Appendix X

Surface Water Management Plan (GHD 2023)

Moora Quartzite Mine Closure Plan

Surface Water Management Plan

SIMCOA Operations Pty Ltd

10 October 2023

→ **The Power of Commitment**

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[Compliance statement]

The Power of Commitment

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1. Introduction

The Moora Quartzite Mine (the mine) is located approximately 15 km north of the Moora townsite and within the Wheatbelt region of WA. The mine is wholly owned and operated by SIMCOA Operations Pty Ltd (SIMCOA) and produces high purity quartzite for subsequent processing at SIMCOA's silicon manufacturing plant in Kemerton.

GHD Pty Ltd (GHD) is currently undertaking an update of the Mine Closure Plan (MCP) to facilitate regulatory approvals for undertaking dewatering activities at the existing mine, as well as development of a proposed greenfield mine (North Kiaka) located north of the existing mine. As part of the Department of Mines, Industry Regulation and Safety's (DMIRS) requirements, a Surface Water Management Plan (SWMP) is needed to support the MCP's objectives and outcomes.

1.1 Scope and purpose of work

GHD has been engaged by SIMCOA to prepare a SWMP document to accompany the MCP. The scope of this SWMP is as follows:

– Characterisation of existing surface water features and interactions;
– Identification of potential risks to surface water features and management of those risks;
– Hydrological and hydraulic analysis of stormwater flows within and adjacent to the mine site, for both the existing and post-closure scenarios; and
– Development of a conceptual surface water management strategy/plan for implementation post-closure of mine.

This SWMP has been developed with close consideration to the closure objectives from the MCP (GHD, 2023a). Closure objectives that are relevant to this SWMP are as follows:

– Ensure any seepage and runoff will comply with water quality criteria (WQC) to be agreed with regulators and does not contain excessive sediment loads posing a risk to final land use;
– Ensure water quality of local and regional surface and groundwater resources are not compromised; and
– Ensure surface water movement is free draining within the rehabilitated landform/areas and not prone to erosion or ponding.

Similar to the MCP, this SWMP is a living document and should be continually reviewed and updated to reflect future changes to the mining plan.

1.2 Disclaimer and limitations

This report: has been prepared by GHD for SIMCOA Operations Pty Ltd and may only be used and relied on by SIMCOA Operations Pty Ltd for the purpose agreed between GHD and SIMCOA Operations Pty Ltd as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than SIMCOA Operations Pty 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.

GHD has prepared this report on the basis of information provided by SIMCOA Operations Pty Ltd 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.

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. Site overview

This section provides an overview of the both the existing mine and proposed North Kiaka mine (collectively referred to as the Site) from a surface water context. Detailed characterisation of the surface water setting that is specific to the Site is provided in this section; the MCP (GHD, 2023a) should be referred to for a broader, regional context of the setting, as well as non-surface water details that are periphery to the SWMP.

2.1 Mine layout

The Moora Quartzite Mine currently occupies an estimated disturbance area of 70 ha and comprises the following components:

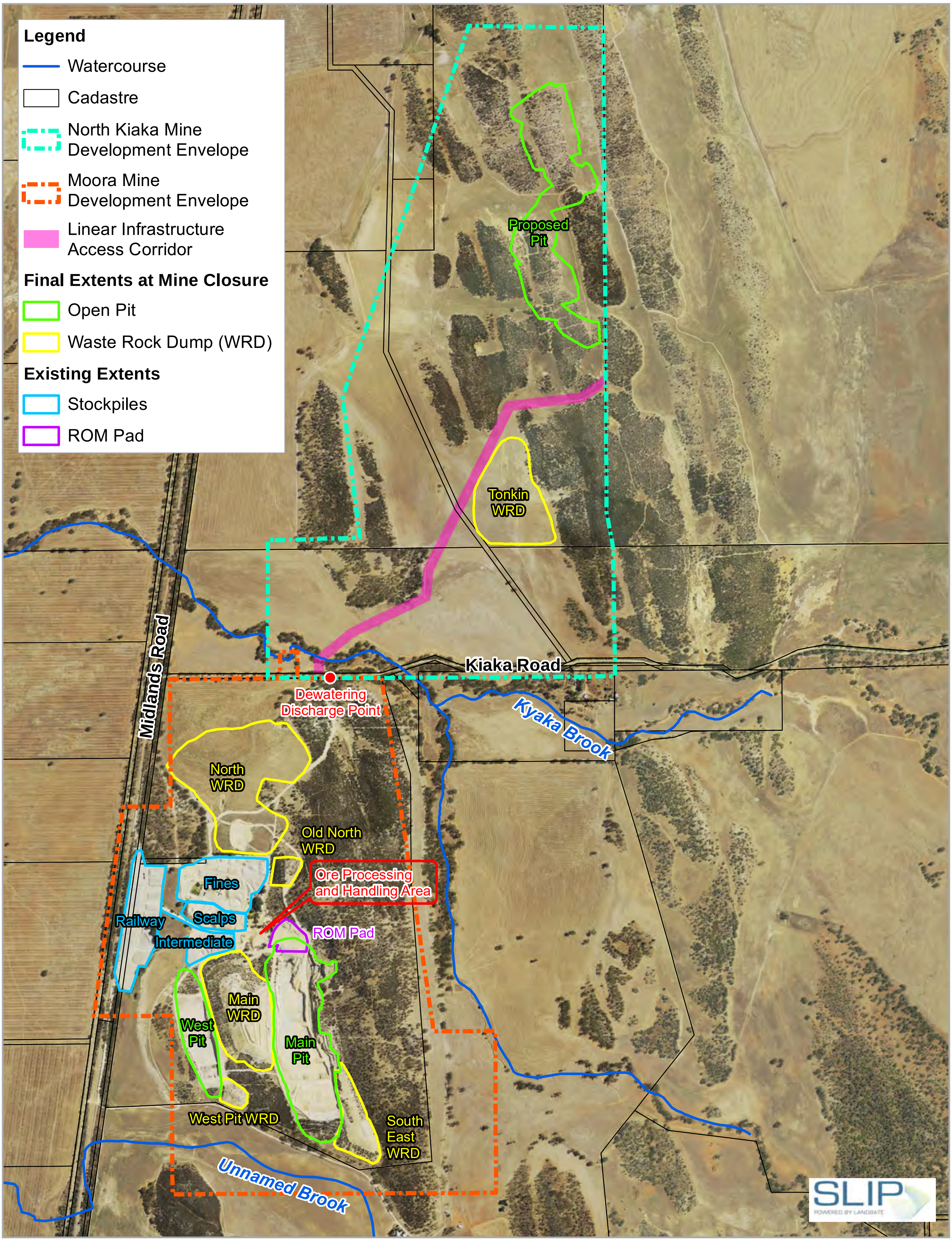
– Two open mining pits, namely the Main Pit and West Pit;
– Abandonment bund around the two open mining pits;
– Five Waste Rock Dumps (WRD), including:
  - Two active WRDs, namely the Main WRD and North WRD;
  - Three rehabilitated and inactive WRDs, namely the South East WRD, West Pit WRD and Old North WRD;
– Four different stockpiles areas, for fines, intermediate, scalps and railway stockyard;
– A Run-of-Mine (ROM) pad;
– An ore processing and handling area, covering a crusher and screening plant, laydown area and a silt/settling pond; and
– Non-process infrastructure, such as offices, car park area, workshops, sheds and refuelling facilities.

Both pits are currently being operated above the water table, but mining below the water table is planned in 2024. This would involve a dewatering pipeline system (including pumps and tanks) that runs from the West Pit to the Main Pit, then northwards to a discharge point beside Kyaka Brook. Works Approval W6391/2020/1 (DWER, 2021) indicates that mine dewater will be reused according to the following hierarchy (in order of priority):

– Onsite reuse for ore beneficiation, dust suppression and road watering by pumping dewater into an onsite water storage dam;
– Offsite reuse by local pastoralists and the Shire of Moora through the provision of a water holding tank and standpipe; and
– Surplus dewater will be discharged into the Kyaka Brook.

SIMCOA further plans to establish a new mine (North Kiaka) approximately 2 km north of the existing Moora Mine, which would extend the overall life-of-mine by up to 20 years. The proposed North Kiaka mine will include a new open mining pit, a new WRD (namely the Tonkin WRD) and various associated infrastructure. The existing mine and proposed North Kiaka mine will be connected by a linear infrastructure access corridor that crosses the Kyaka Brook.

Figure 1 presents both the existing and proposed mine layouts.



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0 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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GHD

Simcoa Operations Pty Ltd
Moora Quartzite Mine Closure Plan
Surface Water Management Plan

Project No. 12518217
Revision No. 1
Date 24/08/2020

Existing and Proposed Mine Layout

FIGURE 1

Data source: GHD: Moora Mine Development Envelope - 20200226, North Kiaka Mine Development Envelope - 20200609;
Simcoa: Linear Infrastructure Access Corridor - 20200605, Open Pit - 20200806, Waste Rock Dump - 20200806; Stockpiles - 20200716, ROM Pad - 20200716;
DWER: Watercourse - 20130902; Landgate: Cadastre - 20180607, Moora Feb 2012 Mosaic - 201202. Created by: lhyoong

2.2 Topography and soil landscape

The Site is located on a topographic rise that backs onto a rocky outcrop to the east and slopes gradually to the west (Actis, 2011). Runoff predominantly flows from an east-to-west direction over the Site, across Midlands Road through the various culvert and bridge crossings, before finally discharging into the Coonderoo River. Small portions of the Site's northern and southern tips may also drain towards the nearby brooks (i.e., tributaries of Coonderoo River) as dictated by topography.

According to the Department of Primary Industries and Regional Development's (DPIRD) soil landscape mapping (2019), the majority of the Site (where mining activities are located on) is situated within the Coorow 7 (258Cw_7) soil-landscape subsystem, which is characterised by very gently to moderately inclined hill slope and hill crests.

The subsystem, in turn, overlaps an ancient plain with low relief on weathered granite. There is no connected drainage, but salt lake chains occur as remnants of ancient drainage systems and now only function in very wet years (DPIRD, 2019). The Coorow 7 subsystem drains westward onto the Ranfurly 1 (256Ra_1) subsystem, which consists of the alluvial plain of Coonderoo River.

The DPIRD (2019) further provides the following land quality attributes for the Coorow 7 subsystem (only relevant attributes have been listed below):

- 0% probability of pH_{CaCl2} < 4.5 (strongly acidic) at surface and top 80 cm of topsoil;
- 70% probability of high subsurface acidification susceptibility;
- 0% probability of pH_{CaCl2} > 7 (alkaline) at surface;
- 0% probability of moderate to extreme salinity risk at surface;
- 0% probability of moderate salinity hazard;
- 0% probability of high water repellence susceptibility;
- 20% probability of a very shallow to shallow physical crop rooting depth;
- 30% probability of extremely low to low soil water storage capacity;
- 19% probability of high to extreme wind erosion hazard;
- 3% probability of very high to extreme water erosion hazard;
- 0% probability of very poor to poor site drainage potential;
- 0% probability of moderate to very high waterlogging and inundation risk;
- 0% probability of moderate to high flood hazard; and
- 9% probability of high to extreme phosphorus export hazard.

In summary, the findings above indicate that the Site is well drained and has relatively low risk of flooding. There is also a relatively high risk of subsurface acidification, which may impact on potential agricultural activities that might occur after closure of the mine.

A soil characterisation study was carried out by Soilwater Consultants at the proposed North Kiaka mine (Soilwater, 2019). The study identified that geology within the area comprises of either unweathered quartzite outcrops (with limited topsoil) or weathered/unweathered granite covered by a surficial gravel layer. The study report indicated that the gravel layer's topsoil exhibits high to severe water repellence, which would restrict infiltration of rainfall. Further, the subsoil was simulated to be highly erosion resistant and the topsoil less so.

2.3 Climate

Climate at the Site is characterised as semi-arid and warm Mediterranean with hot, dry summers and cool, wet winters. Approximately half of the observed rainfall occurs in the winter months of June, July and August.

The nearest active rainfall gauging site is located at the Berkshire Valley weather station (site number 008008), which is about 12 km southeast of the Site. The station is operated by the Bureau of Meteorology and has been in operation since January 1907. Figure 2 shows the historical annual rainfall totals over the past 116 years (from 1907 to 2022). The 5-year moving rainfall average shown on the same figure indicates a gradual declining rainfall trend, with annual rainfall totals dropping by about 50 mm over the past century.

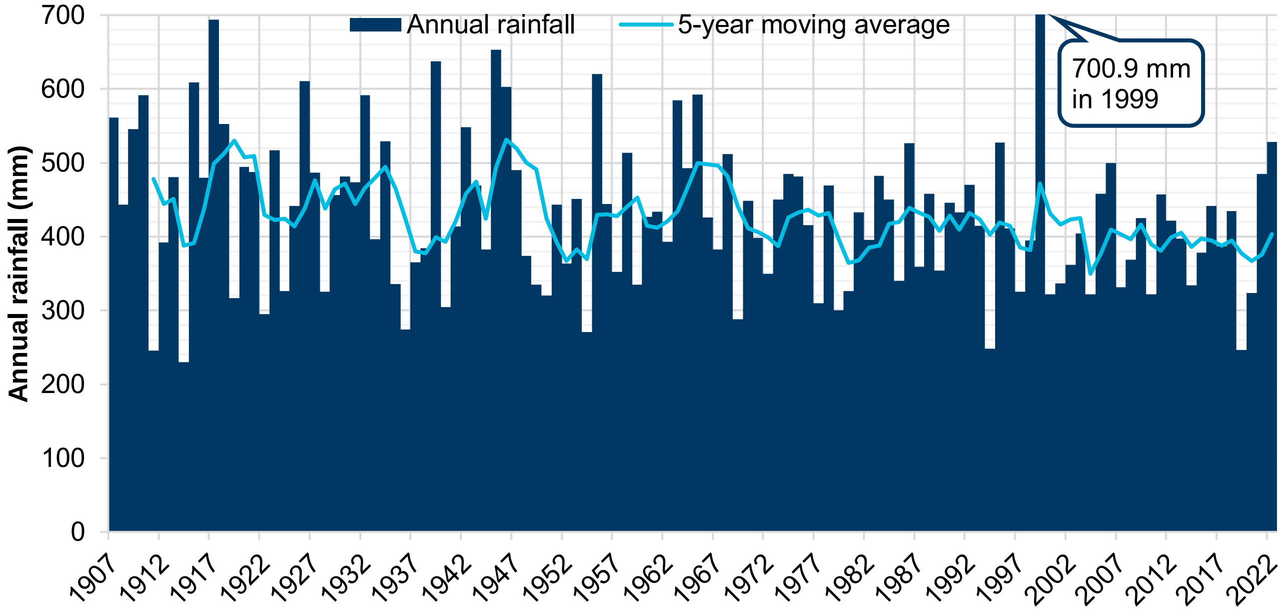


Figure 2 ***Historical annual rainfall totals measured at the Berkshire Valley weather station***

The wettest year on record is 1999, which includes the major flood event observed at Moora in March. There are no observed or known flood events at or in close vicinity to the Site. This is further backed up by informal conversations with site personnel (Geary M., pers. comm., 24 July 2020), who informed that there were no significant signs of flooding at the Site after the March 1999 storm event, other than some ponding in the Main Pit. Further, no storm events of significance have been noted at the Site since 1999.

