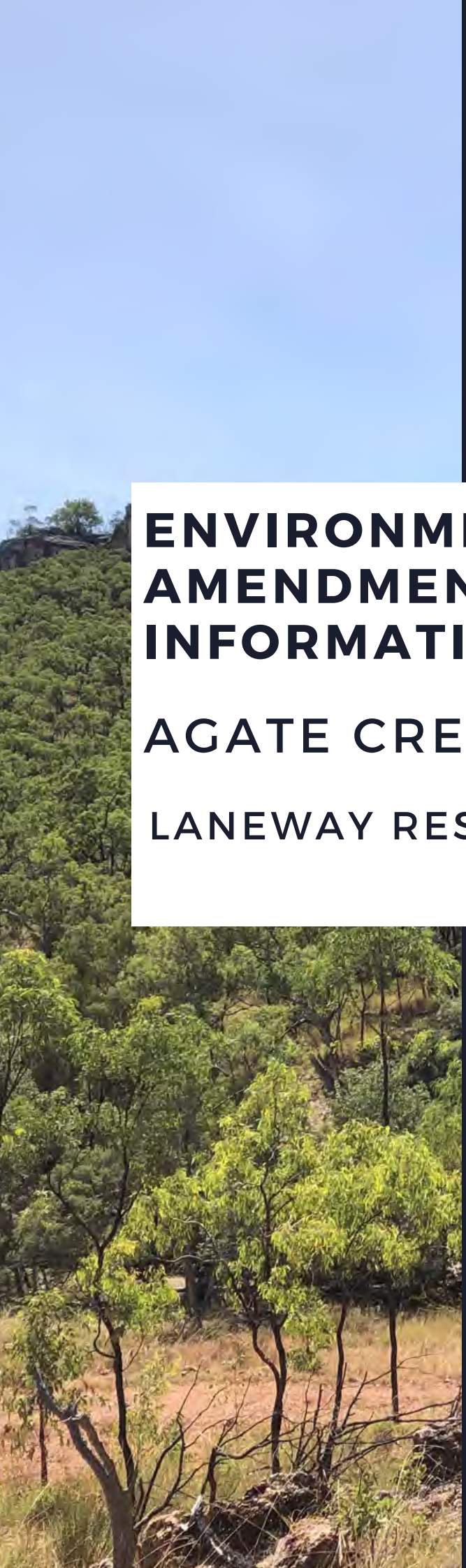

ENVIRONMENTAL AUTHORITY AMENDMENT - SUPPORTING INFORMATION REPORT

AGATE CREEK GOLD MINE

LANEWAY RESOURCES LIMITED

SEPTEMBER 2022

WULGURU TECHNICAL SERVICES

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1. Introduction

The Agate Creek Gold Mine (Agate Creek) is located off Rungulla Road, approximately 40km south-west of Forsayth, north Queensland. Laneway Resources Limited (herein referred to as LWR), commenced operations at Agate Creek during 2019 and consisted of the extraction of gold ore via open cut methods, with ore exported offsite. Operations have been conducted under Environmental Authority (EA) EPSL03068015 and the Eligibility Criteria and Standard Conditions for Mining Lease Activities (ESR/2016/2241).

Wulguru Technical Services Pty Ltd (WTS) were engaged by LWR to prepare this Supporting Information Report for a site-specific Environmental Authority Application (EA), replacing the existing EA (EPSL03068015), allowing the expansion of operations at Agate Creek.

This report is submitted to the Department of Environment and Science (DES) in support of LWR's EA application and provides a detailed response to the following guidelines:

- *Approval processes for Environmental Authorities* (Department of Environment and Science, 2019b, Department of Environment and Science, 2016);
- *Application requirements for activities with impacts to air* (Department of Environment and Science, 2017a);
- *Application requirements for activities with impacts to land* (Department of Environment and Science, 2017b);
- *Application requirements for activities with impacts to water* (Department of Environment and Science, 2017c);
- *Application requirements for activities with noise impacts* (Department of Environment and Science, 2017d); and
- *Application requirements for activities with waste impacts* (Department of Environment and Science, 2019a).

1.1. Purpose

The purpose of this document is to outline the proposed Agate Creek expansion and assess the existing environmental values and potential environmental impacts that may arise. A risk assessment has been completed for the identified potential impacts and reasonable and appropriate mitigation measures are proposed.

1.2. Project Location

Agate Creek is located off Rungulla Road, 40km south-west of Forsayth and is bound by the LWR owned Mine Development License (MDL402). Land covered under MDL402 is used for cattle pasture. Directly west of ML 100030 is the Rungulla Resource Reserve The property details are provided in Table 1.

Table 1. Property Description

Company Name - ABN	Laneway Resources Limited – 75 003 049 714
Lot on Plan	Lot 2 on SP242983 and Lot 7 on SP275179
Mining Lease	ML100030
Property Size	689.3 ha
Local Government Area	Etheridge Shire Council
Zoning Information	Rural

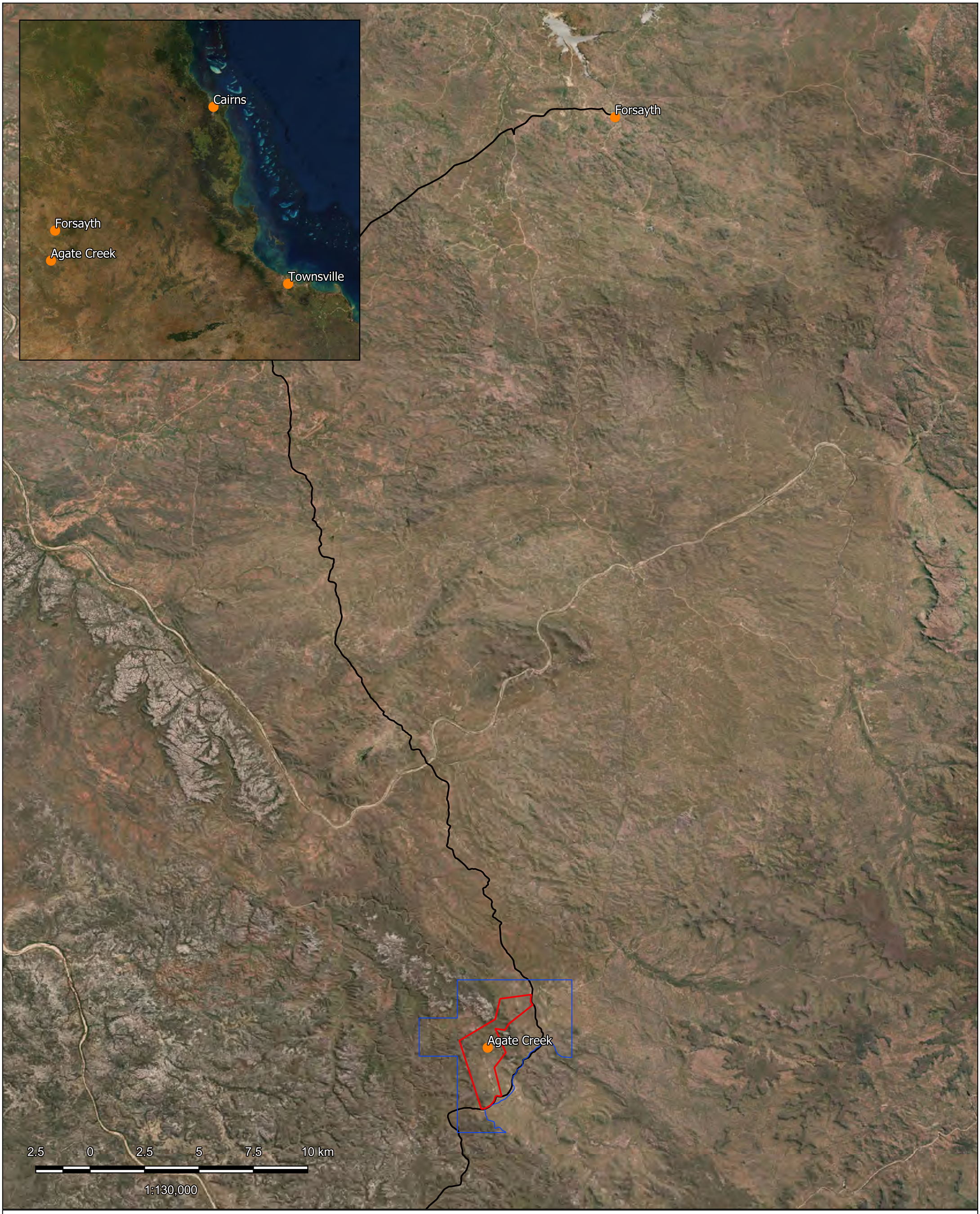

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Figure 1. Agate Creek Gold Project Locality

Legend

- Key Features
- Access Road
- Mineral Development Licence
- Mining Lease

ESRI Satellite

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1.3. Legislative Context

1.3.1. Environmental Protection Act 1994 (Qld)

The *Environmental Protection Act 1994 (Qld)* (EP Act) is Queensland's primary piece of environmental legislation. The object of the EP Act is to 'protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends'.

'Environment' is defined under the Act as (section 8):

- Ecosystems and their constituent parts, including people and communities
- All natural and physical resources
- The qualities and characteristics of locations, places and areas, however large or small, that contribute to their biological diversity and integrity, intrinsic or attributed scientific value or interest, amenity, harmony and sense of community
- The social, economic, aesthetic and cultural conditions that affect, or are affected by, things mentioned in paragraphs (a) to (c).

To ensure the protection of Environmental Values, LWR is required to ensure they meet the requirements of the EP Act and its subordinate legislations.

1.3.2. Mineral Resources Act 1989 (Qld)

The *Mineral Resources Act 1989 (Qld)* (MR Act) provides for the assessment, development, and utilisation of mineral resources. The MR Act establishes a framework to facilitate mining-related activities through the leasing of prospecting, exploration, mineral development, and mining tenure.

Approval is required to mine minerals specified in the lease and for all purposes necessary to effectually carry on the mining as well as purposes other mining specified in the ML and associated with, arising from, or promoting the activity of mining. Mining and production and associated activities including processing and rehabilitation must be conducted within a ML.

1.4. Justification for Project

The Agate Creek expansion is a greenfield and brownfield mine development which will extend the life of Agate Creek. Ore from Agate Creek is to be exported to the Kempton Minerals Pty Ltd owned (a subsidiary of LWR) Georgetown Gold Project (Georgetown). Gold ore transported and processed is critical to the continued operations at both Agate Creek and Georgetown.

The project will create additional local jobs during construction and operation while also prolonging employment opportunities for workers at both Agate Creek and Georgetown. Additionally, LWR will predominately utilise local resources and labour, injecting money into the local communities of the Etheridge Shire.

All resource extraction activities contribute to the state budget via taxes and royalties applied on the mineral resources extracted during the operations and during associated commerce.

1.5. Alternatives to Project

Agate Creek is operated under EA EPSL03068015 which states that operations are to be conducted in accordance with the Standard Conditions of the Code of Environmental Compliance for Mining Lease Projects. Standard Conditions detail that “the mining activity does not, or will not, at any one time, cause more than 10ha of land to be significantly disturbed”. Current operations at Agate Creek are at the 10ha limit. Current target resources of the Sherwood and Sherwood west resource areas (Section 3.3.4.1) are outside current disturbance areas. An expansion to operations is critical for the continuation of mining at Agate Creek, there are no other alternatives to the expansion.

1.6. Consultation with Department of Environment and Science

LWR and WTS attended a pre-lodgement with the Department of Environment and Science (DES) for the recommencement of Georgetown and the expansion of operations at Agate Creek. The meeting provided DES with detail on the upcoming LWR projects and milestones.

On the 29/03/2022, WTS submitted the EA Amendment for the recommencement of operations at Georgetown, processing Agate Ore up to 45,000 tpa. This EA Amendment was approved on 6 May 2022. The submission of the Agate Creek EA application for the expansion of operations is the next milestone for LWR as discussed with DES.

1.6.1. Proposed Environmental Authority Application

The proposed site-specific EA application is to allow for the expansion of mining at Agate Creek to allow the mining of 250,000 tpa of gold ore. The proposed EA will encompass the footprint of ML100030 and supersede EPSL03068015 (standard conditions), replacing it with an EA with site specific conditions.

1.6.2. Environmentally Relevant Activities

Environmentally Relevant activities (ERAs) are defined under the Environmental Protection Act 1994 (EP Act) and regulated under the EA. Proposed ERAs are listed in Table 2.

Table 2. Approved environmentally relevant activities for the Project as listed in EPSL03068015.

ERA Number	Description
Schedule 3 (16)	Mining gold ore
Ancillary 08	Chemical Storage 1 - Storing a total of 50t or more of chemicals of dangerous goods class 1 or class 2, division 2.3 under subsection (1)(a)
Ancillary 33	Crushing, milling, grinding or screening; Crushing, grinding, milling or screening more than 5000t of material in a year

1.6.3. Notifiable Activities

The following notifiable activities are to be associated with the Project:

- **Notifiable Activity 7: Chemical Storage** - storing more than 10 t of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code..
- **Notifiable Activity 24: Mine Wastes** - storing hazardous mine or exploration wastes, including, for example, tailings dams, overburden or waste rock dumps containing hazardous contaminants.

2. Project Description

2.1. Current Operations

Agate Creek activities currently encompass the extraction of gold ore and the storage of waste rock from the Sherwood open cut pit, situated at approximately 2.3 km north of the mine entrance. Mining is conducted via standard truck and shovel techniques at a rate of 45,000t/annum of gold ore. Mined ore is transported to the ROM pad (1km north of the mine entrance). Waste rock is transported to and disposed of the Sherwood Waste Rock Dump (WRD) as required. Ore is loaded onto road trains at the ROM before it is transported to Georgetown for processing. Other current activities include resource exploration and other administrative activities. Current mine domains are displayed on Figure 2.

2.2. General Arrangement of the Proposed Expansion

LWR are proposing to expand current operations across the Sherwood and Sherwood West resource areas (Section 3.3.4.1) under ML100030, extracting up to 250,000 tpa of gold ore across 6 individual open cut pits. The expansion of operations will include the following mine domains:

- Six open cut pits;
- Four Non-Acid Forming (NAF) Waste Rock Dumps (WRDs);
- Topsoil stockpile areas;
- 0.4 Ha expanded Run of Mine;
- Water Storage Dam; and
- Sediment ponds.

Ore is to be transported off site to Georgetown for processing. No processing activities (other than ore crushing for haulage to Georgetown) will occur. Access to Agate Creek is to remain as Rungulla Road/Agate Creek Road /Cobb Road and onto Georgetown via Forsayth Road.

A figure has been proposed in Appendix N, for inclusion in the EA.

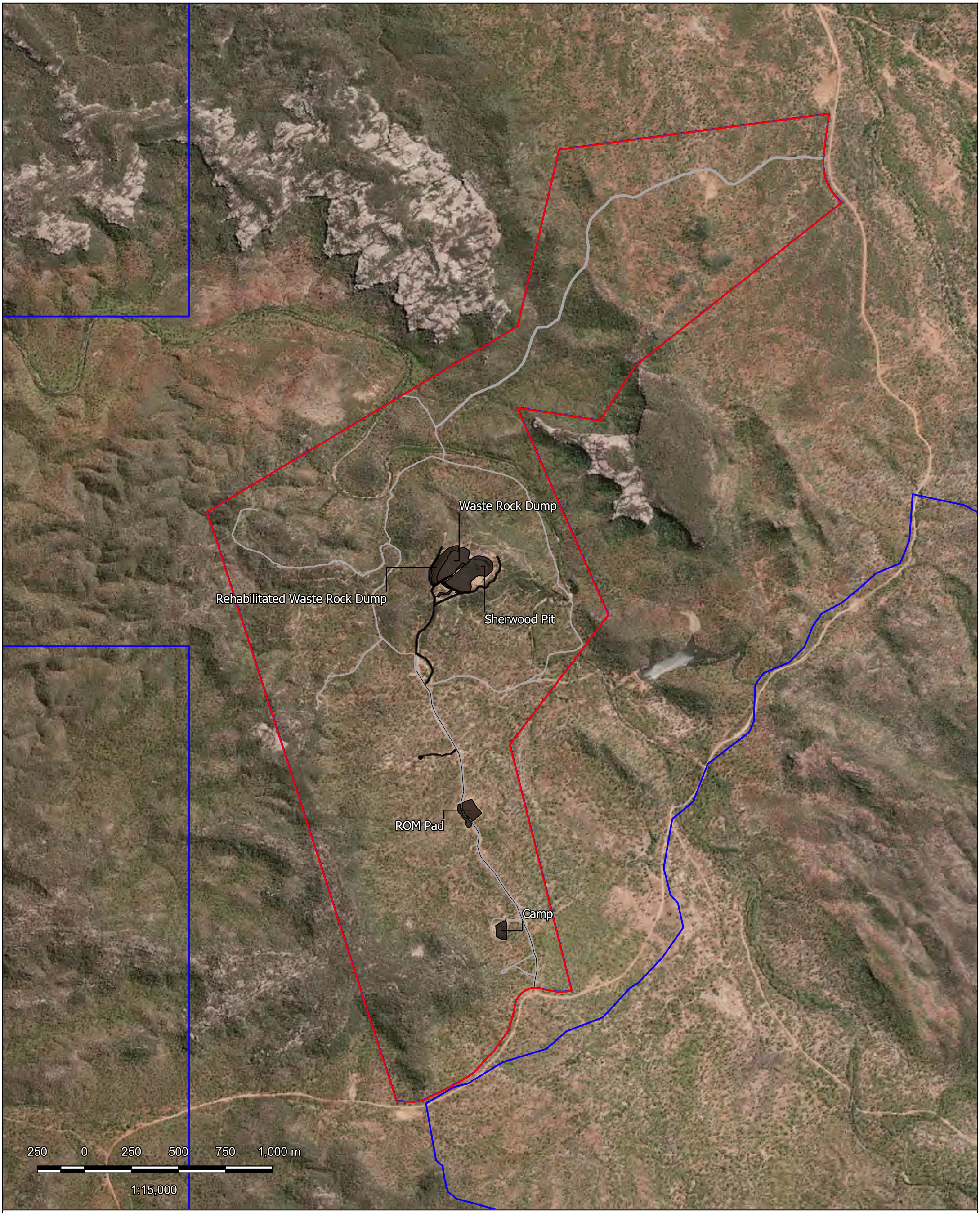

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Figure 2. Current Site Layout

Legend

Mine Tenure
- Mineral Development Licence
- Mining Lease
- Mine Features

Site Roads
- Existing Landholder
- Existing Landholder /Haul Road
- Operational

ESRI Satellite

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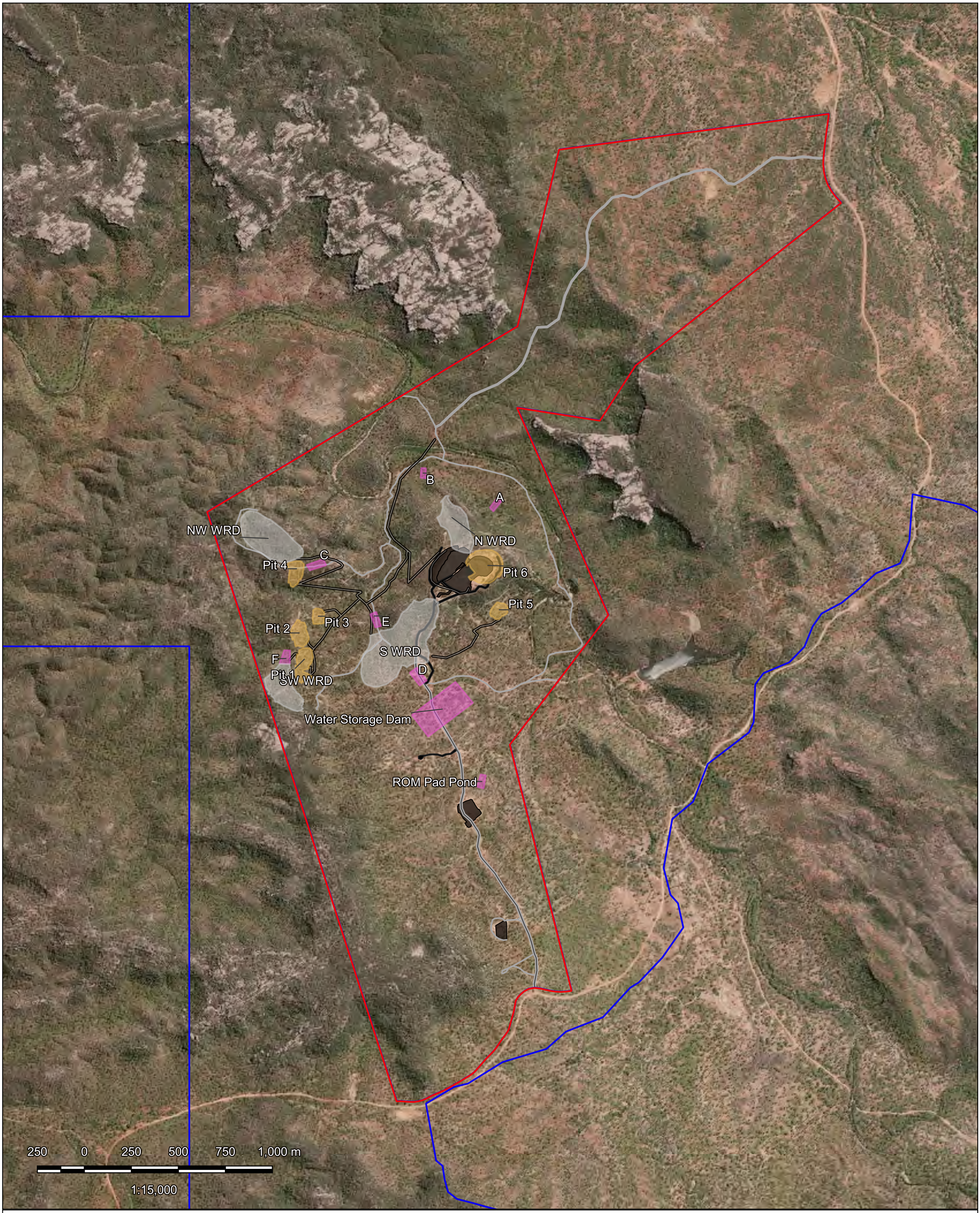

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Figure 3. Proposed Expansion Layout

Legend

- Mineral Development Licence
- Mining Lease
- Existing Mine Features

Site Roads

- Existing Landholder
- Existing Landholder/Haul Road
- Operational

Proposed Mine Features

- Waste Rock Dump
- Pit
- Water Storage and Management
- Haul Road

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2.3. Proposed Activities

2.3.1. Method and Scale of Activities

Mining will consist of an open cut along with associated mine infrastructure. An overview of the mining schedule is presented below in Table 3. Surface footprint of the Project is outlined in Figure 3.

Table 3. Summary of Activities

Year	Activity	Milestone
2022 (Q3-Q4)	• Continue mining existing Sherwood open cut pit. • Begin processing at the Georgetown Processing Plant. • Geological exploration. • Commence construction of the expanded mining domains.	• Gain approval for Agate Creek expansion • Commencement of the expansion project
2022 (Q4) – 2023 (Q1)	• Continued mining of gold ore from Sherwood Open Cut. • Mining Commences in the Sherwood and Sherwood West Pits (1-6).	First production of gold ore from the expansion
2024	Continued mining of gold ore	

2.3.2. Construction

The commencement date for construction is dependent upon the timing of the Project approvals process. However, it is anticipated construction of the open cut, haul roads and associated mine infrastructure is planned to commence in quarter four of 2022 (September-December). Construction activities will include: (but not limited to):

- Vegetation clear and grubbing;
- Topsoil stripping;
- Civil works;
- Construction of infrastructure (upgrade to site access road, construction of new access tracks. Pads, water pipelines and hard stands etc.);
- Expansion to administration buildings;
- Expanded fuel storage facilities;
- Expanded workshop areas; and
- Development of the mining domains in preparation for mining (water management, WRD, open cut pits, ROM etc.).

2.3.3. Site Preparation

Site preparation will commence after acquiring required approvals. Site preparation will concentrate on the initial site clearance works for expansion mine domains.

Site clearance activities will be on an as needed basis to coincide with construction requirements and to minimise the extent and duration of cleared areas being exposed at any one time. Clearing activities will utilise bulldozers or excavators to fell vegetation sequentially prior to being grubbed into manageable stockpiles. Vegetation stockpiles will either be transported directly to the topsoil stockpile areas or mulched and transported to the topsoil stockpile areas. Mulch/vegetation will be retained on site and utilised in future rehabilitation activities.

With vegetation cleared and grubbed, topsoil and subsoil will be stripped from proposed mining domains. Topsoil stripping will be conducted via bulldozers. Soils will be stripped to the depth of the available resource (See Appendix A) and transported to the topsoil stockpile area for future use during rehabilitation. All other unsuitable material (e.g., saline soils, dispersive soils etc.) will be transported to the WRDs. With soils stripped land preparation will cease, and civil works will commence.

2.3.4.Civil Works

Civil works will involve the construction of foundations for Agate Creek mining domains, including (but not limited to):

- Earthworks, including cut and fill as required to form foundations;
- Installation of permanent and temporary water management and Erosion and Sediment Control (ESC) features;
- Trenching and laying of reticulated services and any other underground pipelines and services; and
- Internal and haul road construction, required for access. Construction of the internal roads will be phased over the life of the construction and operations of the mine.

2.3.5. Infrastructure Construction

Infrastructure work will commence with the completion of required civil works. Infrastructure to be constructed are outlined below.

2.3.5.1. Run of Mine

The ROM will be expanded by a total of 0.4 ha facilitating staging of ore for transport to Georgetown.

2.3.5.2. Diversion Drains and Flood Protection Bunds

The drains and bunds will be located strategically around the main areas of activity to separate the clean stormwater from the potentially mine affected water (MAW).

2.3.5.3. Sediment Ponds

Seven sediment ponds are proposed to contain site water (sediment laden runoff) from the WRDs.

2.3.5.4. Water Storage

One water storage will be constructed at Agate Creek south of the southern WRD. The storage has no internally drained catchments, with transfers to be received via pumping from the pit and the sump (as required). The storage will contain water for site demands (e.g., dust suppression).

2.3.5.5. Waste Rock Dumps

Four NAF WRDs will be constructed during construction and operations of Agate Creek, to remove burden overlying the resource. The NAF WRDs are to be located around the Pits 1 - 6 and are to be referred to as the north-west, north, south, and south-west WRDs (Figure 3).

2.3.5.6. Administration

The administration disturbance area will not be expanded. However additional facilities will be provided such as accommodation block, laundries, offices, crib rooms etc.

2.3.5.7. Wash Down Facilities

Heavy vehicle and light vehicle washdown facilities will be located on site. The washdown facilities will comprise:

- Wash pad for washing with handheld high-pressure water cannons;
- Grit traps and oil / water separators; and
- Reticulation of washdown water to an environmental water storage pond.

2.3.5.8. Lighting

Additional lighting will be installed, operated, and maintained in accordance with AS 4282:1997 Control of the Obtrusive Effects of Outdoor Lighting, as required. Controls stipulated in this standard include consideration of the location and orientation of lighting as well as the selection and maintenance of luminaries. Any further mitigation (for example shielding, further restricting the use of lighting) will be implemented on an as needed basis.

2.3.6. Mining Activities

2.3.6.1. Open Cut Mining

The proposed expansion will increase mining of gold ore from 45,000 tpa at the Sherwood Pit, to 250,000 tpa across six open cut pits. Mining will occur in stages, targeting ore with optimal waste to ore strip ratio to increase productivity and minimise upfront waste movement costs.

Standard drill, blast, and truck and shovel methods will be utilised. Key open cut mining activities to be undertaken during the proposed term of the mining lease are:

- Geological exploration;
- Construction of infrastructure and pits;
- Waste excavation;
- Mineral mining;
- Ore transportation; and
- Progressive rehabilitation.

2.3.7. Ore Transport and Processing

Ore from open cut pits 1 - 6 will be transported along internal haul roads to the ROM. Ore will crushed where required and loaded onto road trains by front end loader (or similar) and transported to Georgetown via Rungulla/ Cobb Road. Ore received by Georgetown will be processed via the Georgetown plant. Gold processing is detailed in Figure 4.

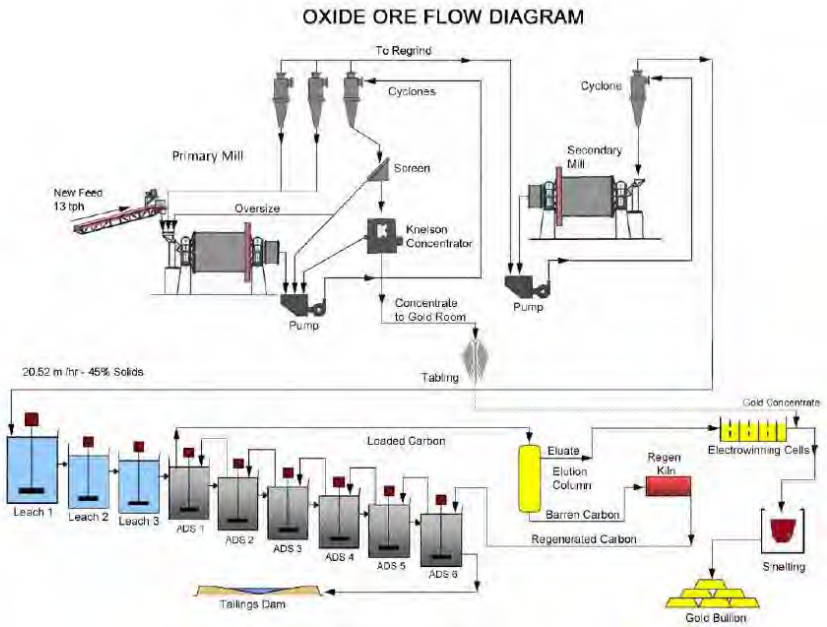

Figure 4. Simplified Schematic of Oxide Gold Extraction

2.4. Native Title

The Ewamian People are the traditional owners of land occupied by the Site, whose country occupies the Gulf of Carpentaria savannah lands in the upper Gilbert and Einasleigh River catchments (Ewamian Aboriginal Corporation, 2021).

All Native Title matters for the Ewamian People are now managed by Ewamian Limited. LWR has successfully negotiated and registered a Cultural Heritage Management Agreement (CHMA) and an Indigenous Land Use Agreement (ILUA)which covers the existing Agate Creek Project area along with any other areas held by LWR and designated as being traditional landholdings of the Ewamian People. LWR maintains a good working relationship with Traditional owners which includes employment opportunities where possible (Laneway Resources Limited, 2021).

Previously, artefacts have been identified within the ML. These artefacts are outside of the proposed disturbance areas. LWR will continue to ensure the artefacts remain safe from mining activities.

2.5. Workforce

2.5.1. Workforce Skills

Workforce skills required will vary depending upon the stage of development. The construction workforce is likely to be mainly contractors and subcontractors appointed to undertake various components of the Project.

Main construction skills required will be:

- Equipment operators and supervisors;
- Tradespeople (for example fabrication, boilermakers, carpenters, plumbers and electricians);
- Designers, surveyors and engineers; and
- Superintendents and managers.

Operation of the open cut mine will require workers in the following categories:

- Open cut mine operators including operators of truck and shovel fleet;
- Tradespeople including diesel fitters, electrical tradespeople and mechanical fitters;
- Technical services and support including: –Geological–Engineering–Health and safety–Environmental services–Laboratory and quality control;
- Machinery operation and maintenance workers;
- Managers and production supervisors; and
- Administrative and support areas such as office staff, catering, cleaning and transportation.

2.6. Progressive Rehabilitation and Closure Plan

The progressive rehabilitation of the Project is to occur for the life of the mine. Progressive rehabilitation will occur when:

- the land is no longer being mined;
- the land is no longer being used for operating infrastructure or machinery for mining including dam or water storage; or
- the land is not needed for mining of a probable or proved ore reserve;

The Agate Creek Progressive Rehabilitation Closure Plan (PRCP) has been prepared. This section of the report outlines the post mining landform, with the PRCP to go into detail into stages the proposed rehabilitation actions for disturbance areas, rehabilitation schedules and designs as well as details on budgets for rehabilitation activities.

2.6.1. Assessment of Post Mining Land Use Options

As part of the assessment of Post Mining Land Use (PMLU) options it is acknowledged that the EP Regulation requires that each PMLU:

1. Is viable having regard to the use of land in the surrounding region, and
2. Satisfies at least one of the following:
    a. The use is consistent with how the land was used before a mining activity was carried out on the land;
    b. The use is consistent with a development approval relating to the land;
    c. The use is consistent with a use of the land, other than a use that is mining, permitted under a State or Commonwealth Act, including, for example, a planning instrument under the Planning Act 2016; and
    d. The use will deliver, or is aimed at delivering, a beneficial environmental outcome.

Grazing on all mine domains, except the WRDs and open cut pits was determined to be the most suitable PMLU for Agate Creek. The WRDs PMLU is to be native habitat meanwhile the open cut pits are to be Non-Use Management Areas (NUMAs). This was determined by considering the environmental, economic, and social benefits of each PMLU.

2.6.2. Description of the Post-mining Land Use

The most suitable PMLU for each RA is shown in Table 4. The PMLUs were determined by considering the environmental, economic, and social benefits of each PMLU. Table *5* further describes how these PMLU's meet the requirements of the EP Regulation.

Table 4 Proposed PMLUs

Table *5*

Table 5. Requirements of a PMLU

Requirement of the PMLU	Justification
The land is safe and structurally stable, and	Final landforms will be designed and certified by suitably qualified persons. After initial rehabilitation, structures will continue to be monitored by suitably qualified persons to assess stability. Erosion monitoring will be conducted to assess stability. The slopes of the project will be made safe to support cattle grazing. Fencing will be constructed to prevent cattle ingress to WRDs. Pits 1-4 will be backfilled with waste rock material and returned to native ecosystem. During rehabilitation, areas may be fenced to prevent cattle grazing until vegetation has established and the landform is unlikely to cause erosion and sedimentation.
There is no environmental harm being caused by anything on or in the land, and	All contaminants will be removed from domains and encapsulated within the WRDs. A contaminated land assessment will be conducted following rehabilitation activities to verify the removal of contaminants. All infrastructure will be removed from site during the demolition phase of rehabilitation. The site will be revegetated to reduce the possibility of erosion. Ongoing surface and groundwater monitoring will be conducted to assess the potential for environmental harm.
The land can sustain a Post Mining Land Use (PMLU).	The proposed PMLUs of low intensity grazing and native ecosystem is consistent with surrounding land uses. Water dams and residual voids (Pits 5 – 6) will remain as water storages, suitable for stock, consistent with the surrounding PMLU.
The PMLU is viable having regard to the use of land in the surrounding region, and	The Etheridge Shire is a significant beef producing region. The proposed PMLU of low intensity cattle grazing is consistent with previous and current land uses in the area. The PMLU of native ecosystem for RA1 and RA3 is consistent with the pre-mining land use of the area. Water dams and residual voids (Pits 5 – 6) will remain as water storages, suitable for stock, consistent with the surrounding proposed PMLU.
The PMLU satisfies at least one of the following: a. the use is consistent with how the land was used before a mining activity was carried out on the land	The proposed PMLUs of low intensity cattle grazing and native ecosystem are consistent with how the land was used before a mining activity was carried out on the land.

Requirement of the PMLU	Justification
b. the use is consistent with a development approval relating to the land – c. the use is consistent with a use of the land, other than a use that is mining, permitted under a State or Commonwealth Act, including, for example, a planning instrument under the Planning Act 2016 d. the use will deliver, or is aimed at delivering, a beneficial environmental outcome.	

2.6.3. Proposed PMLUs

2.6.3.1. RA1 – Open Cut Pits (Pits 1-4)

2.6.3.1.1. Overview

This RA includes Open Cut Pits 1 – 4 and is situated on undulated terrain of the Sherwood and Sherwood West resource areas. RA1 will be backfilled with waste rock and vegetated to a PMLU of native ecosystem.

2.6.3.1.2. Outcome

The proposed post mine land use for the Open Cut Pits post closure is to native ecosystem.

2.6.3.1.3. Environmental Benefit

Pits 1-4 are located on the western boundary of the mining lease. Returning this RA to native ecosystem will provide connectivity to the surrounding environment. Additionally, native ecosystem will have less impact on the rehabilitated landform, ensuring long term stability of the structure.

2.6.3.1.4. Economic Benefit

Native ecosystem will have less impact on the rehabilitated landform, reducing the need for ongoing maintenance of the structure. This will reduce ongoing rehabilitation costs and ensure stability of the landform.

2.6.3.1.5. Social Benefit

The social benefit of re-establishing native ecosystem is the visually amenity and cohesion to the surrounding environment.

2.6.3.2. RA2 – Open Cut Pits (Pits 5-6)

2.6.3.2.1. Overview

This RA includes Open Cut Pits 5 and 6 and is situated on undulated terrain of the Sherwood and Sherwood West resource areas. RA2 will be utilised as water storage on closure and will have fencing installed to prevent cattle/human ingress.

2.6.3.2.2. Outcome

The proposed post mine land use for the Open Cut Pits post closure is to be water storage, which additionally may provide highwall habitat for some native species.

2.6.3.2.3. Environmental Benefit

The mean annual rainfall for the project is approximately 820 mm with most rainfall occurring during January. Long term outlooks predict rainfall to reduce however with an increased likelihood of more intense events across the year. This seasonal rainfall impacts on water security for the surrounding land use of cattle grazing. Landholders largely rely upon small farmers dams as well as groundwater resources to support grazing activities.

The PMLU of water storage will support the surrounding PMLU and provide a more consistent water source, throughout the year. It will also reduce the amount of groundwater accessed by graziers.

With the completion of the open cut pits, there is a potential for the residual void highwalls to be used as highwall habitat for fauna. Particularly, the highwalls and benches of the pit maybe be utilised by birds, bats and potentially macropods who can scale the pit benches. The following species have the potential to use the open cut pit high walls as habitat:

- *Falco cenchroides* (Nankeen Kestrel);
- *Falco peregrinus* (Peregrine Falcon);
- *Chalinolobus gouldii* (Gould's Wattled Bat);
- *Chalinolobus picatus* (Little Pied Bat);
- *Miniopterus orianae oceanensis* (Bentwing Bat);
- *Ozimops lumsdenae* (Northern Free-tailed Bat);
- *Scotorepens greyii/sanborni* (Northern Broad-nosed Bat);
- *Setirostris eleryi* (Hairy-nosed Free-tailed Bat); and
- *Vespadelus troughtoni* (Eastern Cave Bat).

The most likely species to utilise the high wall are the Peregrine Falcon and Nankeen Kestrel. Both species are known to use cliff faces/ highwalls as habitat and have been recorded in the region (Atlas of Living Australia, 2021). The Bentwing Bat, Northern Free-tailed Bat, Northern Broad-nosed Bat, and Eastern Cave Bat were all identified at the Project during the SLR Consulting (2021) Flora and Fauna Survey.

2.6.3.2.4. Economic Benefit

Future landowners of the Project area will likely be pastoralists as per the surrounding land uses. Rehabilitating the open cut pits to water storages will provide an alternative water source, leading to a direct economic benefit to the future landholder.

2.6.3.2.5. Social Benefit

Future landholders will likely be pastoral holdings. Providing a water source suitable for stock would result in a PMLU that is consistent with surrounding land uses.

2.6.3.3. RA3 – Waste Rock Dumps

2.6.3.3.1. Overview

The proposed activities include four WRDs within the ML. On closure, material from the WRDs will be backfilled into Pits 1- 4. Any residual material will be reshaped on the WRD to form a stable landform which reflects the surrounding landscape. The WRDs will be topsoiled, and the landform will be left for vegetation to naturally re-establish.

2.6.3.3.2. Outcome

The proposed PMLU for the RA3 is native ecosystem.

2.6.3.3.3. Landform Design

The preferred PMLU for WRDs native habitat and is to be reflective of the current pre-mining landform characterised by undulated terrain.

To achieve the final landform:

- All material not exported offsite for processing will be disposed of within the WRDs.
- Contaminated material identified in contaminated land assessments will be disposed of within the WRD
- Domains will be shaped to drain similarly to the pre-mining landform;
- Subsoil will be spread where required to assist in achieving a free draining, low gradient landform;
- Topsoil will be spread to a thickness of 0.20cm for vegetation establishment.
- WRDs will be fenced off to prevent cattle ingress.

- Native grasses and groundcover species will be allowed to self-establish. Where self-establishment is not achieved, seeding will occur.

Geometrical Design

The WRDs are designed as a low-profile structure located in valleys. The WRDs require access ramps to allow dumping of waste rock and maintenance access to the structure. Access ramps are located from ridges to limit the road lengths and ramp grades (ATC Williams, 2022).

Any unexpected PAF material will must be encapsulated by NAF material. A NAF base is proposed to be constructed to provide a platform upon which any PAF material can be placed to prevent contaminant migration into the receiving environment (ATC Williams, 2022).

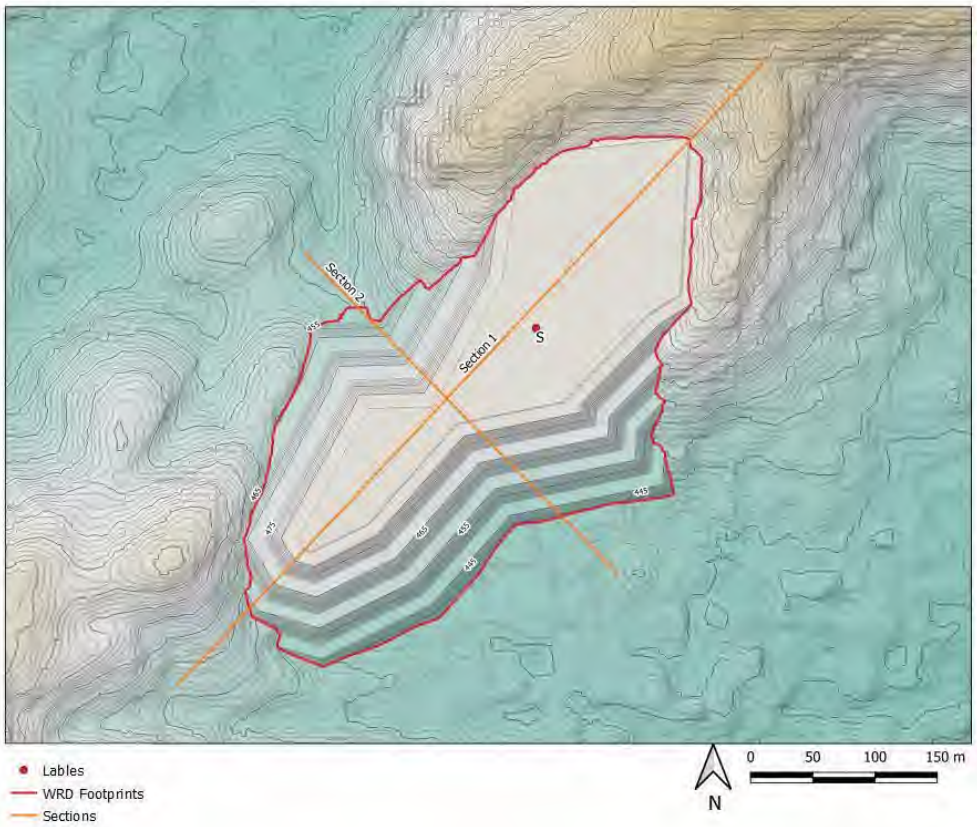

Figure 5. Waste Rock Dump (South) Cross Section Example (ATC Williams, 2022)

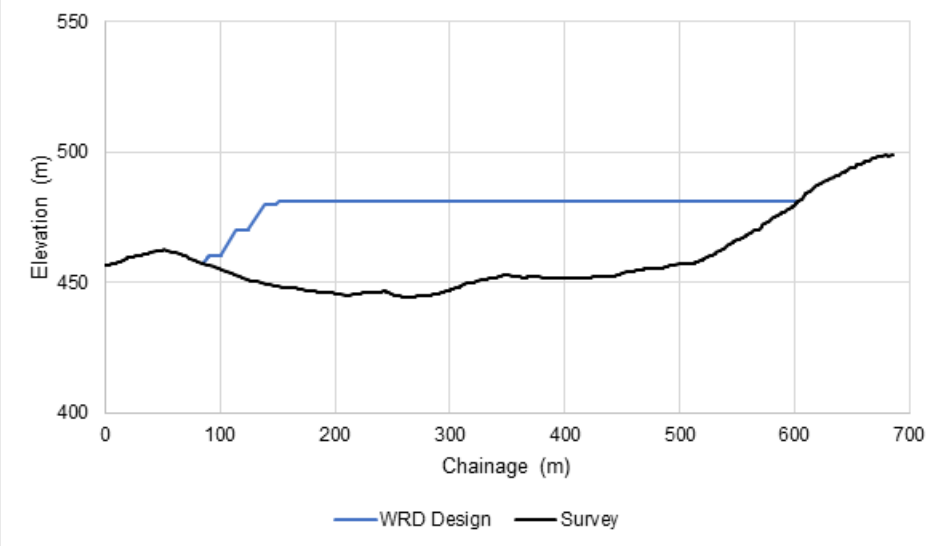

Figure 6. Waste Rock Dump (South) Cross Section 1 (ATC Williams, 2022)

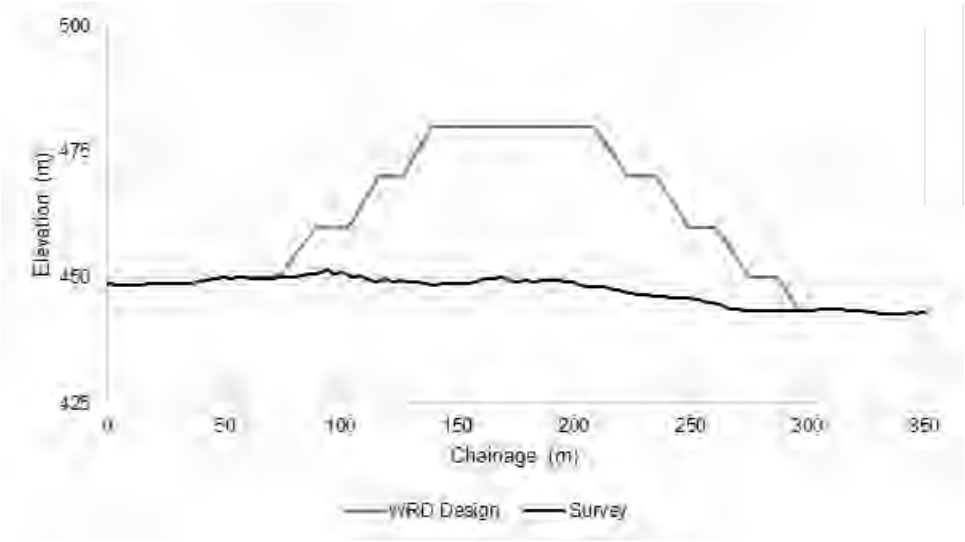

Figure 7. Conceptual WRD Design Cross Section 2

2.6.3.3.4. Environmental Benefit

The pre mining land use includes native vegetation. Establishment of native ecosystem (groundcover) on the WRD as the PMLU is reflective of the current pre-mining land use.

Native vegetation will result in an increase in plant biodiversity and in turn, the habitat for native fauna which would subsequently increase the biodiversity of the region. Native habitat consisted of groundcover species will produce seed and flowers throughout the seasons, which may be utilised by native fauna, therefore helping support local ecosystems Additionally, other than occasional watering during closure, no further activities would be required to form a stable landform.

2.6.3.3.5. Economic Benefit

The WRDs are to be fenced off to prevent cattle ingress, in turn protecting the native groundcover, and to preventing damage to the WRD surface. There is no economic benefit of native habitat on the WRD.

2.6.3.3.6. Social Benefit

The social benefit of re-establishing native ecosystem is the visually amenity and cohesion to the surrounding environment.

2.6.3.4. RA4 - Mine Infrastructure Areas

2.6.3.4.1. Outcome

The proposed post mine land use for RA4 is low intensity grazing. The exception to this is Landholder tracks, which will be retained for future use.

2.6.3.4.2. Landform Design

The preferred PMLU for the rehabilitation areas is to be reflective of the current pre-mining landform characterised by undulating hills, and relatively flat land draining towards Agate Creek.

To achieve the final landform:

- Infrastructure will be decommissioned and removed;
- Sediment dams and the water storage dams will be desilted, with material removed and disposed of in the WRDs;
- Domains will be shaped by plant to drain similarly to the pre-mining landform;
- Subsoil will be spread where required to assist in achieving a free draining, low gradient landform;
- Topsoil will be spread to a thickness of ~20cm for vegetation establishment; and
- Native grasses and groundcover species self-establish. Where self-establishment is not achieved, seeding of the access tracks will occur.

2.6.3.4.3. Environmental Benefit

The establishment of low intensity grazing will provide a good coverage of vegetation, which will minimise the chance of erosion due to runoff. The establishment of pasture on the domains will also limit the amount of fuel load, reducing the impact of potential bushfires.

The pasture covered PMLU may also provide a food source for native fauna. The pasture cover will produce seed and flowers throughout the seasons, which may be utilised by native fauna, therefore helping support local ecosystems.

Additionally, other than occasional watering during closure, no further activities would be required to form a stable landform consistent with grazing.

2.6.3.4.4. Economic Benefit

Establishing grazing pastures will result in a lower cost of direct seeding and a quicker establishment of adequate vegetation cover, potentially leading to an earlier relinquishment of Mine Leases. Additionally, the future landowners of the expansion area will likely be pastoralists as per the surrounding land uses. Low-intensity grazing will result in an increase in the weight of stock, leading to a direct increase in the economic benefit to the future landholder.

Additionally, other than occasional watering during closure, no further activities would be required to form a stable landform consistent with grazing.

2.6.3.4.5. Social Benefit

Future landholders will likely be pastoral holdings. Returning the land to grazing pastures will be preferential as this would result in a PMLU that is consistent with surrounding land uses.

2.6.3.5. RA5 - Water Storage

A Landholder agreement is in place with Howlong Station to retain water management structures for water storage. A copy of the agreement is provided in Appendix D. Water quality monitoring

throughout operations will determine if treatment or removal of water and sediment is required. The structures will be made safe and non-polluting for being given to the landholder.

2.6.3.5.1. Outcome

The proposed PMLU for the RA5 is water storage.

2.6.3.5.2. Environmental Benefits

Similar to RA2, the PMLU of water storage will support the surrounding PMLU and provide a more consistent water source, throughout the year. It will also reduce the amount of groundwater accessed for grazing activities.

2.6.3.5.3. Economic Benefit

Future landowners of the Project area will likely be pastoralists as per the surrounding land uses. Provide an additional water source, will lead to a direct economic benefit to the future landholder.

2.6.3.5.4. Social Benefit

Future landholders will likely be pastoral holdings. Providing a water source suitable for stock would result in a PMLU that is consistent with surrounding land uses.

2.6.3.6. RA6 - Exploration

Exploration disturbance is rehabilitated, within 12 months of disturbance activities, in accordance with the Code of Environmental Compliance for Exploration and Mineral Development.

2.6.3.6.1. Outcome

The proposed PMLU for the RA6 is low intensity grazing.

2.6.3.6.2. Environmental Benefits

The establishment of low intensity grazing will provide a coverage of vegetation, which will minimise the chance of erosion as a result of runoff. The establishment of pasture on the domains will also limit the amount of fuel load, reducing the impact of potential bushfires.

The pasture covered PMLU may provide a food source for native fauna. The pasture cover will produce seed and flowers throughout the seasons, which may be utilised by native fauna, therefore helping support local ecosystems.

Additionally, other than occasional watering during closure, no further activities would be required to form a stable landform consistent with grazing.

2.6.3.6.3. Economic Benefit

Establishing grazing pastures will result in a lower cost of direct seeding and a quicker establishment of adequate vegetation cover, potentially leading to an earlier relinquishment of Mine Leases.

Future landowners of the Agate Creek will likely be pastoralists as per the surrounding land uses. Rehabilitating to low-intensity grazing will provide an additional grazing area, leading to a direct increase in the economic benefit to the future landholder.

Additionally, other than occasional watering during closure, no further activities would be required to form a stable landform consistent with grazing.

2.6.3.6.4. Social Benefit

Future landholders will likely be pastoral holdings. Returning the land to grazing pastures will result in a PMLU that is consistent with surrounding land uses.

2.6.4. Rehabilitation Areas and Milestones

Project activities are grouped in the PRCP by Rehabilitation Areas (RAs), defined under the Progressive Rehabilitation and Closure Plans guideline as “an area of land in the PMLU to which a rehabilitation milestone for the post-mining use relates”. Each RA will have assigned Rehabilitation Milestones (RMs) defined as each significant event or step necessary to rehabilitate the land to a stable condition (Department of Environment and Science, 2021).

The RAs and RMs for the Agate Creek Gold Mine are detailed in Table 6.

Table 6. Rehabilitation Areas and Rehabilitation Milestones

Rehabilitation Area		Rehabilitation Milestone	
RA1	Open cut pits 1 - 4	RM1	Infrastructure decommissioning and removal
RA2	Open cut pits 5 - 6	RM2	Remediation of contaminated land
RA3	Waste Rock Dumps	RM3	Landform development and reshaping (RA1)
RA4	Mine Infrastructure Area	RM4	Landform development and reshaping (RA2)
RA5	Water Storages	RM5	Landform development and reshaping (RA3)
RA6	Exploration	RM6	Landform development and reshaping (RA4)
		RM7	Landform development and reshaping (RA5)
		RM8	Surface preparation
		RM9	Revegetation (native ecosystem)
		RM10	Revegetation (grazing)
		RM11	Achievement of surface requirements (native ecosystem)
		RM12	Achievement of surface requirements (grazing)
		RM13	Achievement of post-mining land use to a stable condition (native ecosystem)
		RM14	Achievement of post-mining land use to a stable condition (grazing)
		RM15	Achievement of post-mining land use to a stable condition (water storage)

400 0 400 800 1,200 1,600 m

1:25,000

Client: Laneway Resources Ltd
Project number: 2021.09001
CRS: GDA2020 EPSG: 7844
Date: 11 October 2022

Print as A3

Figure 8. Rehabilitation Areas

Legend

Mine Tenure
- MDL
- Mining Lease

ESRI Satellite

Rehabilitation Areas
- RA1
- RA2
- RA3
- RA4
- RA5
- RA6

Post Mine Land Use
- Low intensity Grazing
- Native Ecosystem
- Recreation
- Water Storage

Disclaimer:
Whilst every effort and care has been taken to ensure the accuracy of this report, Wulguru Technical Services Pty Ltd makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or inconsequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.
Digital data for this report is available on the Queensland Government Spatial Portal at https://qldspatial.information.qld.gov.au.

WULGURU TECHNICAL SERVICES

2.6.5. Summary of Key Rehabilitation and Management Practices

Table 7 details the key rehabilitation activities for each relevant activity. The rehabilitation activities drive achievement of the rehabilitation and management milestones and inform the associated PRCP schedule.

Table 7. Key Rehabilitation Activities to Drive Achieve Rehabilitation Milestones

Rehabilitation Area	Relevant Activities	Rehabilitation Activities	Rehabilitation Timing	Rehabilitation Milestones
RA1	Open cut pits 1-4	• Pits will be backfilled with waste rock and suitably compacted • The surface will be shaped to ensure a safe, stable landform. • Landform will be topsoiled and ripped to promote vegetation growth. • Landforms will be seeded with species relevant to the regional ecosystem. • Domain to be monitored for rehabilitation success.	• The timing of rehabilitation will depend on any probable or proved ore reserve remaining within the pit on closure. • Approximately 2035	RM3 RM9 RM11 RM13
RA2	Open cut pits 5-6	• Pits are to be stabilised by securing the highwalls to ensure a safe, stable landform. • Once deemed stable, a bund and fencing will be erected around the open cut to prevent ingress. • Monitor water quality to assess whether the PMLU has been achieved.	• The timing of rehabilitation will depend on any probable or proved ore reserve remaining within the pit on closure. • Approximately 2035	RM4 RM15
RA3	Waste Rock Dumps Topsoil dump	• Undertake assessment for contaminated land and remediate if required. • Remove contaminated material and dispose of in WRD. • Spread remaining over the WRD areas. • Shape landform to be free draining and of similar shape to the surrounding topography. • Spread topsoil on landform to a minimum thickness of 20cm.	• Waste rock will be removed from dumps to backfill the pit. The timing of rehabilitation will depend on any probable or proved ore reserve remaining within the pit on closure. • Topsoil stockpiles will be utilised in rehabilitation of other RAs. The footprint will be available all topsoil resources have been exhausted. • Approximately 2035	RM5 RM8 RM9 RM11 RM13

Rehabilitation Area	Relevant Activities	Rehabilitation Activities	Rehabilitation Timing	Rehabilitation Milestones
		• Conduct analysis on spread topsoil to determine whether topsoil is suitable to achieve the PMLU, or whether ameliorants/ fertiliser is required. • Where required, apply ameliorants/ fertiliser. • Rip landform parallel to landform contours. • Apply selected pasture seed mix to landform. • Monitor to assess rehabilitation success and whether the PMLU has been achieved.		
RA4	ROM ROM Stockpiles	• Undertake assessment for contaminated land and remediate if required. • Remove contaminated material and dispose of offsite (if required). • Shape landform as per Figure 7. • Spread topsoil on landform to a minimum thickness of 20cm. • Conduct analysis on spread topsoil to determine whether topsoil is suitable to achieve the PMLU, or whether ameliorants/ fertiliser is required. • Where required, apply ameliorants/ fertiliser. • Rip landform parallel to landform contours. • Apply selected pasture seed mix to landform. • Monitor to assess rehabilitation success and whether the PMLU has been achieved	• Area will be available for rehabilitation with the completion of mining in 2025 • Landform establishment by 2027 • Seeding to be completed by end 2032	RM1 RM2 RM6 RM8 RM10 RM12 RM14
	Access roads and tracks Mine haul road	• Undertake assessment for contaminated land and remediate if required.	• Ore may be processed after mining has been completed. Area will be	RM1 RM2 RM6

Rehabilitation Area	Relevant Activities	Rehabilitation Activities	Rehabilitation Timing	Rehabilitation Milestones
	Laydown yards Camps/administration	• Remove contaminated material and dispose of offsite (if required). • Decommission any remnant infrastructure and remove/dispose of. • Shape landform to be free draining and of similar shape to the surrounding topography. • Spread topsoil on landform to a minimum thickness of 20cm. • Conduct analysis on spread topsoil to determine whether topsoil is suitable to achieve the PMLU, or whether ameliorants/ fertiliser is required. • Where required, apply ameliorants/ fertiliser. • Rip landform parallel to landform contours. • Apply selected pasture seed mix to landform. • Monitor to assess rehabilitation success and whether the PMLU has been achieved.	available for rehabilitation once processing has been complete. • Landform establishment by 2027. • Seeding to be completed by end 2032. • Access tracks account for 0.2 Ha of RA3. Access tracks are required for the PMLU and therefore, not included in this PRCP schedule. • 7.28 ha of tracks will be retained under a landholder agreement. Remaining tracks and haul roads will commence rehabilitation in 2026.	RM8 RM10 RM12 RM14
RA5	Water storage dam Sediment Ponds	• Decommission any remnant infrastructure from mining. • Undertake assessment for contaminated land and remediate if required. • Remove contaminated material and dispose of offsite (if required). • Monitor water quality to assess whether the PMLU has been achieved.	• Required as a water supply for rehabilitation of other mining domains.	RM1 RM2 RM7 RM15

Rehabilitation Area	Relevant Activities	Rehabilitation Activities	Rehabilitation Timing	Rehabilitation Milestones

RA6	Exploration Drill Pads and Tracks	• Decommission drill holes (if required):
		  ○ Seal drill holes by an appropriately qualified person
		  ○ Cut collar below ground level
		• Decommission drill pads, removing infrastructure and rubbish.
		• Undertake assessment for contaminated land and remediate if required. Contaminated material to be disposed of offsite (if required).
		• Shape landform to be free draining and of similar shape to the surrounding topography.
		• Spread topsoil on landform to a minimum thickness of 200mm.
		• Conduct analysis on spread topsoil to determine whether topsoil is suitable to achieve the PMLU, or whether ameliorants/ fertiliser is required.
		• Where required, apply ameliorants/ fertiliser.
		• Rip landform parallel to landform contours.
		• Apply selected pasture seed mix to landform.
		• Monitor to assess rehabilitation success and whether the PMLU has been achieved.
			• Exploration pads and tracks available for remediation with the completion of exploration.
			• Landform establishment to occur in 2026.
			• Seeding to be completed by end 2026.
				RM1
				RM2
				RM8
				RM10
				RM12
				RM14

3. Existing Environment

3.1. Climate

Agate Creek is located in the dry tropics' region and experiences hotter and wetter periods during the summer months (wet season) and drier, cooler periods during the winter months (dry season). LWR operates a weather station at the Agate Creek camp (Lat. -19.0127, Lon. 143.5500).

The highest temperature for 2021 was recorded in October (37.1°C) whilst the highest monthly average temperature was recorded in December (29.1°C). The minimum temperature recorded in 2021 was recorded in July (15.1°C) with the minimum average temperature recorded in June (21°C). A total of 1212.1 mm of rainfall was recorded at the Agate Creek Camp station in 2021 (Weatherlink 2022). A summary of the 2021 climate summaries is provided in Figure 9.

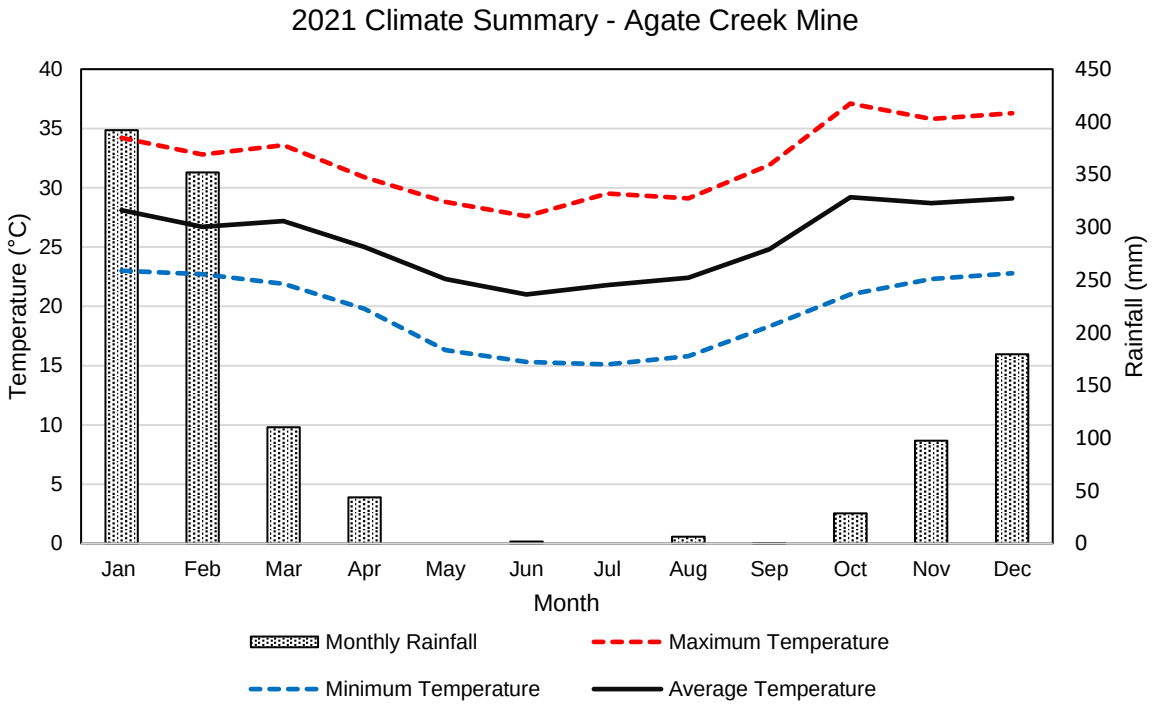

Figure 9. Monthly Rainfall and Maximum and Minimum Temperatures (Weatherlink, 2022).

3.2. Topography and Hydrology

The topography of Agate Creek includes steep sandstone scarps and formations to the west and steeply undulating hills to gently undulating terrain on the ML. The Project is between 420 m and 550 m Australian Height Datum (AHD) (Queensland Government, 2021). There are ephemeral watercourses (unnamed 1st and 2nd order creeks) that flow across the Project. Most surface water eventually flows into Agate Creek, a 4th order stream that flows approximately south-east to north-west though the central part of the ML as shown in Figure 10.

3.3. Waters

3.3.1. Surface Water

3.3.1.1. Environmental Values

The Environmental Protection Policy (Water and Wetland Biodiversity) (EPP Water) details the water quality basins and their specific management intent. The Agate Creek is situated in the Gilbert Drainage Basin (Basin no. 917), which is not included in the EPP Water. Environmental values and water quality objectives have not been formally documented for the Gilbert River Basin, therefore ANZECC Guidelines are applicable. Based on the location and surrounding land use, the environmental values associated with the Gilbert River Basin are:

- **Aquatic ecosystems:** The intrinsic value of aquatic ecosystems, habitat and wildlife in waterways and riparian areas, for example, biodiversity, ecological interactions, plants, animals, key species (such as turtles, platypus, seagrass and dugongs) and their habitat, food and drinking water. Waterways include perennial and intermittent surface waters, groundwaters, tidal and non-tidal waters, lakes, storages, reservoirs, dams, wetlands, swamps, marshes lagoons, canals, natural and artificial channels and the bed and banks of waterways.
- **Farm water supply/use** : Suitability of domestic farm water supply, other than drinking water. For example, water used for laundry and produce preparation.
- **Stock watering**: Suitability of water supply for production of healthy livestock.
- **Primary recreation:** Health of humans during recreation which involves direct contact and a high probability of water being swallowed, for example, swimming, surfing, windsurfing, diving and water-skiing. Primary recreational use, of water, means full body contact with the water, including, for example, diving, swimming, surfing, waterskiing and windsurfing.
- **Secondary recreation**: Health of humans during recreation which involves indirect contact and a low probability of water being swallowed, for example, wading, boating, rowing and fishing. Secondary recreational use, of water, means contact other than full body contact with the water, including, for example, boating and fishing.

- **Visual recreation**: Amenity of waterways for recreation which does not involve any contact with water—for example, walking and picnicking adjacent to a waterway. Visual recreational use, of a water, means viewing the water without contact with it.
- **Drinking water supply:** Suitability of raw drinking water supply. This assumes minimal treatment of water is required, for example, coarse screening and/or disinfection
- **Industrial use**: Suitability of water supply for industrial use, for example, food, beverage, paper, petroleum and power industries, mining and minerals refining/processing. Industries usually treat water supplies to meet their needs.
- **Cultural and spiritual values:** Indigenous and non-indigenous cultural heritage, for example:
    - custodial, spiritual, cultural and traditional heritage, hunting, gathering and ritual responsibilities
    - symbols, landmarks and icons (such as waterways, turtles and frogs)
    - lifestyles (such as agriculture and fishing).

3.3.2. Existing Surface Water Monitoring

Surface water monitoring has been conducted by LWR regularly. A summary of results from November 2020 to January 2022 is provided in Table 8.

Table 8. Surface Water Monitoring January 2021 to January 2022.

Parameters						Dissolved Major Cations				Total Metals															
Site ID	pH	EC	TDS	Sulfate	Chloride	Calcium	Mg	Na	K	Al	As	Cd	Cr	Co	Cu	Pb	Mn	Mo	Ni	Se	Zn	B	Fe	Total Mercury	Fluoride
SWA01	**Number of records: 9**																								
Maximum	8.04	334	217	2	21	30	9	30	5	2.21	0.004	0.000	0.001	0.001	0.001	0.001	0.413	0.002	0.002	0.005	0.01	0.025	1.3	0.000	1.8
Minimum	7.13	115	75	0.5	4	8	2	10	3	0.03	0.001	0.000	0.001	0.001	0.001	0.001	0.022	0.001	0.001	0.005	0.0025	0.025	0.18	0.000	0.4
Mean	7.639	187	121.571	1.222	7.667	15.444	4.889	16.111	3.333	0.391	0.002	0.000	0.001	0.001	0.001	0.001	0.146	0.002	0.001	0.005	0.005	0.025	0.573	0.000	1.171
Median	7.63	203	132	1	6	14	5	13	3	0.22	0.002	0.000	0.001	0.001	0.001	0.001	0.106	0.002	0.001	0.005	0.0025	0.025	0.38	0.000	1
SWA02	**Number of records: 6**																								
Maximum	8.37	304	198	3	8	37	12	15	4	0.62	0.002	0.000	0.001	0.001	0.001	0.001	0.196	0.002	0.001	0.005	0.008	0.025	0.66	0.000	0.9
Minimum	7.34	159	103	0.5	5	15	4	11	3	0.01	0.001	0.000	0.001	0.001	0.001	0.001	0.017	0.0005	0.001	0.005	0.003	0.025	0.05	0.000	0.4
Mean	7.782	225.333	146.333	1.417	6	24.667	7.667	12.667	3.833	0.192	0.001	0.000	0.001	0.001	0.001	0.001	0.066	0.001	0.001	0.005	0.004	0.025	0.232	0.000	0.683
Median	7.77	225.5	146.5	0.75	5.5	23	7	12	4	0.075	0.001	0.000	0.001	0.001	0.001	0.001	0.052	0.001	0.001	0.005	0.003	0.025	0.09	0.000	0.75
SWA04	**Number of records: 2**																								
Maximum	6.87	83	54	3	8	3	5	7	2	1.4	0.002	0.000	0.001	0.001	0.004	0.001	0.053	0.001	0.002	0.005	0.003	0.025	1.39	0.000	0.3
Minimum	6.71	53	34	2	4	2	2	5	2	0.11	0.001	0.000	0.001	0.001	0.002	0.001	0.01	0.001	0.001	0.005	0.003	0.025	0.28	0.000	0.3
Mean	6.79	68	44	2.5	6	2.5	3.5	6	2	0.755	0.001	0.000	0.001	0.001	0.003	0.001	0.032	0.001	0.001	0.005	0.003	0.025	0.835	0.000	0.3
Median	6.79	68	44	2.5	6	2.5	3.5	6	2	0.755	0.001	0.000	0.001	0.001	0.003	0.001	0.032	0.001	0.001	0.005	0.003	0.025	0.835	0.000	0.3
SWA05	**Number of records: 4**																								
Maximum	9.39	210	136	1	7	22	7	14	4	2.1	0.001	0.000	0.001	0.001	0.001	0.002	0.016	0.001	0.002	0.005	0.006	0.025	1.37	0.000	0.7
Minimum	7.48	130	84	0.5	4	12	4	9	4	0.07	0.001	0.000	0.001	0.001	0.001	0.001	0.006	0.001	0.0005	0.005	0.003	0.025	0.08	0.000	0.4
Mean	8.345	175.75	114	0.75	5.5	17.5	5.5	12	4	0.608	0.001	0.000	0.001	0.001	0.001	0.001	0.009	0.001	0.001	0.005	0.003	0.025	0.517	0.000	0.55
Median	8.255	181.5	118	0.75	5.5	18	5.5	12.5	4	0.13	0.001	0.000	0.001	0.001	0.0005	0.0005	0.007	0.001	0.0005	0.005	0.003	0.025	0.1	0.000	0.55
SWA06	**Number of records: 2**																								
Maximum	6.98	147	96	8	9	7	10	8	3	0.45	0.001	0.000	0.001	0.001	0.003	0.001	0.054	0.001	0.001	0.005	0.003	0.025	0.37	0.000	0.7
Minimum	6.76	115	75	7	4	5	6	6	3	0.03	0.001	0.000	0.001	0.001	0.001	0.001	0.014	0.001	0.001	0.005	0.003	0.025	0.07	0.000	0.6
Mean	6.87	131	85.5	7.5	6.5	6	8	7	3	0.24	0.001	0.000	0.001	0.001	0.002	0.001	0.034	0.001	0.001	0.005	0.003	0.025	0.22	0.000	0.65
Median	6.87	131	85.5	7.5	6.5	6	8	7	3	0.24	0.001	0.000	0.001	0.001	0.002	0.001	0.034	0.001	0.001	0.005	0.003	0.025	0.22	0.000	0.65
SWA07	**Number of records: 2**																								
Maximum	6.39	119	77	2	23	2	2	16	4	4.23	0.004	0.000	0.002	0.002	0.004	0.004	0.065	0.001	0.003	0.005	0.014	0.025	3.66	0.000	0.2
Minimum	5.57	96	62	2	20	1	2	13	3	0.45	0.001	0.000	0.001	0.001	0.001	0.001	0.016	0.001	0.001	0.005	0.003	0.025	0.4	0.000	0.2
Mean	5.98	107.5	69.5	2	21.5	1.5	2	14.5	3.5	2.34	0.002	0.000	0.001	0.001	0.003	0.002	0.041	0.001	0.002	0.005	0.008	0.025	2.03	0.000	0.2
Median	5.98	107.5	69.5	2	21.5	1.5	2	14.5	3.5	2.34	0.002	0.000	0.001	0.001	0.003	0.002	0.041	0.001	0.002	0.005	0.008	0.025	2.03	0.000	0.2
SWA08	**Number of records: 2**																								
Maximum	7.17	138	90	5	13	9	6	10	4	2.68	0.002	0.000	0.001	0.001	0.002	0.002	0.013	0.001	0.002	0.005	0.008	0.025	2.22	0.000	0.3
Minimum	6.72	102	66	5	9	5	3	8	4	0.31	0.001	0.000	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.003	0.025	0.13	0.000	0.2
Mean	7.17	138	90	5	13	9	6	10	4	0.31	0.001	0.000	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.003	0.025	0.13	0.000	0.2
Median	6.945	120	78	5	11	7	4.5	9	4	1.495	0.001	0.000	0.001	0.001	0.001	0.001	0.012	0.001	0.001	0.005	0.005	0.025	1.175	0.000	0.25
SWA09	**Number of records: 1**																								
Maximum	7.87	238	155	2	8	24	5	21	3	0.22	0.0005	0.00005	0.0005	0.0005	0.001	0.0005	0.004	0.0005	0.0005	0.005	0.0025	0.025	0.12	0.00005	0.3
Minimum	7.87	238	155	2	8	24	5	21	3	0.22	0.0005	0.00005	0.0005	0.0005	0.001	0.0005	0.004	0.0005	0.0005	0.005	0.0025	0.025	0.12	0.00005	0.3
Mean	7.87	238	155	2	8	24	5	21	3	0.22	0.0005	0.00005	0.0005	0.0005	0.001	0.0005	0.004	0.0005	0.0005	0.005	0.0025	0.025	0.12	0.00005	0.3
Median	7.87	238	155	2	8	24	5	21	3	0.22	0.0005	0.00005	0.0005	0.0005	0.001	0.0005	0.004	0.0005	0.0005	0.005	0.0025	0.025	0.12	0.00005	0.3

3.3.3. Groundwater

3.3.3.1. Environmental Values

There are currently no Environmental Values provided in guidelines relating to the Gilbert Drainage Basin. The most relevant environmental values were derived from the EPP (Water and Wetland Biodiversity) 2019 which include:

- For waters that may be used for agricultural purposes – the suitability of the water for agricultural purposes
- For waters that may be used for recreation or aesthetic purposes – the suitability of water for -
    - Primary recreational use; or
    - Secondary recreational use; or
    - Visual recreational use
- For water that may be used for drinking water – the suitability of the water for supply as drinking water having regard to the level of treatment of the water
- For waters that may be used for industrial purposes – the suitability of the water for industrial use
- The cultural and spiritual values of the water.

3.3.3.2. Background Groundwater Monitoring

Ten groundwater bores were monitored over 13 monitoring events at Agate Creek. Summaries of monitoring results is provided in Table 9.

It is noted that additional bores have been established at Agate Creek during 2021. These bores will be incorporated into the groundwater monitoring network. Newly constructed bore information is provided in Section 4.4.9

Table 9. Summary of Groundwater Monitoring

	pH Value	EC	Total Dissolved Solids	Sulfate	Aluminium	Arsenic	Cadmium	Chromium	Cobalt	Copper	Lead	Manganese	Molybdenum	Nickel	Selenium	Zinc	Boron	Iron	Mercury	Fluoride
Units	pH Units	µS/cm									mg/L									
CCWB517																				
Min	7.58	2110	1370	16	0.04	0.002	0.00005	0.0005	0.0005	0.0005	0.0005	0.09	0.002	0.0005	0.0025	0.0025	0.22	0.08	0.00005	4.4
Max	8.18	2710	1760	28	3.28	0.004	0.0004	0.002	0.002	0.004	0.002	0.721	0.027	0.002	0.005	0.07	0.44	3.37	0.00005	7.9
Mean	7.96	2376.15	1544.62	22.23	0.51	0.002538	0.0001	0.000654	0.000958	0.001115	0.000615	0.446833	0.010083	0.000962	0.004808	0.018167	0.315	0.575833	0.00005	6.24
Median	8.01	2400	1560	23	0.11	0.002	0.00005	0.0005	0.0005	0.0005	0.0005	0.469	0.0055	0.0005	0.005	0.013	0.31	0.145	0.00005	6.7
CCWB518																				
Min	7.16	556	361	78	0.04	0.024	0.00005	0.0005	0.0005	0.0005	0.0005	0.042	0.004	0.008	0.005	0.014	0.14	0.025	0.00005	2.6
Max	7.84	827	538	147	0.48	0.047	0.0002	0.0005	0.0005	0.005	0.001	0.322	0.019	0.025	0.005	0.038	0.21	0.38	0.00005	3.3
Mean	7.56	687.46	446.77	105.31	0.15333	0.03654	0.00016	0.00050	0.00050	0.00200	0.00058	0.12692	0.00933	0.01577	0.00500	0.02446	0.17333	0.0900	0.00005	2.91
Median	7.61	680	442	100	0.075	0.035	0.0002	0.0005	0.0005	0.002	0.0005	0.092	0.0075	0.016	0.005	0.024	0.17	0.065	0.00005	2.9
CCWB519																				
Min	6.42	130	84	10	0.82	0.002	0.00005	0.001	0.006	0.002	0.0005	0.723	0.001	0.01	0.005	0.056	0.025	1.01	0.00005	0.2
Max	6.88	154	100	13	26.3	0.006	0.0001	0.035	0.022	0.018	0.011	1.18	0.004	0.062	0.005	0.385	0.025	40.9	0.00005	0.3
Mean	6.63	142.56	92.67	11	6.52	0.002888889	0.00006	0.008222222	0.009375	0.005888889	0.002666667	0.8465	0.001875	0.02	0.005	0.118111111	0.025	9.64	0.00005	0.27
Median	6.64	143	93	11	2.865	0.002	0.00005	0.004	0.0075	0.004	0.001	0.77	0.002	0.013	0.005	0.075	0.025	3.66	0.00005	0.3
CCWB520																				
Min	7.68	634	412	46	0.41	0.01	0.00005	0.0005	0.002	0.001	0.0005	0.134	0.016	0.001	0.005	0.032	0.14	1.13	0.00005	1.5
Max	8.16	725	471	101	68.6	0.255	0.0046	0.056	0.184	0.486	0.117	9.73	0.042	0.16	0.02	7.08	0.2	363	0.00005	2.1
Mean	7.97	681.75	443.17	77.5	11.78	0.04525	0.00055	0.006708333	0.024727273	0.060083333	0.014833333	1.501818182	0.026363636	0.021583333	0.006363636	0.938166667	0.164545455	45.04	0.00005	1.86
Median	8.04	679.5	441.5	81	5.86	0.0225	0.000075	0.0005	0.006	0.007	0.003	0.662	0.025	0.0055	0.005	0.426	0.16	4.88	0.00005	1.9
CCWB521																				
Min	8.26	689	448	60	0.6	0.016	0.00005	0.0005	0.0005	0.0005	0.001	0.026	0.0005	0.0005	0.005	0.0025	0.33	0.3	0.00005	11.4
Max	8.53	761	495	78	21.4	0.022	0.0005	0.019	0.017	0.043	0.07	0.955	0.003	0.024	0.005	0.167	0.39	21.4	0.00005	16.6

	pH Value	EC	Total Dissolved Solids	Sulfate	Aluminium	Arsenic	Cadmium	Chromium	Cobalt	Copper	Lead	Manganese	Molybdenum	Nickel	Selenium	Zinc	Boron	Iron	Mercury	Fluoride
Units	pH Units										mg/L									
Mean	8.41	719.46	467.62	70.38	7.08	0.018230769	0.00014	0.003692308	0.0035	0.008384615	0.014538462	0.2445	0.001708333	0.004653846	0.005	0.036961538	0.359166667	4.91	0.00005	14.29
Median	8.4	720	468	70	4.975	0.018	0.00005	0.002	0.002	0.004	0.006	0.118	0.002	0.002	0.005	0.016	0.36	2.165	0.00005	14.4
CCWB522																				
min	6.76	313	203	24	1	0.002	0.00005	0.001	0.002	0.001	0.0005	0.59	0.002	0.003	0.005	0.011	0.13	1.6	0.00005	3.9
max	7.37	339	220	28	42.7	0.029	0.0004	0.05	0.04	0.035	0.035	1.92	0.015	0.101	0.005	0.326	0.19	77.6	0.00005	4.7
mean	7.10	324	210.54	25.69	10.45	0.008231	0.00013	0.011462	0.010167	0.008077	0.007808	0.8555	0.006833	0.023538	0.005	0.075385	0.16	18.36	0.00005	4.19
median	7.14	326	212	26	4.975	0.004	0.00005	0.004	0.005	0.003	0.003	0.714	0.0055	0.012	0.005	0.028	0.16	8.185	0.00005	4.1
CCWB523																				
min	5.45	91	59	6	0.02	0.0005	0.00005	0.0005	0.003	0.0005	0.0005	0.206	0.0005	0.003	0.005	0.05	0.025	0.23	0.00005	0.4
max	6.76	142	92	9	12.9	0.008	0.0004	0.018	0.025	0.02	0.05	1.05	0.003	0.035	0.005	0.329	0.025	23.5	0.00005	1.1
mean	6.410769231	113.1538462	73.53846154	7.153846154	1.865833333	0.001769231	0.0001	0.0025	0.0075	0.002538462	0.005692308	0.509583333	0.000833333	0.008230769	0.005	0.097384615	0.025	3.205833333	0.00005	0.538461538
median	6.54	108	70	7	0.145	0.001	0.00005	0.0005	0.006	0.0005	0.0005	0.4835	0.0005	0.006	0.005	0.071	0.025	0.855	0.00005	0.5
CCWB524																				
min	7.11	416	270	64	0.12	0.001	0.00005	0.0005	0.0005	0.0005	0.0005	0.074	0.003	0.0005	0.005	0.006	0.025	0.09	0.00005	1.4
max	7.72	486	316	83	5.33	0.01	0.0009	0.005	0.004	0.004	0.008	0.344	0.009	0.006	0.005	0.097	0.05	7.13	0.00005	1.7
mean	7.44	459.62	298.77	70.08	0.783333333	0.007076923	0.000146154	0.000846154	0.001	0.001192308	0.001153846	0.1385	0.005583333	0.0015	0.005	0.025692308	0.03125	1.045833333	0.00005	1.52
median	7.46	462	300	69	0.395	0.007	0.00005	0.0005	0.0005	0.0005	0.0005	0.104	0.0045	0.001	0.005	0.015	0.025	0.46	0.00005	1.5
CCWB525																				
min	6.39	615	400	108	0.01	0.0005	0.00005	0.0005	0.006	0.0005	0.0005	3.14	0.002	0.013	0.005	0.051	0.025	0.025	0.00005	0.4
max	7.73	713	463	128	26.4	0.156	0.0039	0.043	0.068	0.207	0.111	4.88	0.014	0.208	0.005	2.34	0.025	95.8	0.00005	0.6
mean	6.97	667.75	433.92	119.58	2.50	0.016708333	0.00055	0.004125	0.017727273	0.018833333	0.009833333	4.01	0.006090909	0.047416667	0.005	0.307416667	0.025	8.96	0.00005	0.54
median	6.975	665.5	432.5	120	0.11	0.0035	0.0003	0.0005	0.013	0.001	0.0005	3.94	0.006	0.034	0.005	0.115	0.025	0.2	0.00005	0.6

	pH Value	EC	Total Dissolved Solids	Sulfate	Aluminium	Arsenic	Cadmium	Chromium	Cobalt	Copper	Lead	Manganese	Molybdenum	Nickel	Selenium	Zinc	Boron	Iron	Mercury	Fluoride
Units	pH Units										mg/L									
CCWB526																				
min	7.58	1330	864	87	0.05	0.001	0.00005	0.0005	0.0005	0.0005	0.0005	0.038	0.004	0.0005	0.005	0.006	0.5	0.025	0.00005	0.6
max	8.59	1540	1000	101	0.66	0.004	0.0005	0.0005	0.002	0.066	0.019	0.781	0.017	0.002	0.005	0.119	0.66	0.67	0.00005	1
mean	8.03	1475.38	958.85	92.54	0.193333333	0.002230769	0.0001	0.0005	0.000708333	0.006192308	0.002153846	0.379333333	0.01	0.001115385	0.005	0.025	0.555	0.174583333	0.00005	0.81
median	8.04	1490	968	93	0.125	0.002	0.00005	0.0005	0.0005	0.001	0.0005	0.3585	0.009	0.001	0.005	0.012	0.545	0.12	0.00005	0.8

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3.3.4. Geology and Soils

3.3.4.1. Geology

The Project is situated within the Etheridge Goldfield. The region's gold mineralisation is described as predominantly epithermal and meso thermal systems within quartz veining, stockworks and breccias associated with the felsic volcanic units of the Permian Kennedy Igneous Group and the Proterozoic Forsayth Batholith (Laneway Resources Limited, 2022).

The target is the Sherwood and Sherwood West deposits. Gold mineralisation at Sherwood is a low-sulphidation, adularia-sericite type epithermal system genetically related to the emplacement of Permo-Carboniferous porphyritic rhyolite and andesite extrusives and intrusives. Most mineralisation occurs within the Robertson Fault Zone, at the intersection of the Robin Hood Fault. The mineralised zones are interpreted as boiling outflow zones, likely fossil geysers. The Agate Creek Fault forms the eastern boundary but mineralisation is open in all other directions. Sherwood West is hosted within a brecciated rhyolite, infilling a thrust fault truncated in the north by the Zig Zag Fault. The Sherwood West Fault is infilled with Permian rhyolites which host gold mineralisation in chalcedonic quartz veining and breccias. (Laneway Resources Limited, 2022). Site geology is shown on Figure 11.

3.3.4.1.1. Soils

WTS was engaged to undertake a soils and land suitability assessment (SLSA) of the ML to inform components of the EA application and PRCP (WTS, 2022). The SLSA focused on areas of minimal disturbance to previously undisturbed land, evaluating resources such as topsoil material availability, suitability for use in rehabilitation and potential constraints to plant growth.

The distribution of main soil types within the SLSA area were identified, validated and refined from the field survey, which was conducted according to land resource assessment guidelines (The National Committee on Soil and Terrain, 2009). WTS (2022) identified four soil map units across the ML. Representative soil profiles are described in Table 10 and distribution of soils is mapped in Figure 12.

Table 10. Representative Soil Profiles (Wulguru Technical Services, 2022)

Soil Management Unit	Depth (cm)	Area (ha)	Area (percentage)
Brown Mellic Kandosol	30	232.58	34.86
Red Massive Gypsic Vertosol	20	63.97	9.32
Brown Bleached Kandosol	30	83.51	12.18
Brown Lithsolic Rudosol	0	299.13	43.62

3.3.5. Bioregions

Agate Creek is located on the boundary of the Einasleigh Uplands and Gulf Plains Bioregions.

The Einasleigh Uplands bioregion has a tropical climate with moderate- to high-rainfall summers. The bioregion consists of a series of rugged hills and ranges, dissected plateaus as well as alluvial and sand plains. The bioregion is dominated by eucalypt woodlands and is used extensively for grazing with some mining, cropping and horticulture (Rangelands, 2008).

The Gulf Plains is characterised by has a monsoonal climate with a winter dry season and a summer wet season. The tropical savanna vegetation comprises mainly eucalypt and tea-tree open woodlands. The regional economy is mainly based on cattle grazing with some prawn fishing, mining and tourism (Rangelands, 2008).

3.3.6. Flora

3.3.6.1. Regulated Vegetation

Regulated vegetation is vegetation where the clearing or maintenance activities are managed through vegetation classification being Category A, Category B, Category C, Category R or Category X. The site is covered by Category B – remnant vegetation.

3.3.6.2. Regional Ecosystem Mapping

Regional ecosystems (REs) are described as *"vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil*" (Sattler and Williams 1999, Vegetation Management Act 1999). REs mapped at Agate Creek are detailed in Table 11.

Table 11. Regional Ecosystems Mapped at the Project (State of Queensland, 2021)

RE	Description	VM Class	EPBC Biodiversity Status
9.3.20	*Eucalyptus microneura* +/- *Corymbia* spp. +/- E. *leptophleba* woodland on alluvial plains	Least Concern	No Concern at Present
9.11.30	*Acacia leptostachya* low woodland with emergents on stony and rocky metamorphic hills	Least Concern	No Concern at Present
9.5.10	*Eucalyptus microneura* +/- *Terminalia* spp. low woodland on sand sheets	Least Concern	No Concern at Present
2.11.1	*Eucalyptus melanophloia* low woodland on skeletal soils on metamorphics hills	Least Concern	No Concern at Present
2.10.5	*Acacia shirleyi* woodland and *Triodia* pungens hummock grassland on scarps and stony ledges	Least Concern	No Concern at Present
9.11.16	*Eucalyptus crebra* +/- *Corymbia erythrophloia* or C. pocillum woodland on steep to rolling hills	Least Concern	No Concern at Present

RE	Description	VM Class	EPBC Biodiversity Status
9.12.11	*Eucalyptus crebra* and/or E. whitei +/- *Corymbia erythrophloia* open woodland on steep to rolling hills on igneous rocks	Least Concern	No Concern at Present

3.3.6.3. Matters of State Environmental Significance

Desktop assessments determined the presence of one Matter of State Environmental Significance (MSES) at Agate Creek being MSES regulated vegetation (defined watercourse). The MSES Protected Area – Rungulla Resource Reserve is situated approximately 260m from the western boundary of the site.

3.3.7. Wetlands

There are four mapped wetland areas within 5 km of the Project, two of which are modified lacustrine wetland systems (State of Queensland, 2021). There are no mapped wetlands of high ecological significance within or surrounding the ML.

3.3.8. Protected Areas

The Rungulla National Park, located to the west of the ML, covers an area of 120,063 ha of land. It is protected under the *Nature Conservation Act 1992* (NC Act). The Rungulla Resource Reserve is also protected under the NC Act, covering 9444.45 ha of land.

3.3.9. Matters of National Environmental Significance

3.3.9.1. Flora Species – Threatened Species

The Protected Matters Search Tool (PMST) (Department of Agriculture Water and the Environment DAWE, 2022) identified three threatened flora species with the potential to exist within 50km of Agate Creek. Threatened Species are detailed in Table 12.

Table 12. Threatened Flora to Possibly Occur within 50km of the Project

Flora	EPBC Status	Type of Presence
Cycas cairnsiana	Vulnerable	Species or species habitat likely to occur within area
Cycas platyphylla	Vulnerable	Species or species habitat likely to occur within area
Dichanthium setosum	Vulnerable	Species or species habitat likely to occur within area

3.3.9.2. Threatened Fauna

15 fauna species of conservation significance were identified through the Protected Matters Search Tool to potentially occur at Agate Creek. These species are shown in Table 13 .

Table 13. PMST listed Threatened Species with the potential to occur within 50 km of the Project.

Taxa	Name	EPBC Status	Type of Presence
Bird	*Calidris ferruginea* (Curlew Sandpiper)	Critically Endangered	Species or species habitat may occur within area
	Erythrotriorchis radiatus (Red Goshawk)	Vulnerable	Species or species habitat may occur within area
	Erythrura gouldiae (Gouldian Finch)	Endangered	Species or species habitat may occur within area
	Falco hypoleucos (Grey Falcon)	Vulnerable	Species or species habitat may occur within area
	Neochmia ruficauda ruficauda (Star Finch)	Endangered	Species or species habitat may occur within area
	Rostratula australis (Australian Painted Snipe)	Endangered	Species or species habitat may occur within area
	Tyto novaehollandiae kimberli (Masked Owl)	Vulnerable	Species or species habitat may occur within area
Mammals	*Dasyurus hallucatus* (Northern Quoll)	Endangered	Species or species habitat may occur within area
	Macroderma gigas (Ghost Bat)	Vulnerable	Species or species habitat may occur within area
	Mesembriomys gouldii rattoides (Black-footed Tree-rat)	Vulnerable	Species or species habitat may occur within area
	Petauroides minor (Greater Glider)	Vulnerable	Species or species habitat may occur within area
	Phascolarctos cinereus (Koala)	Endangered	Species or species habitat may occur within area
	Rhinolophus robertsi (Large-eared Horseshoe Bat)	Vulnerable	Species or species habitat may occur within area
	Saccolaimus saccolaimus nudicluniatus (Bare-rumped Sheath-tailed Bat)	Vulnerable	Species or species habitat may occur within area
Shark	*Pristis pristis* (Freshwater Sawfish)	Vulnerable	Species or species habitat may occur within area

3.3.9.3. *Migratory Species*

15 migratory species of conservation significance were identified through the Protected Matters Search Tool to potentially occur at Agate Creek. These species are shown in Table 14.

Table 14. Migratory Species

Taxa	Name	EPBC Status	Type of Presence
Bird	*Apus pacificus* (Fork-tailed Swift)	N/A	Species or species habitat may occur within area
	Cuculus optatus (Oriental Cuckoo)	N/A	Species or species habitat may occur within area
	Hirundo rustica (Barn Swallow)	N/A	Species or species habitat may occur within area
	Motacilla cinerea (Grey Wagtail)	N/A	Species or species habitat may occur within area
	Motacilla flava (Yellow Wagtail)	N/A	Species or species habitat may occur within area
	Rhipidura rufifrons (Rufous Fantail)	N/A	Species or species habitat may occur within area
	Actitis hypoleucos (Common Sandpiper)	N/A	Species or species habitat may occur within area
	Calidris acuminata (Sharp-tailed Sandpiper)	N/A	Species or species habitat may occur within area
	Calidris ferruginea (Curlew Sandpiper)	Critically Endangered	Species or species habitat may occur within area
	Calidris melanotos (Pectoral Sandpiper)	N/A	Species or species habitat may occur within area
	Gallinago hardwickii (Latham's Snipe)	N/A	Species or species habitat may occur within area
	Glareola maldivarum (Glareola maldivarum)	N/A	Species or species habitat may occur within area
	Pandion haliaetus (Osprey)	N/A	Species or species habitat may occur within area
	Tringa nebularia (Common Greenshank)	N/A	Species or species habitat may occur within area
Shark	*Pristis pristis* (Freshwater Sawfish)	Vulnerable	Species or species habitat may occur within area

3.3.9.4. *EPBC Act Threatened Ecological Communities*

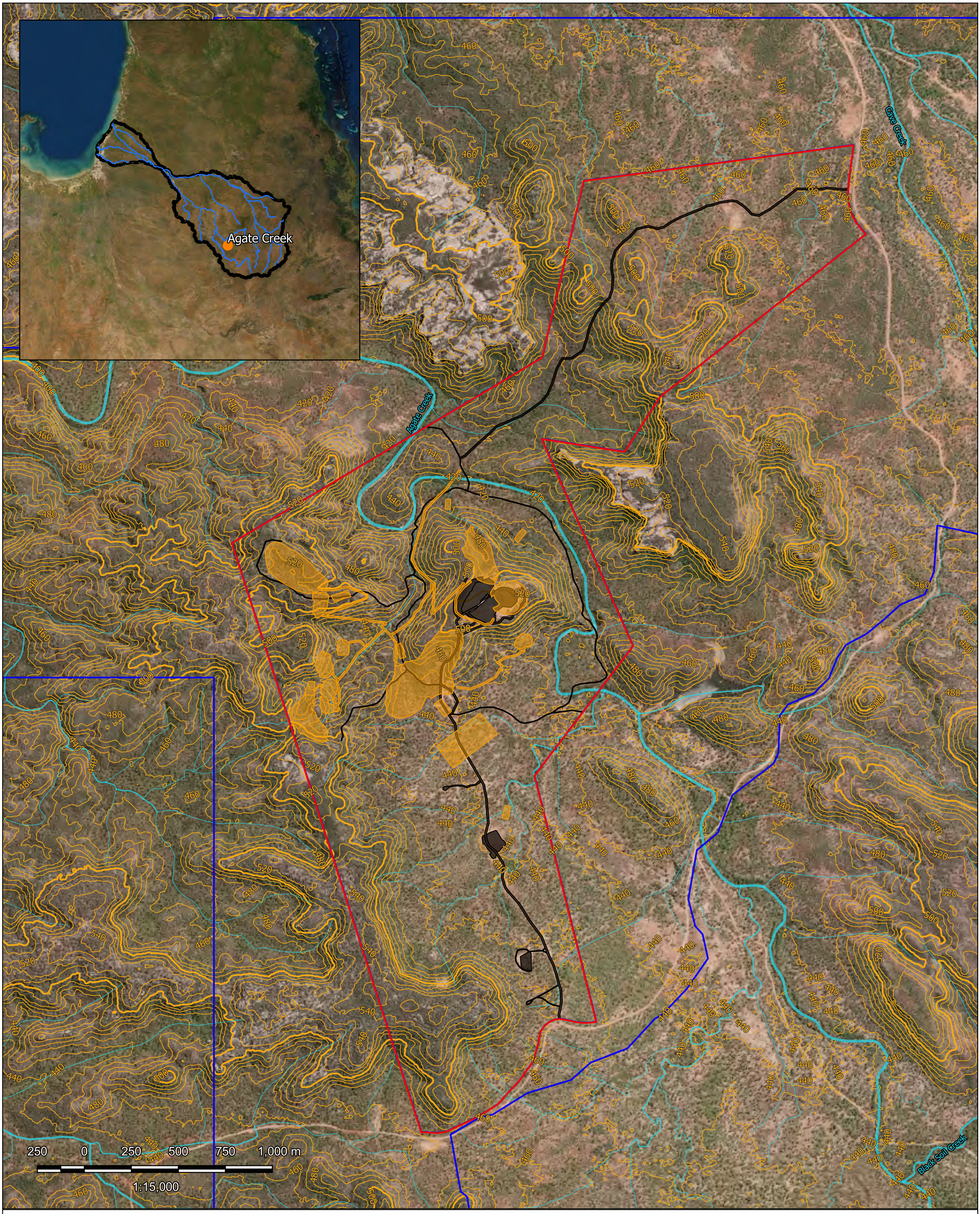
The PMST did not identify any Threatened Ecological Communities (TECs) that were likely to occur within a 10 km radius of Agate Creek. No threatened ecological communities were identified at Agate Creek (DAWE, 2022.).

3.3.9.5. Areas of High Ecological Significance

The PMST indicates no results of areas of high ecological significance present within the Agate Creek. There are no mapped wetlands of high ecological significance within or near Agate Creek (DAWE, 2022).

3.3.9.6. Prescribed environmental matters as defined in the *Environmental Offsets Act 2014* (Qld)

There are no legally secured offset areas within the ML. Furthermore, as there is no residual impact anticipated as a result of the Agate Creek expansion, no offsets are required under the *Environmental Offsets Act 2014.*



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Project number: 2021.08003
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Date: 1 June 2022

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Figure 10. Topography and Drainage

Legend

- Mineral Development Licence
- Mining Lease
- Existing Mine Features
- Proposed Mine Features
- Gilbert Basin
- Major Rivers
- 10m Contour

Watercourse - Stream Order

- 0
- 1
- 2
- 3
- 4

ESRI Satellite

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250 0 250 500 750 1,000 m

1:15,000

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Figure 11. Surface Geology

Legend

Mine Tenure
- Mineral Development Licence
- Mining Lease
- Existing Mine Features
- Proposed Mine Features

Surface Geology
- Big Surprise Tuff
- Black Soil Andesite
- Corbett Formation
- CPia-Kennedy Province
- CPir-Kennedy Province
- Daniel Creek Formation
- Daniel Creek Formation/s
- Dead Horse Metabasalt
- Dead Horse Metabasalt/a
- Hampstead Sandstone
- Lane Creek Formation/c
- Qa-QLD
- Robin Hood Granodiorite
- Talaveras Rhyolite
- Thunder Egg Rhyolite
- TQr-QLD

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250 0 250 500 750 1,000 m

1:15,000

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Figure 12. Ground-truthed Soils

Legend

Mine Tenure
- Mineral Development Licence
- Mining Lease
- Existing Mine Features
- Proposed Mine Features

Ground-truthed Soils
- Brown Bleached Kandosol
- Brown Lithsolic Rudosol
- Brown Mellic Kandosol
- Red Massive Gypsic Vertosol

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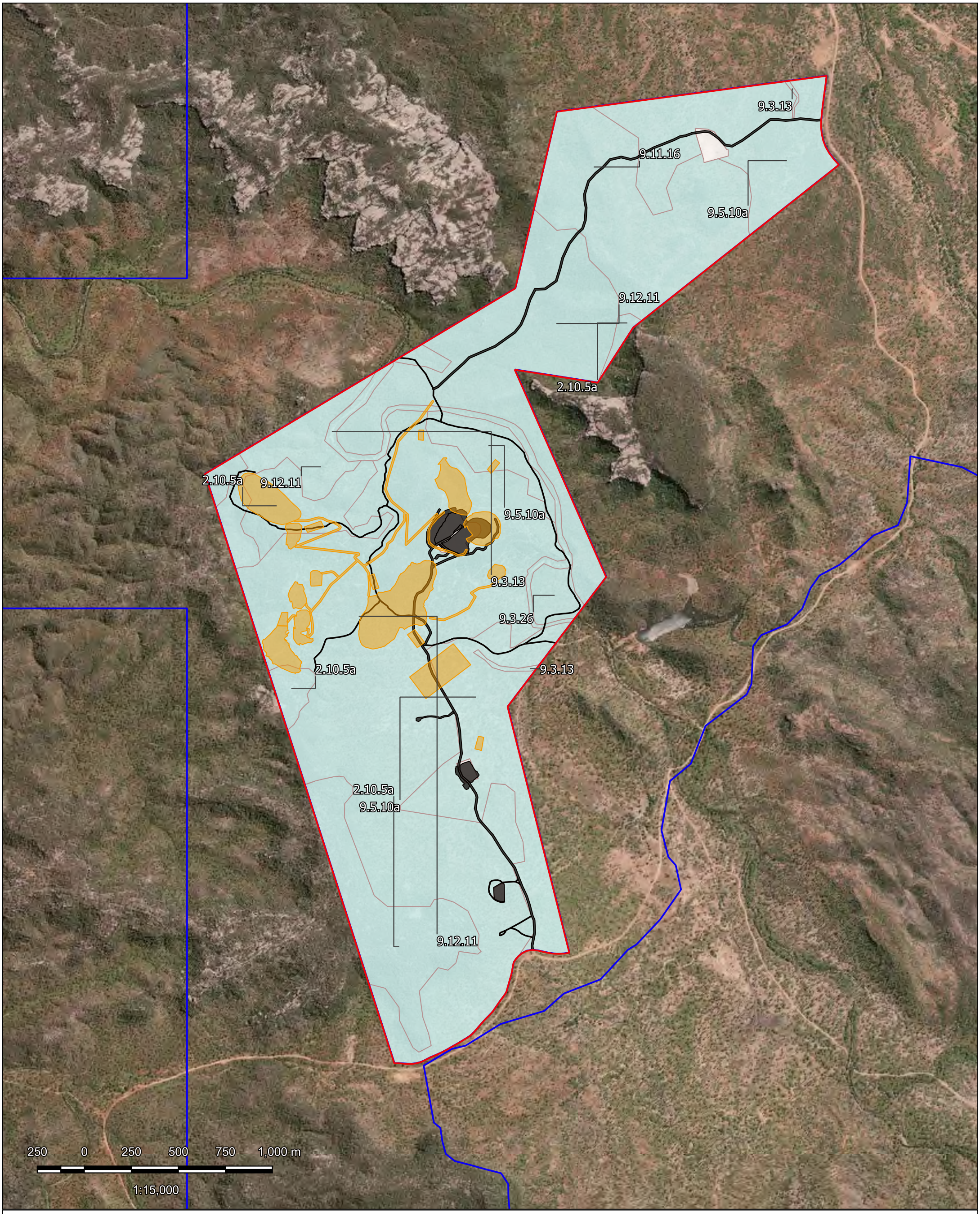

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CRS: GDA2020 EPSG: 7844
Date: 11 July 2022

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Figure 13. Ground-truthed Regional Ecosystems

Legend

Mine Tenure
- Mineral Development Licence
- Mining Lease
- Mine Features
- Proposed Mine Features

Groundtruthed REs
- Least Concern
- Non-Remnant

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Agate Creek Camp Ground

Rungulla Resources Reserve

Rungulla National Park

400 0 400 800 1,200 1,600 m

1:25,000

Client: Laneway Resources Ltd
Project number: 2021.09001
CRS: GDA2020 EPSG: 7844
Date: 11 July 2022

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Figure 14. MSES

Legend

- Mineral Development Licence
- Mining Lease
- Existing Mine Features
- Proposed Mine Features
- Main Tracks
- 2km Buffer

ESRI Satellite

Sensitive Receptors

- WH - END or VUL
- RV - Essential Habitat
- Rungulla National Park (Cat A ESA)
- Rungulla Resources Reserve (Cat C ESA)
- Protected Plant Trigger
- Tourist Area

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4. Potential Environmental Impacts and Management

4.1. Air Impacts

In preparing this application, consideration has been given to guideline *ESR/2015/1840 – Application requirements for activities with impacts to air* (Department of Environment and Science, 2017a). DES is required to assess the application against the requirements stated in the *Environmental Protection Act 1994*, EP Regulation and Environmental Protection (Air) Policy 2019 (EPP Air) to meet the environmental objective and performance outcomes described below:

Environmental Objective

'The activity will be operated in a way that protects environmental values of air:'

Performance Outcome

There is no discharge to air of contaminants that may cause an adverse effect on the environment from the operation of the activity, or

All of the following:

Fugitive emissions of contaminants from storage, handling and processing of materials and transporting materials within the Project are prevented or minimised.

Contingency measures will prevent or minimise adverse effects on the environment from unplanned emissions and shut down and start up emissions of contaminants to air.

Releases of contaminants to the atmosphere for dispersion will be managed to prevent or minimise adverse effects on environmental values.

RISK OF ENVIRONMENTAL IMPACT: LOW

4.1.1. Surrounding Land and Sensitive Receptors

A sensitive receptor is defined under the EPP Air as an area or place where noise is measured. Sensitive receivers can include:

- Residence dwellings;
- Library and educational institutions;
- Childcare centre or kindergarten;
- School or playground;
- Hospital, surgery or other medical institution;
- Commercial and retail activity;
- Protected area or critical area;
- Marine park; or
- Park or garden that is open to the public (EPP Air, 2019).

Four sensitive receivers have been identified within 45km of Agate Creek. However, there is only one sensitive receiver within 2km, the Agate Creek Campground. Sensitive receptors are detailed in Table 15 and shown on Figure 15.

Table 15. Sensitive Receptors (SEG, 2022)

Receptors (Homesteads)	Distance (km)	Bearing (degrees)
Camping ground	1.5	120
Old campground	11	125
Homestead 01 (Dave Terry station)	8	55
Homestead 02	25	330
Forsayth	45	7

4.1.2. Description of Ambient Air Quality

Ambient air quality of the Project is expected to be generally in accordance with Air Quality Objectives detailed in Schedule 1 of the EPP Air.

Air contaminants are commonly categorised into ‘criteria pollutants’, ‘air toxics’ and ‘other air pollutants’ (Department of Environment and Science, 2017a). Criteria pollutants are common air pollutants found in relatively high concentrations. The National Environmental Protection (Ambient Air Quality) Measure identifies and provides target ambient concentrations for the following criteria pollutants:

- carbon monoxide (CO);
- lead and compounds;
- oxides of nitrogen (NOX);
- particulate matter < 10 µm (PM10);
- particulate matter < 2.5 µm (PM2.5);
- sulfur dioxide (SO2); and
- ozone as a surrogate for photochemical oxidants.

The chemical nature of particles and their interaction with human tissue can influence the health impacts. The EPP Air provides air quality objectives for a number of criteria pollutants and air toxics. 'Other air pollutants' are those not included in the above categories. These contaminants are generally less hazardous and less common and are less likely to have published quality standards. Individual chemical species that have the potential to cause odour nuisance but do not have an established toxicity threshold can be considered in this list.

4.1.2.1. Air Quality Objectives

Schedule 1 of the EPP (Air) details the Air Quality Objectives (AQO) to be achieved and maintained during operation of the Project. The applicable AQO to the Project are outlined in Table 16.

Table 16. Air Quality Objectives – EPP (Air)

Indicator	Environmental Value	Air Quality Objectives µg/m3 (except where noted)	ppm (volume/ volume)	Period	Days
Carbon monoxide	Protecting aesthetic environment	22	0.006	30 minutes	
	Health and wellbeing	11 mg/m^3	9	8 hours	
$PM_{2.5}$	Health and wellbeing	25		24 hours	
		8		1 year	
PM_{10}	Health and wellbeing	50		24 hours	
		25		1 year	
total suspended particles	Health and wellbeing	90		1 year	

4.1.2.2. Dust

As a general guide, dusts having diameters of 7 to 10 µm are mostly large enough to be caught by nose and throat. Particles in the range 0.5 to 7 µm are small enough to reach the lung yet large enough to be retained. Since these dusts remain in the lung, they may be hazardous to health and well-being.

The applicable air quality criteria from EPP (Air) and the National Environmental Protection Measure (NEPM) are outlined in Table 17.

Table 17. NEPM Air Quality Criteria (Dust)

Pollutant	Averaging period	Goal within 10 years Maximum allowable exceedances	Maximum concentration
Particles as PM10	1 day	5 days a year	50 µg/m3
Particles as PM2.5	1 day		25 µg/m3
	1 Year		8 µg/m3

A future goal is recommended to be adopted by the states. The goal for the year 2025 comprises:

a) PM2.5 - 7 µg/m3 averaged over one year; and

b) PM2.5 - 20 µg/m3 averaged over 24 hours.

Dust Air Quality criteria are qualities of the air environment that are important to human health and wellbeing. Qualities of the air environment that may cause environmental nuisance includes dust fallout. Air quality criteria applicable to environmental nuisance include:

- total suspended particulate 90 µg/m3 averaged over a year; and,
- dust deposition of 120 mg/m2/day averaged over one month.

4.1.2.3. Visibility Reducing Particles

Visibility reducing particles are particles less than 1 µm that may remain suspended in the atmosphere for long periods, obscuring visibility. The EPP (Air) states that to protect the aesthetics of the environment, visibility reducing particles may be limited to 20km of visibility in the air environment averaged over 1 hour.

4.1.2.4. Odour

Odour impacts are a potential source of environmental nuisance to sensitive receptors. Typical odour causing compounds include carbon disulfide, formaldehyde, hydrogen sulfide, toluene, styrene and tetrachloroethylene. Odour causing compounds may also include those generated from intensive industries such as sewage treatment, food processing or agricultural activities. Odours are not expected to be generated as a result of the Project.

Agate Creek Camp Ground

Rungulla Resources Reserve

Rungulla National Park

400 0 400 800 1,200 1,600 m

1:25,000

Client: Laneway Resources Ltd
Project number: 2021.09001
CRS: GDA2020 EPSG: 7844
Date: 11 July 2022

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Figure 15. Sensitive Receptors

Legend

- Mineral Development Licence
- Mining Lease
- Existing Mine Features
- Proposed Mine Features
- Main Tracks
- 2km Buffer

ESRI Satellite

Sensitive Receptors

- WH - END or VUL
- RV - Essential Habitat
- Rungulla National Park (Cat A ESA)
- Rungulla Resources Reserve (Cat C ESA)
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4.1.3. Current Air Quality Conditions

Potential sources of particulate emissions from the surrounding environment primarily comprise:

- farming and grazing activities;
- existing mining operations;
- unsealed roads; and
- smoke from grass/bush fires (permitted or otherwise).

