	17/4/19	15:20	28.8	6.7	83	79.5	7.25	17.3
MBC03	18/4/19	8:30	27.3	6.7	82	77.5	7.42	17.8
Reference								
CC02	19/4/19	8.39	27.6	7.1	152	89.2	7.21	10.4
CC01	18/4/19	13:55	28.6	7.3	134	78.1	7.97	12.9
CK7	19/4/19	7:30	27.0	7.1	130	88.9	7.58	5.1
CC03	18/4/19	10:45	27.8	7.2	128	82.3	8.05	10.8

Results in yellow are above the relevant SSTV

4.2.2 Laboratory analysis

Table 4-3 and Table 4-4 present the laboratory analytical results for surface water samples collected in April 2019 in Mount Bundey and Coulter Creek sites, respectively. Free cyanide, WAD cyanide and total cyanide were not detected in concentrations above the laboratory limit of reporting (LOR) at any site. Therefore, these data have not been included in Table 4-3 or Table 4-4. Laboratory certificates of analysis showing data for all measured parameters are provided in Appendix A.

The ionic composition of water varied between sites. Water at MBC06 contained high concentrations of bicarbonate alkalinity, sulfate, chloride, magnesium and potassium, relative to all other sites. The concentration of sulfate at MBC06 exceeded the SSTV and was over 50 times higher than sulfate concentrations recorded at any other site.

Water samples from MBC0 and MBC03 were dominated by carbonate alkalinity and sodium, with concentrations of these ions many multitudes higher than concentrations at all other sites. Water at all other sites, including all control and reference sites, was dilute, with comparatively low concentrations of all major ions.

Concentrations of dissolved aluminium exceeded the SSTV at adjacent sites SWTG09 and SWTG1 and downstream sites MBC01A, SWTG2 and SWTG3, with the highest concentration observed at MBC01A. Dissolved aluminium concentrations were below the SSTV at all control and reference sites, indicating possible contributions of aluminium to Mount Bundey Creek from overland flows from Toms Gully Mine.

Adjacent site MBC06 was the only site at which the concentration of dissolved aluminium was below the LOR. Water at this site, however, had the highest concentrations of dissolved arsenic, cobalt, manganese, nickel and uranium of all sites, with the cobalt and nickel concentrations exceeding the SSTVs. Concentrations of the above elements at MBC06 were observed to be many times higher than those at other sites in April 2019, indicating a localised impact at this site, potentially from groundwater seepage that is also suspected to be contributing to the very high EC observed at this site. Water at downstream site SWTG2 exceeded the SSTVs for dissolved copper and zinc, and was the only site at which dissolved cadmium was observed in concentrations above the LOR.

The elevated dissolved metal concentrations observed at MBC06 and SWTG2, as well as the elevated concentrations of dissolved aluminium, copper, nickel and zinc observed at some adjacent and downstream sites, compared with concentrations at control and reference sites, indicate a potential influence from runoff or overland flows from Toms Gully Mine areas during wet conditions. The impacts do not persist downstream from MBC06 and SWTG2, with furthest downstream sites MBC03 and SWTG3, containing comparatively reduced concentrations of metals apart from aluminium. As such, any impacts on aquatic ecosystems due to water quality are likely to be localised.

Table 4-3 Laboratory surface water quality results Mount Bundey Creek sites, April 2019

Analyte	Units	LOR	Control		Adjacent					Downstream			SSTV
			SWTG1C	SWTG1A	SWTG09	SWTG1	MBC0	MBC06	MBC01A	SWTG2	MBC03	SWTG3	
Physicochemical parameters													
TDS	mg/L	10	42	61	60	48	1120	4530	74	60	975	71	NA
TSS	mg/L	5	8	35	24	11	27	10	134	7	54	17	NA
Major ions													
Bicarbonate alkalinity	mg/L	1	12	10	15	10	6	179	11	10	87	27	NA
Carbonate alkalinity	mg/L	1	<1	<1	<1	<1	846	4	<1	<1	620	<1	NA
Hydroxide alkalinity	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA
Total alkalinity as CaCO3	mg/L	1	12	10	15	10	852	183	11	10	707	27	NA
Sulfate as SO_4	mg/L	1	1	1	<1	1	1	3340	11	11	57	12	210
Chloride	mg/L	1	2	2	3	2	3	19	2	2	3	3	NA
Calcium	mg/L	0.5	1.1	0.9	1.5	1.1	1.2	216	2.8	2.7	2.4	4	NA
Magnesium	mg/L	0.5	1	1.1	1.2	1.1	<0.5	583	2	2	<0.5	2.5	NA
Potassium	mg/L	0.5	0.9	1	0.9	1.1	1.3	2.5	0.9	1	1.1	1.3	NA
Sodium	mg/L	0.5	3	3.1	4.4	3.1	430	52.9	3.2	3.1	348	3.6	NA
Dissolved metals													
Aluminium	mg/L	0.005	0.164	0.197	0.606	0.433	0.028	<0.005	0.773	0.386	0.042	0.470	0.295*
Arsenic	mg/L	0.0002	0.0007	0.0006	0.0005	0.0006	0.0010	0.0019	0.0006	0.0007	0.0010	0.0006	0.042
Cadmium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00015	<0.00005	0.00033	<0.00005	<0.00005	0.0004
Chromium	mg/L	0.0002	0.0002	0.0002	0.0010	0.0003	<0.0002	<0.0002	0.0005	0.0003	<0.0002	0.0004	0.0060
Cobalt	mg/L	0.0001	0.0002	<0.0001	0.0002	0.0001	<0.0001	0.0027	0.0002	0.0006	<0.0001	0.0001	0.0014
Copper	mg/L	0.0005	<0.0005	<0.0005	0.0014	<0.0005	0.0006	0.0014	0.0018	0.0027	0.0009	0.0015	0.0018
Iron	mg/L	0.002	0.681	0.351	0.411	0.448	0.012	0.057	0.590	0.495	0.010	0.759	2.7
Manganese	mg/L	0.0005	0.0246	0.0010	0.0021	0.0009	<0.0005	0.8060	0.0019	0.0680	<0.0005	0.0016	2.5
Nickel	mg/L	0.0005	<0.0005	<0.0005	0.0007	<0.0005	<0.0005	0.0246	0.0018	0.0045	<0.0005	0.0015	0.0130
Uranium	mg/L	0.00005	0.00011	0.00006	0.00012	0.00007	0.00006	0.0227	0.0001	0.00012	0.00006	0.00008	NA
Zinc	mg/L	0.001	<0.001	<0.001	0.004	<0.001	0.002	0.014	0.007	0.015	<0.001	0.004	0.015

Analyte	Units	LOR	Control		Adjacent					Downstream			SSTV
			SWTG1C	SWTG1A	SWTG09	SWTG1	MBC0	MBC06	MBC01A	SWTG2	MBC03	SWTG3	
Total metals													
Aluminium	mg/L	0.005	0.842	0.679	0.604	0.621	0.536	0.039	0.695	0.543	0.037	0.526	NA
Arsenic	mg/L	0.0002	0.0010	0.0009	0.0006	0.0009	0.0010	0.0030	0.0010	0.0010	0.0008	0.0013	NA
Cadmium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00025	0.00047	0.00035	<0.00005	0.00015	NA
Chromium	mg/L	0.0002	0.0008	0.0006	0.0012	0.0006	0.0006	0.0003	0.0006	0.0005	<0.0002	0.0007	NA
Cobalt	mg/L	0.0001	0.0003	0.0002	0.0005	0.0002	0.0002	0.002	0.0033	0.0007	<0.0001	0.0042	NA
Copper	mg/L	0.0005	0.0007	0.0007	0.0021	0.0008	0.0017	0.002	0.0047	0.0036	0.0009	0.0029	NA
Iron	mg/L	0.002	1.120	0.922	0.616	0.804	0.860	0.798	1.070	0.920	0.003	2.010	NA
Lead	mg/L	0.0001	0.0005	0.0005	0.0006	0.0004	0.0026	<0.0001	0.0007	0.0004	<0.0001	0.0005	NA
Manganese	mg/L	0.0005	0.0259	0.0114	0.0301	0.0040	0.0106	0.4680	0.1350	0.0630	<0.0005	0.1960	NA
Nickel	mg/L	0.0005	<0.0005	<0.0005	0.001	<0.0005	0.0008	0.0266	0.0061	0.0054	<0.0005	0.0041	NA
Uranium	mg/L	0.00005	0.00013	0.00011	0.00011	0.00009	0.00010	0.02270	0.00022	0.00016	0.00011	0.00016	NA
Zinc	mg/L	0.001	<0.001	<0.001	0.009	0.016	0.048	0.030	0.026	0.022	<0.001	0.018	NA

Results in yellow are above the relevant SSTV

* SSTV for aluminium applies for pH >6.5

Table 4-4 Laboratory water quality results Coulter Creek sites, April 2019

Analyte	Units	LOR	Reference				SSTV
			CC02	CC01	CK7	CC03	
Physicochemical parameters							
TDS	mg/L	10	87	93	79	86	NA
TSS	mg/L	5	8	35	<5	5	NA
Major ions							
Bicarbonate alkalinity	mg/L	1	12	12	12	12	NA
Carbonate alkalinity	mg/L	1	<1	<1	<1	<1	NA
Total alkalinity as CaCO3	mg/L	1	12	12	12	12	NA
Sulfate as SO_4	mg/L	1	30	24	26	25	210
Chloride	mg/L	1	2	2	2	3	NA
Calcium	mg/L	0.5	5.1	4.6	4.6	4.4	NA
Magnesium	mg/L	0.5	5.2	4.4	4.6	4.5	NA
Sodium	mg/L	0.5	4.3	3.8	3.8	3.6	NA
Potassium	mg/L	0.5	2.2	1.8	2	1.8	NA
Dissolved metals							
Aluminium	mg/L	0.005	0.126	0.250	0.087	0.162	0.295*
Arsenic	mg/L	0.0002	0.0006	0.0006	0.0008	0.0008	0.042
Cadmium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.0004
Chromium	mg/L	0.0002	0.0003	0.0003	0.0002	0.0002	0.006
Cobalt	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0014
Copper	mg/L	0.0005	<0.0005	<0.0005	0.0007	0.0009	0.0018
Iron	mg/L	0.002	0.559	0.604	0.553	0.544	2.7
Manganese	mg/L	0.0005	0.0022	0.0020	0.0028	0.0016	2.5
Nickel	mg/L	0.0005	<0.0005	<0.0005	0.0020	0.0019	0.013
Uranium	mg/L	0.00005	0.00008	0.00008	0.00010	0.00011	NA
Zinc	mg/L	0.001	0.003	<0.001	0.005	0.004	0.015
Total metals							
Aluminium	mg/L	0.005	0.209	0.212	0.289	0.191	NA
Arsenic	mg/L	0.0002	0.0008	0.0009	0.0009	0.0009	NA
Cadmium	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	NA
Chromium	mg/L	0.0002	0.0004	0.0005	0.0004	0.0003	NA
Cobalt	mg/L	0.0001	0.0003	0.0003	0.0008	0.0006	NA
Copper	mg/L	0.0005	0.0006	0.0008	0.0009	0.0008	NA
Iron	mg/L	0.002	0.921	0.911	0.882	0.694	NA
Lead	mg/L	0.0001	0.0005	0.0006	0.0005	0.0002	NA
Manganese	mg/L	0.0005	0.0956	0.0598	0.0512	0.0382	NA
Nickel	mg/L	0.0005	0.0008	0.0008	0.0026	0.0028	NA
Uranium	mg/L	0.00005	0.00012	0.00014	0.00015	0.00015	NA
Zinc	mg/L	0.001	0.005	0.004	0.012	0.005	NA

Results in yellow are above the relevant SSTV

* SSTV for aluminium applies for pH >6.5

4.3 Sediment quality

4.3.1 Particle size distribution

Particle size distribution results for sediment samples collected in April 2019 are displayed in Figure 4-1. Sediment collected from control sites SWTG1C and SWTG1A, and adjacent site SWTG1, contained the highest proportion of coarse particles, each comprised of over 50 percent gravel, and only 5-6 percent fine particles (clay or silt). Sediment samples collected from adjacent sites SWTG09 and MBC06, and reference sites CC01 and CC03, contained the highest proportion of fine particles, with samples from each site comprising over 50 percent clay or silt.

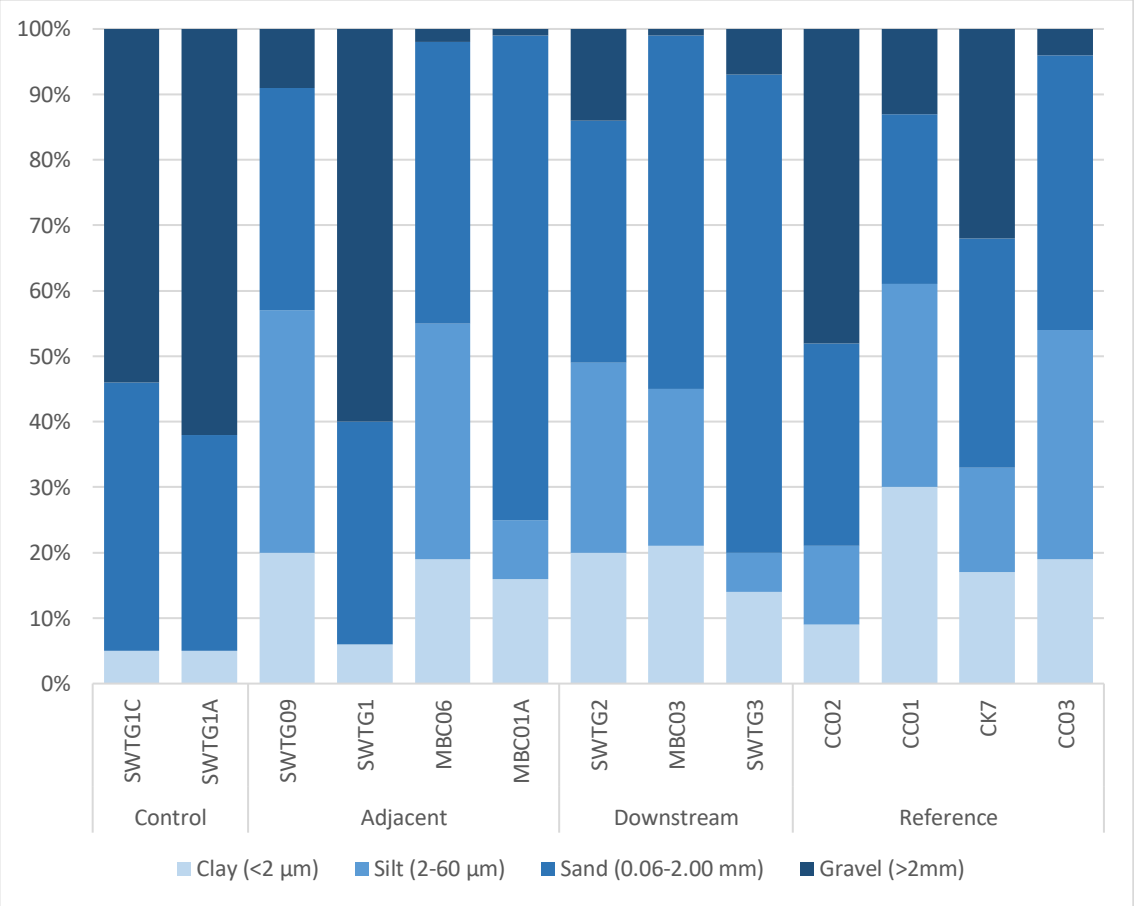

Figure 4-1 Particle size distribution in sediment samples collected April 2019

4.3.2 Laboratory analysis

Table 4-5 and Table 4-6 present the results of the laboratory analysis of sediment samples collected in April 2019 at Mount Bundey and Coulter Creek sites respectively. Parameters measured at concentrations below the LOR at all sites and have not been presented in Table 4-5 and Table 4-6. Laboratory certificates of analysis showing data for all measured parameters are provided in Appendix A.

Concentrations of all 1M HCl-extractable sediment metals were below the respective DGVs at all sites in 2019, except for cadmium at site MBC06 which is adjacent to the mine.

As with water at Mount Bundey Creek sites, the sediments at MBC06 and SWTG2 contained higher concentrations of metals than all other sites in the study area. Along with elevated cadmium, the sediment at MBC06 also contained the highest concentration of acid-extractable aluminium, arsenic, copper, iron, nickel, uranium and zinc of all sites in the study area. Sediment collected from downstream site SWTG2 contained the highest concentrations of chromium, cobalt, lead and manganese of all sites. Of these metals, there are only DGVs for chromium and lead and these DGVs were not exceeded at SWTG2.

MBC06 contained the highest concentration of total organic carbon of all sites in the study area, followed by SWTG2, as well as both sites containing a relatively high proportion of fine sediment particles (clay and silt) compared to other sites (Figure 4-1). These factors are likely to have contributed to the higher concentrations of metals identified in the sediments at these sites, as metals are known to bind preferentially to organic carbon and fine sediment particles (Simpson and Batley 2016).

Despite elevated metal concentrations in the water at some sites adjacent to and downstream of Toms Gully Mine, concentrations of most metals in sediments were low across the project area. It is recommended that sediment monitoring be continued in future monitoring events to determine whether any accumulation of sediment metals is occurring in Mount Bundey Creek under lower flow conditions.

Table 4-5 Laboratory sediment quality results Mount Bundey Creek sites, April 2019

Analyte	Units	LOR	Control		Adjacent				Downstream			DGV	GV-high
			SWTG1C	SWTG1A	SWTG09	SWTG1	MBC06	MBC01A	SWTG2	MBC03	SWTG3		
1M HCl-extractable metals													
Aluminium	mg/kg	50	120	100	710	130	1540	420	1080	500	790	NA	NA
Arsenic	mg/kg	1	<1.0	<1.0	<1.0	<1.0	4.3	<1.0	1.4	<1.0	<1.0	20	70
Cadmium	mg/kg	0.1	<0.1	<0.1	0.2	<0.1	1.6	<0.1	0.6	0.2	0.3	1.5	10
Chromium	mg/kg	1	<1.0	<1.0	1.5	<1.0	1.6	<1.0	2.8	<1.0	<1.0	80	370
Cobalt	mg/kg	0.5	1	1	2.3	0.8	4.3	1.7	8.3	<0.5	4.9	NA	NA
Copper	mg/kg	1	<1.0	<1.0	8.4	<1.0	31.4	3.2	14.2	10.1	7.3	65	270
Iron	mg/kg	50	940	630	2240	920	6680	660	6120	660	2640	NA	NA
Lead	mg/kg	1	3.8	3.7	13.3	3.5	9.5	4.9	13.6	5.2	6.6	50	220
Manganese	mg/kg	10	85	113	72	71	82	69	400	14	109	NA	NA
Nickel	mg/kg	1	<1.0	<1.0	2.3	<1.0	11.4	<1.0	4.8	1.1	4.0	21	52
Uranium	mg/kg	1	<1.0	<1.0	1.1	<1.0	3.6	<1.0	1.2	<1.0	<1.0	NA	NA
Zinc	mg/kg	1	1.4	1.4	7.3	1.6	60.8	4.7	31.6	6.2	26.8	200	410
Total recoverable metals													
Mercury	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.15	1
Cyanide													
Free cyanide	mg/kg	1	<1	<1	1	<1	<1	<1	<1	<1	<1	NA	NA
WAD cyanide	mg/kg	1	<1	<1	1	<1	<1	<1	<1	<1	<1	NA	NA
Total cyanide	mg/kg	1	<1	<1	2	<1	3	<1	2	<1	1	NA	NA
Other parameters													
TOC	%	0.02	0.35	0.08	1.19	0.11	5.04	0.16	3.42	0.67	0.99	NA	NA
Moisture content	%	0.1	22.3	18.8	40.2	17.8	47.6	22.2	38.6	26.2	28.8	NA	NA

Results in yellow are above the relevant DGV

Results in gold are above the GV-high

Table 4-6 Laboratory sediment quality results Coulter Creek sites, April 2019

Analyte	Units	LOR	Reference				DGV	GV-high
			CC02	CC01	CK7	CC03		
1M HCl-extractable metals								
Aluminium	mg/kg	50	260	410	380	320	NA	NA
Arsenic	mg/kg	1	<1.0	<1.0	<1.0	<1.0	20	70
Cadmium	mg/kg	0.1	<0.1	<0.1	0.2	0.2	1.5	10
Chromium	mg/kg	1	<1.0	<1.0	<1.0	<1.0	80	370
Cobalt	mg/kg	0.5	2.2	1.8	10.3	7.3	NA	NA
Copper	mg/kg	1	1.2	3	3.7	4.5	65	270
Iron	mg/kg	50	930	1300	2090	2260	NA	NA
Lead	mg/kg	1	18.4	14.5	22.7	14.1	50	220
Manganese	mg/kg	10	137	114	410	221	NA	NA
Nickel	mg/kg	1	<1.0	<1.0	6.2	3.3	21	52
Uranium	mg/kg	1	3.5	1.3	1.2	1.2	NA	NA
Zinc	mg/kg	1	1.7	1.2	38.6	17.6	200	410
Total recoverable metals								
Mercury	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	0.15	1
Cyanide								
Free cyanide	mg/kg	1	<1	<1	<1	<1	NA	NA
WAD cyanide	mg/kg	1	<1	<1	<1	<1	NA	NA
Total cyanide	mg/kg	1	<1	<1	<1	<1	NA	NA
Other parameters								
TOC	%	0.02	0.08	0.27	0.67	0.4	NA	NA
Moisture content	%	0.1	18.6	24.4	26.2	25.7	NA	NA

Results in yellow are above the relevant DGV

Results in gold are above the GV-high

4.4 Macroinvertebrate community

4.4.1 Univariate indices

Taxa richness results for samples collected in April 2019 are presented in Figure 4-2. Taxa richness was lowest at adjacent site MBC06, where a maximum of 15 taxa were collected from the two replicate samples. All other samples collected from potentially impacted sites adjacent to and downstream of Toms Gully Mine contained between 22 and 28 taxa. Taxa richness was also low at the furthest upstream site on Mount Bundey Creek, control site SWTG1C, and the furthest downstream site on Coulter Creek, reference site CC03.

Taxa richness was highest at Coulter Creek reference site CC01, and decreased in a downstream direction from this point. At control sites, taxa richness was much higher at SWTG1A than at SWTG1C, with 25 taxa collected in both replicates at SWTG1A, compared with 18 taxa in both replicates at SWTG1C.

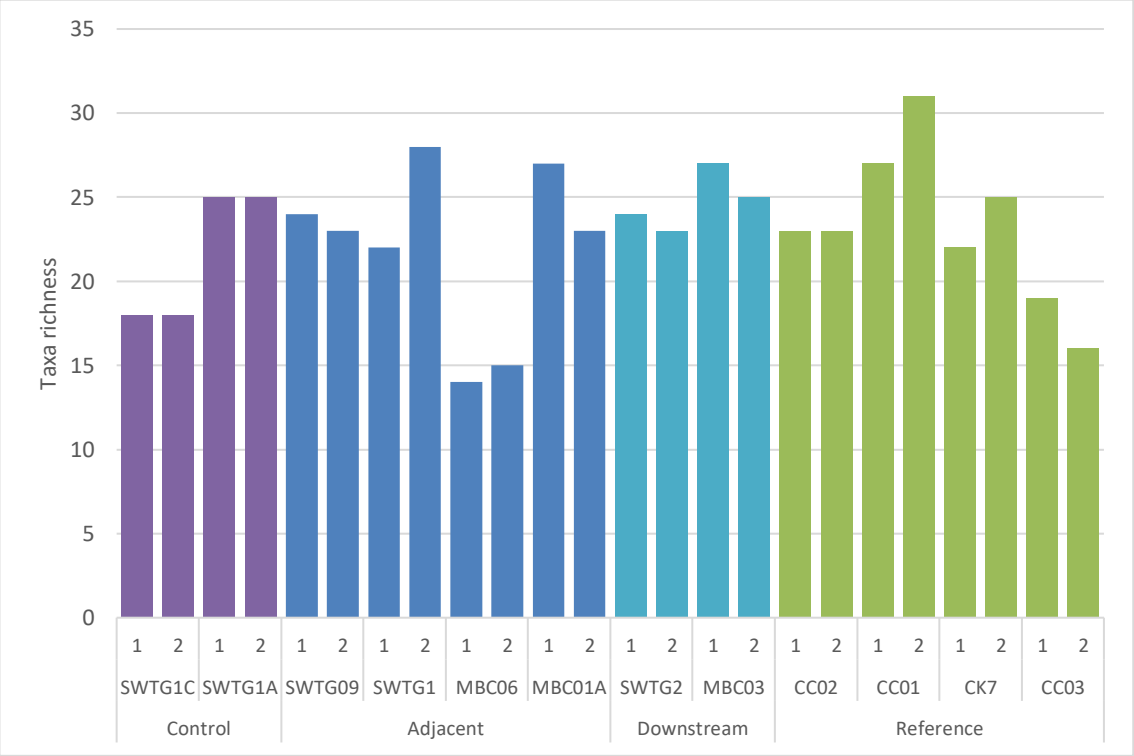

Figure 4-2 Taxa richness of samples collected April 2019

PET richness results for samples collected in April 2019 are presented in Figure 4-3. PET richness ranged between 2 and 6 across all samples collected. PET richness was highest at adjacent sites SWTG1 and MBC01A, reference site CC01, and in one replicate sample from downstream site MBC03. As with taxa richness, PET richness was lowest at MBC06 adjacent to Toms Gully Mine. MBC03 displayed the greatest variability between samples, with a 3 and 6 taxa collected in replicate one and two, respectively, while PET richness in replicate samples at all other sites differed by no more than one PET taxon.

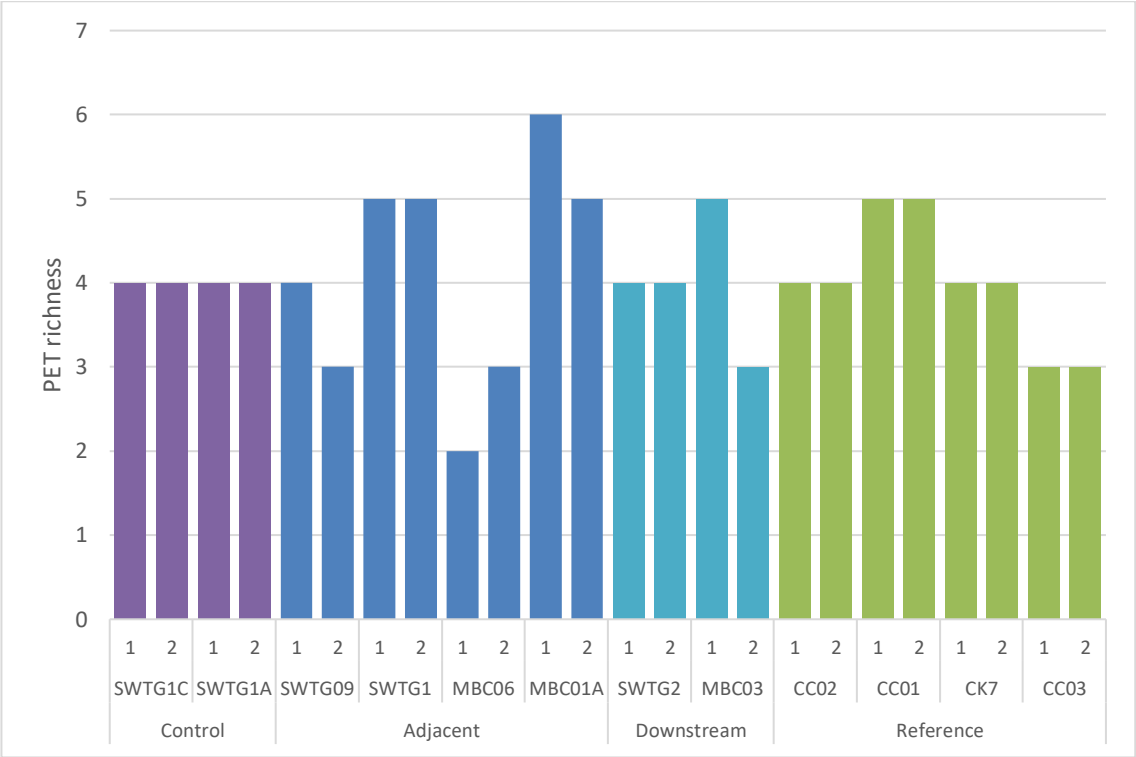

Figure 4-3 PET richness of samples collected April 2019

SIGNAL-2 results for samples collected in April 2019 are presented in Figure 4-4. The highest SIGNAL-2 score was observed in one replicate sample from downstream site MBC03, though this site demonstrated considerable variability in SIGNAL-2 scores between samples. SIGNAL-2 scores were also high at both control sites, adjacent sites SWTG1 and MBC01A, and reference site CC02. SIGNAL-2 scores were lowest at adjacent sites SWTG09 and MBC06.

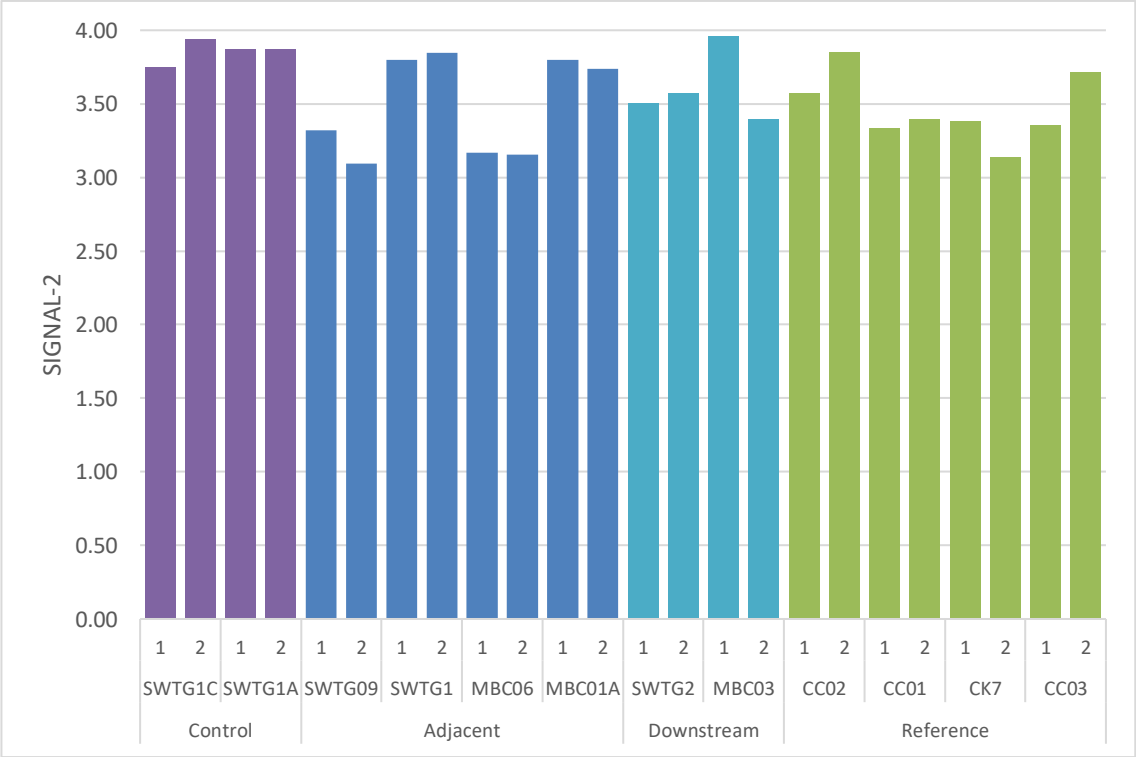

Figure 4-4 SIGNAL-2 results of samples collected April 2019

A total of 49 macroinvertebrate families were collected during the April 2019 sampling event. The distribution of those taxa across 14 orders is displayed in Figure 4-5, based on the relative abundance of each macroinvertebrate order collected in a sample.

The macroinvertebrate community composition of samples is fairly similar across all sites, with the majority of samples comprising primarily of Diptera, Ephemeroptera and Hemiptera. The community composition at MBC06 was the most distinct, with both replicate samples containing a larger proportion (more than three-quarters) of Diptera than all other sites. No Gastropoda were collected in either MBC06 sample, a group which were collected in every sample. SWTG1 was the only site at which Diptera were not the most abundant macroinvertebrate order, with Ephemeroptera instead making up the majority the samples at this site.

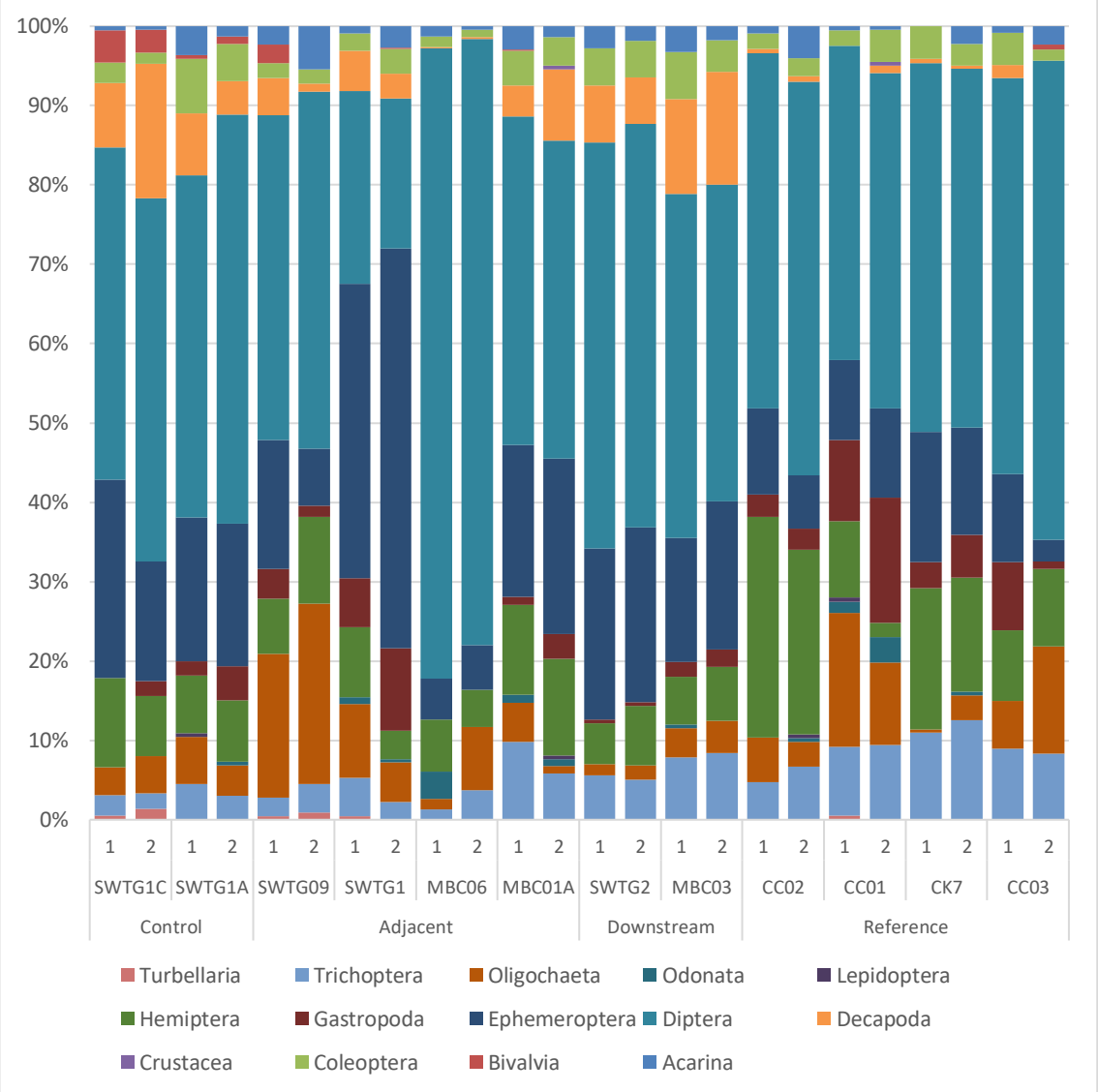

Figure 4-5 Macroinvertebrate community composition based on relative abundance of macroinvertebrate orders, April 2019

The results of the Darwin-Daly AUSRIVAS model are presented in Figure 4-6. The protocol for interpretation of AUSRIVAS model outputs stipulates that where two samples from the same site are found to be in different bandwidths, the lower bandwidth be assigned for the site. This resulted in sites SWTG1C, CC01, CK7 and CC03 being placed in Band B, despite having one replicate sample which scored in Band A. Band B indicates that these sites are significantly impaired with some taxa that were expected to be collected, not observed at these sites in 2019.

Sites SWTG1A, SWTG1, MBC01A, SWTG2 and MBC03, were placed in Band A, indicating that these sites are similar to reference condition, with most of the expected taxa collected in both replicate samples.

OE50 scores were lowest in both replicate samples from MBC06, with replicate 1 containing fewer than 50 percent of the taxa that were expected to be found by the model.

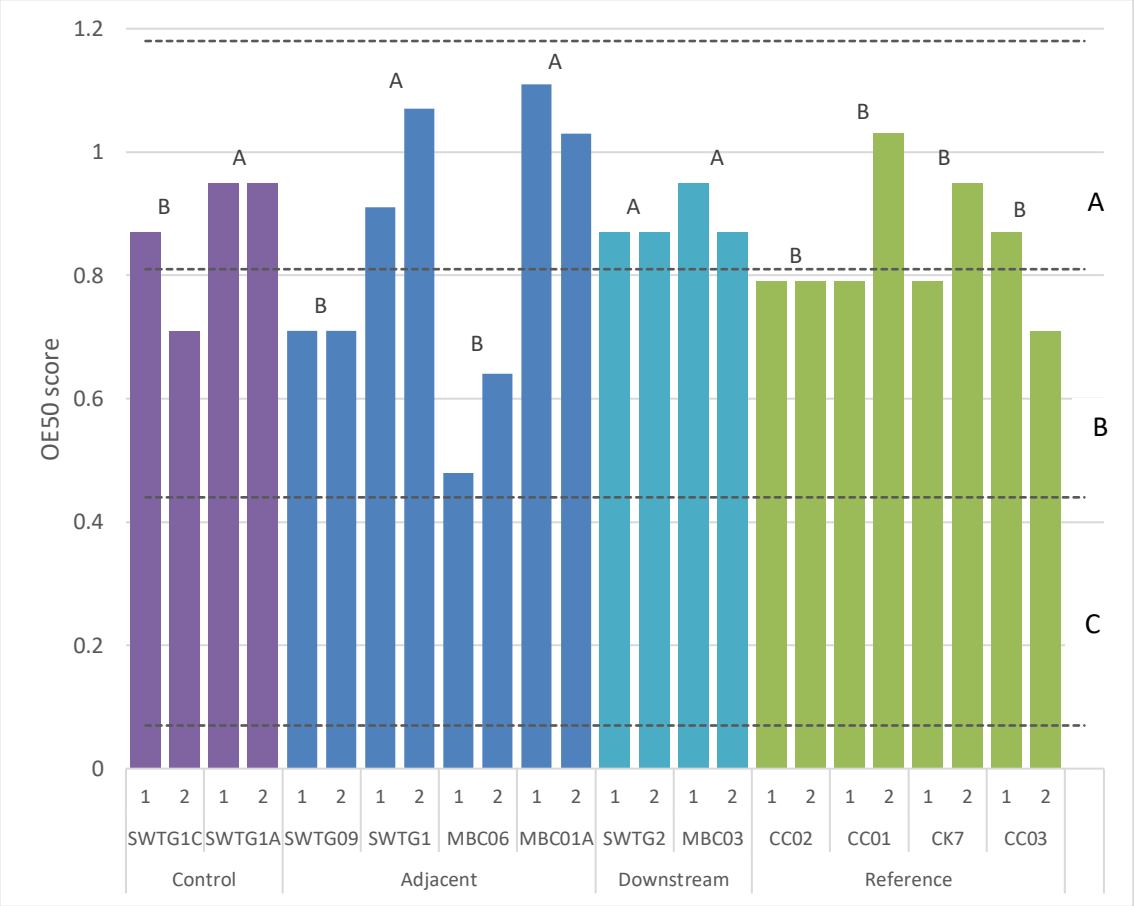

Figure 4-6 AUSRIVAS OE50 results and bandings for sites sampled in 2019

Macroinvertebrate samples collected from MBC06 in 2019 contained the lowest taxa richness, PET richness, SIGNAL-2 score and AUSRIVAS OE50 score of all sites indicating that the macroinvertebrate community at this site was in the poorest condition. Given that the macroinvertebrate habitat at MBC06 was similar to that observed at other sites, it is likely that the very high EC and elevated metal concentrations in water and sediment samples at this site have impaired the macroinvertebrate community. In addition to this, the different ionic composition of water at this site compared to others may have influenced the macroinvertebrate community, causing taxa that were expected to be found at the site to be absent from samples.

These impacts were not observed downstream from this point, with all other sites adjacent to and downstream of Toms Gully Mine displaying improved macroinvertebrate health in comparison to results observed at MBC06. The elevated concentrations of dissolved copper and zinc observed in water samples from SWTG2 do not appear to have had an impact on the macroinvertebrate health at this site, with a relatively high PET richness and SIGNAL-2 observed compared to other sites in the study area, and an AUSRIVAS OE50 Band A ranking, indicating the macroinvertebrate community at the site is similar to that expected in a site of reference condition.

The macroinvertebrate community at MBC01A, the site immediately downstream of TSF2, contained the highest PET richness and OE50 scores of all sites, as well as high SIGNAL-2 scores relative to scores at all other sites in the study area. This indicates that any runoff from TSF2 is unlikely to be impacting the macroinvertebrate communities in Mount Bundey Creek, as well as demonstrating that the impacts observed at MBC06, the site immediately upstream from MBC01A, are localised and do not persist downstream from this point.

There was some evidence of impairment of the macroinvertebrate community at SWTG09, with reduced AUSRIVAS OE50, PET richness and SIGNAL-2 observed compared to other sites. The water and sediment quality results do not provide an explanation for the observed impairment. Although the aluminium concentration exceeded the SSTV in the water sample collected at this site in April 2019, it was no higher than some other sites at which the macroinvertebrate condition was improved. The habitat was relatively consistent with other sites, although, evidence of cattle and pig disturbance was observed as was debris indicating flooding prior to sampling.

4.4.2 Multivariate analysis

The non-metric MDS plot displayed in Figure 4-7 provides an indication of the relative similarity in the macroinvertebrate community composition between samples collected in 2019.

Samples collected from downstream sites were all clustered closely together, demonstrating minimum of 80 percent similarity in the macroinvertebrate community composition of these samples. Similarly, samples collected from control sites also demonstrated at least 80 percent similarity to each other, while also showing similarity to select adjacent site samples. Samples collected from reference sites were separated from other site types, and were mostly similar to each other, with the exception of replicate 2 from CC03, which demonstrated a unique community composition.

Samples collected from adjacent site MBC06 were 80 percent similar to each other, but were separated from all other samples collected in 2019, reflecting the difference in macroinvertebrate community composition at this site caused by the poor water and sediment quality observed.

ANOSIM identified that there was a significant (p<5%) difference in community composition between site types (Table 4-7). The pairwise tests identified the macroinvertebrate community composition of samples collected at reference sites was significantly different (p<5%) to samples collected from all other site types. As reference sites are on Coulter Creek, while all other site types are on Mount Bundey Creek, it is likely that natural geological differences account for these change in community composition. The community composition at control sites was also determined to be significantly different (p<5%) to that at downstream sites in 2019. This result is also likely to be due to environmental differences in the upstream and downstream reaches of Mount Bundey Creek.

Table 4-7 ANOSIM pairwise test results for 2019 samples by site type

Groups	R statistic	Significance level %	Possible permutations
Control, Adjacent	0.034	29.5	495
Control, Downstream	0.708	2.9	35
Control, Reference	0.684	0.2	495
Adjacent, Downstream	-0.013	44.8	495
Adjacent, Reference	0.226	1.5	6435
Downstream, Reference	0.381	2.0	495

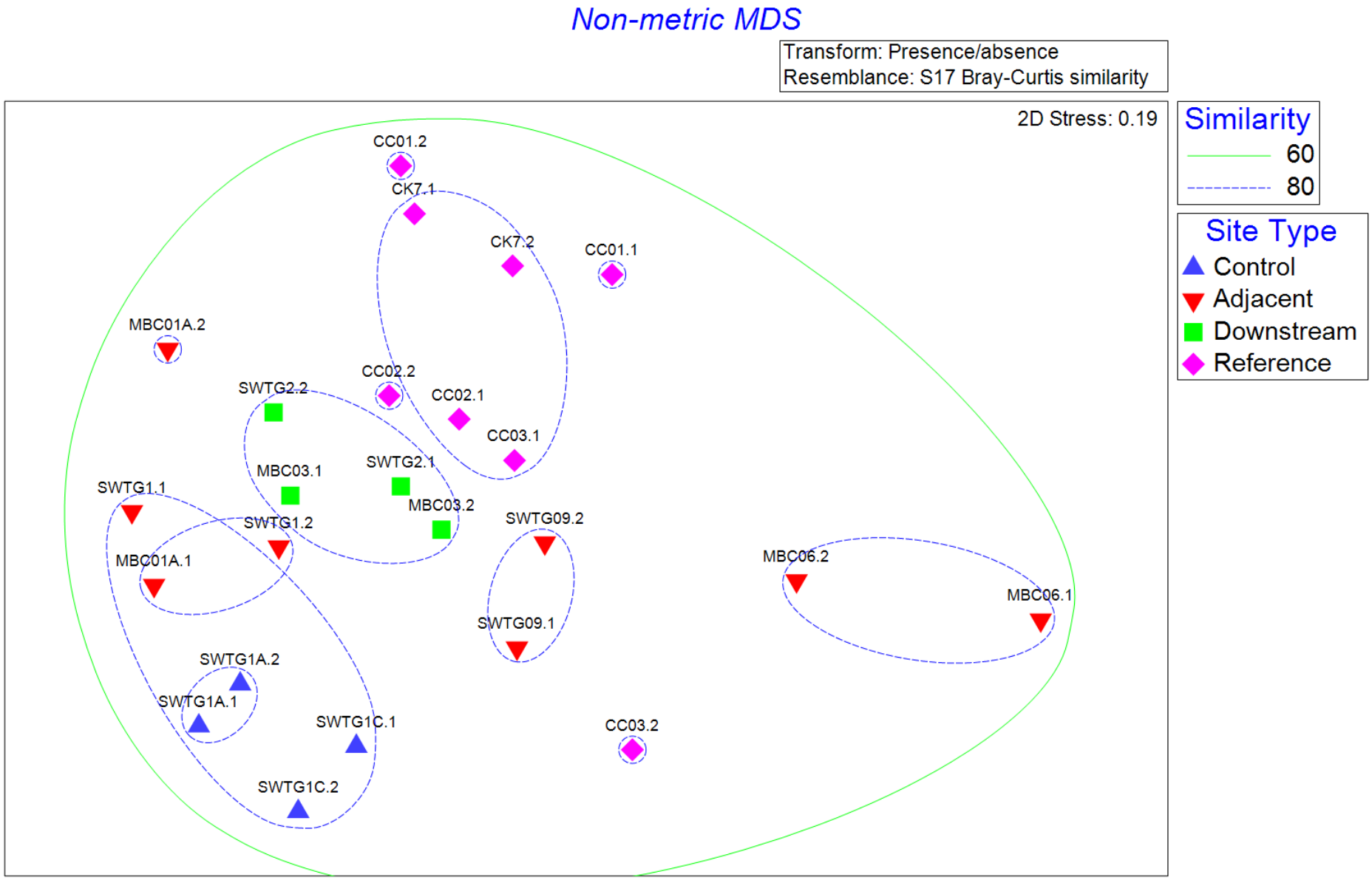

Figure 4-7 NMDS demonstrating relative similarity of macroinvertebrate communities in samples collected in 2019

The non-metric MDS plot displayed in Table 4-8 provides an indication of the relative similarity in the macroinvertebrate community composition between samples collected during different sampling events. Due to the high number of samples displayed, the stress of the plot is >0.20, and as such, the results should be interpreted with caution.

Replicate samples collected from each site in 2017, 2018 and 2019 were pooled to allow for the presentation of a single point for each site and sampling event and to minimise the stress in the plot. Only one macroinvertebrate sample was collected at each site in 2015 which may explain the differences observed in community composition during this sampling event and the greater variability between samples collected in this year.

Points are roughly clustered into years demonstrating similarity in community composition between different sites during the same sampling event. This indicates that the macroinvertebrate community composition varies more temporally than spatially within the study area. All samples collected in 2017 are clustered closely together with a minimum of 70 percent similarity between sites. Similarly, the majority of sites sampled in 2018 and 2019 are clustered together with a similarity of 70 percent or greater.

Samples collected from MBC06 in 2018 and 2019 are grouped together, but are separated from the large grouping of samples from other sites from these sampling events. This similarity in community composition is likely due to the unique composition of the water at this site which has been evident since the 2018 sampling event (GHD 2017; GHD 2018a).

ANOSIM identified that there were significant differences (p<5%) in community composition between sampling events. Pairwise testing indicated a significant difference (p<5%) in the macroinvertebrate community composition between each year of sampling, indicating that the macroinvertebrate community composition has been distinct during each sampling event (Table 4-8).

These results demonstrate the importance of accounting for temporal variability when assessing macroinvertebrate condition in the study area. Macroinvertebrate communities are sensitive to environmental changes, such as different flow conditions and water availability that can differ between sampling events.

Table 4-8 ANOSIM pairwise test results for samples by sampling event

Groups	R statistic	Significance level %	Possible permutations
2015, 2017	0.608	0.01	2496144
2015, 2018	0.496	0.01	2496144
2015, 2019	0.487	0.01	1352078
2017, 2018	0.426	0.01	5200300
2017, 2019	0.754	0.01	5200300
2018, 2019	0.136	0.70	5200300

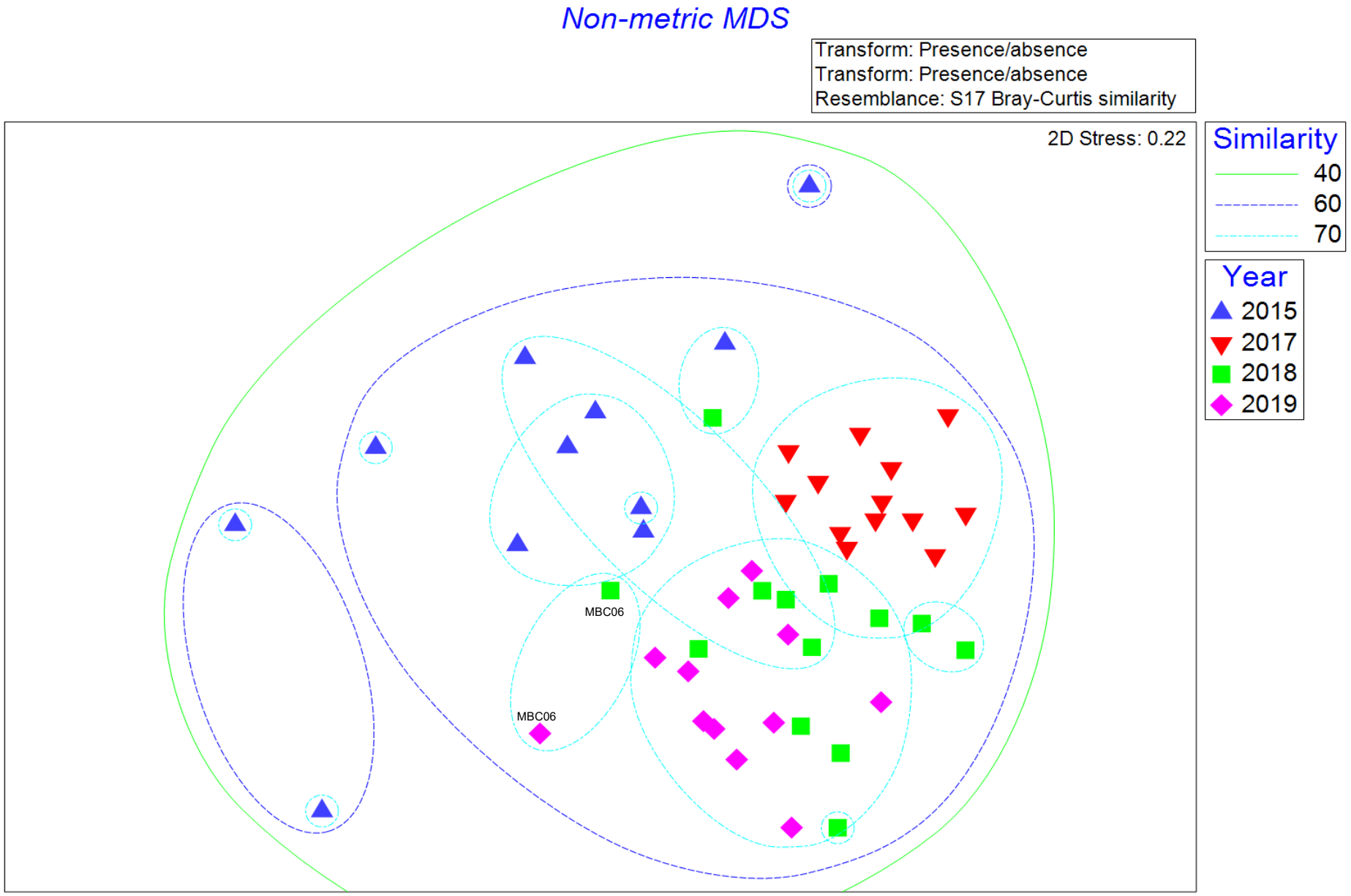

Figure 4-8 NMDS demonstrating relative similarity of macroinvertebrate communities in samples by sampling event

4.5 Fish community

Electrofishing was attempted at SWTG1, but the turbidity of the water made it difficult to see stunned fish. Electrofishing was not attempted at any other site due to deep, turbid, or fast flowing water. Bait traps were deployed at sites listed in Table 3-7.

One Mouth Almighty (*Glossamia aprion*) was caught in a bait trap deployed at SWTG1. Archer fish (*Toxotes sp.*) were observed in deep pools at CK7 but were not captured in bait traps.

No other fish species were observed at any site in 2019.

4.6 Water monitors

4.6.1 Sampling effort

Camera units were deployed at six sites across the study areas and were active for between 116 and 120 days, depending on deployment date (Table 4-9). Camera unit M1 was bumped by an animal and stopped taking photos on 31 May 2019, after 43 days of operation. Camera unit M5 malfunctioned soon after deployment and captured photos for 16 hours only. All other cameras were working effectively for the full length of deployment.

Table 4-9 Remote camera locations and deployment

Camera code	Camera in	Camera out	Days deployed	Comments
M1	18/04/2019	14/08/2019	118	Located at MBC01. Stopped taking photos on 31/5/19 (operational for 43 days).
M3	16/04/2019	14/08/2019	120	Located at SWTG1A.
M4	20/04/2019	14/08/2019	116	No associated aquatic ecology site.
M5	17/04/2019	14/08/2019	119	Located at SWTG2. Operational for 16 hours only.
M7	17/04/2019	14/08/2019	119	Located at MBC01A.
M8	19/04/2019	14/08/2019	117	Located at SWTG3.

4.6.2 Target species

One Mertens' Water Monitor (*Varanus mertensi*) was recorded by camera unit M3, upstream of the mine area on 16 June 2019 (Photo 4-1). Two *V. mertensi* were recorded by camera unit M8, at the site furthest downstream of the mine on Mount Bundey Creek, the first on 7 June 2019 (Photo 4-2) and the second on 11 July 2019 (Photo 4-3). This was the largest number of *V. mertensi* recorded in the study area during aquatic ecology monitoring between 2015 and 2019. No *V. mertensi* were observed at any site on Mount Bundey Creek adjacent to Toms Gully Mine or immediately downstream.

There were no sightings of *V. mitchelli* on any of the remote camera units in 2019, as have been the case in previous monitoring events. A large number of non-target species were recorded on cameras during deployment.

Photo 4-1 **Mertens' Water Monitor (***Varanus mertensi*) photographed on camera unit M3 on 16/6/19

Photo 4-2 **Mertens' Water Monitor (***Varanus mertensi*) photographed on camera unit M8 on 7/6/19

Photo 4-3 **Mertens' Water Monitor (***Varanus mertensi*) photographed on camera unit M8 on 11/7/19

4.6.3 Non-target species

Remote cameras recorded 30 non-target species across the study area. No non-target species listed under the *Territory Parks and Wildlife Conservation Act* or the *Environmental Protection and Biodiversity Conservation Act* (1999) were observed at any site in 2019.

A number of introduced species were found on all camera units except M5, including cattle and pigs. Wild dogs were common in 2019, as was the case in 2018, being recorded on all cameras except M1 and M8. No cane toads were observed in 2019, contrary to 2018 monitoring which recorded cane toads at three sites.

The most common native species recorded was the Agile Wallaby (*Macropus agilis*). A wide variety of native bird species were also observed across the sites, with White Ibis (*Threskionis Molucca*) and Nankeen Night Heron (*Nycticorax caledonicus*) observed at all sites where cameras were operational for the full duration of the study.

Native rodent species were less common in 2019 than 2018, and the threatened species Pale Field Rat (*Rattus tunneyi*) and Black-footed Tree Rat (*Mesembriomys gouldii*) that were observed in 2018 were not recorded at any site in 2019. These species, however, were both observed at M5 in 2018, and may not have been observed in 2019 due to the malfunction of the camera unit at this site.

A full list of species that could be positively identified can be found in Appendix F.

5. Conclusions and recommendations

5.1 Conclusions

The key results of 2019 aquatic ecology monitoring are:

- *In situ* water quality results indicated EC was elevated above the SSTV at the majority of sites in the study area in 2019, though results were lower than those observed in 2018.
- Similarly, dissolved oxygen concentrations were below the SSTV at most sites in 2019, though results at all sites except MBC06 were higher in 2019 than 2018, likely due to higher flow in 2019.
- The elevated EC that was first observed at MBC06 in 2018 persisted in 2019. As identified in 2018, it is likely that this elevated EC, along with highly elevated concentrations of sulfate, calcium and magnesium, when compared with results from all other sites, are present at MBC06 due to seepage from groundwater. EC and concentrations of all major ions were lower at MBC06 in 2019 than 2018, likely due to the slightly higher water level causing a dilution to groundwater seepage present at the site.
- Concentrations of dissolved aluminium were elevated above the SSTV at a number of sites adjacent to and downstream of Toms Gully Mine. At MBC06 dissolved cobalt and nickel exceeded the SSTVs, while at SWTG2, dissolved copper and zinc exceeded the SSTVs. Concentrations of all dissolved metals were below the SSTVs at all control and reference sites, suggesting that runoff from Toms Gully Mine may be contributing metals to Mount Bundey Creek during wet conditions.
- Sediment quality in the study area was generally good in 2019, with only cadmium at MBC06 found in concentrations above the DGV, indicating the potential for toxicity to aquatic biota.
- The macroinvertebrate community at MBC06 was in the poorest condition of all sites, with the lowest taxa richness, PET richness, SIGNAL-2 scores and OE50 scores of all sites. These impacts are likely due to the poor quality water and sediment quality observed at this site due to seepage from contaminated groundwater.
- The macroinvertebrate community at MBC01A contained the highest PET richness and OE50 scores of all sites, as well as high SIGNAL-2 scores relative to scores at all other sites in the study area. This site is immediately downstream of both TSF2 and MBC06, indicating that the impacts observed at MBC06 do not persist downstream and potential runoff from TSF2 has not impacted the health of the macroinvertebrate community at this site during this sampling event.
- Historical analysis of macroinvertebrate communities has indicated that there has been significant temporal variability in the study area, likely due to the differing wet season conditions.
- Due to unsuitable conditions, electrofishing was not conducted in 2019. This lead to only a single fish being recorded in the study area during this monitoring event, a significant decline from previous monitoring events.
- Three sightings of Mertens' Water Monitors *(Varanus mertensi*) were recorded in 2019 at two sites, including one site upstream of Toms Gully Mine, and one site far downstream. No monitors were observed at any site adjacent to the mine or immediately downstream.

- Fewer non-target threatened species were observed in 2019 than 2018, though this may have been influenced by the malfunction of camera unit M5, where threatened species Pale Field Rat (*Rattus tunneyi*) and Black-footed Tree Rat (*Mesembriomys gouldii*) were observed in 2018.

5.2 Recommendations

The following recommendations are made for future monitoring:

- Site SWTG1A was moved 100 m downstream for sampling in 2019 due to water depth and clarity, and associated safety issues. It is recommended that this new location be retained for ongoing monitoring due to easier site access and improved safety.
- MBC01 was relocated 700 m downstream and sampled as MBC01A in 2019 as recommended in the 2018 report (GHD 2018a) due to disturbance of original site by a cattle crossing. MBC01A also contains a cattle crossing, but was much less degraded, with much less erosion, and was considered safer to sample. It is recommended that MBC01A be retained in future monitoring programs. There should be ongoing assessment of cattle disturbance during future monitoring events and if further degradation occurs an alternative site may need to be sought.
- It was recommended in the 2018 report (GHD 2018a) that site CC02 be moved due to major modifications to the creek channel by a cattle crossing. On return to the site in 2019, the area downstream of the cattle crossing had settled, and silt accumulated the previous year had been washed away. The macroinvertebrate habitats at the site looked to not be impacted so the original site was retained. It is recommended that this site be retained in the monitoring program although relocation should be considered if future degradation occurs due to cattle access.
- Sediment quality was monitored in Mt Bundey and Coulter Creeks during the annual aquatic ecology survey for the first time in 2019; noting that it has previously been assessed around the Toms Gully site by GHD (2018b). This monitoring has determined that despite elevated metal concentrations in the water at some sites adjacent to and downstream of Toms Gully Mine, there was little accumulation of these metals in sediments. It is recommended that sediment monitoring be continued in future monitoring events to determine whether any accumulation of sediment metals is occurring in Mount Bundey Creek under lower flow conditions and to provide a baseline for potential future mining. Sediment monitoring should also be repeated in Coulter Creek to provide a gauge of natural environmental variability.
- It is recommended that future monitoring be carefully timed, taking into consideration the volume and timing of rainfall during the wet season, so that receding water levels at the back of the seasonal hydrograph and water clarity are suitable for electrofishing, whilst also ensuring that safety during sampling is maintained.

6. References

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Appendices

Appendix A – Laboratory certificates of analysis

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1912530**	Page	: 1 of 14
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MS NICOLE CONROY	Contact	: Andrew Epps
Address	: LEVEL 5 66 SMITH STREET DARWIN NT, AUSTRALIA 0800	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61 7 3552 8639
Project	: 432262302	Date Samples Received	: 24-Apr-2019 08:15
Order number	: ----	Date Analysis Commenced	: 24-Apr-2019
C-O-C number	: ----	Issue Date	: 03-May-2019 17:08
Sampler	: Cameron Crawford		
Site	:		
Quote number	: EN/005/18		
No. of samples received	: 29		
No. of samples analysed	: 29		

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.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Dianne Blane	Laboratory Coordinator (2IC)	Newcastle - Inorganics, Mayfield West, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

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.

- EG094: It has been confirmed by re-digestion and re-analysis that total Cobalt and Manganese concentrations are less than dissolved for sample ES1912530 - #009. For all other samples and analytes where AF is greater than total, the difference is within experimental variation of the methods.
- TDS by method EA-015 may bias high for various samples due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SWTG1C	SWTG1A	SWTG1	SWTG2	SWTG3
				Client sampling date / time	16-Apr-2019 00:00	15-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-016	ES1912530-017	ES1912530-018	ES1912530-019	ES1912530-020
					Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		22.3	18.8	17.8	38.6	28.8
EA150: Particle Sizing									
+75µm	----	1	%		95	95	94	48	78
+150µm	----	1	%		94	95	94	40	74
+300µm	----	1	%		94	94	91	29	65
+425µm	----	1	%		93	91	87	25	55
+600µm	----	1	%		90	88	82	22	42
+1180µm	----	1	%		72	75	69	18	17
+2.36mm	----	1	%		47	56	56	12	2
+4.75mm	----	1	%		32	40	41	7	<1
+9.5mm	----	1	%		17	22	11	<1	<1
+19.0mm	----	1	%		2	<1	<1	<1	<1
+37.5mm	----	1	%		<1	<1	<1	<1	<1
+75.0mm	----	1	%		<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size									
Clay (<2 µm)	----	1	%		5	5	6	20	14
Silt (2-60 µm)	----	1	%		<1	<1	<1	29	6
Sand (0.06-2.00 mm)	----	1	%		41	33	34	37	73
Gravel (>2mm)	----	1	%		54	62	60	14	7
Cobbles (>6cm)	----	1	%		<1	<1	<1	<1	<1
EA152: Soil Particle Density									
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3		2.60	2.54	2.62	2.47	2.54
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Aluminium	7429-90-5	50	mg/kg		120	100	130	1080	790
Arsenic	7440-38-2	1.0	mg/kg		<1.0	<1.0	<1.0	1.4	<1.0
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	<0.1	0.6	0.3
Cobalt	7440-48-4	0.5	mg/kg		1.0	1.0	0.8	8.3	4.9
Chromium	7440-47-3	1.0	mg/kg		<1.0	<1.0	<1.0	2.8	<1.0
Copper	7440-50-8	1.0	mg/kg		<1.0	<1.0	<1.0	14.2	7.3
Iron	7439-89-6	50	mg/kg		940	630	920	6120	2640
Lead	7439-92-1	1.0	mg/kg		3.8	3.7	3.5	13.6	6.6
Manganese	7439-96-5	10	mg/kg		85	113	71	400	109
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	<1.0	4.8	4.0
Zinc	7440-66-6	1.0	mg/kg		1.4	1.4	1.6	31.6	26.8

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	SWTG1C	SWTG1A	SWTG1	SWTG2	SWTG3
				Client sampling date / time	16-Apr-2019 00:00	15-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-016	ES1912530-017	ES1912530-018	ES1912530-019	ES1912530-020
					Result	Result	Result	Result	Result
EG020-SDH: 1M HCl Extractable metals by ICPMS									
Uranium	7440-61-1	1.0	mg/kg		<1.0	<1.0	<1.0	**1.2**	<1.0
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	1	mg/kg		<1	<1	<1	<1	<1
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	1	mg/kg		<1	<1	<1	**2**	**1**
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	1	mg/kg		<1	<1	<1	<1	<1
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**0.35**	**0.08**	**0.11**	**3.42**	**0.99**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	MBC02A Received as MBC01A	MBC03	MBC06	SWTG09	CK7
			Client sampling date / time	17-Apr-2019 00:00	18-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00	24-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	ES1912530-022	ES1912530-023	ES1912530-024	ES1912530-025	ES1912530-026
				Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	22.2	26.2	47.6	40.2	26.2
EA150: Particle Sizing								
+75µm	----	1	%	73	52	35	33	65
+150µm	----	1	%	64	37	18	18	55
+300µm	----	1	%	46	14	11	12	45
+425µm	----	1	%	39	7	10	11	42
+600µm	----	1	%	28	4	8	11	40
+1180µm	----	1	%	3	2	4	10	37
+2.36mm	----	1	%	<1	<1	1	8	30
+4.75mm	----	1	%	<1	<1	<1	8	17
+9.5mm	----	1	%	<1	<1	<1	7	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	16	21	19	20	17
Silt (2-60 µm)	----	1	%	9	24	36	37	16
Sand (0.06-2.00 mm)	----	1	%	74	54	43	34	35
Gravel (>2mm)	----	1	%	1	1	2	9	32
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.57	2.45	2.45	2.48	2.59
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	420	500	1540	710	380
Arsenic	7440-38-2	1.0	mg/kg	<1.0	<1.0	4.3	<1.0	<1.0
Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.2	1.6	0.2	0.2
Cobalt	7440-48-4	0.5	mg/kg	1.7	<0.5	4.3	2.3	10.3
Chromium	7440-47-3	1.0	mg/kg	<1.0	<1.0	1.6	1.5	<1.0
Copper	7440-50-8	1.0	mg/kg	3.2	10.1	31.4	8.4	3.7
Iron	7439-89-6	50	mg/kg	660	660	6680	2240	2090
Lead	7439-92-1	1.0	mg/kg	4.9	5.2	9.5	13.3	22.7
Manganese	7439-96-5	10	mg/kg	69	14	82	72	410
Nickel	7440-02-0	1.0	mg/kg	<1.0	1.1	11.4	2.3	6.2
Zinc	7440-66-6	1.0	mg/kg	4.7	6.2	60.8	7.3	38.6

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	MBC02A Received as MBC01A	MBC03	MBC06	SWTG09	CK7
				Client sampling date / time	17-Apr-2019 00:00	18-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00	24-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-022	ES1912530-023	ES1912530-024	ES1912530-025	ES1912530-026
					Result	Result	Result	Result	Result
EG020-SDH: 1M HCl Extractable metals by ICPMS									
Uranium	7440-61-1	1.0	mg/kg		<1.0	<1.0	**3.6**	**1.1**	**1.2**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	1	mg/kg		<1	<1	<1	**1**	<1
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	1	mg/kg		<1	<1	**3**	**2**	<1
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	1	mg/kg		<1	<1	<1	**1**	<1
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**0.16**	**0.67**	**5.04**	**1.19**	**0.67**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	CC03	CC02	CC01	CK-DUP	----
			Client sampling date / time	24-Apr-2019 00:00	24-Apr-2019 00:00	24-Apr-2019 00:00	24-Apr-2019 00:00	----
Compound	CAS Number	LOR	Unit	ES1912530-027	ES1912530-028	ES1912530-029	ES1912530-030	--------
				Result	Result	Result	Result	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	25.7	18.6	24.4	34.7	----
EA150: Particle Sizing								
+75µm	----	1	%	42	76	31	70	----
+150µm	----	1	%	18	71	23	57	----
+300µm	----	1	%	7	68	18	42	----
+425µm	----	1	%	6	67	16	37	----
+600µm	----	1	%	5	66	15	34	----
+1180µm	----	1	%	4	61	14	29	----
+2.36mm	----	1	%	3	42	13	23	----
+4.75mm	----	1	%	2	12	10	19	----
+9.5mm	----	1	%	<1	<1	5	15	----
+19.0mm	----	1	%	<1	<1	<1	<1	----
+37.5mm	----	1	%	<1	<1	<1	<1	----
+75.0mm	----	1	%	<1	<1	<1	<1	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	19	9	30	13	----
Silt (2-60 µm)	----	1	%	35	12	31	13	----
Sand (0.06-2.00 mm)	----	1	%	42	31	26	49	----
Gravel (>2mm)	----	1	%	4	48	13	25	----
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	----
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.56	2.60	2.57	2.55	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES								
Aluminium	7429-90-5	50	mg/kg	320	260	410	880	----
Arsenic	7440-38-2	1.0	mg/kg	<1.0	<1.0	<1.0	1.1	----
Cadmium	7440-43-9	0.1	mg/kg	0.2	<0.1	<0.1	0.3	----
Cobalt	7440-48-4	0.5	mg/kg	7.3	2.2	1.8	12.0	----
Chromium	7440-47-3	1.0	mg/kg	<1.0	<1.0	<1.0	2.1	----
Copper	7440-50-8	1.0	mg/kg	4.5	1.2	3.0	5.2	----
Iron	7439-89-6	50	mg/kg	2260	930	1300	3120	----
Lead	7439-92-1	1.0	mg/kg	14.1	18.4	14.5	20.5	----
Manganese	7439-96-5	10	mg/kg	221	137	114	406	----
Nickel	7440-02-0	1.0	mg/kg	3.3	<1.0	<1.0	8.2	----
Zinc	7440-66-6	1.0	mg/kg	17.6	1.7	1.2	48.5	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	CC03	CC02	CC01	CK-DUP	----
				Client sampling date / time	24-Apr-2019 00:00	24-Apr-2019 00:00	24-Apr-2019 00:00	24-Apr-2019 00:00	----
Compound	CAS Number	LOR	Unit		ES1912530-027	ES1912530-028	ES1912530-029	ES1912530-030	--------
					Result	Result	Result	Result	----
EG020-SDH: 1M HCl Extractable metals by ICPMS									
Uranium	7440-61-1	1.0	mg/kg		**1.2**	**3.5**	**1.3**	**1.6**	**----**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	**----**
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	1	mg/kg		<1	<1	<1	<1	**----**
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	1	mg/kg		<1	<1	<1	<1	**----**
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	1	mg/kg		<1	<1	<1	<1	**----**
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**0.40**	**0.08**	**0.27**	**0.67**	**----**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SWTG1C	SWTG1A	SWTG1	SWTG2	SWTG3
			Client sampling date / time	[16-Apr-2019]	15-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00
Compound	CAS Number	LOR	Unit	ES1912530-001	ES1912530-002	ES1912530-003	ES1912530-004	ES1912530-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.60	7.22	7.19	7.13	7.53
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	29	28	29	45	73
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	42	61	48	60	71
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	8	35	11	7	17
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	12	10	10	10	27
Total Alkalinity as CaCO3	----	1	mg/L	12	10	10	10	27
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1	1	1	11	12
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	2	2	2	2	3
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	0.5	mg/L	1.1	0.9	1.1	2.7	4.0
Magnesium	7439-95-4	0.5	mg/L	1.0	1.1	1.1	2.0	2.5
Sodium	7440-23-5	0.5	mg/L	3.0	3.1	3.1	3.1	3.6
Potassium	7440-09-7	0.5	mg/L	0.9	1.0	1.1	1.0	1.3
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS								
Aluminium	7429-90-5	5	µg/L	164	197	433	386	470
Arsenic	7440-38-2	0.2	µg/L	0.7	0.6	0.6	0.7	0.6
Cadmium	7440-43-9	0.05	µg/L	<0.05	<0.05	<0.05	0.33	<0.05
Chromium	7440-47-3	0.2	µg/L	0.2	0.2	0.3	0.3	0.4
Cobalt	7440-48-4	0.1	µg/L	0.2	<0.1	0.1	0.6	0.1
Copper	7440-50-8	0.5	µg/L	<0.5	<0.5	<0.5	2.7	1.5
Iron	7439-89-6	2	µg/L	681	351	448	495	759

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	SWTG1C	SWTG1A	SWTG1	SWTG2	SWTG3
				Client sampling date / time	[16-Apr-2019]	15-Apr-2019 00:00	17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-001	ES1912530-002	ES1912530-003	ES1912530-004	ES1912530-005
					Result	Result	Result	Result	Result
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued									
Lead	7439-92-1	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	7439-96-5	0.5	µg/L		**24.6**	**1.0**	**0.9**	**68.0**	**1.6**
Nickel	7440-02-0	0.5	µg/L		<0.5	<0.5	<0.5	**4.5**	**1.5**
Uranium	7440-61-1	0.05	µg/L		**0.11**	**0.06**	**0.07**	**0.12**	**0.08**
Zinc	7440-66-6	1	µg/L		<1	<1	<1	**15**	**4**
EG094T: Total metals in Fresh water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		**842**	**679**	**621**	**543**	**526**
Arsenic	7440-38-2	0.2	µg/L		**1.0**	**0.9**	**0.9**	**1.0**	**1.3**
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	**0.35**	**0.15**
Chromium	7440-47-3	0.2	µg/L		**0.8**	**0.6**	**0.6**	**0.5**	**0.7**
Cobalt	7440-48-4	0.1	µg/L		**0.3**	**0.2**	**0.2**	**0.7**	**4.2**
Copper	7440-50-8	0.5	µg/L		**0.7**	**0.7**	**0.8**	**3.6**	**2.9**
Iron	7439-89-6	2	µg/L		**1120**	**922**	**804**	**920**	**2010**
Lead	7439-92-1	0.1	µg/L		**0.5**	**0.5**	**0.4**	**0.4**	**0.5**
Manganese	7439-96-5	0.5	µg/L		**25.9**	**11.4**	**4.0**	**63.0**	**196**
Nickel	7440-02-0	0.5	µg/L		<0.5	<0.5	<0.5	**5.4**	**4.1**
Uranium	7440-61-1	0.05	µg/L		**0.13**	**0.11**	**0.09**	**0.16**	**0.16**
Zinc	7440-66-6	1	µg/L		<1	<1	**16**	**22**	**18**
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**0.32**	**0.28**	**0.28**	**0.48**	**0.87**
Total Cations	----	0.01	meq/L		**0.29**	**0.30**	**0.31**	**0.46**	**0.60**
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**2**	**2**	**2**	**2**	**3**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MBC0	MBC01A	MBC03	MBC06	SWTG09
				Client sampling date / time	17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-006	ES1912530-007	ES1912530-008	ES1912530-009	ES1912530-010
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		10.8	7.76	10.5	8.32	7.74
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		2040	46	1600	4400	34
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		1120	----	975	----	----
Total Dissolved Solids @180°C	----	10	mg/L		----	74	----	4530	60
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		27	134	54	10	24
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		846	<1	620	4	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		6	11	87	179	15
Total Alkalinity as CaCO3	----	1	mg/L		852	11	707	183	15
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		1	11	57	3340	<1
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		3	2	3	19	3
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	0.5	mg/L		1.2	2.8	2.4	216	1.5
Magnesium	7439-95-4	0.5	mg/L		<0.5	2.0	<0.5	583	1.2
Sodium	7440-23-5	0.5	mg/L		430	3.2	348	52.9	4.4
Potassium	7440-09-7	0.5	mg/L		1.3	0.9	1.1	2.5	0.9
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		28	773	42	<5	606
Arsenic	7440-38-2	0.2	µg/L		1.0	0.6	1.0	1.9	0.5
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	0.15	<0.05
Chromium	7440-47-3	0.2	µg/L		<0.2	0.5	<0.2	<0.2	1.0
Cobalt	7440-48-4	0.1	µg/L		<0.1	0.2	<0.1	2.7	0.2
Copper	7440-50-8	0.5	µg/L		0.6	1.8	0.9	1.4	1.4

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MBC0	MBC01A	MBC03	MBC06	SWTG09
				Client sampling date / time	17-Apr-2019 00:00	17-Apr-2019 00:00	18-Apr-2019 00:00	17-Apr-2019 00:00	16-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-006	ES1912530-007	ES1912530-008	ES1912530-009	ES1912530-010
					Result	Result	Result	Result	Result
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued									
Iron	7439-89-6	2	µg/L		12	590	10	57	411
Lead	7439-92-1	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	7439-96-5	0.5	µg/L		<0.5	1.9	<0.5	806	2.1
Nickel	7440-02-0	0.5	µg/L		<0.5	1.8	<0.5	24.6	0.7
Uranium	7440-61-1	0.05	µg/L		0.06	0.10	0.06	22.7	0.12
Zinc	7440-66-6	1	µg/L		2	7	<1	14	4
EG094T: Total metals in Fresh water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		536	695	37	39	604
Arsenic	7440-38-2	0.2	µg/L		1.0	1.0	0.8	3.0	0.6
Cadmium	7440-43-9	0.05	µg/L		<0.05	0.47	<0.05	0.25	<0.05
Chromium	7440-47-3	0.2	µg/L		0.6	0.6	<0.2	0.3	1.2
Cobalt	7440-48-4	0.1	µg/L		0.2	3.3	<0.1	2.0	0.5
Copper	7440-50-8	0.5	µg/L		1.7	4.7	0.9	2.0	2.1
Iron	7439-89-6	2	µg/L		860	1070	3	798	616
Lead	7439-92-1	0.1	µg/L		2.6	0.7	<0.1	<0.1	0.6
Manganese	7439-96-5	0.5	µg/L		10.6	135	<0.5	468	30.1
Nickel	7440-02-0	0.5	µg/L		0.8	6.1	<0.5	26.6	1.0
Uranium	7440-61-1	0.05	µg/L		0.10	0.22	0.11	22.7	0.11
Zinc	7440-66-6	1	µg/L		48	26	<1	30	9
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		17.1	0.50	15.4	73.7	0.38
Total Cations	----	0.01	meq/L		18.8	0.47	15.3	61.1	0.39
Ionic Balance	----	0.01	%		4.64	----	0.37	9.35	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		3	3	2	10	3

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	CK7	CC03	CC02	CC01	CK-DUP
				Client sampling date / time	19-Apr-2019 00:00	18-Apr-2019 00:00	19-Apr-2019 00:00	18-Apr-2019 00:00	19-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-011	ES1912530-012	ES1912530-013	ES1912530-014	ES1912530-015
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		7.30	7.28	7.30	7.23	7.23
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		73	72	82	71	72
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	10	mg/L		79	86	87	93	82
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	5	8	35	6
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		12	12	12	12	11
Total Alkalinity as CaCO3	----	1	mg/L		12	12	12	12	11
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		26	25	30	24	25
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		2	3	2	2	3
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	0.5	mg/L		4.6	4.4	5.1	4.6	4.8
Magnesium	7439-95-4	0.5	mg/L		4.6	4.5	5.2	4.4	4.7
Sodium	7440-23-5	0.5	mg/L		3.8	3.6	4.3	3.8	7.0
Potassium	7440-09-7	0.5	mg/L		2.0	1.8	2.2	1.8	2.2
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		87	162	126	250	125
Arsenic	7440-38-2	0.2	µg/L		0.8	0.8	0.6	0.6	0.8
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	7440-47-3	0.2	µg/L		0.2	0.2	0.3	0.3	0.4
Cobalt	7440-48-4	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	0.1
Copper	7440-50-8	0.5	µg/L		0.7	0.9	<0.5	<0.5	1.4
Iron	7439-89-6	2	µg/L		553	544	559	604	588