The Moora weather station (site number 008091) is the only station within a 50 km radius of the Site that recorded evaporation. However, historical evaporation data is only available over a short five-year period between 1967 and 1972. To this end, interpolated climate data estimates from the SILO climate database (Queensland Department of Environment and Science, 2023) was used to better characterise the Site's climate instead.

Figure 3 presents the monthly rainfall and pan evaporation averages over the most recent ten-years (from 2013 to 2022) that were derived from the SILO estimates. The figure demonstrates that evaporation exceeds rainfall throughout the entire year, which contributes to the ephemeral nature of surface water features at the Site.

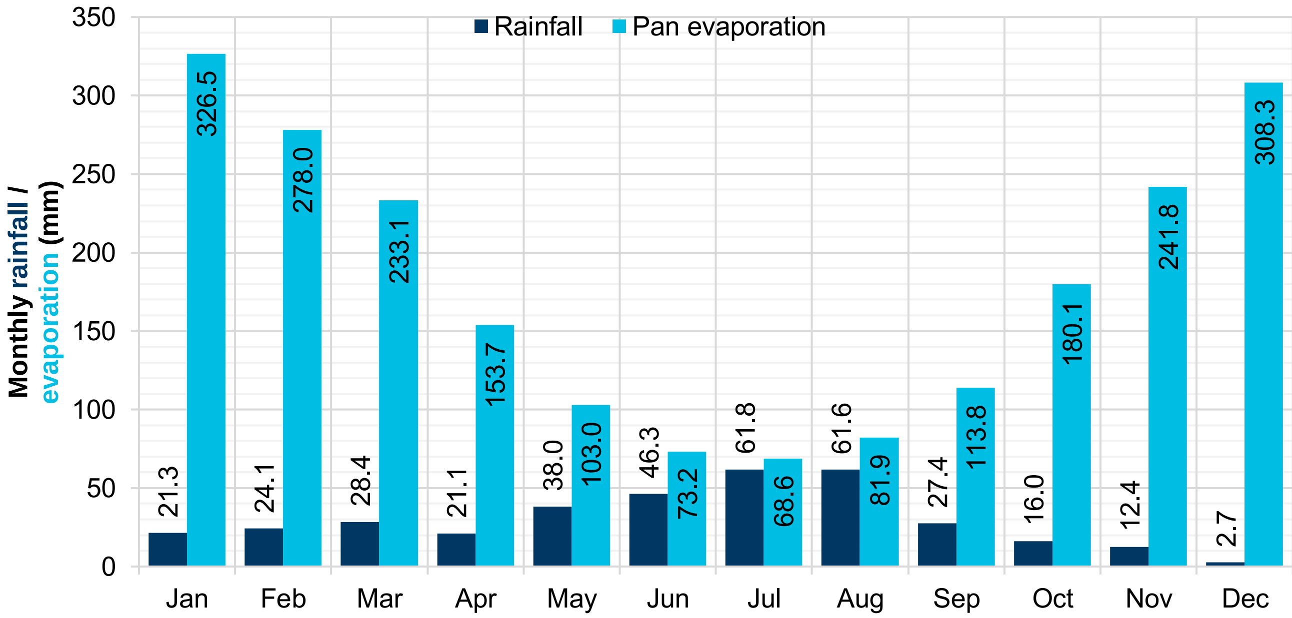


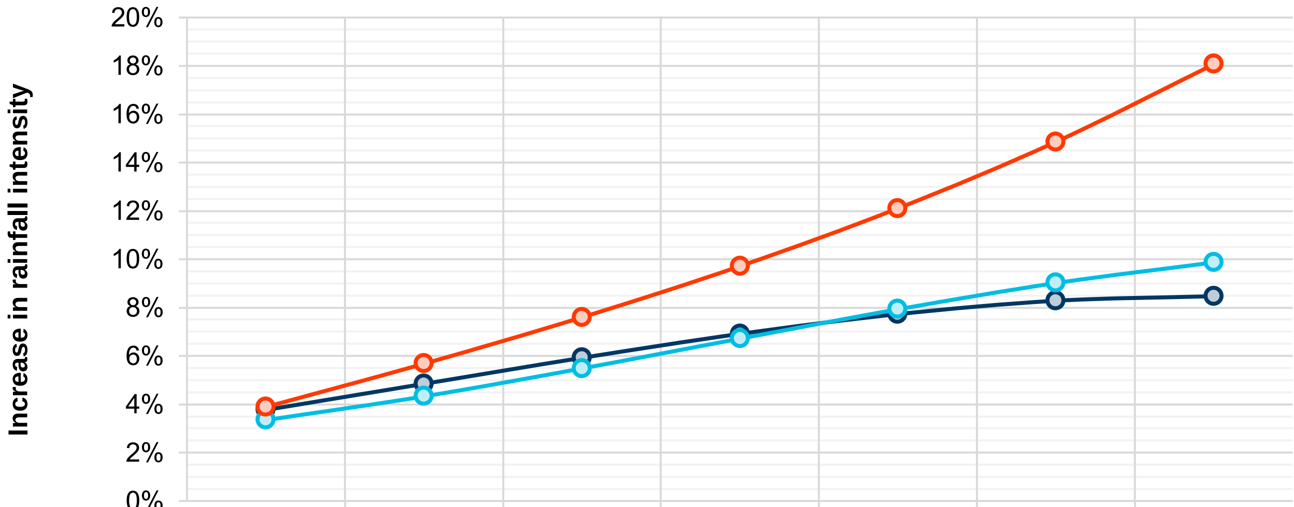
Figure 3 ***Average monthly rainfall and evaporation from 2013 to 2022***

Climate change

The *Climate Change in Australia* website (CSIRO and Bureau of Meteorology, 2015) informs that the Flatlands West Natural Resource Management region, in which the Site is located, is projected to have the following changes as a result of climate change:

– Decreases in both winter and spring rainfall, with decreases in winter rainfall of up to 15% by 2030 (with high confidence);
– Substantial increases in temperatures, with annual averages in 2030 projected to be around 0.5-1.2°C above the climate of 1986-2005 (with very high confidence);
– Increased intensity of extreme rainfall events (with medium confidence);
– Increased time spent in drought (with high confidence); and
– Increase in potential evapotranspiration in all seasons (with high confidence).

Estimates of the projected increase in rainfall intensity within the aforementioned region is given by the *ARR Data Hub* (Babister, Trim, Testoni, & Retallick, 2020) and reproduced in Figure 4 for the various Representative Concentration Pathways (RCPs). Depending on the RCP scenario, the projected increase in rainfall intensity could be as high as 7-10% at mine closure (around 2060).



	2030	2040	2050	2060	2070	2080	2090
RCP 4.5	3.8%	4.8%	5.9%	6.9%	7.7%	8.3%	8.5%
RCP 6.0	3.3%	4.3%	5.5%	6.7%	7.9%	9.0%	9.9%
RCP 8.5	3.9%	5.7%	7.6%	9.7%	12.1%	14.9%	18.1%

Figure 4 ***Projected increase in rainfall intensities***

2.4 Surface water hydrology

The Site is situated within the catchment of Coonderoo River, which generally flows from the Yarra Yarra Lakes in the north to the Moora townsite in the south. The Coonderoo River is a tributary of the Moore River and joins into the greater river at Moora.

As shown in Figure 6, three tributaries of the Coonderoo River flow adjacent to the Site, namely:

- Prye Brook to the north of the open pit in the proposed North Kiaka mine;
- Kyaka Brook between the existing and proposed North Kiaka mines; and
- Unnamed brook immediately south of the open pits in the existing mine.

Figure 6 also informs the catchment areas of the three brooks mentioned above, with Midlands Road as the outlet boundary of the catchments. The remnant areas between the brook catchments and Midlands Road generally have little concentration of flows and drain towards the Coonderoo River via overland sheet flows.

Based on the Department of Water and Environmental Regulation's (DWER) *Water Information Reporting*, the only streamflow gauging station that is of relevance to the Site is at the Dallaroo West Road (site ref. 617014) crossing of Coonderoo River (see Figure 6). The station is located approximately 7 km southwest of the Site and was only active over a 2-year period between January 2002 and January 2004.

Only historical stage records were available from the Dallaroo West Road station, of which the daily averages are presented in Figure 5. The figure demonstrates that flow in the Coonderoo River is generally ephemeral, with sustained streamflow only occurring in the winter months of July and August. The presence of baseflow in the river could not be accurately confirmed due to the short period of records.

There are a number of high-quality stream gauging stations located about 10-15 km south or southeast of the Site that provide continuous flow records. However, these stations are all located along the north branch of Moore River before the Coonderoo River joins in, hence do not receive flows from the Site.

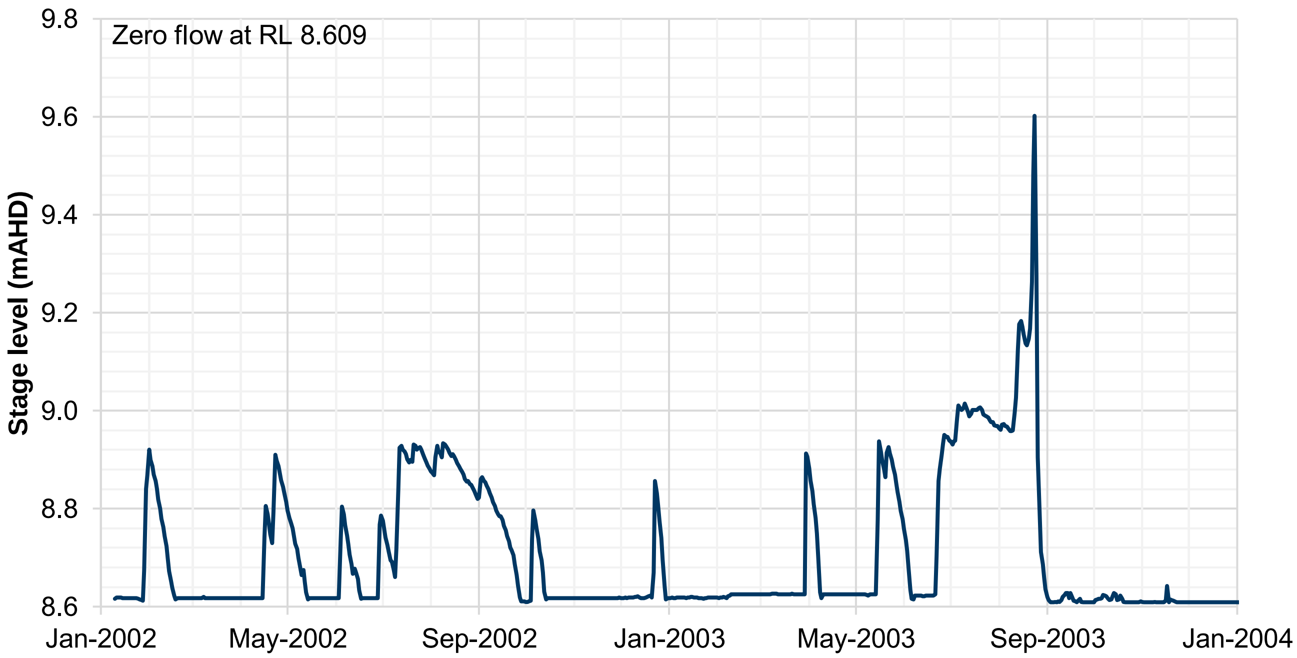
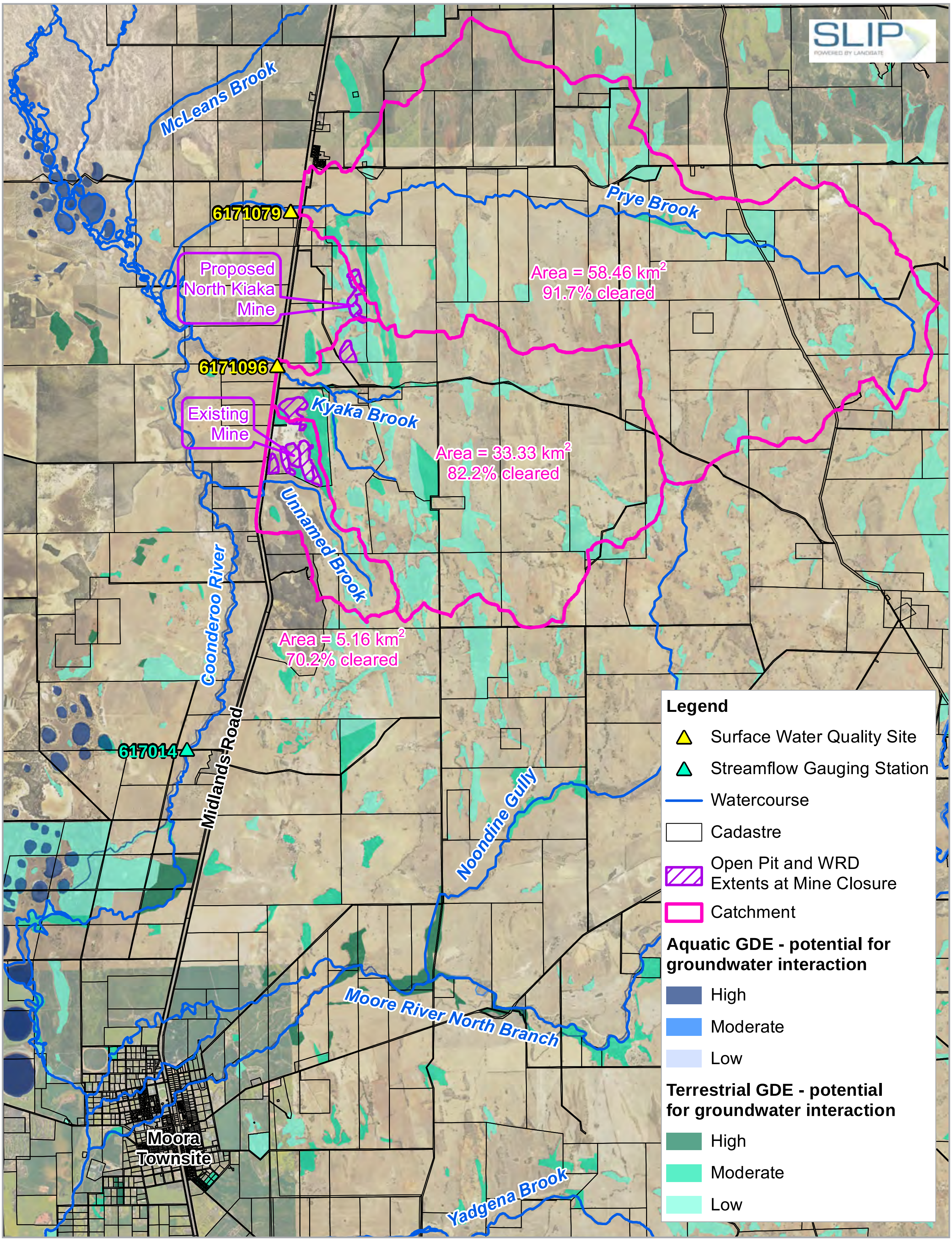