Due to the lack of other industries in the area, the majority of emissions from the surrounding areas would be crustal matter that is released from farming activities, mining activities and unsealed roads. The characteristic of these emissions are particulates and dusts made up of crustal matter rather than other material that has specific limits. Based on this the air quality indicators that are processed in this report are PM2.5, PM10, TSP, and dust deposition.

4.1.4. Predicted Air Impacts

This section outlines the results of the Air Quality modelling conducted by SEG (2021) to determine the potential impact of air emissions from the Agate Creek expansion at nearby sensitive areas. The detailed impacts to air report are included in Appendix B.

4.1.4.1. Methodology

Modelling of the predicted average ground level concentrations consisted of three phases:

1. Preparation of meteorological data The Air Pollution Model (TAPM) and Calmet;
2. Development of an emissions database using Australian National Pollution Inventory 'Emission Estimation Technique Manual for Mining Version 3.1';
3. Modelling of the likely downwind ground level concentrations using Calpuff (SEG, 2021).

4.1.4.1.1. Preparation of Meteorological Data

TAPM is a prognostic meteorological and air pollution dispersion model developed by CSIRO. TAPM was utilised to predict meteorology and pollutant concentration for a range of pollutants potentially emitted by the Project. The model consists of coupled prognostic meteorological and air pollution concentration components, eliminating the need to have site-specific meteorological observations. Instead, the model predicts the flows important to local-scale air pollution, such as sea breezes and terrain induced flows, against a background of larger-scale meteorology provided by synoptic analyses (SEG, 2022).

The TAPM meteorological file developed for the site covered the two year period 2019 & 2020. This period was used for modelling since it is a comprehensive period and the most recent data sets. TAPM was configured with 4 nested grids with grid spacing of 30000m, 10000m, 3000m and 1000m.

Additionally 40 grid points were used with 30 vertical grids. The model was centred on the location -18°59.5' and 143°32'. All other settings were as per default (SEG, 2022).

The representative frequency of Pasquil stability classes for the region is based TAPM and represent the stability of the atmosphere. Stability Classes are detailed in Table 18.

Table 18. Frequency of Stability Classes at Site (SEG, 2021)

Stability Class	Description	Frequency of Occurrence (%)
A	Very unstable	4
B	Moderately unstable	15
C	Slightly unstable	15
D	Neutral	25
E	Slightly stable	18
F	Stable	24

4.1.4.1.2. Development of the Emissions Database

The Emissions Database for the Project's particulate emissions was based on the National Pollution Inventory Emission Estimation Technique for Mining Version 3.1 (National Pollution Inventory (NPI), 2012). Mining activities and processes with the potential to produce particulate emissions were identified. Flowcharts for handling of material were developed and an emission factor attributed to every handling point, handling activity and transport section (SEG, 2022).

A four-step process has been used to calculate emissions:

1. Identify sources of emissions
2. Obtain information of the scale of the activity
3. Apply the relevant emissions factor equation or default emission factor from NPI to the activity data
4. Where applicable, apply control efficiency reduction factors-based water truck use or built-in controls (SEG, 2022).

One modelling case is addressed for the Project based on the proposed operations including a truck and excavator to extract the waste and ore. The ore will then be taken to the ROM Pad. The modelling case is detailed in Table 19.

Table 19. Emissions Database Modelling Case for the Project (SEG, 2022).

Item	Case
Maximum monthly ROM Ore (Tonnes/month) Maximum monthly mining waste (Tonnes/month)	16,667 83,333
Relevant operations	Excavators on overburden and ore Haul trucks to waste dumps Haul trucks to ROM Graders on internal roads Water trucks on internal roads Bulldozer on overburden Road trains taking ROM to offsite processing Drilling and Blasting
Type of Emission	Crustal Matter (soil, etc.)

Table 20. Particulate Emissions for Main Emitting Activities (SEG, 2022).

Activity	Includes Control Factor	Emissions [t/a] for Particulate Fraction (Operations scaled to full year)		
		TSP	PM10	PM2.5
Excavator loading trucks	N/A	30.4	14.6	1.8
Trucks moving on site	Water Cart Level 2 Waterings (75%)	17.2	5.1	.6
Trucks dumping overburden		12.2	4.4	.5
Trucks dumping ore		2.4	0.9	0.1
Dozer		22.3	5.4	0.7
Grader		0.3	0.1	<0.1
Front end loader		5.9	2.8	.4
Watercart		11.1	3.3	0.4
Export truck on site		19.3	5.7	0.7
Drilling	N/A	18.4	0.2	<0.1
Blasting	N/A	0.4	0.2	<0.1
Wind erosion	N/A	1.8	0.9	0.1

4.1.4.1.3. Dispersion Model

Calpuff v7 was used by SEG (2022) to determine the downwind ground level particulate concentrations and dust depositions utilising the exported 3D wind data from TAPM. The metrological grid was set for 50 by 50 cells with a cell dimension of 500m by 500m. Terrain was imported from SRTM 30m DEM3. CALPUFF was configured to use TAPM 3D wind data as an initial guess field for the model. All other settings were kept at the recommended default (SEG, 2022).

The pit sources were combined and modelled as a single area source in the Calpuff model. The area source is modelled as having dimensions similar to the extent of the source and an elevation of 3m above local terrain. A sampling/calculation grid of 76 by 76 grid with 500m spacing and a receptor at each of the sensitive receptors was used to develop the contours (SEG, 2022).

4.1.4.2. Results of Air Quality Modelling

4.1.4.3. Meteorological Data

The predominant wind direction during the year is from the north-east through to the south-east.

4.1.4.3.1. Calpuff Modelling

Calpuff modelling determined that the Agate Creek expansion is predicted to comply with the air quality objectives at all sensitive receptors. The impact to air quality to the sensitive receptors and environment is therefore deemed minimal. The results of the Calpuff Modelling are presented in

Table 21.

Table 21. Predicted Air Quality Concentration for Sensitive Receptors (including assumed ambient levels) (SEG, 2022).

Receptor*	Calculated Particulate and Dust Levels at Nearby Sensitive Receptors						
	PM2.5 (24 hour maximum) (µg/m^3)	PM2.5 (Annual Average) (µg/m^3)	PM10 (24 hour maximum) µg/m^3)	Number of Days Exceedance of 50 µg/m^3 PM10 (Maximum) Per 5 years	PM10 (Annual Average) (µg/m^3)	TSP (Annual Average) (µg/m^3)	Dust Deposition (Maximum month mg/m^2/day)
Limit	**25**	**8**	**50**	**0**	**25**	**90**	**120**
Existing Ambient	8	7	22	-	20	28	53
Camping Ground	9	7	31	0	21	30	93
Old Camping Ground	8	7	22	0	20	30	53
Homestead1	8	7	22	0	20	28	53
Homestead2	8	7	22	0	20	28	53

* The Mine Camp is not a sensitive receptor and is included in Appendix B for reference only.

4.1.4.4. Summary of Impacts

Modelling of air quality impacts suggests that the expansion of operations at Agate Creek will not have a significant impact of sensitive receivers, with emissions at sensitive receptors modelled to meet the

air quality criteria (Section 4.1.2). Additional management measures are proposed to further reduce the air emissions form Agate Creek (Section 4.1.5).

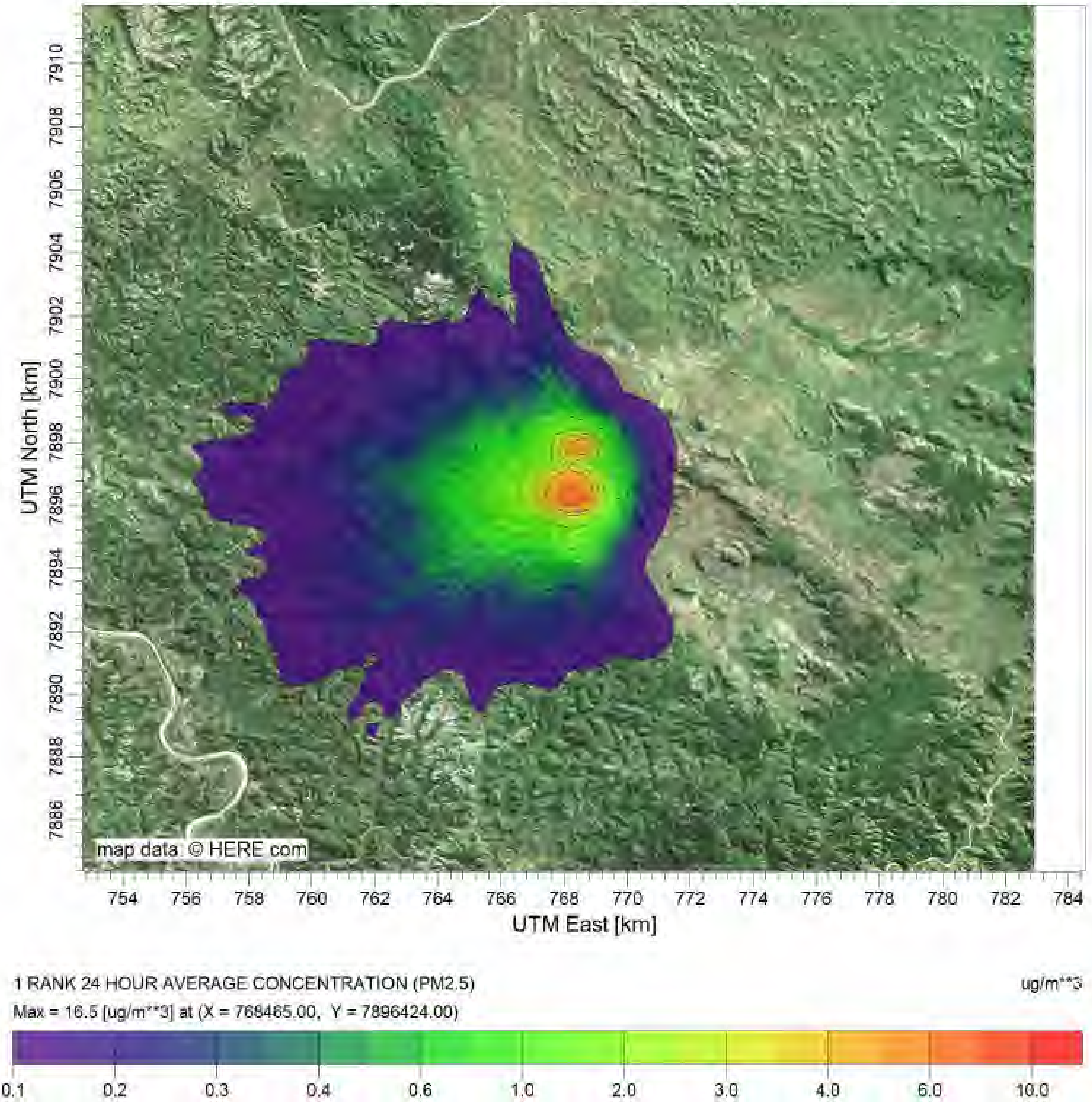

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Figure 16. PM2.5 24 Hour Maximum

Source: Simpson Engineering Group
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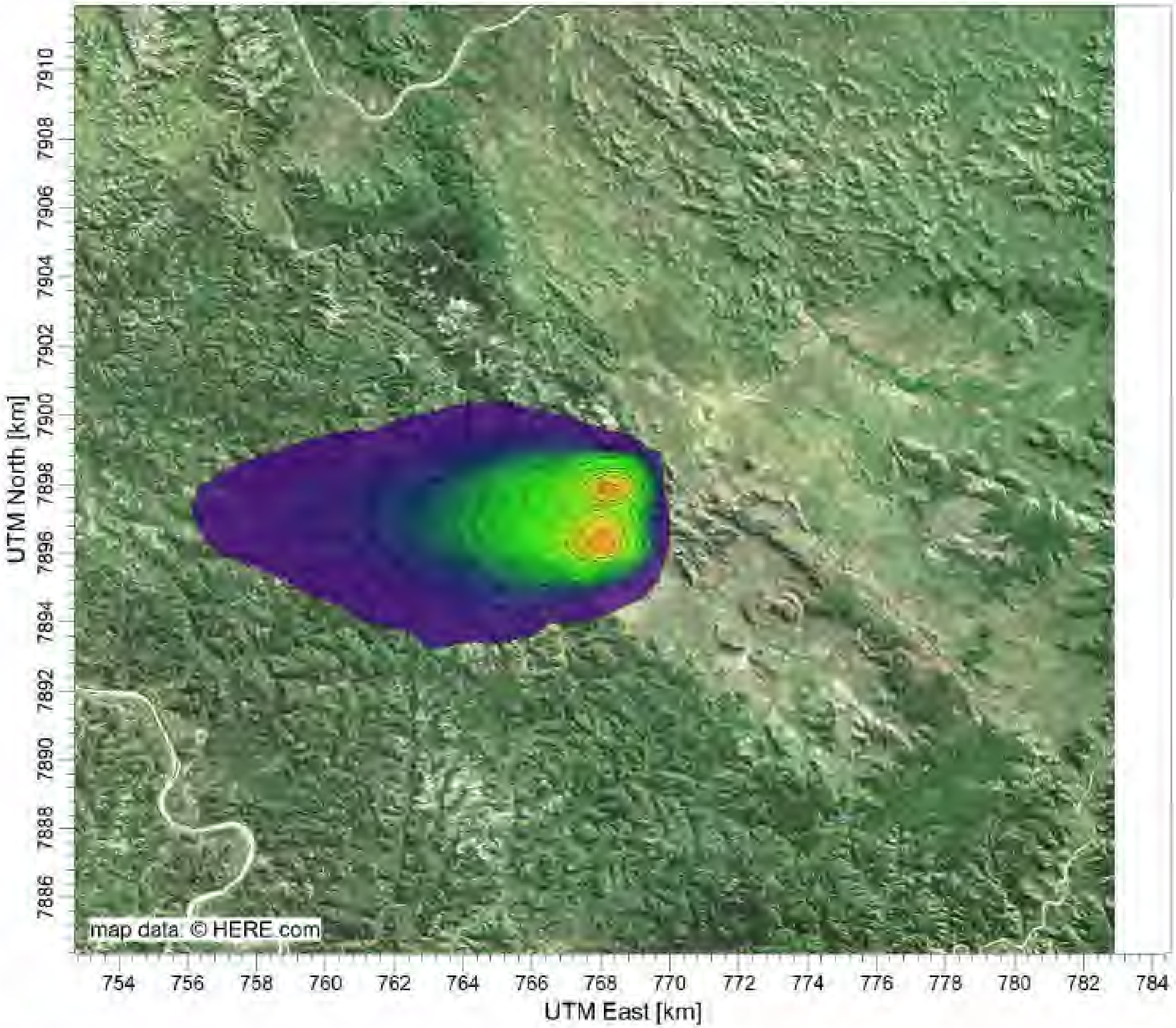

VALUE RUN LENGTH AVERAGE CONCENTRATION (PM2.5) ug/m**3

Max = 4.557 [ug/m**3] at (X = 767965.00, Y = 7896424.00)

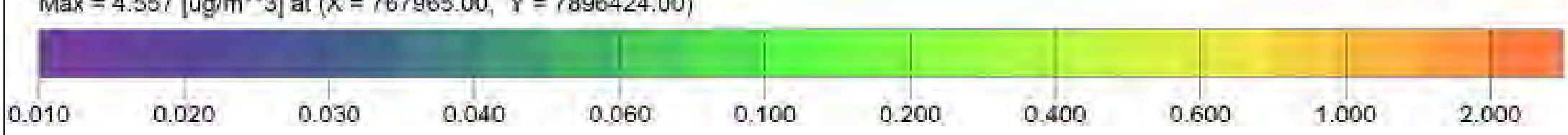

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Figure 17. PM2.5 Annual Average

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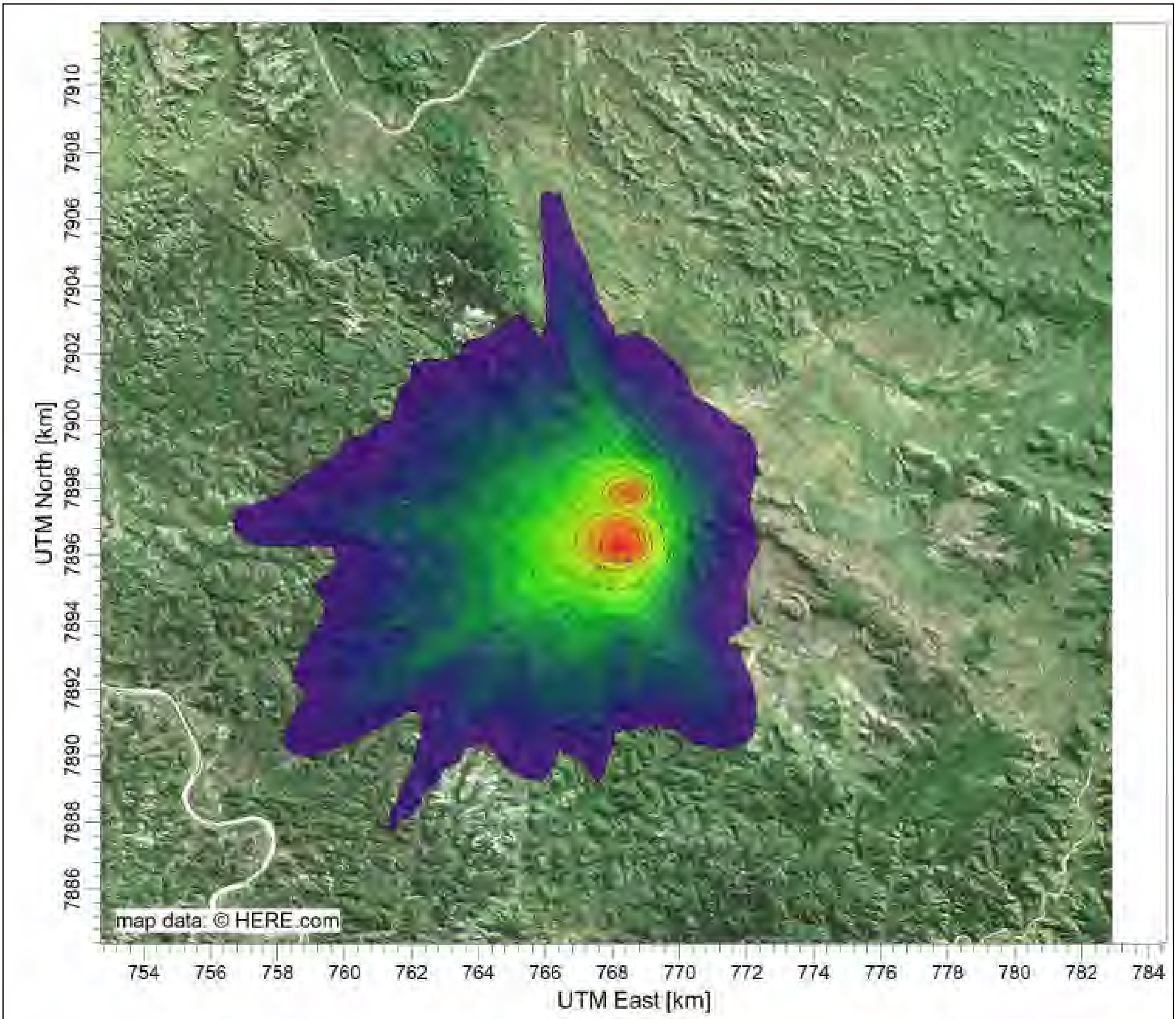

1 RANK 24 HOUR AVERAGE CONCENTRATION (PM10) ug/m**3

Max = 138.6 [ug/m**3] at (X = 768465.00, Y = 7896424.00)

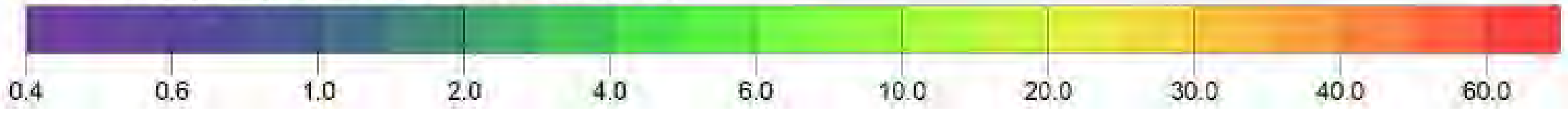

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Figure 18. PM10 24 Hour Maximum

Source: Simpson Engineering Group
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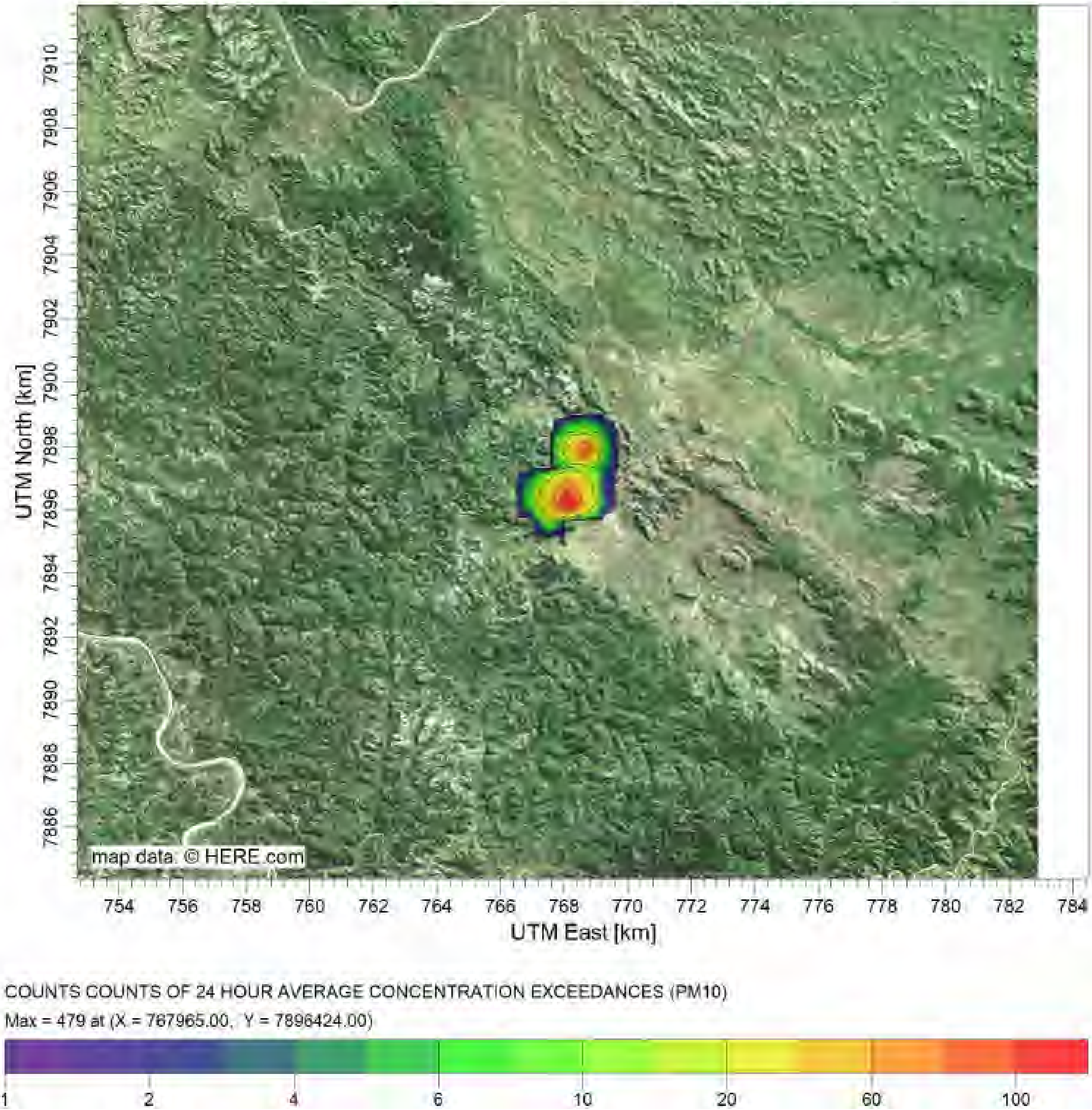

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Figure 19. PM10 - Number of Days that Exceed Limit on 2 Year Model

Source: Simpson Engineering Group
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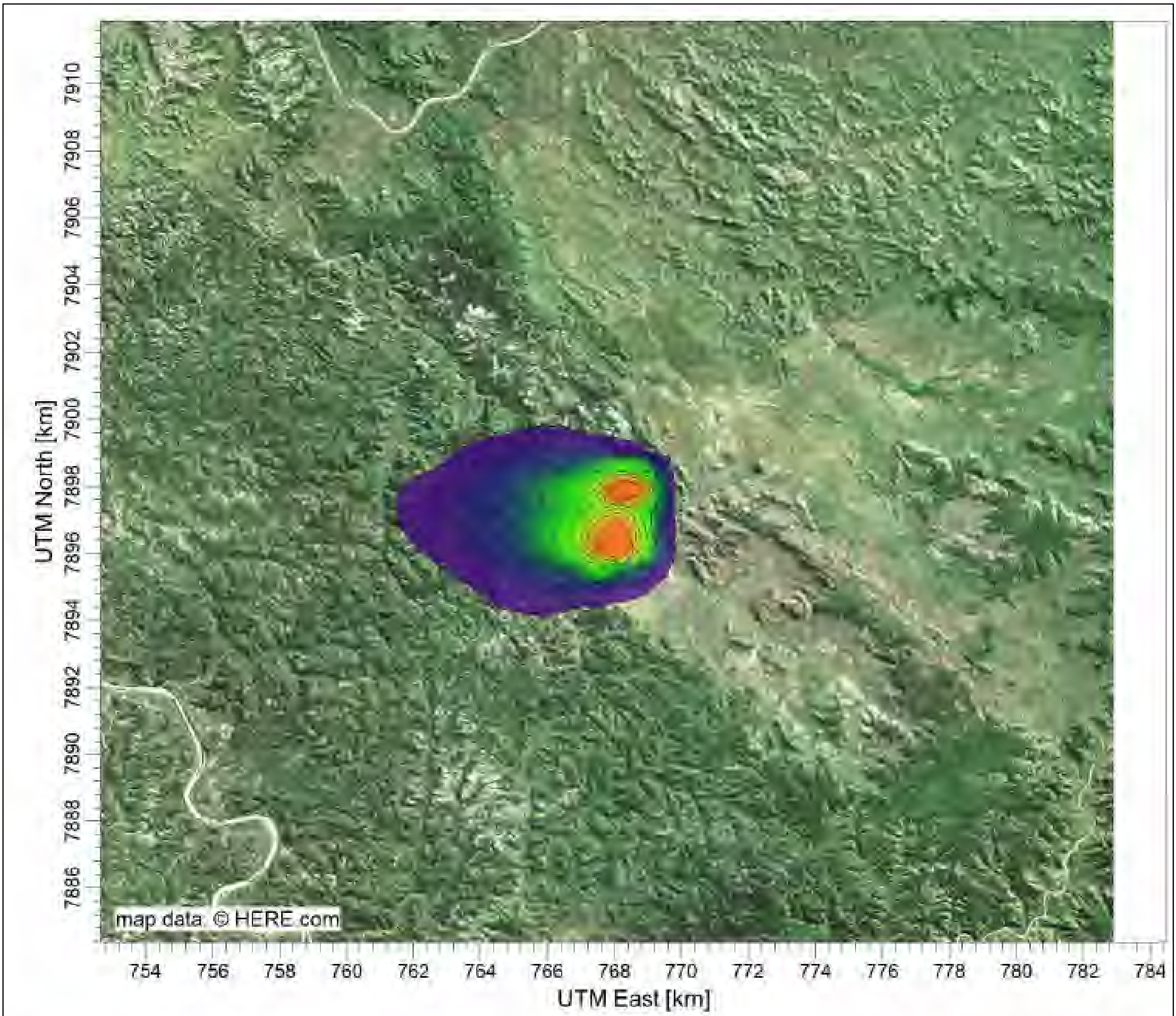
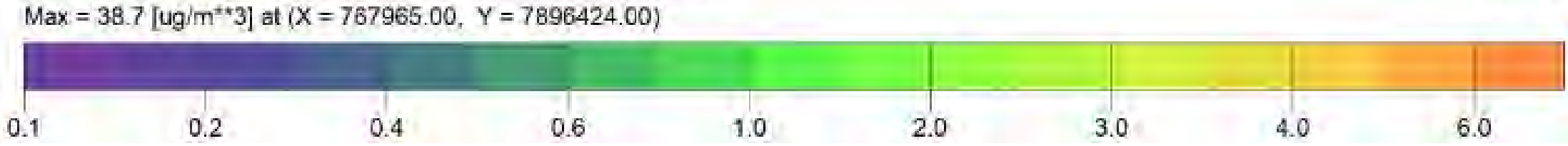


VALUE RUN LENGTH AVERAGE CONCENTRATION (PM10) ug/m**3

Max = 38.7 [ug/m**3] at (X = 767965.00, Y = 7896424.00)



Client: Laneway Reources Ltd
Project number: 2021.08003
Coordinate Reference System: GDA 2020 Z54
Date: 1 June 2022

Print as A3

Figure 20. PM10 Annual Average

Source: Simpson Engineering Group
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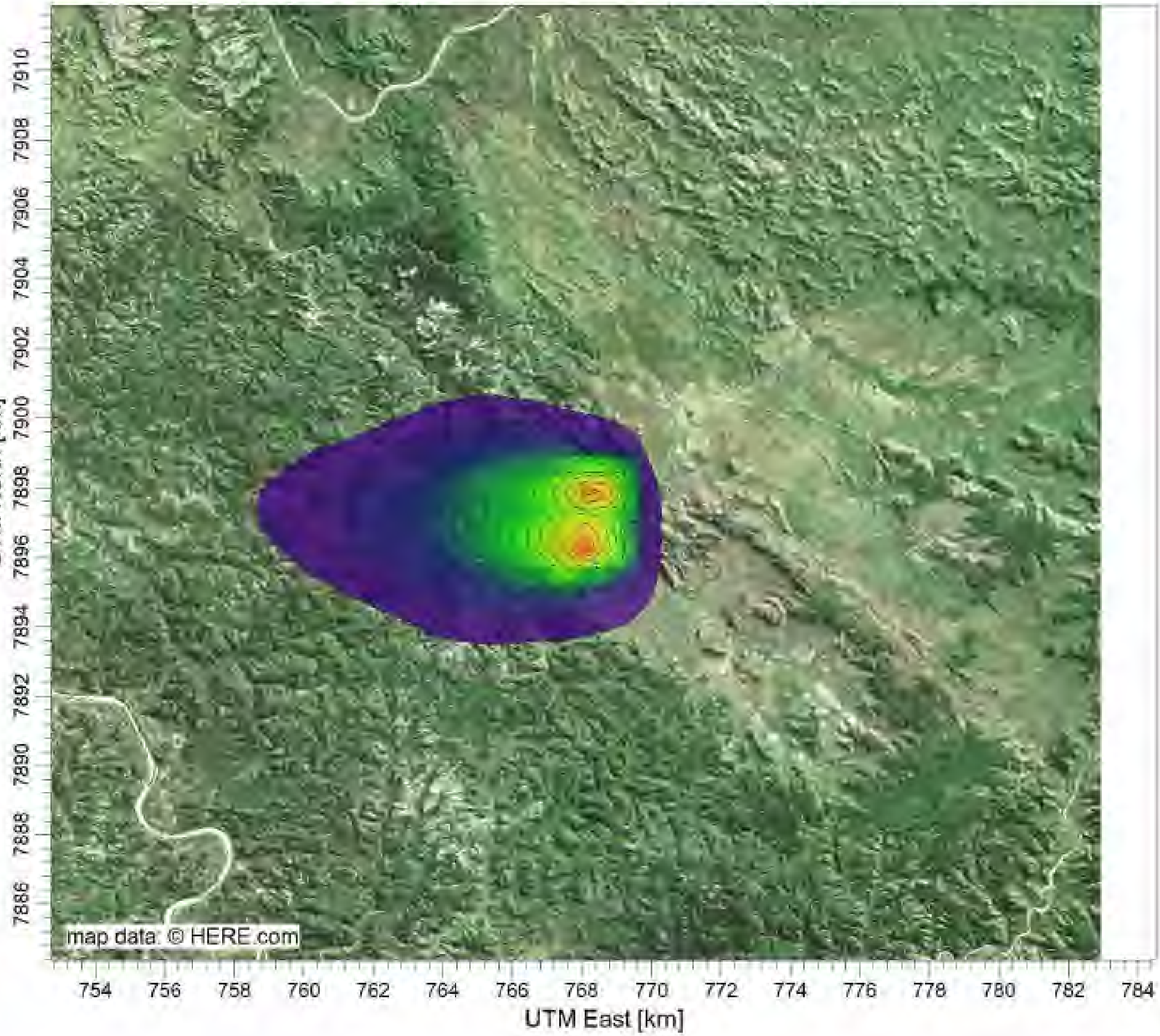
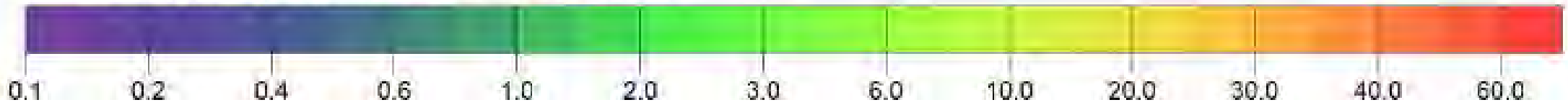


VALUE RUN LENGTH AVERAGE CONCENTRATION (TSP) ug/m**3

Max = 134.6 [ug/m**3] at (X = 767965.00, Y = 7896424.00)



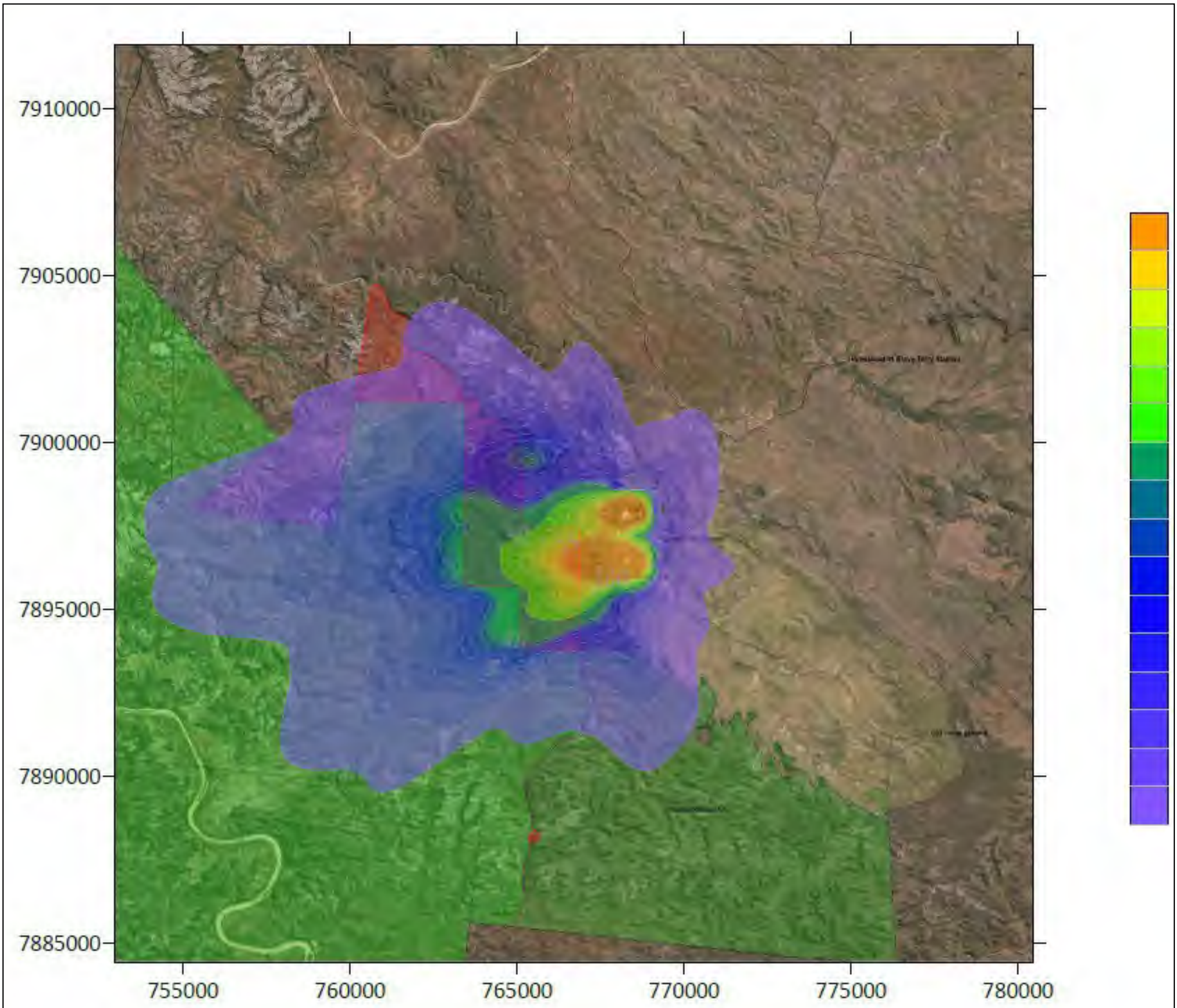
Client: Laneway Reources Ltd
Project number: 2021.08003
Coordinate Reference System: GDA 2020 Z54
Date: 1 June 2022

Print as A3

Figure 21. TSP Annual Average

Source: Simpson Engineering Group
Issued for Reporting

WUGUNU TECHNICAL SERVICES



Client: Laneway Reources Ltd
Project number: 2021.08003
Coordinate Reference System: GDA 2020 Z54
Date: 1 June 2022

Print as A3

Figure 22. Dust Deposition

Source: Simpson Engineering Group
Issued for Reporting

WULGURU TECHNICAL SERVICES

4.1.5. Management of Air Impacts

Modelling indicates that the AQO can be met during operation of the Agate Creek expansion. However, to further mitigate air emissions, the measures detailed in Table 22 are to be implemented.

Table 22. Dust Mitigation Measures (SEG, 2022).

Source	Mitigation Measure
Waste Material Dumping	Disturb the minimum area necessary for mining and rehabilitate promptly.
Haul Roads	Maintain haul roads in good condition and regular use of water truck. Use of chemical suppressants if haul roads become too slippery.
Other Roads	Keep road distances to a minimum and maintain in good condition and regular use of water truck. Only drive on prepared/designated roads
Management	The site Air Quality Management Plan is to include a reactive component. Active management strategies such as reduction dust mitigation when meteorological monitoring indicates favourable wind directions.
Landholder consultation	Consultation with potentially impacted landowners and negotiation of relevant mitigation measures.

4.1.5.1. Operating Hours

The Agate Creek is a 24-hour operation from Monday to Sunday. The mitigation measures discussed in Table 22 are proposed to be implemented to minimise the impacts throughout the ongoing operation.

4.1.5.2. Complaints

In the instance that a complaint is received in relation to air quality, an incident will be recorded and include details such as:

- Date;
- Time;
- Details of complainant;
- Reason for complaint;
- Investigations undertaken;
- Conclusions formed; and
- Actions taken.

Records of any complaints will be retained by LWR and made available for inspection on request by the administering authority. Corrective investigative measures may involve periodic monitoring of air emissions at the sensitive receiver to determine impact, and the implementation of mitigation measures.

4.1.5.3. Vehicle and Equipment Maintenance

Air quality impact mitigation and management strategies for vehicles and equipment will include the operation and maintenance of vehicles and equipment in accordance with the manufacturer's specifications. This includes avoiding excessive revving of engines, maintaining vehicles in good working order, and operating within normal business hours.

4.1.5.4. Operating Hours

Agate Creek is a 24-hour operation from Monday to Sunday (including road haulage of ore). The mitigation measures discussed throughout Section 4.1.5 are proposed to be implemented to minimise the impacts throughout the ongoing operation.

4.2. Noise Impacts

In preparing this application, consideration has been given to guideline *ESR/2015/1838 – Application requirements for activities with noise impacts* (Department of Environment and Science, 2017d). DES is required to assess the application against the requirements stated in the *Environmental Protection Act 1994*, EP Regulation and the Environmental Protection (Noise) Policy 2019 (EPP Noise) to meet the environmental objective and performance outcomes described below:

Environmental Objective

'The activity will be operated in a way that protects the environmental values of the acoustic environment.'

Performance Outcome

Sound from the activity is not audible at a sensitive receptor, or

The release of sound to the environment from the activity is managed so that adverse effects on environmental values, including health and wellbeing and sensitive ecosystems, are prevented or minimised.

RISK OF ENVIRONMENTAL IMPACT: LOW

4.2.1. Sensitive Places

The Schedule 1 of the EPP (Noise) details sensitive receivers of noise impacts. Noise sensitive receivers include:

- Residence dwellings;
- Library and educational institutions;
- Childcare centre or kindergarten;
- School or playground;
- Hospital, surgery or other medical institution;
- Commercial and retail activity;
- Protected area or critical area;
- Marine park; or
- Park or garden that is open to the public

The Project's sensitive receptors are identified in Table 23. The campground is currently used by people accessing the Agate Creek fossicking area. Homestead 01 (Dave Terry Station) is located 8km northeast of the Project. The next closest dwelling, Homestead 02, is approximately 25km northwest of the project.

Table 23. Sensitive Receptors

Receptors (Homesteads)	Distance (km)	Bearing (degrees)
Mine camp	1.9	175
Camping ground	1.5	120
Old campground	11	125
Homestead 01 (Dave Terry station)	8	55
Homestead 02	25	330
Forsyth	45	7

4.2.2. Description of Ambient Noise Levels

4.2.2.1. Acoustic Quality Objectives

Schedule 1 of the EPP (Noise) details the Acoustic Quality Objectives (AQO) to be achieved and maintained during operation of the Project. The applicable AQO to the Project are outlined in Table 24.

Table 24. Schedule 1 Acoustic Quality Objectives (EPP Noise)

Sensitive Receptor	Time of Day	Acoustic Quality Objectives (measured at the receptor) *dB(A)*			Environmental Value
		$L_{Aeq, adj, 1hr}$	$L_{A10, adj, 1hr}$	$L_{A1, adj, 1hr}$	
Residence (for outdoors)	Daytime and evening	50	55	65	Health and wellbeing
Residence (for indoors)	Daytime and evening	35	40	45	Health and wellbeing
	Night-time	30	35	40	Health and wellbeing, in relation to the ability to sleep
Library and educational institution (including a school, college and university) (for indoors)	When open for business or when classes are being offered	35			Health and wellbeing
Childcare centre or kindergarten (for indoors)	When open for business other than when the children usually sleep	35			Health and wellbeing
Childcare centre or kindergarten (for indoors)	When the children usually sleep	30			Health and wellbeing, in relation to the ability to sleep
School or playground (for outdoors)	When the children usually play outside	55			Health and wellbeing, and community amenity
Hospital, surgery or other medical institution (for indoors)	Visiting hours	35			Health and wellbeing
Hospital, surgery or other medical institution (for indoors)	Anytime, other than visiting hours	30			Health and wellbeing, in relation to the ability to sleep
Commercial and retail activity (for indoors)	When the activity is open for business	45			Health and wellbeing, in relation to the ability to converse
Protected area or critical area	Anytime	The level of noise that preserves the amenity of the existing area or place			Health and biodiversity of ecosystems
Marine park	Anytime	The level of noise that preserves the amenity of the existing marine park			Health and biodiversity of ecosystems
Park or garden that is open to the public (whether or not on payment of an amount) for use other than for sport or organised entertainment	anytime	The level of noise that preserves the amenity of the existing park or garden			Community amenity

The area is predominately rural and is without significant human activity. Background noise level measurements have not been undertaken.

4.2.3. Model Mining Conditions

The Queensland Guideline “Model Mining Conditions” (ESR/2016/1936) can be used as a basis for proposing environmental protection commitments in the application documents and used to expedite the process of developing appropriate conditions for an environmental authority for a mining project in consultation with the administering authority. Noise Limits for ESR/2016/1936 are detailed in Table 25.

Table 25. Noise Limits - ESR/2016/1936

Sensitive Place						
Noise Level dB(A) measured as:	Monday to Saturday			Sundays and Public Holidays		
	7am to 6pm	6pm to 10pm	10pm to 7am	7am to 6pm	6pm to 10pm	10pm to 7am
$L_{Aeq, adj, 15m}$	CV = 50 AV = 5	CV = 45 AV = 5	CV = 40 AV= 0	CV= 45 AV=5	CV = 40 AV = 5	CV = 35 AV = 0
$L_{A01, adj, 15m}$	CV=55 AV=10	CV=50 AV=10	CV=45 AV=5	CV=50 AV=10	CV=45 AV=10	CV=40 AV=5

4.2.4. Air Blast Overpressure Nuisance

The Queensland Guideline Model mining conditions (ESR/2016/1936) has limits for peak particle velocity and air blast overpressure from Blasting, described in Table D2 - Blasting noise limits (SEG, 2022). Blasting Noise Limits are outlined in Table 26.

Table 26. Blasting Noise Limits – ESR/2016/1936

Blasting Noise Limits	**Sensitive or commercial place limits** **Monday to Friday - 6 pm** **Saturday 6 am – 6 pm**	**Sundays and publicholidays**
Airblast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time	either no blasting or limits justified by proponent not lessstringent than 7am – 6pm
Ground vibrationpeak particle velocity	5mm/second peak particle velocity for 9out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	either no blasting or limits justified by proponent not lessstringent than 7am – 6pm

4.2.5. Sleep Disturbance

Sleep disturbance is a major effect of environmental noise due to the physiological and mental functioning effects for sensitive receptors (WHO, 1999). Ambient and maximum instantaneous noise levels at the ear of the sleeper and the number of events during the night-time period are directly related to the ability to sleep and the probability of experiencing a change of sleep state or awakening (WHO, 1999) (SEG, 2022).

As a rule, in planning for short-term or transient noise events, for good sleep over eight hours, the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45dBA maxLpA more than 10-15 times per night. The corresponding external noise level, assuming partially closed windows, is 52dBA maxLpA (LAmax), measured in the free field. For larger number of events per night, the noise level goal is reduced by 10*log(Number of events/10). Hence if there are 100 events per night (over an 8 hour period) the external noise level goal would become 42 dB(A) free field (SEG, 2022).

4.2.6. Low Frequency Noise

The DEHP Ecoaccess Guideline “Assessment of Low Frequency Noise” identifies industrial sources and processes often having high noise levels and frequency content less than 200 Hz which can result in annoyance to quiet sensitive receptors such as residences and offices (SEG, 2022)

Low frequency noise annoyance is to be avoided with the overall sound pressure level inside residencies not exceeding 50 dB (Linear) where noise emissions exhibit unbalanced frequency spectra (SEG, 2022).

4.2.7. Blasting Criteria

The Noise and Vibration guideline (ESR/2016/2169), specifies that blasting should generally be limited to the hours of 7:00 am to 6:00 pm. Blasting outside these recommended times should be approved only where:

a) blasting during the preferred times is clearly impracticable (in such situations blasts should be limited in number and stricter air blast overpressure and ground vibration limits should apply); or
b) there is no likelihood of persons in a noise-sensitive place being affected because of the remote location of the blast site (SEG, 2022).

Blasting activities must be carried out in such a manner that if blasting noise should propagate to a noise-sensitive place, then:

a) the air blast overpressure must be not more than 115 dB(linear) peak for 9 out of any 10 consecutive blasts initiated, regardless of the interval between blasts; and
b) the air blast overpressure must not exceed 120 dB(linear) peak for any blast (SEG, 2022).

Blasting operations must be carried out in such a manner that if ground vibration should propagate to a vibration-sensitive place:

a) the ground-borne vibration must not exceed a peak particle velocity of 5 mm per second for nine out of any 10 consecutive blasts initiated, regardless of the interval between blasts; and,
b) the ground-borne vibration must not exceed a peak particle velocity of 10 mm per second for any blast (SEG, 2022).

4.2.8. Summary of Noise and Vibration Goals

Based on the previous segments in Section 4.2, Table 27 provides a summary of the NQO relevant to the Project.

Table 27. Summary of Noise and Vibration Goals for the Project (SEG, 2022)

Location	Time Period	Monday to Saturday Mining		Sundays and Public Holidays Mining		Low Frequency Noise Limit [dB]	Blasting to Avoid Annoyance at Sensitive Receptors	
		$L_{Aeq, adj, 1 hr}$ [dB(A)]	$L_{A01, adj, 1 hr}$ [dB(A)]	$L_{Aeq, adj, 1 hr}$ [dB(A)]	$L_{A01, adj, 1 hr}$ [dB(A)]		Noise [dBLin Peak]	Vibration PPV [mm/s]
All Residential Receptors	Day	35	40	35	40	50	115 dB (Linear) Peak for nine out of ten consecutive blasts initiated and not greater than 120 dB(Linear) Peak at any time	5 mm/second peak particle velocity for nine out of ten consecutive blasts and not greater than 10 mm/second peak particle velocity at any time
	Evening	35	40	35	40	50		
	Night	33	38	33	38	50		
Commercial Receptors	Day	40	-	40	-	-		
	Evening	40	-	40	-			
	Night	38	-	38	-			

Note: No blasting to occur on Sundays or Public Holidays without notification to sensitive receptors.

4.2.9. Predicted Noise Impacts

SEG (2022) was engaged by WTS on behalf of LWR to conduct a Noise and Vibration Assessment based on the proposed activities. Results of the Noise and Vibration Assessment are detailed below.

4.2.9.1. Modelling Methodology

4.2.9.1.1. Digital Terrain Noise Model

SEG (2022) created a digital terrain noise model of the site and surroundings has been developed using PEN3D software General Prediction Model (GPM), based on the method contained in a book by Bies and Hansen (1998). The basic equation adopted by the GPM is:

$$Lp = Lw - 20\ log10(r) - 10log10(4\pi) + AE$$

Where:

Lp is the sound pressure level at an observer

Lw is the sound power level of the source, in octave bands from 63 Hz to 8 kHz

20 log10(r) + 10log10(4π) is the distance attenuation (spherical)

AE is the excess attenuation factors

The excess attenuation factors AE comprise:

$$AE = Aa + Ag + Am + Ab + Af$$

Where:

Aa = Excess attenuation due to air absorption from Sutherland *et. al*. (1974)

Ag = Excess attenuation due to ground reflection

Am = Excess attenuation due to meteorological effects

Ab = Excess attenuation due to barriers

Af = Excess attenuation due to forests.

The full report containing a detailed description of the methodology is provided in Appendix C.

4.2.9.1.2. Meteorology

Temperature Inversion

The total night-time period from June to August was analysed to determine the frequency of inversions It is known that temperature inversions are common night-time and early morning periods however, the likelihood inversions are reduced with wind speed. Inversion analysis is detailed in Table 28.

Table 28. Inversion Analysis June to August (6 pm to 7 am) (SEG, 2022).

Wind Speeds	Percentage of Time Occurring (%)
Calms	1
Winds less than 1 m/s	2
Wind 1 to 2 m/s	12
Wind 2 to 3 m/s	23
Wind 3 to 4 m/s	32
Wind 4 to 5 m/s	22
Wind over 5 m/s	10

Wind Effects

The wind direction and wind speeds were analysed to determine whether wind effects need to be considered. For this analysis, the wind speed was limited to 3 m/s since higher wind speeds tend to increase the ambient noise. Each season and each time period (day, evening and night) was analysed and winds were not found to occur more than 30 percent of the time in any direction. It is noted however than easterly winds are common throughout the year and as a consequence a single wind case at night has been included in the noise model. (SEG, 2022).

Meteorology Modelling Cases Assessed is detailed in Table 29.

Table 29. Meteorology Modelling Cases Assessed (SEG, 2022)

Case	Wind speed [m/s]	Wind Direction [degrees from North]	Vertical Temp Profile [ºC/100 m]	Air Temp [ºC]
Day	0	0	-3	25
Evening (Neutral)	0	0	0	15
Night (Inversion)	0	0	3	10
Night west wind	3	225	1	10

4.2.9.1.3. Noise Model Parameters

Main Noise Sources

SEG (2022) reviewed the equipment noise levels expected to be utilised at the Project based on similar mining projects (Table 30). The noise levels are expressed as a sound power level; the overall sound power levels are “A” weighted which emulates the way the human ear responds to sound (SEG, 2022). The main operational noise sources include:

- Loaders operation in the Pits;
- Dozers;
- Rock drill;
- Blasting;
- Dump trucks (in Pits); and
- Various surface earth working machines.

Table 30. Sound Power Level (Watts) ($L_{Aeq(1\ hr)}$) in dB(A) for Major Fleet

Fleet Item	SWL $L_{Aeq(1\ hr)}$ dB(A)	Number on Plant
Mining Excavator (Hitachi EX1800)	115	1
Haul Truck (CAT 789)	115	4
Dozer (CAT D10)	111	1
Grader (CAT 16M)	109	1
Water Truck (Komatsu HD785 Water Truck)	114	1
Production Drill	116	1
Diesel Generator	109	1

Blasting

SEG (2022) modelled the noise effected of blasting including the effects of meteorology using PEN3D. The equations were originally developed and verified for the Collinsville coal mine in Central Queensland. The basic equation for blast overpressure is:

dBL = 20*log(3557/0.00005) – 20*1.26*log(Distance) + 20*1.268 3* log(MIC) + 3

The proposed maximum instantaneous charge (MIC) weight is 1700 kg. For a MIC of 1700 kg, the blast overpressure at 1000 m is 120 dB Linear peak. (SEG, 2022).

For vibration, the peak particle velocity in mm/s is:

V = 2000 * (Distance/(MIC)^0.5)^-0.6

For the proposed MIC of 1700 kg, the peak vibration velocity at 1000 m is 12.2 mm/s (SEG, 2022).

4.2.9.2. Modelling Results

A noise model was developed for the fully operational Agate Creek expansion representing the peak noise emissions. Table 31 displays the calculated $LA_{eq(15\ min)}$ noise levels at the sensitive receptor for all modelling cases.

Table 31. Predicted Noise Level at Sensitive Receptors (SEG, 2022).

Location	Time Period	Monday to Saturday Mining Noise		Sundays and Public Holidays Mining Noise		Low Frequency Noise [dB]	Blasting to Avoid Annoyance at Sensitive Receptors	
		$L_{Aeq, adj, 1 hr}$ [dB(A)]	$L_{A01, adj, 1 hr}$ [dB(A)]	$L_{Aeq, adj, 1 hr}$ [dB(A)]	$L_{A01, adj, 1 hr}$ [dB(A)]		Noise [dBLin Peak]	Vibration PPV [mm/s]
Acoustic Quality Objective - All Residential Receptors	Day	**35**	**40**	**35**	**40**	**50**	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB(Linear) Peak at any time	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time
	Evening	**35**	**40**	**35**	**40**	**50**		
	Night	**30**	**35**	**30**	**35**	**50**		
Acoustic Quality Objective - Commercial Receptors	Day	**40**	-	**40**	-	-		
	Evening	**40**	-	**40**	-			
	Night	**35**	-	**35**	-			
Homestead 01	Day	<thh	<thh	<thh	<thh	18	100	0.05
	Evening	8	12	8	12	20	-	-
	Night	18	23	18	23	36	-	-
	Night (with wind)	21	26	21	23	338	-	-
Old campground	Day	<thh	<thh	<thh	<thh	18	98	0.05
	Evening	<thh	<thh	<thh	<thh	17	-	-
	Night	16	20	16	20	30	-	-
	Night (with wind)	20	27	20	27	32	-	-

Note: <thh represents a noise level below the threshold of human hearing.

Results of modelling indicate that:

- The noise from the operation of Agate Creek is expected to readily comply with the proposed operational environmental goals at all sensitive receptors.
- The blast over pressure and blast vibrations from the blasting at the mine (MIC of 1700kg) is expected to readily comply with the proposed environmental goals all sensitive receptors.
- The low frequency noise from the operation of the mine is expected to comply with the proposed environmental goals at all sensitive receptors (SEG, 2022).

4.2.10. Noise Mitigation

Based on the modelling results, SEG (2022) recommended that the Project implements normal practices to maintain all equipment in good serviceable condition and it is not necessary to provide any further mitigation measures. As such, this section details the proposed mitigation and management strategies to further decrease the noise and vibrations.

4.2.10.1. Complaints

In the instance that a complaint is received in relation to noise quality, an incident will be recorded and include details such as:

- Date;
- Time;
- details of complainant;
- reason for complaint;
- investigations undertaken;
- conclusions formed; and
- actions taken.

Records of any complaints will be retained by LWR and made available for inspection on request by the administering authority. Corrective investigative measures may involve periodic monitoring of air emissions at the sensitive receiver to determine impact, and the implementation of mitigation measures.

4.2.10.2. Vehicle and Equipment Maintenance

Noise quality impact mitigation and management strategies for vehicles and equipment will include the operation and maintenance of vehicles and equipment in accordance with the manufacturer's specifications. This includes avoiding excessive revving of engines, maintaining vehicles in good working order, and operating within normal business hours.

4.3. Land Impacts

In preparing this application, consideration has been given to guideline *ESR/2015/1839 – Application requirements for activities with impacts to land* (Department of Environment and Science, 2017b). DES is required to assess the application against the requirements stated in the *Environmental Protection Act 1994* and the EP Regulation to meet the environmental objective and performance outcomes described below:

Environmental Objective

'The activity is operated in a way that protects the environmental values of land including soils, subsoils, landforms and associated flora and fauna.'

Performance Outcome

There is no actual or potential disturbance or adverse effect to the environmental values of land as part of carrying out the activity, or

All of the following:

(a) activities that disturb land, soils, subsoils, landforms and associated flora and fauna will be managed in a way that prevents or minimises adverse effects on the environmental values of land, and

(b) areas disturbed will be rehabilitated or restored to achieve sites that are:

I. safe to humans and wildlife;

II. non-polluting;

III. stable; and

IV. able to sustain an appropriate land use after rehabilitation or restoration.

(c) the activity will be managed to prevent or minimise adverse effects on the environmental values of and due to unplanned releases or discharges, including spills and leaks of contaminants.

(d) the application of water or waste to land is sustainable and is managed to prevent or minimise adverse effects on the composition or structure of soils and subsoils.

RISK OF ENVIRONMENTAL IMPACT: MEDIUM

4.3.1. Overview of Land Impacts

Impacts to land will occur as a result of the Agate Creek expansion. The establishment of the mining footprint (Figure 3) will involve the clearing and grubbing of vegetation, the stripping of topsoil, as well as the establishment of the open cut pit and other ancillary infrastructure. Expected land disturbance is included in Table 32.

Table 32. Expected Land Disturbance

Mine Domain	Estimated Disturbance Area (Ha)	Type of Disturbance
Open Cut Pits		
Pit 1	1.37	Vegetation clearing and mining.
Pit 2	1.03	
Pit 3	0.49	
Pit 4	0.94	
Pit 5	0.64	
Pit 6	4.46	
Waste Rock Dump		
N WRD	5.88	Vegetation clearing, cut and fill, waste rock disposal, Topsoil storage
NW WRD	5.61	
SW WRD	3.04	
S WRD	11.35	
Water Management		
Water Storage Dam (MAW Dam)	4.50	Vegetation clearing, excavation of material, bund construction
Sediment Pond A	0.21	
Sediment Pond B	0.15	
Sediment Pond C	0.34	
Sediment Pond D	0.43	
Sediment Pond E	0.28	
Sediment Pond F	0.34	
Sediment Pond ROM	0.24	
Mine Infrastructure Areas		
ROM Pad	0.4	Vegetation clearing, cut and fill
Haul Roads	4.79	
Total (Estimate)	46.49	-

4.3.2. Acid Producing Rock

4.3.2.1. Waste Rock Characterisation

C&R Consulting (2022) has conducted a geochemical waste rock characterisation (WRC) assessment of Agate Creek waste rock. The WRC incorporated the collection of samples from regular intervals (i.e., every 3 m) at drillholes across the proposed 6 pits. These drillholes were chosen to represent a cross-section of the rock profile in each proposed open-cut pit. A total of 260 rock samples were collected from 27 drill holes.

All 260 samples dispatched to the ALS laboratory underwent static & kinetic geochemical testing to evaluate the risk associated with the potential oxidation of sulphides, acid generation, and the presence of metals/metalloids and salts. Sample hole IDs and locations are detailed in in Table 33, Sampling locations within the pits are displayed on Figure 23 to Figure 28.

Table 33. Summary of Samples Taken Across the Proposed Pits (C&R Consulting, 2022)

Proposed pit	Waste tonnes	Number of holes	Hole ID	Number of samples	Number of samples/pit
Pit 1	750,195	4	CCGC338	7	22
			CCGC339	1	
			CCGC340	7	
			CCGC341	7	
Pit 2	348,570	3	CCGC321	9	22
			CCGC343	7	
			CCGC344	6	
Pit 3	51,627	2	CCGC323	5	14
			CCGC324	9	
Pit 4	229,591	5	CCGC316	9	34
			CCGC319	11	
			CCGC345	7	
			CCGC346	1	
			CCGC347	6	
Pit 5	57,318	2	CCGC326	7	18
			CCGC329	11	
Pit 6	2,236,780	11	CCGC302	3	150
			CCGC303	9	
			CCGC306	11	
			CCGC308	11	
			CCGC309	1	
			CCGC311	21	
			CCGC334	6	

Proposed pit	Waste tonnes	Number of holes	Hole ID	Number of samples	Number of samples/pit
			CCGC336	1	
			CCGC349	14	
			CCGC354	25	
			CCGC356	48	
Total	**3,3774,081**	**27**	**-**	**260**	**260**

4.3.2.2. Static Analysis

Static geochemical tests provide information on waste rock characteristics at a single point in time (C&R Consulting, 2022). Each sample (Table 33) underwent static geochemical testing for:

- pH;
- Electrical conductivity (EC);
- Total sulphur;
- Acid neutralising capacity (ANC);
- Net acid generation (NAG);
- Net acid production potential (NAPP);
- Major dissolved anions for Cl, F and SO4; and
- Total metals/metalloids (Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, V and Zn).

4.3.2.3. Kinetic Analysis

Kinetic leach column (KLC) tests accelerate the weathering of samples and provide information on the magnitude and/or effects of dynamic processes that result from weathering. Unlike static tests, KLC tests measure the varying geochemical characteristics of sample effluent over a prolonged period of time (C&R Consulting, 2022).

Four samples were dispatched to a NATA-accredited laboratory for KLC tests: one from Pit 1, one from Pit 4 and two from Pit 6. These large KLC samples (>25 kg) represent a considerable proportion of the waste rock profile of each pit.

Each kinetic leachate column underwent kinetic geochemical testing for:

- pH;
- EC;
- Total dissolved solids (calculated);
- Hardness;
- Acidity;
- Alkalinity;
- Major cations for Ca, Mg, Na and K;
- Major anions for Cl, F and SO4; and
- Dissolved metals/metalloids for (Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Mo, Mn, Ni, Pb, Sb, Se, Te, Th, U, V and Zn).

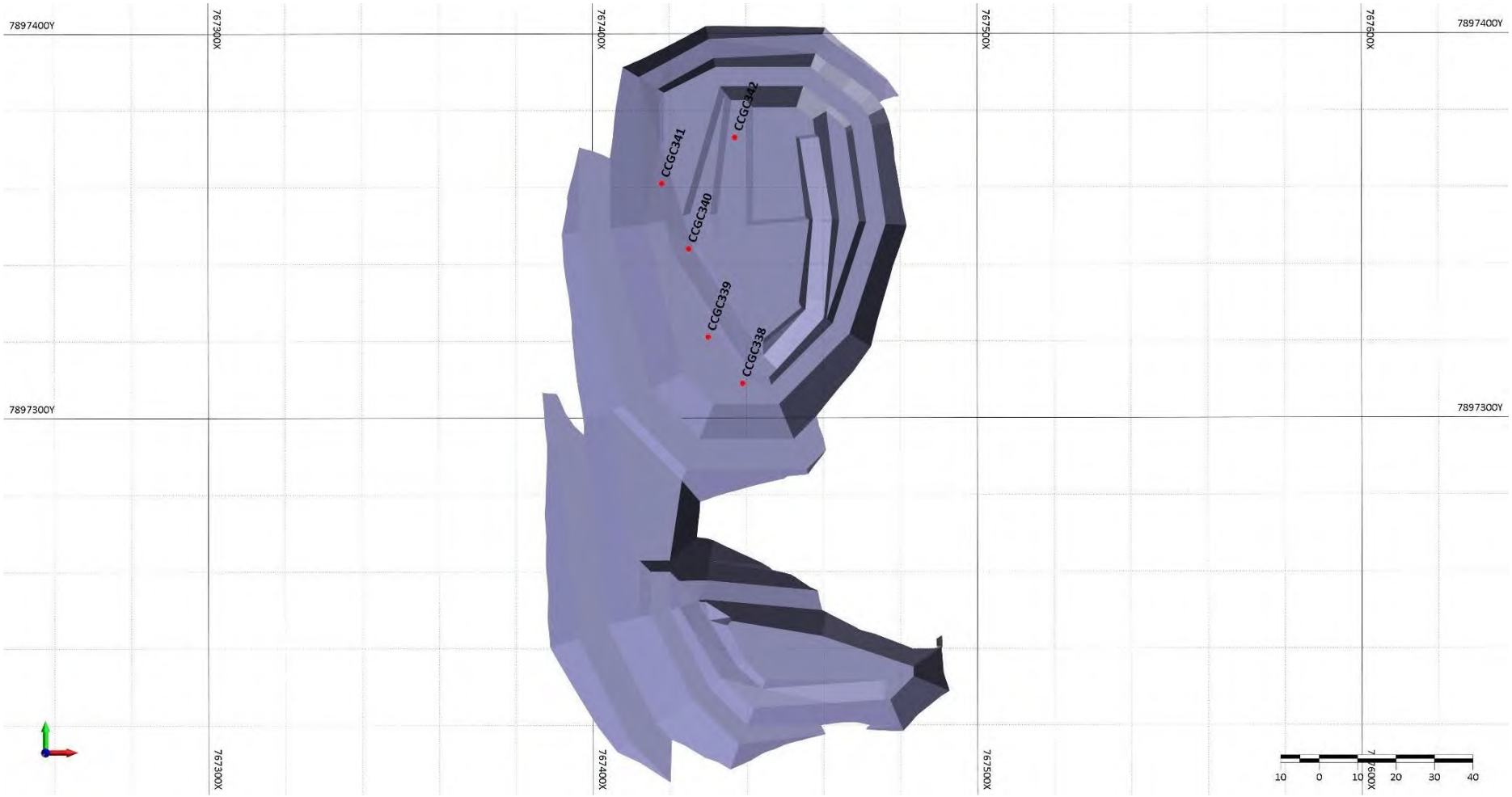


Figure 23. Location of Exploration Drill Holes Sampled in Pit 1 (Laneway Resources Limited, 2022)

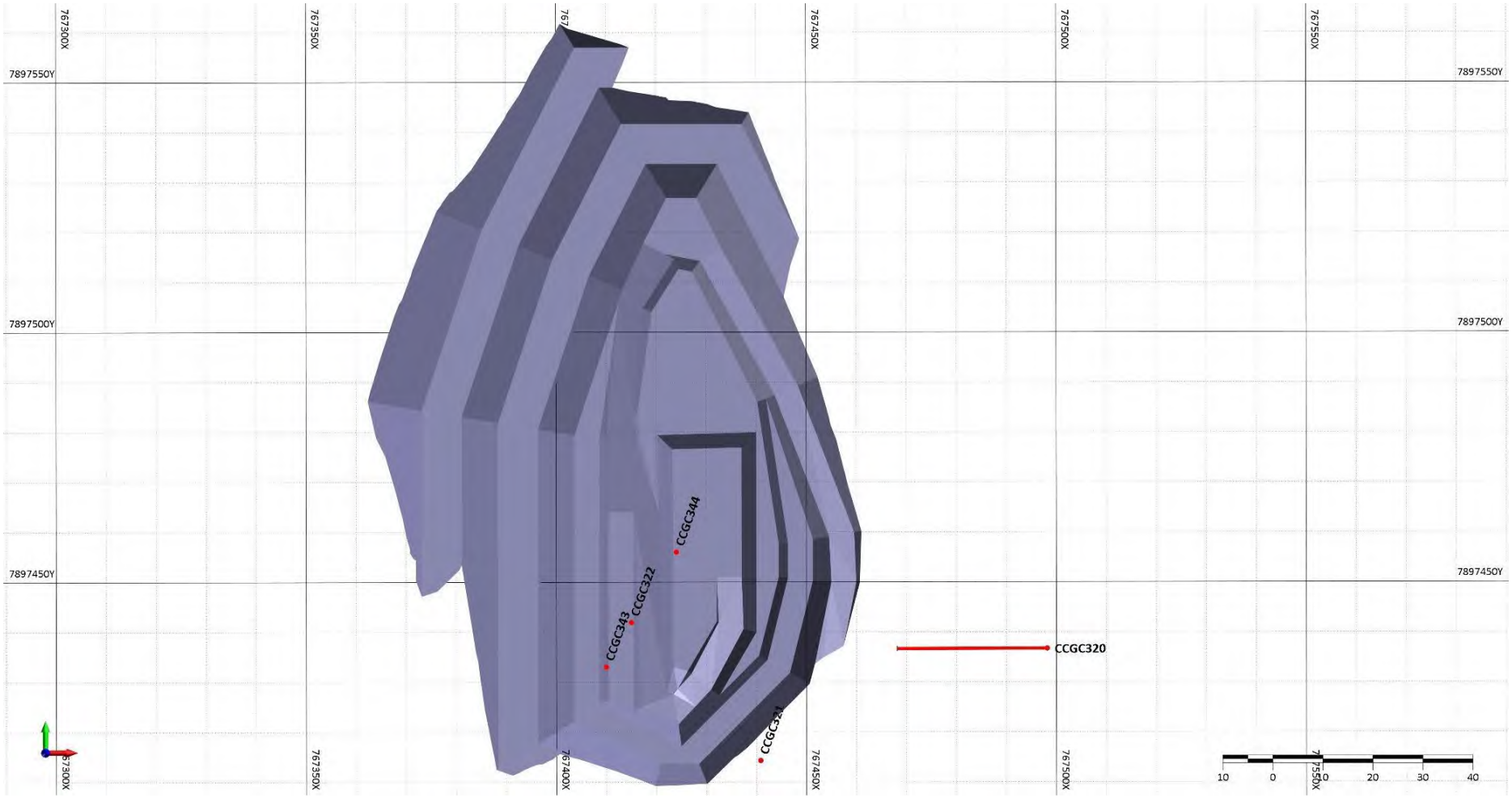


Figure 24. Location of exploration drill holes sampled in Pit 2 (Laneway Resources Limited, 2022)

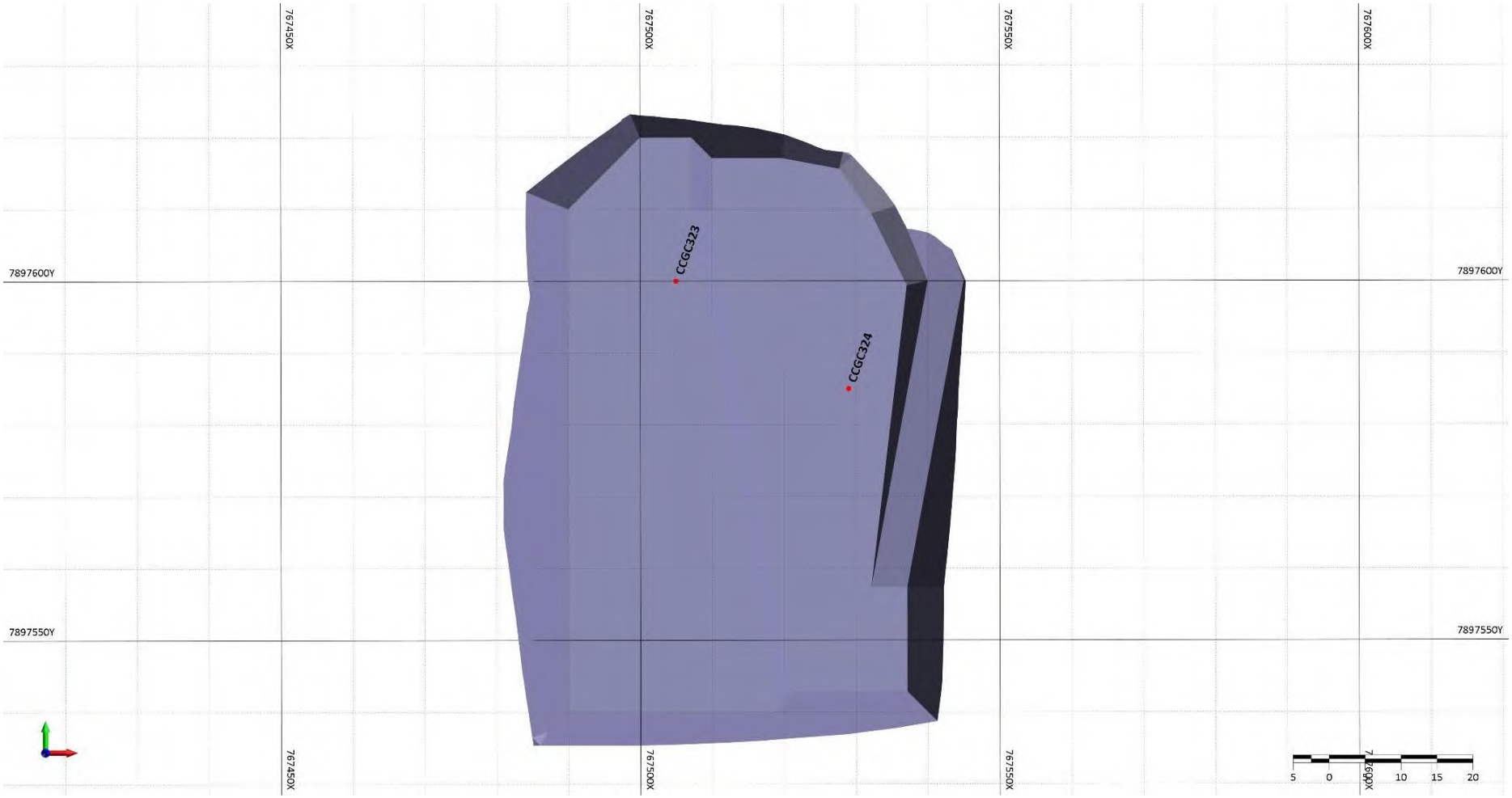


Figure 25. Location of exploration drill holes sampled in Pit 3. (Laneway Resources Limited, 2022)

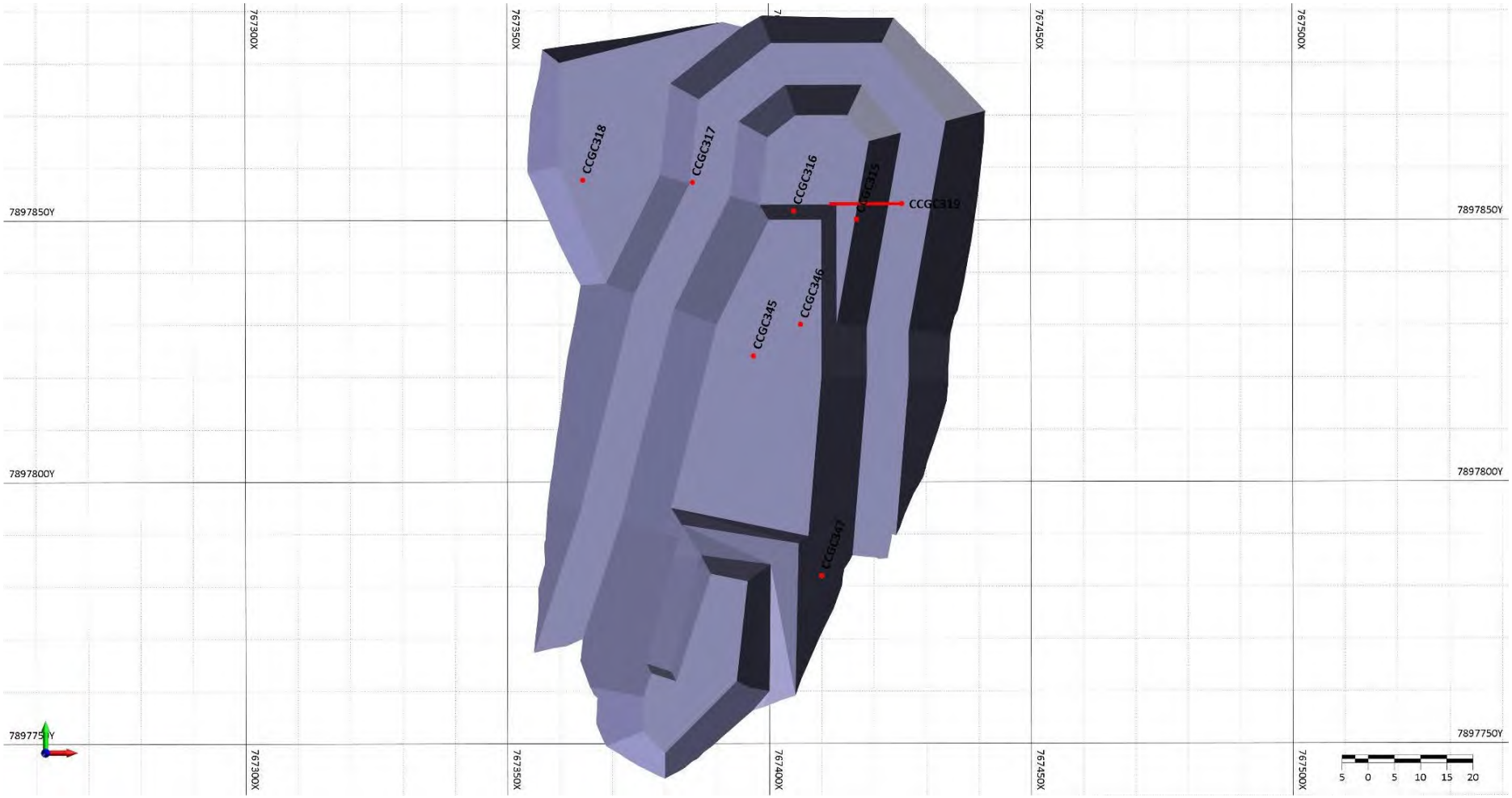


Figure 26. Location of exploration drill holes sampled in Pit 4.

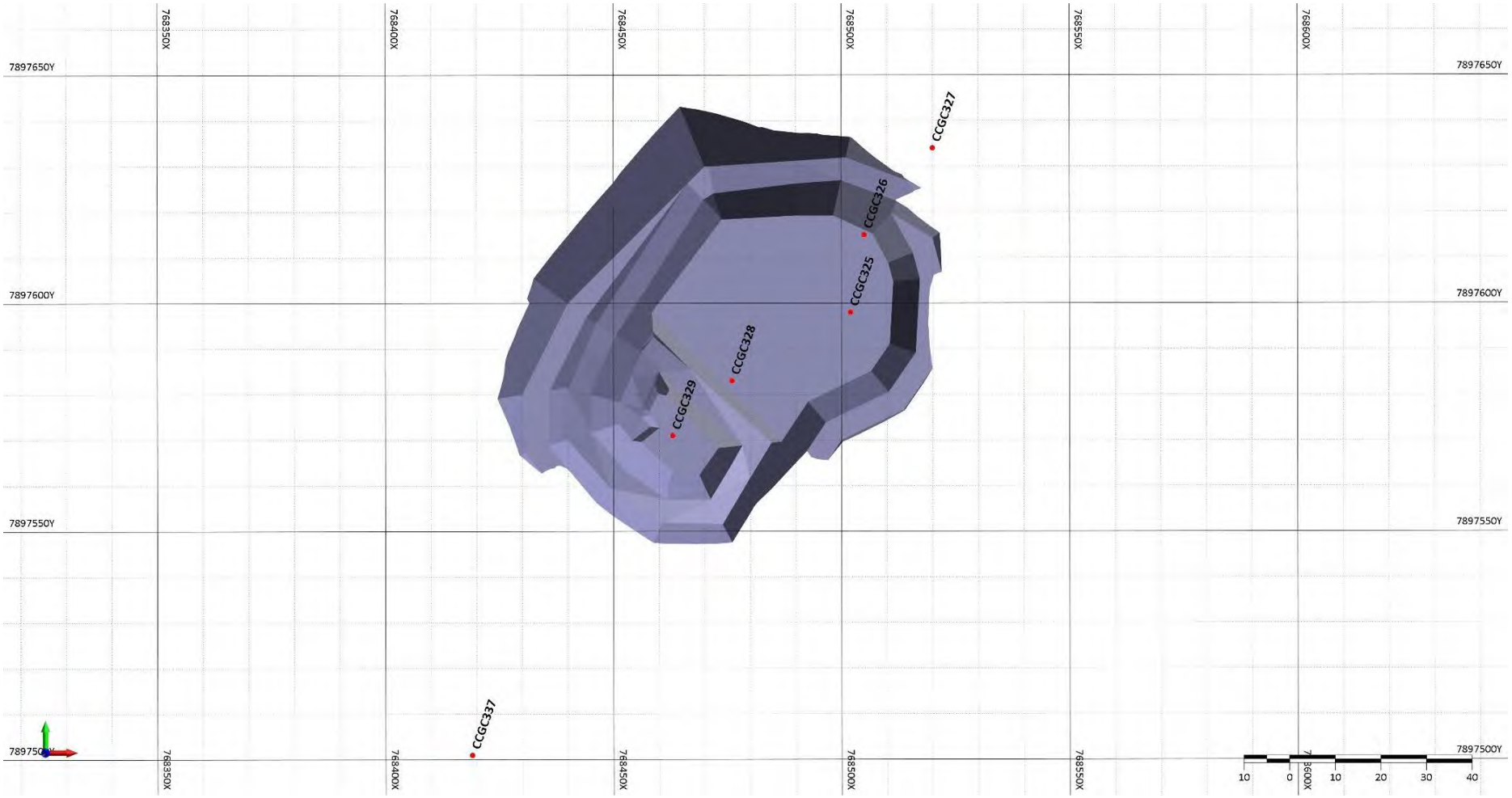


Figure 27. Location of exploration drill holes sampled in Pit 5.

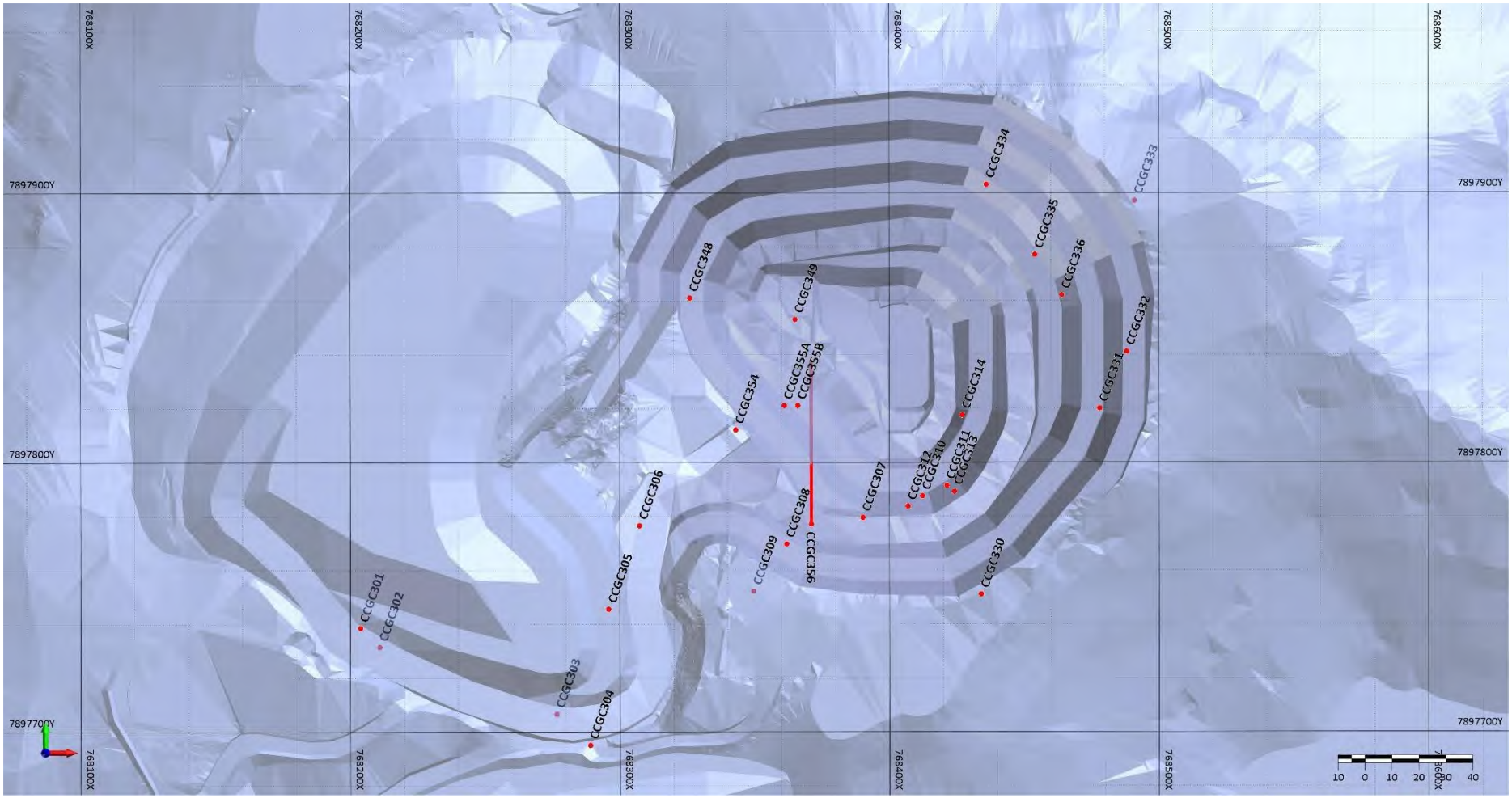


Figure 28. Location of exploration drill holes sampled in Pit 6.

4.3.2.4. Acid Base Account Results

4.3.2.4.1. pH Value

The majority of the samples were in the neutral range, however, slightly acidic samples were prevalent, indicative of the waste rock lithology. Of the 260 waste rock samples, the median pH value was 6.7pH (neutral) with values ranging from 4.5pH (slightly acidic) to 8.8pH (slightly basic) (Figure 29).

It is noted that both low and high pH results in the waste rock are expected to be a worst case scenario due to the laboratory methods (fluid extract from crushed samples with a very high surface area to solution ratio). Further, for significant runoff to occur at Agate Creek, the expected rainfall dilution factor would be greater than 1:5 (sample:water) ratio utilised in analysis thus counteracting the resulting acidity or alkalinity. (C&R Consulting, 2022).

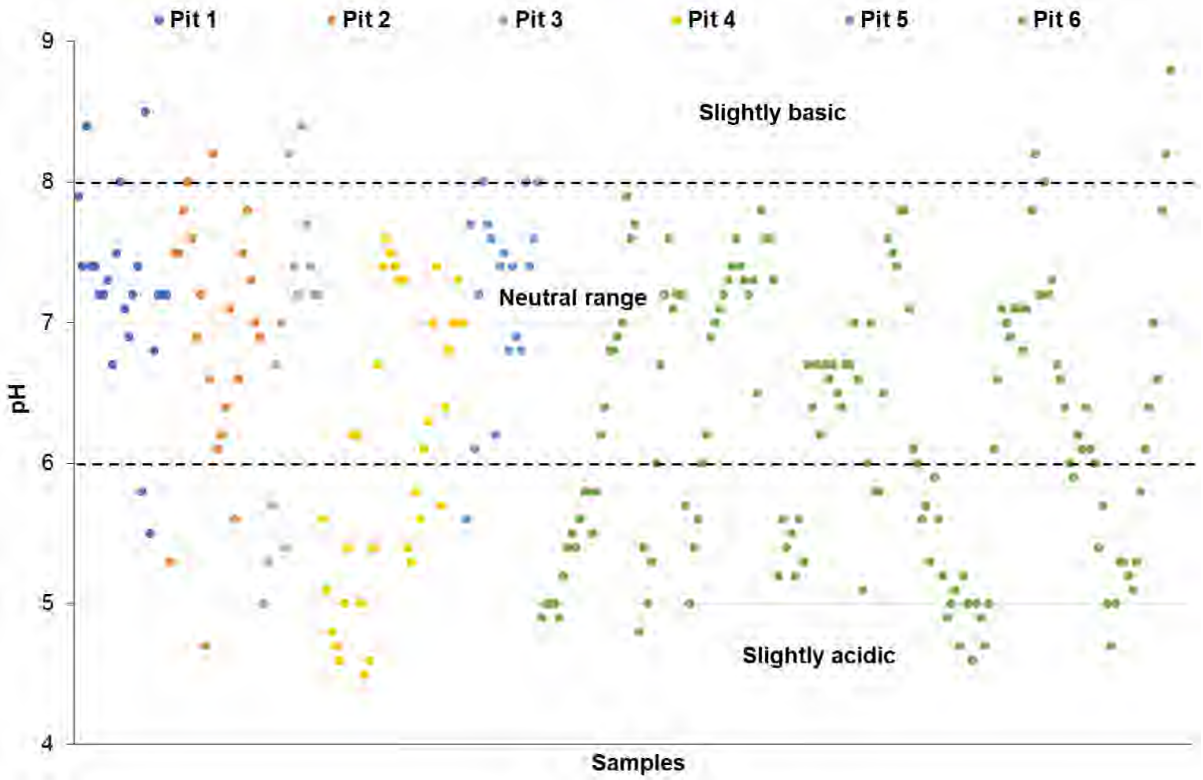


Figure 29. pH Values for Agate Creek Waste Rock Samples (C&R Consulting, 2022)

4.3.2.4.2. Electrical Conductivity

Majority of the waste rock samples have low electrical conductivity (EC) values (<300 µS/cm). The results ranges from 7 µS/cm to 1,680 µS/cm with a low median of 43.5 µS/cm. With the exception of an outlier from Pit 2 (1,680 µS/cm), all EC results were below 500 µS/cm (C&R Consulting, 2022).

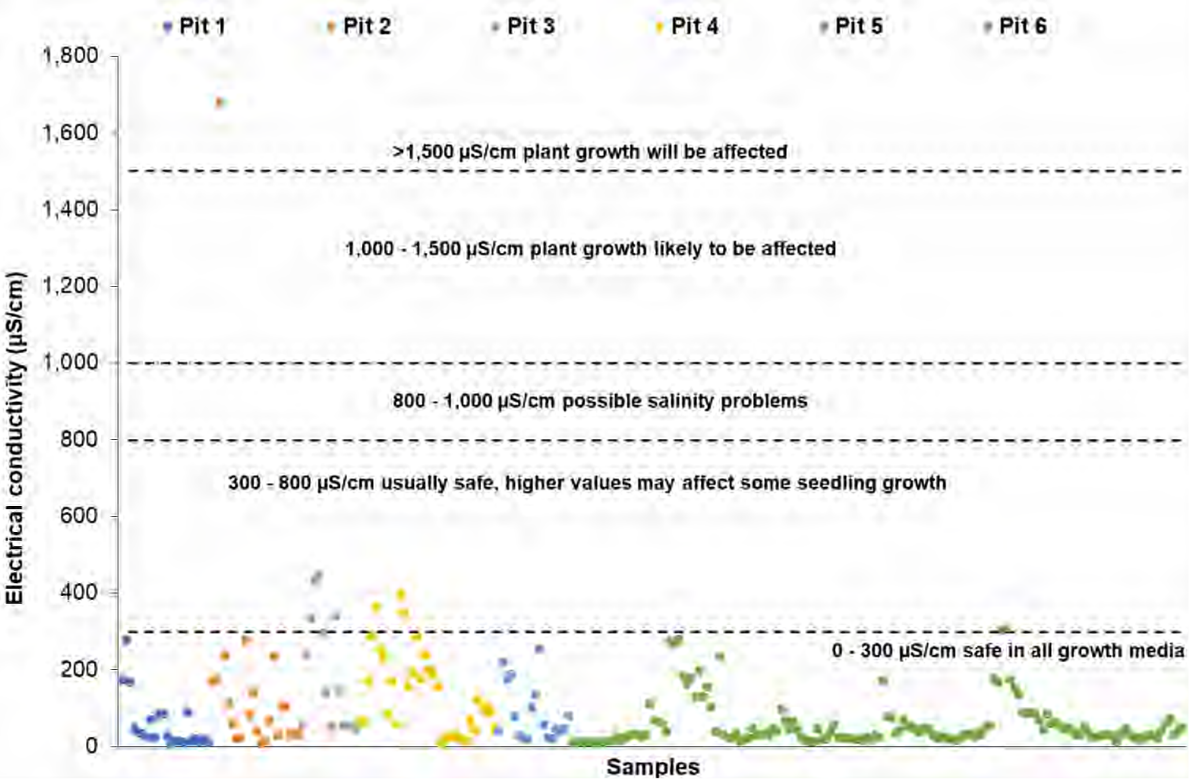


Figure 30. Electrical Conductivity for Agate Creek Waste Rock Samples (C&R Consulting, 2022).

4.3.2.4.3. Total Sulphur

Sulphur levels measured in the waste rock samples were extremely low with majority of the samples being below the limit of reporting (<0.01%) with the one outlier being 3.05%. As such, majority of the waste rock is considered barren with respect to total sulphur (C&R Consulting, 2022).

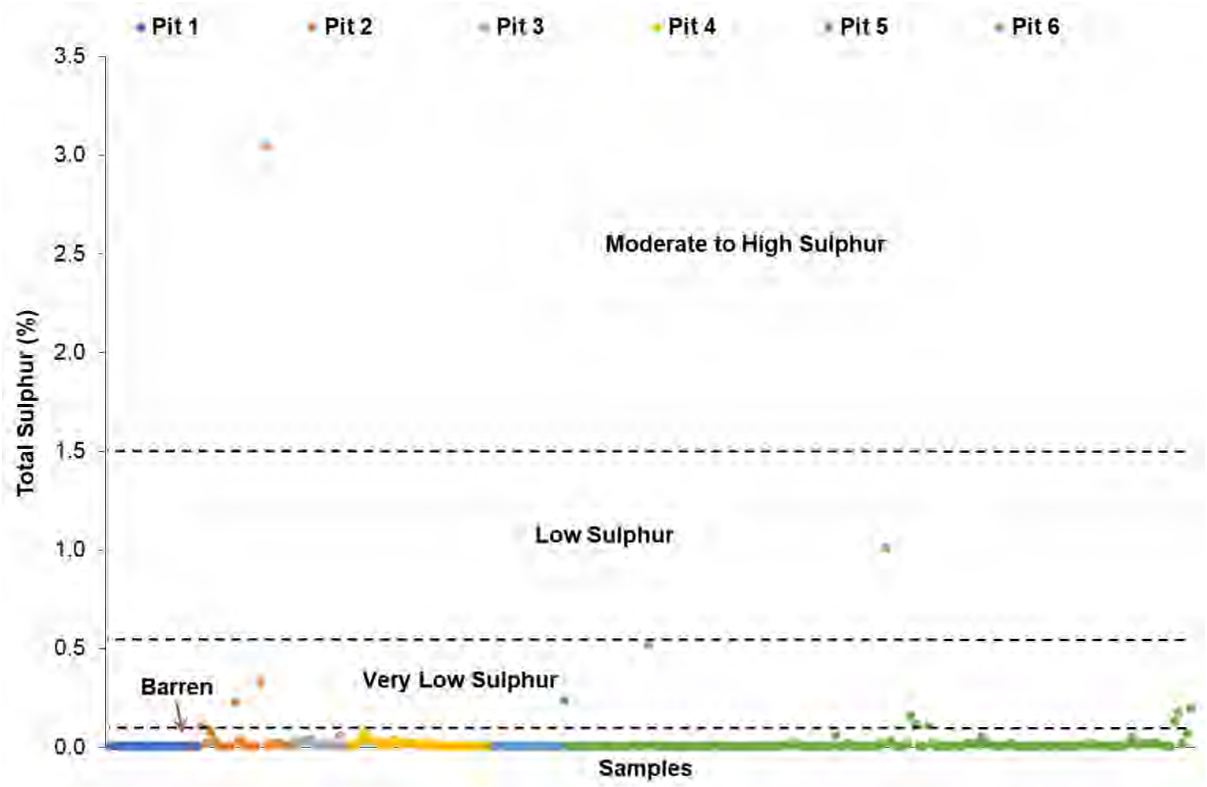


Figure 31. Total Sulphur Concentration for Agate Creek Waste Rock Samples (C&R Consulting, 2022).

4.3.2.4.4. Maximum Potential Acidity

Maximum Potential Acidity (MPA) is the maximum amount of acid that can be produced by the oxidation of sulphur-bearing minerals in the waste rock material. MPA is calculated from the total sulphur content. The MPA – that could be generated by the 260 Agate Creek waste rock samples – ranges from 0.15 to 93.3 kg H_2SO_4/t and has a low median value of 0.15 kg H_2SO_4/t. (C&R Consulting, 2022).

4.3.2.4.5. Acid Neutralising Capacity

Acid Neutralising Capacity (ANC) is related to the amount of acid neutraliser (usually carbonate minerals) in the waste rock sample. ANC is determined experimentally by reacting a standardised acid mixture with a known amount of waste rock sample – and is reported as kg H_2SO_4/t eq. (equivalent). The ANC of the 260 Agate Creek waste rock samples ranges from 0.25 to 28.0 kg H_2SO_4/t eq., with a low median of 3.0 kg H_2SO_4/t eq. (C&R Consulting, 2022).

4.3.2.4.6. ANC:MPA Ratio

The ANC:MPA ratio can assist in classifying the potential for waste rock samples to generate acid. The low and negligible risk samples contain more acid-neutralising than acid-generating minerals, whereas the potential and increased risk samples contain more acid-generating than acid-neutralising minerals. To summarise the Agate Creek waste rock sample ANC:MPA ratio results:

- 204 samples are considered to be of negligible to low risk;
- 41 samples are deemed to be a potential risk; and

- 15 samples are regarded as an increased risk.

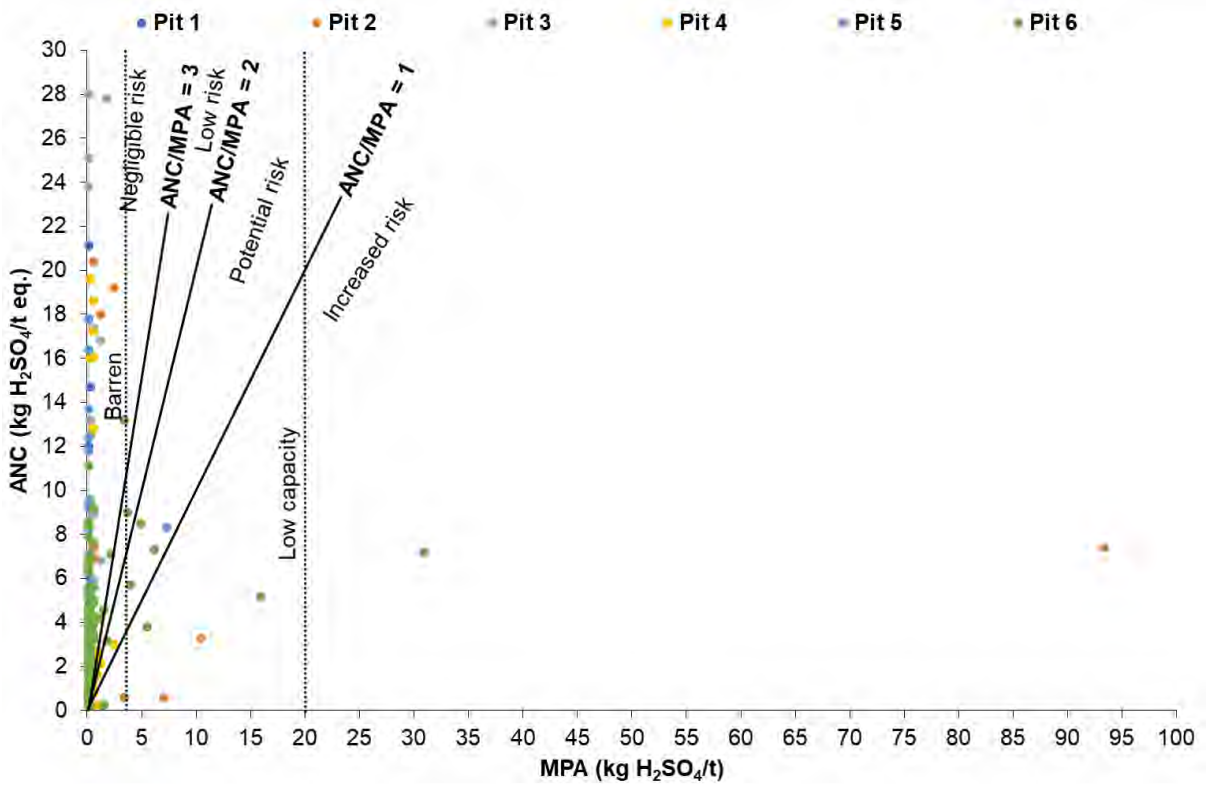


Figure 32. ANC:MPA Results for Agate Creek Waste Rock Samples.

4.3.2.4.7. Net Acid Production Potential (NAPP)

NAPP is a theoretical calculation of the net acid producing (or consuming) value of a rock sample. The NAPP values provide classify the acid forming potential of a material (C&R Consulting, 2022).

Table 34. NAPP Classification Categories (C&R Consulting, 2022; Miller, 1997).

ARD Classification	NAPP Value (kg H_2SO_4/t)
Potentially Acid Forming (PAF)	>10
Uncertain	0 to 10
Non-Acid Forming (NAF)	-50 to 0
Acid Consuming Material	< -50

Of the 260 waste rock samples, 45 have positive NAPP values. However, most of these positive samples are in the uncertain range, with only three samples having values greater than 10. These are associated with either Pit 2 or Pit 6 (C&R Consulting, 2022).

4.3.2.5. Net Acid Generation Results

NAG analysis is used to measure the net amount of acid produced by a waste rock sample. Samples with a NAG(pH) (oxidised pH) below 4.5 may be acid generating. Samples with a NAG(pH) equal or greater than 4.5 (≥4.5) are unlikely to be acid producing (C&R Consulting, 2022).

The majority of Agate Creek waste rock samples have a NAG(pH) greater than 4.5pH and a NAPP value below 0. Five sample has a negative NAPP value and NAG (pH) below 4.5 pH. Several samples have NAPP values slightly above 0 that coincide with NAG(pH) in excess of 4.5 pH. These are classified as uncertain PAF. Six samples are PAF, with a NAG(pH) less than 4.5 pH and a positive NAPP value (C&R Consulting, 2022).

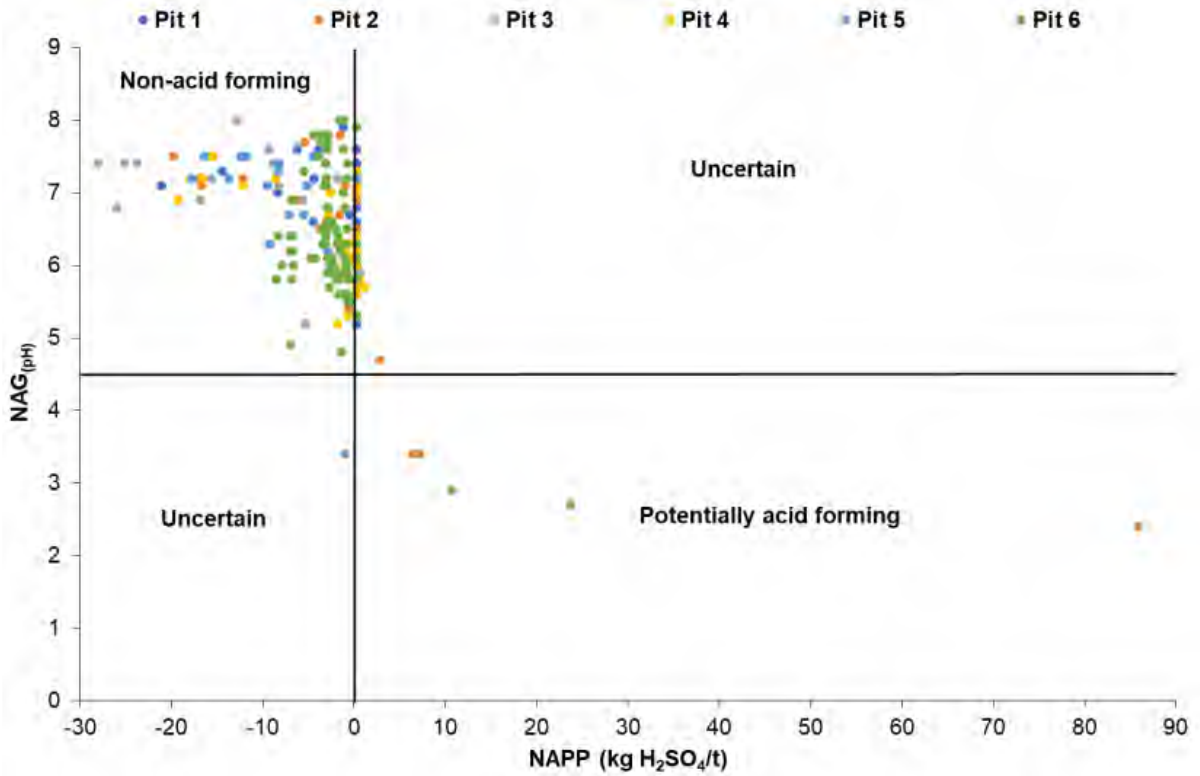


Figure 33. NAG(pH) Versus NAPP for Agate Creek Waste Rock Samples (C&R Consulting, 2022).

NAG(pH) versus total sulphur geochemical classification criteria for the waste rock samples is presented in Table 35 and shows that the majority of waste rock is NAF.

Table 35. Geochemical classification criteria for Agate Creek waste rock samples (C&R Consulting, 2022).

Geochemical Classification	Total Sulphur (%)	NAG (pH)	Pit 1	Pit 2	Pit 3	Pit 4	Pit 5	Pit 6
NAF (barren)	≤0.1	-	22	18	14	34	17	142
NAF (very low sulphur)	>0.1 to ≤0.55	≥ 4.5	0	1	0	0	0	1
NAF (low sulphur)	0.55 to 1.5	≥ 4.5	0	0	0	0	0	0
PAF (very low sulphur)	0.1 to ≤0.55	< 4.5	0	2	0	0	1	6
PAF (low sulphur)	0.55 to 1.5	< 4.5	0	0	0	0	0	1

Geochemical Classification	Total Sulphur (%)	NAG (pH)	Pit 1	Pit 2	Pit 3	Pit 4	Pit 5	Pit 6
PAF (moderate to high sulphur)	>1.5	< 4.5	0	1	0	0	0	0
Percentage of NAF samples			100%	86.4%	100%	100%	94.4%	95.3%
Percentage of very low sulphur PAF samples			0%	9.1%	0%	0%	6%	4.0%
Percentage of low sulphur PAF samples			0%	0%	0%	0%	0%	0.7%
Percentage of moderate to high sulphur PAF samples – actionable levels			0%	4.5%	0%	0%	0%	0%

Of the 260 Agate Creek waste rock samples, only six samples could be categorised as PAF:

- Three samples in Pit 2;
- One sample in Pit 5; and
- Seven samples in Pit 6.

However, these samples make up less than 14% of total samples and sulphur values are still very low to low (with the exception of Pit 2). It is therefore expected that only one of these six samples presents an acid drainage issue because:

- The amount of produced acid would be negligible; and
- Any acid produced by the samples will be buffered by the surrounding NAF rock that makes up more than 90% of the waste rock.

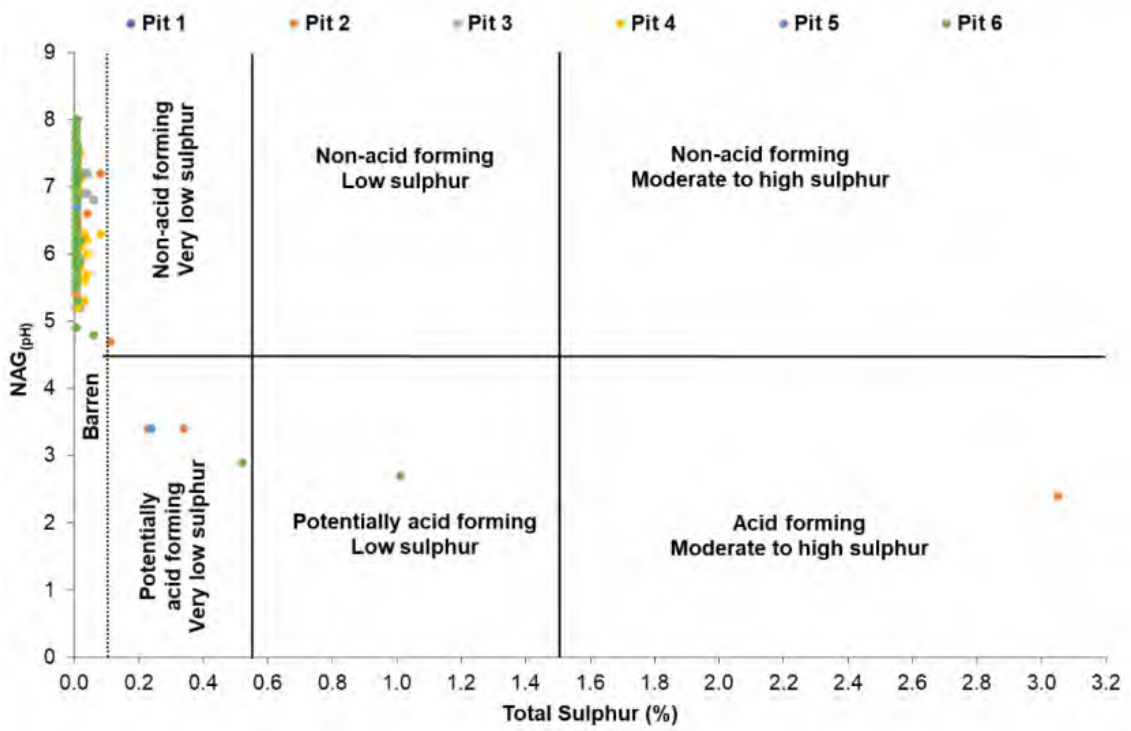


Figure 34. NAG(pH) versus sulphur for Agate Creek waste rock samples.

4.3.2.6. Metal/Metalloid Analyses

Static multi-element scans were undertaken to assess natural background elemental levels, and to identify if any elements (particularly metals and metalloids) are present in the waste rock at concentrations that may be of environmental concern with respect to revegetation and water quality. Results are detailed below.

4.3.2.6.1. Geochemical Abundance Index

Total metal and metalloid concentrations have been compared against average crustal abundance of unmineralised soils (INAP, 2014). The geochemical abundance index (GAI) elemental enrichment, by relating actual concentration in a sample with the average crustal abundance on a $\log_2$ scale (C&R Consulting, 2022). Results of the multi-element scans and GAIs is provided in Table 37.