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	CK7	CC03	CC02	CC01	CK-DUP
				Client sampling date / time	19-Apr-2019 00:00	18-Apr-2019 00:00	19-Apr-2019 00:00	18-Apr-2019 00:00	19-Apr-2019 00:00
Compound	CAS Number	LOR	Unit		ES1912530-011	ES1912530-012	ES1912530-013	ES1912530-014	ES1912530-015
					Result	Result	Result	Result	Result
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS - Continued									
Lead	7439-92-1	0.1	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	7439-96-5	0.5	µg/L		2.8	1.6	2.2	2.0	4.7
Nickel	7440-02-0	0.5	µg/L		2.0	1.9	<0.5	<0.5	2.2
Uranium	7440-61-1	0.05	µg/L		0.10	0.11	0.08	0.08	0.12
Zinc	7440-66-6	1	µg/L		5	4	3	<1	7
EG094T: Total metals in Fresh water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		289	191	209	212	283
Arsenic	7440-38-2	0.2	µg/L		0.9	0.9	0.8	0.9	1.0
Cadmium	7440-43-9	0.05	µg/L		<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	7440-47-3	0.2	µg/L		0.4	0.3	0.4	0.5	0.4
Cobalt	7440-48-4	0.1	µg/L		0.8	0.6	0.3	0.3	0.8
Copper	7440-50-8	0.5	µg/L		0.9	0.8	0.6	0.8	0.8
Iron	7439-89-6	2	µg/L		882	694	921	911	868
Lead	7439-92-1	0.1	µg/L		0.5	0.2	0.5	0.6	0.6
Manganese	7439-96-5	0.5	µg/L		51.2	38.2	95.6	59.8	48.2
Nickel	7440-02-0	0.5	µg/L		2.6	2.8	0.8	0.8	2.6
Uranium	7440-61-1	0.05	µg/L		0.15	0.15	0.12	0.14	0.16
Zinc	7440-66-6	1	µg/L		12	5	5	4	8
EK025SF: Free CN by Segmented Flow Analyser									
Free Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	<0.004
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		0.84	0.84	0.92	0.80	0.82
Total Cations	----	0.01	meq/L		0.82	0.79	0.92	0.80	0.99
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		3	3	3	3	4

Appendix B – Raw macroinvertebrate data

Mount Bundey Creek sites

Order	Family/Sub-family	SWTG1C_1	SWTG1C_2	SWTG1A_1	SWTG1A_2	SWTG09_1	SWTG09_2	SWTG1_1	SWTG1_2	MBC06_1	MBC06_2	MBC01A_1	MBC01A_2	SWTG2_1	SWTG2_2	MBC03_1	MBC03_2
Acarina	*Acarina*	1	1	67	15	50	92	10	22	13	3	27	17	75	15	37	27
Bivalvia	*Corbiculidae*	8	5	8	10	50											
Bivalvia	*Hyriidae*		1	1	1				1			1					
Coleoptera	*Dytiscidae*	1		42	20		8		7	13	5	18	17	63	22	16	27
Coleoptera	*Elmidae*							10	4							5	
Coleoptera	*Gyrinidae*			33	20			5	7			5				11	7
Coleoptera	*Hydraenidae*			25	10				4			5	17				
Coleoptera	*Hydrochidae*			25	5	10	15					5		13	4	11	7
Coleoptera	*Hydrophilidae*	4	3			30	8	10	4			9	11	50	11	26	20
Crustacea	*Conchostraca sp.*												6				
Decapoda	*Atyidae*	10	22	33	10	100	15	45	15			27	89	188	44	126	180
Decapoda	*Palaemonidae*	5	12	106	38			12	8			7	22	3	1	8	28
Decapoda	*Parathelphusidae*	1	2	4	1	1	2	1	3	2	1	2		1	2	2	5
Diptera	*Ceratopogonidae*	8	11	100	15	20	46	40	26		5	14	6	50	11	37	93
Diptera	*Chironominae*	34	45	317	275	440	377	135	70	396	176	200	317	775	233	205	247
Diptera	*Culicidae*					10	46	10	4	26	11	5		50		21	13
Diptera	*Orthocladiinae*	2		17	5	10	8	30	33			41	72	75	56	26	60
Diptera	*Tabanidae*			8								9					
Diptera	*Tanypodinae*	38	41	350	300	400	285	60	15	378	237	114	100	400	107	189	187
Diptera	*Tipulidae*				5				7					13	4	16	
Ephemeroptera	*Baetidae*	22	19	100	20	160	92	110	104	52	26	100	67	175	37	79	167
Ephemeroptera	*Caenidae*	17	9	183	155	170	31	300	300		5	55	200	388	133	84	113
Ephemeroptera	*Leptophlebiidae*	10	4	50	35	20		10	11			23	6	13	7	16	
Gastropoda	*Ancylidae (Planorbidae)*		4	33	50	80	23	70	85			9	33			5	33

Order	Family/Sub-family	SWTG1C_1	SWTG1C_2	SWTG1A_1	SWTG1A_2	SWTG09_1	SWTG09_2	SWTG1_1	SWTG1_2	MBC06_1	MBC06_2	MBC01A_1	MBC01A_2	SWTG2_1	SWTG2_2	MBC03_1	MBC03_2
Gastropoda	*Planorbidae*												6	13	4	16	
Hemiptera	*Belostomatidae*					10											
Hemiptera	*Gelastocoridae*											5					1
Hemiptera	*Gerridae*			17	10	10	8		4	1	3			13		11	13
Hemiptera	*Mesoveliidae*				5	10	15		4		3			38	7		7
Hemiptera	*Micronectidae*	22	16	108	75	70	138	100	19	39	16	100	150	50	22	58	60
Hemiptera	*Nepidae*						1								1	1	1
Hemiptera	*Notonectidae*					20	8			26	5						
Hemiptera	*Pleidae*					30	15							25	22		13
Hemiptera	*Veliidae*			8					4					13	7		7
Lepidoptera	*Crambidae*			8									6				
Odonata	*Coenagrionidae*				5			10									
Odonata	*Isostictidae*									9							
Odonata	*Libellulidae*								4	26		9	6			5	
Odonata	*Zygoptera*												6				
Oligochaeta	*Oligochaeta*	7	10	108	45	390	385	105	41	13	45	45	11	38	15	42	60
Trichoptera	*Calamoceratidae*															5	
Trichoptera	*Ecnomidae*											5					
Trichoptera	*Hydroptilidae*							10	4			5	6				
Trichoptera	*Leptoceridae*	5	4	83	35	50	62	45	15	13	21	82	67	150	41	84	127
Turbellaria	*Dugesiidae*	1	3			10	15	5									

Coulter Creek sites

Order	Family/Sub-family	CC02_1	CC02_2	CC01_1	CC01_2	CK7_1	CK7_2	CC03_1	CC03_2
Acarina	*Acarina*	20	47	8	11		45	5	14
Bivalvia	*Corbiculidae*								3
Bivalvia	*Hyriidae*								1
Coleoptera	*Dytiscidae*	20	5	9	44	31	18	1	9
Coleoptera	*Hydraenidae*				11		9	5	
Coleoptera	*Hydrochidae*				11				
Coleoptera	*Hydrophilidae*	10	5	23	11	31	27	17	
Coleoptera	*Scirtidae*	10	16		22	8			
Crustacea	*Conchostraca sp.*				11				
Decapoda	*Atyidae*		5						
Decapoda	*Palaemonidae*	10	2		22	8	9	7	
Decapoda	*Parathelphusidae*	3	1		1	1		2	
Diptera	*Ceratopogonidae*	10	26	38	22	54	55	17	11
Diptera	*Chironominae*	390	284	315	256	446	509	119	254
Diptera	*Culicidae*	20		15	78	54	45	12	3
Diptera	*Orthocladiinae*	130	89	123	156	92	173	12	6
Diptera	*Tabanidae*				11				
Diptera	*Tanypodinae*	400	184	138	522	138	136	119	97
Ephemeroptera	*Baetidae*	120	42	85	156	146	82	48	3
Ephemeroptera	*Caenidae*	90	32	69	122	131	191	14	14
Ephemeroptera	*Leptophlebiidae*	20	5	8					
Gastropoda	*Ancylidae (Planorbidae)*	20	26	138	356	46	91	33	6
Gastropoda	*Planorbidae*	40		15	33	8	18	14	
Gastropoda	*Viviparidae*		5	9	2	1	1		
Hemiptera	*Belostomatidae*						1		
Hemiptera	*Gerridae*	10	32	8			27	5	3
Hemiptera	*Mesoveliidae*	20		8	11	8	18		
Hemiptera	*Micronectidae*	510	226	115	11	254	227	45	57
Hemiptera	*Nepidae*	1							
Hemiptera	*Notonectidae*			8	11				
Hemiptera	*Ochteridae*						9		
Hemiptera	*Pleidae*	50	16	15	11	31	9		
Hemiptera	*Veliidae*					8			
Lepidoptera	*Crambidae*		5	8					
Odonata	*Coenagrionidae*				22				
Odonata	*Isostictidae*				11				
Odonata	*Libellulidae*			8	34				
Odonata	*Lindeniidae*			8					
Odonata	*Zygoptera*		5	8	11		9		
Oligochaeta	*Oligochaeta*	120	37	269	256	8	64	33	83
Trichoptera	*Calamoceratidae*				11				
Trichoptera	*Ecnomidae*								
Trichoptera	*Hydroptilidae*			15	33	31	18		
Trichoptera	*Leptoceridae*	100	79	123	189	154	236	50	51
Turbellaria	*Dugesiidae*			8					

Appendix C – Water quality QA

Analyte	Units	LOR	CK7	CK-DUP
Physicochemical parameters				
TDS	mg/L	10	79	82
TSS	mg/L	5	<5	6
Major ions				
Bicarbonate alkalinity as CaCO3	mg/L	1	12	11
Carbonate alkalinity as CaCO3	mg/L	1	<1	<1
Hydroxide alkalinity as CaCO3	mg/L	1	<1	<1
Total alkalinity as CaCO3	mg/L	1	12	11
Sulfate as SO4	mg/L	1	26	25
Chloride	mg/L	1	2	3
Calcium	mg/L	0.5	4.6	4.8
Magnesium	mg/L	0.5	4.6	4.7
Sodium	mg/L	0.5	3.8	7
Potassium	mg/L	0.5	2.0	2.2
Dissolved metals				
Aluminium	mg/L	0.005	0.087	0.125
Arsenic	mg/L	0.0002	0.0008	0.0008
Cadmium	mg/L	0.00005	<0.00005	<0.00005
Chromium	mg/L	0.0002	0.0002	0.0004
Cobalt	mg/L	0.0001	<0.0001	0.0001
Copper	mg/L	0.0005	0.0007	0.0014
Iron	mg/L	0.002	0.553	0.588
Lead	mg/L	0.0001	<0.0001	<0.0001
Manganese	mg/L	0.0005	0.0028	0.0047
Mercury	mg/L	0.0001	<0.0001	<0.0001
Nickel	mg/L	0.0005	0.002	0.0022
Uranium	mg/L	0.00005	0.0001	0.00012
Zinc	mg/L	0.001	0.005	0.007
Total metals				
Aluminium	mg/L	0.005	0.289	0.283
Arsenic	mg/L	0.0002	0.0009	0.001
Cadmium	mg/L	0.00005	<0.00005	<0.00005
Chromium	mg/L	0.0002	0.0004	0.0004
Cobalt	mg/L	0.0001	0.0008	0.0008
Copper	mg/L	0.0005	0.0009	0.0008
Iron	mg/L	0.002	0.882	0.868
Lead	mg/L	0.0001	0.0005	0.0006
Manganese	mg/L	0.0005	0.0512	0.0482
Mercury	mg/L	0.0001	<0.0001	<0.0001
Nickel	mg/L	0.0005	0.0026	0.0026
Uranium	mg/L	0.00005	0.00015	0.00016
Zinc	mg/L	0.001	0.012	0.008
Cyanide				
Free cyanide	mg/L	0.004	<0.004	<0.004
Weak acid dissociable cyanide	mg/L	0.004	<0.004	<0.004
Total cyanide	mg/L	0.004	<0.004	<0.004

Appendix D – Sediment quality QA

Analyte	Units	LOR	CK7	CK-DUP
			24/04/2019	24/04/2019
1M HCl-extractable metals				
Aluminium	mg/kg	50	380	880
Arsenic	mg/kg	1	<1.0	1.1
Cadmium	mg/kg	0.1	0.2	0.3
Cobalt	mg/kg	0.5	10.3	12
Chromium	mg/kg	1	<1.0	2.1
Copper	mg/kg	1	3.7	5.2
Iron	mg/kg	50	2090	3120
Lead	mg/kg	1	22.7	20.5
Manganese	mg/kg	10	410	406
Nickel	mg/kg	1	6.2	8.2
Uranium	mg/kg	1	1.2	1.6
Zinc	mg/kg	1	38.6	48.5
Total recoverable metals				
Mercury	mg/kg	0.1	<0.1	<0.1
Cyanide				
Free Cyanide	mg/kg	1	<1	<1
Weak Acid Dissociable Cyanide	mg/kg	1	<1	<1
Total Cyanide	mg/kg	1	<1	<1
Other parameters				
Total Organic Carbon	%	0.02	0.67	0.67
Moisture Content	%	0.1	26.2	34.7

Appendix E – Macroinvertebrate identification QA

Aquatic Ecology Services

Macroinvertebrate Identification Quality Assurance Certificate

Site Code: CC02
Identification Date: 13/6/2019
QA Date: 24/6/2019

Replicate: 2 of 2
Identifier: TS
Senior Taxonomist: S. Jones

Habitat: Edge
Identification Level: Family

Taxonomy	Original Count	QA Count	Comment
Acarina	9	8	Possible transfer issue
Dytiscidae	1	1	
Hydrophilidae	1	1	
Scirtidae	3	3	
Atyidae	1	1	
Ceratopogonidae	5	5	
Chironominae	54	52	Possible transfer issue
Orthocladiinae	17	16	Possible transfer issue
Tanypodinae	35	35	
Baetidae	8	7	Possible transfer issue
Caenidae	6	6	
Leptophlebiidae	1	1	
Ancylidae (Planorbidae)	5	5	
Viviparidae	1	1	
Gerridae	6	6	
Micronectidae	43	42	Possible transfer issue
Pleidae	3	3	
Crambidae	1	1	
Zygoptera	1	1	
Oligochaeta	7	6	Possible transfer issue
Leptoceridae	15	15	

Percentage Correct: 100%

QA Result: Pass

Tara Steele

_____

Identifying Taxonomist

Susan Jones

_____

Senior QA Taxonomist

Aquatic Ecology Services

Macroinvertebrate Identification Quality Assurance Certificate

Site Code: SWTG2
Identification Date: 18/6/2019
QA Date: 24/6/2019

Replicate: 2 of 2
Identifier: TS
Senior Taxonomist: S. Jones

Habitat: Edge
Identification Level: Family

Taxonomy	Original Count	QA Count	Comment
Acarina	4	4	
Dytiscidae	6	5	Possible transfer issue
Hydrochidae	1	1	
Hydrophilidae	3	3	
Atyidae	12	12	
Ceratopogonidae	3	3	
Chironominae	63	63	
Orthocladiinae	15	15	
Tanypodinae	29	29	
Tipulidae	1	1	
Baetidae	10	10	
Caenidae	36	36	
Leptophlebiidae	2	1	
Planorbidae	1	1	
Mesoveliidae	2	2	
Micronectidae	6	6	
Pleidae	6	6	
Veliidae	2	2	
Oligochaeta	4	4	
Leptoceridae	11	11	

Percentage Correct: 100%

QA Result: Pass

Tara Steele

_____

Identifying Taxonomist

Susan Jones

_____

Senior QA Taxonomist

Appendix F – Remote camera species list

Group	Common Name	Scientific Name	Listing	Camera unit					
			NT	M1	M3	M4	M5	M7	M8
Bird	Australian White Ibis	*Threskionis molucca*			✓	✓		✓	✓
Bird	Pacific Black Duck	*Anas superciliosa*						✓	
Bird	Restless flycatcher	*Myiagra inquieta*							✓
Bird	Bar-shouldered Dove	*Geopelia humeralis*			✓	✓			✓
Bird	Black Kite	*Milvus migrans*						✓	
Bird	Blue-faced honeyeater	*Gracula cyanotis*					✓		
Bird	Black-necked Stork	*Ephippiorhynchus asiaticus*			✓				✓
Bird	Blue-winged Kookaburra	*Dacelo leachii*			✓				✓
Bird	Goshawk / Sparrowhawk	*Accipter spp.*			✓	✓			
Bird	Brown Goshawk	*Accipiter fasciatus*							✓
Bird	Bush-Stone Curlew	*Burhinus grallarius*							✓
Bird	Burdekin Duck	*Tadorna radjah*							✓
Bird	Great Egret	*Ardea modesta*		✓		✓		✓	✓
Bird	Intermediate Egret	*Ardea intermedia*				✓		✓	
Bird	Pied Cormorant	*Phalacrocorax varius*			✓	✓			
Bird	Nankeen Night Heron	*Nycticorax caledonicus*			✓	✓		✓	✓
Bird	Nankeen Kestrel	*Falco cenchroides*				✓	✓		
Bird	Straw-necked Ibis	*Threskionis spinicollis*			✓	✓			
Bird	Tawny Frogmouth	*Podargus strigoides*				✓			
Bird	Torresian Crow	*Corvus orru*						✓	
Bird	Whistling Kite	*Haliastur sphenurus*				✓			
Bird	White-faced Heron	*Egretta novaehollandiae*			✓	✓		✓	
Bird	Bush-Stone Curlew	*Burhinus grallarius*			✓				
Mammal	Agile Wallaby	*Macropus agilis*		✓	✓	✓		✓	✓
Mammal	Cattle	*Bos indicus/taurus*		✓	✓	✓		✓	
Mammal	Dingo	*Canis lupus dingo*			✓	✓	✓	✓	
Mammal	Pig	*Sus scrofa*				✓		✓	✓
Mammal	Water Rat	*Hydromys chrysogaster*				✓		✓	✓
Mammal	Northern Brown Bandicoot	*Isoodon macrourus*			✓				
Mammal	Echidna	*Tachyglossus aculeatus*							✓
Reptile	Mertens' Water Monitor	*Varanus mertensi*	VU		✓				✓

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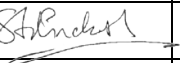
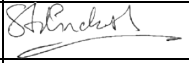
Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	Zoe Lagerroth	Stuart Winchester		Stuart Winchester		17/10/2019

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APPENDIX B1

Toms Gully Underground Project

Mine Closure Plan

December 2019

Document Control Record

Prepared by:	Charles Hastie
Position:	Chief Mining Engineer
Signed:	
Date:	05/12/2019

Approved by:	Mark Qui
Position:	Director
Signed:	
Date:	05/12/2019

Revision Status

Revision No.	Description of Revision	Date	Comment	Approved
1.0	First Issue	18/09/15	First issue released by Preston Consulting in 2015 for the purpose of the EIS draft.	
2.0	Second Issue	8/08/18	Updated after EIS comments. Submitted for EIS Supplement	MQ
3.0	Third Issue	10/07/19	Updated after EIS Supplement comments. Submitted for EIS Amendment.	MQ
4.0	Fourth Issue	04/09/19	Updated to reflect timing of disposal of existing tailings into Toms Gully	MQ

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1. Scope and Purpose

Primary Gold Limited (Primary) is proposing to re-commence underground mining and on-site processing of gold ore at the Toms Gully Underground Project (the TGU Project). Primary is a Western Australia (WA) based mineral exploration company operating in both WA and the Northern Territory (NT).

TGU is located within the Old Mount Bundey Station, approximately 90 km south-east of Darwin, Northern Territory (NT). Toms Gully has operated infrequently since 1988 and has been in Care and Maintenance since November 2010, with Primary acquiring the TGU Project in 2013. This Mine Closure Plan (MCP) for the TGU Project is being submitted as part of Primary Gold's Environmental Impact Statement (EIS) supplement for the TGU Project.

The purpose of this MCP is to provide a methodology for the closure of the TGU Project on tenements ML29812, ML29814 and MLN1058 in accordance with the requirements of the TGU Project Terms of Reference (ToR) (NT EPA 2014). This MCP has been prepared in accordance with the (then) WA Department of Mines and Petroleum (DMP) and the WA Environmental Protection Authority (EPA) Guidelines for Preparing Mine Closure Plans (DMP & EPA 2015).

The MCP will be reviewed throughout the life of the project to consider the addition of future mining areas and infrastructure (if required), changing site conditions, changing technologies, the success of rehabilitation activities and stakeholder expectations. An updated version of this MCP will also be submitted with the TGU Mining Management Plan (as required under the NT *Mining Management Act 2001*).

2. Project Summary

The Toms Gully Project was discovered in 1986 by Carpentaria Exploration Company Pty Ltd and the mine was subsequently developed in 1988 as an open cut mine. The project operated until 1991 while a room and pillar underground mine commenced from the east end of the pit in January 1990 (CGAO 2011). During this period the two evaporation ponds, tailings storage facility 1 (TSF1) and associated infrastructure were developed.

The mine and associated leases were sold to Esmeralda Exploration Ltd, which allowed the pit to flood. Ownership was then transferred to Kakadu Resources NL (KR) in 1993. KR constructed a new 250,000 tonne per annum Carbon-in-Leach (CIL) plant in 1995 to re-process sulphide and oxide tailings which created the need for TSF2. The Oxbow Wetland was also constructed during this period. During the CIL plant development, dewatering from the open pit commenced through approved waste water discharges during the wet season. A crushing circuit was added to the CIL circuit to process sulphide/oxide ores from the nearby Quest 29 project; however the inability to segregate high and low grade ore saw all of the ore treated in the Q29 dump heap leach facility.

The Toms Gully open pit was fully dewatered by mid-2001 and production once again recommenced in January 2006. In February 2007, the mine suffered flood damage to underground operations from a

tropical cyclone. This led to the sale of the Project in July 2007 when the mine was dewatered and refurbished for the purpose of recommencing production in August 2008; however the operator went into administration. In November 2009, Toms Gully was acquired by Crocodile Gold Australia Operations (CGAO), which is now Kirkland Lake Gold with dewatering, refurbishment and development commencing following the Mining Management Plan (MMP) and Water Management Plan approvals. Mining was halted again in November 2010 and the mine was placed into Care and Maintenance.

In 2013, Primary Gold acquired the TGU Project from CGAO. A feasibility study indicated a maiden Probable Ore Reserve of 775,000 tonnes at 6.9 g/t for 175,000 ounces of gold, which allowed for the recommencement of gold production at Toms Gully.

2.1. Disturbance Table

The current site disturbances (and proposed disturbances) are outlined in Table 1 below.

There were minor discrepancies in disturbance areas between the previously submitted 2013 MMP Security Calculation compared to the 2015 Mine Closure Plan (MCP) submitted as per the Draft EIS. Since there were no formal explanations or reasoning given for the disturbance areas calculated in the 2015 MCP, those values were not taken as an accurate representation of site disturbances.

In order to rectify the discrepancies, 2016 LiDAR imagery across the site was used to calculate more accurate disturbance calculations. See Table 1 below for the most recent and accurate disturbance table for the TGU Project.

Table 1: TGU Project 2018 Disturbance Table

Disturbance Domain	2013 Disturbance Area Calculation (ha)	2019 Disturbance Area (ha)	Comments
Oxide WRD (WRD1)	25	25	-
Sulphide WRD (WRD2)	20	28.5	LiDAR 2016 imagery shows a larger disturbance than previously reported.
TSF1	10	10	-
TSF2	12.25	13.05	The oxbow wetland (4.39 ha) has been included in this calculation
Water Ponds / Dams	13.3	14	Subtracted the process pond (0.7 ha) from the Area of Infrastructure (processing area) and added it to Water Ponds/Dams.
Area of Infrastructure (processing area)	4	9.84	LiDAR 2016 imagery shows a larger area of disturbance than previously reported.

Disturbance Domain	2013 Disturbance Area Calculation (ha)	2019 Disturbance Area (ha)	Comments
Drill Pads and Sumps	2.25	2.25	-
Tracks / Roads	2	2	-
Pit	-	15	LiDAR 2016 imagery was used to calculate 15 ha.
Proposed Water Storage Dam	-	16 ha	Proposed to construct a water storage dam for the storage of treated water and excess water on site.
Proposed Boxcut to access the Toms Gully ore body.	-	2 ha	Box cut to allow access to the Toms gully ore body further down dip allowing tailings and waste rock to be deposited into the pit during operation.
Proposed borrow pits and associated access tracks	-	58	Borrow pit material is required for the construction of the water storage dam embankments.
TOTAL	**88.8**	**195.64**	

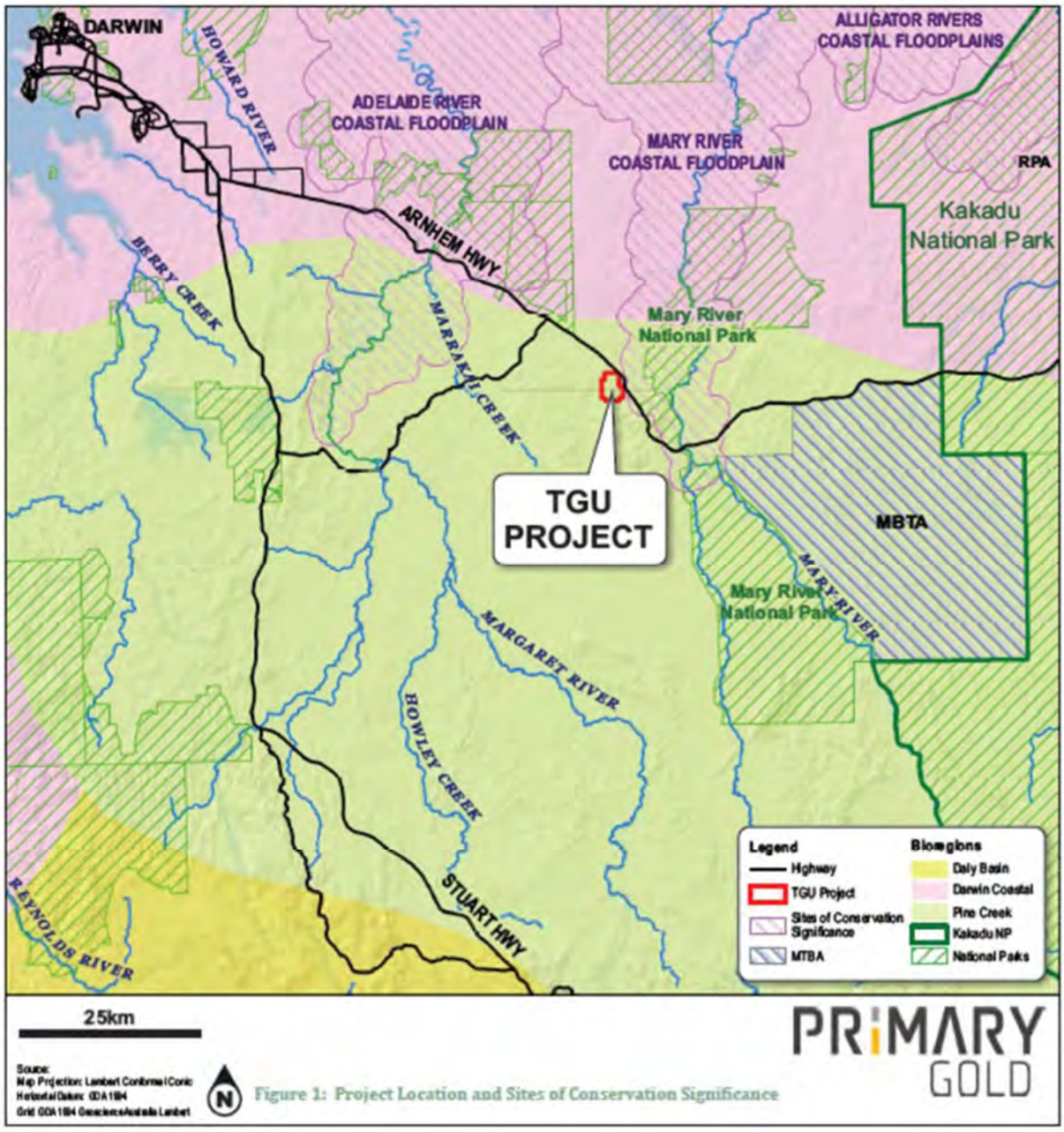

Figure 1: Project Location

2.2. Location, Tenure and Land Use

The TGU project is located approximately 90 km south-east of Darwin within the Pine Creek Bioregion (Figure 1).

Toms Gully is within the Mary River catchment which is not considered to be under intensive use, but does support a wide range of land and water uses including, pastoralism (63%), conservation (31%) and defence training (6%). Other land uses include mining, tourism and recreation, wildlife harvesting, commercial fishing and horticulture (Schultz et al 2002).

The TGU Project is located entirely within Mineral Lease MLN1058, which lies within the Old Mount Bundey Station (Perpetual Pastoral Lease 1163, NT Portion 4937). MLN1058 covers an area of 681 ha and is solely owned by Primary Minerals NL. Primary Minerals NL is a subsidiary of Primary Gold Limited. A number of additional tenements owned by Primary Minerals NL are located to the north and south of MLN1058. A list of the mining interests associated with the TGU Project is provided in Table 2.

Table 2: Register of Ownership for Mining Interests

Title No.	Holder	Status	Area	Comment
MLN1058	Primary Minerals NL	Granted	681 ha	Project located entirely within this lease
ML29812	Primary Minerals NL	Granted	158 ha	Directly North of TGU Project
ML29814	Primary Minerals NL	Granted	84 ha	Directly South of TGU Project

Toms Gully is located approximately 10 km from the rural subdivision of Marrakai and 63 km from labour and services at the community of Humpty Doo. Access to the mine is via a 2 km access road off the Arnhem Highway east of Marrakai. Proximal infrastructure includes the Corroboree Park Tavern and roadhouse approximately 11 km west of the TGU Project by road, three granite quarries approximately 5 km to the east, and the Mary River Wilderness Retreat and Bark Hut Inn 13 km east. Infrastructure associated with the Old Mount Bundey Station pastoral operations is located adjacent to the Toms Gully site and includes accommodation, grazing and irrigation infrastructure including fences, bores, watering points, tracks and paddocks.

Tourism, mining and horticulture are significant contributors to the region's economy (referring to the Alligator and Humpty Doo Australian Bureau of Statistics' statistical SA2 areas), although the biggest single employer is mining (Bradley 2015). Land use in the region reflects the economic contributions and includes agriculture (pastoral stations and orchards), tourist facilities, conservation reserves and mining areas. Active mining operations in the region include Energy Resources of Australia Limited's Ranger uranium mine near Jabiru, Kirkland Lake Gold's gold operations near Pine Creek and granite quarries near Mount Bundey.

The principal tourist attractions in the region are the Litchfield, Djukbinj, Kakadu and Mary River National Parks with the Adelaide River and Mary River systems being popular locations for recreational fishing.

Recreational fishing locations downstream within the Mary River system includes Hardies Creek (approximately 10 km downstream from the Arnhem Highway crossing), Corroboree Billabong (approximately 20 km downstream) and Shady Camp (approximately 60 km downstream).

2.3. Background

The TGU Project is a brownfield site with established mine site infrastructure and landforms including:

- Toms Gully Open Pit (15 ha);
- Toms Gully Underground portal (located in the base of the pit);
- Oxide Waste Rock Dump (WRD) (25ha);
- Sulfide WRD (28.5 ha);
- TSF1 (or first TSF) (10 ha);
- TSF2 (or second TSF) (8.66 ha);
- Process Plant, including ROM Pad (9.84 ha);
- Offices, Workshop and Sheds;
- Arterial Infrastructure including roads, power reticulation, bores, pipelines and site drainage;
- Evaporation Ponds 1 and 2 (14 ha);
- Oxbow Wetlands (4.39 ha); and
- Lake Bazzamundi.

Since acquiring Toms Gully, Primary Gold has undertaken feasibility studies and plans to complete the following major works to recommence underground mining and ore processing on site:

- Construction of a new 1 GL (16 ha) water storage dam (WSD);
- Construction of a Boxcut and associated decline to enter the ore body further down dip;
- Placement of future tailings into the pit under water;
- Placement of tailings from TSF1 and 2 whether reprocessed or not into the pit under water;
- Once emptied of tailings, repurpose TSF1 to be a water dam provided structure can be upgraded to ANCOLD 2012, stability suitable and seepage minimized;
- Place all future underground waste rock in the pit;
- Establishment of a standalone water treatment plant; and
- Upgrade the Process Plant.

Existing infrastructure, how it will be used for the TGU Project and new infrastructure required are summarised in Table 3. The major features are shown in Figure 2 and 3.

Table 3: Development Plan for the TGU Project

Item	Development Plan For TGU Project
Process Plant	Refurbish and re-use
Power supply and reticulation	Re-use and add diesel generator if grid power not cost competitive.
Offices and workshop	Refurbish and re-use

Item	Development Plan For TGU Project
TSF1	Remove tailings and potentially reprocess then place tailings in the pit beneath a water layer. If tailings are not reprocessed then placement in the pit will occur. TSF1 assessed and converted into a structure to manage water and sediment from the sulfide waste rock dump at closure.
TSF2	Remove tailings and potentially reprocess then place tailings in the pit beneath a water layer. If tailings are not reprocessed then placement in the pit will occur. TSF2 assessed and if suitable upgraded to ANCOLD 2012 (including the management of seepage) to allow the facility to be used as a water holding structure to manage water during operations. If used as a water dam will be rehabilitated at cessation of operations with the removal of the embankments. If not used for water storage once tailings removed TSF2 rehabilitated.
Sulfide WRD	Investigate options for long term closure. Including the capping with boxcut material.
Oxide WRD	Investigate options for long term closure. Including the capping with boxcut material.
Evaporation Pond 1	Empty initially, treat water to improve water quality. Then remains in use
Evaporation Pond 2	Empty initially, treat water to improve water quality. Then remains in use
Water production bores	Refurbish and re-use
Water monitoring bores	Refurbish and re-use
Oxbow Wetlands	Continued use as passive treatment for runoff from Oxide WRD
Site drainage	Improve and re-use
Water supply dam	Construct new. Retain for pastoralist at closure if suitable
Lake Bazzamundi	Release fresh bore water into area. Pastoralist to utilise for grazing
Mine Pit	Place all tailings and future underground waste rock into the pit. Displaced water treated to SSTVs water quality. In addition inert waste from plant demolition placed in pit at closure
New Boxcut and Decline	Construction of the decline allowing the retention of a barrier pillar thus retaining the pit with water for disposal of AMD generating tailings and waste rock.
Existing underground workings	Place all tailings and future underground waste rock in the pit this material may fill the existing underground workings. Displaced water treated to SSTVs water quality.
New underground workings	Where practicable if scheduling enables and mining voids are available place some waste in mined out voids.
ROM Pad	Re-use
Haul roads and access roads	Re-use where relevant to TGU Project

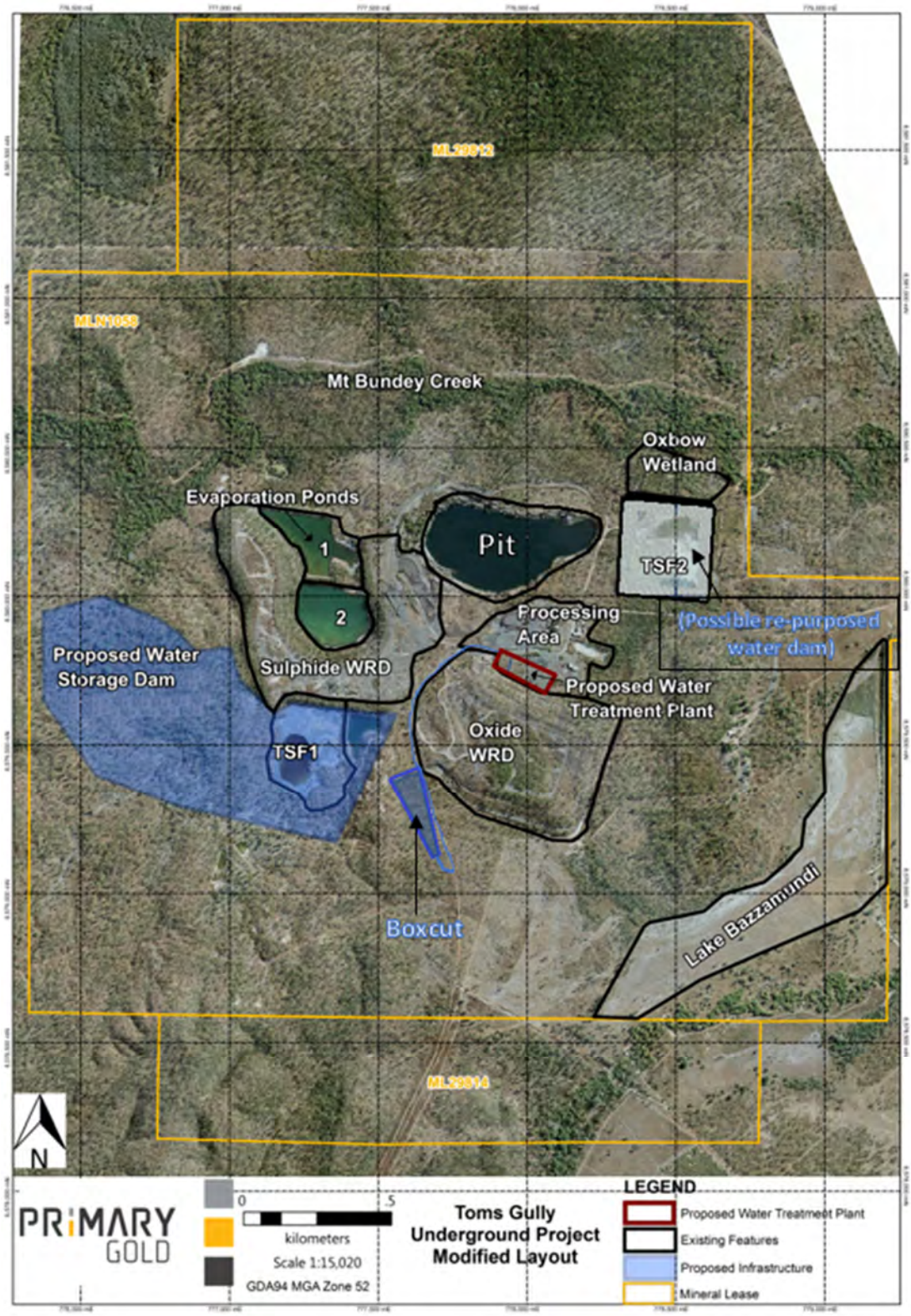

Figure 2: 2018 TGU Site Layout

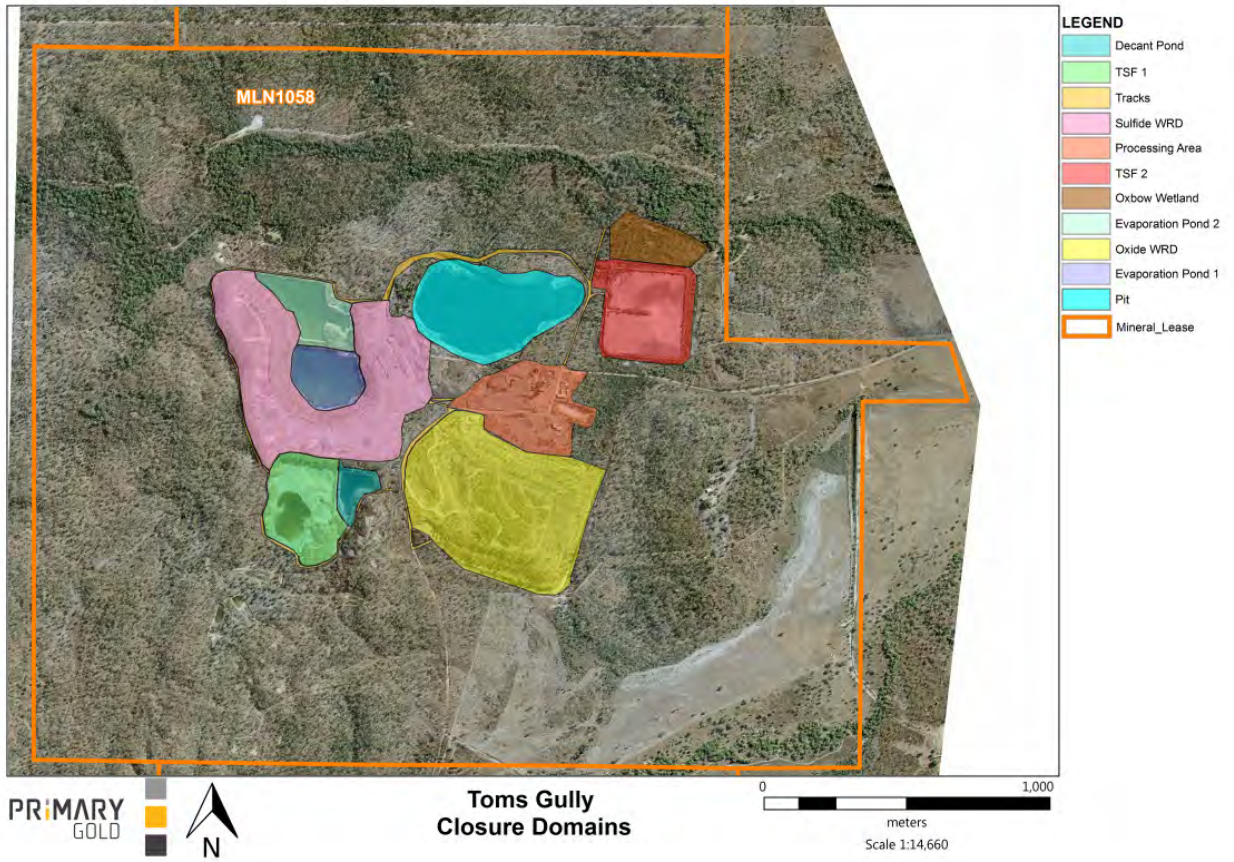

Figure 3: Toms Gully Existing Closure Domains

3. Identification of Closure Obligations and Commitments

Obligations and commitments relating to rehabilitation and closure have been derived from the NT *Mining Management Act 2001*; NT EPA Toms Gully ToR (NT EPA 2014); Primary Gold's MMP (Primary Gold 2013a) and Primary Gold's Access Agreement with Old Mount Bundey Station. These are presented in Tables 3 - 7.

Table 4: Mining Management Act Closure Obligations

Section of Mining Management Act	Obligation/Commitment
42 Notification of proposed cessation of mining activities	The operator for a mining site must notify the Minister in writing of the proposed cessation of mining activities on the site that is not in accordance with the MMP as soon as practicable before cessation.
46 Certificate of Closure	(1) On completion of the rehabilitation of a mining site to the satisfaction of the Minister, the operator for the site may apply to the Minister for a certificate of closure in respect of the site. (2) When the operator has met the closure criteria for the mining site, the Minister must: (a) issue to him/her a certificate of closure in respect of the site; and (b) return or relinquish any outstanding security provided by the operator.

Table 5: NT EPA Terms of Reference Closure Obligations

Section of ToR	Obligation/Commitment
5.10.2 Assessment of Risks	The EIS should include assessment of risks to successful rehabilitation and closure including: • the TGU Project not realising its projected outcomes (i.e. delays, unexpected or forced closure, falling gold prices, etc.) • inadequate identification and management of materials with AMD/NMD/SD potential changes in the assumptions used as a basis for the post-closure risk assessment • natural extreme events, including earthquakes, cyclones, rain depressions, fire and flood.
5.10.2 Assessment of Risks	The EIS should identify and assess environmental risks associated with a potential short and long term period of Care and Maintenance for the TGU Project and site.
5.10.3 Mitigation	Demonstrate that identified risks associated with rehabilitation, revegetation, closure and periods of Care and Maintenance for the TGU Project will be avoided, mitigated or otherwise minimised to a low level.
5.10.3 Mitigation	A draft MCP specific to the TGU Project, should be prepared to address identified risks.
5.10.3 Mitigation	The MCP should provide an outline of the risks and

Section of ToR	Obligation/Commitment
	demonstrate that all relevant issues and appropriate management measures have been identified.
5.10.3 Mitigation	The MCP should demonstrate that ecologically sustainable mine closure can be achieved consistent with agreed post-mining outcomes and land uses, and without unacceptable liability to the Territory.
5.10.3 Mitigation	The MCP should include: • mitigation measures to address identified risks • measures required to prevent contamination of surface and groundwater resources • measures to ensure that tailings and overburden with AMD/NMD/SD potential, and poor quality mine waters, will be physically isolated from the environment, and not result in any short (whilst operational), medium (post closure and under institutional control) or long term (post-institutional control) detrimental ecological impacts • measures to minimise the long term introduction and control of weeds • revegetation strategies for disturbed sites to utilise local native plant species similar in type, density and abundance to those existing in adjacent areas • assessment of the void geochemistry, including modelling to predict the likely post mining water quality in the open pit once it is left to accumulate water • measures to ensure the environmental sustainability and full containment of contaminated mine and pit-water post-closure • measures to ensure the stabilisation of erosion, to a level similar to comparable landforms in surrounding undisturbed areas • contingencies to make landforms and mine components secure and non-polluting in the event of unexpected or temporary closure, or failure of rehabilitation, revegetation or closure actions
5.10.3 Mitigation	The MCP should identify how risks from the site will be managed should the TGU Project be temporarily closed or suspended at any stage of the mine operation and development.
5.10.4 Monitoring	The EIS should describe proposed: • post-mining monitoring and reporting to be used to evaluate and report on the effectiveness and performance of the mitigation measures. • contingency measures to be implemented in

Section of ToR	Obligation/Commitment
	the event that monitoring demonstrates that management measures have not been effective. • Provide outcome and assessment criteria that will give early warning that management and mitigation measures are not achieving the outcomes and benefits expected and identified by the Proponent.

Table 6: Primary Golds MMP Closure Obligations

Section of Mining Management Plan	Obligation/Commitment
3.5 Environmental Commitments	Maintain structural integrity of landforms.
3.5 Environmental Commitments	Maintain effective erosion and sediment control where required.
3.5 Environmental Commitments	Conduct biannual inspections of rehabilitated areas (including landfills).
3.5 Environmental Commitments	Remediate gullies on the west side of the Sulphide Waste Rock Dump.
3.5 Environmental Commitments	Conduct weed control activities in consultation with local landholder as necessary and in accordance with the Site Weed Action Plan.
3.5 Environmental Commitments	Develop a Closure Plan by June 2014.

Table 7: Primary Golds 2014 Access Agreement with Old Mount Bundey Station Closure Commitments and Obligations

Section of Access Agreement	Obligation/Commitment
Section 2	Adhere to closure and rehabilitation obligations set out in Schedule 2.
Schedule 2 - Toms Gully Site Rehabilitation	Modifications/improvements maybe required (to Schedule 2 items) based on further engineering studies, developments in rehabilitation techniques or recent department guidelines.
Schedule 2 - Toms Gully Site Rehabilitation	Tailings dams – stabilise, implement effective water management strategy, capped and contoured to support revegetation.
Schedule 2 - Toms Gully Site Rehabilitation	Mine – secure site with bunding and fencing to minimise risk to public and pastoral operations.
Schedule 2 - Toms Gully Site Rehabilitation	Waste dumps – rehabilitate any live areas, encapsulate PAF, batter slopes, suitable capping, preparation for revegetation, seeding. Manage areas with evidence of oxidation and erosion.

Section of Access Agreement	Obligation/Commitment
Schedule 2 - Toms Gully Site Rehabilitation	Process water and evaporation dams – remove contaminated material to pit prior to rehabilitation.
Schedule 2 - Toms Gully Site Rehabilitation	Water storage dams – if not required for pastoral operations, remove contaminated material, breach walls and re-contoured to ensure flow through.
Schedule 2 - Toms Gully Site Rehabilitation	Processing plant and buildings – remove processing plant. If not required by pastoralist, remove remaining buildings, fixed plant and footings.
Schedule 2 - Toms Gully Site Rehabilitation	ROM Pads – remove or cover, contour and re-seed
Schedule 2 - Toms Gully Site Rehabilitation	Roads –rehabilitate roads not required by pastoralist.
Schedule 2 - Toms Gully Site Rehabilitation	Refuse dump – appropriate capping, shaping to ensure drainage from the site.

Table 8: Primary Golds 2018 Mine Closure Plan Obligations

Section of MCP	Obligation/Commitment
Socio-economic impacts	Primary will engage the local stakeholders and the community to ensure the community is prepared for the closure of the mining operations.
End Land Uses	Primary's obligation is to return the land to a condition that enables the landholder to economically use the land and also significantly reduce the environmental impact for the future.
Characterisation of Current Impacts	As the site is further developed, reviews will be undertaken to ensure there are adequate numbers of groundwater monitoring bores and that they are appropriately placed.
Characterisation of Current Impacts	Land that is cleared of mine waste materials (e.g., waste rock, tailing) during rehabilitation and left exposed will be tested for contamination
Characterisation of Current Impacts	Areas downstream of sources of significant contamination will also be tested for soil contamination.
Final Closure Activities	All site roads will be reviewed with the landholder to determine which roads will be required to be left for the long term management of the site.
Inspection and Maintenance Programme	Primary will adapt its current inspection and maintenance program to cover areas rehabilitated as part of the closure program.

Section of MCP	Obligation/Commitment
Post-mining land use	Primary will complete studies to advance development of a long term closure solution for the OWRD and SWRD as well as EP1 and EP2 legacy features
Post-mining land use	If the WSD and Lake Bazzamundi are affected by mining they will also form part of the livestock exclusion precinct.

4. Stakeholder Engagement

The Stakeholders of relevance to the closure of the TGU Project include:

- Government Regulators
  - NT EPA
  - Department of Primary Industry and Resources (DPIR)
  - Department of Environment and Natural Resources (DENR)
  - Department of Infrastructure, Planning and Logistics (DIPL)
- Old Mt Bundey Pastoral Station Lease Holder
- Traditional Owners / Northern Land Council
- Community members (e.g. Amateur Fishers Association NT, future employees, local businesses, surrounding pastoralists or residents)

Regular formal and informal meetings with the above stakeholders are an important component of closure planning. As such, on-going consultation, specifically with the underlying pastoral lease holder and other community members, will be maintained by Primary throughout the life of the TGU Project.

The key objectives of the closure stakeholder consultation program for the TGU Project include:

- Informing local stakeholders of the closure planning process and allowing opportunities for stakeholder input into planning decisions;
- Informing local stakeholders of the proposed timeframe for closure, including key closure planning milestones (such as the preparation of a final decommissioning plan) and decision points (such as the designation of end land uses for rehabilitated sites);
- Identifying and providing a forum for discussing stakeholder aspirations and concerns regarding closure;
- Identifying any closure issues not covered in this or subsequent closure plans.

The key stakeholder for the TGU Project and for closure is the lease holder of the Old Mount Bundey Pastoral Station (Pastoralist). Major closure interests for the landowner are returning as much land as possible to the pre-existing pastoral land use and retention of certain fixed assets post closure.

A summary of stakeholder engagement to date for the TGU Project as a whole is provided in Table 9.

Table 9: Stakeholders Consulted as Part of the EIS Process for the TGU Project

Stakeholder	Date	Description of Engagement	Stakeholder Comments/Issues	Response to Stakeholder Comments/Issues	Stakeholder Response
NT EPA	Jan 2016 – Dec 2017	Clarifications with respect to work required for EIS supplement	Primary to provide a revised Mine Closure Plan which addresses management and mitigation of closure risks in more detail.	More baseline work undertaken across the project site to better inform impacts and risks.	TBC. The Addendum including updated documents to be assessed once lodged
NT EPA	July 2018	Response to NT EPA comments on draft EIS – particularly in relation to the closure phase of the project. These comments were addressed throughout the revised Mine Closure Plan submitted as part of the EIS supplement.	Primary provided a response to the NT EPA comments on the draft EIS, specifically relating to closure. The primary comments from the EPA were: • Requirements to provide specific completion criteria and rehabilitation monitoring due to short life of mine • Ensuring sustainable and safe end land use for the pastoralist • The management of AMD • The management of the WSD post closure	Primary has updated the MCP to provide more specific details of completion criteria and rehabilitation monitoring as seen in Sections 6 and 11.2 respectively. Proposed management measures for AMD now includes a stand-alone water treatment plant which will treat all site water to meet SSTVs before being discharged. All tailings placed in the pit. Investigations into long term rehabilitation of WRD are being undertaken.	TBC. The Addendum including updated documents to be assessed once lodged
NT Department of Primary Industry and Resources (DPIR), previously the Department of Mines and Energy	2015 submission of EIS draft	MMP process with respect to EIS assessment MMP requirements Water treatment	Further investigation is required into the anticipated quality and quantity of flow and impact on the Mary River system. PG need to provide a commitment to the 3D Groundwater modelling (and costs) prior to approval. A key concern would be the	PG has committed water quality discharge to meet updated SSTVs implemented, thus impacts to Mary River catchment are significantly reduced. 3D groundwater modeling and contaminant transport has been undertaken to better	TBC. The Addendum including updated documents to be assessed once lodged

Stakeholder	Date	Description of Engagement	Stakeholder Comments/Issues	Response to Stakeholder Comments/Issues	Stakeholder Response
			potential for pit leaching AMD contaminated water into surrounding groundwater systems, and furthermore, surface water catchments.	understand impacts of AMD to groundwater systems. A water treatment system has been proposed to treat AMD contaminated water and tailings material will be placed in the pit.	
NT Department of Environment and Natural Resources (DENR)	2015 submission of EIS draft	Water Discharge Licence and comments on Draft EIS document.	No systematic survey of biodiversity values has been undertaken across the tenement as part of the EIS. A number of threatened fauna species have been assessed by the Department as possibly occurring within the project area. However no targeted survey of fauna has been undertaken over the tenement.	The required water discharge licence and any associated permits under the Water Act will be sought. Flora and fauna surveys have now been undertaken across the project with only one conservation significant species found upstream of the TGU Project (Merten's Water Monitor). Impacts to significant species are not expected.	TBC. The Addendum including updated documents to be assessed once lodged
NT National Parks and Wildlife Commission	2015 submission of EIS draft	General company introduction and offer of information. Comments on EIS Draft provided by the department.	The Mary River National Park is one of the Northern Territory's most important parks for biodiversity conservation and protects natural values that are nationally and internationally significant. It is also an important location for NT tourism and recreational fisherman.	Additional surface water monitoring and contaminant transport modelling have indicated that once water reaches SWTG2 (downstream location before Arnhem Highway), SSTVs for ecosystem protection levels have been reached (except for aluminum – however this is possibly attributed to natural causes as upstream data is showing the same result). Significant impacts to the Mary NP and catchment is	TBC. The Addendum including updated documents to be assessed once lodged

Stakeholder	Date	Description of Engagement	Stakeholder Comments/Issues	Response to Stakeholder Comments/Issues	Stakeholder Response
				not expected as a result of the TGU Project.	
Amateur Fishers Association of NT (AFANT)	2015 submission of EIS draft	General company and Project information. EIS comment process.	AFANT is concerned with the health of downstream aquatic ecosystems in Mount Bundey Creek and Mary River National Park as a result of the Tom's Gully Underground Project (TGUP) as these areas include the iconic fishing locations of Hardies Billabong, Corroboree Billabong, Shady Camp and the Mary River system. The main concerns revolve around the discharge of water into Mount Bundey Creek. AFANT is comfortable with the water being treated to meet 80% ANZECC and ARMCANZ (2000a) criteria however strong El Nino influence resulting in more extreme weather events but reduced overall rainfall in the Mary River Catchment should be considered. We have an extremely strong interest in ensuring that the proposed mining operations and post closure rehabilitation of the site can be conducted in a manner that removes any current and future water and	Proposed to improve the water quality at the discharge point to be within SSTVs, if this cannot be achieved then it is anticipated that the water quality target will be at the SSTV developed by the CSIRO. PG will take into consideration the seasonal rainfall each season including El Nino events and discharge accordingly. PG have also updated their site completion criteria to be S.M.A.R.T and will aim to achieve a stable and non-polluting site at closure.	TBC. The Addendum including updated documents to be assessed once lodged

Stakeholder	Date	Description of Engagement	Stakeholder Comments/Issues	Response to Stakeholder Comments/Issues	Stakeholder Response
			pollution risks at the TGUP site.		
Old Mt Bundey Pastoral Station Owner T Harrower	15/08/2016	Site meeting. Discussed livestock access to Toms Gully in particular access to the Oxbow area at Mount Bundy Creek and water quality at Rustlers Roost that meets livestock drinking quality.	Pastoralist indicated that stock had not gone through the fence at Toms Gully and also the paddock covering the oxbow was not used as the vegetation made the mustering and management of stock hard.	Ongoing management of stock exclusion at Toms Gully	Ongoing
Old Mt Bundey Pastoral Station Owner T Harrower	13/12/2016	Telephone discussion and email.	Concerns were raised about vegetation across Toms Gully and next to infrastructure.	Pastoralist contracted to spray vegetation around infrastructure, maintain firebreaks and undertaken controlled burning during cooler months to limit fire load.	Ongoing
Old Mt Bundey Pastoral Station Owner T Harrower and G Keppel	28/06/2017	Onsite meeting	Details on the proposed acid mine drainage baseline testing and water quality at Toms Gully. Waste rock dump drilling and tailings sampling were discussed and the reasons why.	Ongoing consultation on site acid mine drainage conditions and work.	Ongoing

Stakeholder	Date	Description of Engagement	Stakeholder Comments/Issues	Response to Stakeholder Comments/Issues	Stakeholder Response
Old Mt Bundey Pastoral Station Owner T Harrower and G Keppel	09/11/2017	Onsite Meeting: • Update on Toms Gully approvals and wet season care and maintenance requirements. • Discussed Tom Gully water treatment options and potential water disposal options including potential pastoral use.	• Pastoralist interested in potential water use however quality needs to be suitable for his usage.	• Water treatment needs to deliver suitable water quality outcomes.	Pastoralist to continue to monitor and provide pumping services to maintain water levels thus preventing overtopping during wet season maintenance across Toms Gully, Quest 29 and Rustlers Roost.
Old Mt Bundey Pastoral Station Owner T Harrower	15/12/2017	Telephone discussion	• Pastoralist interested in using treated water for pasture irrigation and use for mango production. • Water needs to be of appropriate quality.	• Water treatment needs to be “fit for purpose”	Ongoing discussion as water treatment option is being developed.
Old Mt Bundey Pastoral Station Owner T Harrower	3/11/2018	Telephone discussion	• Volume of water that could be used for activities is 200ML a year.	• Water treatment needs to be “fit for purpose”	Ongoing discussion on providing water.

Stakeholder	Date	Description of Engagement	Stakeholder Comments/Issues	Response to Stakeholder Comments/Issues	Stakeholder Response
Owner of land north of Arnhem Highway and downstream of Mt Bundy Creek.	27/06/2017	Meeting	• Landowner raised concerns that his gates may be rusting due to being downstream of the Toms Gully site. • Primary gave details of the current activities and studies at the Toms Gully, Rustlers Roost and Quest 20 site.	• It was discussed that no permitted releases of water had occurred since operations ceased and that each wet season water levels in the facilities were monitored with excess water from the evaporation pond and tailings dams pumped to the Toms Gully pit. As this pit has excess capacity. • Ongoing communications and information to be provided. • Primary provided contact details in case the landowner wanted to discuss any further concerns issues	Ongoing
Department of Primary Industry and Resources L Reif & A Razafimamonjy	22/3/2016	Site Inspection. Visit served as a site familiarisation.	Concerns that were raised: • Cattle accessing poor quality water. • Management of declared weeds. • Overtopping of Toms Gully pit.	• Water quality across all sites assessed against livestock drinking water guidelines. Only Toms in exceedance. Discussed with pastoralist in 2016 to ensure fence at Toms is inspected to keep cattle out. • Primary has an ongoing weed spraying program. • At Toms Gully a site based groundwater model is being constructed then will form the basis of the water management strategy. Rustlers Roost and Quest 29	• Continued monitoring of water quality and inspection of Toms Gully fences required. • Weed control program ongoing. • Requirement for drill hole auditing to commence. • Ongoing monitoring of Toms Gully pit fireboard.

Stakeholder	Date	Description of Engagement	Stakeholder Comments/Issues	Response to Stakeholder Comments/Issues	Stakeholder Response
				are less advanced as desktop quotes are yet to be received. • Sufficient freeboard is available at Toms Gully pit.	
Department of Primary Industry and Resources L Reif & team members from the DPIR tech support team	23/3/2018	Site inspection of the areas where overtopping events at Toms Gully and Quest 29. Visit served as a site familiarisation.	Concerns that were raised: • The reversal of Toms Gully from a sink to a source for groundwater. • Ensuring freeboard was maintained during wet season.	• Sufficient freeboard maintained via pumping water between water holding facilities. • Primary discussed baseline work for EIS.	NT EPA required ongoing monitoring of the site and management of water to prevent overtopping events and maintain freeboard.
Department of Primary Industry and Resources J Sumner, R Syna & team members from the DPIR mining and tech support teams	3/06/2018	Meeting. Primary provided an update on EIS Supplement preparation, requirements for the Section 14A, proposed water and tailings treatment option.	DPIR provided information on the requirements for seeking approval for a water and tailings treatment pilot plant	Primary lodged an application seeking approval for a pilot plant and included all requirements set out by DPIR.	TBC. DIPR is currently assessing application for water and tailings pilot plants.
NT EPA section of the Department of Environment and Natural Resources M Browne &	23/3/2018	Site inspection of the areas where overtopping events at Toms Gully and Quest 29. Visit served as a site familiarisation.	Concerns that were raised: • The possibility for overtopping events to discharge potential pollution off mining tenure. • Need to ensure adequate systems and freeboard are maintained during wet	Sufficient freeboard maintained via pumping water between water holding facilities. Ongoing monitoring of the site and management of water to prevent overtopping events and maintain freeboard.	NT EPA required ongoing monitoring of the site and management of water to prevent overtopping events and maintain freeboard.

Stakeholder	Date	Description of Engagement	Stakeholder Comments/Issues	Response to Stakeholder Comments/Issues	Stakeholder Response
team member from NT EPA pollution section.			season to prevent discharge events.		
NT EPA section of the Department of Environment and Natural Resources L Bradley, S Strohmayr & M Trueman.	3/06/2018	Meeting. Primary provided an update on EIS Supplement preparation, requirements for the Section 14A, proposed water and tailings treatment option.	The NT EPA raised the matter of providing a level of certainty when presenting environmental and closure outcomes.	Further baseline geochemical and water studies completed to inform closure planning. Throughout the risk assessment process and within the completion criteria in the EIS supplement, Primary Gold has justified the level of certainty in given residual risk levels relating to closure.	TBC. NT EPA will assess the EIS supplement and would include an assessment against the NT factors and objectives.
NT EPA section of the Department of Environment and Natural Resources K Fitzpatrick & M Trueman. And Department of Primary Industry and Resources F Perrett, and J Pottage.	29/11/2018	Telephone conversation. Primary provided an update on the EIS Addendum preparation and project changes for the Section 14A, proposed tailings and waste rock management.	Concerns were raised on the deposition of tails and waste rock into the base of the pit and the maintenance of a water cover.	Further baseline geochemical and water studies completed to inform closure planning and management of the pit water.	Assessment of EIS addendum that will include details of waste rock, tails and pit water management.

Stakeholder	Date	Description of Engagement	Stakeholder Comments/Issues	Response to Stakeholder Comments/Issues	Stakeholder Response
NT EPA section of the Department of Environment and Natural Resources NT EPA Board K Fitzpatrick & M Trueman.	6/12/2018	Meeting. Primary provided an update on EIS Addendum preparation and project changes for the Section 14A, proposed tailings and waste rock management.	The NT EPA raised the matter of providing a level of certainty on pit water quality over varying seasons with respect to placement of tailings and waste rock in the pit.	Further baseline geochemical and water studies completed to inform closure planning and management of the pit water.	NT EPA will assess the EIS addendum that will include geochemical and water modelling of the pit.

Primary will continue to consult with the relevant stakeholders prior to implementing the closure of the TGU Project (Table 10) and take into account the comments received during the closure process.

Table 10: Stakeholder Engagement Strategy

Stakeholder	Engagement Description	Timing
NT EPA	Phone call and follow up email (meeting if required)	(1) Prior to finalizing any significant changes in closure designs or (2) prior to submitting any revisions/updates of the TGU MCP or (3) immediately prior to the closure of the TGU Project.
NT DPIR	Phone call and follow up email (meeting if required)	
Northern Land Council/ TOs	Phone call and follow up email (meeting if required)	
Old Mt Bundey Pastoralist	Phone call and email (meeting if required) Primary Gold will obtain agreement from the Pastoralist of infrastructure to be retained for future responsibility of the Pastoralist.	
Other government departments	Phone call and follow up email	Prior to finalizing any significant changes in closure designs or immediately prior to the closure of the TGU Project.
Local community and businesses (where relevant)	Phone call and follow up email	Prior to finalizing any significant changes in closure designs or immediately prior to the closure of the TGU Project.

5. Post-mining land use(s) and closure objectives

The TGU Project has been split into a number of closure domains for the purposes of this MCP. This assists in developing appropriate closure strategies for the specific requirements of each domain at hand. There are 9 closure domains are as follows:

(1) Toms Gully Open Pit and Underground Portal (Existing)
(2) Processing Area (including ROM Pad) (Existing)

(3) TSF1 and TSF2 (Existing)
(4) Oxide and Sulphide WRDs (Existing)
(5) Evaporation Ponds 1 and 2 (Existing)
(6) Haul Roads and Access Tracks (Existing)
(7) Proposed Water Storage Dam (New)
(8) Surface and Groundwater bores (Existing)
(9) Boxcut and Decline (New)

5.1. Post-Mining Land Use

The TGU project has predominantly been used for pastoralism (grazing) in the past. Primary will aim to return as much of the land as possible to a condition that enables pastoralism to continue and also significantly reduce the environmental impact for the future.

Recent stakeholder engagement noted that the pastoralist expects to be able to use the area around the mine for grazing and also utilise some infrastructure such as sheds and workshops. Therefore Primary will work to achieve this outcome by rehabilitation and treating mine affected water to Site Specific Trigger Values. Currently or water quality values, Primary has gained approval for the installation of a water and tailings treatment pilot plant onsite to trial the treatment of mine affected water in the pit to a quality suitable for discharge into Mt Bundey Creek and for use by third parties for agricultural or horticultural uses. Based on the results of this trial, more definitive closure strategies (in particular for the evaporation ponds and water storage dams) can be determined. It is intended that tailings in TSF1 and TSF2 will be placed into the Toms Gully Pit beneath a water cover to minimize oxidation. Tailings removal will eliminate the landforms associated with tailings at closure.

An amendment to the approved 2013 MMP has been submitted to DPIR detailing the nature of the pilot treatment plant (Authorization 0740-01). Whilst the water treatment process and tailings placement is being undertaken, the interim closure strategy is to demarcate a livestock exclusion precinct, see section 5.1.1. for more details.

5.1.1. TGU Legacy Areas

Considering the landowner's expectations and the presence of historical legacy infrastructure (waste dumps, evaporation ponds and TSF1 and 2), Primary Gold proposes to segregate the site into pastoral grazing and livestock exclusion precincts (Figure 4). The pastoral grazing precinct will be able to support grazing in the short term. The livestock exclusion precinct will be regarded as a temporary livestock exclusion zone and have restricted access whilst the water is being treated successfully, TSF1 and TSF2 are being rehabilitated after tailings removal (TSF1 immediately after tailings removal and TSF2 after use as a water storage facility), the landscape stabilises, is revegetated and investigations conducted to ensure rehabilitation is safe and sustainable to support pastoral grazing.

The livestock exclusion precinct forms the core of the site, including the two TSFs, the sulfide and oxide WRDs, Process Plant, evaporation ponds, Oxbow Wetlands and the pit footprint. Within the livestock exclusion precinct, the land use will continue to be restricted access until rehabilitation has stabilized and

mine affected water has shown a long term (at least 5 sample rounds) trend of being within ANZECC livestock guidelines. Initial targets will be to stabilise and revegetate the landscape with the available materials. Access by people will be restricted via maintenance of the existing fence that separates this area from the remainder of the pastoral lease.

The remainder of MLN1058 forms the pastoral grazing precinct which includes the new water storage dam and existing Lake Bazzamundi. Both will be retained as water storage assets for the Pastoralist should they be required. The initial targeted land use for the pastoral precinct will be activities including pastoral grazing and water capture in support of grazing. In the event that the water quality within the new water storage dam or Lake Bazzamundi are not within ANZECC livestock guidelines; in consultation with the underlying pastoralist and the relevant regulators these areas will be included in the livestock inclusion precinct whilst being remediated.

By splitting the site into two precincts, a substantial portion of MLN1058 can return to its desired land use shortly after completion of the TGU Project. Restricted access to the livestock exclusion precinct recognises that rehabilitation will take time to establish and become stable and sustainable and some historical landforms (such as the oxide and sulphide WRDs) will not be fully rehabilitated yet in the timeframe of the TGU Project. Primary will undertake studies to advance development of a long term closure solution for these legacy landforms. During closure planning and dependent on the post mining land use it is intended these areas will be integrated into the future land use practices.

Over time it may be possible for some areas of the livestock exclusion precinct to be released to the pastoral precinct. However it is envisaged the WRDs are likely to remain restricted from pastoral use for an extended period. Primary will obtain agreement from the Pastoralist of infrastructure to be retained for future responsibility of the Pastoralist. Fencing and bunding of the livestock exclusion precinct will isolate these landforms from risks associated with destabilisation by grazing.

It has also been identified (GHD 2019) in a site conceptual model that the historical WRD, TSF and ROM Pad area are acting as sources of AMD whilst the evaporation ponds and other water storage areas are acting as AMD pathways (Figure 8). This legacy of AMD across the site is resulting in contamination of groundwater and may be reducing the quality of water in the Mt Bundey Creek. The recommencement of the TGU site by Primary has some opportunities to remediate or reduce the AMD sources and pathways on site – placement of tailings in the pit, re-processing tailings and/or treating the tailings, treating AMD contaminated water sources and increasing groundwater monitoring efforts.

Since the legacy of the TGU project dates back many years with various operators, there have not been efforts in recovering topsoil and thus a case of topsoil deficit exists for the site. Primary will harvest topsoil in all new cleared areas and use these sources in areas that most need it. Where practical potential growth mediums when identified will be recovered and used to augment establishment of vegetation. A materials balance will be updated once clearing has been completed as part of the recommencement of operations.

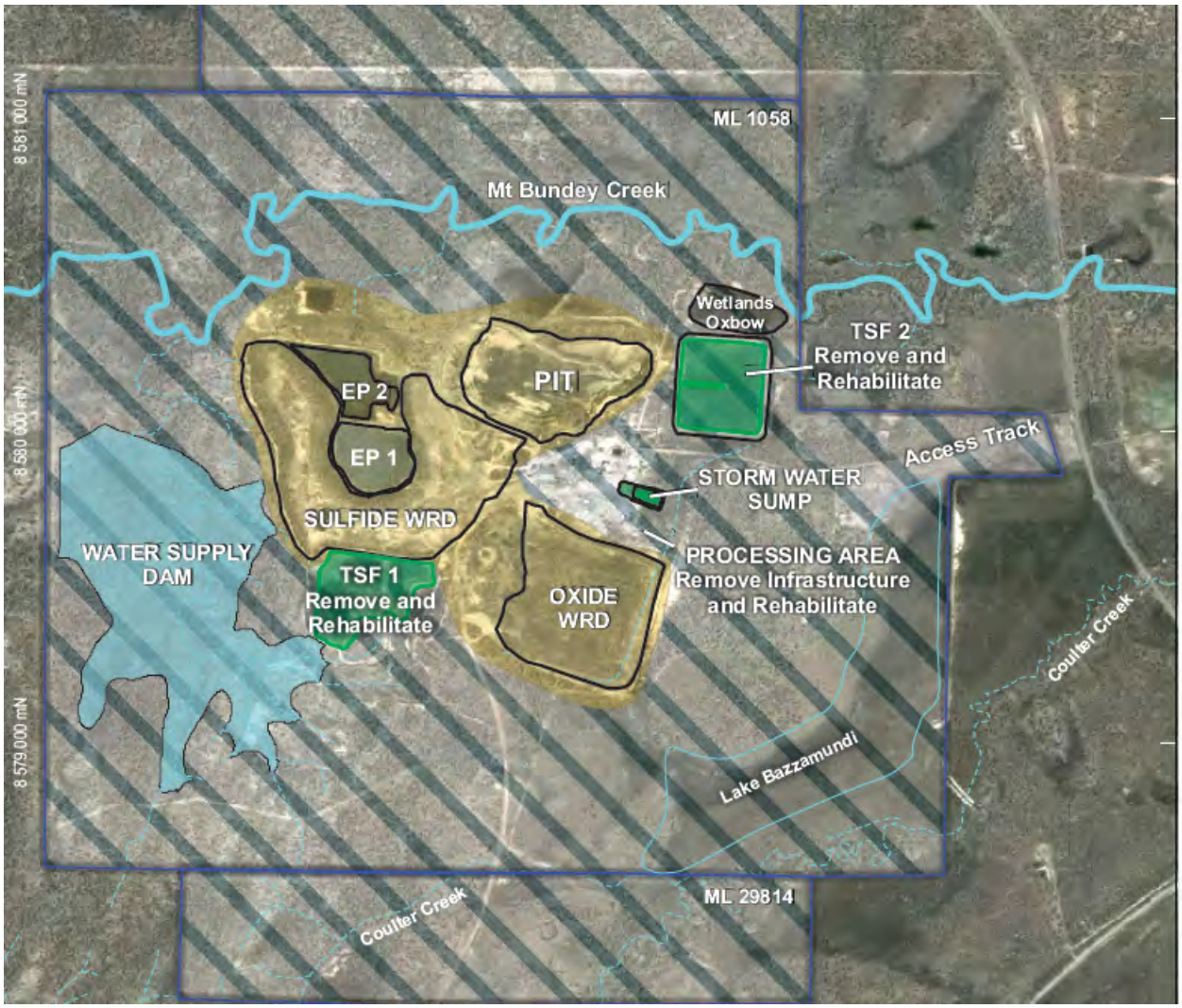

Figure 4: Post Mining Land Use

5.2. Closure Objectives

In the Northern Territory, proposed actions that have the potential to have a significant effect on the environment require environmental impact assessment (EIA) under the *Environmental Assessment Act 1994* (EA Act). In 2018, the NT EPA released a guideline document which communicates the NT EPA environmental factors and objectives associated with the NT *Environmental Assessment Act 1994* (EA Act). The NT EPA developed environmental factors and objectives to improve certainty and increase transparency within the EIA process (Table 10). The objectives are used by the NT EPA to judge whether the environmental impact of a proposal may be significant.

The NT EPA's environmental objectives specifically for rehabilitation and closure of the TGU Project are (as stated in the ToR, (NT EPA 2014)):

- Rehabilitation will achieve a stable and functioning landform, consistent with the surrounding landscape and other environmental values, and will remove potential for long or post closure impacts on downstream water quality, beneficial uses or environmental values.
- Closure (and Care and Maintenance) planning will effectively achieve containment of all mine-related environmental contaminants on-site, for the very long term, without need for ongoing management, intervention or expenditure, and allow for post-closure return to agreed land uses on the site

In consideration of a) the NT EPA's ToR objectives, b) the NT EPA's Environmental Factors and Objectives Guideline (NT EPA 2018) and c) the site's historical legacies; Primary has developed two key overall closure objectives:

(1) To reduce the long term environmental risks posed by the TGU Project; and
(2) Make environmental improvements to the site so as to have a lower liability.

Table 11 provides strategies for meeting the overall project objectives and specific closure objectives for key Project components and infrastructure, such as tailings, water dams and WRDs.

Table 11: NT EPA Environmental Factors and Objectives

Theme	Factor	Objective	Strategies identified to address closure objectives
Land	Terrestrial Flora and Fauna	Protect the NT's flora and fauna so that biological diversity and ecological integrity are maintained.	**Revegetation** Rehabilitation of final landform to support self-sustaining, functional ecosystems comprising suitable, local flora species, as far as is achievable based on the available revegetation resources on site

Theme	Factor	Objective	Strategies identified to address closure objectives
			Disturbed surfaces ripped, contoured and rehabilitated with available material Removal of all infrastructure from site
	Terrestrial Environmental Quality	Maintain the quality of land and soils so that environmental values are protected.	**<u>Landforms (WRD, TSF & Water Dams)</u>** Engineering of a safe and stable final waste rock landform The final waste rock landform will be safe and stable and blend with the local topography A non-polluting landform will be created Implement safe and secure tailings strategies that will place tailings from TSF1 and TSF2 into the Toms Gully pit. Improve site drainage to minimise the generation of contaminated runoff by removing sheeting, mined waste and or processed material that may come into contact with surface water. Ensure that any contaminated runoff is directed to an appropriate storage or treatment facility
Water	Aquatic Ecosystems	Protect aquatic ecosystems to maintain the biological diversity of flora and fauna and the ecological functions they perform.	Integrity of the Mt Bundey and Coulter Creeks is maintained (both quality and flow of water) Reduce the potential surface sources of acid mine drainage (i.e. placement of surface tailings in the pit).

Theme	Factor	Objective	Strategies identified to address closure objectives
	Inland Water Environmental Quality	Maintain the quality of groundwater and surface water so that environmental values including ecological health, land uses and the welfare and amenity of people are protected.	Surface and groundwater hydrological patterns, flows and quality will not be significantly altered by final landform. Reduce interaction of water with waste rock and tailings
People and Communities	Social economic and Cultural Surroundings	Protect the rich social, economic, cultural and heritage values of the NT.	All legally binding conditions and commitments relevant to mine closure and rehabilitation will be met. Provide opportunity for Pastoralist to assume responsibility for existing infrastructure and rehabilitate remaining areas Secure site access to ensure that risks to public safety and livestock will be minimised

6. Completion Criteria

Using the closure objectives from Section 5.2 and knowledge gained from additional studies, completion criteria have been prepared for the TGU Project and are presented in Table 13. Criteria are specific to each domain, with indicators to measure rehabilitation success. The completion criteria have been developed in consultation with stakeholders, and will be refined as necessary, following future stakeholder consultation.

Primary note that completion criteria should be:

- Specific enough to reflect the projects existing environmental, social and economic context
- Measurable to demonstrate that rehabilitation is trending towards baseline levels
- Achievable so that criteria being measured is attainable
- Relevant to the objectives being measures and flexible to adapt to any change in circumstances

- Timely, so that criteria can be monitored over appropriate time frames to ensure results are meeting

In general, all monitoring during closure will occur six monthly or annually until relinquishment, or until data is trending towards completion criteria/baseline.

6.1. Analogue Sites

Analogue sites have been chosen using the flora survey undertaken by Low Ecological Services across the Toms Gully Project area (LES 2017). The analogue sites will be used to measure completion criteria of vegetation once each closure domain has been rehabilitated. The analogue sites were chosen for each closure domain based on soil type and slope/aspect to ensure the closure domain is consistent with the analogue site environment. The species list found at each analogue site is listed in Table 12, it is expected that some of these species should appear after rehabilitation at each closure domain.

The analogue sites were developed using a 50 x 50 m quadrat and therefore rehabilitation monitoring will include two quadrats at 50 m x 50 m within each closure domain to measure against completion criteria.

Table 12: Vegetation analogue sites for closure domains (LES 2017)

Closure Domain	Corresponding Analogue Site	Location	Species List
Processing Area, tops of OWRD and SWRD, Haul roads and access tracks	ST4 (Lowland Woodland)	12°50'35.77"S, 131°32'52.80"E	**Canopy-storey** *Eucalyptus miniata, Corymbia bleeseri, Erythrophleum chlorostachys, E. tectifica, Xanthostemon paradoxus, E. tetradonta, C. dichromophloia, E. tintinnans, C. polycarpa and E. confertiflora* **Mid-Storey** *+/-Buchanania obovata/Livistona inermis/Livistona humilis/Terminalia ferdinandiana/Grevillea spp./ Petalostigma pubescens, P. quadriloculare* **Ground-Storey** *+/-Triodia bitextura/ Grevillea pteridifolia/Tephrosia humifusa /Sauropus glauceus/Eragrostis sp./Eriachne avenacea/ E. mucronate/annual Sorghum* during the late dry season and +/- *Chrysopogon latifolius, Buchnera linearis, Stylidium* sp., *Panicum mindanaense/seminudum, Sorghum plumosum, Heteropogon tricteus, Ampelocissus acetosa, Eriachne obtusa, Achizachyrium pseudeulalia, Mnesithea rottboeloides, Mesophaerum suaveolens*

Closure Domain	Corresponding Analogue Site	Location	Species List
			(weed) and *Eriachne schultzii* in the post-wet season.
Slopes of WRDs	Cam T3.2 (Rocky slope)	12°50'3.95"S, 131°34'2.89"E	**Canopy-storey** *Eucalyptus miniata, Erythrophleum chlorostachys, Corymbia polycarpa and Ficus platypoda* **Mid-Storey** *Cochlospermum fraseri, Brachychiton megaphyllus, Petalostigma pubescens, P. quadriloculare, Acacia holoseicea, Buchnania obovata and Ampellocissus acestosa.* **Ground-Storey** Weed species *Andropogon gayanus, Pennisetum pedicillatus and Mesophaerum suaveolens with density increasing closer to the station track.*
Areas of TSFs once embankments have been removed or modified.	Cam T2 (seasonally inundated plain)	12°49'21.72"S, 131°33'24.01"E	**Canopy-storey** *Lophostemon lactifluus and some Erythrophleum chlorostachys +/- Miliusa traceyi/Ficus virens var. virens/Corymbia bella/C. polycarpa/C. bleeseri* **Mid-Storey** *Melaleuca viridiflora/Pandanus spiralis/Melaleuca nervosa/Acacia lamprocarpa/Bauhinia malabarica/Gardenia megasperma/Buchanania obovate* **Ground-Storey** *Mesophaerum suaveolens (weed) +/- Imperata cylindrica/ Cynodon dactylon (weed)/ Abrus precatoriusduring the late dry season and +/- Calopogonium mucunoides, Andropogon gayanus, Mesophaerum suaveolens/Eriachne triseta post-wet season.*

Table 13: Completion Criteria for the TGU Project

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
Toms Gully Open Pit and Underground Portal	Engineering of a safe and stable final landform	Presence of abandonment bund or fence. Filling of pit with PAF waste rock and tailings whilst maintaining permanent water cover to reduce the risk of AMD formation.	Annual visual monitoring of bunds and pit walls. Audit against tails and waste rock deposition.
	A non-polluting landform will be created	Water quality (within pit and runoff) within livestock consumption levels and/or SSTVs	At closure, surface water sampling will continue as per current site operational water monitoring program, until results can prove water quality has stabilized at which point a reduction in the surface water monitoring program will be negotiated with regulators and stakeholders.
Proposed Boxcut and associated Decline	Engineering of a safe and stable final landform	Presence of abandonment bund or fence. Entry of Portal gated to prevent access to underground workings.	Annual visual monitoring of bunds, Boxcut walls and gates. The water level in the Boxcut will flood the bottom 3 to 8m of the 40m deep Boxcut when mining is completed. This water will be above any sulphide rock and a water blanket will prevent oxidation occurring
Processing Area (including ROM Pad)	Removal of all infrastructure from site	All buildings or other structures removed or disposed of appropriately (unless required by	Vegetation cover, composition and species richness monitoring (annual) after substrate/ regenerative material has been put in place for at least three years to monitor progress or until

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
		a third party taking a controlling interest in the leases) Removal of all infrastructures (e.g. signage) associated with haulage and access roads Removal of reactive waste or remnant ore. No waste on site.	relinquishment (or trending towards completion criteria)
	Disturbed surfaces ripped, contoured and rehabilitated with available material. Rehabilitation to support self-sustaining, functional ecosystems comprising suitable, local flora species.	Processing area ripped, available topsoil material spread over. No new introduced weed species (9 introduced species are existing at Toms Gully, see LES 2017 for species list) Processing area domain similar to analogue site ST4. Where, within 50 x 50 m quadrat: • 30% of quadrat is bare ground, • 5% of quadrat is woodland top-storey cover species of at least	Annual rehabilitation monitoring program

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
		two different species (see table 12 for species list) • 20 % mid-story of at least two different species (see table 12 for species list) • 45 % understory of at least two different species (see table 12 for species list)	
TSF1 and TSF2	Engineering of a safe, stable and non-polluting final landform areas	TSF1 and TSF2 tailings removed and placed in the pit. Either removal or levelling of TSF2 embankments producing an area slightly above grade. TSF1 emptied of tailings. Emptied facility and embankments geotechnically assessed and modified for use during closure as a sediment and water capture basis.	Annual visual monitoring of surface water drainage (including visual inspection of rills and scours) until relinquishment. Where required tailings structure Decommissioning Report
	Improve site drainage to minimise the generation of contaminated runoff and ensure that any contaminated runoff is directed to	Direct water away and have the areas as water shedding.	Annual visual monitoring of surface water drainage (including visual inspection of rills and scours) until relinquishment.