Figure 5 Historical daily stage level averages at Dallaroo West Road



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0 1 2 3 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

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Moora Quartzite Mine Closure Plan
Surface Water Management Plan

Project No. 12518217
Revision No. 0
Date 24/08/2020

Surface Water Features

FIGURE 6

Data source: GHD: Surface Water Quality Site - 20200825, Streamflow Gauging Station - 20200825, Catchment - 20200804; DWER: Watercourse - 20130902; Simcoa: Open Pit and WRD Extents at Mine Closure - 20200806; BoM: Aquatic GDE - 20190715, Terrestrial GDE - 20190715; Landgate: Cadastre - 20180607, Moora Feb 2012 Mosaic - 201202.
Created by: lhyoong

2.5 Surface water quality

The DWER's *Water Information Reporting* only reveals two surface water quality sites that are immediately downstream of the Site and with minimal influence by flows from other catchments. The sites are located at the Midlands Road crossings of Prye Brook and Kyaka Brook respectively (see Figure 6). Grab sampling was performed at both sites once only on 7 September 1999. The measured water quality from these samples is summarised in Table 1.

Table 1 Historical surface water quality measurements at Prye Brook and Kyaka Brook

Site	Brook crossing	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
6171079	Prye Brook	1.10	0.08	5	3
6171096	Kyaka Brook	0.96	0.06	6	5

With the exception of Total Phosphorus, all measured water quality variables are below the recommended values in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018), as detailed in Section 5.5. Considering the slight risk of phosphorus export (refer Section 2.2) from the Site, the monitoring of phosphorus in the water quality monitoring plan is of particular importance.

2.6 Surface water and groundwater receptors

The Site drains directly into the Prye Brook, Kyaka Brook and unnamed brook south of the existing mine. All three brooks then drain into the Coonderoo River immediately west. These watercourses are the only known downstream surface water receptors of relevance to the Site.

About 5 km southwest of the Site (and northwest of the Moora townsite), the Coonderoo River flows through a wetland system that consists numerous open water basins with limited interconnectivity between them, before joining into the north branch of Moore River. These wetlands have been mapped by the WA Department of Biodiversity, Conservation and Attractions at a regional scale as part of the Wheatbelt Wetlands Stage 1. These wetlands are not recognised to be of significance nationally (by the *Directory of Important Wetlands in Australia*) or internationally (under the *Ramsar Convention on Wetlands*).

The DWER's Public Drinking Water Source Areas (PDWSA) online mapping tool (Public drinking water source areas online mapping tool, 2020) indicates that the nearest PDWSAs are the Moora, Moora Eastern and Watheroo Water Reserves at some 20 km southwest, 10 km south and 20 km north of the Site respectively. All three reserves are situated either within a different catchment (i.e., Moora and Moora Eastern) or upstream (i.e., Watheroo), hence are not affected by mining activities on the Site.

According to the Bureau of Meteorology's Groundwater Dependent Ecosystems (GDE) Atlas (Groundwater Dependent Ecosystems Atlas, 2019), the Coonderoo River and wetlands are aquatic ecosystems with high potential for groundwater interaction. The atlas also identified (terrestrial) vegetation communities adjacent to the Site with low to moderate potential for groundwater interaction, as shown in Figure 6.

2.7 Groundwater

Hydrogeological investigations conducted by Saprolite Environmental in October 2011 (Saprolite, 2012) suggested limited to no interaction between surface water features and the groundwater table. The investigation involved four monitoring bores between the North WRD and Main Pit in the existing mine, in which the groundwater potentiometric level was surveyed at approximately 215-216 mAHD or 3-20 m below ground level.

Further, a site visit done by GHD personnel on 23 July 2020 did not find any obvious surface expressions of groundwater within the existing mine extents.

The proposed mining plan at Moora Mine involves progressive excavation of both the Main and West Pits to levels at or below the groundwater table in the near future. This would necessitate occasional discharge of pit dewater to the adjacent Kyaka Brook. Post-closure though, there will be no interaction between the groundwater and surface water sources.

3. Surface water risk assessment

A qualitative surface water risk assessment has been undertaken to identify the potential risks and environmental impacts of mine closure on downstream surface water receptors, as well as the mechanisms to manage risks. The assessment was conducted in alignment to the following guidelines:

– Mine Closure Plan Guidance – How to prepare in accordance with Part 1 of the Statutory Guidelines for Mine Closure Plans from the DMIRS (2023); and
– *A framework for developing mine-site completion criteria in Western Australia* from the Western Australian Biodiversity Science Institute (2019).

Outcomes of this risk assessment are fed into an overarching risk assessment detailed in the MCP (GHD, 2023a). The following subsections details the findings and outcomes of the assessment.

3.1 Assessment process and outcomes

The risk assessment methodology adopted in this SWMP closely follows the process undertaken for the MCP (GHD, 2023a); detailed descriptions of the methodology are reported in that document. The methodology involved assessing all identified surface water risks prior to and after implementation of proposed treatment measures.

The ratings for each identified risk are based on the ranking matrix shown in Table 2. To enable reasonable assessment of the risk consequences, a good understanding of the materials on Site is essential, as summarised in Section 3.2.

Table 2 Risk ranking matrix

		Consequence rating				
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Likelihood rating	**Rare**	Low	Low	Low	Medium	Medium
	Unlikely	Low	Low	Medium	Medium	High
	Possible	Low	Medium	Medium	High	High
	Likely	Medium	Medium	High	High	Extreme
	Almost certain	Medium	High	High	Extreme	Extreme

The risk assessment process and corresponding results are detailed in Table 3. This assessment is only applicable to the post-closure scenario and assumes that the closure works program described in the MCP (GHD, 2023a) will be undertaken.

3.2 Materials characterisation

Materials from the West and Main Pits were sampled and analysed to determine geochemical characteristics of ore and waste rock materials above ground (GHD, 2020) and below ground (GHD, 2022) as included in Appendix A of the MCP. The following text provides an overview of the characterisation of waste rock and soil respectively. There are no known contaminated sites within or near the Site.

3.2.1 Sample location

The GHD (2020) study involved the collection of 12 samples from rock faces exposed within West Pit and Main Pit at variable depths (i.e., material mined above the groundwater table), with all locations randomly selected (see Figure 7). Samples were assessed for acid generation, metals leachability, asbestos content and radioactivity (max. 12 samples), and confirmed as low risk for all markers.

The GHD (2022) study involved sampling and characterization of materials present below the water table (5 drill holes within the pits, 5 drill holes external to the pit to capture hanging wall characteristics). The majority of sample were sourced from depths below the water table (210 mAHD) up to a maximum depth of approximately 180 mAHD. Based on the field log, the lithology of the samples was quite consistent, mainly quartz or chert. A small proportion of samples were found to be saprolite clay.