Table 36. Geochemical abundance index classification categories (C&R Consulting, 2022)

GAI	Enrichment Factor	Classification
<1	Less than 3-fold enrichment	Not enriched
1	3- to 6-fold enrichment	Not enriched
2	6- to 12-fold enrichment	Slightly enriched
3	12- to 24-fold enrichment	Significantly enriched
4	24- to 48-fold enrichment	Significantly enriched
5	48- to 96-fold enrichment	Highly enriched
6	Greater than 96-fold enrichment	Highly enriched

Table 37. Multi-Element Analyses, Results and Geochemical Abundance Indices for Agate Creek Waste Rock Samples (C&R Consulting, 2022)

Element	Unit	Limit of reporting	ACA	n	N#	Statistics			Guideline	GAI Statistics			
						Min.	Median	Max.	HIL~ Recreational C'	Min. GAI	Median GAI	Max. GAI	Number of GAIs ≥3
Aluminium	mg/kg	50	82,000	260	260	380	1,300	41,000	-	0	0	0	0
Antimony	mg/kg	0.1	0.2	4	4	0.2	0.4	1.8	-	0	0	2	0
Arsenic	mg/kg	5	1.5	260	154	BLOR^	6.5	206	300	1	2	6	42
Barium	mg/kg	10	500	260	206	BLOR	20	530	-	0	0	0	0
Beryllium	mg/kg	1	2.6	260	33	BLOR	BLOR	6	90	0	0	0	0
Cadmium	mg/kg	1	0.11	260	6	BLOR	BLOR	2	90	2	2.5	3	3
Chromium	mg/kg	2	100	260	245	BLOR	8	90	300	0	0	0	0
Cobalt	mg/kg	2	20	260	196	BLOR	5	190	300	0	0	2	0
Copper	mg/kg	5	50	260	206	BLOR	11	364	17,000	0	0	2	0
Iron	mg/kg	50	41,000	260	260	380	15,650	107,000	-	0	0	0	0
Lead	mg/kg	5	14	260	195	BLOR	9	111	600	0	0	2	0
Manganese	mg/kg	5	950	260	243	BLOR	192.5	4,260	19,000	0	0	1	0
Mercury	mg/kg	0.1	0.05	260	2	BLOR	BLOR	0.3	80	2	2	2	0
Molybdenum	mg/kg	0.1	1.5	4	4	0.2	1.85	3.7	-	0	0	0	0
Nickel	mg/kg	2	80	260	232	BLOR	8	291	1,200	0	0	1	0
Selenium	mg/kg	5	0.05	260	1	BLOR	2.5	8	700	6	6	6	1
Thallium	mg/kg	0.1	0.6	4	1	BLOR	BLOR	0.1	-	0	0	0	0
Thorium	mg/kg	0.1	12	4	4	0.6	0.85	1.7	-	0	0	0	0
Uranium	mg/kg	0.1	2.4	4	4	0.3	0.45	0.6	-	0	0	0	0
Vanadium	mg/kg	5	160	260	191	BLOR	9	406	-	0	0	0	0
Zinc	mg/kg	5	75	260	238	BLOR	35	395	30,000	0	0	1	0

* Average crustal abundance (Bowen, 1979).

Number of reported measurements that were not below the limit of reporting.

BLOR = Below Limit of Reporting

27% of the waste rock samples are significantly enriched with respect to arsenic. The sole sample with selenium above the limit of reporting suggests that the waste rock enriched with respect to selenium. However, a GAI of 5 would be obtained even if half of the LOR value (2.5 mg/kg) were to be applied to the GAI assessment. Because of analytical limitations in measurement precision, any sample that included selenium testing would automatically be associated with a high GAI. Of the three cadmium samples at or above the LOR, only one result reached a GAI of 3 (C&R Consulting, 2022).

4.3.2.6.2. Contaminant Limits

Table 37 displays the metals/metalloid concentrations of Agate Creek waste rock samples of which have been compared against the National Environment Protection Measure (NEPM) health-based investigation level (HIL) guidelines for 'Recreational C' – public open space scenario (National Environment Protection Council [NEPC], 2013). It is demonstrated that all analysed metals/metalloids would meet the 'Recreational C' limits (C&R Consulting, 2022).

4.3.2.7. Static Water Quality Analyses

Static water quality multi-element scans were undertaken on water extracts in order to assess water quality characteristics that could potentially be sourced from the waste rock in leachate. Results of static water quality multi-element scans have been compared with the ANZECC and ARMCANZ (2000) guidelines for livestock drinking water. The results of static water quality multi-element scans are detailed below (C&R Consulting, 2022).

4.3.2.7.1. Salinity

The Electrical Conductivity (EC) of the water extracts from waste rock samples ranges from 7 µS/cm to 1,680 µS/cm with a median value of 43.5µS/cm. These EC values generally represent fresh water and are well below the ANZECC and ARMCANZ (2000) livestock drinking water trigger limit of 5,970 µS/cm (C&R Consulting, 2022). It should be noted that the ECs of the water extracts are higher than that expected of the surface runoff and seepage as dissolution rates will be lower in the waste rock dumps than in the static laboratory samples (C&R Consulting, 2022).

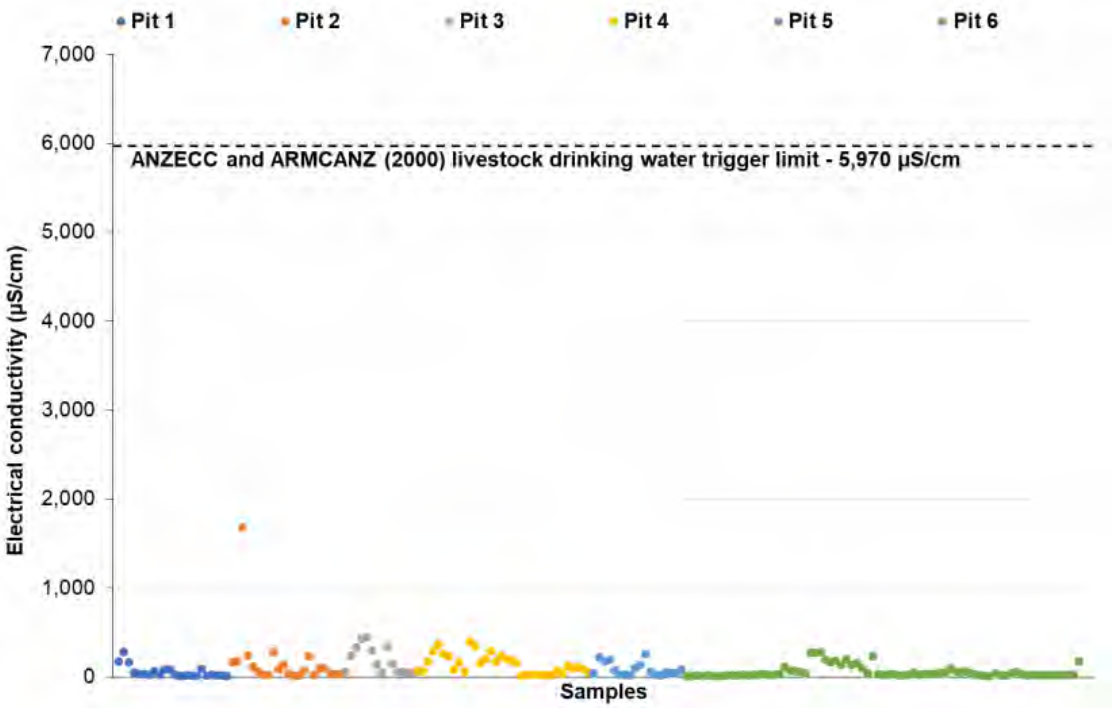


Table 38.Electrical Conductivity for Water Extracts from Agate Creek Waste Rock Samples (C&R Consulting, 2022)

4.3.2.7.2. Fluoride

The fluoride values of the water extracts ranges from <1 mg/L to 63 mg/L with a median value of 4 mg/L. In water extracts, fluoride exceeded the low-risk trigger level for livestock drinking water (2 mg/L) on multiple occasions. Elevated fluoride is prevalent in most of the waste rock. However, these fluoride levels are not unusual for the Agate Creek area which is a volcanic province with much of the rock, surface water and groundwater are enriched with respect to fluoride. The risk of fluoride enrichment in the receiving environment is low (C&R Consulting, 2022).

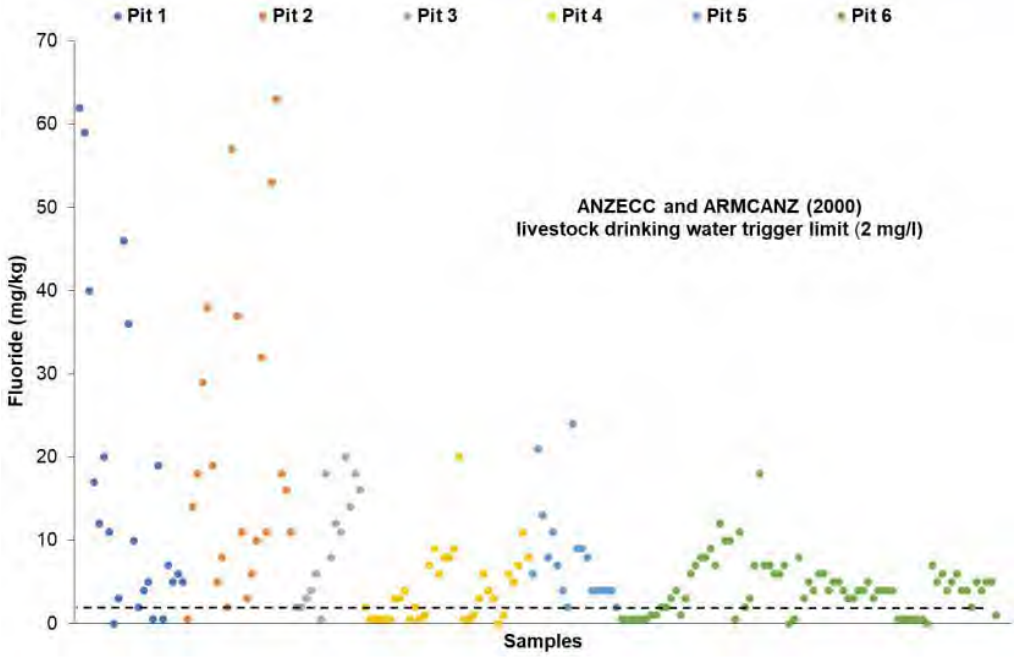


Figure 35. Fluoride values for water extracts (C&R Consulting, 2022).

4.3.2.7.3. Sulphate

Dissolved sulphate levels of the water extracts range from 5 mg/L to 1,780 mg/L and have a median value of 20 mg/L. The exception to this is one value sample in Pit 2, all results were below the ANZECC and ARMCANZ (2000) beef cattle livestock drinking water trigger limit of 1,000 mg/L (C&R Consulting, 2022).

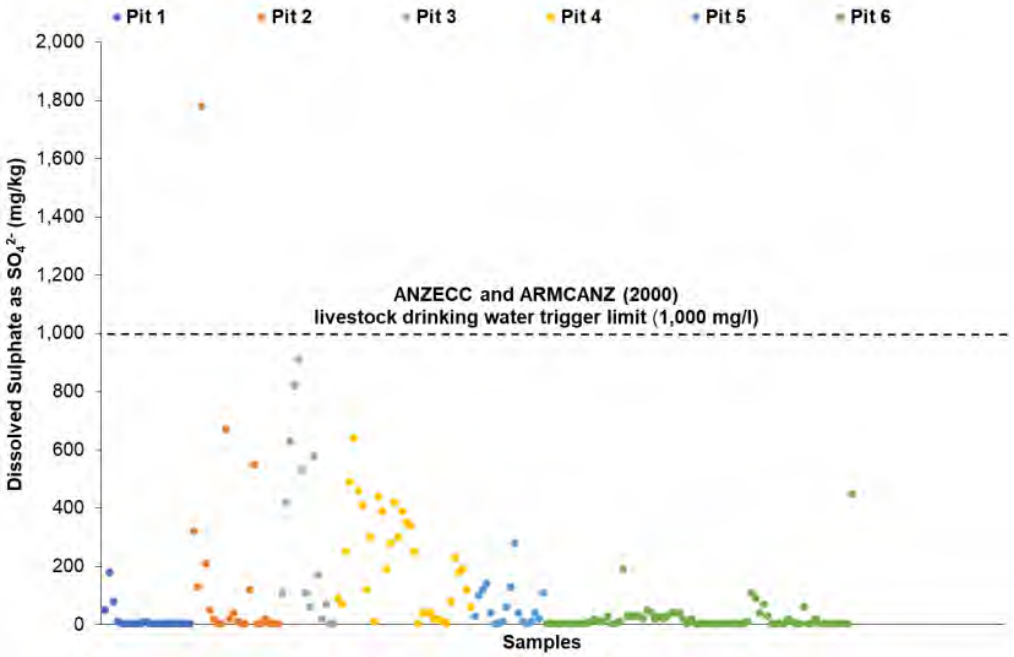


Figure 36.Sulphate Values for Water Extracts from Agate Creek Waste Rock Samples L (C&R Consulting, 2022)

4.3.2.8. Kinetic Leach Column Results

In order to understand potential for waste rock to leach environmental contaminants into the surrounding environment, Kinetic Leach Column (KLC) tests were undertaken. KLC tests providing a comprehensive indication of chemical reactivity of waste materials under the storage conditions (C&R Consulting, 2022). The results of KLC analysis is summarised in Table 39.

Table 39. Kinetic Leach Multi-Element Results (C & R Consulting, 2022)

Quality Characteristic	Limit of Reporting	Livestock Guideline[1]	Freshwater Ecosystems Guideline[2]	Bore ID	Leach 0	Leach 1		Leach 2		Leach 3		Leach 4		Leach 5	
					V	V	C	V	C	V	C	V	C	V	C
pH[3]	0.01	5 – 9	NA[4]	CCGC339	6.49	6.50	-	6.24	-	6.48	-	6.15	-	6.30	-
				CCGC346	5.82	6.30	-	5.88	-	5.98	-	5.59	-	5.45	-
				CCGC309	6.38	5.51	-	6.53	-	6.87	-	5.48	-	6.00	-
				CCGC336	5.84	5.88	-	5.57	-	5.66	-	5.40	-	5.55	-
EC[3](µS/cm)	1	5,970[5]	NA[4]	CCGC339	553	68	-	49	-	44	-	41	-	36	-
				CCGC346	231	223	-	43	-	38	-	36	-	36	-
				CCGC309	20	14	-	15	-	14	-	10	-	17	-
				CCGC336	38	13	-	21	-	21	-	25	-	18	-
Sulphate (mg/L)	1	1,000	NA	CCGC339	3	BLOR	3.5	BLOR	4	BLOR	4.5	BLOR	5	BLOR	5.5
				CCGC346	49	63	112	12	124	11	135	10	145	10	155
				CCGC309	BLOR	BLOR	1	BLOR	1.5	BLOR	2.0	BLOR	2.5	BLOR	3
				CCGC336	1	BLOR	1.5	BLOR	2	BLOR	2.5	BLOR	3	1	4
Fluoride (mg/L)	0.1	2	NA	CCGC339	6.6	4.0	10.6	2.4	13.0	2.1	15.1	2.0	17.1	2.1	19.2
				CCGC346	0.6	0.8	1.4	0.5	1.9	0.4	2.3	0.5	2.8	0.5	3.3
				CCGC309	0.4	BLOR	0.45	BLOR	0.5	BLOR	0.55	BLOR	0.6	BLOR	0.65
				CCGC336	0.2	BLOR	0.25	BLOR	0.3	BLOR	0.35	0.1	0.45	0.1	0.55
Aluminium (mg/L)	0.01	5	0.055	CCGC339	BLOR	0.07	0.075	0.16	0.235	0.02	0.255	0.01	0.265	0.02	0.285
				CCGC346	BLOR	0.01	0.015	0.04	0.055	0.02	0.075	BLOR	0.08	0.01	0.09
				CCGC309	0.06	0.01	0.07	0.01	0.08	0.01	0.09	BLOR	0.095	BLOR	0.10
				CCGC336	0.03	BLOR	0.035	BLOR	0.04	BLOR	0.045	BLOR	0.05	BLOR	0.055
Arsenic (mg/L)	0.001	0.5	0.013	CCGC339	BLOR	0.001	0.0015	BLOR	0.002	0.002	0.004	BLOR	0.0045	BLOR	0.005
				CCGC346	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC309	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC336	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
Boron (mg/L)	0.05	5	0.37	CCGC339	0.19	0.13	0.32	0.07	0.39	0.08	0.47	0.12	0.59	0.11	0.70

Quality Characteristic	Limit of Reporting	Livestock Guideline[1]	Freshwater Ecosystems Guideline[2]	Bore ID	Leach 0	Leach 1		Leach 2		Leach 3		Leach 4		Leach 5	
					V	V	C	V	C	V	C	V	C	V	C
				CCGC346	0.17	1.15	1.32	0.18	1.5	0.19	1.69	0.25	1.94	0.30	2.24
				CCGC309	BLOR	BLOR	0.05	BLOR	0.075	BLOR	0.1	0.07	0.17	BLOR	0.195
				CCGC336	0.13	0.26	0.39	0.42	0.81	0.69	1.5	0.96	2.46	0.80	3.26
Cadmium (mg/L)	0.0001	0.01	0.0002	CCGC339	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC346	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC309	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC336	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
Copper (mg/L)	0.001	1.0[6]	0.0014	CCGC339	BLOR	BLOR	0.001	0.001	0.002	BLOR	0.0025	BLOR	0.003	BLOR	0.0035
				CCGC346	BLOR	0.002	0.0025	BLOR	0.003	BLOR	0.0035	BLOR	0.004	BLOR	0.0045
				CCGC309	BLOR	BLOR	0.001	0.001	0.002	BLOR	0.0025	BLOR	0.003	BLOR	0.0035
				CCGC336	0.002	BLOR	0.0025	BLOR	0.003	BLOR	0.0035	BLOR	0.004	BLOR	0.0045
Lead (mg/L)	0.001	0.1	0.0034	CCGC339	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC346	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC309	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC336	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
Manganese (mg/L)	0.001	NA	1.900	CCGC339	0.031	0.004	0.035	0.003	0.038	0.003	0.041	0.002	0.043	0.002	0.045
				CCGC346	0.018	0.035	0.053	0.003	0.056	0.004	0.06	0.003	0.063	0.004	0.067
				CCGC309	BLOR	BLOR	0.001	0.006	0.007	0.009	0.016	0.004	0.02	0.016	0.036
				CCGC336	0.015	0.006	0.021	0.017	0.038	0.015	0.053	0.013	0.066	0.007	0.073
Mercury (mg/L)	0.0001	0.002	0.0006	CCGC339	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC346	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC309	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC336	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
Nickel	0.001	1.0	0.011	CCGC339	BLOR	BLOR	0.001	BLOR	0.0015	0.001	0.0025	BLOR	0.003	BLOR	0.0035

Quality Characteristic	Limit of Reporting	Livestock Guideline[1]	Freshwater Ecosystems Guideline[2]	Bore ID	Leach 0	Leach 1		Leach 2		Leach 3		Leach 4		Leach 5	
					V	V	C	V	C	V	C	V	C	V	C
(mg/L)				CCGC346	BLOR	0.003	0.0035	BLOR	0.004	BLOR	0.0045	BLOR	0.005	BLOR	0.0055
				CCGC309	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC336	BLOR	BLOR	0.001	BLOR	0.0015	0.001	0.0025	BLOR	0.003	BLOR	0.0035
Zinc (mg/L)	0.005	20	0.008	CCGC339	BLOR	BLOR	0.005	BLOR	0.0075	0.024	0.0315	BLOR	0.034	BLOR	0.0365
				CCGC346	BLOR	0.131	0.1335	BLOR	0.136	BLOR	0.1385	BLOR	0.141	BLOR	0.1435
				CCGC309	BLOR	BLOR	0.005	BLOR	0.0075	BLOR	0.010	BLOR	0.0125	BLOR	0.015
				CCGC336	BLOR	0.007	0.0095	0.011	0.0205	0.010	0.0305	0.006	0.033	0.007	0.040
Acidity[3] as $CaCO_3$ (mg/L)	1	NA	NA	CCGC339	3	2	-	BLOR	-	3	-	1	-	3	-
				CCGC346	2	3	-	BLOR	-	3	-	1	-	3	-
				CCGC309	2	1	-	BLOR	-	2	-	2	-	3	-
				CCGC336	2	1	-	BLOR	-	3	-	2	-	3	-

[1] Australian guidelines for livestock drinking water - trigger values (low risk) (ANZG, 2018). Note: Metal guideline values are based on the total fraction, whereas results are provided as dissolved. Care must be taken when undertaking comparisons.

[2] Australian guidelines for aquatic freshwater ecosystems - 95% species protection level (ANZG, 2018). Note: Metal guideline values are based on the dissolved fraction.

[3] Cumulative results are not provided for pH, EC or acidity as these values are deemed inappropriate for assessing these quality characteristics.

[4] pH and EC guidelines for freshwater ecosystems for tropical regions are not representative of the climatic and/or geological conditions at Agate Creek.

[5] EC has been calculated from the tolerances of livestock (beef cattle) to total dissolved solids in livestock drinking water using a 1.4925 multiplier (ANZG, 2018).

[6] Cattle trigger value (low risk) for copper is cited.

Indicates an exceedance of the relevant livestock drinking water guideline value.

Indicates an exceedance of the relevant freshwater ecosystems guideline value.

V – Raw value.

C – Running cumulative total.

NA – Not available.

BLOR – Below the limit of reporting.

4.3.2.8.1. pH Value

pH remains relatively stable over the course of the KLC tests. Three of the samples show marginal decreasing trend while CCGC309 recorded a pH decrease after the first leach, before increasing over leaches 2 and 3. Although there are marginal decreases over time are seen at most sample sites, no samples show a significant increase in acidity over time (C&R Consulting, 2022).

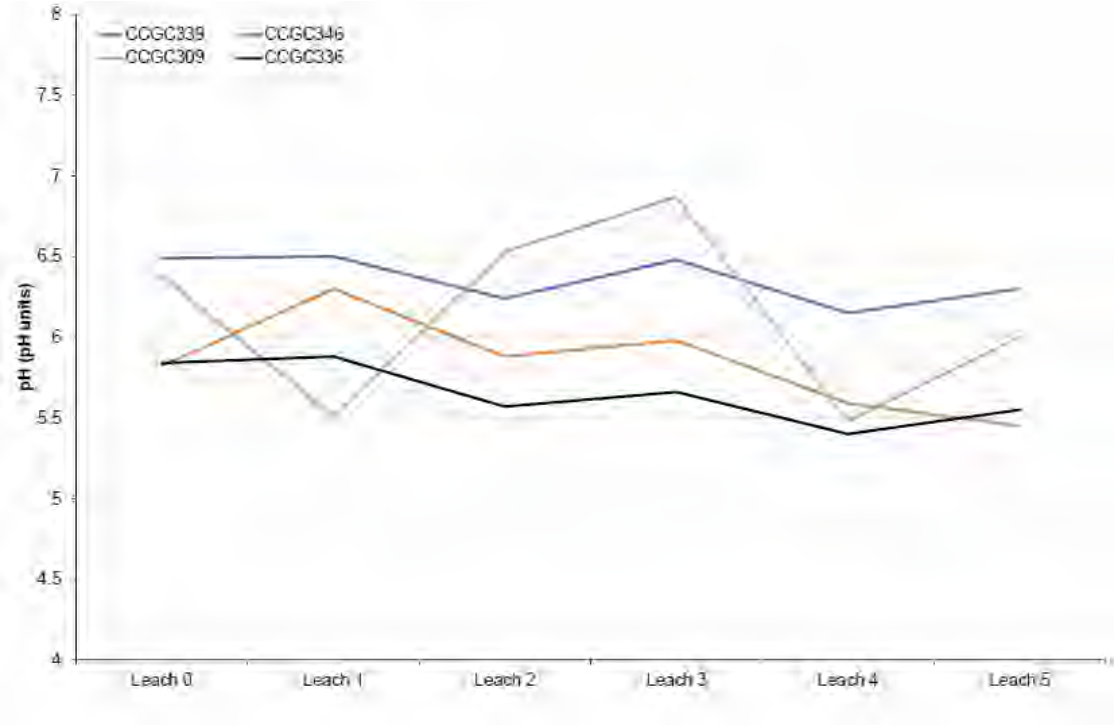


Figure 37. Trend in pH of each KLC (C&R Consulting, 2022)

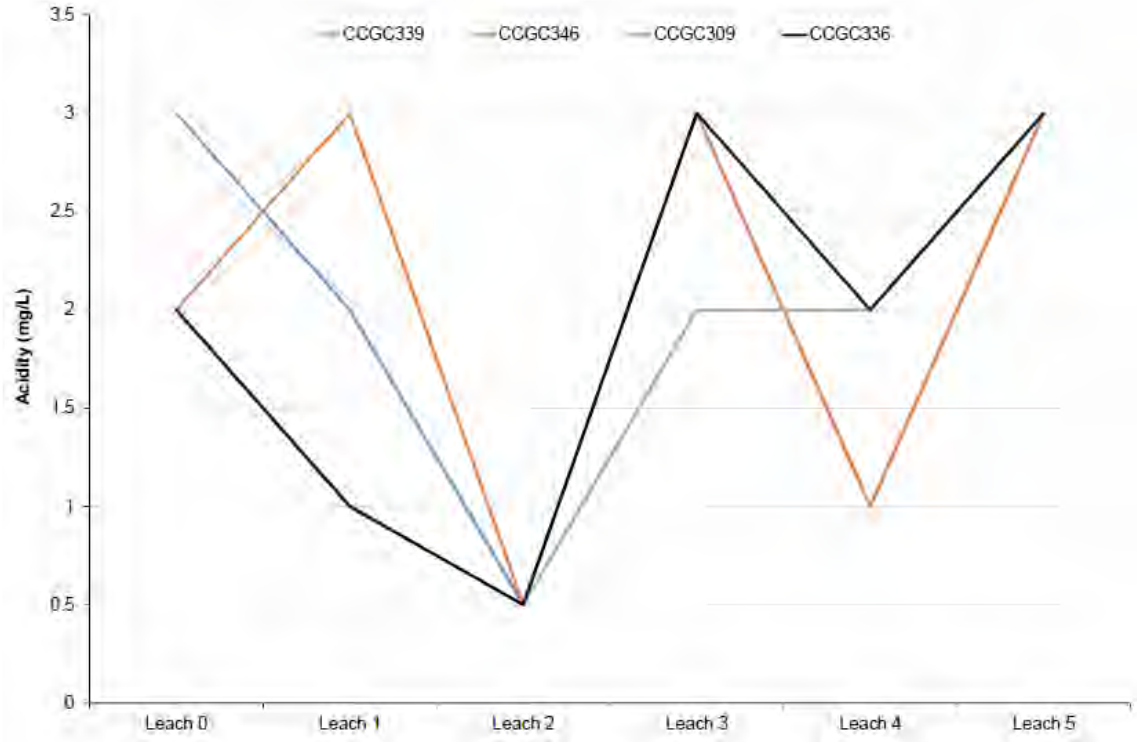


Figure 38. Trends in acidity observed in each KLC tested sample over time (C&R Consulting, 2022).

4.3.2.8.2. Electrical Conductivity

Electrical conductivity will not accumulate over time and each result representing an individual snapshot in time. Conductivity in all samples generally falls each leach, ranging from 553 to 20 µS/cm in leach 0 to 41, to 10 µS/cm in leach 4 (C&R Consulting, 2022).

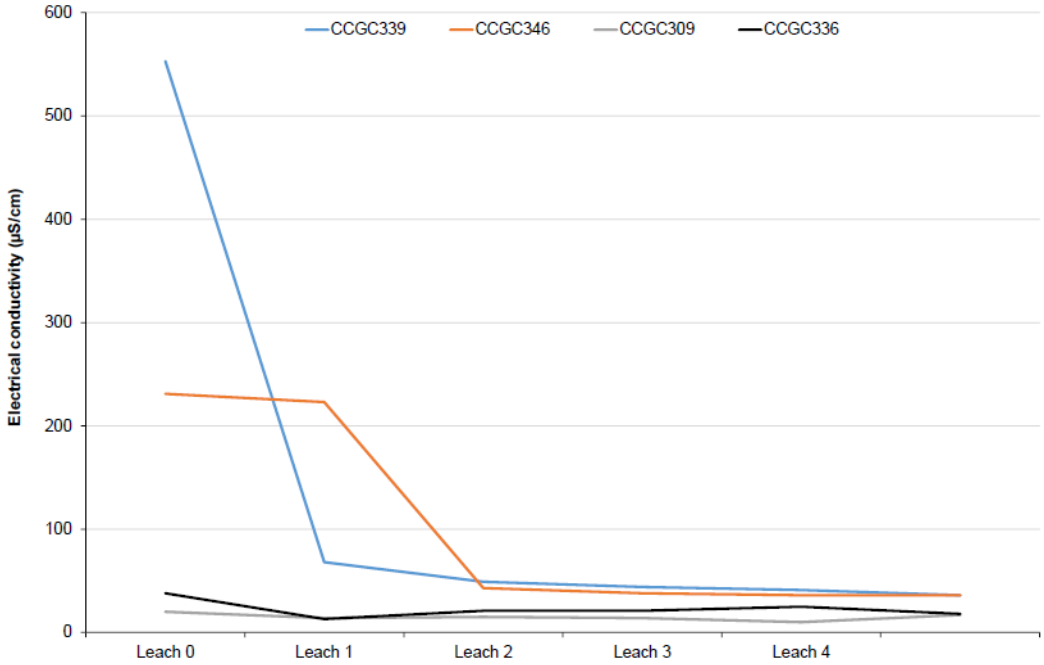


Figure 39. Trends in Electrical Conductivity of each KLC (C&R Consulting, 2022)

4.3.2.8.3. Metals/Metalloids

Majority of metal concentrations were found to be compliant with guideline values, or slightly exceeded values in the cumulative results at the end of KLC.

For slight exceedances, cumulative results were found to exceed the 95% species protection level for aquatic ecosystems after leach 4. This slight exceedance is a result of the conservative method used to calculate the cumulative value in the event of below the LOR values, combined with the number of leaches performed, and the relatively low guideline value. As such, it is suggested that slight exceedances of the guideline values within Agate Creek Mine's waste rock are not of environmental concern (C&R Consulting, 2022).

Cumulative values are of use in assessing total load that may build up via evaporation in any downstream sediments and may be available for later mobilisation in flow events. Four metals or metalloids were regularly recorded above their respective aquatic ecosystem guideline values Including:

- Dissolved aluminium;
- Dissolved boron;
- Dissolved copper; and
- Dissolved zinc (C&R Consulting, 2022).

Values for aluminium were opportunistic up to Leach 3 due to the erratic behaviour of leaches after which a consistent overall drop for all samples was observed. Non-compliance values (above 0.055 mg/L) were observed in CCGC309 at Leach 0 and CCGC339 at Leaches 1 and 2. Leach 2 exceeded 0.150 mg/L. After Leach 2, levels in all samples decreased. Accumulated values in all samples (except for CCGC336) exceed the 0.055 mg/L threshold (C&R Consulting, 2022).

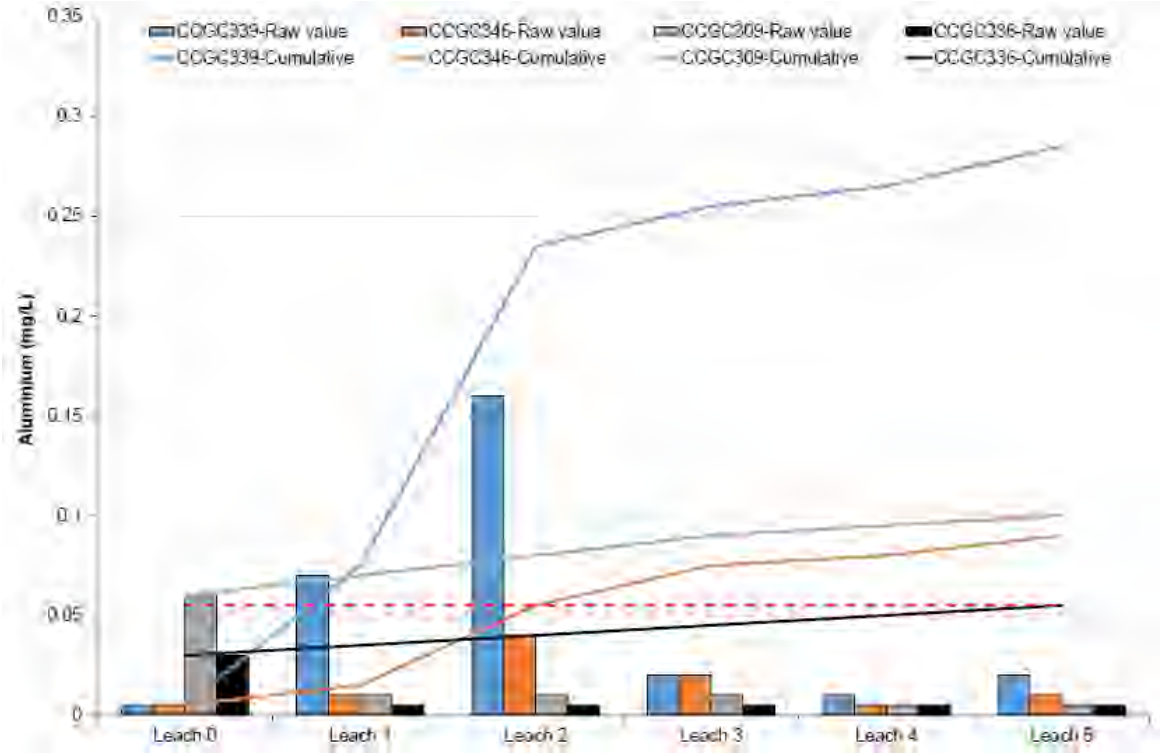


Figure 40. Trends in Aluminium of each KLC (C&R Consulting, 2022)

Dissolved Boron levels were elevated initially prior to dropping to relatively compliant levels in later leaches. The exception to this is CCGC336 (Pit 6) which increased in dissolved boron concentrations with each leach. However, the results of leach 5 show the values of dissolved boron began to decrease. The higher boron values from CCGC336 may be a response of the clay minerals present, to the slight decrease in pH (increase in acidity) shown by the same sample over the 5 leaches. (C&R Consulting, 2022)

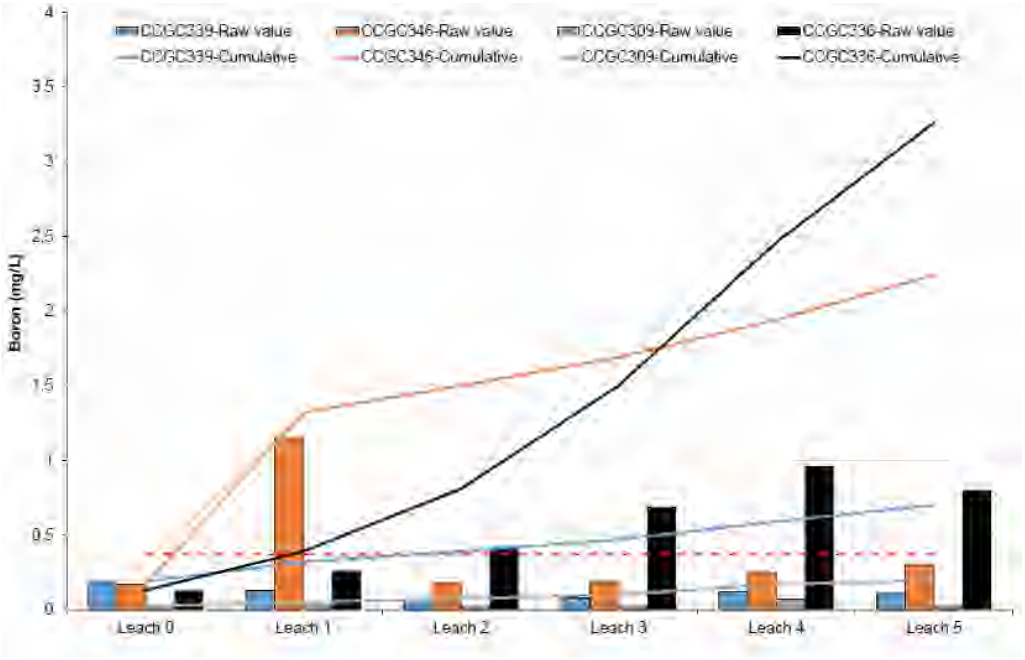


Figure 41. Cumulative trends and individual leach values of dissolved boron (C&R Consulting, 2022)

Dissolved copper slightly exceeded the guideline value on two occasions in two separate samples (CCGC346 (from Pit 4) and CCGC336 (from Pit 6)). Levels of copper within the waste rock generally leach rapidly from the system at marginal levels prior to reducing to compliant concentrations. While the accumulation of copper within aquatic environments can be of environmental concern, it is predicted that the relatively low levels of copper leaching from the Agate Creek Mine waste rock are of negligible concern to its downstream receiving environment (C&R Consulting, 2022).

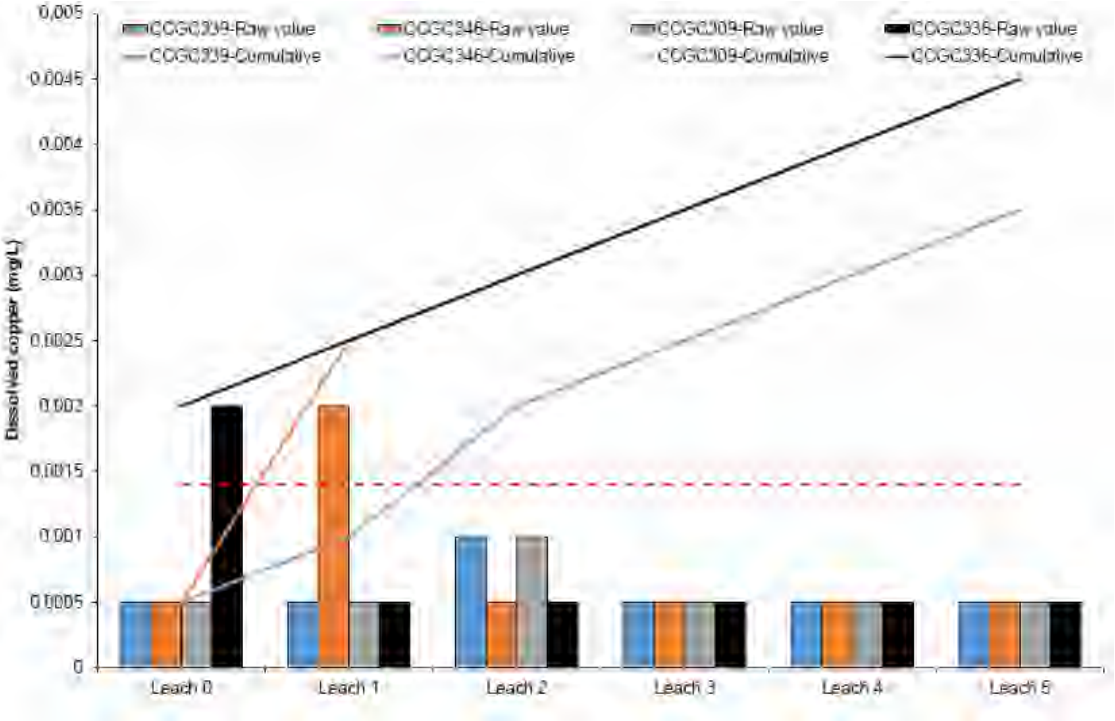


Figure 42. Cumulative Trends and Individual Leach Values of Dissolved Copper (C&R Consulting, 2022)

CCGC346 (Pit 4) leach 1 recorded a large spike of dissolved zinc, but recorded levels below the LOR on every other leach. CCGC309 (in Pit 6) recorded values below the LOR. The most likely source of these zinc and copper in solution is the geological context via desorption from negatively charged manganese oxy-hydroxide colloids, and or, possibly negatively charged aluminium oxy-hydroxide colloids (C&R Consulting, 2022).

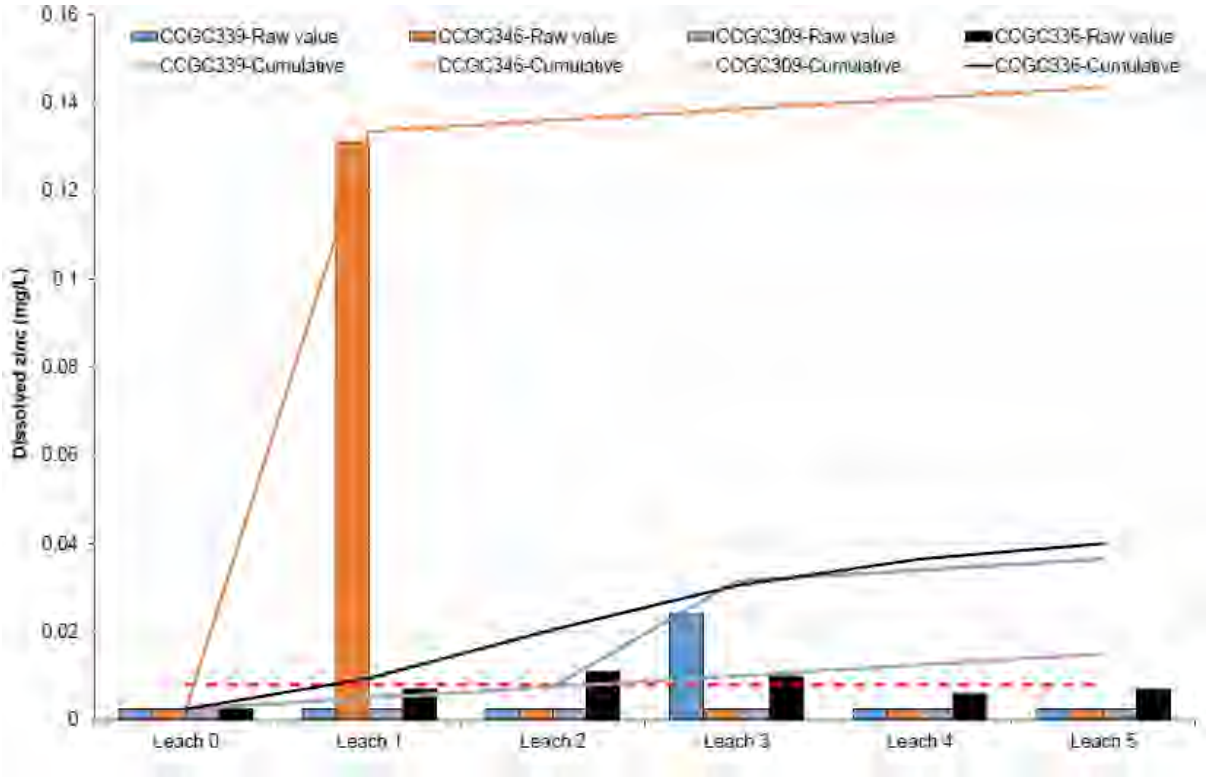


Figure 43. Cumulative Trends and Individual Leach Values of Dissolved Zinc (C&R Consulting, 2022)

4.3.2.8.4. Fluoride

Fluoride KLC tests show that there is an overall accumulation of fluoride with successive leaching in sample CCGC339. However, all other samples particulates are constant with successive leaches. For CCGC309, fluoride fell from 6.6 mg/L in Leach 0, to 4 mg/L in Leach 1, to 2.0 mg/L in Leach 4. The initial high level is probably due to the presence of the alteration mineral fluorite (CaF2) and its dissolution. Successive leaches reduce the influence of this mineral by dissolution .

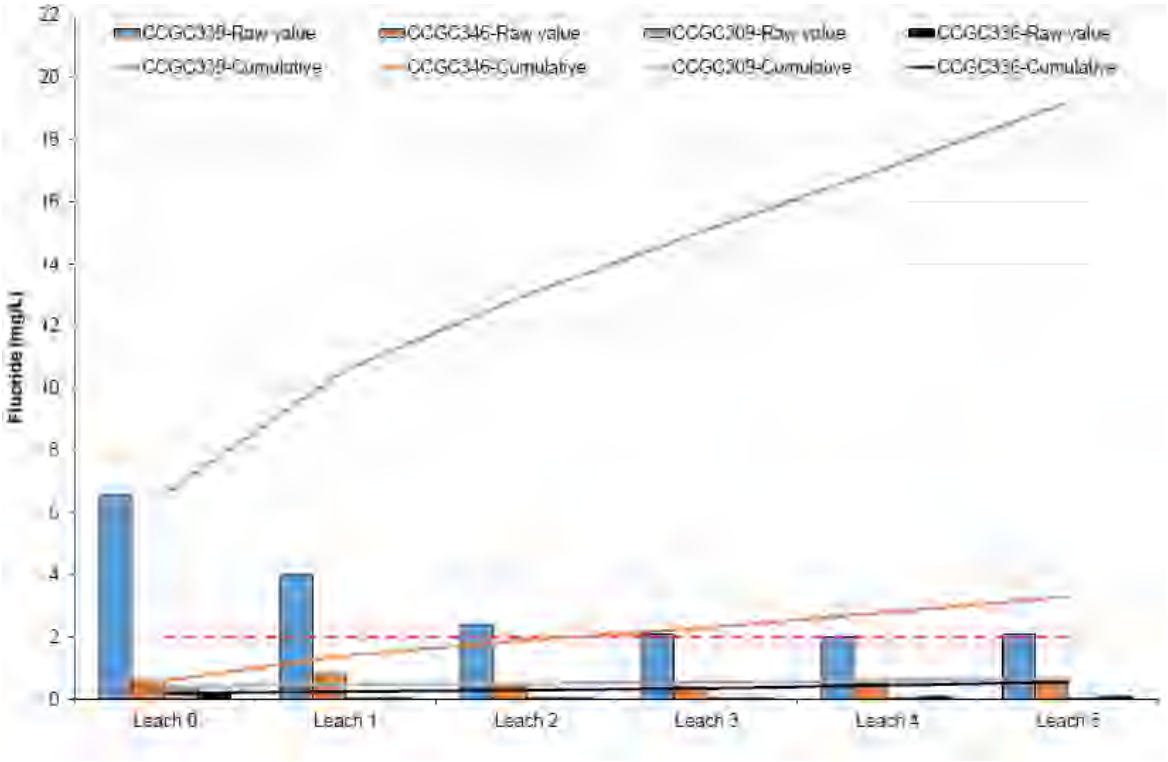


Figure 44. Cumulative Trends and Individual Leach Values of Fluoride (C&R Consulting, 2022)

4.3.2.9. Potential Impact of Waste Rock

4.3.2.9.1. Acid Mine Drainage

Of the 260 samples analysed, only 11 samples could be categorised as PAF. These samples are all found in Pits 2, 5 and 6, with 7 samples being found in Pit 6 alone. All of these, with the exception of one sample in Pit 2, have very low to low sulphur values. Therefore, only one sample presents any possibility of acid mine drainage (C&R Consulting, 2022). Therefore:

- The amount of any acid potentially produced will be small, and
- Any acid produced by the waste rock will be buffered by the surrounding NAF rock which makes up >90% of the waste rock.

Therefore, it is considered that the acid mine drainage risk posed by the waste rock associated with the project is very low.

4.3.2.9.2. Salinity

The Electrical Conductivity of the Agate Creek waste rock samples leachate ranged from 7 to 1680 µS/cm with a very low median value of 43.5 µS/cm. These values are all within appropriate guideline values for freshwater systems. Salinity is not an issue in the management of the Agate Creek waste rock dumps (C&R Consulting, 2022).

4.3.2.9.3. Elements

Levels of Fluoride were above the guideline level of 2 mg/L in many of the waste rock samples (static tests). Results ranged from >0.5 mg/L to 63 mg/L. Fluoride values are not common for the Agate Creek area which is a volcanic province where fluorine enrichment is not unexpected. The possibility of a high ambient level implies that the overall risk associated with fluoride is low. In the KLC results, fluoride trended down to the compliance level of 2 mg/L by the 4th leach, supporting the overall proposition that the overall environmental risk from fluoride is low (C&R Consulting, 2022).

Dissolved sulphate levels in the static test results from waste rock samples range from 5 mg/L to 1760 mg/L with a low median value of 20 mg/L. Only one sample from Pit 2 is above the ANZECC and ARMCANZ (2000) Livestock Drinking Water Guideline of 1000 mg/L. Sulphate values in the Kinetic Leach Tests were all within compliance levels. Based on these results the environmental risk from sulphate is considered low (C&R Consulting, 2022).

KLC tests indicate concentrations of aluminium, boron, copper and zinc above guideline values. These exceedances were relatively low and were probably associated with adsorbed species on colloids being included in the “dissolved” analyses. As such, these exceedances are considered to impact only a very low to low environmental risk to the Agate Creek waste rock dumps (C&R Consulting, 2022).

4.3.2.9.4. Risk of Waste Rock Impacts

The WRC of waste rock across the 6 proposed pits at Agate Creek from are considered to be of low risk to the receiving environment given the results of Static (Section 4.3.2.4 - 4.3.2.7) and Kinetic (Section 4.3.2.8) analyses. However, to further mitigate the potential for unpredicted impacts, the waste rock will be managed in accordance with the measures outlined in Section 4.3.9.

4.3.3. Tailings

Agate Creek will be mined as an ore source for the Georgetown gold processing plant (75km north). Ore will be mined, temporarily stockpiled at the ROM, loaded onto road trains and transported to Georgetown for processing under EA EPML00899813. No mine tailings will be produced during operations and pose no risk to the receiving environment.

4.3.4. Acid Sulfate Soils

Acid Sulfate Soils (ASS) form in coastal areas lower than 5 m AHD. The Project is located above 5 m AHD and the risk of encountering ASS is considered very low. No impacts relating to ASS are expected.

4.3.5. Waste Storage

Waste storage must be considered a temporary, and not a permanent, solution to waste management. Waste should always be safely stored pending removal. Where waste cannot be stored in suitable containers, the siting of a storage location and the preparation of a suitable storage pad is critical. Waste

sources, streams and management are included in Section 4.5 which addresses the requirements of *ESR/2015/1836 Application Requirements for Activities With Waste Impacts*.

4.3.6. Areas of Regional Interest

Areas of regional interest are managed under the *Regional Planning Interests Act 2014*. No areas of regional interest are identified over the Project, and none are proposed to be impacted.

4.3.7. Soil Erosion Hazard

Soil erosion presents a hazard on downstream receptors, particularly where ground cover is disturbed, and the soil is subject to erosive agents of wind and water. Soil erosion occurs when soil particles detach and are transported off site. Soil erodibility is dependent the capacity of soils to transmit water downwards and the structural stability of soil which is dependent on:

- Soil texture;
- Organic matter content;
- Dispersion; and
- Soil structure.

WTS conducted a Soils and Land Suitability Assessment (SLSA) during November 2021. An element of the SLSA was to assess the soil erosion susceptibility. The results of soil erosion susceptibility assessments are summarised in Table 40.

Table 40. Soil Erosion Susceptibility

Soil Type	Sodicity	Texture	Topography	Vegetation	Erosion Risk
Brown Mellic Kandosol	Non-Sodic	Loam	Gently undulating.	Sparse *Eucalyptus microneura +/- Terminalia spp. low woodland*	Moderate susceptibility due sparse erosion protection
Red Massive Gypsic Vertosol	Non-Sodic	Clay Loam to Clay	Flat to gently undulating	Sparse *Eucalyptus crebra and/or E. whitei +/- Corymbia erythrophloia open woodland*.	Moderate susceptibility due sparse erosion protection
Brown Bleached Kandosol	Non-Sodic	Sandy Loam	Flat to gently undulating.	Sparse *Eucalyptus microneura +/- Terminalia spp. low woodland*.	Moderate susceptibility due sparse erosion protection

Brown Lithsolic Rudosol	Non-Sodic	Loam	Steep hills	Sparse *Eucalyptus crebra and/or E. whitei +/- Corymbia erythrophloia open woodland*	Moderate susceptibility due sparse erosion protection

No soils were determined to have a high risk of erosion susceptibility. All soil types express a moderate soil erosion risk due to the naturally sparse erosion protection. LWR will manage the moderate erosion risks in accordance with Section 4.3.9.7.

4.3.8. Flora and Fauna

In 2021, SLR Consulting conducted a Terrestrial Flora and Fauna Baseline Assessment (Appendix E). The purpose of the assessments, were to:

- Examine the occurrence of MSES and MNES in accordance with current State and Commonwealth legislation;
- Examine the terrestrial flora and fauna biodiversity values within the study area; and
- Examine the presence and status of species and communities identified to occur within the study area based on ground-truthing field assessments.

To add to the baseline assessments, WTS (2022) conducted a Significant Residual Impact Assessment (SRI) to further understand the potential impacts to flora and fauna regarding the proposed expansion (Appendix F). The SRI was prepared to assess the potential residual impacts to high environmental value areas. The results of both assessments are detailed below.

4.3.8.1. Flora and Fauna Assessment Methodologies

The baseline assessment conducted by SLR Consulting (2021) consisted of a desktop analysis and field surveys.

The desktop analysis encompassed:

- Project planning and definition of objectives;
- Assignment of qualified ecologists;
- Detailed desktop studies;
- Review of previous studies;
- Collation of existing records; and
- Literature review of species and potential threats and impacts.

The field surveys phase encompassed:

- Systematic, targeted and incidental flora surveys;

- Vegetation community mapping and assessments; and
- Systematic, targeted and incidental fauna surveys.

4.3.8.2. Flora Results

Six Regional Ecosystems were ground-truthed within the flora study area including REs 2.10.5a, 9.3.13, 9.3.26, 9.5.10a, 9.11.16 and 9.12.11. The ground-truthed REs have a 'least concern' VM Act status and a 'no concern at present' biodiversity status. The exception to this is REs 9.3.13 and 9.3.26, which have an 'of concern' biodiversity status (SLR Consulting, 2021).

Table 41. Georeferenced Regional Ecosystems (SLR Consulting, 2021)

RE ID	Description
2.10.5a	Dominated by Paperbark gums, with associated tree species including *Corymbia* spp. and *Callitris intratropica* (Northern cypress pine). Lancewood was also locally dominant in some areas. The sub-canopy layer was typically dominated by the *Acacia leptostachya* (Showy wattle) and *Acacia julifera*. The shrub layer was generally dominated by the previously mentioned Acacia species and *Petalostigma banksia* (Quinine bush), *Alphitonia excelsa* (Soap bush) and *Grevillia mimosoides* (Tar Grevillia). Groundcover within this community was sparse during both surveys, with evidence of annual forbs, such as *Gomphrena flaccida* (Bunched Gomphrena) and *Polycarpaea corymbosa* (Oldman's cap), A variety of grass species were also observed, including *Schizachyrium fragile* (Firegrass), *Aristida* spp., Triodia sp. (Spinifex), *Arundinella nepalensis* (River grass), and *Cymbopogon bombycinus* (Lemon-scented grass). RE occurred on sandstone scarps, outcrops and plateaus within the study area.
9.3.13	Dominated by *Eucalyptus camaldulensis* (Red river gum), *Melaleuca fluviatilis* (Weeping tea-tree), and *Lophostemon grandifloras* (Swamp box). The ground layer was generally dominated by a variety of grass species including *Megathyrsus maximus* (Green panic), *Bothriochloa pertusa, B. bladhii, and B. decipiens* (Indian, Forest and Pitted bluegrass), Dichanthium sericeum (Queensland bluegrass), *Panicum* sp. and *Setaria surgens* (Pigeon grass).
9.3.26	Dominant trees consist of Eucalyptus microneura (Gilbert river box), Corymbia confertiflora including (Broad-leaved carbine) and *Eucalyptus camaldulensis*. A species of *Tephrosia* was the dominant shrub with other species, such as *Crotalaria* spp. also common. Identifying grasses was difficult given grazing, however, many tussock and smaller species were identified.
9.5.10a	Dominant trees included *Eucalyptus microneura*, *Corymbia terminalis* (Desert bloodwood) and *Erythrophleum chlorostachys* (Cooktown ironwood). The shrub layer was dominated by Carissa lanceolata (Conkerberry). The ground layer was impacted by cattle. Where identifiable, the dominant species within the ground layer of this community generally comprise *Aristida* spp., *Heteropogon contortus* (Black speargrass), *Themeda triandra* (Kangaroo grass) and *Dichanthium sericeum*
9.11.16 9.12.11	The floristic and structural components of these two communities throughout the study area are very similar and the main different between these communities is the surface geology on which they occur. RE 9.11.16 occurs within the north-eastern portion of the study area on folded metamorphics, whereas RE 9.12.11 occurs within the southern and central portions of the study

RE ID	Description
	area on igneous rocks. Both communities were dominated by *Eucalyptus crebra* (Narrow-leaved ironbark), with a variable sub-canopy to shrub layer that may include a combination of *Petalostigma banksia*, *Acacia leptostachya, Grevillea parallela* (Silver oak), Alphitonia excelsa or several other species. The ground layer in these communities were typically dominated by Aristida spp.

4.3.8.2.1. Non-Remnant Vegetation

Small sections within the study area comprised of non-remnant vegetation and included areas around the existing Agate Creek pit, waste rock dump, run of mine, mining camp, workshop facilities, and a previously cleared area within the northeast portion of the ML (SLR Consulting, 2021).

4.3.8.2.2. EPBC Act Threatened Ecological Communities

No EPBC Act Threatened Ecological Communities were ground-truthed to occur within the study area (SLR Consulting, 2021).

4.3.8.2.3. Environmentally Sensitive Areas

No Environmentally Sensitive Areas (ESA) were ground-truthed to occur within the study area. One Category A ESA, the Rungulla National Park, is State mapped to the southwest of the study area and one Category C ESA, is also State mapped to the southwest of the study area (SLR Consulting, 2021).

4.3.8.2.4. Flora Species

No threatened flora species, as listed under the NC Act and EPBC Act, were identified to occur within the study area. 147 flora species from 51 families were recorded within the study area (SLR Consulting, 2021). Further details on flora species are provided in Appendix E.

4.3.8.3. Fauna Results

4.3.8.4. Essential Habitat

No areas of protected wildlife (vulnerable or endangered) habitat or essential habitat were located during field surveys. It is unlikely that any areas of protected wildlife (vulnerable or endangered) habitat or essential habitat will be significantly impacted by the development of Agate Creek (SLR Consulting, 2021).

4.3.8.4.1. Birds

49 species were identified within the study area. All the identified species are generally common. No NC Act or EPBC Act EVNT or migratory species were identified to occur on site (SLR Consulting, 2021).

4.3.8.4.2. Mammals

A total of 22 mammal species were identified within the study area during surveys. All these are listed as least concern under the NC Act and are not listed under the EPBC Act. All of the identified mammal species are generally common in similar habitats throughout the region (SLR Consulting, 2021).

4.3.8.4.3. Reptiles

18 reptile species were identified within the study area. Geckos and skinks were the most species-rich reptile families observed. The Gilbert Ground Gecko (NCA status – Least Concern, Conservation Significance – no), described in early November 2020, was found within the study area. This species has a restricted range and previously, only known to occur within the vicinity of Gilberton Station. However, the detection of this species within the study area represents an ~20km range extension for this poorly known and recently described species (SLR Consulting, 2021).

4.3.8.4.4. Amphibians

Three native amphibian species were identified during surveys including the *Litoria inermis* (Bumpy rocket frog), *Litoria rubella* (Naked tree frog), and *Platyplectrum ornatum* (Ornate burrowing frog), all of which are common within the local area and surrounding region.

Table 42. Fauna Observations (SLR Consulting, 2021)

Status		Family	Scientific name	Common name	Survey site						
NCA	EPBC				1	2	3	4	5	6	Incidental
Birds											
LC	-	Anatidae	*Anas superciliosa*	Pacific black duck							X
LC	-	Podicepidae	*Tachybaptus novaehollandiae*	Australasian grebe							X
LC	-	Columbidae	*Geophaps scripta*	Squatter Pigeon							X
LC	-	Columbidae	*Ocyphaps lophotes*	Crested pigeon	X						X
LC	-	Columbidae	*Geopelia striata*	Peaceful dove	X		X	X			X
LC	-	Columbidae	*Phaps chalcoptera*	Common bronzewing	X	X					X
LC	-	Podargidae	*Podargus strigoides*	Tawny frogmouth	X						X
LC	-	Eurostopodidae	*Eurostopodus argus*	Spotted nightjar							X
LC	-	Accipitridae	*Aquila audax*	Wedge-tailed eagle							X
LC	-	Accipitridae	*Accipiter fasciatus*	Brown goshawk			X	X			X
LC	-	Accipitridae	*Haliastur sphenurus*	Whistling kite							X
LC	-	Accipitridae	*Milvus migrans*	Black kite							X
LC	-	Falconidae	*Falco berigora*	Brown falcon		X					X
LC	-	Gruidae	*Grus rubicunda*	Brolga							X
LC	-	Otididae	*Ardeotis australis*	Australian bustard				X			
LC	-	Cacatuidae	*Calyptorhynchus banksii*	Red-tailed black-cockatoo	X						X
LC	-	Cacatuidae	*Cacatua galerita*	Sulphur-crested cockatoo							X
LC	-	Cacatuidae	*Eolophus roseicapillus*	Galah							X
LC	-	Cuculidae	*Centropus phasianinus*	Pheasant coucal				X			
LC	-	Cuculidae	*Scythrops novaehollandiae*	Channel-billed cuckoo				X			
LC	-	Strigidae	*Ninox novaeseelandiae*	Southern boobook				X	X		X
LC	-	Psittacidae	*Platycercus adscitus*	Pale-headed rosella	X	X	X	X		X	X
LC	-	Psittacidae	*Aprosmictus erythropterus*	Red winged parrot				X			
LC	-	Psittacidae	*Trichoglossus haematodus moluccanus*	Rainbow lorikeet	X	X					X
LC	-	Halcyonidae	*Dacelo leachii*	Blue-winged kookaburra	X	X					X

Status		Family	Scientific name	Common name	Survey site						
NCA	EPBC				1	2	3	4	5	6	Incidental
LC	-	Halcyonidae	*Dacelo novaeguineae*	Laughing kookaburra			X				X
LC	-	Ptilonorhynchidae	*Ptilonorhynchus nuchalis*	Great bowerbird							X
LC	-	Acanthizidae	*Gerygone albogularis*	White-throated gerygone							X
LC	-	Acanthizidae	*Smicrornis brevirostris*	Weebill	X						X
LC	-	Pardalotidae	*Pardalotus striatus*	Striated pardalote	X		X				X
LC	-	Meliphagidae	*Entomyzon cyanotis*	Blue-faced honeyeater	X						X
LC	-	Meliphagidae	*Manorina flavigula*	Yellow-throated miner	X		X				X
LC	-	Meliphagidae	*Melithreptus albogularis*	White-throated honeyeater	X		X	X			
LC	-	Meliphagidae	*Philemon corniculatus*	Noisy Friarbird	X	X		X	X	X	X
LC	-	Meliphagidae	*Philemon citreogularis*	Little friarbird		X					
LC	-	Campephagidae	*Coracina novaehollandiae*	Black-faced cuckoo-shrike	X		X	X			X
LC	-	Oriolidae	*Oriolus sagittatus*	Olive-backed oriole			X				
LC	-	Artamidae	*Artamus minor*	Little woodswallow		X	X				X
LC	-	Corcoracidae	*Struthidea cinerea*	Apostlebird							X
LC	-	Artamidae	*Cracticus nigrogularis*	Pied butcherbird	X		X	X		X	X
LC	-	Artamidae	*Cracticus torquatus*	Grey butcherbird		X	X				X
LC	-	Artamidae	*Strepera graculina graculina*	Pied currawong	X	X	X		X	X	X
LC	-	Artamidae	*Cracticus tibicen*	Australian magpie	X		X	X			X
LC	-	Rhipiduridae	*Rhipidura leucophrys*	Willie wagtail	X						X
LC	-	Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail		X					
LC	-	Corvidae	*Corvus orru*	Toressian Crow	X	X	X	X			X
LC	-	Monarchidae	*Grallina cyanoleuca*	Magpie lark							X
LC	-	Nectariniidae	*Dicaeum hirundinaceum*	Mistletoebird	X		X	X			X
LC	-	Estrildidae	*Taeniopygia bichenovii*	Double-barred finch			X				
Mammals											
*	-	Bovidae	*Bos taurus*	European cattle			X	X			X
LC	-	Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied sheathtail bat				X	X	X	X

Status		Family	Scientific name	Common name	Survey site						
NCA	EPBC				1	2	3	4	5	6	Incidental
LC	-	Emballonuridae	*Taphozous troughtoni*	Troughton's sheathtail bat				X	X	X	X
LC	-	Potoroidae	*Aepyprymnus rufescens*	Rufous bettong	X						X
*	-	Leporidae	*Oryctolagus cuniculus*	European rabbit							X
LC	-	Macropodidae	*Macropus robustus*	Common wallaroo				X		X	X
LC	-	Macropodidae	*Macropus giganteus*	Eastern grey kangaroo							X
LC	-	Miniopteridae	*Miniopterus australis*	Little bent-wing bat			X				
LC	-	Miniopteridae	*Miniopterus orianae*	Eastern bent-wing bat				X	X	X	X
LC	-	Molossidae	*Chaerephon jobensis*	Greater northern freetail bat		X	X	X	X	X	X
LC	-	Molossidae	*Ozimops lumsdenae*	Northern freetail bat			X	X	X		X
LC	-	Molossidae	*Ozimops ridei*	Ride's freetail bat							X
LC	-	Rhinolophidae	*Rhinolophus megaphyllus*	Eastern Horseshoe Bat	X						X
LC	-	Vespertilionidae	*Chalinolobus nigrogriseus*	Hoary wattled bat				X	X	X	X
LC	-	Vespertilionidae	*Nyctophilus sp.*	Long-eared bat			X				
LC	-	Vespertilionidae	*Scotorepens balstoni*	Inland broad-nosed bat	X						X
LC	-	Vespertilionidae	*Scotorepens greyii*	Little broad-nosed bat	X	X	X	X	X		X
LC	-	Vespertilionidae	*Scotorepens sanborni*	Northern broad-nosed bat			X	X			X
LC	-	Vespertilionidae	*Vespadelus troughtoni*	Eastern cave bat	X		X	X	X	X	X
LC	-	Vespertilionidae / Molossidae	*Chalinolobus nigrogriseus / Ozimops ridei*	Hoary wattled bat / Ride's freetail bat							X
LC	-	Vespertilionidae	*Chalinolobus nigrogriseus / Scotorepens greyii*	Hoary wattled bat / Little broad-nosed bat				X		X	X
LC	-	Vespertilionidae	*Scotorepens greyii / Scotorepens sanborni*	Little broad-nosed bat / Northern broad-nosed bat				X	X		X
Reptiles											
LC	-	Elapidae	*Acanthophis antarcticus*	Common death adder							X
LC	-	Elapidae	*Demansia papuanensis*	Greater black whip snake							X
LC	-	Diplodactylidae	*Amalosia rhombifer*	Zigzag velvet gecko		X		X		X	
LC	-	Scincidae	*Ctenotus sp.*	-	X						
LC	-	Diplodactylidae	*Diplodactylus platyurus*	Eastern fat-tailed gecko						X	

Status		Family	Scientific name	Common name	Survey site						
NCA	EPBC				1	2	3	4	5	6	Incidental
LC	-	Gekkonidae	*Gehyra dubia*	Dubious dtella				X			X
LC	-	Gekkonidae	*Gehyra einasleighensis*	Einasleigh rock dtella				X	X		
LC	-	Gekkonidae	*Heteronotia binoei*	Bynoe's gecko				X	X	X	X
*	-	Gekkonidae	*Hemidactylus frenatus*	Asian house gecko							X
LC	-	Gekkonidae	*Oedura argentea*	Silver-eyed velvet gecko					X		X
NE	NE	Diplodactylidae	*Lucasium iris*	Gilbert ground gecko					X		
LC	-	Diplodactylidae	*Oedura castelnaui*	Northern velvet gecko		X				X	
LC	-	Pygopodidae	*Lialis burtonis*	Burton’s legless lizard				X			
LC	-	Scincidae	*Carlia munda*	Shaded-litter rainbow skink	X	X					
LC	-	Scincidae	*Carlia schmeltzii*	Robust rainbow skink			X				
LC	-	Scincidae	*Cryptoblepharus sp.*	-						X	
LC	-	Scincidae	*Morethia taeniopleura*	Fire-tailed skink			X				X
LC	-	Varanidae	*Varanus tristis*	Black-headed monitor				X			X
Amphibians											
*	-	Bufonidae	*Rhinella marina*	Cane toad			X		X		X
LC	-	Hylidae	*Litoria inermis*	Bumpy rocket frog							X
LC	-	Hylidae	*Litoria rubella*	Desert tree frog							X
LC	-	Limnodynastidae	*Platyplectrum ornatum*	Ornate burrowing frog			X				

Status: NE = Not Evaluated, LC = Least Concern , * = non-native to Australia

NCA = Nature Conservation Act 1992, EPBC = Environment Protection and Biodiversity Conservation Act 1999

4.3.8.5. Impacts to Fauna and Flora

4.3.8.5.1. Clearing Impact to Remnant Vegetation

Land clearing is required for the development of the Project. Clearing and land preparation activities will be conducted as per the methodologies outlined in Section 2.3. Flora assessments confirmed that the clearing will only impact REs of 'least concern'. It is unlikely there will be any significant impacts to any 'of-concern' or 'endangered' REs as a result of Agate Creek expansion.

4.3.8.5.2. Remnant Vegetation Associated with a Watercourse

Remnant vegetation associated with a watercourse or drainage feature shown on the Vegetation Management Watercourse and Drainage Feature Map (as certified under the VM Act) is classified as a MSES under the Queensland Environmental Offsets Framework. The extent to which remnant vegetation associated with a watercourse is considered a protected matter is determined by the bioregional context and stream order of the watercourse or drainage feature (SLR Consulting, 2021).

There are several mapped watercourse and drainage features within the study area surrounded by remnant vegetation. Therefore, the extent of vegetation communities within the defined distance of the banks of the mapped watercourse/drainage features is a MSES.

Clearing of mining domains for the majority, avoids watercourse/drainage features. The exception to this is the area around the SW WRD and Pits 1 and 2 where the development will intersect one defined watercourse. Any clearing of remnant vegetation within 5m of the defining banks of these mapped watercourse or drainage features that is also in excess of the relevant clearing thresholds may be classified as a significant residual impact (SLR Consulting, 2021). As such the SRI has been prepared to assess the potential residual impacts (Section 4.3.8.6).

4.3.8.5.3. Protected Matters and ESAs

No protected matters or ESAs were identified within the Agate Creek study area. Two protected ESAs under the *EP Regulation 2008* are mapped to occur to the southwest of the study area (SLR Consulting, 2021).

4.3.8.5.4. Protected Wildlife and Essential Habitat

No areas of protected wildlife (vulnerable or endangered) habitat or essential habitat were located during field surveys (SLR Consulting, 2021).

4.3.8.5.5. Watercourse habitat and Wetlands

The study area does not contain any wetland protection areas or wetlands of high ecological significance. The watercourses present are not 'high ecological value waters' as identified under the Environmental Protection (Water) Policy 2009. No wetlands of international importance (Ramsar wetlands) are located within the study area (SLR Consulting, 2021).

4.3.8.5.6. Conservation Significant Flora Species

Seven conservation significant flora species were identified on State mapping with having the potential to occur within 20km of the study area. None were detected within the study area during field surveys. However, likelihood of occurrence assessments determined that six of these species had a moderate to high likelihood of occurring within the study area. The 6 species and the potential impacts are detailed below

Pluchea punctata

Pluchea punctata is a plant of the Asteraceae (sunflower) family and listed as endangered under the NC Act although is not listed under the EPBC Act. It is known to occur from a single location near Forsayth. It has been documented to occur on hill slopes with vegetation dominated by *Eucalyptus microneura* (Gilbert River Box) and *Triodia* spp (Spinifex). Hill slopes within the study area are generally dominated by *Eucalyptus crebra* (Narrow-leaved Ironbark) and not *Eucalyptus microneura*. *Triodia* spp. were the dominant ground layer in small patches associated with *Eucalyptus crebra* dominated areas that were generally on hill crests. Although the study area is considered suitable habitat for this species it is likely not present within the study area and therefore, it is unlikely that significant impacts will occur to this species as a result of the expansion (SLR Consulting, 2021).

Labichea brassii

Labichea brassii is a plant of the Leguminosae (legume) family and is listed as near threatened under the NC Act and not listed under the EPBC. There are seven records of the species within 20km of the study area (within the Rungulla National Park). It has been documented to occur sandstone plateaus in RE 2.10.2x1. There are sandstone scarps and plateaus within the and near the study area and is considered suitable habitat. Field surveys did not identify this species to be present within the study area. Therefore, it is considered unlikely that *Labichea brassii* will be impacted as a result of the expansion (SLR Consulting, 2021).

Leptospermum pallidum

Leptospermum pallidum is a plant of the Myrtaceae family and is listed as Near threatened under the NC Act and not listed under the EPBC. There are two local records of this species within 20km of the study area (within the Rungulla National Park). Species has been observed on a low sandstone hill among large boulders with a metamorphic substrate within RE 2.10.5x1. There are sandstone scarps and plateaus within the study area with RE 2.10.5x1 vegetation. *Leptospermum pallidum* is considered easily recognisable and despite expensive survey efforts, it was not detected at Agate Creek. Therefore, it is considered that *Leptospermum pallidum is* not likely to exist within the survey area, and unlikely to be significantly impacted by the expansion (SLR Consulting, 2021).

Dichanthium setosum

Dichanthium setosum is a plant of the Poaceae (grass) family and is listed as Least concern under the NC Act and Vulnerable under the EPBC Act. There are no records of *Dichanthium setosum* within 20km of the study area, however, the study area is on the north-western edge of the modelled distribution. This species is identified to occur on heavy soils in woodland or open woodland usually dominated by *Acacia harpophylla* (Brigalow) or *Eucalyptus* species. Suitable habitat for Dichanthium setosum within the study area includes the lowland flood plains dominated by *Eucalyptus microneura* as well as the Agate Creek overflow area. However, suitable habitat within the study area is heavily impacted by grazing, and field surveys did not identify *Dichanthium setosum* to occur within the study area. It is unlikely that *Dichanthium setosum* will be significantly impacted by the expansion (SLR Consulting, 2021).

Drummondita calida

Drummondita calida is a plant of the Rutaceae (citrus) family and is listed as vulnerable under the NC Act and is not listed under the EPBC Act. There is one local record of this *Drummondita calida* within 20km of the study area. *Drummondita calida* has been located on very exposed and sparse low shrubland on bare sandstone plateaux to low open woodland on sandstone with large boulders. RE 2.10.5a is the dominant community on sandstone scarps and plateaus within the study area and is considered potentially suitable local. However, Drummondita calida was not identified during extensive field surveys and therefore, it is considered unlikely to exist within the study area. The Agate Creek expansion is unlikely to significantly impact *Drummondita calida* (SLR Consulting, 2021).

Solanum carduiforme

Solanum carduiforme is a plant of the Solanaceae (nightshades) family and is listed as vulnerable under the NC Act and not listed under the EPBC Act. There are two local records of this species within a 20km of the study area. *Solanum carduiforme* is noted to grow on sandstone either with minimal soil or amongst spinifex on deep sandy soil. Within the study area, REs 2.10.5x2 and 2.10.2x1 are considered suitable habitat. However, *Solanum carduiforme* was not identified during extensive field surveys and therefore, it is considered unlikely to exist within the study area. The Agate Creek expansion is unlikely to significantly impact *Solanum carduiforme* (SLR Consulting, 2021).

4.3.8.5.7. Conservation Significant Fauna Species

Macroderma gigas

Macroderma gigas (Ghost Bat) is listed as endangered under the NC Act and as vulnerable under the EPBC Act. Records do not show local records of this species within a 20km of the study area. However, this species was considered to have a moderate likelihood of occurring within the study area. Macroderma gigas have different types of roosts depending on the purpose. Night roosts are used during foraging spells at night and include rock crevices and shallow overhangs or mine adits. Day roosts are in limestone or sandstone caves, large granite boulder scree or mine adits. Ground-truthing assessments did not indicate the presence of suitable roosting habitat within the study area.

Additionally, no echolocation calls were recorded from this species during field surveys. As *Macroderma gigas* is not to occur within the study area, the development of Agate Creek expansion is unlikely to impact *Macroderma gigas* (SLR Consulting, 2021).

Phascolarctos cinereus

Phascolarctos cinereus (Koala) is listed as vulnerable under both the NC Act and EPBC Act. Records showed the presence of three local records within a 20km of the study area and is considered to have a moderate likelihood of occurring within the study area. Suitable habitat is defined as any forest or woodland containing species that are known food trees including Eucalyptus spp and related genera, (Corymbia spp., Angophora spp. and Lophostemon spp). Reliable soil moisture is also important factors in determining suitable habitat. With a moderate likelihood of Phascolarctos cinereus occurring within the study area, habitat assessment has been conducted in accordance with the EPBC Act *Referral Guidelines for the Vulnerable Koala* (SLR Consulting, 2021). The assessment is summarised in Table 43.

Table 43. Koala Habitat Assessment (SLR Consulting, 2021).

Attribute	Score	Habitat Assessment	
Koala occurrence	0	Desktop studies	DAWE (2020) states that the Koala, or Koala habitat, is likely to occur within a 20km buffer from the study area. Additionally, DES (2020b) identified three local records of the Koala within 20km of the study area. However, a review of these records (QLD Globe, 2020) identified that these occurrences were all pre 2000.
		Field studies	Searches throughout the study area revealed no evidence of Koalas during baseline assessments.
Vegetation structure and composition	2	Ground-truthing assessments revealed that the study area is mostly dominated by Eucalypt woodlands of varying structural complexity. Throughout these woodlands, a variety of known food trees for the Koala were identified, which were dominated by the Gilbert river box, River red gum, and Narrow-leaved ironbark.	
Habitat connectivity	2	A combination of desktop and field studies revealed that the study area is part of a contiguous landscape above 1000ha in size.	
Key existing threats	1	There is potential for a low to moderate level of traffic within the study area during project operations. No wild dogs or Dingoes were identified within the study area during baseline assessments, however there is the potential for Dingoes to occur. Key existing threats has been scored as 1 (medium) as there is at least some threat from vehicle strike and dog attack present.	

Attribute	Score	Habitat Assessment
Recovery value	0	The interim recovery objectives for koalas within the project area include: • Protect and conserve the quality and extent of habitat refuges for the persistence of the species during droughts and periods of extreme heat, especially in riparian environments and other areas with reliable soils moisture and fertility. • Maintain the quality, extent and connectivity of large areas of koala habitat surrounding habitat refuges. The study area is mostly dominated by open woodland communities on plains and slopes where soil moisture and fertility is not reliable. Riparian habitat dominated by River red gum within the study area occurs along highly ephemeral watercourses where soil moisture may persist for longer periods. However, riparian habitat within the study area is marginal with few very large trees. Larger watercourses with more dense riparian vegetation are present within the surrounding region, which likely provide greater value to koala recovery objectives within inland areas. Overall, it is considered that potential Koala habitat within the study area is unlikely to be important for achieving the interim recovery objectives for Koalas in inland areas.
Total score	5	Decision: Habitat potentially critical to the survival of the Koala – an assessment of significance is required.

While the study area supports potentially suitable habitat for the *Phascolarctos cinereus*, given the absence of any evidence of this species occurring within the study area, it is important to consider the following characteristics:

- A habitat score of five represents a moderate habitat value and, in this case, the score is based entirely on habitat suitability as local records of this species are within 16 to 20km of the study area and are all >20 years old.
- The scale of disturbance within the study area is low compared to the size of the surrounding area of remnant vegetation. Any clearing within the study area is not likely to impact broader connectivity values for this species (SLR Consulting, 2021).

It is unlikely that the expansion will result in a significant impact to any local individuals or populations of *Phascolarctos cinereus* due to the lack of any evidence of this species occurring within the study area, no recent local records, and a relatively minor loss of potentially suitable habitat for this species (SLR Consulting, 2021).

Rhinolophus robertsi

Rhinolophus robertsi (Large-eared Horseshoe Bat) is listed as endangered under the NC Act and as vulnerable under the EPBC Act. Records do not indicate the presence of this species within a 20km of the study area. However, this species was considered to have a moderate likelihood of occurring within the study area. Suitable roosts for *Rhinolophus robertsi* is tree hollows and vegetation, or in open habitats such as under creek banks and road culverts, in rockpiles, and relatively shallow caves in drier times. It is also opportunistic, taking advantage of disused underground mines. The study area may provide suitable habitat, particularly in sheltered areas where vegetation is thicker. However, open woodland communities of the study area are not preferable habitat to individuals. Surveys did not detect the echolocation calls despite eight detector nights in various habitats throughout the study area. Therefore, as *Rhinolophus robertsi* was not detected surveys and no unique or generally preferable habitat occurs within the study area, it is considered unlikely that this species occurs at Agate Creek and would not be significantly impacted by the expansion of Agate Creek (SLR Consulting, 2021).

Lucasium iris

Lucasium iris (Gilbert Ground Gecko) not currently evaluated under the NC Act and EPBC Act. Records indicate that *Lucasium iris* is found in the western Einasleigh Uplands bioregion in a localised area of the Gregory Range on Gilberton Station. It is known to occur on low rocky hills with many small escarpments, talus slopes and washout areas. One individual of this species was identified within the study area on sandstone formations within RE 2.10.5a. RE 9.11.16, is noted to be a RE that *Lucasium iris* occurs within was also ground-truthed within the study area. However, no individuals of this species were identified within this RE. Although this species is not currently listed, the Agate Creek expansion within the study area is unlikely to significantly impact this species (SLR Consulting, 2021).

4.3.8.6. Significant Residual Impact

A Significant Residual Impact (SRI) has been prepared to assess the risk of residual impacts to vegetation intercepting a watercourse and species of conservation significance. This section details the results of the SRI.

4.3.8.6.1. Vegetation Intercepting a Watercourse

Planned mining and associated infrastructure disturbance areas at the time of this report indicate impacts to vegetation associated with watercourses within the ML. These disturbance areas relate to the following planned features and infrastructure:

- Linear infrastructure:
    - 10 m wide proposed haul roads with access to Pits 1, 2 and 3 with underlying stream order 1 watercourse with vegetation comprised of RE 9.12.11 (sparse) (disturbance area 1);
    - 10 m of haul road proposed to cross a section of Agate Creek which is a stream order 4 watercourse with vegetation comprised of REs 9.3.13 (mid-dense) and 9.12.11 (sparse) (disturbance area 2); and

- Non-linear infrastructure:
    - 1.468 ha of RE 9.12.11 (sparse) vegetation intersecting a stream order 1 watercourse that underlies a portion of sediment dam 3A, Pit 1, and a southern section of Pit 2 (disturbance area 3);
    - 0.283 ha underlying the Sherwood West Waste Rock Dump (SW WRD), including a small portion of the upper most reach of a second stream order 1 watercourse draining west that shares a margin with the SW WRD footprint. RE present is 9.12.11 (sparse) (disturbance area 4).

The total proposed area of disturbance of vegetation associated with watercourses is 2.594 ha. Table 44 details the outcome of the residual impact test for regulated vegetation (defined watercourse).

Table 44. Significant residual impact test for regulated vegetation criteria table

		Clearing in a regional ecosystem that is: *endangered* or of *concerned*	**Clearing in the portion of a regional ecosystem that lies within a mapped wetland**	**Clearing in a regional ecosystem that is within the defined distance of a watercourse.**
1	For clearing for linear infrastructure: • greater than 25 m wide in a grassland (structural category) regional ecosystem; or • greater than 20 m wide in a sparse (structural category) regional ecosystem; or • greater than 10 m wide in a dense to mid-dense (structural category) regional ecosystem. For clearing other than clearing for linear infrastructure: • area greater than 5 ha where in a grassland (structural category) regional ecosystem; or • area greater than 2 ha where in a sparse (structural category) regional ecosystem; or • area greater than 0.5 ha where in a dense to mid-dense(structural category) regional ecosystem.	No	No	**Disturbance area 1:** Linear infrastructure ~10 m wide in vegetation with sparse vegetation. – Providing disturbance does not exceed 20 m then – ***No*** **Disturbance area 2:** Linear infrastructure ~10 m wide in vegetation with mid-dense and sparse vegetation. – Providing disturbance does not exceed 10 m then – ***No*** Disturbance areas 3 and 4: 1.751 ha of non-linear infrastructure in vegetation with sparse vegetation. – Providing disturbance does not exceed a total of 2 ha then – ***No***
2	Clearing within 50 m of the defining bank	N/A	No	N/A
3	Clearing within 5 m of the defining bank	N/A	N/A	***Yes*** – clearing includes areas within 5 m of the defining bank
For a prescribed activity to have a significant residual impact on a regional ecosystem that is within the defined distance of watercourses, criteria 1 and 3 must be exceeded, therefore, - **No significant impact**				

4.3.8.6.2. Habitat for Conservation Significant Flora and Fauna

Each flora and fauna SRI matter identified by the baseline flora surveys (Section 4.3.8.5) and SRI desktop reviews (Appendix F) have been assessed against the relevant significant impact guidelines to determine if the Agate Creek Expansion would have a SRI on listed flora and fauna. The SRI is included in Appendix F. The SRI determined the following:

Conservation significant flora:

- *Cycas cairnsiana* – vulnerable (EPBC, NCA) - ***No Significant Residual Impact;.***
- *Dichanthium setosum* – vulnerable (EPBC Act) - ***No Significant Residual Impact;***
- *Drummondita calida* – vulnerable (NC Act) - ***No Significant Residual Impact;***
- *Labichea brassii* – near threatened (NC Act) - ***No Significant Residual Impact;***
- *Leptospermum pallidum* – near threatened (NC Act) - ***No Significant Residual Impact;***
- *Pluchea punctata* - endangered (NC Act) - ***No Significant Residual Impact;*** and
- *Solanum carduiforme* – vulnerable (NC Act) - ***No Significant Residual Impact.***

Threatened Fauna:

- Common death adder (*Acanthophis antarcticus*) – vulnerable (NC Act) - ***No Significant Residual Impact;***
- Ghost bat (*Macroderma gigas*) – endangered (NC Act), vulnerable (EPBC Act) - ***No Significant Residual Impact;***
- Grey falcon (*Falco hypoleucos*) – vulnerable (EPBC, NCA) - ***No Significant Residual Impact;***
- Koala (*Phascolarctos cinerus*) – endangered (NC Act), endangered (EPBC Act) - ***No Significant Residual Impact***; and
- Large-eared horsehoe bat (*Rhinolophus robertsi*) – endangered (NC Act), vulnerable (EPBC Act) - **No Significant Residual Impact.**

Special Least Concern Fauna:

- Long-beaked echidna – (*Tachyglossus aculeatus*) – special least concern (NC Act) - ***No Significant Residual Impact.***

Listed Migratory Species:

- Caspian tern (*Hydroprogne caspia*) – migratory (EPBC), special least concern (NCA) - ***No Significant Residual Impact;***
- Common greenshank – (*Tringa nebularia*) – migratory wetland, overfly marine area (EPBC), special least concern (NCA) - ***No Significant Residual Impact;***

- Little curlew (*Numenius minutus*) - migratory wetland, overfly marine area (EPBC), special least concern (NCA) - ***No Significant Residual Impact.***: and
- Rufous fantail (*Rhipidura rufifrons*) - migratory, overfly marine area (EPBC), special least concern (NCA) - ***No Significant Residual Impact;***

Listed Marine Species:

- Cattle Egret (*Ardea ibis*) – overfly marine area (EPBC) - ***No Significant Residual Impact;***
- Magpie goose (*Anseranas semipalmata*) - overfly marine area (EPBC) - ***No Significant Residual Impact***; and
- Rainbow bee-eater (*Merops ornatus*) - overfly marine area (EPBC) - ***No Significant Residual Impact.***

It should be noted that potential habitat for many of the above-mentioned flora and fauna species is present within the site and therefore the relevant level of diligence will be undertaken with respect to the preclearance of areas prior to disturbance to ensure the project meets the condition for environmental harm.

4.3.9. Land Management

4.3.9.1. Waste Rock Management

The waste rock will be placed in separate “out-of-pit” WRDs at locations displayed in Figure 3. The waste rock characterisation findings indicate that majority of the waste rock is NAF material and that the Acid Rock Drainage (ARD) risk from waste rock at Agate Creek is low. Therefore, the WRDs are to be considered NAF dumps and will be managed accordingly. However, to ensure that proper waste rock management is achieved, LWR will implement a material identification system with the aim of identifying and material that does not adhere to NAF classification. The identification system will include:

- Survey control or as required based on material movement records;
- Maintaining an up-to-date waste rock block model;
- Mapping of pit walls and mined faces according to the lithologies;
- Blast hole logging to assist in this waste characterisation and
- Visual inspections and sampling to differentiate material.

The sampling and testing programme will be completed on the same schedule as ore determination to include it in the mine schedule. Records of the volume of each waste rock type mined during each shift will be kept.

4.3.9.2. Waste Rock Placement

Generally, it is anticipated that the waste rock will be dumped within the designated storage areas and reworked with dozers to form a the WRD design (Figure 3). Dump trucks will be routed across the surface to provide tyre compaction to the waste. No additional compaction or moisture controls of the waste rock is proposed.

4.3.9.3. Waste Rock Leachate Management

Agate Creeks water management strategy was developed to segregate acid rock drainage, neutral mine drainage and saline drainage. Leachate management is detailed in Table 45 .

Table 45. Water/Leachate Management Strategy (ATC Williams, 2022)

Structure	Drainage	Details
Open Cut Pits	Neutral Drainage, Acid Rock Drainage	It is proposed that water contained within the Open Cut Pit be pumped to the Water Storage Dam over the operational period of the project
Water Storage Dam	Saline Drainage, Acid Rock Drainage	The Water Storage Dam will contain site impacted stormwater runoff from the Pits and dirty water from Sediment Ponds. The operating objective for this storage is to maintain sufficient capacity to contain site water and limit overflow, as well as provide make-up water storage.

Sediment Ponds	Sediment Laden/Runoff	A number of sediment ponds are proposed to capture runoff from the WRDs and disturbed areas. The objective is to capture sediment within the Sediment Ponds and transfer this dirty water to the Water Storage Dam. There is potential to release this water directly off-site in large rainfall events, subject to water quality testing.

4.3.9.4. Waste Rock Dumps Conceptual Design

Waste rock dumps have been designed to be permanent storages for waste rock at Agate Creek. The waste dump design is based on the mining waste schedule quantity and involves selective mining and placement of waste rock to form NAF WRDs The key objective of the waste rock dump design is to ensure that the final landform is safe, stable and non-polluting (ATC Williams, 2022).

4.3.9.5. Geometrical Design

The WRDs are designed as a low-profile structure located in valleys. The WRDs require access ramps to allow dumping of waste rock and maintenance access to the structure. Access ramps are located from ridges to limit the road lengths and ramp grades (ATC Williams, 2022).

Any unexpected PAF material will must be encapsulated by NAF material. A NAF base is proposed to be constructed to provide a platform upon which any PAF material can be placed to prevent contaminant migration into the receiving environment (ATC Williams, 2022).

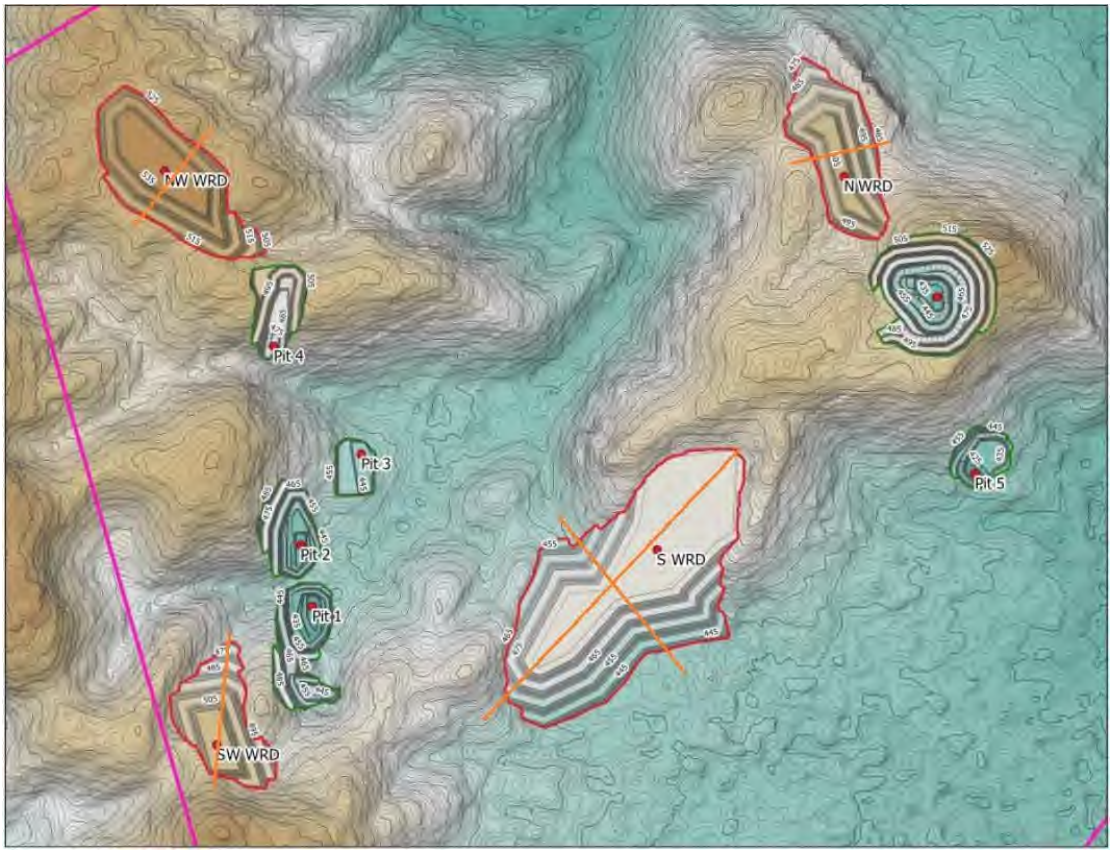


Figure 45. Waste Rock Dump Cross Sections (Orange) (ATC Williams, 2022)

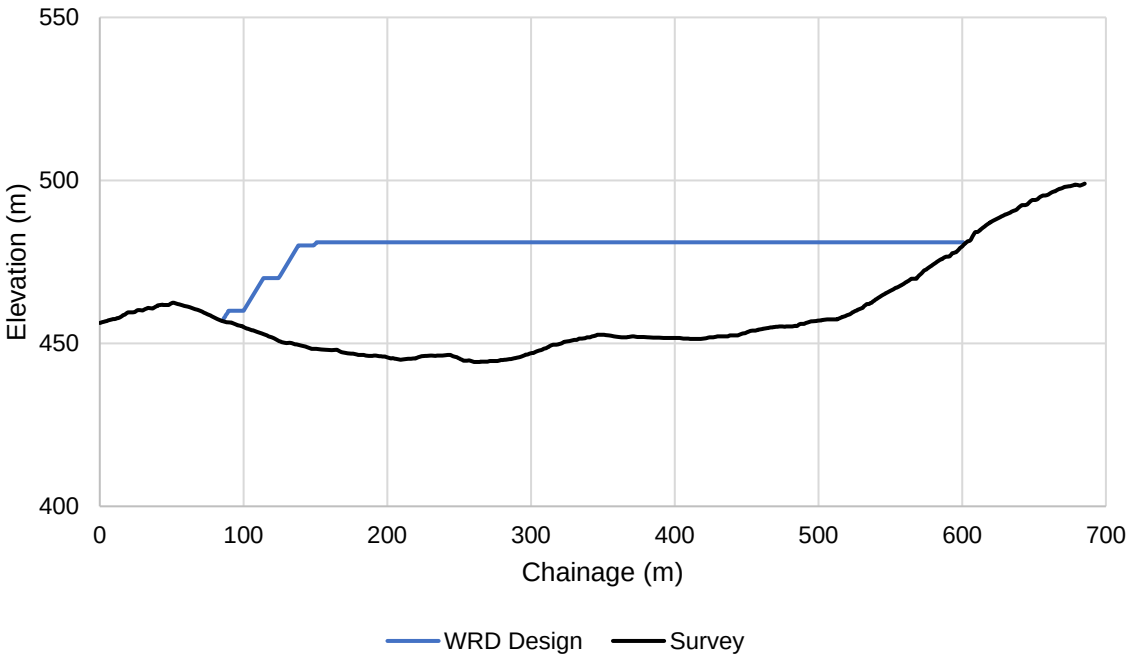


Figure 46. Southern Waste Rock Dump Cross Section (Northeast-Southwest) (ATC Williams, 2022)

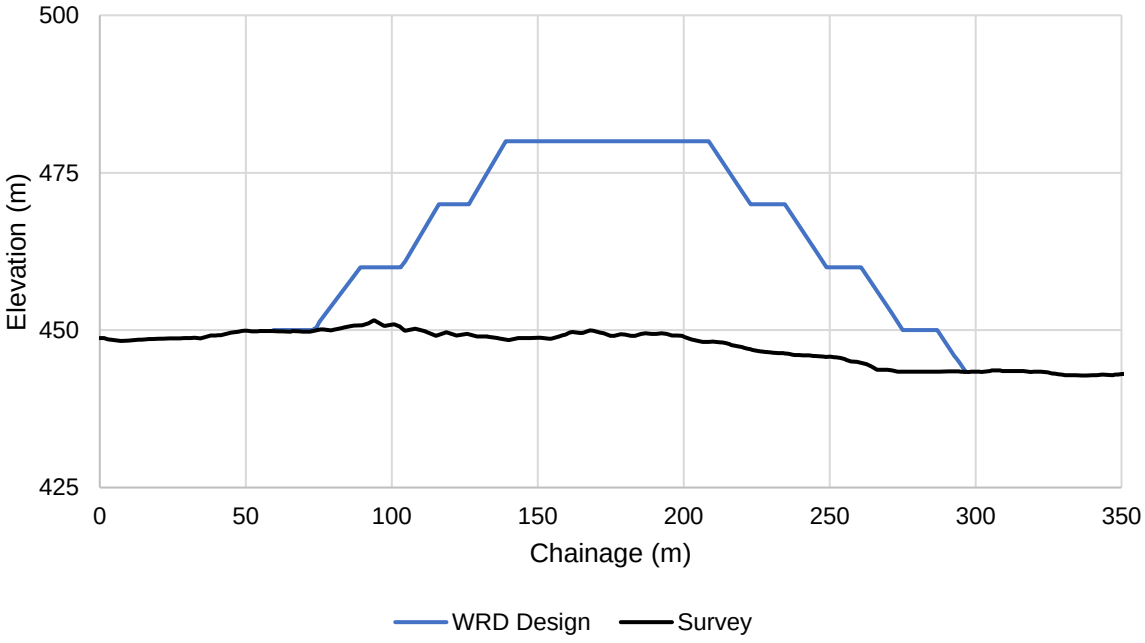


Figure 47. Southern Waste Rock Dump Cross Section (Northwest-Southeast) (ATC Williams, 2022)

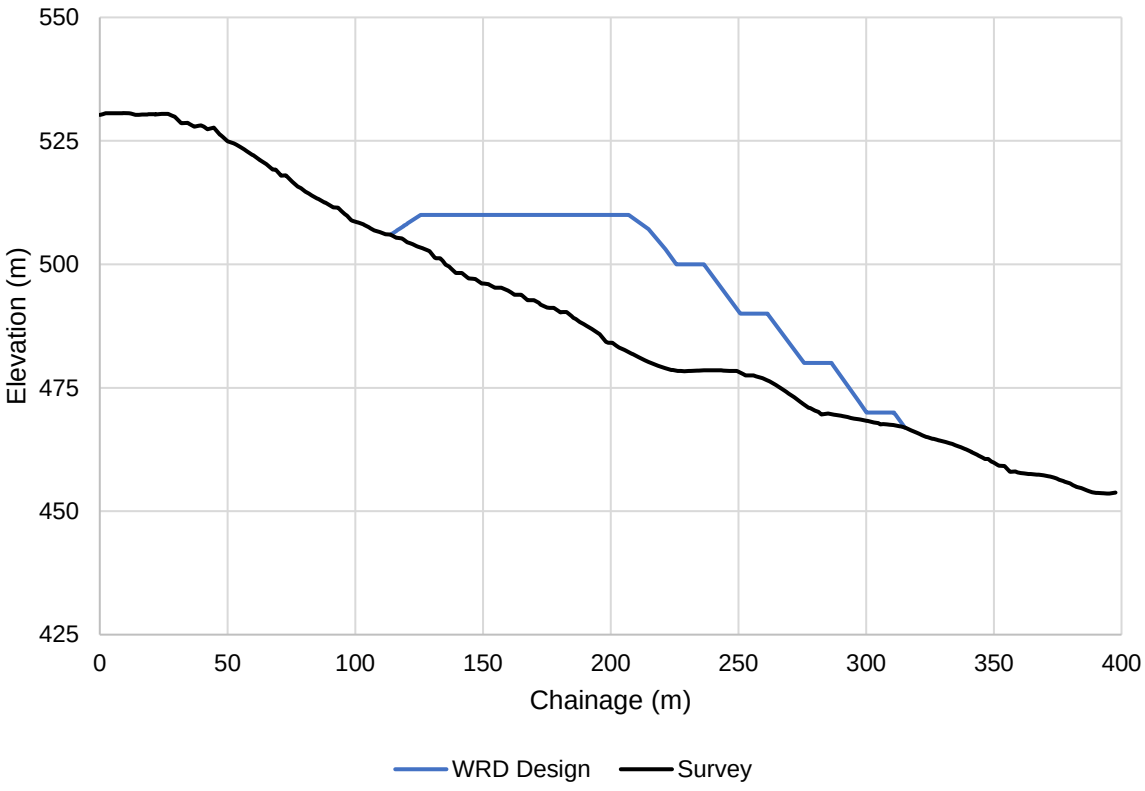


Figure 48. Southwest Waste Rock Dump Cross Section (South-North)

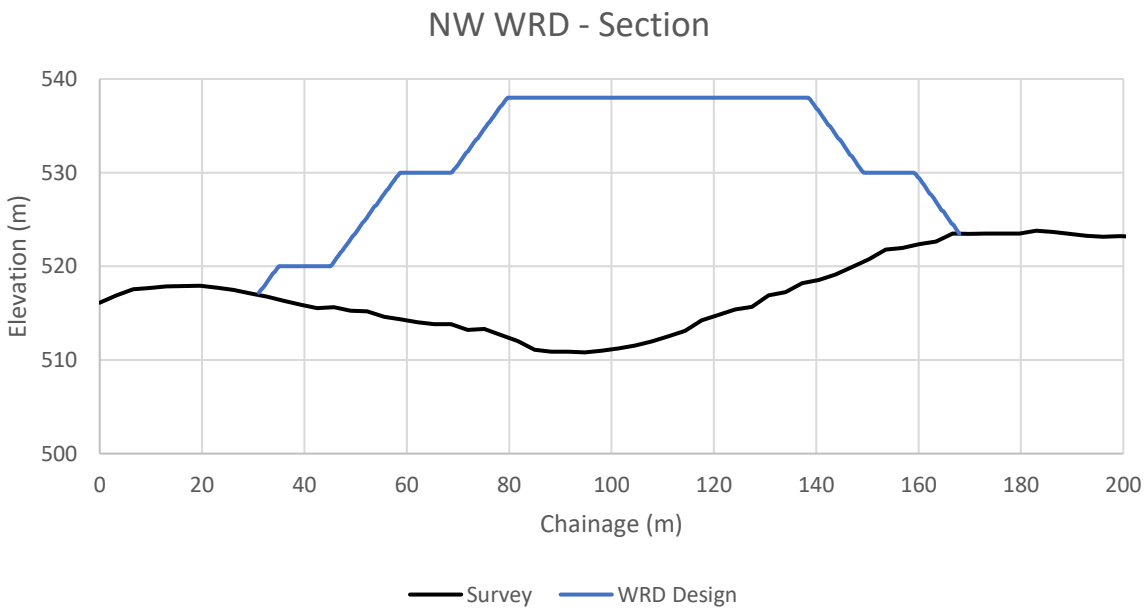


Figure 49. Northwest Waste Rock Dump Cross Section (Southeast-Northwest)

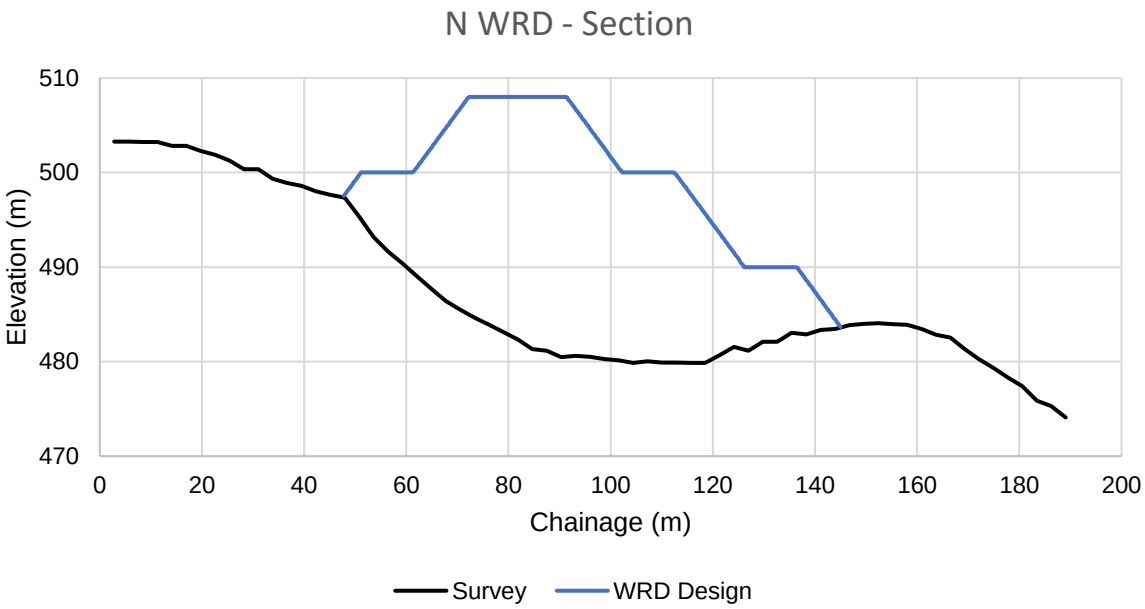


Figure 50. North Waste Rock Dump Cross Section (South-North)

4.3.9.6. Stability Analysis

The southwestern WRD has selected for the Stability Assessment as it is characterised as a large dump height (i.e. 43 m high) and relatively steep slope of natural ground surface.

4.3.9.6.1. Material Properties

The stability analysis adopted the same shear strength envelopes for the foundation materials Gecko Geotechnics report. Material properties are detailed in Table 46.

Table 46. Foundation Material Properties (ATC Williams, 2022)

Foundation Material	Main Rock Type	Design UCS (MPa)	Geological Strength Index (GSI)
Completed Weathered or Residual Material	Granite / Rhyolite	0.5	20 – 30
Weathered Rock	Granite / Rhyolite / Breccia	5	35 – 45

4.3.9.6.2. Seismicity

According to the Geoscience Australia seismic hazard map, the site is located within relatively low seismicity area with Peak Ground Acceleration (PGA) of 0.01g for 1 in 500-year earthquakes and of 0.03g for 1 in 2500-year earthquakes. Those PGA were adopted for a pseudostatic stability analysis for the waste dump (ATC Williams, 2022).

4.3.9.6.3. Stability Analysis and Outcomes

The parameter adopted for the stability analysis are summarised in Table 47.

Table 47. Adopted Geotechnical Parameters (ATC Williams, 2022)

Foundation Material	γ (kN/m^3)	Shear Strength Envelope
Completed Weathered or Residual Material	20	Hoek-Brown Model (UCS=0.5MPa, GSI=20, mi=10, D=0)
Weathered Rock	22	Hoek-Brown Model (UCS=5MPa, GSI=35, mi=10, D=0)
Waste Rock	20	Lower Bound Strength (Leps, 1970) $\tau = 1.446\ \sigma^{0.898}$

Table 48. Stability Analysis – Factor of Safety (ATC Williams, 2022)

Loading Conditions	Factor of Safety	Recommended Min. FOS [1] (Hawley and Cunnings, 2017)	Appendix B Figure
Static	1.42	1.3	B.1
Pseudo-Static - PGA of 0.01g	1.12	1.05	B.2
Pseudo-Static - PGA of 0.03g	1.09		B.3

The analytical outcomes indicate the current waste dump slope meets the recommended minimum FoS for both static and pseudo-static loading conditions.

4.3.9.6.4. Waste Rock Dump Monitoring and Reporting

Confirmation of NAF material is intersected during mining as expected, will be controlled on a laboratory-based analysis that uses rapid onsite techniques to verify characterisation. Sample selection will be undertaken to provide sufficient samples for each lithological unit and mass of material extracted from the open pit. Selected waste rock samples will be analysed at a National Association of Testing Authorities (NATA) accredited laboratory for the following:

- NAPP (Total Sulfur, CRS, MPA and ANC);
- Paste pH, pH5:1, EC5:1 and 5:1 Leachate analysis;
- NAG pH, NAG4.5 and NAG7.0; and
- Total carbon and total organic carbon.

Kinetic leaching or successive leaching protocols will be undertaken for major units in the waste rock material to assess any oxidation potential and the potential for environmental impact.

Visual Inspections

Suitably qualified mine geologists will carry out weekly visual inspections on each area of the waste rock dumps to evaluate the performance and condition of the facilities. The toe sections of the waste rock dumps shall be assessed for seepage, and if seepage is observed, it will be recorded. Sedimentation ponds downstream of each WRD will be monitored as required to determine the quality of waters leaching off each WRD as required.

Reporting

The results of the visual inspections and all laboratory-based analyses will be recorded and documented in a suitable storage system developed for Agate Creek.

4.3.9.7. Soil Erosion

The SLSA identified that all soil types identified at Agate Creek express a moderate erosion risk. The SLSA identified the following as potential management actions to be taken at Agate Creek:

- Prioritising land clearing so as to only disturb areas necessary for development;
- Divert clean water and upstream catchments around proposed disturbances;
- Manage on site “dirty/ impacted” waters in such a way as to capture and treat sediment laden waters prior to leaving site;
- Ensure soil resources stockpiled are placed away from drainage areas, roads, machinery, transport, and grazing areas;
- Undertake progressive rehabilitation activities on landforms no longer required for operations.
- Staging the clearing activities where possible such that this is limited only in areas which are being actively cleared, therefore, limiting the time such areas are exposed;
- Erosion and Sediment Control Plans will be developed in accordance with IECA best practice guidelines such that these will highlight how far in advance vegetation clearing can be undertaken prior to construction works; and
- Develop and implement management strategies (as above) through an EM Plan and Erosion and Sediment Control Management Plan in line with all statutory legislation and regulations;
- General vegetation clearing and soil stripping should not be undertaken until earthwork and construction operations are ready to commence. All proposed erosion and sediment control measures will be implemented prior to, or in conjunction with, clearing activities.
- Prior to commencement of clearing and soil stripping, the limits of these works need to be clearly delineated by pegs placed at intervals on each side of the disturbed area by a suitably qualified supervisor.

- All operations will be planned to ensure that there is no damage to any trees, cropping or pasture areas outside the limits to be cleared.

Specific details of erosion and sediment control management will be detailed in an Erosion and Sediment Control Plan (ESCP) The ESCP will be prepared with reference to the IECA Best Practice Erosion and Sediment Control document. The ESCP will be prepared as detailed drawings prepared by a suitably qualified person and supporting information which will:

- Detail the erosion and sediment specific EV of the site (e.g., climate, topography, drainage etc.);
- Provide details on soil types and erodibility;
- Detail the stages of construction and Project progression;
- Determine site catchments during the construction and operational phases;
- Provide Erosion and Sediment Controls (ESC) for each stage of development;
- Include calculations of ESCs features to be constructed; and
- Include management measure to ensure ESC are operational.

4.3.9.8. Topsoil Management

A Topsoil Management Plan (TMP) will be prepared for Agate Creek as a subsection of the Agate Creek Environmental Management Plan. The TMP will be prepared to ensure that soils recovered during the construction phase of the Project maintain integrity and are able to be used in rehabilitation. The TMP includes:

- A description of the existing soils utilising ground-truthed soil types;
- Detailed topsoil stripping procedure that aims to maximise volumes of suitable topsoil removed
- Detailed stockpile design and maintenance procedure;
- Erosion and sediment control measures to be implemented to prevent the loss of soil resources
- Topsoil application procedures; and
- Reporting, inspection and review requirements.

4.3.9.8.1. Topsoils Stripping Procedure

LWR will implement the following topsoil stripping procedure which aims to optimise the potential for plant growth and propagules for natural regeneration during rehabilitation activities:

- Prior to stripping topsoil, LWR will review the area of stripping activities to determine the desired depth and determine the most suitable storage location within the topsoil stockpile area or

determine whether the material is not suitable for rehabilitation and whether material should be transported to the WRDs.