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
	an appropriate storage or treatment facility	No downstream contamination of surface water as tailings removed from contact with runoff.	Water monitoring to record the water quality surrounding the areas.
	Rehabilitation of final landform area to support self-sustaining, functional ecosystems comprising suitable, local flora species	No new introduced weed species within TSF domain other than the 9 existing species. Embankments if retained for TSF1 similar to analogue site CamT3.2. Where within 50 x 50 m quadrat: • 30% coverage of bare ground • 5% canopy storey cover • 20 % of mid story species which include at least two different species from Table 12 and • 45 % understory cover Flat areas of TSF similar to CamT2, a seasonally inundated plain. Where within 50 x 50 m quadrat: • 30% coverage of bare ground • 5% canopy storey cover	Annual rehabilitation monitoring program.

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
		• 20 % of mid story species which include at least two different species from Table 12 • 45% ground cover of at least two of the species from Table 12	
Oxide and Sulfide WRDs	Engineering of a safe and stable final waste rock landform which blends into local topography	Short term criteria: Undertake further investigations on WRDs to confirm final rehabilitation strategy regarding AMD Medium term criteria: Final landform includes suitable batters (maximum slope 18 degrees) Long term criteria: Final landform is stable, where erosion rates are below 5 t/ha/year	Audit of final slopes and surface profile against approved landform designs Monitoring of landform safety and stability in relation to design criteria (during annual rehabilitation monitoring) Conduct erosion inspection (surface water drainage, rills and scours) following completion of rehabilitation works, and continued observation until relinquishment (or trending towards completion criteria) Historical WRDs will have further studies conducted to advance their future rehabilitation
	Improve site drainage to minimise the generation of contaminated runoff and ensure that any	Runoff from OWRD is captured within existing drainage line past TSF2 and into the Oxbow Wetland,	At closure, surface water sampling will continue as per current site operational water monitoring program, until results can prove water quality

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
	contaminated runoff is directed to an appropriate storage or treatment facility	which effectively acts as a detention basin. Capping of SWRD and OWRD with inert boxcut waste to reduce water percolation through the waste rock profile. OWRD bund with sufficient capacity to hold volumes for storm events (i.e. no overtopping of OWRD bund). SWRD runoff captured in TSF1, EP1 and EP2. No downstream contamination of surface water from waste rock runoff (i.e. water quality results within SSTVs or water quality supply triggers)	has stabilized at which point a reduction in the surface water monitoring program will be negotiated with regulators and stakeholders Report prepared on contamination assessment and remediation. Capping of OWRD and SWRD completed to design parameters.

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
	Rehabilitation of final landform to support self-sustaining, functional ecosystems comprising suitable, local flora species, as far as is achievable based on the available revegetation resources on site.	No new introduced weed species within WRD domain other than the 9 existing species. Slopes of waste dumps similar to analogue site CamT3.2 Within 50 x 50 m quadrat: • 30% coverage of bare ground • 5% canopy cover • 20% of mid story species which include at least two different species from Table 12) and • 50% understorey coverage Top of waste rock dump similar to analogue site ST4, within 50 x 50 m quadrat: • 30% bare ground, • 20 % mid storey of at least two different species (Table 12) • 50 % understorey coverage.	Vegetation cover, composition and species richness monitoring (annual) for at least three years to monitor progress or until relinquishment (or trending towards completion criteria) Annual rehabilitation monitoring using baseline vegetation report (LES 2017) Photo monitoring
Evaporation Ponds 1 and 2	A non-polluting landform will be created	Water quality within evaporation ponds meet ANZECC livestock guidelines	At closure, surface water sampling will continue as per current site operational water monitoring program, until results can prove water quality

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
		No downstream contamination of surface water from evaporation pond runoff (i.e. water quality results within SSTVs or water quality trigger values)	has stabilized at which point a reduction in the surface water monitoring program will be negotiated with regulators and stakeholders. Water monitoring will continue until relinquishment (or trending data towards completion criteria). Adherence to Site Specific Trigger Values and Action Plan
	Improve site drainage to minimise the generation of contaminated runoff and ensure that any contaminated runoff is directed to an appropriate storage or treatment facility	Remove acid mine drainage salts from base of evaporation ponds for treatment. No downstream contamination of surface water from evaporation pond runoff (i.e. water quality results within SSTVs or water quality trigger values)	Annual visual inspections (and immediately after significant rainfall event) until relinquishment (or trending towards completion criteria)
Haul Roads and Access Tracks	Disturbed surfaces ripped, contoured and rehabilitated with available material	No new introduced species (other an existing 9 species) Roads within flat landscape similar to ST4. Where in a 50m x 50m quadrat:	Annual visual monitoring of surface water drainage (including visual inspection of rills and scours) Vegetation cover, composition and species richness monitoring (annual) for at least three

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
		• 30% bare ground, • 20 % mid storey of at least two different species (Table 12) • 50 % understory cover	years to monitor progress or until relinquishment (or trending towards completion criteria) Photo monitoring
Proposed Water Storage Dam	A non-polluting landform will be created	Short term criteria: Fencing off of WSD if water quality not within ANZECC livestock guidelines Medium Term Criteria: Water quality within WSD meets ANZECC livestock guidelines Long term criteria: No downstream contamination of surface water from WSD runoff (i.e. water quality results within SSTVs or water quality trigger values.) Suitably integrated into pastoral activities for agreed transfer to pastoralist.	At closure, surface water sampling will continue as per current site operational water monitoring program, until results can prove water quality has stabilized at which point a reduction in the surface water monitoring program will be negotiated with regulators and stakeholders. Water monitoring will continue until relinquishment (or trending data towards completion criteria). Adherence to Site Specific Trigger Values and Action Plan
	Engineering of a safe and stable final landform	WSD as built design report in line with approved proposed design report	Annual visual monitoring (or after significant rainfall event) of structural integrity of WSD

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
		No overtopping or spills of WSD No structural failure of WSD	
Lake Bazzamundi	Improve site drainage to minimise the generation of contaminated runoff and ensure that any contaminated runoff is directed to an appropriate storage or treatment facility	No downstream contamination of surface water within Lake Bazzamundi or from runoff (i.e. water quality results within SSTVs or water quality trigger values.))	At closure, surface water sampling will continue as per current site operational water monitoring program, until results can prove water quality has stabilized at which point a reduction in the surface water monitoring program will be negotiated with regulators and stakeholders. Water monitoring will continue until relinquishment (or trending data towards completion criteria).
Social and Community Surroundings	Secure site access to ensure that risks to public safety and livestock will be minimised	No human or livestock injury, illness or death from mine affected water or being trapped in pit/holes.	Annual visual monitoring Monitoring of complaints register
	Livestock exclusion precinct fenced to restrict access. Pit abandonment bund or fence. Boxcut abandonment bund or fence.	No human or livestock injury, illness or death from mine affected water or being trapped in pit/holes.	Annual visual monitoring Monitoring of complaints register Bi-annual inspections of fencing

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
	Prevent access to underground portals while boxcut is filling with water.		
	Provide opportunity for Pastoralist to assume responsibility for suitable infrastructure and rehabilitate remaining areas	Documented agreement with Pastoralist specifying which assets are to be retained for the Pastoralist's benefit and responsibility.	Executed agreement with Pastoralist. Physical inspection following infrastructure removal.
Surface and Groundwater	Baseline integrity of groundwater and surface quality is maintained	Groundwater table / surface water is not contaminated post closure No downstream contamination of groundwater or surface water Adherence to Site Specific Trigger Values	At closure, surface water sampling will continue as per current site operational water monitoring program, until results can prove water quality has stabilized at which point a reduction in the surface water monitoring program will be negotiated with regulators and stakeholders. Water monitoring will continue until relinquishment (or trending data towards completion criteria).
	Surface and groundwater hydrological patterns, flows and quality will not be significantly altered by final landforms	Deep ripping of compressed surfaces to facilitate surface water drainage and retention/establishment of water diversions structures to manage water flow.	Annual visual monitoring Annual aquatic ecosystem health monitoring

Closure Domain	Closure Objective	Completion Criteria	Measurement Tools
		No decline in flora and fauna health attributable to the quality or quantity of TGU Project surface water runoff No decline in aquatic ecosystem health attributable to the quality or quantity of TGU Project surface water runoff	Visual monitoring of flora Annual aquatic ecosystem health monitoring

7. Collection and Analysis of Closure Data

7.1. Climate

The climate of the region for the TGU Project is tropical and experiences two distinct seasons. The monsoonal wet season occurs from November to April and is marked by high humidity, temperature and evaporation. The dry season occurs from May to October and is generally cooler and less humid.

The Middle Point Ranges meteorological station (No. 014090) is located approximately 39 km north-east of the TGU Project at an elevation of 14 m Australian Height Datum (AHD). The annual average rainfall recorded at Middle Point Ranges between 2001 and 2018 is 1393.5 mm. The majority of rainfall occurs during the wet season with very high rainfall intensities typical of the northern region of Australia. The average monthly rainfall is highest in January (308.1 mm) and lowest in July (0.4 mm) (BoM 2018).

The mean maximum temperature is 37.4°C and the mean minimal temperature is 14.5°C.

Figure 5 shows the monthly average temperature and rainfall for the Middle Point Ranges area.

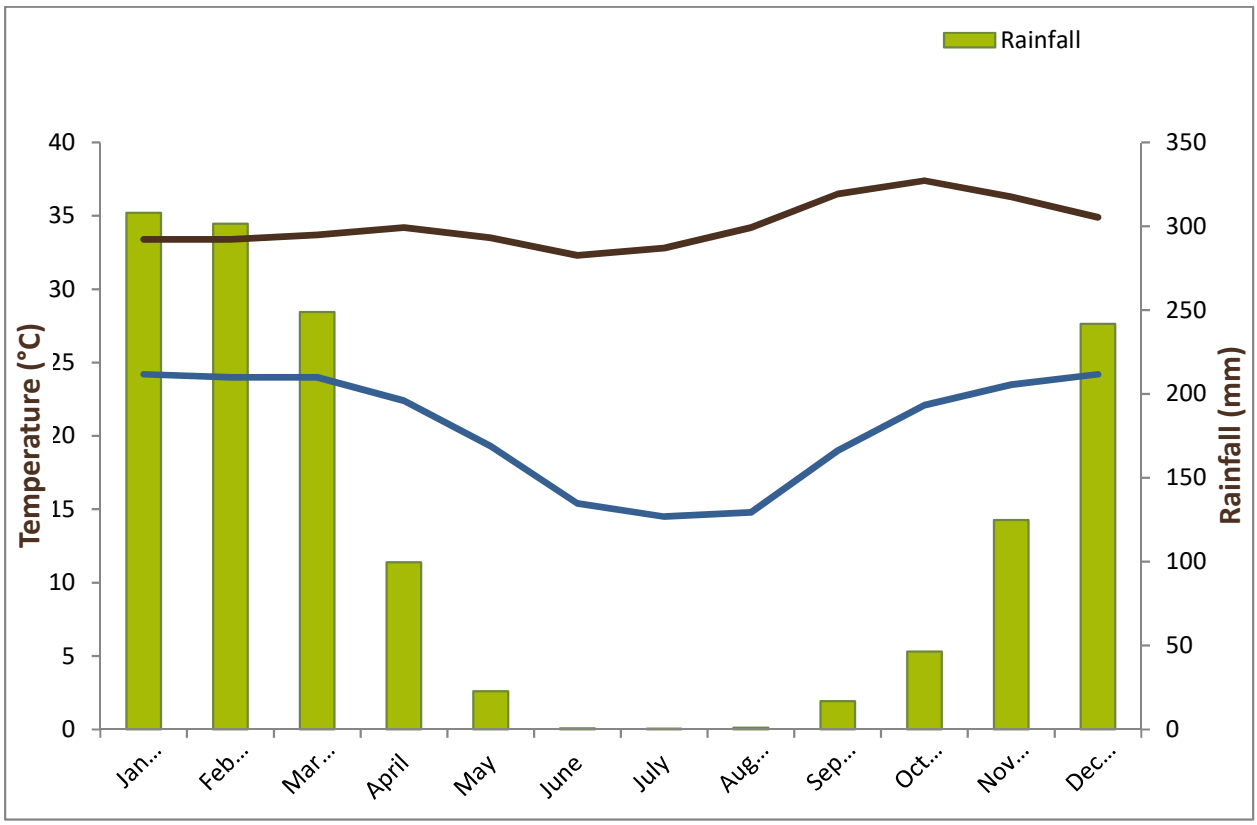

Figure 5: Climate Statistics for Middle Point Ranges 2001-2018 (BoM 2018)

Potential Closure Issues/Opportunities

- High intensity monsoonal rainfall may lead to erosion of landforms, sedimentation and the potential for AMD to runoff beyond site boundary

7.2. Topography

The land surface at the TGU Project site comprises a series of small ridges and dissected hills drained by small stream channels which flow north into Mount Bundey Creek approximately 300 m north of Toms Gully open pit. Surface elevation reaches 51 mAHD in the southwest corner of the MLN1058 and falls to 16 mAHD in the low-lying areas (Figure 6). An artificial wetland, Lake Bazzamundi is located in the south west corner of the mine lease, and has been used to store mine water and stock compliant bore water.

No water has been actively pumped to Lake Bazzamundi since the cessation of underground dewatering towards the end of 2010. The lake has a relatively large catchment size and passively overflows from the east into Coulter Creek and Mt Bundey Creek. Lake Bazzamundi is currently used for stock watering purposes.

Topographic data has been improved by the acquisition of LiDAR data in 2017 which has a 0.5m contour interval data set and 1 metre DEM across the site. Outside of that, there is landsat based contour data that has low spatial resolution (+/- 30 m) (GHD 2015a).

Potential Closure Issues/Opportunities

- Natural topography of site drains towards Mt Bundey Creek leading to potential of AMD contaminated runoff into creek and downstream ecosystems
- Contamination of Lake Bazzamundi from runoff of TGU site

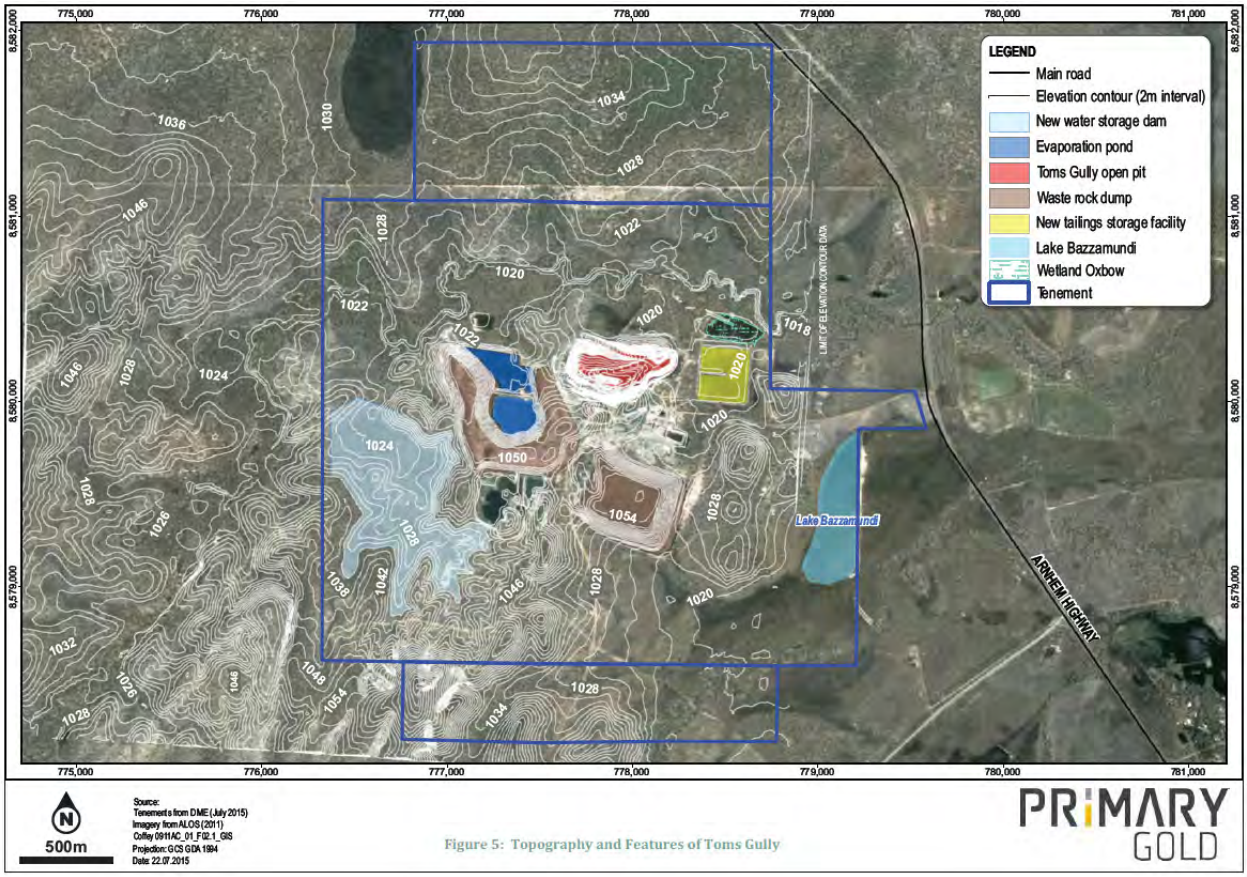

Figure 6: Topographical Features at TGU

7.3. Geology

The Wildman Siltstone Formation within the Mount Partridge Group and the Woodcutters Supergroup consists of predominantly banded, dark grey siltstone, and black, silty shale, with beds of quartz sandstone. The sediments were deposited in a shallow marine, prodelta or mid- shelf depositional setting during the Orosirian (2029 Ma to 1890 Ma) geologic period (Figure 7). The Wildman Siltstone forms the host rock on site.

The Cullen Supersuite comprises a number of I-type granitic plutons which intruded approximately 1,835 to 1,820 million years before present. The Mount Bundey Suite is part of the Cullen Supersuite and comprises the Mount Bundey Granite and the Mount Goyder Syenite.

The Mount Goyder Syenite outcrops to the east of the open pit and the Crabb Fault. The syenite intrusion has been intersected by the existing mine decline. The syenite intrusion has produced a hornfels aureole approximately 500 m wide in the Wildman Siltstone host rock.

The mineralisation is a direct result of mesothermal quartz veins associated with the post tectonic, granitic intrusions; in particular, the Mount Bundey Pluton (Sheppard 1996). Toms Gully represents the first recognition of gold-quartz vein mineralisation in a thrust fault in the Pine Creek Inlier (Sheppard 1996). The mineralisation is contained to the west by the Williams Fault, to the east by the Crabb Fault and is thought to extend for around one kilometre down plunge. Figure 7 shows the site geology and structural constraints on mineralisation.

Sulphides comprise between 10 to 40 percent of the ore, with a ratio of pyrite (FeS_2) to arsenopyrite (FeAsS) of between 2 and 5:1 (Sheppard 1996). Minor pyrrhotite (Fe(1-x)S where x = 0 to 0.2), chalcopyrite ($CuFeS_2$), loellingite ($FeAs_2$), sphalerite (ZnS) and galena (PbS) are also present (Sener 2004). This suggests that mineralisation in these deposits was introduced while the rocks were in thermal and chemical equilibrium with the hydrothermal fluids as alteration haloes around the veins are not present (Sener 2004). The mining implications mean that minimal waste rock is required to be generated to mine the ore using underground mining methods.

The site has historic issues associated with acid mine drainage (AMD) from both WRDs, both TSFs and water within the pit void.

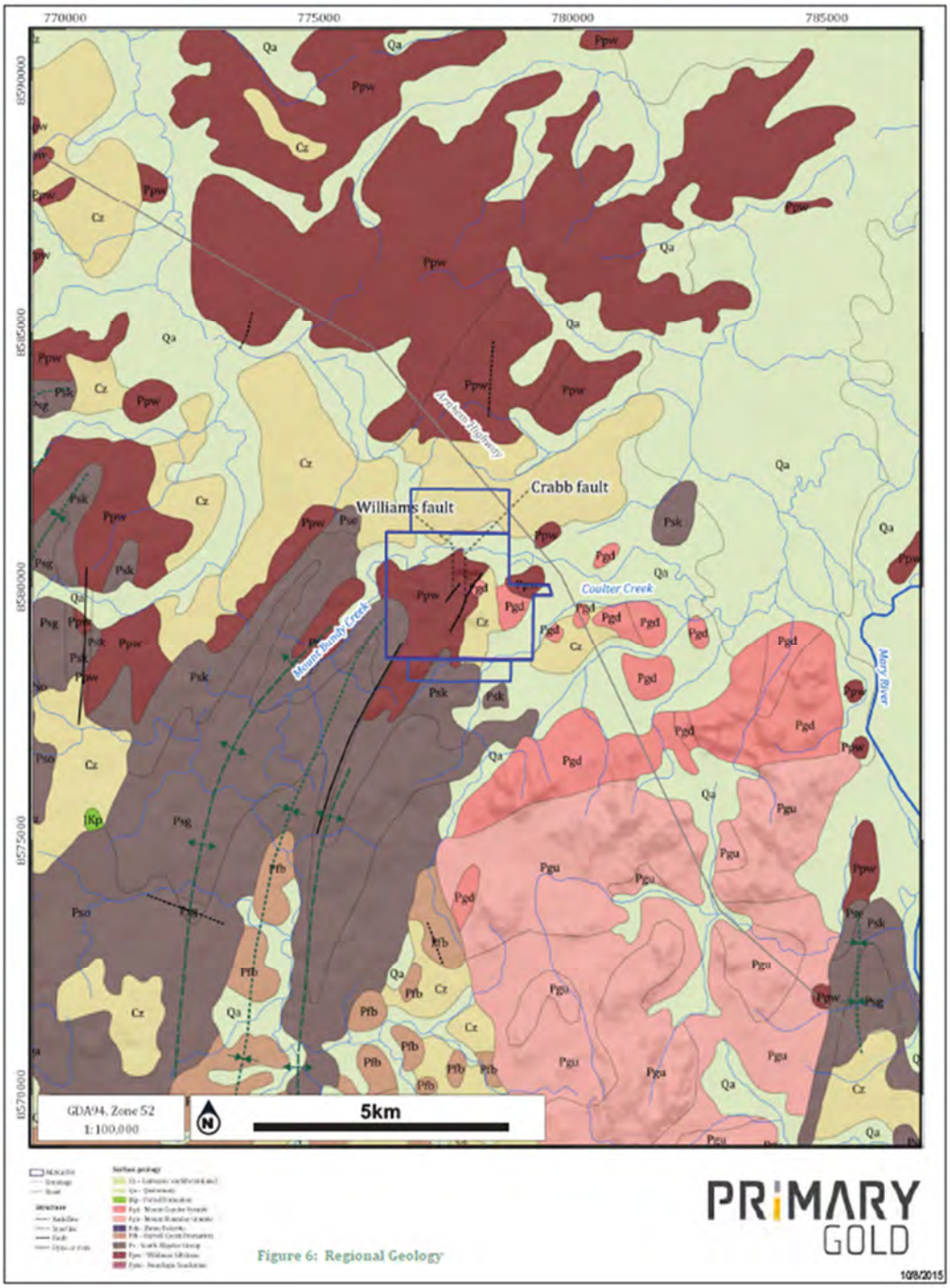

Figure 7: Regional Geology

7.3.1. Geochemical Baseline and Conceptual Site Model

An AMD study was conducted for the TGU Project by GHD in 2014/2015 which included the analyses of 83 samples (2015c). This was updated to include more recent data from 2017 as well as considering surface water, groundwater and aquatic ecology data to create a conceptual site model (source – pathway – receptor) of baseline conditions at Tom's Gully (GHD 2018). The 2017 geochemical sampling program included the collection and analysis of almost 300 samples from historic waste rock dumps and tailings storage facilities on site, sediment and surface water. In 2018, the proposed Boxcut waste rock was geochemically tested (GHD 2019).

The work has confirmed that historic mineral waste (OWRD, SWRD, TSF1, TSF2, RoM Pad stockpiles) and water storage structures on site (Old Decant Pond, Evaporation Pond 1, Evaporation Pond 2, Stormwater Pond, Oxbow Wetland) are acting as acid, saline and metalliferous drainage sources and pathways respectively.

As sources, there are varying levels of contaminated drainage risk from each structure, with the bulk of potential and retained acidity residing in the SWRD, TSF1, TSF2 and OWRD. However, the rate of acidity generation, particularly within the SWRD and OWRD, is relatively slow – being a median of 0.4 kg H_2SO_4/t/yr and 0.05 H_2SO_4/t/yr respectively. This means that acidity loads from both structures can be effectively managed using traditional water management solutions, including storage, treatment and seasonal dilution to reduce elements consistent with saline and metalliferous drainage to environmentally benign concentrations for licenced offsite release.

GHD (2018b) concluded that contamination, of at least shallow groundwater, has occurred around the SWRD and OWRD, Evaporation Ponds 1 and 2 and TSF1 and TSF2, based on monitoring exhibiting localised areas of elevated sulfate or low pH and elevated metals. Based on current relative groundwater elevations, the hydraulic gradient is inwards to the pit, which is likely to capture groundwater flow from beneath the various mine–related contamination sources noted above. Therefore, the bulk of groundwater contaminants leaching from point sources on site is reporting to the pit lake.

Data from geochemical analysis and risk assessment was used to develop a conceptual site model which is shown in Figure 8. The site conceptual model illustrates the potential contamination pathway from the TGU Project and how receptors may be affected. GHD (2018) identified that the primary sources of contamination (AMD) are the SWRD, OWRD, TSF1 and 2. The three key pathways identified for potential transfer of contaminants from sources to receptors are: a) sediment, b) surface water in storages (evaporation ponds, pit lake, stormwater pond, old decant pond) and c) groundwater.

Potential Closure Issues/Opportunities

- AMD contamination of groundwater and surface water (particularly Mt Bundey Creek)
- WRDs and TSFs are acting as AMD sources and therefore need to be managed in the long term

- The mineralised geology at Tom's Gully includes sulfides that comprise between 10 and 40 per cent of the ore at Tom's Gully. Iron, arsenic, zinc and lead, at a minimum, may pose an environmental risk given the level of historic disturbance on site.
- Acidity loads in both WRDs can be effectively managed using traditional water management solutions, including storage, treatment and seasonal dilution to reduce elements consistent with saline and metalliferous drainage to environmentally benign concentrations for licenced offsite release.
- Use of Boxcut material for rehabilitation.
- Minimising the passive release of AMD into the environment north of the SWRD and EP2
- Saline and metalliferous acidic through flow and leachate from the OWRD is overtopping the OWRD bund and discharging towards Lake Bazzamundi during periods of extended rainfall and/or wet season storm events (evidenced by acidity, sulfo-salts and environmentally deleterious elements migrating away from the OWRD bund).
- The OWRD bund should therefore be increased in capacity to allow storage of larger rainfall events.
- Opportunities to further reduce AMD risk through placement of existing tailings in the pit (tailings may or may not be re-processed) and deposition of the future tailings stream in the pit, which has both acid producing and consuming elements.

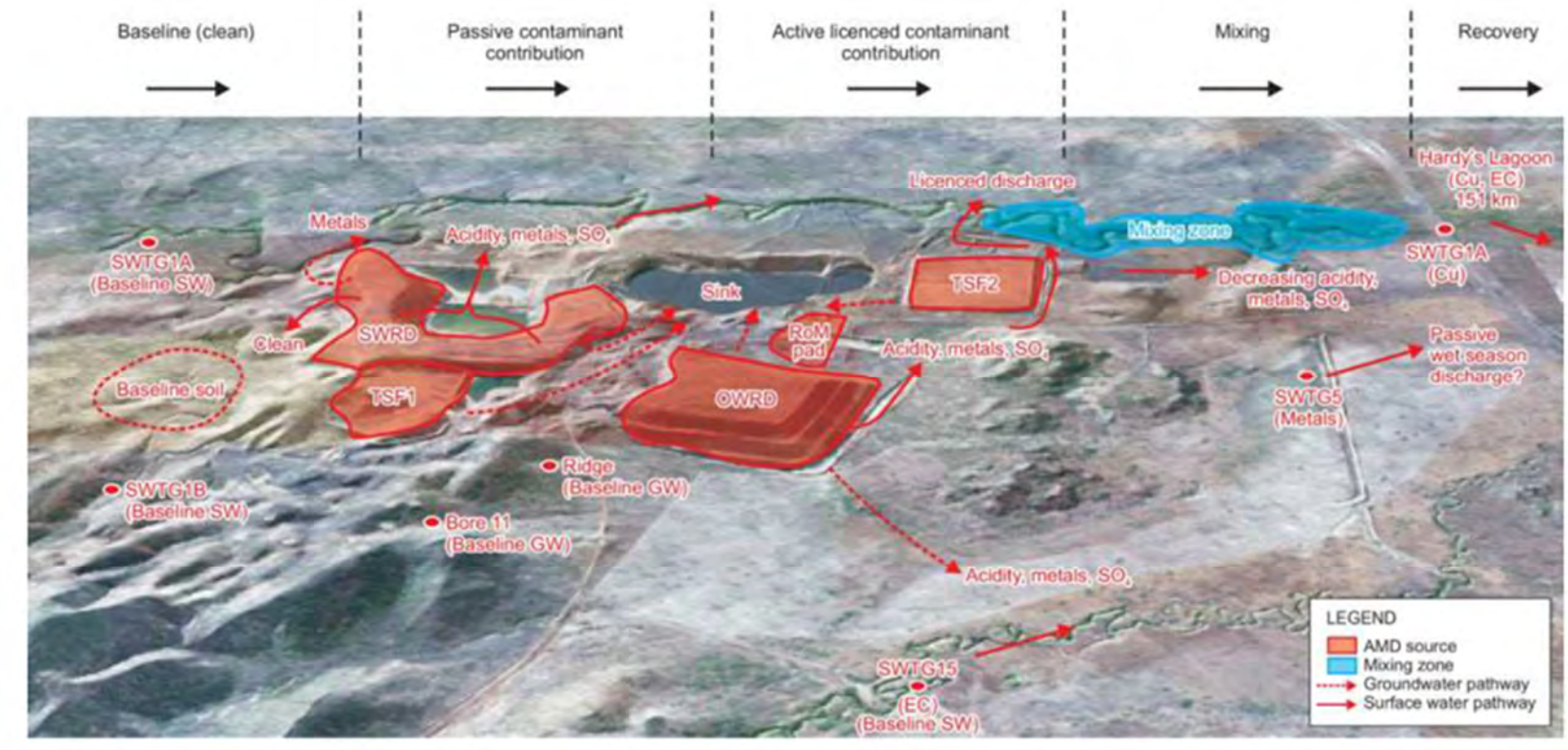

Figure 8: TGU Project Site Conceptual Model

7.4. Soils

Soil cover on site is generally thin with alluvial sediments largely confined to present day drainage features rather than being laterally extensive (GHD 2015c). Three distinctive soil types have been identified for the area, which are associated with different plant communities (Primary Gold 2013b):

- Skeletal and gravelly yellow lithosoils associated with low woodland;
- Shallow lithosoils and deep red earths associated with open forests; and
- Extensive alluvium (black soils) associated with low open woodland/grassland.

Hill and Edmeades (2008) mapped the potential acid sulphate soils (ASS) of the Darwin Region and noted that investigations in Queensland have revealed that ASS sediments generally occur below 5 mAHD, dependent on tidal range. The TGU Project site is located above this level, and the mapping prepared by Natural Resources, Environment, the Arts and Sports (NRETAS) presented in Hill and Edmeades (2008) indicates that the TGU Project area is not considered to be an ASS risk.

Potential Closure Issues/Opportunities

- Lack of availability of topsoil for rehabilitation
- Stability of rehabilitated areas and landforms
- Erosion of rehabilitated landforms with subsequent sedimentation and dust
- Ensure all growth medium recovered from proposed clearing areas

7.5. Waste Rock Characterization

7.5.1. Existing Waste Rock Dumps and their Characterization

There are currently two existing waste rock dumps from previous mining operations being the oxide waste rock dump (OWRD) and the sulfide waste rock dump (SWRD). Both are known to contain a portion of acid-forming minerals and both are known to be actively generating acid and metalliferous drainage. GHD, using drilling data generated in 2017, along with 12D software and LiDAR imagery, estimates the approximate volume of waste rock in the OWRD is 3.97 million m^3, and the SWRD is around 3.27 million m^3.

The majority of minerals identified in the waste rock dumps were inert, being; quartz, mica and clays - around 80% (in the RoM Pad), 75% (SWRD), and 85% (OWRD). The remaining balance of minor minerals were classified as non-diffracting or unidentified; which are usually amorphous secondary minerals. The presence of up to 11.1% dolomite and 1.9% calcite in the OWRD and up to 4.8% dolomite in the SWRD indicates some neutralizing capacity is inherent in both structures (GHD 2018).

Oxide waste rock dump

The median pH value for the 114 samples analysed was 4.4 (classified as very low) increasing to 5.6 as pH_{OX} when a rapid oxidant is introduced. A median EC1:5 of 96 µS/cm (classified as very low) suggests a very low potential for saline drainage, supported by a very low median chloride value of <10 mg/kg. The

median total sulfur value for the 114 samples was 0.04%.The median chromium reducible sulfur concentration was 0.01%. This would suggest the presence of a majority of acid-forming and non-acid forming sulfate species in the total sulfur content reported from the OWRD. Waste rock in the OWRD may be seen as being potentially acid forming (low capacity). Sulfur concentrations are relatively low in the OWRD, and there are pockets of neutralising carbonate present at up to around 11%. The median NAG test results support a low acid forming capacity (GHD 2018). Of the 3.97 million $m^{3,}$ there remains a total potential acid load of around 3,761 tonnes of H_2SO_4. These results indicate manageable long-term risk (GHD 2018).

Sulfide waste rock dump

The median pH value for the 79 samples analysed was 3.8 (classified as very low) decreasing to 3.2 as pH_{OX} when a rapid oxidant is introduced. A median EC of 1,340 µS/cm (classified as high), suggests a high potential for saline drainage, despite the very low median chloride value of <10 mg/kg. The median total sulfur value for the 79 samples was 0.62%, with the median chromium reducible sulfur value of 0.21%. When the median total sulfur NAPP value of 16.2 kgH_2SO_4/t is considered along with the median pH_{OX} value of 3.2, waste rock in the SWRD may be seen as being potentially acid forming (high capacity). Exposed sulfidic waste rock within SWRD is a source of acid and metalliferous drainage as evidenced by water quality running off the unrehabilitated inner surface (SWTG13) into the evaporation ponds (GHD 2018). In contrast, surface water running off the rehabilitated western surface of SWRD (SWTG9) was entirely compliant with all respective SSTVs. Of the 3.27 million m^3, there remains a total potential acid load of around 115,031 tonnes of H_2SO_4

7.5.2. Boxcut Waste Rock

Excavation of the boxcut will produce approximately 660,000 tonnes of waste rock. The material is predominately non-acid forming with less than 5% of samples reporting as uncertain and no sample reporting as potentially acid forming. Kinetic NAG testing confirmed the above findings with no pH readings below 4.5.

7.5.3. Tailings Material in TSF 1 and TSF 2

The $pH_{1:5}$ is very low for TSF1 (3.0) and medium for TSF2 (6.2), they both become very low (TSF1 = 2.2 and TSF 2 = 3.0) once a rapid oxidant is added as pH_{OX}. $EC_{1:5}$ was very high for TSF1 (2,100 µS/cm) and TSF2 (2,110 µS/cm). There are higher total sulfur and chromium reducible sulfur concentrations in TSF1 relative to TSF2; perhaps indicating an evolving process circuit over time and/or ore imported from another site for processing. Neither TSF1 or 2 contain sufficient neutralising capacity relative to their maximum potential acidity (based on total sulfur) to offset acid generation as demonstrated by a NPR of 0.3 and below. In summary, TSF1 and TSF2 remain significant point sources of acid and metalliferous drainage based on the data presented above (GHD 2018).

7.5.4. Sediment

Results from the baseline geochemistry report indicate that sediment in the Old Decant Pond is alkaline and has significant acid consuming potential (GHD 2018). Sediment in both Evaporation Ponds 1 and 2 is

acidic, with very low pH values with high EC and very low chloride content. While both Evaporation Ponds contain sulfur, the vast majority is in the non-reduced state, suggesting a low net acid production potential. However, assuming the presence of some sparingly soluble acid generating sulfate minerals such as jarosite, and using the total sulfur NAPP values, there is potential for acid formation from these sediments.

Potential Closure Issues/Opportunities

- The mining implications are that relatively minimal waste rock would be generated when mining the ore bearing mineralisation.
- Use of suitable boxcut waste rock to cap SWRD and OWRD.
- Mined waste rock placed in the pit beneath a water blanket.
- OWRD is potentially acid forming (low capacity) and the long term risk is manageable.
- SWRD contains a large potential acidity store and must be managed to account for this.
- Both TSF1 and TSF2 are significant sources of acidity.
- Removal of TSF1 and TSF2 tailings and placement under a water blanket (i.e. within pit) thus eliminating two acid generating sources.

7.6. Surface Water

7.6.1. Regional Surface Water

Toms Gully is located in the Mary River catchment. The headwaters of the Mary River are located near Douglas Springs, approximately 60 km east of Pine Creek. The river flows generally north- west, until meeting the main tributary, the McKinlay River, 155 km downstream and just 2 km south off the Arnhem Highway crossing (GHD 2015b).

7.6.2. Local Surface Water

At a local level, Toms Gully is within the Mount Bundey Creek catchment, which comprises a series of small ridges and dissected hills that are drained by small, steep rivulets which converge into the creek. The majority of the catchment upstream of the TGU Project area consists of outcropping rock with thin soil cover and shallow alluvium drainage lines. The total catchment area upstream from the mine is approximately 117 km^2 (GHD 2015b). Mount Bundey Creek flows west to east along the northern section of the TGU Project area (GHD 2015b).

Mount Bundey Creek is approximately 30 km long with 13 km upstream of the TGU Project site. The creek has several tributaries upstream of the TGU Project area. Downstream from the TGU Project site it drains into Hardies Creek, and then the Mary River. Flows in Mount Bundey Creek have been recorded at Monitoring Station G8180031 on Mount Bundey Creek located directly downstream of TGU Project site by the bridge over the Arnhem Highway. Table 14 shows that in peak flow months daily flows averaging in excess of 400 ML/day regularly occur, coinciding with flows in excess of 5 m^3/sec.

Table 14: Monthly and Daily Flow Rates (m^3/sec) of Mt Bundey Creek at Monitoring Station G8180031

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	315.2	283.4	272.8	85.3	11.8	1.1	1.0	3.9	10.5	53.9	129.7	247.1	1395.9
Lowest	67.6	52.5	54.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	23.6	869.6
5th %ile	131.2	119.6	74.7	1.6	0.0	0.0	0.0	0.0	0.0	0.4	33.2	99.9	903.8
10th %ile	176.4	141.5	102.2	7.6	0.0	0.0	0.0	0.0	0.0	3.8	45.0	125.7	1028.1
Median	300.4	251.8	254.5	53.2	3.0	0.0	0.0	0.0	3.3	38.9	116.3	240.8	1289.4
90th %ile	466.2	465.5	480.1	164.3	35.0	0.5	0.0	5.1	28.3	125.3	239.5	387.6	1807.2
95th %ile	570.4	548.5	505.4	214.9	51.1	5.1	0.8	17.4	38.1	156.9	262.8	447.3	1960.0
Highest	886.6	601.0	646.5	1000.5	82.7	26.2	33.6	83.0	76.0	210.0	342.8	499.4	2494.2

Coulter Creek is one of the tributaries of Mount Bundey Creek and flows southwest to east (to the south of the TGU Project area). The confluence of Coulter Creek with Mount Bundey Creek is downstream of the TGU Project area, and compliance monitoring site SWTG2.

The *Water Act 2011* (NT) provides a framework for the declaration of beneficial use and objectives in the NT. The Mount Bundey Creek Beneficial Use Declaration (1997) states that: "stock water supply is the beneficial use extending from the Arnhem Highway Crossing approximately 10 km downstream". The remainder of Mount Bundey Creek has aquatic ecosystem protection objectives defined as 'freshwater' aquatic ecosystem protection guidelines (ANZECC 1992). However, this guideline has been superseded by ANZECC (2000).

The current site water drainage features are shown in Figure 9.

7.6.3. Surface Water within Site Storage Ponds

According to the 2018 baseline geochemistry report (GHD 2018), The Evaporation Ponds (EP1 and EP2), the RO Pond, the Old Decant Pond (ODP) and the pit lake (TGM Pit) are all storing acid and metalliferous water with varying compliance against SSTVs.

7.6.4. Drainage

The OWRD is a source of acid and metalliferous drainage as evidenced by water sampled in the OWRD bund (OWRD). Water transferred on site from the OWRD bund to LDP1 (SWTG12) via the engineered drainage line does not meet SSTV values for most contaminants. The same drainage becomes more dilute from OWRD as it approaches LDP1 (SWTG12) as the dilution effects of water retained in the Wetland Oxbow is realized (Figure 9). Once the discharged surface water passes through the Mt Bundey Creek mixing zone between LDP1 (SWTG12) and SWTG2, surface water quality has returned to background or baseline concentrations for all parameters except copper (GHD 2018).

Downstream sampling locations beyond SWTG2, being SWTG3 and SWTG16 are mostly compliant with SSTVs and consistent with baseline conditions, with the exception of slightly elevated zinc and copper (SWTG3) and EC and copper (SWTG16); suggesting influences beyond that of Tom's Gully on downstream surface water quality (GHD 2018).

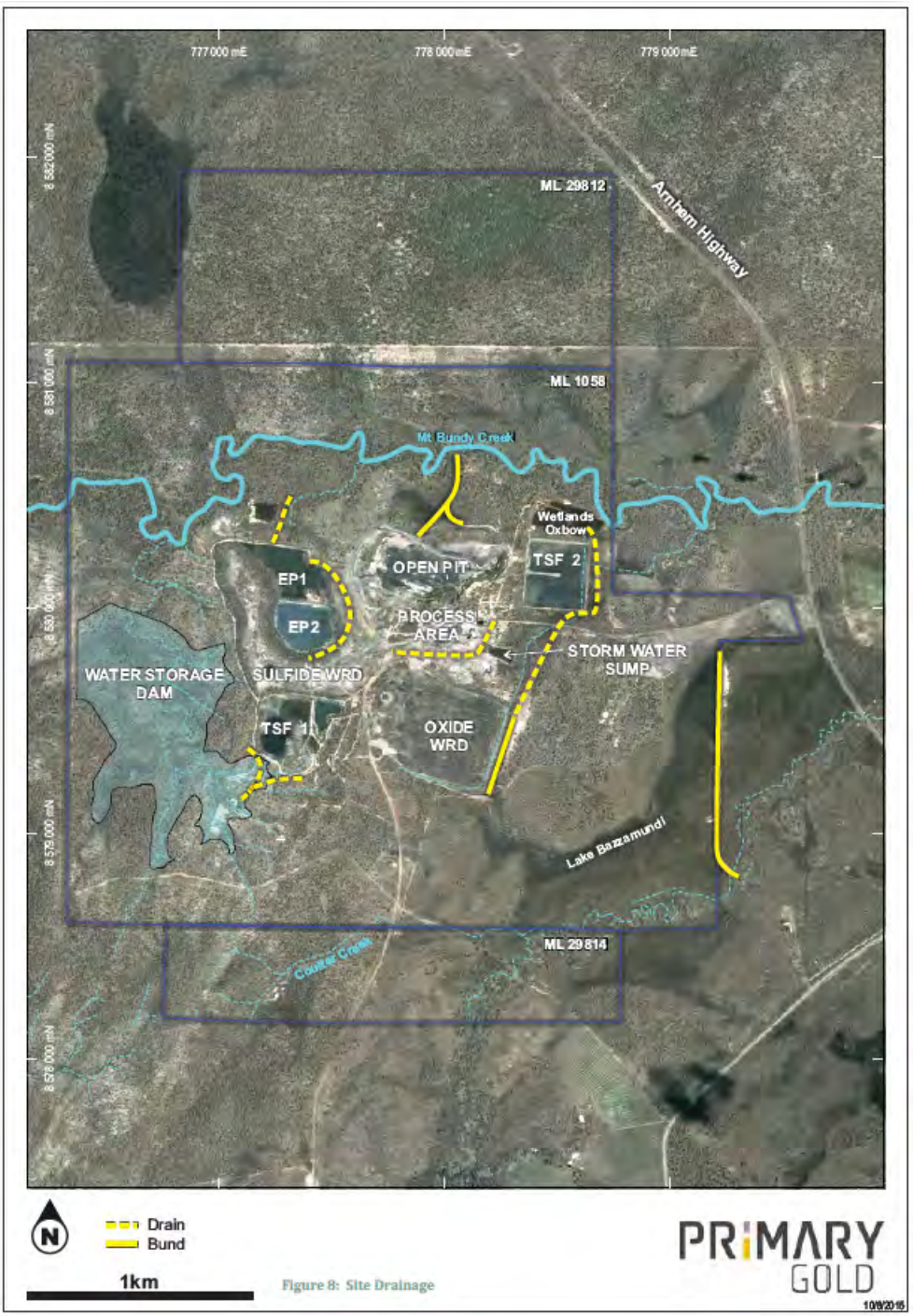

Figure 9: TGU Project Site Drainage

7.6.5. Site Surface Water Quality

Onsite surface water chemistry data has been reliably monitored since January 2007 and remains ongoing. The surface water monitoring locations are shown in Table 15 (Figure 10 and 11). The results of the water monitoring are submitted to DPIR on a quarterly basis (Table 16).

Table 15: TGU Current Surface Water Monitoring Program

		POSITION		
Site Code	Sample Location / Description	GRID: UTM DATUM: WGS84		
		Zone	EASTING	NORTHING
SWTG1A	Mt Bundy Creek, upstream of TGM and it's Influences - Control	52L	776407.65	8580531.93
SWTG 2	Mt Bundy Creek, at Arnhem Hwy bridge, downstream of TGM	52L	779558.33	8580421.83
SWTG 3	Mt Bundy Creek, further downstream of SWTG 2	52L	782298.33	8579333.18
SWTG 4	Wetlands area on mine site access road. Downstream of plant runoff pond (spillway)	52L	778473.44	8579934.30
SWTG 5	Artificial Wetlands contiguous to the pastoral property (Lake Bazzamundi).	52L	779203.50	8579773.54
SWTG 6	Wetlands Oxbow (WO) middle of wetland area Nth of Tailings dam#2	52L	778547.75	8580411.80
CK 7	Spillway at Arnhem Hwy (runoff from Lake Bazzamundi)	52L	779828.93	8579516.25
OWRD	Seepage/runoff collected in diversion drain around Oxide Waste Rock Dump	52L	778266.14	8579330.55
SWTG 8	Mixing overflow of runoff and ODP, to be sampled when overflowing	52L	777408.00	8579371.00
SWTG 10	Seepage/runoff collected in diversion drain from Oxide Waste Rock Dump, water diversion flow to WO.	52L	778348.13	8579597.32
SWTG 11	Entrance to Wetland Oxbow	52L	778657.11	8580282.09
SWTG 12	Weir gate at wetland-discharge point #2, monitored when discharge occurs	52L	778547.75	8580458.61
RO POND	Runoff Pond down gradient of Mill site, RoM and Workshop	52L	778222.00	8579831.00
SWTG TAILS#2	New Tailings storage facility (NTD)	52L	778617.50	8580264.04
SWTG TAILS#1	Old Tailings storage facility (OTD)	52L	777232.10	8579348.91
EP 1	Evaporation Pond 1 (Upper Pond)	52L	777432.33	8580000.64
EP 2	Evaporation Pond 2 (Lower Pond)	52L	777301.09	8580251.19
ODP	Old Decant Pond, next to Old Tailings storage facility #1	52L	777498.87	8579531.24

		POSITION		
Site Code	**Sample Location / Description**	**GRID: UTM DATUM: WGS84**		
		Zone	**EASTING**	**NORTHING**
SWTG 9	Runoff from Sulfide Waste Rock Dump, prior to joining creek.	52L	776764.00	8580100.00
TGM PIT	Tom's Gully Open Pit	52L	778111.80	8580205.30
SWTG14	Downstream of the Oxide WRD, before entry to Lake Bazzamundi.	52L	778237	8579070
SWTG1B	Mount Bundey Creek, further upstream to SWTG1A (2.8km)	52L	775576	8578950
SWTG13	Surface water runoff from the Sulfide WRD prior to it flowing into the Evap. ponds.	52L	777491	8580016
SWTG16	Hardy's Lagoon, approx. 15km downstream form TGM.	52L	783391	8585230
SWTG15	Creek line upstream of influence from the OWRD.	52L	778353	8578330

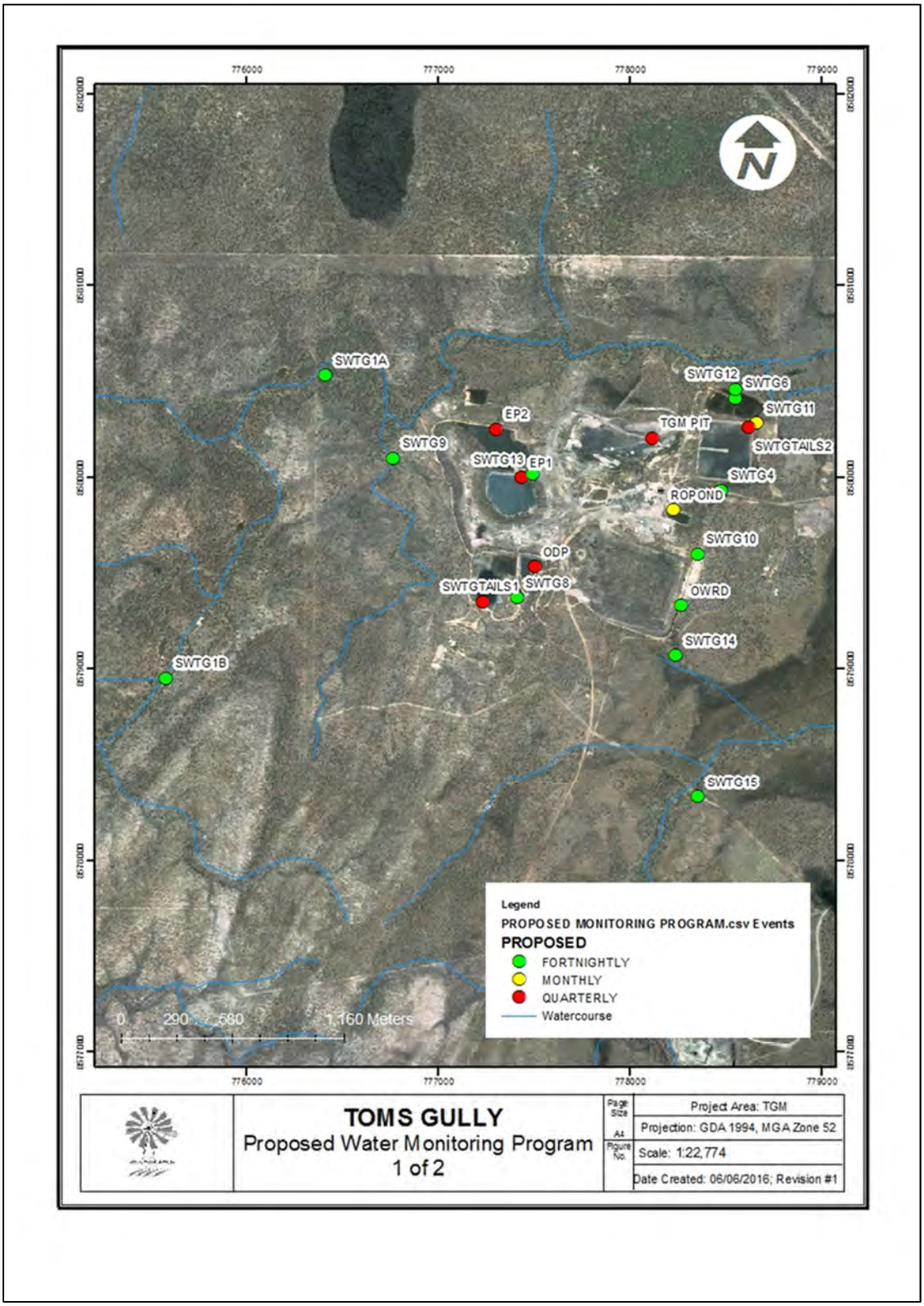

Figure 10: Surface Water Monitoring Locations at TGU Project

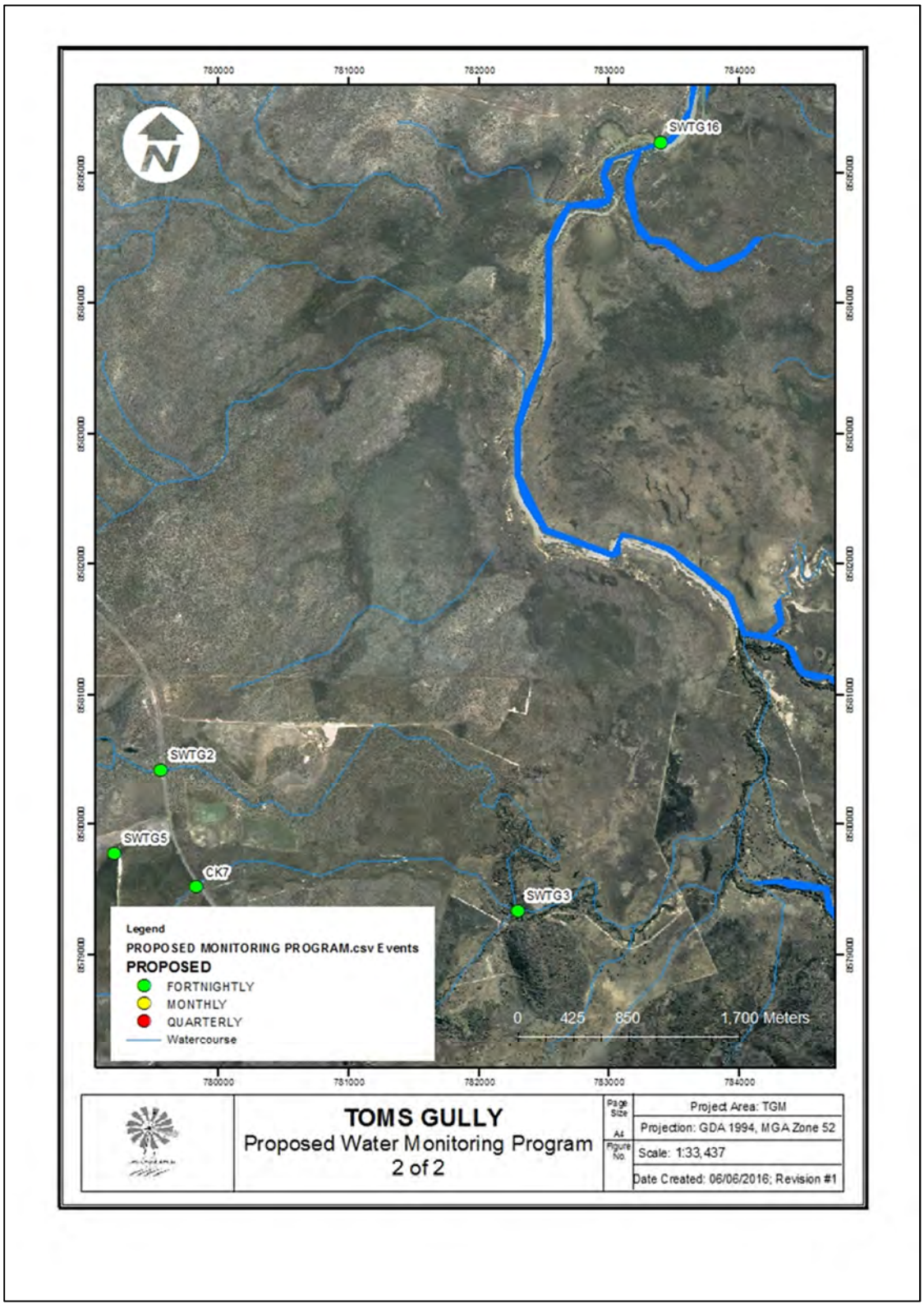

Figure 11: Surface Water Sampling Location at TGU Project

Table 16: SWTG Water Quality Data: July 2002 – February 2015

Analyte	Units	Number	Min	Median	Max	SSTV (2018)
Physiochemical Characteristics						
pH	pH	212	3.38	6.25	7.94	5.8-8.0
Electrical Conductivity	µS/cm	213	12	**97**	1,351	41
Turbidity, NTU	NTU	2	35	59.5	84	87
Total Suspended Solids	mg/L	87	<5	12	140	54
Temperature	°C	72	19.8	28	37.1	-
Environmental Indicators						
Hardness (CaCO3)	mg/L	79	<3	16	160	-
Carbonate (CO3)	mg/L	85	0	2.5	<5	-
Bicarbonate (HCO3)	mg/L	118	<1	17.5	134.1	-
Alkalinity (CaCO3)	mg/L	86	<1	17	44	-
Calcium	mg/L	113	<0.1	3.4	121	-
Magnesium	mg/L	80	<0.5	1.8	120	-
Potassium	mg/L	79	0.7	1.2	3.2	-
Sodium	mg/L	111	<0.1	3.7	52.1	-
Chloride	mg/L	79	<1	2	9	-
Cyanide	mg/L	6	<0.004	0.005	0.02	-
Sulphate	mg/L	133	<1	18	1,640	210
Ammonia	mg/L	2	0.165	0.5875	1.01	1.4
Metals/Metalloids (Filtered)						
Aluminum	µg/L	145	0.4	110	14,000	295
Arsenic (total)	µg/L	163	0.6	0.95	5	42
Cadmium	µg/L	163	0.04	0.68	28	-
Chromium	µg/L	82	0.4	0.5	2	6
Cobalt	µg/L	163	0.15	**4**	227	-
Copper	µg/L	163	0.96	**3**	223	1.8
Iron	µg/L	162	<20	290	1,800	2700
Lead	µg/L	122	<0.01	0.5	3.77	5.6
Manganese	µg/L	166	<5	185	12,500	2,500
Molybdenum	µg/L	45	<0.05	0.25	207	-
Nickel	µg/L	142	<1	6.95	355	13
Uranium	µg/L	55	0.051	0.20	5.5	-
Zinc	µg/L	165	2	**42**	1,430	15

**Red = exceedance of 2018 revised SSTVs for the TGU Project (Stauber & Batley 2018).*

7.6.6. Site Aquatic Ecosystem Quality

The standard surface water quality monitoring was supplemented by water sampling as part of an aquatic ecology study conducted in May 2017 in which physical and chemical water quality was measured at 13 sites on Mount Bundey and Coulter Creeks (GHD 2018c). The range of sites sampled is provided in Table 17 (Figure 12).

Table 17: Water Monitoring Sites form GHD Aquatic Study 2018c (in addition to Surface Water Quality Sampling Program)

Site	GPS Coordinate UTM (GDA 94 Zone 52L)		Altitude (m)	Location	Site Type
	Easting	Northing			
Mount Bundey Creek Catchment					
SWTG1A	776351	8580503	27	Mount Bundey Creek upstream of mine at lease boundary.	Control
SWTG1	776825	8580290	25	Mount Bundey Creek at confluence of tributary draining EP1 and EP2	Potentially Impacted
SWTG2	779558.33	8580421.83		Mt Bundy Creek, at Arnhem Hwy bridge, downstream of TGM	Potentially Impacted
SWTG3	782278	8579366	16	300 m upstream of confluence between Mount Bundey Creek and Coulter Creek	Control
SWTG09	776766	8580098	26	Tributary adjacent to EP1 and EP2	Potentially Impacted
MBC0	777606	8580736		Mount Bundey Creek upstream of tributary draining EP1 and EP2	Downstrea m
MBC01	778724	8580370	21	Mount Bundey Creek at confluence of tributary draining New Tailings Dam area	Potentially Impacted
MBC03	780604	8580044	19	Mount Bundey Creek 500 m downstream of MBC02	Potentially Impacted
MBC06	777293	8580350	22	Mount Bundey Creek on downstream tributary draining EP1 and EP2	Potentially Impacted
Coulter Creek Catchment					
CC01	779293	8578801	21	Coulter Creek. Approx. 1 km upstream from CK7	Reference
CC02	778299	8578355	26	Coulter Creek. Approx. 2 km upstream from CK7	Reference

Site	GPS Coordinate UTM (GDA 94 Zone 52L)		Altitude (m)	Location	Site Type
	Easting	Northing			
CC03	780166	8579675	17	Coulter Creek. ~750 m downstream of CK7	Reference
CK7	779807	8579538	17	Coulter Creek. Existing monitoring site located at highway crossing	Reference

The Aquatic study found that coincident with reduced water quality downstream of the mine site, the relative abundance of in stream macroinvertebrates was lower for sites MBC01, SWTG2, MBC03 and SWTG3 relative to the upstream baseline site SWTG1A and reference sites on Coulter Creek. In addition, aquatic ecology monitoring data were used to develop a Darwin-Daly AUSRIVAS model that revealed that sites MBC01 and MBC03 were rated as significantly impaired, with reduced community composition.

The highest number of fish species recorded in the May 2017 sampling event coincided with distance from the mine site, with the downstream site (SWTG3) returning the highest number of fish species (10); slightly more than the baseline site (SWTG1A) (8). This observation supports the water quality data, which shows recovery to near-background conditions at SWTG3. Four species were identified at MBC01, six species at SWTG2 and five at MBC03. Fish health was also noted to be poor at MBC01, with several Spangled Perch showing signs of Tropical Ulcerative Syndrome (red spot disease); brought on by acidic pH values and subsequently elevated aluminum concentrations. A number of seven-spot Archerfish were observed swimming sluggishly at the same site.

GHD (2018c) suggested that the absence of many species from MBC01 and SWTG2 was likely due to the lower pH and higher EC at those two sites being outside the preferred tolerance ranges for several local species. Lower pH values would allow for higher concentrations of dissolved metals in the water column.

Overall, the water quality and aquatic ecology monitoring data in GHD (2018c) suggests that water quality in Mt Bundey Creek is poorest adjacent to TSF2 and the Wetland Oxbow.

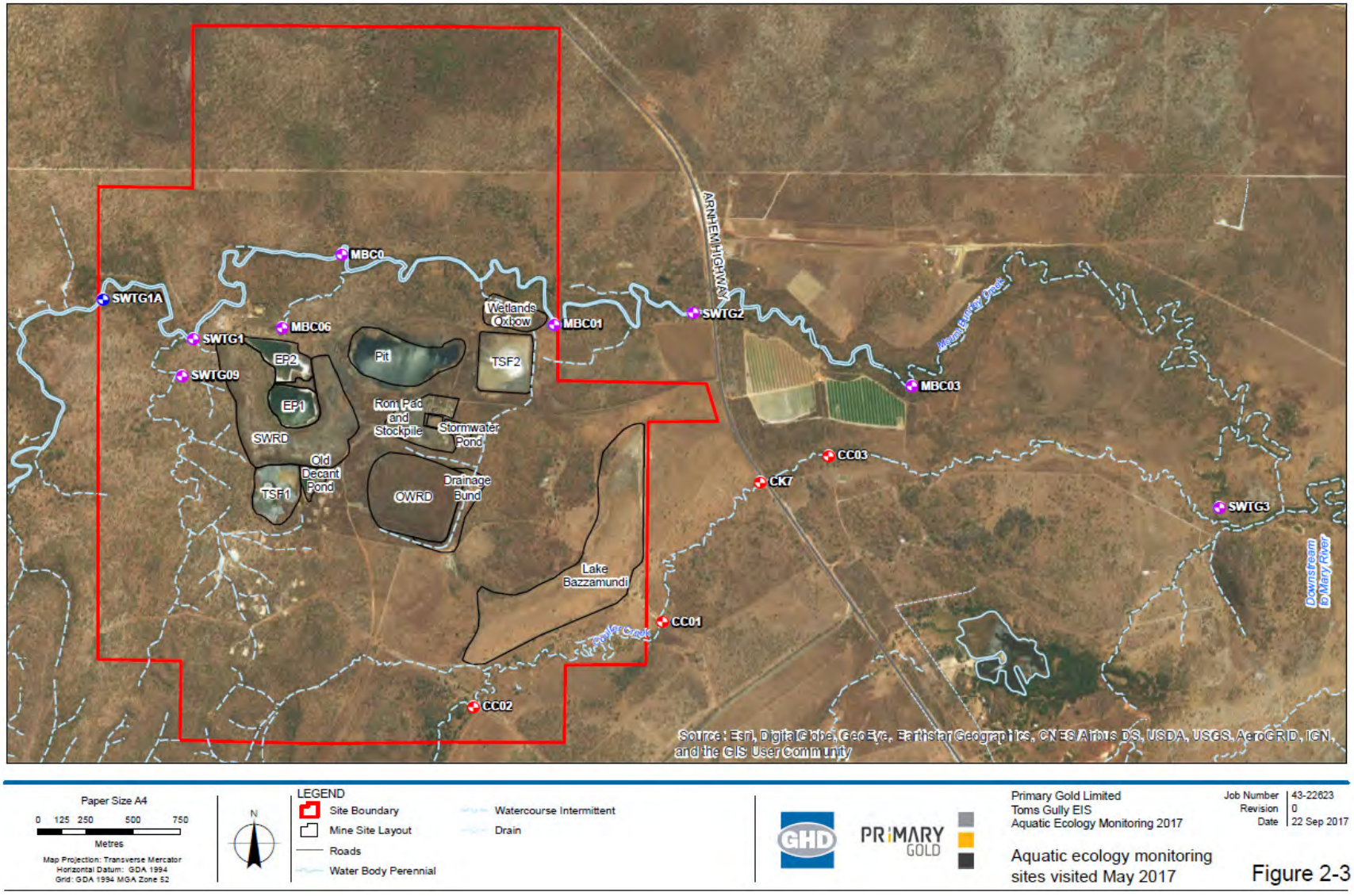

Figure 12: 2017 Aquatic Sampling Site Locations

Table 18: Water Monitoring Results from GHD Aquatic Survey (GHD 2018c)

Site	Time of Sampling	Temp (˚C)	pH	Electrical Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	Turbidity (NTU)
SSTVs (2018)	**N/A**	**N/A**	**5.8-8.0**	**41**	**N/A**	**N/A**	**87**
SWTG1A	11:24	23.1	**8.75**	**49.8**	5.26	61.5	2.3
SWTG1	15:51	25.3	**9.18**	**53.7**	5.69	69.3	3.5
SWTG2	07:25	24.8	6.51	**279.0**	5.21	62.9	1.3
SWTG3	15:00	24.7	7.78	**122.9**	3.88	46.7	6.6
SWTG09	13:50	25.3	**8.71**	**155.6**	1.75	21.3	12.3
MBC01	13:23	24.9	**5.46**	**472.1**	4.47	54.1	2.9
MBC03	16:20	25.3	**8.15**	**190.5**	4.96	60.1	6.6
MBC06	11:48	24.4	7.04	**236.4**	1.17	14.0	18.2
MBC0	13:13	25.2	6.97	35.6	4.28	52.1	8.3
CC01	16:25	25.5	**8.36**	**154.2**	1.62	19.7	11.1
CC02	14:27	22.1	**8.39**	**423.8**	0.26	3.2	6.9
CC03	11:03	24.0	**8.48**	**165.4**	1.90	22.6	35.6
CK7	10:14	24.6	7.93	**203.6**	2.05	24.7	**747.1**

**Red = exceedance of 2018 revised SSTVs for the TGU Project (Stauber & Batley 2018).*

Potential Closure Issues/Opportunities

- Results for the site at the confluence of Mount Bundey Creek and the tributary which receives discharges from the Toms Gully site around the TSF2 area, indicated that the runoff is acidic and moderately saline, with elevated concentrations of metals.
- The Evaporation Ponds (EP1 and EP2), the RO Pond, the Old Decant Pond (ODP) and the pit lake (TGM Pit) are all storing acid and metalliferous water.
- Insitu treatment of the pit lake to improve water quality.

7.7. Groundwater

7.7.1. Groundwater Distribution

Previous work by AGEC (2004) and Rockwater (1994) has identified three broad groundwater systems/hydrogeological units within the project area. They are:

- Upper weathered profile in the Wildman Siltstone and more distance metasediments and igneous rocks, with relatively low permeability;
- "Fresh" Wildman Siltstone and other fractured rock aquifers with moderate to high permeability; and
- The highly permeable ore body fault zone and the Crabb Fault

The weathered profile extends to a depth of 40 m below ground level with enhanced primary porosity and higher storage due to the weathering of the siltstone (Coffey & Partners, 1988). Groundwater levels may be up to 50 m below ground level, but are generally less than 20 m (AGEC 2015).

The degree of fracturing in the Wildman Siltstone is highly heterogeneous with the most intensive fractures along the fold axes of a series of north-south trending gentle folds. Where the siltstone is relatively flat bedded, there is minimal fracturing and the siltstone is either dry or produces low yield. Previous studies have noted that water inflows during drilling increased significantly when the ore zone was intersected (Coffey & Partners, 1988).

The Crabb Fault, which defines the eastern extent of the ore zone and consists primarily of quartz laminated with black shale and sulphides, is highly permeable near the open pit (Rockwater, 1995). Previous studies have suggested the Crabb Fault may restrict the hydraulic connectively to the east. During pumping tests, bore P90, which is located to the east of the Crabb Fault, responded significantly slower to pumping compared with a monitoring bore located to the west of the fault.

7.7.2. Recharge and Groundwater Flow

Recharge to the fractured groundwater system, the ore zone and Crabb Fault, is likely to be via direct infiltration where they outcrop, via seepage from the overlying weathered siltstone and due to direct contact with the mine voids. Other than the immediate pit area, it is unlikely that there is significant

recharge from the local creeks given their ephemeral flow and the elevation of the surrounding groundwater above creek level, where measured. Figure 13 shows groundwater contours across the site are generally south west to north east, with the resultant general flow direction of north east (GHD 2018b). Recharge is highly seasonal with almost all recharge occurring late in the wet season months from November to April, with a lag between peak rainfall and peak recharge of approximately 3 months. The moisture balance suggests that 20% of annual rainfall recharges the groundwater system. This is high, being at the upper end of the expected range for the northern part of Australia where the soil profile becomes saturated during the wet season promoting deep drainage.

Historical mining data indicates groundwater inflows to the open cut pit were approximately 30 L/s to 40 L/s (Coffey, 2015). This was achieved by a combination of dewatering bores and in mine pumping. By 2010, the underground mine and pit was dewatered using 3 in-mine pumps discharging a total of 32 L/s (AGE, 2015). No data are available on local creek ephemeral base flow, including Mt Bundy Creek.

A survey of the site by Primary Gold indicates the water level in the pit is approximately 1004 mRL (mine datum). Water level data from two bores, G9 and WB3, which are located to the north of the pit, are 1014 mRL and 1012 mRL respectively. Bores to the south also show groundwater levels above the level in the pit showing it is acting as a groundwater sink (AGEC 2015) – where groundwater flows toward this local low point.

7.7.3. Hydraulic Parameters

Table 16 presents a summary of the hydraulic parameters from historic pumping tests completed at the TGU Project site.

Table 19: Hydraulic Parameters (AGEC 2015)

Groundwater unit	Transmissivity (m^2/day)		Hydraulic conductivity (m/day)		Storativity	
	Range	Geoman	Range	Geoman	Range	Geoman
Weathered siltstone	No data available					
Fractured and jointed siltstone	6-48	24	0.1-1	0.5	No data available	
Ore zone and Crabb Fault zone	220-915	323	6-14	9.5	2×10^{-4} – 1×10^{-5}	6.1×10^{-5}
Siltstone and ore zone (open holes)	15-915	71	-	-	1×10^{-3} – 3×10^{-5}	2.8×10^{-4}

The data suggests the hydraulic conductivity of the ore zone and Crabb Fault is significantly higher than the surrounding Wildman Siltstone which correlates well to drilling observations at the TGU Project site.

The ore zone is reported to become more massive with depth and it is assumed that the hydraulic conductivity of the ore zone reduces progressively down-dip of the open pit (AGEC, 2004). A storage coefficient of 10-3 to 10-5 suggests that the ore zone and Crabb Fault are confined or semi-confined aquifers (AGEC 2015).

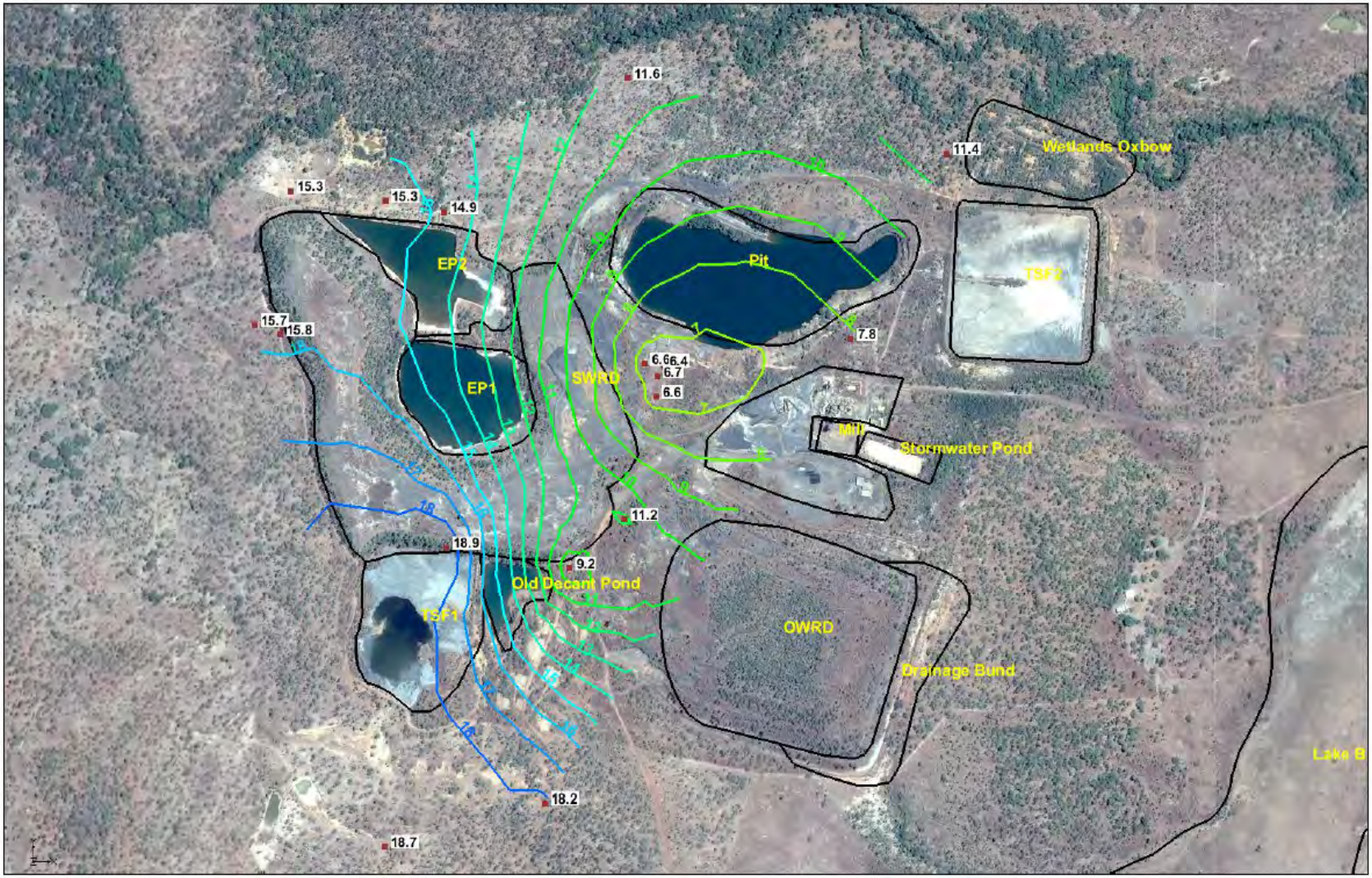

Figure 13: December 2016 Groundwater levels and contours (mAHD)

7.7.4. Groundwater Quality

Historical and current groundwater quality data has been compiled from the following sources:

- 62 samples collected from 18 bores between December 2010 and April 2014 as a part of regular groundwater monitoring;
- 46 samples from 12 bores collected between January 1992 and April 1993 (Dames & Moore, 1993);
- Four samples collected from bores WB1, WB4, WB5 and WB6 at the end of 48 hour pumping tests (Rockwater, 1995); and
- 29 samples from registered bore data held within the NT Water Data Portal (DLRM, 2015).

Groundwater monitoring is currently undertaken at the project site with the groundwater monitoring network comprising nine bores, the details of which are shown in Table 20, in addition to the historical bores not regularly monitored. The location of the bores is shown on Figure 14.

Table 20: Groundwater Monitoring Bore Details

Monitoring Bore	Coordinates		Elevation[a] at TOC (m AHD)*	Depth (m BGL)	Screen Interval (m BTOC)		Date Installed
	Easting	Northing			Top	Bottom	
Currently Monitored Bores (AGE 2015)							
WB1P (Ridge Bore)	777559	8579124	54.2	-	-	-	-
WB5P	776808	8579425	31	106.88	58.8	106.9	19/11/94
BORE 11	777288	8579016	37.1	-	-	-	-
OB11	777186	8580322	20.1	-	-	-	-
G1	777009	8580348	25.3	15.5	13.5	15.5	18/09/91
G2	777683	8579727	42.7	21.5	19.5	21.5	18/09/91
G8	777021	8580019	33.5	26	22	26	20/09/91
G9*	777663	8580478	21.9	30.5	28.5	30.5	21/09/91
RN29694 (WB4P)*	776935	8580080	27.1	95.83	42	95.8	21/11/94

Multiple groundwater analyses are available for several bores at the site (n = 149) and average results are provided in Table 21. Groundwater ranges from fresh (<500 mg/L TDS or 770 <uS/cm EC) in G9, Bore 11 and Ridge Bore to saline in OB11, which was the only bore to consistently exceed stock watering guidelines for EC and sulfate. G1 consistently exceeded the stock watering guidelines sulfate and pH.

Table 21: Summary of Groundwater Geochemistry to 2018 (GHD 2018b)

	Analyte (mg/L)				
Monitoring Bore	**SO4**	**Cd**	**Co**	**Ni**	**EC (uS/cm)**
WB1P (Ridge Bore)	1	0	3	11	168
P100	465	0	5	2	1167
Bore 11	138	4	45	190	177
OB10	1999	-	-	-	3562
OB11	2602	7	106	33	3884
G1	866	0	2	12	1716
G8	514	63	929	1548	1165
G9	35	1	5	13	294
RN29694 (WB4P)*	15	-	-	-	433

Generally, the groundwater was circumneutral to slightly acidic, with the exception of G8, which had a pH between 3.9 and 5.61. The elevated sulfate (and metals where analysed), but neutral pH in the shallow bores OB10 (-8.76 mAHD), OB11 (3 mAHD) and G1 (9.2 mAHD) suggests there has been impact from oxidised sulfides with neutralisation of acidity. This is likely to be due to seepage from the adjacent evaporation pond EP2. Based on the chemistry of these bores and an area of white staining, suggesting a salt scald around G1, it is possible there is some local shallow discharge to Bundy Creek, 100 m to the northwest of G1. G8 had the highest elevated concentrations of several metals (aluminium, cadmium, cobalt, copper and nickel) in comparison to multiple guidelines as well as the surrounding bores. This suggests groundwater in the area is impacted by the immediately adjacent waste rock dump.

The groundwater results were compared against the Australian Drinking Water Guidelines – Health and Aesthetic (ADWG) (NHMRC, NRMMC, 2011), ANZECC & ARMCANZ Protection of Freshwater Ecosystem Values 80% and 90% (FAE80% and FAE90%) and the ANZECC & ARMCANZ 2000 Livestock Watering guidelines (ANZECC & ARMCANZ, 2000).