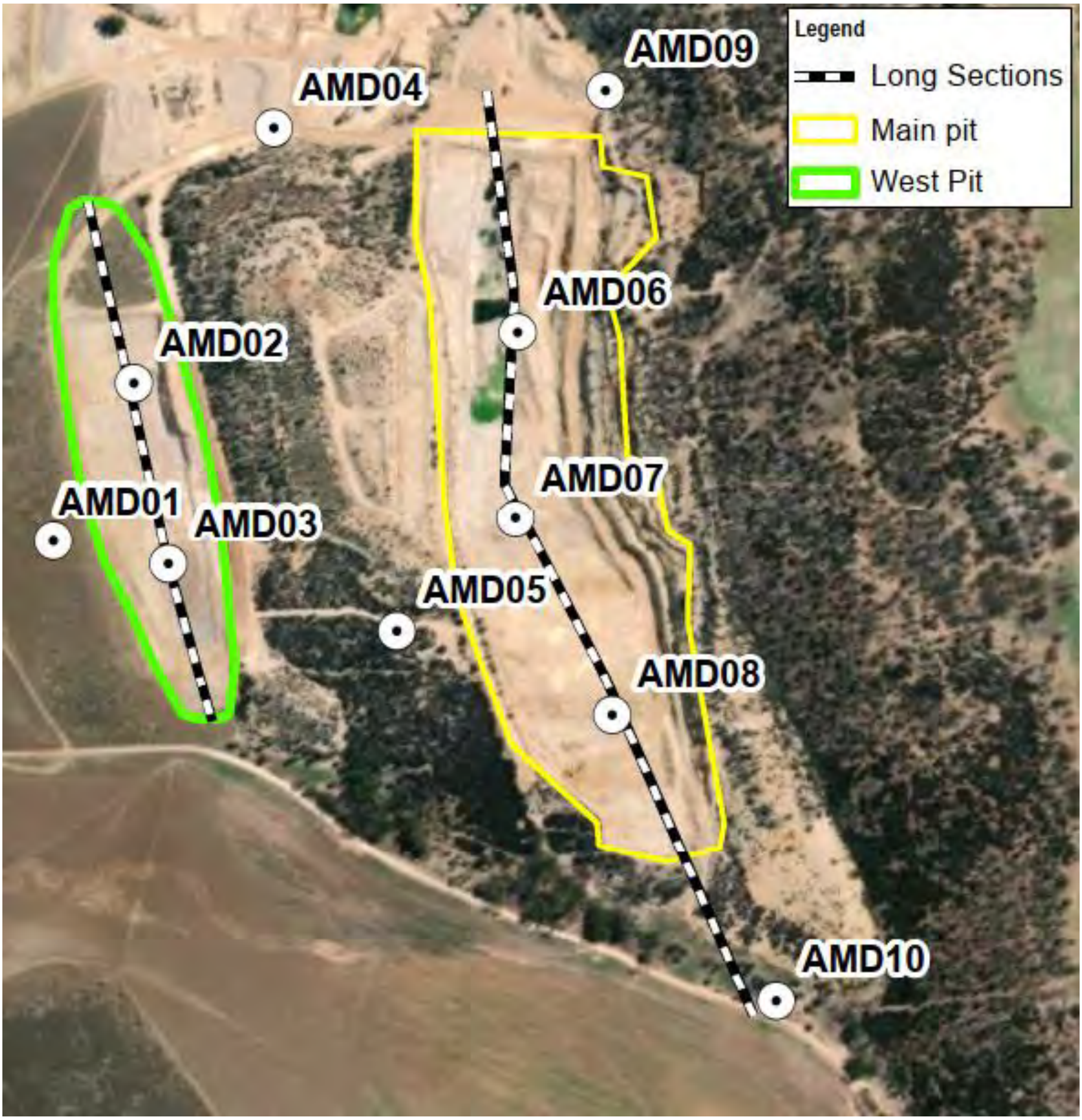


Figure 7 *Pit outline and drill hole location plan (GHD, 2022)*

Table 3 Mine closure surface water risk assessment

Risk source	Risk pathways	Potential impacts to surface water receptors	Pre-treatment ratings			Proposed treatment	Post-treatment ratings		
			Likelihood	Consequence	Raw risk		Likelihood	Consequence	Treated risk
Surface water runoff from demolished process and non-process infrastructure sites, as well as rehabilitated road, hardstand areas and stockpile pads.	Erosion of rehabilitated areas due to: – Poor rehabilitation and/or revegetation; – Poor design/construction of drainage controls; – Extreme storm events exceeding the design capacity of drainage controls; and/or – Grazing pressures.	– Increased sediment loads to surface water features. – Erosion of drainage flow paths.	Possible	Moderate	Medium	– Re-profile and revegetate all disturbed areas to ensure free drainage and minimise potential for erosion. – Adequate design and construction of drainage controls. – Discourage stock grazing on rehabilitated areas.	Unlikely	Minor	Low
Surface water runoff from rehabilitated landforms (i.e., WRDs).	Erosion of rehabilitated areas due to: – Poor landform design and/or placement of waste; – Poor rehabilitation and/or revegetation; – Poor design/construction of drainage controls; – Extreme storm events exceeding the design capacity of drainage controls; and/or – Grazing pressures.	– Increased sediment loads to surface water features. – Erosion of drainage flow paths.	Possible	Moderate	Medium	– Re-profile and place physically stable materials on outer surface of landforms to minimise potential for erosion. – Adequate design and construction of drainage controls. – Implement erosion controls, such as contour banks, vegetation and rock protection, along preferential drainage flow paths where applicable and in accordance to best practices. – Discourage stock grazing on rehabilitated areas.	Unlikely	Minor	Low
Surface water runoff discharge into open pits.	– Poor design/construction of drainage controls. – Poor design of abandonment bund.	– Erosion of pit walls.	Possible	Moderate	Medium	– Assess long term pit water quality with respect to external catchment runoff quality. – Divert surface water flows away from pits where possible. If not fully achievable, limit discharge points to minimise erosion extents of pit wall. – Implement erosion controls at discharge points.	Unlikely	Minor	Low
Surface water runoff from workshops, refuelling areas and fuel/oil storage areas.	– Leaching of contaminants (e.g., hydrocarbons or other chemicals) from contaminated soils.	– Contamination of surface water and groundwater features/resources.	Possible	Moderate	Medium	– Undertake testing for contaminated soils after mine closure. – Remediate any contaminated soils where possible. Dispose the remainder that cannot be remediated via appropriately licensed waste facilities. – Use imported clean fill where required.	Unlikely	Minor	Low
Seepage flows from rehabilitated landforms (i.e. WRDs).	– Leaching of contaminants, including PAF materials, from WRDs.	– Contamination of surface water and groundwater features/resources.	Possible	Moderate	Medium	– Evaluate geochemistry of waste rock. – Monitor post-closure water quality in existing surface water and groundwater features/resources.	Unlikely	Minor	Low
Spillage flows from sewage works.	– Spillage of raw sewage at mine closure.	– Contamination of surface water and groundwater features/resources.	Possible	Moderate	Medium	– Complete removal of sewage plant and associated infrastructure. – Rehabilitate sewage works area.	Unlikely	Minor	Low
Settling pond storage.	– Unintended detention of surface water flows. – Remobilisation of settled contaminants in pond.	– Site is not free draining; reductions in pre-mining surface water flows. – Contamination of surface water and groundwater features/resources.	Likely	Minor	Medium	– Decommission and fill all settling ponds at mine closure. Filling should be done in a manner that allows free draining of surface water runoff. – Divert surface water flows around ponds if filling is not possible.	Unlikely	Minor	Low
Open pit storage.	– Unintended detention of surface water flows. – Failure of abandonment bund.	– Site is not free draining; reductions in pre-mining surface water flows.	Almost certain	Insignificant	Medium	– Divert surface water flows around pits where possible.	Possible	Insignificant	Low

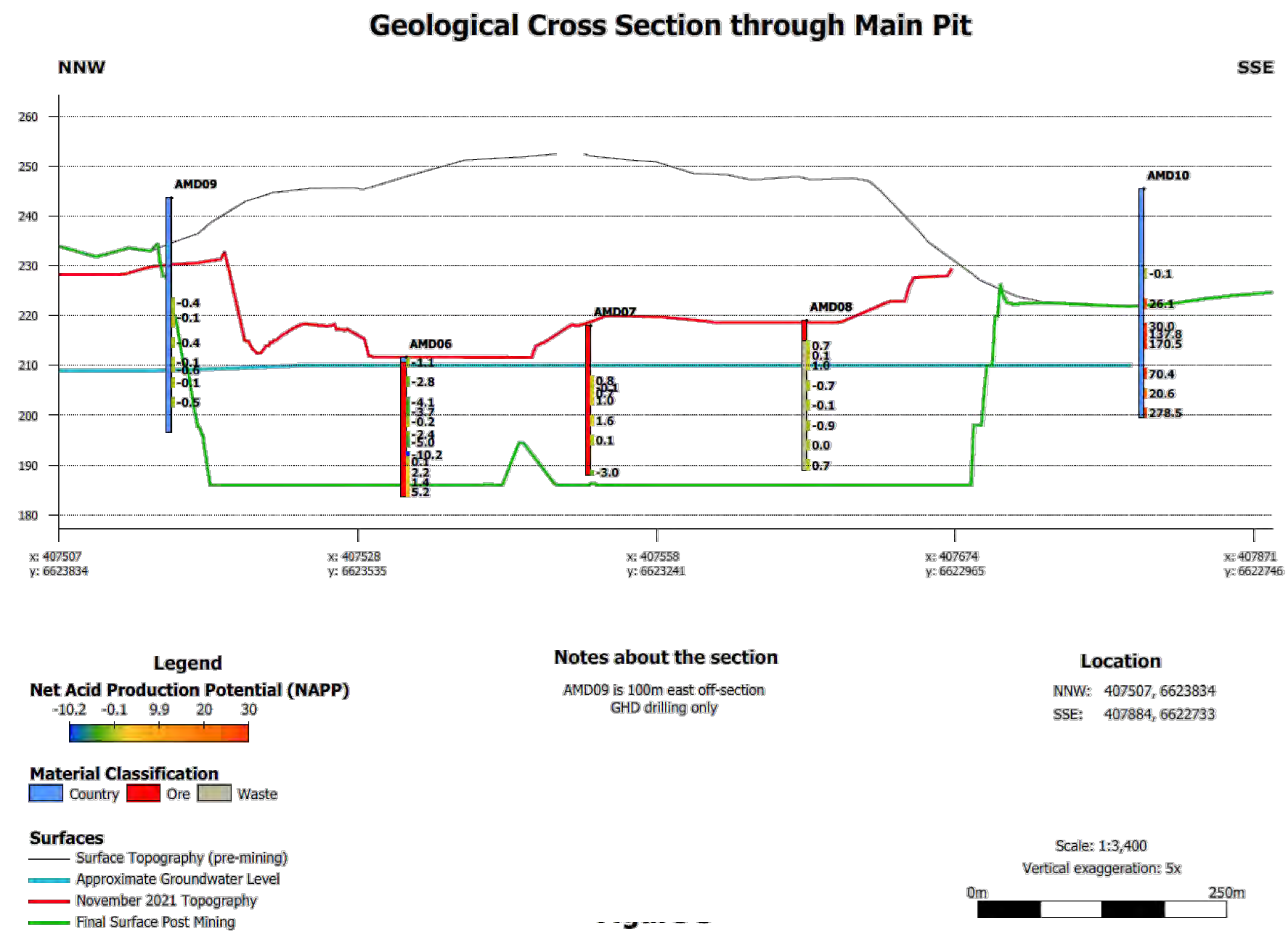


Figure 8 Geological cross section through the Main Pit

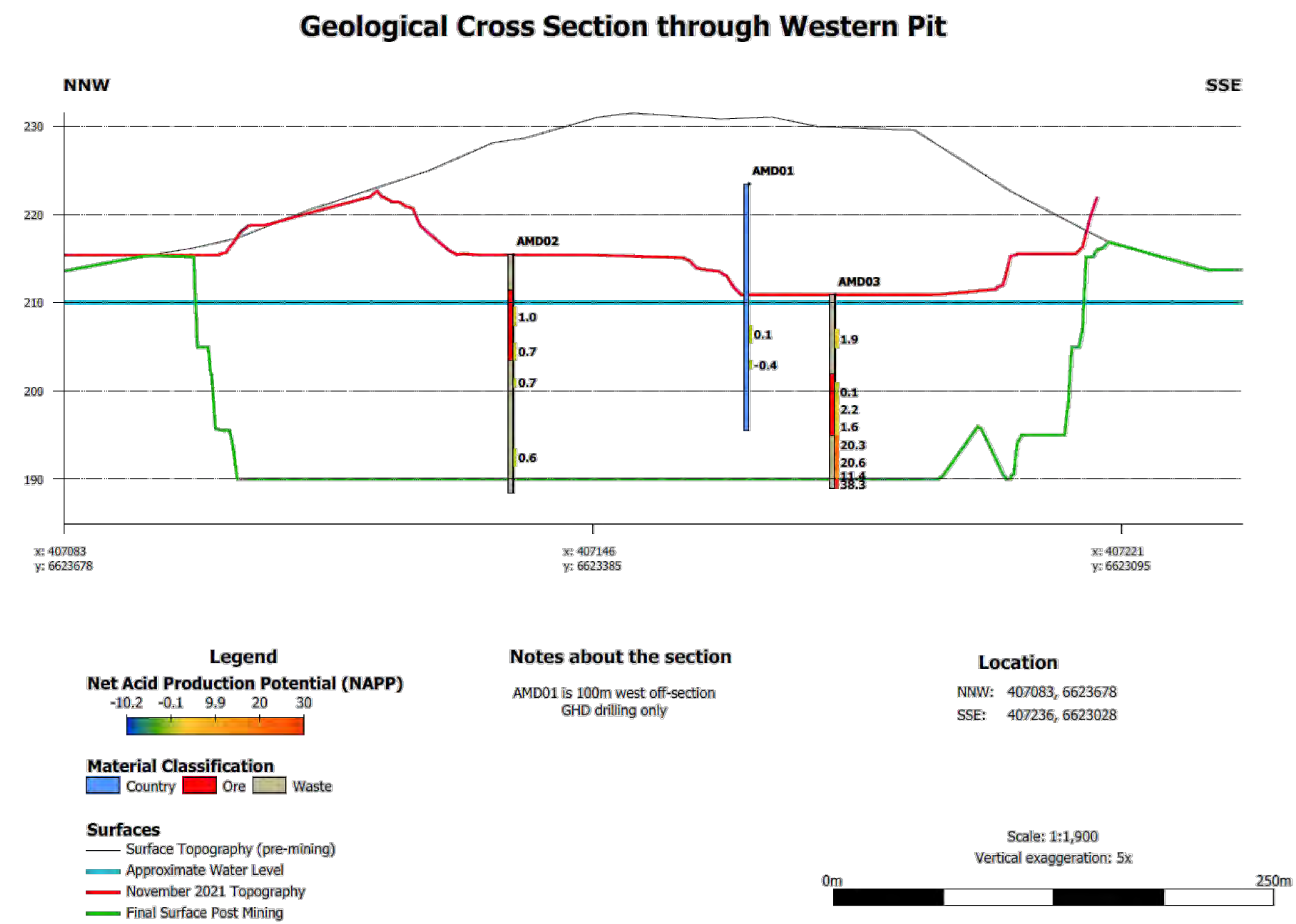


Figure 9 Geological cross section through the West Pit

3.2.2 Methodology

Drilling method used was rotary air drilling which pulverises the rocks and every meter is collected on the ground as drill spoil. The sample comes up as a mixture of rock fragments and weathered rock materials. These are then sampled as 1 or 2 m composites based on lithology, and then sent to the laboratory for testing (GHD, 2022).

Samples collected were sent to a NATA accredited laboratory (ALS) for testing. The laboratory classifies these sample types as soil, although they are fragmented and weathered rock materials.

3.2.3 Characterisation results

Laboratory testing of samples collected within and surrounding the pits as shown in Figure 7. The testing of the materials was to screen for potential risks and provide confidence in the previous characterisation of the waste-rock (GHD, 2019). Waste rock material was classified as either Non-Acid Forming (NAF) or Uncertain (UC) based on the NAG Capacity and ANC of the material (GHD, 2020; GHD, 2022).

Table 4 Laboratory testing (GHD, 2020; GHD, 2022)

Parameters	Material characterisation above ground (GHD 2020)	Material characterisation below ground (GHD 2022)
Acid neutralising capacity (ANC)	12	85
Net acid generation (NAG)	12	85
Sulfur speciation	6	74
Metals comprehensive	6	46
Leach testing (major-ions, pH, EC, metals)	6	46
Radioactivity (screen/gross alpha and beta)	4	10
Asbestos mineral fibres	12	10

The drilling within the waste rock (limited to five holes), indicates acidic leaching will occur at concentrations that have potential to impact the receiving environment (e.g., seepage into creeks), from an estimate of 15% to 30% of the volume of waste rock to be excavated (ore/waste model absent). Although better spatial and vertical delineation is required, acidic leaching conditions are not indicated from the reminder of waste rock (estimated at 70% to 85%) (GHD, 2022).

The material characterisation of above ground samples showed oxidation of iron sulphides such as pyrite, a trace mineral which occurs in the chert ore body, can cause metalliferous drainage under circum-neutral pH conditions (GHD, 2020). Based on these results, it is expected that the observed weak acidity likely generated by other minerals (e.g., iron) will be subject to buffering and dilution, and therefore should not pose an adverse risk or persistence of acidic conditions within the subsurface (GHD, 2020).

The presence of sulphides below the water table poses a risk of impact should acidic waters mobilise metals into the surface water and groundwater system (GHD, 2022). The material will require management to reduce the risk of metals leaching from the waste rock dump areas discharging into the environment (GHD, 2022). A PAF management plan was developed by GHD (2023b) to provide guidance on the management of the waste rock produced during the development and operation of the Moora Mine.

From the total metals analysis, bismuth, selenium, tungsten, cobalt, sulphur, antimony, thorium, uranium and zinc were found to be elevated over the crustal average and, if acidic conditions occur, these metals may leach from the geological profile (GHD, 2022).

The leaching results in GHD (2022) indicate that metals such as aluminium, chromium, copper, lanthanum, lead, nickel, zinc and mercury, leach at concentrations that exceed the drinking water guidelines and/or ecological guidelines. The leaching of these metals occurs in the laboratory under neutral conditions (e.g: without the mobilisation effects of acidic conditions), and any monitoring of groundwater and seepage under neutral conditions derived from the mine site should include these metals. Acidic conditions are likely to cause an increase the number and concentration of dissolved metals (GHD, 2022).

Dewatering and lowering of the groundwater table has the potential to expose acid-producing material (sulphides) in the upper saturated profile of the ex-pit material. The best estimate of water quality is indicated as possibly ranging from mildly acidic to strongly acidic. Any abstracted acidic water will require management and treatment to neutralise the waters and remove associated elevated metal concentrations, prior to discharge to the proposed receiving environment, the creeks associated with the area (GHD, 2022).

Pit lake modelling by GHD (GHD, 2021) has confirmed that evaporation (assumed to be approximately 0.22 ML/day on average) exceeds groundwater inflow (assuming the rate of inflow is 0.14 ML/day as reported by Saprolite (2016)) and therefore the pits would be mostly dry during operations.