- Machinery imported to site for topsoil stripping will be required to present such machinery in a weed-free condition to ensure that weeds are not introduced to topsoil seed banks
- LWR will use a bulldozer, articulated scraper, or similar appropriate equipment to recover topsoil resources. Soils may require ripping to recover soil resources.
- Soil striping should be conducted where possible, during moist soil conditions.
- Disturbance areas will be stripped progressively, as required.
- Where rehabilitation areas are prepared, recovered soils are to be placed directly on rehabilitation areas.
- Where rehabilitation areas are not prepared, recovered topsoils are to be transported to the Topsoil stockpile area for storage.

4.3.9.8.2. Topsoil Stockpile Design

Topsoils stockpiles will be shaped in a fashion which does not compromise the integrity of soils being stockpiled. Topsoil and subsoils are to be stored separately in low piles (<2m) adjacent to WRDs or as bunds. Long term stockpiles will be revegetated as soon as possible to minimise loss of soil integrity, prevent weed infestation, and maintain soil organic matter levels and microbiological activity. Where stockpiles will remain onsite for an extended amount of time (>6 months), stockpiles are to be revegetated with a cover crop where natural covers to not establish.

4.3.9.8.3. General Stockpile Management

The following general stockpile management measures are to be implemented by LWR at all times:

- Stockpile storage times are to be minimised as much as practically possible to ensure the integrity of topsoil is maintained, where practical reuse stockpiled topsoil within 12 months of storage.
- Any new topsoils are to be logged. Information to be collected includes (but not limited to) the location of the stockpile and soil type stockpiled.
- Stockpiles are to have identification signage at all times. Signage will include the stockpile number and date of completion.
- Stockpiles are to be located away from drainage lines to minimise the risk of erosion.
- Limit the height of topsoil stockpiles to 2 m.
- Where natural recruitment fails, stockpile surfaces are seeded or hydro-mulched to reduce the risk of erosion.
- Appropriate weed control strategies are implemented.

4.3.9.9. Flora Management

This proposal requires land covered by Category B (least concern) vegetation to be cleared. Clear and grubbing during the development of Agate Creek is not expected to have a significant residual impact on MSES vegetation, MNES vegetation or regulated vegetation (Section 4.3.8 and Section 4.3.8.6). However, LWR will implement management measures outlined below to further mitigate the risk of impact on vegetation as a result of the proposed development.

4.3.9.9.1. Avoidance

The SLR Agate Creek Terrestrial Flora and Fauna Baseline Assessment reported that there were no Regional Ecosystems (RE) listed as 'endangered' or 'of concern' under the VM Act ground-truthed within the ML. As such, MSES vegetation and offset triggers will be avoided.

Where avoidance cannot occur, such as within vegetation intercepting a watercourse, the SRI Assessment investigated the impact of disturbance. All areas of disturbance within regulated vegetation were deemed to have no significant residual impact as a result of the proposed development. Nonetheless, where possible, clearing and development will be avoided and minimised.

4.3.9.9.2. Clearing And Vegetation Management

Vegetation will be impacted by Agate Creek. During construction activities the following measures should be implemented to minimise disturbance impacts and any potential harm to habitat values, and flora and fauna present within the area:

- The boundary of areas to be cleared will be clearly marked, to ensure the disturbance footprint is minimised.
- Clearing will occur in a sequential manner to allow any fauna present in the area to escape to areas away from construction activities.

Vegetation stockpiles will provide habitat for small ground-dwelling mammals and reptiles during the construction phase. It is important to locate these stockpiles away from high traffic areas and ensure they are not isolated from contiguous vegetation at the edge of the site. This will reduce the likelihood of fauna travelling across the site.

Cleared vegetation should be managed according to the following best practice principles:

- Where possible, logs and large branches with hollows will be reserved and stockpiled separately (at the edge of the site) for rehabilitation purposes.
- Any mulching will occur as near as possible to the time of clearing to prevent the establishment of stockpiles as fauna habitat

4.3.9.9.3. Weed Management

A number of pest plant species and restricted invasive plants were identified by desktop analysis and field surveys (SLR Consulting, 2021). Where appropriate, LWR will implement the following management measures during the construction phase and operational phases of the Project:

- Develop and implement a Weed Management Plan as a subsection of the overarching EMP;
- Vehicles and machinery brought on site should be clean and free of weeds, dirt and other material that may contain weed seeds and cause exotic species to become established within the works areas;
- Weed spread should be minimised by implementing some control measures within the proposed works areas prior to construction;
- Disturbance sites and stockpiles should be regularly monitored for incidence of weed species;
- Where any weed establishment is identified, appropriate control measures should be implemented to minimise the impacts of weeds on native habitat; and
- Weed control activities should specifically target weeds listed under the Biosecurity Act 2014 or listed as declared or priority weeds under the local government pest management plan, however, new and emerging environmental weeds should also be targeted

4.3.9.10. Fauna Management

There is a risk that clear and grubbing associated with the construction of the proposed development will impact on fauna. Excavated areas can pose a risk to native fauna through entrapment and exposure.

A fauna spotter-catcher will be on site during the vegetation clearing. The fauna spotter-catcher will hold a current rehabilitation permit and will be present during clearing activities. The role of the spotter-catcher will be to ensure animal escape paths are maintained and relocate fauna located within the disturbance area as necessary.

Excavated areas will also be checked regularly for trapped fauna, including early in the morning and the late afternoon. Safe egress points should be included to allow fauna to escape of their own accord. Any fauna that cannot escape of its own accord will be removed in a manner that is safe for both the animal and the person handling the animal. A suitably qualified and experienced person will handle dangerous fauna species such as snakes.

4.3.9.11. Waste management

LWR resources will manage wastes at Agate Creek in accordance with the waste and resource management hierarchy. Waste management is detailed in Section 4.5.

4.3.9.12. Unplanned and Uncontrolled Releases

Unplanned and uncontrolled releases from Agate Creek are possible as a result of unforeseen circumstances, poor maintenance or inclement weather. The following will be implemented by LWR to ensure there are no unplanned and uncontrolled releases to land.

4.3.9.13. Maintenance Scheduling

All light vehicles, plant and static machinery will be inspected and maintained as per the manufactures specifications. Where defects are identified, LWR appointed contractors will attend to site to conducted required maintenance.

4.3.9.14. Handling and Storage of Chemicals and Fuels

All chemicals and fuels will be stored in accordance with Australia Standard (AS) 1940 The storage and handling of flammable and combustible liquids. Chemicals and fuels proposed to be handled and stored onsite include residual fuels and oils and greases. Chemicals and fuels are proposed to be stored in appropriate containers (e.g. fuel drums) on bunded pallets, cabinets, etc.

All waste chemical, fuels and oils will be stored in appropriate containers and removed from the Project by a licenced third-party waste management company.

4.3.9.15. Spill Management

All spills will be mitigated through the use of onsite spill kits. All employees will be appropriately trained in the use of spill kits including containment, absorption, and recovery. Any spill over 20 L will be recorded as an incident and appropriately documented.

4.4. Water Impacts

In preparing this application, consideration has been given to guideline *ESR/2015/1837 – Application requirements for activities with impacts to water* (Department of Environment and Science, 2017c). DES is required to assess the application against the requirements stated in the *Environmental Protection Act 1994*, EP Regulation and the EPP Water to meet the environmental objective and performance outcomes described below:

Environmental Objective

'The activity will be operated in a way that protects environmental values of waters.'

Performance Outcome

There is no actual or potential discharge to waters of contaminants that may cause an adverse effect on an environmental value from the operation of the activity.

All of the following:

(a) The storage and handling of contaminants will include effective means of secondary containment to prevent or minimise releases to the environment from spillage or leaks.
(b) Contingency measures will prevent or minimise adverse effects on the environment due to the unplanned releases or discharges of contaminants to water.
(c) The activity will be managed so that stormwater contaminated by the activity that may cause an adverse effect on an environmental value will not leave the Project without prior treatment.
(d) The disturbance of any acid sulfate soil, or potential acid sulfate soil, will be managed to prevent or minimise adverse effects on environmental values.
(e) Acid producing rock will be managed to ensure that the production and release of acidic waste is prevented or minimised, including impacts during operation and after the environmental authority has been surrendered.
(f) Any discharge to water or a watercourse or wetland will be managed so that there will be no adverse effects due to the altering of existing flow regimes for water or a water course or wetland.
(g) For a petroleum activity, the activity will be managed in a way that is consistent with the coal seam gas water management policy, including the prioritisation hierarchy for managing and using coal seam gas water and the prioritisation hierarchy for managing saline waste.
(h) The activity will be managed so that adverse effects on environmental values are prevent or minimised.

Environmental Objective

The activity will be operated in a way that protects the environmental values of groundwater and any associated surface ecological systems.

Performance Outcome

Both of the following apply:

(a) There will be no direct or indirect release of contaminants to groundwater from the operation of the activity.

(b) There will be no actual or potential adverse effect on groundwater from the operation of the activity.

Or, the activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.

Some activities involving direct releases to groundwater are prohibited by the EP Regulation.

RISK OF ENVIRONMENTAL IMPACT: LOW

4.4.1. Water infrastructure

Water infrastructure to be included in the Agate Creek expansion consist of:

- Six Open cut pits;
- Seven sediment basins;
- One MAW dam; and
- Bunding.

Water management infrastructure is displayed Figure 3.

4.4.2. Natural Rainfall & Evaporation

Agate Creek is located in the dry tropics' region and experiences hotter and wetter periods during the summer months (wet season) and drier, cooler periods during the winter months (Section 3.1). Analysis of rainfall and evaporation over the past 10 years (SILO,2022) indicates that PAN evaporation far exceeds rainfall with a rainfall total of 6293.4mm vs and evaporation total of 25,388.7mm.

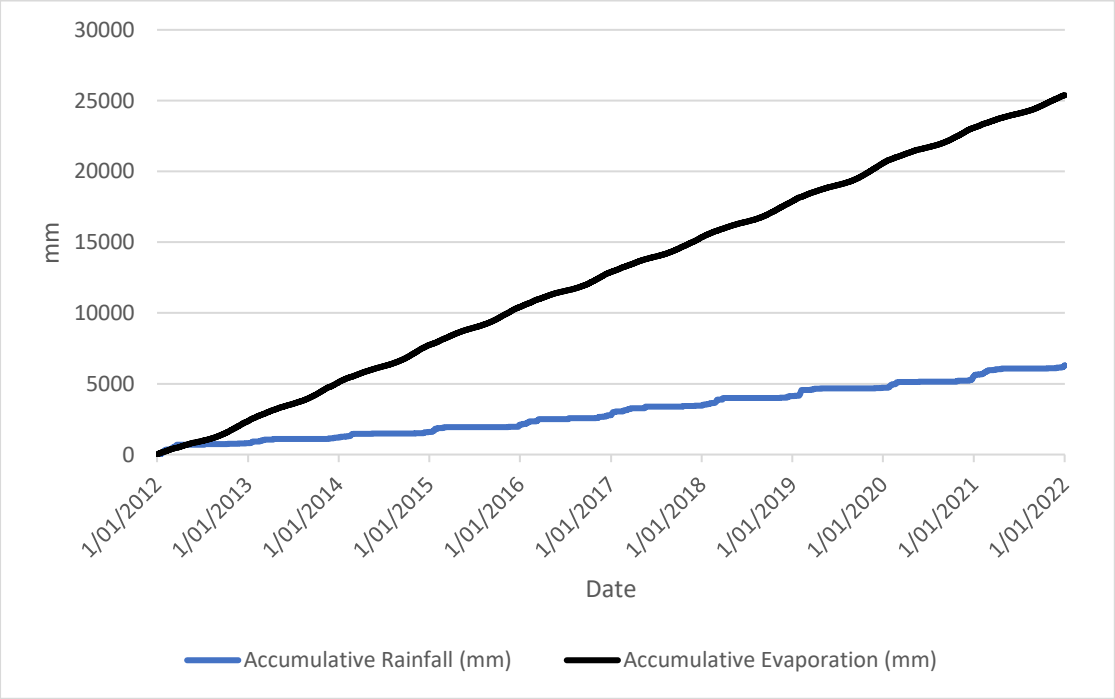


Figure 51.Daily Pan Evaporation vs Daily Rainfall 2012 – 2022

4.4.3. Water Management Strategy

Clean water diversion bunds/drains will be positioned around WRDs and open cut pits to divert any clean water away from the disturbance footprint. Clean water runoff discharges centrally to the tributaries of Agate Creek located within the subject site.

4.4.3.1. Site Water Management

The water management strategies with respect to the Project are detailed in Table 49.

Table 49. Site Water Management (ATC Williams, 2022)

Domain	Management Strategy
Bunding	Will separate mine affected water and runoff from clean surface water. Mine impacted water will be directed into the water storages across the Project for reuse on site.
MAW Dam	The MAW Dam will contain site impacted runoff from the Open Cut Pits and dirty water from the sediment ponds. The operating objective for this storage is to maintain sufficient capacity to contain site water and limit overflow, as well as to provide make-up water for site water demands, namely dust suppression.
Open Cut Pits	It is proposed that water contained within the Open Cut Pits is pumped to the MAW Dam over the operational period of the project (when required for mining operations).
Sediment ponds	Seven (7) sediment ponds are proposed to be operational on site, to capture and treat sediment-laden runoff from the WRDs. The objective with respect to water contacting these surfaces is to capture sediment within the sediment ponds, with the potential to release this water directly off-site, subject to water quality testing.
Evaporation	As per Section 4.4.2, evaporation far exceeds the annual rainfall totals. Water stored in water management structures will readily evaporate at an average rate of 6.95mm/m^2/day. Additional evaporation will be achieved by the implementation of forced evaporation (accelerated evaporation systems or similar)

4.4.4. Water Infrastructure Requirements

As there will be no processing at Agate Creek, the site does not require process water dams or tailings storage facilities. Deposition of waste rock will occur in such a way as to limit any potential interaction of any unexpected PAF rock with rainfall runoff (NAF encapsulation of any unexpected PAF rock). Water infrastructure proposed for the site is limited to sediment ponds designed to capture runoff from disturbed site areas. Other minor disturbed areas such as hardstands and camp areas will need localised erosion and sediment control measures (ATC Williams, 2022).

4.4.4.1. Sediment Pond Sizing

Sediment pond sizes were determined by the following criteria:

- Spill risk of <20% (to achieve 80% hydraulic efficiency) as per the State Planning Policy and generally in accordance with IECA guidelines.

The required volume for the sediment storage was also determined based on the estimated soil loss of approximately 270 t/ha/yr and assumed clean out frequency of every 6 months if required or at the end of the dry season pending the next wet season (ATC Williams, 2022).

Table 50. Sediment Ponds Details (ATC Williams, 2022)

Pond	Catchment Area (ha)	Settling Zone Volume (ML)	Sediment Storage Volume (ML)	Total Storage Volume (ML)	Depth from Spillway (FSL) (m)	Length at FSL (m)	Width at FSL (m)
A	1.72	2.7	0.2	3.9	2.5	75	23
B	2.73	4.1	0.3	4.4	2.7	85	27
C	5.84	6.5	0.7	7.2	2.7	103	33
D	7.92	8.8	0.9	9.7	2.9	113	37
E	5.84	6.5	0.7	7.2	2.7	103	33
F	3.24	4.2	0.4	4.6	2.6	88	28
Rom Pad	2.5 ha	4.1	0.3	4.4	2.7	85	27

4.4.4.2. Water Storage Dam

The Water Storage Dam is to be located to the southwest of the southern WRD and receives input from the open cut pits and sediment ponds where quality does not allow discharge. The dam will incorporate a spillway which directs flows west towards Agate Creek.

Table 51. Water Storage Dam (ATC Williams, 2022)

Parameter	Value*
Indicative Depth (m)	4.4 m
Total Storage to Emergency Spillway	250 ML
Internal Batter Slopes	1 (V) : 3 (H)
External batter Slopes	1 (V) : 3 (H)

*It is noted that a conservative approach has been implemented when sizing the MAW dam. Dam volumes mat be reduced where expected water quality indicates higher quality.

4.4.4.3. Discharges and Releases

Discharges from site will only occur during excessive rainfall events. Discharges will occur via the sediment ponds where quality allows for discharge, or via the Water Storage Dam emergency spillway. Water discharged will flow west towards Agate Creek (ATC Williams, 2022).

Table 52. Spillway Design Criteria (ATC Williams, 2022)

Design Criteria Consequence Category for 'dam break'	Flood Passage Spillway capacity	Flood Ingress Prevention Flood level for embankment crest levels
Significant consequence	1:100 AEP to 1:1,000 AEP	Spillway design flood peak level + wave run-up allowance for 1:10 AEP wind

4.4.4.4. Potential Contaminant Sources

Potential contaminants have been determined from the results of WRD characterisation and the proposed design of the Project (Table 53).

Table 53. Possible Contaminant Sources (ATC Williams, 2022)

Possible Contaminate Source	Likely Contaminant
Water Storages	pH, EC, metals, sulphate
ROM Pad	Suspended solids, metals, sulphate
Waste Rock Dump	Suspended solids, metals, sulphate
Open Cut Pit	Arsenic, metals, sulphate
Administration offices and workshops	Hydrocarbons and chemicals

4.4.4.5. Expected Water Quality

The EA does not stipulate specific Water Quality Objectives (WQO) or contaminant trigger values for the Agate Creek. ATC Williams Water Management Plan details WQOs derived from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality Guidelines for Slightly to Moderately Disturbed systems. However, these WQO are lower than background water quality from existing sample results for Agate Creek (Table 8). Therefore, given the environmental condition, the WQO adopted for this reporting period are ANZECC Guidelines (2000) for Livestock Drinking Water Quality (Appendix L). These WQO are also referred to in the Receiving Environment Monitoring Program of which monitoring

has commenced in preparation of the Agate Creek expansion. The proposed water quality and contaminant limits for the project site are outlined in Table 54.

Table 54. Receiving Environment Trigger and Contaminant Limits

Analyte	Unit	WQO	WQO (Dissolved)
pH (field)	pH Unit	6.0-7.5	-
Total Dissolved Solids @180°C	mg/L	4000	-
Dissolved Oxygen saturation	%	90-120	-
Calcium	mg/L	1000	-
Sulfate	mg/L	1000	-
Aluminium	mg/L	5	5
Arsenic	mg/L	0.5	0.5
Boron	mg/L	5	5
Cadmium	mg/L	0.01	0.01
Chromium	mg/L	1	1
Cobalt	mg/L	1	1
Copper	mg/L	1	1
Lead	mg/L	0.1	0.1
Mercury	mg/L	0.002	0.002
Molybdenum	mg/L	0.15	0.15
Nickel	mg/L	1	1
Selenium	mg/L	0.02	0.02
Zinc	mg/L	20	20

4.4.5. Site Water Balance

A Water Balance Model (WBM) has been developed to assess the proposed water management strategy and assess spill risk. Goldsim Pro has been used to conduct dynamic probabilistic simulation modelling based on a daily climatic record for the Project. An integrated catchment yield analysis for the site catchments was also coupled with the WBM.

The objectives of this modelling are summarised as follows:

- Assess the performance of the proposed site water management system;
- Quantify the site impacted water generated on site; and
- Determine any additional water storage requirements and identify potential options for the short and long-term management of water at the site (ATC Williams, 2022).

4.4.5.1. Water Balance Model Inputs

The Water Balance Model has been developed to reflect expected site conditions within the modelling horizon.

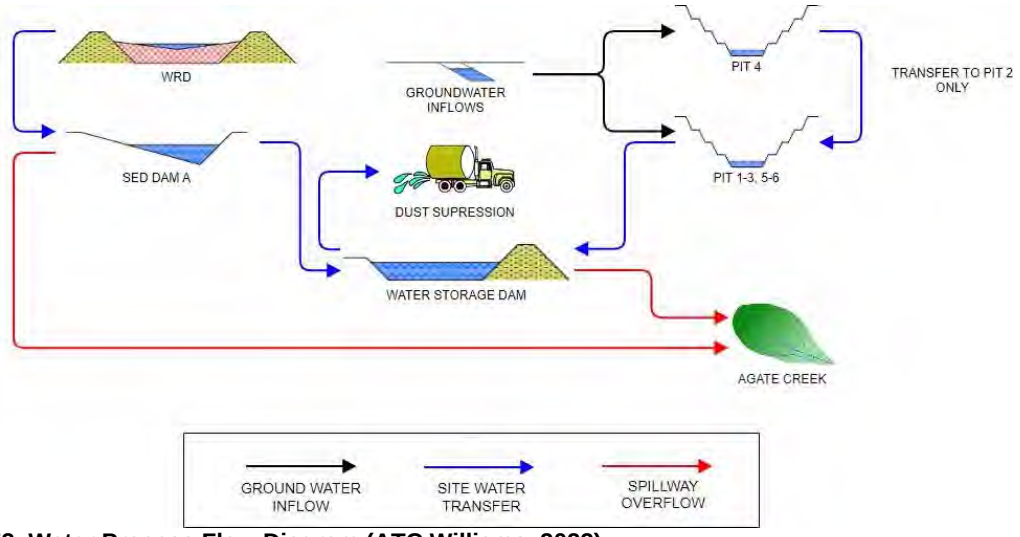


Figure 52. Water Process Flow Diagram (ATC Williams, 2022)

4.4.5.2. Storage Conditions

The total storage capacities of the water storages have been based on the footprint available within the site infrastructure area. Primary inputs for site storages are detailed in Table 55.

Table 55. Modelled Site Storage Properties (ATC Williams, 2022)

Storage	Storage Capacity (ML)	Initial Storage Volume (ML)
MAW Dam	165.0	Empty
Open Cut Pit 1	114.8	Empty
Open Cut Pit 2	71.0	Empty
Open Cut Pit 3	19.1	Empty
Open Cut Pit 4	3.5	Empty
Open Cut Pit 5	28.7	Empty
Open Cut Pit 6	751.3	Empty
Sediment Dam A	2.7	Empty
Sediment Dam B	4.1	Empty
Sediment Dam C	6.5	Empty
Sediment Dam D	8.8	Empty
Sediment Dam E	6.5	Empty

Sediment Dam F	4.2	Empty
Rom Pad Sediment Pond	4.1	Empty

4.4.5.3. Groundwater Inflows

A hydrogeological assessment (Section 4.4.9) adopted groundwater inflow rates for the proposed pits presented in based on the proximity of the monitoring bores to the proposed pits. Groundwater inflow rates are detailed in Table 56.

Table 56. Site Storage Capacities (ATC Williams, 2022)

Storage	Max Inflow Rates (ML/day)
PIT 1, 2, 3, 4	0.004
PIT 5, 6	0.008

4.4.5.4. Pumping Schedule

Water transfers, other than water sourcing for operational demands are detailed in Table 57.

Table 57. Site Transfers (ATC Williams, 2022)

Source	Destination	Pumping Rate*	Activation Condition*	Deactivation Condition
Pits 1-3, 5-6	Water Storage Dam	30 L/sec	Occurs when water volume within Open Cut Pit exceeds 3.5 ML	Deactivated when water depth within Open Cut Pit is at 0.5 m.
Pit 4	Pit 2	30 L/sec	Occurs when water depth within Open Cut Pit exceeds 1.5 m.	Deactivated when water depth within Open Cut Pit is below 0.5 m.
Sediment Ponds	Water Storage Dam	30 L/sec	Occurs when water volume within storage exceeds 1.0 ML	Deactivated when water volume within storage is below 0.5 ML

*Where storage volumes exceed evaporation/forced evaporation capacity to reduce water levels

4.4.5.5. Site Water Demands

Operational site water demands are detailed in Table 58.

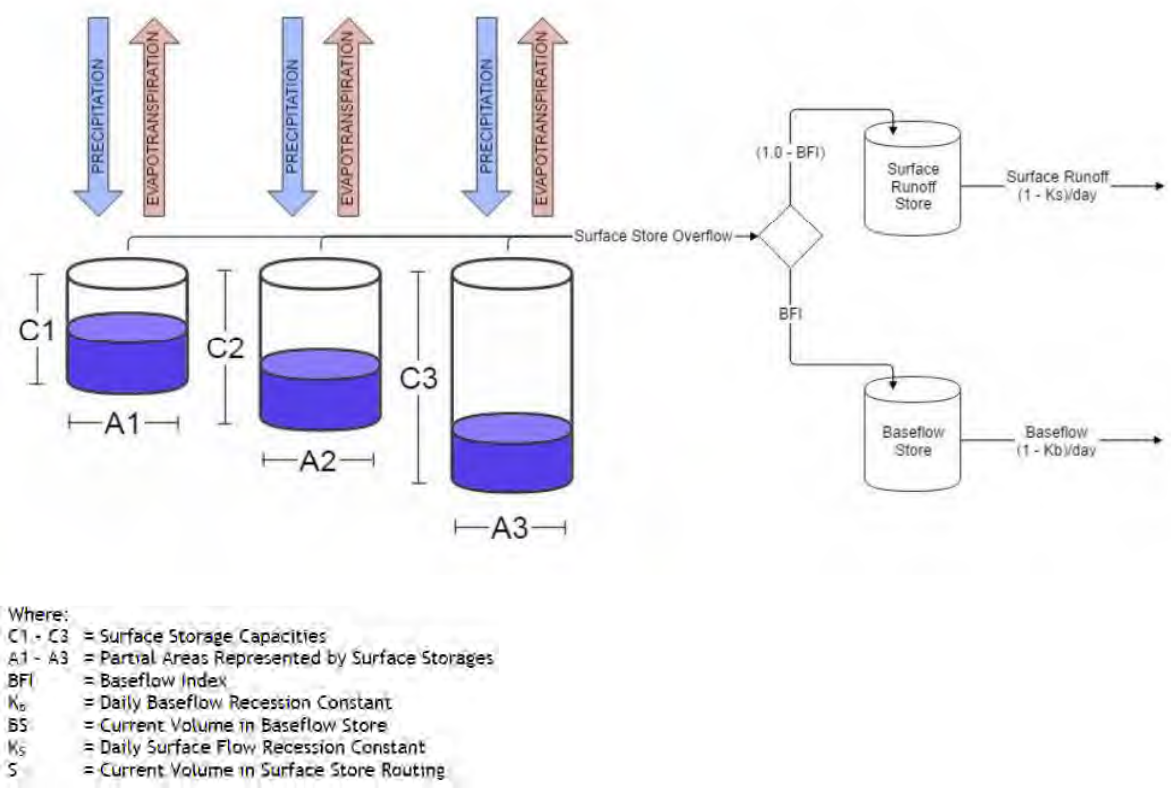
Table 58. Site Water Demands

Source	Demand	Rate	Comment
Water Storage Dam	Dust Suppression	0.2 ML/day	Active as required

4.4.5.6. Catchment Runoff Estimation

SILO long paddock climate data was used to Model rainfall. The Australian Water Balance Model (AWBM) was utilised to simulate daily runoff from rainfall generated across Agate Creek sub-catchment types. Catchment areas reporting to each storage have been assessed based on the proposed mine layout (ATC Williams, 2022).

The AWBM was used to simulate the different catchment types and the average yields from these catchments. Model parameters have been selected based on experience with similar water balance model studies and chosen to be slightly conservative. Runoff yields are calculated dynamically using the AWBM and the determined runoff volumes are conveyed to site storage elements (dams) on a daily timestep basis (ATC Williams, 2022).



Where:
C1 - C3 = Surface Storage Capacities
A1 - A3 = Partial Areas Represented by Surface Storages
BFI = Baseflow Index
K_b = Daily Baseflow Recession Constant
BS = Current Volume in Baseflow Store
K_S = Daily Surface Flow Recession Constant
S = Current Volume in Surface Store Routing

Figure 53. Schematic Of AWBM Model Structure (ATC Williams, 2022)

Table 59. Model Parameters (ATC Williams, 2022)

Catchment Type	Split Areas			Storage Capacities(mm)			Average Surface Stores	Ks (day-1)	BFI	Kb (day-1)
	A1	A2	A3	C1	C2	C3				
Natural	0.134	0.433	0.433	12	120	250	162 mm	0	0.3	0.8
Hardstand	1	0	0	10	10	0	10 mm	0	0	1
Waste	0.2	0.8	0	10	300	0	242 mm	0.9	0.2	0.9
Open Cut	0.1	0.9	0	5	20	0	18.5 mm	0	0	1

Catchment types and areas were designated using the initial concept WRD and Pit design with areas of catchments.

Table 60. Open Cut Pit Catchment Types (ATC Williams, 2022)

	Catchment Area (ha)					
	Pit 1	Pit 2	Pit 3	Pit 4	Pit 5	Pit 6
Open Cut	1.37	0.66	0.12	1.01	0.30	0.85
Storage Area at FSL	0.83	0.54	0.43	0.09	0.40	2.35
Total Catchment Area	**2.20**	**1.20**	**0.55**	**1.10**	**0.70**	**3.20**

Table 61. Water Management Dams Catchment Types (ATC Williams, 2022)

	Catchment Area (ha)							
	MAW Dam	Pond A	Pond B	Pond C	Pond D	Pond E	Pond E	ROM Pond
Hardstand	-	-	-	-	-	-		2.5
Waste	-	1.5	2.5	5.5	7.5	5.5	3.0	
Storage Area at FSL	4.50	0.17	0.23	0.34	0.43	0.34	0.24	0.23
Total Catchment Area	**4.50**	**1.70**	**2.73**	**5.84**	**7.92**	**5.84**	**3.24**	**2.73**

4.4.5.7. WBM Results

A summary of the WBM results is provided in Table 62.

Table 62. Maximum Spill Probability Over Operational Period (ATC Williams, 2022)

Storage	Spill Probability	Minimum Containment Criteria
Water Storage Dam	<1.0%*	5.0%
Pits 1, 2, 3, 4, 5, 6	<1.0%	N/A
Sediment pond A	<20%	N/A
Sediment pond B	<20%	N/A
Sediment pond C	<20%	N/A
Sediment pond D	<20%	N/A
Sediment pond E	<20%	N/A
Rom Pad Pond	<20%	N/A

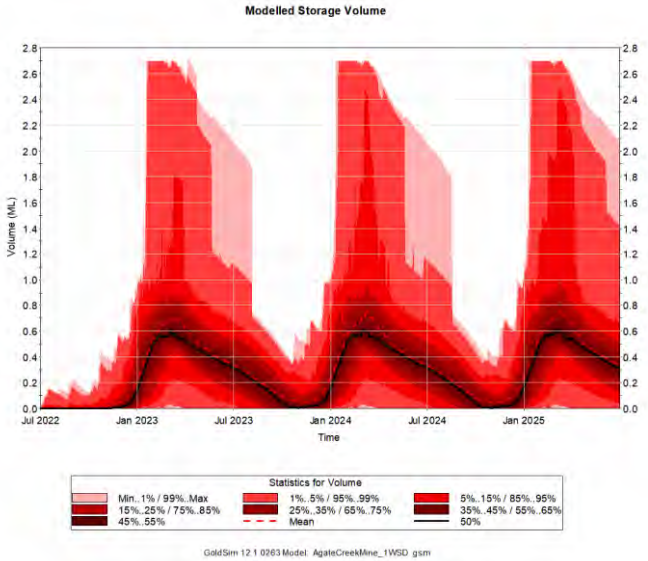
4.4.5.8. Performance Implications

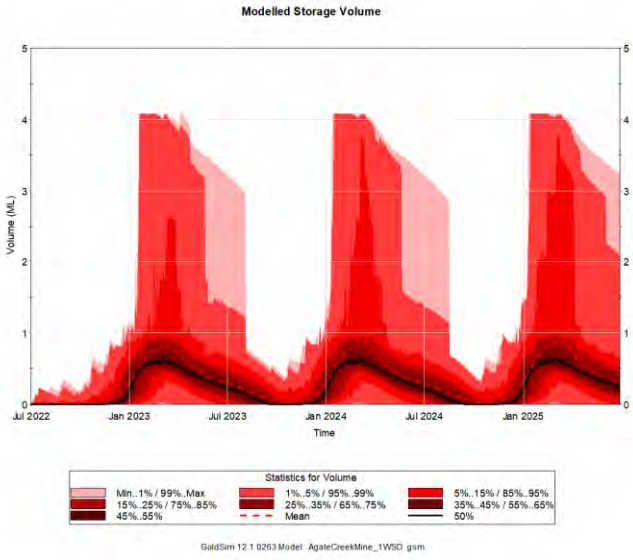
The MAW dam is classified as a 'Significant' consequence structure and has a minimum containment criterion of 5% AEP. However, as the site water quality not known at this stage, the MAW Dam has been conservatively sized to have a spill risk less than 1%. There may be opportunities to reduce this volume once the pit and WRD runoff water quality is better understood (ATC Williams, 2022).

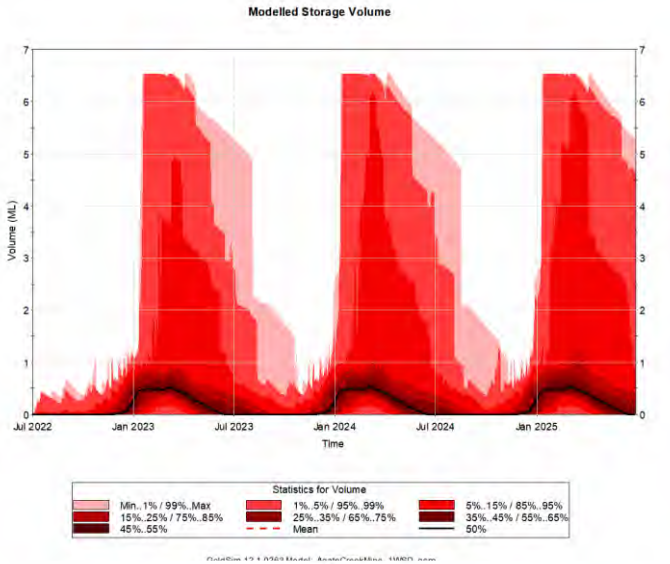
Dewatering of the open cut pits occurs within the WBM; however, the pits still accumulate water in moderate to major rainfall events. The model results indicate maximum modelled water storage volume for the median condition ranges from 0.3-2.2 ML only (ATC Williams, 2022).

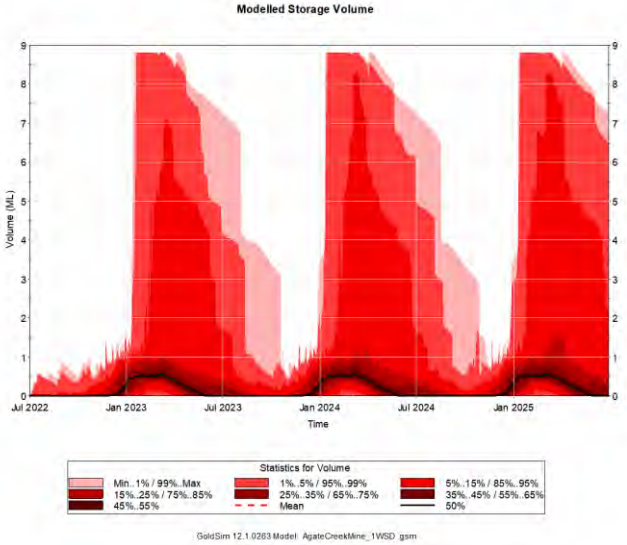
Table 63. Open Cut Pits Modelled Storage Volumes (ATC Williams, 2022)

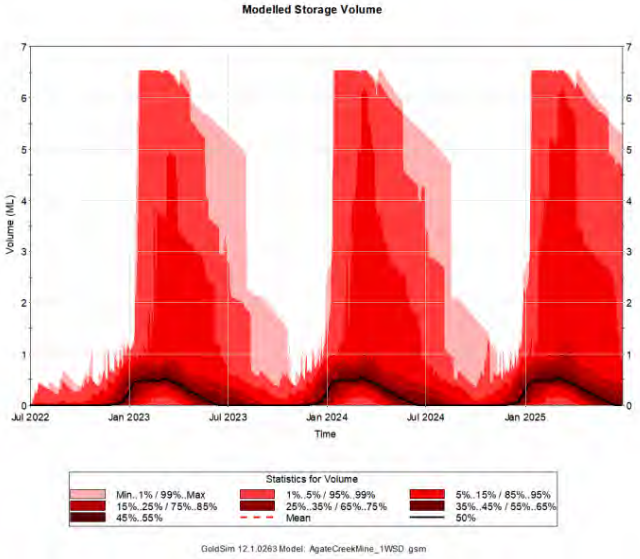
Pits	Max. Median Storage (5% AEP) ML	Max. Storage Volume (5% AEP) ML	Max Capacity (FSL) ML
Pit 1	1.9	9.8	114.8
Pit 2	1.7	7.7	71.04
Pit 3	2.2	3.6	19.09
Pit 4	0.3	0.5	3.47
Pit 5	2.0	3.6	28.67
Pit 6	1.6	12.4	751.30

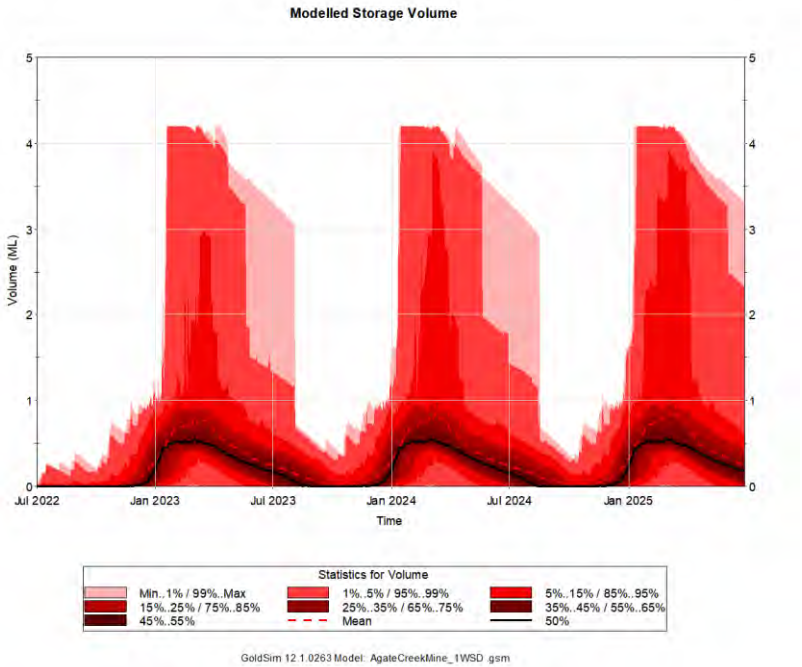

Modelled Storage Volume
Volume (ML)
Time
Jul 2022
Jan 2023
Jul 2023
Jan 2024
Jul 2024
Jan 2025
Statistics for Volume
Min..1% / 99%..Max
15%..25% / 75%..85%
45%..55%
1%..5% / 95%..99%
25%..35% / 65%..75%
Mean
5%..15% / 85%..95%
35%..45% / 55%..65%
50%
GoldSim 12.1.0263 Model: AgateCreekMine_1WSD.gsm


Modelled Storage Volume
Volume (ML)
Time
Jul 2022
Jan 2023
Jul 2023
Jan 2024
Jul 2024
Jan 2025
Statistics for Volume
Min..1% / 99%..Max
15%..25% / 75%..85%
45%..55%
1%..5% / 95%..99%
25%..35% / 65%..75%
Mean
5%..15% / 85%..95%
35%..45% / 55%..65%
50%
GoldSim 12.1.0263 Model: AgateCreekMine_1WSD.gsm


Modelled Storage Volume
Volume (ML)
Time
Jul 2022
Jan 2023
Jul 2023
Jan 2024
Jul 2024
Jan 2025
Statistics for Volume
Min..1% / 99%..Max
15%..25% / 75%..85%
45%..55%
1%..5% / 95%..99%
25%..35% / 65%..75%
Mean
5%..15% / 85%..95%
35%..45% / 55%..65%
50%


Modelled Storage Volume
Volume (ML)
Time
Jul 2022
Jan 2023
Jul 2023
Jan 2024
Jul 2024
Jan 2025
Statistics for Volume
Min..1% / 99%..Max
15%..25% / 75%..85%
45%..55%
1%..5% / 95%..99%
25%..35% / 65%..75%
Mean
5%..15% / 85%..95%
35%..45% / 55%..65%
50%
GoldSim 12.1.0263 Model: AgateCreekMine_1WSD.gsm


Modelled Storage Volume
Volume (ML)
Time
Jul 2022
Jan 2023
Jul 2023
Jan 2024
Jul 2024
Jan 2025
Statistics for Volume
Min..1% / 99%..Max
15%..25% / 75%..85%
45%..55%
1%..5% / 95%..99%
25%..35% / 65%..75%
Mean
5%..15% / 85%..95%
35%..45% / 55%..65%
50%
GoldSim 12.1.0263 Model: AgateCreekMine_1WSD.gsm



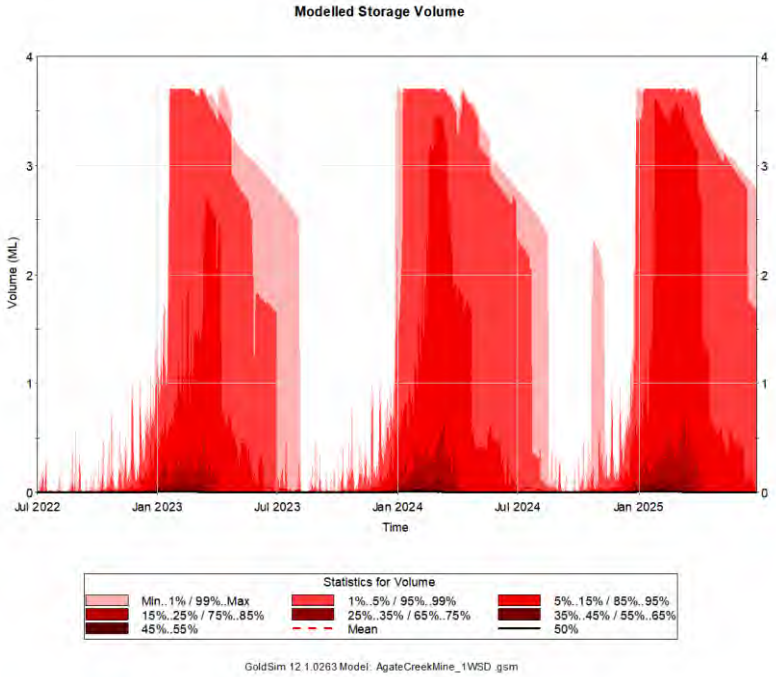


Figure 54. Sedimentation Ponds 1 - 7 (Left - Right) Modelled Storage Volume

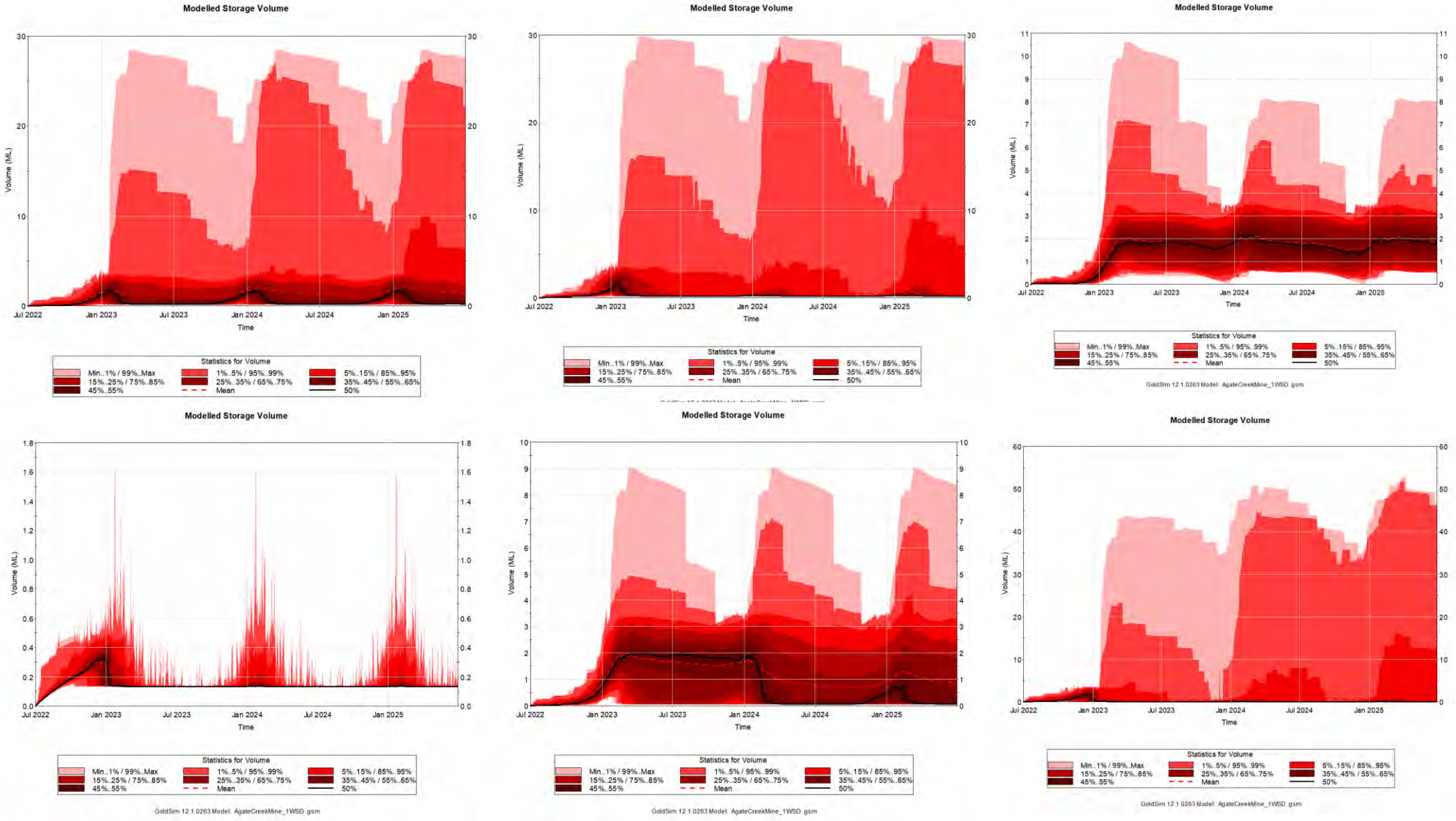


Figure 55. Pits 1 - 6 (Left - Right) Modelled Storage Volume

4.4.6. Hydrologic Assessment

A hydrological model was developed by ATC Williams (2022) in RORB software to analyse the peak flow at the critical locations by selecting the critical duration and associated ARR temporal pattern. The hydrograph was then used for the 2D hydraulic modelling. The peak flow estimates were also compared to ARR's Regional Flood Frequency Estimation Tool (RFFE) to validate the model (ATC Williams, 2022).

4.4.6.1. Hydrologic Assessment Model

Agate Creek catchment boundaries were calculated using Shuttle Radar Topography Mission (SRTM) elevation data. The RORB lag parameter followed ARR's recommended formula based on catchment area as the RORB lag parameter was developed from a series of calibrated models for several QLD gauges (ATC Williams, 2022).

Table 64. Hydrologic Model Inputs (ATC Williams, 2022)

Parameter	Value
Total Area	64.8km^2
Catchment Type	Natural
K_c Lag Parameter	8.02
Non – linitery 'm' Value	0.80
Initial Loss Continuing Loss	24mm 6.3mm/year
Pre-burst Applied	No
Areal Reduction Factors	Yes

Figure 56. Modelled Catchments (ATC Williams, 2022)

4.4.6.2. Hydrologic Model Results

Results of the Hydrologic assessment via RORB is detailed in Table 65. Results of the Hydrologic Assessment were used in the development of the Hydraulic Assessment (Section 4.4.7).

Table 65 RFFE Comparison at Agate Creek (ATC Williams, 2022)

Annual Exceedance Probability % (AEP)	RFFE Tool Peak Flow (m^3/s)			RORB Peak Flow (m^3/s)
	Lower Confidence Limit (5%)	Discharge	Higher Confidence Limit (5%)	Median Event
50	22	54	131	45
20	45	103	243	102
10	59	145	357	126
5	73	190	500	160
2	90	260	748	208
1	105	319	988	271

4.4.7. Hydraulic Assessment

Hydraulic analysis of the Project has been undertaken using the two-dimensional (2D) finite difference program TUFLOW, to investigate flood behaviour. The model is based on a robust finite difference solution scheme that can compute both sub-critical and supercritical flow regimes. The selected hydraulic solver for the 2D model was the HPC scheme (ATC Williams, 2022).

4.4.7.1. Model Domains

The TUFLOW model was set up to quantify the impacts of the 1:100 AEP and 1:1,000 AEP and includes the following mine areas:

- Open cut Pits 1 – 6;
- Four waste rock dumps;
- Seven sediment basins; and
- MAW dam.

4.4.7.2. Base Topography

The topographical base for the TUFLOW model was developed from the Shuttle Radar Topography Mission (SRTM)-derived 1 Second data.

4.4.7.3. Direct Rainfall and Inflow Hydrographs

Direct rainfall was adopted over the mine site area, whist an inflow hydrograph was used at the upstream end of the model extents to represent flow within Agate Creek. The rainfall and hydrograph adopted represented the critical duration based on the RORB outputs for the median peak flow of the 0.1% AEP event with no losses (ATC Williams, 2022).

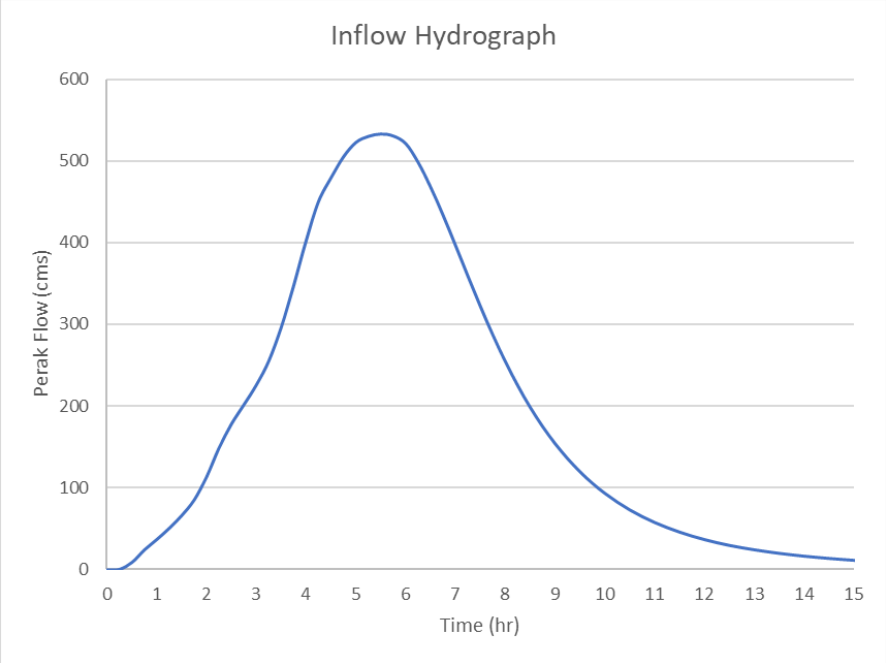


Figure 57. 0.1% AEP Agate Creek Inflow Hydrograph (ATC Williams, 2022)

4.4.7.4. Structures

4.4.7.4.1. MAW Dam

The MAW Dam is to be located to the south of the Pit developments and will receive inputs form the open cut pits and sediment basins (when discharge is not possible due to quality) via pumped transfer. The geometric parameters of the concept design for the proposed MAW dam are detailed in Table 66.

Table 66. MAW Dam Details (ATC Williams, 2022)

Parameter	Value
Indicative Depth (m)	4.4 m
Total Storage to Emergency Spillway	250 ML
Internal Batter Slopes	1 (V) : 3 (H)
External batter Slopes	1 (V) : 3 (H)

4.4.7.4.2. Sediment Pond Sizing

Proposed sediment ponds sizes were set with a spill risk of <20% (to achieve 80% hydraulic efficiency) as per the State Planning Policy (SPP) requirements. The required volume for the sediment storage was also determined based on the estimated soil loss of approximately 270 t/ha/yr and an assumed clean out frequency of every six (6) months (Table 67).

Table 67. Sediment Ponds Details (ATC Williams, 2022)

Pond	Catchment Area (ha)	Settling Zone Volume (ML)	Sediment Storage Volume (ML)	Total Storage Volume (ML)	Depth from Spillway (FSL) (m)	Length at FSL (m)	Width at FSL (m)
A	1.72	2.7	0.2	3.9	2.5	75	23
B	2.73	4.1	0.3	4.4	2.7	85	27
C	5.84	6.5	0.7	7.2	2.7	103	33
D	7.92	8.8	0.9	9.7	2.9	113	37
E	5.84	6.5	0.7	7.2	2.7	103	33
F	3.24	4.2	0.4	4.6	2.6	88	28
Rom Pad	2.5 ha	4.1	0.3	4.4	2.7	85	27

4.4.7.5. Boundary Conditions

Outflow boundary conditions were placed as illustrated on Diagram 5. The outflow boundary conditions were modelled as free-draining outlets with slopes approximated from the elevation data (0.5% was adopted to Agate Creek). It was assumed that Agate Creek is not impacted by backwater or tailwater levels at this location (ATC Williams, 2022).

4.4.7.6. Surface Roughness

Default surface roughness was modelled as a depth-varying Manning's 'n' value. Aerial imagery indicates similar vegetation conditions over the undisturbed site areas and the external catchments. A depth-varying Manning's 'n' value was adopted for the natural grasses due to the relatively high natural grassland over the catchment surfaces and sheet flow conditions being dominant within the flatter areas of the catchment (ATC Williams, 2022).

Table 68. Manning's Surface Roughness Parameters (ATC Williams, 2022)

Description	Manning's 'n'	Infiltration (IL, CL) (mm)	Losses Direct Rainfall Depth (IL, CL) (mm)
Floodplain (default where not overlayed by a material below)	Depth varying: Depth = 0 m to < 0.3 m, n = 0.2 Depth ≥ 0.3 m, n = 0.050	0, 0	0, 6.3
Medium Density Trees	0.075	0, 0	0, 6.3
Channel Flow	**0.030**	**0, 0**	

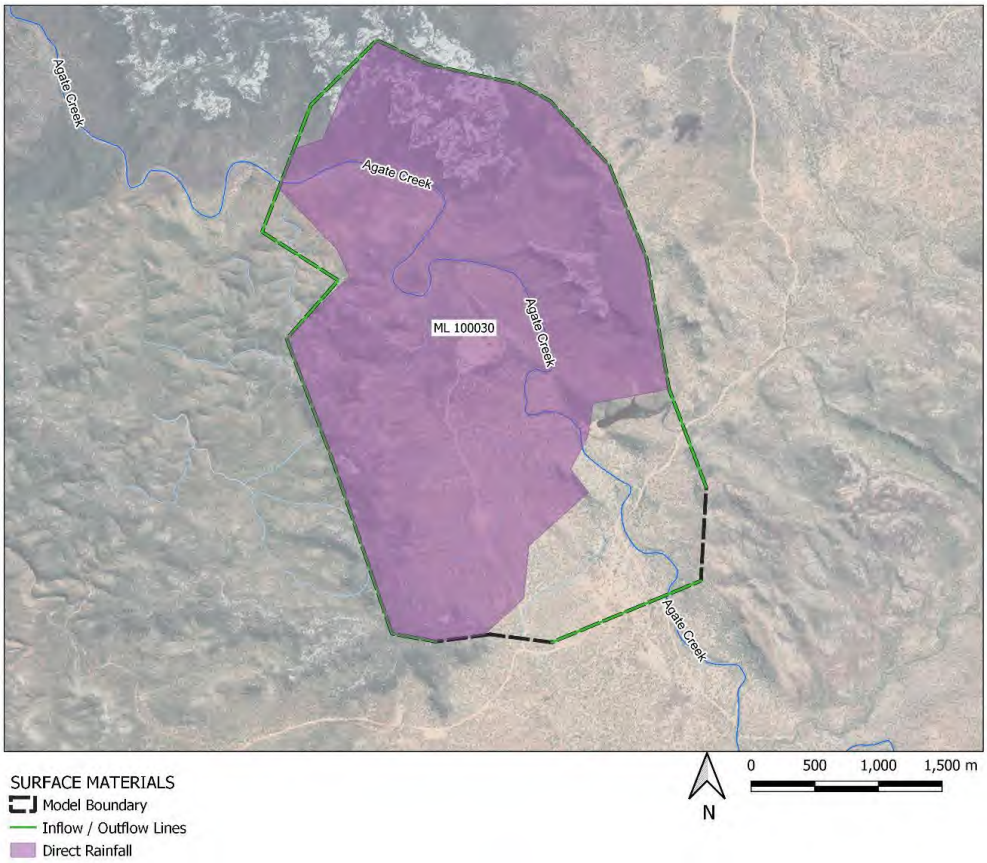


Figure 58. Tuflow Model Extents (ATC Williams, 2022)

4.4.7.7. Tuflow Results

4.4.7.7.1. Flood Depths and Elevations

Flooding of Agate Creek overtops the creek's banks and generally follows the watercourse alignment. The 0.1% event maximum flood depths vary from shallow depths on the outer banks to approximately 6-8 m in deeper areas of the creek. Flow predominately runs along the eastern extents of the proposed mine development area and flows to the northwest. Pit 5 within the southern portion of the mine development area was found to have the least freeboard to the estimated flood levels at approximately 6 m. All remaining pit voids were well clear of the of the floodplain (ATC Williams, 2022).

4.4.7.7.2. Elevations

Agate Creek stream is modelled to experience high magnitude event velocities due to the relatively narrow channel and high peak flows. For the 0.1 % AEP event, velocity over the inundated Agate Creek floodplain varies between 0.5 - 5 m/s. Flow velocities from gullies were of less magnitude at only 0.5 m/s to 1.5 m/s (ATC Williams, 2022).

4.4.7.7.3. Development Implications

The Agate Creek expansion footprint are all clear of the 0.1% floodplain extents. Pit 5 was found to have the least freeboard to the 0.1% floodplain water surface elevation at approximately 6 m above the adjacent maximum water surface elevations (ATC Williams, 2022).

Figure 59. 0.1% AEP Maximum Water Elevation

LEGEND

- MINE LEASE
- EXISTING SITE CONTOURS 10m
- ASSUMED FLOODPLAIN EXTENTS

MAXIMUM WATER ELEVATION (RL m)

- 400
- 410
- 420
- 430
- 440
- 450

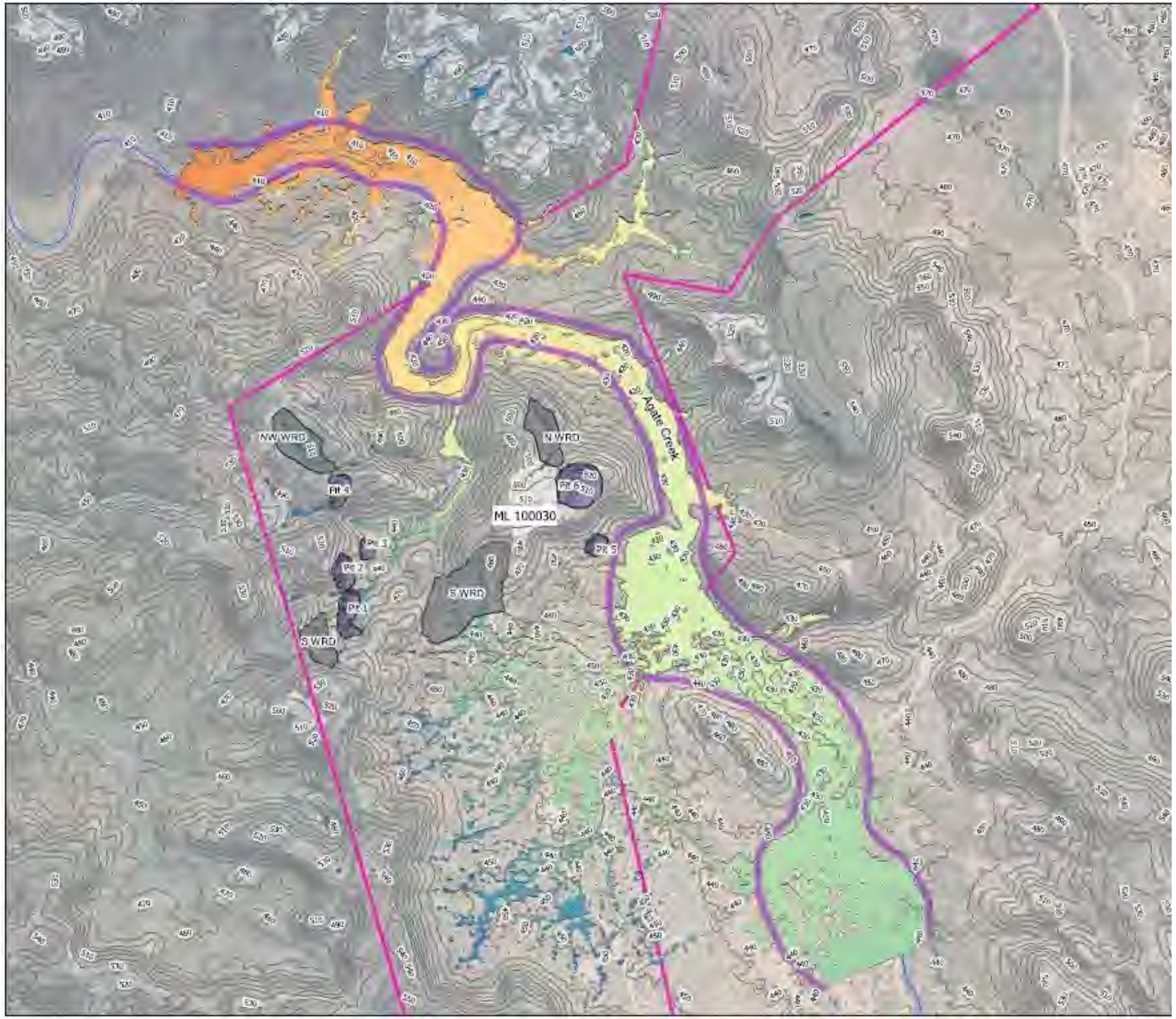


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Figure 60. 0.1% AEP Maximum Velocity

LEGEND

- MINE LEASE
- EXISTING SITE CONTOURS 10m
- ASSUMED FLOODPLAIN EXTENTS

MAXIMUM VELOCITY (m/s)

- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0
- 6.0

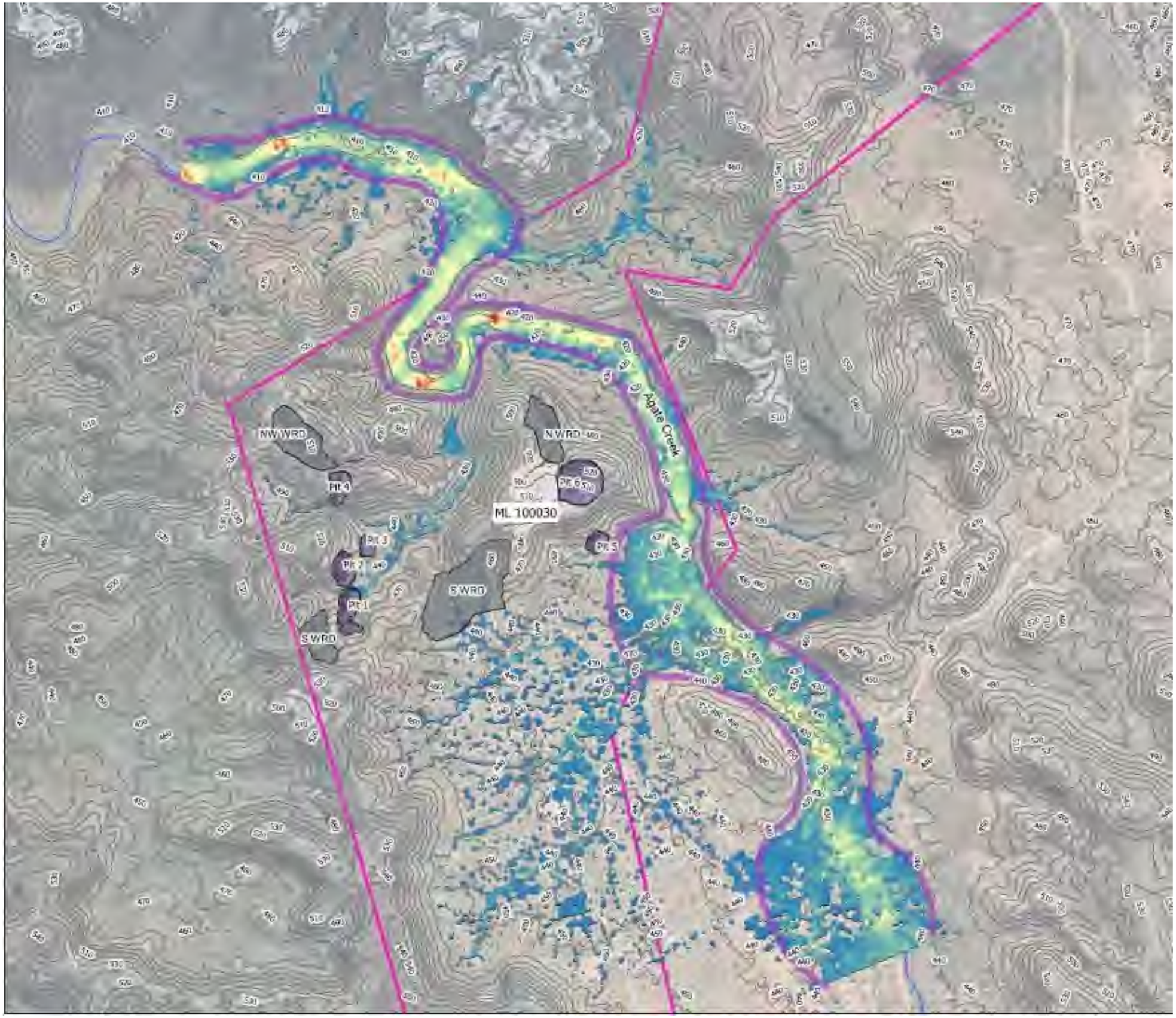

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Figure 61. 0.1% AEP Maximum Water Depth

LEGEND

- MINE LEASE
- EXISTING SITE CONTOURS (5m)
- ASSUMED FLOODPLAIN EXTENTS

MAXIMUM WATER DEPTH (m)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8

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4.4.8. Consequence Category Assessment

The Consequence Category Assessment involved a desktop review of potential harm associated with failure-to-contain scenarios, and the dam break scenario. The Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (the Manual) sets out the requirements of the administering authority for a consequence category assessment and certification of the design of regulated structures, constructed as part of environmentally relevant activities under the Environmental Protection Act (1994) (ATC Williams, 2022).

The purpose of the Manual is to:

- Guide the assessment of the consequence category of all structures as a part of activities of this EAA.
- Guide the determination of the structures that require formal documentation
- Provide approved methods for specifying the design performance and monitoring requirements for those structures (ATC Williams, 2022).

Assessment criteria for Consequence Category assessments are based on the following failure event scenarios.

- Failure to Contain – Seepage: Spills or release to ground/groundwater via seepage from the floor and/or sides of the structure.
- Failure to Contain – Overtopping: Spills or releases from the structure that result from loss of containment due to overtopping of the structure.
- Failure to Contain – Dam Break: Collapse of the structure due to any possible cause (ATC Williams, 2022).

Under these scenarios, several modes of failure are possible as described below:

- A failure to contain scenario means a release from the structure that results from loss of containment due to excessive seepage, overtopping of the structure and/or other deficiencies in water management aspects of the storage. Although such a failure mechanism is typically non-flood producing, failure to contain events may involve the release of contaminants, which could endanger environmental values or human life/wellbeing.
- A dam break scenario involves the partial or complete collapse of a structure due to any possible cause (ATC Williams, 2022).

Consequence Category Assessment for Agate Creek water management structures are outlined in Table 70 and Table 71.

Table 69. Consequence Category Assessment Criteria (ATC Williams, 2022)

Environmental Harm	Consequence Category High	Significant	Low
Harm to Humans	Location such that people are routinely present in the failure path and if present loss of life to greater than 10 people is expected[8]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario.	location such that people are routinely present in the failure path and if present loss of life to 1 person or greater but less than 10 people is expected[7]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario.	Location such that people are not routinely present in the failure path and loss of life is not expected[7]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario.
General Environmental Harm	Location such that: • Contaminants may be released to areas of MNES, MSES or HEV waters that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment (Significant Values); and • Adverse effects[11] on Significant Values are likely; and • The adverse effects[10] are likely to cause at least one of the following: ○ loss or damage or remedial costs greater than $50,000,000; or ○ remediation of damage is likely to take 3 years or more; or ○ permanent alteration to existing ecosystems; or the area of damage (including downstream effects) is likely to be at least 5 km².	Location such that contaminants may be released so that adverse effects[10] (that are not already authorised to be disturbed to at least the same extent under other conditions of the authority subject to any applicable offset commitment) either: a. Would be likely to be caused to Significant Values but those adverse effects[10] would not be likely to meet the thresholds for the High Consequence Category and instead would be likely to cause at least one of the following: i. loss or damage or remedial costs greater than $10,000,000 but less than $50,000,000; or ii. remediation of damage is likely to take more than 6 months but less than 3 years; or iii. significant alteration to existing ecosystems; or iv. the area of damage (including downstream effects) is likely to be at least 1 km² but less than 5 km². or b. Would be likely to be caused to environmental values classed as slightly or moderately disturbed waters[12], wetland of general ecological significance13, riverine areas, springs or lakes and associated flora and fauna (Moderate Values), and the adverse effects[10] are likely to cause at least one of the following: i. loss or damage or remedial costs greater than $20,000,000; or ii. remediation of damage is likely to take more than 1 year; or iii. significant alteration to existing ecosystems; or the area of damage (including downstream effects) is likely to be at least 2 km².	Location such that either: a. Contaminants are unlikely to be released to areas of Significant Values or Moderate Values; or b. Contaminants are likely to be released to those areas, but would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects[10]
General Economic Loss or Property Damage	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require $1 million and greater but less than $10 million in rehabilitation, compensation, repair or rectification costs[13].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require $10 million or greater in rehabilitation, compensation, repair or rectification costs[14].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require less than $1 million in rehabilitation, compensation, repair or rectification costs[13]

7 To be used for all failure event scenarios

8.'People routinely present in the failure path' could be considered to be people who occupy buildings or other places of occupation that lie within the failure impact zone. For the purposes of this Manual, this should refer to people other than site personnel engaged by the resource operation and located on the tenements and tenure associated with the resource operation; for other ERAs, it would be the 'premises referred to in the authority'. It should be noted that while this is appropriate for the assessment of consequence categories in accordance with this Manual, adherence to the requirements of this Manual does not limit, amend, or change in any way, any other requirements to be complied with under relevant health and safety acts or legislation that requires the safety of site personnel to be considered.

9 When considering potential impacts on groundwater, it is not envisaged that a full hydrogeological assessment will be required in all cases. Any consideration of potential impacts on groundwater systems should consider the water quality of the potential receiving aquifer as well as the quality of fluid stored in the regulated dam. Existing groundwater drawdown in areas surrounding resource operations (e.g. drawdown as a result of mine pit or underground mine dewatering) can also be considered when assessing the consequence of dam seepage on groundwater systems.

10 'An adverse effect on human health means a physiological effect on human health and does not include an impact on the quality of downstream water that merely negatively affects taste and which is unlikely to cause persons to become physically ill.

11 Adverse effects includes chronic and acute effects where an acute effect is on living organism/s which results in severe symptoms that develop rapidly, and a chronic effect is an adverse effect on a living organism/s which develops slowly. In some instances, it may be necessary to carry out or reference existing ecological/toxicological studies to assess the impacts of contaminants on living organisms.

12 See Water EPP for definitions

13 Wetland of general ecological significance' means a wetland shown on a map of referable wetland as a 'general ecologically significant wetland' or 'wetland of other environmental value'.

14 This does not include the holder's own mine or gas production, on-site industrial or commercial assets, the holder's workers' accommodation, agricultural facilities on the holder's land such as a farm shed or farm dam or infrastructure solely for servicing the holder.

Table 70. Consequence Category Assessment - MAW Dam (ATC Williams, 2022)

Environmental Harm	Consequence Category Failure to Contain – Seepage	Failure to Contain – Overtop	Failure to Overtop – Dam Break
Harm to Humans	All bores identified are understood to be associated with landowner activities. In the event of a seepage failure of the WSD, the impact of humans is expected to impact less than 10 people as there are no bores registered for human consumption located on Agate Creek. The WSD shall be lined, and as such a seepage failure is considered unlikely. **Consequence Category is assessed as Low**.	Impounded waters and material within the WSD consist of pumped transfers from the Pits and sediment ponds. Waters may contain elevated levels of pH, electrical conductivity (EC) and other chemical properties. Water quality sampling indicated that the site water quality is not likely to meet the threshold for a 'Significant' consequence category. In the event of overtopping of the WSD, spills are expected to flow east towards Agate Creek. Overtopping of the WSD is considered unlikely as it filled via pump transfer or direct rainfall from a small catchment area. **Consequence Category is assessed as Low**.	In the event of a dam break failure of the WSD, impounded waters will flow east towards, and enter Agate Creek. In a dam break scenario, a maximum of 250 ML may be released. Approximately 3 km to the south, along the southern boundary of the mine lease, Rungulla Road (an unsealed road) provides access to local landowners and to the site. Due to the upstream location of the Rungulla Road to WSD, dam break flows and inundation to the road is considered unlikely. Non site personnel may be present (but not likely) in the failure path during a dam break failure. **Consequence Category is assessed as Low**.
General environmental harm	In the event of a seepage failure, the 'Regulated vegetation – intersecting a watercourse' to the east within Agate Creek and its unnamed tributaries may be impacted. Water quality sampling indicated that the site water quality is not likely to meet the threshold for a 'Significant' consequence category. The WSD shall be lined, and as such a seepage failure is considered unlikely. **Consequence Category is assessed as Low**.	Impounded waters and material within the WSD consist of pumped transfers from the Pits and sediment ponds. Waters may contain elevated levels of pH, EC, and other chemical properties. Sampling of waters contained in the WSD should be undertaken upon construction and commissioning. Overtopping would only occur in extreme rainfall events and therefore runoff would be significantly diluted with natural surface flows and the Agate Creek watercourse. In the event of an overtopping failure, the 'Regulated vegetation – intersecting a watercourse' to the east within	In the event of a dam break failure, the 'Regulated vegetation – intersecting a watercourse' within Agate Creek and its unnamed tributaries is likely to be impacted. **Consequence Category is assessed as Significant.**

		Agate Creek and its unnamed tributaries may be impacted; however, it is considered a Low consequence. **Consequence Category is assessed as Low**.	
General economic loss or property damage	Approximately 3 km to the south of the subject site and along the southern boundary of the mine lease, Rungulla Road (an unsealed road) provides access to local landowners and to the site. In the event of a seepage failure, the remediation/repair costs associated with repairing this road are expected to be less than $1 million. **Consequence Category is assessed as Low**.	Approximately 3 km to the south of the subject site and along the southern boundary of the mine lease, Rungulla Road (an unsealed road) provides access to local landowners and to the site. In the event of an overtopping failure, the remediation costs associated with repairing this road are expected to be less than $1 million. **Consequence Category is assessed as Low**.	Approximately 3 km to the south of the subject site and along the southern boundary of the mine lease, Rungulla Road (an unsealed road) provides access to local landowners and to the site. In the event of a dam break failure, the remediation/repair costs associated with repairing this road are expected to be less than $1 million. **Consequence Category is assessed as Low**.
Overall Consequence Category	**Low**	**Low**	**Significant**

Table 71. Consequence Category Assessment – Sediment Dams (ATC Williams, 2022)

Environmental Harm	**Consequence Category** **Failure to Contain – Seepage**	**Failure to Contain – Overtop**	**Failure to Overtop – Dam Break**
Harm to Humans	All bores identified are understood to be associated with landowner activities. In the event of a seepage failure of the WSD, the impact of humans is expected to impact less than 10 people as there are no bores registered for human consumption located on Agate Creek. **Consequence Category is assessed as Low**.	Impounded waters within the sediment ponds consist of runoff from the WRDs. Water quality sampling indicated that the site water quality is not likely to meet the threshold for a 'Significant' consequence category In the event of overtopping of the sediment ponds, spills are expected to flow towards Agate Creek or its unnamed tributaries to the east of the site. Overtopping would only occur in large rainfall events and therefore runoff would be diluted with natural surface flows and the Agate Creek watercourse. **Consequence Category is assessed as Low**.	In the event of a dam break failure of the sediment ponds, impounded waters will flow east towards, and enter Agate Creek. Approximately 3 km to the south, along the southern boundary of the mine lease, Rungulla Road (an unsealed road) provides access to local landowners and to the site. Due to the upstream location of the Rungulla Road to WSD, dam break flows and inundation to the road is considered unlikely. Non site personnel may be present (but not likely) in the failure path during a dam break failure **Consequence Category is assessed as Low**.

General environmental harm	In the event of a seepage failure, the 'Regulated vegetation – intersecting a watercourse' to the east within Agate Creek and its unnamed tributaries may be impacted. Water quality sampling indicated that the site water quality is not likely to meet the threshold for a 'Significant' consequence category. **Consequence Category is assessed as Low**.	Impounded waters within the sediment ponds consist of runoff from the WRDs. This water is dirty water that is assumed to be predominately sediment laden. In the event of overtopping of the sediment ponds, spills are expected to flow towards Agate Creek or its unnamed tributaries to the east of the site. **Consequence Category is assessed as Low**.	In the event of a dam break failure of the sediment ponds, the 'Regulated vegetation – intersecting a watercourse' within Agate Creek and its unnamed tributaries is likely to be impacted. Water quality in the Sediment Ponds is proposed to be predominantly sediment laden and therefore of Low consequence if released. **Consequence Category is assessed as Low**.
General economic loss or property damage	Approximately 3 km to the south of the subject site and along the southern boundary of the mine lease, Rungulla Road (an unsealed road) provides access to local landowners and to the site. In the event of a seepage failure, the remediation/repair costs associated with repairing this road are expected to be less than $1 million. **Consequence Category is assessed as Low**.	Approximately 3 km to the south of the subject site and along the southern boundary of the mine lease, Rungulla Road (an unsealed road) provides access to local landowners and to the site. In the event of a seepage failure, the remediation/repair costs associated with repairing this road are expected to be less than $1 million. **Consequence Category is assessed as Low**.	Due to the upstream location of the Rungulla Road to the sediment ponds, dam break flows and damage to the road is considered unlikely. **Consequence Category is assessed as Low**.
Overall Consequence Category	**Low**	**Low**	**Low**

4.4.9. Groundwater

Groundwater assessments as a part of the Agate Creek expansion have been conducted via on site groundwater observations as well as the development of mathematical models, to determine if the Agate Creek would result in impact to regional aquifers and the receiving environment. Sections below outline the results of the groundwater assessment.

4.4.9.1. Groundwater Monitoring Network

Ten groundwater bores were drilled in June 2020 with monitoring of these bores commencing in October 2020 on a monthly basis initially. Bores are now monitored on a quarterly basis. The bore construction details are detailed in Table 72.

Table 72. Groundwater Monitoring Bore Network

Bore ID	Easting	Northing	Ground level (m AHD)	Top of	Total depth (m BGL)	Screened interval (m BGL)	Geology unit
CCWB517	768399.5	7896463	435.6	0.6	55	49 – 55	Robin Hood Granodiorite
CCWB518	767768.1	7897706	431.4	0.6	73	67 – 73	Andesite/Rhyolite
CCWB519	767302	7897863	517.18	0.62	85	79 – 85	Corbett Formation Metasediments
CCWB520	767947.2	7897838	434.96	0.59	73	67 – 73	Andesite
CCWB521	768700.6	7898079	420.94	0.6	73	67 – 73	Corbett Formation Metasediments
CCWB522	768761.9	7897724	434.2	0.6	73	67 – 73	Corbett Formation Metadolerite
CCWB523	768321.3	7897579	449.6	0.61	73	67 – 73	Robin Hood Granodiorite
CCWB524	768173.6	7897670	496.06	0.64	91	85 – 91	Robin Hood Granodiorite
CCWB525	768166.9	7897930	498.77	0.62	103	97 – 103	Corbett Formation Metasediments
CCWB526	767709.7	7896909	449.4	0.66	73	67 – 73	Corbett Formation Metasediments

4.4.9.2. Groundwater Quality

Groundwater level and quality monitoring commenced from October 2020. Groundwater monitoring was generally undertaken in accordance with State and National guidelines and involved the recording of bore Standing Water Levels (SWLs) as well as the collection of samples for analysis. Parameters analysed as a part of the groundwater assessment are outlined in Table 73. Results of monitoring are included in Section 3.3.3.

Table 73. Water Quality Parameters Analysed (C&R Consulting, 2022).

Parameter	Unit
Water level	Metres below top of collar (mTOC)
pH (field)	pH units
pH (laboratory)	pH units
Electrical conductivity (EC) (field)	mS/cm
Electrical conductivity (EC) (laboratory)	mS/cm
Sulfate (SO42-),	mg/L
Fluoride (F-)	mg/L
Total and dissolved aluminium (Al)	mg/L
Total and dissolved arsenic (As)	mg/L
Total and dissolved cadmium (Cd)	mg/L
Total and dissolved chromium (Cr)	mg/L
Total and dissolved Cobalt (Co)	mg/L
Total and dissolved copper (Cu)	mg/L
Total and dissolved lead (Pb)	mg/L
Total and dissolved manganese (Mn)	mg/L
Total and dissolved molybdenum (Mo)	mg/L
Total and dissolved Nickel (Ni)	mg/L
Total and dissolved selenium (Se)	mg/L
Total and dissolved zinc (Zn)	mg/L
Total and dissolved Boron (B)	mg/L
Total and dissolved iron (Fe)	mg/L
Total and dissolved mercury (Hg)	mg/L
Major ions - calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), bicarbonate (HCO3-), and carbonate (CO3-2),	mg/L

4.4.9.3. Hydraulic Parameters

Hydraulic conductivities were derived from existing groundwater studies (Lait, 2020). Hydraulic conductivities ranged from:

- 6.57 x 10–8 m/sec for CCWB523 to
- 5.06 x 10–7 m/sec for CCWB518.

From assessing the range in the hydraulic conductivities (5 orders of magnitude), both linear and logarithmic solutions for inflow rates were obtained for the methodology of Marinelli and Niccoli (2000) as displayed in Table 74 (C&R Consulting, 2022).

Table 74. Inferred linear and logarithmic inflow rates (C&R Consulting, 2022).

Bore CCWB	Linear Inflow Rate m3/sec	Log Inflow Rate m3/sec
CCWB517	4.464×10^{-5}	2.795×10^{-5}
CCWB518	4.825×10^{-5}	3.037×10^{-5}
CCWB519	3.707×10^{-5}	2.348×10^{-5}
CCWB520	–	–
CCWB521	1.756×10^{-5}	1.498×10^{-5}
CCWB522	1.306×10^{-5}	1.351×10^{-5}
CCWB523	1.040×10^{-5}	1.271×10^{-5}
CCWB524	3.570×10^{-5}	2.275×10^{-5}
CCWB525	4.390×10^{-5}	2.735×10^{-5}
CCWB526	1.954×10^{-5}	1.568×10^{-5}

4.4.9.4. Potentiometric Surface, Recharge, Flow and Discharge

The 12-month period of monitoring between October 2020 and October 2021 was assessed to determine trends within the Agate Creek groundwaters. Standing Water Levels (SWLs) during the assessment period showed all bores (excluding CCWB526) recorded SWL increases which ranged between 0.17 m (CCWB517) and 3.71 m (CCWB521). An overall average increase of 1.38 m was observed across the network. Increases across the network are likely a result of the extremely low hydraulic conductivities, and the groundwater system is continuing to reach equilibrium (C&R Consulting, 2022).

Between December 2020 and February 2021, 765.4 mm of rain fell in the region. All bores within the Agate Creek recorded a positive change SWL, representing a recharging of the aquifer. This indicates that groundwaters readily respond to rainfall events (C&R Consulting, 2022).

A potentiometric surface of groundwater elevations has been prepared from the groundwater monitoring bore network. It is thought that there is some degree of hydraulic continuity across Agate Creek. The potentiometric surface shows that groundwater flows follow loosely follows topography, with groundwater moving from areas of high elevation towards Agate Creek (C&R Consulting, 2022).

The three bores located in proximity to Agate Creek reflect the areas of lowest groundwater elevations. Elevation differences between the bed of Agate Creek and CCWB521 supports the understanding that the groundwater system does not impact or interact with flow in Agate Creek. The potentiometric surface is displayed on Figure 63 (C&R Consulting, 2022).

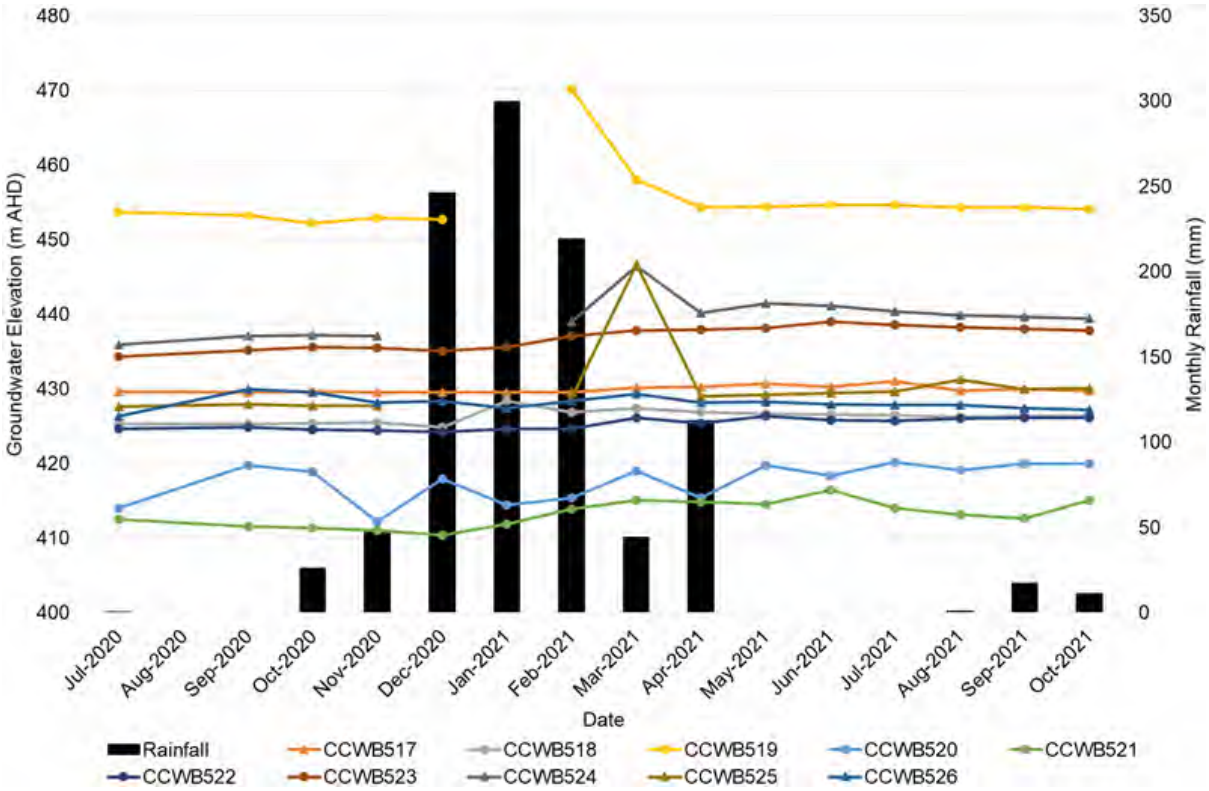

Figure 62. Changes in groundwater Elevations in Response to Rainfall (C&R Consulting, 2022)

Figure 63. Potentiometric surface contours

Legend

Agate Creek mining lease
Void 5-m contours

Bore Network

Monitoring bore
Production bores
Groundwater contours

Watercourse

Agate Creek
Minor watercourse

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Project number: 2021.08003
Coordinate Reference System: GDA 2020 Z54
Date: 1 June 2022

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4.4.9.4.1. Groundwater Quality

pH

Majority of bores reflect mildly alkaline conditions, although with some bores have trending towards slightly acidic conditions. Screened in the Corbett Formation Metasediment, CCWB521 is alkaline with waters ranging from 8.26 to 8.53 whereas bore CCWB523 screened in the Robin Hood Granodiorite, reflects acidic conditions with a median value of 6.5 (C&R Consulting, 2022).

CCWB525 has the greatest pH range (6.39 – 7.73). pH levels of CCWB525 trend downwards over the monitoring period. Changes in pH between July 2020 and October 2021 are likely to reflect the low hydraulic conductivity with each bore gradually reaching equilibrium. All pH values are within ranges reflective of the rock type encountered across the groundwater network (C&R Consulting, 2022).

All pH values across the Agate Creek network remain within the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) guidelines for livestock drinking water (C&R Consulting, 2022).

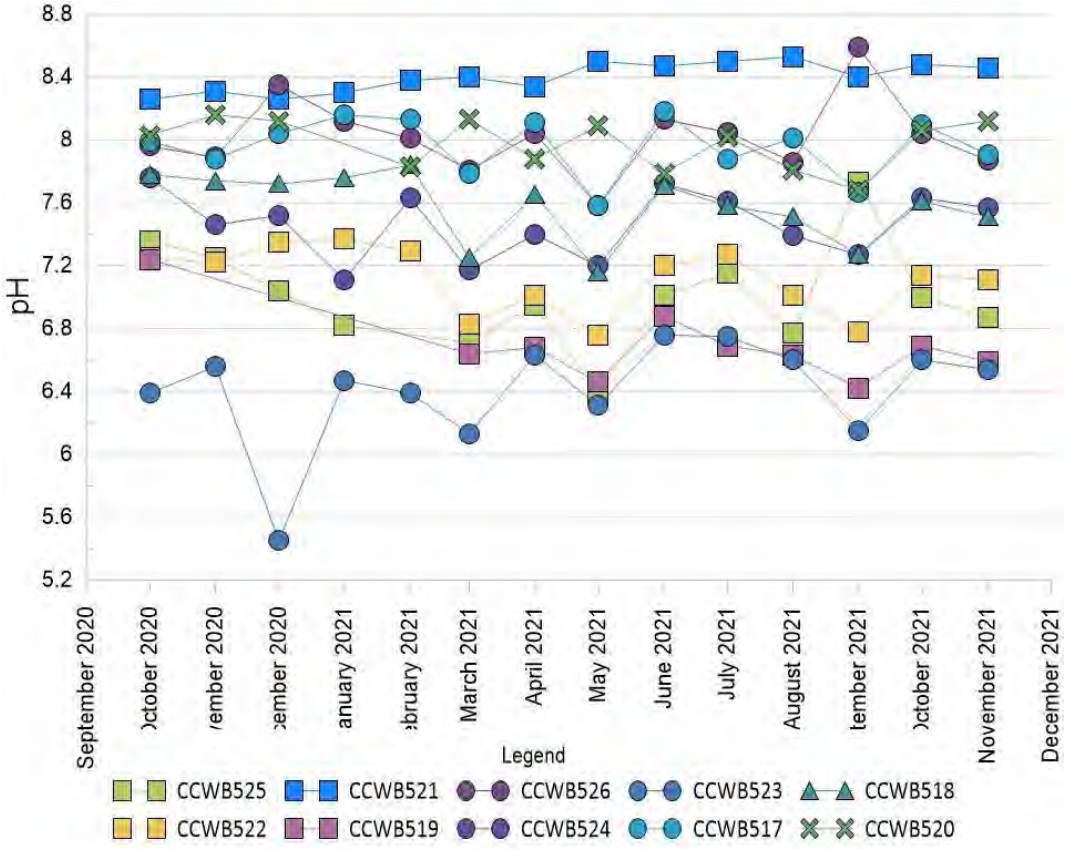


Figure 64. pH Values Within the Agate Creek Groundwater (C&R Consulting, 2022)

Electrical Conductivity

Majority of bores have freshwater quality (<1,560 µS/cm) with the exception of CCWB517 and CCWB526. CCWB517 and CCWB526 are considered slightly brackish (1,560 – 4,680 µS/cm). All formations reflect stable conditions, with small fluctuations detected in CCWB517 following the significant wet season rainfall events between December 2020 and February 2021 (C&R Consulting, 2022).

Total Dissolved Solids

Electrical conductivity can be used to calculate the concentration of Total Dissolved Solids (TDS) (µS/cm) x 0.67 = TDS (mg/L). The Majority of bores excluding CCWB517 and CCWB526 are below the Australian drinking water guideline value of 600 mg/L for TDS. CCWB526 is regarded as poor quality (900 – 1200 mg/L), CCWB517 is considered to be unacceptable (> 1200 mg/L). However, all bores meet the livestock drinking water guideline value for TDS of 4000 mg/L (C&R Consulting, 2022).

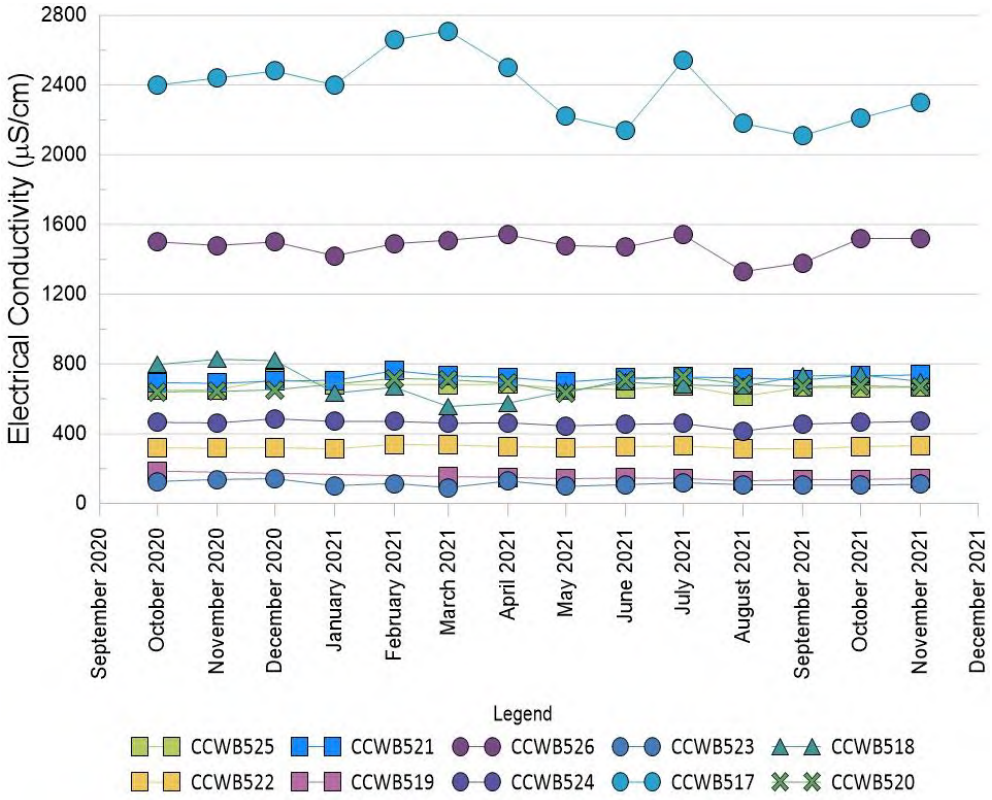


Figure 65.Electrical conductivity values within Groundwaters

Ionic Composition

Seven different water types exist at Agate Creek. Differing water types are evident in the Piper diagram (Figure 66), with most waters forming individual clusters spatially excluded from one another. The dominant cation for most bores is sodium, whereas bicarbonate is the primary anion in eight of ten bores. CCWB518 and CCWB525 are distinguishably different due to calcium being the primary cation. The dominance of bicarbonate anions also explains the slightly alkaline pH values (C&R Consulting, 2022).

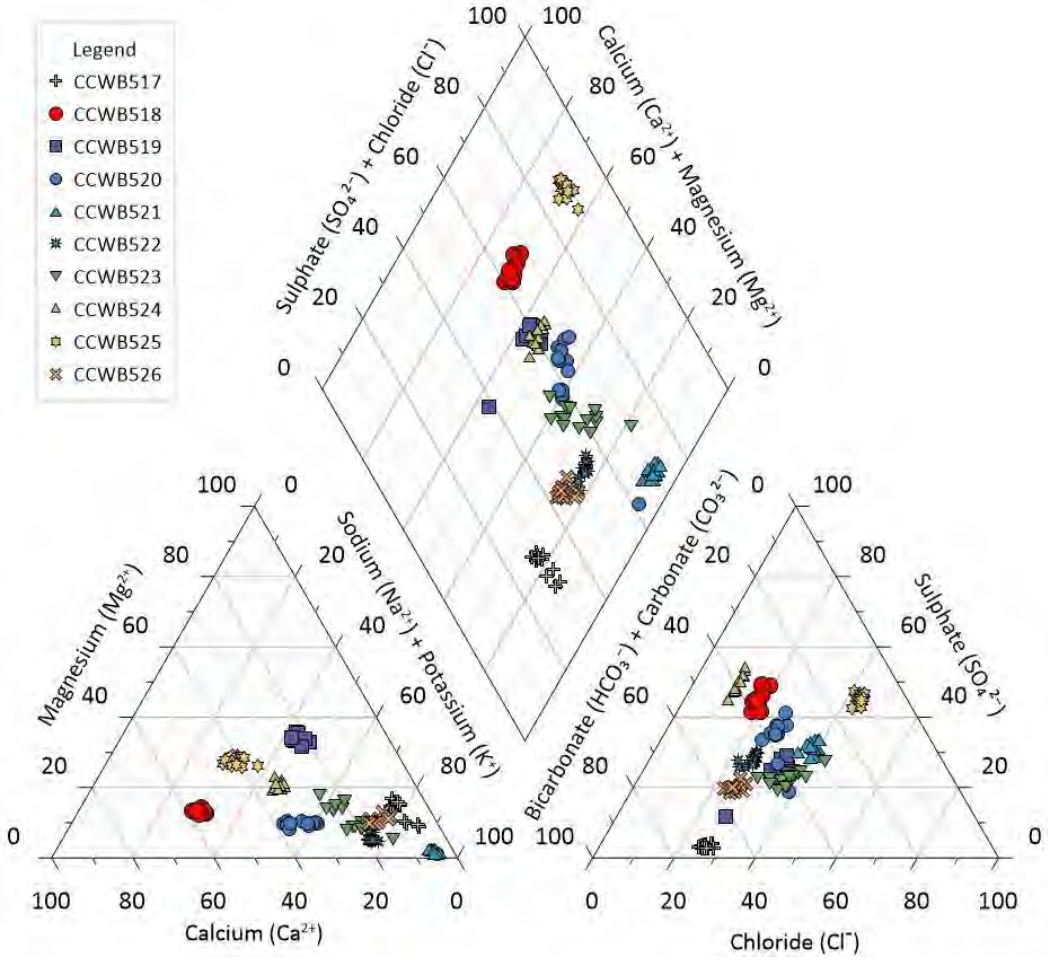


Figure 66. Ionic composition of all groundwaters (C&R Consulting, 2022)

Metals and Metalloids

Where groundwaters are in good condition, the intent is to maintain existing water quality (ANZECC and ARMCANZ, 2000). Where groundwaters interact with surface waters, groundwater quality should not compromise identified environmental values and water quality guidelines for those waters (C&R Consulting, 2022).

Due to the good quality of the groundwaters at Agate Creek (excluding CCWB517 and CCWB526), analytes have been compared against the Australian guidelines for drinking water and ANZECC and ARMCANZ (2000) guidelines for livestock. Dissolved metals and metalloids, the Australian drinking water guideline values are referenced, whereas total metals and metalloids are compared against the livestock drinking water guidelines guideline values (C&R Consulting, 2022).

Mean dissolved arsenic concentrations of CCWB518, CCWB520 and CCWB521 exceeded the Australian drinking water guideline with values ranging between 0.016 mg/L and 0.037 mg/L. CCWB518 has significantly elevated concentrations compared to other bores. Elevated levels of arsenic are attributed to the heavily altered geology intersected by CCWB518 (veins, rhyolite and andesite) (C&R Consulting, 2022).

The drinking water guideline limit for dissolved manganese is 0.5 mg/L. Most bores do not exceed this limit. CCWB519 and CCWB522 had marginally elevated mean values of 0.72 mg/L and 0.55 mg/L, respectively, whereas CCWB525 reported a markedly higher mean value of 3.83 mg/L (C&R Consulting, 2022).

The drinking water guideline for dissolved nickel is 0.02 mg/L, in comparison to the calculated mean for CCWB525 which equals 0.31 mg/L. The elevated dissolved nickel in CCWB525 correlates with the raised dissolved manganese concentrations. Dissolved manganese has a high adsorption capacity to available metals within the respective system. These naturally elevated levels are consistent with the weathered granite lithology encountered in CCWB525 (C&R Consulting, 2022).

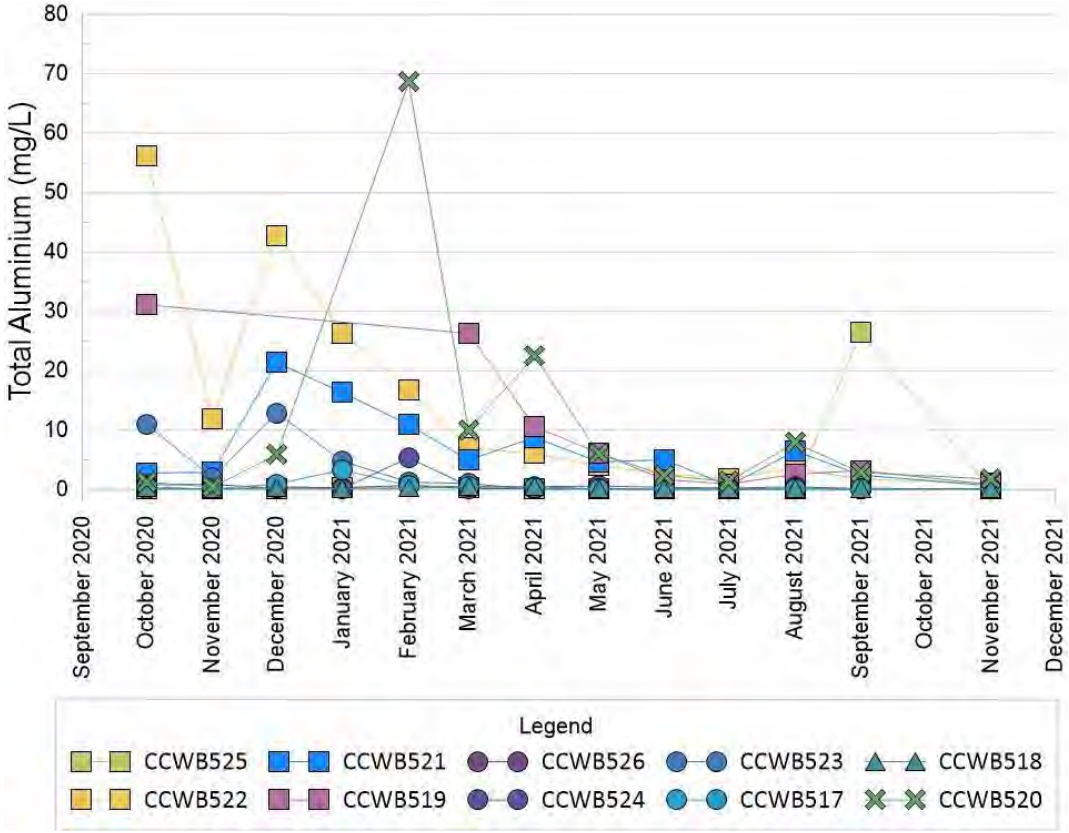


Figure 67. Concentrations of Total Aluminium in Groundwater (C&R Consulting, 2022)

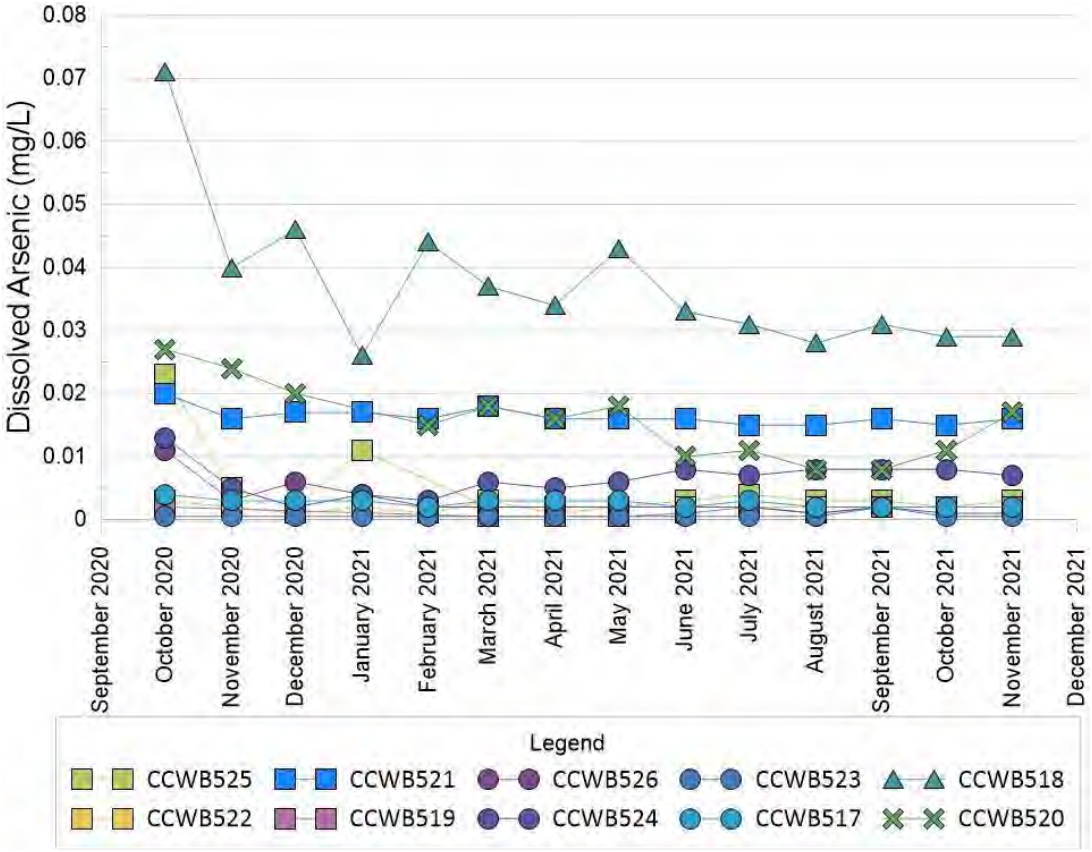


Figure 68. Dissolved Arsenic Concentrations in Groundwater (C&R Consulting, 2022)

Fluoride

The guideline limits for fluoride are 1.5 mg/L and 2 mg/L for drinking water and livestock drinking water, respectively quality (ANZECC and ARMCANZ, 2000). Four of the Agate Creek groundwater bores express a mean value below the human drinking limit. Six meet the livestock drinking water limit. CCWB521 fluoride concentrations are double that of any other bore. CCWB521 also displays the greatest level of variation over the 18-month monitoring period, ranging between 12.1 mg/L and 16.6 mg/L. Conversely, the southern-most bore (CCWB517) initially reported stable Fluoride concentrations. However, levels appear to have risen during the wet season. Concentrations of Fluoride levels are consistent with felsic volcanic rocks (i.e granite) which often contain fluorine-rich minerals. CCWB518, CCWB520, CCWB522 and CCWB524 also exceeded both drinking water guideline values, although all concentrations remained stable throughout the monitoring period. All fluoride concentrations at Agate Creek are deemed to be naturally occurring (C&R Consulting, 2022).

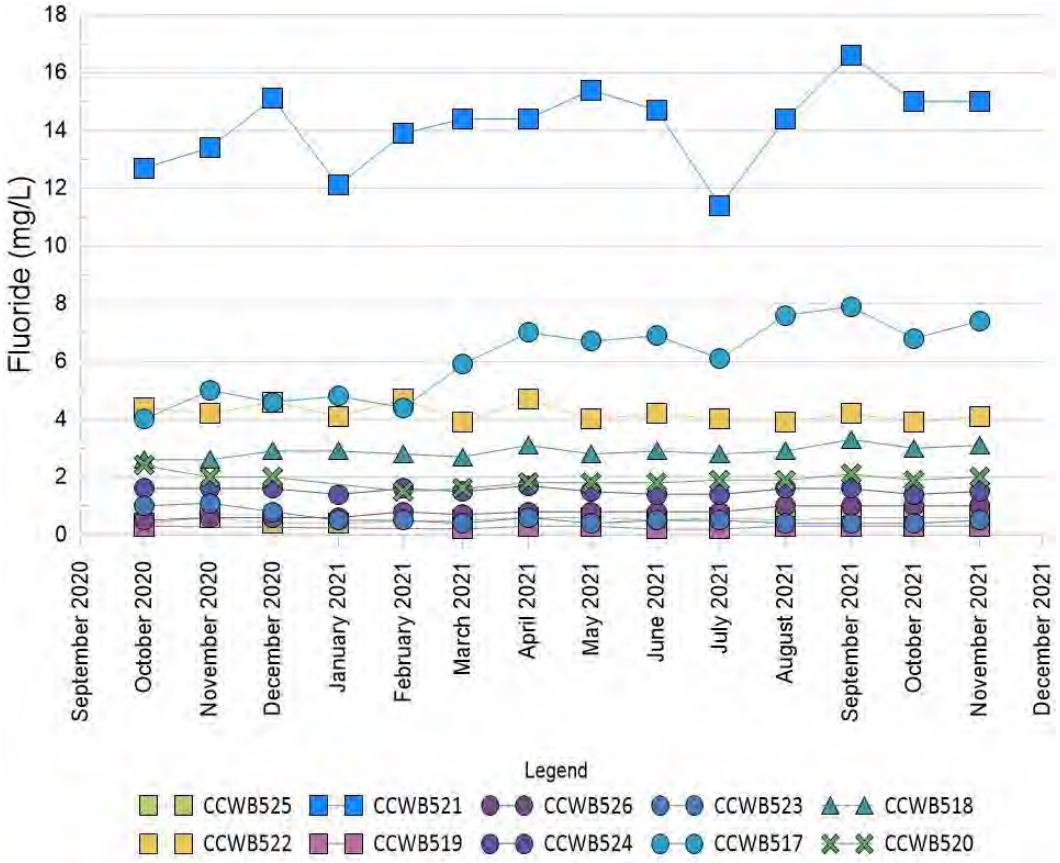


Figure 69. Concentrations of Fluoride in Groundwaters (C&R Consulting, 2022)

4.4.9.5. Groundwater Impact

4.4.9.5.1. Groundwater Take

Inflow rates have been utilised to calculate the relationship between groundwater flows and the pits. Assuming all groundwater flows are directed towards the pits, then:

- For the linear case, an inflow of 8,521.31 m^3/year may be predicted (16.20 L/min); and
- For the logarithmic case, an inflow of 5,958.51 m^3/year may be predicted (11.329 L/min).

Groundwater flows of CCWB519 are predicted to impact the pits 1 - 4 at a rate of 1.410 L/min. It should be noted that these values must be considered worst-case scenarios. From the flow rates and distances, the individual flows from bores CCWB518, CCWB524 and CCWB525 are those most likely to impact the Pit 6. Flows from the three bores may all combine to give a flow of 7.686 L/min on a linear model and 4.828 L/min on a logarithmic model. These are considered relatively low flows and are reasonable estimates of likely inflows (C&R Consulting, 2022).

4.4.9.5.2. Environmental Values

Groundwater Resources

Hydraulic conductivities at Agate Creek site are very low to low (10^{-8} to 10^{-7} m/sec) which implies that inflows into the pits will also be low. Inflows are most likely to be 4.828 to 7.686 L/min. Impact on flows from CCWB524, CCWB525 and CCWB518 may occur on the Pit 6 over 4 to 31.5 years. However, it is more likely to be 10 to 31.5 years. A low-flow impact (1.410 L/min) may occur on a 10-year time span from CCWB519 and 125 m to the west of this bore. The two distant bores, CCWB517 and CCWB526, may experience an impact over at least an 80-year time span (C&R Consulting, 2022).