Aesthetic guidelines

Several groundwater bores exceed the ADWG aesthetic guideline values (NHMRC and NRMMC, 2011) for one or more analytes. With the exception of Ridge bore and RN29693, all other bores periodically exceed for sulfate and G8 exceeding the trigger values for aluminium, copper and zinc. In addition, OB11, G8, G9, and P100 periodically exceed triggers for ADWG aesthetic guideline values (NHMRC and NRMMC, 2011) for pH, hardness and iron.

Health guidelines

Bore G8 consistently exceeded the health based guideline values for sulfate, cadmium, manganese, and nickel with the occasional sample exceeding the arsenic guideline value. G9 consistently exceeded the trigger value for lead and, similarly to G8, there were exceedances for manganese and nickel. OB11 consistently exceeded for Cadmium, Manganese and Nickel. Notably, the Ridge Bore also exceeded the health based guideline (NHMRC and NRMMC, 2011) for Manganese.

7.7.4.1. Aquatic ecosystems and stock watering guidelines

Groundwater bore G8 exceeded the FAE80% and FAE90% trigger values for aluminium, cadmium, copper, nickel, zinc and lead. G9 and OB11 both occasionally exceeded the trigger values for cadmium and copper and more consistently exceeded the trigger values for nickel and zinc.

G8 had correspondingly elevated concentrations of several metals (aluminium, cadmium, cobalt, copper and nickel) above stock watering guidelines.

7.7.5. Conceptual Hydrogeological Model

AGE (2019), shown in Appendix R, prepared a model determining the inflow from the pit and surrounding ground for the new mining scenario of creating a separate decline to the underground workings. The following key observations can be made:

- Water will flow from the pit to the underground workings in an increasing percentage as the underground workings are excavated 0% to 85% over three years. Maximum total inflow to the underground workings is 27L/s or 851ML per year.
- The underground workings will fill up within eight months after mining has been completed (at the predicted inflow of 18L/s at the end of mining).

From GHD (2018) EIS Supplement Appendix C, section 6.4 the following observations were made

- The modelled heads indicate that the mine pit and connected underground workings remain a groundwater sink through evaporative losses from the pit surface.
- This is likely to result in capture of groundwater contamination from the various site sources such as the TSFs and WRDs.
- The modelled water level in the mine workings have a strong, rapid influence on water levels within the ore zone but have significantly less effect on groundwater outside of the zone between the two faults.
- There is room for improvement in transient calibration by further varying storage coefficients.
- Water levels in the various water storages, including the TSFs and evaporations ponds, are likely to have a significant impact on nearby groundwater levels.

Potential Closure Issues/Opportunities

- Contamination, of at least shallow groundwater, has occurred around waste rock dumps, evaporation ponds and tailings dams, based on monitoring exhibiting localised areas of elevated sulfate or low pH and elevated metals.

Figure 14: Groundwater Monitoring Bore Locations

7.8. Flora

The TGU Project lies within the Pine Creek bioregion. The Pine Creek Bioregion consists mainly of rugged ridges and undulating plains with eucalypt woodlands and patches of monsoon forest (Bastin & ACRIS Management Committee, 2008). Land use types in the bioregion include aboriginal lands, conservation, pastoralism, rural freehold, horticulture and mining (Bastin & ACRIS Management Committee, 2008). There is significant fire activity in the bioregion (particularly in the late dry season) due to large tracts of grazing land that have nil to low levels of pastoral development and consequent minimal firebreaks and control measures. Feral animals (pigs, cattle, horses and buffalo) and weeds (especially mission grass and gamba grass) are widespread (DOTE 2008).

Low Ecological Services (LES) conducted two onsite flora and fauna survey from 1st – 7th November 2016 and 4th – 10th May 2017. These surveys were designed to gain a more detailed understanding of the environment of the survey areas, as well as to survey for species of conservation significance (LES 2017). The survey included Toms Gully, Rustlers Roost and Quest 29 project areas. Overall, more flora species were recorded in all survey areas during the post-wet season survey (May 2017: n = 186) than the late dry season survey (November 2016: n = 102) which was likely due to the higher soil moisture available from wet season rainfall (LES 2017).

Site descriptions were carried out within a 50 m x 50 m quadrat at all live and camera-trapping sites (eight sites in each survey area). Site descriptions provided an overall snapshot of the landscape, geology, soil, dominant flora species and vegetation structure and density at each site.

During the late dry season survey (November 2016), 62 flora species were identified in the Toms Gully survey area, with an additional 14 specimens that could not be identified to species level. During the post wet season survey (May 2017) 115 flora species recorded in the Toms Gully survey area and an additional 20 specimens that could not be identified to species level (LES 2017).

7.8.1. Threatened Flora Species

Twenty-six species of conservation significance were identified by the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* Protected Matters Search Tool (EPBC PMST) or the *Territory Parks and Wildlife Conservation Act 2006* (TWPC Act) database as occurring or potentially occurring within a 20 km radius of the survey areas. The EPBC PMST identified two endangered flora species, *Helicteres macrothrix* and *Stylidium ensatum*, and one vulnerable flora species, *Goodenia quadrifida*, as potentially occurring within 20 km of the survey areas. Interrogation of the NT Flora Atlas identified records of *H. macrothrix* and *G. quadrifida* within the same search area, along with records of *Schoutenia ovata*, which is listed as vulnerable under the TPWC Act. No threatened ecological communities were identified within 20 km of the lease areas.

No flora species of conservation significance were recorded during either the November 2016 or May 2017 surveys of the Toms Gully Project Area. Several flora species could not be identified to species level; however all were determined not to be a threatened species outlined in the desktop survey due to their

genus, description and/or location. In 2018, a targeted survey by LES for *H. macrothrix* was conducted across the proposed area of the water dam. No individual plants were identified.

7.8.2. Introduced and Weed Species

Weeds of National Significance (WoNS) are declared based on invasiveness, potential for spread and environmental, social and economic impacts. Strategic plans for WoNS are developed as a result of their declaration, which define responsibilities and identifies strategies and actions to control the species. Landholders and managers are ultimately responsible for managing WoNS, and the state/territory government is responsible for overall legislation and administration (Department of Sustainability, Environment, Water, Population and Communities, 2012).

In the NT, a plant is declared a weed if it has been identified for control, eradication or prevention of entry into the NT. All landholders, land managers and land users must comply with the declaration classification. Based on the risk of harm they could cause and how difficult they are to control, weeds are placed into the following classes:

- Class A – to be eradicated
- Class B – growth and spread to be controlled
- Class C – not to be introduced into the NT

The dry season flora survey identified four introduced flora species in the Toms Gully survey area and nine introduced species during the post wet season. One of these species, *Andropogon gayanus* (gamba grass), is a WoNS. See Table 22 below for full list of recorded introduced species at the TGU Project.

Table 22: Introduced flora species identified in the lease areas, including NT and WoNS Status

Species Name	Common Name	Status		Site	
		NT	WoNS	Nov 2016	May 2017
Andropogon gayanus	Gamba grass	B, C	X	ST1, ST4, WRD, CT3,	ST1, CT2, CT3,
Calopogonium mucunoides	Calopo	-	-		ST1, CT1, CT3,
Heliotropium indicum				ST2	
Hibiscus sabdariffa					CT1, CT4
Hymenachne amplexicaulis	Olive hymenachne	B, C		ST2, ST3, WRD, CT1, CT2	ST2, ST3, CT1, CT2, CT3, CT4
Passifllora foetida					ST1
Pennisetum pedicellatus	Mission grass (annual)				ST1, ST2, ST3, CT1, CT3
Sida acuta	Spinyhead sida	B, C			CT1, CT4,
Xanthium strumarium	Ngoora burr	B, C			ST1

Gamba grass (*Andropogon gayanus*)

Gamba grass is a perennial tussock grass that grows up to 70 cm diameter and 4 m tall. The leaf blades are up to 60 cm long and 1.5-5 cm wide with a prominent white midrib. The flowering stems have up to six groups of 2-18 loosely branched primary branches. The flower spikelets are arranged in pairs, with one spikelet sessile and the other stalked. The seeds of gamba grass are light brown to brownish-black, 2-3 mm long and 1 mm wide (DSEWPaC, 2013a).

Gamba grass mostly grows in pastures and along roads, but can be invasive in other habitats such as savanna. Gamba grass invasion leads to dramatically increased fire intensity. More intense fires are harder to control and can result in a reduction in the woody component of a vegetation community. Gamba grass seed is dispersed by wind or water, and can also be spread during hay transport or in mud attached to vehicles and machinery. Gamba grass can be controlled by herbicide application of young and regrowing plants before seed maturity (DSEWPaC, 2013a).

Potential Closure Issues/Opportunities

- Unsuccessful rehabilitation due to Gamba Grass (WoNS) outcompeting native vegetation and seedlings;
- Unable to meet closure criteria due to the presence of weeds.

7.9. Vegetation

A desktop review of vegetation of the Project area included accessing flora records and distributions from DLRM and Commonwealth PMST databases. Results of the database search provided an overview of vegetation records, and an overview of flora species and communities known or predicted to occur in the Project area.

Ground-truthing of preliminary vegetation mapping within the Mineral Lease (ML) was undertaken on 14 April 2015. Field assessment was undertaken to verify vegetation type and condition, and included the collection of the following data at 21 sites across the ML:

- Vegetation type – documentation of vegetation structure and taxonomic composition
- Vegetation extent – mapping the extent of each vegetation type
- Vegetation condition – degree of vegetation change or modification

Figure 15 depicts native vegetation mapping (type and condition) at the Toms Gully site.

7.9.1. Vegetation Units

Vegetation in the lease areas has been mapped at a scale of 1: 100 000 in the Vegetation Survey of the Northern Territory (Wilson, et al., 1990). There are two broad vegetation types occurring within the TGU Project area as described in Table 23.

Table 23: Description of vegetation types within Toms Gully (T) as mapped by Wilson et al. (1990)

Vegetation Unit	Broad Vegetation Classification	Structural Formation	Fine Vegetation Description
4	Eucalyptus with grass understorey	Open forest	*Eucalyptus miniata, Eucalyptus tetrodonta, Eucalyptus nesophila* open-forest with Sorghum grassland understorey
15	Eucalyptus with grass understorey	Woodlands	*Eucalyptus tectifica, Eucalyptus latifolia* woodland with Sorghum grassland understorey

A desktop review of vegetation of the Project area included accessing flora records and distributions from DLRM and Commonwealth ecological databases. Results of the database search provided an overview of vegetation records, and an overview of flora species and communities known or predicted to occur in the Project area (GHD 2015). Field assessment was undertaken to verify vegetation type and condition, and included the collection of data at 21 sites across the ML. During the survey 4 vegetation units were described as per Table 24.

Table 24: Surveyed Vegetation Units at Toms Gully (GHD 2015)

Vegetation Unit No.	Vegetation Unit Name	Vegetation Description
1	Darwin Stringybark (*Eucalyptus tetrodonta),* Darwin Woollybutt (*E. miniata*) and Ironwood (*Erythrophleum chlorostachys*) open woodland to open forest	This map unit largely comprises the native Eucalypt woodlands occurring at Toms Gully. The dominant plant species are characteristically *Eucalyptus tetrodonta* (Darwin Stringybark) and *E. miniata* (Darwin Woollybutt) either singly or in co-dominant stands with *Erythrophleum chlorostachys* (Ironwood) as subdominant species. Other frequently occurring species in the upper-storey are *Terminalia ferdinandiana* (Kakadu Plum) and, on hill sides, *Corymbia dichromophloia* (Small-fruited Bloodwood). *Livistona humilis* (Sand Palm), *Terminalia ferdinandiana* (Kakadu Plum), *Gardenia megasperma* and Acacia species are present in the sparse mid-storey, while the under-storey is typically a grassland with Sorghum intrans (Annual Sorghum), Hibiscus species, and in some areas the declared weed **1Andropogon gayanus* (Gamba Grass).
2	Paperbark (Melaleuca spp.) woodland to open forest	This map unit comprises the paperbark vegetation communities occurring at Toms Gully. The upper-storey is characterised by the dominance of *Melaleuca* species, with *M. viridiflora* (Broad-leaved Paperbark) most frequently present. Other canopy species include *Acacia auriculiformis* (Black Wattle), *Lophostemon lactifluus*, *Eucalyptus australasica* (White Gum) and *Eucalyptus polycarpa* (Long-fruited Bloodwood) with *Pandanus spiralis* occurring in the midstorey.

Vegetation Unit No.	Vegetation Unit Name	Vegetation Description
3	Riparian forest corridor	This map unit occurs in the immediate vicinity of Mt Bundey Creek and Coulter Creek. Plant species composition varies along the creek, but generally includes species indicative of high soil moisture levels. *Bambusa arnhemica* (Bamboo) was the most common species. Other species included *Acacia auriculiformis* (Black Wattle), *Melaleuca leucadendra* (Weeping Paperbark), *Syzygium armstrongii* and *Barringtonia acutangula* (Freshwater Mangrove).
4	Cleared areas	This map unit comprises previously disturbed, cleared or constructed areas for mining and mining related activities within Toms Gully. The map unit consists of bare ground or various degrees of regrowth ranging from grasslands, grasslands with isolated trees/shrubs, open to closed shrublands and open woodlands. Typical plant species encountered in this map unit are *Acacia holosericea* (Silver-leaved Wattle), *Acacia auriculiformis* (Black Wattle) and *Petalostigma pubescens* (Quinine Bush). In the understorey, colonising species include: **Andropogon gayanus* (Gamba Grass), *Sorghum intrans* (Annual Sorghum) and **Melinis repens* (Red Natal Grass).

7.9.2. Vegetation Condition

Vegetation condition assessment utilised the VAST (Vegetation Assets, States and Transitions) classification framework (Thackway & Lesslie 2005). Vegetation condition is classified into one of seven condition classes. The condition of the vegetation communities 1-3 within the Toms Gully mine site area included (Figure 15):

- 'I Residual', for the largely undisturbed native Eucalypt woodlands north of Mt Bundey Creek
- 'II Modified', for the native Eucalypt and Paperbark woodlands impacted by grazing in the south-east of Toms Gully
- 'IIb Modified regeneration tolerates/endures', for native Eucalypt woodlands invaded by Gamba Grass in the east of Toms Gully
- 'III Transformed', for a grazed grassland with isolated trees near the entrance
- 'IIIa Transformed – native woody regrowth' for cleared areas e.g. north of Mt Bundey Creek with native woody regrowth

The condition of the vegetation type 4 within the previous mining operational area varied from IIIa to VI

- 'IV Replaced – adventive' for cleared areas with Gamba Grass regrowth
- 'V Replaced – managed' for the constructed wetland filter
- 'VI Removed – bare ground' such as roads and infrastructure

Native vegetation type and condition is mapped for the Toms Gully Mine site in Figure 15.

7.9.3. Groundwater Dependent Vegetation

Groundwater dependent vegetation and associated ecosystems (GDEs) access subsurface groundwater to meet all or some of their water requirements. Figure 16 shows the location of potential GDEs in proximity to the TGU Project area. Potential GDEs are generally located along Mount Bundey Creek.

Potential Closure Issues/Opportunities

- Rehabilitation of highly disturbed areas with lack of topsoil material
- Controlling gamba grass WoNS to ensure closure criteria are met
- Introduction of new weeds to rehabilitated areas
- AMD contamination of Mt Bundey Creek

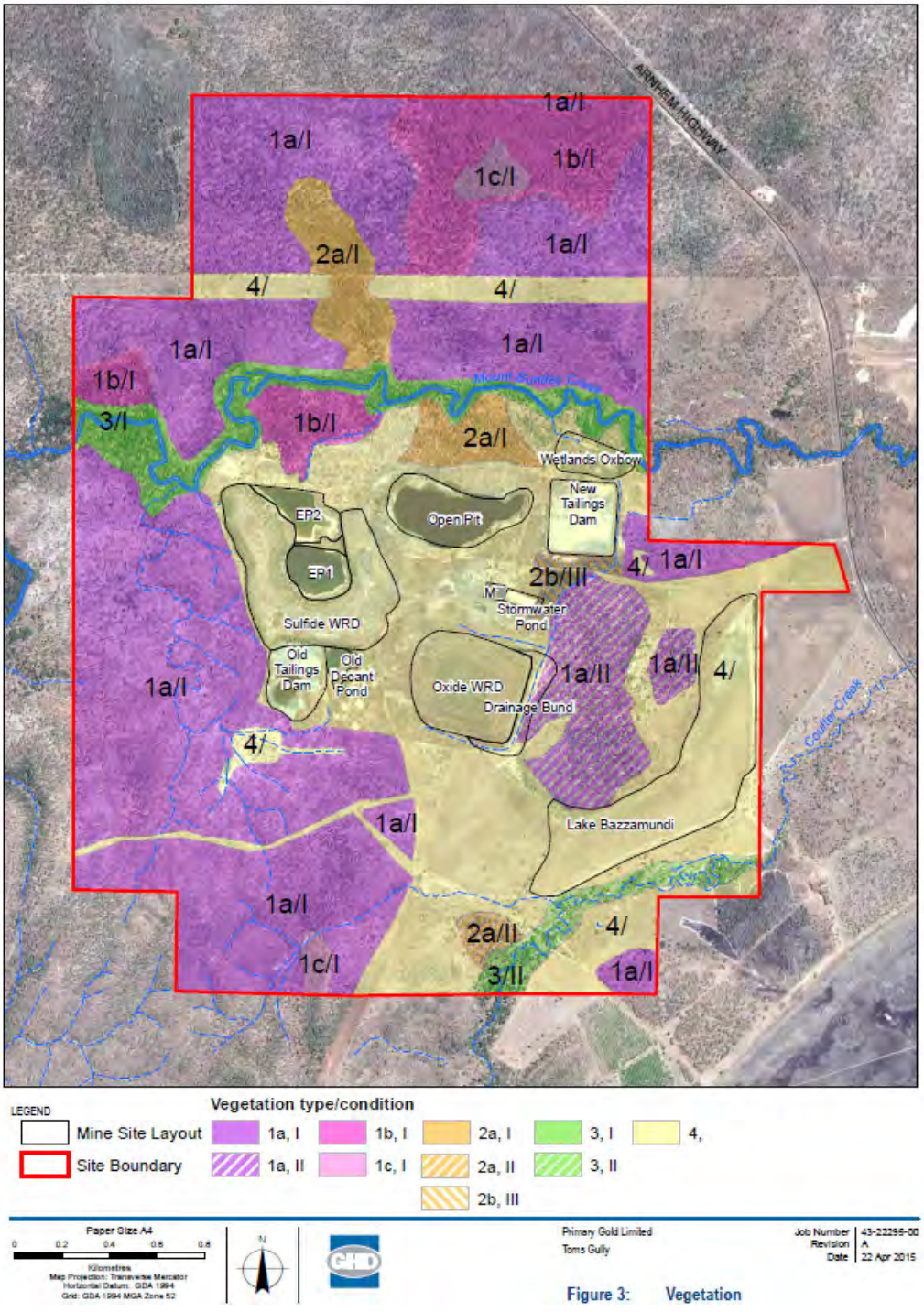

Figure 15: Surveyed Vegetation Units at TGU (GHD 2015)

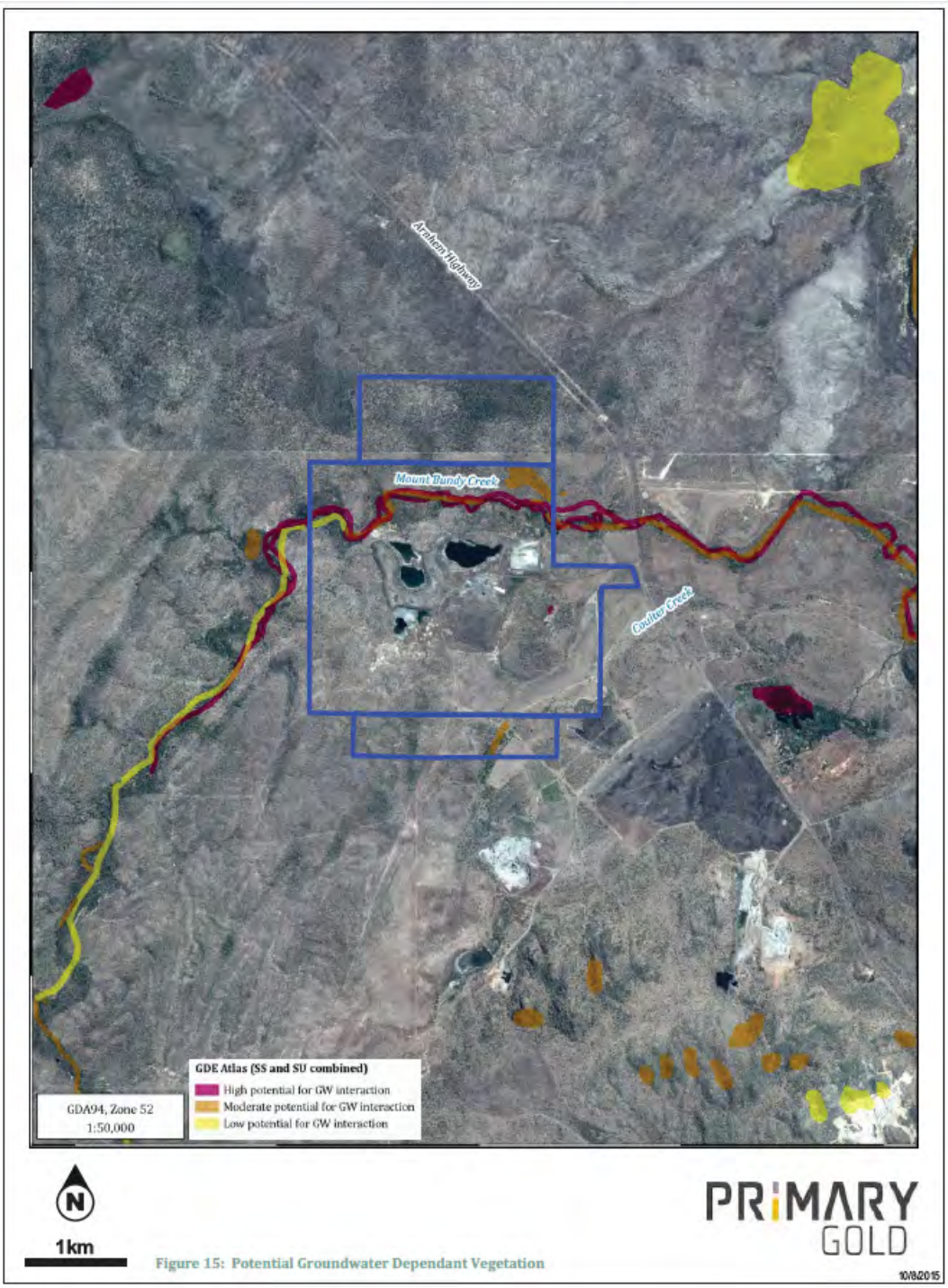

Figure 15: Potential Groundwater Dependant Vegetation

Figure 16: Potential Groundwater Dependent Vegetation

7.10. Terrestrial Fauna

Low Ecological Services (LES) conducted two onsite flora and fauna survey from 1st – 7th November 2016 (late dry season) and 4th – 10th May 2017 (post wet season). These surveys were designed to gain a more detailed understanding of the environment of the survey areas, as well as to survey for species of conservation significance (LES 2017). The survey areas included Toms Gully, Rustlers Roost and Quest 29 Project Areas. Overall, there was a higher number of fauna species recorded during the November 2016 survey (n = 139) than during the May 2017 survey (n =121). Birds made up the majority of species recorded in all survey areas during both survey times. There was a noticeably higher number of mammal species in the Toms Gully survey area during the November 2016 survey (n = 16), and this was due to a greater number of bat species being recorded in this area during this time (LES 2017).

During the November 2016 survey, seventy-one species were recorded in the Toms Gully survey area; 47 bird species, 17 mammal species, nine reptile species and nine amphibian species. During the May 2017 survey, seventy-seven species were recorded in the Toms Gully survey area; six amphibians, one arthropod, 58 birds, 16 mammals and five reptiles (LES 2017).

7.10.1. Threatened Fauna

The EPBC PMST identified 32 fauna species listed as threated under the EPBC Act as occurring or potentially occurring within 20 km of lease areas. Four are listed as critically endangered, 13 as endangered and 25 as vulnerable. Of these species, six occur in marine habitats and will not be discussed further. These species are humpback whale (*Megaptera novaehollandiae*), Loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), Hawksbill turtle (*Eretmochelys imbricate*) and olive ridley turtle (*Lepidochelys olivacea*). Records of four species listed as endangered and four species listed as vulnerable under the EPBC Act were identified by the NT Fauna Atlas within a 20 km radius of the survey areas. The NT Fauna Atlas also identified records of 14 species listed as threatened under the TPWC Act within a 20 km radius of the survey areas. One of these species is listed as critically endangered, one as endangered and 12 as vulnerable (LES 2017).

Despite targeted survey effort for threatened species identified by the NT Fauna Atlas and PMST, no threatened fauna species listed under the TPWC Act or EPBC Act were recorded at Toms Gully during the November 2016 and May 2017 on-ground surveys. No fauna species listed as migratory were recorded during the November 2016 on-ground survey (LES 2017).

Three species listed as near-threatened under the TPWC Act were recorded during the two on-ground survey at Toms Gully; the orange leaf-nosed bat (*Rhinonicteris aurantia*), the bush-stone curlew (*burhinus grallarius*) and the yellow-rumped mannikin (*Lonchura flaviprymna*) (LES 2017).

7.10.2. Introduced Fauna

Six introduced fauna species were recorded at the Toms Gully project area during both surveys, these included horse, house mouse, cane toad, pig, cat and cattle.

Potential Closure Issues/Opportunities

- Unable to rehabilitate highly disturbed areas and re-instate fauna habitats

7.11. Aquatic Ecosystems

A baseline aquatic ecology study was carried out in 2015, which coincided with an abnormally low rainfall wet season. In response to this, a second round of monitoring under higher rainfall conditions was requested by DPIR. GHD, in discussions with Primary, DPIR and the EPA, developed a scope of works for this study. The overall goal of monitoring was to:

- Build on the current data set to characterise the aquatic environments surrounding Toms Gully Mine.
- Collect water quality samples to be analysed in a laboratory, to aid in the interpretation of biological data.
- Monitor the presence or likely presence of Water Monitors (*Varanus mertensi* and *Varanus mitchelli*)

Sampling was undertaken between 19 and 26 May 2017. Work was scheduled to begin in April, but high rainfall over the wet season denoted that additional time was required to allow the watercourses to return to a steady state of flow. The key findings are as follows:

- Some sites featured low pH and high conductivity compared with sites upstream of mining infrastructure, as well as elevated concentrations of dissolved metals. Even though low pH and elevated EC is a feature of the study area based on the findings of GHD (2015), some values were outside of the SSTVs. The location of those sites in relation to existing mine infrastructure suggests a possible impact of those on the water quality in receiving waters, though local factors cannot be ruled out;
- An additional four species of fish were added to those collected in 2015, for 17 of the 37 known species of the area found in Mount Bundey Creek.
- Some fish species collected at a single site adjacent to Toms Gully Mine were found to be in poor condition, swimming sluggishly or having legions. The cause of which is unknown, but could be related to localised poor water quality at that site. As there were no other fish found with behavioral or physical impairments downstream of this site, it is possible that the impact is localised or may be caused by another factor in the environment. Fish diversity was also found to be lower at sites downstream of and including the site, which corresponded with higher concentrations of some dissolved metals
- A total of 55 macroinvertebrate taxa were recorded from the study area in May 2017 from 13 sites. Those fauna included all taxa sampled previously by Crocodile Gold in 2010 and 2012 and GHD in 2015 as well as some additional taxa. Accordingly, taxa richness was generally higher this

year compared to previous years. Although taxa richness was higher,

- The macroinvertebrate community did not comprise a high number of pollution sensitive families, regardless of site type. This denotes that the community of the study area is made up of robust families that are less sensitive to changes in water quality and flow. Although there were some differences seen in the community close to tailings storage facility 2, habitat availability was found to be a greater driver of the macroinvertebrate community in the study area than water quality, and the poorer results were likely a consequence of differences in habitat at those sites.
- A single Mertens Water Monitor (*Varanus mertensi*) was recorded on a camera upstream of Toms Gully Mine. Habitat appropriate for both species of Water Monitors was identified adjacent to and downstream of the mine, yet no Water Monitors were seen on cameras. A large number of non-target species were captured including Cane Toads (*Rhinella marina*) and feral pigs (*Sus scrofa*), as well as a feral cat. These are likely having a detrimental impact on water monitor populations across the region.

Potential Closure Issues/Opportunities

- Ongoing monitoring of fish communities is required to track water quality during operations and closure.

7.12. Sites of Conservation Significance

Sites of Conservation Significance (SoCS) are 67 sites identified as the most important sites for biodiversity that need further protecting in the Northern Territory. Sites of Botanical Significance (SoBS) are defined as area that have botanical features distinguishing them from the surrounding landscape, and that are important for general plant conservation and for specifically mentioned species (White, et al 2000a). The Mary River coastal floodplain SoCS is adjacent to the Toms Gully survey area. There are no SoBS within 20 km of the survey areas.

The Toms Gully survey borders the Mary River coastal floodplain SoCS (Figure 17). The Mary River coastal floodplain is unusual in that it lacks a single channel through the floodplain to the ocean (Department of Natural Resources, Environment, the Arts and Sport, n.d.). The main land use in this SoCS is pastoral, with other uses including conservation, recreation, tourism and mining (Department of Natural Resources, Environment, the Arts and Sport, n.d.). The Mary River coastal floodplain consists of a mosaic of wet and dry habitats that support large populations of waterbirds and a major breeding area for fish species such as Barramundi (Department of Natural Resources, Environment, the Arts and Sport, n.d.). The Mary River system is suffering degradation as a result of impact from introduced species and fire (Department of Natural Resources, Environment, the Arts and Sport, n.d.). The Mary River coastal floodplain SoCS is of international significance for threatened species and wildlife aggregations, national (but possibly

international) significance for wetlands and regional significance for its flora (Department of Natural Resources, Environment, the Arts and Sport, n.d.).

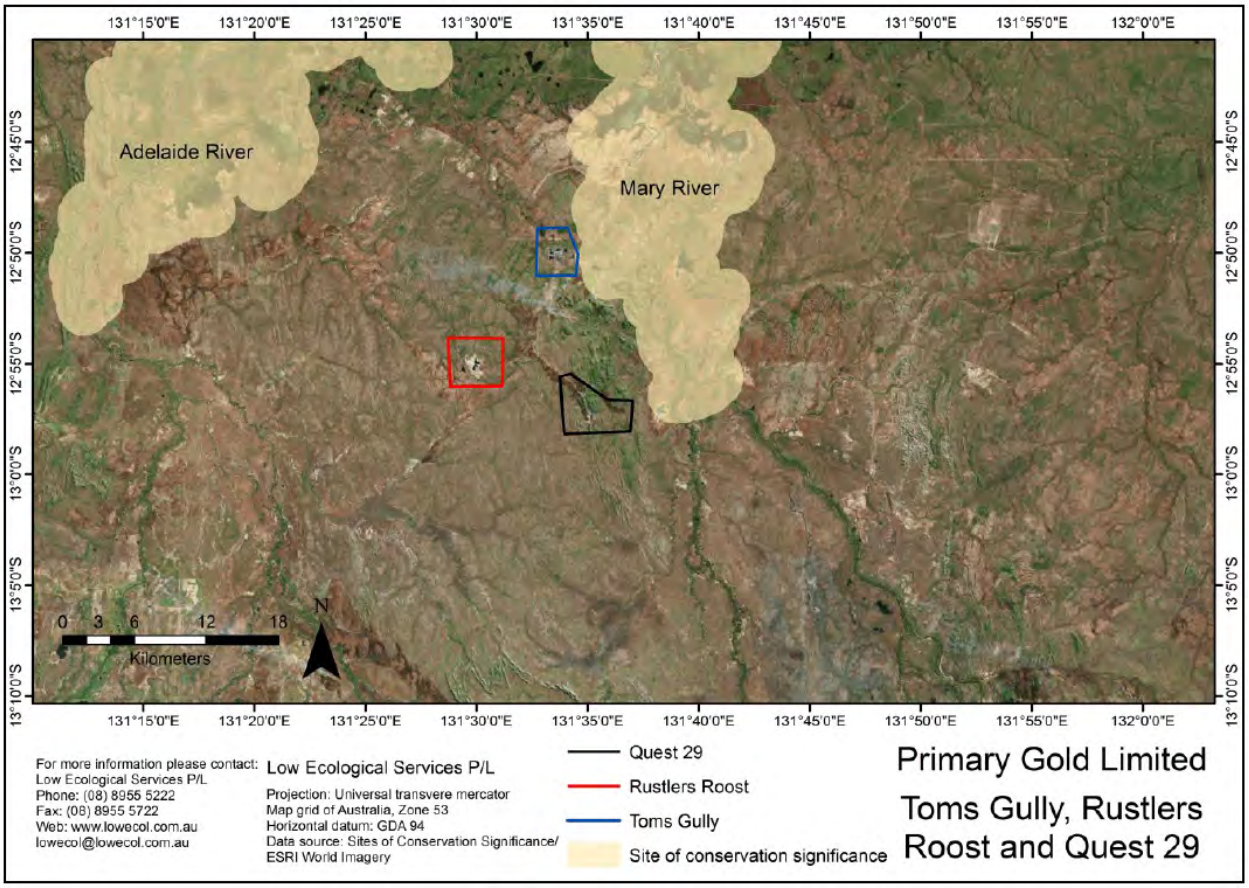

Figure 17: Sites of Conservation Significance in the area surrounding Toms Gully

Potential Closure Issues/Opportunities

- Downstream impacts on Mt Bundey creek from mining which flows towards the Mary River floodplain system

7.13. Indigenous and Cultural Heritage

A heritage search and survey was undertaken on 10 March 2015. The response from the DLPE showed that there are no previously recorded Aboriginal archaeological sites, or nominated, provisional or declared heritage places located within the area of NT Portion 4937 (Old Mount Bundey Station) on 10 March 2015. Additionally, in 30 July 2015 a sacred site survey was completed over the proposed area of future disturbance. In 2018, the proposed area of the water dam was covered by an archaeological survey. No archeological sites were located (Jung 2018)

Potential Closure Issues/Opportunities

- No significant closure issues relating to heritage

7.14. Domain Specific Information

7.14.1. Overall Site

The TGU Project site is currently under Care and Maintenance. The current regime of Care and Maintenance for the existing site features is mandated via the MMP (Primary Gold 2013a) and includes:

- Regular inspections of infrastructure features;
- Repair of damage from erosion;
- Water management;
- Fuel reduction burning;
- Weed management; and
- General water management.

The overall site layout is shown as expected after the implementation of the TGU Project in Figure 2.

7.14.2. Open Pit and Underground Portal

The Toms Gully Pit was mined from 1988 to 1991 with a total of 356,561 tonnes of ore mined. The pit footprint is approximately 15 ha, with a depth of 69 m and maximum void volume of 4,660 ML. The pit contains two portals to access the underground mine. Water accumulating in the pit has a generally high metal content and has a pH of approximately 3-4. It currently sits at a level approximately 10-12 m below local groundwater.

During operations the pit will not be dewatered with tailings and waste rock placed in the pit by a floating head and a stacker systems respectively.

At closure, the pit will contain tailings (1.28Mt new and existing surface tailings) and waste rock (1.51Mt boxcut and underground) with an indicative water cover of 25 metres. This assumes the Boxcut waste is placed in the pit. If the Boxcut waste is placed on the waste dumps the cover will be 30 metres without the Boxcut waste in the pit.

7.14.3. Boxcut and Underground Portal (Proposed)

The boxcut will cover an area of 2 ha and will be approximately 40 metres deep with a decline commencing at the base to intersect the ore body.

At the cessation of mining the decline opening at the base of the boxcut will have a gate constructed to prevent unauthorized access by the public and prevent the entry of fauna. Around the boxcut a bund will be established to prevent the ingress of surface water and to manage public safety by preventing inadvertent public access. After closure water will fill the base of the pit approximately 30 metres below the natural surface.

7.14.4. Oxide Waste Rock Dump

The 25 ha Oxide WRD was constructed during open pit mining in the late 1980's to early 1990's and was closed out and rehabilitated by the early 2000's. The waste rock dump has a shallow cover of growth medium and has some vegetative cover. Some areas of historic vegetation death (attributable to bushfire damage) are evident on the dump.

Runoff from rainfall is currently free to run in channels or via sheet flow over the battered sides of the WRD and reports via a channel to the Oxbow Wetland. The catch drain around the base of the Oxide WRD requires regular inspection and maintenance. On the Process Plant side of the WRD small areas have been excavated.

The Oxide WRD contains acid generating material with the few runoff water samples obtained having a median pH of 4.4. The appearance of salts in sections of the catch drain and the poor water quality is evidence that PAF material was not appropriately encapsulated. There remains a total potential acid load of around 3,761 tonnes of H_2SO_4 in the OWRD (GHD 2018). It is also important to note that sulfur concentrations are relatively low in the OWRD, and there are pockets of neutralising carbonate present at up to around 11%. The 2017 sampling data showed a median total sulfur value of 0.04%, with an average of 0.05% over 114 samples, which indicates manageable long-term risk (GHD 2018).

7.14.5. Sulphide Waste Rock Dump

The 28.49 ha Sulphide WRD was constructed during open pit mining and development of the underground declines. It is unclear how the Sulphide WRD was built and whether or not the waste was characterised and placed appropriately. The WRD has been sheeted with material that supports a tree cover. Some erosion gullies have historically appeared during the wet season and require remediation.

The SWRD contains a large potential acidity store and will be managed to account for this. There remains a total potential acid load of around 115,031 tonnes of H_2SO_4 in the SWRD.

There is a laydown area on top of the dump that will require contouring and compacting. Water is shed from the WRD on all sides. The water that is shed into the centre of the horseshoe shaped WRD is collected in two evaporation ponds. These ponds have median pH values of 3.6 and 4.0 respectively, largely due to concentration via the seasonal evaporation cycle.

Potential Closure Issues for both WRDs

- Sources of AMD
- Potential water percolating through the waste rock dump profile
- Variable vegetative cover on the WRDs
- Use of boxcut material and associated growth medium to provide additional capping to the WRDs
- Contamination of groundwater surrounding WRDs

7.14.6. Processing Area

The site has a 0.25 Mtpa CIL processing plant which was constructed in 1995 with the crushing circuit added in 1999. The Process Plant contains:

- Primary and secondary crushing units;
- Milling circuit comprising primary and secondary ball mills, tertiary tower mill, float circuit, leach feed thickener, lime silo and grinding mill;
- CIL circuit;
- Elution circuit;
- Gold room;
- Reagent mixing and storage tanks;
- Process water dam;
- Process water storage tanks; and
- Process plant workshop.

Drainage from the processing plant area is directed to the Stormwater storage pond.

Potential Closure Issues for both WRDs

- ROM Pad and associated stockpiles sources of AMD
- Lack of growth medium available to re-spread over cleared areas

7.14.7. TSF1 (First)

TSF1 was established as a 10 ha valley fill impoundment with a downstream dam wall. Some of the tailings were retreated and stored in TSF2 with approximately 250,000 t of tailings remaining in TSF1 (Figure 2). This area fills with water each wet season (up to 135 ML). The median pH of this water from past monitoring is 2.6.

7.14.8. TSF2 (second)

TSF2 is a 8.66 ha paddock impoundment with a central decant causeway. Whilst the TSF was filled using perimeter discharge it was by single point spigot rather than multi point spigot. Approximately 125,000 t of tailings is stored in this impoundment (Figure 2) that appears to be a mix of sulphide and oxide tailings. TSF2 has sufficient storage capacity to receive 75 ML of water. The water accumulating in TSF2 is reported to have a median pH of 4.5 from past monitoring.

Potential Closure Issues for both TSFs

- Both TSFs sources of AMD
- Lack of growth medium available to re-spread over TSF
- Geotechnical instability prior to closing of facilities
- GHD (2018b) concluded that contamination, of at least shallow groundwater, has occurred around the TSFs

- Current shape of the TSF1 as a valley fill impoundment which has had some tailings removed and retreated. Consequently the TSF1 forms a hung catchment, contaminating stored rainwater
- Opportunity to remove tailings from TSF1 and TSF2 to the Toms Gully pit.
- Once tailings removed a modified TSF1 used to capture sediment and surface runoff on the southern side of SWRD.
- Once tailings removed a modified TSF2 potentially used to store water then rehabilitated at closure.

7.14.9. Water Storage Features

Lake Bazzamundi is a "constructed" wetland formed via a water retaining structure along the paddock and licence boundary. It has been historically used to store excess water from dewatering bores. Water quality within Lake Bazzamundi has been maintained at livestock drinking levels to maintain flexibility and use for pastoral grazing.

The TGU Project will also have a new Water Storage Dam (WSD) at closure. Construction of the WSD will enable harvesting of topsoil and construction materials (including clays that may be used for capping material). This material will be saved for construction and rehabilitation purposes across site.

Two evaporation ponds are located adjacent to the Sulfide WRD (Figure 2). The purpose of these ponds is to capture, retain and evaporate poor quality water running off or seeping from the Sulfide WRD. They have also been used to receive excess water from the TSFs

The oxbow wetland is used as a passive water treatment system for water directed to it from the drain around the base of the Oxide WRD. It drains to Mount Bundey Creek. It covers an area of about 4.39 ha and may be flooded during the wet season when Mount Bundey Creek breaks its banks. The current site drainage is shown in Figure 9.

Potential Closure Issues/Opportunities

- Water storage features on site (Old Decant Pond, Evaporation Pond 1, Evaporation Pond 2, Stormwater Pond, Oxbow Wetland) are acting as acid, saline and metalliferous drainage pathways (GHD 2018b)
- GHD (2018b) concluded that contamination, of at least shallow groundwater, has occurred around the Evaporation Ponds 1 and 2, based on monitoring that exhibits localised areas of elevated sulfate or low pH and elevated metals.

8. Identification and Management of Closure Issues

The identification of closure issues was conducted in accordance to the 2016 Leading Practice Sustainable Development in Mining handbooks published by the DFAT as related to mine closure (DFAT 2016a) and mine rehabilitation (DFAT 2016b).

The ToR (NT EPA 2014)) requires that rehabilitation and closure planning, and contingency planning for periods of Care and Maintenance should be completed. The planning is to take into account results of materials characterisation, data on the local environmental and climatic conditions, and consideration of potential impacts through contaminant pathways and environmental receptors. The ToR requires an assessment of risks to successful rehabilitation and closure including:

- The TGU Project not realising its projected outcomes (i.e. delays, unexpected or forced closure, falling gold prices, etc.);
- Inadequate identification and management of materials with AMD/NMD/SD potential;
- Changes in the assumptions used as a basis for the post-closure risk assessment; and
- Natural extreme events, including earthquakes, cyclones, rain depressions, fire and flood.

The ToR also states that the EIS should identify and assess environmental risks associated with a potential short and long term period of Care and Maintenance for the TGU Project and site. Assessment and planning should consider all potential TGU Project development stages, and plan to fulfil all relevant environmental objectives and obligations. A risk assessment was undertaken to identify the potential risks associated with the closure plan and mine rehabilitation at the TGU Project.

8.1. Risk Assessment Process

Risks associated with the TGU Project were identified and documented in the ToR. Following this, Primary Gold utilised a workshop and document review processes to identify and quantify risks which culminated in an initial risk assessment. This initial risk assessment has been revised twice taking into consideration the NT EPA and stakeholder comments on the draft EIS and EIS Supplement Risk Registers and using further additional baseline investigations to inform this most recent closure Risk Register.

The risk assessment workshops adopted a systematic approach, aligned with standard risk assessment and management methodologies including:

- AS/NZS ISO 31000:2009: Risk management - Principles and Guidelines (Standard);
- HB 203:2012: Environmental risk management - Principles and process (Guide); and
- HB 158:2010: Delivering assurance based on ISO 31000:2009 - Risk management - Principles and Guidelines (Guide).

The risk assessment has also been developed with consideration of the NT EPA Environmental Factors and Objectives (NT EPA 2018) to ensure that residual impacts can be managed in a manner that the objectives of each environmental factor can be met.

Risk relates to the effect of uncertainty on objectives. These objectives are primarily environmental goals within the EIS as well as the objectives of the NT EPA for each environmental factor applicable to the Toms Gully Project. Risks are determined and assessed using a combination of the likelihood of occurrence and the consequence of an event. Identifying risks for the projects closure phase is based on the failure of control of the environment, people, or equipment in hazardous situations.

Assessment of risk has been conducted through considerations of the circumstances around risks, identifying necessary controls to address potential impacts and assuming effective implementation of planned and committed mitigation of potential impacts. Mitigation is proposed, where possible, to reduce residual risk (risk after mitigation) to below "Extreme" or "High" risk outcomes to the extent reasonably practicable.

Table 25 provides a summary of the qualitative risk matrix adopted and the levels of risk for the various consequence and likelihood combinations.

Table 25: Qualitative Risk Analysis Matrix

	Consequence				
Likelihood	**(1) Insignificant**	**(2) Minor**	**(3) Moderate**	**(4) Major**	**(5) Significant**
(A) Almost certain	**High**	**High**	**Extreme**	**Extreme**	**Extreme**
(B) Likely	**Moderate**	**High**	**High**	**Extreme**	**Extreme**
(C) Possible	**Low**	**Moderate**	**High**	**Extreme**	**Extreme**
(D) Unlikely	**Low**	**Low**	**Moderate**	**High**	**Extreme**
(E) Rare	**Low**	**Low**	**Moderate**	**High**	**High**

	Consequence				
Likelihood	**(1) Insignificant**	**(2) Minor**	**(3) Moderate**	**(4) Major**	**(5) Significant**
(A) Almost certain	**15**	**10**	**6**	**3**	**1**
(B) Likely	**19**	**14**	**9**	**5**	**2**
(C) Possible	**22**	**18**	**13**	**8**	**4**
(D) Unlikely	**24**	**21**	**17**	**12**	**7**
(E) Rare	**25**	**23**	**20**	**16**	**11**

Extreme	**1**	**8**
High	**9**	**16**
Moderate	**17**	**20**
Low	**21**	**25**

Definitions of likelihood are provided in Table 26. Likelihoods are categorized around the probability of occurrence, within the context of reasonable timeframes and frequencies given the project life. A brief description of each risk classification and the likely responses is also provided below in Table 27.

Table 26: Definition of Likelihood Classification

Rating	Likelihood	Frequency	Probability	Catastrophic
A	Almost certain	More than once per month	The event is expected to occur at some time as there is a history of continuous occurrence with similar projects/activities	91-100%
B	Likely	Less than once per month, but more than once per year	There is a strong possibility the event will occur as there is a history of frequent occurrence with similar projects/activities.	61-90%
C	Possible	Less than once per year, but more than once per five years	The event might occur at some time as there is a history of infrequent occurrence of similar issues with similar projects/activities.	41-60%
D	Unlikely	Less than once per five years	Not expected, but there's a slight possibility it may occur at some time.	11-40%
E	Rare	Unlikely to ever occur	Highly unlikely, but it may occur in exceptional circumstances.	0-10%

Table 27: Description of Risk Classification

Rating	Definition
Extreme	Unacceptable risks primarily critical in nature in terms of consequences (e.g. extensive and long term environmental harm, permanent sacred site damage, fatality, massive economic impacts) that are considered a possibility through to almost certain to occur. Such risks significantly exceed the risk acceptance threshold and require comprehensive control measures, and additional urgent and immediate attention towards the identification and implementation of measures to reduce the level of risk.
High	Typically relate to significant to critical consequences (e.g. a major environmental or heritage damage, and considerable safety, social or economic impacts) that are inclined to cut across the possible to almost certain likelihood ratings. These are also likely to exceed the risk acceptance threshold and although proactive control measures have been planned or implemented, a very close monitoring regime and additional actions towards achieving further risk reduction is required
Moderate	As suggested by the classification, medium level risks span a group of risk combinations varying from relatively low consequence / high likelihood to mid-level consequences /mid-level likelihood, to relatively high consequence / low likelihood scenarios across environmental, social and economic areas. These risks are likely to require active monitoring as they are positioned on the risk acceptance threshold
Low	These risks are below the risk acceptance threshold and although they may require additional monitoring in certain cases are not considered to require active management. In general such risks represent relatively low likelihood and low to mid-level consequence scenarios.

Table 28 describes the types of consequences that have been identified and assessed as part of the risk assessment process. These are grouped into environmental factors and consider social factors.

Table 28: Consequence Classification

	Consequence				
Factors	(1) Insignificant	(2) Minor	(3) Moderate	(4) Major	(5) Significant
Biodiversity, Flora & Fauna and Ecosystems	Alteration or disturbance to an isolated area that is unlikely to affect the habitat species or ecosystem	Alteration or disturbance to less than 5% of a habitat, species or ecosystem resulting in a minor, recoverable impact within 1 year	Alteration or disturbance to 5-30% of a habitat, species or ecosystem resulting in a moderate, recoverable impact within 1-2 years	Alteration or disturbance to 30-70% of a habitat, species or ecosystem result in in a major, recoverable impact within 3-10 years	Alteration of more than 70% of a habitat, species or ecosystem resulting in an extinction or permanent change, or reduce threshold level below 30%. Recovery, if possible is greater than 10 years
Land Degradation	Negligible impact to isolated area	Contained low impact, not impacting on any environmental value	Uncontained impact, able to be rectified in short-term without causing pollution or contamination	Extensive hazardous impact on an environmental value requiring long-term remediation	Uncontained hazardous impact with residual effect, even with long term remediation
Water Resources	Negligible impact to site area and no effect to the use of water	Contained low impact with negligible effect on the use of the water	Uncontained impact that will affect the use of the water but can be remediated in the short term	Extensive hazardous impact that requires long term remediation	Uncontained hazardous impact with residual effect, even with long term remediation
Air Quality	No Detectable impact	Contained low impact not impacting on any environmental value	Uncontained impact that will impact on an environmental value, but able to be remediated in short term	Extensive hazardous impact on an environmental value that requires long term remediation	Uncontained hazardous impact on one or more environmental values with residual effect, even with long term remediation
Mine Closure	Site is safe, stable and non-polluting and does not significantly impact the post mining land use	The site is safe, all major landforms are stable and any stability or pollution issues are contained and require no residual management. Post mining land	The site is safe and any stability or pollution issues require minor, ongoing maintenance by end land-user	The site cannot be considered safe, stable or non-polluting without long-term management. Agreed end land-use requires	The site is unsafe, unstable and is causing pollution or contamination that will cause an ongoing residual impact. The post mining land use cannot be achieved.

	Consequence				
Factors	(1) Insignificant	(2) Minor	(3) Moderate	(4) Major	(5) Significant
		use is not compromised significantly.		ongoing management.	
People	Incident with or without minor injury. No impact on human health or very minor short term inconvenience or symptoms	Injuries requiring first aid treatment. Minor short term inconvenience or symptoms to human health	Injury or illness requiring medical treatment. Short term or reversible disabling effect (impairment) to human health	Injuries requiring hospitalisation. Serious long term or permanent disabling effects on human health (one person	Loss of life / fatality or long term or permanent disabling effects on human health

The level of certainty surrounding the proposed risk rankings was also assessed in accordance with Table 29. Where proposed mitigation measures resulted in a reduction in risk ranking from inherent risk to residual risk, justifications for this were also provided.

Table 29: Level of Certainty

Control Rank	Description	Guidance
C1	Low	Risk ranking is based on subjective opinion or relevant past experiences.
C2	Moderate	Risk ranking is based on similar conditions being observed previously and/or qualitative analysis.
C3	High	Risk ranking is based on testing, high fidelity modelling or simulation, use of prototype or experiments. Analysis is based on verified models and/or data. Assessment is based on an historical basis.

8.2. Risk Identification

A risk assessment workshop was initially undertaken on 10 February 2015 to assist in identifying the key environmental, human health and social-cultural risks associated with the TGU Project and to develop appropriate management measures to be used in the EIS and subsequent Management Plans (GHD 2015). The workshop was attended by a suitably diverse group of personnel including the Primary Gold Managing Director and suitably experienced environmental scientists and hydrogeologists. The risk assessment workshop focused on the following key risk areas:

- Failure of existing / new infrastructure;
- Acid, Neutral and Saline Mine Drainage;
- Water management;
- Erosion and Sedimentation;
- Biodiversity;

- Human Health and Safety;
- Rehabilitation and Closure;
- Cultural Heritage; and
- Social and economic impacts

As mentioned earlier, this risk assessment has since been updated (2018 and 2019) to take into consideration the NT EPAs comments on the draft EIS, EIS Supplement, project changes as well as the NT EPA's guideline on environmental factors and objectives.

The Risk Register is an active document which will be modified and updated as additional information and/or management plans are created. The document will facilitate communication with key project stakeholders, and provide transparency around the proposed development of the TGU Project.

In total 48 environmental aspects were identified and evaluated, and categorised into the following five hazard groups:

- Water and AMD (18 risks);
- Biodiversity (12 risks);
- Rehabilitation and Closure (8 risks);
- Cultural Heritage (1 risk); and
- Miscellaneous (9 risks).

See Table 1 of Risk Register (Appendix G of Addendum to the Supplement) for full risk matrix regarding closure. The main risk areas related to:

- Acid mine drainage from WRDs, TSFs and processing area
- Lack of topsoil to rehabilitate the area
- Long term positive water balance
- Pit lake becomes a groundwater source with poor water quality

Over the residual risk ranking for closure is high (average = 16) and therefore these risks need to be managed appropriately. Primary acknowledge the high risk of closure and are working towards establishing sound management measures (i.e. placing of all tailings and future waste rock material in the pit and, commencement of studies into the AMD contained in the waste rock dumps).

8.3. Risk Assessment and Management

For each identified risk, the associated impacts and proposed mitigation measures were determined. A consequence and likelihood (following implementation of proposed mitigation measures) were then determined which resulted in a risk rating being generated. The risk assessment process results in four risk ratings – Low, Medium, High and Extreme. The application of risk mitigation measures usually results in a reduction in either or both of the likelihood of the risk event occurring. The resultant risk is called

residual risk. A summary table of identified risks for closure is provided in Table 30. This outlines the relevant mitigation measures for each closure risk or identified issue.

Table 30: Identification of Key Closure Issues

Disturbance Domain	Closure Issue	Potential Impact	Potential Mitigation Strategy	Residual Risk
All domains	Already an extensively disturbed area - insufficient topsoil volumes available	Unsuccessful vegetation re-establishment Reduced aesthetic value of the landscape Weed succession Erosion leading to changes in the landform	Implement weed hygiene measures Monitor erosion and mitigate with ripping, compaction and contouring as appropriate to support vegetation growth Observational evidence onsite suggests regrowth requires minimal growth medium – therefore recovered topsoil from future proposed cleared areas (WSD and borrow area) will be used as viable seed bank/growth medium where required Placement of tailings from TSFs into the Toms Gully pit, to reduce AMD potential. TSF1 used for water and sediment management associated with SWRD and TSF2 removed and rehabilitated. All facilities are to be capped in situ. Therefore a much smaller surface area requires topsoil medium. Recover topsoil and growth medium from proposed clearing areas and stockpile for rehabilitation at closure	Moderate
	Potential hydrocarbon or chemical contamination from spills/leaks	Groundwater and/or surface water contamination	During operations, all hydrocarbons and chemicals to be stored in bunded areas and in accordance with AS standards	Moderate

Disturbance Domain	Closure Issue	Potential Impact	Potential Mitigation Strategy	Residual Risk
		Localised soil contamination, leading to prevention of vegetation growth	Assessment of any potentially contaminated areas as part of mine decommissioning Any hydrocarbon contaminated material to be remediated or disposed offsite Water monitoring program continued to be implemented at closure	
	Establishment of weeds	Weeds significantly impact on success of rehabilitation	Site induction to cover identification of 9 weed species existing on site Annual vegetation monitoring to include presence of weeds Implement weed hygiene measures on equipment prior to being brought to site Dispose or bury weed infested topsoil Keep weed infested topsoil separate from topsoil to be used in rehabilitation	Low
	Geotechnical instability - failure of pit wall, WRD, WSD or TSFs if containing tails	Land degradation (loss of flora and fauna habitat and AMD contamination). Public and/or livestock injury.	Construction of abandonment bund and signage preventing public entry Geotechnical assessment prior to closure Removal of TSFs Annual post-closure monitoring and inspections of site	Low

Disturbance Domain	Closure Issue	Potential Impact	Potential Mitigation Strategy	Residual Risk
Waste Rock Dumps	OWRD and SWRD acting as acid, saline and metalliferous drainage sources.	Groundwater or surface water contamination Contamination of surrounding soils Completion criteria and environmental objectives unable to be met	Minimising the passive release of AMD into the environment north of the SWRD and EP2. Acidity loads from both structures can be effectively managed using traditional water management solutions, including storage, treatment and seasonal dilution to reduce elements consistent with saline and metalliferous drainage to environmentally benign concentrations. Cap WRD with material from box cut to reduce seepage into the dumps. Primary Gold has committed to not using waste rock for construction materials – eliminating the risk of spreading existing or creating new liabilities	High
	Surfaces of landforms may be susceptible to erosion	Unsuccessful vegetation regrowth An unsafe, unstable and polluting landform at closure	Existing WRDs are to be retained with management focusing on investigating causes of AMD and potential solutions, maintenance of drainage controls and monitoring.	Low
Pit and Underground Portal	Pit acting as AMD pathway	Groundwater or surface water contamination	No dewatering of pit to expose sulfides Insitu treatment of water to reduce metals and increase pH. Investigate the potential for insitu pit passive sulfate reducing bioreactor/bacteria.	Moderate

Disturbance Domain	Closure Issue	Potential Impact	Potential Mitigation Strategy	Residual Risk
			Ensure sufficient freeboard in pit at all times	
	Public and livestock safety risk	Livestock and/or public injury or death	Signage and abandonment bund erected at closure	Low
	Pit lake becomes groundwater source	When pit void it has reached equilibrium with surrounding groundwater, it could become a groundwater source, enabling water to migrate away from the pit. This could lead to a gradual development of plume of contaminated groundwater.	Modelling of pit water levels after closure This scenario is only likely to be temporary due to the excess of average annual evaporative rates/demand over rainfall Water in pit deferred by the TGU Project as it treats and places water in to the newly constructed WSD prior to being released from site. Investigate the potential for insitu treatment of water with a sulfate reducing bioreactor.	Moderate
	Tailings and waste rock in pit is not sufficiently capped with water at closure.	PAF waste rock and tailings material exposed to oxygen and reacts	Calculated volumes of waste rock and tailings to ensure volumes sufficient. Use of floating head for tailings and stacker for waste rock. Regular movement of floating head and stacker to position material in the deeper sections of the pit. Only removing displaced water to maintain a constant water depth.	Low

Disturbance Domain	Closure Issue	Potential Impact	Potential Mitigation Strategy	Residual Risk
Processing Area Domain (including ROM Pad)	Infrastructure remaining at closure	Visual amenity impact to visitors, local community or pastoralist Safety risk to livestock or public	Removal of all plant and other equipment/buildings to be undertaken in a safe manner Ensure stakeholder engagement and community consultation undertaken prior to closure phase of operations	Low
	Compaction	Rehabilitated plant species unable to reach adequate rooting depths	Deep rip contours	Moderate
	ROM Pad and associated stockpiles acting as AMD source	Groundwater or surface water contamination	Remove stockpiles and reprocess Place any AMD contaminated soils or materials in the pit under a water cover. Manage runoff via appropriate drainage and treat runoff before discharging Drainage/runoff controls retained at closure	Low
Access and Haul Roads Domain	Compaction	Rehabilitated plant species unable to reach adequate rooting depths Reduced infiltration of rainfall	Deep rip roads and access tracks	Low
TSF 1 and 2	High to very high saline, acid and metalliferous drainage risk/source	Groundwater or surface water contamination either via runoff or seepage	The tailings stored in TSF1 and TSF2 site will be placed in the pit with the base of the facility	Low

Disturbance Domain	Closure Issue	Potential Impact	Potential Mitigation Strategy	Residual Risk
			cleaned of tailings, which would lower metals concentrations, thereby reducing acid potential. Drainage/runoff controls retained at closure	
	Surfaces of landforms may be susceptible to erosion	Unsuccessful vegetation regrowth An unsafe, unstable and polluting landform at closure	TSF1 assess and upgraded for the management of runoff and sediment from the SWRD at closure. TSF2 walls removed at closure if it is used as a water storage facility. Erosion monitoring during rehabilitation and after a significant rainfall event	Low
Proposed Water Storage Dam	Overtopping of WSD or embankment failure	Adverse impacts to Mt Bundey Creek and downstream aquatic ecosystems with movement and deposition of sediments and damage to vegetation and fauna downstream. Localised increase in groundwater levels. Impact on structural integrity of engineered embankments.	Potential transfer of dam responsibility and management to pastoralist. Closure of TGU Project new features designed and constructed to ensure that water quality of Mount Bundey Creek and the post- mining pastoral grazing land use areas is protected.	Low
Evaporation Ponds 1 and 2 (and other water storage facilities)	Evaporation ponds acting as AMD pathway in site conceptual model	Groundwater or surface water contamination either via runoff or seepage	Manage runoff via appropriate drainage and treat runoff before discharging Investigate insitu water treatment options. Drainage controls retained at closure	Moderate

Disturbance Domain	Closure Issue	Potential Impact	Potential Mitigation Strategy	Residual Risk
Lake Bazzamundi	Water quality not within livestock guidelines	Livestock illness or death Detrimental impacts to natural ecosystems	Monitoring of surface water Treatment of runoff before discharge If necessary, include Lake Bazzamundi in livestock exclusion precinct	Low
Other Considerations				
Groundwater / Surface Water	Use of processing chemicals or hydrocarbons	Soil and/or groundwater and/or surface water contamination Hindrance to vegetation re-growth	All chemicals or hydrocarbons stored on site will be bunded and stored in accordance with AS standards Weekly inspections of storage areas, regular servicing of vehicles/machinery and regular maintenance of processing plant Spill kits will be available at all times near all refueling areas, chemical storage areas and on vehicles/machinery	Moderate
	AMD sources and pathways on site	Groundwater and/or surface water contamination	Positioning of tailings in pit and rehabilitation of safe, stable and benign TSF feature Treatment of AMD water on site using water treatment plant Implementation of drainage control measures and maintenance of these drainage controls to ensure all runoff is captured and retained and then treated before being discharged Maintenance of WRD and treatment of runoff water from WRD	Moderate

Disturbance Domain	Closure Issue	Potential Impact	Potential Mitigation Strategy	Residual Risk
			Water quality within SSTV and water quality values	
	Long term positive water balance	Water storage features that contain poor quality water with low pH and high concentrations of metals which is unsuitable for livestock consumption	Implementation of Water Management Plan and Water Monitoring Program during operations – water monitoring to continue at closure. Improved site drainage, completed baseline investigations to better understand sources and identify potential remedial actions to reduce impacts. Close landforms (including WRD's) to be water shedding to reduce retained water on site.	High
Financial	Funds not available to rehabilitate and close the mine is accordance with this plan	Unable to rehabilitate site consistent with Mine Closure Plan and unable to meet agreed closure objectives	Allow adequate financial provisioning for rehabilitation and closure to ensure closure objectives are met Planning shall include consultation with key stakeholders.	Moderate
	Unplanned closure (possibly due to natural disaster or financial climate)	Site not rehabilitated to required standards. Increased potential for offsite impacts from AMD, erosion and sedimentation.	Infrastructure design to withstand extreme events Ongoing management of levels in water infrastructure Improve site drainage controls Financial provisioning for closure implementation Stakeholder engagement with surrounding landholders	Moderate

Disturbance Domain	Closure Issue	Potential Impact	Potential Mitigation Strategy	Residual Risk
Land-use	Changes to landholder/community/ government expectations over agreed post mining land use	Changes to rehabilitation methodology and completion criteria included in Mine Closure Plan	Continue stakeholder engagement throughout life of project to ensure final post mining land-use acceptable to stakeholders The mine closure process shall enable the Toms Gully mining leases to be closed and rehabilitated so that pastoral grazing land use may be resumed over the majority of the land.	Moderate

9. Closure Implementation

Primary Gold will undertake rehabilitation progressively, with closed areas being revegetated as soon as practicable. Infrastructure removal activities will commence on completion of operations. A schedule for closure implementation is provided in Table 32.

9.1. Summary of Closure Strategies

Primary Gold has adopted the following key rehabilitation and closure strategies for the TGU Project:

- The long term liability and risk associated with tailings storage and future waste rock disposal shall be addressed using industry best practice so that tailings are encapsulated sub-aqueously within the pit.
- The long term liability and risk associated with the existing WRDs shall be investigated to ensure a safe, stable and non-polluting landform; and
- Site infrastructure shall be removed and land rehabilitated to create a precinct within the tenements for pastoral land use, an area of restricted land use and temporary livestock exclusion.

9.2. Closure Objectives

In consideration of a) the NT EPA's ToR objectives, b) the NT EPA's Environmental Factors and Objectives Guideline (NT EPA 2018) and c) the site's historical legacies; Primary Gold has developed two key overall closure objectives:

(1) To reduce the long term environmental risks posed by the TGU Project; and
(2) Make environmental improvements to the site so as to have a lower liability.

In order to meet the overall site closure objectives as above, Primary Gold has set the following targets:

- No impact to significant flora and fauna species beyond that which is approved as part of the EIS process;
- Total vegetation clearing does not exceed that which is approved as part of the EIS process;
- No new weed or pathogen species introduced as a result of TGU Project construction, operation or rehabilitation;
- No increase in weed or pathogen distribution throughout the TGU Project area;
- No significant fire events occur as a result of the TGU Project;
- No decline in flora and fauna health attributable to the quality or quantity of TGU Project surface water runoff;
- All areas will be rehabilitated to agreed completion criteria; and
- Historical WRDs will have further studies conducted to advance their future rehabilitation

9.3. Closure Work Programs for Closure Domains

The TGU Project will be divided up into two major closure domains (or precincts):

1) Livestock Exclusion Precinct and
2) Pastoral Precinct

The closure strategy for the TGU Project has split the site into these two domains in order to return as much of the land as possible back to pastoralism (see Figure 4). Pending closure monitoring results, some domains may be moved from the Livestock Exclusion Precinct to the Pastoral Precinct once they are safe for livestock (water) consumption or grazing.

This section outlines the closure implementation for each domain within each precinct and identifies likely required actions (Table 31).

Table 31: Closure Domains / Precincts

Livestock Exclusion Precinct	Pastoral Precinct
The overall objective for the livestock exclusion precinct is for the TGU Project to leave the site with a long term neutral water balance, with no new contamination arising, and continued containment and long term solutions identified for the existing features.	The overall objective for the pastoral precinct is for the TGU Project
Open Pit and Underground Portal	Water storage dam
Sulfide and Oxide WRDs	Surrounding land
TSF1 (removed at closure)	Lake Bazzamundi.
TSF2 (water and sediment management structure.	
Process Plant (including ROM Pad, offices and workshops)	
Arterial Infrastructure (pipelines, roads, power lines, site drainage)	
Evaporation Ponds	
Oxbow Wetlands	
Boxcut	

9.3.1. Pit and Underground Portal

The pit and underground portal domain covers an area of 15 ha. The base of the pit (-70 mRL) is well beneath the predicted long term pit water level of 15 AHD. The following closure actions are planned for this domain:

- Full dewatering of the pit will not occur with water removed as required due to the deposition of tailings and waste rock.
- Placement of all tailings (existing and future) and future underground waste rock in the deeper sections of the pit. With an approximate water cover of 25 metres.
- An abandonment bund with suitable materials will be in place and will be located outside of the theoretical zone of potential pit instability (as per the Western Australian guideline Safety Bund Walls Around Abandoned Open Pit Mines [Department of Industry and Resources 1997]).
- A monitoring program will be implemented to monitor the water level and characterise changes to water quality in the pit. Treat in-situ water chemistry if required to prevent acidification.
- Investigate the potential to establish an insitu sulfide bioreactor in the pit for water treatment in line with defined water quality.
- A gate will be installed at the pit entry for the initial stage of closure to allow access for monitoring and placement of selected materials (either inert concrete or footings contaminated with acid or metals). This will eventually be replaced by competent rock at the completion of monitoring of the pit.

At this stage no post mining land use is identified other than restricted access.

9.3.2. Boxcut and Underground Decline

The boxcut and underground decline domain covers an area of 2 ha. The base of the boxcut is 40 metres below the surrounding ground level. It is anticipated that the underground workings and the lower 10 metres of the boxcut will fill within 8 months. The following closure actions are planned for this domain:

- Undertake detailed surveys of the underground workings and boxcut. These will be forwarded to the DPIR for their records
- Underground workings will have any hydrocarbons or other contaminating materials removed to the surface and infrastructure of value removed.
- Infrastructure not containing contaminating materials and not of any commercial value will be left in situ, Primary will ensure this infrastructure does not present a health and safety hazard by ensuring the material does not protrude from the base of the boxcut and does not have the potential to release any chemicals if the material breaks down.
- Ventilation shafts, and alternative egress points will be sealed and to prevent access. Any infrastructure associated with these (e.g. vent fans) will be removed.
- If not already fenced, vent shafts outside of the boxcut boundary will be fenced to preclude access
- An abandonment bund with suitable materials will be in place and will be located outside of the theoretical zone of potential boxcut instability (as per the Western Australian guideline Safety Bund Walls Around Abandoned Open Pit Mines [Department of Industry and Resources 1997]).

- Waste rock from the boxcut portal if suitable will be placed on the waste rock dumps to limit the egress of water. If unsuitable will be placed in the base of the pit.
- The underground workings and base of the boxcut will be allowed to fill with water to prevent any PAF material from oxidizing. Historical observations of the underground recharge indicate a 20L/s influx of water this filling rate will flood the underground workings and base of the boxcut in approximately 244 days.
- A monitoring program will be implemented to monitor the water level and characterise changes to water quality in the boxcut.
- A gate will be installed at the boxcut entry for the initial stage of closure to allow access for monitoring and placement of selected materials (i.e. inert concrete). This will eventually be replaced by competent rock at the completion of monitoring of the boxcut.
- A gate will be installed at the decline entry to prevent the public and fauna entry. The gate will be left and will eventually be covered by water.

At this stage no post mining land use is identified other than restricted access.

9.3.3. TSF 1

TSF1 is a valley fill impoundment with a downstream dam wall occupying 10 ha. All tailings will be removed with the base of the structure cleared of tailings. If TSF1 can be upgraded to comply with ANCOLD 2012/fit for purpose Primary Gold intends to use TSF1 as a sediment basin to capture runoff and sediment from the southern face of the SWRD, it has identified that the TGU Project can have a positive impact on reducing its liability. Primary will make use of the Bioaqua Process (water treatment plant) to potentially process both existing and future tailings to extract gold, mixed metal oxides, sulfur and silica thus reducing volume and creating more benign tailings. If this does not occur then the tailings will be placed in the pit without processing.

The closure option for TSF1:

- To reprocess old tailings or place old tailings in pit at closure. Use a “Slurrytrak” or a small dredge as produced by CGC (Cooper Group of Companies) that can operate in wet and soft sands. The tails are excavate and placed in the Slurrytrak hopper or sucked up by the dredge. Water is injected into the tails to liquify, then pumped via a pipe to the process plant or pit for disposal.
- Clean up TSF1 floor to remove residual tailings.
- No truck haulage required, no dust, no extra roads required to be built. Pipes are already in place from current dewatering of old tailings dams.
- Existing TSF1 footprint will effectively become an empty dam.
- Upgrade TSF1 to ANCOLD 2012 guidelines to act as a sediment and water catchment basin.
- Treat any surface water in the TSF and transfer to the WSD or use directly into the process plant during operations;
- Depending on the design of the catchment basin. The embankments are seen as a potential capping resource and will be removed or partially removed for pushing upstream over the TSF

footprint to achieve external drainage. Alternatively, embankment material can be made available for other site rehabilitation requirements;

- Place soil won from stripping the WSD over the surface of the TSF footprint. This may be a combination of capping and growth medium; and
- Where areas are not used as a water capture area rip/scarify the floor of the TSF and seed with native species.

9.3.4. TSF 2

TSF2 is a paddock style TSF occupying 13.05 ha. Primary Gold plans to assess the facility complies with ANCOLD 2012 guidelines once tailings have been removed. Tailings removal will occur if tailings is process or not. Similar to TSF 1,.

Rehabilitation of TSF2 would be as follows:

- To reprocess old tailings or place old tailings in pit at closure. Use a "Slurrytrak" or a small dredge as produced by CGC (Cooper Group of Companies) that can operate in wet and soft sands. The tails are excavate and placed in the Slurrytrak hopper or sucked up by the dredge. Water is injected into the tails to liquify, then pumped via a pipe to the process plant or pit for disposal.
- Clean up TSF2 floor to remove residual tailings.
- Existing TSF2 footprint will effectively become an empty dam.
- If achievable upgrade TSF2 to ANCOLD 2012 guidelines and minimize seepage to use as a water storage dam during operations.
- If required treat any surface water in the TSF and transfer to the WSD or use directly into the process plant during operations;
- At the cessation of operations. The embankment are seen as a potential capping resource and may be removed or partially removed by pushing the embankments over the TSF footprint to achieve a small mound at closure where the TSF2 stood. Alternatively, embankment material can be made available for other site rehabilitation requirements;
- Place soil won from stripping the WSD or borrow areas over the surface of the TSF footprint. This may be a combination of capping and growth medium; and
- Rip/scarify the TSF area and seed with native species.

9.3.5. Sulphide and Oxide WRD

Primary Gold does not intend to utilise, add to or disturb either WRD during the course of the TGU Project. However in the course of the TGU Project, Primary Gold proposes to undertake necessary further studies which will contribute to establishing a sustainable long term post mining land use solution for both WRDs to commence this process both WRDs were drilled in 2017 to identify the distribution and volumes AMD materials helping to understand the future for acid and metalliferous drainage generation. Further studies could include:

- Additional drainage studies, to identify seepage and drainage issues/locations and measures to improve drainage into and off the waste dump to minimise water ingress. These will

include wet season observation of water flows, ponding and ingress into the WRDs, pre- wet season observation of areas of water discharge and salt crystallisation to locate areas of seepage exiting the WRDs;

- Sampling and analysis of areas of seepage, installation of additional monitoring bores as required;
- Cover/barrier studies in conjunction with the materials balance (Suitable Boxcut material used for capping) to determine types and quantities of materials would be required to develop a cover that could sustain vegetation, limit oxygen ingress, prevent water recharge and ensure stability; and
- Update the rehabilitation materials mass balance pending completion of stripping from the WSD. Topsoil in excess of those required for rehabilitation elsewhere on the TGU Project (e.g. TSFs) could potentially be retained for future application on the WRDs.

Examples of maintenance activities Primary Gold will complete include:

- Cleaning of drains and salt crystallisation areas before the wet season, with materials removed placed at base of pit;
- Pre-wet season inspection and maintenance of drainage features; and
- Post event observation of WRD surfaces with remedial actions on any erosion areas or ponding.

9.3.6. Processing Area

The process plant will continue to operate after cessation of mining to process the remaining ore stockpiles on the ROM and to conduct campaign milling during mill clean up. It may also process the tailings from TSF1 if not previously processed by the mill or by the Bioaqua Process. The following steps are envisaged to rehabilitate the process plant (including use of the Process Plant in the lead up to closure to minimise post closure liabilities).

Pre-closure

- Continued processing and salvage of ore on the ROM pad to the maximum possible extent. On the presumption sub-economic ore will be PAF (based on GHD 2015 and 2018), it may be cost effective to process sub-economic ore in place of load and haul to the base of the pit;
- An initial clean-up of the plant will be conducted in the last weeks of processing, which will include removal of built up material (ore) on tanks, launders, pipes, sumps, crusher floor, bins and hoppers. This material can then be returned to the process via sump pumps;
- Draw processing water using the worst quality water source possible. This is done on the basis it will be easier to manage better quality water than poor quality water post closure;
- Review procedures to focus on plant shutdown and undertake cyanide decontamination safety training;
- Hazard Operability and Workplace Risk Assessment and Control assessments to be conducted;
- Implement planned rundown of reagent and other spares to minimal inventories;

- In the last two weeks of cyanide consumption, tanks should be drained to process any organo-cyanide sludges at the bottom of the storage tanks;
- Clean up and decontamination of plant facilities; and
- Water treatment of contaminated water.

Closure

Once processing of ROM ore has been completed, full cleanup of the plant will begin in conjunction with two other processes, gold scavenging and cyanide decommissioning. The main activities likely at this stage are described below:

- A gold scavenging crew will scour through low energy gravity traps to remove gold or gold concentrates for either smelting, or further processing/refining through a third party;
- Small batches of material collected from clean-up activities will require milling at times during the first few weeks of closure;
- Once tanks have been emptied, they can be accessed via trap doors. Tanks will be washed out with high pressure water, followed by a specialist contractor to scour the tanks using twin plane nozzles. The last stage of tank cleaning will be a rinse with sodium hypochlorite solution to destroy any residual cyanide. Due to hazards associated with tanks containing cyanide, hazard assessments, having continuous atmospheric monitoring, spotters and use of Confined Space Entry Permits are required;
- Other reagent tanks will be emptied and cleaned of sludge, hosed out and left to drain by leaving trap doors open;
- Process tanks will be emptied in a manner that maximises economic recovery of loaded carbon and the logistics of being able to pump carbon to elution;
- As tanks are emptied, mud on walls will be dislodged by hoses (or high pressure water where required). It is possible a heavy, iron rich sediment may exist at the base of tanks which will need physical removal to TSF2 (if it is to be rehabilitated as a landform). Once tanks have been cleaned, they will be left to drain by leaving trap doors open;
- Bins, chutes and hoppers will be hosed out and left to drain or have drainage holes cut in them;
- Any cyanide pipelines will be flushed with five volumes of potable water, followed by flushing with a sodium hypochlorite solution. Non-cyanide pipelines will only be flushed with water;
- Once flushed, pipelines will be drained by breaking flanges at low points;
- Pumps and mechanical equipment will be washed down externally with raw water to remove process slurry and cyanide;
- The elution circuit and gold room will continue to be used to complete electrowinning and smelting from the plant carbon inventory and from gravity trap gold recovery. Once completed, electrowinning cells will be washed out with fresh water;
- Once loaded carbon has been stripped, it will be bagged and sold;
- Electrical reticulation will be progressively isolated as areas no longer require electricity;
- Excess compressed air systems shut down and statutory pressure vessel inspections

conducted at the time of shut down;

- Once clean-up is complete, the storm water storage pond and process water pond will be drained, have sediment cleaned out and liners removed. These dams will be used as plant catchment sumps with the aim of reducing sediment release during storm events; and
- Radiation devices will be removed and sent offsite for secure storage and or sale.

Demolition

Once the plant has been cleaned up and decontaminated of reagents, gold and process slurry, removal can begin. Depending on the economic cycle at the time, Primary Gold may elect to sell the plant or parts of the plant, relocate the plant to another project or demolish the plant as scrap. Demolishing the plant as scrap is the base case for this plan as it is also relevant to relocation and sale of the plant as there will always be some remnants of infrastructure which requires demolition/scrapping such as concrete. The following steps are envisaged:

- A specialist contractor will be appointed to deconstruct the plant. This will typically involve unbolting, cutting and in limited circumstances demolishing infrastructure. Equipment will be separated as specific assets (e.g. mill) or cut to lengths (e.g. steel pipe) in order to suitable for transport from site;
- Whilst most of the steel work and infrastructure will be removed from site as it will have scrap value. A portion of the plant will not have scrap value such as concrete pillars, slabs and scrap timber. These will be broken up and excavated onto trucks before haulage to the base of the pit;
- An assessment of contamination will be conducted to determine if there are areas which require remediation prior to rehabilitation. Areas to be targeted will include under cyanide, leach and elution tanks and hydrocarbon tanks, and any areas which have substantial staining suggestive of contamination;
- Any hydrocarbon contaminated soil will be excavated and taken to a bioremediation pad to be remediated;
- Any chemically contaminated soil will be excavated and taken to the base of the pit;
- Buried services will be excavated to 0.5 m depth;
- Any residual slurry/ore in the plant footprint will be graded into windrows, then excavated and taken to the base of the pit;
- The surface of the process plant will then be levelled off/re-contoured to match the surrounding landscape;
- Soil may be placed over the plant footprint, if sufficient material is available; and
- The process plant footprint will then be ripped to a depth of at least 0.5 m and seeded with native species.

Successful rehabilitation of the process plant will enable pastoral grazing as a post mining land use.

ROM Pad

The following steps are envisaged for rehabilitation of the ROM pad:

- The ROM pad will undergo a clean-up at the end of operations to process all economically feasible ore and any sub-optimal materials which are cheaper to process and receive marginal revenue compared to the cost of rehandle to the bottom of the pit;
- Once all ore has been processed and the crusher removed as part of deconstruction of the process plant, the ROM pad will be reshaped to form a surface which can be rehabilitated as a landform. If AMD material is present, it will be excavated and returned to the base of the pit;
- If available, topsoil shall be placed over the ROM footprint; and
- The surface of the ROM will then be ripped to a depth of at least 1 m and seeded with native species.

Offices, Workshops and Sheds

At closure, there will initially be ongoing use of offices and workshops to manage rehabilitation, closure activities and maintain earthmoving equipment conducting earthworks. Based on the current Access Agreement between Primary Gold and the Pastoralist, retention of these assets for the beneficial use of the Pastoralist is an option. If this process doesn't occur the offices, workshops and sheds will be removed. The main closure issue for the offices, workshops and sheds is ensuring those buildings to be retained are handed over with a clear understanding of responsibilities between Primary Gold and the Pastoralist.