3.2.4 Soil material

Soils sampled from 17 sites across the proposed North Kiaka mine in 2019 in the Soilwater (2019) study (considered to be representative of soils within the Site) were analysed for both physical and chemical properties at Soilwater Analysis (SWA) and CSBP laboratories in Perth. The study revealed that geology within the Site is relatively simple, comprising of either:

– Unweathered quartzite, which form the observed ridges; and
– Weathered granite, which is covered by a surficial gravel layer and form the lower topographic areas.

Laboratory testing and erosion modelling (Soilwater, 2019) indicated that:

– All gravelly soils, including both topsoil and subsoil, are structurally stable and friable; and
– All granitic saprolite is structurally unstable, dispersive and highly erodible.

Accordingly, the study (Soilwater, 2019) concluded the gravelly soils are optimal soil material for use in rehabilitation of the outer surface of the WRD landforms, while usage of the granitic saprolite should be avoided.

4. Preliminary flood assessment

GHD completed a preliminary flood assessment to inform surface water management at the Site. The aim of this assessment is to:

– Determine the potential changes in flood hydraulics at mine closure, with cognisance to the closure landform and structure; and
– Provide conceptual designs of surface water drainage controls to minimise changes on existing surface water features and dependent ecosystems at post-closure.

This flood assessment addresses a key closure objective from the MCP (GHD, 2023a), which obliges SIMCOA to "*ensure surface water movement is free draining within the rehabilitated landform/areas and not prone to erosion or ponding*". The other closure objectives under the water and drainage aspect pertain to either water quality or pit lake, hence are beyond the scope of this assessment.

The assessment involved simulation of flood conditions on both existing and post-closure mine landforms in the 1 in 2,000 Annual Exceedance Probability (AEP) storm event. This extreme storm event AEP was selected as any new drainage control that is designed to satisfy the closure objectives would need to be permanent in nature.

The following subsections describe the flood assessment approach, outcomes and recommendations respectively.

4.1 Flood model setup

A two-dimensional fixed-grid flood model was developed using TUFLOW (Version 2020-01-AB) for the simulation of both existing and post-closure flood conditions. Modelling was undertaken using a 'rainfall-on-grid' approach, in which rainfall is directly applied on a grid describing the Site's topography. Details of the model setup are given in subsequent subsections.

4.1.1 Digital elevation model

A Digital Elevation Model (DEM) describing the topography of the Site was developed using the following information (in order of descending priority):

– Triangulated irregular networks of both the main and west pits in the existing mine dated 13 December 2019 (supplied by SIMCOA on 15 July 2020);
– Triangulated irregular networks of the proposed open pit and Tonkin WRD to the north of Kyaka Brook (supplied by SIMCOA on 3 June 2020);
– 1 m interval contours approximately covering the mining tenements in which the existing and proposed North Kiaka mines are located in (supplied by SIMCOA on 15 July 2020); and
– 2 m interval contours covering majority of the southwest WA region, which were produced by DPIRD as part of the *Land Monitor* project between 1998 and 2000.

The post-closure WRD landforms (including the Main, West Pit, North, Old North and South East WRDs) were modelled on the DEM by artificially raising their footprint areas. The final design levels or surface for these landforms were not available for the purposes of this assessment.

The DEM was generated as a grid of 10 m square cells. Adoption of DEM cell sizes smaller than the selected value was considered impractical given the relatively low resolution of the contour datasets above.

4.1.2 Rainfall

The 1 in 2,000 AEP design rainfall hyetographs to be applied over the modelling domain were derived in accordance with the *Australian Rainfall and Runoff* (ARR) 2019 (Ball, et al., 2019) and involved the following tasks:

– Extraction of design rainfall depths for all 24 standard durations (ranging from 10 minutes to 168 hours) from the Bureau of Meteorology's Design Rainfall Data System (Design Rainfall Data System, 2016);
– Application of rainfall areal reduction factors as prescribed in Chapter 4 in Book 2 of the ARR 2019; and

– Application of rainfall temporal patterns as defined by the Generalised Short Duration Method (for both short and intermediate durations) and Revised Generalised Tropical Storm Method (for both intermediate and long durations).

4.1.3 Surface roughness

Surface roughness within the modelling domain was characterised by applying the following Manning's roughness coefficient values to each cell of the DEM:

– 0.065 for cleared or mining areas; and
– 0.075 for uncleared or heavily vegetated areas.

The extent of uncleared areas adopts the native vegetation extents defined by DPIRD. The DPIRD dataset is updated annually based on digital aerial photography and was last updated in May 2020.

4.1.4 Losses

The flood model utilises an initial-continuing loss approach to estimate rainfall loss and excess. The loss values to be adopted were inferred from the two reference sources below:

– *Moora Flood Management Study* (Water Studies, 2000); and

  The study simulated flood extents within the Moore River for storm events up to the 1% AEP. The study mainly focuses on the Moora townsite but does provide calibrated hydrological parameters for upstream catchments (which encompasses the modelling domain).

– *ARR Data Hub* (Babister, Trim, Testoni, & Retallick, 2020).

  The hub provided regional loss estimates throughout the whole of Australia (other than the interior arid region) at a resolution of about 2.5 km.

For the initial loss, the *ARR Data Hub* (Babister, Trim, Testoni, & Retallick, 2020) indicated a regional loss estimate of 54 mm (weighted average by catchment area); while calibration in the Moora Flood Management Study (Water Studies, 2000) yielded values ranging from 50 mm to 190 mm. However, these values were not applied directly in modelling due to the rainfall-on-grid approach adopted in this SWMP. To account for surface depression storages already present on the DEM, as well as pre-burst rainfall totals, a conservative initial loss value of 10 mm was used instead.

The adopted continuing loss value was a constant 3 mm/hr, which is consistent with the values from both references above.

Prior to simulation, the DEM was also pre-wetted by applying a rainfall burst (of 250 mm) for the purpose of filling unconnected surface depressions on the DEM. The pre-wetted DEM is then used at the start of all model simulations.

4.1.5 Boundary conditions

An open flow boundary along the perimeter of the modelling domain was assumed. This effectively simulates free discharge of flood waters out of the model and towards low lying areas external to the domain.

Despite the proximity to the Coonderoo River wetlands to the west, flood waters in the river/wetlands are not expected to encroach the Site in the 1 in 2,000 AEP storm event. This was further verified by simulating a 1 in 2,000 AEP peak discharge, which was conservatively estimated through extrapolation of the *Regional Flood Frequency Estimation Model* (Rahman & Haddad, 2016) results, at a continuous constant rate within the Coonderoo River segment beside the modelling domain. The simulation demonstrated that the river flood extents do not extend past Midlands Rd to its east.

Given the findings above, a defined water level boundary to simulate the river/wetland flood levels at west of the Site was not warranted.

4.1.6 Limitations of modelling

The flood model has been developed specifically to fulfil the scope requirements of this SWMP and suitable for design at a conceptual level only. Further refinement of the model is possible but will require acquisition of higher quality datasets (e.g., topography, land use extents, etc.).

The following aspects were not covered in modelling due to the reasons given below:

– The impacts of climate change have not been considered.

  There are no common established approaches to project the impacts of climate change on rare and extreme storm events. The interim climate change guidelines endorsed in Book 1 of ARR 2019 only provides guidance up to the 1% AEP storm event, which is far smaller than the requirements of this assessment (i.e., 1 in 2,000 AEP).

– Abandonment bunds were not incorporated into this model.

  Abandonment bunds are proposed to be constructed from unweathered, freely draining and dumped rockfill. The free draining nature of these bunds will not alter existing flow paths and therefore the model outputs remain valid.

– Small drainage structures have not been incorporated into the model.

  Structures, such as culvert and bridge crossings along Midlands Rd, could not be simulated to a reasonable degree of accuracy and thus excluded from modelling accordingly. This was due to the following reasons:

  - Lack of information (i.e., levels and sizes) to characterise the structures; and
  - DEM cell size (i.e., 10 m) that is larger than majority of drainage structures.

In addition, calibration of the flood model was not undertaken due to the absence of relevant monitoring data within or near the modelling domain. The nearest stream gauging sites are located approximately 15 km south at the Moora townsite and 12 km southeast at Berkshire Valley, where the catchment land use and soil characteristics are noted to differ from those within the domain.

4.2 Modelling outcomes

Figures depicting the simulated maximum flood depths and flow velocities for the 1 in 2,000 AEP storm event are annexed in Appendix A. Flood results (in Figures A1 to A6) within the open mine pit extents have been masked as they do not represent the long term pit lake levels, which have been determined separately in a *Pit Like Recovery Assessment* (GHD, 2021). Changes in flood extents (in Figures A5 and A6) within the WRD footprint areas are also not shown as the results are not directly comparable (due to topographical changes).

In general, maximum flood depths and flow velocities within the Site are less than 200 mm and 0.6 m/s respectively in both the existing (see Figures A1 and A2) and post-closure (see Figures A3 and A4) scenarios. Exceedances of the aforementioned limits mostly occur at or near formalised drainage flow paths.

The observed changes in flood hydraulics (see Figures A5 and A6) at post-closure are summarised as follows:

– Increased flood depths and flow velocities at west of Tonkin WRD, southeast of Old North WRD, east of South East WRD and west of West Pit WRD due to diversion of existing flow paths around the WRDs;

– Deeper flood waters and higher flow velocities to the north of North WRD due to encroachment of the WRD onto the floodplain of Kyaka Brook;

– Ponding at the west side of Tonkin WRD and North WRD due to trapped low spot;

– Increased ingress of flood waters into both the Main and West Pits due to runoff from the Main WRD. The Main WRD is located within the abandonment bund extents so its runoff will shed into both pits.; and

– Reduced flood depths and flow velocities around the proposed pit due to interception and detention of rainfall within the pit.

Changes to the peak discharge rates within the Prye Brook, Kyaka Brook and unnamed brook south of the existing mine were also noted to be negligible, thus indicating minimal impacts to the existing brook flow regimes.

4.3 Proposed controls

As Section 4.2 indicates, the simulated post-closure surface water impacts are minimal, hence negating the need for significant engineered features, structures or interventions for surface water management. Nevertheless, a number of localised drainage controls have been proposed to achieve better conformance to the MCP (GHD, 2023a) closure objectives.

Figure 11 shows the proposed surface water drainage controls for the Site at post-closure.

4.3.1 Open pits

All open pits, including the existing Main Pit, West Pit and proposed northern pit, are located on hilltops with fairly insignificant external catchment areas draining into them. Ingress of flood waters from the external catchments may be further reduced by constructing open drains immediately beside the pit abandonment bunds, as shown in Figure 10.

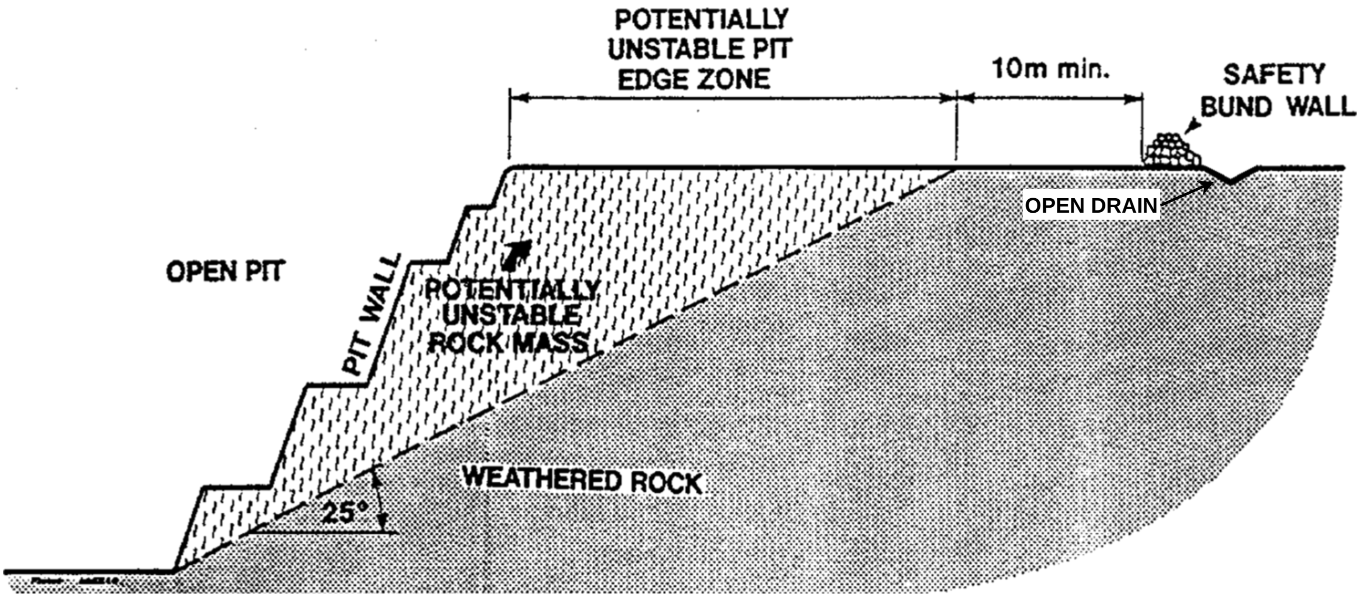


Figure 10 Open drain beside pit abandonment bund

The construction of open drains would reduce flood water shedding into the open pits, thereby reducing the risk of pit instability and wall erosion. The proposed open drain alignments are shown in Figure 11. The downstream ends of open drains are to transition to the natural surface by daylighting.

It should be noted that the topography along the proposed open pit's southeast boundary is relatively low. This renders construction of an open drain along this boundary not feasible as significant earthworks would be required to facilitate downstream discharge to lower lying areas. This also means that ingress of runoff near the middle of the pit's eastern side (denoted by the discharge point on Figure 11) cannot be avoided.