Any impacts are predicted to be minor and will remain on the mine lease over at least 80 years. Considering all aforementioned factors, the overall risk to the sampled aquifers – and from the relatively small inflows into both the main pits and the minor pits (pit 1-5) to the west of CCWB519 – is very low to low (C&R Consulting, 2022).

Groundwater Users

No registered groundwater bores are located within 10km of Agate Creek. The impact to other groundwater users is considered to be negligible.

Groundwater-Dependent Ecosystems

There are no mapped groundwater-dependant ecosystems or springs within the Mine Lease. The nearest mapped groundwater-dependent ecosystem is a subterranean aquifer associated with the Hamstead Sandstone aquifer at Cobbold Gorge, downstream of the Agate Creek. The southern edge of this groundwater-dependent ecosystem is approximately 15 km northwest of the ML boundary. Considering the poor hydraulic conductivity measured and that the modelled minor drawdown will not surpass the mining lease boundary for several decades, it is unlikely that mining will interact with the associated groundwater-dependent ecosystems. Additionally, the potentiometric contours support the understanding that the groundwater systems present within the mining lease do not impact or interact with flow in Agate Creek (C&R Consulting, 2022).

Groundwater Quality

Agate Creek groundwater expresses good quality water, with most bores meeting drinking water quality guidelines for both human and livestock consumption, excluding fluoride. Potential risks to groundwater from the expansion of mining relate to the storage and interaction with waste rock. A waste rock characterisation assessment has been prepared as a part of this EAA, to determine the environmental implications of producing up waste rock (Section 4.3.2).

Agate Creek waste rock contains relatively benign lithology, predominantly consisted of felsic volcanics. It is expected that both the low and high pH results in the waste rock are a worst-case scenario. Therefore, the pH of runoff from the proposed open-cut pits waste rock will not be as low or high as that reflected in the waste rock sample test results. Also, in order for significant runoff to occur at Agate Creek, the rainfall dilution factor should be greater than the 1:5 (sample:water) ratio used in

the extract solutions. This, in turn, would counteract the resulting acidity or alkalinity. In general, most waste rock samples are in the neutral to slightly acidic range indicative of the waste rock lithology (felsic volcanics) (C&R Consulting, 2022).

The electrical conductivity of the Agate Creek waste rock samples ranges from 7 µS/cm to 1,680 µS/cm and has a very low median value of 43.5 µS/cm. Most Agate Creek waste rock samples have low electrical conductivity values (<300 µS/cm). Apart from an outlier in Pit 2 (1,680 µS/cm), EC values in all waste rock samples are below 500 µS/cm. The relatively low electrical conductivity recorded in most waste rock samples correlates with the good quality reported in the groundwater, whereby the highest electrical conductivity is approximately 2,400 µS/cm. It is therefore unlikely that seepage and infiltrations from the waste rock dumps would result in increases in the salinity of the associated groundwater system (C&R Consulting, 2022).

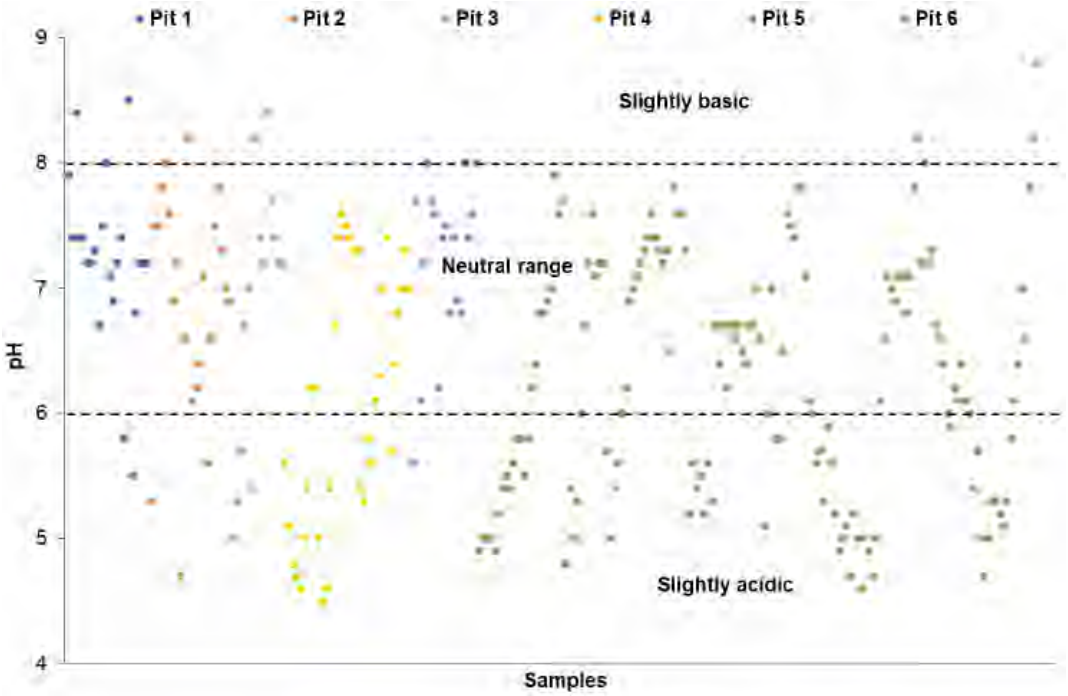


Figure 70. pH values for Agate Creek waste rock samples (C&R Consulting, 2022)

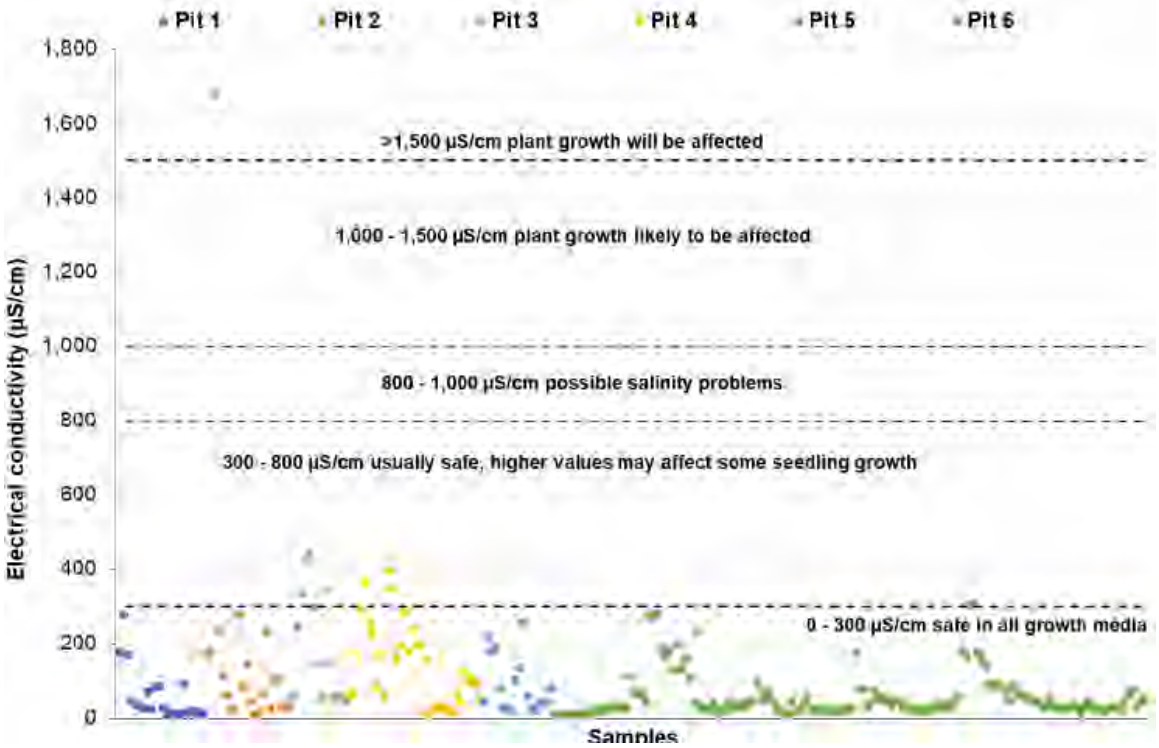


Figure 71. Electrical conductivity for Agate Creek waste rock samples (C&R Consulting, 2022)

The NAG testing demonstrates that most Agate Creek waste rock samples have a NAG(pH) greater than 4.5 and a NAPP value below (i.e., not acid generating). In contrast, two samples have a NAG(pH) greater than 4.5 and a net acid production potential (NAPP) value above 0 (these are classified as uncertain PAF [potentially acid-forming]), whereas at least one sample is certainly PAF, having a NAG(pH) less than 4.5 and a positive NAPP value (C&R Consulting, 2022).

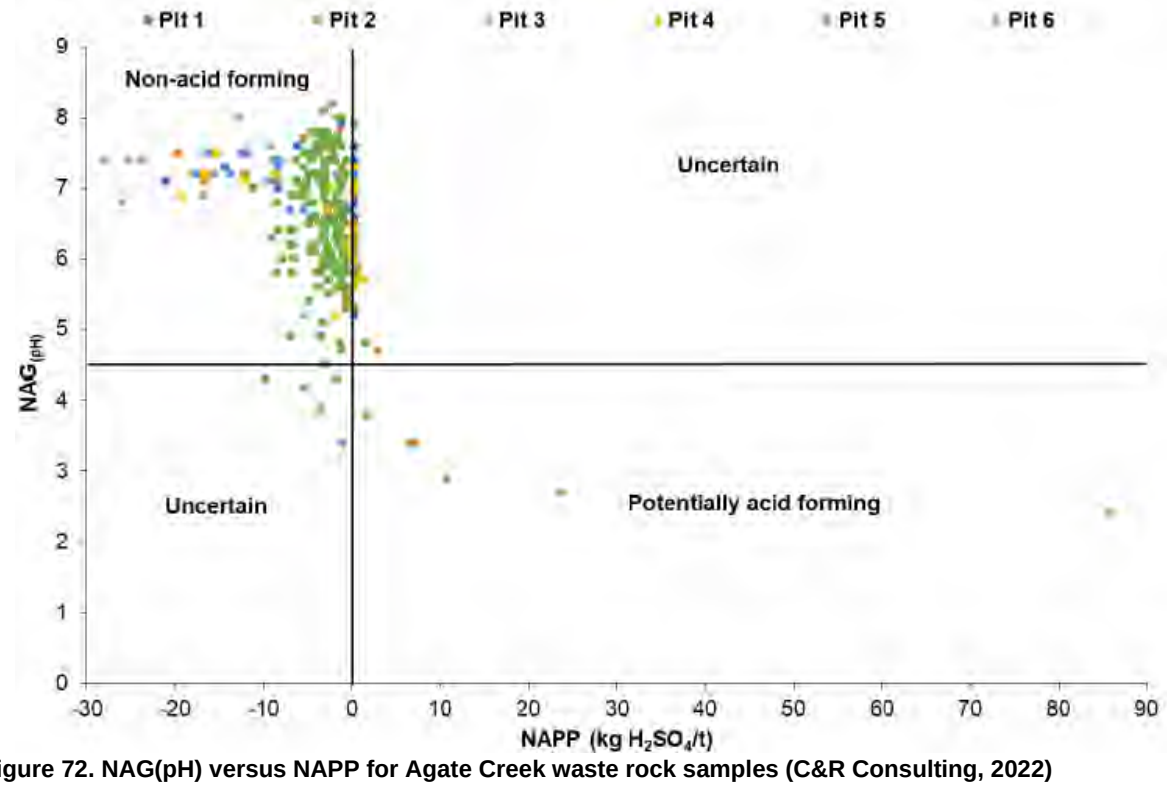


Figure 72. NAG(pH) versus NAPP for Agate Creek waste rock samples (C&R Consulting, 2022)

Applying the NAG(pH) and total sulphur geochemical classification criteria, most waste characterisation samples are NAF or barren. Of the 260 Agate Creek waste rock samples, there are only 11 samples that could be categorised as PAF (C&R Consulting, 2022):

- Three samples in Pit 2;
- One sample in Pit 5; and
- Seven samples in Pit 6.

These samples make up less than 14% of the total sample size and their sulphur values are still very low to low except for one sample in Pit 2. It is therefore expected that only one of these eleven samples presents an acid drainage issue because of the amount of produced acid would be negligible and any acid produced by the samples will be buffered by the surrounding NAF (C&R Consulting, 2022).

A broad range of analytes were assessed using both static tests and KLC tests. While irregular exceedances of conservative guideline were identified for a number of quality characteristics, only fluoride was found to be at levels of concern to the associated receiving environments (Fluoride). However, fluoride was already noted to be elevated, above livestock drinking water values, in several bores across, with levels recorded greater than 16 mg/L. KLC determined while maximum values of 6.6 mg/L were observed in initial leaches, these values quickly became compliant with the livestock drinking water guideline value of 2 mg/L during subsequently leaches. Based on these levels and the levels of fluoride already observed within the groundwater systems across the project site, seepage and infiltration from the waste rock dumps are predicted to have negligible influence on the groundwater quality throughout the area (C&R Consulting, 2022).

4.4.9.6. Impact Summary

The lithologies of Agate Creek indicate that the hydraulic conductivities are in the very low to low range. Pump tests completed on monitoring bores determined that hydraulic conductivities ranged between 6.57×10^{-8} m/sec and 5.06×10^{-7} m/sec. Any impacts to groundwater availability are predicted to be minor and will remain on the Mine Lease over ~80-year time span. The Agate Creek expansion presents an overall very low to low risk to the aquifers from the relatively small inflows into the pits (C&R Consulting, 2022).

Additionally, the impact to users is deemed to be negligible. No landholder groundwater bores were identified within 5 km of the mining lease boundary. The closest GDE is associated with the sandstone aquifer approximately 10 km north (C&R Consulting, 2022).

The potentiometric surface suggests that groundwater flow follows the surface topography to lower elevation beside Agate Creek (CCWB521). The elevation difference between the bed of Agate Creek and CCWB521 supports argument that the groundwater systems present within the mining lease do not impact or interact with flow in Agate Creek (C&R Consulting, 2022).

The greatest threat to water quality from mining operations comes from the increased volume of waste rock present on the surface. However, most waste rock samples (Appendix D) returned pH, electrical conductivity characteristic of NAF material and presents low environmental risk to surrounding groundwaters (C&R Consulting, 2022).

Based on the available data, this groundwater assessment has determined that the expansion of the Agate Creek mining operations would present a low environmental risk to the hydrogeological systems present (C&R Consulting, 2022). However, to further mitigate any potential impacts to groundwaters or the receiving environment, LWR will implement management measures detailed in Section 4.4.11.3.

4.4.10. Aquatic Vertebrate Assessment

C&R Consulting (2022) conducted an Aquatic Vertebrate Assessment of Agate Creek to determine whether the proposed development of Agate Creek would potentially impact aquatic invertebrates. The methodologies used and results of the assessments are detailed below and in Appendix J.

4.4.10.1. Assessment Locations

Vertebrate surveys were conducted within Agate Creek and it's multiple tributaries. Actual surveys were only undertaken where surface waters were present. Assessment locations are displayed in Table 67.

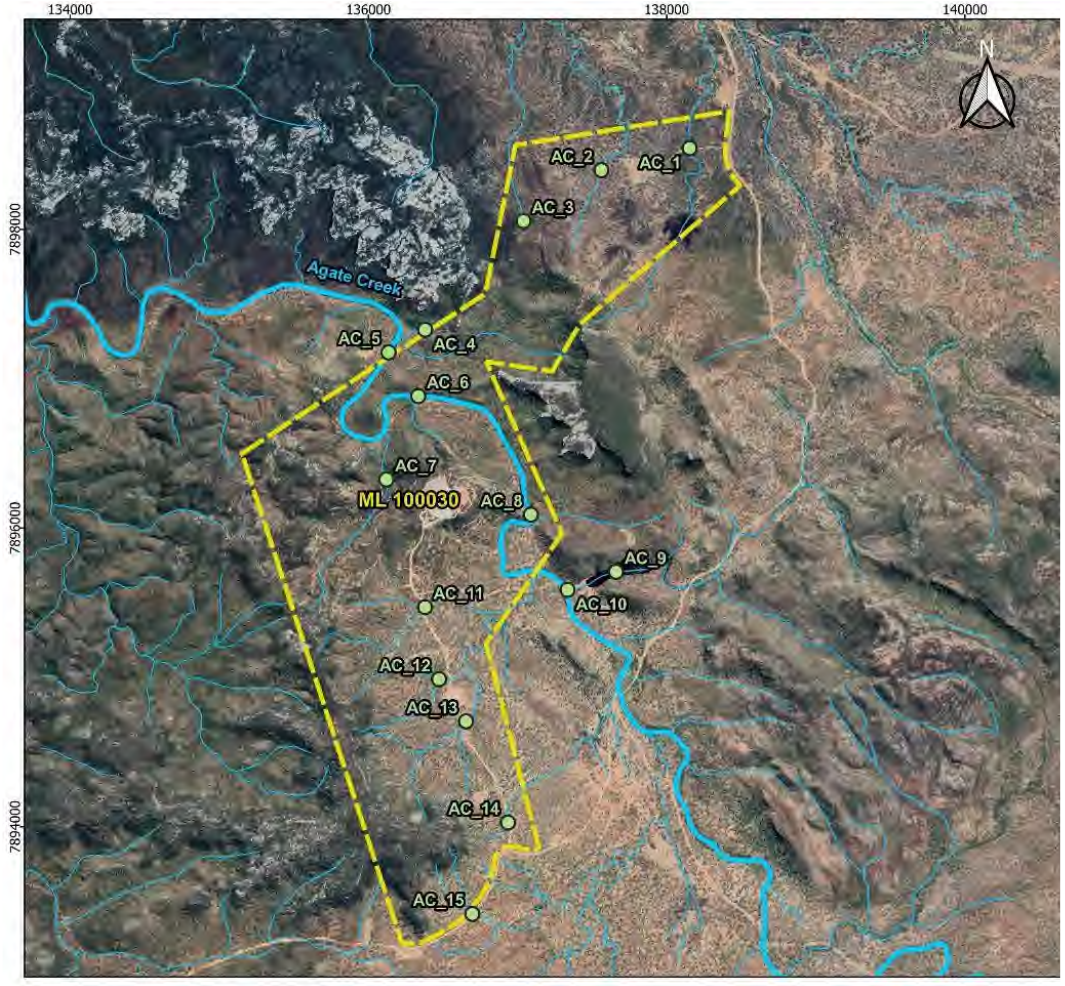


Figure 73. Aquatic Vertebrate Monitoring Locations (C&R Consulting, 2022).

4.4.10.2. Fish And Large Macroinvertebrate Communities Surveys

Fish communities were surveyed using a combination of backpack electrofishing, baited traps and dip nets, dependent on habitat type present. Backpack electrofishing was preferred however, baited traps were also deployed to target fish, crustaceans and freshwater turtles (C&R Consulting, 2022).

Collected fish were enumerated, identified, measured (to determine life history stage) and photographed. Freshwater fish surveys were conducted in accordance with the methods developed for the NAFF atlas project, the survey guidelines for Australia's threatened fish and in accordance with the Australian Code of Electrofishing Practice 1997, under the animal ethics approval CA2020/02/1354 and general fisheries permit 253191(C&R Consulting, 2022). Monitoring Locations are displayed on Figure 73.

Turtle Communities

Freshwater turtle surveys were conducted to identify any turtle species that may be present at Agate Creek. Turtle communities at each targeted site were assessed via visual surveys. Baited cathedral traps were also employed at, where suitable habitat was available (C&R Consulting, 2022).

4.4.10.3. Other Aquatic Vertebrates

The potential presence of other aquatic vertebrates in the region was assessed through the completion of a literature review and database searches. Database searches indicated that freshwater crocodile (Crocodylus johnsoni) have the potential to inhabit the greater area. No other aquatic vertebrates with statutory protection were revealed from database searches (C&R Consulting, 2022).

4.4.10.4. Assessment Results

4.4.10.4.1. Fish Communities

Four species of freshwater fish were identified at two sites during the 2021 field survey. All collected species were potamodromous in relation to movement ecology and habitat affiliation. The most abundant species were chequered rainbowfish (*Melanotaenia splendida inornata*). No fish species listed under the EPBC Act or the NC Act were found during the field surveys (C&R Consulting, 2022).

Table 75. Fish Community Results (C&R Consulting, 2022)

Scientific Name	Common Name	Site	
		AC_9	AC_10
Ambassis macleayi	Reticulated glassfish	1	–
Leiopotherapon unicolor	Spangled perch	3	10
Melanotaenia splendida inornata	Chequered rainbowfish	26	50
Neosilurus hyrtlii	Hyrtl's catfish	3	1
Total diversity		**4**	**1**

4.4.10.4.2. Freshwater Turtle Community

No freshwater turtles were observed within the project site. The distribution and extent of freshwater turtles within the Gilbert River catchment area remains poorly known. The lack of freshwater turtles observed during the surveys is reflective of:

- The ephemeral nature of the waters within the project site
- The near absence of both lotic and lentic refugial waterholes, combined with the short period of time since the establishment of the one lentic environment samples;
- The position of the project site in the upper reaches of the Gilbert River catchment area; and
- The seasonal timing of the survey (C&R Consulting, 2022).

4.4.10.4.3. Other Aquatic Vertebrates

The only other aquatic vertebrate identified as occurring within the Agate Creek was *Crocodylus johnsoni* (freshwater crocodile). However, there are no large, perennial, lentic environments within the mid to upper reaches of larger watercourses at Agate Creek which *Crocodylus johnsoni prefers*. Therefore, the *Crocodylus johnsoni* is not expected to utilise Agate Creek (C&R Consulting, 2022).

4.4.10.5. Potential Impacts to Aquatic Vertebrates

Agate Creek will be mined as an ore source for Georgetown. All ore will be transported off-site, limiting the potential for producing contaminants on site. The waste rock has also been found to be relatively benign (Appendix G).

With the majority of mining occurring on the western side of Agate Creek, there will be minimal development around (or through) the Agate Creek itself. Therefore, the main impacts to aquatic ecosystems is increased runoff of sediment-laden water from disturbed areas. However, the establishment of the proposed sediment ponds and other standard best-practice soil erosion and sediment control measures will limit the potential for sediment-laden waters to enter the receiving environment (C&R Consulting, 2022).

Therefore, the potential impacts to the receiving environment and the associated environmental values from Agate Creek is expected to be of minor risk.

4.4.11. Management Measures

4.4.11.1. Structure Management

4.4.11.1.1. Design Storage Allowance

The Design Storage Allowance (DSA) is the volume required to accommodate inflows during the wet season, thus preventing unauthorised release of water to the environment. The DSA must be available in each regulated structure (or network of linked containment systems with a shared DSA volume) on 1 November of each year. This DSA volumes must be assessed each year and is based on the actual available storage in each of the regulated structures (ATC Williams, 2022).

The Manual outlines two acceptable methods for calculating the DSA, namely:

1. Method of deciles; or,
2. Method of operational simulation (ATC Williams, 2022)..

The method of deciles utilises historical data to estimate probabilistic wet season rainfall depths and considers other process inputs over the wet season. Operational simulation accounts for the site water management system and is undertaken through site water balance modelling (ATC Williams, 2022).

DSA for the MAW Dam is detailed in Table *76.*

Table 76. Design Storage Allowance for the MAW Dam (ATC Williams, 2022).

Parameter	Water Storage Dam
Consequence Category	Significant
Critical Wet Period	1 Nov to 31 May
Design Risk	5% AEP*
Calculated Runoff and Transfer Inputs	165 ML
DSA (including 50% DSM)	250 ML

4.4.11.1.2. Mandatory Reporting Level

The Mandatory Reporting Level (MRL) is derived by selecting the highest volume required in a regulated dam to contain:

- The runoff from the contributing catchment of the particular dam for a 72-hour duration storm at a defined annual exceedance probability (AEP); and,
- A wave allowance at that AEP as estimated using a recognised engineering method.

When the MRL is exceeded for a structure, the holder of the EA is required to inform the administering authority. MRL for the MAW Dam is detailed in Table *77* (ATC Williams, 2022).

Table 77. Mandatory Reporting Level (ATC Williams, 2022).

Parameter	Water Storage Dam
Design Risk	1 in 10 AEP, 72hr event
Rainfall Total	218.0 mm
Catchment Area	4.5 ha
Runoff Coefficient	1.0
Extreme Storm Storage (ESS) Volume	9.8 ML

4.4.11.1.3. Emergency Spillway

An emergency spillway is a mandatory requirement for any regulated dam, with design criteria for the spillway design based on the Manual and reproduced in Table 78.

Table 78. Spillway Design Criteria (ATC Williams, 2022).

Design Criteria	Flood Passage	Flood Ingress Prevention
Consequence Category for 'dam break'	Spillway capacity	Flood level for embankment crest levels
Significant consequence	1:100 AEP to 1:1,000 AEP	Spillway design flood peak level + wave run-up allowance for 1:10 AEP wind

4.4.11.1.4. Drainage Management

Drains/bunds will be installed used to collect and convey site water. These drains/bunds are to be constructed around the proposed pits and WRDs to contain and convey any site water to the sediment ponds and minimise potential impacts to the downstream environment (ATC Williams, 2022).

Clean water diversion drains are to be designed to accommodate a 1 in 100 AEP design storm event. This criterion has been adopted given the significance of clean water diversion drains to protect downstream mine infrastructure from local flood inundation (ATC Williams, 2022).

4.4.11.1.5. Water Volume Management

As discussed in the WBM, the potential spill of pits and structures is considered unlikely where the water management in accordance with Appendix H. However, to further reduce water levels LWR are to purchase a series of forced evaporation systems which will be fixed to either the highwall of open cut pits or top of the MAW Dam batter. Evaporative systems will function by pumping water into a fan. Air is then compressed through a tapered barrel and propels controlled-size water droplets via nozzles.

Droplets expelled will then actively evaporate. It is thought that forced evaporation systems will be suitable at maintaining low water levels in water management structures.

4.4.11.2. Surface Waters

4.4.11.2.1. Monitoring Program

Receiving Environment Monitoring Program (REMP) has been developed by WTS and sampling commenced during 2021. The REMP has been prepared to monitor for any potential impact on receiving waters as a result of Agate Creek Activities. The REMP involves sediment, surface water, and macroinvertebrate sampling at upstream and downstream locations biannually (wet and dry season). Details on the REMP are provided below and included in Appendix H:

Monitoring Locations

Monitoring sites upstream of mining influences were selected as reference sites and the receiving waters downstream from mining disturbance have been classified as impact sites. These sites have been established to provide a comparison with selected reference sites, which are located upstream from mining disturbance. At total of 14 sites comprise the REMP for Agate Creek Gold Mine (6 reference and 8 impact sites) (WTS 2021). Reference and impact sites were compared to assess potential impact to the receiving environment that may be a result of mining disturbance. REMP sites are listed in Table 79.

Table 79. Description of REMP sites sampled in September 2021 and March 2022.

Site	Northing	Easting	Description
ACUSR01	769082.9	7897145	**Reference site**. Agate Creek, approx. 250m upstream of the ML boundary (outside boundary) and 50m upstream of a tributary entering Agate Creek from below a dam.
ACUSR02	767577.8	7896882	**Reference site**. Unnamed first order tributary of Agate Creek (flowing east), approx. 600m upstream of the crossing along the haul road.
ACUSR03	767408.7	7897154	**Reference site.** Unnamed first order tributary of Agate Creek (flowing north-east), approx. 1.2km upstream of the confluence with Agate Creek.
ACUSR04	767831.5	7896317	**Reference site**. Unnamed first order tributary of Agate Creek (flowing east-north-east), approx. 600m upstream of the crossing along the haul road, just north of the mine camp.
ACUSR05	767997.4	7895853	**Reference site**. Unnamed first order tributary of Agate Creek (flowing north-north-east), approx. 700m upstream of the crossing along the haul road, just south of the mine camp.
ACUSR06	769431.2	7899965	**Reference site**. Unnamed first order tributary of Cave Creek (flowing north-north-east), approx. 450m upstream of ACDSI08; 25m upstream (south) of the crossing along the haul road, west of the ROM.
ACDSI01*	768122.6	7898517	**Impact site.** Unnamed tributary of Agate Creek (flowing north), approx. 100m upstream of the confluence with Agate Creek; downstream of Sherwood Open Cut pit.
ACDSI02	768838.4	7897179	**Impact site**. Unnamed first order tributary of Agate Creek (flowing north), approx. 140m upstream of the confluence with Agate Creek; downstream of Sherwood West Open Cut pit.
ACDSI03	767873.3	7898010	**Impact site.** Unnamed first order tributary of Agate Creek (flowing north-east), approx. 1000 downstream of ACUSR03; 200m upstream of the confluence with Agate Creek; downstream of Sherwood West Open Cut pit.
ACDSI04	767682.5	7898273	**Impact site.** Agate Creek, approximately 3km downstream of ACUSR01, downstream of all mine operations and tributaries flowing into Agate Creek.

Site	Northing	Easting	Description
ACDSI05	768854.7	7897720	**Impact site.** Agate Creek, approximately 1.1km downstream of ACUSR01, downstream of Sherwood West Open Cut pit and mine camp; upstream of Sherwood Open Cut pit.
ACDSI06	767908.5	7898338	**Impact site.** Agate Creek, approximately 300m upstream of ACDSI04, downstream of Sherwood Open Cut pit; upstream of tributaries flowing from Sherwood West Open Cut pit.
ACDSI07	767936	7898807	**Impact site.** Agate Creek, approximately 700m downstream of ACDSI04 (just outside ML boundary), downstream of all mine operations and tributaries flowing into Agate Creek.
ACDSI08	769589.3	7900254	**Impact site.** Unnamed first order tributary of Cave Creek (flowing north-north-east), approx. 450m downstream of ACUSR06; downstream of ROM (just outside ML boundary).

Surface Water Sampling

Water quality monitoring is to be undertaken in accordance with DEHP's Monitoring and Sampling Manual 2009 (Department of Environment and Science, 2018) which provides common techniques, methods and standards for sample collection, handling and data management. Due to the ephemeral nature of the watercourses in the region, water can only be sampled where sufficient surface water is present. Physico-chemical parameters and field observations are also recorded where possible as detailed in Table 80.

Table 80. REMP Analytes

Parameter	Units	Comments
pH	pH units	Hand-held water quality meter, calibrated daily
Electrical Conductivity	µS/cm	Laboratory Analysis
Total Dissolved Solids	mg/L	
Alkalinity (Hydroxide, Carbonate, Bicarbonate and Total as $CaCO_3$)	mg/L	
Sulfate as SO_4	mg/L	
Chloride	mg/L	
Fluoride	mg/L	
Major Cations (Ca, Mg, Na, K)	mg/L	
Total Anions and Cations	meq/L	
Total Hardness as $CaCO_3$	mg/L	
Metals (Total and Dissolved; Aluminium, Arsenic, Boron, Cadmium, Chromium, Copper, Cobalt, Iron, Manganese, Mercury, Molybdenum, Nickel, Lead, Selenium, Zinc)	mg/L	
Dissolved oxygen	mg/L and or % saturation	Hand-held water quality meter, calibrated daily
Temperature	mg/L	Hand-held water quality meter, calibrated daily
Electrical Conductivity (EC)	µS/cm	Hand-held water quality meter, calibrated daily
Turbidity and/or Total Dissolved Solids (TDS)	FNU or ppm	Hand-held water quality meter, calibrated daily
Water level	m	Maximum at deepest point
Visible flow upstream of site	NA	Yes or No

Parameter	Units	Comments
Visible flow downstream of site	NA	Yes or No
Water surface	NA	Glassy, smooth/minor ripples, turbulent
Water colour	NA	Hue and intensity
Water clarity	NA	Record maximum depth at which bottom can be seen
Visual and olfactory anomalies	NA	Record and photograph any films, foam, slicks, unusual debris or algal blooms and any unusual odours
Weather (current and past 24 hrs)	NA	e.g. current conditions, average cloud cover over past 2 hours; rainfall in last 24 hrs

Sediment Sampling

Stream sediment sampling is to be conducted in accordance with DEHP's Monitoring and Sampling Manual 2009 (Department of Environment and Science, 2018). Sediment samples are to be collected from the waterbody (if water was present) or from within the main channel, for dry creek beds, and placed in containers provided by the laboratory. Samples are preserved and stored according to laboratory instructions and delivered to the laboratory within the specified holding times. The analysis is conducted for the parameters detailed in Table 81.

Table 81. Laboratory Parameters for Sediment Samples

Parameter	Units
Moisture content	%
Particle Size Distribution (PSD)	%
Metals (Total; Antimony, Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Zinc)	mg/kg
Particle size distribution for cobble (>60mm), gravel (2-60mm), sand (0.075 to 2mm) and fines (< 0.075mm)	%

Macroinvertebrates

Macroinvertebrate sampling and monitoring is conducted in accordance with Australia-Wide Assessment of River Health: Queensland Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual (Department of Natural Resources DNR, 2001).

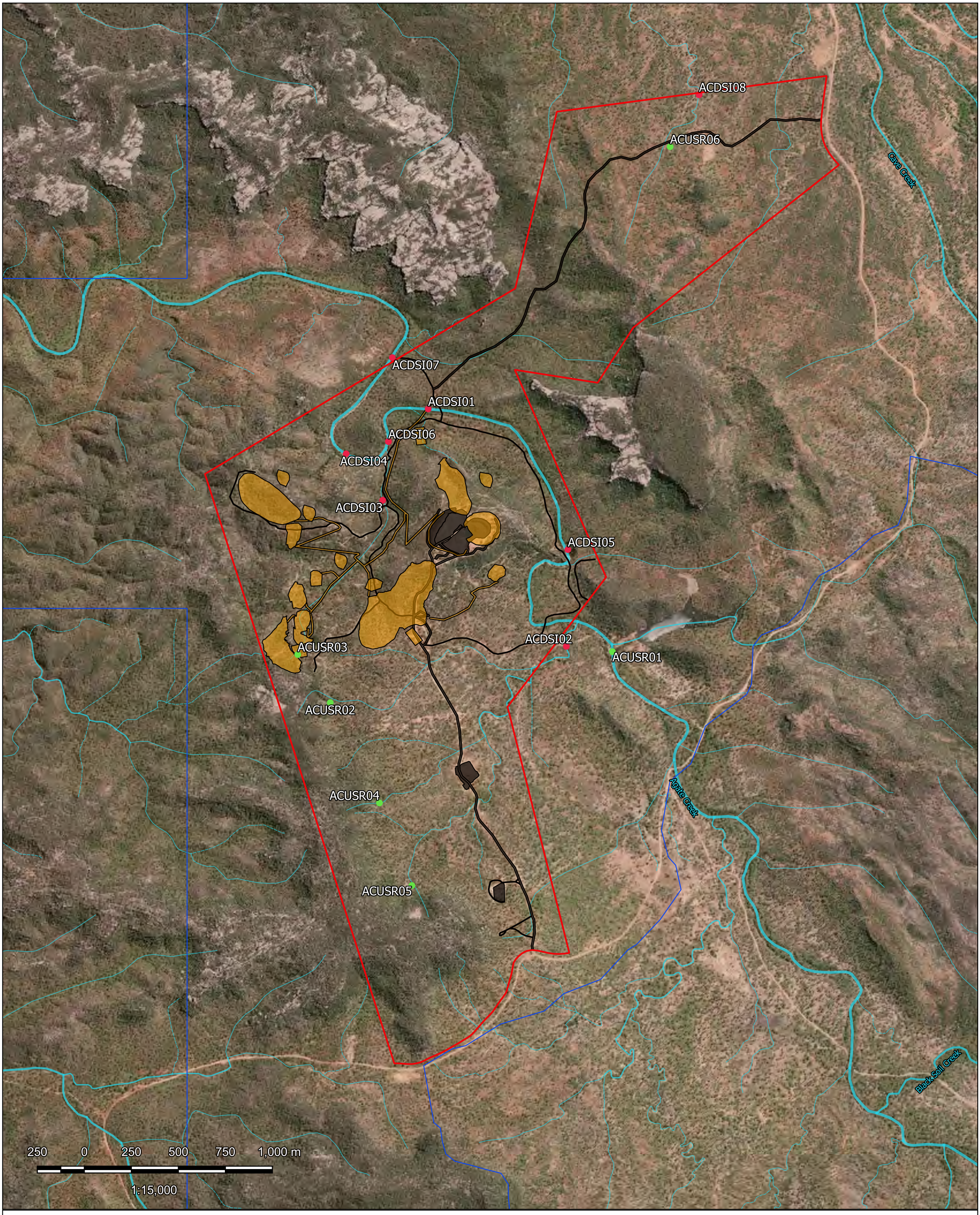
Macroinvertebrate samples are collected at all sites where surface water and appropriate habitat was present. Samples are collected with a 250 micrometre mesh net. A total of 10 m of habitat is sampled from a bed and an edge habitat (two samples per site). During the previous round of the REMP, during

the dry season only one site had sufficient surface water to provide macroinvertebrate habitat whereas during the wet season round, six sites had sufficient water and habitat.

Habitat assessments, including observations regarding the stream flow conditions, substrate, riparian zone and surrounding land use (i.e. based on AUSRIVAS data sheets), are completed at each site using a georeferenced data collection application pre-loaded on field crews' mobile phones and/or tablets. Photos are taken upstream, across the channel and downstream. Macroinvertebrate samples are preserved in the field using 70% ethanol, then processed in the laboratory following AUSRIVAS protocols. Macroinvertebrates were identified to family level (or a lower/higher taxonomic level, as recommended by AUSRIVAS and other literature), by an AUSRIVAS accredited aquatic ecologist using a stereo microscope. The abundance of each taxon was recorded.

REMP Reporting

A REMP report will be prepared for Agate Creek on an annual basis following on a yearly basis. The REMP report will summarise the results of monitoring conducted during the previous year of monitoring and determine whether the receiving environment has been impacted by the Project. The REMP will be prepared by suitably qualified person, with reference to facilitate the requirements of the EA and will be prepared with reference to the REMP guidelines developed by the ANZECC (2000), Department of Environment and Science (2014).



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Project number: 2021.09001
CRS: GDA2020 EPSG: 7844
Date: 11 July 2022

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Figure 74. REMP Monitoring Locations

Legend

- Mineral Development Licence
- Mining Lease
- Existing Mine Features
- Proposed Mine Features

Watercourse - Stream Order

- 0
- 1
- 2
- 3
- 4

REMP Locations

- Impact
- Reference

ESRI Satellite

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4.4.11.3. Groundwaters

4.4.11.3.1. Groundwater Monitoring Plan

Groundwater will continue being monitored at Agate Creek throughout the proposed development to detect potential impacts to EVs from changes in water levels and quality. Significant changes will trigger investigations and preventative measures to be implemented appropriately by LWR. Until the integrity of the bores without bentonite seals can be assessed, all bores will continue to be monitored. Monthly monitoring is necessary during the first year of the proposed activities to refine the current data and groundwater modelling. Once the initial monthly monitoring campaign is complete, quarterly monitoring is to continue for the life of Agate Creek.

Groundwater samples will be collected in accordance with the relevant guidelines and conventions specified in the Monitoring and sampling manual (DES, 2018), and in compliance with, for example, AS/NZS 5667:11 1998 (Australian/New Zealand standards, 2016). The samples will be preserved and forwarded to a National Association of Testing Authorities (NATA) accredited water laboratory for analysis.

An internal Groundwater Management Plan (GMP) will be developed for Agate Creek. The GWP will include:

- Background to the GMP;
- Monitoring requirements of the GMP;
- Detail analytes to be maintained;
- Outline the Methodologies of monitoring;
- Detail data interpretation methodologies; and
- Outline reporting requirements.

The GWP should be reviewed at a minimum, biannually in the first year and annually following. The GMP and review should include:

- Assessing groundwater level and quality;
- Consistently updated groundwater monitoring figures (e.g. contour map, time series plots, etc.);
- Comparisons and discussions of groundwater levels;
- Review of monitored groundwater quality with respect to current data, compliance criteria, and relevant guidelines;
- Discussion of results and trends; and
- During review stages, assess suitability of monitoring network and compliance criteria

4.4.11.3.2. Groundwater Monitoring Locations

Groundwater monitoring is to continue on a quarterly basis throughout the operation of the Agate Creek expansion. The monitoring network will include the ten bores included in the Groundwater Impact Assessment and 12 additional bores recently established bores (Table 82).

Table 82. Groundwater Monitoring Network

Bore ID	Easting	Northing	Ground Level	Casing Above Ground	Total Depth	Screened Interval
	MGA94 Zone 54		m AHD	m	m BGL	m BGL
CCWB517	768400	7896463	435.6	0.6	55	49 – 55
CCWB518	767768	7897706	431.4	0.6	73	67 – 73
CCWB519	767302	7897863	517.18	0.62	85	79 – 85
CCWB520	767947	7897838	434.96	0.59	73	67 – 73
CCWB521	768701	7898079	420.94	0.6	73	67 – 73
CCWB522	768762	7897724	434.2	0.6	73	67 – 73
CCWB523	768321	7897579	449.6	0.61	73	67 – 73
CCWB524	768174	7897670	496.06	0.64	91	85 – 91
CCWB525	768167	7897930	498.77	0.62	103	97 – 103
CCWB526	767710	7896909	449.4	0.66	73	67 –73
CCWB527	767660	7897458	461.50		31	25 – 31
CCWB528	767955	7898381	415.49	0.57	73	67 – 73
CCWB529	770217	7900144	463.85	0.54	31	25 – 31
CCWB530	767948	7898378	422.80	0.67	7	4 – 7
CCWB531	767997	7898782	420.39	0.66	55	49 – 55
CCWB532	770221	7900138	469.62	0.55	7	4 – 7
CCWB533	769580	7900063	473.09	0.6	25	19 – 25
CCWB534	768655	7895516	454.09	0.52	25	19 – 25
CCWB535	768681	7897248	407.91	0.6	7	4 – 7
CCWB536	768622	7897214	440.68	0.57	19	13 – 19
CCWB537	768005	7898801	420.66	0.62	19	13 – 19
CCWB538	768651	7895513	468.83	0.6	7	4 – 7

Water quality parameters to be monitored are based on site geology, site history, the results of baseline monitoring data, and waste rock characterisation. Parameters include those required for interpretation purposes (e.g., major anions and cations) and those that are recommended for compliance purposes. Water quality parameters to be monitored are detailed in Table 83.

Table 83. Groundwater Monitoring Parameters

Parameter	Units
Standing Water Level (SWL)	m BGL
pH	pH units
Electrical Conductivity (EC)	µS/cm
Total Dissolved Solids (TDS)	mg/L
Sulfate	mg/L
Chloride	mg/L
Dissolved major cations – Calcium, Magnesium, Sodium, Potassium	mg/L
Total Metals – Al, As, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Zn, Bo, Fe, Hg.	mg/L
Total Fluoride	mg/L
Dissolved Metals – Al, As, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Zn, Bo, Fe.	mg/L

4.4.11.3.3. Groundwater Bore Integrity Investigation

It is noted in Appendix K that there is a potential that bores CCWB517 - CCWB527 may not meet the Minimum Construction Requirements for Water Bores in Australia guideline (National Uniform Drillers Licensing Committee, 2020) with speculation that the bentonite seal has not been installed appropriately above the screened interval. LWR will conduct an investigation into the bore integrity upon approval of the EA application and if determined by the investigation that the bores are not constructed as per the Minimum Construction Requirements for Water Bores in Australia, these bores may be re-established.

4.4.11.3.4. Maintenance Scheduling

All light vehicles, plant, and static machinery will be inspected and maintained in accordance with the manufactures specifications. Where defects are identified, LWR appointed contractors will attend to site to conducted required maintenance.

4.4.11.3.5. Handling and Storage of Chemicals and Fuels

All chemicals and fuels will be stored in accordance with *Australia Standard (AS) 1940 The storage and handling of flammable and combustible liquids*. Chemicals and fuels proposed to be handled and stored onsite include residual fuels and oils and greases. Chemicals and fuels are proposed to be stored in appropriate containers (e.g. fuel drums) on bunded pallets, cabinets, etc.

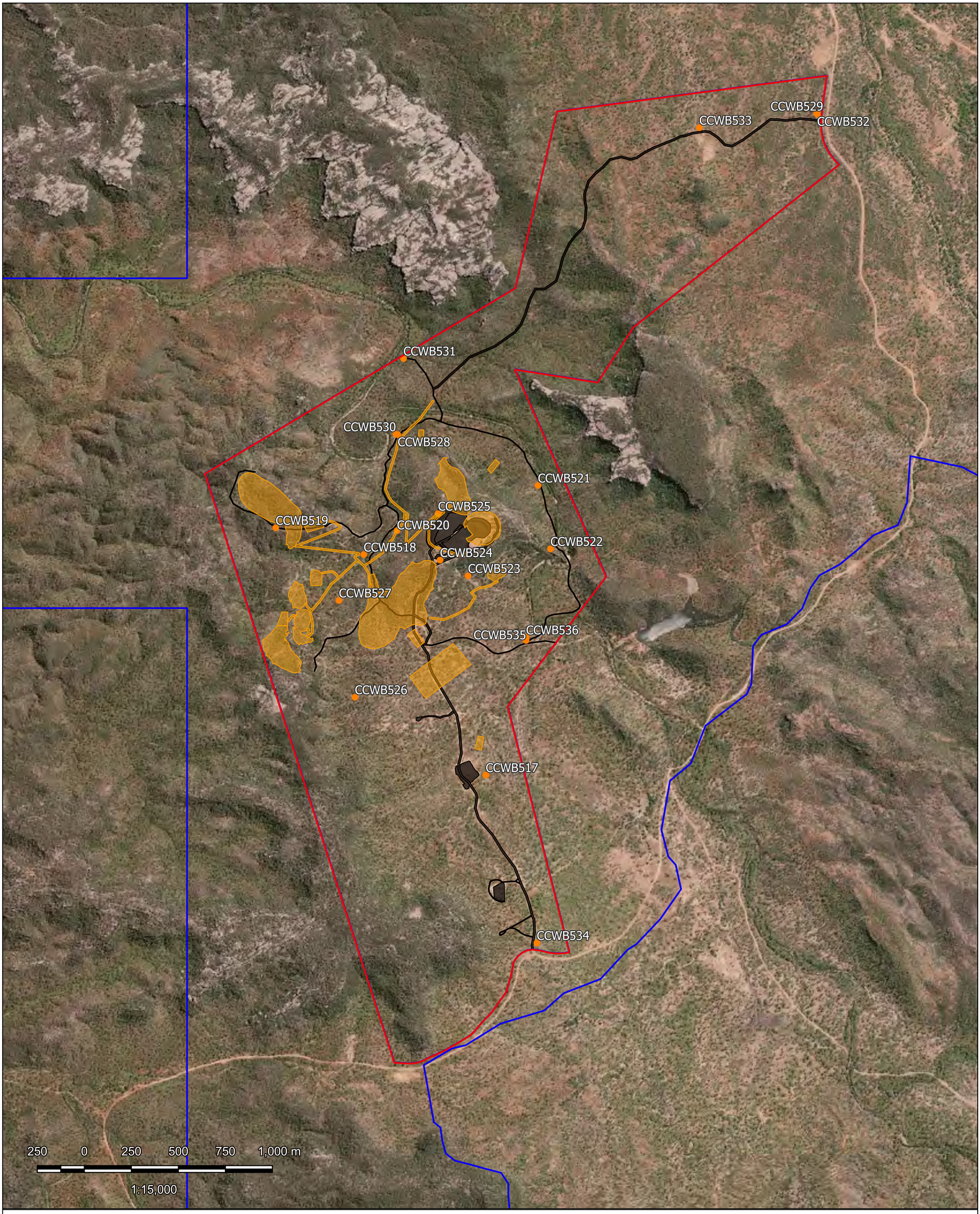
All waste chemical, fuels and oils will be stored in appropriate containers and removed from the Agate Creek by a licenced third-party waste management company.

4.4.11.3.6. Spill Management

All spills will be mitigated through the use of onsite spill kits. All employees will be appropriately trained in the use of spill kits including containment, absorption, and recovery. Any spill over 20 L will be recorded as an incident and appropriately documented.

4.4.11.3.7. Mitigating Impacts on Production Bores

There is minimal data regarding the production and camp bores. Each extraction point must be fitted with a flow meter to accurately measure take volumes. This will provide additional scope for assessment when the annual groundwater reviews are completed to determine whether any impact has occurred to water levels and/or quality (C&R Consulting, 2022).



Client: Laneway Resources Ltd
Project number: 2021.09001
CRS: GDA2020 EPSG: 7844
Date: 11 July 2022

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Figure 75. Groundwater Monitoring

Legend

- Mineral Development Licence
- Mining Lease
- Existing Mine Features
- Proposed Mine Features
- Monitoring Bores

ESRI Satellite

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4.5. Waste Impacts

In preparing this report, consideration has been given to guideline *ESR/2015/1836 - Application requirements for activities with waste impacts* (Department of Environment and Science, 2019a). DES is required to assess the application against the requirements stated in the *Environmental Protection Act 1994*, the Environmental Protection Regulation 2019 (EP Regulation) and the *Waste Reduction and Recycling Act 2011* to meet the environmental objective and performance outcomes described below:

Environmental Objective

'Any waste generated, transported, or received as part of carrying out the activities is managed in a way that protects all environmental values'.

Performance Outcome

Waste generated, transported, or received, is managed in accordance with the waste and resource management hierarchy in the *Waste Reduction and Recycling Act 2011*; and
If waste is disposed of, it is disposed of in a way that prevents or minimises adverse effects on environmental values.

RISK OF ENVIRONMENTAL IMPACT: LOW

4.5.1. Types of Waste

Waste generation will occur during all phases of the Agate Creek Project. Where appropriate there are methods to minimise waste by changing disposal methods as shown in Table 84.

Table 84. Agate Creek Waste Sources

Waste	Generation	Method of Re-use/Disposal	Phase of Development
Topsoil	Stripped during land preparation	Stockpiled onsite for reuse in rehabilitation.	Construction / Operation
Vegetation	Generated during land clearing and preparation	Vegetation will be stick raked and stockpiled to be mulched at a later date. Mulch to be stockpiled on site to be reused in rehabilitation.	Construction / Operation
Waste rock	Generated during open cut mining/establishment and construction activities	Used for constructing pads and mine roads or stored in waste rock dumps. NAF waste rock will also be reused during rehabilitation. During mine closure, majority of NAF material remaining will be used in landform shaping.	Construction / Operation
General waste	Generated by day-to-day activities	Organics disposed of within a designated disposal site within the WRD footprints. Other general waste transported offsite for disposal.	Construction / Operation
Sewage	Generated by workforce	Treat at onsite septic systems. Treated sludge to be removed offsite by regulated waste contractor as required.	Construction / Operation
Scrap metal	Generated by day-to-day activities	Transported offsite and sold as scrap steel for recycling	Construction / Operation
Waste oil and grease	Generated by day-to-day activities	Collected from site by waste contractor as required.	Construction / Operation
Waste tyres	Generated by day-to-day activities	Excess tyres stockpiled for later disposal	Construction / Operation
Vehicle batteries	Generated by day-to-day activities	Removed offsite by regulated waste contractor as required.	Construction / Operation

4.5.2. Proposed Volumes of Waste

The Project will generate quantities of waste as a result of site activities. Predominantly, wastes generated by the extraction of ore includes waste rock and topsoil. Other minor sources of wastes are generated from day-to-day activities (e.g., general waste, oils & greases, tyres etc.).

Proposed volumes of wastes to be generated by the Project are detailed in Table 85.

Table 85. Estimated waste volumes

Waste Type	Disturbance Footprint (m^2)	Estimated Volume
Topsoil**	6.2	124,000m^3
Vegetation	37.63	N/A
Waste rock	23.45	~2,700,000
General waste	N/A	-*
Sewage	N/A	-*
Scrap metal	N/A	-*
Waste oil and grease	N/A	-*
Waste tyres	N/A	-*
Vehicle batteries	N/A	-*

* Volumes are currently unknown and dependant on actual Project activities
** Calculated on an average topsoil depth of 20cm, Excluding areas of Brown Lithic Rudosol (Appendix D & Figure *12*).

4.5.3. Waste Treatment Process

Waste treatment process can be defined as a process where one waste undergoes significant chemical change to transform it into product or secondary waste. Where waste treatment occurs, investigative analysis on the resulting waste may be required. The waste produced by the Project and their required treatment are as follows:

- Topsoil – Once stripped, stored on site. No treatment required;
- Vegetation – Stockpiled and stored on site. Potentially mulched, no further treatment.
- Waste Rock – Stored as per Section 4.3.5. No treatment required.
- General Waste – Removed from site, no treatment required.
- Sewage – Treated onsite via existing septic systems.
- Scrap Tyres – Disposed of onsite in designated tyre disposal location, no treatment will be undertaken.
- Oils and Greases - Removed from site, no treatment required.
- Scrap Metal - Removed from site, no treatment required.
- Vehicle batteries - Removed from site, no treatment required.

4.5.3.1. *Waste Transport*

Wastes that cannot be disposed of at Agate Creek are to be transported offsite. General wastes will be collected from Agate Creek by an appointed waste contractor and disposed of at an Etheridge Shire Council refuse facility. Regulated wastes will be collected by a certified regulated waste contractor and disposed of at a suitable regulated waste disposal site. Regulated waste certificates will be generated by the appointed regulated waste contractor, and records kept within an internal LWR data management system.

LWR will not transport wastes, with all waste movements to be conducted by a qualified and licensed contractor.

4.5.4. Management of Waste Impacts

4.5.4.1. Overview

In preparing supporting information relating to waste impacts, due consideration has been given to the waste and resource management hierarchy (Figure 76). Measures proposed for the minimisation and management of waste have been considered in line with this hierarchy with disposal considered to be the final option.

Figure 76. Waste and resource management hierarchy

4.5.4.2. Disposal of Wastes

The primary waste produced by Agate Creek is NAF waste rock and of the. This is to be disposed of in the out of pit WRDs. The WRD disposal areas have been designed to ensure that the receiving environment is not impacted by any unexpected contaminants within the NAF material. Topsoil is an inert waste of mining and is to be stored on site, adjacent to WRDs if possible. Once transported to the topsoil stockpile areas, topsoil will be stabilised with a cover crop to ensure material is not lost to erosion. Topsoil will remain capped until reused in progressive rehabilitation. No further disposal actions will occur.

General wastes, oils & greases, sewage, scrap metal and vehicle batteries will all be produced by everyday mining and ancillary activities. These wastes are to be temporarily stored within the mine infrastructure area. Non compatible wastes will be segregated, with general wastes and carboard disposed of onsite within a designated disposal location within one of the the WRD footprint. Recyclable wastes and regulated wastes will be recovered by appointed waste collection contractors for removal offsite.

4.5.4.2.1. Waste Rock Storage

The primary waste expected to be produced by Agate Creek is NAF waste rock material. The waste rock will be placed in out-of-pit WRDs. The waste rock disposal areas (Figure 3) have been designed to ensure that the receiving environment is not impacted by the material.

The waste rock characterisation (WRC) assessment indicated that the waste rock at Agate Creek is almost completely NAF material. The small percentage of PAF material will be appropriately blended with waste rock containing an excess of acid-neutralising capacity (ANC) to minimise the risk of any PAF waste rock (C&R Consulting, 2022).

NAF material will be used for the construction of the other infrastructure areas as required (Haul roads, pads, dam spillways etc.).

4.5.4.2.2. Waste Rock Placement

Waste rock dumps have been designed to be permanent storages for waste rock at Agate Creek. The waste dump design is based on the mining waste schedule quantity and involves selective mining and placement of waste rock to form NAF WRDs The key objective of the waste rock dump design is to ensure that the final landform is safe, stable and non-polluting (ATC Williams, 2022).

4.5.4.3. Geometrical Design

The WRDs are designed as a low-profile structure located in valleys. The WRDs require access ramps to allow dumping of waste rock and maintenance access to the structure. Access ramps are located from ridges to limit the road lengths and ramp grades (ATC Williams, 2022).

Any unexpected PAF material will must be encapsulated by NAF material. A NAF base is proposed to be constructed to provide a platform upon which any PAF material can be placed to prevent contaminant migration into the receiving environment (ATC Williams, 2022).

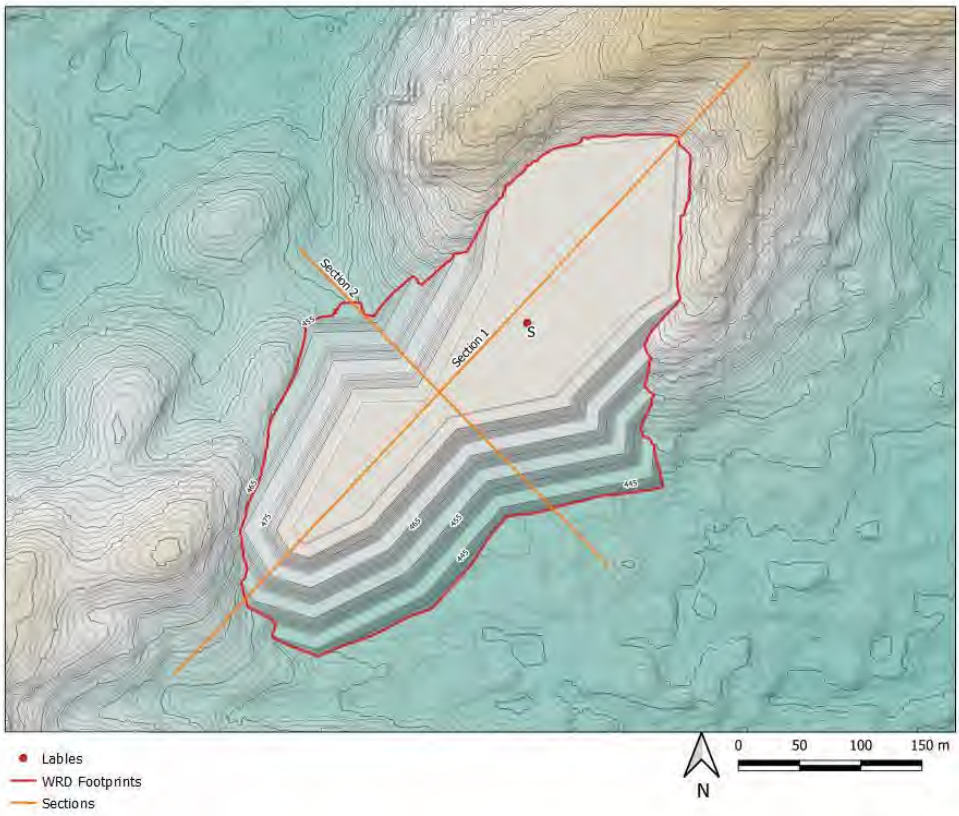

Figure 77. Waste Rock Dump (South) Cross Section Example (ATC Williams, 2022)

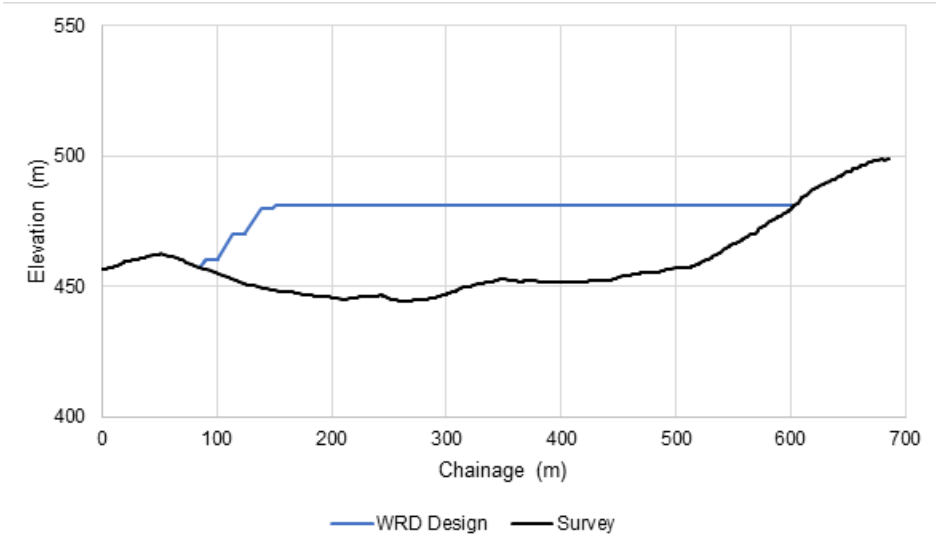

Figure 78. Waste Rock Dump (South) Cross Section 1 (ATC Williams, 2022)

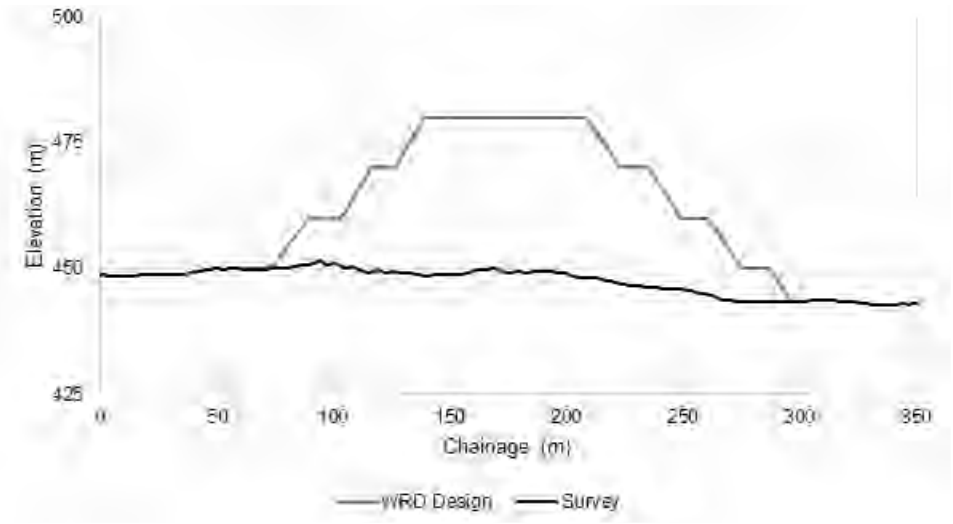

Figure 79. Waste Rock Dump (South) Cross Section 2 (ATC Williams, 2022)

4.5.4.3.1. Waste Rock Dump Monitoring and Reporting

The waste rock management strategy involves the placement of NAF rock. The process will be controlled on a laboratory-based analysis that uses rapid onsite techniques to verify whether material remains NAF as expected. Information gathered will be added to the geological block model.

Laboratory-Based Testing

Sample selection will be undertaken to provide sufficient samples for each lithological unit and mass of material extracted from the open pit. Selected waste rock samples will be analysed at a National Association of Testing Authorities Australia registered laboratory for the following:

- NAPP (Total Sulfur, CRS, MPA and ANC);
- Paste pH, pH5:1, EC5:1 and 5:1 Leachate analysis;
- NAG pH, NAG4.5 and NAG 7.0; and
- Total carbon and total organic carbon.

Kinetic leaching or successive leaching protocols will be undertaken for major units in the waste rock material to assess oxidation potential and likely environmental impact.

Waste Rock Visual Inspections

Suitably qualified mine geologists will carry out weekly visual inspections on each area of the waste rock dumps to evaluate the performance and condition of the facilities. The toe sections of the waste rock dumps shall be assessed for seepage, and if seepage is observed, the specific location and flow rate will be recorded.

Reporting

The results of the visual inspections and all laboratory-based analyses will be recorded and documented in a suitable storage system developed for the Agate Creek project.

4.5.4.4. *Spills and Incidents*

LWR will maintain appropriate spill kits onsite to manage spills that may occur during the day-to-day operations. As a minimum, spill kits will be located at oil/water storage areas and locations where the dismantling of vehicles may result in spills (e.g. engine removal, draining of sumps, etc.).

In the event of an incident occurring, LWR will act to contain the spill immediately. A record of the incident will be made and investigated; as a minimum, the following will be recorded:

- date of incident
- location of incident
- description of incident
- whether the incident is contained onsite
- whether members of the public or public spaces were potentially impacted
- actions taken to rectify/prevent the incident from occurring in the future.

In the instance that an incident occurs that requires notification to the DES, a report will be made to the DES Pollution Hotline.

4.5.4.5. *Waste Tracking and Documentation*

Waste tracking will be undertaken by LWR for both un-regulated and regulated wastes. Records of unregulated wastes such as general wastes (food scraps, containers etc.) will be maintained by LWR. Via the Project management system. Details to be recorded for unregulated wastes will include:

- Type of wastes;
- Volumes;
- Date;
- Time; and
- Disposal location.

Regulated waste collection contractors are required to complete a waste tracking certificate with the aim of recording the movements of regulated waste from the generator to the treatment, recycling or disposal facility.

5. Environmental Risk Assessment

5.1.1. Overview

An environmental risk assessment has been prepared in relation to the proposed activity by LWR. The risk methodology utilised has been developed based on the Australia and New Zealand Standard AS/NZS for Risk Management – Principles and Guidelines (ISO 31000:2018).

The risk management process involves the systematic application of policies, procedures, and practices to the activities of communicating and consulting, establishing the context and assessing, treating, monitoring, reviewing, recording, and reporting risk.

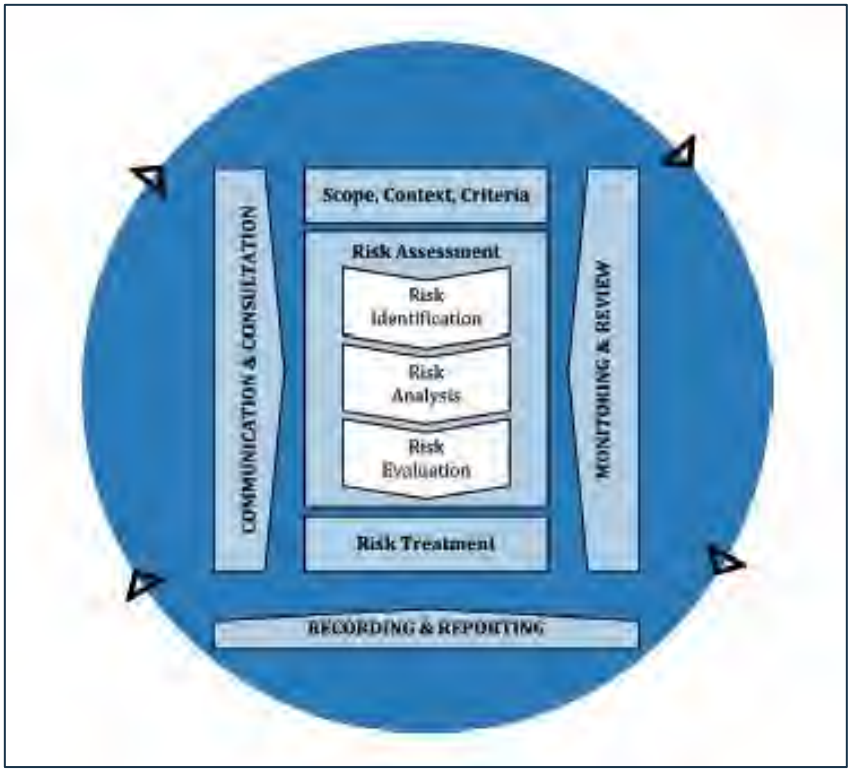

Figure 80. ISO 31000: 2018 Risk management process

5.1.2. Risk Identification

The purpose of risk identification is to find, recognise and describe risks that might help or prevent an organisation achieving its objectives. Relevant, appropriate and up-to-date information is important in identifying risks (Standards Australia, 2018).

The following factors and the relationships among these factors have been considered by this risk assessment:

- Tangible and intangible sources of risk
- Causes and events

- Threats and opportunities
- Vulnerabilities and capabilities
- Changes in the external and internal context
- Indicators or emerging risks
- The nature and value of assets and resources
- Consequences and their impacts on objectives
- Limitations of knowledge and reliability of information
- Time-related factors
- Biases, assumptions, and beliefs of those involved.

5.1.3. Risk Analysis and Evaluation

The purpose of risk analysis is to comprehend the nature of risk and its characteristics, including, where appropriate, the level of risk. Risk analysis can be undertaken with varying degrees of detail and complexity, depending on the purpose of the analysis, the availability and reliability of information and the resources available. Risk analysis techniques can be qualitative, quantitative or a combination of these and should include:

- The likelihood of events and consequences
- The nature and magnitude of consequences
- Complexity and connectivity
- Time-related factors and volatility
- The effectiveness of existing controls
- Sensitivity and confidence levels.

A likelihood of occurrence and severity of consequence rating has been assigned to each identified risk in accordance with the risk matrix detailed in Table 86. Control measures have been developed following the identification of risks to achieve a level of risk that is considered to be an acceptable level, as described in Table 87.

Table 86. Risk matrix

Likelihood of Occurrence	Severity of Consequence				
	Catastrophic (5)	Major (4)	Moderate (3)	Minor (2)	Insignificant (1)
Almost certain (5)	10	9	8	7	6
Likely (4)	9	8	7	6	5
Possible (3)	8	7	6	5	4
Unlikely (2)	7	6	5	4	3
Rare (1)	6	5	4	3	2

Table 87. Risk Scores

Risk Score	Risk Rating	Actions Required
9 – 10	Extreme	Requires immediate action to reduce risk score.
7 – 8	High	Requires an action plan approved by senior management.
5 – 6	Moderate	Specific monitoring and procedures required.
2 - 4	Low	Management through routine procedures and protocols.

5.1.4. Risk Assessment Results

Risks identified were assessed using the methodology described above. Ten risks were identified with all six rated as ‘Low’ and no risks were identified above this category. All risks considered the existing and proposed controls to reduce the level of risk to as low as reasonably practicable. Control strategies are reflected in Table 88.

Table 88. Risk Assessment

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
Land	Erosion	4	2	5	• Limiting disturbance to required areas and occurring in conjunction with clearing activities • Diversion and catchment of surface water • Progressive rehabilitation • Supervision of land clearance	2	1	3	• Internal Erosion and Sediment Control Management Plan to ensure all risk controls are implemented where necessary	All soil types at the Project as identified by the SLSA have high erosion susceptibility
Land	Impacts to flora and fauna from clearing	4	4	8	• Avoidance of areas not required to be disturbed • Avoidance of MSES vegetation and offset triggers where possible • Boundary of areas to be cleared will be clearly marked • Clearing to occur in sequential manner to allow fauna to escape • Appropriate weed management including wash down of all vehicles and machinery brought on site • Fauna spotter-catcher appointed during vegetation clearing • Regular checks of excavated areas • Include safe egress points	2	2	4	• The Significant Residual Impact Assessment identified no significant residual impact to MSES flora or fauna • Weed Management Plan to be implemented	In the event of excessive clearing, that area will be rehabilitated
Land	Excessive clearing of vegetation	3	3	6	• Provide crew with accurate mapping of activities, access routes • Regular visual inspection of disturbance area to ensure clearing has been minimised.				No further treatment	In the event of excessive clearing from an activity, the area will be rehabilitated.
Land	Storage/use of fuels, plant, vehicles, and chemicals resulting in a spill to land.	2	3	5	• Fuels and chemicals stored in appropriate containers and drums	2	1	3	• Include regular inspection of plant equipment, vehicles,	In the event of a release of fuel/oil/lubricants/chemicals to land, an investigation will

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
					• Use and maintenance of vehicles and plant equipment according to the manufacturers specifications • Storage of containers and drums of bunded pallets with appropriate distances from conflicting substances and ignition sources • Appropriately sized spill kits located at fuel and chemical storage locations				chemicals, and facilities by a suitably qualified person (e.g. facility manager). • Regular inspection oof facilities to ensure that fuels and chemicals are appropriately stored. • All personnel appropriately trained in the use of spill kits	be undertaken to understand the source, cause, and extent of potential environmental impacts.
Water/Land	Unexpected Acid Mine Drainage	3	4	7	• Blending of identified PAF material into waste rock with higher levels of acid neutralising capacity • Visual inspections of WRDs	2	2	4	• Blending of identified PAF material into waste rock with higher levels of acid neutralising capacity	The WRC identified little PAF material in the Agate Creek samples. Material with excess acid neutralising capacity was prevalent within the samples.
Water	Solute pollution to surface waters and groundwaters as a result of runoff	3	3	6	• Appropriate erosion control methods • Frequent groundwater and surface water monitoring • Receiving Environment Monitoring Program (REMP) to identify downstream impacts	2	2	4	• Monitoring results will be compared to appropriate contaminant limits such as the ANZECC (2000) livestock drinking water limits	Alarming results from the REMP or routine monitoring will trigger an investigation into the exceedances as well as further appropriate water management strategies implemented.
Water	Storage/use of fuels, plant, vehicles, and chemicals resulting in a spill to water.	2	3	5	• Fuels and chemicals stored in appropriate containers and drums • Use and maintenance of vehicles and plant equipment according to the manufacturers specifications • Storage of containers and drums of bunded pallets with appropriate distances from conflicting substances and ignition sources	2	1	3	• Include regular inspection of plant equipment, vehicles, chemicals, and facilities by a suitably qualified person (e.g. facility manager). • Regular inspection oof facilities to	In the event of a release of fuel/oil/lubricants/chemicals to land, an investigation will be undertaken to understand the source, cause, and extent of potential environmental impacts.

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
					• Appropriately sized spill kits located at fuel and chemical storage locations				ensure that fuels and chemicals are appropriately stored. • All personnel appropriately trained in the use of spill kits	
Waste	Storage of fuels and chemicals with the risk of fire	3	4	7	• Fuels and chemicals stored in appropriate containers and drums. • Storage of containers and drums on bunded pallets with appropriate distances from conflicting substances and ignition sources. • Fire suppression equipment (e.g. fire hoses, extinguishers, etc.) located at appropriate points to contain fire. • All flammable and combustible chemicals stored in accordance with AS1940.	2	2	4	• Include regular inspection of plant equipment, vehicles, chemicals, and facilities by a suitably qualified person (e.g. fire extinguisher inspector). • Regular inspection oof facilities to ensure that fuels and chemicals are appropriately stored. • All personnel appropriately trained in storing fuels and chemicals	N/A
Waste	Storage of tyres with rick of fire.	3	4	7	• Tyres stored within workshop with appropriate distances from conflicting substances and ignition sources. • Fire suppression equipment (e.g. fire hoses, extinguishers, etc.) located at appropriate points to contain fire.	2	2	4	• Include regular inspection of equipment and facilities by a suitably qualified person • Regular removal of tyre stockpile by customer to ensure stockpile does not exceed storage capacity	

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
Air	Excessive dust resulting in nuisance at a sensitive receptor	3	3	6	• Regular visual inspection of laydown and work areas • Use and maintenance of vehicles according to the manufacturer's specifications	2	1	3	Use of hoses to suppress dust where required.	In the event of a complaint being made to LWR, a record will be made and investigation undertaken
Noise	Excessive noise resulting in nuisance at a sensitive receptor	3	3	6	• Regular visual inspection of laydown and work areas • Use and maintenance of vehicles in accordance with the manufacturer's specifications	2	1	3	Operating hours limited to Monday-Sunday between 6:00 am and 6:00 pm	In the event of a complaint being made to LWR, a record will be made and investigation undertaken

6. Conclusions and Recommendations

This report is submitted to the DES in support of Laneway Resources Limited's application for a site specific EA for the Agate Creek Mine (ML100030) and provides a detailed response to the following guidelines:

- Approval processes for Environmental Authorities (Department of Environment and Science, 2019b)
- Application requirements for activities with impacts to air (Department of Environment and Science, 2017a)
- Application requirements for activities with impacts to land (Department of Environment and Science, 2017b)
- Application requirements for activities with impacts to water (Department of Environment and Science, 2017c)
- Application requirements for activities with noise impacts (Department of Environment and Science, 2017d)
- Application requirements for activities with waste impacts (Department of Environment and Science, 2019a)

Risks were assessed in accordance with ISO 31000:2018 and identified six risks. All risks were 'Low' and no risks were identified above this category. All risks considered the existing and proposed controls to reduce the level of risk to as low as reasonably practicable. Control strategies are reflected in supporting information contained within this document (Table 88).

It is recommended that this application for ERA 62 (1) (a) be accepted with appropriate and reasonable conditions.

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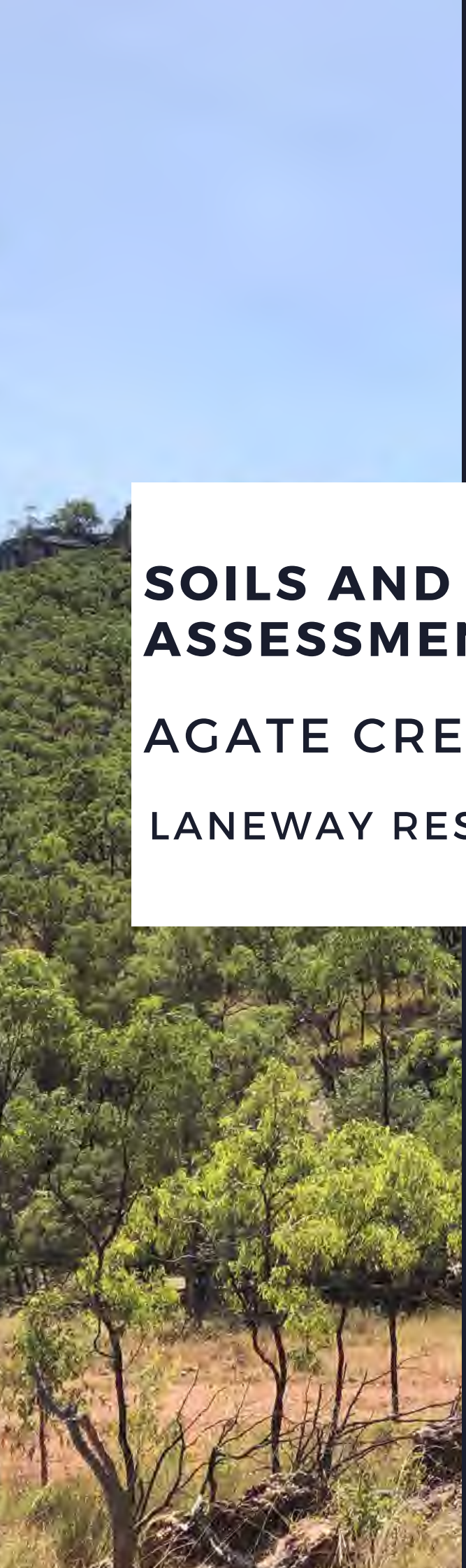
Appendix A – Land Suitability Assessment



SOILS AND LAND SUITABILITY ASSESSMENT

AGATE CREEK GOLD MINE

LANEWAY RESOURCES LIMITED

JULY 2022

WULGURU TECHNICAL SERVICES

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1. Introduction

Laneway Resources Limited (Laneway) is the owner and operator of the Agate Creek Gold Mine (Agate Creek) – Environmental Authority (EA) EPSL03068015. Wulguru Technical Services Pty Ltd (WTS) has been engaged to undertake a Soils and Land Suitability Assessment (SLSA) for Agate Creek.

This SLSA report provides a baseline understanding of soil and land resources, and their suitability for use in rehabilitation activities at Agate Creek. The Project focused on areas of minimal disturbance to previously undisturbed land, evaluating resources such as topsoil material availability, suitability for use in rehabilitation and potential constraints to plant growth.

1.1. Purpose and Objectives

The purpose of this report is to evaluate the soil mapping units and land resources available within the Project's Mining Lease (ML). The objectives of this Project are to:

- Identify and map soil mapping units and terrain that occurs within the ML;
- Classify and determine soil types according to observed and analysed physical and chemical characteristics;
- Validate Land Suitability Classifications within the ML; and
- Validate topsoil resources and rehabilitation materials.

1.2. Project Description

Agate Creek is situated on the boundary area of Einasleigh and Woolgar Goldfields of north Queensland approximately 50km south of Forsayth. Laneway has mined gold ore from the Sherwood Pit since the granting of Mining Lease (ML)100030 in 2019.

Ore is extracted via conventional open cut mining techniques and is transported to the Run of Mine (ROM) Pad 1km south of the open cut. The ore is processed offsite, with ore transported via Agate Creek/North head Road.

Project mining domains include:

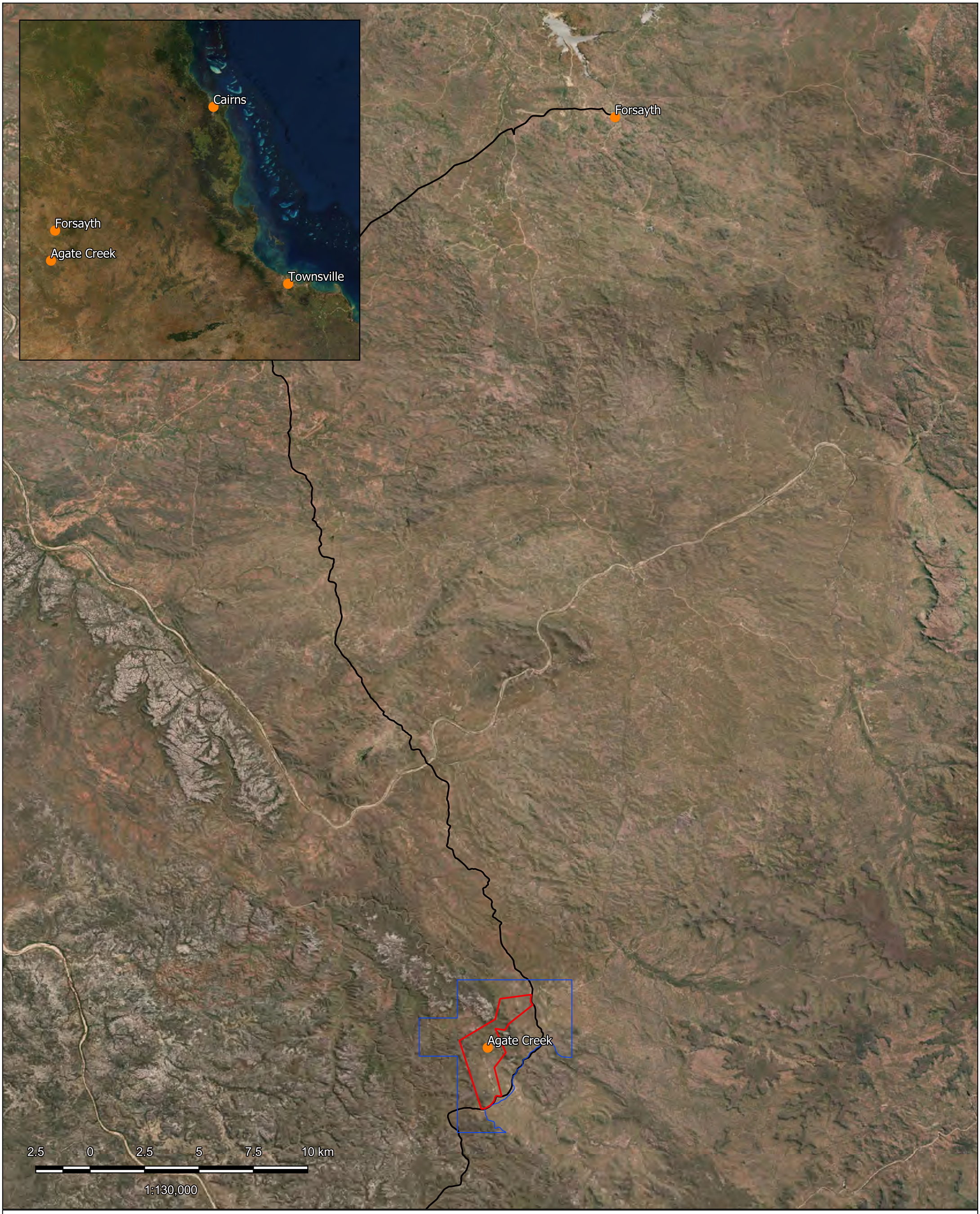
- 4 Waste Rock Dumps;
- ROM Pad;
- 6 Open Cut Pits;
- Water Management Infrastructure;
- Accommodation village including sewage treatment infrastructure; and
- Mine Infrastructure Areas (MIA) (including workshops, administration buildings, fuel and oil storages, roads and carparks, and other ancillary infrastructure).

1.3. Project Location

Agate Creek is located 50km south of Forsayth, Queensland. Agate Creek is bound by pastural land currently under Laneway held Mineral Development License (MDL) 402. Access to Agate Creek is via the Agate Creek Road. Project details are outlined in Table 1.

Table 1. Property Description

Company Name – ABN	Laneway Resources Limited 75 003 049 714
Lot on Plan	Lot 4 on BD164
Mining Lease	ML 100030
ML Area	689.3
Local Government Area	Etheridge Shire Council
Zoning Information	Rural



Client: Laneway Resources Ltd
Project number: 2021.09001
CRS: GDA2020 EPSG: 7844
Date: 11 July 2022

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Figure 1. Agate Creek Gold Project Locality

Legend

- Key Features
- Access Road
- Mineral Development Licence
- Mining Lease

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2. Existing Environment

2.1. Climate

The Project is located in the dry tropics' region and experiences hotter and wetter periods during the summer months (wet season) and drier, cooler periods during the winter months (dry season).

LWR operates a weather station at Agate Creek (Lat. -19.0127, Lon. 143.5500). Mean maximum temperatures recorded in 2021 were 32.8°C – 34.2°C from January to March and 27.6°C – 29.1°C from June to August. Mean minimum temperatures recorded in 2021 were 21.9°C – 23.0°C from January to March and 15.1°C – 15.8°C from June to August. A total of 1016 mm rainfall was recorded at the Agate Creek Camp station in 2021 (Weatherlink 2022).

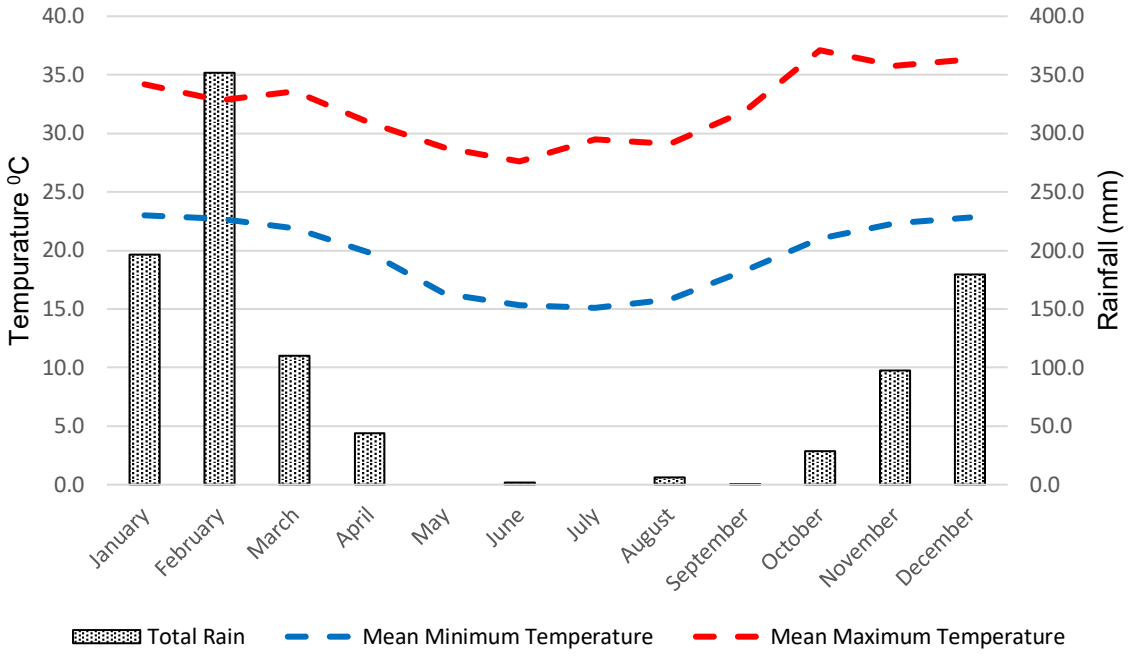


Figure 2. Mean Temperature and Rainfall at Agate Creek Weather Station

2.2. Topography and Hydrology

The topography of the Site includes steep sandstone scarps and formations to the west, with the western boundary bordered by the Gregory Range, along with steeply undulating hills, gullies and gently undulating open woodland and seasonal floodplain (SLR Consulting, 2021). The Project is between 420 m and 550 m Australian Height Datum (AHD) (Queensland Government, 2021). There are ephemeral watercourses/shallow drainage depressions (unnamed 1st and 2nd order creeks) that flow across the Project. Most surface water eventually flows into Agate Creek, a 4th order stream that flows approximately south-east to north-west though the central part of the ML as shown in Figure *3*.

2.3. Geology

Agate Creek is situated within the Etheridge Goldfield which has a rich history of gold mining prospects, the most significant being the Kidston deposit approx. 60km east of Agate Creek. Gold mineralisation of Agate Creek includes epithermal and meso-thermal systems within quartz veining, stockworks and breccias associated with the felsic volcanic units of:

- **Permian Kennedy Igneous Group** - Mostly felsic igneous rocks and less commonly intermediate to mafic. Intrusive and extrusive in roughly equal proportions. Characterised by rhyolitic (& subordinate dacitic) ignimbrites (& lavas) in volcanic subsidence structures (cauldrons), and granitic intrusions in ring complexes, sub-circular plutons and batholiths. Also various felsic & mafic dyke swarms (Geoscience Australia, 2002); and
- **Proterozoic Forsayth Batholith** - light to dark grey, biotite granite and granodiorites (Geoscience Australia, 2002).

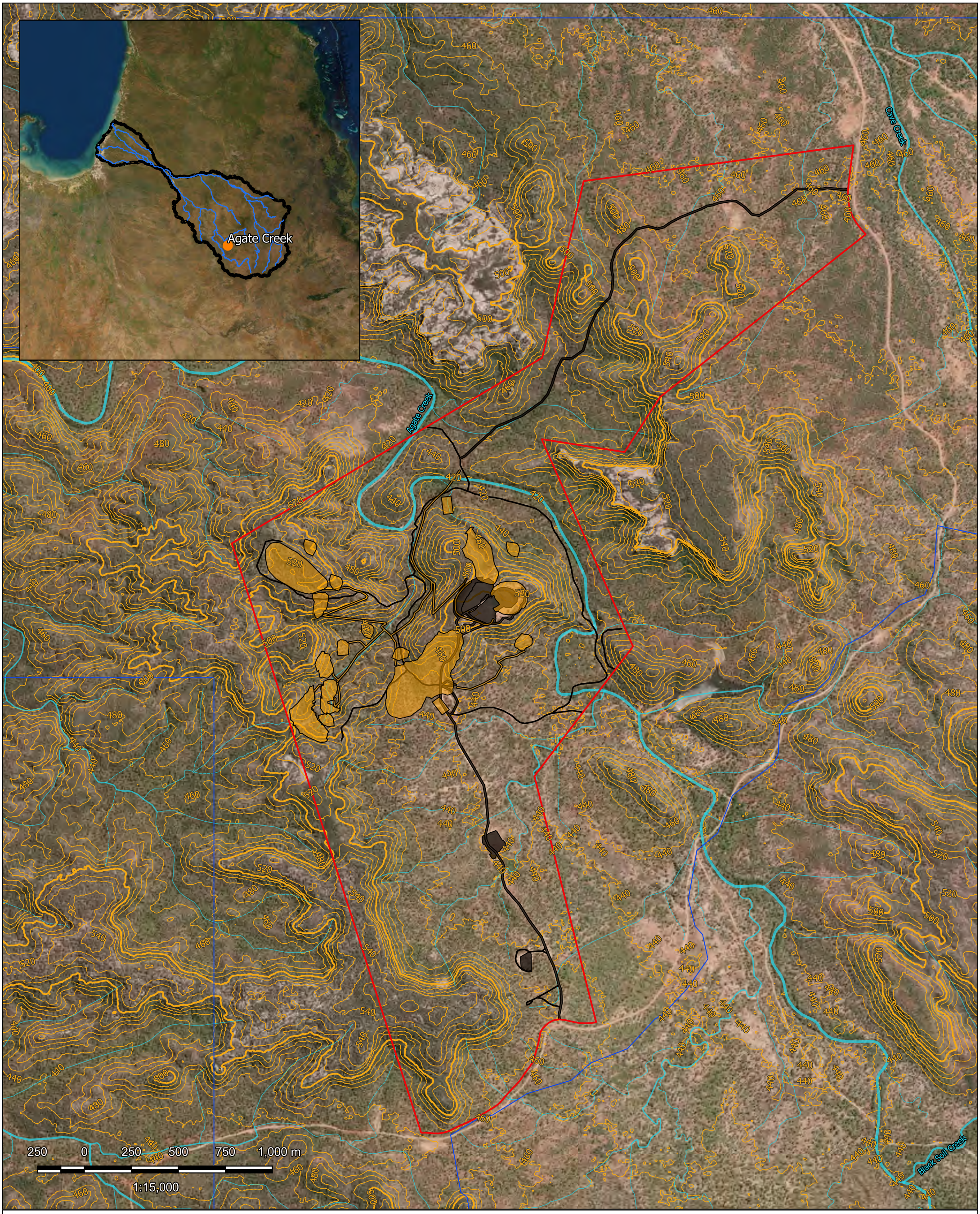
Agate Creek Geology is displayed on Figure 3.

2.4. Soils

There is limited information on soils at Agate Creek. According to the Atlas of Australian Soils (1:2,000,000), there are two soil types found at the Project, as described in Table 3 (ARIS,2013).

Table 2. Soil Types of the Project (Queensland Government, 2021a)

ATLAS 1:2000000 Code	Soil Type Description	Sub Soils Factual Key
LL8	uniform medium, nonbleached A2 horizon, underlain by B horizon of value/chroma=5YR	Uc4.2 Dr2.12 Dr2.22
Ta11	duplex yellow-grey, hard setting A horizon, A2 horizon nonbleached, acid pedal mottled B horizon	Dr2.22 Dr2.21 Uc4.2 Uc4.1 Gn2.11 Gn2.21 Gn2.45
JK23	uniform coarse, A2 horizon nonbleached underlain by non coherent col B horizon value/chroma=5	Uc4.11 Uc4.12 Uc2.12 Uc2.21 Uc5.21 Gn2.11 Gn2.14



Client: Laneway Resources Ltd
Project number: 2021.08003
CRS: GDA2020 EPSG: 7844
Date: 1 June 2022

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Figure 3. Topography and Hydrology

Legend

- Mineral Development Licence
- Mining Lease
- Existing Mine Features
- Proposed Mine Features
- Gilbert Basin
- Major Rivers
- 10m Contour

Watercourse - Stream Order

- 0
- 1
- 2
- 3
- 4

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250 0 250 500 750 1,000 m

1:15,000

Client: Laneway Resources Ltd
Project number: 2021.09001
CRS: GDA2020 EPSG: 7844
Date: 11 July 2022

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Figure 4. Surface Geology

Legend

Mine Tenure
- Mineral Development Licence
- Mining Lease
- Existing Mine Features
- Proposed Mine Features

Surface Geology
- Big Surprise Tuff
- Black Soil Andesite
- Corbett Formation
- CPia-Kennedy Province
- CPir-Kennedy Province
- Daniel Creek Formation
- Daniel Creek Formation/s
- Dead Horse Metabasalt
- Dead Horse Metabasalt/a
- Hampstead Sandstone
- Lane Creek Formation/c
- Qa-QLD
- Robin Hood Granodiorite
- Talaveras Rhyolite
- Thunder Egg Rhyolite
- TQr-QLD

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3. Soil Survey

The distribution of main soil types within the SLSA area were identified, validated and refined from the field survey, which was conducted according to land resource assessment guidelines (The National Committee on Soil and Terrain, 2009). The methods and results for the field and laboratory assessment are described herein.

3.1. Methodology

3.1.1. Background Information

Descriptions of soil types/ units and their distribution with landforms and parent material refer to the Australian Soil Resource Information System (ASRIS). Preliminary soil unit boundaries were developed from:

- Publicly available reports and data sources – Geological mapping, Qspatial databases, etc.
- Topographic mapping.

3.1.2. Field Investigations

A 'free survey' was adopted that complied with land suitability assessment criteria. Soil unit boundaries varied from abrupt/clear to gradual and trends were associated with variations along geological mapping units and topographic sequences. Professional judgement was utilised to identify appropriate reference and detailed observation sites, check sites were utilised to confirm soil boundaries and points of interest.

Survey design details relating to map scale and survey density were developed in accordance with McKenzie et al. (2008b) (Table 4). Seven detailed observation sites were recorded with three submitted for laboratory analysis. 15 check sites were collected to determine soil boundaries and units. On this basis it is considered that the survey design was sufficiently detailed to assess soil properties and their distribution across the Assessment area.

Table 3. Field survey observations.

Class	Observations	Land Suitability	Actual for Project
	Minimum map scale	1:50,000	1:50,000
	Site density	1 Site/ 20 ha	1 site/ 20 ha
	Total number	7	7
I	Detailed profiles	1	7
II	Reference profiles with laboratory data	1	7
III	Check Sites	21	21

[1] One reference site with laboratory analysis for each soil type identified.

3.1.3. Laboratory Analytes

Soils were classified from profile morphology and laboratory analyses according to the Australian Soil Classification (ASC) system. Laboratory samples were collected and submitted to a National Association of Testing Authorities (NATA) laboratory, ALS Environmental,for analysis of the following analytes:

- pH;
- Electrical conductivity;
- Moisture content;
- Particle size distribution;
- Exchangeable Cations;
- Bicarbonate Extractable Potassium;
- Sulphate;
- Chloride;
- Total metals (As,Cd, Cr, Cu, Fe, Pb, Ni, Zn, Hg);
- Nitrite plus Nitrate;
- Kjeldahl Nitrogen;
- Total Nitrogen;
- Total Phosphorus; and
- Total Organic Carbon.

4. Results

4.1. Soil Map Units

WTS identified four soil map units across the Project. Representative soil profiles are described in Table 5 and distribution of soils is mapped in Figure 5.

Table 4. Representative Soil Profiles Soil Management Unit Reference Site Area (ha) Area (percentage)

Soil Management Unit	Reference Site	Area (ha)	Area (%)
Brown Mellic Kandosol	S1	232.58	34.86
Red Massive Gypsic Vertosol	S3	63.97	9.32
Brown Bleached Kandosol	S4	83.51	12.18
Brown Lithsolic Rudosol	S5	299.13	43.62

250 0 250 500 750 1,000 m

1:15,000

Client: Laneway Resources Ltd
Project number: 2021.09001
CRS: GDA2020 EPSG: 7844
Date: 11 July 2022

Print as A3

Figure 5. Ground-truthed Soils

Legend

Mine Tenure
- Mineral Development Licence
- Mining Lease
- Existing Mine Features
- Proposed Mine Features

Ground-truthed Soils
- Brown Bleached Kandosol
- Brown Lithsolic Rudosol
- Brown Mellic Kandosol
- Red Massive Gypsic Vertosol

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4.2. Soil Profile 1 – Brown Mellic Kandosol

Project: Agate Creek SLSA **Site: S1**

Location: Agate Creek Mine, Qld

Described by: Matthew Ayre

Date: 23/11/2022

Site Description

Geology: Sgr

Landform pattern: Mid slope

Element: -

Permeability: -

Microrelief: Normal

Microrelief component: No record

Drainage: Well

Slope: 3-5 %

Rock outcrops: None

Surface coarse fragments: -

Surface condition: Firm

Disturbances: Grazing

Australian Soil Classification: [AB] [DO] [KA]

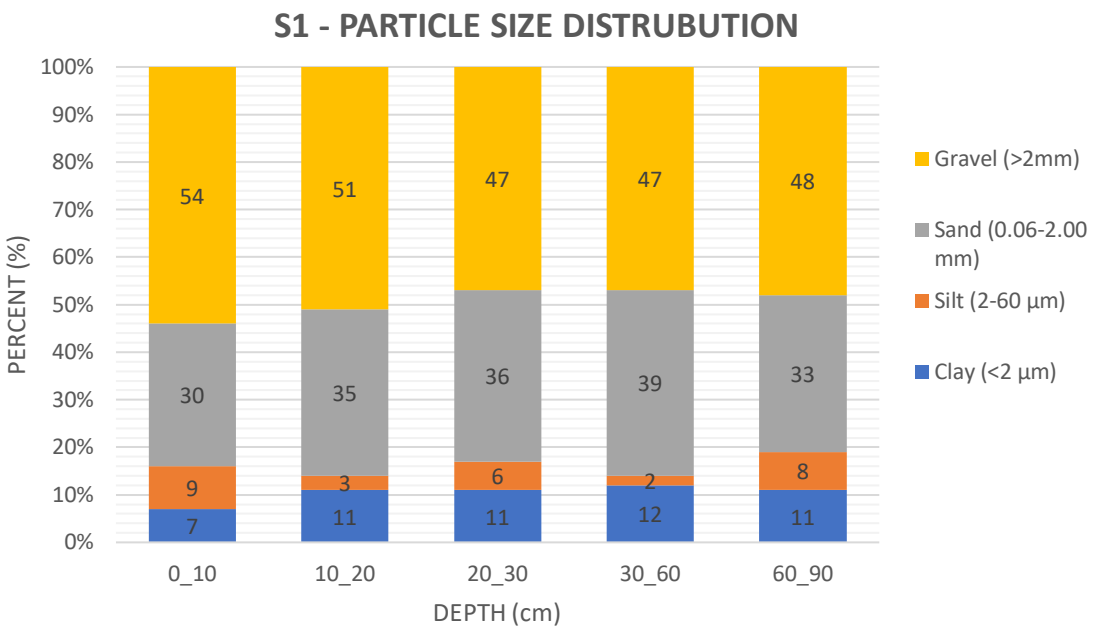
Profile Morphology

Horizon	Depth (cm)	Description
A1	0 - 10	Brown – 5/3 7.5 YR, loamy coarse sand with many coarse earthy segregations (gravel), single grain granular structure, few roots (very fine), nil mottling, well drained with gradual transition to B1 Horizon
B1	10-90	Light brown – 6/3 7.5 YR, loamy coarse sand with many coarse earthy segregations (gravel) single grain granular structure, few roots (very fine), nil mottling, well drained with gradual transition to B2 Horizon

Depth (cm)	pH	EC (µS/cm)	Nitrite + Nitrate as N (NOx)	TKN (mg/kg)	TN (mg/kg)	TP (mg/kg)	TOC (%w/w)	Colwell K (mg/kg)
0 - 10	6.2	20	1.0	190	190	144	0.23	921
10 - 20	6.1	5	1.4	150	150	173	0.16	575
20 - 30	5.9	4	0.8	140	140	155	0.19	437
30 - 60	5.9	4	0.2	110	110	129	0.14	349
60 - 90	6.0	4	0.2	110	110	146	0.13	280

Depth (cm)	Exc. Na (meq/100g)	Exc. K (meq/100g)	Exc. Ca (meq/100g)	Exc. Mg (meq/100g)	Cation Exc. Capacity (meq/100g)	ESP (%)	Ca:Mg Ratio	S (mg/kg)
0 - 10	<0.1	0.4	1.9	0.6	2.9	1.2	3.2	<10
10 - 20	<0.1	0.3	1.0	0.6	1.9	0.8	1.7	<10
20 - 30	<0.1	0.2	0.8	0.4	1.4	0.8	2.0	<10
30 - 60	<0.1	0.2	0.5	0.7	1.6	3.2	0.7	<10
60 - 90	0.1	0.2	0.5	0.9	2.4	6.2	0.6	<10

Particle Size Distribution



4.3. Soil Profile 3 – Red Massive Gypsic Vertosol

Project: Agate Creek SLSA Site: S3

Location: Agate Creek Mine

Described by: Matthew Ayre

Date: 23/11/2022

Site Description

Geology: PLco

Landform pattern: Mid Slope

Element: -

Permeability: -

Microrelief: Normal

Microrelief component: No record

Drainage: Poor

Slope: 3-5 %

Rock outcrops: No rock

Surface coarse fragments: -

Surface condition: Firrn

Disturbances: Remnant vegetation

Australian Soil Classification:

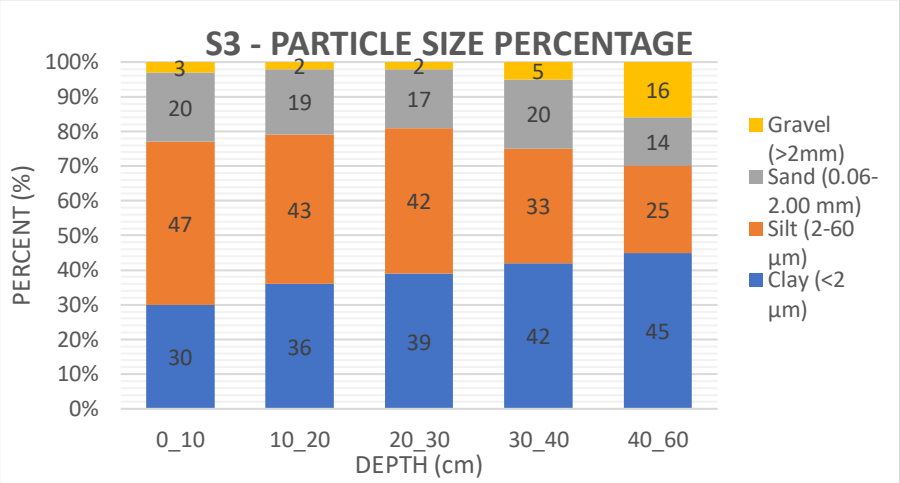
Profile Morphology

Horizon	Depth (cm)	Description
A1	0-20	Redish brown (5/4 5YR) clay loam with no segregations, weak structure with angular blocky peds (5-20 mm), few roots (fine), poorly drained, gradual transition to B1
B1	20-30	Light redish brown (6/4 2.5 YR) clay with few gypseous nodules, moderate structure with angular blocky peds (5-10mm), nil roots, poorly drained, gradual transition to B2
B2	30-60	Red (4/6 2.5 YR) clay with few segregations (gravel), weak to moderate structure with angular blocky peds (2-10mm), nil roots, poorly drained.

Depth (cm)	pH	EC (µS/cm)	Nitrite + Nitrate as N (NOx)	TKN (mg/kg)	TN (mg/kg)	TP (mg/kg)	TOC (%w/w)	Colwell K (mg/kg)
0-10	7.0	42	0.2	780	780	169	1.76	1170
10-20	6.6	10	0.3	700	700	138	1.29	522
20-30	6.8	5	<0.2	430	430	117	0.76	278
30-40	6.8	6	<0.2	880	880	294	0.60	162
40-60	6.8	4	<0.2	820	820	219	0.47	129

Depth (cm)	Exc. Na (meq/100g)	Exc. K (meq/100g)	Exc. Ca (meq/100g)	Exc. Mg (meq/100g)	Cation Exc. Capacity (meq/100g)	ESP (%)	Ca:Mg Ratio	S (mg/kg)
0-10	<0.1	1.4	13.0	7.4	21.7	0.1	1.8	<10
10-20	<0.1	0.8	9.8	7.0	17.6	0.2	1.4	<10
20-30	<0.1	0.4	10.6	7.8	19.0	0.3	1.4	<10
30-40	<0.1	0.3	10.4	7.8	18.6	0.3	1.3	<10
40-60	<0.1	0.2	9.3	7.1	16.7	0.4	1.3	<10

Particle Size Distribution



4.4. Soil Profile 4 – Brown Bleached Kandosol

Project: Agate Creek SLSA Site: S4

Location: Agate Creek Mine

Described by: Matthew Ayre

Date: 23/11/2022

Site Description

Geology: PLco

Landform pattern: Flat

Element: -

Permeability: -

Microrelief: Normal

Microrelief component: -

Drainage: Well

Slope: 0-1%

Rock outcrops: No rock

Surface coarse fragments: -

Surface condition: Firm

Disturbances: Remnant Vegetation

Australian Soil Classification:

Profile Morphology

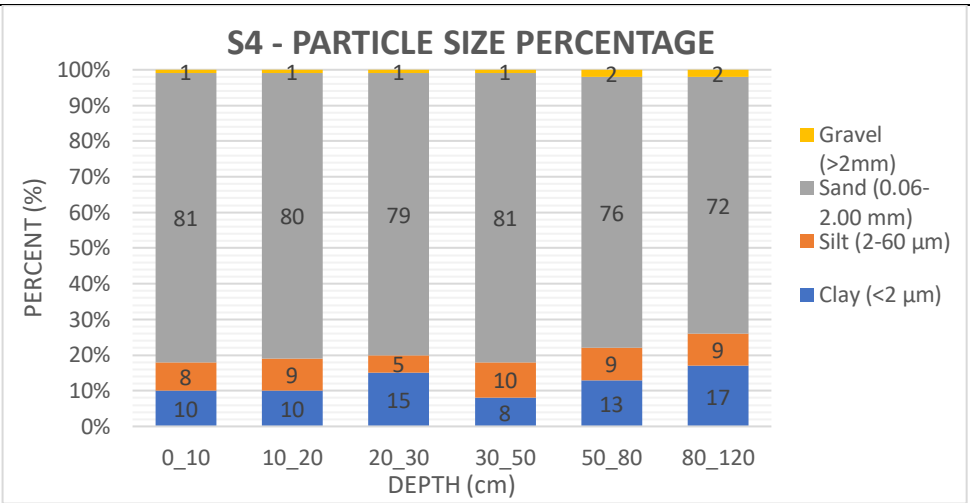
Horizon	Depth (cm)	Description
A1	0-10	Brown (4/2 7.5YR) loamy sand with no segregations, weak structure with angular blocky peds (5-20 mm), roots common, well drained, clear transition to B1 horizon.
B1	10-50	Light brown (6/3 7.5 YR) sandy loam with no segregations, weak structure with angular blocky peds, nil roots, well drained, clear transition to B2 horizon.
B2	50-80	Pink to light brown (7/3 7.5YR) sandy loam, with no segregations, weak structure with subangular blocky peds (10-20mm), moderately drained, moist, clear transition to B3 horizon.
B3	80-120	Brown (5/4 7.5YR) sandy loam with few ferruginous nodules, moderate structure with subangular blocky peds, nil roots, moderately drained, moist.