The likely steps required for these assets:

- As part of consultation prior to closure, Primary Gold will obtain agreement with the Pastoralist which structures are to be retained;
- Offices identified for retention will be swept out and cleaned for handover to the landowner. If any offices are not required, they will either be taken offsite (as part of sale or relocation by Primary Gold) or demolished. The demolished offices will be placed at the base of the open pit or in an approved landfill. Any concrete slabs such as walkways will be broken up and placed at the base of the open pit;
- Sheds identified for retention will be cleaned out for handover to the owner. If any sheds are not required, they will be dismantled and taken offsite as scrap. Underlying concrete slabs will be removed and taken to the base of the open pit;
- The workshop will also be cleaned out for handover to the landowner if identified for retention. If not required, the workshop will be dismantled and taken offsite as scrap. Concrete will be broken up, excavated and placed at the base of the pit;
- A contamination assessment will be conducted around the workshop footprint to determine if any contamination needs to be excavated for bioremediation;
- Buried services across the offices shed and workshops areas which have not been retained will be removed to a depth of 0.5 m. If the landowner requires buried services to be retained, they will be retained. This may necessitate leaving some non-essential buried services to avoid impacting on retained infrastructure; and

- The ground surface of removed buildings will then be ripped to a depth of 0.5 m and seeded with native species.

Successful rehabilitation of offices, workshops and sheds will enable pastoral grazing or support of pastoral grazing as a post mining land use.

9.3.7. Evaporation Ponds

The evaporation ponds will not be disturbed as part of the recommencement of operations at TGU. At closure, from a safety perspective, Primary Gold will maintain the fence around the evaporation ponds to exclude unauthorised personnel and livestock. The water within the evaporation pond will be treated using a water treatment process that removes metals and lowers sulfate. The long term rehabilitation of the ponds is linked to the sulfide WRD and as such will be included in the further closure planning.

9.3.8. Oxbow Wetlands

The Oxbow Wetlands serve the purpose of a polishing wetlands prior to discharge of water from site to Mount Bundey Creek. The wetlands are stable and considered to have more ecological value to be retained rather than be rehabilitated.

The proposed post-mining land use for the Oxbow Wetlands is retention as wetlands.

9.3.9. Arterial Infrastructure

Arterial infrastructure includes pipelines, roads, bores and power reticulation. These transcend the livestock exclusion and pastoral grazing precincts.

Pipelines

Pipelines will be retained for the length of their useful life on the TGU Project. Some pipelines will be removed shortly after closure whereas as others used for site water management will be retained for a substantial period after closure.

Pipelines will be cut to lengths for being put on trucks and transported offsite for recycling and/or if not contaminated transferred to the Pastoralist.

Roads

Across the site are haul roads and access roads, of which some will have little to no use after closure. Others will be an integral part of post closure site management or transferred to the Pastoralist (by agreement with Primary Gold). This includes roads for ongoing monitoring, access to retained infrastructure or accessing other parts of the Mount Bundey station.

Rehabilitation protocol for roads is provided below:

- At or before closure, Primary Gold intends to meet with the landowner to identify which roads should be retained for future use by the landowner;

- Roads superfluous to needs, will have their shoulders pushed in then ripped as deep as possible (to the limitations of the bulldozer used) but will target 1 m;
- The roads will then be seeded with native species; and
- Road blocks may also be installed on rehabilitated roads to prevent public access points to the rehabilitation.

Bores

Once their useful life has concluded, monitoring bores will be sealed by grouting and have their collars cut. The Pastoralist may elect (by agreement with Primary Gold) to retain production bores for future use. If bores are to be retained, they will have a fenced enclosure installed around them. If they are not to be retained, they will be sealed by grouting and have their collars cut. Bores may be retained for use by the Pastoralist by written agreement.

Power

Power lines will be retained across the site, but will be isolated at the process plant or offices/workshops once no longer required, to prevent fire risks.

9.3.10. Lake Bazzamundi

Lake Bazzamundi will continue to be available as a water storage for pastoral grazing. The management of Lake Bazzamundi is expected to revert to the pastoralist upon closure of the TGU Project.

9.3.11. Water Storage Dam

The WSD may be retained in some form at closure as an available water store for pastoral grazing. In the case the Pastoralist does not wish to retain the WSD, anticipated closure activities include:

- In the dry season, transfer remaining water to the open pit;
- The embankment is seen as a potential capping resource and will be removed or partially removed for pushing upstream over the WSD footprint to achieve external drainage. Alternatively embankment material can be or made available for other site rehabilitation requirements;
- If stockpiled topsoil is still available, place topsoil over the WSD footprint; and
- Scarify the floor of the TSF and seed with native species.

9.4. Final Landform Designs

The final landform designs have been conceptualized for the infrastructure across the site. In general all structures will be water shedding and drainage management across site will be retained to ensure appropriate management of clean and mine affected water. Annual inspections of the site will be undertaken until relinquishment to ensure structural stability and rehabilitation progress.

9.4.1. Pit and Underground Portal

The underground waste from Toms Gully will be placed within the pit using a stacker, approximately 25m below the local water table (if Boxcut material is not placed onto the waste dumps). The in - pit waste storage will occur concurrently with the deposition of tailings into the pit. In practice some waste will be left underground in stoping areas fully mined. The quantity left underground is difficult to quantify at this stage. Thus, the in-pit waste will not be filled up to designed levels but it can contain all the waste if necessary. See Figure 18 for the final infill design of the pit.

The estimated total volume of waste from the underground and Boxcut (Boxcut placed in pit if material not suitable for rehabilitation) to be placed in the pit is ~776,903 lcm.

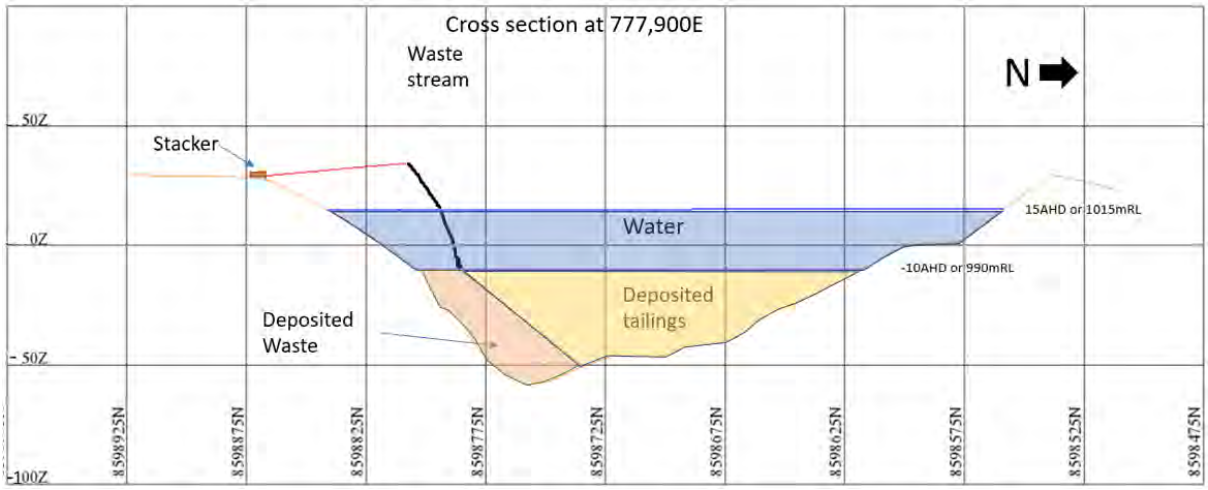

Figure 18: Indicative Backfilled Pit Design

The existing tailings from TSF1 and TSF2 totaling 250,000 tonnes and 125,000 tonnes respectively and all future tailings totaling 900,000 tonnes will be deposited in the pit using a moveable floating head. This form of deposition will deposit the tailings sub-aqueously below the water level. The floating head will be regularly moved to spread the tailings out evenly across the base of the pit thus resulting in the top of the tailings being level.

9.4.2. TSF 1 and TSF2

TSF 1 will likely decrease in size once the tailings have been removed. The structures will then be upgraded to align with ANCOLD 2012 guidelines to be used for sediment and water capture.

TSF 2 after tailings removal may or may not be used as a water dam during operations. The ultimate rehabilitation strategy will be to flattened out the embankments by either levelling or removal of the embankments. Once flattened the area will be ripped and seeded.

9.4.3. Waste Rock Dumps

Further investigations into the final remediation of the waste rock dump are still being undertaken. It is likely that the dumps will have a final slope of 18 degrees. The final landform will be dome shaped to ensure water shedding with a consolidated cap sourced from the Boxcut and other suitable sources.

9.4.4. Evaporation Ponds

The evaporation ponds are likely to remain in situ at closure. The embankments will be inspected to ensure structural integrity. The water within the evaporation ponds will be treated via the water treatment plant. They will be fenced to ensure livestock exclusion. It is envisaged the removal and rehabilitation of the evaporation ponds will be tied to the development of a long term solution and rehabilitation of the Sulfide WRD. Once the water has been treated to a suitable quality it may be discharged and the ponds backfilled and ripped.

9.4.5. Water Storage Dam

Unless the pastoralist requests to obtain the dam and take over responsibility then the dam will be rehabilitated. The embankments will be used for rehabilitation material or as construction material to remediate existing infrastructure. The liner (if present) will be removed and base of dam ripped and scarified and topsoil re-spread.

9.4.6. Drainage and Erosion Control Infrastructure

All drainage control measures and sediment bunds will remain in situ to ensure the separation of clean water and mine-affected water runoff.

10. Closure Schedule

An indicative closure schedule is provided in Table 32. The schedule incorporates a number of assumptions. The most significant assumptions (which are not implied to the below decisions) are:

- There is no active Care and Maintenance phase, therefore underground dewatering pumps will not continue to operate after closure and the process plant will not be maintained after completion of cyanide decontamination and cleaning;
- The TGU Project achieves completion criteria during closure resulting in the Minister for DPIR issuing Primary Gold a Certificate of Closure and relinquishment of bonds.

Not included in the schedule is a breakdown of wet and dry seasons. As guidance, earthworks will be conducted during the dry season wherever possible which influence the schedule. In addition, the gold resource at Toms Gully will be subject to further evaluation, exploration or mining studies or authorisation processes which may also influence the schedule.

Table 32: Closure Schedule for Toms Gully

Major or Significant Aspect/Task to Closure	Planning and Development Phase	Operations Year 1	Operations Year 2	Operations Year 3	Closure Year 1	Closure Year 3	Closure Year 5	Closure Year 10
Stakeholder engagement								
Prepare MMP								
Stripping of capping and growth medium from WSD								
Treatment and transfer of pit water to WSD if required to create capacity.								
Upgrade site drainage								
Construct Boxcut and Decline								
Remove tailings from TSF1								
Remove tailings from TSF2								
TSF rehabilitation study								
Waste dump investigations								
Notifications of closure								
Establish abandonment bunds								
Survey underground								

Major or Significant Aspect/Task to Closure	Planning and Development Phase	Operations Year 1	Operations Year 2	Operations Year 3	Closure Year 1	Closure Year 3	Closure Year 5	Closure Year 10
Stop dewatering pumps								
Seal underground access points								
Establish site fencing								
Issue list of potential assets for retention by								
Process plant rundown and preparation for								
Gold scavenging								
Final cleaning of plant								
Office archiving and ensure all electronic data is being								
Remove residual ore and AMD material from ROM								
Monitoring, rehabilitation and maintenance								
Rehabilitate ROM pad								
Plant demolition								
Contamination assessment								
Rehabilitate process plant footprint								

Major or Significant Aspect/Task to Closure	Planning and Development Phase	Operations Year 1	Operations Year 2	Operations Year 3	Closure Year 1	Closure Year 3	Closure Year 5	Closure Year 10
Rehabilitate TSF1 walls								
Rehabilitate TSF2 walls								
Rehabilitate WSD (if required)								
Remove water and tailings treatment plant.								
Handover retention assets to Pastoralist								
Certificate of completion issued								
Relinquishment of bonds								

11. Closure Monitoring and Maintenance

Each year after the rainy season of this MCP, an assessment of the success of the rehabilitation will be made to determine the rehabilitation requirements for the following months. Measurement of the progress and performance of the TGU rehabilitation will be monitored against closure objectives and criteria.

The closure and rehabilitation monitoring and maintenance program will aim to:

- Ensure surface and groundwater quality leaving the site satisfies discharge requirements and is not having an incremental impact on the downstream environment;
- Calibrate actual pit water levels and chemistry against anticipated levels and quality;
- Check the stability of landforms and determine if any minor remedial works are required;
- Assess the evolution of landforms towards being stable revegetated system;
- Inspect site drainage to ensure drains are maintained as fit for purpose;
- Inspect gates and fencing around site to ensure unauthorised access is not occurring or fences are damaged allowing livestock to enter the livestock exclusion precinct;
- Prevent uncontrolled spread of fire;
- Control the spread of weeds; and
- Manage water levels around site to minimise risks of unplanned release.

11.1. Water Monitoring

The current site operational water monitoring program (See Water Management Plan) will continue to be implemented during closure until such a time that data can show a trend towards baseline levels. At this point, and in consultation with EPA and DPIR, the monitoring program will be reduced to focus on compliance locations.

11.1.1. Surface Water Monitoring

Surface water monitoring will comprise (as per site operational program):

- Pit water levels and quality;
- WSD water levels and quality;
- Discharge water volumes and quality (including runoff from OWRD, Processing Area, Lake Bazzamundi etc.);
- Compliance sites on Mount Bundey Creek and Coulter Creek;
- TSF1, TSF2 and decant pond water quality and levels until rehabilitation is conducted; and
- Evaporation pond levels and quality.

11.1.2. Groundwater Monitoring

Groundwater monitoring will comprise of monitoring 9 bores in total:

- TSF groundwater monitoring bores (levels and quality);

- Regional bores (levels); and
- Specific impact bores around site (quality).

11.2. Rehabilitation Monitoring

Rehabilitation monitoring will occur annually during closure and will occur until completion criteria are met (see Section 6). The monitoring will occur a few weeks after the wet season to allow for the stability, erosion and drainage of infrastructure can be adequately assessed. The monitoring program will be consistent with the leading practice guidelines for mine rehabilitation (DFAT 2016a and 2016b).

The rehabilitation monitoring program is outlined in Table 33 below.

Table 33: Rehabilitation Monitoring Plan

TGU Project Area	Description of Monitoring	Time of Monitoring	Completion Criteria	Contingency
Waste Rock Dumps	• Vegetation species and health monitoring of 50 x 50 m quadrat (2 quadrats on each WRD) • 2 x photo monitoring points on each WRD • Visual inspections of erosion gullies, drainage and stability • Weed control	Annually (or until completion criteria are being met) A few weeks after the wet season	As per Table 12	See Section 12.1
TSFs	• Vegetation species and health monitoring of 50 x 50 m quadrat (2 quadrats on each TSF) • 2 x photo monitoring points on each TSF • Visual inspections of erosion gullies, drainage and stability • Weed control	Annually (or until completion criteria are being met) A few weeks after the wet season	As per Table 12	See Section 12.1
Water Storage Areas	• Water sampling as per operational water monitoring program • Maintenance of fencing • Visual inspections for freeboard, runoff drainage and stability	Annually (or until completion criteria are being met) A few weeks after the wet season	As per Table 12	See Section 12.1

TGU Project Area	Description of Monitoring	Time of Monitoring	Completion Criteria	Contingency
Proposed Water Storage Dam	• Water sampling as per operational water monitoring program • Visual inspections for freeboard, runoff drainage and stability	Annually (or until completion criteria are being met) A few weeks after the wet season	As per Table 12	See Section 12.1
General cleared areas	• Vegetation species and health monitoring of 50 x 50 m quadrat • Photo monitoring • Weed Control	Annually (or until completion criteria are being met) A few weeks after the wet season	As per Table 12	See Section 12.1
Pit	• Surface water monitoring as per operational monitoring program • Potentially treatment of water via insitu sulphide bioreactor	Annually (or until completion criteria are being met) A few weeks after the wet season	As per Table 12	See Section 12.1
Groundwater and Surface Water	• Continuation of operational water monitoring program • Visual inspections of abandonment bund, stability and runoff drainage • Aquatic ecosystem health monitoring	As per current operational monitoring program	As per Table 12	See Section 12.1

Vegetation Species and Health Monitoring

50 x 50 m quadrats will be established at closure as rehabilitation monitoring sites. These quadrats will be monitored annually for:

- Species coverage and diversity of species
- Weeds

Erosion and Sediment Control Monitoring

Erosion monitoring will be conducted on landforms rehabilitated as part of the TGU Project. Transects approximately 50 m long will be established across slopes to quantify erosion. This will be supplemented by a walkover inspection to determine if any gullies are becoming hazardous. This could be a substantial trip/fall hazard for people or livestock, or deep erosion that has penetrated through the surface layer. Such gullies will be identified for repair works.

Additionally, all drainage lines will be inspected for any sediment build up or instability and remedial work will be undertaken when necessary. Sediment bunds will also be inspected for stability and effectiveness.

11.3. Inspections and Maintenance

The Care and Maintenance and closure inspection program for TGU Project will be similar to that currently used for the Care and Maintenance program. The proposed inspection program is outlined below.

In general, all inspections described below will be undertaken annually during the closure phase (or after a significant rainfall event, >200 mm).

11.3.1. Drainage

Inspections will be undertaken to ensure drainage structures have not been compromised by storm activity. It is anticipated inspections and maintenance of drainage will be conducted on both a pre-emptive and reactive basis. In the dry season, a thorough annual inspection will identify drains requiring remedial works or sediment removed to be completed before the next wet season. During the wet season, inspections will check overall drain integrity after trigger storm events (once safe) to identify any structures in urgent need of repair or other management action.

Maintenance of drainage is expected to occur for the first three years after rehabilitation whereby the likelihood of excess sediment build up or erosion of drains is reduced.

11.3.2. Fencing

At closure, fences will isolate the livestock exclusion precinct from the pastoral precinct and to secure the site from unauthorised access. Fencing will allow the landowner to graze through the pastoral grazing precinct but prevent livestock accessing areas which could pose risks to livestock. Gates will be installed for access to the livestock exclusion precinct and site access points for monitoring and/or maintenance whilst excluding unauthorised personnel. In addition to fencing, abandonment bunding will be installed around the pit and boxcut to prevent inadvertent vehicle incursion to the pit or boxcut.

Fences, gates and abandonment bunds will be inspected routinely to ensure they have not been compromised by either natural events (e.g. trees falling) or vandalism/damage. Signs of unauthorised entry or damage to locks will also be checked.

11.3.3. Fire

Fire will be managed consistent with Primary Gold's Environmental Management Plan (EMP) (Primary Gold 2015b). Fire breaks have been installed around the site and key infrastructure for protection against bushfires. The firebreak network has historically been implemented in conjunction with the Pastoralist to ensure that fire breaks are optimised (Primary Gold 2013c).

Fuel reduction burns are carried out on site post wet season. This is to reduce the ferocity of bushfires on site when they occur. Back burns are also used to provide fire breaks. With new areas of rehabilitation, fire breaks may need to be adjusted prior to controlled burns to minimise adverse impacts to new rehabilitation.

Burns are also used to control some of the pest weed species as a broad acre management strategy.

11.3.4. Pests and Weeds

Pests and Weeds will be managed consistent with Primary Gold's EMP (Primary Gold 2015b).

Management options employed for weeds is dependent on the species present but includes grazing, spot spraying, cut and touch, broad acre spraying and controlled burn offs.

Weed inspections will still occur during the post closure period, with specific attention given to high traffic areas such as roads, ROM pad surrounds, and workshops.

Earthmoving equipment mobilised to site will need to be washed at the wash-down bay to prevent new weeds being introduced to site. The wash-down bay will continue to require maintenance during the rehabilitation phase of closure.

11.3.5. Rehabilitation Compliance Inspections

Once the bulk of a rehabilitation domain has been completed, an inspection of the area will be completed to check rehabilitation earthworks were conducted to design, and other features of the rehabilitated landscape have been incorporated.

Status updates of rehabilitated areas will be provided in the annual MMP submitted to DPIR.

11.3.6. Water Management Infrastructure Inspections

Whilst undertaking water monitoring, inspections will be undertaken of essential water management infrastructure to ensure it is not damaged and operating to expectations. Items inspected will include:

- Operational pipelines for leaks;
- Operational pumps for serviceability;
- Fauna egress and/or trapped in water storage bodies; and
- New seepage, cracks or damage to embankments of water storage bodies.

11.4. Reporting of Monitoring and Maintenance

Monitoring data, rehabilitation and maintenance inspections will be reported annually in the MMP submitted to the DPIR. Where a significant incident has been identified during inspections, these will be reported to the DPIR as an incident under Section 29 of the *Mining Management Act 2001*.

12. Financial Provisioning for Closure

Primary Gold understands it has obligations under the *Mining Management Act 2001* (MMA) to ensure sufficient funds and resources are available to conduct rehabilitation. Primary Gold is committed to provisioning for closure to ensure adequate funds are available to rehabilitate the site, conduct post closure monitoring and fund any required remediation activities.

The financial provision will be based on the total area of disturbance of each domain for the proposed project and estimated volumes of material requiring placement, hours of equipment usage and man hours required. The financial provisioning will be reviewed annually along with the MMP Security Calculation tool.

12.1. Contingencies

Table 34 identifies the contingencies identified in the event of different outcomes than those assumed and planned for in the preceding sections of this plan.

Table 34: Contingencies for Unplanned Outcomes

Outcome	Assessment Criteria	Contingency
Insufficient material for capping	Mass balance is less than determined requirements.	Source suitable material from Rustlers Roost Waste Rock Dump.
Insufficient space to store waste rock underground (this is additional to the main storage method of placing waste into the pit)	Stope sequence issue, development issue	Waste rock to be placed in of the pit as per planned storage method
Insufficient space to place waste rock and tailings in the pit	More material than calculated	Investigate placing more waste rock underground.
Poor water quality discharged from site	Monitoring records of discharge, compliance limit exceeded	Suspend discharge (if possible). Advise DME and NT EPA. Conduct investigation.
Contaminated groundwater extends from pit or TSF	Monitoring bore water quality exceeds internal triggers	Resample bore/s. Undertake investigation of cause. Advise DME and NT EPA of outcome and proposed response
Fire jumps firebreaks	Bushfire on site	Protect personnel as first priority and critical infrastructure if possible.
New weed outbreak	Weed identified in inspection	Determine best control strategy and implement.

Outcome	Assessment Criteria	Contingency
Excessive erosion on TSF rehabilitation	Erosion monitoring shows erosion is continuing or gullies become hazardous	Identify cause of erosion. Ameliorate cause then repair erosion
Rehabilitation does not meet completion criteria	Rehabilitation monitoring, Rehabilitation Completion Inspection	Investigate cause of failure. Address cause of failure and monitor subsequent performance
Unauthorised access to site or pit is occurring	Vehicle tracks, cut locks, broken fences, livestock in mine	Repair fence, replace locks and remove livestock.
Water in storage dams do not meet livestock consumption quality	Water monitoring results exceed ANZECC livestock quality guidelines	Fence off water storage dams and inform pastoralist Rehabilitate and remove dam

13. Management of Information and Data

This MCP captures a summary of data relevant to closure planning and will be progressively updated to capture and summarise current closure planning information. Given the short life of the TGU Project, it is expected there will be minimal information infrastructure established at Toms Gully site itself. Information generated during operations of relevance to closure will be stored electronically at the Perth Corporate office and will be made available to regulators when required.

In addition to this MCP, Primary will capture the following information during both the operational phase and post-mining phase:

- Results of any rehabilitation monitoring or trials
- The digital mapping of the area rehabilitated and status of rehabilitation
- Record keeping requirements for the mining and placement of AMD materials mined or processed by the TGU Project as per the AMD Management Plan
- A survey of the Boxcut and underground will be conducted to provide an accurate record of the extents of mining for use by future operators with a copy to be provided to the DPIR
- All key approvals, technical reports and electronic data will be stored in Primary Gold's server in its corporate office to ensure it is available for future reference.

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APPENDIX C

Primary Gold Limited

Toms Gully EIS - Baseline Studies

Groundwater Assessment & Modelling

March 2018

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

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1. Introduction

1.1 Project background

Toms Gully Mine, located near Mount Bundey in the Northern Territory, has been in operation since 1988. The Toms Gully resource was discovered in 1986 by the Carpentaria Exploration Company. Following its discovery the project area has been operating intermittently under the ownership of several different operators, most recently Crocodile Gold, until 2010. Then, after a period of Care and Maintenance, it was divested to Primary Gold Ltd. Operating conditions at Toms Gully Mine have been subject to obligations outlined in the Public Environmental Review (PER) and associated documents that were released in 1988 and a series of waste discharge licences (WDLs).

Primary Gold Limited, the new lease owner, proposes to recommence underground mining and ore processing at the Toms Gully Mine. This will include:

- construction of a new process water dam;
- dewatering and refurbishment of the existing workings;
- upgrade of the new Tailings Storage Facility (TSF); and
- refurbishment and upgrade of the processing circuit.

The NT EPA determined that the Project required assessment under the *Environmental Assessment Act* at the level of an Environmental Impact Statement (EIS). A draft EIS document was lodged with the NT EPA in 2015. Subsequently comments were received, and this document contains further work in response to comments raised regarding hydrological conditions at the Toms Gully site.

1.2 Purpose of this report

The purpose of this report is to further define the current baseline hydrogeology of the site and provide a basis from which to identify existing conditions including hydrogeological impacts from previous mining operations, and against which to measure future hydrogeological impacts of the proposed mining operations.

1.3 Scope and limitations

1.3.1 Scope of works

The scope of works for this study includes:

- Review all available previous hydrogeological investigations;
- Identify any gaps in baseline data;
- Address critical data gaps;
- Update the site Conceptual Hydrogeological Model (CHM);
- Develop and calibrate a baseline numerical groundwater flow model to describe current conditions and to provide a basis for simulation of potential impacts.

1.3.2 Limitations

This report has been prepared by GHD for Primary Gold Limited and may only be used and relied on by Primary Gold Limited for the purpose agreed between GHD and the Primary Gold Limited as set out in section 1.3.1 of this report.

GHD otherwise disclaims responsibility to any person other than Primary Gold Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described throughout this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Primary Gold Limited and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has not been involved in the preparation of the EIS and has had no contribution to, or review of the EIS, other than in the Groundwater Model Report. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in, any other part of the EIS.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

1.4 Assumptions

GHD has assumed that the spatial hydrogeological, geochemical and other data provided by Primary Gold are accurate and representative of current site conditions. GHD recognises that the near-mine bore elevations have been inferred from LIDAR-derived ground elevations and hand-held GPS coordinates and consequently are not considered to have sub-metre accuracy. Beyond the extent of the LIDAR coverage, the location and elevation accuracy is likely to be even lower. Details of monitoring bore construction were not available for most bores but GHD has assumed they have been appropriately constructed and provide representative water samples and groundwater levels.

1.5 Previous investigations

Based on data presented in previous reports, historical hydrogeological assessments undertaken in the Project Area include the following reports were produced, of which only reports 5, 12 and 13 were available for review for the current baseline study:

1. Coffey & Partners Pty Ltd, (1988) A geotechnical and hydrogeological assessment, including inflow estimates for design of the mine, plant, and tailings storage facilities.
2. Dames & Moore Pty Ltd, (1991) Design and installation of ten groundwater monitoring bores, nine of which were to be incorporated into the water quality monitoring network of 13 groundwater sampling points and seven surface water sites.
3. Dames & Moore Pty Ltd, (1993) Assessment of surface water and groundwater quality data and recommendations for future monitoring of groundwater.
4. Rockwater Pty Ltd (1993) Assessment of the dewatering requirements of the open cut, including a pumping test (DB2) to estimate hydraulic parameters, used to construct a MODFLOWEM model to simulate pit dewatering.
5. Rockwater Pty Ltd (1994a) Initial assessment of the hydrogeology based on existing data and proposed drilling and testing program for developing and testing the groundwater supplies.
6. Rockwater Pty Ltd (1994b) Assessment of pumping requirements required to dewater the existing pit within three months, based on a numerical model to simulate the dewatering requirements.
7. Rockwater Pty Ltd (1995) Installation and testing of 6 groundwater exploration holes (WB1 to WB6), and 4 production bores (WB1P, WB4P, WB5P, and WB6P). Included a 48 hour constant rate pumping test on each production bore to determine aquifer hydraulic properties.
8. Evantech Pty Ltd (1997) provided a short summary of issues surrounding disposal of excess water in the Project Area.
9. Water Studies Pty Ltd (2000). A groundwater inflow assessment for the open pit and water balance simulations to assess the potential to dewater the pit during the 2000 dry season.
10. H2O Pty Ltd (2001) A rehabilitation program on 4 bores, DB2, P62, P68, and P73, which included jetting and surging or airlifting each bore between 4-11 hours.
11. Australasian Groundwater and Environmental Consultants (AGE) Pty Ltd (2004a, and 2004b) Two reports providing a hydrogeological assessment and numerical modelling of dewatering options. Included recommendations for an expanded groundwater monitoring network and testing regime.
12. Coffey. (2015). Toms Gully Gold Mine Water Balance Model.
13. Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) (2015). Review of groundwater inflow data collected since 2005. The previous numerical model was updated to provide groundwater inflow estimates to the existing and proposed underground mine areas.
14. Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) (2015). Groundwater Impact Assessment. Review of previous reports, updating of conceptual hydrogeological model, development of updated monitoring network to define baseline conditions and assess future impacts on water levels and chemistry and assessment of impacts from dewatering, surface water, tailings and waste rock storage. The report included a description of baseline geochemistry and hydraulic properties, upon which this study builds.

2. Site description

2.1 Regional Climate

The Toms Gully Mine project area is within tropical northern Australia and has a tropical monsoonal climate with a pronounced wet season from October to April (Figure 2-1) Long-term rainfall data was available from the Bureau of Meteorology (BoM) weather station located at Wildman Rangers (Station 14275) which is the nearest active BoM rainfall station to the site.

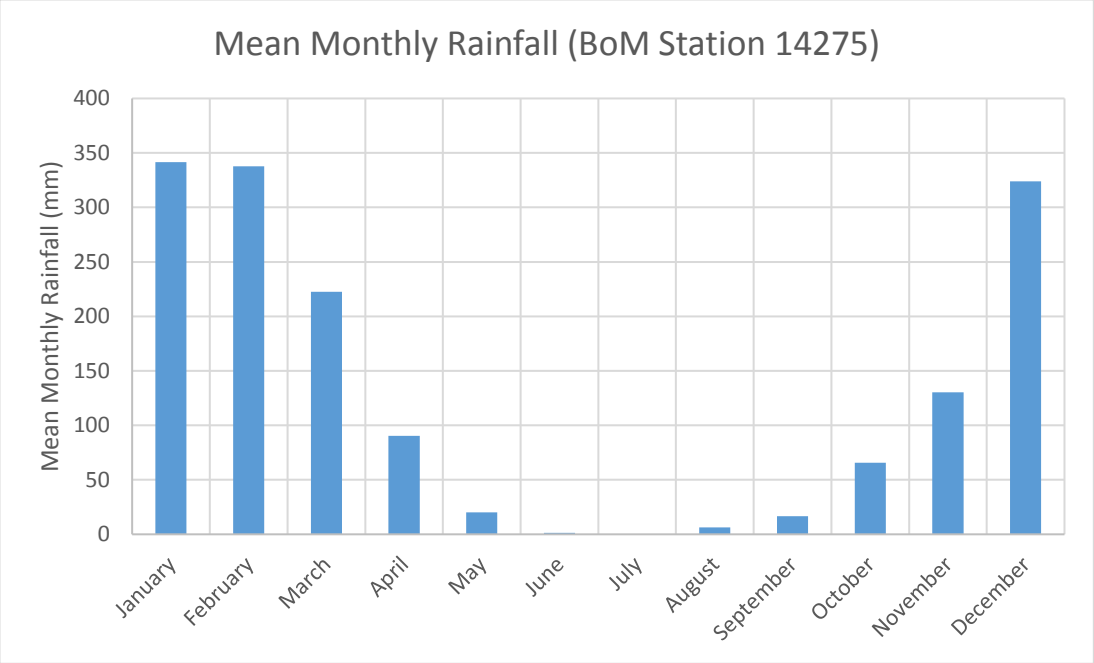

Figure 2-1 Mean monthly rainfall (BoM station 14275)

Water courses in the project area are ephemeral and cease to flow during the late dry season, but have regular flows during the wet season, extending into the early dry season for the major water courses. Some seasonal and semi-permanent waterholes exist in the project area. These are likely to be ecologically important as they likely serve as a refuge for fish and aquatic reptiles during the dry season (GHD, 2015).

2.2 Surface water features

The Toms Gully Mine site is within the Mount Bundy Creek catchment, which comprises a series of small ridges and dissected hills that are drained by small, steep rivulets, which converge into Mount Bundy Creek. The majority of the catchment upstream of the project area consists of outcropping rock with thin soil cover and shallow alluvium drainage lines. The total catchment area upstream from the mine is approximately 117 km^2. Mount Bundy Creek flows west to east along the northern section of the project area. Coulter Creek is a tributary of Mount Bundy Creek and flows southwest to east (to the south of the project area). Coulter Creek flows into Mount Bundy Creek downstream of the project area.

Mount Bundy Creek is approximately 30 km long with approximately 13 km upstream of the mine site. The creek has several tributaries upstream of the project area and ultimately drains into Hardies Creek then the Mary River. The *Water Act* provides a framework for the declaration of beneficial use and objectives in the Northern Territory. Currently Mount Bundy Creek Beneficial Use Declaration (1997) states that: Stock water supply is the beneficial use extending from the Arnhem Highway Crossing approximately 3 km downstream. The

remainder of Mount Bundy Creek has aquatic ecosystem protection objectives defined as 'Fresh waters' aquatic ecosystem protection guidelines (ANZECC & ARMCANZ, 1992). However, this guideline has been superseded by ANZECC & ARMCANZ (2000) and these values have been replaced with the 80% species protection level for water quality assessment (GHD, 2015) and 95% species protection level for this report as a conservative approach. Note that both the 80% and 95% protection level offer a greater level of ecosystem protection that the stock watering trigger values. Several small waterholes were observed along Bundy Creek during the dry season, some of which, adjacent to the open cut area, appeared to be spring fed as indicated by damp areas on the creek bank, but significant groundwater discharges were not observed (Wyatt Pers comm 2018).

2.3 Mine Features

In a hydrogeological context, the significant mining features (Figure 2-2) include:

- Flooded open cut pit and connected underground workings;
- Water storage dam (referred to as Lake Bazzamundi);
- Evaporation Ponds (EP1 and EP2)
- Tailings storage facilities (TSF1 and TFS2); and
- Waste rock dumps (Sulphide WRD and Oxide WRD).

LEGEND

- Mine Site Layout
- Water Body Perennial
- Watercourse Intermittent

Paper Size A4

0 250

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

N

Primary Gold Limited
Toms Gully EIS\Groundwater Assessment

Job Number 43-22623
Revision 0
Date 22 Sep 2017

Mine Site Layout

Figure 2-2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

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Data source: Commonwealth of Australia (Geoscience Australia): DTDB, 2015. ESRI: Imagery, 2017. Created by: tmorton

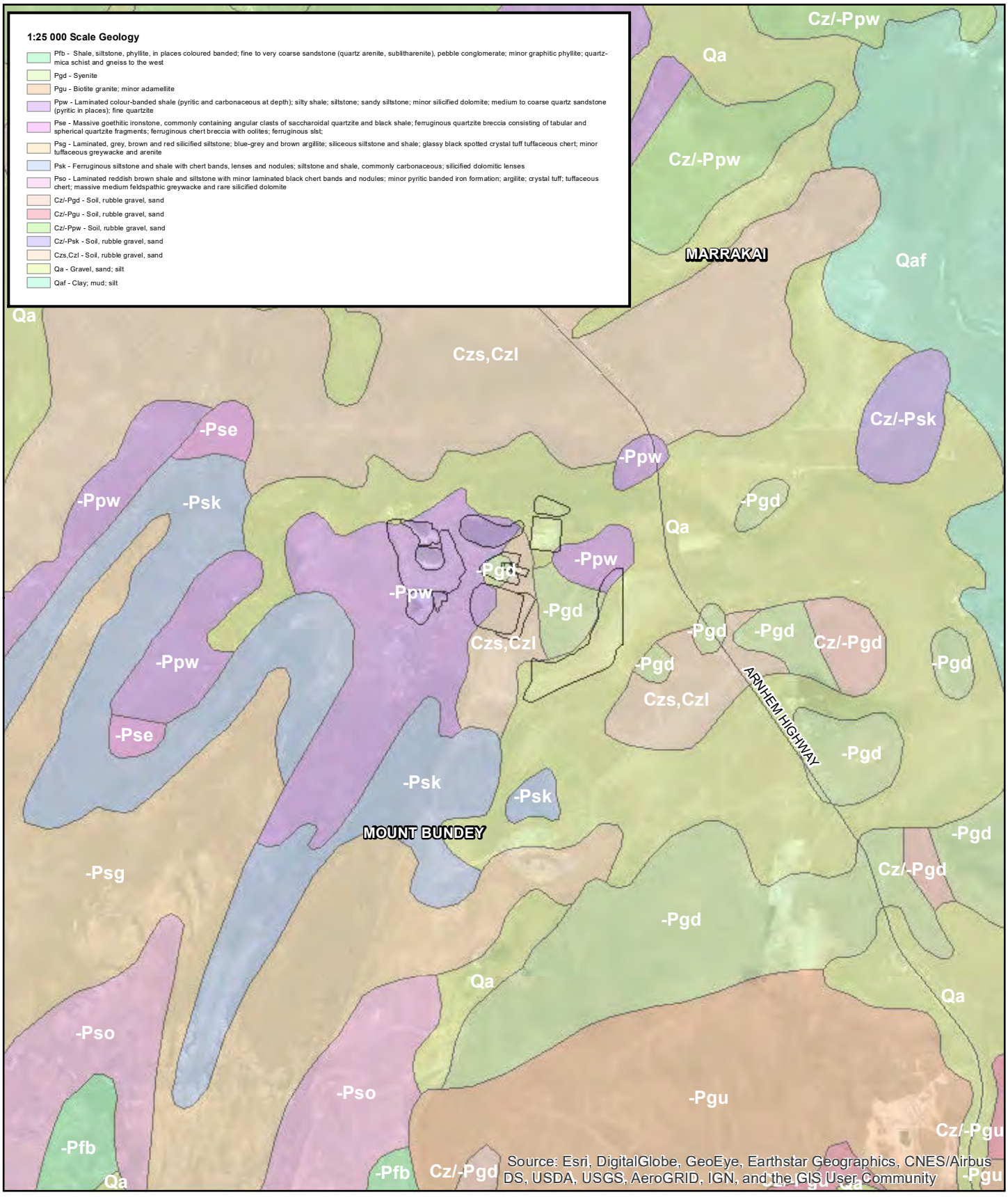
3. Geology and topography

Soil cover is generally thin (0.5 to 4 m) and alluvial sediments are confined to present day drainage features and not laterally extensive. The surface elevation of the Project Site reaches 51 m Australian Height Datum (AHD) in the southwest corner of the mining lease and falls to 16 mAHD in the low-lying areas. The local geology is summarised in Table 3-1 and Figure 3-1 below.

Table 3-1 Summary of Local Geology (compiled from AGEC 2004 and Rockwater 1994)

Area	Description
Geology	
Alluvium	Mount Bundy Creek crosses the Project area approximately 300 m north of the Toms Gully Pit. The thickness or presence of alluvium associated with this water course is unknown. A review of aerial photography suggests, if present, it is confined to the present day channel and not laterally extensive. Rockwater (1994) considered the alluvial sediments to be relatively clayey.
Wildman Siltstone	The Wildman Siltstone part of the Mount Partridge Group and the Woodcutters Supergroup consists of siliceous, predominantly banded, dark grey siltstone, and black, silty shale, with beds of quartz sandstone. The sediments were deposited in a shallow marine, prodelta or mid-shelf depositional setting during the Orosirian (2029 Ma to 1890 Ma) geologic period. It is commonly highly fractured. The Wildman Siltstone is the host rock at the site.
Cullen Supersuite	The Cullen Supersuite comprises of a number of I-type granitic plutons which formed approximately 1835 Ma to 1820 Ma. The Mount Bundey Suite is part of the Cullen Supersuite and comprises of the Mount Bundey Granite and the Mount Goyder Syenite. The Mount Goyder Syenite outcrops to the east of the Open Pit and the Crabb Fault. The intrusion was intersected by the decline. The intrusion has produced an approximately 500 m wide hornfelsed aureole in the siltstone which is generally more resistant to weathering compared to the intrusion. The syenite is not extensively fractured
Lamprophyre Dykes	Lamprophyre dykes have been identified within pre-existing structures at Toms Gully Mine. Although the dykes intrude both members of the Mount Bundey Suite, they are thought to be co-genetically and temporally related to the granitoids.
Geological Structures	
Folding	A series of gentle folds are mapped across the Project site including a fold in the pit wall. The fold axes trend north-northeast and plunge gently to the south, parallel to the plunge of the quartz vein.
Crabb Fault	The Crabb Fault is a south-southwest trending fault which dips to the west at approximately 80 degrees. The Crabb fault intersects the eastern end of Toms Gully Open Pit and represents the eastern extent of gold mineralisation. Although the apparent displacement of the Crabb Fault is small, the quartz vein steepens significantly to the east of the fault and changes in strike from east-west to northeast-southwest. The nature of the Crabb Fault zone is highly variable, at the Open Pit high wall the fault is a fractured rock mass up to 15 m wide and has resulted in slope failures during mining. However, at the low wall there is little evidence of the fault. Where the fault has been intruded by dykes, the material is often highly weathered and of very low strength. It contains sulfides, fractured quarts and laminated black shale.
Williams Fault	The Williams Fault is located approximately 400 m west of the Crabb Fault and is believed to be the western extent of the ore zone. Previous investigations suggest

Area	Description
	that there is approximately 15 m displacement along the Williams Fault at the Project Site. Dyke intrusions have been identified at random locations along the fault trace, with localised quartz infilling.
Ore Zone Fault	The ore zone is in the form of a 0.5-4 m-thick, quartz-filled breccia zone, with associated arsenopyrite and pyrite, along an unnamed thrust fault, dipping at a shallow angle to the south. It extends at least 1500 m down dip from the open cut.



LEGEND

Mine Site Layout

Roads

Paper Size A4

0 0.5 1 1.5 2

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

N

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Toms Gully EIS\Groundwater Assessment

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Revision 0
Date 22 Sep 2017

Site Geology

Figure 3-1

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Data source: Commonwealth of Australia (Geoscience Australia): DTDB, 2015. ESRI: Imagery, 2017. Created by: tmorton

4. Hydrogeological characterisation

4.1 Hydrogeological Units

Previous work by AGEC (2004) and Rockwater (1994) has identified three broad groundwater systems/hydrogeological units within the project area. They are:

- Upper weathered profile in the Wildman Siltstone and more distance metasediments and igneous rocks, with relatively low permeability;
- "Fresh" Wildman Siltstone and other fractured rock aquifers with moderate to high permeability; and
- The highly permeable ore body fault zone and the Crabb Fault

The fresh Wildman Siltstone acts as a fractured rock aquifer with little to no primary porosity between fracture zones. Typical of fractured rock aquifers, the permeability is dependent of regional tectonic fracturing, characterised by vertical jointing and the discrete faulting noted above, overprinted with extensive sub-horizontal jointing associated with stress relief as overlying rock is removed by erosion. Fracturing is more intense along fold axes (Coffey, 2015).

In most lithologies, the density of this stress-relief fracturing gradually decreases with depth, typically becoming negligible at around 50-100 m below surface. The fracturing is commonly partially blocked by clayey weathering products at the base of the weathering profile. Although the extent of fracturing will vary with primary lithology, tectonic and erosional history, a typical permeability profile (with approximate depths), which tends to follow topography, may be:

- Shallow extremely weathered rock and soil/alluvium (0-10 m)
- Low to moderate-permeability, partially weathered fractured rock with clay filled stress-relief and tectonic fractures to a depth of 40 m (Coffey, 1988);
- Permeable, fractured rock with open stress-relief and tectonic fractures (40-60 m);
- Deep low-permeability rock with tectonic fracturing only (60-100 m+).

The adjacent syenite and other igneous rock are likely to follow a similar pattern, complicated by the addition of cooling fractures/joints, although it was observed at the site to be significantly less permeable (Rockwater, 1994) .

The ore zone is bounded to the west by the Williams Fault and to the east by the Crabb Fault and is the primary aquifer at the site. It comprises a mylonite and breccia zone around 1-2 m thick, dipping initially at around 30° to the south at the sub/outcropping, northern end (~30 mAHD), and flattening out to less than 10° at the southern end, from around 400 m down-dip, at a depth of around 200 m (-210 to -230 mAHD). Airlifted yields from exploration boreholes drilled in the ore zone were relatively high, at up to 25 L/s with an average of 5 L/s, where recorded (AGEC, 2004).

The Crabb Fault, approximately 15 m wide, is also highly permeable in places (AGEC, 2004) whereas the Williams fault is considered to be a low-permeability flow barrier.

4.2 Groundwater monitoring

Groundwater monitoring is currently undertaken at the project site with the groundwater monitoring network comprising nine bores, the details of which are shown in Table 4-1, in addition to the historical bores not regularly monitored. The location of the bores and the loggers is shown on Figure 4-1. In December 2016, GHD installed groundwater level loggers in

three monitoring bores (DB1, WB4P and G9) and a single logger on the Pit to automatically record the fluctuation in groundwater and pit water level. Logger data from 08/12/2016 to 06/07/2017 was available for this study. The bore locations are based on hand-held GPS or historic approximate locations, with elevations based on LIDAR ground surface elevations for near-mine bores and SRTM data for others and some bores show a significant difference between GPS and database location data. Consequently the locations and ground elevations (and resultant groundwater elevations) potentially have significant errors. It is proposed to carry out a differential GPS survey in the next dry season to improve location accuracy.

Table 4-1 Groundwater Monitoring Network

Monitoring Bore	Coordinates		Elevation[a] at TOC (m AHD)*	Depth (m BGL)	Screen Interval (m BTOC)		Date Installed
	Easting	Northing			Top	Bottom	
Currently Monitored Bores (AGE 2015)							
WB1P (Ridge Bore)	777559	8579124	54.2	-	-	-	-
WB5P	776808	8579425	31	106.88	58.8	106.9	19/11/94
BORE 11	777288	8579016	37.1	-	-	-	-
OB11	777186	8580322	20.1	-	-	-	-
G1	777009	8580348	25.3	15.5	13.5	15.5	18/09/91
G2	777683	8579727	42.7	21.5	19.5	21.5	18/09/91
G8	777021	8580019	33.5	26	22	26	20/09/91
G9*	777663	8580478	21.9	30.5	28.5	30.5	21/09/91
RN29694 (WB4P)*	776935	8580080	27.1	95.83	42	95.8	21/11/94
Other Existing and Historical Monitoring Bore							
S01#	777477	8579112	51.29	-	-	-	27/04/15
W6#	777330	8579561	43.85	55	40	55	14/06/88
No. 1#	777330	8579561	43.85	79	67	79	15/11/87
WB2 (Oxide dump bore)#	777680	8579480	45	-	-	-	10/11/94
WB6P (Tailings bore)	777316	8579631	40.1	108.32	60.6	108.3	24/11/94
DB2#	777879	8579910	34	110	95	110	18/07/93
DB1*	777746	8579911	40.4	132	78	132	14/07/93
W7#	776930	8579990	32	93	78	93	16/06/88
W4#	776930	8580160	32	73	63	73	9/06/88
W5#	776930	8580300	27	65	50	65	12/06/88
RN035637#	777580	8580319	28	-	-	-	22/02/07
W01#	778353	8580376	21	-	-	-	17/06/05
W02#	778354	8580441	21	-	-	-	17/06/05
WB3	778340	8580420	18.5	-	-	-	13/11/94
P90	778124	8580051	22.4	-	-	-	-
P62	777751	8580001	44.8	-	-	-	-
P68#	777782	8579972	38	-	-	-	-
P73#	777850	8579991	30	-	-	-	-
Gully Bore#	777385	8579183	48	-	-	-	-
G3	777352	8580420	18.6	18	12	18	18/09/91
G4#	777373	8580051	31	42	30	42	18/09/91
G5#	778253	8579448	32	10.5	8.5	10.5	19/09/91
G6	777182	8579325	35.2	42.5	36.5	42.5	19/09/91
G7a	777246	8580558	22.72	18.5	16.5	18.5	20/09/91
G7b	777246	8580541	22.72	38	32	38	22/09/91

Monitoring Bore	Coordinates		Elevation[a] at TOC (m AHD)*	Depth (m BGL)	Screen Interval (m BTOC)		Date Installed
	Easting	Northing			Top	Bottom	
G10#	777546	8579602	45	-	-	-	21/09/91
OB10	777296	8580330	19.0	~30	-	-	-
RN034537	778581	8579656	37	242	84	242	7/05/05
RN034538	778581	8579656	37	187.7	44	187.7	12/05/05

* Logger installed December 2016

a Elevation based on LIDAR or SRTM.

Not inspected as part of this study and elevations by SRTM hence elevation ± 10 m

4.3 Groundwater usage

The NT groundwater database (accessed 2017) contains 37 registered bores (Table 4-2) within a 4 km radius of the lease boundaries, including 18 registered bores (bold and underlined) included in the monitoring network (Table 4-1). The locations of these bores are shown in Figure 4-2. The bores are used primarily for stock or domestic supplies, with yields ranging from less than 1 L/s to 25 L/s. The high-yielding production bores are generally less than 50 m deep.

The coordinates in the NT database appear to be based on sketched locations from the licence application rather than survey data as they show a significant mismatch (some in the order of 1 km) with the site bores with GPS survey locations.

Table 4-2 Registered Bores

Bore number	Other name	Use	Drilled depth (m)	Water level (mbGL)	Yield (L/s)
RN005881	B 1 MT.BUNDY MINE CAMP SITE	investigation	45.7	10.7	0.94
RN005882	B 2 MT. BUNDY MINE CAMP SITE	not in use	45.7	-	0
RN005912	NO.3 MT BUNDY STN SITE K	production	36.6	7.9	25
RN006924	Mt Bundy Mine No 1	production	54.9	8.8	4.54
RN008712	MT. BUNDY STN. CRUSHER SITE	production	10.6	1.8	1.5
RN024729	BALDWIN T OLD MT BUNDY MINE	production	16	3	0.5
RN024730	BALDWIN T OLD MT BUNDY MINE	production	20	2.5	0.38
RN025598	No. 1	production	79	7	5.1
RN026200	W4	production	73	8	3.12
RN026201	W5	production	65	8	7.2
RN026202	W6	production	55	8	4.5
RN026203	W7	production	93	7	12.5
RN027479	POLICE CADETS BORE MT. BUNDY AREA	production	32	-	10
RN027654	QUARRY INDUSTRIES MT.BUNDY	production	66.7	-	1
RN027956	HOMESTEAD NO.2 OLD MT.BUNDY	production	39	7	3
RN028318	DB2	production	110	57.6	5
RN028319	DB1	observation	132	69.8	3
RN028786	BARRY COULTER 1/93 MOUNT BUNDY	production	78	44.5	1

RN029677	W02	investigation	74.3	-	0
RN029678	W01	investigation	-	-	0
RN029679	S01	investigation	-	-	0
RN029690	WB2	observation	121.6	31.4	2.5
RN029691	WB3	observation	115.5	7.8	0.5
RN029692	WB1P	production	114	39	10
RN029693	WB5P	production	111	12.1	10
RN029694	WB4P	production	96	11.9	15
RN029695	WB6P	production	108	23.6	6
RN033879	CHRISTIAN OUTREACH CENTRE (T. BALDWIN)	not in use	54	-	0
RN033880	CHRISTIAN OUTREACH CENTRE (T. BALDWIN)	production	54	8	12
RN033881	CHRISTIAN OUTREACH CENTRE (T. BALWIN)	production	72	-	13
RN034537	RENERSONS N/L MINE	production	242	-	5
RN034538	RENERSONS N/L MINE	production	187.7	-	4
RN035637	RENISONS	other	265	-	3
RN035786	B.F. COULTER	Irrigation	30	10	16
RN036024	B.F. COULTER	none	60	dry	dry
RN037520	Drill & Fire Pty ltd	production	40	3	0.5
RN038456	B.F. Coulter (Boral Quarries)	production	79	10	1

Paper Size A4

0 40 80 160 240 320 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

N

LEGEND

- Groundwater monitoring bores
- Mine Site Layout
- Water Body Perennial
- Watercourse Intermittent
- Drain

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Job Number 43-22623
Revision A
Date 14 Mar 2018

Near Mine Groundwater Monitoring Locations

Figure 4-1

G:\43\2262304\GIS\Maps\Working\Report\4322623_103_Near Mine Bores_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: drockliff

Paper Size A4

0 35 70 140 210 280 350

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

N

LEGEND

- Registered Bores
- Mine Site Layout
- Water Body Perennial
- Watercourse Intermittent
- Drain

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Toms Gully EIS\Groundwater Assessment

Job Number 43-22623
Revision A
Date 14 Mar 2018

Registered Bores

Figure 4-2

G:\43\2262304\GIS\Maps\Working\Report\4322623_105_Registered_Bores_RevA.mxd

2 Salamanca Square Hobart TAS 7000 Australia T 61 3 6210 0600 F 61 3 6210 0601 E hbamail@ghd.com W www.ghd.com

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: drockliff

4.4 Groundwater levels and flow

4.4.1 Historical data

Pre-mining groundwater levels in the northern part of the mine ranged from 15 mAHD to 18 mAHD (Coffey, 1988), with the watertable in the pit area at approximately 16 mAHD (Rockwater, 1993). AGE (2015) noted that bore WB3, to the northeast of the open cut, did not show a response during pit dewatering in 2004 (Figure 4-3), suggesting a lack of connection to the faults or mine voids and a low hydraulic conductivity to the east of the Crabb Fault. In contrast DB1 and DB2 showed a direct connection to the pit, plotting along the same curve as the pit water level and P90 showed a partial connection, plotting as a subdued version of the pit water level drop. Primary Gold (2015) presented a cross section schematic representing the contempory groundwater levels relative to the mine features (Figure 4-4).

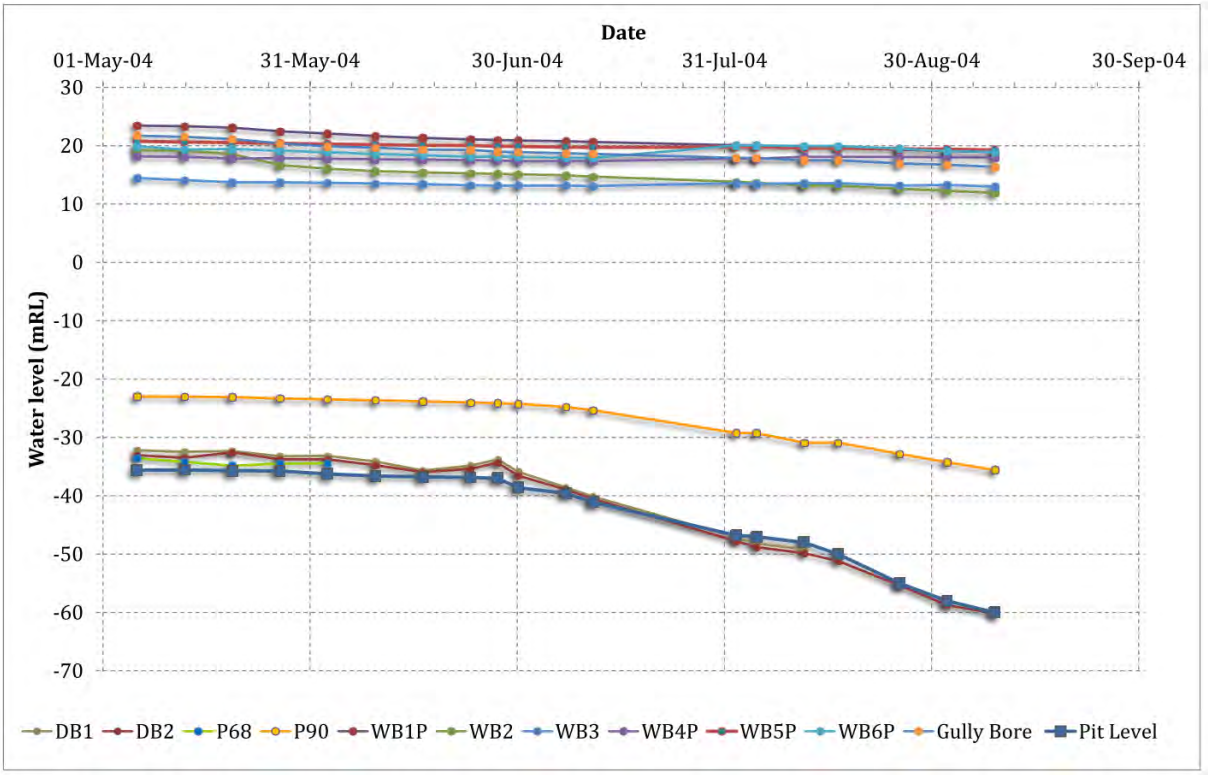

Figure 4-3 Groundwater Hydrographs 2004 (AGE 2015)

4.4.2 Groundwater levels 2016-2017

Groundwater levels in the vicinity of the mine were measured in all accessible bores on 8 December 2016 with water level loggers fitted to bores DB1, WB4P and G9 and the open cut pit lake, along with a barometric logger. The readings, which ranged from 4.10 m to 38.98 m below the top of casing (BToC) or 6.6 to 18.0 mAHD[1], represent end of dry season conditions. Simple Krigged contours of water levels (Figure 4-5), which do not take into account geological or other hydrological conditions, show a hydraulic gradient in December 2016 towards the flooded opencut. The apparent low point is displaced south of the pit due to the lack of monitoring points on the northern perimeter. At the time, the water level in the open cut was approximately 6.8 mAHD and the adjacent bed of Bundy Creek, around 350 m to the north of the pit perimeter, is at an elevation of 13 mAHD. This indicates that the open cut was likely to

[1] Bore collar elevations are based on LIDAR ground elevations lateral coordinates are based on hand-held GPS and consequently are considered to only have metre-order accuracy at best.

be acting as a sink for surrounding groundwater, including that beneath the various waste rock dumps and tailings storage facilities.

Groundwater levels were elevated around the sulfide waste rock dump (SWRD) and adjacent evaporation ponds (EP1 and EP2). This is consistent with observations of limited capping and surface drainage on the waste rock dump top and side slopes and porous nature of the waste rock, which will result in high levels of recharge. Similar mounding around the SWRD and oxide waste rock dump (OWRD) were noted by Dames and Moore (1993). However, water levels were similar at the two southernmost bores Bore 11 and WB1P Ridge Bore, suggesting localised recharge from the WRD was not the only source of mounding, with seepage from TSF1 and Old Decant Pond being a potential source. It is also possible that the shallow bores such as G1, OB111 and OB10 intercept shallow aquifers.

Water level data, recorded at 6-hourly intervals from 8 December 2016 to 6 July 2017 (date of most recent download) are presented in Figure 4-6 to Figure 4-7. The pit and monitoring bores show a clear increase in water levels over the wet season. Bore DB1 (Figure 4-6) closely mimics the open cut pit water level (Figure 4-7), increasing from around 6.5 mAHD to 8.95 mAHD and dropping to 8.88 mAHD over the remainder of the logged period to 6 July 2017, suggesting near direct connection of the local aquifer with the pit or underground voids. At the end of the logging period, the water level in the pit was still around 4 m below Bundy Creek bed level and the surrounding groundwater, indicating the pit was still acting as an evaporative sink.

G9 and WP4B showed an increase of around 4 to 5 m until the end of March 2017, then a steady decline of around 1.5 to 2 m until July 2017, which is typical of seasonal groundwater recharge and discharge. At all times, the water level in the pit was below the surrounding groundwater level, other than for DB1.

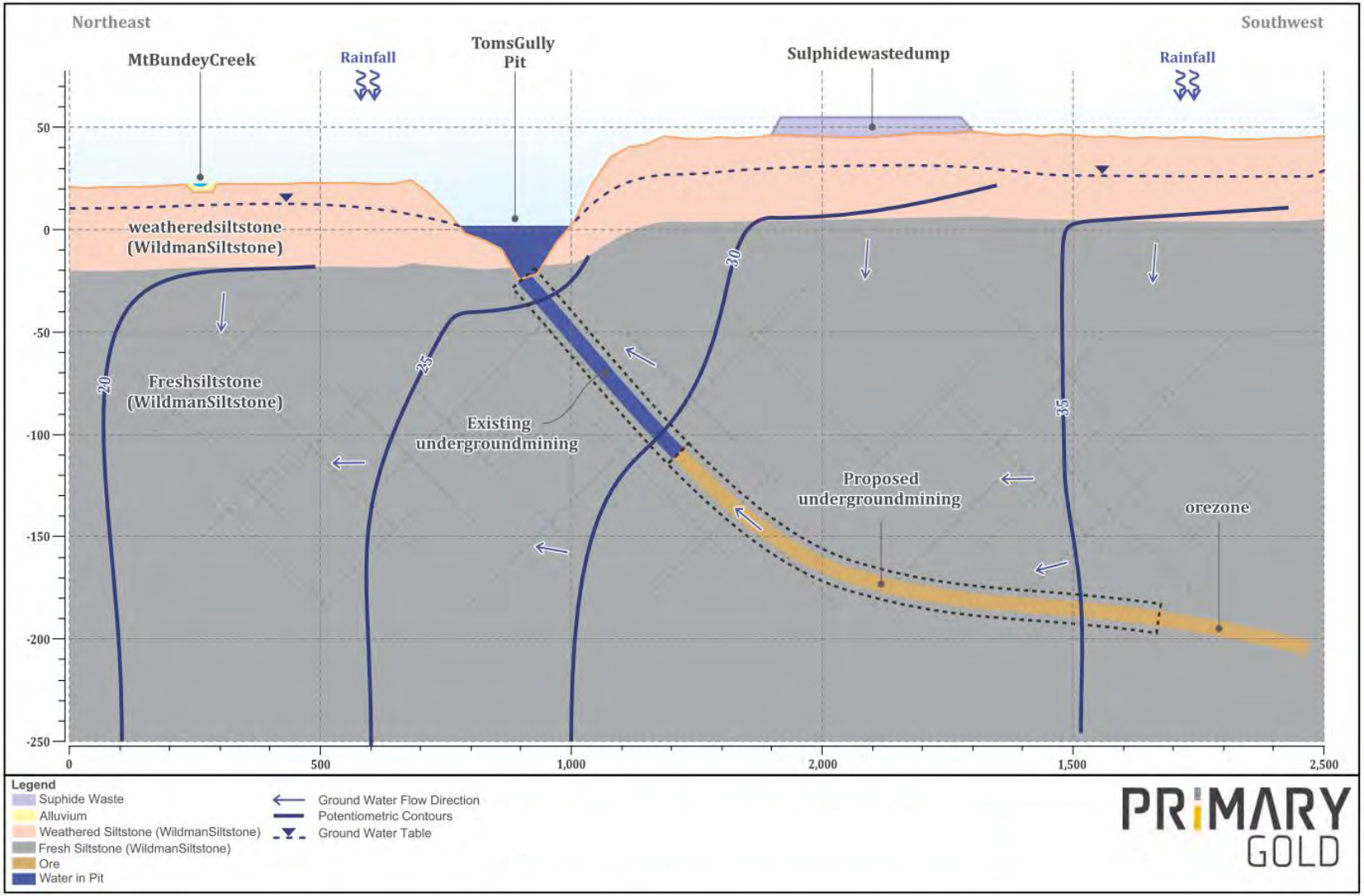

Figure 4-4 Site groundwater cross-section contours in mAHD (Primary Gold, 2015)

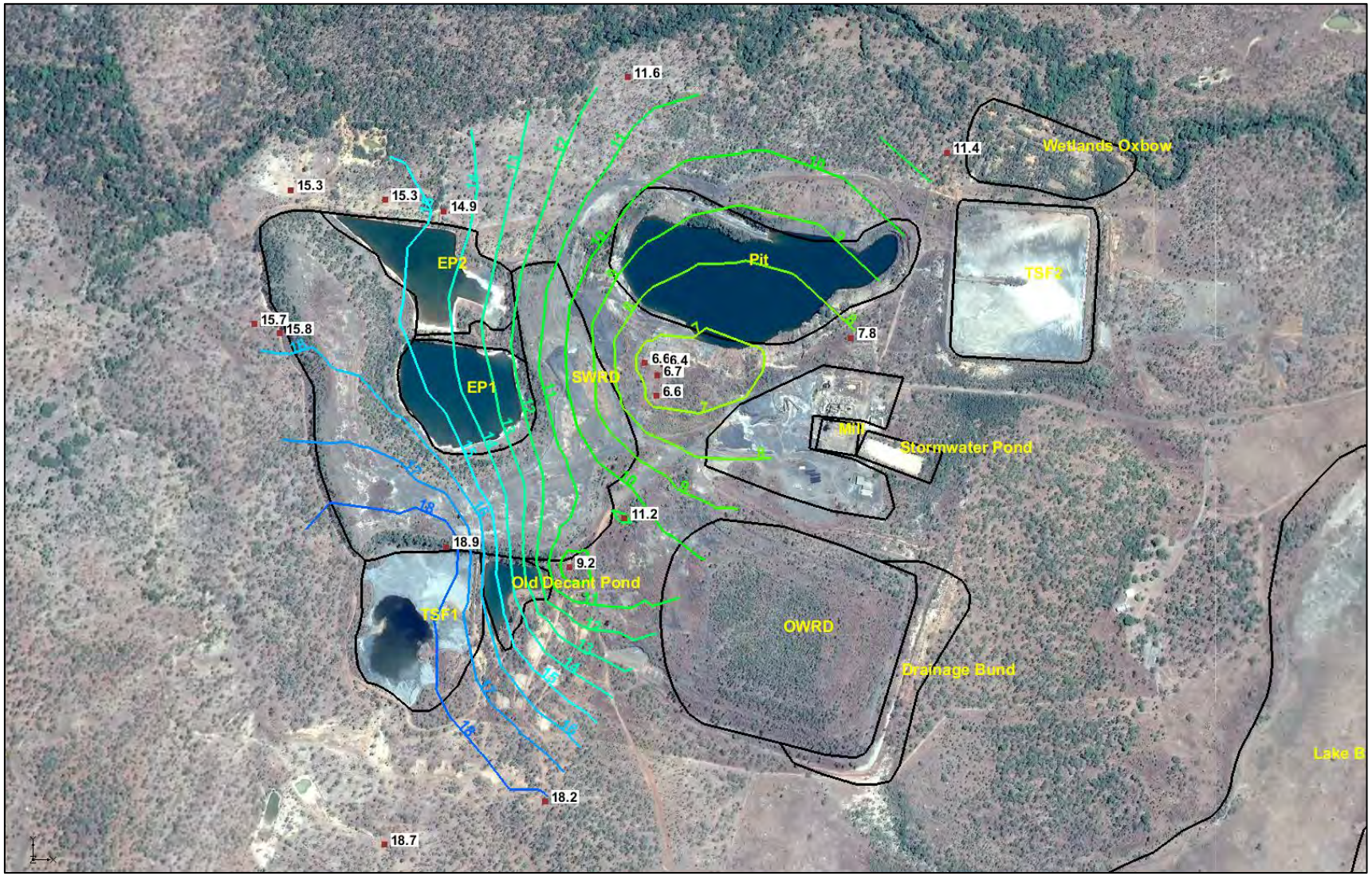

Figure 4-5 December 2016 groundwater levels and contours (mAHD)

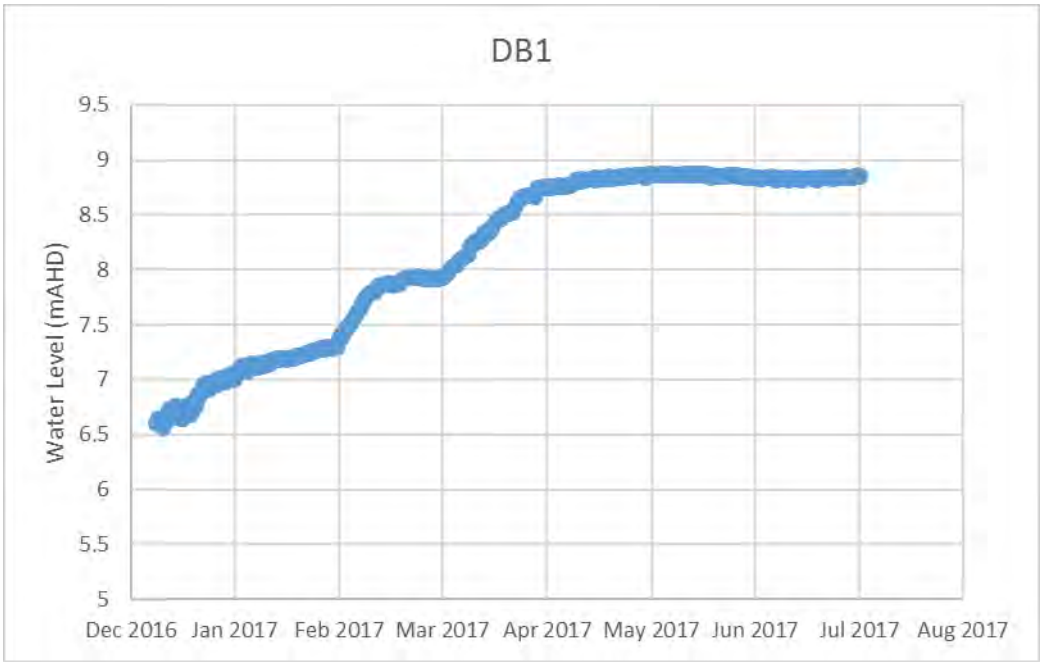

Figure 4-6 Water levels DB1

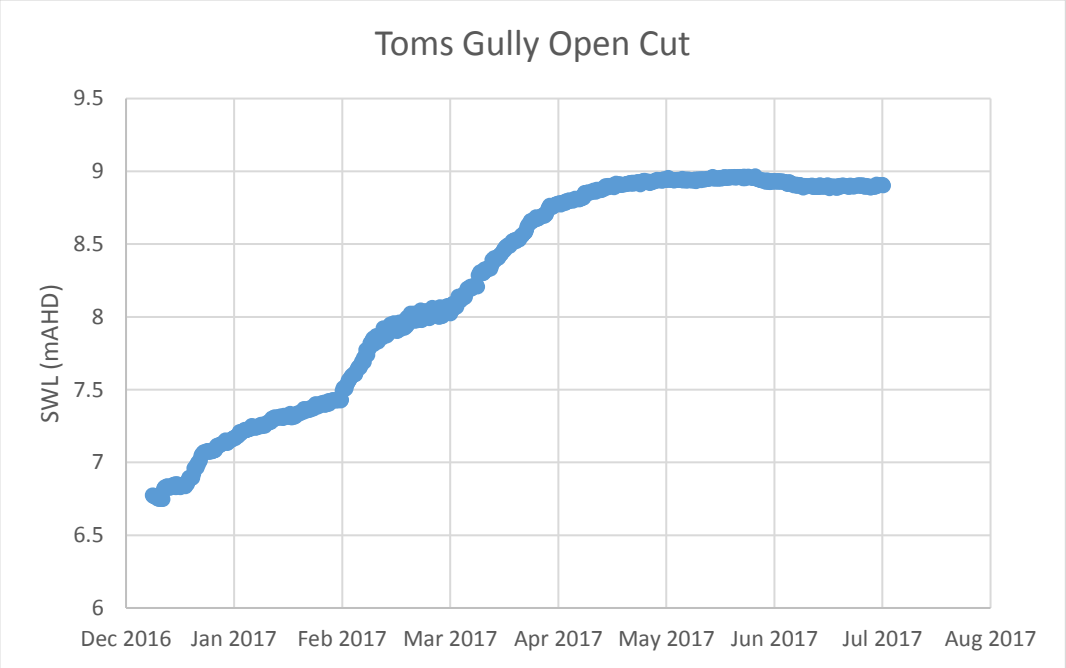

Figure 4-7 Water Levels Open Cut

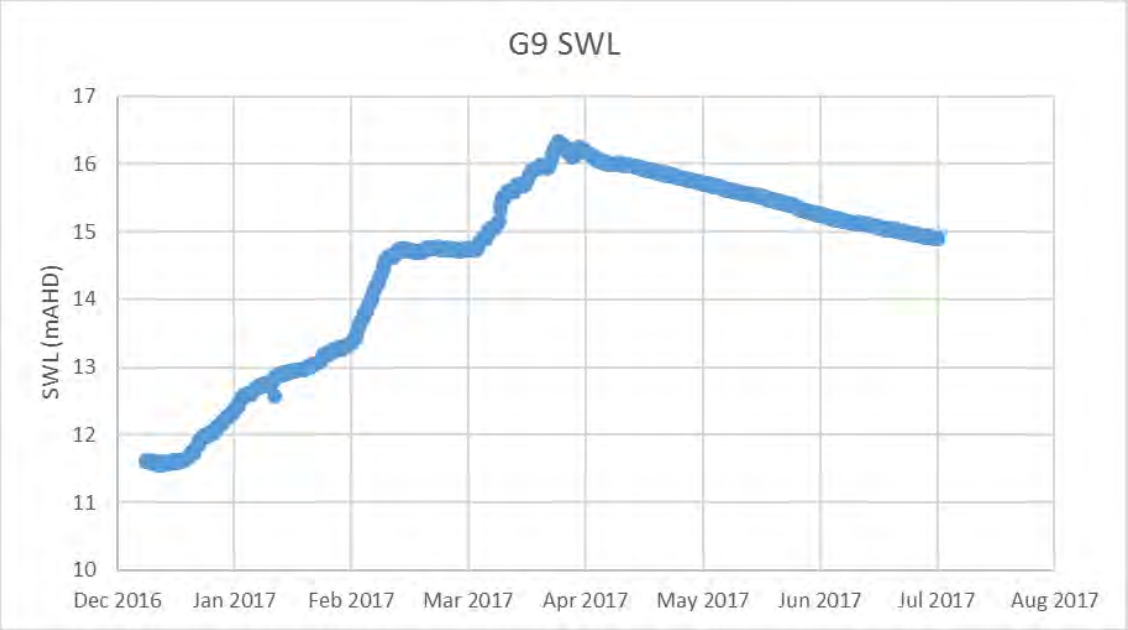

Figure 4-8 Water levels G9

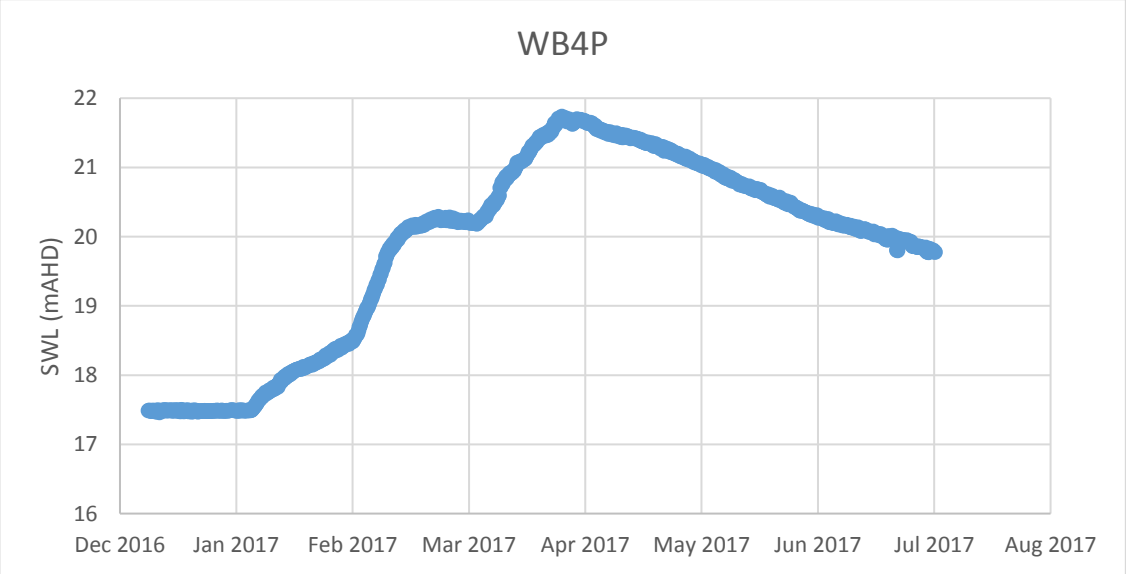

Figure 4-9 Water levels WB4P

4.5 Groundwater recharge and discharge

Recharge to the fractured groundwater system, the ore zone and Crabb Fault, is likely to be via direct infiltration where they outcrop, via seepage from the overlying weathered siltstone and due to direct contact with the mine voids. Other than the immediate pit area, it is unlikely that there is significant recharge from the local creeks given their ephemeral flow and the elevation of the surrounding groundwater above creek level, where measured.

Recharge estimates, for the grid segment at 12.85º S 131.55º E, were derived from the Deep Drainage values from Bureau of Meteorology's Australian Landscape Water Balance web site http://www.bom.gov.au/water/landscape.

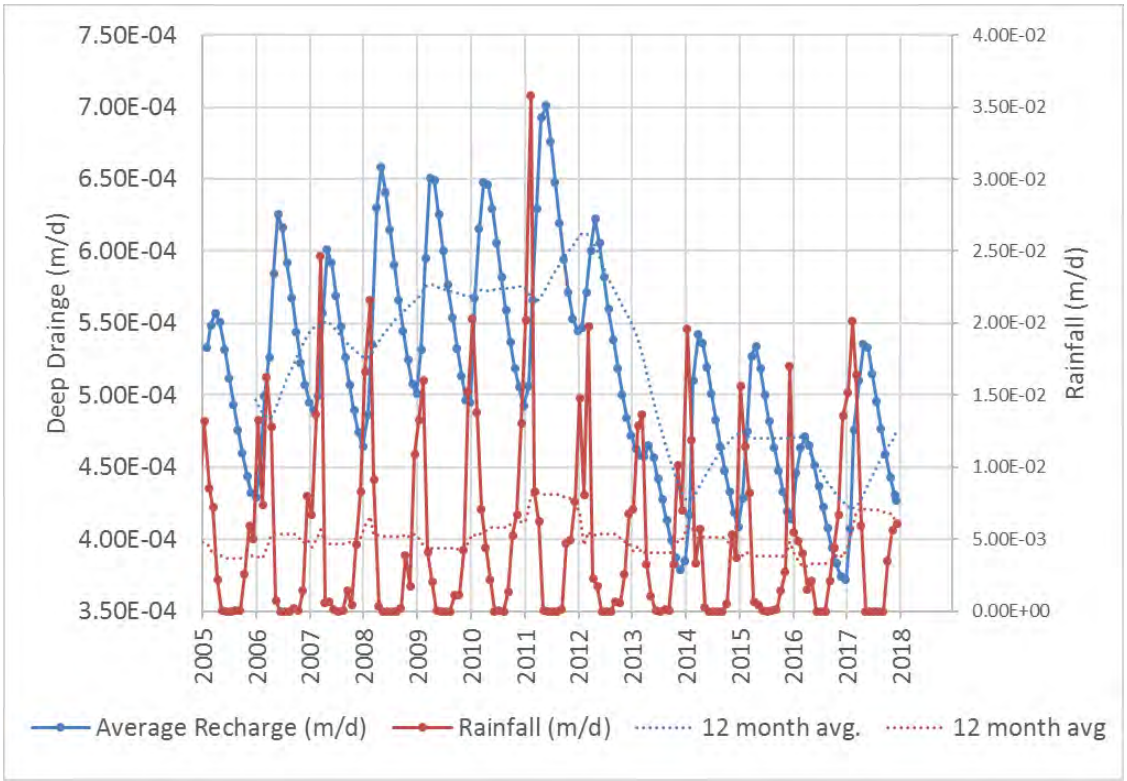

Figure 4-10 Estimated recharge and rainfall (BOM)

The data show recharge is highly seasonal with almost all recharge occurring late in the wet season months from November to April, with a lag between peak rainfall and peak recharge of approximately 3 months. The moisture balance suggests that 20% of annual rainfall recharges the groundwater system. This is high, being at the upper end of the expected range for the northern part of Australia where the soil profile becomes saturated during the wet season promoting deep drainage.

Historical mining data indicates groundwater inflows to the open cut pit were approximately 30 L/s to 40 L/s (Coffey, 2015). This was achieved by a combination of dewatering bores and in-mine pumping. By 2010, the underground mine and pit was dewatered using 3 in-mine pumps discharging a total of 32 L/s (AGE, 2015). No data are available on local creek ephemeral baseflow, including Bundy Creek.

4.6 Groundwater Chemistry

Multiple groundwaters analyses are available for several bores at the site (n = 149) and average results are provided on Figure 4-11. Groundwater ranges from fresh (<500 mg/L TDS or 770 <uS/cm EC) in G9, Bore 11 and Ridge Bore to saline in OB11, which was the only bore to consistently exceed stock watering guidelines for EC and sulfate. G1 consistently exceeded the stock watering guidelines sulfate or pH.

The groundwater results were compared against the Australian Drinking Water Guidelines – Health and Aesthetic (ADWG) (NHMRC, NRMMC, 2011), ANZECC & ARMCANZ Protection of Freshwater Ecosystem Values 80% and 90% (FAE80% and FAE90%) and the ANZECC & ARMCANZ 2000 Livestock Watering guidelines (ANZECC & ARMCANZ, 2000). These results are shown in Table 4-3 - Table 4-6.

LEGEND

- Groundwater monitoring bore
- Mine Site Layout
- Water Body Perennial
- Watercourse Intermittent

Paper Size A4

0 250

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 52

N

Primary Gold Limited
Toms Gully EIS\Groundwater Assessment

Job Number 43-22623
Revision 1
Date 22 Sep 2017

Summary Geochemistry

Figure 4-11

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 **T** 61 2 4979 9999 **F** 61 2 4979 9988 **E** ntlmail@ghd.com **W** www.ghd.com.au

G:\43\2262304\GIS\Maps\Working\4322623_106_Summary_Geochem_RevA.mxd

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Data source: Commonwealth of Australia (Geoscience Australia): DTDB, 2015. ESRI: Imagery, 2017. Created by: tmorton

Generally, the groundwater was circumneutral to slightly acidic, with the exception of G8, which had a pH between 3.9 and 5.61. The elevated sulfate (and metals where analysed), but neutral pH in the shallow bores OB10 (-8.76 mAHD), OB11 (3 mAHD) and G1 (9.2 mAHD) suggests there has been impact from oxidised sulfides with neutralisation of acidity. This is likely to be due to seepage from the adjacent evaporation pond EP2. Based on the chemistry of these bores and an area of white staining, suggesting a salt scald around G1, it is possible there is some local shallow discharge to Bundy Creek, 100 m to the northwest of G1.