4.3.2 Waste rock dumps

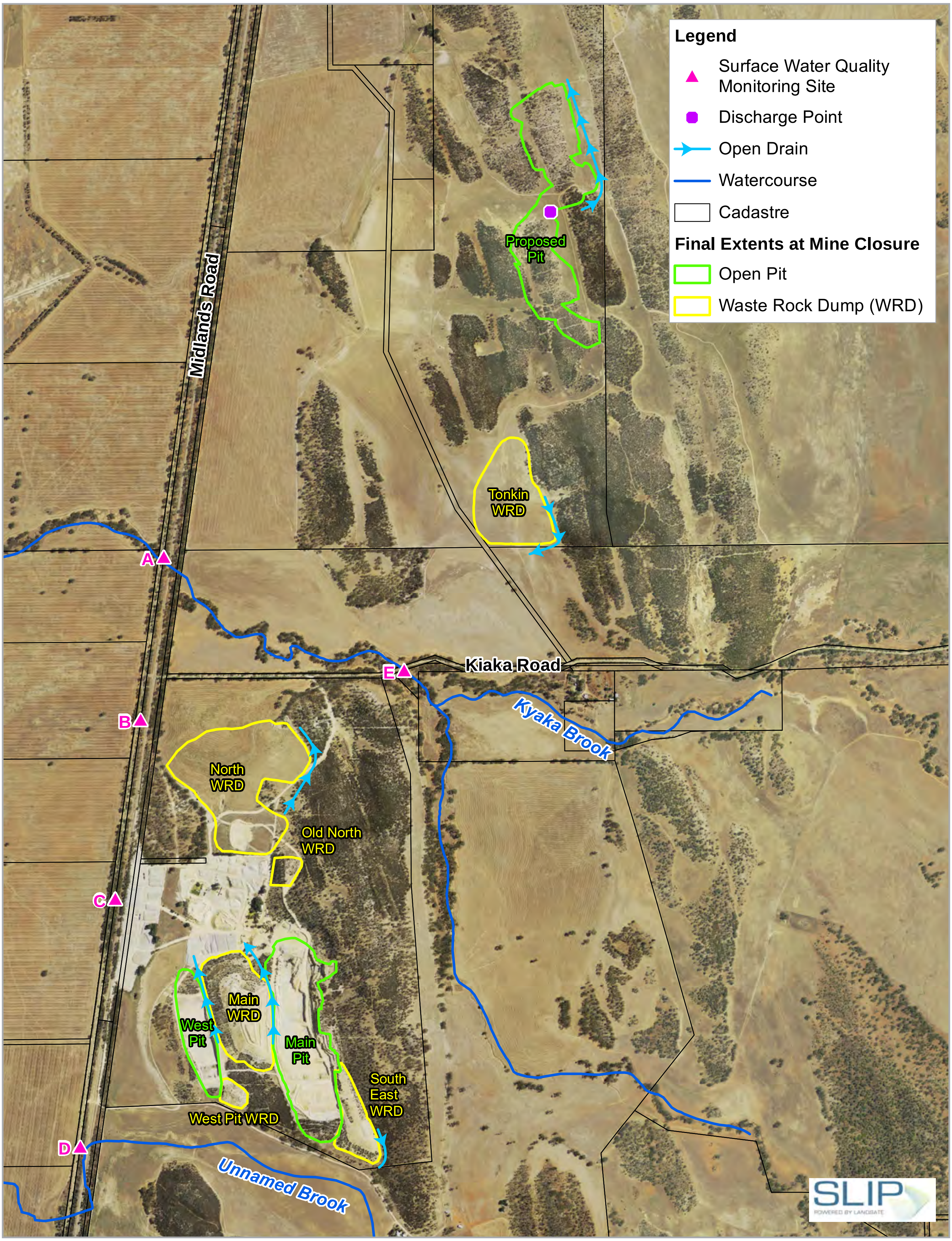
The MCP (GHD, 2023a) dictates that the WRDs are to be rehabilitated by re-profiling side slopes to form a stable surface, as well as developing a self-sustaining vegetation community. This requirement should enable sufficient protection to withstand scouring and erosion at all WRD landforms up to the 1 in 2,000 AEP.

The simulated flow velocities were noted to be relatively high (i.e., in excess of 1.0 m/s) at the batter toes of the following WRDs:

– Along western perimeter and southwest corner of Tonkin WRD;
– Northwest of the North WRD; and
– Southeast corner of the South East WRD.

Further scour and erosion protection are not proposed at this stage, considering that a well vegetated batter slope can tolerate flow velocities in excess of 1.0 m/s, and that the simulated storm event is extreme (i.e., 1 in 2,000 AEP). It is therefore suggested that the erosion potential at WRD areas is monitored regularly over the mine operational period and controls are implemented accordingly where erosion is detected.

Open drains have also been proposed along the northeast boundary of North WRD and southwest boundary of Tonkin WRD (see Figure 11) to drain the trapped low spots resultant from placement of the WRDs. Similar to the proposed open pit, the low spot beside the North WRD could not be fully drained due to it being significantly lower than the surrounding area. Where possible, slight modifications to the WRD footprints should be considered so that the ponding extents at low spots can be minimised.



1:20,000 (at A4)

0 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Simcoa Operations Pty Ltd
Moora Quartzite Mine Closure Plan
Surface Water Management Plan

Concept Surface Water Management Strategy

Project No. 12518217
Revision No. 2
Date 11/01/2021

FIGURE 11

Data source: GHD: Surface Water Quality Monitoring Site - 20200824, Discharge Point - 20200824; Simcoa: Open Pit - 20200806, Waste Rock Dump - 20200806; DWER: Watercourse - 20130902; Landgate: Cadastre - 20180607, Moora Feb 2012 Mosaic - 201202. Created by: lhyoong

5. Post-closure water quality monitoring

5.1 Monitoring objectives

Post-closure monitoring of water quality is required to demonstrate adherence to the following closure objectives from the MCP:

– Ensure any seepage and runoff will comply with water quality criteria to be agreed with regulators and does not contain excessive sediment loads posing a risk to final land use; and
– Ensure water quality of local and regional surface and groundwater resources are not compromised.

Monitoring will involve sampling of surface water at selected locations around the Site and assessing water quality against established baseline or appropriate guideline values where applicable. Monitoring is likely to be event-based since the brooks are ephemeral only.

The monitoring of pit lake water quality has been excluded from this SWMP, since both the Main Pit and West Pit are likely (GHD, 2021) to be largely empty/dry after mine closure, and any pit lakes formed would be shallow and have negligible influence on local surface water features and resources as outlined in GHD's (2021) *Pit Lake Recovery Assessment*.

The subsequent subsections detail the various considerations for the proposed monitoring plan.

5.2 Selection of monitoring sites

A total of five surface water quality monitoring sites have been proposed, of which their locations are shown in Figure 11. These sites were selected with close consideration to the mine layout (see Figure 1), catchment and watercourses (see Figure 6), geomorphology, topography, as well as accessibility. Private lots adjacent to the Site are fenced along most of their perimeter, and so were assumed to be inaccessible for water quality monitoring purposes.

Sites A to D have been positioned next to Midlands Road to allow easy access and at the upstream end of existing culvert crossings that drain the Site. At post-closure, these sites inform the water quality draining off from the rehabilitated landforms, since their catchments incorporate the WRD footprint areas noted in Table 5. These sites are also unlikely to be disturbed by mining activities on Site, hence opportunistic sampling may be carried out while mining is in progress to assist characterisation of Site water quality.

Table 5 Proposed water quality monitoring sites

Site	Coordinates*		Landforms covered in upstream catchment
	Easting	Northing	
A	407,020	6,625,268	Tonkin WRD
B	406,928	6,624,614	North WRD
C	406,826	6,623,895	Old North WRD and Main WRD
D	406,686	6,622,900	Main WRD, West Pit WRD and South East WRD
E	407,985	6,624,812	None; undisturbed catchment

**** Notes: Coordinates assume the Map Grid of Australia 1994, Zone 50 map projection and are approximate only.***

Site E is located near a culvert crossing across Kiaka Road. This site is located on the upper reaches of Kyaka Brook, near where two of its tributaries meet (see Figure 11). The upstream catchment draining towards this site has no existing or planned mining activities on it. As such, it is intended that Site E will be used to inform the background water quality in nearby catchments.

No monitoring sites have been proposed along Prye Brook to the north of the proposed North Kiaka mine as none of the rehabilitated landforms or WRDs drain towards the said brook. The proposed open pit does overlap a small fraction of Prye Brook's catchment but does not have any bearing on the downstream surface water quality.

Potential revisions to monitoring sites

The selection of water quality monitoring sites was done based on a desktop review of available data. The location of the sites nominated in Table 5 should not be considered final, due to gaps in the provided information below:

– The resolution of topographical datasets (listed in Section 4.1.1) could be too coarse to reveal potential diversions/barriers to flow paths that may be present; and
– Absence of drainage information (e.g., culvert and bridge crossings, etc.) along the railway line next to Midlands Road.

The information gaps above could lead to incorrect catchment extents being assumed, and in turn, lead to redundant monitoring sites that do not fulfil the purposes of this SWMP. Consequently, it is recommended the site locations are reviewed again when better information (e.g., feature survey data) becomes available in future.

5.3 Sampling methodology

The sampling of surface water is to be undertaken in accordance with Australian Standard *AS/NZS 5667.1:1998 (R2016): Water quality - Sampling*. Relevant parts of the standard include:

– Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples; and
– Part 6: Guidance on sampling of rivers and streams.

Sampling at the Sites is to be conducted annually over a period of ten years after mine closure and completion of closure program of works, in line with the post-closure monitoring program specified in the MCP (GHD, 2023a). Considering the ephemeral nature of watercourses near the Site, sampling should ideally be performed during or immediately after storm events in winter to capitalise on available streamflow.

Water quality monitoring prior to the proposed North Kiaka mine expansion is recommended but optional only. Ideally, some sampling should be conducted at Sites A and E prior to expansion in order to establish the baseline water quality at Kyaka Brook. However, it is acknowledged that this task is unlikely achievable given the limited time available between preparation of this SWMP and commissioning of the new Site.

5.4 Assessed analytes

Water quality parameters were selected to facilitate comparison with appropriate guidelines where available and consider potential contaminants that may be introduced as a result of mine development and operation.

With consideration to the risk assessment outcomes detailed in Section 3, it is recommended that the collected water samples are analysed for the following suite:

– Physicochemical parameters, including pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, total suspended solids (TSS), biochemical oxygen demand (BOD);
– Major cations and anions, including calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), sulfate (SO_4), alkalinity and hardness;
– Nutrients, including total nitrogen (TN), total Kjeldahl nitrogen (TKN), total oxidised nitrogen (NO_x-N), nitrite-N (NO_2-N), nitrate-N (NO_3-N), ammonia-N (NH_3-N), total phosphorus (TP), filterable reactive phosphorus (FRP); and
– Metals, including arsenic (As), beryllium (Be), bismuth (Bi), boron (B), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), selenium (Se), strontium (Sr), and zinc (Zn).

5.5 Surface water quality baseline

The analysed water quality at Sites A to D is to be assessed against a baseline to determine whether the closure objectives are met or not. In the absence of good quality surface water quality records at the Site (see Section 2.5), Default Guidelines Values (DGVs) from the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018) are to be adopted as baseline instead. The DGVs serve to provide a generic starting point for assessing water quality (ANZG, 2018).

As mentioned earlier in Section 5.2, it is intended that Site E will be used to infer background water quality in the catchment. Assuming collection of an adequate amount of reference samples, water quality variables with measurements (at Site E) higher than the DGVs may adopt the higher values as site specific baseline.

5.5.1 Final land use

The MCP (GHD, 2023a) indicates that, beyond the footprint areas of constructed landforms and open pits, the majority of the Site is to be converted to low intensity agricultural land use. This is consistent with adjacent land uses, on which pasture grazing is the predominant activity.

In alignment with the MCP closure objective 1 (see Section 5.1), the ANZG (2018) guidelines relating to primary industries – livestock drinking water are applicable to this particular land use. The ANZG (2018) guidelines redirects to the earlier *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 3, Primary Industries – Rationale and Background Information* (ANZECC & ARMCANZ, 2000) for the DGVs. The livestock drinking water DGVs for selected water quality parameters are reproduced in Table 6.

Table 6 Default guideline values for primary industries – livestock drinking water quality (ANZECC & ARMCANZ, 2000)

Parameter	Low risk guideline value[1] (mg/L)
Physiochemical	
Total dissolved solids (TDS)	< 4000
Anions	
Sulfate (SO_4)	< 1000
Nutrients	
Nitrate-N (NO_3-N)	338.6
Nitrite-N (NO_2-N)	9.11
Metals	
Aluminium (Al)	5
Arsenic (As)	0.5
Boron (B)	5
Cadmium (Cd)	0.01
Chromium (Cr)	1
Cobalt (Co)	1
Copper (Cu)	0.4 (sheep) / 1 (cattle)
Lead (Pb)	0.1
Mercury (Hg)	0.002
Molybdenum (Mo)	0.15
Nickel (Ni)	1
Selenium (Se)	0.02
Zinc (Zn)	20

[1] Metals guideline values relate to the total concentration of the constituent.

5.5.2 Surface water receptors

Post-closure monitoring objective 2 (see Section 5.1) relates to the maintenance of surface water and groundwater quality. As reported in Section 2.6, identified downstream surface water receptors include Prye Brook, Kyaka Brook and the unnamed brook south of the existing mine. DGVs for lowlands in southwest Australia (see Table 7) have been adopted for these receptors.

Table 7 Default guideline values for southwest Australia lowland river (ANZECC & ARMCANZ, 2000)

Parameter	Unit	Guideline value	
		Lower limit	Upper limit
Physiochemical			
pH	-	6.5	8.0
Electrical conductivity (EC)	µS/cm	120	300
Turbidity	NTU	-	10-20[2]
Nutrients			
Total nitrogen (TN)	mg/L	-	1.2
Total oxidised nitrogen (NO_x-N)	mg/L	-	0.15
Ammonia-N (NH_x-N)	mg/L	-	0.08
Total phosphorus (TP)	mg/L	-	0.065
Filterable reactive phosphorus (FRP)	mg/L	-	0.04
Metals[3]			
Aluminium (Al)			0.055
Arsenic (As)			0.024
Boron (B)			0.37
Cadmium (Cd)[4]			0.0002
Chromium (Cr)[4]			0.001
Copper (Cu)[4]			0.0014
Lead (Pb)[4]			0.0034
Manganese (Mn)			1.9
Mercury (Hg)			0.0006
Nickel (Ni)[4]			0.011
Selenium (Se)			0.011
Zinc (Zn)			0.008

[2] Representative of base river flow.
[3] Trigger values for toxicants at 95% level of freshwater species protection.
[4] Default trigger value. Value should be adjusted for site specific hardness in accordance with ANZECC & ARMCANZ (2000).