Depth (cm)	pH	EC (µS/cm)	Nitrite + Nitrate as N (NOx)	TKN (mg/kg)	TN (mg/kg)	TP (mg/kg)	TOC (%w/w)	Colwell K (mg/kg)
0-10	6.5	18	292	630	630	168	0.96	292
10-20	6.7	12	277	390	390	164	0.54	277
20-30	6.5	11	270	210	210	116	0.32	270
30-50	6.4	8	222	150	150	126	0.18	222
50-80	6.4	6	193	120	120	142	0.15	193
80-120	6.5	17	308	140	140	125	0.23	308

Depth (cm)	Exc. Na (meq/100g)	Exc. K (meq/100g)	Exc. Ca (meq/100g)	Exc. Mg (meq/100g)	Cation Exc. Capacity (meq/100g)	ESP (%)	Ca:Mg Ratio	S (mg/kg)
0-10	<0.1	0.4	3.2	0.8	4.4	<0.1	4.0	292
10-20	<0.1	0.4	2.2	0.6	3.1	0.3	3.7	277
20-30	<0.1	0.4	2.1	0.6	3.0	0.3	3.5	270
30-50	<0.1	0.3	1.9	0.5	2.7	0.4	3.8	222

50-80	<0.1	0.2	2.1	0.8	3.1	0.8	2.6	193
80-120	<0.1	0.4	3.6	2.1	6.2	1.2	1.7	308

Particle Size Distribution



4.5. Soil Profile 5 – Brown Lithsolic Rudosol

Project: Agate Creek SLSA **Site: S5**

Location: Agate Creek Mine

Described by: Matthew Ayre

Date: 25 November 2021

Site Description

Geology: PLco

Landform pattern: Hillock

Element: -

Permeability: -

Microrelief: Normal

Microrelief component: -

Drainage:

Slope: 10%

Rock outcrops: Rocky to very rocky

Surface coarse fragments: Many

Surface condition: Firm

Disturbances: Remnant Vegetation

Australian Soil Classification: [AB] [HJ] [RU]

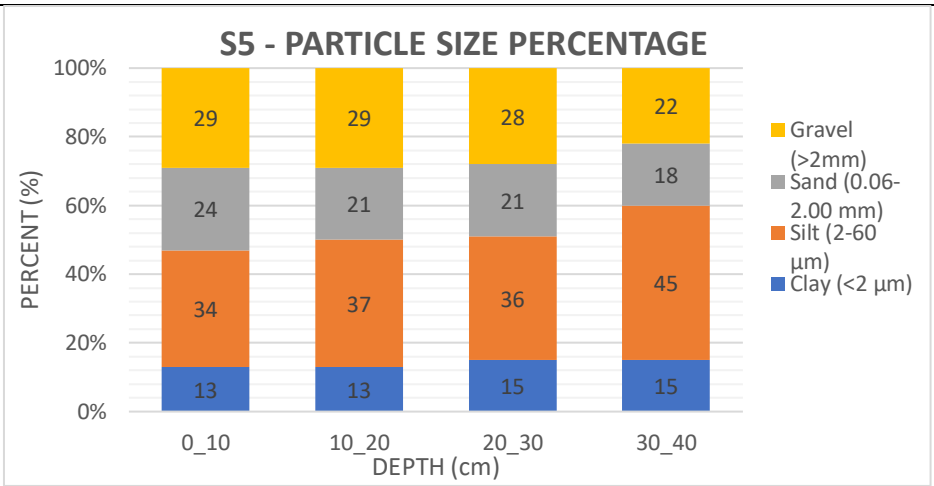
Profile Morphology

Horizon	Depth (cm)	Description
A1	0-20	Brown (4/2 7.5YR) loam with very many segregations (gravel to cobbles), weak structure with subangular blocky peds (5-10 mm), well drained, clear transition to B1 Horizon.
B1	20-40	Pink to light brown (7/3 7.5YR) loam with very many segregations (gravel to cobbles), massive structure, well drained, abrupt transition to C1 Horizon
C1	-	Parent Material

Depth (cm)	pH	EC (µS/cm)	Nitrite + Nitrate as N (NOx)	TKN (mg/kg)	TN (mg/kg)	TP (mg/kg)	TOC (%w/w)	Colwell K (mg/kg)
0 - 10	5.3	6	0.7	510	510	256	0.90	224
10 - 20	5.3	4	0.5	360	360	169	0.60	115
20 - 30	5.0	3	0.4	280	280	325	0.34	109
30 - 40	5.3	2	0.4	190	190	359	0.22	<100

Depth (cm)	Exc. Na (meq/100g)	Exc. K (meq/100g)	Exc. Ca (meq/100g)	Exc. Mg (meq/100g)	Cation Exc. Capacity (meq/100g)	ESP (%)	Ca:Mg Ratio	S (mg/kg)
0 - 10	<0.1	0.3	0.5	0.5	2.1	1.2	1.0	<10
10 - 20	<0.1	0.1	0.2	0.4	2.3	2.6	0.5	<10
20 - 30	<0.1	0.2	0.2	0.4	1.9	2.4	0.5	<10
30 - 40	<0.1	0.1	<0.1	0.4	1.3	2.0	<0.1	<10

Particle Size Distribution



5. Land Assessment

5.1. Land Suitability Assessment

Land Suitability has been assessed using the methods and criteria provided in the Guideline for Agricultural Land Evaluation (Department of Science Information Technology and Innovation and Department of Natural Resources and Mines, 2015) and Guideline for Land Suitability Assessment Techniques (Department of Mines and Energy, 1995). This assesses how suitable an area of land is for two major rural agricultural enterprises: rainfed broadacre cropping and beef cattle grazing.

The Land Suitability assessment cross-references each soil unit's characteristics with suitability criteria from Department of Mines and Energy (1995). The Land Suitability assessment uses a five-class system, where Class 1 indicates that the land is most suitable for the enterprise and Class 5 the least suitable. The overall land suitability ranking for each specific soil unit is determined by the most severe limitation, or a combination of the varying limitations. Land is considered less suitable as the severity of limitations for a land use increases. The increasing limitations may reflect any combination of:

- Reduced potential for production;
- Increased inputs to achieve an acceptable level of production; and/or
- Increased inputs required to prevent land degradation.

The Land Suitability Classes are described in Table 6.

Table 5. Land Suitability Classes

Class	Suitability	Limitations	Description
1	Suitable	Negligible	Highly productive land requiring only simple management practices to maintain economic production.
2	Suitable	Minor	Land with limitations that either constrain production, or require more than the simple management practices of class 1 land to maintain economic production.
3	Suitable	Moderate	Land with limitations that either further constrain production, or require more than those management practices of class 2 land to maintain economic production.
4	Unsuitable	Severe	Currently unsuitable land. The limitations are so severe that the sustainable use of the land in the proposed manner is precluded. In some circumstances, the limitations may be surmountable with changes to knowledge, economics or technology.
5	Unsuitable	Extreme	Land with extreme limitations that preclude any possibility of successful sustained use of the land in the proposed manner.

WTS' analysis provides a considered approach to land suitability assessments whereby each soil management unit's characteristics have been cross-referenced against Department of Mines and Energy (1995) and Guidelines for Agricultural Land Evaluation in Queensland (Department of Science Information Technology and Innovation and Department of Natural Resources and Mines, 2015). The overall land suitability class for each SMU is determined by the most severe limitation, or a combination of varying limiting components under both the rainfed broadacre cropping and beef cattle grazing.

5.1.1. Plant Available Water Capacity and Effective Rooting Depth

The primary land suitability assessment attribute is 'moisture'. The indicator for moisture is Plant Available Water Capacity (PAWC). PAWC is an estimate of the amount of moisture stored in the soil profile that is available for plant extraction. It is generally defined as the difference between field capacity and permanent wilting point. PAWC is calculated for the soil profile by summing the available water capacity over the soil's effective rooting depth (ERD). For the purposes of this assessment, PAWC is calculated based on the soil texture methods detailed in *How to demonstrate that land in the strategic cropping area does not meet the criteria for strategic cropping land* (Department of State Development Manufacturing Infrastructure and Planning, 2014). Soil water storage based on field texture is outlined in Table 7.

Table 6. Soil Texture Table (Department of State Development Manufacturing Infrastructure and Planning, 2014)

Soil Texture	Soil Water Storage
Sand; clayey sand; loamy sand	4 mm / 100 mm
Sandy loam	5 mm / 100 mm
Loam; silty loam; sandy clay loam	6 mm / 100 mm
Clay loam; clay loam, sandy; silty clay loam	8 mm / 100 mm
Silty clay; clays with <45% clay fraction	10 mm / 100 mm
Clays with >45% clay fraction	12 mm / 100 mm

Effective rooting depth is defined as the soil depth to which 90% of the plant roots will extract water and can be estimated through observed rooting depth, soil chemical parameters or a standardised soil rooting depth (McKenzie et al., 2008a). For the purposes of this assessment methodologies employed to determine ERD, and subsequently PAWC are determined based on guideline *How to demonstrate that land in the strategic cropping area does not meet the criteria for strategic cropping land* (Department of State Development Manufacturing Infrastructure and Planning, 2014) (Table 8).

Table 7. Effective Rooting Depth Criteria

Descriptor	ERD Limitation Threshold
Electrical Conductivity	> 0.8 dS/cm
Chloride	> 800 ppm
Sodicity	> 15%
pH	<= 5.0
Soil Structure	Moderate or strong columnar structure. Sandy free draining horizons. Significant rock content.

5.1.2. Beef Cattle Grazing

Limitations for Beef Cattle Grazing suitability on improved pastures have been assessed in accordance with Department of Mines and Energy (1995), including categories:

- Water availability;
- Nutrient deficiency;
- Soil physical factors;
- Salinity;
- Rockiness;
- Microrelief;
- pH;
- ESP;
- Wetness;
- Topography;
- Water erosion;
- Flooding; and
- Vegetation.

Note: a depth of 0.6 m has been assumed for root zone depth for any profile in which weathered rock, and/ or a salt bulge was absent as outlined in Department of Mines and Energy (1995).

5.1.2.1. Water Availability

PAWC thresholds for land suitability classes are as follows:

- **Class 1:** > 125 mm;
- **Class 2:** 100 – 125 mm;
- **Class 3:** 75 – 100 mm;
- **Class 4:** 50 – 75 mm;
- **Class 5:** <50 mm.

The thresholds stated are based on pasture generally, and do not account for specific pasture species. Land Suitability Classes are described in Table 9.

Table 8. Water Availability

SMU	ERD	PAWC	Land Suitability Class
Brown Mellic Kandosol	20mm	90	2
Red Massive Gypsic Vertosol	20mm	20	5
Brown Bleached Kandosol	20mm	120	1
Brown Lithsolic Rudosol	10mm	20	5

5.1.2.2. Nutrient Deficiency

Nutrient deficiency for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 10.

Table 9. Nutrient Deficiency Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	*Eucalyptus microneura +/- Terminalia spp. low woodland on sand sheets*. Nitrate as N < 3mg/ kg, Cowell Potassium >143mg/kg.	2
Red Massive Gypsic Vertosol	*Eucalyptus crebra and/or E. whitei +/- Corymbia erythrophloia open woodland on steep to rolling hills on igneous rocks.* Nitrate as N < 3mg/ kg, Cowell Potassium >143mg/kg	2
Brown Bleached Kandosol	*Eucalyptus microneura +/- Terminalia spp. low woodland on sand sheets*. Nitrate as N >3mg/ kg, Cowell Potassium >143mg/kg	2
Brown Lithsolic Rudosol	*Eucalyptus crebra and/or E. whitei +/- Corymbia erythrophloia open woodland on steep to rolling hills on igneous rocks* Nitrate as N < 3mg/ kg, Cowell Potassium >143mg/kg.	2

5.1.2.3. Soil Physical Factors

Soil physical factors for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 11.

Table 10. Soil Physical Factor Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Soft soils with a hard setting surface when dry.	2
Red Massive Gypsic Vertosol	Soft soils with a hard setting surface when dry.	2
Brown Bleached Kandosol	Soils with a loose, soft surface when dry.	2
Brown Lithsolic Rudosol	Large soil aggregate size on surface (>20mm)	4

5.1.2.4. Salinity

Salinity limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 12.

Table 11. Salinity Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Rootzone Electrical Conductivity < 0.15 dS/cm or rootzone Chloride <300 ppm.	1
Red Massive Gypsic Vertosol	Rootzone Electrical Conductivity < 0.15 dS/cm or rootzone Chloride <300 ppm.	1
Brown Bleached Kandosol	Rootzone EC < 0.15 dS/cm or rootzone Chloride <300 ppm.	1
Brown Lithsolic Rudosol	Rootzone EC < 0.15 dS/cm or rootzone Chloride <300 ppm.	1

5.1.2.5. Rockiness

Salinity limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 13.

Table 12. Rockiness Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	No Rock	2
Red Massive Gypsic Vertosol	No Rock	2
Brown Bleached Kandosol	No Rock	1
Brown Lithsolic Rudosol	60-200mm (cobbles) 20-50%.	4

5.1.2.6. Microrelief

Microrelief limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 14.

Table 13. Microrelief Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Melonholes cover < 20 % surface area.	1
Red Massive Gypsic Vertosol	Melonholes cover < 20 % surface area.	1
Brown Bleached Kandosol	Melonholes cover < 20 % surface area.	1
Brown Lithsolic Rudosol	Melonholes cover < 20 % surface area.	1

5.1.2.7. pH

pH limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 15.

Table 14. pH Limitation

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	pH 5.9 – 6.2	1
Red Massive Gypsic Vertosol	pH 6.8 – 7.0	1
Brown Bleached Kandosol	pH 6.4 – 6.7	1
Brown Lithsolic Rudosol	pH 5.0 – 5.3	1

5.1.2.8. Exchangeable Sodium Percentage (ESP)

ESP limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 16.

Table 15. ESP Limitation

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	ESP (10 cm) < 5.0	1
Red Massive Gypsic Vertosol	ESP (10 cm) < 5.0	1
Brown Bleached Kandosol	ESP (10 cm) < 5.0	1
Brown Lithsolic Rudosol	ESP (10 cm) < 5.0	1

5.1.2.9. Wetness

Wetness limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 17.

Table 16. Wetness Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Non rigid soils with non sodic subsoils (ESP < 15) within 60 cm of the surface. Well drained	1
Red Massive Gypsic Vertosol	Non rigid soils with non sodic subsoils (ESP < 15) within 60 cm of the surface. Well drained	1
Brown Bleached Kandosol	Non rigid soils with non sodic subsoils (ESP < 15) within 60 cm of the surface. Well drained	1
Brown Lithsolic Rudosol	Non rigid soils with non sodic subsoils (ESP < 15) within 60 cm of the surface. Well drained	1

5.1.2.10. Topography

Topography limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 18.

Table 17. Topography Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Flat to slightly undulated terrain suitable for efficient use of machinery, efficient installation and maintenance of infrastructure and/or irrigation requirements	1
Red Massive Gypsic Vertosol	Flat to slightly undulated terrain suitable for efficient use of machinery, efficient installation and maintenance of infrastructure and/or irrigation requirements	1
Brown Bleached Kandosol	Flat to slightly undulated terrain suitable for efficient use of machinery, efficient installation and maintenance of infrastructure and/or irrigation requirements	1
Brown Lithsolic Rudosol	Slope 10-20%, heavy machinery not safe to use	4

5.1.2.11. Water Erosion

Water erosion limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 19.

Table 18. Water Erosion Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Slopes on 1 – 3 % on all other soils .	1
Red Massive Gypsic Vertosol	Slopes < 3% on all other soils.	1
Brown Bleached Kandosol	Slopes < 3% on all other soils.	1
Brown Lithsolic Rudosol	Stable soils with 10-20% slope	3

5.1.2.12. Flooding

Flooding limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 20.

Table 19. Flooding Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Periodic flooding (from once in 50 years to whenever stream flow increases).	2
Red Massive Gypsic Vertosol	Periodic flooding (from once in 50 years to whenever stream flow increases).	2
Brown Bleached Kandosol	Flooding frequency of approximately 1 in 10 years	3
Brown Lithsolic Rudosol	No flooding or flooding less than 1 in 10 years	1

5.1.2.13. Vegetation

Vegetation limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 21.

Table 20. Vegetation Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	*Eucalyptus microneura +/- Terminalia spp. low woodland on sand sheets*.	2
Red Massive Gypsic Vertosol	*Eucalyptus crebra and/or E. whitei +/- Corymbia erythrophloia open woodland on steep to rolling hills on igneous rocks*.	4
Brown Bleached Kandosol	*Eucalyptus microneura +/- Terminalia spp. low woodland on sand sheets*.	2
Brown Lithsolic Rudosol	*Eucalyptus crebra and/or E. whitei +/- Corymbia erythrophloia open woodland on steep to rolling hills on igneous rocks*	4

5.1.2.14. Summary of Land Suitability Class for Beef Cattle Grazing

Overall, SMUs were found to be limited by Vegetation, Water Availability, Nutrients and pH. These factors combined have the potential to limit pasture and therefore livestock production across much of the Site.

No land was identified within the Site that was deemed suitable for beef cattle grazing (i.e. Class 1, 2 or 3) with 100 % of the Site found to require significant inputs to maintain production, encountering extreme limitations (Class 5).

Table 21. Summary of Land Suitability Classes for Beef Cattle Grazing

Limitation	Brown Mellic Kandosol	Red Massive Gypsic Vertosol	Brown Bleached Kandosol	Brown Lithsolic Rudosol
Water Availability	2	5	1	5
Nutrient Deficiency	2	2	2	2
Soil Physical Factors	2	2	2	4
Salinity	1	1	1	1
Rockiness	2	2	1	4
Microrelief	1	1	1	1
pH	1	1	1	1
ESP (10cm)	1	1	1	1
Wetness	1	1	1	1
Topography	1	1	1	4
Water Erosion	1	1	1	3
Flooding	2	2	3	1
Vegetation	2	4	2	4
Land Suitability Class	**2**	**5**	**3**	**5**

5.1.3. Rainfed Broadacre Cropping

Limitations for Rainfed Broadacre Cropping (Cropping) have been assessed in accordance with thresholds detailed in Department of Mines and Energy (1995), including:

- Water Availability;
- Nutrient Deficiency;
- Soil physical factors;
- Soil workability;
- Salinity;
- Rockiness;
- Microrelief;
- Wetness;
- Topography;
- Water Erosion; and
- Flooding.

Assessment of the SMUs suitability for cropping has been conducted in accordance with Department of Science Information Technology and Innovation and Department of Natural Resources and Mines (2015).

Note: a depth of 0.6 m has been assumed for root zone depth for any profile in which weathered rock, and/ or a salt bulge was absent as outlined in Department of Mines and Energy (1995).

5.1.3.1. Water Availability

PAWC thresholds for land suitability classes are as follows:

- Class 1: > 150 mm;
- Class 2: 125 - 150 mm;
- Class 3: 100 - 125 mm;
- Class 4: 75 - 100 mm;
- Class 5: <75 mm.

The thresholds stated are based on pasture generally, and do not account for specific pasture species. Land Suitability Classes are described in Table 23.

Table 22. Water Availability

SMU	ERD	PAWC	Land Suitability Class
Brown Mellic Kandosol	20mm	90	2
Red Massive Gypsic Vertosol	20mm	20	5
Brown Bleached Kandosol	20mm	120	1
Brown Lithsolic Rudosol	10mm	20	5

5.1.3.2. Nutrient Deficiency

Nutrient deficiency for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 24.

Table 23. Nutrient Deficiency Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	*Eucalyptus microneura +/- Terminalia spp. low woodland on sand sheets*. Nitrate as N < 3mg/ kg, Cowell Potassium >143mg/kg.	2
Red Massive Gypsic Vertosol	*Eucalyptus crebra and/or E. whitei +/- Corymbia erythrophloia open woodland on steep to rolling hills on igneous rocks*. Nitrate as N < 3mg/ kg, Cowell Potassium >143mg/kg	2
Brown Bleached Kandosol	*Eucalyptus microneura +/- Terminalia spp. low woodland on sand sheets*. Nitrate as N >3mg/ kg, Cowell Potassium >143mg/kg	2
Brown Lithsolic Rudosol	*Eucalyptus crebra and/or E. whitei +/- Corymbia erythrophloia open woodland on steep to rolling hills on igneous rocks* Nitrate as N < 3mg/ kg, Cowell Potassium >143mg/kg.	2

5.1.3.3. Soil Physical Factors

Soil physical factors for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 25.

Table 24. Soil Physical Factors Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Soft soils with a hard setting surface when dry.	2
Red Massive Gypsic Vertosol	Soft soils with a hard setting surface when dry.	2
Brown Bleached Kandosol	Soils with a loose, soft surface when dry.	2
Brown Lithsolic Rudosol	Large soil aggregate size on surface (>20mm)	4

5.1.3.4. Soil Workability

Soil workability limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 26.

Table 25. Soil Workability Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Soft soils with a hard setting surface when dry.	2
Red Massive Gypsic Vertosol	Soft soils with a hard setting surface when dry.	2
Brown Bleached Kandosol	Soils with a loose, soft surface when dry.	2
Brown Lithsolic Rudosol	Large soil aggregate size on surface (>20mm)	4

5.1.3.5. Salinity

Salinity limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 27.

Table 26. Salinity Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Rootzone Electrical Conductivity < 0.15 dS/cm or rootzone Chloride <300 ppm.	1
Red Massive Gypsic Vertosol	Rootzone Electrical Conductivity < 0.15 dS/cm or rootzone Chloride <300 ppm.	1
Brown Bleached Kandosol	Rootzone EC < 0.15 dS/cm or rootzone Chloride <300 ppm.	1
Brown Lithsolic Rudosol	Rootzone EC < 0.15 dS/cm or rootzone Chloride <300 ppm.	1

5.1.3.6. Rockiness

Salinity limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 28.

Table 27. Rockiness Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	No Rock	2
Red Massive Gypsic Vertosol	No Rock	2
Brown Bleached Kandosol	No Rock	1
Brown Lithsolic Rudosol	60-200mm (cobbles) 20-50%.	4

5.1.3.7. Microrelief

Microrelief limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 29.

Table 28. Microrelief Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Melonholes cover < 20 % surface area.	1
Red Massive Gypsic Vertosol	Melonholes cover < 20 % surface area.	1

Brown Bleached Kandosol	Melonholes cover < 20 % surface area.	1
Brown Lithsolic Rudosol	Melonholes cover < 20 % surface area.	1

5.1.3.8. Wetness

Wetness limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 30.

Table 29. Wetness Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Non rigid soils with non sodic subsoils (ESP < 15) within 60 cm of the surface. Well drained	1
Red Massive Gypsic Vertosol	Non rigid soils with non sodic subsoils (ESP < 15) within 60 cm of the surface. Well drained	1
Brown Bleached Kandosol	Non rigid soils with non sodic subsoils (ESP < 15) within 60 cm of the surface. Well drained	1
Brown Lithsolic Rudosol	Non rigid soils with non sodic subsoils (ESP < 15) within 60 cm of the surface. Well drained	1

5.1.3.9. Topography

Topography limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 31.

Table 30. Topography Limitations

SMU	Limitation	Land Suitamnbility Class
Brown Mellic Kandosol	Flat to slightly undulated terrain suitable for efficient use of machinery, efficient installation and maintenance of infrastructure and/or irrigation requirements	1
Red Massive Gypsic Vertosol	Flat to slightly undulated terrain suitable for efficient use of machinery, efficient installation and maintenance of infrastructure and/or irrigation requirements	1
Brown Bleached Kandosol	Flat to slightly undulated terrain suitable for efficient use of machinery, efficient installation and	1

SMU	Limitation	Land Suitamnbility Class
	maintenance of infrastructure and/or irrigation requirements	
Brown Lithsolic Rudosol	Slope 10-20%, heavy machinery not safe to use	4

5.1.3.10. Water Erosion

Water erosion limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 32.

Table 31. Water Erosion Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Slopes on 1 – 3 % on all other soils .	1
Red Massive Gypsic Vertosol	Slopes < 3% on all other soils.	1
Brown Bleached Kandosol	Slopes < 3% on all other soils.	1
Brown Lithsolic Rudosol	Stable soils with 10-20% slope	3

5.1.3.11. Flooding

Flooding limitations for each SMU is based on thresholds in Department of Mines and Energy (1995) and presented in Table 33.

Table 32. Flooding Limitations

SMU	Limitation	Land Suitability Class
Brown Mellic Kandosol	Periodic flooding (from once in 50 years to whenever stream flow increases).	2
Red Massive Gypsic Vertosol	Periodic flooding (from once in 50 years to whenever stream flow increases).	2
Brown Bleached Kandosol	Flooding frequency of approximately 1 in 10 years	3
Brown Lithsolic Rudosol	No flooding or flooding less than 1 in 10 years	1

5.1.3.12. Summary of Land Suitability Class for Rainfed Broadacre Cropping

Overall, SMUs were found to be limited by Vegetation, Topography and Erosion. These factors combined have the potential to limit production across much of the Site. Vegetation is dominated by woody species on undulating terrain with highly erosive properties, making SMUs unsuitable for grazing.

No land was identified within the Site that was deemed suitable for rainfed broadacre grazing (i.e. Class 1, 2 or 3), with approx.. 82.1 % (109.14 ha) of the Site found to require extreme inputs to maintain production (Class 5), 17.9 % (23.86 ha) encountering significant limitations (Class 4) (Table 34).

Table 33. Summary of Land Suitability Classes for Rainfed Broadacre Cropping

Limitation	Brown Mellic Kandosol	Red Massive Gypsic Vertosol	Brown Bleached Kandosol	Brown Lithsolic Rudosol
Water Availability	2	5	1	5
Nutrient Deficiency	2	2	2	2
Soil Physical Factors	2	2	2	4
Soil Workability	2	2	2	4
Salinity	1	1	1	1
Rockiness	2	2	1	4
Microrelief	1	1	1	1
Wetness	1	1	1	1
Topography	1	1	1	4
Water Erosion	1	1	1	3
Flooding	2	2	3	1
Land Suitability Class	**2**	**5**	**3**	**5**

5.2. Soil Resource Assessment

Topsoil resources are predominantly limited to surface soil horizons, with the upper horizons maintaining seedbank, micro-organisms, nutrients and organics necessary for plant growth and establishment. Generally, soil nutrients and micro-organism activity decrease with depth.

Soil resources are based on factors such as ERD, PAWC, nutrient availability, sodicity, etc. and represent the recommended maximum stripping depth for stockpiling and future rehabilitation. Generally, soil stripping should be timed based on favourable climatic conditions to avoid soil loss, compaction or erosion. Two stage stripping is recommended where sub soils may be encountered, unless topsoil can be recovered in a single pass. Topsoil resources should be placed directly onto rehabilitation areas as soon as possible to limit handling. Where stockpiling is required, it is recommended that stockpiles be shaped to no greater than 2 m high, and stabilised using suitable erosion and sediment controls (e.g. hydromulch, jute mesh, etc.).

Table 35 details the maximum soil resources stripping depths and potential volumes available for use.

Table 34. Maximum Soil Resource Stripping Depths and Potential Volumes Available

SMU	Stripping Depth (cm)	SMU Area (m^2)	Potential Volume Available (m^3)
Brown Mellic Kandosol	0 – 30	2,325,800	697,740
Red Massive Gypsic Vertosol	0 – 20	639,700	127,940
Brown Bleached Kandosol	0 – 30	835,100	250,530
Brown Lithsolic Rudosol	0	2,991,300	0

Respreading of soil resources should occur on prepared, reshaped areas as soon as possible. Where soil resources allow, soils should be spread to a nominal depth of ~20cm on all re-graded spoil or disturbance areas. Soil resources should be spread with fertiliser and seed in one consecutive operation to reduce the potential for soil losses to wind and water erosion.

5.3. Land Stability

5.3.1. Erosion Hazard (Average Rainfall)

The International Erosion Control Association's (IECA) Best Practice Erosion and Sediment Control Guidelines (IECA 2008) sets erosion hazard based on average rainfalls for regions around Australia. IECA erosion hazard for the Mt Isa/Cloncurry Region is detailed in Table *37*.

Table 35. Erosion Hazard (IECA, 2008)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
E	E	H	VL	VL	VL	VL	VL	VL	VL	L	H

5.3.2. Soil Erosion Susceptibility

An assessment of soil erosion susceptibility is given in Table 36, which lists influencing factors for both soil types that have been identified.

Table 36. Soil Erosion Susceptibility

Soil Type	Depth (cm)	Texture	ECEC (meq/100g)	Rating	ESP (%)	Rating	Landform	Vegetation Cover	Erosion Susceptibility
Brown Mellic Kandosol	0 - 10	Loam	1.2	Low	1.2	Non-Sodic	Gently undulating.	Sparse *Eucalyptus microneura +/- Terminalia spp. low woodland*	Moderate susceptibility due sparse erosion protection
	10-60	Loam	1.5	Low	1.6	Non-Sodic			
	60-90	Loam	2.4	Low	6.2	Slightly Sodic			
Red Massive Gypsic Vertosol	0-20	Clay Loam	20	Moderate	0.15	Non-Sodic	Flat to gently undulating	Sparse *Eucalyptus crebra and/or E. whitei +/- Corymbia erythrophloia open woodland*.	Moderate susceptibility due sparse erosion protection
	20-30	Clay	19	Moderate	0.3	Non-Sodic			
	30-60	Clay	17.6	Moderate	0.35	Non-Sodic			
Brown Bleached Kandosol	0-10	Loam	4.4	Low	0.1	Non-Sodic	Flat to gently undulating.	Sparse *Eucalyptus microneura +/- Terminalia spp. low woodland*.	Moderate susceptibility due sparse erosion protection
	10-50	Sandy Loam	2.9	Low	0.35	Non-Sodic			
	50-80	Sandy Loam	3.1	Low	0.8	Non-Sodic			
	80-120	Sandy Loam	6.2	Low	1.2	Non-Sodic			
Brown Lithsolic Rudosol	0 -20	Loam	2.2	Low	1.8	Non-Sodic	Slight to steeply undulated terrain	*Eucalyptus crebra* woodland, +/- *Corymbia pocillum*.	Moderate susceptibility due sparse erosion protection
	20-40	Loam	1.7	Low	2.2	Non-Sodic		*Acacia shirleyi* woodland	

ML 100030

250 0 250 500 750 1,000 m

1:18,000

Client: Laneway Reources
Project number: LWR
Coordinate Reference System: GDA 2020 Z54
Date: 2022-07-27

Map provided for interpretation purposes only.

Print as A0

Figure 6. Erosion Hazard

Legend

ML100030

Moderate Erosion Risk

Disclaimer:
Whilst every effort and care has been taken to ensure the accuracy of this report, Wulguru Technical Services Pty Ltd makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or inconsequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.
Digital data for this report is available on the Queensland Government Spatial Portal at http://www.information.qld.gov.au.

5.3.3. Erosion Management

Management recommendations to reduce the likelihood and potential impact of erosion include:

- Prioritising land clearing so as to only disturb areas necessary for development;
- Divert clean water and upstream catchments around proposed disturbances;
- Manage on site “dirty/ impacted” waters in such a way as to capture and treat sediment laden waters prior to leaving site;
- Ensure soil resources stockpiled are placed away from drainage areas, roads, machinery, transport, and grazing areas;
- Undertake progressive rehabilitation activities on landforms no longer required for operations.
- Staging the clearing activities where possible such that this is limited only in areas which are being actively cleared, therefore, limiting the time such areas are exposed;
- Erosion and Sediment Control Plans will be developed in accordance with IECA best practice guidelines such that these will highlight how far in advance vegetation clearing can be undertaken prior to construction works; and
- Develop and implement management strategies (as above) through an EM Plan and Erosion and Sediment Control Management Plan in line with all statutory legislation and regulations;
- General vegetation clearing and soil stripping should not be undertaken until earthwork and construction operations are ready to commence. All proposed erosion and sediment control measures will be implemented prior to, or in conjunction with, clearing activities.
- Prior to commencement of clearing and soil stripping, the limits of these works need to be clearly delineated by pegs placed at intervals on each side of the disturbed area by a suitably qualified supervisor.
- All operations will be planned to ensure that there is no damage to any trees, cropping or pasture areas outside the limits to be cleared.

Erosion of rehabilitated landforms/ domains reduces the potential for rehabilitation success and closure. In extreme instances, erosion can lead to the failure of structures (e.g. Tailings Storage Facility embankments), resulting in potential for environmental harm via release of sediment and contaminants to downstream receptors.

Pre-development landform is required to be re-established at post-development or post-land use as practical as possible. In areas where infrastructures maybe required for retention (i.e. dams or ponds), a provision for landform design in rehabilitation for such areas is recommended.

6. References

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Appendix A – Certificates of Analysis

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2135923**	Page	: 1 of 17
Client	: **WULGURU TECHNICAL SERVICES PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MATTHEW AYRE	Contact	: Customer Services EB
Address	: 17 MUELLER ST WULGURU QLD WULGURU 4811	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: 2021.09001_Agate Creek SLSA	Date Samples Received	: 09-Dec-2021 07:55
Order number	: ----	Date Analysis Commenced	: 10-Dec-2021
C-O-C number	: ----	Issue Date	: 18-Jan-2022 16:40
Sampler	: MATTHEW AYRE		
Site	: ----		
Quote number	: TV/140/21		
No. of samples received	: 35		
No. of samples analysed	: 35		

ilac-MRA NATA
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, unless the sampling was conducted by ALS. 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*
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the 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.

- ED045G (Chloride) / EK059G (Nitrite and Nitrate as N (NOx): Some samples were diluted due to matrix interference. LOR adjusted accordingly.
- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- EK061G (Total Kjeldahl Nitrogen as N) / EK067G (Total Phosphorus as P): Sample EB2135923_022 (S4_80_120) shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- EK061G (Total Kjeldahl Nitrogen as N): Sample EB2135923_002 (S1_10_20) Shows poor matrix spike recovery due to sample heterogeneity. Confirmed by visual inspection.
- ED006-Exchangeable Cations: Unable to calculate Magnesium/Potassium Ratio for sample 'S7_50_80' (EB2135923-035) as required Exchangeable Magnesium and/or Potassium results are less than the limit of reporting.
- ED007 (Exchangeable Cations by ICP-AES): Unable to calculate Magnesium/Potassium Ratio for some samples as required Exchangeable Magnesium and/or Potassium results are less than the limit of reporting.
- EG005T (Total Metals by ICP-AES): Sample S2_70_90 (EB2135923_011) shows poor duplicate results due to sample heterogeneity. This has been confirmed by visual inspection.
- EK067G (Total Phosphorus as P): Sample EB2135923_011 (S2_70_90) shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S1_0_10	S1_10_20	S1_20_30	S1_30_60	S1_60_90
			Sampling date / time	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-001	EB2135923-002	EB2135923-003	EB2135923-004	EB2135923-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.2	6.1	5.9	5.9	6.0
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	20	5	4	4	4
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	1.2	1.4	1.8
EA150: Particle Sizing								
+75µm	----	1	%	83	86	81	85	79
+150µm	----	1	%	76	76	72	74	71
+300µm	----	1	%	70	70	66	66	65
+425µm	----	1	%	68	67	64	62	62
+600µm	----	1	%	65	64	60	59	59
+1180µm	----	1	%	60	58	54	53	54
+2.36mm	----	1	%	51	49	44	45	45
+4.75mm	----	1	%	26	25	20	25	23
+9.5mm	----	1	%	10	5	<1	5	<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	%	7	11	11	12	11
Silt (2-60 µm)	----	1	%	9	3	6	2	8
Sand (0.06-2.00 mm)	----	1	%	30	35	36	39	33
Gravel (>2mm)	----	1	%	54	51	47	47	48
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.62	2.63	2.57	2.58	2.61
ED005: Exchange Acidity								
ø Exchange Acidity	----	0.1	meq/100g	----	----	<0.1	0.1	0.6
ø Exchangeable Aluminium	----	0.1	meq/100g	----	----	<0.1	<0.1	0.1
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.9	1.0	0.8	0.5	0.5
Exchangeable Magnesium	----	0.1	meq/100g	0.6	0.6	0.4	0.7	0.9
Exchangeable Potassium	----	0.1	meq/100g	0.4	0.3	0.2	0.2	0.2
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	0.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S1_0_10	S1_10_20	S1_20_30	S1_30_60	S1_60_90
			Sampling date / time	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-001	EB2135923-002	EB2135923-003	EB2135923-004	EB2135923-005
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Cation Exchange Capacity	----	0.1	meq/100g	**----**	**----**	**1.4**	**1.6**	**2.4**
Cation Exchange Capacity	----	0.1	meq/100g	**2.9**	**1.9**	**----**	**----**	**----**
Exchangeable Sodium Percent	----	0.1	%	**1.2**	**0.8**	**0.8**	**3.2**	**6.2**
Calcium/Magnesium Ratio	----	0.1	-	**3.2**	**1.7**	**2.0**	**0.7**	**0.6**
Magnesium/Potassium Ratio	----	0.1	-	**1.7**	**2.0**	**2.0**	**3.9**	**4.8**
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	**921**	**575**	**437**	**349**	**280**
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	<10
EG005(ED093)T: Total Metals by ICP-AES								
Iron	7439-89-6	50	mg/kg	**4940**	**6770**	**8810**	**7750**	**9180**
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	<5
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	**5**	**7**	**9**	**8**	**8**
Copper	7440-50-8	5	mg/kg	<5	<5	<5	<5	<5
Lead	7439-92-1	5	mg/kg	**5**	**7**	**11**	**8**	**7**
Nickel	7440-02-0	2	mg/kg	<2	<2	<2	<2	<2
Zinc	7440-66-6	5	mg/kg	<5	<5	<5	<5	<5
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	**1.0**	**1.4**	**0.8**	**0.2**	**0.2**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	**190**	**150**	**140**	**110**	**110**
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	**190**	**150**	**140**	**110**	**110**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	**144**	**173**	**155**	**129**	**146**
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.23**	**0.16**	**0.19**	**0.14**	**0.13**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S2_0_10	S2_10_20	S2_20_30	S2_30_40	S2_40_70
			Sampling date / time	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-006	EB2135923-007	EB2135923-008	EB2135923-009	EB2135923-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.9	5.5	5.6	5.6	5.7
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	17	10	6	4	3
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	1.0	1.1	1.1	<1.0
EA150: Particle Sizing								
+75µm	----	1	%	82	82	84	84	85
+150µm	----	1	%	73	74	76	77	78
+300µm	----	1	%	60	62	65	68	68
+425µm	----	1	%	54	56	59	63	64
+600µm	----	1	%	48	50	55	58	60
+1180µm	----	1	%	39	42	46	51	53
+2.36mm	----	1	%	28	30	35	40	42
+4.75mm	----	1	%	12	13	18	16	15
+9.5mm	----	1	%	2	4	<1	<1	<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	%	7	10	8	10	8
Silt (2-60 µm)	----	1	%	9	7	7	5	7
Sand (0.06-2.00 mm)	----	1	%	53	49	46	42	40
Gravel (>2mm)	----	1	%	31	34	39	43	45
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.57	2.61	2.64	2.60	2.62
ED005: Exchange Acidity								
ø Exchange Acidity	----	0.1	meq/100g	<0.1	0.2	0.2	0.2	0.2
ø Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	0.1	<0.1	<0.1
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.2	1.3	0.9	1.4	1.0
Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.6	0.5	0.7	0.4
Exchangeable Potassium	----	0.1	meq/100g	0.3	0.2	0.2	0.2	0.2
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S2_0_10	S2_10_20	S2_20_30	S2_30_40	S2_40_70
			Sampling date / time	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-006	EB2135923-007	EB2135923-008	EB2135923-009	EB2135923-010
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Cation Exchange Capacity	----	0.1	meq/100g	3.3	2.5	1.9	2.5	1.9
Exchangeable Sodium Percent	----	0.1	%	0.3	0.6	0.9	1.5	1.3
Calcium/Magnesium Ratio	----	0.1	-	2.8	2.2	1.8	2.0	2.5
Magnesium/Potassium Ratio	----	0.1	-	2.5	2.5	2.2	3.4	2.8
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	406	265	244	191	182
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	<10
EG005(ED093)T: Total Metals by ICP-AES								
Iron	7439-89-6	50	mg/kg	4230	7240	4700	5140	5770
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	<5
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	8	10	8	9	14
Copper	7440-50-8	5	mg/kg	<5	<5	<5	<5	<5
Lead	7439-92-1	5	mg/kg	6	7	6	7	11
Nickel	7440-02-0	2	mg/kg	<2	<2	<2	<2	<2
Zinc	7440-66-6	5	mg/kg	<5	<5	<5	<5	<5
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	1.7	2.8	1.1	0.5	0.2
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	290	270	140	80	90
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	290	270	140	80	90
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	101	89	75	64	92
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.48	0.40	0.19	0.11	0.12

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S2_70_90	S3_0_10	S3_10_20	S3_20_30	S3_30_40
			Sampling date / time	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-011	EB2135923-012	EB2135923-013	EB2135923-014	EB2135923-015
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.8	7.0	6.6	6.8	6.8
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	3	42	10	5	6
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.2	5.3	7.4	10.2	9.5
EA150: Particle Sizing								
+75µm	----	1	%	77	21	20	18	24
+150µm	----	1	%	73	16	15	13	18
+300µm	----	1	%	65	12	12	10	15
+425µm	----	1	%	60	10	10	9	13
+600µm	----	1	%	56	8	8	7	11
+1180µm	----	1	%	50	4	4	3	7
+2.36mm	----	1	%	41	2	1	1	5
+4.75mm	----	1	%	15	<1	<1	<1	2
+9.5mm	----	1	%	<1	<1	<1	<1	<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	%	15	30	36	39	42
Silt (2-60 µm)	----	1	%	6	47	43	42	33
Sand (0.06-2.00 mm)	----	1	%	35	20	19	17	20
Gravel (>2mm)	----	1	%	44	3	2	2	5
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.62	2.45	2.56	2.66	2.71
ED005: Exchange Acidity								
ø Exchange Acidity	----	0.1	meq/100g	0.4	----	----	----	----
ø Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.6	13.0	9.8	10.6	10.4
Exchangeable Magnesium	----	0.1	meq/100g	1.0	7.4	7.0	7.8	7.8
Exchangeable Potassium	----	0.1	meq/100g	0.1	1.4	0.8	0.4	0.3
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S2_70_90	S3_0_10	S3_10_20	S3_20_30	S3_30_40
			Sampling date / time	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00	23-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-011	EB2135923-012	EB2135923-013	EB2135923-014	EB2135923-015
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Cation Exchange Capacity	----	0.1	meq/100g	3.3	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	21.7	17.6	19.0	18.6
Exchangeable Sodium Percent	----	0.1	%	2.8	0.1	0.2	0.3	0.3
Calcium/Magnesium Ratio	----	0.1	-	1.6	1.8	1.4	1.4	1.3
Magnesium/Potassium Ratio	----	0.1	-	8.2	5.3	9.1	18.5	27.6
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	125	1170	522	278	162
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	20	<20	<20	<20
EG005(ED093)T: Total Metals by ICP-AES								
Iron	7439-89-6	50	mg/kg	10700	38900	47300	47700	49200
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	<5
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	20	30	37	37	39
Copper	7440-50-8	5	mg/kg	<5	54	80	91	97
Lead	7439-92-1	5	mg/kg	11	5	6	6	7
Nickel	7440-02-0	2	mg/kg	6	31	31	32	35
Zinc	7440-66-6	5	mg/kg	<5	92	73	70	71
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.2	0.2	0.3	<0.2	<0.2
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	70	780	700	430	880
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	70	780	700	430	880
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	59	169	138	117	294
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.10	1.76	1.29	0.76	0.60

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S3_40_60	S4_0_10	S4_10_20	S4_20_30	S4_30_50
			Sampling date / time	23-Nov-2021 00:00	24-Nov-2021 00:00	24-Nov-2021 00:00	24-Nov-2021 00:00	24-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-016	EB2135923-017	EB2135923-018	EB2135923-019	EB2135923-020
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.8	6.5	6.7	6.5	6.4
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	4	18	12	11	8
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	8.1	1.3	1.7	1.5	1.8
EA150: Particle Sizing								
+75µm	----	1	%	30	81	80	80	80
+150µm	----	1	%	26	70	66	66	65
+300µm	----	1	%	24	39	36	34	33
+425µm	----	1	%	22	21	19	18	17
+600µm	----	1	%	21	9	9	9	8
+1180µm	----	1	%	18	2	2	3	2
+2.36mm	----	1	%	16	<1	<1	<1	<1
+4.75mm	----	1	%	12	<1	<1	<1	<1
+9.5mm	----	1	%	7	<1	<1	<1	<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	%	45	10	10	15	8
Silt (2-60 µm)	----	1	%	25	8	9	5	10
Sand (0.06-2.00 mm)	----	1	%	14	81	80	79	81
Gravel (>2mm)	----	1	%	16	1	1	1	1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.73	2.61	2.63	2.65	2.67
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	9.3	3.2	2.2	2.1	1.9
Exchangeable Magnesium	----	0.1	meq/100g	7.1	0.8	0.6	0.6	0.5
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.4	0.4	0.4	0.3
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	16.7	4.4	3.1	3.0	2.7
Exchangeable Sodium Percent	----	0.1	%	0.4	<0.1	0.3	0.3	0.4
Calcium/Magnesium Ratio	----	0.1	-	1.3	4.0	3.7	3.5	3.8

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S3_40_60	S4_0_10	S4_10_20	S4_20_30	S4_30_50
			Sampling date / time	23-Nov-2021 00:00	24-Nov-2021 00:00	24-Nov-2021 00:00	24-Nov-2021 00:00	24-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-016	EB2135923-017	EB2135923-018	EB2135923-019	EB2135923-020
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Magnesium/Potassium Ratio	----	0.1	-	29.1	2.0	1.6	1.6	2.0
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	129	292	277	270	222
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<20	<10	<10	<10	<10
EG005(ED093)T: Total Metals by ICP-AES								
Iron	7439-89-6	50	mg/kg	41500	6480	7240	8280	6800
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	<5
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	33	11	11	12	11
Copper	7440-50-8	5	mg/kg	83	<5	<5	<5	<5
Lead	7439-92-1	5	mg/kg	7	<5	<5	<5	<5
Nickel	7440-02-0	2	mg/kg	30	4	4	4	4
Zinc	7440-66-6	5	mg/kg	59	11	9	10	9
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	<0.2	4.6	3.1	3.0	2.6
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	820	630	390	210	150
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	820	630	390	210	150
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	219	168	164	116	126
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.47	0.96	0.54	0.32	0.18

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S4_50_80	S4_80_120	S5_0_10	S5_10_20	S5_20_30
			Sampling date / time	24-Nov-2021 00:00	24-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-021	EB2135923-022	EB2135923-023	EB2135923-024	EB2135923-025
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.4	6.5	5.3	5.3	5.0
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	6	17	6	4	3
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.5	4.3	3.5	2.2	2.4
EA150: Particle Sizing								
+75µm	----	1	%	77	73	49	48	47
+150µm	----	1	%	63	61	38	37	36
+300µm	----	1	%	31	32	37	36	35
+425µm	----	1	%	17	18	36	35	34
+600µm	----	1	%	9	10	35	34	33
+1180µm	----	1	%	3	3	32	32	31
+2.36mm	----	1	%	1	1	28	28	27
+4.75mm	----	1	%	<1	<1	21	20	16
+9.5mm	----	1	%	<1	<1	8	10	4
+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	%	13	17	13	13	15
Silt (2-60 µm)	----	1	%	9	9	34	37	36
Sand (0.06-2.00 mm)	----	1	%	76	72	24	21	21
Gravel (>2mm)	----	1	%	2	2	29	29	28
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.64	2.72	2.62	2.54	2.56
ED005: Exchange Acidity								
ø Exchange Acidity	----	0.1	meq/100g	----	----	0.8	1.5	1.0
ø Exchangeable Aluminium	----	0.1	meq/100g	----	----	0.4	0.8	0.6
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.1	3.6	0.5	0.2	0.2
Exchangeable Magnesium	----	0.1	meq/100g	0.8	2.1	0.5	0.4	0.4
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.4	0.3	0.1	0.2
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S4_50_80	S4_80_120	S5_0_10	S5_10_20	S5_20_30
			Sampling date / time	24-Nov-2021 00:00	24-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-021	EB2135923-022	EB2135923-023	EB2135923-024	EB2135923-025
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Cation Exchange Capacity	----	0.1	meq/100g	----	----	2.1	2.3	1.9
Cation Exchange Capacity	----	0.1	meq/100g	3.1	6.2	----	----	----
Exchangeable Sodium Percent	----	0.1	%	0.8	1.2	1.2	2.6	2.4
Calcium/Magnesium Ratio	----	0.1	-	2.6	1.7	1.0	0.5	0.5
Magnesium/Potassium Ratio	----	0.1	-	3.0	5.0	2.0	2.9	2.6
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	193	308	224	115	109
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	10	<10	<10	<10
EG005(ED093)T: Total Metals by ICP-AES								
Iron	7439-89-6	50	mg/kg	8020	11600	15700	16800	16300
Arsenic	7440-38-2	5	mg/kg	<5	<5	13	12	11
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	12	14	8	8	8
Copper	7440-50-8	5	mg/kg	<5	5	11	11	11
Lead	7439-92-1	5	mg/kg	<5	<5	<5	<5	<5
Nickel	7440-02-0	2	mg/kg	4	6	5	4	4
Zinc	7440-66-6	5	mg/kg	9	13	6	5	6
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	1.3	0.2	0.7	0.5	0.4
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	120	140	510	360	280
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	120	140	510	360	280
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	142	125	256	169	325
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.15	0.23	0.90	0.60	0.34

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S5_30_40	S6_0_10	S6_10_20	S6_20_30	S6_30_50
			Sampling date / time	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-026	EB2135923-027	EB2135923-028	EB2135923-029	EB2135923-030
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.3	5.1	5.4	5.7	5.4
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	2	7	6	7	8
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.2	2.7	2.2	2.7	2.9
EA150: Particle Sizing								
+75µm	----	1	%	38	64	61	55	54
+150µm	----	1	%	27	54	54	47	48
+300µm	----	1	%	26	43	46	39	41
+425µm	----	1	%	26	35	41	34	37
+600µm	----	1	%	25	28	37	30	34
+1180µm	----	1	%	24	19	28	25	29
+2.36mm	----	1	%	21	12	21	20	24
+4.75mm	----	1	%	14	6	13	13	18
+9.5mm	----	1	%	<1	<1	<1	6	8
+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	%	15	17	18	19	14
Silt (2-60 µm)	----	1	%	45	17	18	25	28
Sand (0.06-2.00 mm)	----	1	%	18	52	40	35	32
Gravel (>2mm)	----	1	%	22	14	24	21	26
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.61	2.74	2.57	2.63	2.67
ED005: Exchange Acidity								
ø Exchange Acidity	----	0.1	meq/100g	0.6	0.5	0.3	0.1	<0.1
ø Exchangeable Aluminium	----	0.1	meq/100g	1.1	0.1	0.2	<0.1	<0.1
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	<0.1	0.8	0.9	1.5	1.6
Exchangeable Magnesium	----	0.1	meq/100g	0.4	0.4	0.5	0.6	0.6
Exchangeable Potassium	----	0.1	meq/100g	0.1	0.2	0.1	0.1	<0.1
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S5_30_40	S6_0_10	S6_10_20	S6_20_30	S6_30_50
			Sampling date / time	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-026	EB2135923-027	EB2135923-028	EB2135923-029	EB2135923-030
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Cation Exchange Capacity	----	0.1	meq/100g	1.3	1.8	1.8	2.4	2.4
Exchangeable Sodium Percent	----	0.1	%	2.0	1.2	2.0	2.0	2.1
Calcium/Magnesium Ratio	----	0.1	-	<0.1	2.0	1.8	2.5	2.7
Magnesium/Potassium Ratio	----	0.1	-	3.3	2.4	4.2	5.6	----
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	<100	160	<100	103	<100
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	110	<10	<20
EG005(ED093)T: Total Metals by ICP-AES								
Iron	7439-89-6	50	mg/kg	16300	13600	17000	15100	15400
Arsenic	7440-38-2	5	mg/kg	10	<5	<5	<5	<5
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	7	8	12	9	10
Copper	7440-50-8	5	mg/kg	13	8	10	10	10
Lead	7439-92-1	5	mg/kg	<5	12	13	12	13
Nickel	7440-02-0	2	mg/kg	4	5	6	5	5
Zinc	7440-66-6	5	mg/kg	6	18	18	16	16
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.4	2.9	2.5	2.4	4.2
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	190	340	260	250	270
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	190	340	260	250	270
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	359	189	164	257	266
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.22	0.38	0.28	0.26	0.21

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S7_0_10	S7_10_20	S7_20_30	S7_30_50	S7_50_80
			Sampling date / time	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-031	EB2135923-032	EB2135923-033	EB2135923-034	EB2135923-035
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.3	6.3	6.7	7.1	7.9
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	31	12	9	7	386
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.2	2.6	2.8	2.3	2.7
EA150: Particle Sizing								
+75µm	----	1	%	78	79	82	83	56
+150µm	----	1	%	66	68	74	78	50
+300µm	----	1	%	36	37	46	60	39
+425µm	----	1	%	23	23	33	49	34
+600µm	----	1	%	15	15	24	40	29
+1180µm	----	1	%	8	7	15	26	21
+2.36mm	----	1	%	3	3	10	16	13
+4.75mm	----	1	%	<1	<1	5	6	6
+9.5mm	----	1	%	<1	<1	<1	<1	<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	%	12	15	11	12	35
Silt (2-60 µm)	----	1	%	7	5	7	4	9
Sand (0.06-2.00 mm)	----	1	%	77	76	71	65	41
Gravel (>2mm)	----	1	%	4	4	11	19	15
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EA152: Soil Particle Density								
Soil Particle Density (Clay/Silt/Sand)	----	0.01	g/cm3	2.59	2.58	2.66	2.62	2.65
ED006: Exchangeable Cations on Alkaline Soils								
ø Exchangeable Calcium	----	0.2	meq/100g	----	----	----	----	5.3
ø Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	----	3.1
ø Exchangeable Potassium	----	0.2	meq/100g	----	----	----	----	<0.2
ø Exchangeable Sodium	----	0.2	meq/100g	----	----	----	----	1.8
ø Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	----	10.2
ø Exchangeable Sodium Percent	----	0.2	%	----	----	----	----	17.8
ø Calcium/Magnesium Ratio	----	0.2	-	----	----	----	----	1.7

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S7_0_10	S7_10_20	S7_20_30	S7_30_50	S7_50_80
			Sampling date / time	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-031	EB2135923-032	EB2135923-033	EB2135923-034	EB2135923-035
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.6	5.2	4.6	4.1	----
Exchangeable Magnesium	----	0.1	meq/100g	1.4	1.8	1.8	1.8	----
Exchangeable Potassium	----	0.1	meq/100g	0.7	0.3	0.3	0.2	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	----
Cation Exchange Capacity	----	0.1	meq/100g	6.7	7.4	6.8	6.3	----
Exchangeable Sodium Percent	----	0.1	%	0.4	0.6	0.6	1.4	----
Calcium/Magnesium Ratio	----	0.1	-	3.3	2.9	2.6	2.3	----
Magnesium/Potassium Ratio	----	0.1	-	2.2	5.4	6.8	7.1	----
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	499	264	164	123	<100
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	70
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	30	10	<10	<10	370
EG005(ED093)T: Total Metals by ICP-AES								
Iron	7439-89-6	50	mg/kg	12900	14700	14600	14200	26200
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	<5
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	11	12	12	12	17
Copper	7440-50-8	5	mg/kg	8	9	8	7	12
Lead	7439-92-1	5	mg/kg	6	7	6	<5	10
Nickel	7440-02-0	2	mg/kg	8	10	9	7	19
Zinc	7440-66-6	5	mg/kg	33	33	32	27	39
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	2.7	1.4	1.7	0.7	0.3
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	600	380	290	220	120
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	600	380	290	220	120
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	176	155	146	145	106

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	S7_0_10	S7_10_20	S7_20_30	S7_30_50	S7_50_80
			Sampling date / time	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00	25-Nov-2021 00:00
Compound	CAS Number	LOR	Unit	EB2135923-031	EB2135923-032	EB2135923-033	EB2135923-034	EB2135923-035
				Result	Result	Result	Result	Result
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**1.29**	**0.96**	**0.68**	**0.43**	**0.17**

Appendix B – Air Impact Assessment

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1 Introduction

Wulguru Technical Services (WTS) on behalf of Laneway Resources Pty Ltd, engaged Simpson Engineering Group (SEG) to prepare a noise and vibration assessment for a proposed metals mining project, Agate Creek Mine Expansion (the Project), 40km south of Forsayth in north Queensland.

The air quality study has adopted regulatory dispersion modelling techniques and the particulate & dust levels have been assessed against the health and amenity goals.

This report addresses the following issues:

- Existing environment;
- Air quality goals
- Air emissions inventory;
- Likely change in air quality following commencement of operation;
- Recommendations for ongoing operation.

1.1 Project Description

The Project is large highly prospective epithermal system located approximately south of Forsayth and 60km west of Kidston in North Queensland. The Project is an expansion of the existing open pit and has a 10 year life 2022 to 2032. The mining will involve conventional excavator and haul trucks to create a pit and external waste dump. The mining fleet comprises 4 trucks, a 30 tonne excavators and associated plant. Road trains take the ROM ore directly to an off-site processing facility. The average production of ore during the open pit phase is 0.25Mt. The mass of waste moved is approximately 1.25Mt per annum. The major emissions from the mine is particulate matter. Odours, fumes and other emissions are minor and would not have any offsite impacts.

1.2 Locality Description

The project is situated in a well-established grazing and mining region. The region is undulating, generally comprising open grazing and native scrublands. The location of the Project is shown on Figure 1. The closest community is Forsayth, situated to the NE of the site. Forsayth is service centre for the farming, mining and tourist industry. The area to the west of the site comprises the Rungulla Resources Reserve and the Rungulla National park. The national park comprises a wide range of sandstone formations, including outcrops of large, sculpted caves and pagoda-like sandstone features. The Agate Creek fossicking area is southwest of the site.

There is one dwelling 8 km from the project and another dwellings within approximately 25 km of the site. It is understood the proponent has reached an agreement with the campground landowner to relocate the campground.

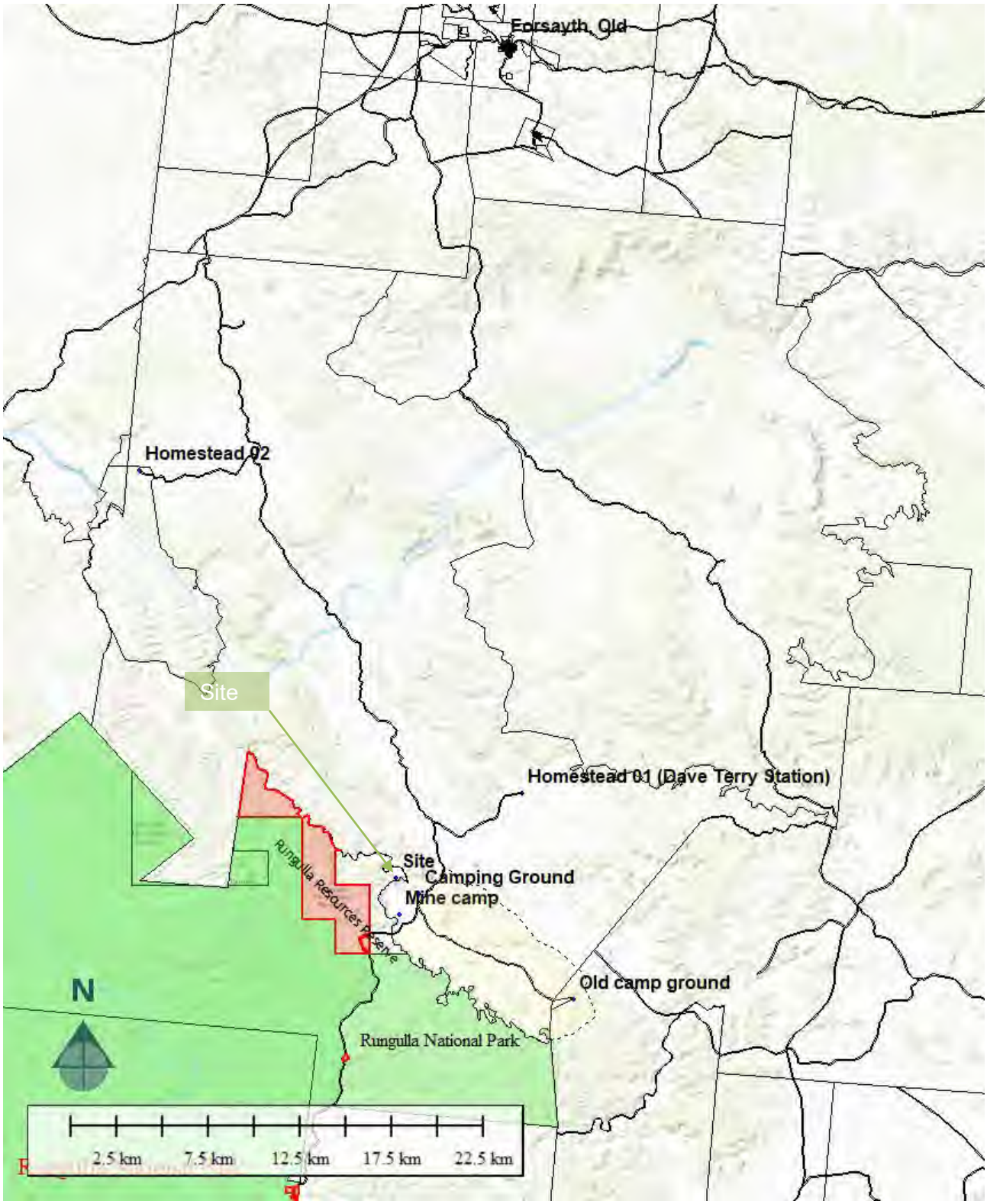


Figure 1: Regional View Showing the Project Area

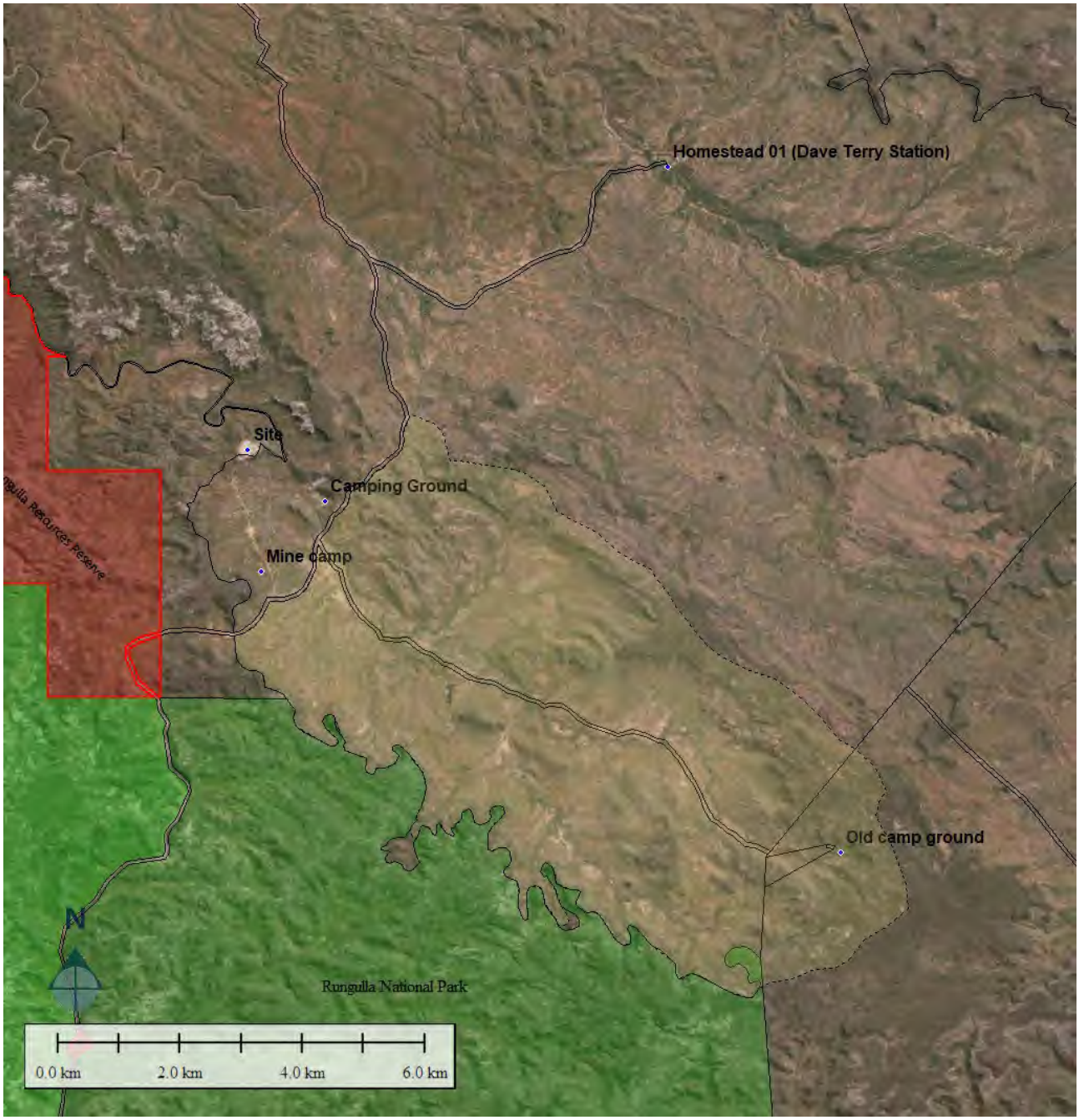


Figure 2: Site and Surroundings

2 Description of Existing Environment

2.1 Climate

The Project is situated in an inland tropical area. The region has a warm to hot climate with two distinct seasons, a dry winter season and a wet summer season. Based on the nearest relevant BOM weather station at Georgetown Airport[1], winter temperatures average from 13 ºC to 30 °C, while summer temperatures range from around 24°C to 37°C. The region averages approximately 820 mm of rainfall each year, falling mostly between December and March.

During the wet summer season, the soil moisture content increases and there is increased grass ground cover. This results in lower dust emissions from most activities, including local roads. During the dry winter season, the soil moisture content reduces (particularly at the surface) and grass cover reduces. The dust emissions are more prevalent from most activities during this period. This is also the period when grass fires (including permit fire) are likely to occur. These types of fire release significant quantities of smoke into the lower atmosphere.

2.2 Air Quality

Potential sources of particulate emissions from the surrounding environment primarily comprise:

- farming and grazing activities;
- existing mining operations;
- unsealed roads; and
- smoke from grass/bush fires (permitted or otherwise).

Due to the lack of other industries in the area, the majority of emissions from the surrounding areas would be crustal matter that is released from farming activities, mining activities and unsealed roads. The characteristic of these emissions are particulates and dusts made up of crustal matter rather than other material that has specific limits. Based on this the air quality indicators that are processed in this report are $PM_{2.5}$, PM_{10}, TSP and dust deposition.

Based on the most recent published DES Queensland National Environment Protection (Ambient Air Quality) Measure monitoring of dust deposition and average PM_{10}, $PM_{2.5}$ monitoring for Townsville[2] the expected particulate and dust exposure levels at all receptor locations at are:

- Dust deposition of 5 $mg/m^2/day$ for all locations
- Particulate concentration of:
  - $PM_{2.5}$(24 hour) = 8 $\mu g/m^3$
  - $PM_{2.5}$(annual average) = 7 $\mu g/m^3$
  - PM_{10}(24 hour) = 22 $\mu g/m^3$
  - $PM_{10(annual\ average)}$ = 20.2 $\mu g/m^3$

2.3 Sensitive Receptors

[1] *Summary statistics CHARTERS TOWERS AIRPORT, Bureau of Meteorology (http://www.bom.gov.au/climate/averages/tables/cw_030124.shtml)*

[2] *Queensland air monitoring 2019, Queensland Government, State of the Environment, (https://www.qld.gov.au/__data/assets/pdf_file/0032/68657/air-monitoring-report.pdf)*

Twelve dwellings have been identified within 20km of the mine. The locations and separation distances are contained in Table 1. There is one dwelling in relatively close proximity (within 5 km) to the project and a further 9 dwellings within approximately 30 km of the site.

Table 1: Sensitive Receptors adjacent to the Mine

Receptors (Homesteads)	**Distance [km]**	**Angle (degrees)**
Mine Camp (non-sensitive receptor)	1.9	170
Campground	1.5	120
Old Camp Ground	11	125
Homestead 01 (Dave Terry station)	8	55
Homestead 02	25	330
Forsayth	45	7

The project's Mine Camp has been included. Whilst this site is modelled it is not classified as a sensitive receptor and is included for reference only.

3 Air Quality Criteria

3.1 Guideline ESR/2015/1840 ERA

The Guideline ESR/2015/1840 ERA describes types of impacts that environmentally relevant activities can have in relation to air and outlines the information to be provided to the department as part of the ERA application process.

There are three key areas to be identified and addressed through the ERA application process:

- Identify the environmental values of the receiving air environment including the identification of any nearby sensitive places.
- Identify the possible impacts due to the proposed activity and all associated risks to environmental values.
- Identify the strategies to mitigate the identified risks to the environmental values

It is necessary to identify the environmental values of the site, this is assisted by the following:

1. Describe the surrounding land
2. Use of a scaled map with site and sensitive receptors
3. Describe site topography
4. Annalise and describe the prevailing site wind direction and speed.
5. Provide a description of the localised ambient air quality.

The department seeks to determine possible impacts to identified environmental values. To assist with this the following information is sought:

1. Identify and provide an overview of emissions and processes.
2. Describe the characteristics of the emissions
3. Identify if an odour impact assessment is required
4. Describe how air emissions will be avoided, minimised or otherwise managed in accordance with the EPP (Air).

Once the value and risk of each impact to the environmental value is known, mitigation strategies can be devised to address the risk. When selecting a mitigation strategy, the following will be provided:

1. Describe the control measure including equipment and techniques used.
2. Identify contingency plans in case of failure in a control measure

3.2 Environmental Protection (Air) Policy

The Queensland Environmental Protection (Air) Policy 2019 (EPP(Air) 2019) commenced in 2019. The EPP (Air) 2019 (Part 2 Section 5) aims to achieve the object of the *Environmental Protection Act 1994* (the Act) in relation to Queensland's air environment. The object of the Act is "... to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development)."

Specifically, the EPP (Air) 2019 addresses the environmental values to be enhanced or protected namely—

(a) the qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems; and

(b) the qualities of the air environment that are conducive to human health and wellbeing; and

(c) the qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property; and

(d) the qualities of the air environment that are conducive to protecting agricultural use of the environment .

To meet the environmental values, Schedule 1 of the EPP (Air) nominates relevant air quality indicators and goals. Relevant air quality indicators from Schedule 1 dealing with particulates are included in Table 1.

Table 2: Excerpt from Environmental Protection (Air) Policy 2019 Schedule 1

Indicator	Environmental value	Air quality objectives ($\mu g/m^3$)	Period
PM2.5	health and wellbeing	25	24 hours
		8	1 year
PM10	health and wellbeing	50	24 hours
		25	1 year
Total Suspended Particles	health and wellbeing	90	1 year

All these indicators are qualities of the air environment that are conducive to human health and wellbeing. The indicators apply at any sensitive or commercial place, such as residences, National Parks schools etc.

3.3 NEPM

The current National Environment Protection (Ambient Air Quality) Measure has been included in Table 3 and Table 4.

Table 3: Excerpt from NEPM Schedule 2 Table 1: Standards and Goal for Pollutants other than Particles as $PM_{2.5}$

Pollutant	Averaging period	Maximum concentration	Goal within 10 years Maximum allowable exceedences
Particles as PM_{10}	1 day	50 µg/m^3	5 days a year

Table 4: Excerpt from NEPM Schedule 2 Table 2: Advisory Reporting Standards and Goal for Particles as $PM^{2.5}$

Pollutant	Averaging period	Maximum concentration
Particles as $PM_{2.5}$	1 day 1 year	25 µg/m^3 8 µg/m^3

A future goal is recommended to be adopted by the states. The goal for the year 2025 comprises:

a) $PM_{2.5}$ - 7 µg/m^3 averaged over one year; and
b) $PM_{2.5}$ - 20 µg/m^3 averaged over 24 hours.

3.4 Site Specific Air Quality Criteria

Particulates are often described as respirable and inhalable. Respirable particulates are those small enough to penetrate the nose and deep into the lung. Respirable particulates that penetrate past the nose and upper respiratory system are likely to be retained in the body. This involves Particulates having an aerodynamic diameter of up to 10 µm. Inhalable particulates are particulates which enter the body but are collected in the nose and upper respiratory system and rejected. Inhalable particulates are those having an aerodynamic diameter of nominally 10 µm and larger.

As a general guide particulates having diameters of 7 to 10 µm are mostly large enough to be caught by nose and throat. Particles in the range 0.5 to 7 µm are small enough to reach the lung yet large enough to be retained. Since these particulates remain in the lung they may be hazardous to health and well-being.

In summary, the applicable air quality criteria (from EPP Air) are:

- Particulate concentration of $PM_{2.5}$ 25 µg/m^3 averaged over 24 hours;
- Particulate concentration of $PM_{2.5}$ 8 µg/m^3 averaged over one year;
- Particulate concentration of PM_{10} of 50 µg/m^3 over a 24-hour averaging time;

- Particulate concentration of PM_{10} of 25 µg/m^3 over one year;
- Total suspended particulate 90 µg/m^3 averaged over a year; and,
- Dust deposition of 120 mg/m^2/day averaged over one month;

All these indicators (except deposition) are qualities of the air environment that are important to human health and wellbeing. The deposition (or dust fallout) is for assessing dust nuisance. The indicators apply at any sensitive or commercial place, such as residences, National Parks, schools, etc.

4 Air Quality Modelling

4.1 Modelling Methodology

Typically, particulate matter is characterised by its size. The particulate size ranges specified in ambient air criteria are total suspended particulate (TSP), particulate matter below 10 microns (PM_{10}) and particulate matter below 2.5 microns ($PM_{2.5}$). TSP includes both the PM_{10} and $PM_{2.5}$ fractions, and PM_{10} includes the 2.5 fraction.

Under normal conditions, particles with aerodynamic diameters of more than PM_{10} will typically fall out and be deposited onto the ground within several minutes of release.

The PM_{10} and $PM_{2.5}$ particulates do not have a significant settling velocity and will behave in a gaseous fashion, that is, the fall out time is significantly longer than a few minutes. The settling velocity for PM_{10} particles is nominally 5 mm/s while for $PM_{2.5}$ it is 0.5 mm/s. This may be compared with PM_{20} where the settling velocity is approximately 20 mm/s (Baumeister et al, 1982).

The air quality modelling methodology comprised three phases namely:

1) preparation of meteorological data The Air Pollution Model (TAPM) and Calmet;
2) development of an emissions database using
   a) Australian National Pollution Inventory “Emission Estimation Technique Manual for Mining Version 3.1”;
3) modelling of the likely downwind ground level concentrations using Calpuff.

4.1.1 Preparation of Meteorological Data

TAPM predicts meteorology and pollutant concentration for a range of pollutants important for air pollution applications. The model consists of coupled prognostic meteorological and air pollution concentration components, eliminating the need to have site-specific meteorological observations. Instead, the model predicts the flows important to local-scale air pollution, such as sea breezes and terrain induced flows, against a background of larger-scale meteorology provided by synoptic analyses.

Some limitations of TAPM include:

- it is not suitable for horizontal domain sizes above approximately 1,000 km by 1000 km.
- it cannot be used to accurately represent deep atmospheric circulations or extreme weather events (cyclones).
- it cannot be used for very steep terrain because of the use of a terrain following coordinate system in the model. Thus, the model cannot represent discontinuities in terrain height (for example, cliffs or bluffs).
- it assumes that cloud processes are resolved by the typical inner grid spacings used in the model (i.e. 3km or less). Therefore, no large-scale cloud convection parameterisation is included.

These limitations are of minor significance to the modelling of pollution for this study. The area of interest is much smaller than the maximum horizontal domain size. Extreme weather events (such

as cyclones) are not of interest from an air pollution perspective. The terrain does not have significant cliffs or bluff bodies within the region and it is expected that the inclusion of large-scale cloud convection would only slightly change the radiation and moisture balances.

TAPM is highly regarded in the scientific community as a suitable tool to develop meteorological data sets for sites without site-specific meteorological observations. However, the meteorological dataset can be improved by incorporating local meteorology.

The TAPM meteorological file developed for the site covered the two year period 2019 & 2020. This period was used for modelling since it is a comprehensive period and the most recent data sets. TAPM was configured with 4 nested grids with grid spacing of 30000m, 10000m, 3000m and 1000m. Additionally 40 grid points were used with 30 vertical grids. The model was centred on the location -18°59.5' and 143°32'. All other settings were as per default.

The general features of winds affecting plume dispersion are illustrated in the wind rose diagrams for the years 2019 to 2020 (Appendix A: Windrose for Site). The wind roses summarise the wind statistics at a 10m height on site, as calculated by the TAPM meteorological model. The wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points – N, NNE, NE, ENE ,E etc. The length of the bar represents the frequency of occurrence of winds from that direction, and the colour of the bar sections correspond to wind speed categories. It is noted that the predominant wind direction during the year is from the north-east through to the south-east. The representative frequency of Pasquil stability classes for the region is based on data from TAPM. Pasquil stability classes represent the stability of the atmosphere. The stability Class F conditions (stable conditions), which result in poor dispersion of pollutants does not occur during the day. Table 5: Frequency of Stability Classes at Site shows the frequency of stability classes for the site.

Table 5: Frequency of Stability Classes at Site

Stability Class	***Description***	***Frequency of Occurrence (%)***
A	Very unstable	4
B	Moderately unstable	15
C	Slightly unstable	15
D	Neutral	25
E	Slightly stable	18
F	Stable	24

4.1.2 Development of the Emissions database

The development of an accurate and representative particulates emissions database has been primarily based on National Pollution Inventory Emission Estimation Technique Manual for Mining Version 3.1 (NPI 2012). The main mining activities and processes that produce, or could produce, particulate emissions were identified for the operations. Flowcharts for handling of waste and ore were developed and an emission factor was attributed to every handling point, handling activity and transport section. In addition, emissions for exposed surfaces were identified and included in the database.

All emission factor equations and default emission factors in NPI are for uncontrolled emissions. However, this database has included the control effects from water trucks as is typically used at mines. In the model of the operations the emissions were calculated as an average and applied for. Calculating emissions is a four-step process:

1. Identify sources of emissions.
2. Obtain information on the scale of the activity.
3. Apply the relevant emission factor equation or default emission factor from NPI to the activity data, see Appendix C: Emissions Development & Justification;
4. Where applicable, apply control efficiency reduction factors-based water truck use or built-in controls.

The proposed operations comprise a truck and excavator to extract the waste and ore. The ore is taken to the ROM pad to the south of the pit and the waste is placed close to the pit and slightly north. The Modelling case is described in Table 6 and the emission factors are described in Table 7.

Table 6: Modelling Case

Item	***Case***
Maximum monthly ROM Ore (Tonnes/month) Maximum monthly mining waste (Tonnes/month)	20,833 104,167
Relevant operations	Excavators on overburden and ore Haul trucks to waste dumps Haul trucks to ROM Graders on internal roads Water trucks on internal roads Bulldozer on overburden B-Double trucks taking ROM to offsite processing Drilling and Blasting
Type of Emission	Crustal Matter (soil, etc.)

Table 7: Particulate Emissions for Main Emitting Activities in Tonnes

Activity	Includes Control Factor	Emissions [t/a] for Particulate Fraction		
		TSP	PM_{10}	$PM_{2.5}$
Excavator Loading Trucks	Water Cart Level 2 Watering (75%)	38.0	18.3	2.3
Trucks Moving on Site		21.4	6.3	0.8
Trucks Dumping Overburden		15.2	5.4	0.7
Trucks Dumping Ore		3.0	1.1	0.1
Dozer		22.3	5.4	0.7
Grader		0.3	0.1	0.0
Front End Loader		7.4	3.5	0.4
Watercart	Water Cart Level 2 Watering (75%)	11.1	3.3	0.4
Export Truck on Site	Water Cart Level 2 Watering (75%)	1.8	0.9	0.1
Drilling	-	19.3	5.7	0.7
Blasting	-	38.0	18.3	2.3
Wind Erosion	-	21.4	6.3	0.8

4.1.3 Dispersion Model

Calmet was used to process the exported 3D wind data from TAPM. The metrological grid was set for 50 by 50 cells with a cell dimension of 500m by 500m. Terrain was imported from SRTM 30m DEM[3]. CALPUFF was configured to use TAPM 3D wind data as an initial guess field for the model. All other settings were kept at the recommended default.

Calpuff v7 was used to determine the downwind ground level particulate concentrations and dust depositions. It is designed to predict ground-level concentrations or deposition of pollutants emitted from one or more sources, which may be stacks, area sources, volume sources, line sources or any combination of these.

The pit sources have been combined and modelled as a single area source in the Calpuff model. The area source is modelled as having dimensions similar to the extent of the source and an elevation of 3m above local terrain. A sampling/calculation grid of 76 by 76 grid with 500m spacing and a receptor at each of the sensitive receptors was used to develop the contours.

Refer to Appendix D for the Calpuff model layout.

[3] *Digital Elevation Data, Geosciences Australia, ga.gov.au/scientific-topics/national-location-information/digital-elevation-data*

4.2 Air Quality Results

The calculated particulate emissions described in Section 4.1.2 were included in the Calpuff model at the appropriate locations. The likely particulate levels due to the operation of the mine at each nearby sensitive receptor have been determined and these are shown in Table 8 for Case 1.

The calculated air pollution contours (including background) are contained in Appendix B: Contours:

- Figure 1: $PM_{2.5}$ (24 hour) maximum with concentration contours expressed in terms of $\mu g/m^3$
- Figure 2: $PM_{2.5}$ (annual average) with concentration contours expressed in terms of $\mu g/m^3$
- Figure 3: PM_{10} (24 hour) highest with concentration contours expressed in terms of $\mu g/m^3$
- Figure 4: PM_{10} (annual average) with concentration contours expressed in terms of $\mu g/m^3$
- Figure 5: TSP (annual average) with concentration contours expressed in terms of $\mu g/m^3$
- Figure 6: Dust Deposition (annual) - maximum month with deposition contours expressed in terms of $mg/m^2/day$

Table 8: Predicted Particulate Concentration and Dust Deposition for Sensitive Receptors (including assumed ambient levels)

Receptor		Calculated Particulate and Dust Levels at Nearby Sensitive Receptors						
		$PM_{2.5}$ (24-hour) Maximum ($\mu g/m^3$)	$PM_{2.5}$ (Annual Average) ($\mu g/m^3$)	PM_{10} (24-hour) Maximum ($\mu g/m^3$)	Number of Days Exceedance of 50 $\mu g/m^3$ PM_{10}(maximum) Per 2 Years	PM_{10} (Annual Average) ($\mu g/m^3$)	TSP (Annual Average) ($\mu g/m^3$)	Dust Deposition (Max month) ($mg/m^2/day$)
Limit		**25**	**8**	**50**	**0**	**25**	**90**	**120**
Existing Ambient		**8**	**7**	**22**	**-**	**20**	**28**	**53**
R1	Mine Camp	12	7	56	1	21	30	93
R2	Camping Ground	9	7	31	0	20	28	59
R3	Old Camping Ground	8	7	22	0	20	28	53
R4	Homestead1	8	7	22	0	20	28	53
R5	Homestead2	8	7	22	0	20	28	53

4.3 Air Quality Assessment

The predicted average ground level concentrations at nearby sensitive areas have been modelled and Section 4.1 contains a full description of the modelling methods. The methodology includes both the expected maximum emission conditions and the worst-case meteorological conditions over a 2-year modelling simulation period. Specifically, the maximum month waste movement was applied for all months of the modelling simulation. This is a highly conservative assumption but adopted to address possible changes to the date of commencement. In reality there is only one peak month and for other months the emissions would be somewhat less normally pro-rata based on total waste and ore extracted/handled. Similarly, if total emissions are lower, then the environmental exposure levels would be pro-rata lower as well.

The ground level predictions were made at all sensitive locations and the contours cover adjacent land. All the techniques used to obtain the predictions have been referenced and key assumptions and data sets explained.

The cumulative effect from the existing uses has been included in the background level assumptions.

It was found that the site readily complies with all air quality goals.

The Mine Camp is not a sensitive receptor for the purpose of an air quality assessment and the results from this location are included for reference only.

4.4 Recommendations and Mitigation Measures

The modelling has incorporated level 2 watering for the haul route and excavator working area. The purpose of this was to provide mitigation for the campground and the workers camp. However, it is likely that these controls could be significantly relaxed when the wind is not blowing towards these receptors.

It is recommended that the mine adopt normal procedures to control dusts from the mine, Table 9 provides a summary of control procedures to mitigate dust emissions.

Table 9: Dust Mitigation Measures

Source	**Mitigation Measure**
Waste Material Dumping	Disturb the minimum area necessary for mining and rehabilitate promptly.
Haul Roads	Maintain haul roads in good condition and regular use of water truck. Investigate use of chemical suppressants if haul roads become too slippery.
Other Roads	Keep road distances to a minimum and maintain in good condition and regular use of water truck. Only drive on prepared/designated roads
Management	The site Air Quality Management Plan is to include a reactive component. Active management strategies such as reduction dust mitigation when meteorological monitoring indicates favorable wind directions.

Landholder consultation	Consultation with potentially impacted landowners and negotiation of relevant mitigation measures.

5 Conclusions

It was determined that the key issues to be addressed in the assessment is dust from all operations. Other types of air emissions have minor and impacts localised to the lease area. In relation to particulates (dusts), EPP(Air) provides environmental objectives associated with health and wellbeing and from the DERM Licensing and Permits, a single nuisance objective was obtained. The NEPM also provides environmental objectives.

The modelling was carried out using TAPM and Calmet to develop the meteorology data set used in the modelling. The particulate dispersion modelling simulation was carried out over 2 year period 2019 to 2020 using Calpuff.

The development of the representative particulate emissions database has been primarily based on National Pollution Inventory Emission Estimation Technique Manual for Mining Version 3.1. The main mining activities and processes that produce, or could produce, particulate emissions were identified for the operations. An emission factor (from NPI) was attributed to all significant handling points, handling activity and transport section. In addition, emissions from exposed surfaces were identified and included in the database.

The predicted average ground level concentrations at nearby sensitive areas were modelled and Section 4.1 Modelling Methodology contains a full description of the modelling methods. The methodology includes both normal and expected maximum emission conditions and the worst-case meteorological conditions.

One modelling case was developed, a fully developed mine operating at the maximum monthly capacity for the mine. Since it is possible that mining commencement could be delayed and to provide operational flexibility, the maximum month mining rate was applied throughout the year, even though it will not be sustained at that rate.

It was found that the mine readily complies with the air quality goals at all sensitive receptors. The modelling incorporated level 2 watering for haul routes and the working pad near the excavator. The watering was included to mitigate impacts at the mining camp and the campground. It is not required for the more distant homesteads.

Glossary of Terms

PM_{10}	particles in the air environment with an equivalent aerodynamic diameter of not more than 10microns.
$PM_{2.5}$	particles in the air environment with an equivalent aerodynamic diameter of not more than 2.5 microns
TSP	total suspended particles are particles in the air environment with an equivalent aerodynamic diameter of not more than 50 microns.
Air Emission	a substance released into the air.
CALMET	a diagnostic 3-dimensional meteorological model
CALPUFF	an air quality dispersion model
CALPOST	a postprocessing package
TAPM	A model that predicts three-dimensional meteorology and air pollution concentrations
Dust	An air suspension of particles of any solid material

References

Hurley PJ, Physick WL, Luhar AK Edwards M (2005) The Air Pollution Model (TAPM) Version 3. Part 2: Summary of Some Verification Studies. CSIRO Atmospheric Research

Scire J, Strimaitas G, Yamartino R (Jan 2000), A User's Guide for the. CALPUFF Dispersion Model. (Version 5).

Katestone Environmental, (May 2006) Air Quality Impact Assessment Study Of The Proposed Ensham Central Project

State of QLD (2019), Environmental Protection (Air) Policy 2019

National Pollutant Inventory (NPI). 2012. *Emission Estimation Technique Manual for Mining, Version 3.1, (January 2012).* Available by download from the NPI website at: http://www.npi.gov.au/reporting/industry-reporting-materials/emission-estimation-technique-manuals

Appendix A: Windrose for Site

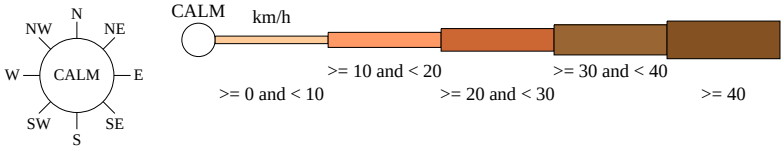
Rose of Wind direction versus Wind speed in km/h (01 Jan 1894 to 10 Oct 2007)

Custom times selected, refer to attached note for details

GEORGETOWN POST OFFICE

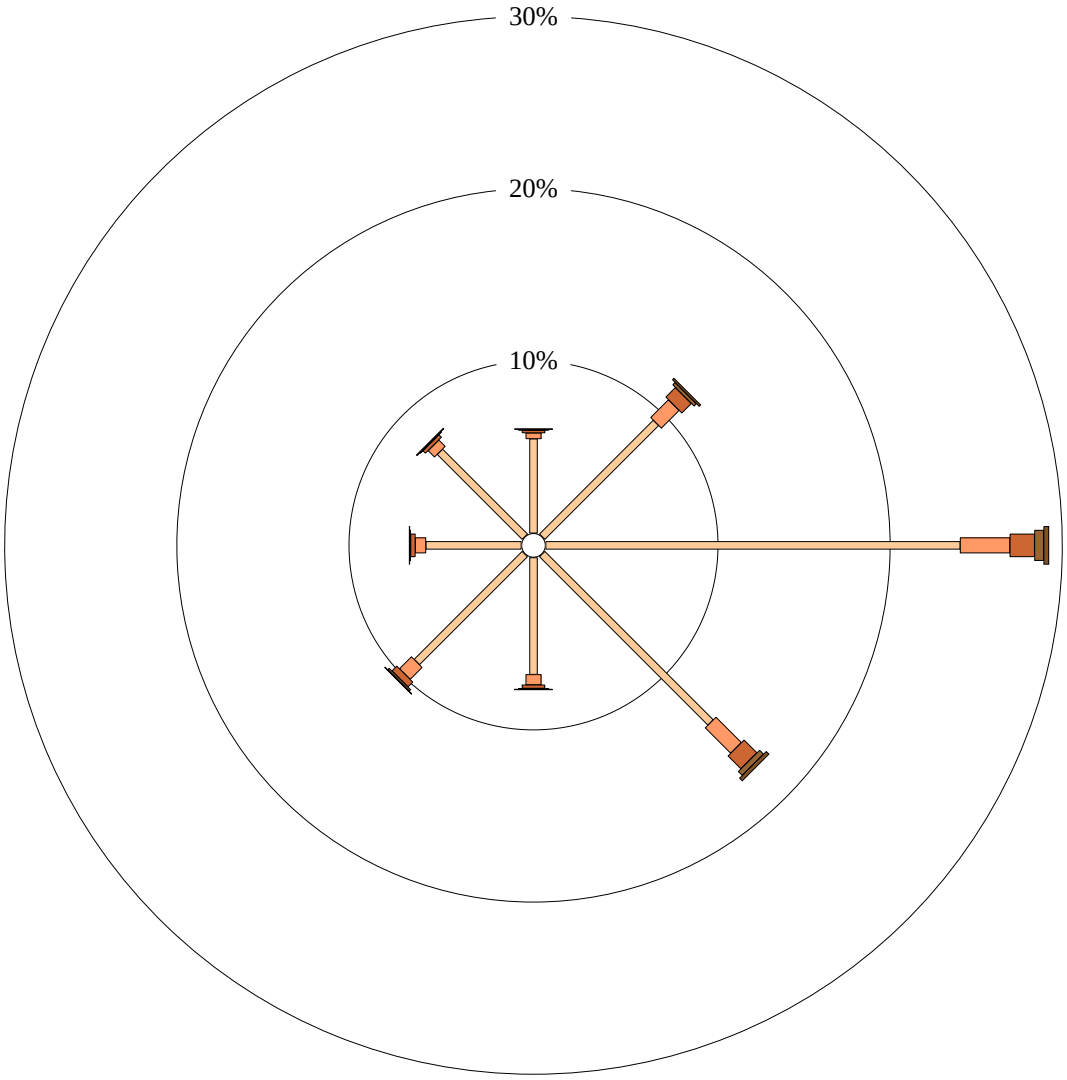
Site No: 030018 • Opened Jan 1872 • Still Open • Latitude: -18.2922° • Longitude: 143.5483° • Elevation 291.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
39046 Total Observations

Calm 3%



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Rose of Wind direction versus Wind speed in km/h (01 Jan 1894 to 10 Oct 2007)

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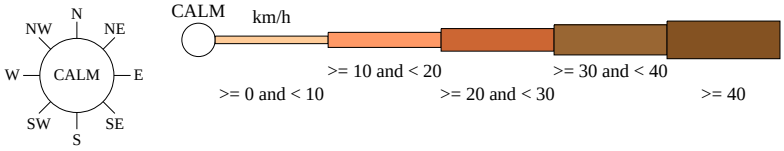
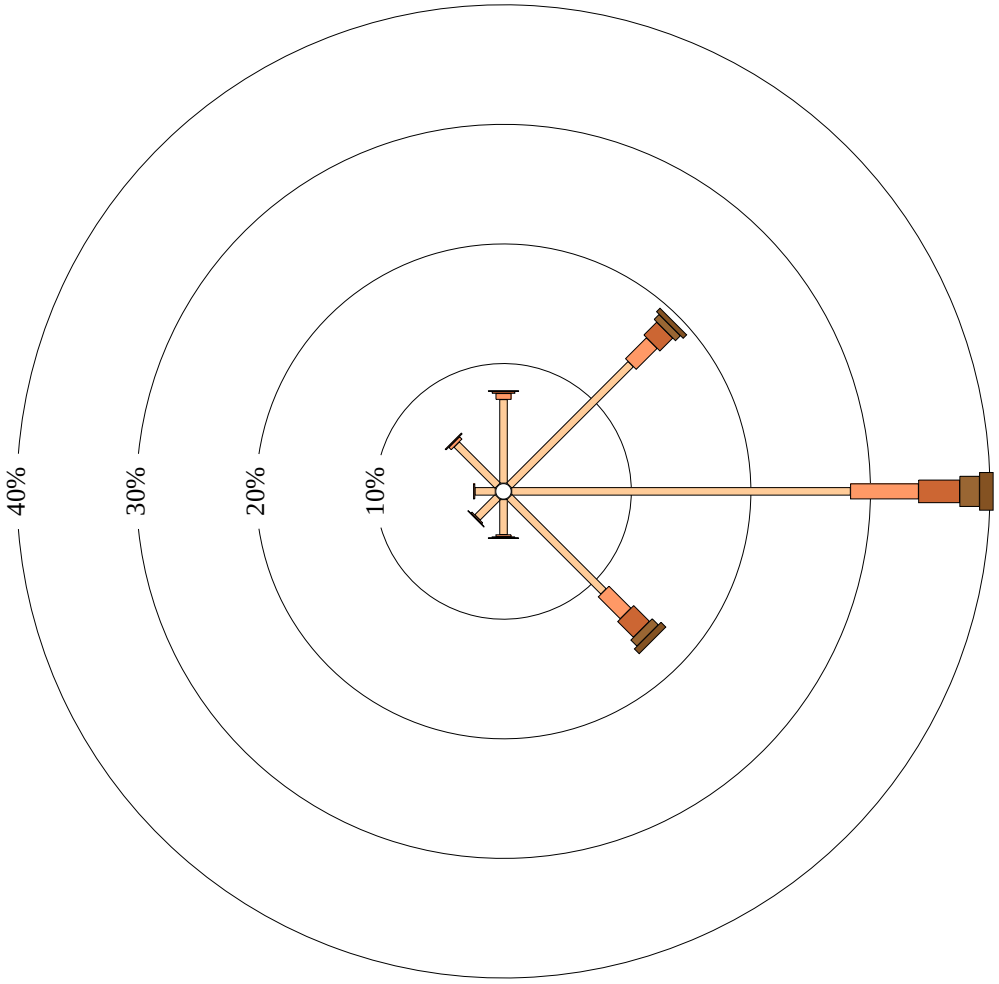


9 am
39917 Total Observations

Calm 3%



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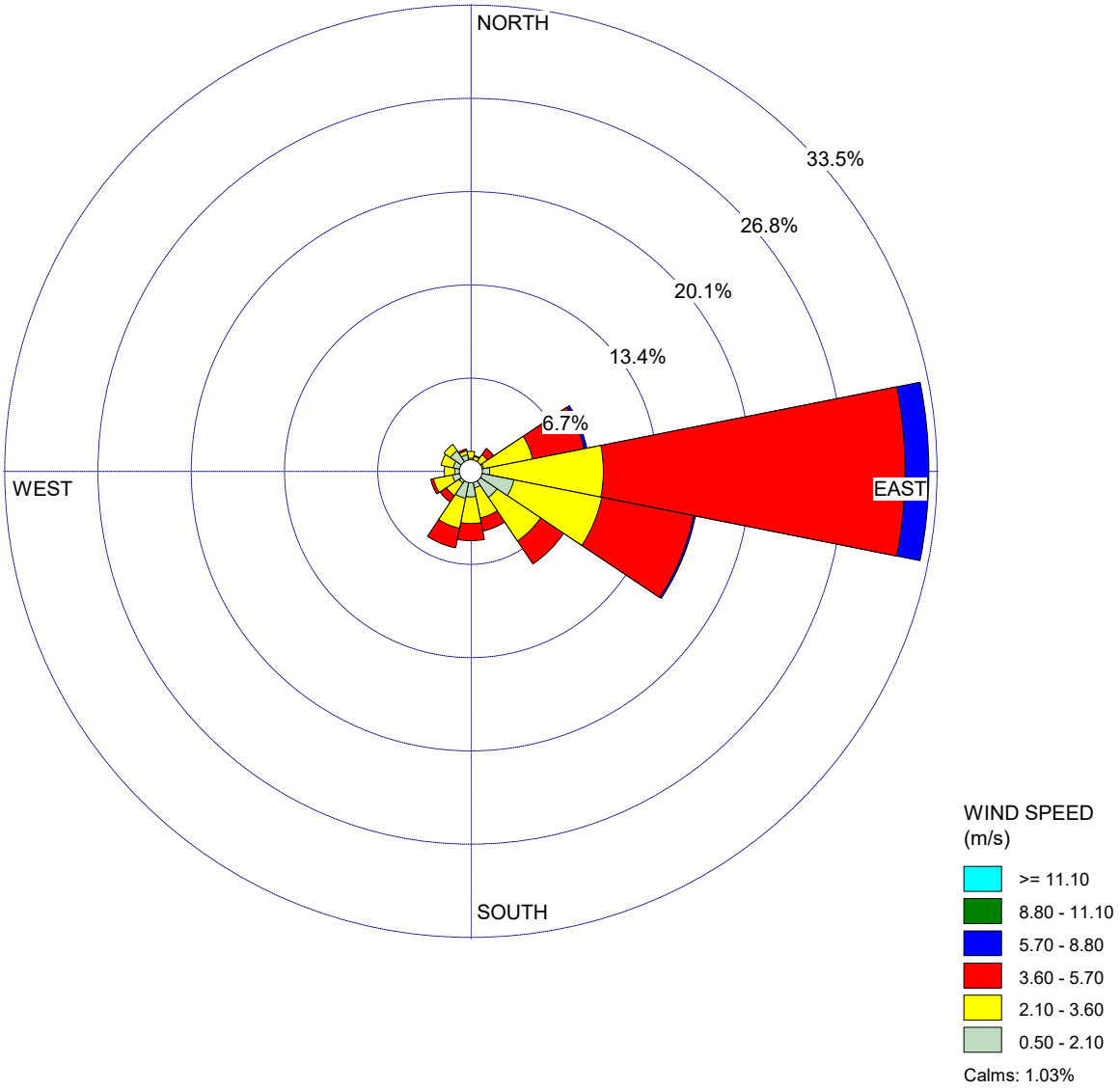
WIND ROSE PLOT:

Agate Creek
3 PM All Seasions

DISPLAY:

Wind Speed
Direction (blowing from)



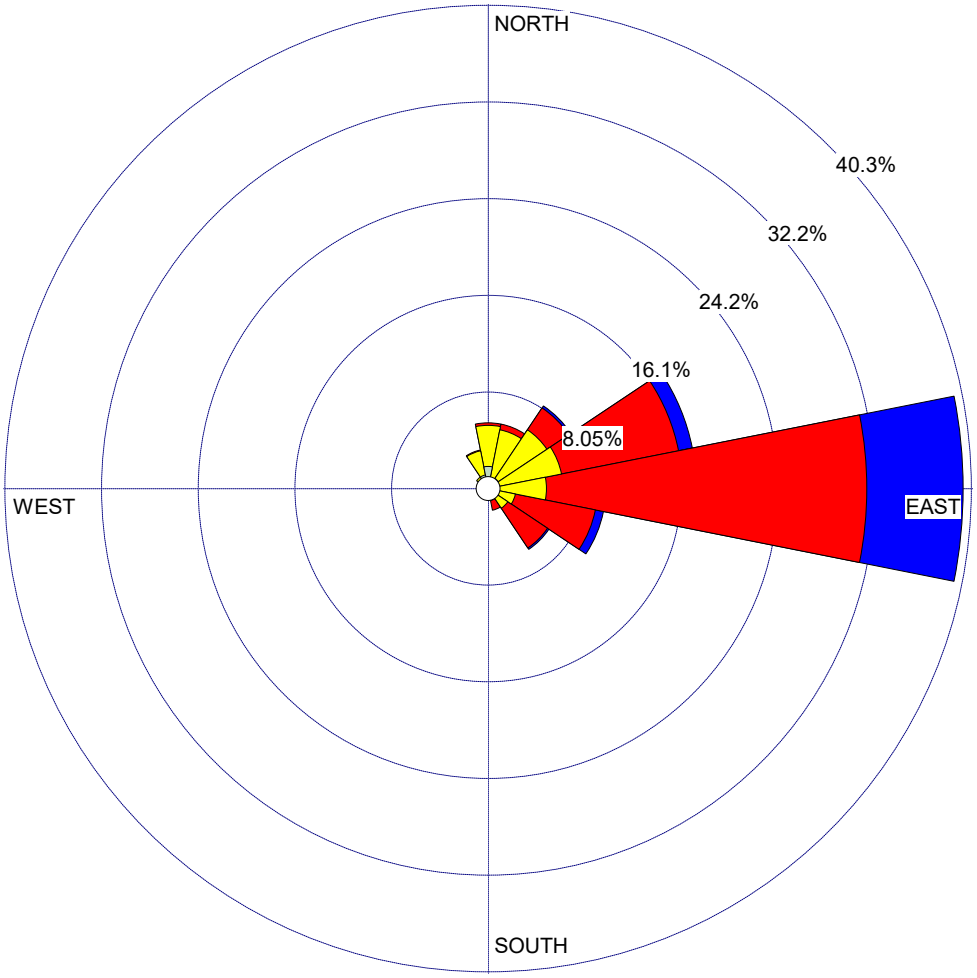
COMMENTS:	DATA PERIOD: **Start Date: 1/01/2019 - 15:00** **End Date: 31/12/2020 - 16:00**	COMPANY NAME: **Simpson Engineering Group**	
		MODELER: **Chris Simpson**	
	CALM WINDS: **1.03%**	TOTAL COUNT: **1462 hrs.**	
	AVG. WIND SPEED: **3.14 m/s**	DATE: **25/01/2022**	PROJECT NO.: **210410**

WIND ROSE PLOT:

Agate Creek
9 am All Seasions

DISPLAY:

Wind Speed
Direction (blowing from)



WIND SPEED
(m/s)

- >= 11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.50 - 2.10

Calms: 0.14%

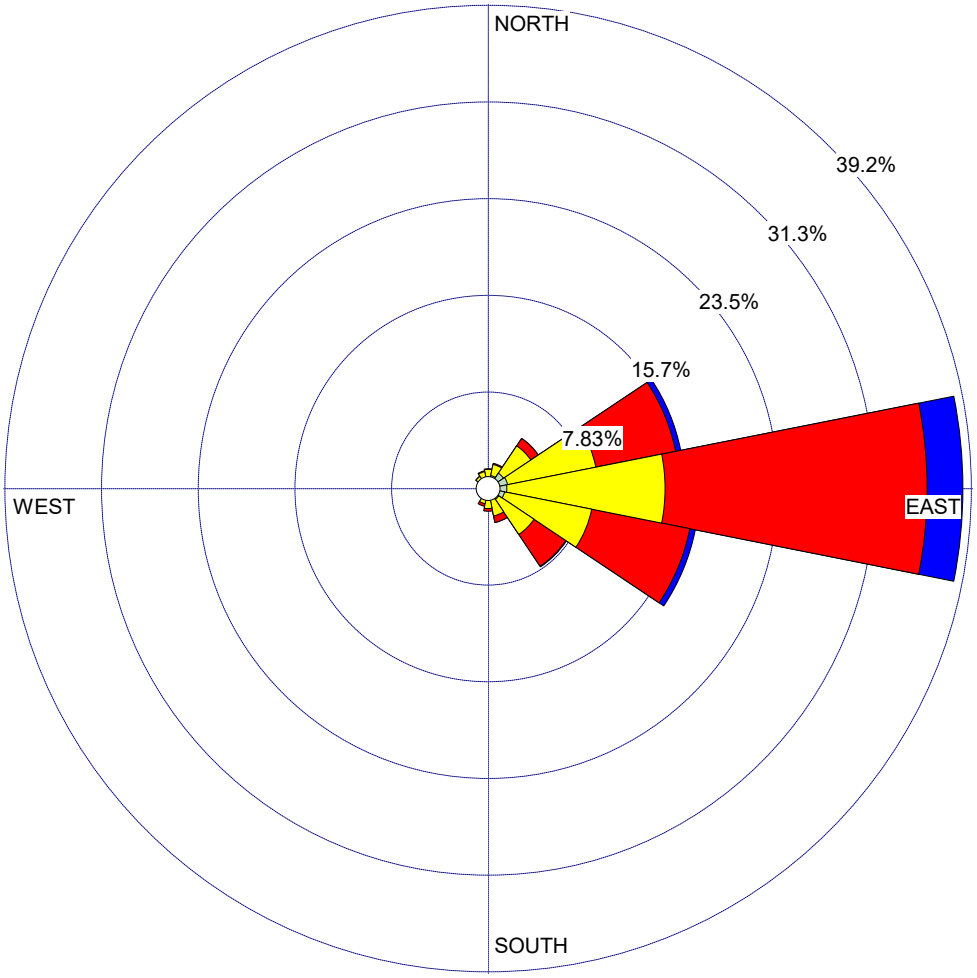
COMMENTS:	DATA PERIOD: **Start Date: 1/01/2019 - 09:00** **End Date: 31/12/2020 - 10:00**	COMPANY NAME: **Simpson Engineering Group**	
		MODELER: **Chris Simpson**	
	CALM WINDS: **0.14%**	TOTAL COUNT: **1462 hrs.**	
	AVG. WIND SPEED: **3.97 m/s**	DATE: **25/01/2022**	PROJECT NO.: **210410**

WIND ROSE PLOT:

Agate Creek
All Hours All Seasions

DISPLAY:

Wind Speed
Direction (blowing from)



WIND SPEED
(m/s)

- >= 11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.50 - 2.10

Calms: 0.50%

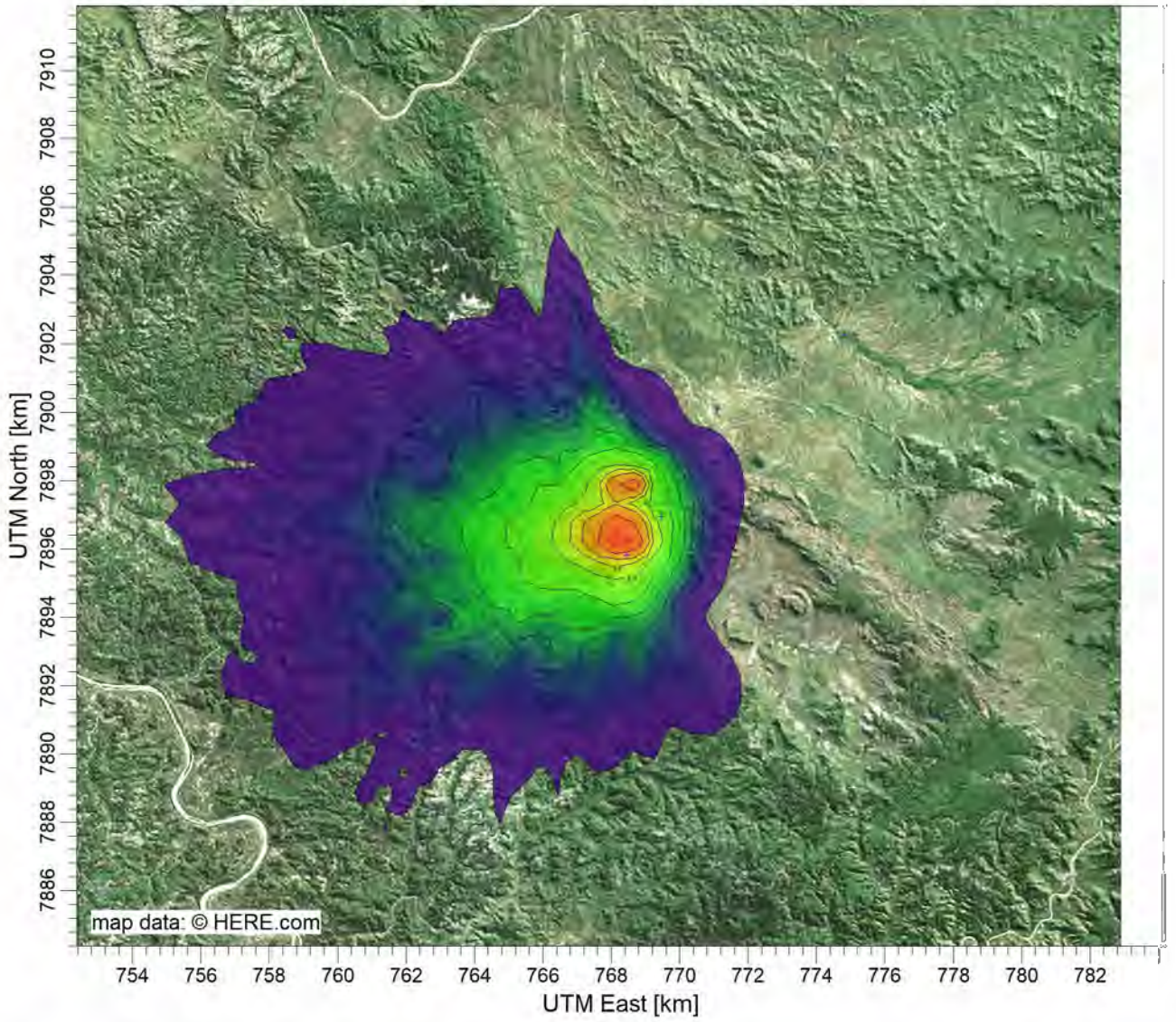
COMMENTS:	DATA PERIOD: **Start Date: 1/01/2019 - 00:00** **End Date: 31/12/2020 - 23:00**	COMPANY NAME: **Simpson Engineering Group**	
		MODELER: **Chris Simpson**	
	CALM WINDS: **0.50%**	TOTAL COUNT: **17544 hrs.**	
	AVG. WIND SPEED: **3.39 m/s**	DATE: **25/01/2022**	PROJECT NO.: **210410**

WRPLOT View - Lakes Environmental Software

Appendix B: Contours

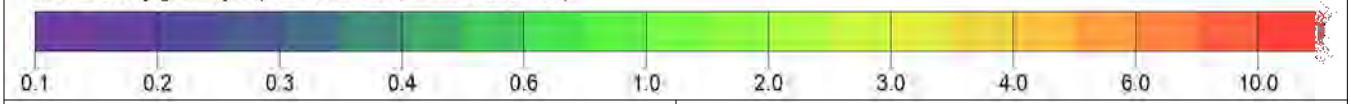
PROJECT TITLE:

Agate Creek Expansion Air Quality Assessment
PM2.5 24 Hour Maximum



1 RANK 24 HOUR AVERAGE CONCENTRATION (PM2.5) ug/m**3

Max = 20.6 [ug/m**3] at (X = 768465.00, Y = 7896424.00)



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:200,000

0 5 km

DATE:

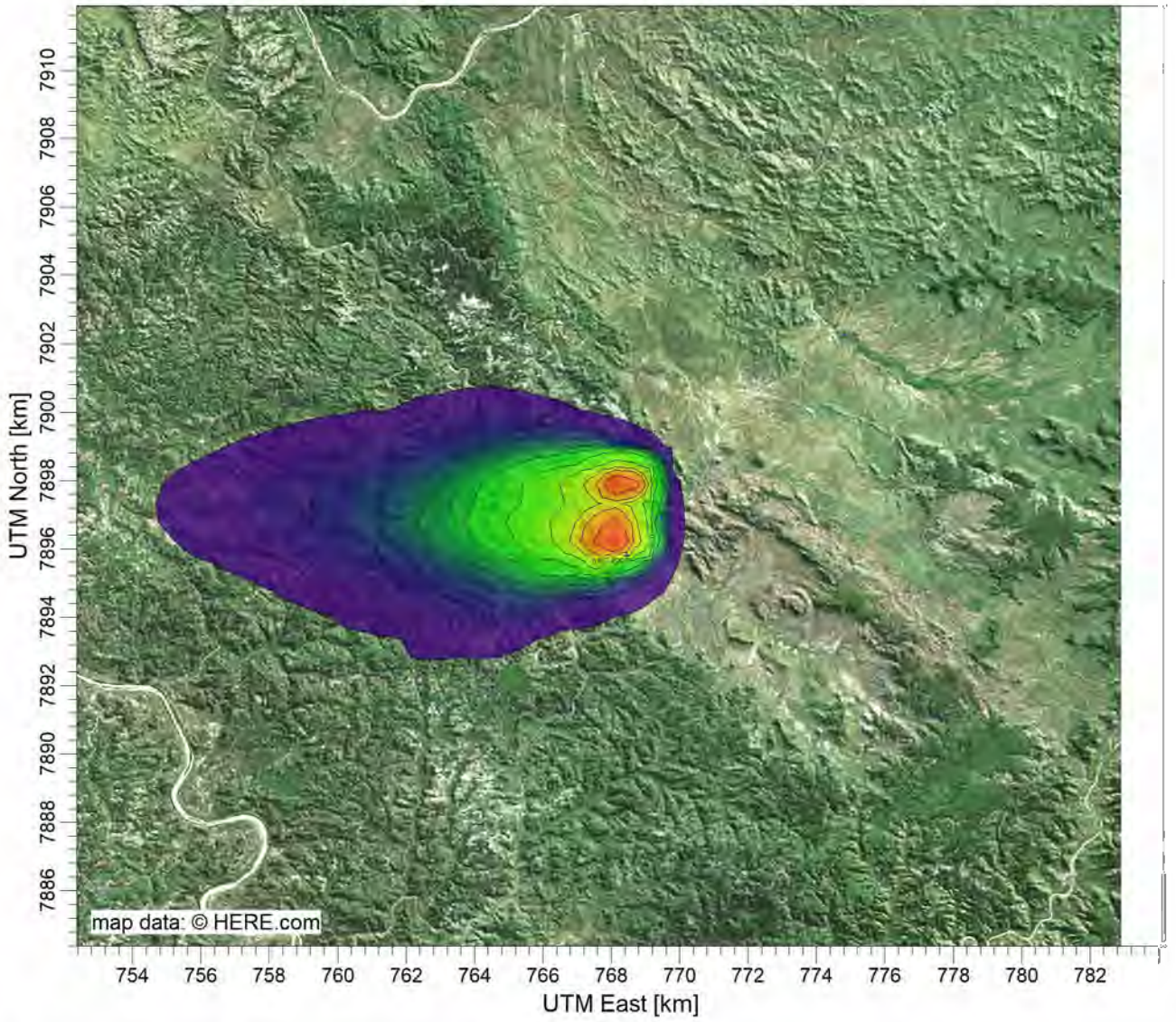
18/08/2022

PROJECT NO.:

210929

PROJECT TITLE:

Agate Creek Expansion Air Quality Assessment
PM2.5 Annual Average



VALUE RUN LENGTH AVERAGE CONCENTRATION (PM2.5) ug/m**3

Max = 5.70 [ug/m**3] at (X = 767965.00, Y = 7896424.00)

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:200,000

0 5 km

DATE:

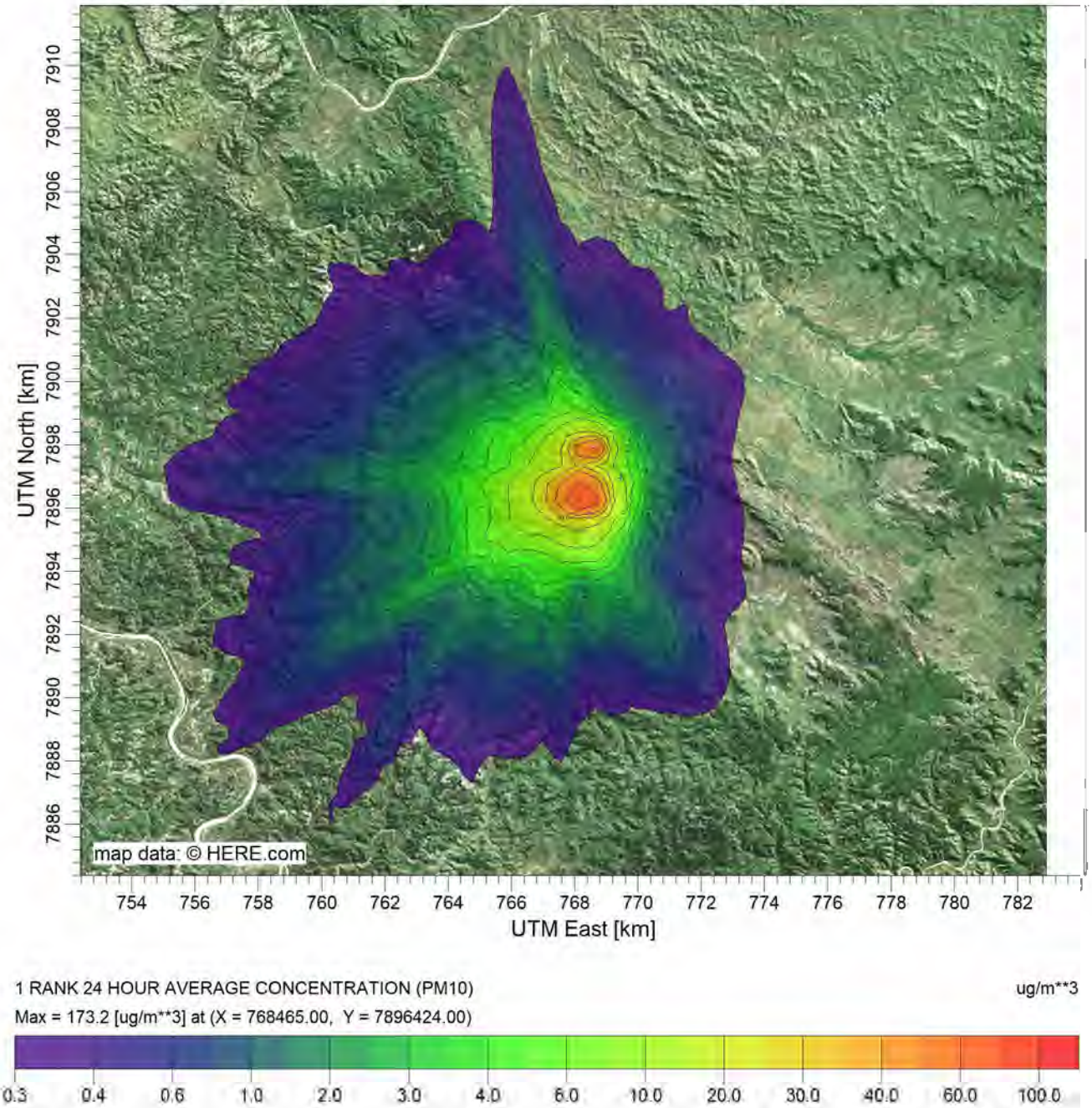
18/08/2022

PROJECT NO.:

210929

PROJECT TITLE:

Agate Creek Expansion Air Quality Assessment
PM10 24 Hour Maximum



1 RANK 24 HOUR AVERAGE CONCENTRATION (PM10) ug/m**3

Max = 173.2 [ug/m**3] at (X = 768465.00, Y = 7896424.00)

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:200,000

0 5 km

DATE:

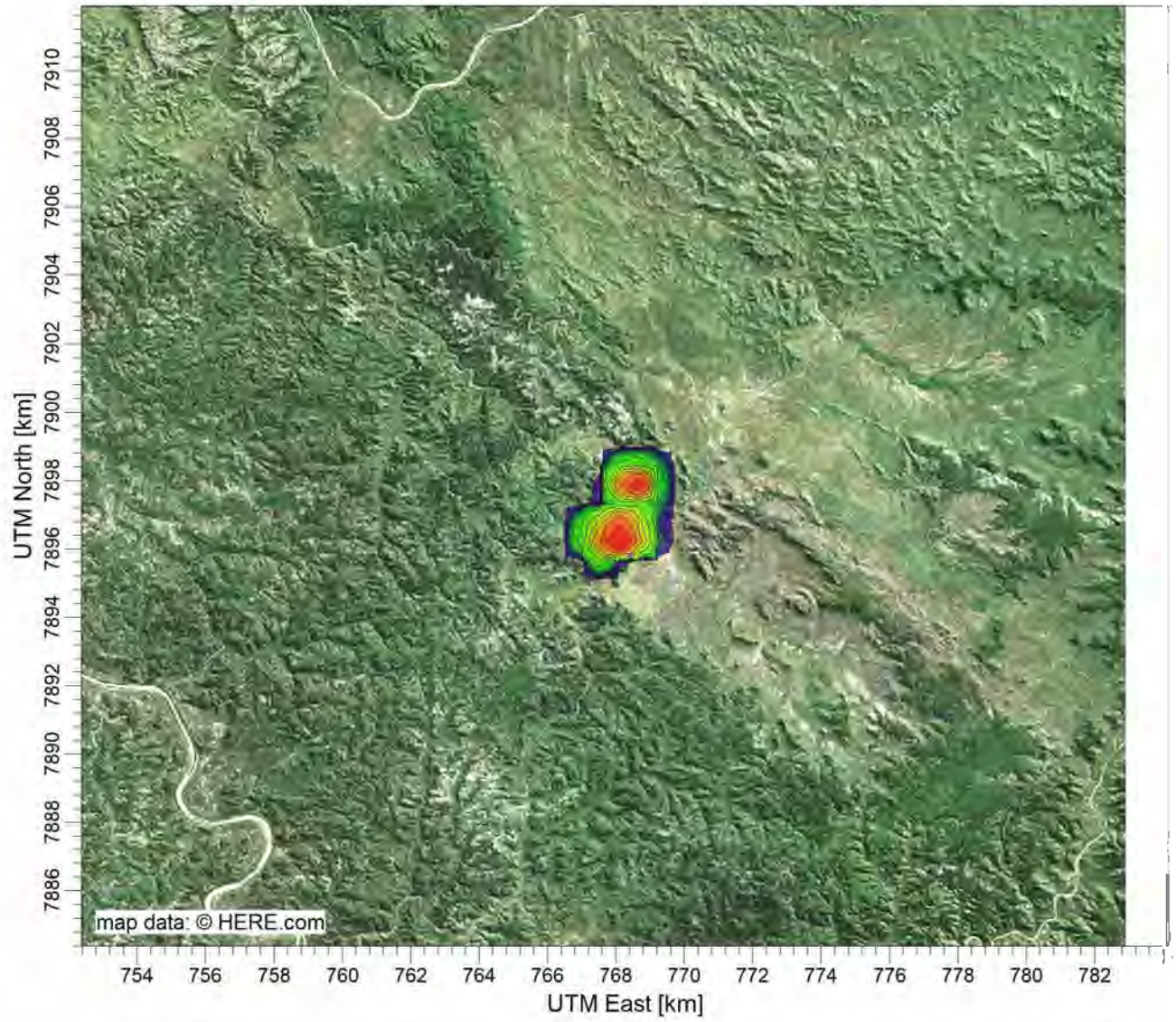
18/08/2022

PROJECT NO.:

210929

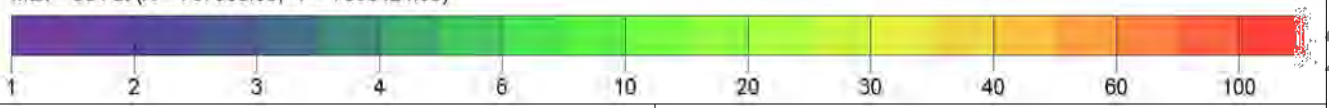
PROJECT TITLE:

Agate Creek Expansion Air Quality Assessment
PM10 - Number of Days that Exceed Limit on 2 Year Model



COUNTS COUNTS OF 24 HOUR AVERAGE CONCENTRATION EXCEEDANCES (PM10)

Max = 504 at (X = 767965.00, Y = 7896424.00)



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:200,000

0 5 km

DATE:

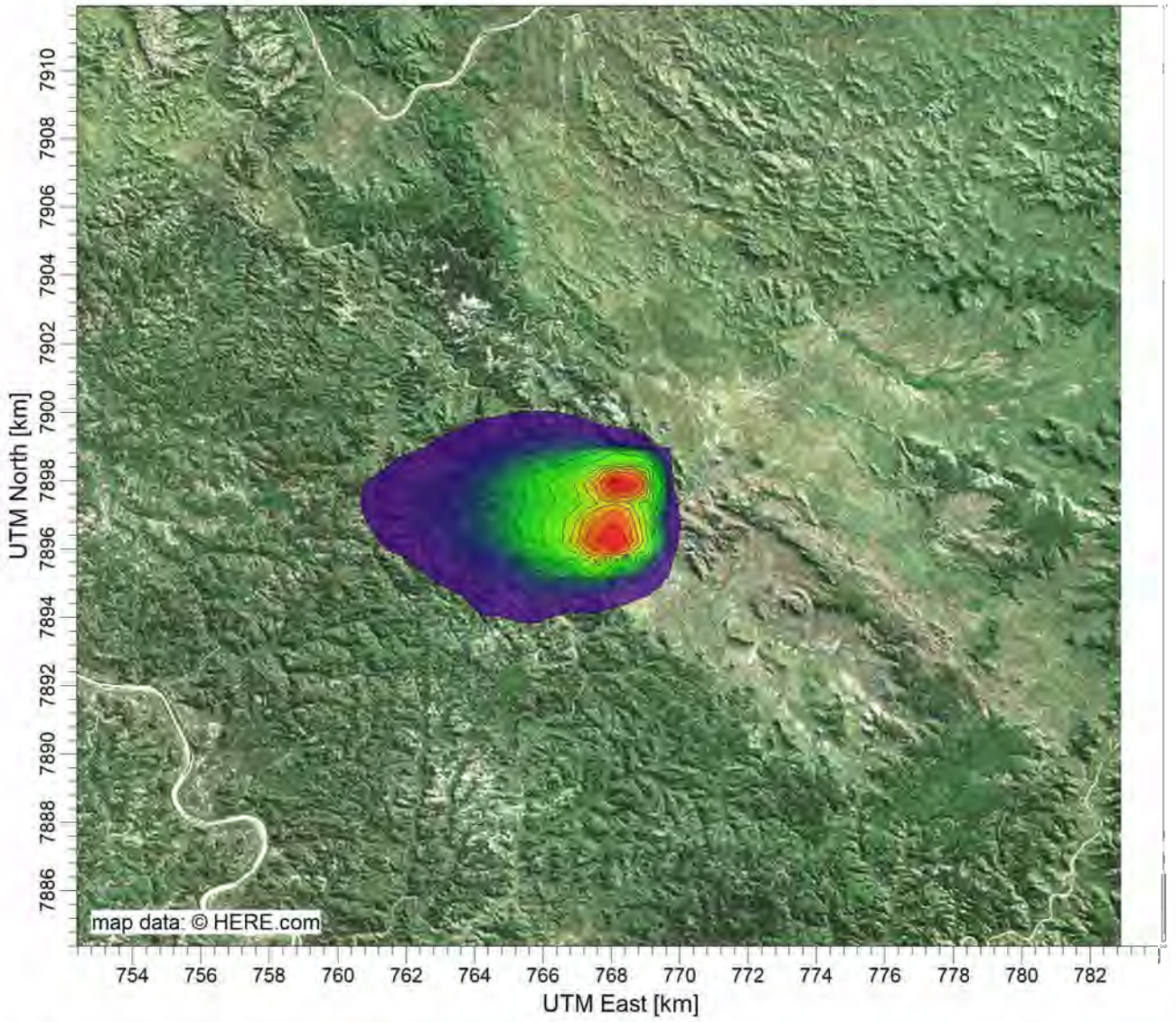
18/08/2022

PROJECT NO.:

210929

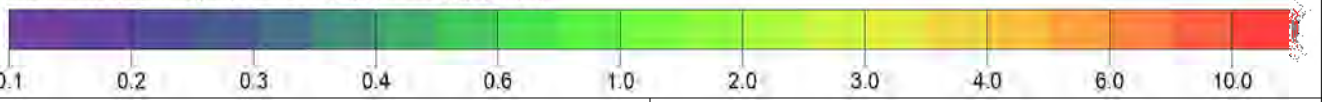
PROJECT TITLE:

Agate Creek Expansion Air Quality Assessment
PM10 Annual Average Concentration



VALUE RUN LENGTH AVERAGE CONCENTRATION (PM10) ug/m**3

Max = 48.4 [ug/m**3] at (X = 767965.00, Y = 7896424.00)



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:200,000

0 5 km

DATE:

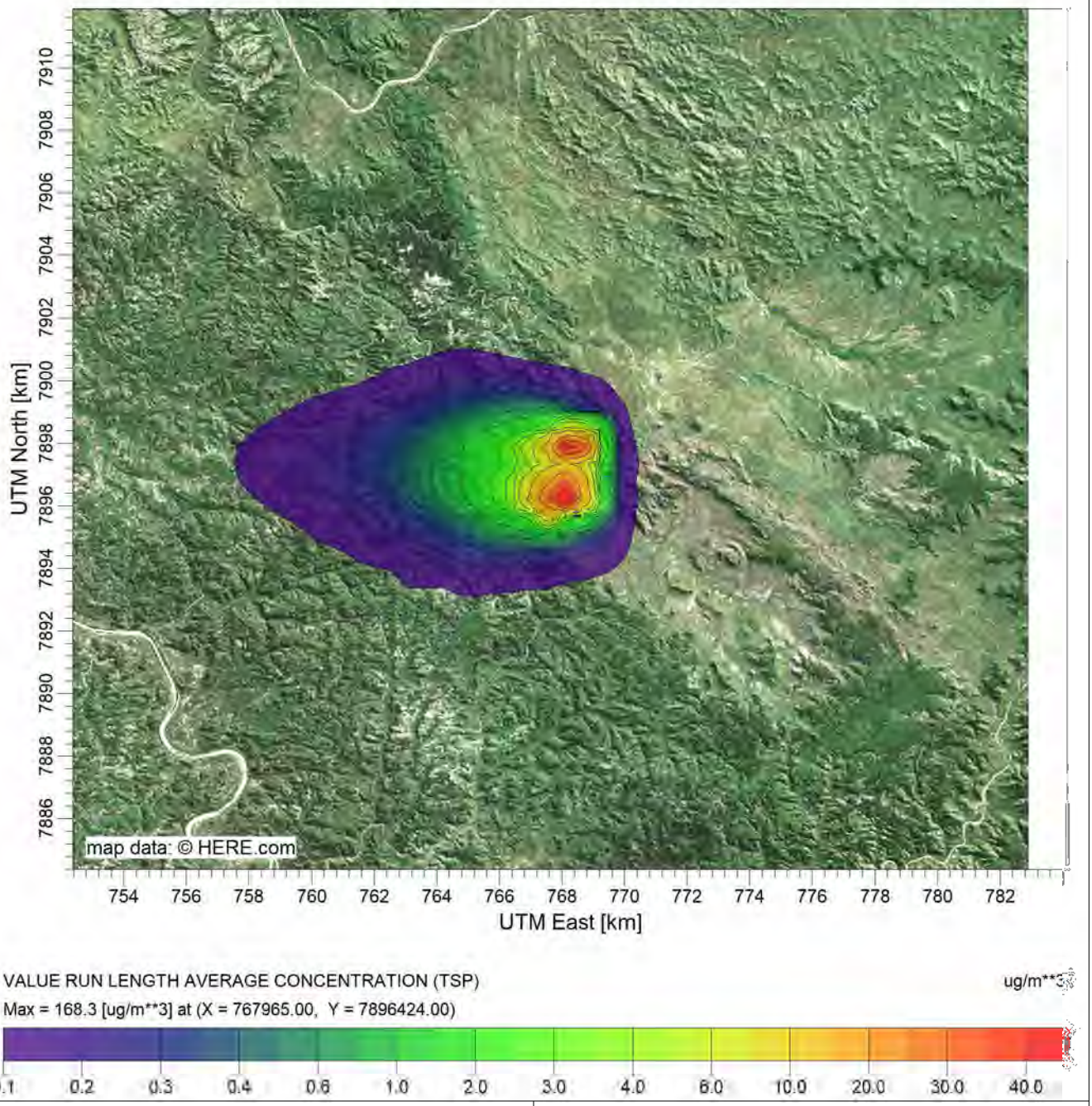
18/08/2022

PROJECT NO.:

210929

PROJECT TITLE:

Agate Creek Expansion Air Quality Assessment
TSP Annual Average Concentration



VALUE RUN LENGTH AVERAGE CONCENTRATION (TSP) ug/m**3

Max = 168.3 [ug/m**3] at (X = 767965.00, Y = 7896424.00)

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:200,000

0 5 km

DATE:

18/08/2022

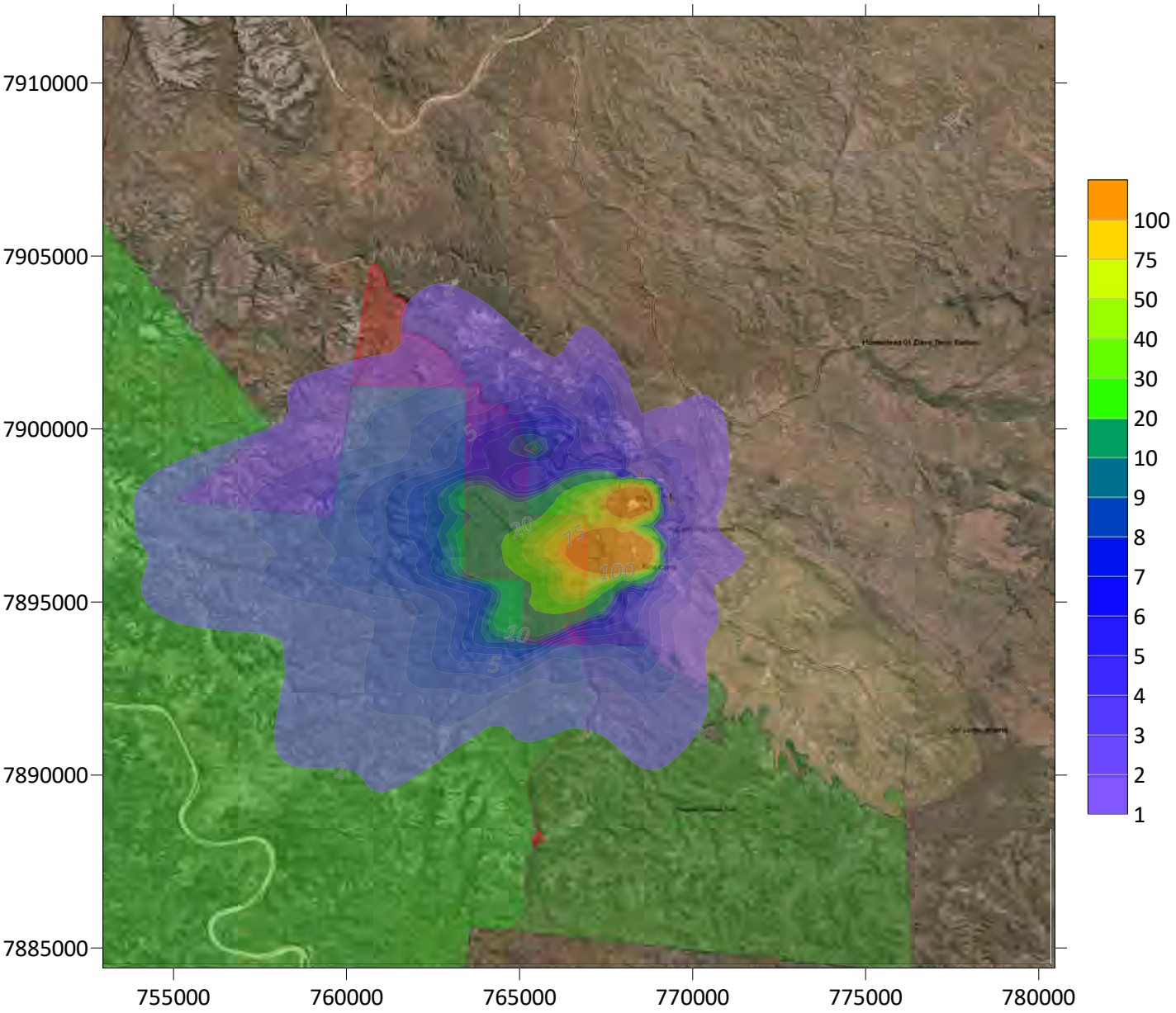
PROJECT NO.:

210929

Figure B6: Dust Deposition Maximum Month – (mg/m^2/day) – Includes assumed background

Dust Deposition - Maximum Month

($\mu g/m^2/day$)



Appendix C: Emissions Development & Justification

Table 2: Emission Factor Equations and Default Emission Factors for Various Operations at Coal Mines 1, 2

Operation/Activity	TSP Equation	PM_{10} Equation	TSP Default Emission Factor	PM_{10} Default Emission Factor	PMR_{10} PM_{10}/TSP Ratio based on Emission Factors	Units	EFR
Draglines (on overburden).	$EF_{TSP} = 0.0046 \times \left(d^{1.1} / M^{0.3} \right)$	$EF_{PM_{10}} = 0.0022 \times \left(d^{0.7} / M^{0.3} \right)$	0.06	0.026	0.43	kg/bcm	B
Excavators/Shovels/ Front-end loaders (on overburden).	See Appendix A Section 1.1.2	See Appendix A Section 1.1.2	0.025	0.012	0.47	kg/t	U
Excavators/Shovels/ Front-end loaders (on coal).	$EF_{TSP} = 0.580 / (M)^{1.2}$	$EF_{PM_{10}} = 0.0447 / M^{0.9}$	0.029	0.014	0.48	kg/t	C
Bulldozers on coal.	$EF_{TSP} = 35.6 \times (s)^{1.2} / (M)^{1.4}$	$EF_{PM_{10}} = 6.33 \times \left((s)^{1.5} / (M)^{1.4} \right)$	102	32.5	0.32	kg/h/vehicle	B
Bulldozer on material other than coal.	$EF_{TSP} = 2.6 \times (s)^{1.2} / (M)^{1.3}$	$EF_{PM_{10}} = 0.34 \times \left((s)^{1.5} / (M)^{1.4} \right)$	17	4.1	0.24	kg/h/vehicle	B
Trucks (dumping overburden).	See Appendix A Section 1.1.6	See Appendix A Section 1.1.6	0.012	0.0043	0.35	kg/t	U
Trucks (dumping coal).	See Appendix A Section 1.1.7	See Appendix A Section 1.1.7	0.010	0.0042	0.42	kg/t	
Drilling.	See Appendix A Section 1.1.8	See Appendix A Section 1.1.8	0.59	0.31	0.52	kg/hole	C
Blasting[3].	$EF_{TSP} = 0.00022 \times A^{1.5}$	$EF_{PM_{10}} = 0.000114 \times A^{1.5}$			0.52	kg/blast	C

Operation/Activity	TSP Equation	PM_{10} Equation	TSP	PM_{10}	PMR_{10}	Units	EFR

			Default Emission Factor	Default Emission Factor	PM_{10}/TSP Ratio based on Emission Factors		
Wheel and bucket[4]	$EF_{TSP} = 0.74 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	$EF_{PM_{10}} = 0.35 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	0.00032	0.00015	0.47	kg/t	C
Wheel generated dust from unpaved roads at industrial sites	$EF_{TSP} = \frac{0.4536}{1.6093} \times 4.9 \times \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	$EF_{PM_{10}} = \frac{0.4536}{1.6093} \times 1.5 \times \left(\frac{s}{12}\right)^{0.9} \times \left(\frac{W \times 1.1023}{3}\right)^{0.45}$	4.23	1.25	0.30	kg/VKT	B
Wheel generated dust from unpaved roads (used by light duty vehicles)	$EF_{TSP} = 1.69 \times \frac{(s/12) \times (S/48)^{0.3}}{(M/0.5)^{0.3}} - 0.0013$	$EF_{PM_{10}} = 0.51 \times \frac{(s/12) \times (S/48)^{0.5}}{(M/0.5)^{0.2}} - 0.0013$	0.94	0.33	0.35	kg/VKT	B
Scrapers (travel mode)	$EF_{TSP} = 9.6 \times 10^{-6} \times s^{1.3} \times W^{2.4}$	$EF_{PM_{10}} = 1.32 \times 10^{-6} \times s^{1.3} \times W^{2.4}$	2.08	0.52	0.25	kg/VKT	A
Scrapers (removing topsoil)	See Appendix A Section 1.1.13	See Appendix A Section 1.1.13	0.029	0.0073	0.25	kg/t	E
Graders	$EF_{TSP} = 0.0034 \times S^{2.5}$	$EF_{PM_{10}} = 0.0034 \times S^{2.0}$	0.19	0.085	0.31	kg/VKT	B
Loading stockpiles	See Appendix A Section 1.1.15	See Appendix A Section 1.1.15	0.004	0.0017	0.42	kg/t	U
Unloading from stockpiles	See Appendix A Section 1.1.15	See Appendix A Section 1.1.15	0.03	0.013	0.42	kg/t	U
Loading to trains	See Appendix A Section 1.1.15	See Appendix A Section 1.1.15	0.0004	0.00017	0.42	kg/t	U
Miscellaneous transfer points (including conveying)	$EF_{TSP} = 0.74 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	$EF_{PM_{10}} = 0.35 \times 0.0016 \times \frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$	0.00032	0.00015	0.47	kg/t/transfer point	U
Wind erosion	See Appendix A Section 1.1.17 to 1.1.18	See Appendix A Section 1.1.17 to 1.1.18	0.4	0.2	0.50	kg/ha/h	U

Equipment		Emission Factor			Factors						Emission Controlled (kg/hr)			Total (T/Annum)		
Type	**Operation**	**TSP**	**PM10**	**Units**	**T/hr**	**Trips/hr**	**Trip km**	**Utilisation**	**Area (ha)**	**Control**	**TSP**	**PM10**	**PM2.5**	**TSP**	**PM10**	**PM2.5**
EX1800		0.025	0.012	kg/t	347						8.7	4.2	0.5	38.0	18.3	2.3
777D (90t)	Moving	4.23	1.25	kg/VKT	347	4	1.2			75%	4.9	1.4	0.2	21.4	6.3	0.8
	Dumping Overburden	0.012	0.0043	kg/t	289						3.5	1.2	0.2	15.2	5.4	0.7
	Dumping Product	0.012	0.0043	kg/t	58						0.7	0.2	0.0	3.0	1.1	0.1
D10		17	4.1	kg/hr/v				0.3			5.1	1.2	0.2	22.3	5.4	0.7
Grader		0.19	0.085	kg/VKT			1.2	0.3			0.1	0.0	<0.1	0.3	0.1	0.0
992 Loader		0.029	0.014	kg/t	58						1.7	0.8	0.1	7.4	3.5	0.4
773 Watercart		4.23	1.25	kg/VKT			1.2	2		75%	2.5	0.8	0.1	11.1	3.3	0.4
Wind Erosion		0.4	0.2	kg/ha/hr					1		0.4	0.2	<0.1	1.8	0.9	0.1
Export Truck		4.23	1.25	kg/VKT	167	4.175	1			75%	4.4	1.3	0.2	19.3	5.7	0.7
Drilling											4.20	0.04	0.01	18.4	0.2	<0.1
Blasting											0.08	0.04	0.01	0.4	0.2	<0.1

The calculations for truck usage are based on 12 hours per day and 30 days per month.

Calculations Relating to Equipment

Dump Truck Analysis	
Distance travelled by dump trucks per loop (km)	1.2
Number of trucks per hour	4
Road Truck Analysis	
Distance Travelled by per loop on site (km)	4.2
Number of trucks per hour	4.2
Grader analysis	
Number of graders	1
Average speed (km/h)	15
Operating hours per month	130
Bulldozer analysis	
Number of bulldozers	2
Equipment utilisation factor	30%
Operating hours per month	108
Wind erosion analysis	
Actively worked areas (ha)	1
Drill & Blasting	
Holes drilled per hour	10
Area of blasting m^2	1000
Number of blasts per week	1

Appendix C – Noise and Vibration Assessment

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1 Introduction

Wulguru Technical Services (WTS) on behalf of Laneway Resources Pty Ltd, engaged Simpson Engineering Group (SEG) to prepare a noise and vibration assessment for a proposed metals mining project, Agate Creek Mine Expansion (the Project), 40km south of Forsayth in north Queensland.

The objective of this assessment is to inform the relevant aspects of Department of Environment and Science Guideline ESR/2015/1838 – Application requirements for activities with noise impacts.

This noise and vibration assessment addresses the following issues:

- likely change in noise environment following development of the mine;
- development of appropriate noise and vibration goals;
- assessment of noise at sensitive receptors and comparison to the noise and vibration goals; and,
- recommendations for relevant impact mitigation measures.

1.1 Project Description

The proposed mine is an expansion of the existing open pit and has a 10 year life 2022 to 2032. The mining will involve conventional excavator and haul trucks to create a pit and external waste dump. The mining fleet comprises 4 trucks, a 30 tonne excavators and associated plant. Road trains take the ROM ore directly to an off-site processing facility. The average production of ore is 0.25Mt. The mass of waste moved is approximately 1.25Mt per annum.

1.2 Locality Description

The project is situated in a well-established grazing and mining region. The region is undulating, generally comprising open grazing and native scrublands. The location of the Project is shown on Figure 1. The closest community is Forsayth, situated to the NE of the site. Forsayth is service centre for the farming, mining and tourist industry. The area to the west of the site comprises the Rungulla Resources Reserve and the Rungulla National park. The national park comprises a wide range of sandstone formations, including outcrops of large, sculpted caves and pagoda-like sandstone features. The Agate Creek fossicking area is southwest of the site.

There is one dwelling 8 km NE of the project and another dwelling approximately 25 km NW of the site. It is understood the proponent has reached an agreement with the campground landowner to relocate the campground.

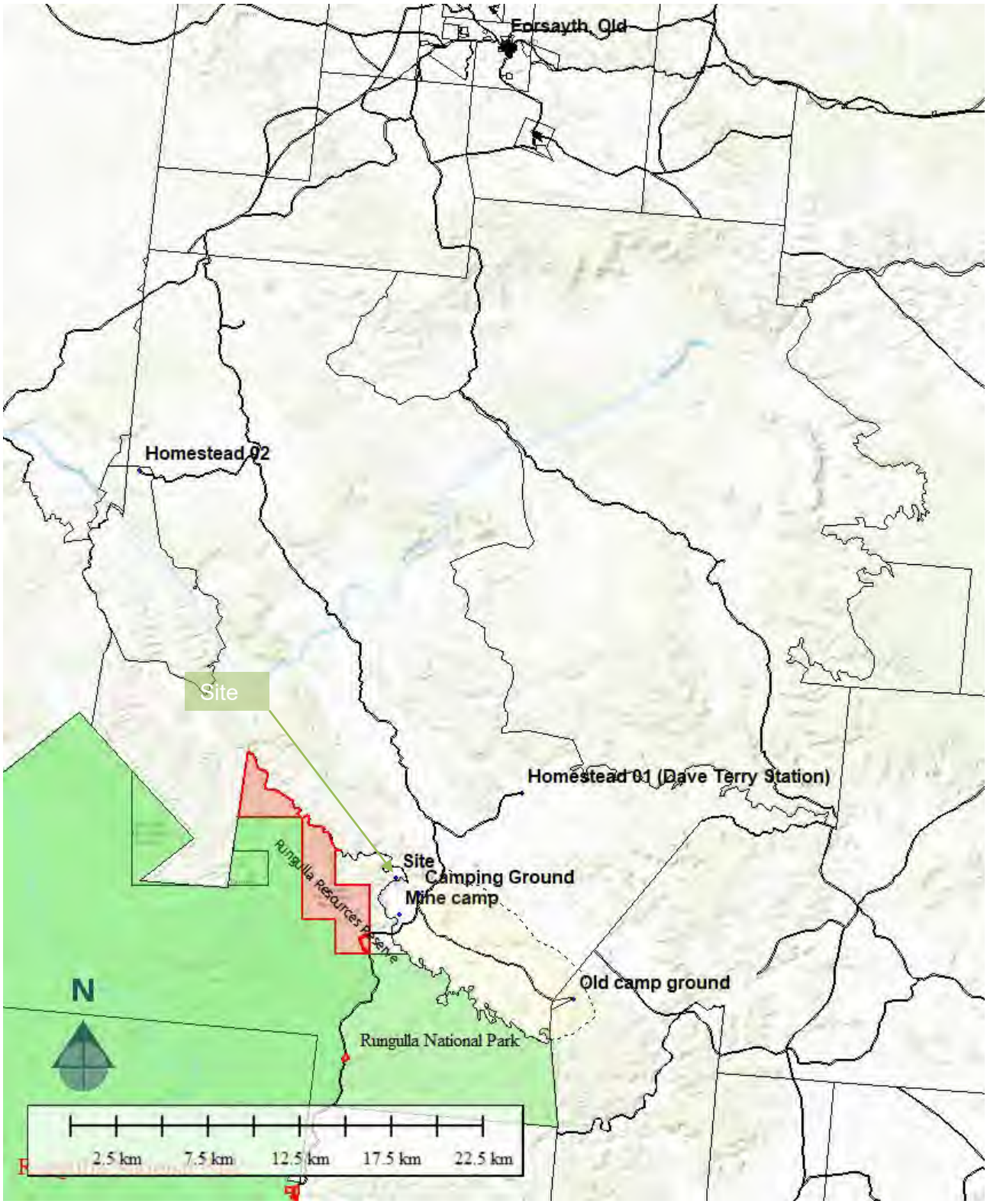

Figure 1: Regional View Showing the Project Area

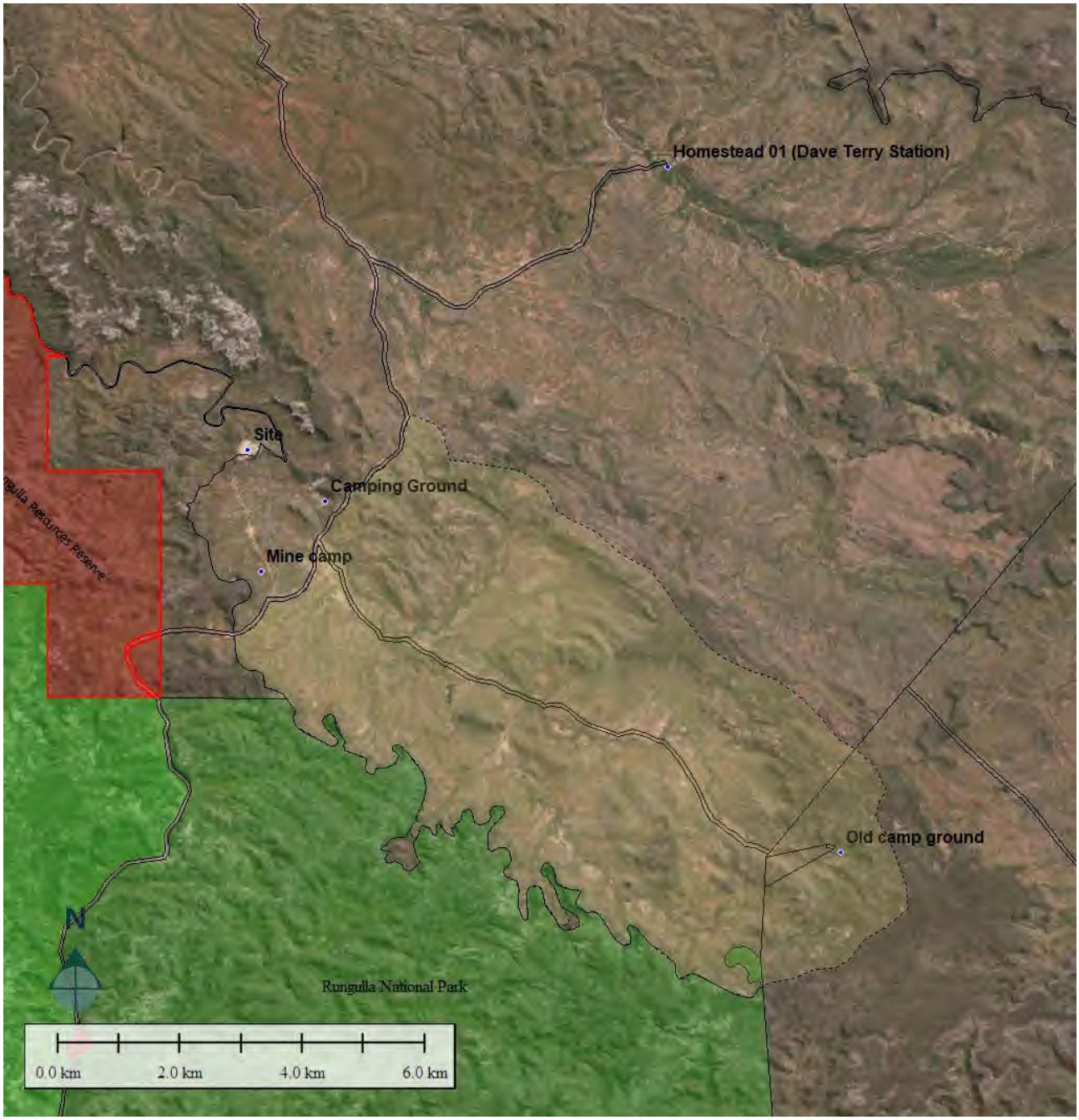

Figure 2: Site and Surroundings

2 Existing Noise Environment

The distance and bearing from the mine to identified sensitive receptors are contained in Table 1. Homestead 01 is identified as prime receptors due to it's proximity to the mine. The remaining receptors are secondary due to the large separation distances. The campground provides convenient camping location for people accessing the Agate Creek fossicking area. However it is understood the owner has been compensated to relocate the camping ground to a more distant location.

Table 1: Sensitive Receptors Surrounding the Mine

Receptors (Homesteads)	Distance [km]	Bearing (degrees)
Mine camp	1.9	175
Camping ground	1.5	120
Old Camp Ground	11	125
Homestead 01 (Dave Terry station)	8	55
Homestead 02	25	330
Forsayth	45	7

Noise level measurements have not been undertaken. The area is predominantly rural and is without significant human activity.

3 Noise and Vibration Criteria

3.1 ERS/2015/1838

The Guideline ESR/2015/1838 describes types of impacts that environmentally relevant activities can have in relation to noise, and outlines the information to be provided to the department as part of the ERA application process.

There are three key areas to be identified and addressed through the ERA application process:

- Identify the environmental values of the receiving acoustic environment including the identification of any nearby sensitive places.
- Identify the possible impacts due to the proposed activity and all associated risks to environmental values.
- Identify the strategies to mitigate the identified risks to the environmental values

It is necessary to identify the environmental values of the site including but not limited to:

1. Identify sensitive places
2. Provide a site description.
3. Provide details of a background noise survey.

The department seeks to determine possible impacts to identified environmental values. To assist with this the following information is sought:

1. Identify all noise, vibration, and air blast overpressure sources, including stationary and mobile sources, associated with the activity. Also provide a scaled map which shows the source of all noise emissions in relation to any existing noise sensitive places
2. Describe in detail, the characteristics of the noise emissions produced.
3. Describe how noise, vibration or airblast overpressure emissions will be avoided, minimised or otherwise managed in accordance with the noise management hierarchy provided in the EPP (Noise).

If it is not possible to mitigate the impacts associated with the noise emission, applicants are to provide a noise impact assessment, which identifies the likely effect of noise from the activity on nearby sensitive places and include:

- Noise modelling contour maps to show predicted noise levels at all potential noise source locations.
- Analysis on whether noise emissions associated with the activity will adversely affect the environmental values of the receiving environment (including noise sensitive places).
- Description of controls (e.g. noise emission limits or operational controls such as operating hours) which are appropriate to protect environmental values.
- A vibration risk assessment for blasting activities, if applicable.

- If blasting is to occur, that blasting activities will be managed in accordance with AS 2187: Explosives.

Due to the rapid growth and increasing density of noise-producing activities in Queensland, the consideration of cumulative noise impacts and background creep is particularly important. For applications where background creep is likely, applicants are encouraged to use modelling to demonstrate that the activity will, to the extent it is reasonable to do so, ensure that background creep in an area or place is prevented or minimised. If the acoustic quality objectives for an area or place are not being achieved or maintained, the noise experienced in the area or place must, to the extent it is reasonable to do so, be dealt with in a way that progressively improves the acoustic environment of the area or place.

3.2 Model mining conditions

The model mining conditions may be used as a basis for proposing environmental protection commitments in the application documents. They may also be used to expedite the process of developing appropriate conditions for an environmental authority for a mining project in consultation with the administering authority. The noise level limits are not linked to specific meteorological conditions; hence the limits apply for all meteorology.

Table D1 – Noise Limits

Sensitive Place						
Noise Level dB(A) measured as:	**Monday to Saturday**			**Sundays and Public Holidays**		
	7 am to 6 pm	**6 pm to 10 pm**	**10 pm to 7 am**	**7 am to 6 pm**	**6 pm to 10 pm**	**10 pm to 7 am**
$L_{Aeq, adj, 15m}$	CV=50 AV=5	CV=45 AV=5	CV=40 AV=0	CV=45 AV=5	CV=40 AV=5	CV=35 AV=0
$L_{A01, adj, 15m}$	CV=55 AV=10	CV=50 AV=10	CV=45 AV=5	CV=50 AV=10	CV=45 AV=10	CV=40 AV=5
Commercial Place						
Noise Level dB(A) measured as:	**Monday to Saturday**			**Sundays and Public Holidays**		
	7 am to 6 pm	**6 pm to 10 pm**	**10 pm to 7 am**	**7 am to 6 pm**	**6 pm to 10 pm**	**10 pm to 7 am**
$L_{Aeq, adj, 15m}$	CV=55 AV=10	CV=50 AV=10	CV=45 AV=5	CV=50 AV=10	CV=45 AV=10	CV=40 AV=5

Table D1 – Noise limits notes:

1. CV = Critical Value
2. AV = Adjustment Value
3. To calculate noise limits in Table D1:
If bg ≤ (CV – AV):
Noise limit = bg + AV
If (CV – AV) < bg ≤ CV:
Noise limit = CV
If bg > CV:
Noise limit = bg + 0
4. In the event that measured bg (LA90, adj, 15 mins) is less than 30 dB(A), then 30 dB(A) can be substituted for the measured background level
5. bg = background noise level (LA90, adj, 15 mins) measured over 3-5 days at the nearest sensitive receptor
6. If the project is unable to meet the noise limits as calculated above alternative limits may be calculated using the processes outlined in the "Planning for Noise Control" guideline.

Table 2: Limits Based on Assumed Background Noise Level

Sensitive Place						
Noise Level dB(A) measured as:	**Monday to Saturday**			**Sundays and Public Holidays**		
	7 am to 6 pm	**6 pm to 10 pm**	**10 pm to 7 am**	**7 am to 6 pm**	**6 pm to 10 pm**	**10 pm to 7 am**
$L_{Aeq, adj, 15m}$	35	35	33	35	35	33
$L_{A01, adj, 15m}$	40	40	38	40	40	38
Commercial Place						
Noise Level dB(A) measured as:	**Monday to Saturday**			**Sundays and Public Holidays**		
	7 am to 6 pm	**6 pm to 10 pm**	**10 pm to 7 am**	**7 am to 6 pm**	**6 pm to 10 pm**	**10 pm to 7 am**
$L_{Aeq, adj, 15m}$	40	40	38	40	40	38

Airblast overpressure nuisance

The model mining conditions for blasting has limits for peak particle velocity and air blast overpressure, described in Table D2 - Blasting noise limits.

Table D2 – Blasting Noise Limits

Blasting noise limits	**Sensitive or commercial place limits**	
	Monday to Friday 6 am - 6 pm **Saturday 6 am – 6 pm**	**Sundays and public holidays**
Airblast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time	either no blasting or limits justified by proponent not less stringent than 7am – 6pm
Ground vibration peak particle velocity	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	either no blasting or limits justified by proponent not less stringent than 7am – 6pm

Typical conditions for Sunday and public holidays may include references such as “No blasting will occur on Sundays or Public Holidays without notification to sensitive receivers”.

3.3 Environmental Protection Act 1994

The objective of the EP Act is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends.

The EP Act states a person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm. This is termed the 'general environmental duty'.

Environmental harm is defined as any adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value, and includes environmental nuisance.

The noise level goals for operations may be determined from the *Environmental Protection (Noise) Policy 2019* (EPP (Noise) 2019). The EPP (Noise) 2019 came into effect on 1 Sept 2019.

The purpose of the EPP(Noise) is to achieve the objects of the Act and achieved by:

a) identifying and declaring the environmental values of the acoustic environment; and
a) stating acoustic quality objectives that are directed at enhancing or protecting the environmental values; and
b) providing a framework for making consistent, equitable and informed decisions that relate to the acoustic environment.

The environmental values to be enhanced or protected under the EPP(Noise) are:

(a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and
(b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following-
    a. sleep;
    b. study or learn;
    c. be involved in recreation, including relaxation and conversation; and
(c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

There are two main considerations namely:

1. Acoustic quality objective (noise levels that are conducive to human health and well-being, ensuring a suitable acoustic environment for individuals to sleep, study or learn, be involved in recreation, including relaxation and conversation; and preserve the qualities of the acoustic environment that are conducive to protecting the amenity of the community); and
2. Management Intent

3.3.1 Acoustic Quality Objectives

The 'Acoustic Quality Objectives' seek to protect the amenity of an acoustic environment. The indoor night-time goals effectively address sleep disturbance and sleep awakenings, while during the day it protects conversation. It should be noted that these are not strictly design limits for individual sources but objectives that are considered to provide acceptable health and wellbeing for the community.

The acoustic quality objectives are expressed as indoor noise level goals for dwellings at Night (10 pm to 7 am) and outdoor noise level goals during the Day (7 am to 6 pm) and Evening (6 pm to 10 pm. These objectives are all contained in Table 3.

The indoor noise quality objective for dwellings is converted to an outdoor noise level by conservatively assuming that the windows of the dwellings are wide open. The equivalent external noise levels (for the dwelling indoor noise level goals in Table 3) measured at least 4 m from the dwelling would be 5 dB higher (to allow for the reduction of noise through the building envelope).

Table 3: Acoustic Quality Objectives for Dwellings and Other Receivers Relevant to the Project during the Day (7 am to 6 pm), Evening (6 pm to 10 pm) and Night (10 pm to 7 am).

Location	**Time of Day**	**Acoustic Quality Objectives (Measured at the receptors) dB(A)**			**Environmental Value**
		$L_{Aeq, adj, 1 hr}$	$L_{A10, adj, 1 hr}$	$L_{A1, adj, 1 hr}$	
Dwelling outdoors	Daytime & evening	50	55	65	Health and wellbeing
Dwelling indoors	Daytime & evening	35	40	45	Health and wellbeing
Dwelling indoors	Night-time	30	35	40	Health and wellbeing, in relation to the ability to sleep
School or playground outdoors	When the children usually play outside	55	-	-	Health and wellbeing, and community amenity
Protected area or critical area	anytime	The level of noise that preserves the amenity of the existing area or place			Health and biodiversity of ecosystems

Source: EPP (Noise) 2019

3.3.2 Managing Intent For Noise

It is intended that noise from an activity that affects or may affect an environmental value to be enhanced or protected under the EPP(Noise) be appropriately managed.

To the extent it is reasonable to do so, noise must be dealt with in a way that ensures-

a) the noise does not have any adverse effect, or potential adverse effect, on an environmental value under this policy; and
b) background creep in an area or place is prevented or minimised.

In the situation where existing noise levels exceed the Acoustic Quality objectives, to the extent it is reasonable to do so, noise at that sensitive place must be dealt with in a way that progressively improves the acoustic environment of the area or place.

Background creep, for noise in an area or place, is described as a gradual increase in the total amount of background noise in the area or place.

The EPP(Noise) does not provide any guidance nor limits regarding how to address background creep.

However, the guiding principles are:

i. Background creep in an area is to be prevented or minimised
ii. Any control requirements are to be reasonable

Background creep can be prevented by ensuring the noise from activity is always below the background noise level. However, this may be excessively onerous for many situations. The EPP(Noise) does not include any guidance regarding how to assess “reasonable” noise control. A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements. Selecting reasonable measures from those that are feasible involves making a judgement to determine whether the overall noise-reduction benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the noise abatement measure. To make such a judgement, consideration may be given to aspects such as noise level impacts, noise mitigation benefits, cost effectiveness and community views.

3.4 Sleep Disturbance WHO Guidelines

Research has shown that the ability to get to sleep and, when asleep, the probability of experiencing a change of sleep state or ultimately of awakening are related to both the ambient and maximum instantaneous noise levels at the ear of the sleeper and the number of events during the night time period (WHO 1999).

As a rule in planning for short-term or transient noise events, for good sleep over eight hours, the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45dBA maxLpA more than 10-15 times per night. According to Guideline Ecoaccess

Planning for Noise Control (EPA 2004), the corresponding external noise level, assuming partially closed windows, is 52dBA maxLpA (L_{Amax}), measured in the free field.

For larger number of events per night, the noise level goal is reduced by 10*log(Number of events/10). Hence if there are 100 events per night (over an 8 hour period) the external noise level goal would become 42 dB(A) free field.

3.5 DEHP Ecoaccess Guideline - Low Frequency Noise

The DEHP Ecoaccess Guideline “Assessment of Low Frequency Noise” identifies a number of industrial sources and processes having high noise levels and frequency content less than 200 Hz.

Industrial sources may exhibit a spectrum that characteristically shows a general increase in sound pressure level with decrease in frequency. Annoyance due to low frequency noise can be high, even though the dB(A) level measured is relatively low. Typically, annoyance is experienced in the otherwise quiet environs of residences, offices and factories adjacent to, or near, low frequency noise sources. Generally, low level/low frequency noises become annoying when the masking effect of higher frequencies is absent. This loss of high frequency components may occur as a result of transmission through the fabric of a building, or in propagation over long distances.

Where a noise emission occurs exhibiting an unbalanced frequency spectra, the overall sound pressure level inside residences should not exceed 50 dB(Linear) to avoid complaints of low frequency noise annoyance.

3.6 Blasting Criteria

Open cut coal mining procedures often include drilling and blasting of overburden material above the coal to make removal of that material easier.

According to the DEHP Ecoaccess Guideline "Noise and Vibration From Blasting" (DERM, 2004), blasting for the mining industry should generally be limited to the hours of 7:00 am to 6:00 pm.

Blasting outside these recommended times should be approved only where:

a) blasting during the preferred times is clearly impracticable (in such situations blasts should be limited in number and stricter airblast overpressure and ground vibration limits should apply); or
b) there is no likelihood of persons in a noise-sensitive place being affected because of the remote location of the blast site.

Blasting activities must be carried out in such a manner that if blasting noise should propagate to a noise-sensitive place, then:

a) the airblast overpressure must be not more than 115 dB(linear) peak for 9 out of any 10 consecutive blasts initiated, regardless of the interval between blasts; and
b) the airblast overpressure must not exceed 120 dB(linear) peak for any blast.

Blasting operations must be carried out in such a manner that if ground vibration should propagate to a vibration-sensitive place:

a) the ground-borne vibration must not exceed a peak particle velocity of 5 mm per second for nine out of any 10 consecutive blasts initiated, regardless of the interval between blasts; and,

b) the ground-borne vibration must not exceed a peak particle velocity of 10 mm per second for any blast.

3.7 Road Traffic Noise Goals

Queensland Department of Transport and Main Roads (QDMR) is responsible for setting noise level limits from road traffic on public roads in Queensland. Typically, the planning goals for roads are met close to the road, i.e. distances up to about 30 m or thereabouts. There are no criteria in Queensland to assess the impact of noise from a road traffic-generating development. However, for existing roads with regular traffic an increase of 3 dB(A) over a short period of time is considered to be a significant increase in traffic noise and an increase which justifies consideration of noise control.

Since there are not any dwellings adjacent to public roads accessing the site, road traffic impacts on public roads will not be considered further.

3.8 Summary of Noise Goals

Model License Conditions

The model license conditions are a composite the two considerations contained (Acoustic quality objectives and background creep) of the *Environmental Protection (Noise) Policy 2019* (EPP (Noise) 2019), assuming a time varying noise source. The model license conditions also include reference to the Planning for Noise control document to develop alternate goals in the event that the project is unable to meet the model noise level goals. These goals apply to mining noise.

Application of Low Frequency Noise Goals

It is possible that, due to the propagation of noise over the large separation distances between the source of noise and the receiver, a loss of high frequency components may occur. Thus, the low frequency noise goal of 50 dB(Linear) applies at noise sensitive receptors. This goal applies to mining noise.

Application of Blasting Limits

The blasting goals apply and it is proposed to carry out the assessment with typical blasting charge weights.

Application of Sleep Disturbance Goals

The maximum noise level from mining during the night is an L_{Amax} of 42 dB(A) free field, on the assumption that the maximum noise levels occur approximately 100 occasions per 8 hour night.

A summary of the noise and vibration goals for this project is contained in Table 4.

Table 4: Summary of Noise and Vibration Goals (free-field)

Location	**Time Period**	***Monday to Saturday Mining***		***Sundays and Public Holidays Mining***		**Low Frequency Noise Limit [dB]**	**Blasting to Avoid Annoyance at Sensitive Receptors**	
		$L_{Aeq,\ adj,\ 1\ hr}$ ***[dB(A)]***	$L_{A01,\ adj,\ 1\ hr}$ ***[dB(A)]***	$L_{Aeq,\ adj,\ 1\ hr}$ ***[dB(A)]***	$L_{A01,\ adj,\ 1\ hr}$ ***[dB(A)]***		**Noise [dBLin Peak]**	**Vibration PPV [mm/s]**
All Residential Receptors	Day	*35*	40	35	40	50	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB(Linear) Peak at any time	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time
	Evening	35	40	35	40	50		
	Night	33	38	33	38	50		
Commercial Receptors	Day	40	-	40	-	-		
	Evening	40	-	40	-			
	Night	38	-	38	-			

Note: No blasting to occur on Sundays or Public Holidays without notification to sensitive receptors

4 Predicted Noise Levels

4.1 Modelling Methodology

A digital terrain noise model of the site and surroundings has been developed using PEN3D software. The PEN3D General Prediction Model (GPM) is based on the method contained in a book by Bies and Hansen (1988, pages 117, 127). The implementation is a more complex variation of the approach to sound propagation described in Concawe (1981). Concawe is one of the most commonly used methodologies to predict outdoor noise propagation from industrial sites. PEN3D also draws on aspects from ISO 9613-2. The PEN3D software was originally developed in 1993 and has been in constant development and review. The basic equation adopted by the GPM is:

$$Lp = Lw - 20 \log_{10}(r) - 10\log_{10}(4\pi) + AE$$

Where:

Lp is the sound pressure level at an observer

Lw is the sound power level of the source, in octave bands from 63 Hz to 8 kHz

$20 \log_{10}(r) + 10\log_{10}(4\pi)$ is the distance attenuation (spherical)

AE is the excess attenuation factors.

The excess attenuation factors AE comprise:

$$AE = Aa + Ag + Am + Ab + Af$$

Where:

Aa = Excess attenuation due to air absorption from Sutherland *et. al*. (1974)

Ag = Excess attenuation due to ground reflection

Am = Excess attenuation due to meteorological effects

Ab = Excess attenuation due to barriers

Af = Excess attenuation due to forests.

PEN3D is a sophisticated environmental noise model incorporating a 3D terrain model that permits accurate representation of the ground, ground cover, tree zones, mounds, barriers and weather conditions. PEN3D calculates a curved noise path based on surface friction, vertical temperature gradients and wind speed. All the noise calculations are based on this curved path. A finite differences approximation method is used to calculate the curved path. The curvature of the path determines the meteorology corrections. The meteorology corrections are frequency and distance dependent and are limited to +12 dB (downwind at night) and –7 dB (upwind and during the day) similar to the Concawe Category 1 and Category 6 meteorological corrections.

The excess attenuation due to ground reflection is obtained by combining the direct wave and the reflected wave incoherently, that is the energy from the ground wave is added to the direct wave. The ground reflection attenuation (or ground effects) will be between 0 and –3 dB (a negative value is an increase in noise levels) for all cases. This contrasts with the coherent reflection approach. The coherent approach is considered to be an “exact” method. For those situations where the source and receiver are located close to the same very hard reflecting plane and the path difference between the direct path and the reflected path is small, then the addition of the reflected wave and the direct wave will result in 6 dB increase rather than a 3 dB increase. However, at large distances the sound pressure level reduces at 12 dB per doubling with the coherent model (not 6 dB as per the incoherent model). This approach, while “exact”, is dubious as Digital Terrain Models (DTM) models are neither of sufficient accuracy nor can noise models truly account for the effects of atmospheric turbulence. Other methods such as the Nordic method or ISO 9613-2 divide the region between the source and receiver into three zones, and those zones closest to the source and to the receiver can potentially have higher absorption values. Consequently, if a noise source was measured say at a distance of 30 m and the sound power level is calculated by the commonly adopted formula PWL = SPL + $10\log10(2\ \pi\ r^2)$ then the calculations using the PEN3D methodology would remain conservatively high for all distances.

The ground reflection (or ground effects) is a complex calculation using the flow resistivity for the surface likely to provide the ground reflection and the likely angle of incidence of the reflected wave to the ground. In those instances where the ground is highly absorptive the excess correction will approach zero. For those surfaces which are highly reflective the correction will be - 3dB, i.e. will lead to an increase in noise levels of 3 dB(A) (simulates hemispherical propagation).

While there are numerous methods to calculate ground effects (some of which provide significant attenuation [reduction of noise levels]), the PEN3D implementation is one of the more conservative estimates of ground effect in the far field. Bies & Hansen (1988) indicate “as the distance from the source or frequency increases, the incoherent model will become more appropriate”.

The theoretical approach to meteorology implies that PEN3D is likely to provide more significant corrections than other models. Thus, at night or during downwind predictions, the PEN3D calculations are likely to result in conservatively high results, i.e. the modelled noise levels are likely to be higher than the measured levels.

The likely barrier attenuations are calculated for four possible curved paths, namely:

- source, to the top of barrier then to the receiver;
- source, reflection from ground (source side), top of barrier, receiver;
- source, top of barrier, reflection from ground (receiver side), receiver; and
- source, reflection from ground (source side), top of barrier, reflection from ground (receiver side), receiver.

These are combined to obtain effective barrier attenuation. In the situation where the source and receiver are well above the ground and the barrier just intercepts line-of-sight then the barrier effect will be 5 dB(A). However, if the source and receiver are close to the ground and the noise barrier just intercepts line of sight (a pebble) the barrier effect will tend to zero.

Once the most likely curved path has been calculated, the method determines if it intercepts any tree zones within the digital terrain model. If the curved noise path travels in the lower 75% of the tree zone then the full excess attenuation is applied for the distance travelled in the tree zone. If the curved noise path travels in the upper 25% of the tree zone then:

a) the average propagation height is determined;
b) the length in the zone is determined; and,
c) the forest excess attenuation is taken to be linearly interpolated between zero at the top of the tree zone and full excess attenuation at 75% height.

Tree zones can potentially provide extremely high attenuation if the tree coverage is large. However, in practice, the curved path adopted in the PEN3D methodology usually results in the noise rays passing above tree zones (at night or during downwind conditions) and only intercepting tree zones if they exist on the tops of hills or whenever the noise ray approaches the ground. Tree zones can potentially provide higher than expected attenuation during calm neutral conditions.

4.2 Meteorology

The meteorology for the site has been analysed to address frequent wind speeds, wind directions and inversions. The meteorology was prepared for the Air Quality Assessment (SEG 2021) and is based on a 5-year modelling simulation, years 2016 to 2020.

4.2.1 Temperature Inversions

The total night-time period during winter (June, July and August) has been analysed to determine the frequency of inversions, as presented in Table 5. Temperature inversions generally occur during the night-time and early morning periods. The likelihood of inversions reduces with wind speed. It was determined that inversions are likely 51% of the time. This indicates that modelling during inversion conditions is appropriate. However, since the terrain is essentially flat without any dominant (katabatic) drainage flows it is not necessary to include a wind component. The wind direction analysis confirmed that the light winds at night are evenly distributed with direction.

It is proposed to model inversions with the following parameters:

- 3 degrees Celsius (°C)/100 m temperature inversion strength
- Zero wind speed
- Air temperature 10ºC.

Table 5: Inversion Analysis June to August (6 pm to 7 am)

Wind speeds	Percentage of Time Occurring (%)
Calms	1
Winds less than 1m/s	2
Wind 1 to 2 m/s	12
Wind 2 to 3 m/s	23
Wind 3 to 4 m/s	32
Wind 4 to 5 m/s	22
Wind over 5 m/s	10

4.2.2 Wind Effects

Wind effects are typically assessed when wind is a feature of the area. Wind is a feature when source-to-receiver wind speeds (at 10 m height) of 3 m/s or below occur for 30 percent of the time or more in any assessment period (day, evening, night) in any season. This differs from the procedure used with temperature inversions, in that the 30 percent occurrence applies to all seasons and each assessment period–and not just the winter season and night/early morning assessment period.

The wind direction and wind speeds were analysed to determine whether wind effects need to be considered. For this analysis, the wind speed was limited to 3 m/s since higher wind speeds tend to increase the ambient noise. Each season and each time period (day, evening and night) was analysed and winds were not found to occur more than 30 percent of the time in any direction. It is noted however than easterly winds are common throughout the year and as a consequence a single wind case at night has been included in the noise model.

The modelling cases adopted in Table 6 are based on the wind distribution.

Table 6: Meteorology Modelling Cases Assessed

Case	Wind speed [m/s]	Wind Direction [degrees from North]	Vertical Temp Profile [ºC/100 m]	Air Temp [ºC]
Day	0	0	-3	25
Evening (Neutral)	0	0	0	15
Night (Inversion)	0	0	3	10
Night west wind	3	225	1	10

4.3 Noise Model Parameters

The DTM of the Project has been based on NASA Shuttle Radar telemetry and contoured at 5m intervals for a zone approximately 1.5km from the site. The remaining DTM is contoured at 20, intervals. The noise model has an adopted ground cover of 'thick grass' as a representation of the combination of the roughness provided by pasture and the taller vegetation that exists throughout the region. The model dose not incorporate excess attenuation factors associated with tree zones.

The operational noise sources comprise:

- loaders operation in the pit;
- dozers;
- rock drill;
- blasting;
- dump trucks (in-pit); and
- various surface earth working machines.

The $L_{Aeq(60\ min)}$ equipment noise levels are contained in Table 7. The noise levels are expressed as a sound power level. The overall sound power levels are "A" weighted. The "A" weighting emulates the way the human ear responds to sound. These noise levels are based on measurements by SEG and published data. Refer to Table 7 for equipment for the modelling case.

All the noise sources have been placed in typical operating positions in the noise model. For instance, the route of the overburden trucks encompasses the haul roads as well as the waste rock emplacement. This are typically elevated positions and completely or partially unscreened by nearby terrain. In practice, an operational mine may choose to operate trucks at night in positions that are screened by stockpiles or waste rock emplacements, and consequently noise reductions are likely to be significantly improved compared with the modelled case.

Table 7: Sound Power Levels ($L_{Aeq(1\ hr)}$) in dB(A) for major fleet with source of data

Fleet Item	SWL $L_{Aeq(1\ hr)}$ dB(A)	Project	Source	Number of Plant
Mining Excavator				
Hitachi EX1800	115	Ensham central Mine	Bassett (2006)	1
Haul Truck				
CAT 789	115	Millenium Mine	Site measurements (2006)	4
Dozer				
CAT D10	111	Baralaba North (2013)	SEG (2012)	1
Grader				
CAT 16M	109	Baralaba North (2013)	SEG (2012)	1
Water Truck				
Komatsu HD785 Water Truck	114	Moolarben Coal Mine	Global Acoustics (2012)	1
Other				
Production Drill	116	Duralie Coal Mine	SLR Consulting (2014)	1
Diesel Generator	109	Estimated	Estimated from library data	1

The noise sources are positioned as follows:

- excavators 5 m above local terrain; and,
- haul trucks, dozers, graders, production drill and other mobile sources at 4 m above local terrain.

There are several items of minor mining plant not included in Table 7. Minor noise sources are comparatively quiet or operated infrequently. The exclusion of this plant from the noise model will not make a noticeable difference in the calculated noise levels at sensitive receptors. In addition, it has been found that the model is relatively insensitive to operating height of the equipment since the model calculates a curved path through the air and for downwind or inversion cases the curved path passes above most obstructions.

Blasting

PEN3D contains a blasting module that includes the effects of meteorology. The basic equations were originally developed and verified for Collinsville coal mine in central Queensland. The basic equation for blast overpressure is:

dBL = 20*log(3557/0.00005) – 20*1.26*log(Distance) + 20 * 1.268 3* log(MIC) + 3

The proponent indicated the maximum instantaneous charge weight has benn nominated to be 1700 kg. For a maximum instantaneous charge weight of 1700 kg, the blast overpressure at 1000 m is 120 dB Lin peak.

For vibration, the peak particle velocity in mm/s is:

V = 2000*(Distance/(MIC)^0.5)^-1.6

For a maximum instantaneous charge weight of 1700 kg, the peak vibration velocity at 1000 m is 12.2 mm/s. This assessment is based on a charge weight of 1700 kg.

4.4 Noise Modelling Results

A noise model has been developed for the one mining stages for the fully operational project representing the peak overburden production of the mine. All the noise models are to obtain the $L_{Aeq(1\ hr)}$. Each item of equipment goes through a repeating short duration cycle representative of operations. The L_{Aeq} noise model incorporates the fluctuating noise levels to obtain the L_{Aeq} at the receiver. This is a mathematically correct analysis as it is independent of the time the noise is generated. However, it is also a conservative methodology as it requires the meteorology to remain constant for the entire hour (i.e. it ignores the small variations in a turbulent atmosphere that lead to variations of actual noise level below the calculated noise level).

Table 8 contains the calculated $L_{Aeq(15\ min)}$ noise levels at the sensitive receptor for all modelling cases in tabular format, Appendix B contains the noise contour diagrams. The results are summarised for the day, evening and night periods. The $L_{eq(15\ min)linear}$ low frequency noise levels are contained in Appendix C. The L_{Amax} is calculated by the noise model and is taken to be the noisiest individual noise source logarithmically added to the calculated L_{Aeq} for all noise sources combined.

The shorter duration modelling period (15 min) can be readily applied to the longer (1 hour) averaging time period without loss of accuracy.

Table 8: Predicted Noise Level at Sensitive Receptors

Location	Time Period	*Monday to Saturday* *Mining Noise*		*Sundays and Public Holidays* *Mining Noise*		Low Frequency Noise [dB]	Blasting to Avoid Annoyance at Sensitive Receptors	
		$L_{Aeq,\ adj,\ 1\ hr}$ *[dB(A)]*	$L_{A01,\ adj,\ 1\ hr}$ *[dB(A)]*	$L_{Aeq,\ adj,\ 1\ hr}$ *[dB(A)]*	$L_{A01,\ adj,\ 1\ hr}$ *[dB(A)]*		Noise [dBLin Peak]	Vibration PPV [mm/s]
All Residential Receptors	Day	*35*	40	35	40	50	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB(Linear) Peak at any time	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time
	Evening	35	40	35	40	50		
	Night	30	35	30	35	50		
Commercial Receptors	Day	40	-	40	-	-		
	Evening	40	-	40	-			
	Night	35	-	35	-			
Homestead 01	Day	<thh	<thh	<thh	<thh	18	100	0.05
	Evening	8	12	8	12	20	-	-
	Night	18	23	18	23	36	-	-
	Night (with Wind)	21	26	21	26	38	-	-
Old camp ground	Day	<thh	<thh	<thh	<thh	16	98	0.05
	Evening	<thh	<thh	<thh	<thh	17	-	-
	Night	16	20	16	20	30	-	-
	Night (with Wind)	20	27	20	27	32	-	-

Note <thh represents a noise level below the threshold of human hearing

5 Assessment of Modelled Noise Levels

Operational Noise Assessment

The noise from the operation of the mine is expected to readily comply with the proposed operational environmental goals (L_{Aeq}, L_{A01}) at all Homesteads and sensitive receptors.

EA Blasting Objectives

The blast over pressure and blast vibrations from the blasting at the min (MIC of 1700kg) mine is expected to readily comply with the proposed environmental goals at all Homesteads and sensitive receptors.

Low Frequency Noise Objectives

The low frequency noise from the operation of the mine is expected to comply with the proposed environmental goals at all Homesteads and noise sensitive receptors.

5.1 Mitigation Measures

It is not necessary to provide any mitigation measures, other than the normal practices to maintain all equipment in good serviceable condition.

6 Conclusions and Recommendations

The assessment of the Project has been based on a conservative modelling methodology.

Initially the meteorology for the site was assessed in detail to determine whether inversions and/or winds were likely to be frequent for the site. It was determined that inversions are frequent in winter. Assessment of wind occurrence indicated that adverse winds occur during the evening and night.

The likely noise levels from operating equipment has been robustly established based on measurements obtained by SEG and from numerous published sources in the public domain. The likely noise emissions were also compared with measurements from similar equipment from other manufacturers to ensure that noise levels were accurate and appropriate.

The DTM map for the site and surroundings was based on NASA shuttle radar mission. The adoption of these contours provides the major features without over emphasising possible noise screening effects of smaller landforms.

One modelling case was adopted representing the peak overburden production and this is conservative for the entire open pit mining phase.

The model mining conditions were adopted as the appropriate goals for the proposal.

It was found that the noise and vibration goals are expected to be easily met at all sensitive receptors during the proposed mining phase.

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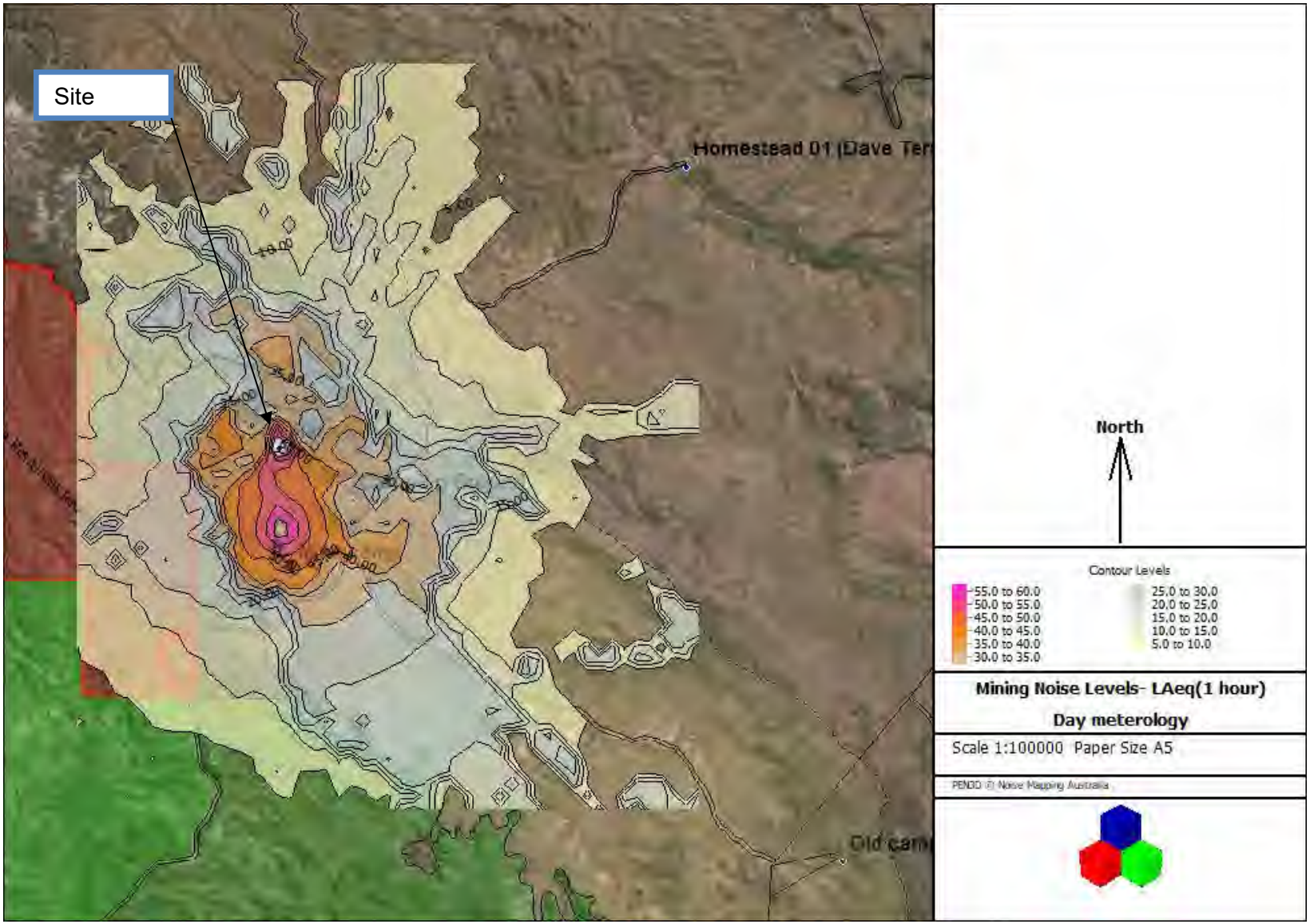
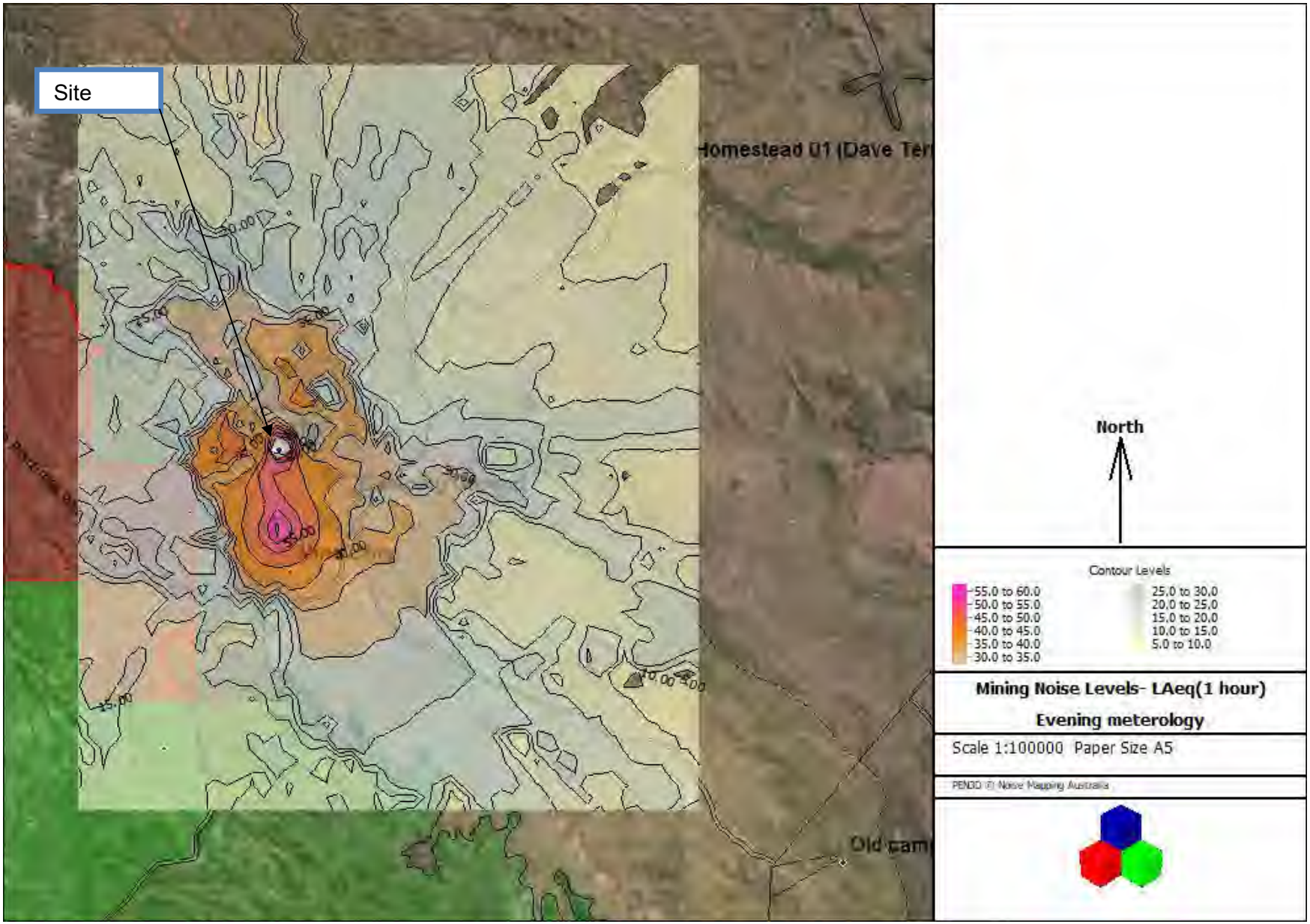
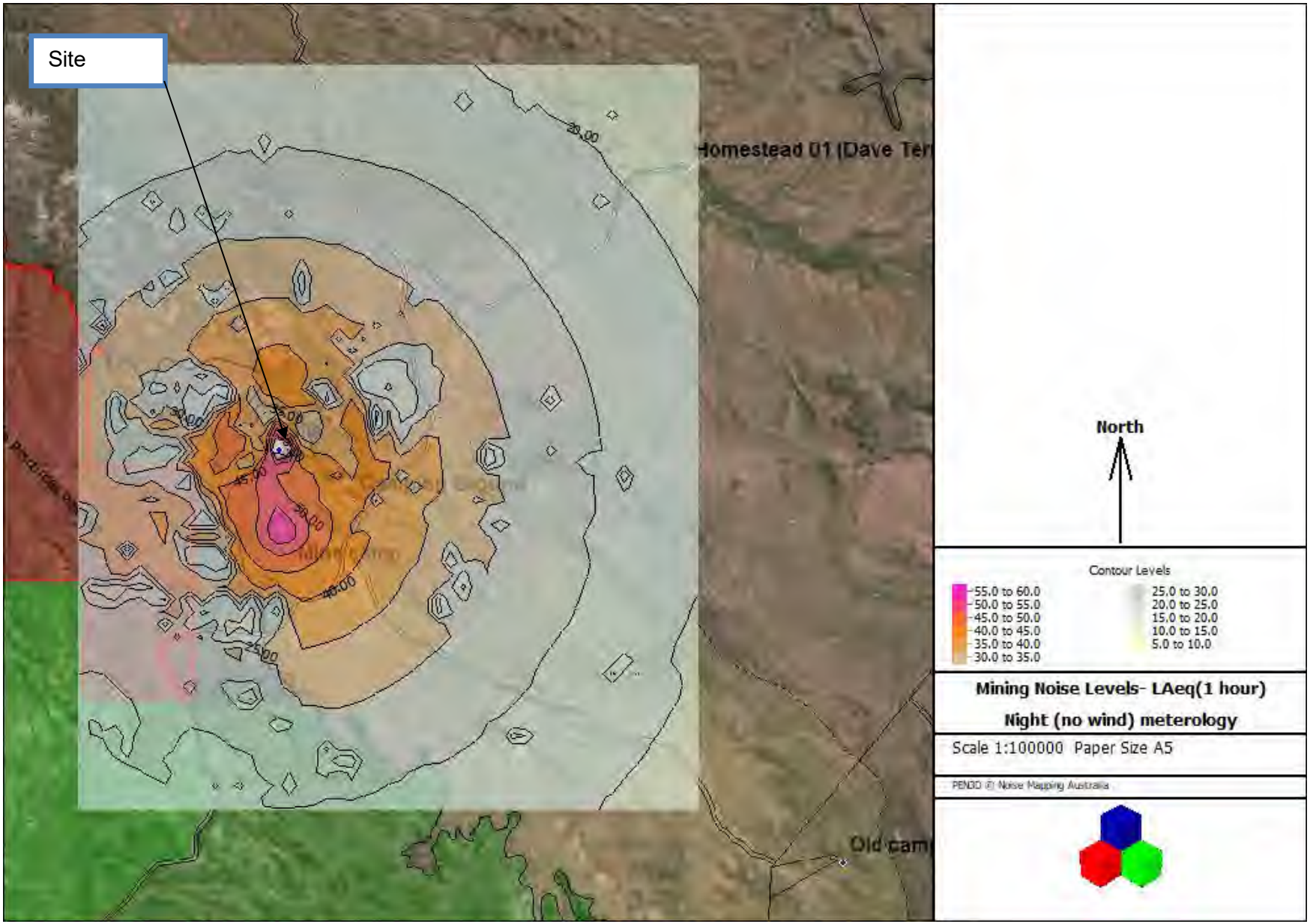
Appendix A: Sound Power Level Details

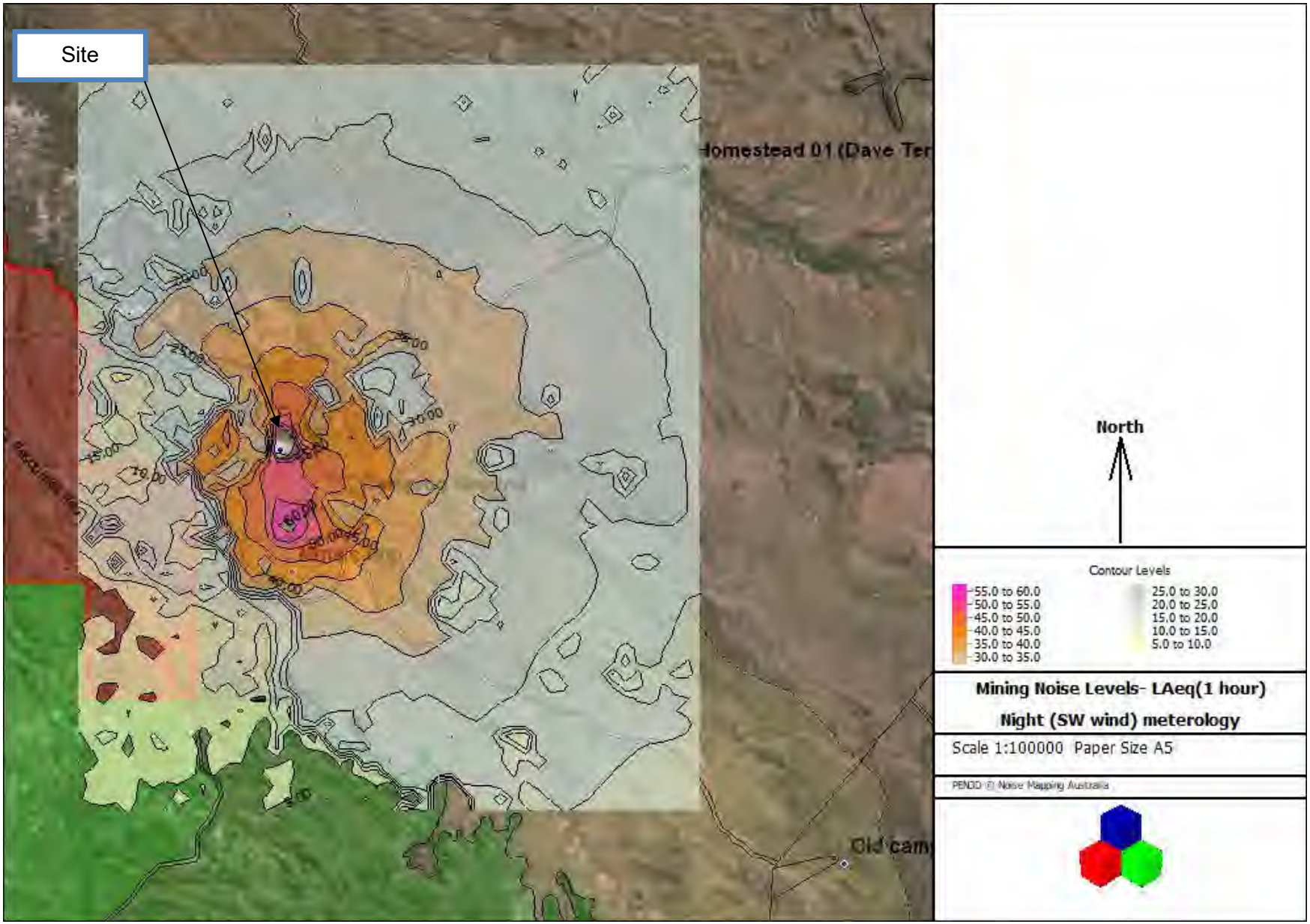
Plant	Octave dB Sound Power Levels in dB at Octave band Hz								Totals	
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**dB(A)**	**dB(Z)**
Mining Excavator										
Hitachi EX1200	96.8	103.9	109.9	112.6	111.9	113.6	107.3	100.8	**118.7**	118.9
Hitachi EX1800	116	117	110	113	111	106	102	99	**115.0**	121.0
30t Excavator	96.0	100.0	97.0	98.0	99.0	100.0	90.0	91.0	**103.0**	105.0
Haul Truck										
CAT 789	99.4	109.3	112.1	109.9	111.9	115.4	110.0	102.7	**112.6**	119.9
Dozer										
CAT D10	104.8	112.6	106.3	111.9	104.4	101.1	97.8	95.9	**111.3**	116.6
Grader										
CAT 16M	110.7	105.9	104.6	103.3	105.0	101.6	98.4	96.8	**109.0**	114.2
Water Cart										
Komatsu HD785 Water Truck	106.0	110.0	107.0	108.0	109.0	110.0	100.0	101.0	**114.0**	116.6
Other										
Production Drill	108.0	114.0	114.0	113.0	110.0	108.0	103.0	98.0	**116.0**	120.0
Diesel generator	87	94	100	102	102	104	97	91	**109.0**	110
B-Double road train	89.0	89.0	93.0	99.0	98.0	97.0	100.0	106.0	**108.0**	108.6

Appendix B: Calculated $L_{Aeq\ 1hr}$ Noise Levels Contour Diagrams

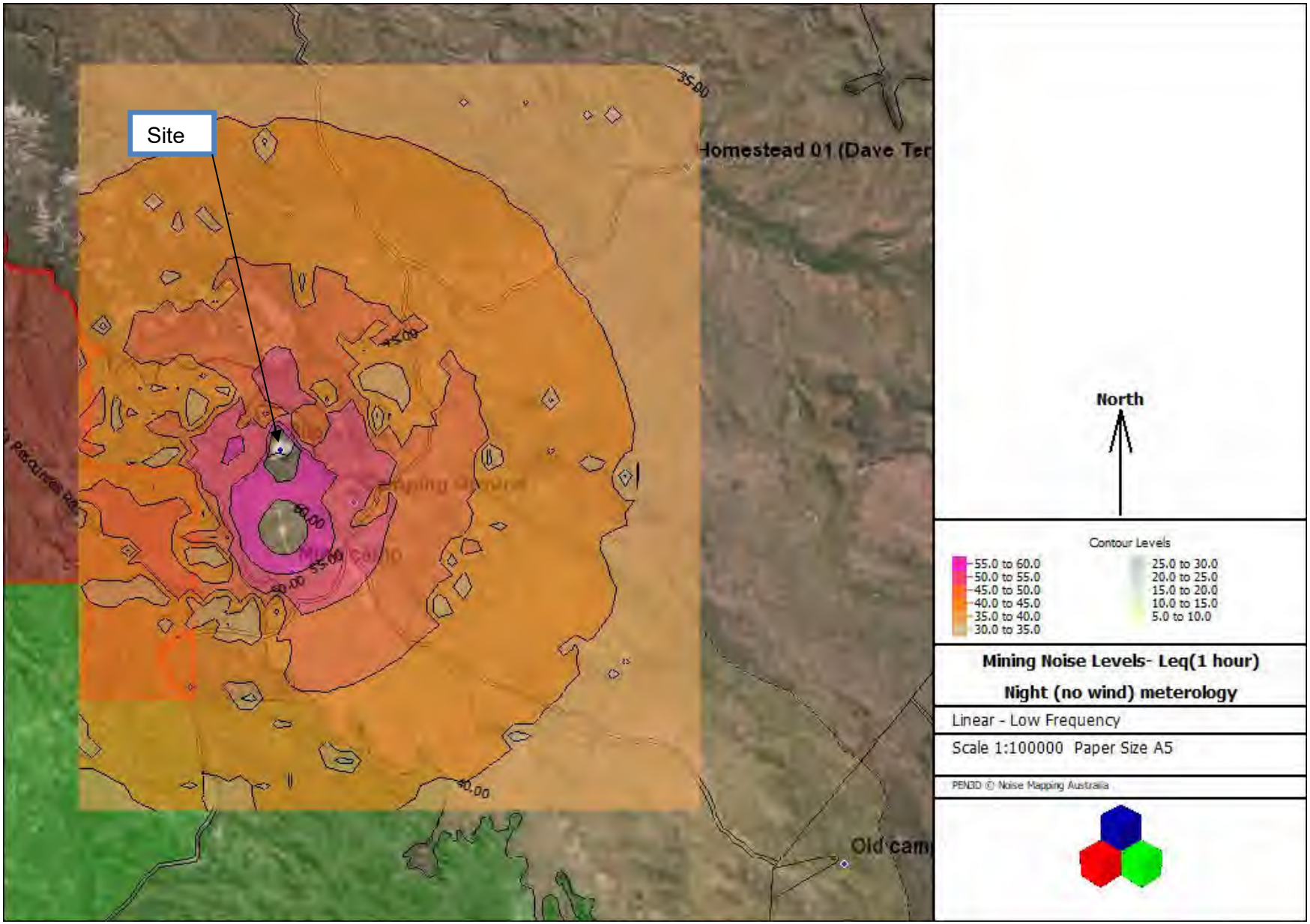

Site
Homestead 01 (Dave Ter
North
Contour Levels
55.0 to 60.0
50.0 to 55.0
45.0 to 50.0
40.0 to 45.0
35.0 to 40.0
30.0 to 35.0
25.0 to 30.0
20.0 to 25.0
15.0 to 20.0
10.0 to 15.0
5.0 to 10.0
Mining Noise Levels- LAeq(1 hour)
Day meterology
Scale 1:100000 Paper Size A5


Site
Homestead 01 (Dave Ter
North
Contour Levels
55.0 to 60.0
50.0 to 55.0
45.0 to 50.0
40.0 to 45.0
35.0 to 40.0
30.0 to 35.0
25.0 to 30.0
20.0 to 25.0
15.0 to 20.0
10.0 to 15.0
5.0 to 10.0
Mining Noise Levels- LAeq(1 hour)
Evening meterology
Scale 1:100000 Paper Size A5
PENDO © Noise Mapping Australia


Site
Homestead 01 (Dave Ter
North
Contour Levels
55.0 to 60.0
50.0 to 55.0
45.0 to 50.0
40.0 to 45.0
35.0 to 40.0
30.0 to 35.0
25.0 to 30.0
20.0 to 25.0
15.0 to 20.0
10.0 to 15.0
5.0 to 10.0
Mining Noise Levels- LAeq(1 hour)
Night (no wind) meterology
Scale 1:100000 Paper Size A5
PENDO © Noise Mapping Australia


Site
Homestead 01 (Dave Ter
North
Contour Levels
55.0 to 60.0
50.0 to 55.0
45.0 to 50.0
40.0 to 45.0
35.0 to 40.0
30.0 to 35.0
25.0 to 30.0
20.0 to 25.0
15.0 to 20.0
10.0 to 15.0
5.0 to 10.0
Mining Noise Levels- LAeq(1 hour)
Night (SW wind) meterology
Scale 1:100000 Paper Size A5
PENDO © Noise Mapping Australia

Appendix C: Low Frequency Noise $L_{Aeq(15\ min)}$ Linear – Based on Night Case


Site
Homestead 01 (Dave Ter
35.00
45.00
50.00
55.00
60.00
40.00
North
Contour Levels
55.0 to 60.0
50.0 to 55.0
45.0 to 50.0
40.0 to 45.0
35.0 to 40.0
30.0 to 35.0
25.0 to 30.0
20.0 to 25.0
15.0 to 20.0
10.0 to 15.0
5.0 to 10.0
Mining Noise Levels- Leq(1 hour)
Night (no wind) meterology
Linear - Low Frequency
Scale 1:100000 Paper Size A5
PEN3D © Noise Mapping Australia

Appendix D – Waste Rock Characterisation Report

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AGATE CREEK GOLD MINE

Waste Rock Characterisation

Report Prepared for:

Date:
August 2022

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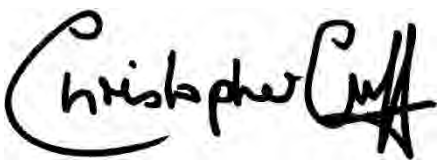

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18 August 2022
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18 August 2022
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7. The report reflects both the information provided to C&R Consulting in documents made available for review and the results of observations and consultations by C&R Consulting staff.

SUMMARY OF RELEVANT INFORMATION

Project Title	Agate Creek Gold Mine – Waste Rock Characterisation
Property Location	Agate Creek Gold Mine
Property Description	Open-cut gold mine
Project Purpose	Conduct a geochemical waste rock characterisation study to support the major environmental authority amendment for the Agate Creek Gold Mine
Project Number	21108
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EXECUTIVE SUMMARY

C&R Consulting Pty Ltd (C&R) were commissioned by Wulguru Technical Services (WTS) to undertake a geochemical waste rock characterisation (WRC) study of the Agate Creek Gold Mine (Agate Creek). This study will form part of the major environmental authority (EA) amendment and progressive rehabilitation and closure plan that WTS are currently preparing on behalf of Agate Creek's current owners, Laneway Resources.

In accordance with the Queensland Department of Environment and Science (DES, 2021) *Guideline – Progressive rehabilitation and closure plans (PRC plans)*, this WRC study has been undertaken to:

"Characterise mine wastes in a report that describes the likely physical behaviour and chemical reactivity of the waste materials under the conditions in which they would be stored. The report must address the constituent elements present, and their likely future speciation and mobility."

To achieve this, 260 rock samples were collected from 27 drill holes across the six proposed open-cut pits. These samples were tested in a National Association of Testing Authorities accredited laboratory for a range of static and kinetic geochemical properties, including acid generation, salinity, major ions and metal/metalloid concentrations.

The undertaken geochemical testing identified that all of the waste rock samples have similar physical and geochemical characteristics. This is to be expected given that most waste rock areas are constructed of the same lithology (volcaniclastic sediment).

The static geochemical results indicate that all waste rock areas:

- Are overwhelmingly non-acid forming, with 90% of the waste rock considered NAF with the potential to buffer any acid that is produced;
- Display low salinity values (mean of 43.5 µS/cm);
- Have some degree of fluoride enrichment; and
- Are not particularly enriched with respect to any of the other elements analysed.

The kinetic geochemical results compared well with the static results, indicating a level chemical stability.

Overall, the waste rock associated with the project is relatively benign and considered of very low to low risk of environmental harm.

1. INTRODUCTION

1.1 BACKGROUND INFORMATION

C&R Consulting Pty Ltd (C&R) have been asked to undertake a geochemical waste rock characterisation (WRC) study of the Agate Creek Gold Mine (Agate Creek) stage 2 expansion, on behalf of Wulguru Technical Services (WTS). This study will form part of a major environmental authority (EA) amendment and progressive rehabilitation and closure plan (PRCP) that WTS are currently preparing on behalf of Agate Creek's current owners, Laneway Resources (Laneway).

Agate Creek is located in north Queensland, approximately 340 km (520 km by road) west of Townsville and 45 km (70 km by road) south of the township of Forsayth (Figure 1). Alluvial gold was reported at Agate Creek in the early 20th century, and was followed by various prospecting activities – including panning, shallow digs and regional exploration.

In February 2015, Laneway lodged a mining lease application for the Agate Creek prospect following a successful 5,000 tonne bulk trial pit. Mining lease (ML) 100030 was granted to Laneway on 7 February 2019, allowing Laneway to mine up to 250,000 tonnes of ore at Agate Creek under EA EPSL03068015 (dated 6 September 2021).

Laneway intends to progress Agate Creek into the stage 2 expansion phase, requiring approval to mine up to 250,000 tonnes of ore and a major EA amendment. In accordance with the Queensland Department of Environment and Science (DES, 2021) *Guideline – Progressive rehabilitation and closure plans (PRC plans)*, a WRC assessment should be undertaken to accompany the major EA amendment submission.

1.2 SCOPE OF WORK

The PRCP guideline (DES, 2021) outlines the WRC reporting requirement:

"Characterise mine wastes in a report that describes the likely physical behaviour and chemical reactivity of the waste materials under the conditions in which they would be stored. The report must address the constituent elements present, and their likely future speciation and mobility."

In order to characterise the mine wastes as per the PRCP guideline, this investigation employed the following scope of works:

- Review existing geological and geochemical data;
- Design a sampling programme to be undertaken as part of the Agate Creek open-cut exploration, reverse-circulation (RC) drilling programme;
- Collate, validate and statistically analyse geochemical test results from a National Association of Testing Authorities (NATA) accredited laboratory;
- Compile a WRC dataset to consider waste rock drainage characteristics and the potential environmental risks these may pose; and
- Conduct a WRC study to provide supporting evidence for the rehabilitation requirements to support the submission of the Agate Creek major EA amendment.

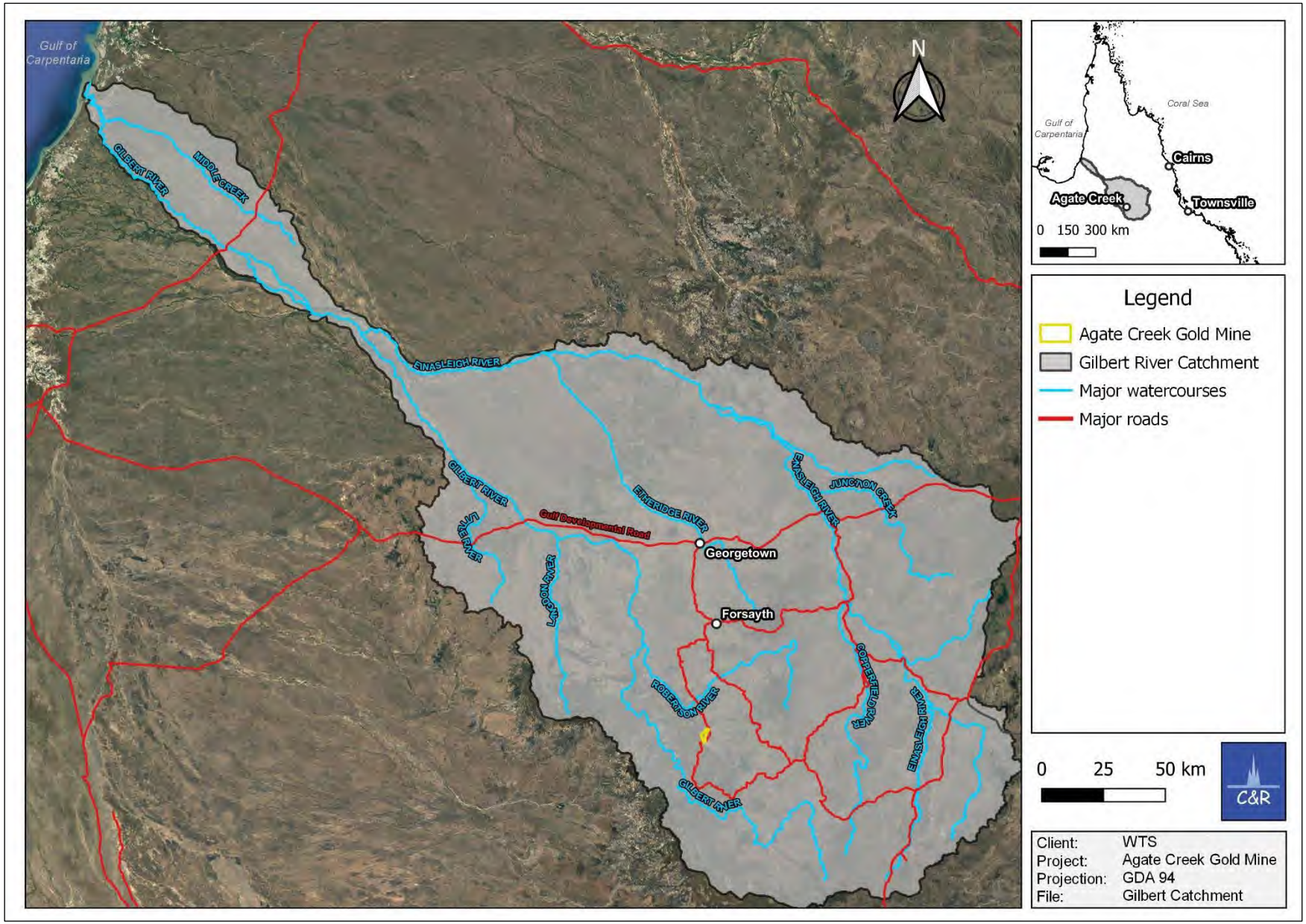

Figure 1: Project site location.

2. SITE DESCRIPTION

Agate Creek is an open-cut gold mining operation located within the Etheridge Shire in north Queensland, within the Gilbert River Basin that flows into the Gulf of Carpentaria (Figure 1). Trial mining commenced at Agate Creek in 2013, with a transition to full-scale production occurring in 2019. All mining activities undertaken at Agate Creek are permitted under the current EA EPSL03068015 (dated 6 September 2021).

2.1 CLIMATE

Agate Creek is located within the seasonally arid tropics, with the area dominated by intense rainfall events throughout the summer months. These rainfall events are often highly variable in their spatial and temporal distribution, with the majority of the rain falling in distinct, spatially separated cells across the landscape. Rainfall throughout the remainder of the year is generally limited to an occasional shower in June or July and evaporation tends to exceed rainfall for almost all days of the year, with the exception of periods with intense rainfall events. The Agate Creek operations are exposed to this seasonal rainfall, whereby it is expected that more than 90% of the rainfall will eventuate as either surface runoff or waste dump seepage.

2.2 GEOLOGY

The Agate Creek deposit is located in the central portion of the Proterozoic Etheridge Province. These Proterozoic Etheridge metamorphic rocks were extensively intruded by Silurian to Early Devonian granitoid batholiths, and dominantly felsic Carboniferous to Early Permian magmatic complexes (Morrison *et al.*, 2019). The mineralisation at Agate Creek is related to the emplacement of Permo-Carboniferous porphyritic rhyolite and andesite extrusives and intrusives, commonly referred to as the Agate Creek Volcanic Group.

Gold mineralisation at Agate Creek is hosted by a low sulphidation, epithermal system consisting of quartz-chalcedony veining, stockwork and breccia. Host rock lithology is predominantly porphyritic rhyolite or andesite that occupy shallow, south-east dipping thrust faults in Silurian granodiorite (Morrison *et al.*, 2019). This host rock is principally volcanic in origin. Therefore, for the purpose of this WRC study, the waste rock is inferred to be entirely composed of the same unit: felsic volcanics with silicified veins and/or breccia.

A series of complex hydrothermal alteration assemblages surround the Agate Creek ore body. These assemblages range from a distal, ubiquitous propylitic zone (chlorite +/- carbonate-epidote-pyrite-haematite) grading inwards to a more proximal, variably argillic to sericitic zone (clay +/- quartz-sericite-pyrite) and locally phyllic zone (silica +/- pyrite or iron oxide) (Morrison *et al.*, 2019). Most of the hydrothermal alteration in the Agate Creek expansion area is predominantly clay +/- silica, sericite and/or pyrite (now weathered to iron oxide). Therefore, alteration was not considered a significant factor in this WRC study.

2.3 PROPOSED OPEN-CUT PITS

2.3.1 STAGE 2 EXPANSION

The stage 2 expansion of the Agate Creek mine involves mining six different open-cut pits (Figure 2). The mine is currently working Pit 6 under the current EA that allows up to 200,000 tonnes of material to be extracted. However, further approval is required to mine Pit 6 deeper – exceeding the 200,000 tonnes limit – as well mining an additional five satellite pits. This proposed Agate Creek stage 2 expansion comprises 3,774,081 tonnes of waste rock material.

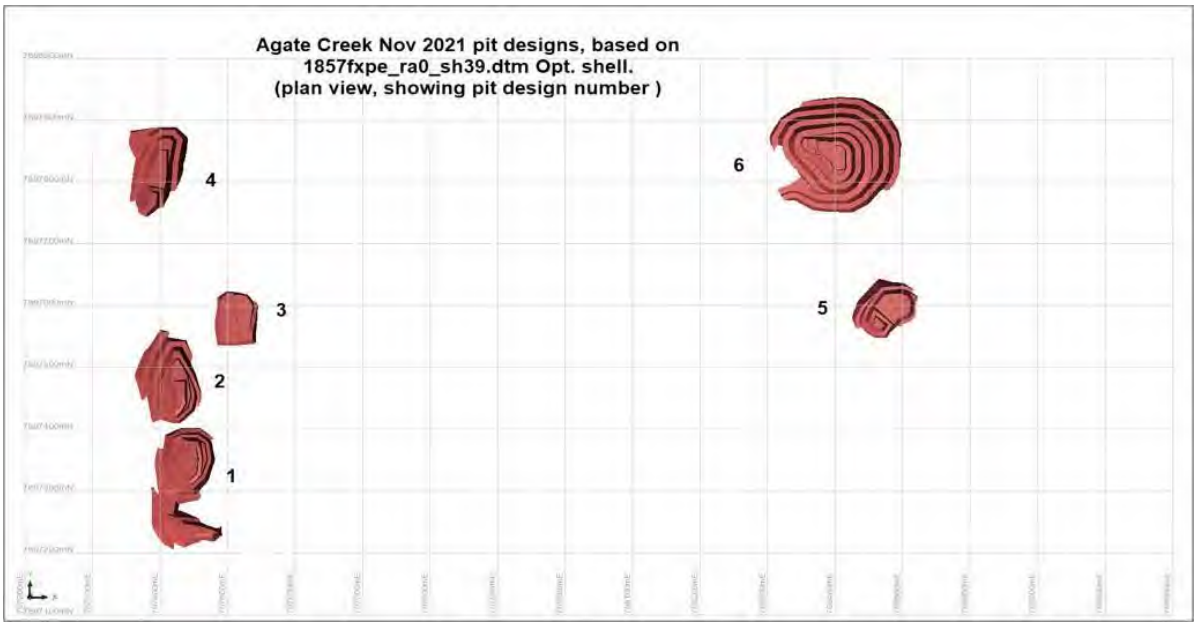

Figure 2: Pit designs for the proposed Agate Creek stage 2 expansion. Figure sourced from WTS.

2.4 WASTE CHARACTERISATION SAMPLING STRATEGY

The waste rock sampling programme for the six proposed open-cut pits was guided by the Australian technical guidelines for the geochemical assessment of mining wastes (Department of Mines and Energy [DME], 1995; Department of Environment and Heritage Protection [DEHP], 2013; Commonwealth of Australia [COA], 2016). The DME (1995) guideline recommends that the tonnage of mined material determine the sampling interval, whereas the more recent guidelines favour a risk-based approach.

The waste characterisation sampling strategy for the Agate Creek stage 2 expansion open-cut pits incorporated the collection of samples from regular intervals (every 3 m) in selected RC drill holes. These selected drillholes were chosen to represent a cross-section of the rock profile in each proposed open-cut pit (Figure 3 to Figure 8).

Figure 9 demonstrates that sampling was undertaken at regular intervals in the selected RC drill holes. The interval spacing was selected to cover all areas anticipated to have acid rock drainage (ARD) potential – including around the ore bodies, alteration zones, transitional material and fresh rock. This sampling methodology was adopted with the aim to provide a good statistical and spatial representation of the waste rock profile in each pit.