G8 had the highest elevated concentrations of several metals (aluminium, cadmium, cobalt, copper and nickel) in comparison to multiple guidelines as well as the surrounding bores. This suggests groundwater in the area is impacted by the immediately adjacent waste rock dump.

4.6.1 Drinking Water Guidelines

Aesthetic guidelines

Several groundwater bores exceed the ADWG aesthetic guideline values (NHMRC and NRMMC, 2011) for one or more analytes. With the exception of Ridge bore and RN29693, all other bores periodically exceed for sulfate and G8 exceeding the trigger values for aluminium, copper and zinc. In addition, OB11, G8, G9, and P100 periodically exceed triggers for ADWG aesthetic guideline values (NHMRC and NRMMC, 2011) for pH Hardness and iron.

Health guidelines

Bore G8 consistently exceeded the health based guideline values for sulfate, cadmium, manganese, and nickel with the occasional sample exceeding the arsenic guideline value. G9 consistently exceeded the trigger value for lead and, similarly to G8, there were exceedances for manganese and nickel. OB11 consistently exceeded for Cadmium, Manganese and Nickel. Notably, the Ridge Bore also exceeded the health based guideline (NHMRC and NRMMC, 2011) for Manganese.

4.6.2 Aquatic ecosystems and stock watering guidelines

Groundwater bore G8 exceeded the FAE80% and FAE90% trigger values for aluminium, cadmium, copper, nickel, zinc and lead. G9 and OB11 both occasionally exceeded the trigger values for cadmium and copper and more consistently exceeded the trigger values for nickel and zinc.

G8 had correspondingly elevated concentrations of several metals (aluminium, cadmium, cobalt, copper and nickel) above stock watering guidelines.

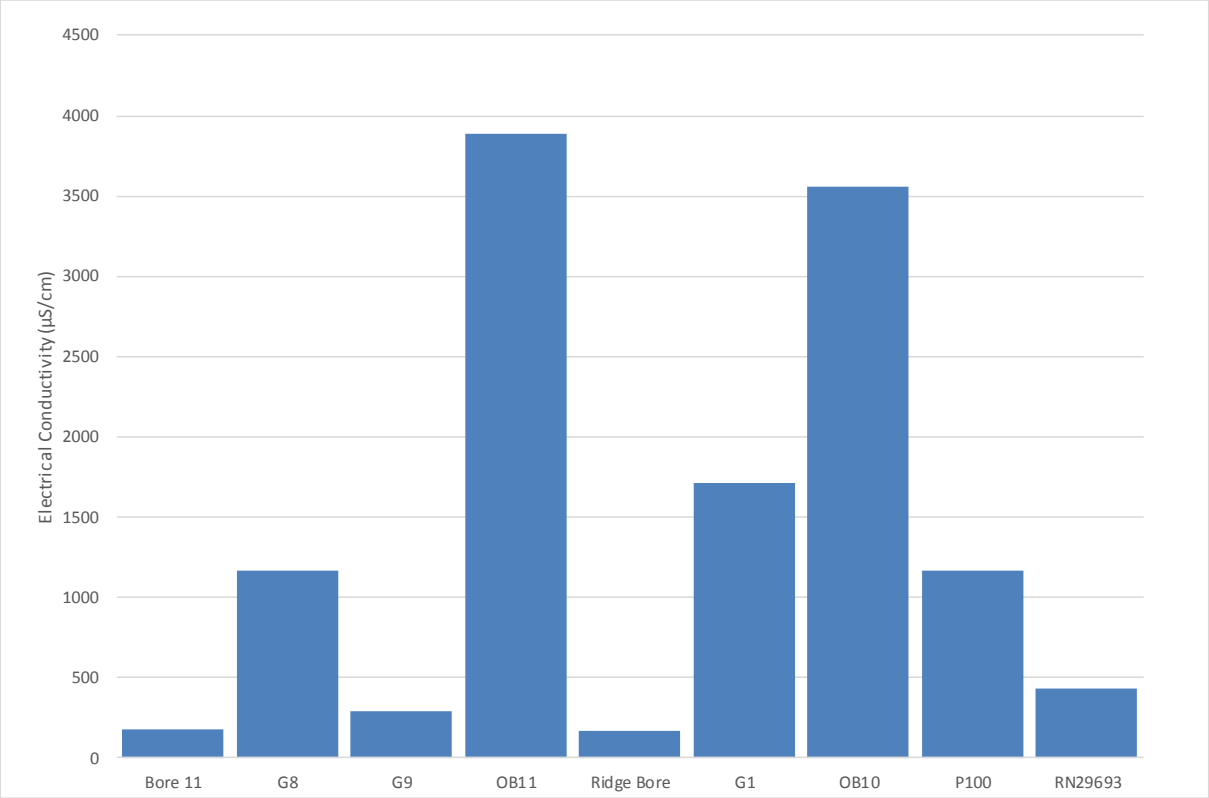

Figure 4-12 Average groundwater EC (uS/cm) to 2018

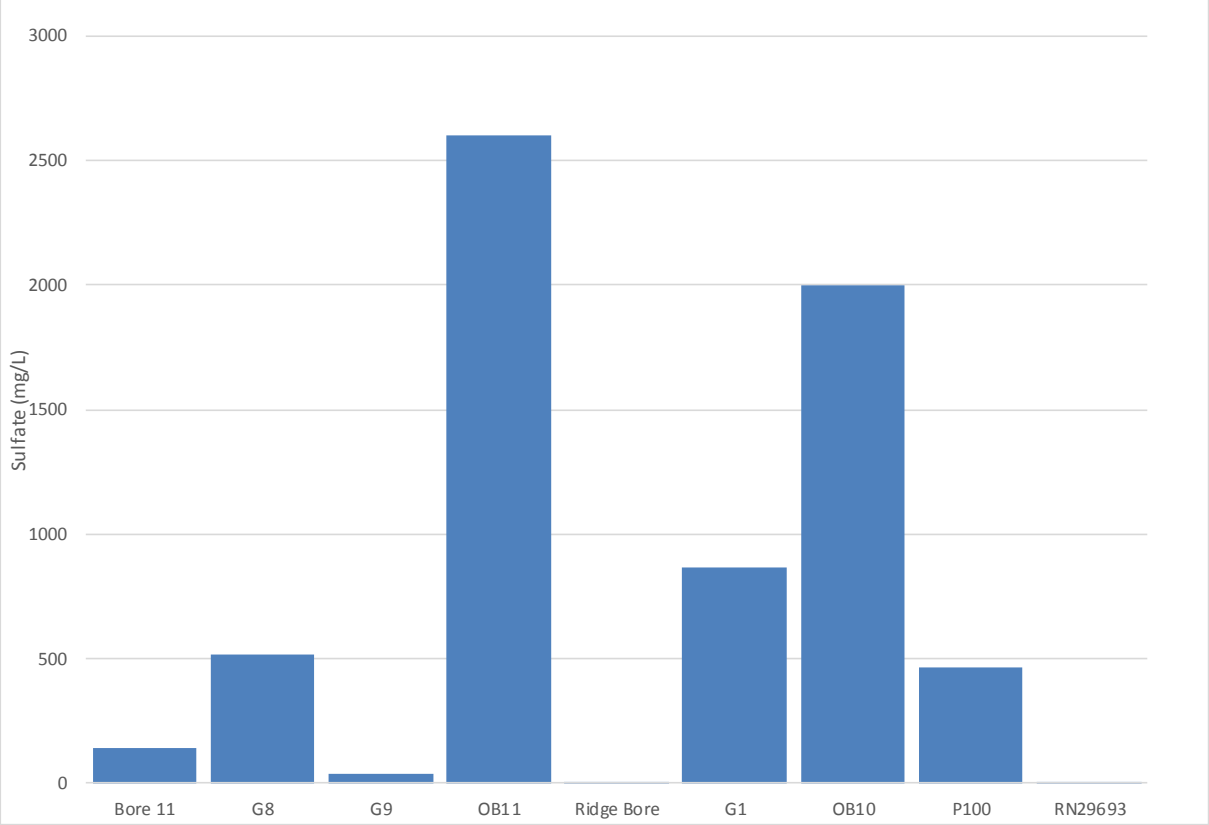

Figure 4-13 Average groundwater SO_4 concentrations (mg/L) to 2018

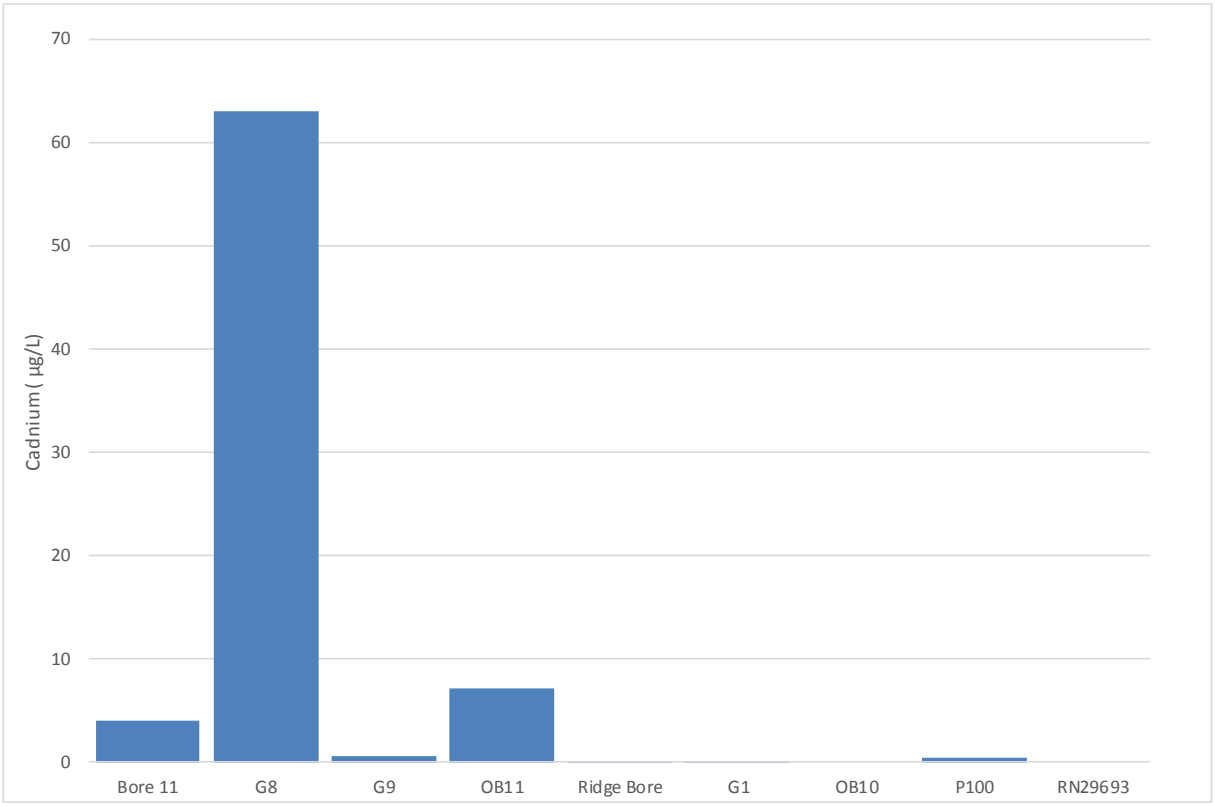

Figure 4-14 Average groundwater Cd concentrations (ug/L) to 2018

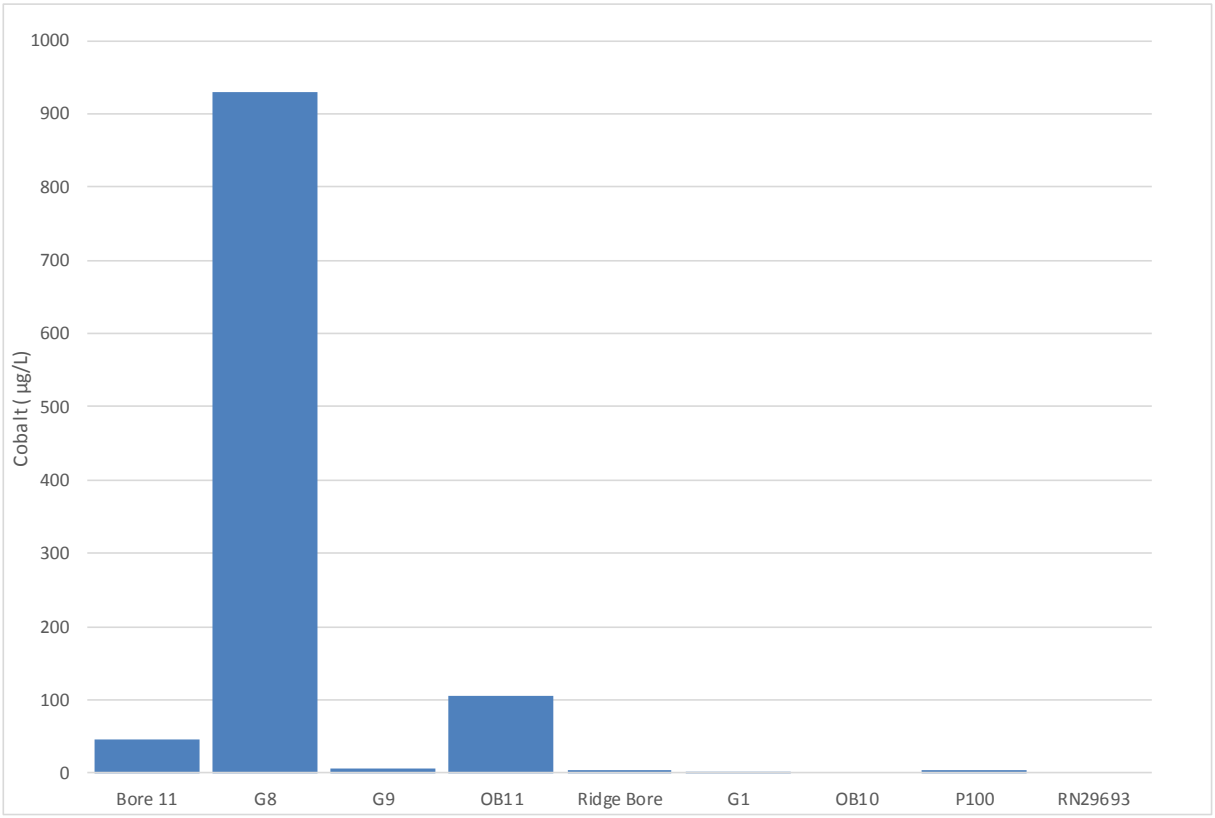

Figure 4-15 Average groundwater Co concentrations (ug/L) to 2018

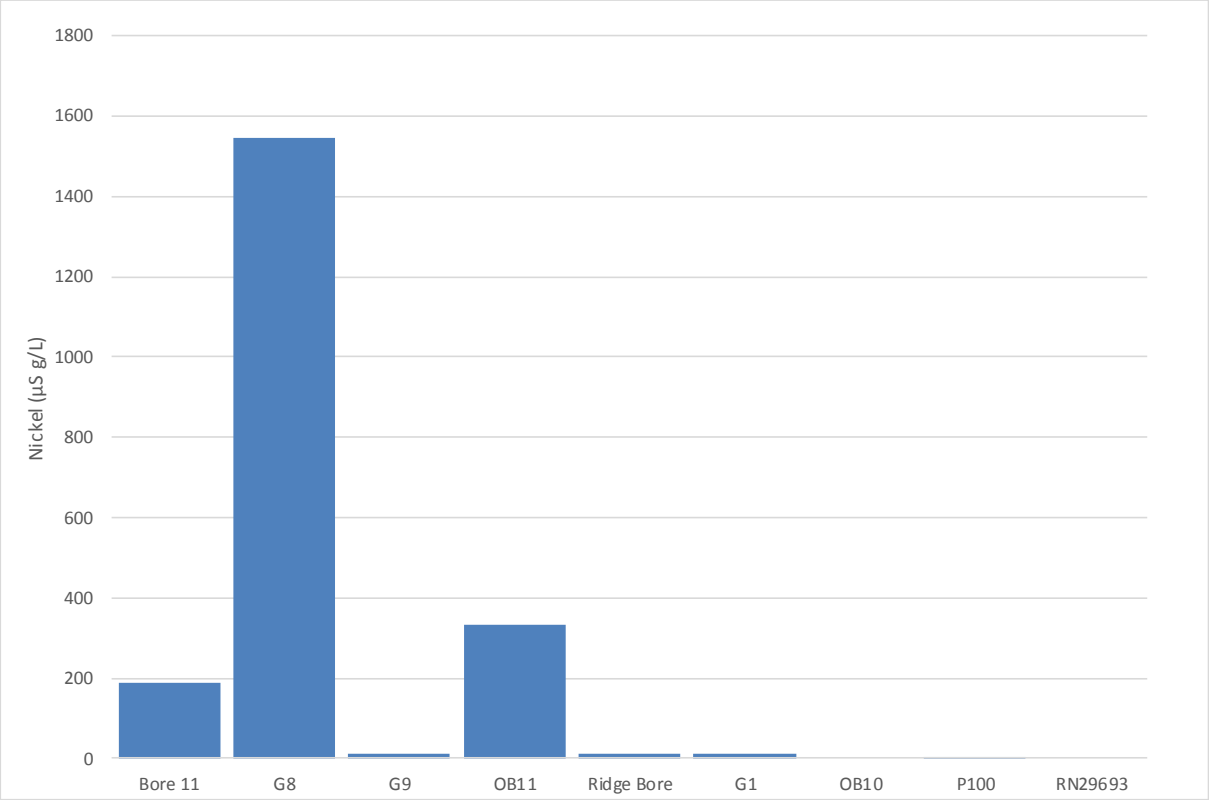

Figure 4-16 Average groundwater Ni, concentrations (ug/L) to 2018

Table 4-3 Groundwater chemistry summary compared against ANZECC Livestock Trigger Values

		Field		Alkalinity					Acidity	Inorganics	Major Ions						Metals										
		Electrical Conductivity (Field)	pH (Field)	Carbonate	Bicarbonate	Alkalinity (total) as CaCO3	Hardness as CaCO3	Hydroxide	Acidity (as CaCO3)	Total Suspended Solids	Calcium (Filtered)	Chloride	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Sulphate	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Cobalt (Filtered)	Copper (Filtered)	Iron (Filtered)	Lead (Filtered)	Manganese (Filtered)	Nickel (Filtered)	Zinc (Filtered)
		µS/cm	pH_Units	mg/L	mg/L	mg/L	mg CaCO3/L	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	µg/L
ANZECC 2000 - Livestock Trigger		3000	6-8							5000	1000					1000	5000	500	10	1000	1000[#1]	500		100		1000	20000
Bore	**Sample Date**																										
BORE 11	9/05/2011	4.69	6	<1	180	180	3100	<1	<2	20	480	8	480	6.6	22	3000	440	11	66	<1	760	5	44,000	<1	31,000	1400	3100
	22/11/2011	270	7.12	<1	120	120		<1			21	9	11	5.8	5.9	2											
	30/01/2012	278.4	7.86	<1	120	120	95	<1	<2	18	17	9	13	6.4	6.5	3	<10	<1	<0.1	<1	<1	<1	310	<1	200	<1	<1
	27/04/2012	241.6	6.65	<5	110	110	79	<5	<2	<5	13	7	11	6.8	6.5	<1	3	<1	<0.1	<1	<1	<1	410	<1	250	1	8
	22/08/2012	241.4	8.03	<5	110	110	73	<5	<5	9	11	7	11	6.1	6.3	<1	27	<1	<0.1	<1	<1	<1	32	<1	94	2	1
	3/04/2013	238.1	7.3	<5	100	100	64	<5	<5	9	9.3	7	9.9	7.2	6.9	<1	<10	<1	<0.1	<1	<1	<1	920	<1	210	<1	7
	26/12/2013	175	7.9	11	66	77		<5			6.7	8	8.3	6.1	5.9	<1											
	20/02/2014	164.8	7.3	15	69	83	49	<5	<2	<5	6.7	8	7.9	6.5	6.2	<1	30	<1	<0.1	<1	<1	1	77	<1	80	1	8
	11/04/2014	163.9	7.62	<5	66	66		<5			7.4	8	9.3	6.5	6.9	<1											
	7/12/2014	160	7.4	<1	63	63		<1			6.2	9.4	7.2	6.2	6.2	0.9											
	13/02/2015	146.2	7			60	41.7		<1	<10	5.8	9.8	6.6	6.2	5.9	1.1	5.6	0.1	<0.02	<0.1	0.04	0.06	<2	0.01	17.3	1800	<0.1
	13/03/2015	158.4	7.46			58	41		<1	<10	5.8	10.5	6.5	6.8	6.4	1.3	5.3	0.1	<0.02	<0.1	0.05	0.09	4	<0.01	23.8	0.17	2.9
	10/04/2015	162.3	7.8			67	41.5		<1	<10	5.7	10	6.6	5.8	6	0.7	2.2	0.15	<0.02	<0.1	0.03	0.13	12	<0.01	25.4	0.12	0.9
	1/09/2015	154.4	8.67			59	40.4		<1	<10	5.7		6.4	6.4	6.8	0.8	6	0.15	0.08	0.1	0.06	3.64	14	0.25	22.6	0.58	12.5
	11/12/2015	154	8.1			53	39.4		<1	<10	5.6	10.8	6.2	6.5	6.8	0.9	6.8	0.2	0.02	<0.1	0.08	1.22	8	0.06	17.2	1.49	2.8
	3/02/2016		8.7			51	38.4		<1	<10	5.6	10.9	5.9	6.3	6.1	0.8	7.2	0.15	<0.02	<0.1	0.06	0.57	8	0.03	18.9	0.28	0.9
	11/05/2016	148	8.7			68	38.1		<1	<10	5.6	10.4	5.9	6.1	6.2	0.7	1.8	0.15	<0.02	<0.1	0.05	0.13	28	0.04	24.1	0.21	0.7
	2/09/2016					62	38.4		<1	<10	5.7	9.9	5.9	6.2	5.8	0.7											
	11/01/2017	120	8.8			63	42		<5	6	6.3	9	6.3	6.2	6.1	<1	<10	<1	<0.1	<1	<1	<1	40	<5	32	<1	2
	26/03/2017	150	8.8			66	42		<5	<5	6.7	10	6.2	6.3	5.8	<1	<10	<1	<0.1	<1	<1	<1	30	<1	67	<1	<1
	26/08/2017	230	8.5			73	59		<5	<5	10	10	8.3	6.3	6.2	19	260	<1	<0.1	<1	3	<1	20	<1	230	13	10
	10/09/2017	180	8.7			73	48		<5	<5	7.4	10	7.1	6.5	6.4	1	<10	<1	<0.1	<1	<1	<1	340	<1	60	<1	9
G8	3/12/2010	1568	4.69	<0.1	<0.1	<0.1	680	<0.1	<2	23	98	34	110	5	15	740	9100	12	90	<1	1200	830	1400	8	18,000	1800	6000
	2/11/2010	1630	4.74	<0.1	<0.1	<0.1		<0.1			98	31	110	5.1	16	820											
	25/01/2011	1152	4.75	<0.1	<0.1	<0.1	17	<0.1	130	380	52	47	62	3.7	21	420	8100	<1	46	<1	860	1600	100	83	13,000	1400	4000
	9/05/2011	1166	4.37	<1	<1	<1	420	<1	93	<5	57	50	68	3.8	22	570	11,000	4	45	<1	830	1200	75	5	17,000	1400	3700
	22/11/2011	1167	4.7	<1	<1	<1		<1			61	45	76	3.6	17	510											
	30/01/2012	1098	4.13	<1	<1	<1	430	<1	180	58	57	36	70	3.7	14	460	8000	<1	58	1	770	1500	400	8	14,000	1300	4100
	11/04/2012	1082	5.61	<5	<5	<5		<5			54	34	59	3.1	14	330											
	27/04/2012	1808	4.74	<5	<5	<5	430	<5	170	<5	60	36	68	3.9	17	460	8100	<1	43	<1	810	1700	28	5	14,000	1300	3700
	22/08/2012	1494	4.28	<5	<5	<5	610	<5	240	26	84	24	96	4.9	14	670	13,000	10	74	<1	1100	1500	2200	7	20,000	1900	6400
	3/04/2013	850	3.9	<5	<5	<5	310	<5	100	8	45	31	49	5.1	13	330	5800	4	36	<1	690	1500	89	4	12,000	1200	3300
	26/12/2013	1075	4.3	<5	<5	<5		<5			64	26	74	4.6	14	440											
	11/04/2014	1022	4.64	<5	<5	<5		<5			70	32	84	4.2	18	430											
	7/12/2014	955	5.1	<1	<1	<1		<1			64.5	33.5	77	6.4	16.8	524											
	20/02/2014	930	4.3	<5	<5	<5	390	<5	170	5	53	36	63	3.8	16	370	7500	6	38	<1	720	1300	63	9	13,000	1300	3700
	13/02/2015	1055	5.3			<1	474		117	20	65.1	36.2	75.7	6.5	15.5	529	3440	0.3	54	0.1	905	1310	8	3.9	15,400	1590	4680
	13/03/2015	941	4.96			<1	409		103	<10	57	35.6	64.8	4.1	14.5	486	8400	0.2	48	0.2	835	1480	94	6.95	14,200	1450	4350
	10/04/2015	1008	4.47			<1	425		182	<10	58.6	30.6	67.8	3.4	12.9	481	7880	<0.05	51.6	0.1	867	1230	134	6.05	14,000	1410	4260
	1/09/2015	1206	4.6			<1	559		125	20	82.3		85.9	5.2	13.6	621	7620	1.4	60.6	<1	1070	776	3060	10.9	16,800	1650	5690
	11/12/2015	1120	4.5			<1	560		80	20	83	25.3	85.7	5.4	13	623	6960	0.05	96.8	0.1	1010	1800	38	5.75	16,500	1590	5440
	18/01/2016					48	30.6		1	40	8.5	3.3	2.3	4.7	3	1	7300	<0.05	63.6	0.1	990	306	138	4.55	16,000	1550	5110
	11/05/2016	1020	4.4			<1	474		134	<10	65.6	30.9	75.2	4.1	14.1	518	7730	<0.5	57.2	<1	922	1150	148	6.29	14,800	1470	4460
	2/09/2016					<1	502		125	<10	70.9	27	78.9	4.3	12.1	568											
	11/01/2017	950	4.7			<5	470		140	6	72	25	71	4.1	13	480	6000	5	67	<1	690	340	2300	6	14,000	1400	4800
	26/03/2017	870	4.2			<5	380		120	<5	50	34	63	3.5	15	410	7900	5	44	<1	690	1700	50	5	12,000	1400	4100
	25/06/2017	1400	4.3			<5	700		160	<5	100	28	110	4.8	17	780	12000	50	96	<1	1400	1000	7200	6	26,000	2100	6800
	10/09/2017	1400	4.4			<5	730		210	28	120	28	110	4.9	16	800	16000	12	130	<1	1300	1400	3500	11	23,000	2200	7300
G9	3/12/2010	372	6.51	<0.1	160	160	160	<0.1	<2	27	48	7.4	9.2	2.8	4	8.2	23	5	0.3	<1	3	4	97	12	180	5	25
	2/11/2010	375.2	6.98	<0.1	150	150		<0.1			49	8.2	8.7	2.9	4.1	6.7											
	25/01/2011	356.2	6.5	<0.1	170	170	<5	<0.1	<2	150	46	7.7	7.7	2.8	4	11	16	5	0.3	<1	3	<1	84	18	240	10	25
	22/11/2011	228.3	7	<1	31	31		<1			8.7	4	2.1	1.3	1.1	3											
	30/01/2012	944	7.07	<1	180	180	470	<1	<2	55	92	8	59	2.9	6.2	280	<10	8	0.2	<1	22	<1	500	<1	1400	67	36
	27/04/2012	379	6.06	<5	25	25	97	<5	<2	<5	20	3	12	1.6	1.9	26	17	<1	0.3	<1	<1	2	<10	12	29	5	19
	22/08/2012	889	7.1	<5	190	190	440	<5	<5	13	88	6	53	2.9	6.1	190	12	6	0.2	<1	13	<1	180	<1	1000	54	24
	3/04/2013	90.7	5.06	<5	38	38	23	<5	<5	<5	4.6	4	2.7	1.6	1.1	34	48	1	2.2	<1	10	15	18	140	330	29	120
	26/12/2013	247	6.4	<5	12	12		<5			9.8	3	8.4	1.9	1.7	12											
	20/02/2014	34.5	5.4	<5	10	10		<5			1.6	2	0.5	1.4	1	1											
	11/04/2014	72.7	6.15	<5	25	25		<5			5.2	3	2.9	1.6	1.4	29											
	7/12/2014	285	6.1	<1	21	21		<1			10.5	4.5	5.9	1.9	1.7	26.6											
	13/02/2015	233	7.1			21	41.7		13	<10	8.4	4.8	5.1	2.1	1.6	24.3	3.5	3.45	0.74	<0.1	2.03	5.18	34	83.5	125	5.92	41.1
	13/03/2015	34.3	7.27			16	37.5		6	<10	7.6	4.6	4.5	2	1.5	22.5	6.4	3.5	0.72	<0.1	3.81	4.37	16	145	225	5.59	54.4
	10/04/2015	223	8.6			13	32.8		12	<10	6.5	4.4	4	1.5	1.3	18.9	4.9	3.6	0.8	<0.1	9.3	5.45	48	141	483	7.68	65.9
	1/09/2015	143.2	7.21			22	47.5		8	<10	9.9		5.6	2	2	24.7	5.4	7.65	0.72	0.1	5.7	1.96	854	238	289	9.42	69.3
	11/12/2015	112	7.1			13	42.6		3	<10	8.9	5.8	4.9	2.1	1.9	22.5	8.3	1.75	1.08	<0.1	4.62	3.94	104	305	235	8.21	99.3
	18/01/2016		6.64			28	62.8		7	20	13.2	5.2	7.3	2	2	31.1	5.1	3.15	0.94	<0.1	4.19	1.79	398	158	208	7.63	73.3
	11/05/2016	143	6.7			30	58.4		11	<10	12.6	4.9	6.5	1.7	1.9	26.5	2	0.8	0.38	<0.1	4.08	1.43	16	33.6	275	6.03	40.2
	2/09/2016					89	117		16	<10	30.1	6.2	10.2	2.3	2.9	31.3											
	11/01/2017	310	7.2			160	170			6	51	7	9.5	2.8	4	5	<10	6	<0.1	<1	<1	<1	320	<5	160	<1	2
	26/03/2017	340	7.1			150	160			<5	50	8	9.3	2.7	4	6	<10	5	<0.1	<1	<1	<1	20	<1	180	<1	2
	25/06/2017	320	7.1			160	170			<5	52	8	9.8	2.8	4.2	6	<10	5	<0.1	<1	<1	<1	540	<1	210	1	8
	10/09/2017	340	7.1			160	200			<5	63	8	10	2.7	4.3	4	<10	5	<0.1	<1	<1	<1	300	<1	150	<1	8
OB11	2/11/2010	4593	7.07	<0.1	390	390		<0.1			480	11	570	2.2	38	3200											
	2/11/2010	4593	7.07	<0.1	390	390		<0.1			450	11	530	2.2	38	3300											
	25/01/2011	2682	7.22	<0.1	360	360	22	<0.1	<2	1300	120	7.2	250	1.7	89	1100	16	2	0.2	<1	<1	<1	<10	<1	<5	1	21
	22/11/2011	4370	6.49	<1	470	470		<1			300	11	570	1.6	83	2700											
	30/01/2012	4755	6.57	<1	390	390	3400	<1	<2	970	510	10	510	4.1	30	3100	<10	2	15	<1	240	2	3500	<1	14,000	730	380
	11/04/2012	4360	5.98	<5	350	350		<5			480	6	480	4	20	2000											
	27/04/2012	4300	5.78	<5	350	350	3400	<5	<2	6	450	8	550	5.2	41	3500	93	<1	6.1	<1	81	3	16	<1	7300	230	120
	22/08/2012	4754	6.69	<5	380	380	3400	<5	<5	6	480	8	530	3.1	31	3800	16	1	5.4	<1	130	1	61	<1	11,000	600	210
	3/04/2013	4300	6.1	<5	410	410	3500	<5	<5	19	450	14	570	3.5	55	2800	29	2	4.3	<1	41	6	17	<1	3100	220	89
	26/12/2013	4500	6.47	<5	390	390		<5			520	9	570	3.5	52	2400											
	20/02/2014	256	5.7	<5	36	36	90	<5	<2	6	11	2	15	1.2	2.9	61	50	1	0.3	<1	<1	4	14	<1	13	7	55
	11/04/2014	353	6.19	<5	29	29		<5			13	2	20	1.2	3.5	60											
	11/04/2014			<5	30	30		<5				2				59											
	7/12/2014	4400	5.6	25	334	359		<1			569	7.8	551	2.7	30.8	3200	242	0.65	5.78	<0.5	130	14.9	<10	0.26	7150	536	276
	13/02/2015	4100	5.5			361	3340		81	10	494	8.4	511	2.7	29.2	2920	16.5	2.45	1.34	<0.5	9.07	1.78	<10	0.03	1060	78.9	35.5
	13/03/2015	4210	5.98			349	3300		37	20	486	9.1	506	3.5	31.7	3030	20	3.45	0.76	<1	1.69	4.41	<20	1.1	183	16.3	34.3
	10/04/2015	4070	6.36			356	3220		73	20	472	8.8	496	2.7	29.8	2810	32.2	2.65	4.4	<1	10.2	3.6	<20	<0.1	3050	126	57.1
	15/12/2015	3400	6.88			245	3260		19	20	536	8.1	467	5.5	25.4	2960	3.4	0.35	11.2	<0.5	273	8.7	76	0.16	15700	620	538
	3/02/2016					310	3540		73	<10	537	9	534	3.5	29.1	3140	4.2	0.8	8.42	<1	15.7	2.11	<20	<0.01	2700	327	195
	11/05/2016	2430	7.2			175	1610		36	<10	235	14.2	248	9.9	18.2	1430	15	2.45	6.34	<1	32	3.85	<20	0.11	10800	207	126
	2/09/2016					311	3620		73	40	558	7.9	541	3.3	26.4	3280											
	11/01/2017	4300	6.7			290	3600		110	22	570	9	530	4.7	32	3000	<10	3	9.4	<1	180	1	8000	<5	13000	490	510
	26/03/2017	4500	6.3			220	3900		130	33	590	9	580	6.7	35	3400	<10	<1	23	<1	530	2	6700	<1	27000	880	1600
	26/08/2017	4700	6.4			280	3800		57	39	600	9	570	4	34	3400	<10	<1	8.9	<1	55	9	80	<1	13000	290	260
	26/08/2017	4700	6.5			280						9				3400											
	10/09/2017	4700	6.5			280	4600		110	78	830	9	610	4.3	34	3600	<10	2	8.8	1	67	8	780	<1	13000	300	270
RIDGE BORE	30/01/2012	279.9	6.4	<1	70	70	6	<1	<2	110	1.3	9	0.7	1.2	2.5	1	<10	1	<0.1	<1	4	<1	63,000	<1	630	15	13
	22/11/2011	99.2	6.38	<1	14	14		<1			1.6	8	0.7	1.4	2.4	<1											
	27/04/2012	213.5	5.54	<5	27	27	16	<5	<2	67	4.2	6	1.3	1.6	2.8	2	50	<1	0.3	<1	6	4	30,000	<1	2200	11	71
	22/08/2012	87	6.1	<5	25	25	14	<5	<5	28	3.6	6	1.2	1.3	2.7	<1	24	<1	0.4	<1	5	<1	4300	<1	710	9	36
	3/04/2013	104	6.8	<5	39	39	15	<5	<5	18	3.7	6	1.3	1.6	3	<1	14	<1	<0.1	<1	<1	2	9200	<1	700	2	31
	26/12/2013	82.4	6.3	<5	13	13		<5			3	7	0.9	1.3	2.5	<1											
	20/02/2014	172.2	6	<5	31	31	14	<5	<2	51	3.7	7	1.2	1.2	2.5	<1	40	<1	0.3	<1	6	5	33,000	<1	2800	13	31
	11/04/2014	288	6.47	<5	55	55		<5			3	7	1.2	1.3	3	<1											
	7/12/2014	270	6.4	<1	3	3		<1			1	7.4	0.6	1.1	2.6	0.7	18	3.55	0.16	<0.1	3.89	0.81	81400	0.01	538	7.77	30.2
	13/02/2015	253	6			15	15.7		86	110	4.3	5.5	1.2	1.9	2.8	1.1	0.6	<0.05	0.02	0.4	5.07	0.02	19400	<0.01	677	51.4	7.5
	13/03/2015	260	6.07			27	7.6		56	80	1.6	6.4	0.9	1.5	3	2	1.1	0.05	<0.02	<0.1	1.66	<0.01	33200	<0.01	703	2.39	3.6
	10/04/2015	255	7.33			59	8.5		114	80	2.1	5.8	0.8	1.1	2.7	0.2	0.4	<0.05	<0.02	<0.1	1.41	0.34	18500	<0.01	606	1.91	2.5
	1/09/2015	223.5	6.88			13	5.4		66	80	1.2		0.6	1.3	3.2	0.2	2.9	<0.5	<0.2	<1	1.64	0.35	13100	<0.1	570	5.95	45.1
	11/12/2015	42	6.6			8	5.6		29	100	1.2	6.2	0.6	1.3	3	0.3	<0.1	<0.05	<0.02	<0.1	2.45	<0.01	25700	<0.01	569	16.4	17.3
	3/02/2016		7.42			20	6.7		105	90	1.6	6.5	0.7	1.3	2.9	0.3	0.4	0.1	0.06	<0.1	1.83	0.1	29400	<0.01	679	7.22	11
	11/05/2016	146	6.4			65	7.2		103	70	1.6	5.5	0.7	1.3	3.1	0.4	0.2	0.05	0.02	<0.1	2.96	0.02	31000	0.02	721	5.45	20.1
	2/09/2016					36	5.4		74	60	1.2	5.3	0.6	1.3	2.9	0.4											
	11/01/2017	120	6.3			63	6		100	62	1.3	5	0.6	1.2	3	<1	<10	1	<0.1	<1	2	<1	42000	<5	440	3	12
	26/03/2017	100	6			50	7		85	52	1.7	5	0.7	1.3	3	<1	<10	<1	<0.1	<1	4	<1	25000	<1	990	6	6
	26/08/2017	130	6.2			63	6		56	75	1.3	5	0.6	1.4	2.9	<1	<10	2	0.1	<1	4	<1	48000	<1	600	13	33
	10/09/2017	71	5.7			28	6		85	76	1.2	5	0.7	1.2	3.1	<1	<10	2	<0.1	<1	3	<1	46000	<1	530	10	13
G1	22/11/2011	1876	7.2	<1	390	390		<1			210	9	110	8.8	24	900											
	22/11/2011	247.2	8.1	<1	56	56		<1			12	4	12	3.8	8.1	52											
	30/01/2012	2229	6.92	<1	340	340		<1			270	8	140	8.6	27	1500											
	30/01/2012	268.8	8.38	<1	84	85		<1			19	4	12	3.7	8.3	39											
	22/08/2012	2367	6.75	<5	200	200		<5			280	5	160	8.2	27	1200											
	22/08/2012	175.3	8.74	9	87	96		<5			6.6	3	9.6	3.7	6.6	1											
	1/09/2015	1938	8.26				828		5	40	142		115	29	32.2	300	28.4	19	<0.2	<1	0.38	0.88	128	0.51	56.6	2.45	13.4
	15/12/2015	2201	7.56			788	1160		10	50	240	12.9	136	17.2	26.3	700	16.7	11.5	<0.1	1	1.16	0.25	128	0.1	326	6.46	4.2
	18/01/2016		7.28			592	1230		26	50	257	12	143	17.9	25.9	810	17.3	7.8	<0.2	<1	0.28	0.1	100	<0.1	364	3.3	3.3
	11/05/2016	2210	7.2			412	1360		72	10	292	9.6	153	12.8	24.5	1080	40.1	6.5	<0.2	<1	0.89	0.86	70	<0.1	397	3.82	9.5
	2/09/2016					299	1490		56	50	323	7.9	166	10.7	22.2	1310											
	11/01/2017	2200	6.4			160	1600		75	5	340	6	170	7.7	22	1300	<10	2	<0.1	<1	2	<1	780	<5	290	11	9
	26/03/2017	2200	6.3			150	1500		55	<5	330	7	170	8	22	1300	<10	2	<0.1	<1	2	<1	330	<1	340	19	5
	25/06/2017	2200	6.4			150	1500		58	13	320	7	170	7.6	23	1300	<10	3	<0.1	<1	3	<1	560	<1	520	28	19
	10/09/2017	2200	6.3			150	1800		70	16

Table 4-4 Groundwater chemistry summary compared against ANZECC Freshwater Aquatic Ecosystem 80 % Values

		Field		Alkalinity					Acidity	Inorganics	Major Ions						Metals										
		Electrical Conductivity (Field)	pH (Field)	Carbonate	Bicarbonate	Alkalinity (total) as CaCO3	Hardness as CaCO3	Hydroxide	Acidity (as CaCO3)	Total Suspended Solids	Calcium (Filtered)	Chloride	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Sulphate	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Cobalt (Filtered)	Copper (Filtered)	Iron (Filtered)	Lead (Filtered)	Manganese (Filtered)	Nickel (Filtered)	Zinc (Filtered)
		µS/cm	pH Units	mg/L	mg/L	mg/L	mg CaCO3/L	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	µg/L
ANZECC FAE80%																	150	360	0.8	40		2.5		9.4	3600	17	31
Bore	**Sample Date**																										
BORE 11	9/05/2011	4.69	6	<1	180	180	3100	<1	<2	20	480	8	480	6.6	22	3000	440	11	66	<1	760	5	44,000	<1	31,000	1400	3100
	22/11/2011	270	7.12	<1	120	120		<1			21	9	11	5.8	5.9	2											
	30/01/2012	278.4	7.86	<1	120	120	95	<1	<2	18	17	9	13	6.4	6.5	3	<10	<1	<0.1	<1	<1	<1	310	<1	200	<1	<1
	27/04/2012	241.6	6.65	<5	110	110	79	<5	<2	<5	13	7	11	6.8	6.5	<1	3	<1	<0.1	<1	<1	<1	410	<1	250	1	8
	22/08/2012	241.4	8.03	<5	110	110	73	<5	<5	9	11	7	11	6.1	6.3	<1	27	<1	<0.1	<1	<1	<1	32	<1	94	2	1
	3/04/2013	238.1	7.3	<5	100	100	64	<5	<5	9	9.3	7	9.9	7.2	6.9	<1	<10	<1	<0.1	<1	<1	<1	920	<1	210	<1	7
	26/12/2013	175	7.9	11	66	77		<5			6.7	8	8.3	6.1	5.9	<1											
	20/02/2014	164.8	7.3	15	69	83	49	<5	<2	<5	6.7	8	7.9	6.5	6.2	<1	30	<1	<0.1	<1	<1	1	77	<1	80	1	8
	11/04/2014	163.9	7.62	<5	66	66		<5			7.4	8	9.3	6.5	6.9	<1											
	7/12/2014	160	7.4	<1	63	63		<1			6.2	9.4	7.2	6.2	6.2	0.9											
	13/02/2015	146.2	7			60	41.7		<1	<10	5.8	9.8	6.6	6.2	5.9	1.1	5.6	0.1	<0.02	<0.1	0.04	0.06	<2	0.01	17.3	1800	<0.1
	13/03/2015	158.4	7.46			58	41		<1	<10	5.8	10.5	6.5	6.8	6.4	1.3	5.3	0.1	<0.02	<0.1	0.05	0.09	4	<0.01	23.8	0.17	2.9
	10/04/2015	162.3	7.8			67	41.5		<1	<10	5.7	10	6.6	5.8	6	0.7	2.2	0.15	<0.02	<0.1	0.03	0.13	12	<0.01	25.4	0.12	0.9
	1/09/2015	154.4	8.67			59	40.4		<1	<10	5.7		6.4	6.4	6.8	0.8	6	0.15	0.08	0.1	0.06	3.64	14	0.25	22.6	0.58	12.5
	11/12/2015	154	8.1			53	39.4		<1	<10	5.6	10.8	6.2	6.5	6.8	0.9	6.8	0.2	0.02	<0.1	0.08	1.22	8	0.06	17.2	1.49	2.8
	3/02/2016		8.7			51	38.4		<1	<10	5.6	10.9	5.9	6.3	6.1	0.8	7.2	0.15	<0.02	<0.1	0.06	0.57	8	0.03	18.9	0.28	0.9
	11/05/2016	148	8.7			68	38.1		<1	<10	5.6	10.4	5.9	6.1	6.2	0.7	1.8	0.15	<0.02	<0.1	0.05	0.13	28	0.04	24.1	0.21	0.7
	2/09/2016					62	38.4		<1	<10	5.7	9.9	5.9	6.2	5.8	0.7											
	11/01/2017	120	8.8			63	42		<5	6	6.3	9	6.3	6.2	6.1	<1	<10	<1	<0.1	<1	<1	<1	40	<5	32	<1	2
	26/03/2017	150	8.8			66	42		<5	<5	6.7	10	6.2	6.3	5.8	<1	<10	<1	<0.1	<1	<1	<1	30	<1	67	<1	<1
	26/08/2017	230	8.5			73	59		<5	<5	10	10	8.3	6.3	6.2	19	260	<1	<0.1	<1	3	<1	20	<1	230	13	10
	10/09/2017	180	8.7			73	48		<5	<5	7.4	10	7.1	6.5	6.4	1	<10	<1	<0.1	<1	<1	<1	340	<1	60	<1	9
G8	3/12/2010	1568	4.69	<0.1	<0.1	<0.1	680	<0.1	<2	23	98	34	110	5	15	740	9100	12	90	<1	1200	830	1400	8	18,000	1800	6000
	2/11/2010	1630	4.74	<0.1	<0.1	<0.1		<0.1			98	31	110	5.1	16	820											
	25/01/2011	1152	4.75	<0.1	<0.1	<0.1	17	<0.1	130	380	52	47	62	3.7	21	420	8100	<1	46	<1	860	1600	100	83	13,000	1400	4000
	9/05/2011	1166	4.37	<1	<1	<1	420	<1	93	<5	57	50	68	3.8	22	570	11,000	4	45	<1	830	1200	75	5	17,000	1400	3700
	22/11/2011	1167	4.7	<1	<1	<1		<1			61	45	76	3.6	17	510											
	30/01/2012	1098	4.13	<1	<1	<1	430	<1	180	58	57	36	70	3.7	14	460	8000	<1	58	1	770	1500	400	8	14,000	1300	4100
	11/04/2012	1082	5.61	<5	<5	<5		<5			54	34	59	3.1	14	330											
	27/04/2012	1808	4.74	<5	<5	<5	430	<5	170	<5	60	36	68	3.9	17	460	8100	<1	43	<1	810	1700	28	5	14,000	1300	3700
	22/08/2012	1494	4.28	<5	<5	<5	610	<5	240	26	84	24	96	4.9	14	670	13,000	10	74	<1	1100	1500	2200	7	20,000	1900	6400
	3/04/2013	850	3.9	<5	<5	<5	310	<5	100	8	45	31	49	5.1	13	330	5800	4	36	<1	690	1500	89	4	12,000	1200	3300
	26/12/2013	1075	4.3	<5	<5	<5		<5			64	26	74	4.6	14	440											
	11/04/2014	1022	4.64	<5	<5	<5		<5			70	32	84	4.2	18	430											
	7/12/2014	955	5.1	<1	<1	<1		<1			64.5	33.5	77	6.4	16.8	524											
	20/02/2014	930	4.3	<5	<5	<5	390	<5	170	5	53	36	63	3.8	16	370	7500	6	38	<1	720	1300	63	9	13,000	1300	3700
	13/02/2015	1055	5.3			<1	474		117	20	65.1	36.2	75.7	6.5	15.5	529	3440	0.3	54	0.1	905	1310	8	3.9	15,400	1590	4680
	13/03/2015	941	4.96			<1	409		103	<10	57	35.6	64.8	4.1	14.5	486	8400	0.2	48	0.2	835	1480	94	6.95	14,200	1450	4350
	10/04/2015	1008	4.47			<1	425		182	<10	58.6	30.6	67.8	3.4	12.9	481	7880	<0.05	51.6	0.1	867	1230	134	6.05	14,000	1410	4260
	1/09/2015	1206	4.6			<1	559		125	20	82.3		85.9	5.2	13.6	621	7620	1.4	60.6	<1	1070	776	3060	10.9	16,800	1650	5690
	11/12/2015	1120	4.5			<1	560		80	20	83	25.3	85.7	5.4	13	623	6960	0.05	96.8	0.1	1010	1800	38	5.75	16,500	1590	5440
	18/01/2016					48	30.6		1	40	8.5	3.3	2.3	4.7	3	1	7300	<0.05	63.6	0.1	990	306	138	4.55	16,000	1550	5110
	11/05/2016	1020	4.4			<1	474		134	<10	65.6	30.9	75.2	4.1	14.1	518	7730	<0.5	57.2	<1	922	1150	148	6.29	14,800	1470	4460
	2/09/2016					<1	502		125	<10	70.9	27	78.9	4.3	12.1	568											
	11/01/2017	950	4.7			<5	470		140	6	72	25	71	4.1	13	480	6000	5	67	<1	690	340	2300	6	14,000	1400	4800
	26/03/2017	870	4.2			<5	380		120	<5	50	34	63	3.5	15	410	7900	5	44	<1	690	1700	50	5	12,000	1400	4100
	25/06/2017	1400	4.3			<5	700		160	<5	100	28	110	4.8	17	780	12000	50	96	<1	1400	1000	7200	6	26,000	2100	6800
	10/09/2017	1400	4.4			<5	730		210	28	120	28	110	4.9	16	800	16000	12	130	<1	1300	1400	3500	11	23,000	2200	7300
G9	3/12/2010	372	6.51	<0.1	160	160	160	<0.1	<2	27	48	7.4	9.2	2.8	4	8.2	23	5	0.3	<1	3	4	97	12	180	5	25
	2/11/2010	375.2	6.98	<0.1	150	150		<0.1			49	8.2	8.7	2.9	4.1	6.7											
	25/01/2011	356.2	6.5	<0.1	170	170	<5	<0.1	<2	150	46	7.7	7.7	2.8	4	11	16	5	0.3	<1	3	<1	84	18	240	10	25
	22/11/2011	228.3	7	<1	31	31		<1			8.7	4	2.1	1.3	1.1	3											
	30/01/2012	944	7.07	<1	180	180	470	<1	<2	55	92	8	59	2.9	6.2	280	<10	8	0.2	<1	22	<1	500	<1	1400	67	36
	27/04/2012	379	6.06	<5	25	25	97	<5	<2	<5	20	3	12	1.6	1.9	26	17	<1	0.3	<1	<1	2	<10	12	29	5	19
	22/08/2012	889	7.1	<5	190	190	440	<5	<5	13	88	6	53	2.9	6.1	190	12	6	0.2	<1	13	<1	180	<1	1000	54	24
	3/04/2013	90.7	5.06	<5	38	38	23	<5	<5	<5	4.6	4	2.7	1.6	1.1	34	48	1	2.2	<1	10	15	18	140	330	29	120
	26/12/2013	247	6.4	<5	12	12		<5			9.8	3	8.4	1.9	1.7	12											
	20/02/2014	34.5	5.4	<5	10	10		<5			1.6	2	0.5	1.4	1	1											
	11/04/2014	72.7	6.15	<5	25	25		<5			5.2	3	2.9	1.6	1.4	29											
	7/12/2014	285	6.1	<1	21	21		<1			10.5	4.5	5.9	1.9	1.7	26.6											
	13/02/2015	233	7.1			21	41.7		13	<10	8.4	4.8	5.1	2.1	1.6	24.3	3.5	3.45	0.74	<0.1	2.03	5.18	34	83.5	125	5.92	41.1
	13/03/2015	34.3	7.27			16	37.5		6	<10	7.6	4.6	4.5	2	1.5	22.5	6.4	3.5	0.72	<0.1	3.81	4.37	16	145	225	5.59	54.4
	10/04/2015	223	8.6			13	32.8		12	<10	6.5	4.4	4	1.5	1.3	18.9	4.9	3.6	0.8	<0.1	9.3	5.45	48	141	483	7.68	65.9
	1/09/2015	143.2	7.21			22	47.5		8	<10	9.9		5.6	2	2	24.7	5.4	7.65	0.72	0.1	5.7	1.96	854	238	289	9.42	69.3
	11/12/2015	112	7.1			13	42.6		3	<10	8.9	5.8	4.9	2.1	1.9	22.5	8.3	1.75	1.08	<0.1	4.62	3.94	104	305	235	8.21	99.3
	18/01/2016		6.64			28	62.8		7	20	13.2	5.2	7.3	2	2	31.1	5.1	3.15	0.94	<0.1	4.19	1.79	398	158	208	7.63	73.3
	11/05/2016	143	6.7			30	58.4		11	<10	12.6	4.9	6.5	1.7	1.9	26.5	2	0.8	0.38	<0.1	4.08	1.43	16	33.6	275	6.03	40.2
	2/09/2016					89	117		16	<10	30.1	6.2	10.2	2.3	2.9	31.3											
	11/01/2017	310	7.2			160	170			6	51	7	9.5	2.8	4	5	<10	6	<0.1	<1	<1	<1	320	<5	160	<1	2
	26/03/2017	340	7.1			150	160			<5	50	8	9.3	2.7	4	6	<10	5	<0.1	<1	<1	<1	20	<1	180	<1	2
	25/06/2017	320	7.1			160	170			<5	52	8	9.8	2.8	4.2	6	<10	5	<0.1	<1	<1	<1	540	<1	210	1	8
	10/09/2017	340	7.1			160	200			<5	63	8	10	2.7	4.3	4	<10	5	<0.1	<1	<1	<1	300	<1	150	<1	8
OB11	2/11/2010	4593	7.07	<0.1	390	390		<0.1			480	11	570	2.2	38	3200											
	2/11/2010	4593	7.07	<0.1	390	390		<0.1			450	11	530	2.2	38	3300											
	25/01/2011	2682	7.22	<0.1	360	360	22	<0.1	<2	1300	120	7.2	250	1.7	89	1100	16	2	0.2	<1	<1	<1	<10	<1	<5	1	21
	22/11/2011	4370	6.49	<1	470	470		<1			300	11	570	1.6	83	2700											
	30/01/2012	4755	6.57	<1	390	390	3400	<1	<2	970	510	10	510	4.1	30	3100	<10	2	15	<1	240	2	3500	<1	14,000	730	380
	11/04/2012	4360	5.98	<5	350	350		<5			480	6	480	4	20	2000											
	27/04/2012	4300	5.78	<5	350	350	3400	<5	<2	6	450	8	550	5.2	41	3500	93	<1	6.1	<1	81	3	16	<1	7300	230	120
	22/08/2012	4754	6.69	<5	380	380	3400	<5	<5	6	480	8	530	3.1	31	3800	16	1	5.4	<1	130	1	61	<1	11,000	600	210
	3/04/2013	4300	6.1	<5	410	410	3500	<5	<5	19	450	14	570	3.5	55	2800	29	2	4.3	<1	41	6	17	<1	3100	220	89
	26/12/2013	4500	6.47	<5	390	390		<5			520	9	570	3.5	52	2400											
	20/02/2014	256	5.7	<5	36	36	90	<5	<2	6	11	2	15	1.2	2.9	61	50	1	0.3	<1	<1	4	14	<1	13	7	55
	11/04/2014	353	6.19	<5	29	29		<5			13	2	20	1.2	3.5	60											
	11/04/2014			<5	30	30		<5				2				59											
	7/12/2014	4400	5.6	25	334	359		<1			569	7.8	551	2.7	30.8	3200	242	0.65	5.78	<0.5	130	14.9	<10	0.26	7150	536	276
	13/02/2015	4100	5.5			361	3340		81	10	494	8.4	511	2.7	29.2	2920	16.5	2.45	1.34	<0.5	9.07	1.78	<10	0.03	1060	78.9	35.5
	13/03/2015	4210	5.98			349	3300		37	20	486	9.1	506	3.5	31.7	3030	20	3.45	0.76	<1	1.69	4.41	<20	1.1	183	16.3	34.3
	10/04/2015	4070	6.36			356	3220		73	20	472	8.8	496	2.7	29.8	2810	32.2	2.65	4.4	<1	10.2	3.6	<20	<0.1	3050	126	57.1
	15/12/2015	3400	6.88			245	3260		19	20	536	8.1	467	5.5	25.4	2960	3.4	0.35	11.2	<0.5	273	8.7	76	0.16	15700	620	538
	3/02/2016					310	3540		73	<10	537	9	534	3.5	29.1	3140	4.2	0.8	8.42	<1	15.7	2.11	<20	<0.01	2700	327	195
	11/05/2016	2430	7.2			175	1610		36	<10	235	14.2	248	9.9	18.2	1430	15	2.45	6.34	<1	32	3.85	<20	0.11	10800	207	126
	2/09/2016					311	3620		73	40	558	7.9	541	3.3	26.4	3280											
	11/01/2017	4300	6.7			290	3600		110	22	570	9	530	4.7	32	3000	<10	3	9.4	<1	180	1	8000	<5	13000	490	510
	26/03/2017	4500	6.3			220	3900		130	33	590	9	580	6.7	35	3400	<10	<1	23	<1	530	2	6700	<1	27000	880	1600
	26/08/2017	4700	6.4			280	3800		57	39	600	9	570	4	34	3400	<10	<1	8.9	<1	55	9	80	<1	13000	290	260
	26/08/2017	4700	6.5			280						9				3400											
	10/09/2017	4700	6.5			280	4600		110	78	830	9	610	4.3	34	3600	<10	2	8.8	1	67	8	780	<1	13000	300	270
RIDGE BORE	30/01/2012	279.9	6.4	<1	70	70	6	<1	<2	110	1.3	9	0.7	1.2	2.5	1	<10	1	<0.1	<1	4	<1	63,000	<1	630	15	13
	22/11/2011	99.2	6.38	<1	14	14		<1			1.6	8	0.7	1.4	2.4	<1											
	27/04/2012	213.5	5.54	<5	27	27	16	<5	<2	67	4.2	6	1.3	1.6	2.8	2	50	<1	0.3	<1	6	4	30,000	<1	2200	11	71
	22/08/2012	87	6.1	<5	25	25	14	<5	<5	28	3.6	6	1.2	1.3	2.7	<1	24	<1	0.4	<1	5	<1	4300	<1	710	9	36
	3/04/2013	104	6.8	<5	39	39	15	<5	<5	18	3.7	6	1.3	1.6	3	<1	14	<1	<0.1	<1	<1	2	9200	<1	700	2	31
	26/12/2013	82.4	6.3	<5	13	13		<5			3	7	0.9	1.3	2.5	<1											
	20/02/2014	172.2	6	<5	31	31	14	<5	<2	51	3.7	7	1.2	1.2	2.5	<1	40	<1	0.3	<1	6	5	33,000	<1	2800	13	31
	11/04/2014	288	6.47	<5	55	55		<5			3	7	1.2	1.3	3	<1											
	7/12/2014	270	6.4	<1	3	3		<1			1	7.4	0.6	1.1	2.6	0.7	18	3.55	0.16	<0.1	3.89	0.81	81400	0.01	538	7.77	30.2
	13/02/2015	253	6			15	15.7		86	110	4.3	5.5	1.2	1.9	2.8	1.1	0.6	<0.05	0.02	0.4	5.07	0.02	19400	<0.01	677	51.4	7.5
	13/03/2015	260	6.07			27	7.6		56	80	1.6	6.4	0.9	1.5	3	2	1.1	0.05	<0.02	<0.1	1.66	<0.01	33200	<0.01	703	2.39	3.6
	10/04/2015	255	7.33			59	8.5		114	80	2.1	5.8	0.8	1.1	2.7	0.2	0.4	<0.05	<0.02	<0.1	1.41	0.34	18500	<0.01	606	1.91	2.5
	1/09/2015	223.5	6.88			13	5.4		66	80	1.2		0.6	1.3	3.2	0.2	2.9	<0.5	<0.2	<1	1.64	0.35	13100	<0.1	570	5.95	45.1
	11/12/2015	42	6.6			8	5.6		29	100	1.2	6.2	0.6	1.3	3	0.3	<0.1	<0.05	<0.02	<0.1	2.45	<0.01	25700	<0.01	569	16.4	17.3
	3/02/2016		7.42			20	6.7		105	90	1.6	6.5	0.7	1.3	2.9	0.3	0.4	0.1	0.06	<0.1	1.83	0.1	29400	<0.01	679	7.22	11
	11/05/2016	146	6.4			65	7.2		103	70	1.6	5.5	0.7	1.3	3.1	0.4	0.2	0.05	0.02	<0.1	2.96	0.02	31000	0.02	721	5.45	20.1
	2/09/2016					36	5.4		74	60	1.2	5.3	0.6	1.3	2.9	0.4											
	11/01/2017	120	6.3			63	6		100	62	1.3	5	0.6	1.2	3	<1	<10	1	<0.1	<1	2	<1	42000	<5	440	3	12
	26/03/2017	100	6			50	7		85	52	1.7	5	0.7	1.3	3	<1	<10	<1	<0.1	<1	4	<1	25000	<1	990	6	6
	26/08/2017	130	6.2			63	6		56	75	1.3	5	0.6	1.4	2.9	<1	<10	2	0.1	<1	4	<1	48000	<1	600	13	33
	10/09/2017	71	5.7			28	6		85	76	1.2	5	0.7	1.2	3.1	<1	<10	2	<0.1	<1	3	<1	46000	<1	530	10	13
G1	22/11/2011	1876	7.2	<1	390	390		<1			210	9	110	8.8	24	900											
	22/11/2011	247.2	8.1	<1	56	56		<1			12	4	12	3.8	8.1	52											
	30/01/2012	2229	6.92	<1	340	340		<1			270	8	140	8.6	27	1500											
	30/01/2012	268.8	8.38	<1	84	85		<1			19	4	12	3.7	8.3	39											
	22/08/2012	2367	6.75	<5	200	200		<5			280	5	160	8.2	27	1200											
	22/08/2012	175.3	8.74	9	87	96		<5			6.6	3	9.6	3.7	6.6	1											
	1/09/2015	1938	8.26				828		5	40	142		115	29	32.2	300	28.4	19	<0.2	<1	0.38	0.88	128	0.51	56.6	2.45	13.4
	15/12/2015	2201	7.56			788	1160		10	50	240	12.9	136	17.2	26.3	700	16.7	11.5	<0.1	1	1.16	0.25	128	0.1	326	6.46	4.2
	18/01/2016		7.28			592	1230		26	50	257	12	143	17.9	25.9	810	17.3	7.8	<0.2	<1	0.28	0.1	100	<0.1	364	3.3	3.3
	11/05/2016	2210	7.2			412	1360		72	10	292	9.6	153	12.8	24.5	1080	40.1	6.5	<0.2	<1	0.89	0.86	70	<0.1	397	3.82	9.5
	2/09/2016					299	1490		56	50	323	7.9	166	10.7	22.2	1310											
	11/01/2017	2200	6.4			160	1600		75	5	340	6	170	7.7	22	1300	<10	2	<0.1	<1	2	<1	780	<5	290	11	9
	26/03/2017	2200	6.3			150	1500		55	<5	330	7	170	8	22	1300	<10	2	<0.1	<1	2	<1	330	<1	340	19	5
	25/06/2017	2200	6.4			150	1500		58	13	320	7	170	7.6	23	1300	<10	3	<0.1	<1	3	<1	560	<1	520	28	19
	10/09/2017	2200	6.3			150	1800		70	16	420	7	170	8	21

Table 4-5 Groundwater chemistry summary compared against ANZECC Freshwater Aquatic Ecosystem 90 % Values

		Field		Alkalinity					Acidity	Inorganics	Major Ions						Metals										
		Electrical Conductivity (Field)	pH (Field)	Carbonate	Bicarbonate	Alkalinity (total) as CaCO3	Hardness as CaCO3	Hydroxide	Acidity (as CaCO3)	Total Suspended Solids	Calcium (Filtered)	Chloride	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Sulphate	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Cobalt (Filtered)	Copper (Filtered)	Iron (Filtered)	Lead (Filtered)	Manganese (Filtered)	Nickel (Filtered)	Zinc (Filtered)
		µS/cm	pH Units	mg/L	mg/L	mg/L	mg CaCO3/L	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	µg/L
ANZECC FAE80%																	80	94	0.4	6		1.8		5.6	2500	13	15
Bore	**Sample Date**																										
BORE 11	9/05/2011	4.69	6	<1	180	180	3100	<1	<2	20	480	8	480	6.6	22	3000	440	11	66	<1	760	5	44,000	<1	31,000	1400	3100
	22/11/2011	270	7.12	<1	120	120		<1			21	9	11	5.8	5.9	2											
	30/01/2012	278.4	7.86	<1	120	120	95	<1	<2	18	17	9	13	6.4	6.5	3	<10	<1	<0.1	<1	<1	<1	310	<1	200	<1	<1
	27/04/2012	241.6	6.65	<5	110	110	79	<5	<2	<5	13	7	11	6.8	6.5	<1	3	<1	<0.1	<1	<1	<1	410	<1	250	1	8
	22/08/2012	241.4	8.03	<5	110	110	73	<5	<5	9	11	7	11	6.1	6.3	<1	27	<1	<0.1	<1	<1	<1	32	<1	94	2	1
	3/04/2013	238.1	7.3	<5	100	100	64	<5	<5	9	9.3	7	9.9	7.2	6.9	<1	<10	<1	<0.1	<1	<1	<1	920	<1	210	<1	7
	26/12/2013	175	7.9	11	66	77		<5			6.7	8	8.3	6.1	5.9	<1											
	20/02/2014	164.8	7.3	15	69	83	49	<5	<2	<5	6.7	8	7.9	6.5	6.2	<1	30	<1	<0.1	<1	<1	1	77	<1	80	1	8
	11/04/2014	163.9	7.62	<5	66	66		<5			7.4	8	9.3	6.5	6.9	<1											
	7/12/2014	160	7.4	<1	63	63		<1			6.2	9.4	7.2	6.2	6.2	0.9											
	13/02/2015	146.2	7			60	41.7		<1	<10	5.8	9.8	6.6	6.2	5.9	1.1	5.6	0.1	<0.02	<0.1	0.04	0.06	<2	0.01	17.3	1800	<0.1
	13/03/2015	158.4	7.46			58	41		<1	<10	5.8	10.5	6.5	6.8	6.4	1.3	5.3	0.1	<0.02	<0.1	0.05	0.09	4	<0.01	23.8	0.17	2.9
	10/04/2015	162.3	7.8			67	41.5		<1	<10	5.7	10	6.6	5.8	6	0.7	2.2	0.15	<0.02	<0.1	0.03	0.13	12	<0.01	25.4	0.12	0.9
	1/09/2015	154.4	8.67			59	40.4		<1	<10	5.7		6.4	6.4	6.8	0.8	6	0.15	0.08	0.1	0.06	3.64	14	0.25	22.6	0.58	12.5
	11/12/2015	154	8.1			53	39.4		<1	<10	5.6	10.8	6.2	6.5	6.8	0.9	6.8	0.2	0.02	<0.1	0.08	1.22	8	0.06	17.2	1.49	2.8
	3/02/2016		8.7			51	38.4		<1	<10	5.6	10.9	5.9	6.3	6.1	0.8	7.2	0.15	<0.02	<0.1	0.06	0.57	8	0.03	18.9	0.28	0.9
	11/05/2016	148	8.7			68	38.1		<1	<10	5.6	10.4	5.9	6.1	6.2	0.7	1.8	0.15	<0.02	<0.1	0.05	0.13	28	0.04	24.1	0.21	0.7
	2/09/2016					62	38.4		<1	<10	5.7	9.9	5.9	6.2	5.8	0.7											
	11/01/2017	120	8.8			63	42		<5	6	6.3	9	6.3	6.2	6.1	<1	<10	<1	<0.1	<1	<1	<1	40	<5	32	<1	2
	26/03/2017	150	8.8			66	42		<5	<5	6.7	10	6.2	6.3	5.8	<1	<10	<1	<0.1	<1	<1	<1	30	<1	67	<1	<1
	26/08/2017	230	8.5			73	59		<5	<5	10	10	8.3	6.3	6.2	19	260	<1	<0.1	<1	3	<1	20	<1	230	13	10
	10/09/2017	180	8.7			73	48		<5	<5	7.4	10	7.1	6.5	6.4	1	<10	<1	<0.1	<1	<1	<1	340	<1	60	<1	9
G8	3/12/2010	1568	4.69	<0.1	<0.1	<0.1	680	<0.1	<2	23	98	34	110	5	15	740	9100	12	90	<1	1200	830	1400	8	18,000	1800	6000
	2/11/2010	1630	4.74	<0.1	<0.1	<0.1		<0.1			98	31	110	5.1	16	820											
	25/01/2011	1152	4.75	<0.1	<0.1	<0.1	17	<0.1	130	380	52	47	62	3.7	21	420	8100	<1	46	<1	860	1600	100	83	13,000	1400	4000
	9/05/2011	1166	4.37	<1	<1	<1	420	<1	93	<5	57	50	68	3.8	22	570	11,000	4	45	<1	830	1200	75	5	17,000	1400	3700
	22/11/2011	1167	4.7	<1	<1	<1		<1			61	45	76	3.6	17	510											
	30/01/2012	1098	4.13	<1	<1	<1	430	<1	180	58	57	36	70	3.7	14	460	8000	<1	58	1	770	1500	400	8	14,000	1300	4100
	11/04/2012	1082	5.61	<5	<5	<5		<5			54	34	59	3.1	14	330											
	27/04/2012	1808	4.74	<5	<5	<5	430	<5	170	<5	60	36	68	3.9	17	460	8100	<1	43	<1	810	1700	28	5	14,000	1300	3700
	22/08/2012	1494	4.28	<5	<5	<5	610	<5	240	26	84	24	96	4.9	14	670	13,000	10	74	<1	1100	1500	2200	7	20,000	1900	6400
	3/04/2013	850	3.9	<5	<5	<5	310	<5	100	8	45	31	49	5.1	13	330	5800	4	36	<1	690	1500	89	4	12,000	1200	3300
	26/12/2013	1075	4.3	<5	<5	<5		<5			64	26	74	4.6	14	440											
	11/04/2014	1022	4.64	<5	<5	<5		<5			70	32	84	4.2	18	430											
	7/12/2014	955	5.1	<1	<1	<1		<1			64.5	33.5	77	6.4	16.8	524											
	20/02/2014	930	4.3	<5	<5	<5	390	<5	170	5	53	36	63	3.8	16	370	7500	6	38	<1	720	1300	63	9	13,000	1300	3700
	13/02/2015	1055	5.3			<1	474		117	20	65.1	36.2	75.7	6.5	15.5	529	3440	0.3	54	0.1	905	1310	8	3.9	15,400	1590	4680
	13/03/2015	941	4.96			<1	409		103	<10	57	35.6	64.8	4.1	14.5	486	8400	0.2	48	0.2	835	1480	94	6.95	14,200	1450	4350
	10/04/2015	1008	4.47			<1	425		182	<10	58.6	30.6	67.8	3.4	12.9	481	7880	<0.05	51.6	0.1	867	1230	134	6.05	14,000	1410	4260
	1/09/2015	1206	4.6			<1	559		125	20	82.3		85.9	5.2	13.6	621	7620	1.4	60.6	<1	1070	776	3060	10.9	16,800	1650	5690
	11/12/2015	1120	4.5			<1	560		80	20	83	25.3	85.7	5.4	13	623	6960	0.05	96.8	0.1	1010	1800	38	5.75	16,500	1590	5440
	18/01/2016					48	30.6		1	40	8.5	3.3	2.3	4.7	3	1	7300	<0.05	63.6	0.1	990	306	138	4.55	16,000	1550	5110
	11/05/2016	1020	4.4			<1	474		134	<10	65.6	30.9	75.2	4.1	14.1	518	7730	<0.5	57.2	<1	922	1150	148	6.29	14,800	1470	4460
	2/09/2016					<1	502		125	<10	70.9	27	78.9	4.3	12.1	568											
	11/01/2017	950	4.7			<5	470		140	6	72	25	71	4.1	13	480	6000	5	67	<1	690	340	2300	6	14,000	1400	4800
	26/03/2017	870	4.2			<5	380		120	<5	50	34	63	3.5	15	410	7900	5	44	<1	690	1700	50	5	12,000	1400	4100
	25/06/2017	1400	4.3			<5	700		160	<5	100	28	110	4.8	17	780	12000	50	96	<1	1400	1000	7200	6	26,000	2100	6800
	10/09/2017	1400	4.4			<5	730		210	28	120	28	110	4.9	16	800	16000	12	130	<1	1300	1400	3500	11	23,000	2200	7300
G9	3/12/2010	372	6.51	<0.1	160	160	160	<0.1	<2	27	48	7.4	9.2	2.8	4	8.2	23	5	0.3	<1	3	4	97	12	180	5	25
	2/11/2010	375.2	6.98	<0.1	150	150		<0.1			49	8.2	8.7	2.9	4.1	6.7											
	25/01/2011	356.2	6.5	<0.1	170	170	<5	<0.1	<2	150	46	7.7	7.7	2.8	4	11	16	5	0.3	<1	3	<1	84	18	240	10	25
	22/11/2011	228.3	7	<1	31	31		<1			8.7	4	2.1	1.3	1.1	3											
	30/01/2012	944	7.07	<1	180	180	470	<1	<2	55	92	8	59	2.9	6.2	280	<10	8	0.2	<1	22	<1	500	<1	1400	67	36
	27/04/2012	379	6.06	<5	25	25	97	<5	<2	<5	20	3	12	1.6	1.9	26	17	<1	0.3	<1	<1	2	<10	12	29	5	19
	22/08/2012	889	7.1	<5	190	190	440	<5	<5	13	88	6	53	2.9	6.1	190	12	6	0.2	<1	13	<1	180	<1	1000	54	24
	3/04/2013	90.7	5.06	<5	38	38	23	<5	<5	<5	4.6	4	2.7	1.6	1.1	34	48	1	2.2	<1	10	15	18	140	330	29	120
	26/12/2013	247	6.4	<5	12	12		<5			9.8	3	8.4	1.9	1.7	12											
	20/02/2014	34.5	5.4	<5	10	10		<5			1.6	2	0.5	1.4	1	1											
	11/04/2014	72.7	6.15	<5	25	25		<5			5.2	3	2.9	1.6	1.4	29											
	7/12/2014	285	6.1	<1	21	21		<1			10.5	4.5	5.9	1.9	1.7	26.6											
	13/02/2015	233	7.1			21	41.7		13	<10	8.4	4.8	5.1	2.1	1.6	24.3	3.5	3.45	0.74	<0.1	2.03	5.18	34	83.5	125	5.92	41.1
	13/03/2015	34.3	7.27			16	37.5		6	<10	7.6	4.6	4.5	2	1.5	22.5	6.4	3.5	0.72	<0.1	3.81	4.37	16	145	225	5.59	54.4
	10/04/2015	223	8.6			13	32.8		12	<10	6.5	4.4	4	1.5	1.3	18.9	4.9	3.6	0.8	<0.1	9.3	5.45	48	141	483	7.68	65.9
	1/09/2015	143.2	7.21			22	47.5		8	<10	9.9		5.6	2	2	24.7	5.4	7.65	0.72	0.1	5.7	1.96	854	238	289	9.42	69.3
	11/12/2015	112	7.1			13	42.6		3	<10	8.9	5.8	4.9	2.1	1.9	22.5	8.3	1.75	1.08	<0.1	4.62	3.94	104	305	235	8.21	99.3
	18/01/2016		6.64			28	62.8		7	20	13.2	5.2	7.3	2	2	31.1	5.1	3.15	0.94	<0.1	4.19	1.79	398	158	208	7.63	73.3
	11/05/2016	143	6.7			30	58.4		11	<10	12.6	4.9	6.5	1.7	1.9	26.5	2	0.8	0.38	<0.1	4.08	1.43	16	33.6	275	6.03	40.2
	2/09/2016					89	117		16	<10	30.1	6.2	10.2	2.3	2.9	31.3											
	11/01/2017	310	7.2			160	170			6	51	7	9.5	2.8	4	5	<10	6	<0.1	<1	<1	<1	320	<5	160	<1	2
	26/03/2017	340	7.1			150	160			<5	50	8	9.3	2.7	4	6	<10	5	<0.1	<1	<1	<1	20	<1	180	<1	2
	25/06/2017	320	7.1			160	170			<5	52	8	9.8	2.8	4.2	6	<10	5	<0.1	<1	<1	<1	540	<1	210	1	8
	10/09/2017	340	7.1			160	200			<5	63	8	10	2.7	4.3	4	<10	5	<0.1	<1	<1	<1	300	<1	150	<1	8
OB11	2/11/2010	4593	7.07	<0.1	390	390		<0.1			480	11	570	2.2	38	3200											
	2/11/2010	4593	7.07	<0.1	390	390		<0.1			450	11	530	2.2	38	3300											
	25/01/2011	2682	7.22	<0.1	360	360	22	<0.1	<2	1300	120	7.2	250	1.7	89	1100	16	2	0.2	<1	<1	<1	<10	<1	<5	1	21
	22/11/2011	4370	6.49	<1	470	470		<1			300	11	570	1.6	83	2700											
	30/01/2012	4755	6.57	<1	390	390	3400	<1	<2	970	510	10	510	4.1	30	3100	<10	2	15	<1	240	2	3500	<1	14,000	730	380
	11/04/2012	4360	5.98	<5	350	350		<5			480	6	480	4	20	2000											
	27/04/2012	4300	5.78	<5	350	350	3400	<5	<2	6	450	8	550	5.2	41	3500	93	<1	6.1	<1	81	3	16	<1	7300	230	120
	22/08/2012	4754	6.69	<5	380	380	3400	<5	<5	6	480	8	530	3.1	31	3800	16	1	5.4	<1	130	1	61	<1	11,000	600	210
	3/04/2013	4300	6.1	<5	410	410	3500	<5	<5	19	450	14	570	3.5	55	2800	29	2	4.3	<1	41	6	17	<1	3100	220	89
	26/12/2013	4500	6.47	<5	390	390		<5			520	9	570	3.5	52	2400											
	20/02/2014	256	5.7	<5	36	36	90	<5	<2	6	11	2	15	1.2	2.9	61	50	1	0.3	<1	<1	4	14	<1	13	7	55
	11/04/2014	353	6.19	<5	29	29		<5			13	2	20	1.2	3.5	60											
	11/04/2014			<5	30	30		<5				2				59											
	7/12/2014	4400	5.6	25	334	359		<1			569	7.8	551	2.7	30.8	3200	242	0.65	5.78	<0.5	130	14.9	<10	0.26	7150	536	276
	13/02/2015	4100	5.5			361	3340		81	10	494	8.4	511	2.7	29.2	2920	16.5	2.45	1.34	<0.5	9.07	1.78	<10	0.03	1060	78.9	35.5
	13/03/2015	4210	5.98			349	3300		37	20	486	9.1	506	3.5	31.7	3030	20	3.45	0.76	<1	1.69	4.41	<20	1.1	183	16.3	34.3
	10/04/2015	4070	6.36			356	3220		73	20	472	8.8	496	2.7	29.8	2810	32.2	2.65	4.4	<1	10.2	3.6	<20	<0.1	3050	126	57.1
	15/12/2015	3400	6.88			245	3260		19	20	536	8.1	467	5.5	25.4	2960	3.4	0.35	11.2	<0.5	273	8.7	76	0.16	15700	620	538
	3/02/2016					310	3540		73	<10	537	9	534	3.5	29.1	3140	4.2	0.8	8.42	<1	15.7	2.11	<20	<0.01	2700	327	195
	11/05/2016	2430	7.2			175	1610		36	<10	235	14.2	248	9.9	18.2	1430	15	2.45	6.34	<1	32	3.85	<20	0.11	10800	207	126
	2/09/2016					311	3620		73	40	558	7.9	541	3.3	26.4	3280											
	11/01/2017	4300	6.7			290	3600		110	22	570	9	530	4.7	32	3000	<10	3	9.4	<1	180	1	8000	<5	13000	490	510
	26/03/2017	4500	6.3			220	3900		130	33	590	9	580	6.7	35	3400	<10	<1	23	<1	530	2	6700	<1	27000	880	1600
	26/08/2017	4700	6.4			280	3800		57	39	600	9	570	4	34	3400	<10	<1	8.9	<1	55	9	80	<1	13000	290	260
	26/08/2017	4700	6.5			280						9				3400											
	10/09/2017	4700	6.5			280	4600		110	78	830	9	610	4.3	34	3600	<10	2	8.8	1	67	8	780	<1	13000	300	270
RIDGE BORE	30/01/2012	279.9	6.4	<1	70	70	6	<1	<2	110	1.3	9	0.7	1.2	2.5	1	<10	1	<0.1	<1	4	<1	63,000	<1	630	15	13
	22/11/2011	99.2	6.38	<1	14	14		<1			1.6	8	0.7	1.4	2.4	<1											
	27/04/2012	213.5	5.54	<5	27	27	16	<5	<2	67	4.2	6	1.3	1.6	2.8	2	50	<1	0.3	<1	6	4	30,000	<1	2200	11	71
	22/08/2012	87	6.1	<5	25	25	14	<5	<5	28	3.6	6	1.2	1.3	2.7	<1	24	<1	0.4	<1	5	<1	4300	<1	710	9	36
	3/04/2013	104	6.8	<5	39	39	15	<5	<5	18	3.7	6	1.3	1.6	3	<1	14	<1	<0.1	<1	<1	2	9200	<1	700	2	31
	26/12/2013	82.4	6.3	<5	13	13		<5			3	7	0.9	1.3	2.5	<1											
	20/02/2014	172.2	6	<5	31	31	14	<5	<2	51	3.7	7	1.2	1.2	2.5	<1	40	<1	0.3	<1	6	5	33,000	<1	2800	13	31
	11/04/2014	288	6.47	<5	55	55		<5			3	7	1.2	1.3	3	<1											
	7/12/2014	270	6.4	<1	3	3		<1			1	7.4	0.6	1.1	2.6	0.7	18	3.55	0.16	<0.1	3.89	0.81	81400	0.01	538	7.77	30.2
	13/02/2015	253	6			15	15.7		86	110	4.3	5.5	1.2	1.9	2.8	1.1	0.6	<0.05	0.02	0.4	5.07	0.02	19400	<0.01	677	51.4	7.5
	13/03/2015	260	6.07			27	7.6		56	80	1.6	6.4	0.9	1.5	3	2	1.1	0.05	<0.02	<0.1	1.66	<0.01	33200	<0.01	703	2.39	3.6
	10/04/2015	255	7.33			59	8.5		114	80	2.1	5.8	0.8	1.1	2.7	0.2	0.4	<0.05	<0.02	<0.1	1.41	0.34	18500	<0.01	606	1.91	2.5
	1/09/2015	223.5	6.88			13	5.4		66	80	1.2		0.6	1.3	3.2	0.2	2.9	<0.5	<0.2	<1	1.64	0.35	13100	<0.1	570	5.95	45.1
	11/12/2015	42	6.6			8	5.6		29	100	1.2	6.2	0.6	1.3	3	0.3	<0.1	<0.05	<0.02	<0.1	2.45	<0.01	25700	<0.01	569	16.4	17.3
	3/02/2016		7.42			20	6.7		105	90	1.6	6.5	0.7	1.3	2.9	0.3	0.4	0.1	0.06	<0.1	1.83	0.1	29400	<0.01	679	7.22	11
	11/05/2016	146	6.4			65	7.2		103	70	1.6	5.5	0.7	1.3	3.1	0.4	0.2	0.05	0.02	<0.1	2.96	0.02	31000	0.02	721	5.45	20.1
	2/09/2016					36	5.4		74	60	1.2	5.3	0.6	1.3	2.9	0.4											
	11/01/2017	120	6.3			63	6		100	62	1.3	5	0.6	1.2	3	<1	<10	1	<0.1	<1	2	<1	42000	<5	440	3	12
	26/03/2017	100	6			50	7		85	52	1.7	5	0.7	1.3	3	<1	<10	<1	<0.1	<1	4	<1	25000	<1	990	6	6
	26/08/2017	130	6.2			63	6		56	75	1.3	5	0.6	1.4	2.9	<1	<10	2	0.1	<1	4	<1	48000	<1	600	13	33
	10/09/2017	71	5.7			28	6		85	76	1.2	5	0.7	1.2	3.1	<1	<10	2	<0.1	<1	3	<1	46000	<1	530	10	13
G1	22/11/2011	1876	7.2	<1	390	390		<1			210	9	110	8.8	24	900											
	22/11/2011	247.2	8.1	<1	56	56		<1			12	4	12	3.8	8.1	52											
	30/01/2012	2229	6.92	<1	340	340		<1			270	8	140	8.6	27	1500											
	30/01/2012	268.8	8.38	<1	84	85		<1			19	4	12	3.7	8.3	39											
	22/08/2012	2367	6.75	<5	200	200		<5			280	5	160	8.2	27	1200											
	22/08/2012	175.3	8.74	9	87	96		<5			6.6	3	9.6	3.7	6.6	1											
	1/09/2015	1938	8.26				828		5	40	142		115	29	32.2	300	28.4	19	<0.2	<1	0.38	0.88	128	0.51	56.6	2.45	13.4
	15/12/2015	2201	7.56			788	1160		10	50	240	12.9	136	17.2	26.3	700	16.7	11.5	<0.1	1	1.16	0.25	128	0.1	326	6.46	4.2
	18/01/2016		7.28			592	1230		26	50	257	12	143	17.9	25.9	810	17.3	7.8	<0.2	<1	0.28	0.1	100	<0.1	364	3.3	3.3
	11/05/2016	2210	7.2			412	1360		72	10	292	9.6	153	12.8	24.5	1080	40.1	6.5	<0.2	<1	0.89	0.86	70	<0.1	397	3.82	9.5
	2/09/2016					299	1490		56	50	323	7.9	166	10.7	22.2	1310											
	11/01/2017	2200	6.4			160	1600		75	5	340	6	170	7.7	22	1300	<10	2	<0.1	<1	2	<1	780	<5	290	11	9
	26/03/2017	2200	6.3			150	1500		55	<5	330	7	170	8	22	1300	<10	2	<0.1	<1	2	<1	330	<1	340	19	5
	25/06/2017	2200	6.4			150	1500		58	13	320	7	170	7.6	23	1300	<10	3	<0.1	<1	3	<1	560	<1	520	28	19
	10/09/2017	2200	6.3			150	1800		70	16	420	7	170	8	21