6. Recommendations

The Prye Brook, Kyaka Brook, unnamed brook south of the existing mine and Coonderoo River are the main surface water receptors downstream of the Site. A qualitative assessment revealed potential surface water risks that may occur at the Site post-closure, of which their impacts can be generally condensed to the following:

– Erosion of existing drainage paths;
– Increased sediment loads to existing surface water features; and
– Contamination of surface water features and resources.

The bulk of the identified risks can be largely mitigated provided that the closure works program described in the MCP (GHD, 2023a) is implemented to a satisfactory degree. A number of these risks also highlighted the need for surface water drainage and erosion controls, which were evaluated in this study through a preliminary flood assessment.

The flood assessment indicated a need for engineered open drains (see Figure 11) at post-closure to minimise erosion due to ingress of runoff into the open pits, as well as drain trapped low spots resultant of placement of WRDs. Strategic discharge points have also been nominated to allow direct discharge of runoff from undisturbed external catchments into the pits, so as to minimise the extents of pit wall erosion.

Diversion of catchment runoff along the proposed open pit's southeast boundary and complete drainage of the trapped low spot next to the North WRD could not be achieved due to topographical constraints. Slight modifications to the WRD footprints can be considered to mitigate ponding at low spots.

No erosion protection measures have been proposed at this stage, given the relatively low flow velocities simulated throughout the Site for the 1 in 2,000 AEP extreme storm event. However, application of erosion protection is recommended where erosion is detected during operation of the mine.

Annual monitoring of surface water quality at five sites (see Figure 11) over a ten-year period after mine closure has also been proposed. These sites have been selected to facilitate monitoring of surface water quality of runoff draining from the rehabilitated landforms. Nevertheless, the positioning of the sites should not be considered final and should be reviewed again when further information becomes available in future.

In the absence of site specific baseline values, the monitored water quality variables will be required to not exceed the ANZECC & ARMCANZ (Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000) default guideline values for primary industries – livestock drinking water quality in order to achieve completion of closure objectives.

The *Pit Lake Recovery Assessment* (GHD, 2021) indicates that the open pits are likely dry throughout the year post-closure, with some inundation occurring over winter only. Consequently, the formation of pit lakes and their associated water quality are expected to have negligible impacts on the surrounding environmental values, and do not warrant post-closure management and monitoring.

7. References

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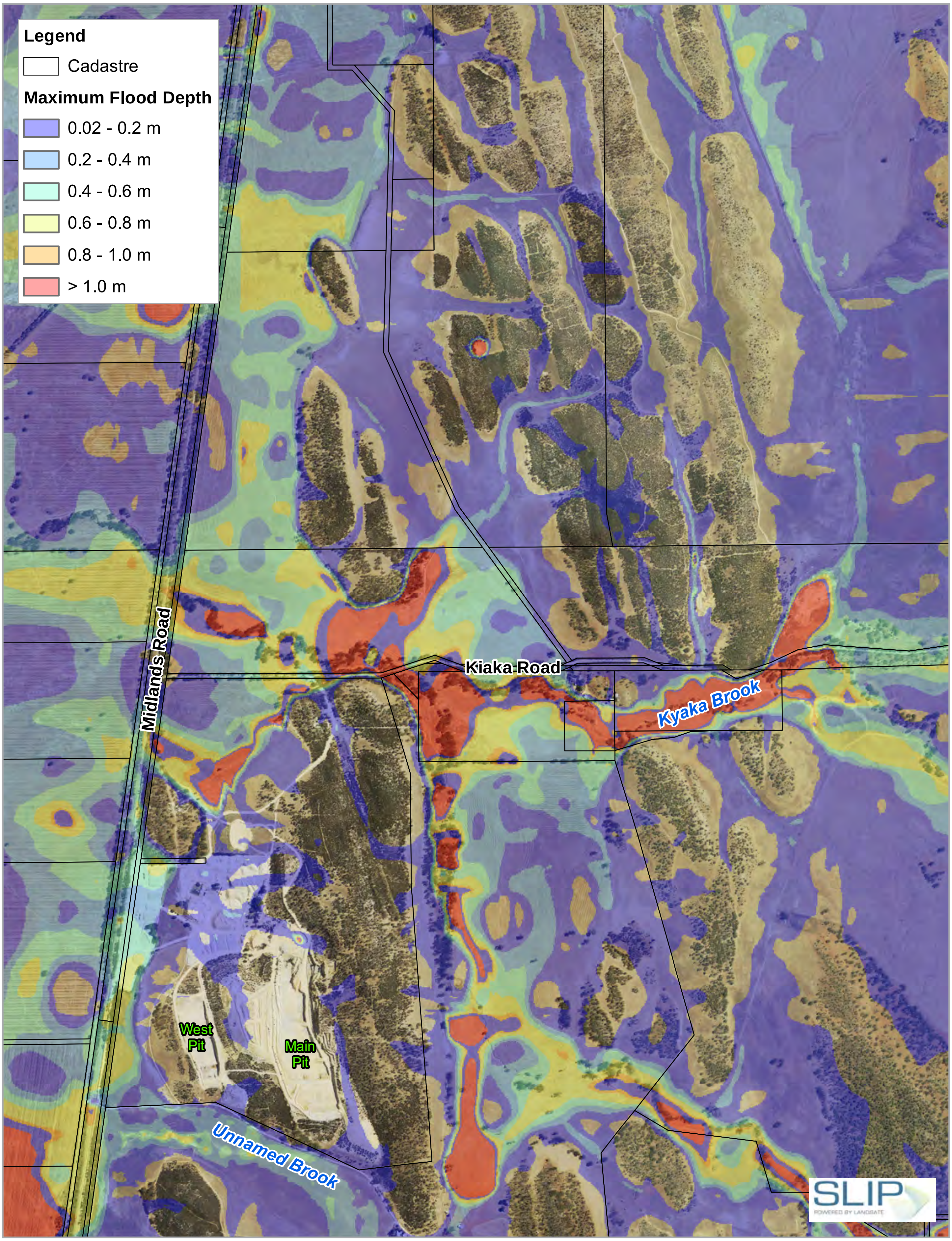
Appendix A

Simulated 1 in 2,000 AEP flood maps



1:20,000 (at A4)

0 200 400 600 800

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

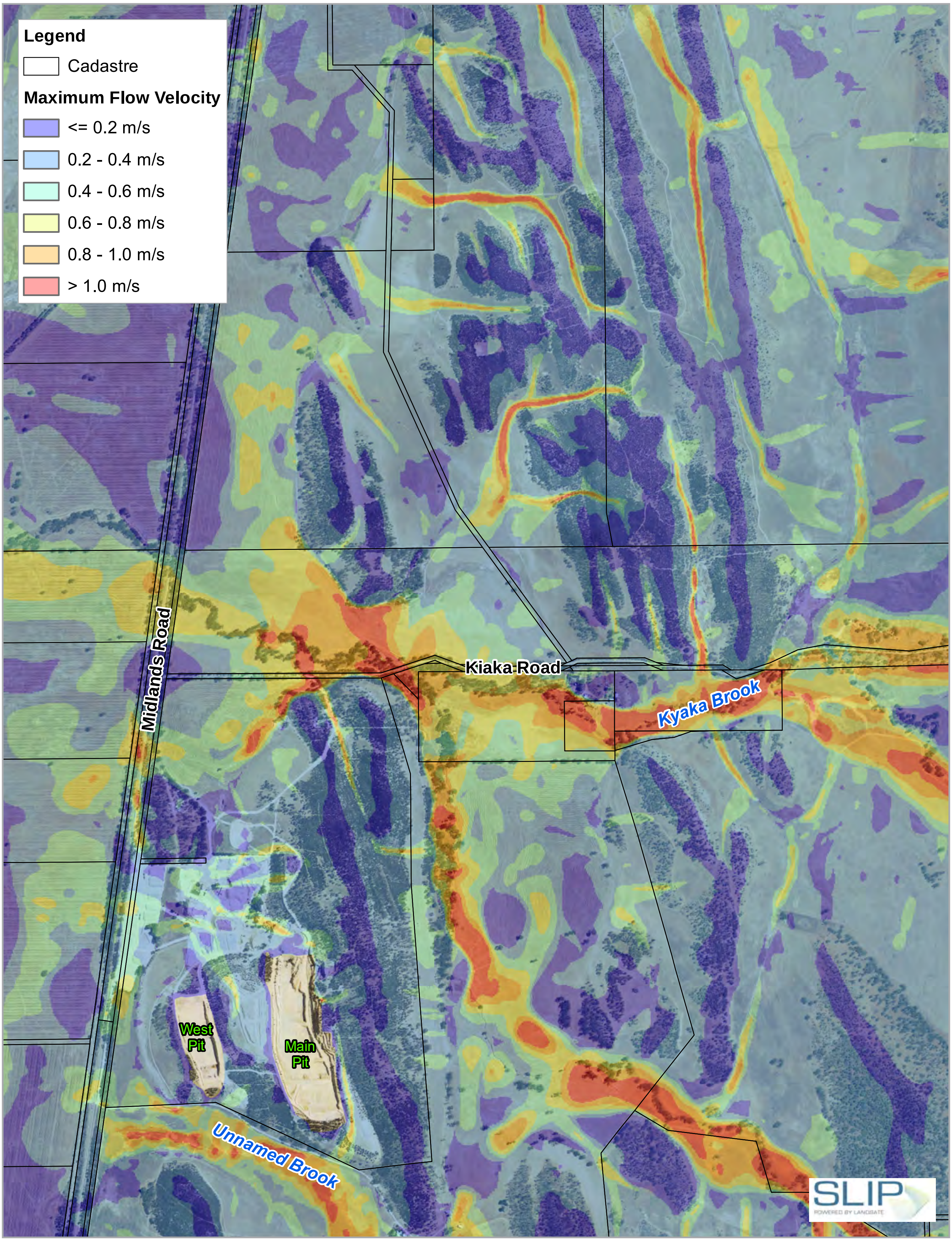
Simcoa Operations Pty Ltd
Moora Quartzite Mine Closure Plan
Surface Water Management Plan

Project No. 12518217
Revision No. 0
Date 24/08/2020

1 in 2,000 AEP Existing Scenario
Simulated Maximum Flood Depths

FIGURE A1

Data source: GHD: Maximum Flood Depth - 20200816; Landgate: Cadastre - 20180607, Moora Feb 2012 Mosaic - 201202. Created by: lhyoong



1:20,000 (at A4)

0 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

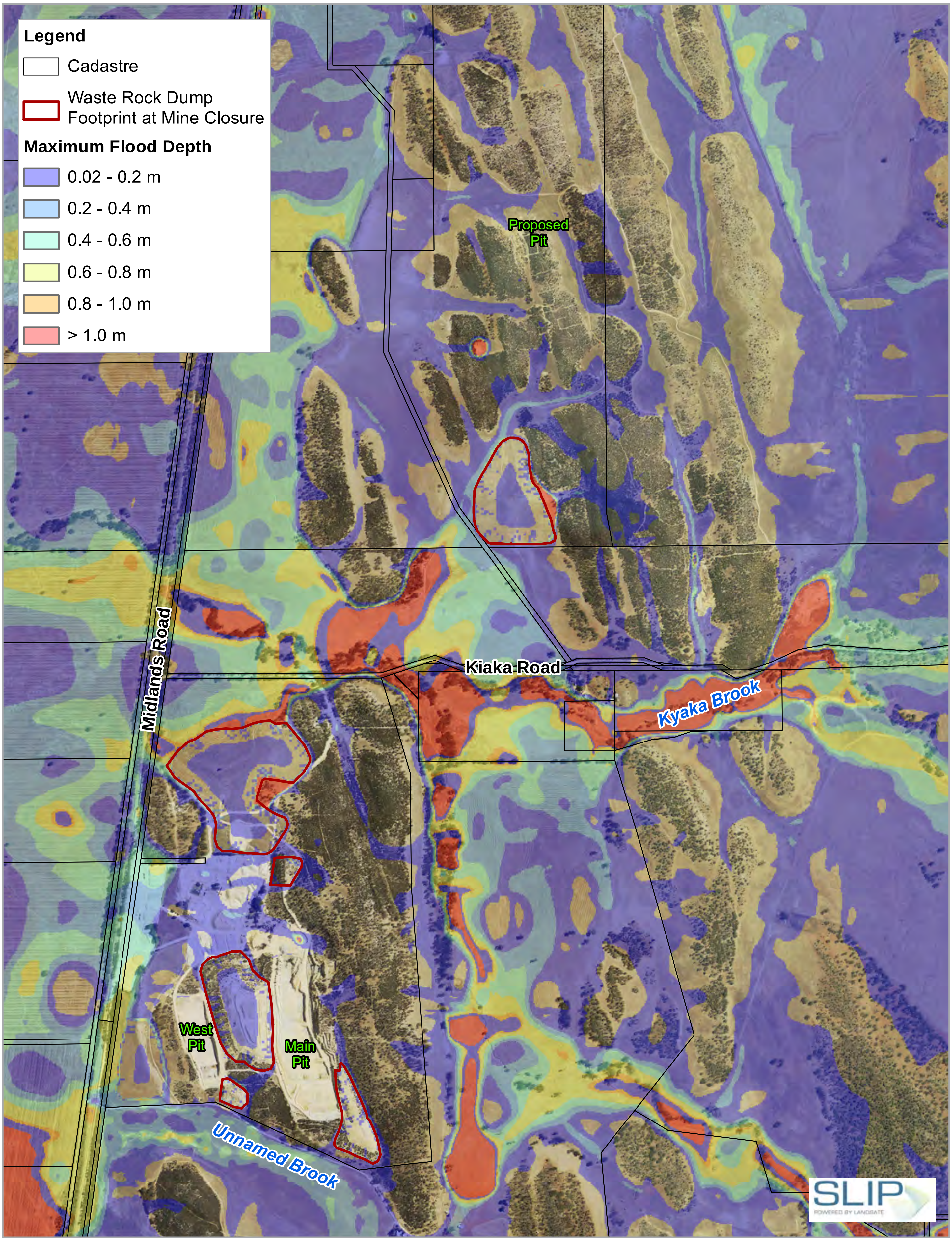
Simcoa Operations Pty Ltd
Moora Quartzite Mine Closure Plan
Surface Water Management Plan