Table 4-6 Groundwater chemistry summary compared against Australian Drinking Water Guidelines (*Health & Aesthetic*)

		Field		Alkalinity					Acidity	Inorganics	Major Ions						Metals										
		Electrical Conductivity (Field)	pH (Field)	Carbonate	Bicarbonate	Alkalinity (total) as CaCO3	Hardness as CaCO3	Hydroxide	Acidity (as CaCO3)	Total Suspended Solids	Calcium (Filtered)	Chloride	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Sulfate	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Cobalt (Filtered)	Copper (Filtered)	Iron (Filtered)	Lead (Filtered)	Manganese (Filtered)	Nickel (Filtered)	Zinc (Filtered)
		µS/cm	pH Units	mg/L	mg/L	mg/L	mg CaCO3/L	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	µg/L
ADWG 2011 - Health																500		10	2	50		2000		10	500	20	
ADWG 2011 - Aesthetic			6.5 - 8.5				200					250			180	250	200					1000	300				3000
Bore	**Sample Date**																										
BORE 11	9/05/2011	4.69	6	<1	180	180	3100	<1	<2	20	480	8	480	6.6	22	3000	440	11	66	<1	760	5	44,000	<1	31,000	1400	3100
	22/11/2011	270	7.12	<1	120	120		<1			21	9	11	5.8	5.9	2											
	30/01/2012	278.4	7.86	<1	120	120	95	<1	<2	18	17	9	13	6.4	6.5	3	<10	<1	<0.1	<1	<1	<1	310	<1	200	<1	<1
	27/04/2012	241.6	6.65	<5	110	110	79	<5	<2	<5	13	7	11	6.8	6.5	<1	3	<1	<0.1	<1	<1	<1	410	<1	250	1	8
	22/08/2012	241.4	8.03	<5	110	110	73	<5	<5	9	11	7	11	6.1	6.3	<1	27	<1	<0.1	<1	<1	<1	32	<1	94	2	1
	3/04/2013	238.1	7.3	<5	100	100	64	<5	<5	9	9.3	7	9.9	7.2	6.9	<1	<10	<1	<0.1	<1	<1	<1	920	<1	210	<1	7
	26/12/2013	175	7.9	11	66	77		<5			6.7	8	8.3	6.1	5.9	<1											
	20/02/2014	164.8	7.3	15	69	83	49	<5	<2	<5	6.7	8	7.9	6.5	6.2	<1	30	<1	<0.1	<1	<1	1	77	<1	80	1	8
	11/04/2014	163.9	7.62	<5	66	66		<5			7.4	8	9.3	6.5	6.9	<1											
	7/12/2014	160	7.4	<1	63	63		<1			6.2	9.4	7.2	6.2	6.2	0.9											
	13/02/2015	146.2	7			60	41.7		<1	<10	5.8	9.8	6.6	6.2	5.9	1.1	5.6	0.1	<0.02	<0.1	0.04	0.06	<2	0.01	17.3	1800	<0.1
	13/03/2015	158.4	7.46			58	41		<1	<10	5.8	10.5	6.5	6.8	6.4	1.3	5.3	0.1	<0.02	<0.1	0.05	0.09	4	<0.01	23.8	0.17	2.9
	10/04/2015	162.3	7.8			67	41.5		<1	<10	5.7	10	6.6	5.8	6	0.7	2.2	0.15	<0.02	<0.1	0.03	0.13	12	<0.01	25.4	0.12	0.9
	1/09/2015	154.4	8.67			59	40.4		<1	<10	5.7		6.4	6.4	6.8	0.8	6	0.15	0.08	0.1	0.06	3.64	14	0.25	22.6	0.58	12.5
	11/12/2015	154	8.1			53	39.4		<1	<10	5.6	10.8	6.2	6.5	6.8	0.9	6.8	0.2	0.02	<0.1	0.08	1.22	8	0.06	17.2	1.49	2.8
	3/02/2016		8.7			51	38.4		<1	<10	5.6	10.9	5.9	6.3	6.1	0.8	7.2	0.15	<0.02	<0.1	0.06	0.57	8	0.03	18.9	0.28	0.9
	11/05/2016	148	8.7			68	38.1		<1	<10	5.6	10.4	5.9	6.1	6.2	0.7	1.8	0.15	<0.02	<0.1	0.05	0.13	28	0.04	24.1	0.21	0.7
	2/09/2016					62	38.4		<1	<10	5.7	9.9	5.9	6.2	5.8	0.7											
	11/01/2017	120	8.8			63	42		<5	6	6.3	9	6.3	6.2	6.1	<1	<10	<1	<0.1	<1	<1	<1	40	<5	32	<1	2
	26/03/2017	150	8.8			66	42		<5	<5	6.7	10	6.2	6.3	5.8	<1	<10	<1	<0.1	<1	<1	<1	30	<1	67	<1	<1
	26/08/2017	230	8.5			73	59		<5	<5	10	10	8.3	6.3	6.2	19	260	<1	<0.1	<1	3	<1	20	<1	230	13	10
	10/09/2017	180	8.7			73	48		<5	<5	7.4	10	7.1	6.5	6.4	1	<10	<1	<0.1	<1	<1	<1	340	<1	60	<1	9
G8	3/12/2010	1568	4.69	<0.1	<0.1	<0.1	680	<0.1	<2	23	98	34	110	5	15	740	9100	12	90	<1	1200	830	1400	8	18,000	1800	6000
	2/11/2010	1630	4.74	<0.1	<0.1	<0.1		<0.1			98	31	110	5.1	16	820											
	25/01/2011	1152	4.75	<0.1	<0.1	<0.1	17	<0.1	130	380	52	47	62	3.7	21	420	8100	<1	46	<1	860	1600	100	83	13,000	1400	4000
	9/05/2011	1166	4.37	<1	<1	<1	420	<1	93	<5	57	50	68	3.8	22	570	11,000	4	45	<1	830	1200	75	5	17,000	1400	3700
	22/11/2011	1167	4.7	<1	<1	<1		<1			61	45	76	3.6	17	510											
	30/01/2012	1098	4.13	<1	<1	<1	430	<1	180	58	57	36	70	3.7	14	460	8000	<1	58	1	770	1500	400	8	14,000	1300	4100
	11/04/2012	1082	5.61	<5	<5	<5		<5			54	34	59	3.1	14	330											
	27/04/2012	1808	4.74	<5	<5	<5	430	<5	170	<5	60	36	68	3.9	17	460	8100	<1	43	<1	810	1700	28	5	14,000	1300	3700
	22/08/2012	1494	4.28	<5	<5	<5	610	<5	240	26	84	24	96	4.9	14	670	13000	10	74	<1	1100	1500	2200	7	20,000	1900	6400
	3/04/2013	850	3.9	<5	<5	<5	310	<5	100	8	45	31	49	5.1	13	330	5800	4	36	<1	690	1500	89	4	12,000	1200	3300
	26/12/2013	1075	4.3	<5	<5	<5		<5			64	26	74	4.6	14	440											
	11/04/2014	1022	4.64	<5	<5	<5		<5			70	32	84	4.2	18	430											
	7/12/2014	955	5.1	<1	<1	<1		<1			64.5	33.5	77	6.4	16.8	524											
	20/02/2014	930	4.3	<5	<5	<5	390	<5	170	5	53	36	63	3.8	16	370	7500	6	38	<1	720	1300	63	9	13,000	1300	3700
	13/02/2015	1055	5.3			<1	474		117	20	65.1	36.2	75.7	6.5	15.5	529	3440	0.3	54	0.1	905	1310	8	3.9	15,400	1590	4680
	13/03/2015	941	4.96			<1	409		103	<10	57	35.6	64.8	4.1	14.5	486	8400	0.2	48	0.2	835	1480	94	6.95	14,200	1450	4350
	10/04/2015	1008	4.47			<1	425		182	<10	58.6	30.6	67.8	3.4	12.9	481	7880	<0.05	51.6	0.1	867	1230	134	6.05	14,000	1410	4260
	1/09/2015	1206	4.6			<1	559		125	20	82.3		85.9	5.2	13.6	621	7620	1.4	60.6	<1	1070	776	3060	10.9	16,800	1650	5690
	11/12/2015	1120	4.5			<1	560		80	20	83	25.3	85.7	5.4	13	623	6960	0.05	96.8	0.1	1010	1800	38	5.75	16,500	1590	5440
	18/01/2016					48	30.6		1	40	8.5	3.3	2.3	4.7	3	1	7300	<0.05	63.6	0.1	990	306	138	4.55	16,000	1550	5110
	11/05/2016	1020	4.4			<1	474		134	<10	65.6	30.9	75.2	4.1	14.1	518	7730	<0.5	57.2	<1	922	1150	148	6.29	14,800	1470	4460
	2/09/2016					<1	502		125	<10	70.9	27	78.9	4.3	12.1	568											
	11/01/2017	950	4.7			<5	470		140	6	72	25	71	4.1	13	480	6000	5	67	<1	690	340	2300	6	14,000	1400	4800
	26/03/2017	870	4.2			<5	380		120	<5	50	34	63	3.5	15	410	7900	5	44	<1	690	1700	50	5	12,000	1400	4100
	25/06/2017	1400	4.3			<5	700		160	<5	100	28	110	4.8	17	780	12000	50	96	<1	1400	1000	7200	6	26,000	2100	6800
	10/09/2017	1400	4.4			<5	730		210	28	120	28	110	4.9	16	800	16000	12	130	<1	1300	1400	3500	11	23,000	2200	7300
G9	3/12/2010	372	6.51	<0.1	160	160	160	<0.1	<2	27	48	7.4	9.2	2.8	4	8.2	23	5	0.3	<1	3	4	97	12	180	5	25
	2/11/2010	375.2	6.98	<0.1	150	150		<0.1			49	8.2	8.7	2.9	4.1	6.7											
	25/01/2011	356.2	6.5	<0.1	170	170	<5	<0.1	<2	150	46	7.7	7.7	2.8	4	11	16	5	0.3	<1	3	<1	84	18	240	10	25
	22/11/2011	228.3	7	<1	31	31		<1			8.7	4	2.1	1.3	1.1	3											
	30/01/2012	944	7.07	<1	180	180	470	<1	<2	55	92	8	59	2.9	6.2	280	<10	8	0.2	<1	22	<1	500	<1	1400	67	36
	27/04/2012	379	6.06	<5	25	25	97	<5	<2	<5	20	3	12	1.6	1.9	26	17	<1	0.3	<1	<1	2	<10	12	29	5	19
	22/08/2012	889	7.1	<5	190	190	440	<5	<5	13	88	6	53	2.9	6.1	190	12	6	0.2	<1	13	<1	180	<1	1000	54	24
	3/04/2013	90.7	5.06	<5	38	38	23	<5	<5	<5	4.6	4	2.7	1.6	1.1	34	48	1	2.2	<1	10	15	18	140	330	29	120
	26/12/2013	247	6.4	<5	12	12		<5			9.8	3	8.4	1.9	1.7	12											
	20/02/2014	34.5	5.4	<5	10	10		<5			1.6	2	0.5	1.4	1	1											
	11/04/2014	72.7	6.15	<5	25	25		<5			5.2	3	2.9	1.6	1.4	29											
	7/12/2014	285	6.1	<1	21	21		<1			10.5	4.5	5.9	1.9	1.7	26.6											
	13/02/2015	233	7.1			21	41.7		13	<10	8.4	4.8	5.1	2.1	1.6	24.3	3.5	3.45	0.74	<0.1	2.03	5.18	34	83.5	125	5.92	41.1
	13/03/2015	34.3	7.27			16	37.5		6	<10	7.6	4.6	4.5	2	1.5	22.5	6.4	3.5	0.72	<0.1	3.81	4.37	16	145	225	5.59	54.4
	10/04/2015	223	8.6			13	32.8		12	<10	6.5	4.4	4	1.5	1.3	18.9	4.9	3.6	0.8	<0.1	9.3	5.45	48	141	483	7.68	65.9
	1/09/2015	143.2	7.21			22	47.5		8	<10	9.9		5.6	2	2	24.7	5.4	7.65	0.72	0.1	5.7	1.96	854	238	289	9.42	69.3
	11/12/2015	112	7.1			13	42.6		3	<10	8.9	5.8	4.9	2.1	1.9	22.5	8.3	1.75	1.08	<0.1	4.62	3.94	104	305	235	8.21	99.3
	18/01/2016		6.64			28	62.8		7	20	13.2	5.2	7.3	2	2	31.1	5.1	3.15	0.94	<0.1	4.19	1.79	398	158	208	7.63	73.3
	11/05/2016	143	6.7			30	58.4		11	<10	12.6	4.9	6.5	1.7	1.9	26.5	2	0.8	0.38	<0.1	4.08	1.43	16	33.6	275	6.03	40.2
	2/09/2016					89	117		16	<10	30.1	6.2	10.2	2.3	2.9	31.3											
	11/01/2017	310	7.2			160	170			6	51	7	9.5	2.8	4	5	<10	6	<0.1	<1	<1	<1	320	<5	160	<1	2
	26/03/2017	340	7.1			150	160			<5	50	8	9.3	2.7	4	6	<10	5	<0.1	<1	<1	<1	20	<1	180	<1	2
	25/06/2017	320	7.1			160	170			<5	52	8	9.8	2.8	4.2	6	<10	5	<0.1	<1	<1	<1	540	<1	210	1	8
	10/09/2017	340	7.1			160	200			<5	63	8	10	2.7	4.3	4	<10	5	<0.1	<1	<1	<1	300	<1	150	<1	8
OB11	2/11/2010	4593	7.07	<0.1	390	390		<0.1			480	11	570	2.2	38	3200											
	2/11/2010	4593	7.07	<0.1	390	390		<0.1			450	11	530	2.2	38	3300											
	25/01/2011	2682	7.22	<0.1	360	360	22	<0.1	<2	1300	120	7.2	250	1.7	89	1100	16	2	0.2	<1	<1	<1	<10	<1	<5	1	21
	22/11/2011	4370	6.49	<1	470	470		<1			300	11	570	1.6	83	2700											
	30/01/2012	4755	6.57	<1	390	390	3400	<1	<2	970	510	10	510	4.1	30	3100	<10	2	15	<1	240	2	3500	<1	14,000	730	380
	11/04/2012	4360	5.98	<5	350	350		<5			480	6	480	4	20	2000											
	27/04/2012	4300	5.78	<5	350	350	3400	<5	<2	6	450	8	550	5.2	41	3500	93	<1	6.1	<1	81	3	16	<1	7300	230	120
	22/08/2012	4754	6.69	<5	380	380	3400	<5	<5	6	480	8	530	3.1	31	3800	16	1	5.4	<1	130	1	61	<1	11,000	600	210
	3/04/2013	4300	6.1	<5	410	410	3500	<5	<5	19	450	14	570	3.5	55	2800	29	2	4.3	<1	41	6	17	<1	3100	220	89
	26/12/2013	4500	6.47	<5	390	390		<5			520	9	570	3.5	52	2400											
	20/02/2014	256	5.7	<5	36	36	90	<5	<2	6	11	2	15	1.2	2.9	61	50	1	0.3	<1	<1	4	14	<1	13	7	55
	11/04/2014	353	6.19	<5	29	29		<5			13	2	20	1.2	3.5	60											
	11/04/2014			<5	30	30		<5				2				59											
	7/12/2014	4400	5.6	25	334	359		<1			569	7.8	551	2.7	30.8	3200	242	0.65	5.78	<0.5	130	14.9	<10	0.26	7150	536	276
	13/02/2015	4100	5.5			361	3340		81	10	494	8.4	511	2.7	29.2	2920	16.5	2.45	1.34	<0.5	9.07	1.78	<10	0.03	1060	78.9	35.5
	13/03/2015	4210	5.98			349	3300		37	20	486	9.1	506	3.5	31.7	3030	20	3.45	0.76	<1	1.69	4.41	<20	1.1	183	16.3	34.3
	10/04/2015	4070	6.36			356	3220		73	20	472	8.8	496	2.7	29.8	2810	32.2	2.65	4.4	<1	10.2	3.6	<20	<0.1	3050	126	57.1
	15/12/2015	3400	6.88			245	3260		19	20	536	8.1	467	5.5	25.4	2960	3.4	0.35	11.2	<0.5	273	8.7	76	0.16	15700	620	538
	3/02/2016					310	3540		73	<10	537	9	534	3.5	29.1	3140	4.2	0.8	8.42	<1	15.7	2.11	<20	<0.01	2700	327	195
	11/05/2016	2430	7.2			175	1610		36	<10	235	14.2	248	9.9	18.2	1430	15	2.45	6.34	<1	32	3.85	<20	0.11	10800	207	126
	2/09/2016					311	3620		73	40	558	7.9	541	3.3	26.4	3280											
	11/01/2017	4300	6.7			290	3600		110	22	570	9	530	4.7	32	3000	<10	3	9.4	<1	180	1	8000	<5	13000	490	510
	26/03/2017	4500	6.3			220	3900		130	33	590	9	580	6.7	35	3400	<10	<1	23	<1	530	2	6700	<1	27000	880	1600
	26/08/2017	4700	6.4			280	3800		57	39	600	9	570	4	34	3400	<10	<1	8.9	<1	55	9	80	<1	13000	290	260
	26/08/2017	4700	6.5			280						9				3400											
	10/09/2017	4700	6.5			280	4600		110	78	830	9	610	4.3	34	3600	<10	2	8.8	1	67	8	780	<1	13000	300	270
RIDGE BORE	30/01/2012	279.9	6.4	<1	70	70	6	<1	<2	110	1.3	9	0.7	1.2	2.5	1	<10	1	<0.1	<1	4	<1	63,000	<1	630	15	13
	22/11/2011	99.2	6.38	<1	14	14		<1			1.6	8	0.7	1.4	2.4	<1											
	27/04/2012	213.5	5.54	<5	27	27	16	<5	<2	67	4.2	6	1.3	1.6	2.8	2	50	<1	0.3	<1	6	4	30,000	<1	2200	11	71
	22/08/2012	87	6.1	<5	25	25	14	<5	<5	28	3.6	6	1.2	1.3	2.7	<1	24	<1	0.4	<1	5	<1	4300	<1	710	9	36
	3/04/2013	104	6.8	<5	39	39	15	<5	<5	18	3.7	6	1.3	1.6	3	<1	14	<1	<0.1	<1	<1	2	9200	<1	700	2	31
	26/12/2013	82.4	6.3	<5	13	13		<5			3	7	0.9	1.3	2.5	<1											
	20/02/2014	172.2	6	<5	31	31	14	<5	<2	51	3.7	7	1.2	1.2	2.5	<1	40	<1	0.3	<1	6	5	33,000	<1	2800	13	31
	11/04/2014	288	6.47	<5	55	55		<5			3	7	1.2	1.3	3	<1											
	7/12/2014	270	6.4	<1	3	3		<1			1	7.4	0.6	1.1	2.6	0.7	18	3.55	0.16	<0.1	3.89	0.81	81400	0.01	538	7.77	30.2
	13/02/2015	253	6			15	15.7		86	110	4.3	5.5	1.2	1.9	2.8	1.1	0.6	<0.05	0.02	0.4	5.07	0.02	19400	<0.01	677	51.4	7.5
	13/03/2015	260	6.07			27	7.6		56	80	1.6	6.4	0.9	1.5	3	2	1.1	0.05	<0.02	<0.1	1.66	<0.01	33200	<0.01	703	2.39	3.6
	10/04/2015	255	7.33			59	8.5		114	80	2.1	5.8	0.8	1.1	2.7	0.2	0.4	<0.05	<0.02	<0.1	1.41	0.34	18500	<0.01	606	1.91	2.5
	1/09/2015	223.5	6.88			13	5.4		66	80	1.2		0.6	1.3	3.2	0.2	2.9	<0.5	<0.2	<1	1.64	0.35	13100	<0.1	570	5.95	45.1
	11/12/2015	42	6.6			8	5.6		29	100	1.2	6.2	0.6	1.3	3	0.3	<0.1	<0.05	<0.02	<0.1	2.45	<0.01	25700	<0.01	569	16.4	17.3
	3/02/2016		7.42			20	6.7		105	90	1.6	6.5	0.7	1.3	2.9	0.3	0.4	0.1	0.06	<0.1	1.83	0.1	29400	<0.01	679	7.22	11
	11/05/2016	146	6.4			65	7.2		103	70	1.6	5.5	0.7	1.3	3.1	0.4	0.2	0.05	0.02	<0.1	2.96	0.02	31000	0.02	721	5.45	20.1
	2/09/2016					36	5.4		74	60	1.2	5.3	0.6	1.3	2.9	0.4											
	11/01/2017	120	6.3			63	6		100	62	1.3	5	0.6	1.2	3	<1	<10	1	<0.1	<1	2	<1	42000	<5	440	3	12
	26/03/2017	100	6			50	7		85	52	1.7	5	0.7	1.3	3	<1	<10	<1	<0.1	<1	4	<1	25000	<1	990	6	6
	26/08/2017	130	6.2			63	6		56	75	1.3	5	0.6	1.4	2.9	<1	<10	2	0.1	<1	4	<1	48000	<1	600	13	33
	10/09/2017	71	5.7			28	6		85	76	1.2	5	0.7	1.2	3.1	<1	<10	2	<0.1	<1	3	<1	46000	<1	530	10	13
G1	22/11/2011	1876	7.2	<1	390	390		<1			210	9	110	8.8	24	900											
	22/11/2011	247.2	8.1	<1	56	56		<1			12	4	12	3.8	8.1	52											
	30/01/2012	2229	6.92	<1	340	340		<1			270	8	140	8.6	27	1500											
	30/01/2012	268.8	8.38	<1	84	85		<1			19	4	12	3.7	8.3	39											
	22/08/2012	2367	6.75	<5	200	200		<5			280	5	160	8.2	27	1200											
	22/08/2012	175.3	8.74	9	87	96		<5			6.6	3	9.6	3.7	6.6	1											
	1/09/2015	1938	8.26				828		5	40	142		115	29	32.2	300	28.4	19	<0.2	<1	0.38	0.88	128	0.51	56.6	2.45	13.4
	15/12/2015	2201	7.56			788	1160		10	50	240	12.9	136	17.2	26.3	700	16.7	11.5	<0.1	1	1.16	0.25	128	0.1	326	6.46	4.2
	18/01/2016		7.28			592	1230		26	50	257	12	143	17.9	25.9	810	17.3	7.8	<0.2	<1	0.28	0.1	100	<0.1	364	3.3	3.3
	11/05/2016	2210	7.2			412	1360		72	10	292	9.6	153	12.8	24.5	1080	40.1	6.5	<0.2	<1	0.89	0.86	70	<0.1	397	3.82	9.5
	2/09/2016					299	1490		56	50	323	7.9	166	10.7	22.2	1310											
	11/01/2017	2200	6.4			160	1600		75	5	340	6	170	7.7	22	1300	<10	2	<0.1	<1	2	<1	780	<5	290	11	9
	26/03/2017	2200	6.3			150	1500		55	<5	330	7	170	8	22	1300	<10	2	<0.1	<1	2	<1	330	<1	340	19	5
	25/06/2017	2200	6.4			150	1500		58	13	320	7	170	7.6	23	1300	<10	3	<0.1	<1	3	<1	560	<1

4.7 Aquifer hydraulic properties

As indicated by the airlift yield discussed in Section 4.1, the fractured rock around the site ranges from relatively impermeable syenite and Williams Fault, through moderately permeable fractured metasiltstones, to the highly permeable Crabb Fault and ore zone fault.

Measured ore zone parameters, derived by AGEC (2004) from pumping tests, are summarised below (Table 4-7).

Table 4-7 AGEC (2004) pumping test results

Airlift bore	Airlift rate (m^3/d)	Obser-vation bore	Dist-ance from airlift bore (m)	Ore zone thick-ness (m)	Max draw-down (m)	Hydraulic Parameters			
						T (m^2/d)	K (m/d)	S	Ss
TG379	328 (3.8 L/s)	TG381	90	2	1.8	20.2	10.1	1.32E-03	6.6E-04
		TG385	121	2	0.29	176	88.3	3.68E-03	1.8E-03
		TG400	180	1	0.24	474	474	7.86E-04	7.9E-04
		TG410	162	1	0.06	272	272	1.17E-03	1.2E-03
		TG371	269	1	0.23	286	286	7.50E-04	7.5E-04
		W82	220		0.28				
TG410	207 (2.4 L/s)	TGG385	39	2	3.85	21.2	10.6	1.54E-04	7.7E-05
		TG387	43	1	2.8	21.4	21.4	5.45E-04	5.5E-04
		TG408	83	2	3.25	19.1	9.6	1.87E-04	9.4E-05
		WB2	60	1	2	28.7	28.7	3.99E-04	4.0E-04
		TG371	146	1	2.5				
		TG409	121	1	0.65				

Previous calibrated models (AGEC, 2004) used Kh of 2-200 m/d for the ore zone fault or reef, decreasing with depth. Unfractured rock to the west of the Williams Fault was assigned a Kh of 0.5 m/d. Storage coefficients are typical of confined and unconfined fractured rock aquifers

The modelled (AGE, 2015) properties are summarised in Table 4-8.

Table 4-8 Modelled Hydraulic properties (AGEC 2015)

Groundwater unit	Transmissivity (m^2/day)		Hydraulic conductivity (m/day)		Storativity	
	range	geomean	range	geomean	range	geomean
weathered siltstone	no data available					
Fractured and jointed siltstone	6 - 48	24	0.1 - 1	0.5	no data available	
Ore zone and Crabb Fault zone	220 - 915	323	6 - 14	9.5	2×10^{-4} 1×10^{-5}	6.1×10^{-5}
Siltstone and ore zone (open holes)	15 - 915	71	-	-	1×10^{-3} 3×10^{-5}	2.8×10^{-4}

5. Conceptual hydrogeological model

Based on the historical investigations and the recent groundwater elevation and chemical data the hydrogeological system at the site can be conceptually described as follows.

- The ore zone and mineralisation occupies a highly permeable, southwards-dipping fault zone, in the order of 1 to 2 m thick, confined by overlying fractured metasediments with low to moderate permeability.
- It is bounded from moderately permeable fractured metasediments, to the west by the relatively impermeable Williams Fault, which potentially acts as a partial horizontal flow barrier and to the east by the highly permeable Crabb Fault.
- Metasediment and Syenite to the east of the Crabb fault are less permeable that those to the west, above or below the ore zone.
- Groundwater through-flow along more permeable zones is likely to be relatively rapid, based on the low salinity.
- Contamination, of at least shallow groundwater, has occurred around waste rock dumps, evaporation ponds and tailings dams, based on monitoring exhibiting localised areas of elevated sulfate or low pH and elevated metals. It is possible that contamination to the northwest of the SWRD and EP2, observed in bores G1 and G8, extends through shallow aquifers to Mt Bundy Creek, approximately 130-300 m to the northwest.
- Recharge is likely to be higher over the waste rock dumps than the natural surface, due to their lack of capping and vegetation.
- Storage is within fractures and joints, making up, in the order of, 1% of the rock volume.
- Recharge is by deep drainage through the overlying soils and fractured rock, with direct recharge to outcropping fault, ore zones and open pit. Recharge is seasonal, reflecting the highly seasonal rainfall, representing in the order of 2 - 20% of rainfall. Given the short-term nature of flow in adjacent creeks and their elevation below surrounding groundwater levels (away from the pit area), they are considered to be sinks or discharge areas, with water being removed by evapotranspiration by riparian vegetation or as baseflow (albeit minor volumes). Average daily calibrated recharge to the entire model domain of 6520 ha is in the order of 7000 m^3.

- The various tailings and water storage dams act as sources or sinks, depending on their water levels relative to surrounding groundwater, with exchange constrained by clayey lining materials.
- Other than in the near-mine area, groundwater is likely to discharge to local creeks.
- The open cut and connected underground workings provide a direct pathway for surface water to the ore zone, with water removed from the system by evaporation from the pit lake surface or added via captured runoff reporting to the pit.
- Based on current relative groundwater elevations, the hydraulic gradient is inwards to the pit, which is likely to capture groundwater flow from beneath the various mine–related contamination sources, such as the tailings and waste rock storage facilities.

6. Numerical Groundwater Model

6.1 Model rationale

A numerical model was constructed to describe existing conditions, including groundwater recharge and discharge areas, groundwater flow paths, and to provide a framework for future impact modelling. The previous modelling for the EIS (AGE, 2015) was limited to 2D modelling and earlier inflow modelling did not include areas to the east of the Crabb Fault and did not extend sufficiently to intersect potential areas of surface-groundwater interaction (AGEC, 2004). To address these issues, a new 3D model was constructed to include the orebody, overlying and underlying materials, and the surrounding units extending to likely hydrogeological flow boundaries at least 3 km from the mine voids.

6.2 Model Construction

6.2.1 Modelling software

The model was constructed using the Groundwater Modelling System (GMS) interface and MODFLOW NWT used with the Upstream Weighting package and Newtonian (NWT) solver. The default “complex” convergence settings were generally used to improve convergence success, albeit for longer run times.

6.2.2 Structure and materials

A 4-layer model was constructed to focus on the mine area and extending at least 3 km to terminate along likely groundwater flow lines along rivers or divides along major topographic divides (indicated in red in Figure 6-1). A grid spacing of 5 m was used in the mine area, expanding to 50 m in the outer areas of the model (Figure 6-5). Cell aspect ratios were 10 or less with a maximum change in adjacent cell relative dimension of 1.5. The model was broadly subdivided into upper fractured and weathered rock (Layer 1 and 2), a middle layer of fractured fresh rock (Layer 3) and a deep layer of weakly fractured rock (Layer 4). The ore zone was modelled in Layer 3, a 2 m-thick zone, with morphology based on digitised contours presented in AGE (2004) and the historical mine layout provided as a DXF by Primary Gold Limited.

Different properties were assigned depending on their parent lithology, depth and location east or west of the Crabb Fault, to reflect the historical observations of aquifer properties and conceptual hydrogeological model. The materials for each layer are shown on Figure 6-3 to Figure 6-6. Initial, pre-calibration material properties were based on the historical data discussed in section 4. No horizontal anisotropy was used and vertical anisotropy ranged from

1 in the deeper materials to 3 in the shallow (upper to middle) materials which are likely to have a higher density of sub-horizontal stress-relief fracturing.

The Williams Fault (Figure 6-2) was modelled as a horizontal flow barrier over its known extent, with a hydraulic characteristic of 0.001. This acts to reduce lateral flow but does not stop it entirely.

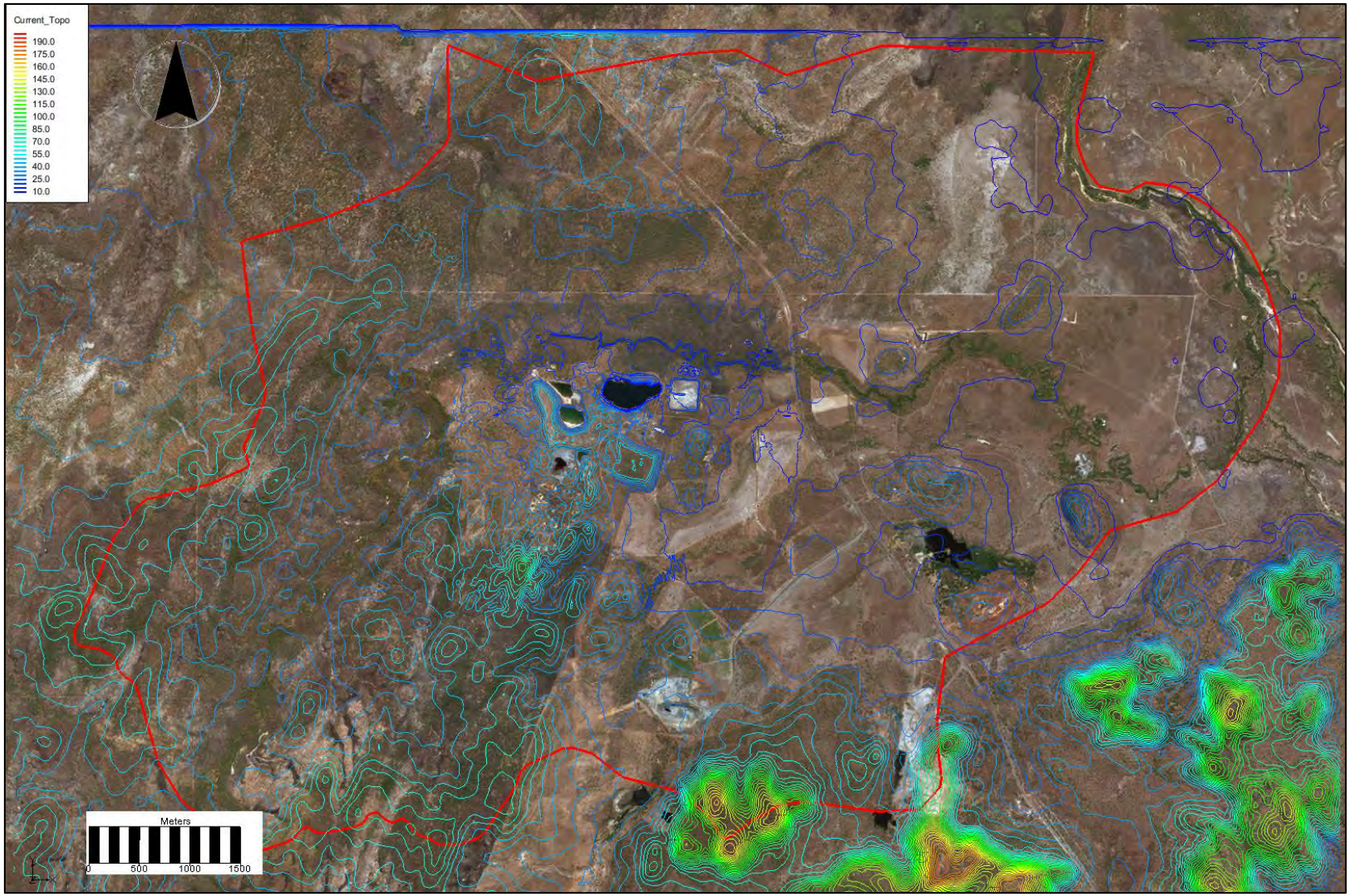

Figure 6-1 Groundwater model extent

Figure 6-2 Williams Fault horizontal flow barrier (brown line)

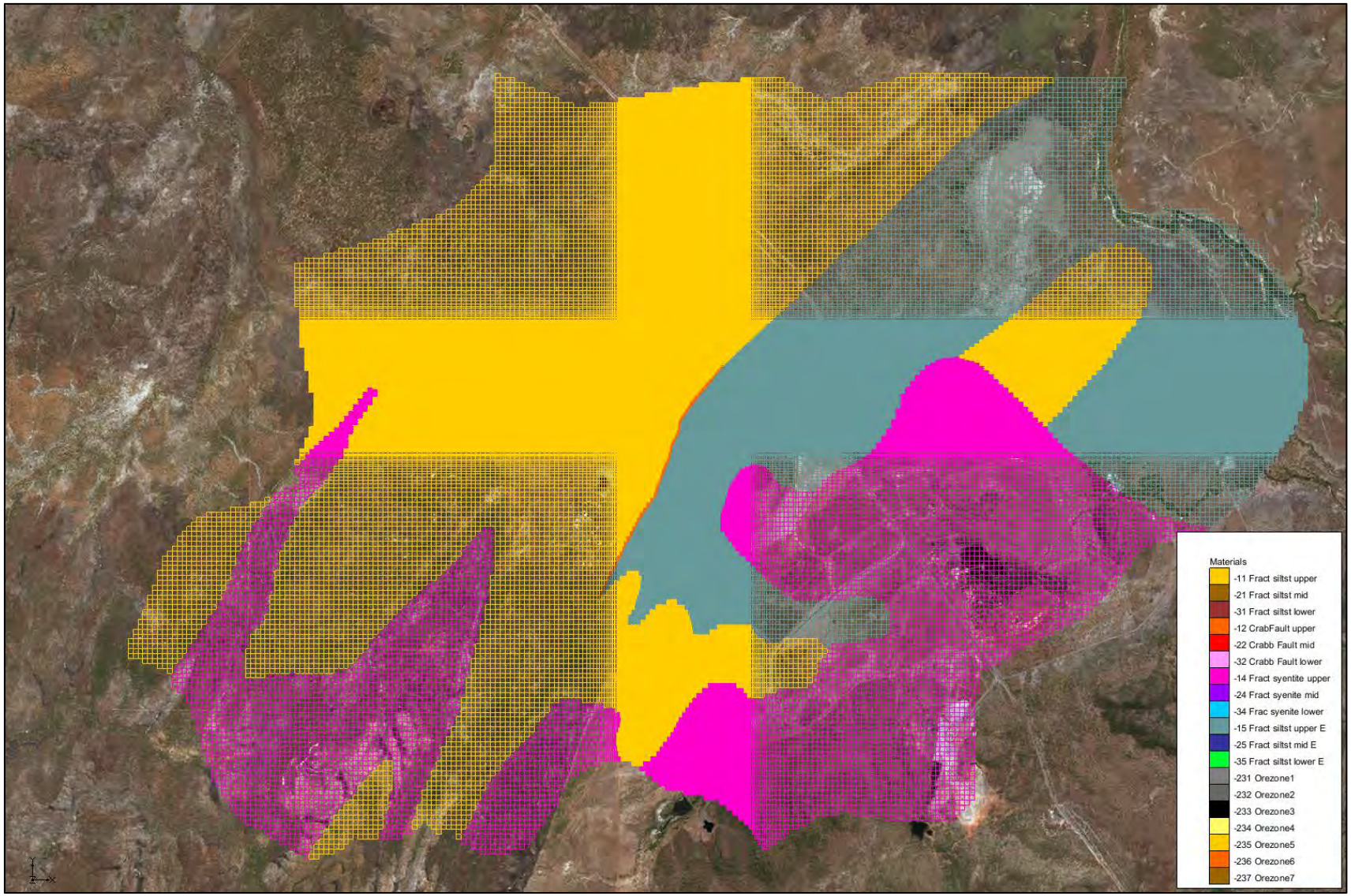

Figure 6-3 Model grid layout – Layer 1

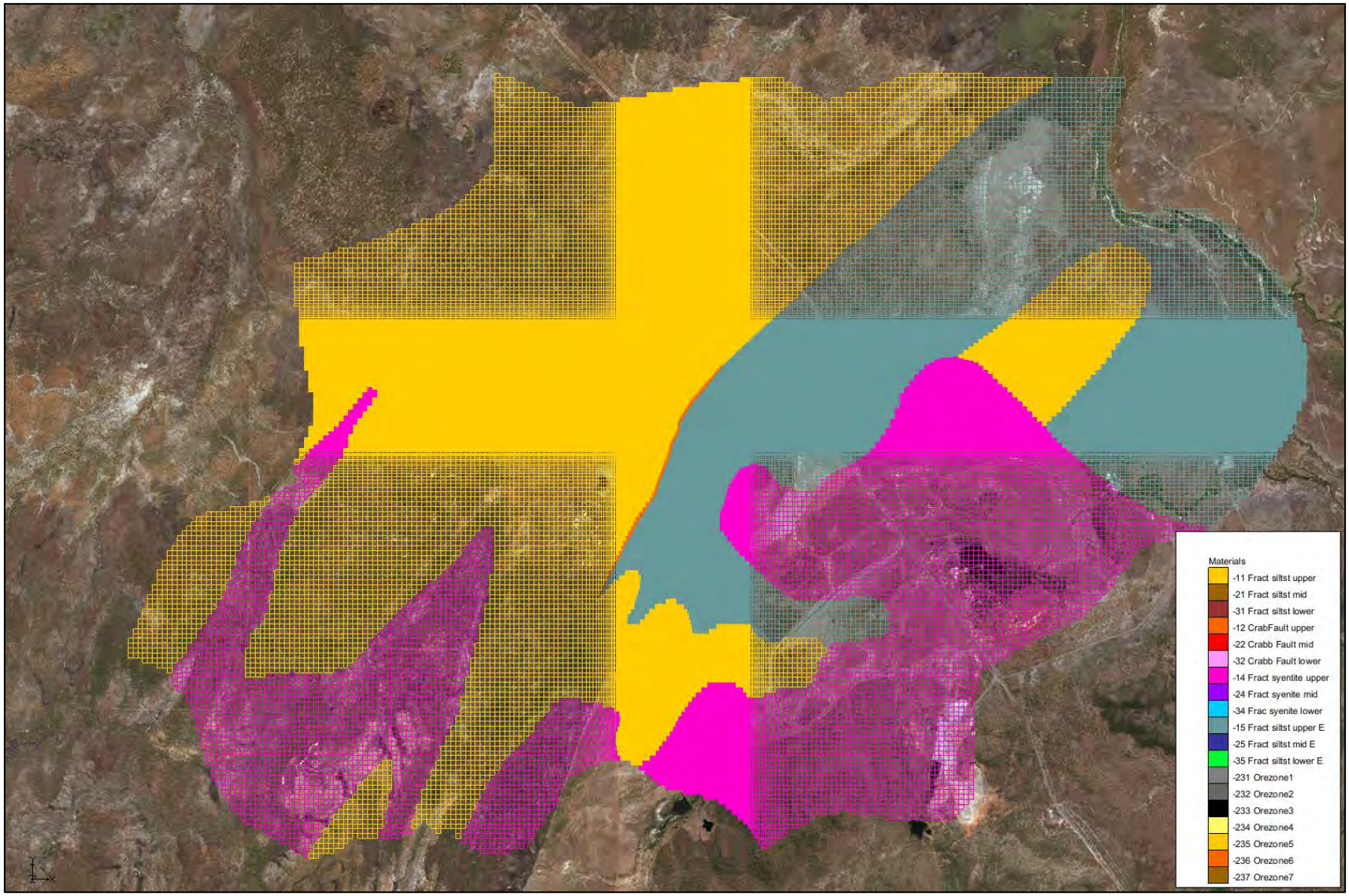

Figure 6-4 Model grid layout – Layer 2

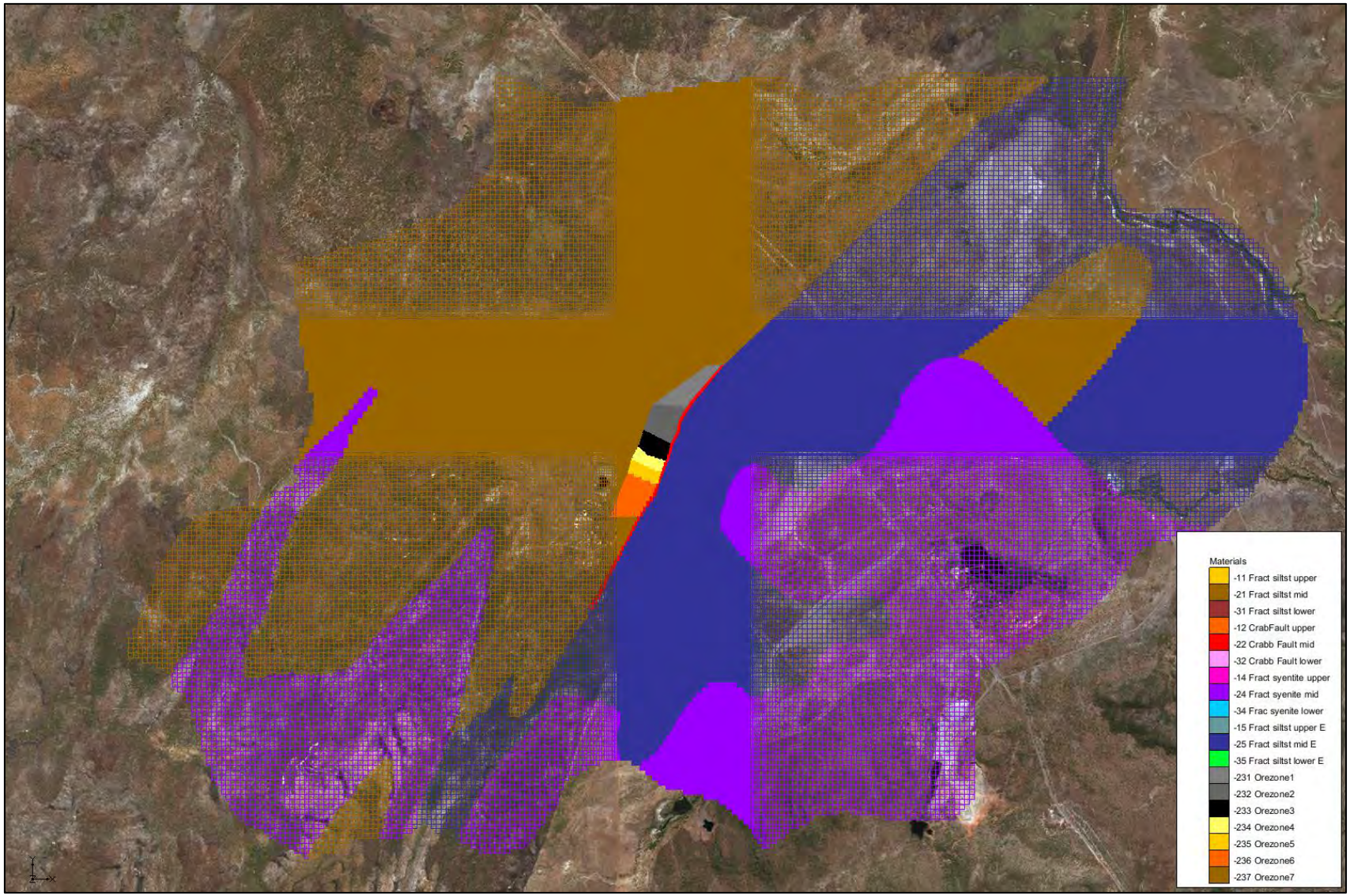

Figure 6-5 Model grid layout – Layer 3

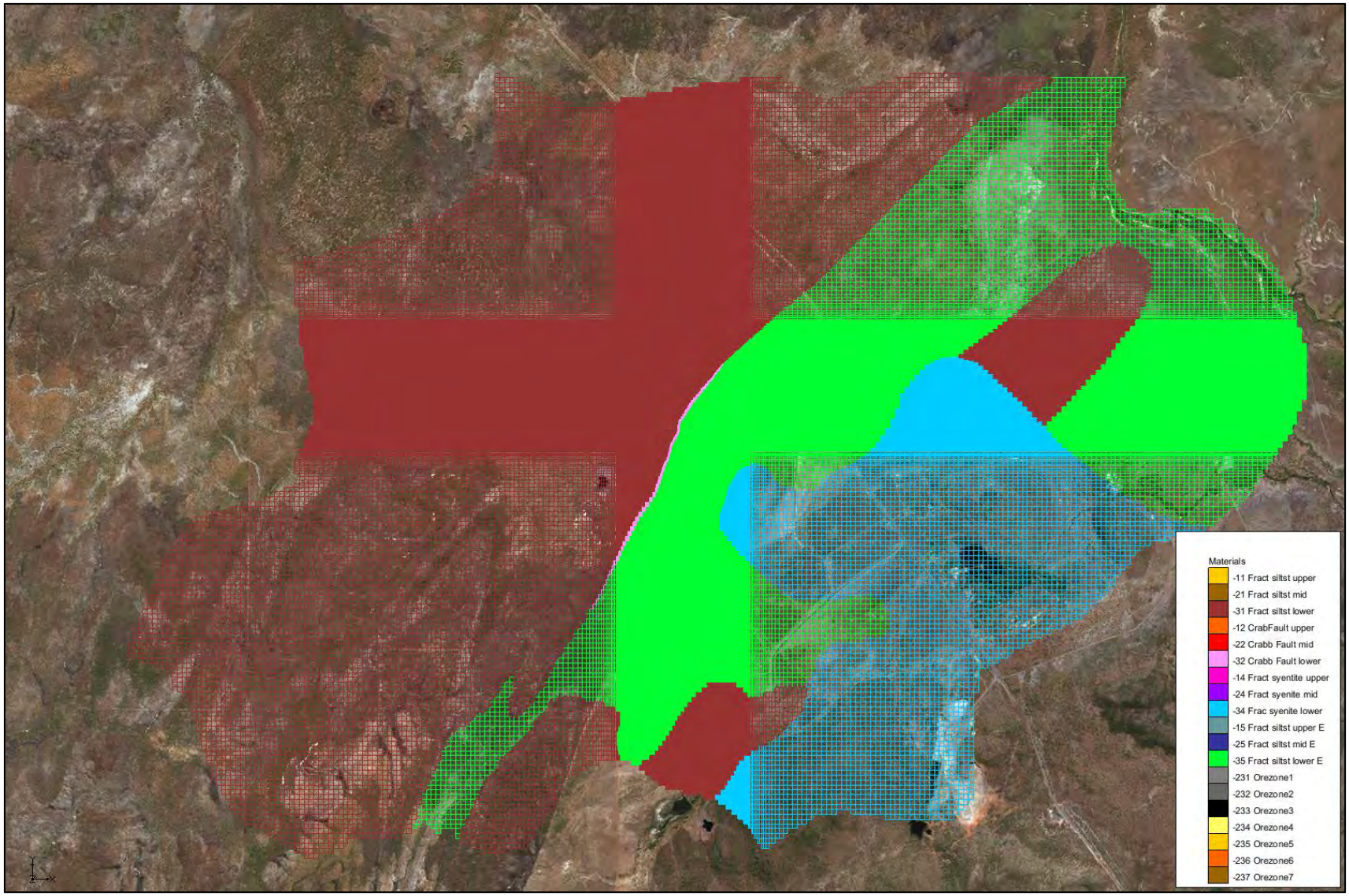

Figure 6-6 Model grid layout – Layer 4

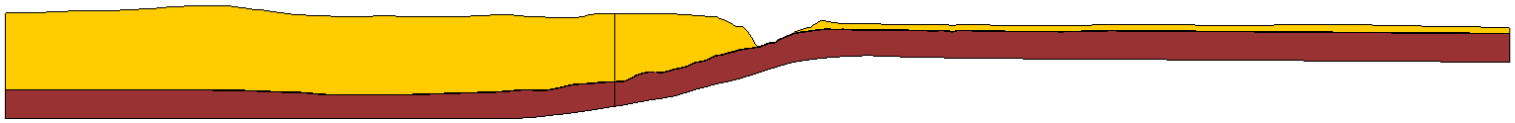

Figure 6-7 Model cross section along ore zone axis

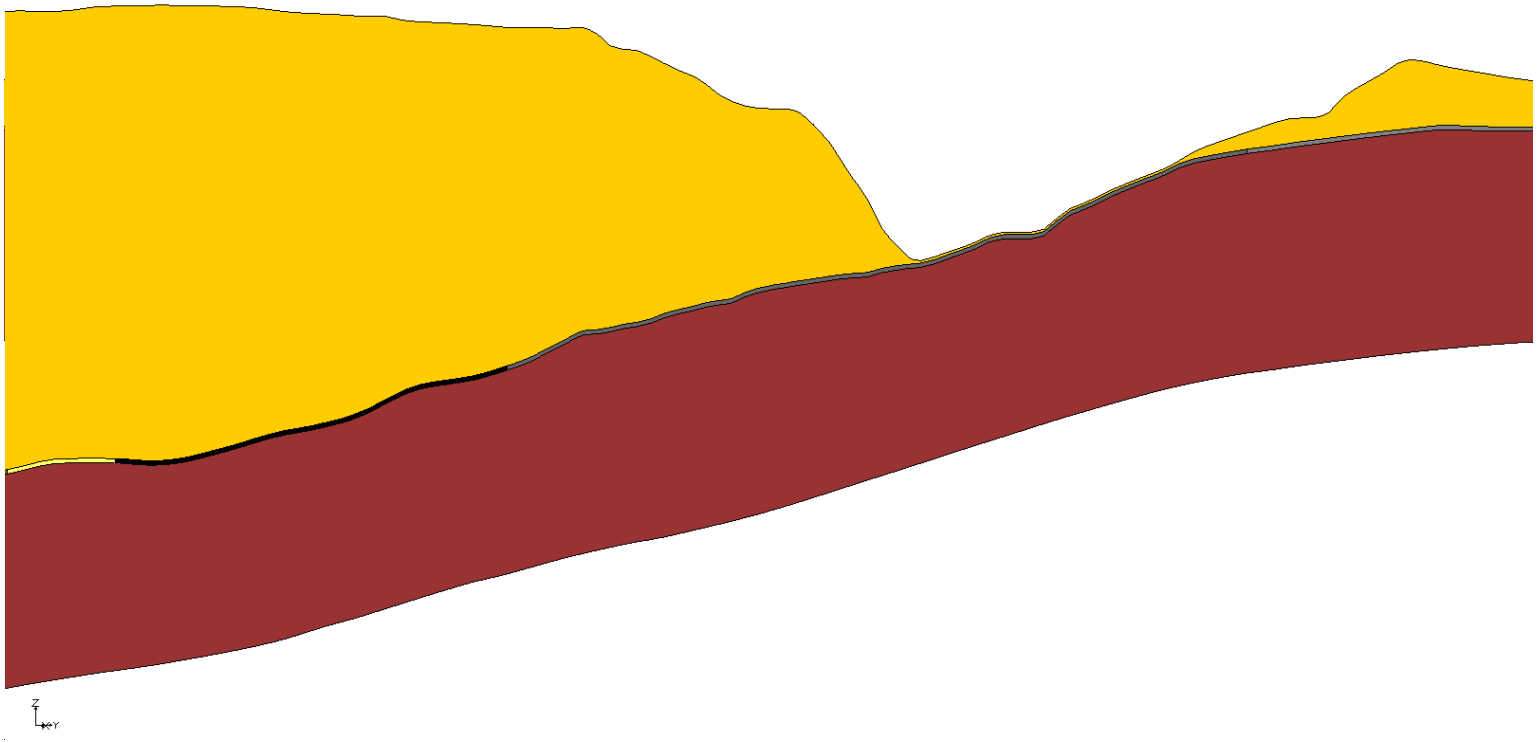

Figure 6-8 Cross section in mine area

6.2.3 Sources and sinks

Internal drainage lines were modelled as Drain (DRN) cells with bed elevations based on the surface topography (green in Figure 6-9).

Large water bodies, including the mine pit lake, TSFs and evaporation ponds modelled as General Head Boundaries (GHB) (brown in Figure 6-9). The underground working were modelled as GHB cells (Figure 6-10), although only the drives were modelled as stope/panel extents were not provided. Given the extent of the drives, however, they are considered adequate for the current modelling. Other than the mine workings, all GHB elevations were static, based on LIDAR levels indicated by shorelines (of mine water features) in the Google Earth (date unknown) aerial photography. The open cut and underground mine GHB elevation was based on the water level logger data (Figure 4-7). GHB conductances were set at 0.001 $m^2/d/m^2$ in the TSF and other water storages, to reflect a thin clay liner, and 1 $m^2/d/m^2$ for the mine void to simulate direct connection with the aquifer.

Recharge was applied over the entire model, initially using the rates indicated in Figure 4-10. Separate recharge zones (Figure 6-11) were provided over the waste rock dumps, to allow for potentially higher recharge due to water being retained in the waste rock dump profile.

All sources and sinks were automatically applied to the appropriate layer based on their elevation, with the exception of the underground workings which were applied to the ore zone in Layer 3.

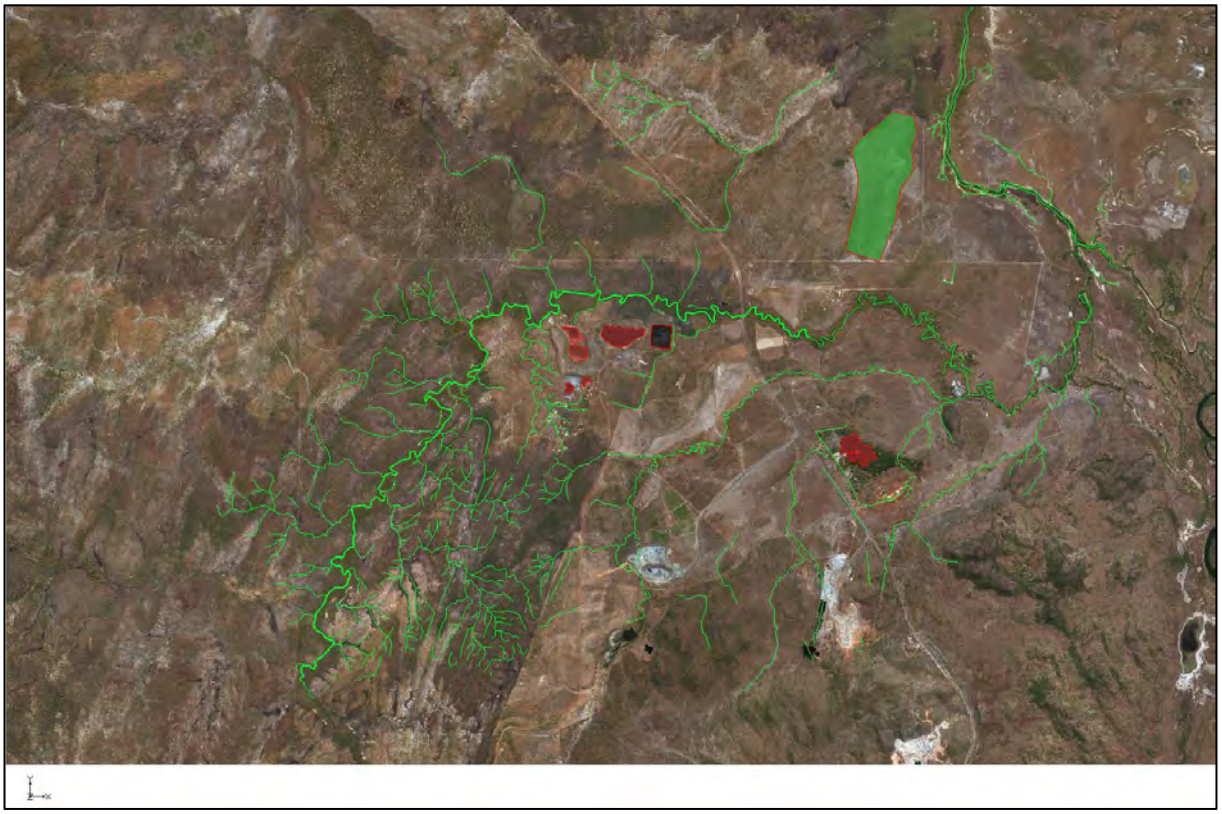

Figure 6-9 Model internal boundary conditions (green = DRN, brown = GHB)

Figure 6-10 Underground workings GHB

Figure 6-11 WRD recharge zones

6.2.4 Observations

Water level observations were input for all bores were levels were recorded and acceptable location data were available Figure 6-12. The observations were assigned to the appropriate layer, based on the bottom of hole data or a default depth of 100 m.

Figure 6-12 Water level observation points

6.3 Model Calibration

6.3.1 Calibration approach

Initial manual calibration of steady-state and transient models was undertaken by adjusting hydraulic conductivity (and storage coefficients for transient models) within the observed range to minimise the root-mean-squared (RMS) residual between observed and modelled groundwater levels. This was followed by automatic parameter estimation using PEST.

6.3.2 Steady State

Steady – state modelling was calibrated against water levels from 8 December 2016 and transient calibration from 8 December 2016 to 6 July 2017.

The best steady-state calibration was achieved in model TG_2017_0040 (Figure 6-13), with the following statistics:

- Mean Residual (Head) -0.39 m
- Mean Absolute Residual (Head) 1.30 m
- Root Mean Squared Residual (Head) 1.48 m
- Scaled RMS (Head) 12%

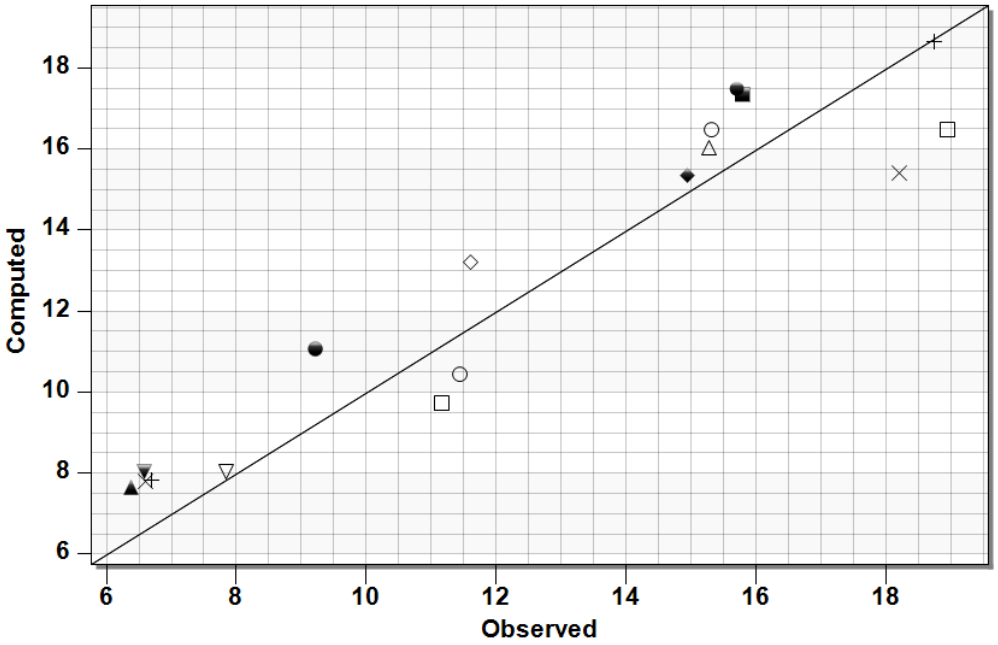

Figure 6-13 Scatter Plot of computed Vs observed head TG_2017_0040

The observed heads and contoured modelled heads are shown in Figure 6-16 to Figure 6-18 for the uppermost layer (Layer 1) and the ore zone layer (Layer 3), along with graphical calibration targets. A green symbol (Figure 6-14) means the residual was less than 2 m and orange indicates a residual between 2 and 4 m. A symbol above the target line indicates the modelled head was greater than the observed head.

The optimum hydraulic conductivity values are presented in below in Table 6-1 and recharge was 0.0001 m/d over the main model area with 0.00011 over the waste rock dumps.

A particle tracking model (Figure 6-19) shows that groundwater from beneath the most likely sources of contamination on site is highly likely to be captured by the open cut pit lake. Travel time are in the order of 50 to hundreds of years outside of the ore and fault zones, but within 10 -20 years within the ore zone.

Table 6-1 TG_2017_0040 Calibrated parameters.

Material	Horizontal K (m/d)	Vertical Anisotropy (Kh/Kv)
-11 Upper fractured siltstone	1.0	3.0
-21 Middle fractured siltstone	1.0	3.0
-31 Lower fractured siltstone	0.447	1.0
-12 Upper Crabb Fault	0.1	1.0
-22 Middle Crab Fault	0.1	1.0
-32 Lower Crab Fault	0.1	1.0
-14 Upper Fractured Syenite	0.005	3.0
-24 Middle Fractured Syenite	1.0	3.0
-34 Lower Fractured syenite	0.080097	1.0
-15 Upper Fractured Siltstone E of Crabb Fault	0.011506	1.0
-25 Middle Fractured Siltstone E of Crabb Fault	1.0	1.0
-35 Lower Fractured Siltstone E of Crabb Fault	0.19972	1.0
-231 Ore zone 1	100.0	3.0
-232 Ore zone 2	300.0	3.0
-233 Ore zone 3	200.0	3.0
-234 Ore zone 4	59.341	3.0
-235 Ore zone 5	10.0	3.0
-236 Ore zone 6	1.0	3.0
-237 Ore zone 7	10.0	3.0

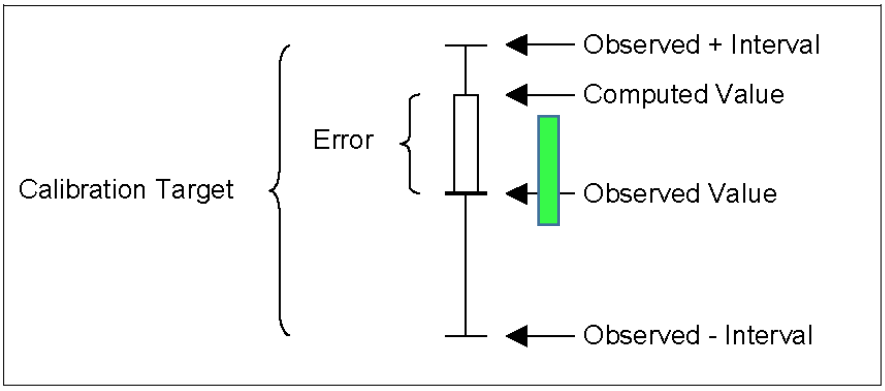

Figure 6-14 Calibration key (for following figures)

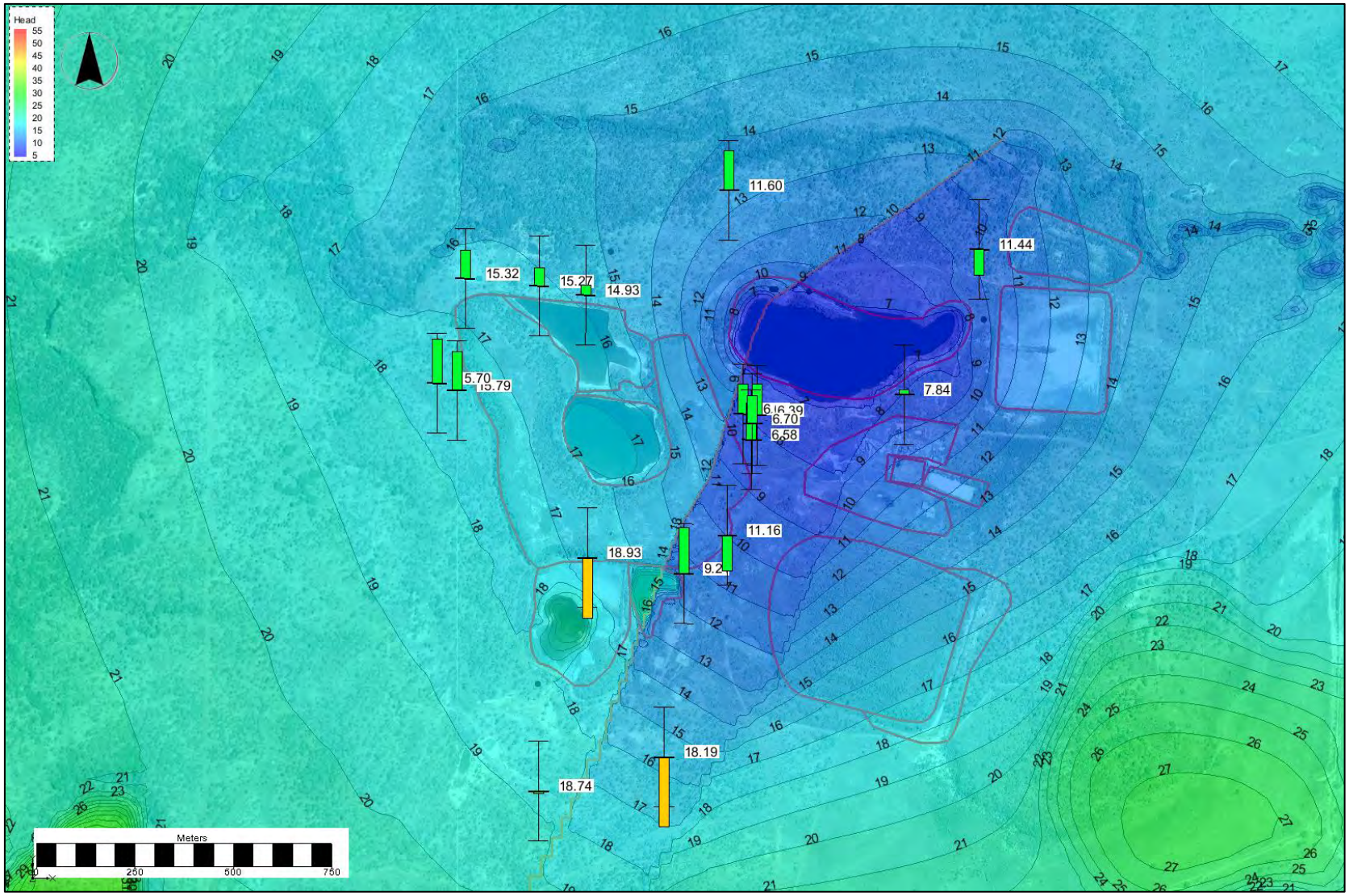

Figure 6-15 Steady-state calibration TG_2017_0040 mine area Layer 1

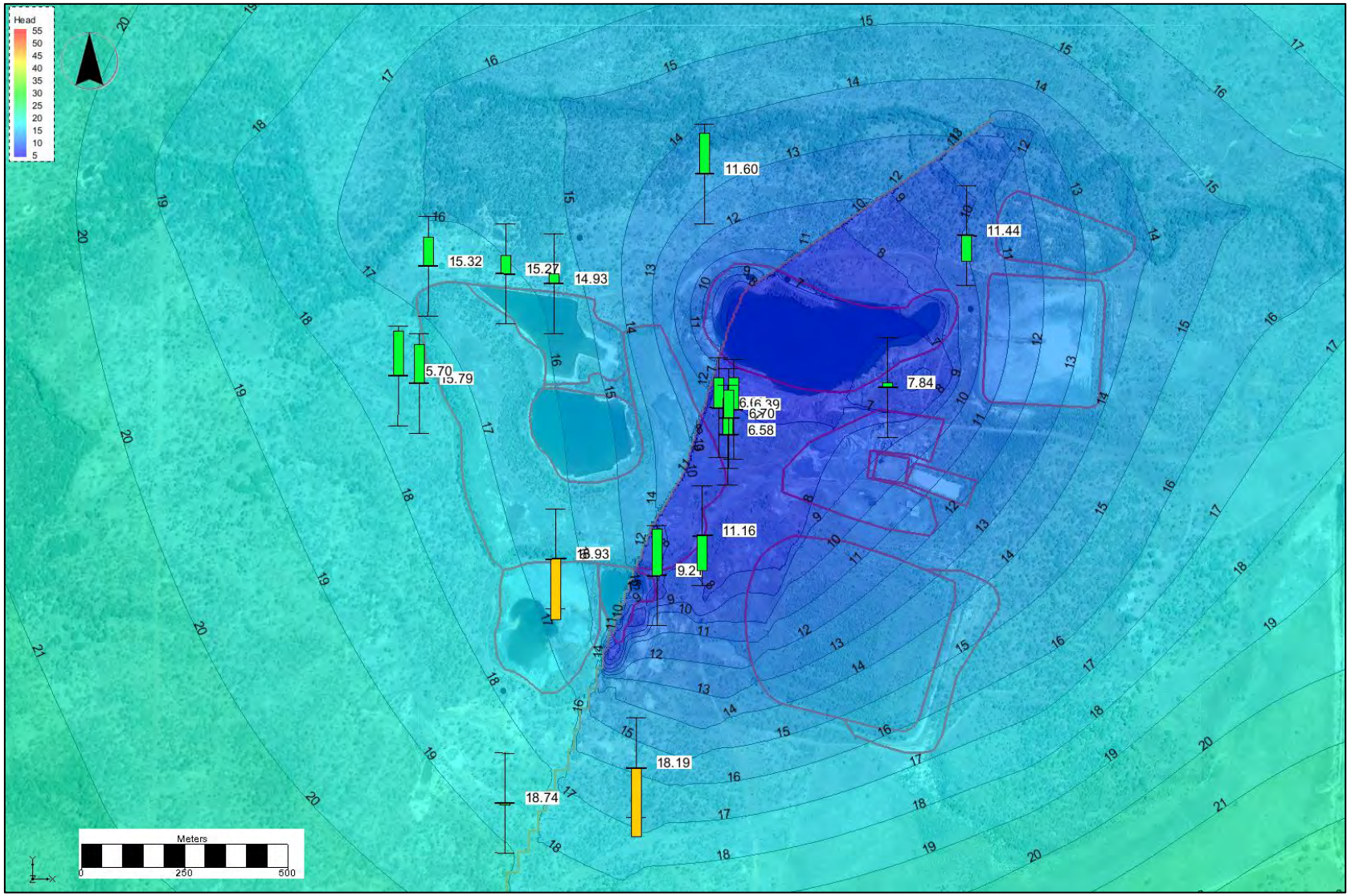

Figure 6-16 Steady-state calibration TG_2017_0040 Mine area Layer 3

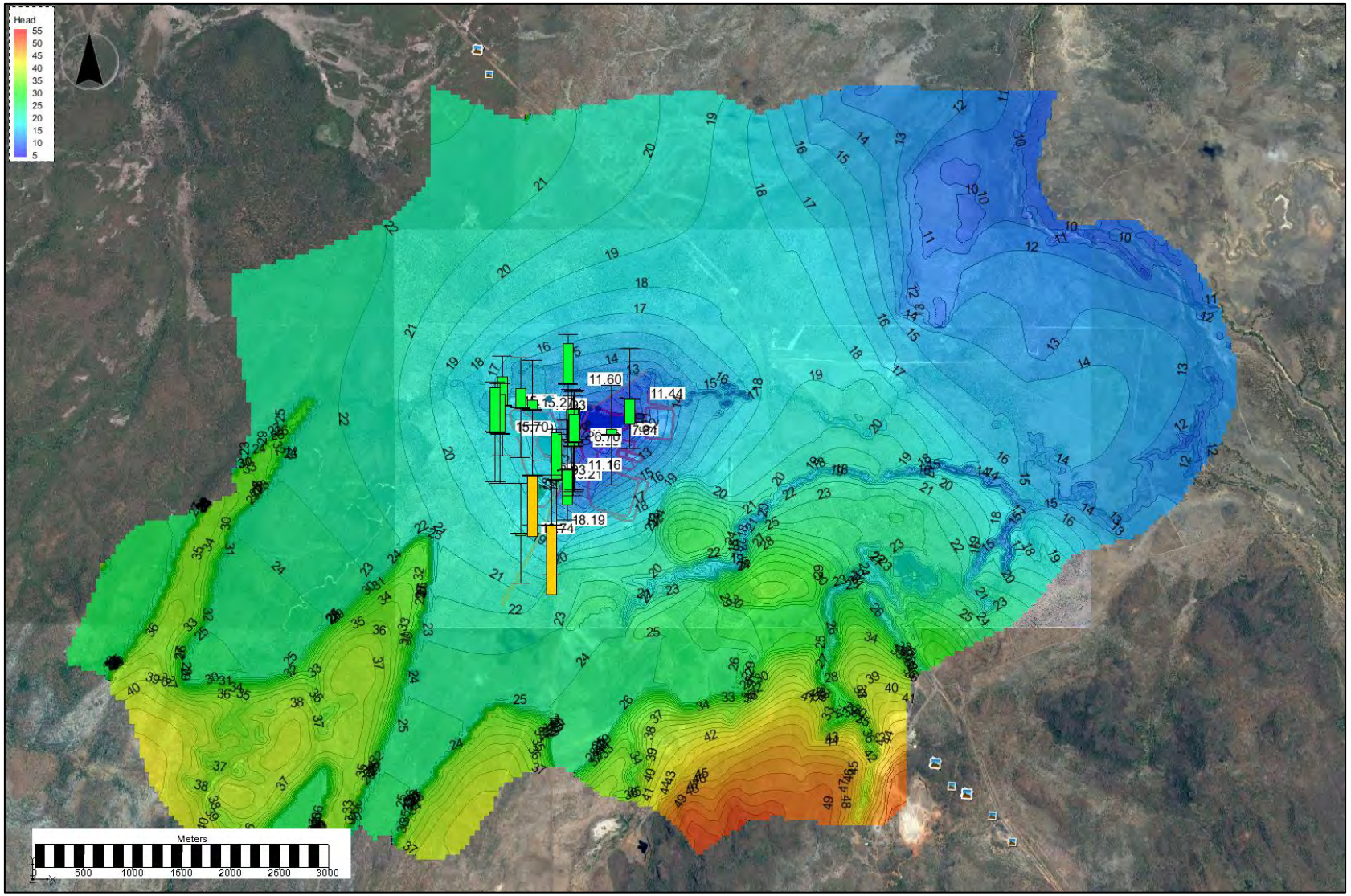

Figure 6-17 Steady-state calibration TG_2017_0040, model-wide area Layer 1

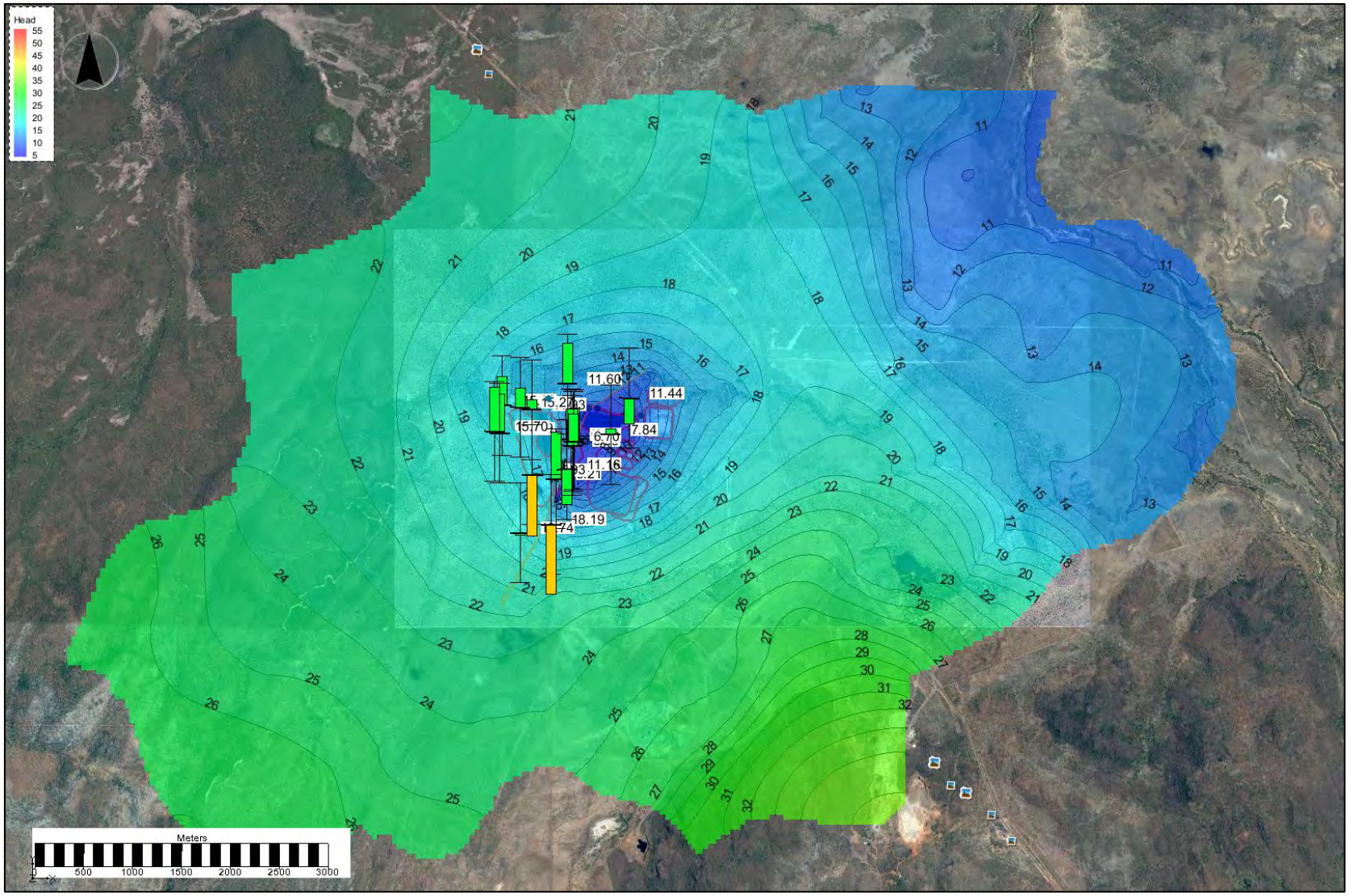

Figure 6-18 Steady-state calibration TG_2017_0040, model wide, Layer 3

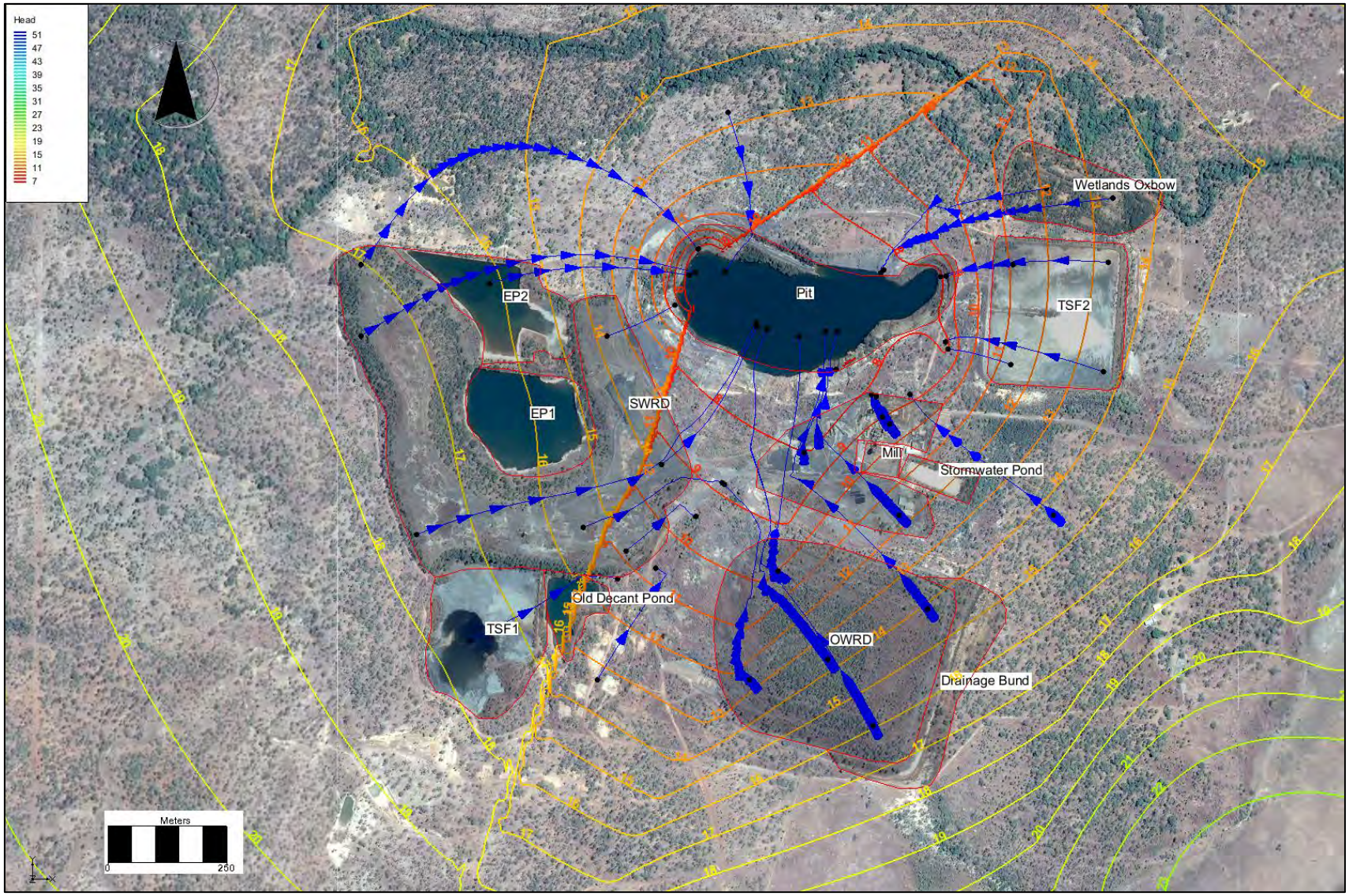

Figure 6-19 Particle Tracking TG_2017_0040 (arrow interval 10 years)

6.3.3 Steady-state sensitivity

Given that there can be many combinations of hydraulic conductivity and recharge that can achieve similar head distributions, TG_2017_0040 was re-run with recharge and hydraulic conductivity divided by a factor of 5 (TG_2017_0044) and 10 (TG_2017_0046).

They achieved RMS values of 1.7 m and 1.22 m, which were only slightly higher the TG_2017_0040 and produced almost identical head distributions. Although formal predictive modelling was not carried out, the model was modified to actively drain the open cut and underground working and the three models achieved inflows of between 3212 m^3/d (TG_2017_0046) and 14937 m3/d (TG_2017_0040). The lowest, from TG_2017_0046, at 37 L/s is close to the estimated historical inflows. This suggests that the average hydraulic conductivity of the bulk of the surrounding area is at the lower end of the measured range.

6.3.4 Transient

Model TG_2017_0040 was run as a transient model, TG_2017_0041 for the period 7 December 2016 to 25 June 2017, using stress periods of 4 days with 4 time steps in each stress period. The heads from TG_20170040 were used as the starting heads. Storage coefficients were consistent in all materials, being 0.0001 (1/m) for Specific Storage “Ss” and 0.01 for Specific Yield “Sy”.

Calibration statistics are summarised as:

- Mean Residual (Head) 0.47 m
- Mean Absolute Residual (Head) 1.77 m
- Root Mean Squared Residual (Head) 1.98 m
- Scaled RMS (Head) 12%

Calibration time series plots are shown for the bores equipped with loggers in Figure 6-20 to Figure 6-22 and modelled head for the near-mine area at the peak water level on 29 March 2017 are shown for Layer 1 in Figure 6-23 and for Layer 3 in Figure 6-24. The bore, DB1 (Figure 6-20) shows a good calibration in terms of the water level trend although the model over predicts heads consistently by around 1.5 m, which is well within the potential datum error. The calibrations for the other bores G9 (Figure 6-21) and WB4P (Figure 6-22) show a broad agreement between observed and modelled overall head levels but variations in modelled heads are less reflective the observed seasonal variations (with the notable exception of DB1 next to the pit). This is likely to be due to overestimation of storage coefficients. No further transient calibration was completed as it was considered to be more appropriate to continue with this phase when additional seasonal data are available after the next data download (following the next/current wet season). This would be further aided by the provision of historical pumping test data, mine dewatering data and historical drawdown data if it were to become available.

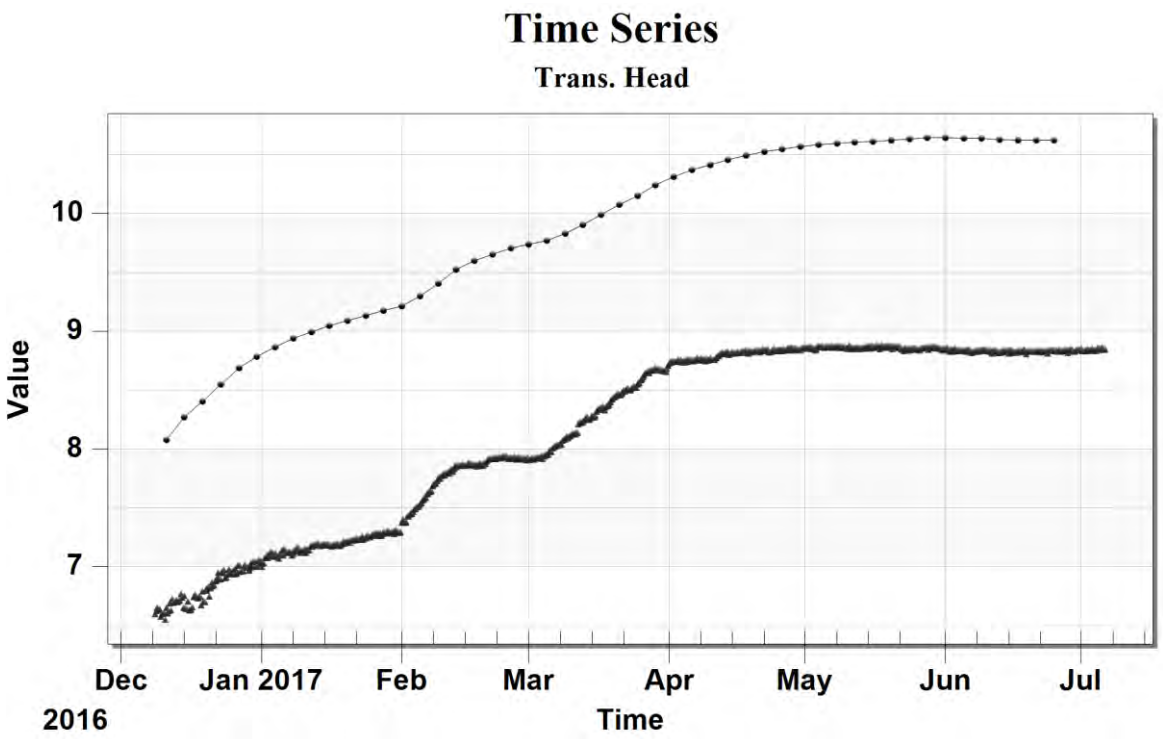

Figure 6-20 DB1 Time series of measured and observed heads (mAHD)

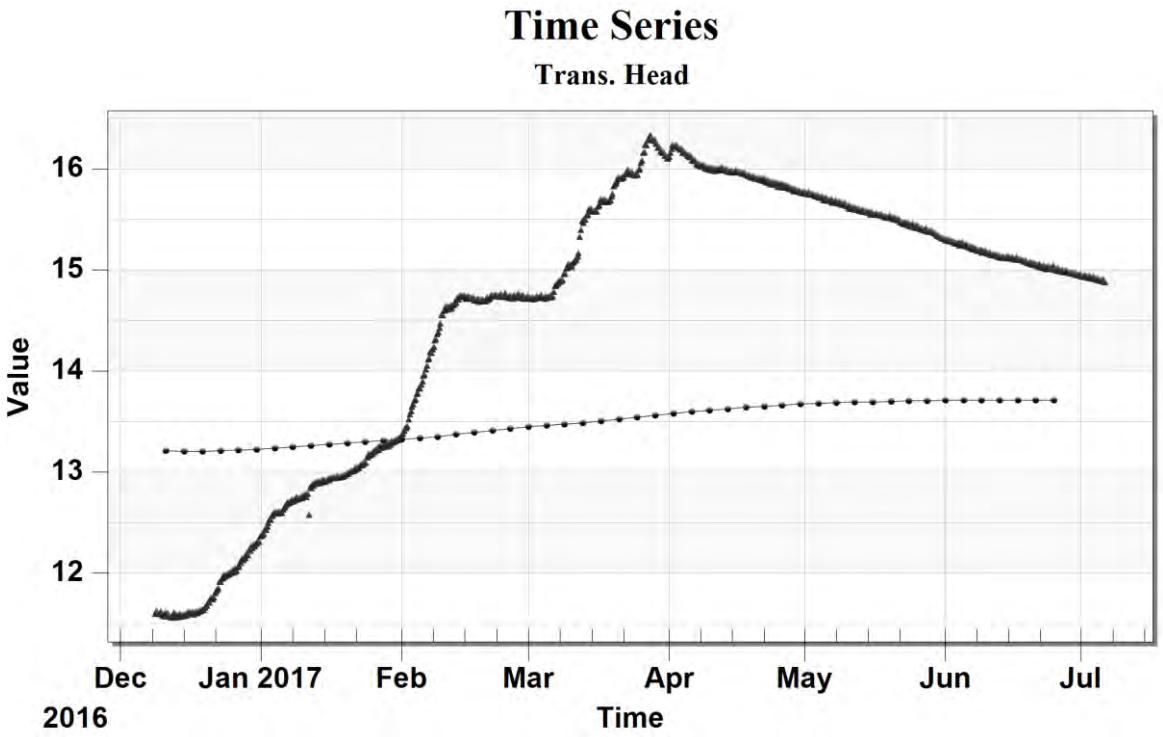

Figure 6-21 G9 Time series of measured and observed heads (mAHD)

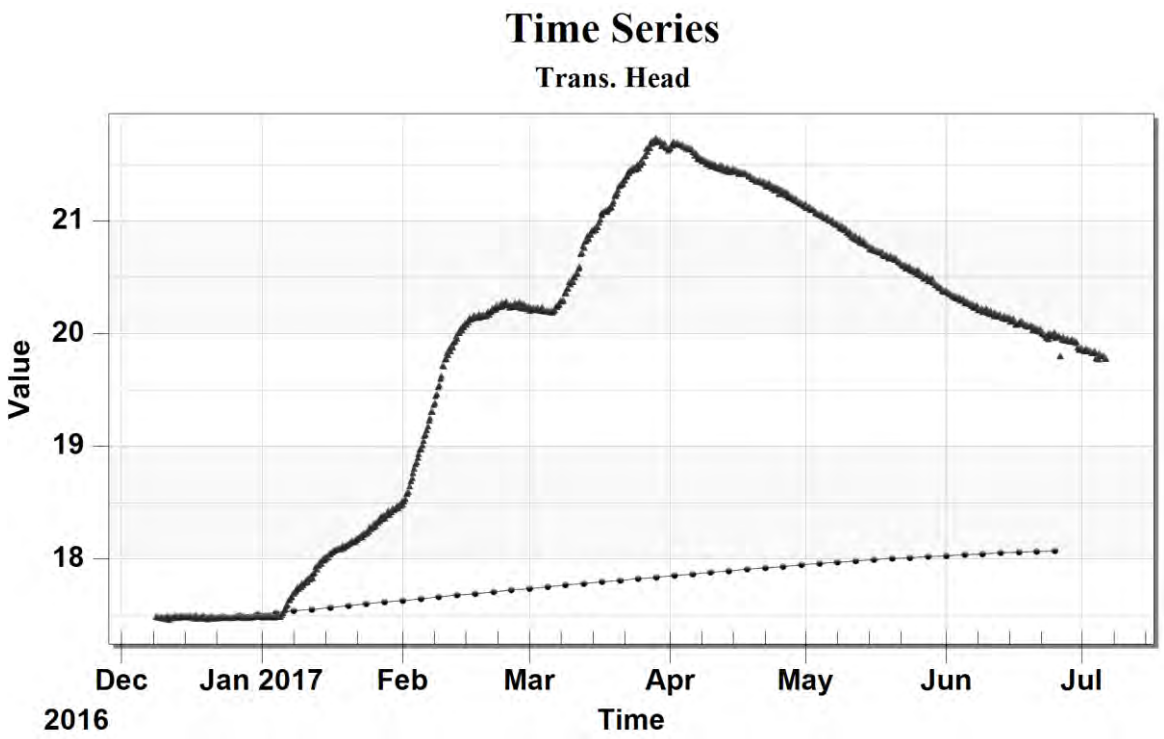

Figure 6-22 WB4P Time series of measured and observed heads (mAHD)

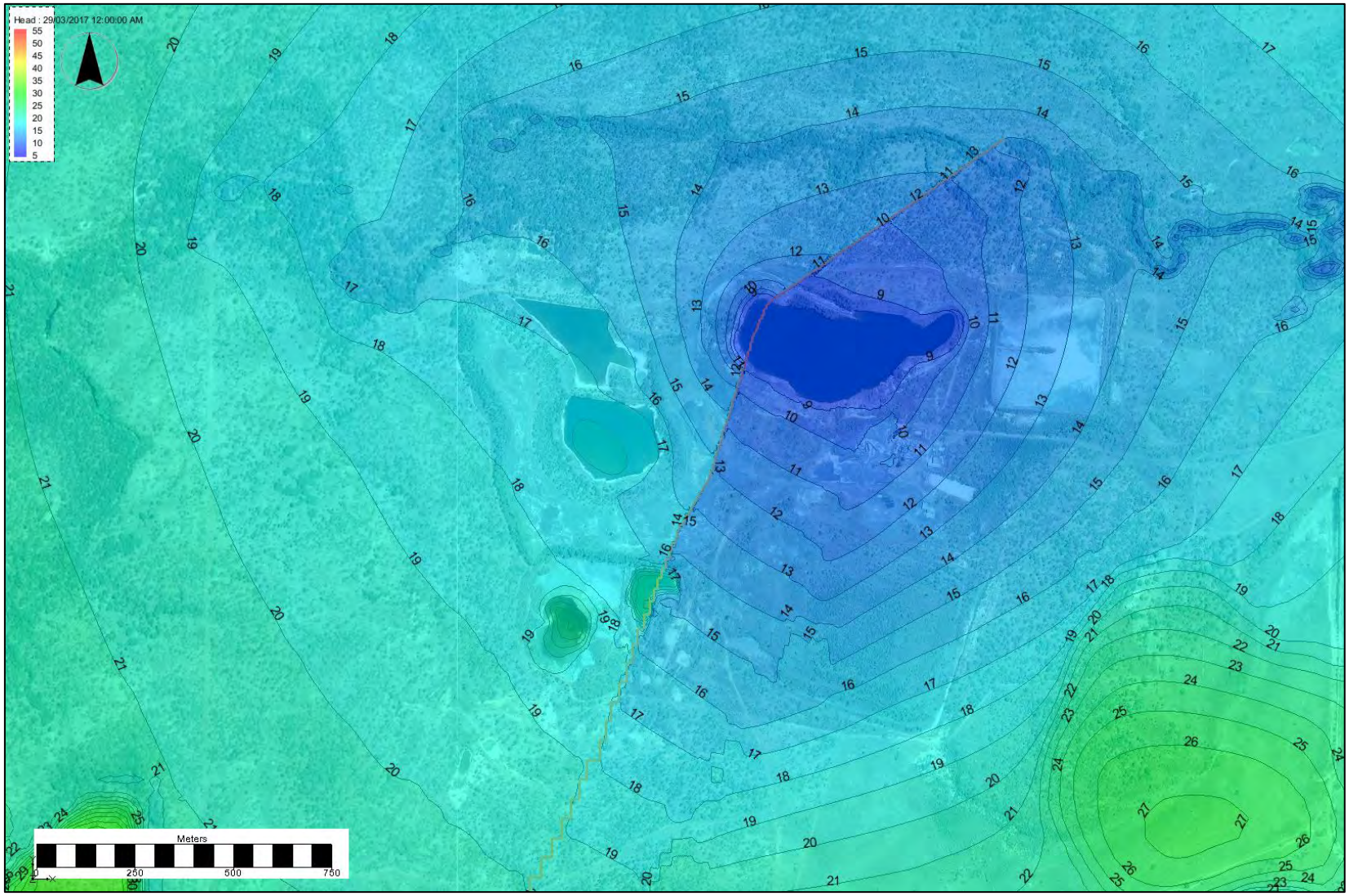

Figure 6-23 Modelled head TG_2017_41 Layer 1 9/03/2017

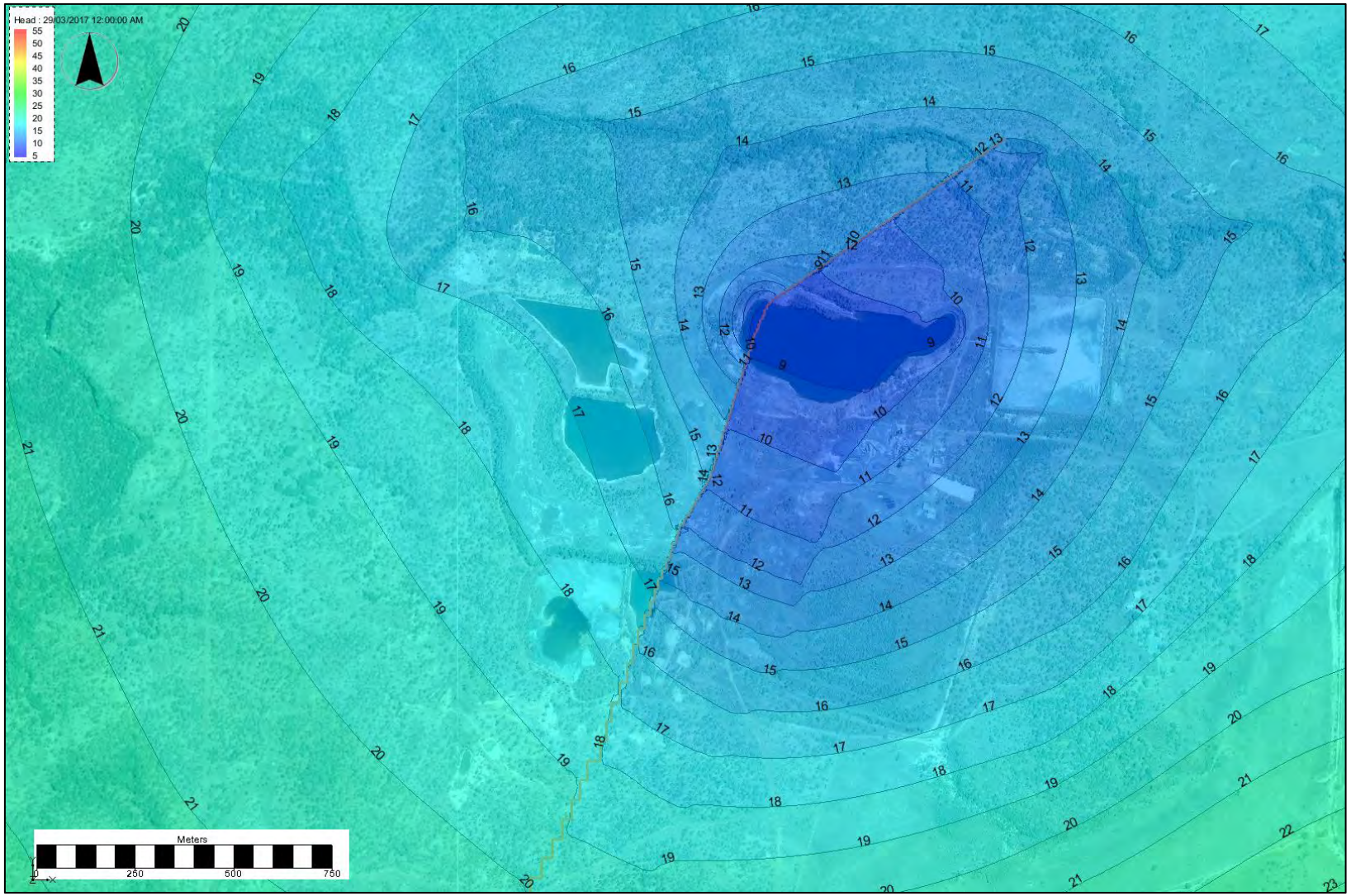

Figure 6-24 Modelled head TG_2017_41 Layer 3 9/03/2017

6.4 Model Observations

As the scope of works for this study was primarily to define baseline conditions and prepare a model for ongoing assessment, predictive modelling has not been carried out. However, the following key observations can be made:

- The modelled heads indicate that the mine pit and connected underground workings remain a groundwater sink through evaporative losses from the pit surface.
- This is likely to result in capture of groundwater contamination from the various site sources such as the TSFs and WRDs.
- The modelled water level in the mine workings have a strong, rapid influence on water levels within the ore zone but have significantly less effect on groundwater outside of the zone between the two faults.
- There is room for improvement in transient calibration by further varying storage coefficients.
- Water levels in the various water storages, including the TSFs and evaporations ponds, are likely to have a significant impact on nearby groundwater levels.

7. Recommendations

7.1 Monitoring

Although the existing network is mostly adequate to detect contamination migration under current conditions, with groundwater migration towards the pit, additional monitoring is recommended to monitor conditions under potential future water management scenarios (as shown in Figure 7-1).

- An additional location (MB_A) is recommended as WB4P and G8 are close enough to the WRD to be contaminated and affected by local elevated recharge through the WRD.
- Prior to commencement of dewatering and new mining operations, additional bores should be installed within the ore zone (MB_B) and to the west (MB_C) and east (MB_D) of the ore zone, immediately southwest of the proposed extent of mining. At each location, a bore targeting the ore zone elevation (~-240 mAHD and around midway up in the overlying rock (~0 m AHD) should be installed.
- Additional shallow bores, nominally to around 0 mAHD or 20 m below surface, recommended to the east of TSF2 (MB_E) and to the immediate NE of the Wetlands Oxbow (MB_F).
- A shallow bore (MB_G) should be installed in the area between the two faults, between the open cut and Bundy Creek.
- All bores should be subjected to regular airlift testing (if percussion drilled) or packer testing (if diamond cored) during drilling and the completed bore subjected to a slug test or constant rate pumping test depending on the yield.
- Given their potential impact on groundwater levels and chemistry, water levels and chemistry in major surface water bodies should be monitored. If data can not be regularly collected by personnel, it is recommended that automatic water level and physico-chemical data loggers are installed.

- Any water discharges, either from surface water storages or from mine dewatering should be metred and recorded to provide regular cumulative flow data.
- In addition to the bores currently fitted with water levels loggers, level loggers are recommended to be fitted to bores Bore11 and G10 to provide a better understanding or seasonal variations. Discharge flow rate frequency measurement will depend on the activity at the site and discharge rates, but daily data should be recorded for active mine dewatering.
- Given the shallow depth of bore G1 and the potential shallow contamination, a deep bore intercepting the deep fractured rock at around -70 mAHD.

7.2 Survey

As accurate groundwater levels are critical for understanding groundwater flow directions and for model calibration, as part of the ongoing model refinement/improvements bore collars and surrounding ground levels should be surveyed for all key monitoring and registered production bores with 5 km of the mine using differential GPS.

For many of the bores, construction details, primarily screen and seal intervals are not known and assumptions have been made on the aquifer intercepted. To improve future modelling accuracy, if the construction details cannot be found with further searching, the monitored bores should be subjected to down-hole geophysical and/or camera inspection to confirm seal and screen intervals.

7.3 Modelling

As noted in the modelling discussion, there is room for improvement in transient calibration once the additional water level data become available after the next data download (following the next/current wet season).

The locations of some mine structures, such as the underground workings and geological structures such as the two major faults, are uncertain, due to lack of accurate grid transformations between local historical surveys and models and a common AHD/MGA94 datum system. The updated mine resource model should be interrogated to provide updated locations of the existing and proposed workings as well as the structure of the ore zone and faults, to provide DXF input of the features (in AHD MGA94) to the model.

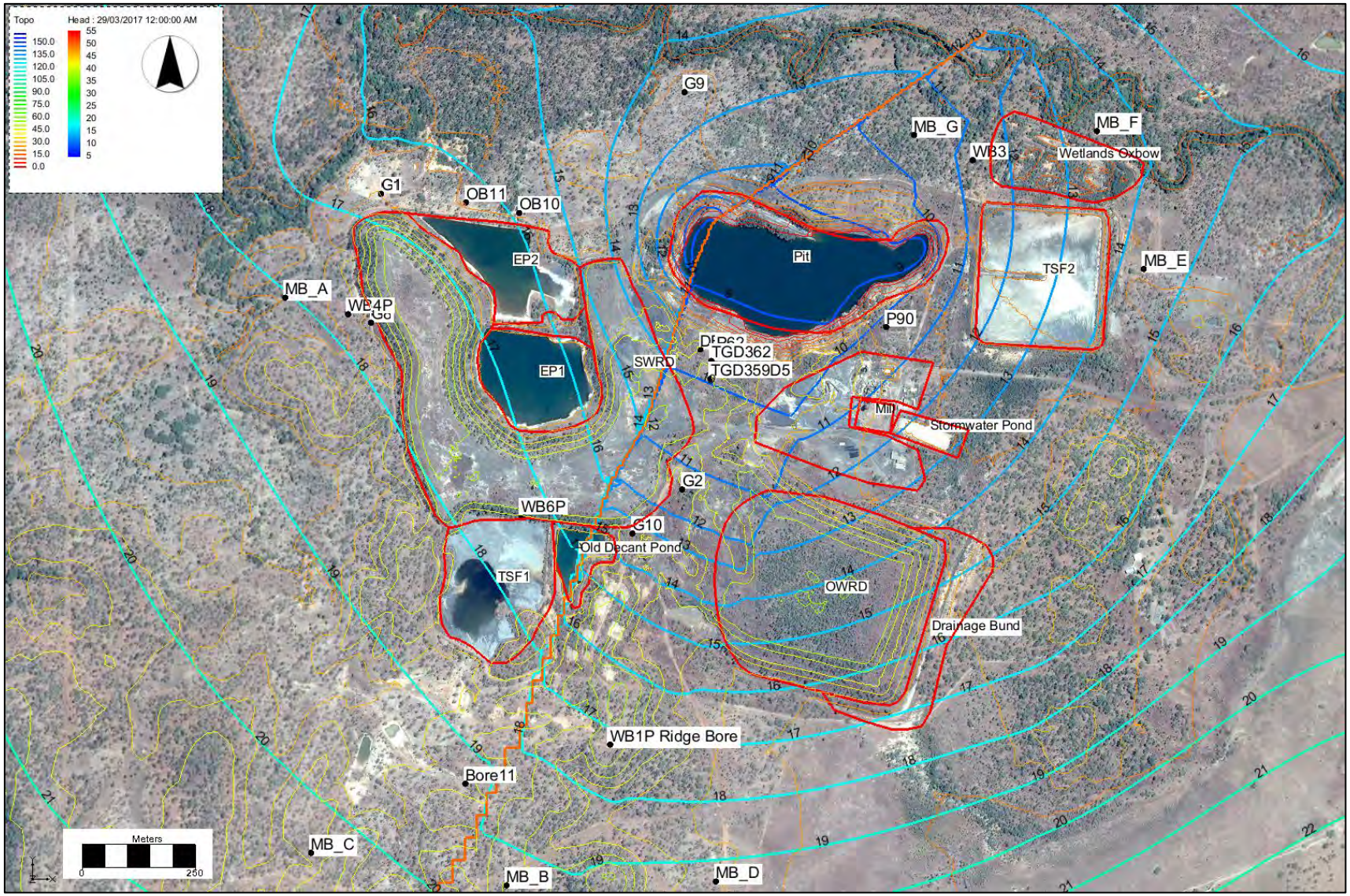

Figure 7-1 Existing and proposed groundwater monitoring locations

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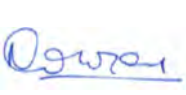
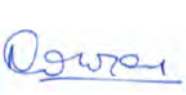
Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	Robert Virtue and Don Rockliff	Lee Evans		Nicole Conroy		21/2/2018
1	Robert Virtue and Don Rockliff	Lee Evans		Nicole Conroy		21/3/2018

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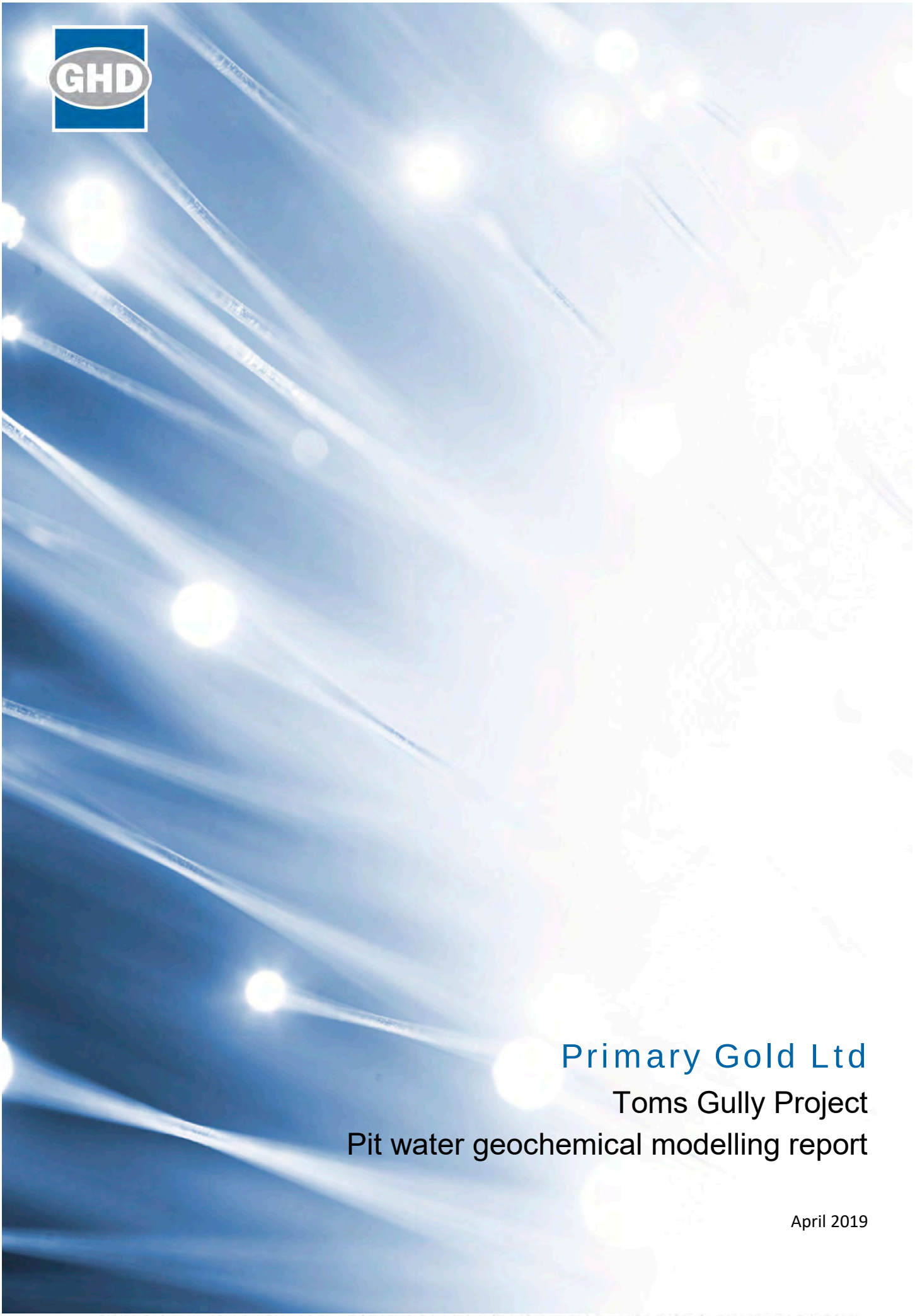
APPENDIX D



Primary Gold Ltd

Toms Gully Project

Pit water geochemical modelling report

April 2019

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

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1. Introduction

1.1 Background

The Toms Gully Project (the Project), located near Marrakai in the Northern Territory, has been in operation intermittently since 1988. The Toms Gully resource was discovered in 1986 by the Carpentaria Exploration Company. Following its discovery, the Project has operated under the ownership of several different entities, most recently Crocodile Gold until 2010; then after a period of care and maintenance, it was divested to Primary Gold Limited (Primary).

Primary, the current lease holder, has applied to recommence underground mining and ore processing at Toms Gully, as described in the Project's Environmental Impact Statement (EIS), Supplementary Environmental Impact Statement (SEIS) and Section 14A amendment (refer to https://ntepa.nt.gov.au/environmental-assessments/register/toms-gully-underground-project). Recent project amendments as described in the Section 14A notification include:

- Subaqueous storage of future underground sulfidic waste rock, almost all from the proposed boxcut and mine development.
- Subaqueous storage of all existing sulfidic tailings from previous operations on site from tailings storage facilities 1 and 2, potentially following re-treatment, plus all future tailings into the Toms Gully pit using a floating head system.
- Treatment of the existing pit water *in situ* throughout operations to maintain circumneutral pH values and thereby reduce dissolved bioavailable metal concentrations by the addition of quicklime or caustic soda.
- Treatment of displaced water from the pit using the proprietary BioAqua process (or contingency option) as waste rock and tailings are added, for off-site licenced discharge once approved.

Primary engaged GHD Pty Ltd (GHD) to undertake geochemical modelling of the pit water to better understand pit water quality risk during operations and post-closure. The work will also assist in determining the most appropriate *in situ* pit water treatment reagent and the volume/mass of reagent which may be required.

1.2 Purpose of this report

The purpose of this report is to assess the risk of water quality impacts to pit water and predict water quality over time from the operational and post-closure scenarios as noted above using geochemical modelling. The work therefore assesses the potential impacts from the proposed modification (Section 14A) to the current project description in the EIS and SEIS. It is also to assist in determining the most appropriate *in situ* pit water treatment reagent and the possible volume/mass of reagent required.

Modelling inputs included pit water quality, waste rock and tailings geochemical composition, densities, volumes and schedules, plus the currently proposed water treatment technologies. It interfaced with completed or concurrent studies for Toms Gully including reports on geochemistry (GHD 2018a and GHD 2019c), the water balance model (GHD 2019a), and groundwater (GHD 2019b).

1.3 Disclaimer

This report has been prepared by GHD for Primary Gold Ltd and may only be used and relied on by Primary Gold Ltd for the purpose agreed between GHD and the Primary Gold Ltd as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Primary Gold Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

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The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Literature review

Acid mine drainage (AMD), acid rock drainage or more commonly now, acid and metalliferous drainage is formed when certain sulfide minerals, most commonly pyrite, are exposed to oxidising conditions (Skousen *et al.* 1998). The conventional practice of land-based disposal of sulfide bearing waste rock and mine wastes including tailings has often resulted in the generation of acidic water and the concomitant leaching of trace metals (Rescan Environmental Services 1989). Subaqueous disposal of mine wastes is a mitigation method commonly used by mines where the water balance deems it appropriate, as it limits oxygen ingress into water-filled pores, which greatly reduces sulfide oxidation, minimises metal leaching and prevents the development of acid drainage (Campbell and Price 2018). Simply, there is less available oxygen in water than in air, not considering anoxic conditions deeper underwater.

In determining the minimum depth of subaqueous disposal required to minimise sulfide oxidation, the key variables are wave activity and the sediment properties of the mine tailings relating to entrainment (Mine Environment Neutral Drainage (MEND) 1998). A review of case histories by MEND (1998) found that subaqueous disposal depths of between one and five metres below the water surface in constructed impoundments had been effective in minimising sulfide oxidation. While dissolved oxygen (DO) concentrations in water at such depths may still be significant, and even supersaturated (depending on submerged photosynthetic activity), this oxygen is preferentially used for the bacterial oxidation of organic matter in sediments (where there is sufficient organic matter present) (Rescan Environmental Services 1989). In most lake sediments, the organic carbon content is usually sufficient to establish anoxic conditions at sediment depths ranging from a few millimetres to one decimetre (Rescan Environmental Services 1989). When complimented by stoichiometrically balanced concentrations of sulfate and metals, sulfate reducing bacteria sequester metals as sulfides, thereby reducing the pool of potential environmental contaminants. This is a natural phenomenon that is found in reducing environments such as peat-bogs and estuarine or lacustrine backswamps.

Actual measurements of DO concentrations in sediment pore water, reported by Campbell and Price (2018), indicate that oxygen can penetrate up to 10 cm depths in sandy sediments, but in silts the oxic-anoxic interface is rarely deeper than one centimetre. Campbell and Price (2018) state that a minimum depth of water cover of one metre is usually sufficient to establish anoxic conditions in sediments overlying subaqueously disposed tailings. Results of field and laboratory testing have confirmed that submerging AMD-generating materials is one of the best available methods for limiting AMD generation over the long term (MEND 2001).

3. Analysis scenarios and methodology

3.1 Geochemical modelling scenarios

Geochemical modelling was undertaken using the PHREEQc (Parkhurst and Appelo 1999) program. The database minteq.v4.dat (Allison *et al.* 1990; USEPA 1998) was used to define thermodynamic data for aqueous species as it contains each of the metals that were to be modelled and is applicable to the temperature and ionic strength of the water being investigated. The following assumptions applied to each modelling scenario:

- Dissolved (or bioavailable), rather than total metals concentrations.
- Half of the laboratory limit of reporting (LOR) was used where laboratory non-detects were retuned.
- Pit water level was set at 15 m AHD. This level returns a volume of 4.1 GL under existing conditions, and is a stable water level under existing conditions based on field notes included with the surface water quality data provided by Primary. It is acknowledged that the groundwater modelling report (GHD 2019b) has indicated the potential for pit water level reductions during mining based on the adopted dewatering and groundwater inflow mitigation methodologies. As such, the water level of 15 m AHD was assumed in order to model the maximum volume of water which could be affected by the oxidation of metal sulfides in deposited tailings and waste rock.
- Interaction of existing sulfides in the walls of the pit with the pit water was not considered, as oxide material in the pit walls is likely to be primarily inert, and any sulfidic material at depth would be flooded,.

Three scenarios with a total of four geochemical modelling runs were undertaken as described in Sections 3.1.1 to 3.1.4 below. In summary, the scenarios were:

- Scenario 1 – the initial treatment of the existing pit water was modelled using quicklime and caustic soda (Section 3.1.1)
- Scenario 2 – pit water quality was modelled after a nominal two years of operations, the two geochemical modelling runs were:
  - Scenario 2a – pit water stratification as per the current conditions was assumed, i.e. anoxic conditions at the solids level in the pit
  - Scenario 2b – loss of pit water stratification due to either a pit water turnover event or migration of oxic water to the bottom of the pit associated with losses of pit water to the groundwater table, i.e. oxidising conditions at the solids level in the pit
- Scenario 3 – pit water quality post closure was modelled. Loss of pit water stratification was not considered due to the predicted final solids level being within the oxic water layer.

3.1.1 Scenario 1 – Initial treatment of pit water

This scenario modelled the reaction of the median pit water quality (refer Appendix A) with quicklime/burnt lime (CaO) and caustic soda (NaOH) (modelled separately) to determine the preferred treatment chemical. It was based on the quantity, and therefore cost, required of each reagent to reach a pH of approximately 8.5, at which metal solubility is generally reduced. Scenario 1 assumes vertically consistent DO concentrations in the pit; the rationale for which is the limited effect DO has on neutralisation reactions between the reagents and sulphuric acid.

Initially, the modelling did not allow for the precipitation of solids following the reaction, and as such, was conservative in terms of the mass of chemicals required. The Scenario 1 output files were inspected for solids with positive saturation indices. Positive saturation indices imply that precipitation of the particular solids was predicted by the model. The solids identified were then entered into the PHREEQc input files to allow for precipitation, and the modelling was repeated to fine-tune estimates of the quantity of quicklime or caustic required to reach the desired pH. The resulting water quality was then tabulated, as were the predicted quantities and nature of precipitates.

3.1.2 Scenario 2a – Pit water quality during operations

Scenario 2a assumed equilibration of the treated pit water quality following the initial treatment modelled under Scenario 1. The following was added to the pit:

- all of the boxcut rock and waste rock extracted from the boxcut and underground mine workings following two years' of mining operations (approximately 1.18 Mt). One third of this rock was assumed to be sulfidic (i.e. approximately 0.39 Mt); and
- the entirety of tailings from the existing, historic tailings storage facilities TSF1 and TSF2.
- a quantity equivalent to two years' tailings deposition during operations (approximately 0.5 Mt). Refer to Appendix C for the waste rock and tailings mineralogy data drawn from GHD (2018a).

As implied above, all boxcut and waste rock has been assumed to be deposited in the pit to conservatively estimate the ratios of solids to water for each modelling scenario. Refer to GHD (2019c) for validation of these assumptions.

The majority of the waste rock and tailings to be deposited subaqueously will lie below a depth of -15 m AHD. That is, in anoxic water (refer to the dissolved oxygen figure in Appendix B in this regard). However, based on the mine schedule and solids densities reported in GHD (2019a), the final solids level in the pit will reach a depth of -7.6 m AHD (when depositing 100 percent of the waste rock in the pit).

Minimal mixing of anoxic and overlying oxic water was assumed. Therefore, the Scenario 2a results will not represent water quality that would be observed in the upper 25 m of the pit.

The waste rock and tailings mineralogy used for Scenario 2a are presented in Appendix C; being from GHD (2018a). Maximum, rather than mean or median, mineral concentrations were used in the modelling to conservatively represent the 'worst case scenario' in terms of acid-forming minerals in waste rock and tailings. These assumptions are deemed conservative as:

- using a maximum value is essentially a 100th percentile for the sulfide, thereby making the assumption that the maxima is in fact the 'average' within the mineral waste. This will increase the maximum potential acidity within the mineral waste.
- all of the minerals present in the waste rock and tailings were assumed to equilibrate with the anoxic water in the pit. In reality, a large proportion of the minerals present would be unreactive, due to being either contained within waste rock/tailings particles (i.e. not directly exposed to the water), or buried beneath more recently deposited waste rock/tailings.

3.1.3 Scenario 2b – Pit water quality during operations, assuming loss of pit water stratification

Modelling for Scenario 2b was based on the same assumptions as those for Scenario 2a, though with a saturated DO concentration based on that which is observed at the surface of the pit under existing conditions. This DO concentration was 7.01 mg/L (refer to the DO figure in Appendix B).

3.1.4 Scenario 3 – Pit water quality post closure

Scenario 3 assumed equilibration of the treated pit water quality following the initial treatment modelled under Scenario 1. No loss of pit water stratification was modelled, as the final solids level in the pit was predicted to be within the oxic water layer. As the water balance model predicts the final 4.6 m of deposited solids to be comprised solely of new tailings generated during mine operations, the new tailings mineralogy (refer Appendix C) was the only addition to this scenario. The post closure solids level in the pit was predicted as -6.9 m AHD (GHD 2019c), i.e. with 3.1 m of tailings within the existing oxic water layer (based on existing conditions). As such, the quantity of new tailings within this oxic layer (approximately 0.283 Mt) was added for Scenario 3.

3.2 Summary of quantity and pit level assumptions

Waste rock and tailings quantities used in the modelling are presented in Table 3-1. Table 3-2 provides oxic and anoxic water volumes within the pit for the modelling.

Table 3-1 Waste rock and tailings quantity assumptions

Modelling scenario	Time	Total quantity of waste rock produced (Mt)	Quantity of sulfidic waste rock deposited in the Pit (Mt)	Quantity of new tailings deposited in the Pit (Mt)	Quantity of old tailing deposited in the Pit (Mt)
Scenario 1	Prior to the deposition of waste rock or tailings in the pit.	No waste rock or tailings deposited in the pit.			
Scenarios 2a and 2b	Following two years of mine operation	1.180	0.393	0.5	0.375 (0.250 from TSF1 and 0.125 from TSF2)
Scenario 3	Following completion of all mining activities	1.51*	0.503*	0.884 (Quantity used in model = 0.283)	0.375*

* Mineralogy not included in the modelling for Scenario 3. Only the rock within the existing oxic water layer was modelled to react with the pit water in Scenario 3.

Table 3-2 Volumetric assumptions

Modelling scenario	Time	Waste rock/tailings level in the Pit (m AHD)	Volume of anoxic water in the Pit (ML)	Volume of oxic water in the pit (ML)
Scenario 1	Prior to the deposition of waste rock or	No waste rock or tailings deposited in the pit.	NA	4,123 (Scenario 1 assumed all water in the Pit to be

Modelling scenario	Time	Waste rock/tailings level in the Pit (m AHD)	Volume of anoxic water in the Pit (ML)	Volume of oxic water in the pit (ML)
	tailings in the pit.			oxic, as discussed in Section 3.1.1.)
Scenario 2a	Following two years of operations of the mine	-19.8	642	2,470
Scenario 2b			0	3,112
Scenario 3	Following completion of all mining activities	-6.9	0	2,246

3.3 Conservativeness of assumptions

The key assumptions adopted for the geochemical modelling have been qualitatively ranked (low, moderate, and high) with justifications in Table 3-3. As Table 3-3 shows, the geochemical modelling undertaken was, overall, highly conservative.

Table 3-3 Conservativeness of assumptions

Scenario(s)	Assumption	Conservativeness	Justification
All	Half of the laboratory LOR was used where laboratory non-detects were retuned.	Moderate	This is standard practice for assuming a concentration below the LOR. The LOR value could be used but this is inaccurate as the LOR, can by definition be observed.
All	Interaction of existing sulfides in the pit with the pit water is not considered	Moderate	Sulfides in the pit walls likely have some effect on pit water quality, though this was not considered for the modelling as the effect is captured by the existing water quality data.
All	Biological processes are not factored into the modelling.	High	Biological processes such as bacterial oxidation of organic matter would likely limit sulfide oxidation through the generation of anoxic conditions leading to sulfate reduction and metals sequestration (Campbell and Price 2018, MEND 2001). However these processes are not readily incorporated into geochemical modelling. Therefore, oxidation reactions which would be unlikely to occur were modelled.
2a, 2b and 3	Waste rock and tailings mineralogy is assumed to be the maxima from GHD (2018a).	High	This accounts for any potential deviation in waste rock and tailings mineralogy from that of the average or median of the samples analysed for GHD (2018a).
2a and 2b	One third of the boxcut and waste rock is assumed to be sulfidic, the	High	Results from GHD (2019c) indicate that the majority of the boxcut rock is inert.

Scenario(s)	Assumption	Conservativeness	Justification
	remaining two-thirds inert.		
2a and 2b	All deposited material is assumed to equilibrate with the pit water.	High	At any one time during site operations, only the topmost layer of deposited material is likely to interact with the overlying water (Rescan Environmental Services 1989). This assumption was as conservative as possible.
3	All material deposited above -10 m AHD is assumed to equilibrate with the pit water	High	While water above -10 m AHD has been shown to be oxic, only the topmost layer of deposited material is likely to interact with the overlying water (Rescan Environmental Services 1989).
3	Pit water is assumed to be in equilibrium with the atmosphere.	High	This allows for the complete oxidation of sulfidic materials in the new tailings, i.e. the 'worst case scenario'

3.4 Water quality assessment

The water quality results from each of the geochemical modelling scenarios were compared to the Site-Specific Trigger Values (SSTVs) for discharge to the environment at the Tom's Gully site (Stauber and Batley 2018), which are reproduced below in Table 3-4.

Table 3-4 SSTVs applicable at Toms Gully (Stauber and Batley 2018)

Parameter	units	SSTV
pH	pH units	5.8-8.0
EC	µS/cm	41
TSS	mg/L	54
Turbidity	NTU	87
Sulfate	mg/L	210
Aluminium (pH>6.5)	mg/L	0.295
Arsenic	mg/L	0.042
Cadmium	mg/L	0.0004
Chromium	mg/L	0.006
Copper	mg/L	0.0018
Iron	mg/L	2.7
Lead	mg/L	0.0056
Manganese	mg/L	2.5
Nickel	mg/L	0.013
Zinc	mg/L	0.015
Total ammonia (pH 8)	mg/L	1.4

The comparisons allowed for an assessment of potential impacts at Toms Gully on aquatic life in the pit and in the receiving environment during operations (in the case of a managed release) and post-closure (in the case of wet weather passive release). This comparison does not take into consideration further treatment of water prior to release that Primary proposes.

4. Results and discussion

4.1 Scenario 1

The initial results for Scenario 1, where the modelling did not account for the precipitation of solids following reactions with quicklime and caustic soda, are presented below in Table 4-1. When accounting for precipitation, the target pH of 8.5 was not reached due to the establishment of equilibria in the pit with atmospheric carbon dioxide and the precipitated solids modelled. Modelling additional reagent use did not result in substantial increases to the pit water pH value.

Table 4-1 Scenario 1 - Quicklime and caustic masses required

	Units	CaO	NaOH
Molecular mass	g/mole	56.077	39.997
Modelled reagent concentration	mg/L	149	220
Resulting pH	pH units	8.54	8.51
Resulting pH accounting for atmospheric equilibrium	pH units	7.851	7.888
Total mass required for the pit	t	611	907

The modelled water quality in the pit following treatment with lime/caustic is shown in Table 4-2. The modelling predicts that following treatment with quicklime or caustic soda, the pit water would exceed the SSTVs for EC, sulfate, cadmium, copper, lead, nickel and zinc. Modelled masses of precipitates resulting for these treatment methodologies are shown in Table 4-3.

Table 4-2 Modelled pit water quality following treatment with lime/caustic

Parameter	Units	CaO treatment	NaOH treatment	Target SSTV for off-site managed release under licence[1]
pH	pH units	7.851	7.888	5.8-8.0
EC	µS/cm	**2401.3**	**2502.3**	41
Total alkalinity as $CaCO_3$	mg/L	44	47	NA
Sulfate as SO_4	mg/L	**1371**	**1402**	210
Chloride	mg/L	7	7	NA
Calcium	mg/L	304	215	NA
Magnesium	mg/L	148	157	NA
Sodium	mg/L	22	148	NA
Potassium	mg/L	8	8	NA
Aluminium	mg/L	0.0005	0.0006	0.295
Arsenic	mg/L	0.005	0.005	0.042
Cadmium	mg/L	**0.077**	**0.079**	0.0004
Cobalt	mg/L	<0.001	<0.001	NA
Chromium	mg/L	0.002	0.002	0.006
Copper	mg/L	**0.003**	**0.003**	0.0018
Iron	mg/L	<0.001	<0.001	2.7
Lead	mg/L	**0.010**	**0.010**	0.0056
Manganese	mg/L	<0.001	<0.001	2.5
Nickel	mg/L	**1.342**	**1.373**	0.013
Uranium	mg/L	0.031	0.032	NA

Parameter	Units	CaO treatment	NaOH treatment	Target SSTV for off-site managed release under licence[1]
Zinc	mg/L	**5.982**	**5.246**	0.015

1: SSTVs are for off-site managed release under licence. Indicative only for operational pit water quality purposes.

Results in **yellow bold** indicate exceedances of the SSTVs.

Table 4-3 Modelled precipitate masses following treatment with lime/caustic

Precipitate		CaO treatment		NaOH treatment	
Name	Formula	g/L	Total (kg)	g/L	Total (kg)
Cobalt ferrite	$CoFe_2O_4$	0.0013	6135	0.0013	6135
Cupric ferrite	$CuFe_2O_4$	0.0011	5305	0.0011	5310
Diaspore	AlOOH	0.0420	197,430	0.0420	197,430
Dolomite (ordered)	$CaMg(CO_3)_2$	0.0712	334,537	0.0235	110,501
Hematite	$Fe2O_3$	0.0011	5061	0.0011	5056
Pyrolusite	MnO_2	0.0193	90,913	0.0193	90,913
Zincite	ZnO	0.0028	13,029	0.0039	18132

The results of Scenario 1 identified quicklime as the preferred reagent. As such, modelling for the following scenario was undertaken using the modelled water quality following treatment with quicklime, and all further in situ treatment of the pit water was assumed to be with quicklime.

4.2 Scenario 2a

Table 4-4 shows the modelled water quality in the Pit for Scenario 2a. Note that this water quality is predicted to apply only to anoxic water at or below -15 m AHD, due to pit stratification being maintained.

Without the addition of quicklime, this scenario results in reduced pH values and increased EC compared to Scenario 1, due to the oxidation of sulfides in the waste rock and tailings allowed by the low DO concentrations observed below -15 m AHD. Calcium, magnesium, potassium and iron concentrations were predicted to increase compared to the Scenario 1 results, whereas aluminium, arsenic and copper concentrations were predicted to decrease. pH, EC, sulfate, cadmium, iron, lead, nickel and zinc were predicted to exceed the SSTVs.

The addition of 112 mg/L of quicklime was predicted to raise the pH of the anoxic water in the pit to about 7.8. This was associated with slightly reduced EC, along with a slightly increased alkalinity and reduced concentrations of sulfate and iron through the precipitation of solids. pH and the iron concentration were predicted to no longer exceed the SSTVs. As a result of the conservative assumptions summarised in Table 3-3, the model predicted acid production to be high for the scenario, thereby requiring more quicklime for neutralisation and pH adjustment than may otherwise be required in reality.

Table 4-4 Modelled pit water quality - Scenario 2a

Parameter	Units	Scenario 2a	112 mg/L CaO added	Target SSTV for off-site managed release under licence[1]
pH	pH units	**5.22**	7.758	5.8-8.0
EC	µS/cm	**13,522**	**13,324**	41
Total alkalinity as $CaCO_3$	mg/L	<1	42	NA
Sulfate as SO_4	mg/L	**9721**	**9558**	210
Chloride	mg/L	7	7	NA
Calcium	mg/L	421	423	NA
Magnesium	mg/L	1337	1329	NA
Sodium	mg/L	22	22	NA
Potassium	mg/L	2623	2623	NA
Aluminium	mg/L	<0.001	<0.001	0.295
Arsenic	mg/L	<0.001	<0.001	0.042
Cadmium	mg/L	**0.077**	**0.077**	0.0004
Cobalt	mg/L	<0.001	<0.001	NA
Chromium	mg/L	0.002	0.002	0.006
Copper	mg/L	<0.001	<0.001	0.0018
Iron	mg/L	**67.3**	0.002	2.7
Lead	mg/L	**0.010**	**0.010**	0.0056
Manganese	mg/L	0.001	0.001	2.5
Nickel	mg/L	**1.342**	**1.342**	0.013
Uranium	mg/L	0.031	0.031	NA
Zinc	mg/L	**5.984**	**5.984**	0.015

1: SSTVs are for off-site managed release under licence. Indicative only for operational pit water quality purposes.

Results in **yellow bold** indicate exceedances of the SSTVs.

4.3 Scenario 2b

Table 4-5 shows the modelled water quality in the pit following two years of mine operations, assuming loss of stratification within the pit, i.e. oxic conditions throughout the water column

A slightly acidic pH value of approximately 5.1 is predicted for this scenario as a result of the oxidation of acid-forming minerals in the deposited waste rock and tailings to the results for Scenario 2a, the addition of quicklime was predicted to raise the pH, and reduce sulfate and iron concentrations, though exceedances of the SSTVs for pH, EC, sulfate, cadmium, nickel and zinc were predicted.

Table 4-5 Modelled pit water quality - Scenario 2b

Parameter	Units	Scenario 2b	73 mg/L CaO added	Target SSTV for off-site managed release under licence[1]
pH	pH units	**5.078**	**8.258**	5.8-8.0
EC	µS/cm	**7415.2**	**7223.0**	41
Total alkalinity as CaCO3	mg/L	<1	2	NA
Sulfate as SO4	mg/L	**4904**	**4773**	210
Chloride	mg/L	7	7	NA
Calcium	mg/L	485	487	NA
Magnesium	mg/L	585	585	NA

Parameter	Units	Scenario 2b	73 mg/L CaO added	Target SSTV for off-site managed release under licence[1]
Sodium	mg/L	22	22	NA
Potassium	mg/L	985	985	NA
Aluminium	mg/L	<0.001	<0.001	0.295
Arsenic	mg/L	<0.001	<0.001	0.042
Cadmium	mg/L	**0.077**	**0.077**	0.0004
Cobalt	mg/L	<0.001	<0.001	NA
Chromium	mg/L	0.002	0.002	0.006
Copper	mg/L	<0.001	<0.001	0.0018
Iron	mg/L	**74.4**	<0.001	2.7
Lead	mg/L	**0.010**	0.010	0.0056
Manganese	mg/L	0.001	0.001	2.5
Nickel	mg/L	**1.343**	**1.343**	0.013
Uranium	mg/L	0.031	0.031	NA
Zinc	mg/L	**5.989**	**1.866**	0.015

1: SSTVs are for off-site managed release under licence. Indicative only for operational pit water quality purposes.

Results in **yellow bold** indicate exceedances of the SSTVs.

4.4 Scenario 3

Modelled water quality following closure of the mine is presented in Table 4-6. More acidity is predicted to be produced in this scenario than in Scenario 2a resulting in lower pit pH values, primarily as a result of the oxidation of pyrite in the new tailings that lie within the oxic zone of the pit. This raised the predicted EC and sulfate concentration.

The addition of 230 mg/L of quicklime is predicted to raise pH to approximately 7.5, and reduce EC and concentrations of sulfate and iron. The EC, and concentrations of sulfate, cadmium, copper, nickel and zinc were predicted to exceed the SSTVs both with and without the addition of quicklime.

Table 4-6 Modelled pit water quality – Scenario 3

Parameter	Units	Scenario 3	230 mg/L CaO added	Target SSTV for off-site managed release under licence[1]
pH	pH units	**2.3**	7.509	5.8-8.0
EC	µS/cm	**15,339**	**14,409**	41
Total alkalinity as CaCO3	mg/L	<1	31	NA
Sulfate as SO4	mg/L	**12,421**	**1247**	210
Chloride	mg/L	1	1	NA
Calcium	mg/L	432	597	NA
Magnesium	mg/L	2465	2477	NA
Sodium	mg/L	22	22	NA
Potassium	mg/L	469	2477	NA
Aluminium	mg/L	<0.001	<0.001	0.295

Parameter	Units	Scenario 3	230 mg/L CaO added	Target SSTV for off-site managed release under licence[1]
Arsenic	mg/L	<0.001	0.001	0.042
Cadmium	mg/L	**0.077**	**0.077**	0.0004
Cobalt	mg/L	0.001	<0.001	NA
Chromium	mg/L	0.002	0.002	0.006
Copper	mg/L	**0.003**	**0.003**	0.0018
Iron	mg/L	0.466	<0.001	2.7
Lead	mg/L	0.010	0.010	0.0056
Manganese	mg/L	0.001	<0.001	2.5
Nickel	mg/L	**1.349**	**1.355**	0.013
Uranium	mg/L	0.031	0.031	NA
Zinc	mg/L	**6.013**	**6.041**	0.015

4.5 Summary

Modelling for Scenario 1 indicated that quicklime/burnt lime (CaO) would be the preferred chemical reagent for the initial treatment of the pit water, due to the lower tonnage of the reagent required and therefore the lower cost for the treatment. The model indicated that approximately 611 tonnes would be required to reach a pH of around 7.8. As atmospheric equilibria with the pit water was assumed, carbonate buffering was established by the model, and additional reagent use did not result in further increases in pit water pH values. However, it is likely that other factors that affect carbonate buffering, such as the consumption of dissolved carbon dioxide by algae for photosynthesis, would result in more alkaline pH values, further reducing the concentrations of some metals through precipitation.

Modelling for Scenario 2, which assumed conditions based on two years of mine operations, indicated that some acidity would be produced as a result of the subaqueous deposition of sulfidic waste rock and tailings. However, it is noted that the modelling did not account for biological processes, such as oxidative organic matter decomposition and bacterial sulfate reduction, which would not only limit the oxidation of sulfides, but would also reduce sulfate and metal concentrations through the precipitation of sulfides. Depending on the thermal and saline stratification of the pit water column, impacts may not be observable at the water surface. In the case of loss of stratification, the modelling indicated slightly acidic pH values in the pit. Such impacts could be actively managed during operations through the addition of further quicklime into the tails deposition stream or applied as an overall pit water treatment. Due to the conservative nature of the modelling, the amount of acidity produced under each modelling scenario was likely overestimated, though it is noted that the volume of water affected could be lower depending on the dewatering and groundwater inflow mitigation methodologies adopted during mining.

For the post-closure scenario (Scenario 3), no pit water turnover event was modelled, as the final solids level in the pit was predicted to be within the oxic water layer. The modelling suggests that acidity would be produced if biological processes do not result in anoxic conditions below the sediments which would accumulate on the surface of the deposited tailings. If routine water quality monitoring indicated acid production in the pit, additional quicklime could be used to adjust the pit pH and reduce metal and sulfate concentrations. A summary of the quicklime requirements for each modelled scenario is presented in Table 4-7, along with indicative costs.

As above, the conservative assumptions used for the post-closure scenario mean that the water quality impacts from the subaqueous deposition of tailings would likely be less than those predicted by the modelling, particularly if active pit water treatment is undertaken during operations.

Routine monitoring of pit water quality prior to, and during operations, will provide confidence in understanding pit limnology, and therefore, post-closure water quality risk.

Table 4-7 Indicative quicklime requirements for pit water pH adjustment.

Scenario	Modelled CaO concentration required for pH adjustment (mg/L)	Volume of acidic water to treat (ML)	Total mass of CaO required (t)
1	149	4100	611
2a	112	642	72
2b	73	3112	227
3	230	2246	517

NB: Costs are indicative only and do not include the capital and operational costs associated with the storage and usage of the quicklime.

5. Conclusions and recommendations

5.1 Conclusions

Geochemical modelling of pit water for operational and post-closure scenarios at Toms Gully Mine has indicated that the use of quicklime/burnt lime (CaO) would most cost-effectively raise pH in the pit to reduce the concentrations of target metals in solution.

The results for the scenario which modelled conditions after two years of operations indicated that only some acidity would be generated in the pit, even in the very unlikely event that the low concentrations of dissolved oxygen present are thermodynamically available for the oxidation of sulfides. When the model accounted for loss of stratification, the higher concentration of dissolved oxygen resulted in more acidity being generated, though for both of these models pH adjustment was shown to be achievable through the further addition of quicklime. Continuous injection of quicklime into the tailings stream would allow for the neutralisation of any acidity produced, should oxidation of sulfides within the tailings occur. The rate of quicklime addition to the tailings would ideally be calibrated based on the results of tailings static and kinetic geochemical results, and pit water quality monitoring.

More acidity was predicted to be generated for the post closure scenario, as the final solids level in the pit is predicted to be within the oxic layer of pit water. This meant that oxidation of all of the sulfides within the oxic water layer was predicted, resulting in a pit water pH lower than that which is currently observed. While a literature review has shown that only the uppermost 10 centimetres of deposited solids are likely to be exposed to oxidation, the acidity predicted by the model could still be actively managed through quicklime addition in the event that reduced pH values are observed in the pit during operations.

The use of quicklime to manage pH in the pit would result in residual alkalinity in the pit, however this was not predicted by the model to raise pH above the upper target SSTV, and no SSTV for alkalinity is required for the project.

5.2 Recommendations

Of the initial pit water treatment options considered in the Section 14A notification, the use of quicklime (CaO) is the preferred solution as it will raise pH within the pit to a suitable level more efficiently that caustic soda.

While this report has shown that acid generation in the pit can be actively managed even in the event of loss of dissolved oxygen stratification in the pit, such an occurrence may result in the requirement of additional quicklime for pit water pH adjustment.

To further refine the risk of loss of stratification in the pit at Toms Gully, a limnological assessment could be undertaken, with the results within this report subsequently validated against the findings of the limnological assessment. Otherwise, if monitoring identifies divergence from the predicted water quality, planned water treatment will need to be undertaken.

It is recommended that a minimum of one metre of water coverage over deposited tailings and waste rock be maintained, as the literature review identified this as a standard minimum depth of cover to ensure the minimisation of metal sulfide oxidation.

Regular monitoring of pit water quality should be continued following the closure of the mine for at least a year, or until stable water quality has been established. This will allow for active management in the case that acidity is generated in the pit post closure, despite the risk of which having been assessed as low.

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Appendices

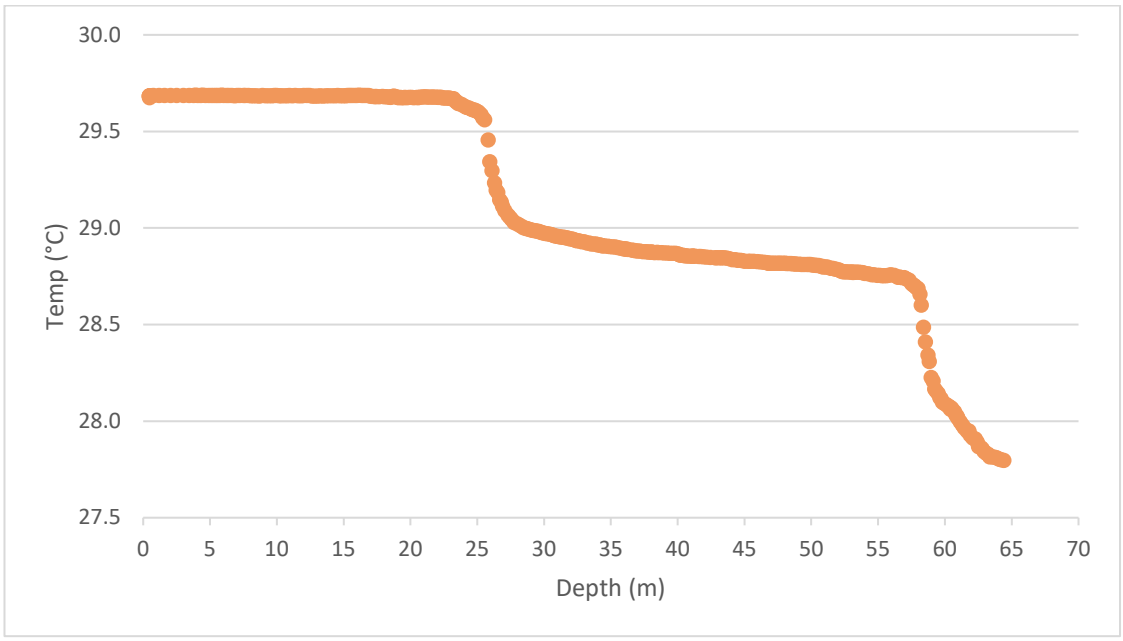
Appendix A – Baseline pit water quality

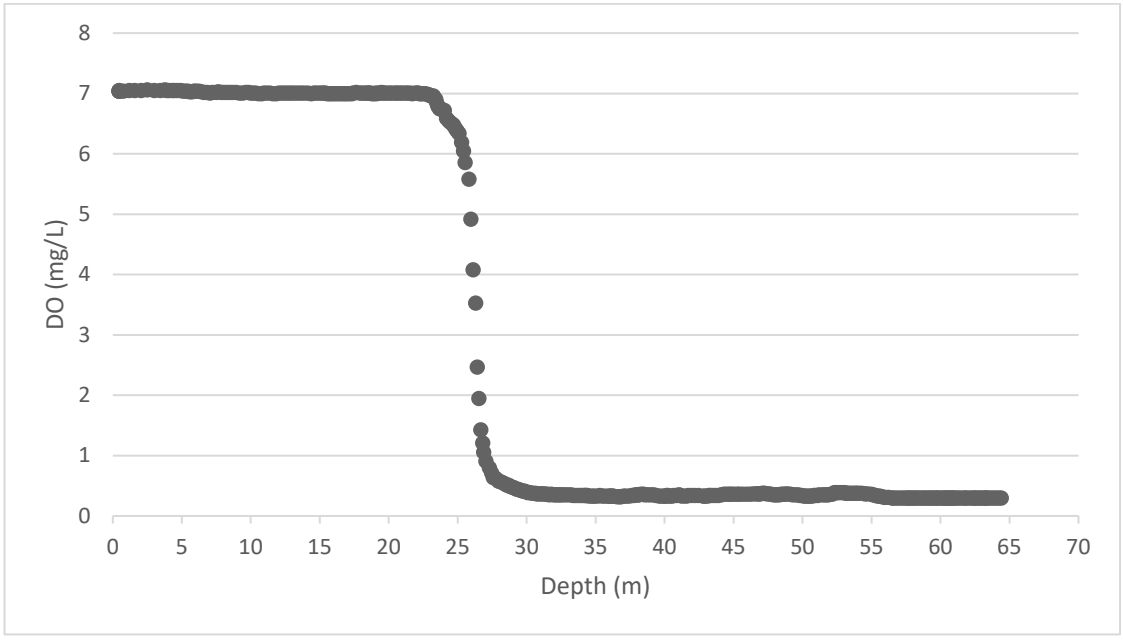
Statistical summary of pit water quality results (Primary site TGMPIT, November 2010 – December 2017), and comparison with results for sampling at depth (Site TGM25, sampled 27 May 2017).

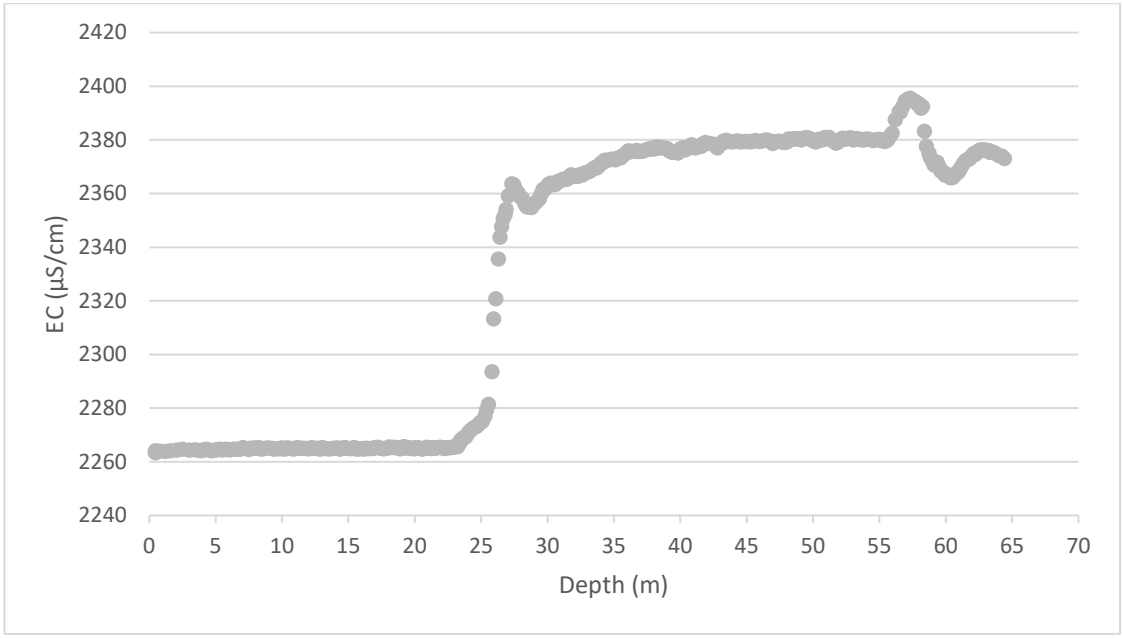
Parameter	Units	n	20th %ile	Median	80th %ile	TGDP25
Physicochemical parameters						
pH	pH units	28	3.1	3.2	3.3	3.02
EC	µS/cm	27	2125	2260	2458	2275
Turbidity	NTU	16	0.5	1.5	5	0.54
Total Suspended Solids	mg/L	26	2.5	2.5	11	NA
Major ions						
Total alkalinity as $CaCO_3$	mg/L	27	1	1	3	<5
Sulfate as SO_4	mg/L	26	1300	1400	1500	1400
Chloride	mg/L	27	6	7	7	7
Calcium	mg/L	26	198	220	230	230
Magnesium	mg/L	26	150	160	169	160
Sodium	mg/L	26	18	22	24	24
Potassium	mg/L	26	7	8	8	8.5
Dissolved metals						
Aluminium	mg/L	28	19.6	24.6	28.36	22
Arsenic	mg/L	28	0.0039	0.0050	0.0071	0.008
Cadmium	mg/L	28	0.0612	0.0788	0.1260	0.052
Cobalt	mg/L	28	0.288	0.327	0.351	0.250
Chromium	mg/L	28	0.0010	0.0018	0.0026	0.001
Copper	mg/L	28	0.224	0.302	0.500	0.180
Iron	mg/L	28	1.7	2.3	5.6	1.9
Lead	mg/L	28	0.0064	0.0097	0.0136	0.007
Manganese	mg/L	28	11.68	12.20	13.60	11
Nickel	mg/L	28	1.24	1.37	1.45	1.2
Uranium	mg/L	18	0.030	0.032	0.034	0.028
Zinc	mg/L	28	7.65	8.33	12.00	6.90

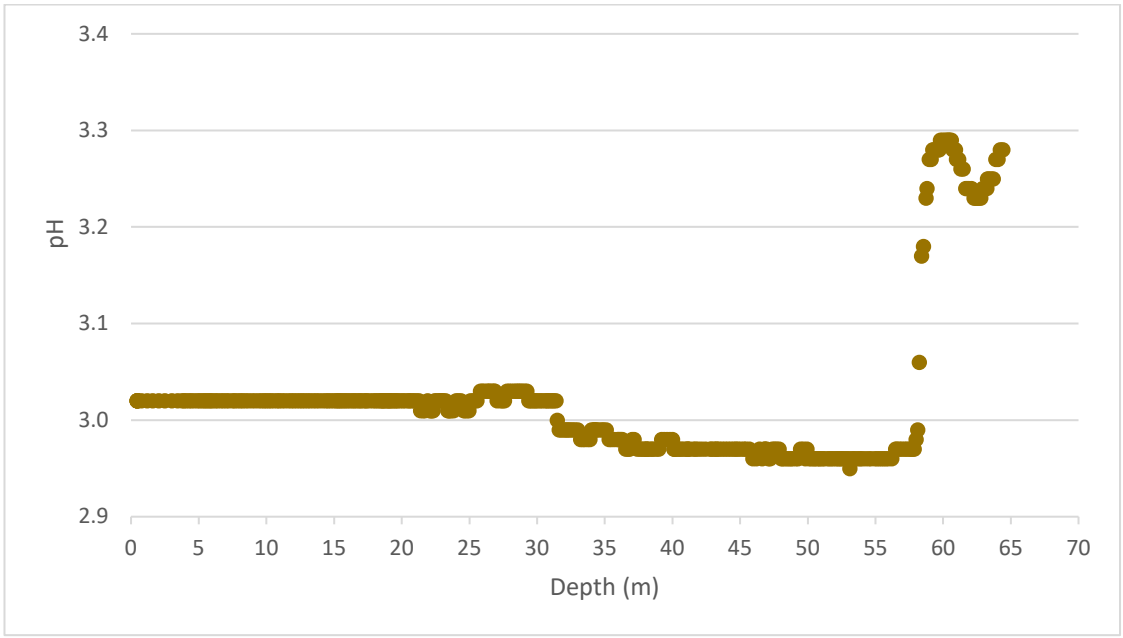
NA – Not analysed

Appendix B – *In situ* water quality depth profiles






2420
2400
2380
2360
2340
2320
2300
2280
2260
2240
EC (µS/cm)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Depth (m)


3.4
3.3
3.2
3.1
3.0
2.9
pH
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Depth (m)

Appendix C – Waste rock and tailings mineralogy

Sulfidic waste rock (GHD 2018a)

Mineral	Maximum % from mineralogy studies	Assumed mass in sulfidic waste rock to be deposited in pit (t)
Jarosite	8.9	44,797
Pyrite	1.4	6543
Siderite	0.1	503
Calcite	0.2	1007
Arsenopyrite	0.4	2013
Gypsum	0.4	2013

Metallurgical tailings sample 1 – assumed to represent 70 percent of the future tailings (GHD 2018a)

Mineral	Maximum % from mineralogy studies	Assumed mass to be deposited in pit (Total over life of mine)
Pyrite	0.5	3150
Marcasite	0.2	1260
Calcite	1.2	7560
Dolomite	22.3	140,490
Siderite	0.6	3780
Gypsum	0.2	1260

Metallurgical tailings sample 2 – assumed to be representative of 30 percent of the future tailings (GHD 2018a)

	%	Assumed mass to be deposited in pit (t)
Total sulfur from static geochemistry analysis	17.4	46,980
%S in FeS_2	53.4	NA
% FeS_2 (Assuming all S in Met tails 2 is present as FeS_2)	32.6	87,954

Old tailings dam (TSF1) (GHD 2018a)

Mineral	Maximum % from mineralogy studies	Assumed mass to be deposited in pit (t)
Pyrite	6.2	15500
Marcasite	0.4	1000
Arsenopyrite	5.0	12500
Jarosite	5.5	13750
Gypsum	0.6	1500

New tailings dam (TSF2) (GHD 2018a)

Mineral	Maximum % from mineralogy studies	Assumed mass to be deposited in pit (t)
Pyrite	3.9	4875
Arsenopyrite	2.5	3125
Jarosite	0.1	125
Gypsum	4.0	5000
Dolomite	2.0	2500
Siderite	1.1	1375

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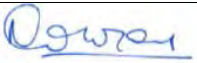
		Name	Signature	Name	Signature	Date
0	Joe Cairns	Matt Brannock Stuart Winchester		Nicole Conroy		24/04/2019

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