1 in 2,000 AEP Existing Scenario
Simulated Maximum Flow Velocities

Project No. 12518217
Revision No. 0
Date 24/08/2020

FIGURE A2

Data source: GHD: Maximum Flow Velocity - 20200816; Landgate: Cadastre - 20180607, Moora Feb 2012 Mosaic - 201202. Created by: lhyoong



1:20,000 (at A4)

0 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

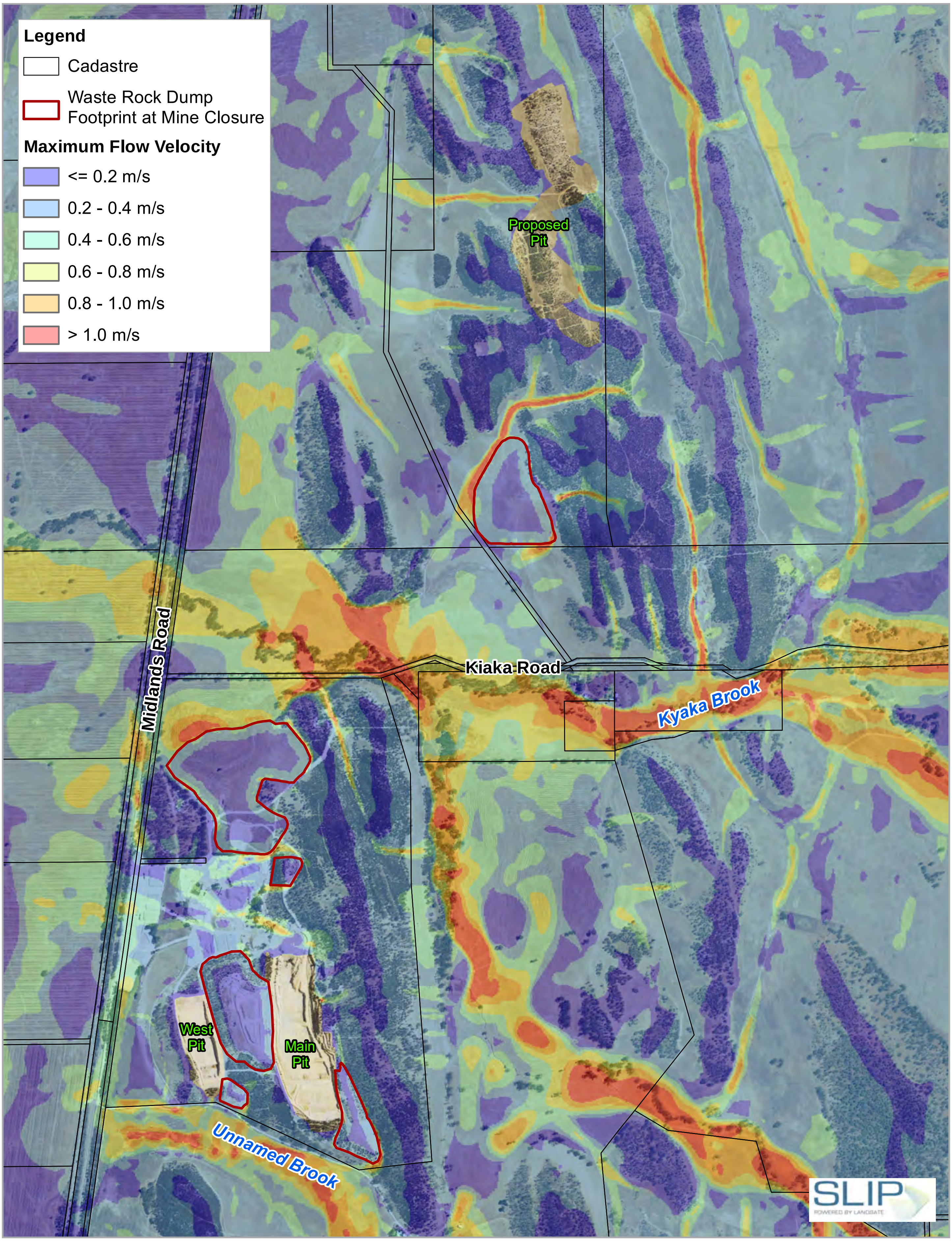
Simcoa Operations Pty Ltd
Moora Quartzite Mine Closure Plan
Surface Water Management Plan

1 in 2,000 AEP Post-Closure Scenario
Simulated Maximum Flood Depths

Project No. 12518217
Revision No. 1
Date 24/08/2020

FIGURE A3

Data source: Simcoa: Waste Rock Dump - 20200806; GHD: Maximum Flood Depth - 20200816; Landgate: Cadastre - 20180607, Moora Feb 2012 Mosaic - 201202. Created by: lhyoong



1:20,000 (at A4)

0 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Simcoa Operations Pty Ltd
Moora Quartzite Mine Closure Plan
Surface Water Management Plan

1 in 2,000 AEP Post-Closure Scenario
Simulated Maximum Flow Velocities

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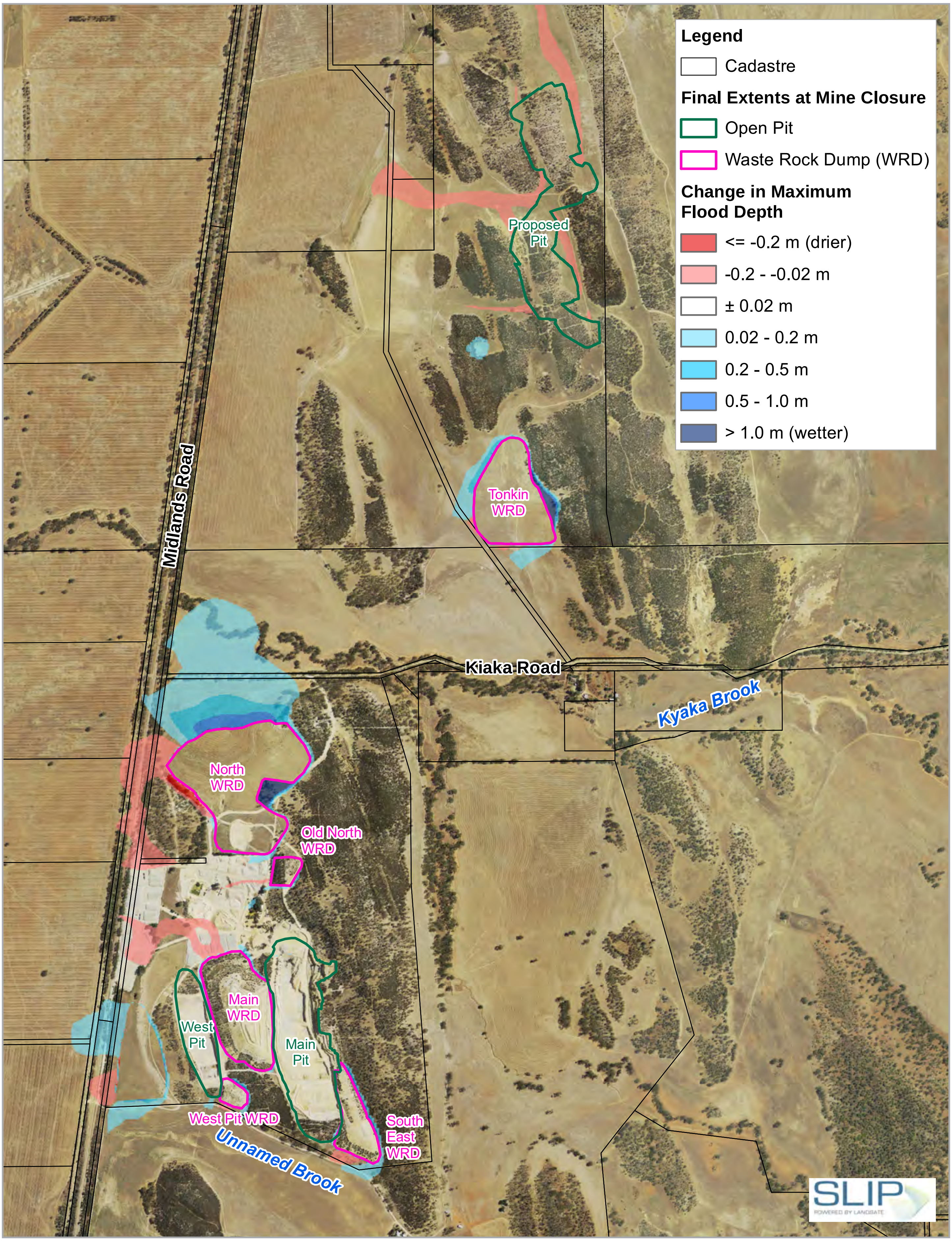
FIGURE A4

Data source: Simcoa: Waste Rock Dump - 20200806; GHD: Maximum Flow Velocity - 20200816; Landgate: Cadastre - 20180607, Moora Feb 2012 Mosaic - 201202. Created by: lhyoong



1:20,000 (at A4)

0 200 400 600 800

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

GHD

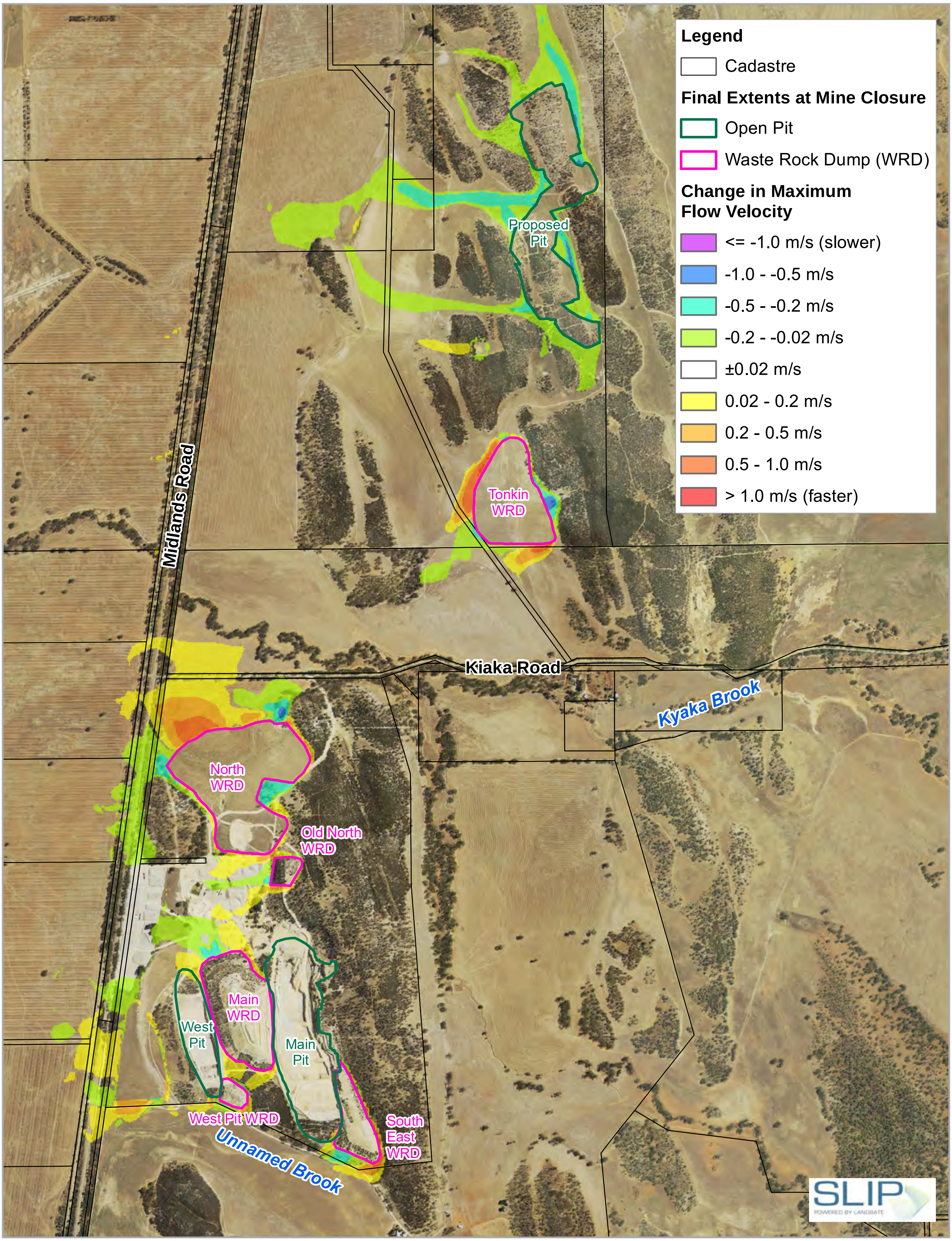
Simcoa Operations Pty Ltd
Moora Quartzite Mine Closure Plan
Surface Water Management Plan

1 in 2,000 AEP Post-Closure Scenario
Change in Maximum Flood Depths

Project No. 12518217
Revision No. 1
Date 24/08/2020

FIGURE A5

Data source: Simcoa: Open Pit - 20200806, Waste Rock Dump - 20200806; GHD: Change in Maximum Flood Depth - 20200816; Landgate: Cadastre - 20180607, Moora Feb 2012 Mosaic - 201202.
Created by: lhyoong



1:20,000 (at A4)

0 200 400 600 800

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

GHD

Simcoa Operations Pty Ltd
Moora Quartzite Mine Closure Plan
Surface Water Management Plan

1 in 2,000 AEP Post-Closure Scenario
Change in Maximum Flow Velocities

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FIGURE A6

Data source: Simcoa: Open Pit - 20200806, Waste Rock Dump - 20200806; GHD: Change in Maximum Flow Velocity - 20200816; Landgate: Cadastre - 20180607, Moora Feb 2012 Mosaic - 201202.
Created by: lhyoong