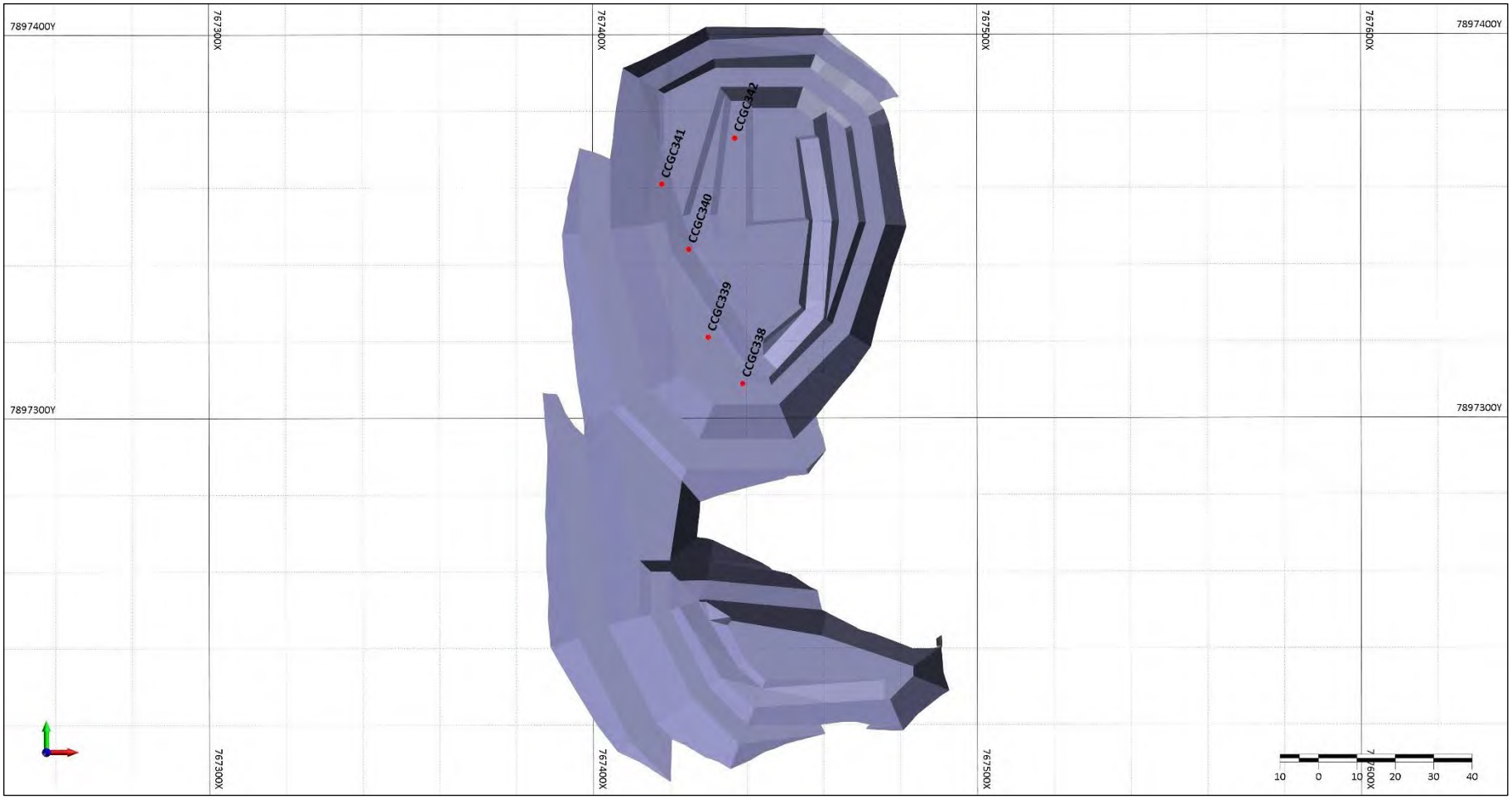

Figure 3: Location of exploration drill holes sampled in Pit 1.

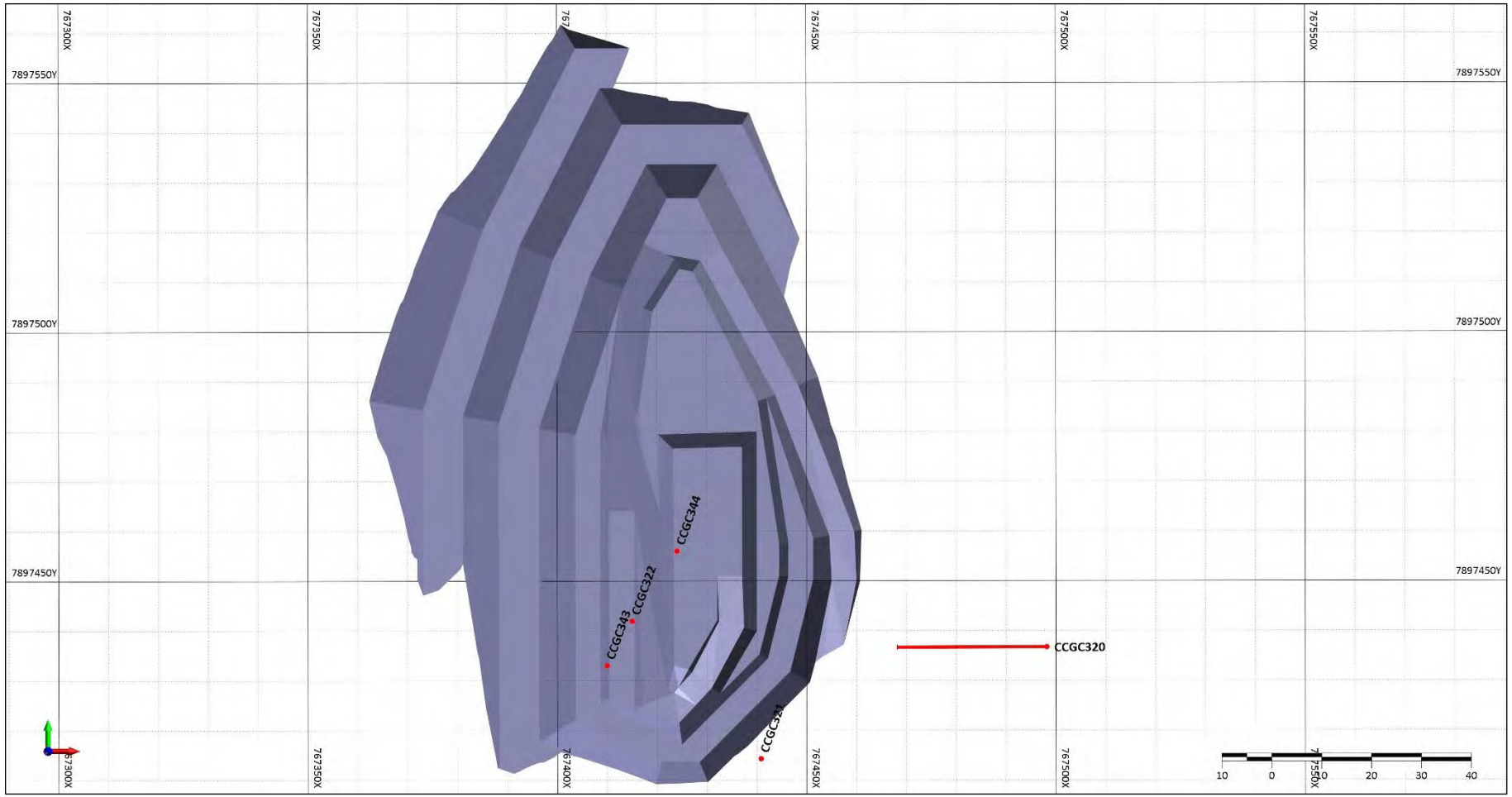

Figure 4: Location of exploration drill holes sampled in Pit 2.

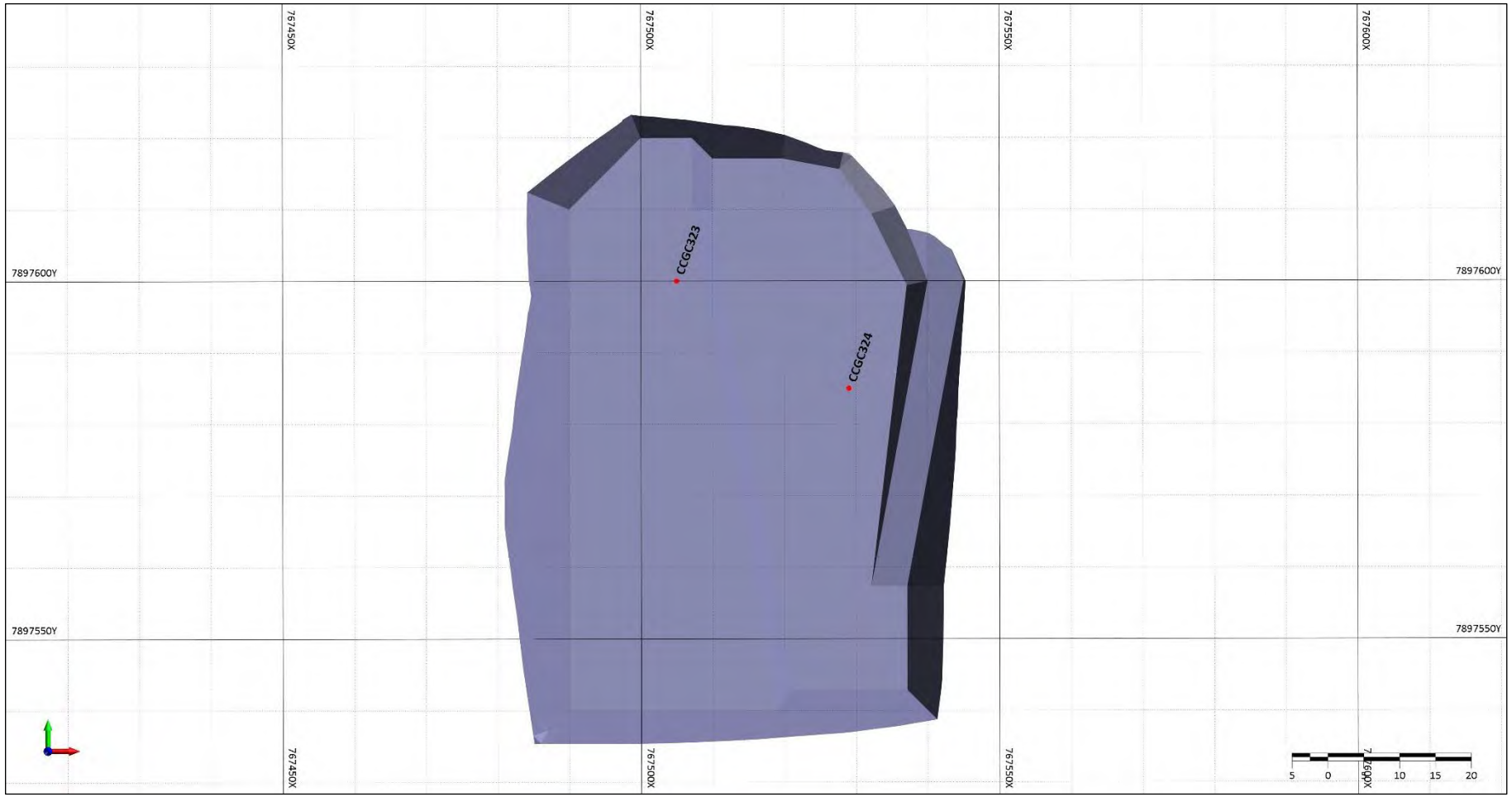

Figure 5: Location of exploration drill holes sampled in Pit 3.

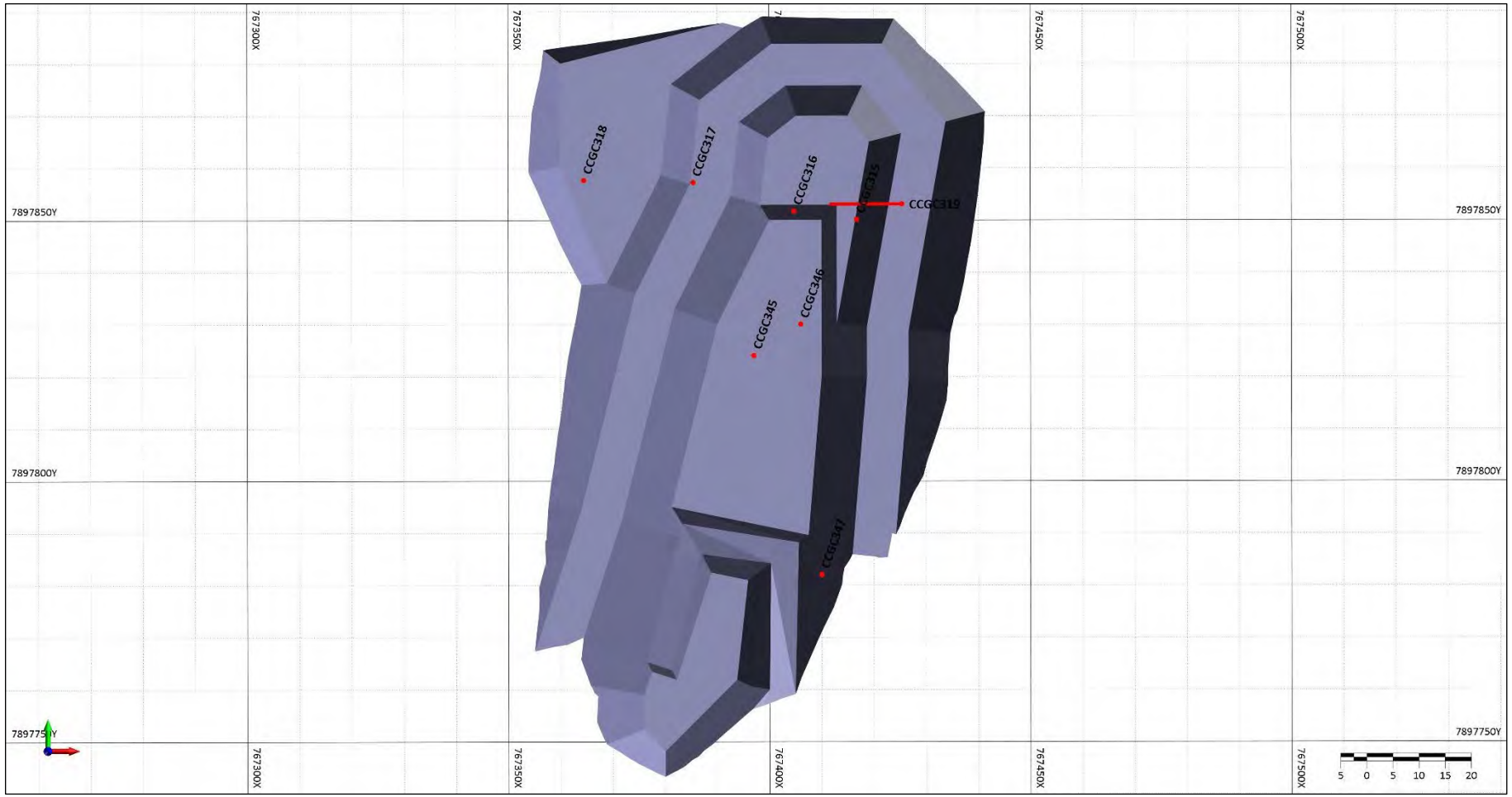

Figure 6: Location of exploration drill holes sampled in Pit 4.

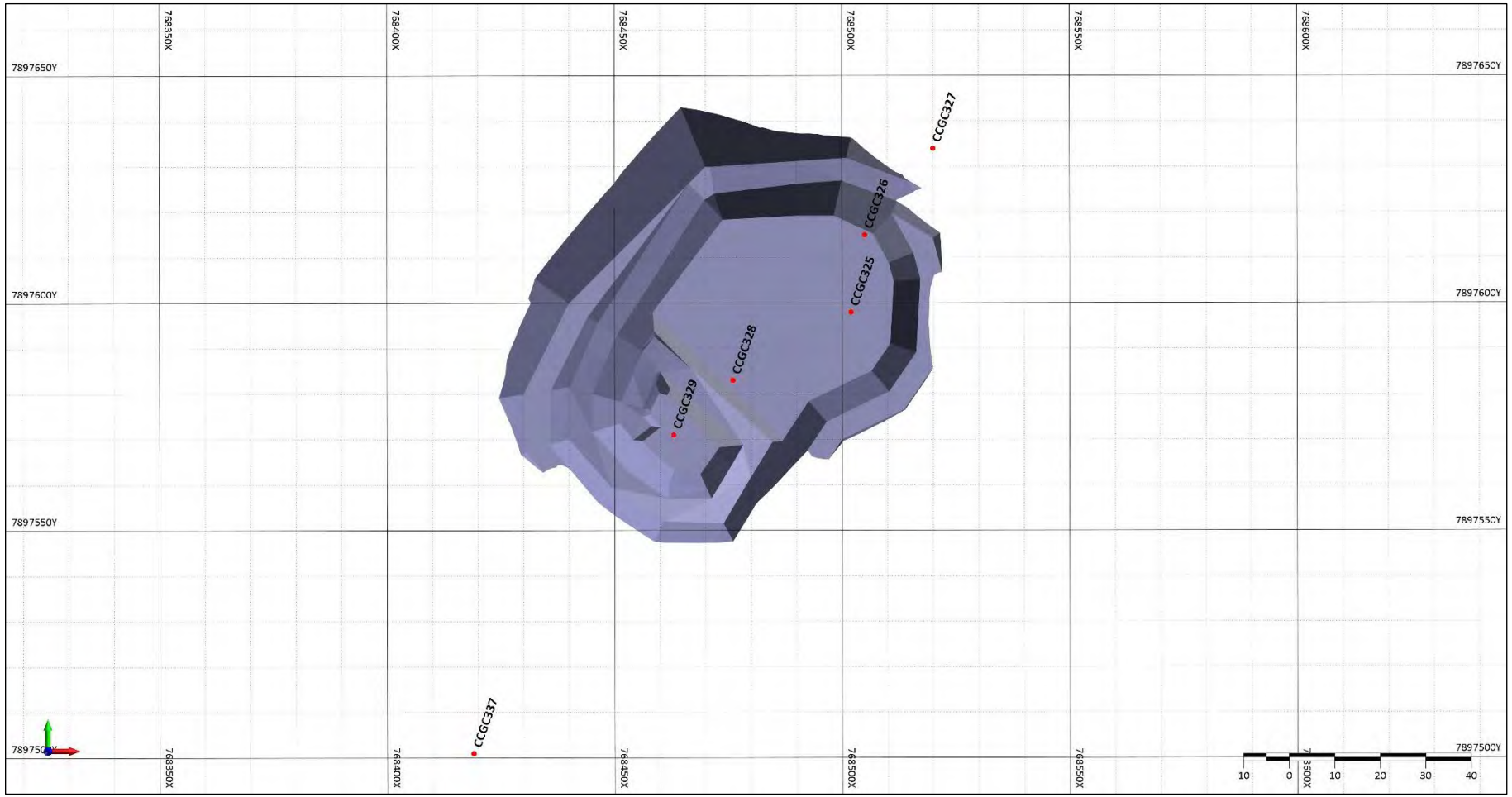

Figure 7: Location of exploration drill holes sampled in Pit 5.

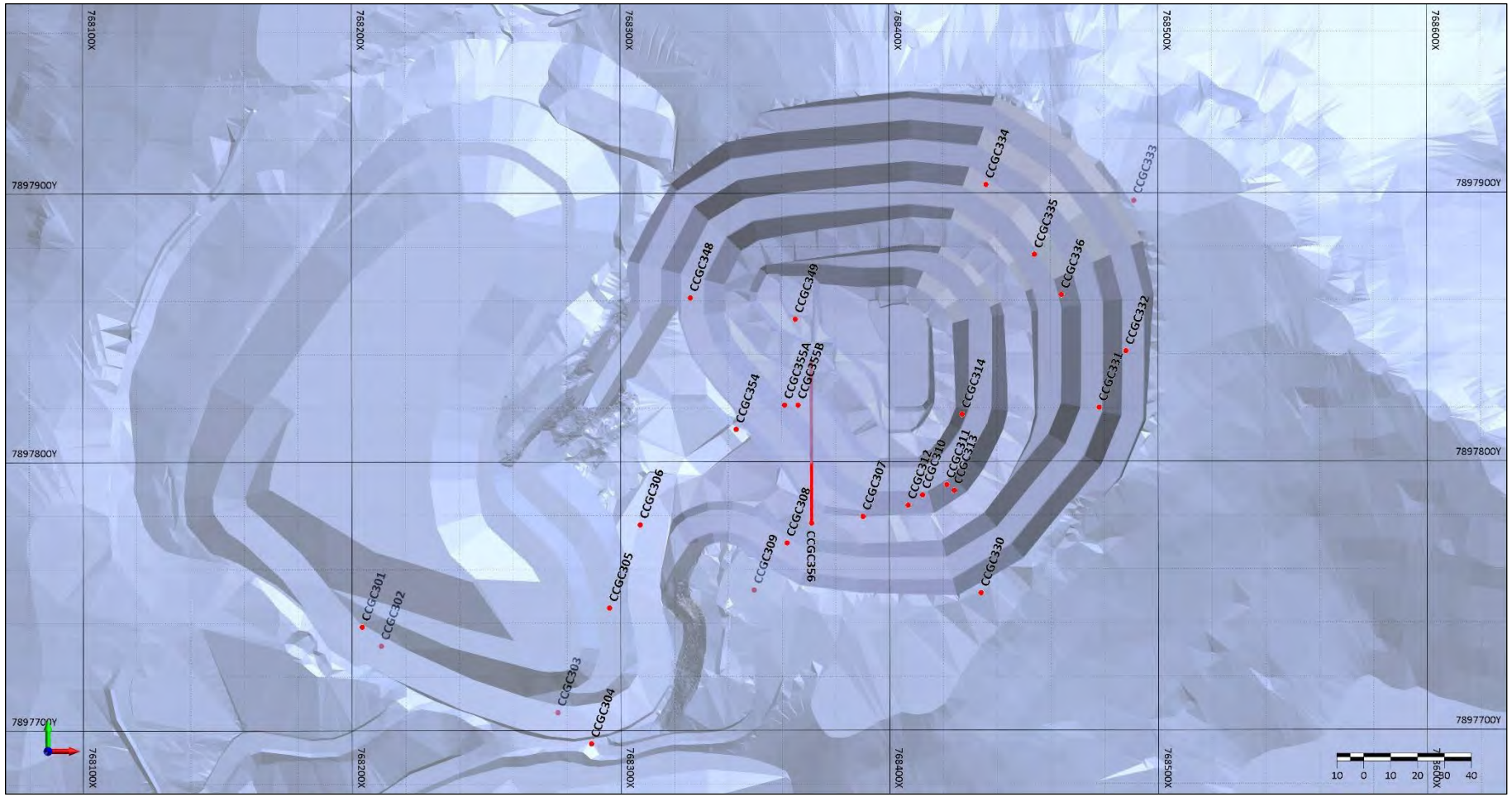

Figure 8: Location of exploration drill holes sampled in Pit 6.

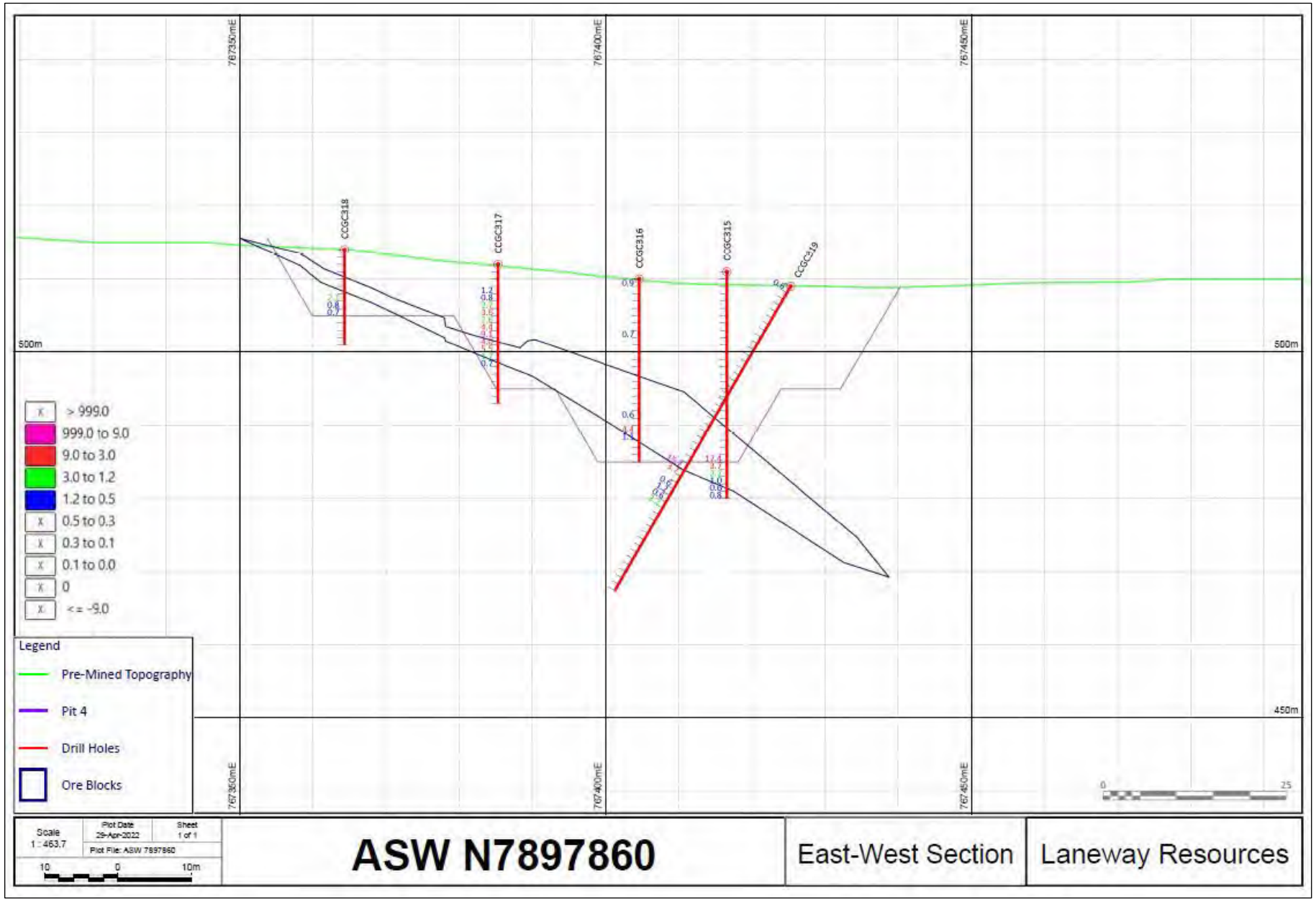

Figure 9: Sample selection example.

3. METHODS

3.1 SAMPLING PROGRAMME

A total of 260 rock samples were collected from 27 drill holes across the six proposed pits. The samples represent the rock type (felsic volcanics) and provide a reasonable distribution of alteration zones and weathering types (oxide, transitional and fresh). The 260 rock samples were taken at regular intervals (generally every 3 m) from select exploration holes (Table 1). Discussions with on-site geologists revealed that it was difficult to accurately determine where the targeted ore occurred within each exploration hole due to the varying ore grades – encountered throughout each hole – that have the potential to be utilised in the future. Therefore, all analysed samples were included in the assessment/investigation to provide a worst-case scenario (because it contains the highly mineralised ore body) characterisation of potential waste rock (Table 1).

Each sample consists of RC chip material collected by Laneway geological personnel at the exploration drilling rig, utilising a cyclone splitter attachment. Laneway provided bulk sample bags for each metre of each exploration hole to a NATA-accredited laboratory. The NATA-accredited laboratory then split the required samples for geochemical analysis. The minimum amount of sample collected (during the split) was 250 g for static tests, with more than 25 kg gathered for kinetic test work.

Table 1: Summary of samples taken across the proposed pits.

Proposed pit	Waste tonnes	Number of holes	Hole ID	Number of samples	Number of samples/pit
Pit 1	750,195	4	CCGC338	7	22
			CCGC339	1	
			CCGC340	7	
			CCGC341	7	
Pit 2	348,570	3	CCGC321	9	22
			CCGC343	7	
			CCGC344	6	
Pit 3	51,627	2	CCGC323	5	14
			CCGC324	9	
Pit 4	229,591	5	CCGC316	9	34
			CCGC319	11	
			CCGC345	7	
			CCGC346	1	
			CCGC347	6	
Pit 5	157,318	2	CCGC326	7	18
			CCGC329	11	
Pit 6	2,236,780	11	CCGC302	3	150
			CCGC303	9	

Proposed pit	Waste tonnes	Number of holes	Hole ID	Number of samples	Number of samples/pit
			CCGC306	11	
			CCGC308	11	
			CCGC309	1	
			CCGC311	21	
			CCGC334	6	
			CCGC336	1	
			CCGC349	14	
			CCGC354	25	
			CCGC356	48	
Total	**3,774,081**	**27**	**-**	**260**	**260**

3.2 GEOCHEMICAL CHARACTERISATION

The geochemical test work was based on industry-recognised procedures for the geochemical characterisation and assessment of mine waste (AMIRA, 2002; The International Network for Acid Prevention [INAP], 2014; COA, 2016).

3.2.1 STATIC TESTS

Static geochemical tests provide information on the bulk geochemical characteristics of samples at a single point in time. They do not provide information on rates of chemical processes – or the release rates due to weathering processes.

All 260 samples dispatched to the ALS laboratory underwent static geochemical testing to evaluate the risk associated with the potential oxidation of sulphides, acid generation, and the presence of metals/metalloids and salts.

Each sample underwent static geochemical testing for:

- pH;
- Electrical conductivity (EC);
- Total sulphur;
- Acid neutralising capacity (ANC);
- Net acid generation (NAG);
- Net acid production potential (NAPP);
- Major dissolved anions for Cl, F and SO_4; and
- Total metals/metalloids for Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, V and Zn.

Furthermore, four selected kinetic leach column samples (refer to Section 3.2.2) underwent additional static geochemical testing for:

- Moisture content;
- Major dissolved cations for Ca, Mg, Na and K; and
- Total metals/metalloids for Mo, Sb, Te, Th, Tl and U.

All static geochemical results are provided in Appendix A.

3.2.2 KINETIC LEACH COLUMN TESTS

Kinetic leach column (KLC) tests accelerate the weathering of samples and provide information on the magnitude and/or effects of dynamic processes that result from weathering. Unlike static tests, KLC tests measure the varying geochemical characteristics of sample effluent over a prolonged period of time.

Four samples were dispatched to a NATA-accredited laboratory for KLC tests: one from Pit 1, one from Pit 4 and two from Pit 6. These large KLC samples (>25 kg) represent a considerable proportion of the waste rock profile of each pit (Table 2).

Table 2: Summary of the KLC samples taken across the proposed pits.

Proposed Pit	Borehole	Composite samples	Interval
Pit 1	CCGC339	V34619 – V34636	0 – 21.6 metres
Pit 4	CCGC346	V34745 – V34762	0 – 21.6 metres
Pit 6	CCGC309	V32228 – V32258	0 – 31.0 metres
	CCGC336	V34048 – V34117	0 – 70.0 metres

Individual leach columns were set up for each of the four samples, with a leachate-analysis cycle undertaken on a fortnightly basis.

Each kinetic leachate column underwent kinetic geochemical testing for:

- pH;
- EC;
- Total dissolved solids (calculated);
- Hardness;
- Acidity;
- Alkalinity;
- Major cations for Ca, Mg, Na and K;
- Major anions for Cl, F and SO_4; and
- Dissolved metals/metalloids for Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Mo, Mn, Ni, Pb, Sb, Se, Te, Th, U, V and Zn.

All kinetic geochemical results are provided in Appendix B.

4. GEOCHEMICAL RESULTS

4.1 ACID BASE ACCOUNT

4.1.1 pH VALUE

The pH value of the 260 waste rock samples ranged from slightly acidic (4.5) to slightly basic (8.8), with a neutral median pH value of 6.7. The standard deviation (SD) of the dataset is 1.0. In general, most waste rock samples are in the neutral range (Figure 10). However, slightly acidic samples are also prevalent, indicative of the waste rock lithology (largely felsic volcanics).

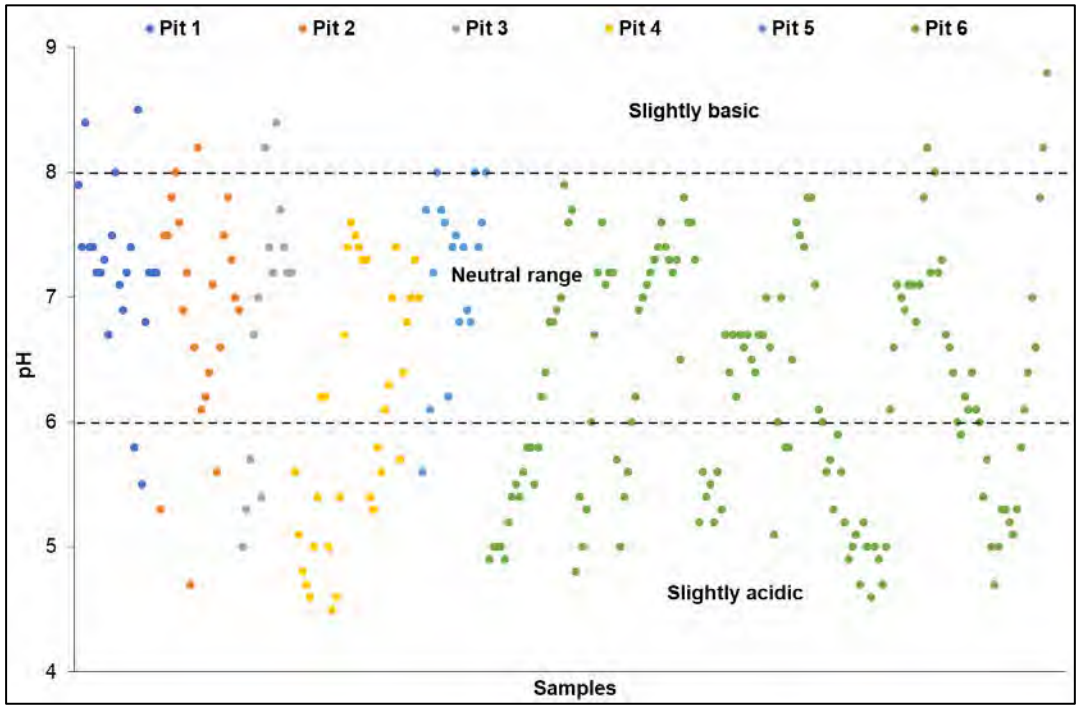

Figure 10: pH values for Agate Creek waste rock samples.

Because of the method of testwork (i.e. fluid extract from crushed samples, with a very high surface area to solution ratio), it is expected that both the low and high pH results in the waste rock are a worst-case scenario. Therefore, it is envisaged that the pH of runoff from the proposed open-cut pits waste rock will not be as low or high as that reflected in the waste rock sample test results. Also, in order for significant runoff to occur at Agate Creek, the rainfall dilution factor would be expected to be greater than the 1:5 (sample:water) ratio used in the extract solutions for analysis. This, in turn, would counteract the resulting acidity or alkalinity.

4.1.2 ELECTRICAL CONDUCTIVITY (EC)

The EC of the 260 Agate Creek waste rock samples ranges from 7 µS/cm to 1,680 µS/cm and has a very low median value of 43.5 µS/cm. Most Agate Creek waste rock samples have low EC values (<300 µS/cm). Apart from an outlier in Pit 2 (1,680 µS/cm), EC values in all waste rock samples are below 500 µS/cm (Figure 11).

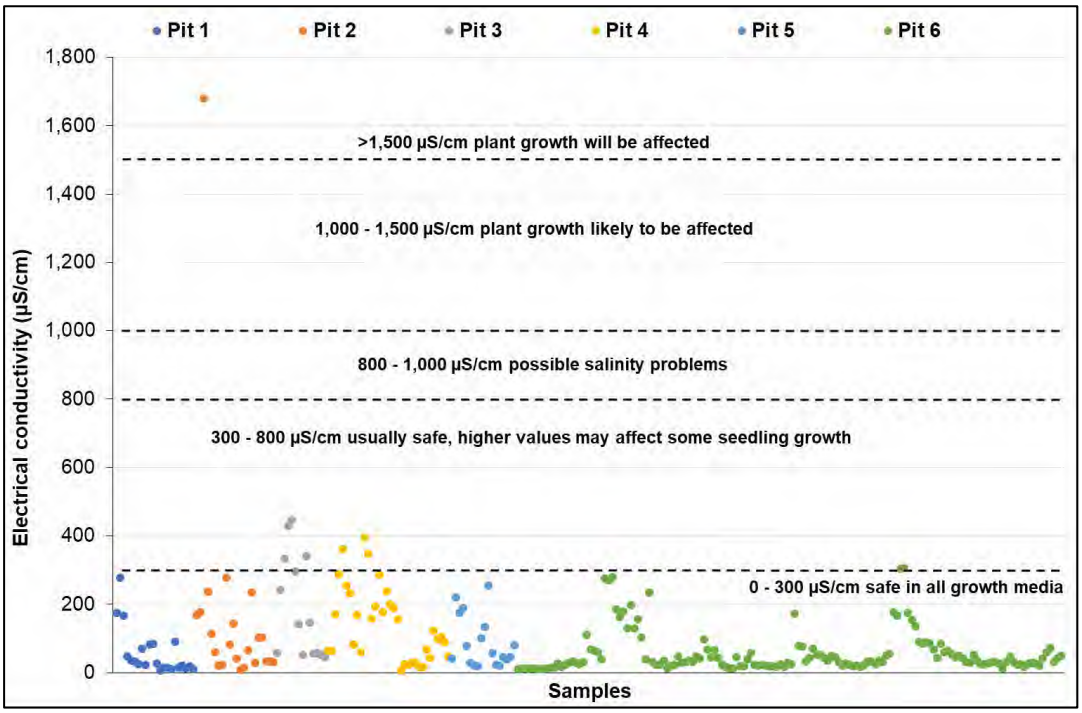

Figure 11: Electrical conductivity for Agate Creek waste rock samples.

4.1.3 TOTAL SULPHUR

The total sulphur (measured by LECO method) of the 260 Agate Creek waste rock samples ranged from <0.01% (i.e. below the limit of reporting [BLOR]) to 3.05%. The median is extremely low, with most samples BLOR. Most of the Agate Creek waste rock is therefore barren (<0.1%) with respect to total sulphur (Figure 12). Except for one value each in Pit 2 (3.05%) and Pit 6 (1.01%), all values above the barren level (i.e. >0.1%) are still classified as very low (<0.55%).

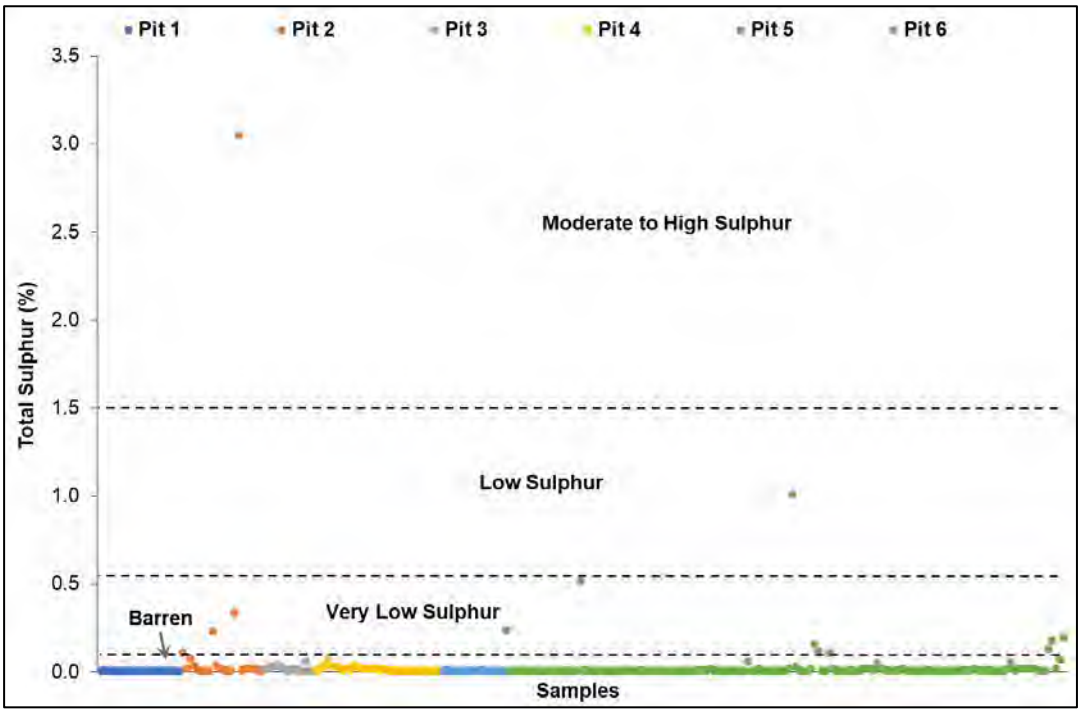

Figure 12: Total sulphur concentration for Agate Creek waste rock samples.

4.1.4 MAXIMUM POTENTIAL ACIDITY

Maximum potential acidity (MPA) is the maximum amount of acid that can be produced by the oxidation of sulphur-bearing minerals in the waste rock material. MPA is calculated from the total sulphur content. The MPA – that could be generated by the 260 Agate Creek waste rock samples – ranges from 0.15 to 93.3 kg H_2SO_4/t and has a low median value of 0.15 kg H_2SO_4/t.

4.1.5 ACID NEUTRALISING CAPACITY (ANC)

ANC is related to the amount of acid neutraliser (usually carbonate minerals) in the waste rock sample. ANC is determined experimentally by reacting a standardised acid mixture with a known amount of waste rock sample – and is reported as kg H_2SO_4/t eq. (equivalent). The ANC of the 260 Agate Creek waste rock samples ranges from 0.25 to 28.0 kg H_2SO_4/t eq., with a low median of 3.0 kg H_2SO_4/t eq.

4.1.6 ANC:MPA RATIO

The ANC:MPA ratio can assist in classifying the potential for waste rock samples to generate acid.

Generally speaking – and depending on the mineralogy – a sample with an ANC:MPA ratio below 1 is likely to be acid forming because it contains more acid-generating than acid-neutralising minerals. Samples with an ANC:MPA ratio of ≥1 but ≤2 have a degree of uncertainty and represent a potential risk, whereas samples with an ANC:MPA ratio of >2 are generally low risk. However, there are exceptions because samples with an MPA of <3.1 kg H_2SO_4/t are considered to contain insufficient acid-forming potential (i.e. they are barren). Conversely, samples with an MPA of >3.1 but <10 kg H_2SO_4/t would, at worst, be classified as low capacity, potentially acid-forming (PAF) material (Figure 13).

The 260 Agate Creek waste rock samples have an ANC:MPA ratio ranging from 0.08 to 183.01, with a median value of 11.93. According to these ANC:MPA ratios, with respect to acid-generation:

- 204 samples are considered to be of negligible to low risk;
- 41 samples are deemed to be a potential risk; and
- 15 samples are regarded as an increased risk.

This is because the low and negligible risk samples contain more acid-neutralising than acid-generating minerals, whereas the potential and increased risk samples contain more acid-generating than acid-neutralising minerals.

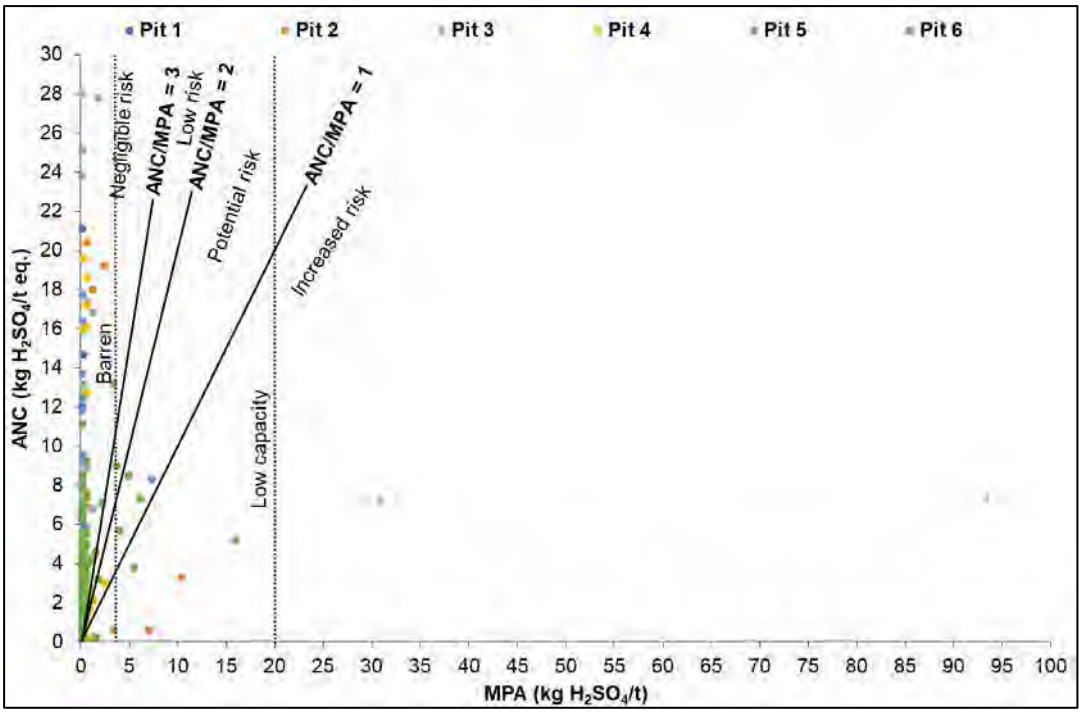

Figure 13: MPA versus ANC for Agate Creek waste rock samples.

4.1.7 NET ACID PRODUCTION POTENTIAL (NAPP)

NAPP is a theoretical calculation of the net acid producing (or consuming) value of a rock sample.

Generally speaking, samples with a negative NAPP value are non-acid forming (NAF), and those with a positive NAPP value are PAF. Miller (1997) provides further categorisation of waste rock material based on the magnitude of the NAPP value (Table 3).

Table 3: NAPP classification categories.

ARD Classification	NAPP Value (kg H_2SO_4/t)
Potentially acid forming (PAF)	> 10
Uncertain	0 to 10
Non-acid forming (NAF)	-50 to 0
Acid consuming material	< -50

Of the 260 waste rock samples, 45 have positive NAPP values. However, most of these positive samples are in the uncertain range, with only three samples having values greater than 10. These are associated with either Pit 2 or Pit 6.

4.2 NET ACID GENERATION (NAG) TEST

The NAG test is used to directly measure the net amount of acid produced by a waste rock sample.

Generally speaking, samples with a $NAG_{(pH)}$ (oxidised pH) below 4.5 may be acid generating and samples with a $NAG_{(pH)}$ equal or greater than 4.5 (≥4.5) are unlikely to be acid producing. However, the NAG test does not estimate acid neutralisation potential. Therefore, AMIRA (2002) recommends the combined use of the NAPP values and the NAG results for a more detailed classification of acid generation.

Figure 14 demonstrates that most Agate Creek waste rock samples have a $NAG_{(pH)}$ of at least 4.5 and a NAPP value below 0. Therefore, they are not acid generating. In contrast, five samples has a negative NAPP value and $NAG_{(pH)}$ below 4.5. In addition, several samples have NAPP values slightly above 0 that coincide with $NAG_{(pH)}$ in excess of 4.5. Both groups are classified as uncertain PAF. Six samples are certainly PAF, having a $NAG_{(pH)}$ less than 4.5 and a positive NAPP value (Figure 14).

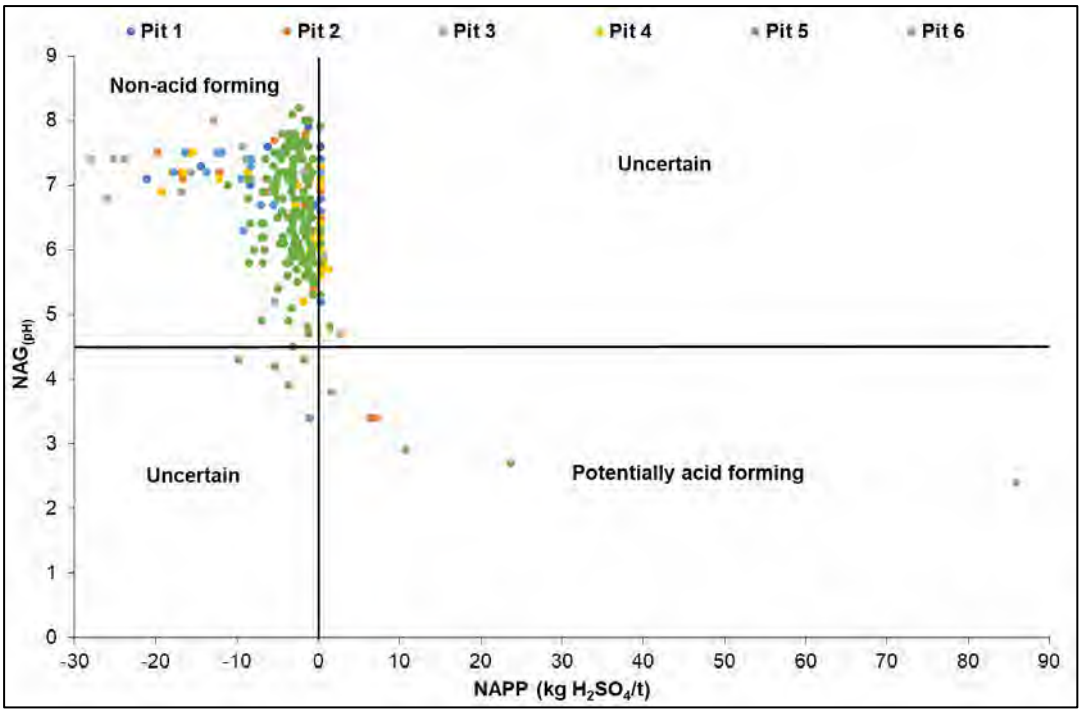

Figure 14: $NAG_{(pH)}$ versus NAPP for Agate Creek waste rock samples.

A summary of the $NAG_{(pH)}$ versus total sulphur geochemical classification criteria for the waste rock samples is presented in Table 4.

Table 4: Geochemical classification criteria for Agate Creek waste rock samples.

Geochemical Classification	Total Sulphur (%)	$NAG_{(pH)}$	Pit 1	Pit 2	Pit 3	Pit 4	Pit 5	Pit 6
NAF (barren)	≤0.1	-	22	18	14	34	17	142
NAF (very low sulphur)	>0.1 to ≤0.55	≥ 4.5	0	1	0	0	0	1
NAF (low sulphur)	0.55 to 1.5	≥ 4.5	0	0	0	0	0	0
PAF (very low sulphur)	0.1 to ≤0.55	< 4.5	0	2	0	0	1	6
PAF (low sulphur)	0.55 to 1.5	< 4.5	0	0	0	0	0	1
PAF (moderate to high sulphur)	>1.5	< 4.5	0	1	0	0	0	0
Percentage of NAF samples			100%	86.4%	100%	100%	94.4%	95.3%
Percentage of very low sulphur PAF samples			0%	9.1%	0%	0%	6%	4.0%
Percentage of low sulphur PAF samples			0%	0%	0%	0%	0%	0.7%
Percentage of moderate to high sulphur PAF samples – actionable levels			0%	4.5%	0%	0%	0%	0%

Applying the $NAG_{(pH)}$ and total sulphur geochemical classification criteria (Table 4), it can be shown that most waste characterisation samples are NAF (Figure 15).

Of the 260 Agate Creek waste rock samples, there are only 11 samples that could be categorised as PAF when the $NAG_{(pH)}$ and total sulphur values are considered:

- Three samples in Pit 2;
- One sample in Pit 5; and
- Seven samples in Pit 6.

These samples make up less than 14% of the total sample size for their respective areas – and their sulphur values are still very low to low except for one sample in Pit 2. It is therefore expected that only one of these eleven samples presents an acid drainage issue because:

- The amount of produced acid would be negligible; and
- Any acid produced by the samples will be buffered by the surrounding NAF rock that makes up more than 90% of the waste rock.

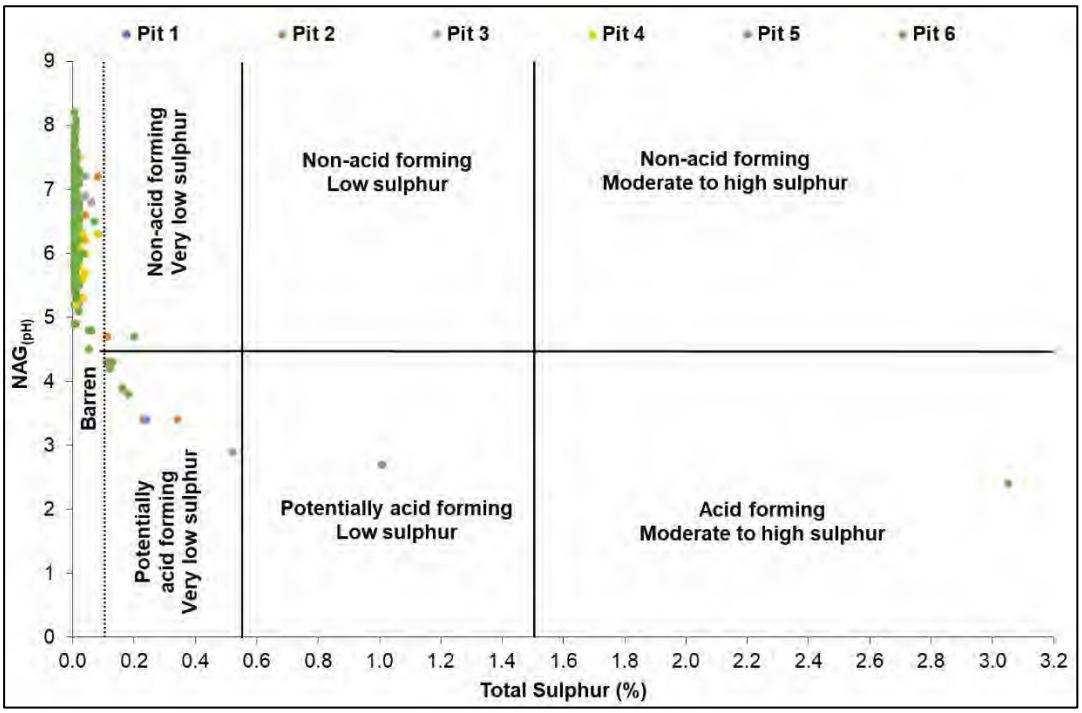

Figure 15: $NAG_{(pH)}$ versus sulphur for Agate Creek waste rock samples.

4.3 METAL/METALLOID ANALYSES

Static multi-element scans were undertaken on the 260 Agate Creek waste rock samples. This test work was carried out to assess natural background elemental levels, and to identify if any elements (particularly metals and metalloids) are present in the waste rock at concentrations that may be of environmental concern with respect to revegetation and water quality.

4.3.1 GEOCHEMICAL ABUNDANCE INDEX

The total metal and metalloid concentrations in the waste rock can be compared to the average crustal abundance of unmineralised soils (INAP, 2014). In this process, the geochemical abundance index (GAI) is used to report on the extent of elemental enrichment, by relating the actual concentration in a sample with the average crustal abundance on a log_2 scale (Table 5).

Table 5: Geochemical abundance index classification categories.

GAI	Enrichment Factor	Classification
<1	Less than 3-fold enrichment	Not enriched
1	3- to 6-fold enrichment	Not enriched
2	6- to 12-fold enrichment	Slightly enriched
3	12- to 24-fold enrichment	Significantly enriched
4	24- to 48-fold enrichment	Significantly enriched
5	48- to 96-fold enrichment	Highly enriched
6	Greater than 96-fold enrichment	Highly enriched

As a general guide, samples with a GAI of 3 or greater indicate enrichment that may warrant further investigation. However, elements identified as enriched may not necessarily be a reason for concern regarding revegetation and/or water quality because:

- The average crustal abundance varies between different literature sources;
- Some elements are more environmentally important than others (i.e. As, Al, Cr, Cd, Cu, Pb, Se and Zn are more important than Ca, Fe, Mg and Na);
- If a sample is shown to be enriched in a particular element, there is no direct correlation that the sample will leach the element at elevated concentrations; and
- The nature of an ore deposit means that the background levels for some elements are expected to be elevated.

Similarly, because an element is not enriched does not mean that it will never be a concern because – under certain conditions (e.g. low pH) – the solubility of some common, environmentally important elements (such as Al, Cu, Cd, Fe and Zn) will increase significantly.

Summaries of the multi-element scans and GAIs for the Agate Creek waste rock samples are presented in Table 6. Boron was intentionally left out of these tables because all of the test results (n = 260) were BLOR (<50 mg/kg). Similarly, all tellurium values were BLOR (<0.5 mg/kg), although the number of measurements (four) is limited. The limit of reporting is well above the normal crustal abundance of tellurium, which is approximately a hundred times lower.

Any laboratory analyses that were reported as BLOR were not included in the GAI-related statistical analysis. The BLOR data were purposely omitted to minimise bias in the GAI calculation and resulting statistics.

Table 6: Summary of multi-element analyses, results and geochemical abundance indices for Agate Creek waste rock samples.

Element	Unit	Limit of Reporting	ACA*	n	n#	Concentration Statistics			NEPM Guideline HIL~ 'Recreational C'	GAI Statistics			
						Min.	Median	Max.		Min. GAI	Median GAI	Max. GAI	Number of GAIs ≥3
Aluminium	mg/kg	50	82,000	260	260	380	1,300	41,000	-	0	0	0	0
Antimony	mg/kg	0.1	0.2	4	4	0.2	0.4	1.8	-	0	0	2	0
Arsenic	mg/kg	5	1.5	260	154	BLOR^	6.5	206	300	1	2	6	42
Barium	mg/kg	10	500	260	206	BLOR	20	530	-	0	0	0	0
Beryllium	mg/kg	1	2.6	260	33	BLOR	BLOR	6	90	0	0	0	0
Cadmium	mg/kg	1	0.11	260	6	BLOR	BLOR	2	90	2	2.5	3	3
Chromium	mg/kg	2	100	260	245	BLOR	8	90	300	0	0	0	0
Cobalt	mg/kg	2	20	260	196	BLOR	5	190	300	0	0	2	0
Copper	mg/kg	5	50	260	206	BLOR	11	364	17,000	0	0	2	0
Iron	mg/kg	50	41,000	260	260	380	15,650	107,000	-	0	0	0	0
Lead	mg/kg	5	14	260	195	BLOR	9	111	600	0	0	2	0
Manganese	mg/kg	5	950	260	243	BLOR	192.5	4,260	19,000	0	0	1	0
Mercury	mg/kg	0.1	0.05	260	2	BLOR	BLOR	0.3	80	2	2	2	0
Molybdenum	mg/kg	0.1	1.5	4	4	0.2	1.85	3.7	-	0	0	0	0
Nickel	mg/kg	2	80	260	232	BLOR	8	291	1,200	0	0	1	0
Selenium	mg/kg	5	0.05	260	1	BLOR	2.5	8	700	6	6	6	1
Thallium	mg/kg	0.1	0.6	4	1	BLOR	BLOR	0.1	-	0	0	0	0
Thorium	mg/kg	0.1	12	4	4	0.6	0.85	1.7	-	0	0	0	0
Uranium	mg/kg	0.1	2.4	4	4	0.3	0.45	0.6	-	0	0	0	0
Vanadium	mg/kg	5	160	260	191	BLOR	9	406	-	0	0	0	0
Zinc	mg/kg	5	75	260	238	BLOR	35	395	30,000	0	0	1	0

* Average crustal abundance (Bowen, 1979).

Number of reported measurements that were not below the limit of reporting.

~ *National Environment Protection (Assessment of Site Contamination) Measure 1999 – Health-based investigation levels* (NEPC, 2013).

^ Below limit of reporting.

Red shaded cells are above the NEPM HIL Guidelines for 'Recreational C' areas.

Orange shaded cells indicate significant enrichment (i.e. ≥ 12 – 24 fold enrichment with respect to the average crustal abundance).

Based on the GAI assessment of the Agate Creek waste rock samples, approximately 27% of the waste rock samples are significantly enriched with respect to arsenic (Table 6). Most (n = 30) of the enriched arsenic samples (n = 42) have a GAI of 3, with a further nine samples attributed a GAI of 4. Two arsenic samples are associated with a GAI of 5, whereas only one sample reaches a GAI of 6.

The sole sample with selenium above the limit of reporting suggests that the waste rock is significantly enriched with respect to that trace element. However, a GAI of 5 would be obtained even if half of the LOR value (2.5 mg/kg) were to be applied to the GAI assessment. Thus, because of analytical limitations in measurement precision, any sample that included selenium testing would automatically be associated with a high GAI.

Of the six cadmium samples at or above the LOR, only three results reached a GAI of 3.

4.3.2 CONTAMINANT LIMITS

The metals/metalloid concentrations of the 260 Agate Creek waste rock samples have been compared against the National Environment Protection Measure (NEPM) health-based investigation level (HIL) guidelines for 'Recreational C' – public open space scenario (National Environment Protection Council [NEPC], 2013). Table 6 demonstrates that all analysed metals/metalloids would meet the 'Recreational C' limits.

4.4 STATIC WATER QUALITY ANALYSES

Static water quality multi-element scans were undertaken on water extracts from the 260 Agate Creek waste rock samples. This testwork was carried out in order to assess water quality characteristics (particularly salinity and soluble anion levels) that could potentially be sourced from the waste rock in leachate.

Before data analysis was undertaken, results below the laboratory limit of reporting (LOR) were entered into the database as half the LOR value, in line with the *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC and ARMCANZ, 2000). Also based on the dilution ratio (1:5) and EC values of the water extracts, all values reported as mg/kg are assumed to be the equivalent in mg/L.

There are no specific regulatory criteria for salinity or anion concentrations from waste rock material on mine sites in Queensland. Furthermore, the current EA for Agate Creek does not specify contaminant release limits for salinity or soluble anions. Consequently, the results for the waste rock water extracts have been compared with the ANZECC and ARMCANZ (2000) guidelines for livestock drinking water.

Note: It is inappropriate to use the ANZECC and ARMCANZ (2000) freshwater ecosystems guidelines to compare the anion and EC levels of the water extracts with environmental trigger levels. This is because the freshwater ecosystems guidelines do not contain anion trigger values. Further, the guidelines only apply tropical criteria for salinity triggers in the Agate Creek area – and do not consider the local geological and climatic conditions (i.e. Agate Creek is in a volcanic province that receives relatively low and highly seasonal rainfall).

4.4.1 SALINITY

The EC of the water extracts from the 260 Agate Creek waste rock samples ranges from 7 µS/cm to 1,680 µS/cm and has a very low median value of 43.5 µS/cm. These EC values generally represent fresh water and are well below the ANZECC and ARMCANZ (2000) livestock drinking water trigger limit of 5,970 µS/cm (Figure 16). Further, the Queensland Government document *Science Notes – Land series – L137* (provided in Appendix C), states that 1,500 to 2,000 µS/cm soil (using a 1 in 5 static test method) is considered slightly saline.

The study only recorded one sample in this range with all other static samples recording values well below 500 µS/cm (Figure 16). This suggests that salinity is not an issue associated with the Agate Creek Mine waste rock.

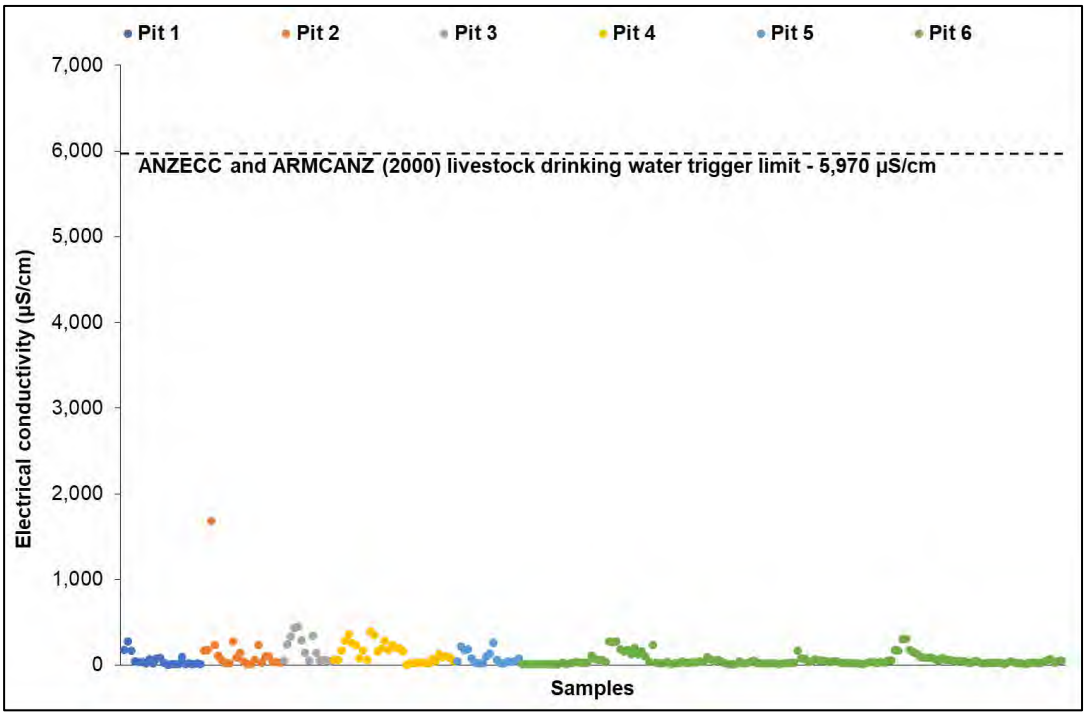

Figure 16: Electrical conductivity for water extracts from Agate Creek waste rock samples.

It should be noted that the ECs of the water extracts are higher than that expected of the surface runoff and seepage from the proposed waste rock material. This is because dissolution rates will be lower in the waste rock dumps than observed in the static laboratory samples. The KLC tests demonstrate this, with lower electrical conductivity values recorded compared to the static results (refer to Section 4.5.2).

4.4.2 FLUORIDE

The fluoride values of the water extracts from the 260 Agate Creek waste rock samples ranges from BLOR (<1 mg/kg) to 63 mg/kg and has a median value of 4 mg/kg. In the 260 water extracts, fluoride exceeded the low-risk trigger level for livestock drinking water (2 mg/L; ANZECC & AMRCANZ, 2000) on multiple occasions (Figure 17). While this guideline value is not directly comparable to the results (as the guideline is for surface waters [mg/L] and not sediment extracts [mg/kg]), exceedances may be of a concern as elevated fluoride is prevalent in most of the waste rock (Table 7). However, these fluoride levels are not unusual for the Agate Creek area. As a volcanic province, much of the rock, surface water and groundwater are enriched with respect to fluoride. Therefore, the risk of fluoride – sourced from the Agate Creek waste rock – further enriching fluoride levels in the receiving environment is low.

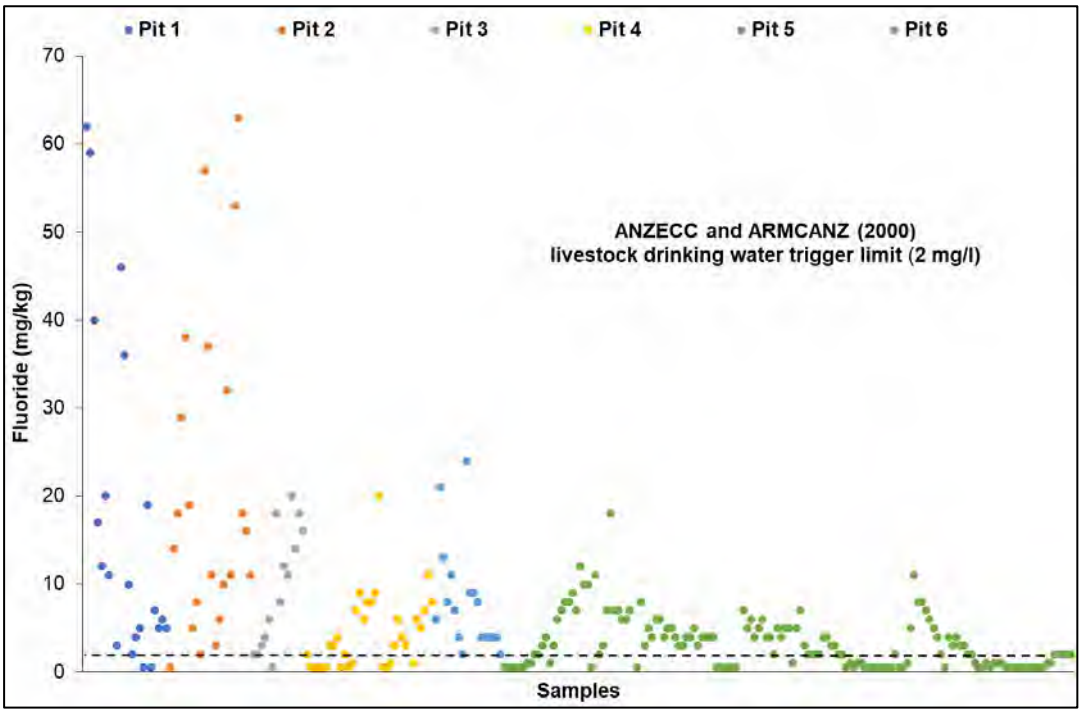

Figure 17: Fluoride values for water extracts from Agate Creek waste rock samples.

Table 7: Fluoride statistics for waste rock sample water extracts.

Fluoride Statistic	Unit	Pit 1	Pit 2	Pit 3	Pit 4	Pit 5	Pit 6
Minimum	mg/L	0.5	0.5	0.5	0.5	2	0.5
Median	mg/L	10	15	9.5	3	6.5	3
Maximum	mg/L	62	63	20	20	24	18
SD	mg/L	19	18	7	4	6	3
cv	%	1.1	0.9	0.7	1.0	0.8	1.0
n	-	21	22	14	33	18	148
Percentage of samples exceeding 2 mg/L		85.7%	90.9%	78.6%	57.6%	88.9%	49.3%

^ BLOR – Below the limit of reporting.

4.4.3 SULPHATE

The dissolved sulphate levels of the water extracts from the 260 Agate Creek waste rock samples range from 5 mg/kg to 1,780 mg/kg and have a low median value of 20 mg/kg. Except for one value (a sample in Pit 2), all results were below the ANZECC and ARMCANZ (2000) beef cattle livestock drinking water trigger limit of 1,000 mg/L (if applied as 1,000 mg/kg; Figure 18). However, the guideline is only used to provide an indication of elevated levels and an exceedance displayed in Figure 18 does not necessarily imply the sample is toxic to cattle. This is because the guideline is developed for surface waters [mg/L] and not sediment extracts [mg/kg]. Instead, these results suggest that sulphate levels within waste rock are not of concern to the environmental values associated with the site.

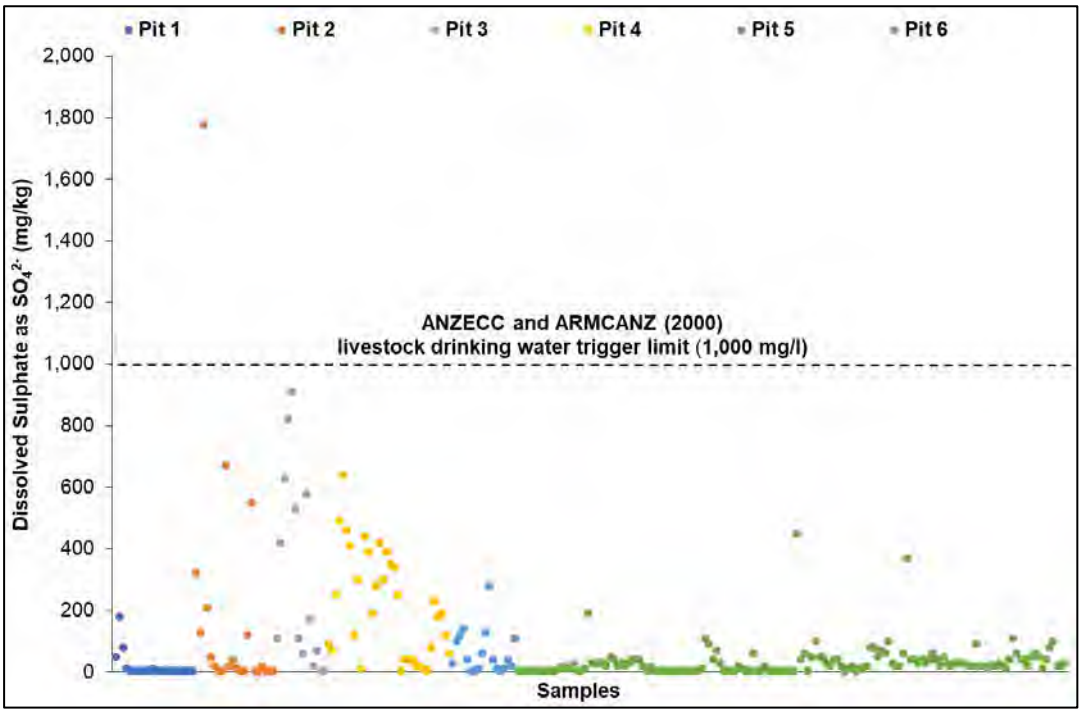

Figure 18: Sulphate values for water extracts from Agate Creek waste rock samples.

4.5 KINETIC LEACH COLUMN WATER QUALITY ANALYSES

In order to understand the potential for the Agate Creek waste rock to leach environmental contaminants into the surrounding environment, KLC tests were undertaken on four composite samples (refer to Section 3.2.2). Unlike static tests, KLC tests measure the varying geochemical characteristics of sample effluent over a prolonged period, consequently providing a better indication of chemical reactivity of waste materials under potential storage conditions.

The results of the waste rock KCL tests have to be considered against the mineralogy, and thus the chemical composition of the host rock and its associated complex hydrothermal alteration assemblages. The waste rock will be dominated by the host rock assemblage of rhyolite and andesite. Mineralogically, the composition of the rhyolite is dominated by alkali feldspars > plagioclase feldspars and quartz with minor biotite, muscovite, pyroxenes, amphiboles, oxides, and glass. Comparably, the mineralogical composition of andesites is dominated by plagioclase feldspars and amphiboles, with minor amounts of quartz, pyroxene, biotite and muscovite.

The composition of the primary mineralogy will be supplemented by material from the complex alteration assemblages (refer Section 2.2). The majority of the rocks will, to some degree, have been subjected to recent weathering cycles which will have changed the primary and alteration mineralogy to a series of minerals of very fine to colloidal particle size, including clay minerals (illite, smectites, kaolinite and mixed layer variants), and hydrated oxyhydroxides of Al, Fe and Mn (e.g. gibbsite, goethite and “birnessite”).

It is the reaction of the above mineral phases that determine the composition of the leach fluid.

Before data analysis was undertaken of the leach data, results below the laboratory LOR were entered into the database as half the LOR value, in line with the *Australian and New Zealand guidelines for fresh and marine water quality* (ANZG, 2018).

There are no specific regulatory criteria for contaminant releases from waste rock material on mine sites in Queensland. Furthermore, the current EA for Agate Creek does not specify contaminant release limits. Consequently, the results for the KLC tests are compared with the ANZG (2018) guidelines for freshwater ecosystems (95% species protection level) and livestock drinking water (Table 8).

Table 8: Summary of kinetic leach multi-element analyses and results.

Quality Characteristic	Limit of Reporting	Livestock Guideline[1]	Freshwater Ecosystems Guideline[2]	Bore ID	Leach 0	Leach 1		Leach 2		Leach 3		Leach 4		Leach 5	
					V	V	C	V	C	V	C	V	C	V	C
pH[3]	0.01	5 – 9	NA[4]	CCGC339	6.49	6.50	-	6.24	-	6.48	-	6.15	-	6.30	-
				CCGC346	5.82	6.30	-	5.88	-	5.98	-	5.59	-	5.45	-
				CCGC309	6.38	5.51	-	6.53	-	6.87	-	5.48	-	6.00	-
				CCGC336	5.84	5.88	-	5.57	-	5.66	-	5.40	-	5.55	-
EC[3] (µS/cm)	1	5,970[5]	NA[4]	CCGC339	553	68	-	49	-	44	-	41	-	36	-
				CCGC346	231	223	-	43	-	38	-	36	-	36	-
				CCGC309	20	14	-	15	-	14	-	10	-	17	-
				CCGC336	38	13	-	21	-	21	-	25	-	18	-
Sulphate (mg/L)	1	1,000	NA	CCGC339	3	BLOR	3.5	BLOR	4	BLOR	4.5	BLOR	5	BLOR	5.5
				CCGC346	49	63	112	12	124	11	135	10	145	10	155
				CCGC309	BLOR	BLOR	1	BLOR	1.5	BLOR	2.0	BLOR	2.5	BLOR	3
				CCGC336	1	BLOR	1.5	BLOR	2	BLOR	2.5	BLOR	3	1	4
Fluoride (mg/L)	0.1	2	NA	CCGC339	6.6	4.0	10.6	2.4	13.0	2.1	15.1	2.0	17.1	2.1	19.2
				CCGC346	0.6	0.8	1.4	0.5	1.9	0.4	2.3	0.5	2.8	0.5	3.3
				CCGC309	0.4	BLOR	0.45	BLOR	0.5	BLOR	0.55	BLOR	0.6	BLOR	0.65
				CCGC336	0.2	BLOR	0.25	BLOR	0.3	BLOR	0.35	0.1	0.45	0.1	0.55
Aluminium (mg/L)	0.01	5	0.055	CCGC339	BLOR	0.07	0.075	0.16	0.235	0.02	0.255	0.01	0.265	0.02	0.285
				CCGC346	BLOR	0.01	0.015	0.04	0.055	0.02	0.075	BLOR	0.08	0.01	0.09
				CCGC309	0.06	0.01	0.07	0.01	0.08	0.01	0.09	BLOR	0.095	BLOR	0.10
				CCGC336	0.03	BLOR	0.035	BLOR	0.04	BLOR	0.045	BLOR	0.05	BLOR	0.055
Arsenic (mg/L)	0.001	0.5	0.013	CCGC339	BLOR	0.001	0.0015	BLOR	0.002	0.002	0.004	BLOR	0.0045	BLOR	0.005
				CCGC346	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC309	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC336	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
Boron (mg/L)	0.05	5	0.37	CCGC339	0.19	0.13	0.32	0.07	0.39	0.08	0.47	0.12	0.59	0.11	0.70
				CCGC346	0.17	1.15	1.32	0.18	1.5	0.19	1.69	0.25	1.94	0.30	2.24
				CCGC309	BLOR	BLOR	0.05	BLOR	0.075	BLOR	0.1	0.07	0.17	BLOR	0.195

Quality Characteristic	Limit of Reporting	Livestock Guideline[1]	Freshwater Ecosystems Guideline[2]	Bore ID	Leach 0	Leach 1		Leach 2		Leach 3		Leach 4		Leach 5	
					V	V	C	V	C	V	C	V	C	V	C
				CCGC336	0.13	0.26	0.39	0.42	0.81	0.69	1.5	0.96	2.46	0.80	3.26
Cadmium (mg/L)	0.0001	0.01	0.0002	CCGC339	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC346	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC309	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC336	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
Copper (mg/L)	0.001	1.0[6]	0.0014	CCGC339	BLOR	BLOR	0.001	0.001	0.002	BLOR	0.0025	BLOR	0.003	BLOR	0.0035
				CCGC346	BLOR	0.002	0.0025	BLOR	0.003	BLOR	0.0035	BLOR	0.004	BLOR	0.0045
				CCGC309	BLOR	BLOR	0.001	0.001	0.002	BLOR	0.0025	BLOR	0.003	BLOR	0.0035
				CCGC336	0.002	BLOR	0.0025	BLOR	0.003	BLOR	0.0035	BLOR	0.004	BLOR	0.0045
Lead (mg/L)	0.001	0.1	0.0034	CCGC339	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC346	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC309	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC336	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
Manganese (mg/L)	0.001	NA	1.900	CCGC339	0.031	0.004	0.035	0.003	0.038	0.003	0.041	0.002	0.043	0.002	0.045
				CCGC346	0.018	0.035	0.053	0.003	0.056	0.004	0.06	0.003	0.063	0.004	0.067
				CCGC309	BLOR	BLOR	0.001	0.006	0.007	0.009	0.016	0.004	0.02	0.016	0.036
				CCGC336	0.015	0.006	0.021	0.017	0.038	0.015	0.053	0.013	0.066	0.007	0.073
Mercury (mg/L)	0.0001	0.002	0.0006	CCGC339	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC346	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC309	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
				CCGC336	BLOR	BLOR	0.0001	BLOR	0.00015	BLOR	0.0002	BLOR	0.00025	BLOR	0.0003
Nickel (mg/L)	0.001	1.0	0.011	CCGC339	BLOR	BLOR	0.001	BLOR	0.0015	0.001	0.0025	BLOR	0.003	BLOR	0.0035
				CCGC346	BLOR	0.003	0.0035	BLOR	0.004	BLOR	0.0045	BLOR	0.005	BLOR	0.0055
				CCGC309	BLOR	BLOR	0.001	BLOR	0.0015	BLOR	0.002	BLOR	0.0025	BLOR	0.003
				CCGC336	BLOR	BLOR	0.001	BLOR	0.0015	0.001	0.0025	BLOR	0.003	BLOR	0.0035
Zinc (mg/L)	0.005	20	0.008	CCGC339	BLOR	BLOR	0.005	BLOR	0.0075	0.024	0.0315	BLOR	0.034	BLOR	0.0365
				CCGC346	BLOR	0.131	0.1335	BLOR	0.136	BLOR	0.1385	BLOR	0.141	BLOR	0.1435
				CCGC309	BLOR	BLOR	0.005	BLOR	0.0075	BLOR	0.010	BLOR	0.0125	BLOR	0.015

Quality Characteristic	Limit of Reporting	Livestock Guideline[1]	Freshwater Ecosystems Guideline[2]	Bore ID	Leach 0	Leach 1		Leach 2		Leach 3		Leach 4		Leach 5	
					V	V	C	V	C	V	C	V	C	V	C
				CCGC336	BLOR	0.007	0.0095	0.011	0.0205	0.010	0.0305	0.006	0.033	0.007	0.040
Acidity[3] as $CaCO_3$ (mg/L)	1	NA	NA	CCGC339	3	2	-	BLOR	-	3	-	1	-	3	-
				CCGC346	2	3	-	BLOR	-	3	-	1	-	3	-
				CCGC309	2	1	-	BLOR	-	2	-	2	-	3	-
				CCGC336	2	1	-	BLOR	-	3	-	2	-	3	-

[1] Australian guidelines for livestock drinking water - trigger values (low risk) (ANZG, 2018). Note: Metal guideline values are based on the total fraction, whereas results are provided as dissolved. Care must be taken when undertaking comparisons.

[2] Australian guidelines for aquatic freshwater ecosystems - 95% species protection level (ANZG, 2018). Note: Metal guideline values are based on the dissolved fraction.

[3] Cumulative results are not provided for pH, EC or acidity as these values are deemed inappropriate for assessing these quality characteristics.

[4] pH and EC guidelines for freshwater ecosystems for tropical regions are not representative of the climatic and/or geological conditions at Agate Creek.

[5] EC has been calculated from the tolerances of livestock (beef cattle) to total dissolved solids in livestock drinking water using a 1.4925 multiplier (ANZG, 2018).

[6] Cattle trigger value (low risk) for copper is cited.

Indicates an exceedance of the relevant livestock drinking water guideline value.

Indicates an exceedance of the relevant freshwater ecosystems guideline value.

V – Raw value.

C – Running cumulative total.

NA – Not available.

BLOR – Below the limit of reporting.

4.5.1 pH VALUE

The KLC results show that pH remains relatively stable over the course of the tests (Table 8 and Figure 19). Three of the samples show a marginal decreasing trend while CCGC309 recorded a drop in pH after the first leach before increasing over leaches 2 and 3 (Table 8 and Figure 19). While a marginal decrease over time is noted at most sites, no samples show a significant increase in acidity over time (Table 8; Figure 19 and Figure 20).

It should be noted that both pH and acidity are inherent properties of the mineralogical composition. Significant changes would only be expected if there were large changes in the overall mineralogy (e.g. total dissolution of phases) during the leaching process.

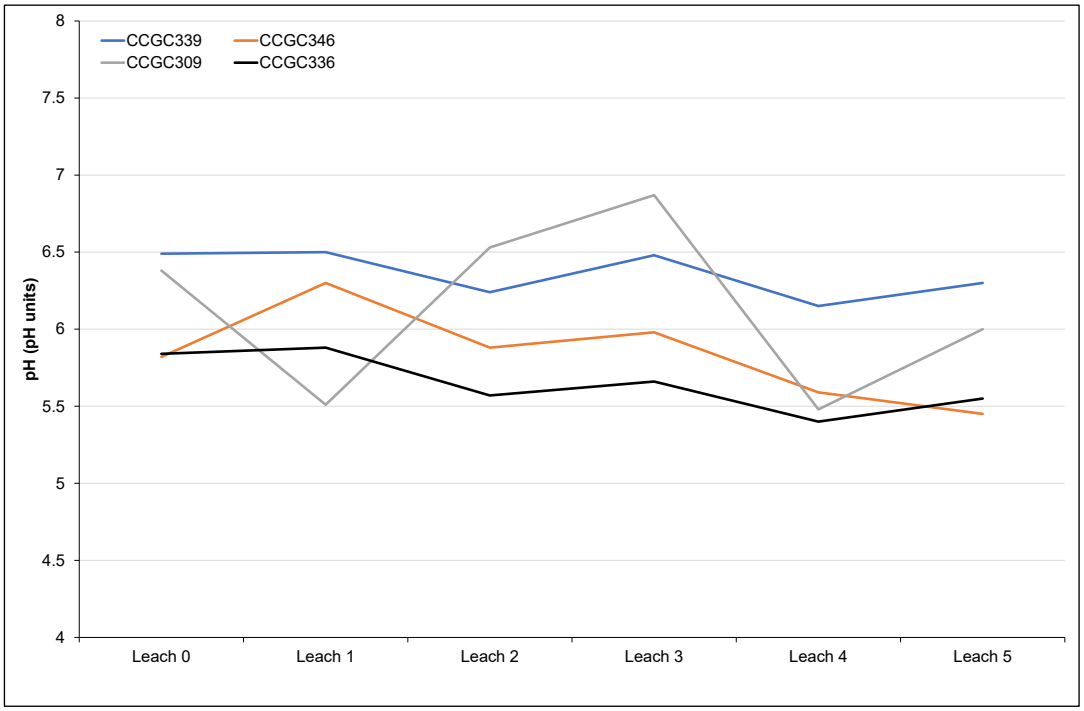

Figure 19: Trend in pH of each KLC tested sample over time.

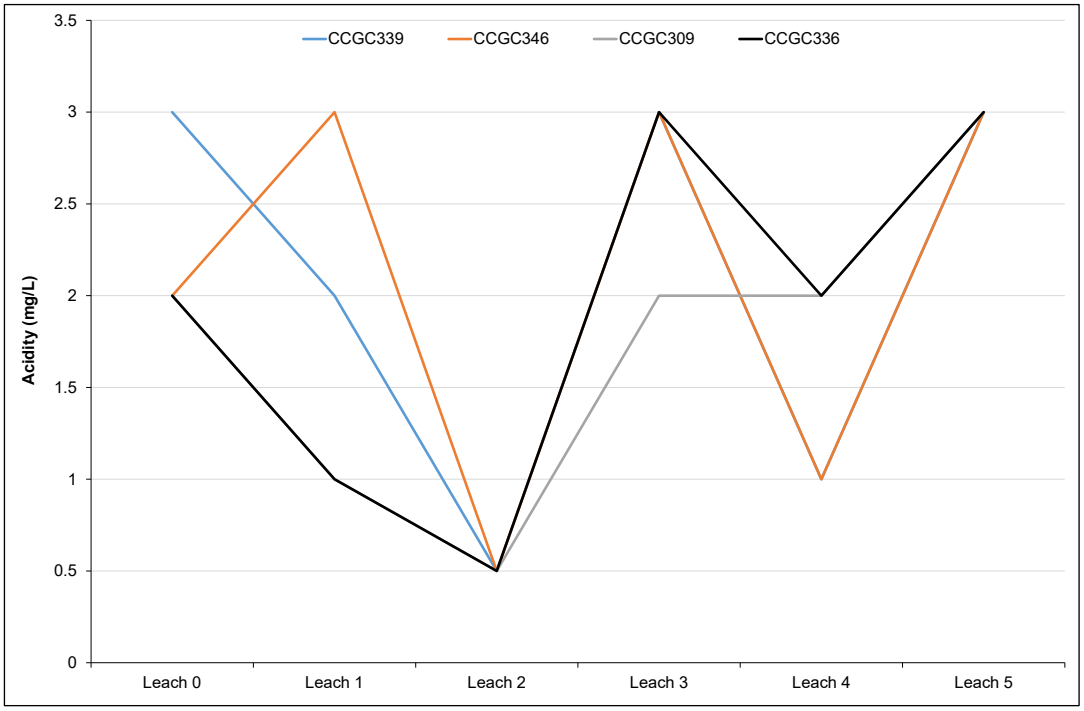

Figure 20: Trends in acidity observed in each KLC tested sample over time.

4.5.2 ELECTRICAL CONDUCTIVITY

Electrical conductivity is a property that will not accumulate over time with each value representing an individual snapshot in time. Thus, between successive leaches, conductivity in all samples generally falls, ranging from 553 to 20 µS/cm in leach 0 to 41, to 10 µS/cm in leach 4 (Table 8 and Figure 21). This is consistent with the general dilution of the leachate over time. These results indicate that each sample would still be considered freshwater under both the US Geological Survey guidelines (i.e. <1,560 µS/cm; refer to https://www.usgs.gov/special-topics/water-science-school/science/saline-water-and-salinity) and the Queensland Government (i.e. <1,500 µS/cm; refer to the Science Note provided in Appendix C). Therefore, salinity is not an issue associated with the Agate Creek Mine waste rock.

While electrical conductivity is not accumulative, the end products, upon evaporation (i.e. salts), are accumulative. This is true of any water evaporating in the bed sands of a stream where halite saturation (i.e. EC > 300,000 µS/cm) are achieved in the dry season.

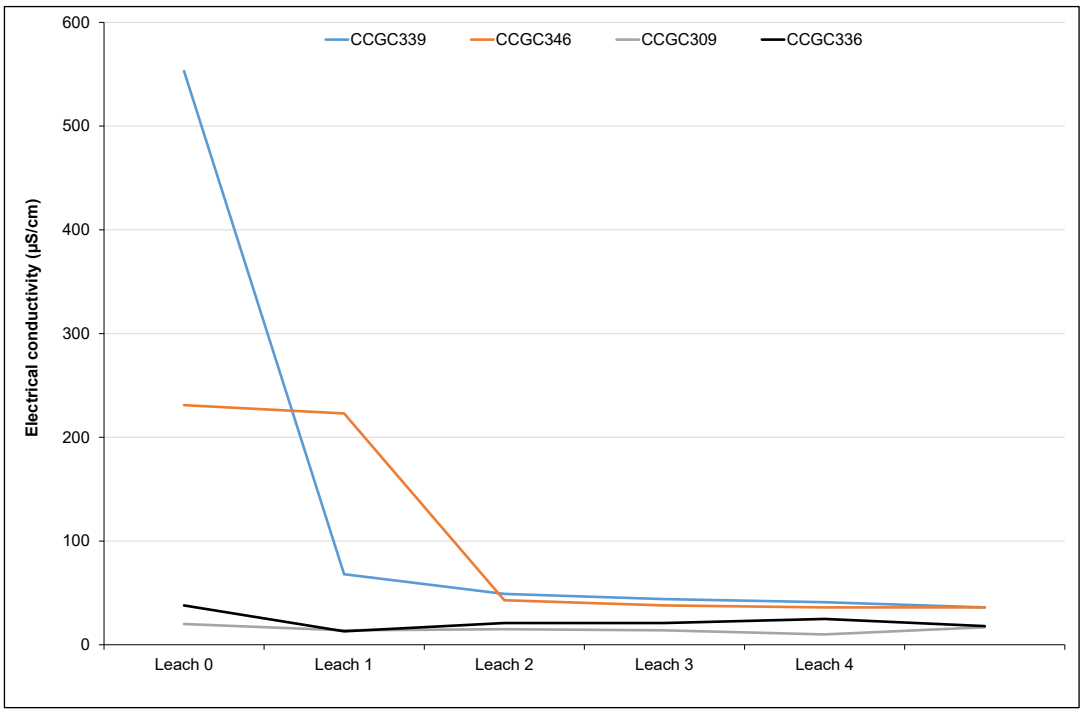

Figure 21: Trends in electrical conductivity observed in each KLC tested sample over time.

4.5.3 METALS / METALLOIDS

Most metal concentrations were found to be either compliant with relevant guideline values, or only exceeded these values in the cumulative results at the end of testing (Table 8). For instance, cadmium was recorded below the LOR in every sample tested. However, the cumulative results were found to exceed the 95% species protection level for aquatic ecosystems after leach 4 (Table 8). This is a result of the conservative method used to calculate the cumulative value in the event of below the LOR values (i.e. adopt a value equal to 50% of the limit of reporting), combined with the number of leaches performed, and the relatively low guideline value. Therefore, although the cumulative value for cadmium appears to have exceeded the aquatic ecosystem guideline value in leach 4, it is suggested that cadmium levels within Agate Creek Mine's waste rock are not of environmental concern.

With respect to metals and metalloids, cumulative values may be of use in assessing the total load that may build up by evaporation in any downstream sediments and may be available for later mobilisation in flow events.

Only four metals or metalloids were regularly recorded above their respective aquatic ecosystem guideline values (Table 8):

- Dissolved aluminium;
- Dissolved boron;
- Dissolved copper; and
- Dissolved zinc.

Values for aluminium (refer Figure 22 and Table 8) were opportunistic up to Leach 3 after which a consistent overall drop for all samples was observed. Erratic behaviour in Leaches 0 to 2 was shown by all samples, except for CCGC336. Non-compliance values (above 0.055 mg/L) were shown by CCGC309 in Leach 0 and CCGC339 in Leaches 1 and 2, with the value in Leach 2 exceeding 0.150 mg/L (Figure 22 and Table 8). After Leach 2, levels

in all samples decrease systematically. Accumulated values in all samples (except for CCGC336) exceed the 0.055 mg/L threshold (Figure 22 and Table 8).

As indicated above, individual levels are largely opportunistic, representing mineral availability to reaction at any particular time. Further, much of the "dissolved" aluminium will be in colloidal form.

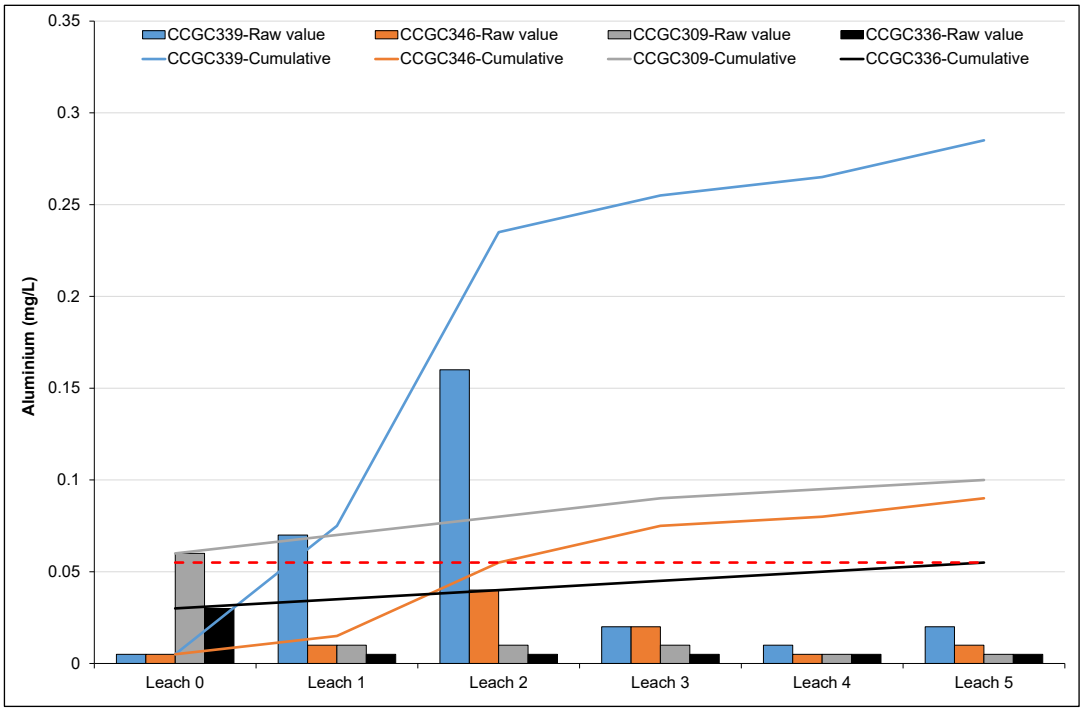

Figure 22: Cumulative trends and individual leach values of dissolved aluminium observed in each KLC tested sample over time compared against the ANZG (2018) 95% species protection level for freshwater systems (red dashed line).

Dissolved Boron levels reacted as expected in all samples (i.e. initially elevated and then relatively compliant levels in later leaches), except CCGC336 (Figure 23). CCGC336 (located in Pit 6) increased in dissolved boron concentrations with each subsequent leach, displaying an almost exponential cumulative rise in values up to leach 4. However, the results of leach 5 show the values of dissolved boron began to decrease (Figure 23). The relatively higher boron values from CCGC336 may be a response of the clay minerals present, in the sample, to the slight decrease in pH (increase in acidity) shown by the same sample over the 5 leaches.

Dissolved copper marginally exceeded the guideline value on two occasions in two separate samples (Figure 24). Both CCGC346 (from Pit 4) and CCGC336 (from Pit 6) recorded one result each above the guideline value with all other results from these two samples recorded below the LOR (Figure 24). Figure 24 shows the levels of copper within the waste rock quickly leach from the system at marginal levels prior to reducing to compliant concentrations. While the accumulation of copper within aquatic environments can be of environmental concern, it is predicted that the relatively low levels of copper leaching from the Agate Creek Mine waste rock are of negligible concern to its downstream receiving environment.

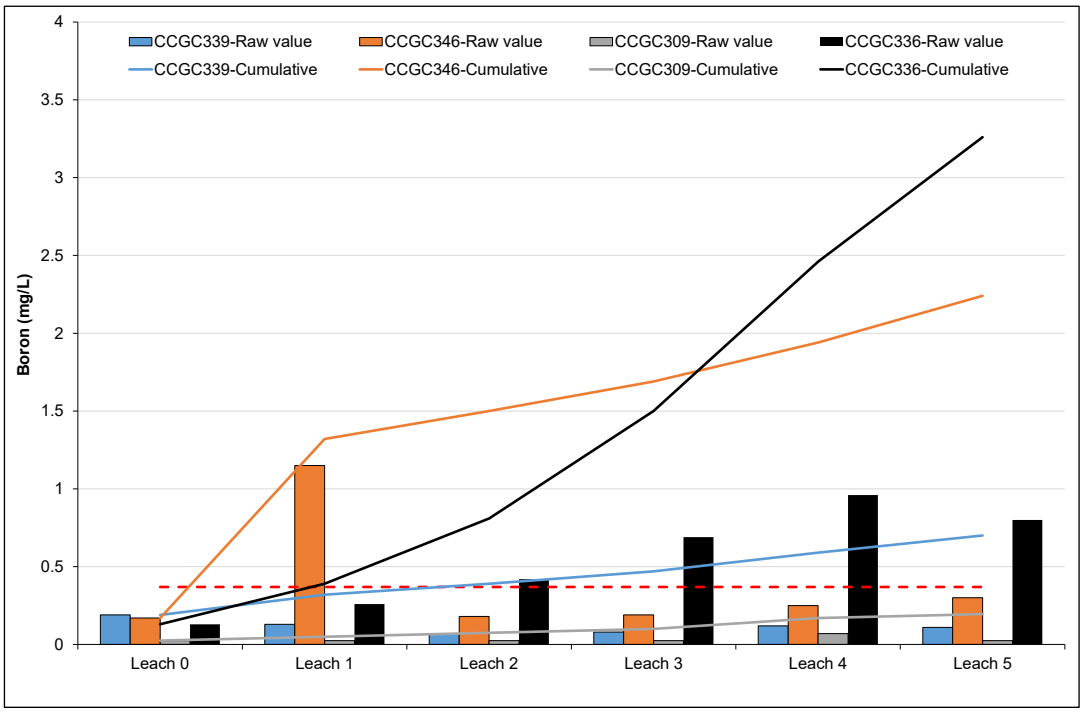

Figure 23: Cumulative trends and individual leach values of dissolved boron observed in each KLC tested sample over time compared against the ANZG (2018) 95% species protection level for freshwater systems (red dashed line).

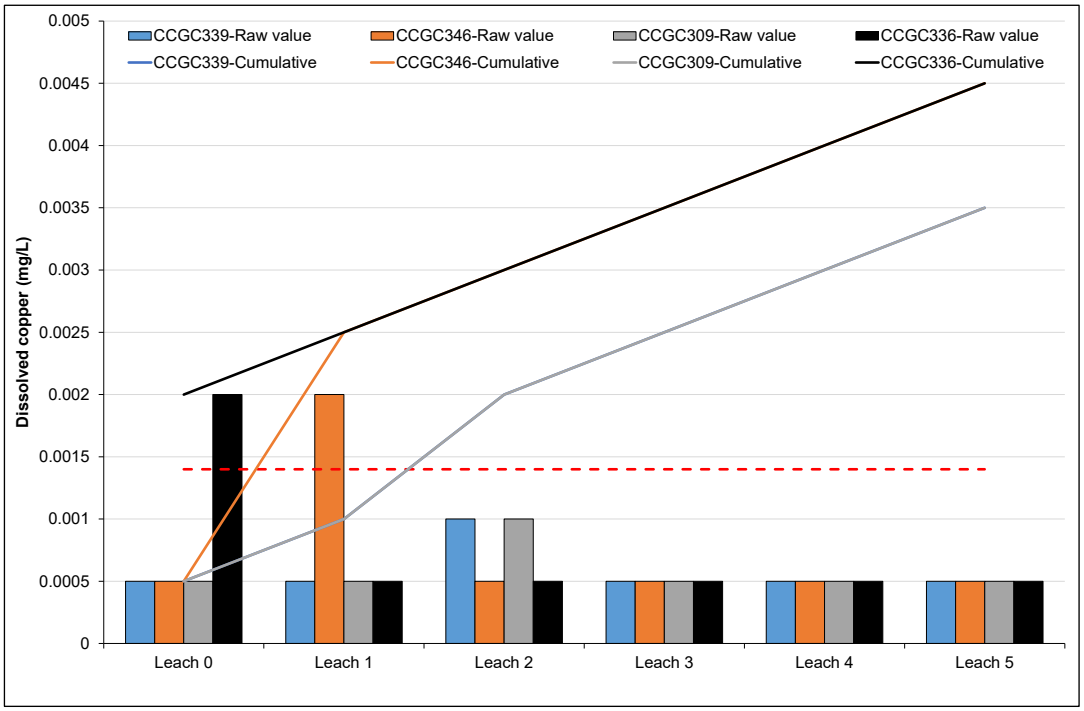

Figure 24: Cumulative trends and individual leach values of dissolved copper observed in each KLC tested sample over time compared against the ANZG (2018) 95% species protection level for freshwater systems (red dashed line).

During leach 1, CCGC346 (Pit 4) recorded one large spike of dissolved zinc (well above the aquatic ecosystem guideline level), but recorded levels below the LOR on every other occasion (Figure 25). CCGC309 (in Pit 6) is the only sample to record all values below the LOR, with no other site following any particular trend in results (Table 8 and Figure 25). In the absence of appreciable sulphate (i.e. evidence of sulphide oxidation) the behaviour of both copper and zinc are problematical. The most likely source of these metals into solution in the geological context (i.e. waste rock) is desorption from negatively charged manganese oxy-hydroxide colloids, and or, possibly negatively charged aluminium oxy-hydroxide colloids. Attempts to investigate these possibilities using correlation analyses have not been entirely successful. Possibly, by including adsorption on to smectite as an additional parameter may lead to success. Modelling at this level is beyond the scope of this current study.

Overall, it is considered likely that the probable sources of both copper and zinc are desorption from oxy-hydroxides and clays. This desorption would be opportunistic in the leaching solution as mineral species, and consequent value, may be elevated, but would be expected to show an overall decrease between successive leaches. This trend is generally consistent with the data up to Leach 5.

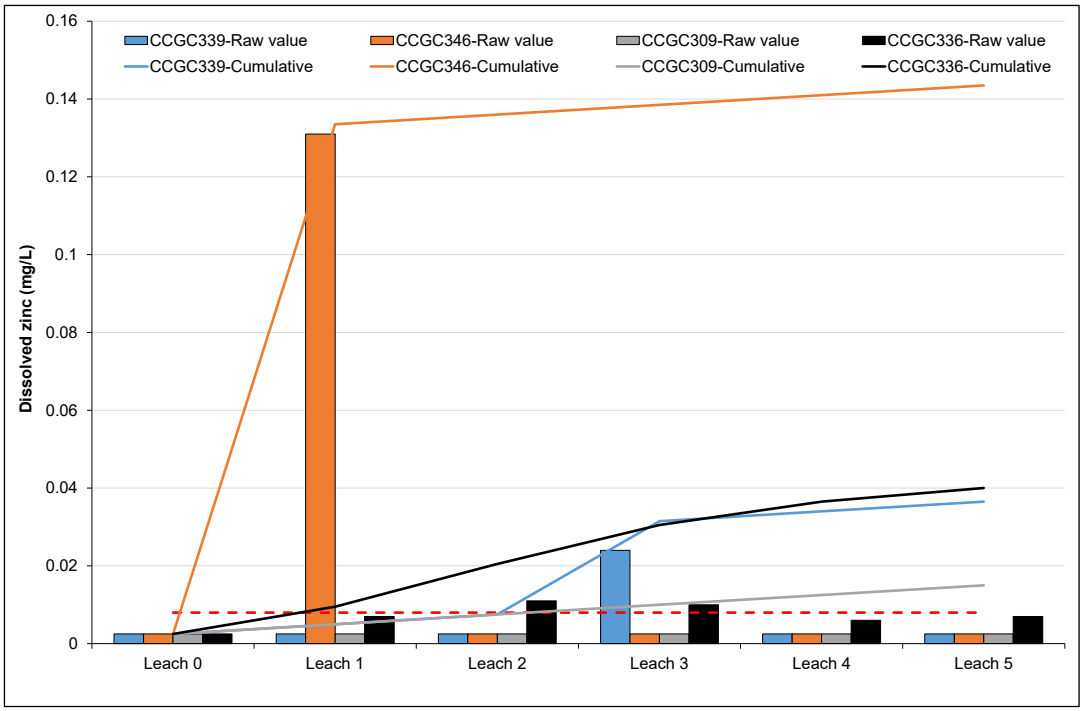

Figure 25: Cumulative trends and individual leach values of dissolved zinc observed in each KLC tested sample over time compared against the ANZG (2018) 95% species protection level for freshwater systems (red dashed line).

4.5.4 FLUORIDE

The KLC test results demonstrate that there is an expected overall accumulation of fluoride with successive leaching in sample CCGC339 (Table 8 and Figure 26). In all other samples (and particularly levels of fluoride), particulates are approximately constant with successive leaches.

For CCGC309, levels of fluoride fell from 6.6 mg/L in Leach 0, to 4 mg/L in Leach 1, to 2.0 mg/L in Leach 4 (Table 8 and Figure 26). The compliance level is 2.0 mg/L. The initial high level is probably due to the presence of the alteration mineral fluorite (CaF2) and its dissolution. Successive leaches reduce the influence of this mineral by dissolution.

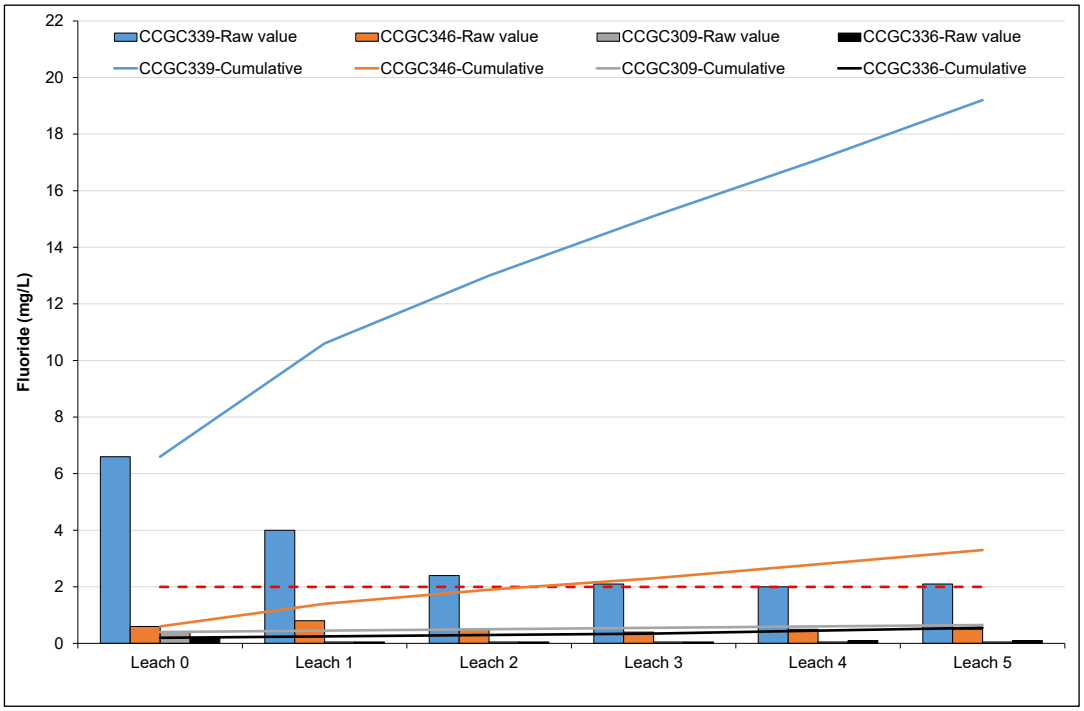

Figure 26: Cumulative trends and individual leach values of fluoride observed in each KLC tested sample over time compared against the ANZG (2018) livestock drinking water value (red dashed line).

5. CONCLUSION AND RECOMMENDATIONS

5.1 ACID MINE DRAINAGE

Static testing of 260 samples from Pits 1 to 6 from Agate Creek Mine were analysed for a broad range of analytes in manners consistent with the relevant protocols. Of the 260 samples analysed only 11 samples could be categorised as PAF. These samples are all found in Pits 2, 5 and 6 with 7 of the 11 being found in Pit 6. All of these, except for one sample in Pit 2, still only have very low to low sulphur values. Therefore, only one sample presents any possibility of acid mine drainage. Thus, it is expected that:

- The amount of any acid potentially produced will be small, and
- Any acid produced by the waste rock will be buffered by the surrounding NAF rock which makes up >90% of the waste rock.

Therefore, it is considered that the acid mine drainage risk posed by the waste rock associated with the project is very low.

5.2 SALINITY

The EC of water from the Agate Creek waste rock samples ranged from 7 to 1680 µS/cm with a very low median value of 43.5 µS/cm. These values are all within (or similar to in the case of the maximum value) appropriate guideline values for freshwater systems. Therefore, it is considered that salinity is not an issued in the management of the Agate Creek waste rock piles.

5.3 ELEMENTS

A broad range of analytes were assessed in both the static leach tests and KLC tests, with the following results of note:

- Fluoride: Levels were above the target level of 2 mg/L in many of the 260 waste rock samples analysed using static tests. The range in values overall was >0.5 mg/L to 63 mg/L. These exceedances may be of concern as fluorine is present in most of the waste rock, principally in the alteration zone minerals (fluorite) and in the micas. However, these fluoride values are not universal for the Agate Creek area which is a volcanic province where fluorine enrichment is not unexpected. The possibility of a high ambient level implies that the overall risk associated with fluoride is low.

  In the kinetic leach results, fluoride trended down to the compliance level of 2 mg/L by the 4th leach, supporting the overall proposition that the overall environmental risk from fluoride is low.
- Sulphate: The dissolved sulphate levels in the static test results from the Agate Creek waste rock samples range from 5 mg/L to 1760 mg/L with a low median value of 20 mg/L. Only one sample from Pit 2 is above the ANZECC and ARMCANZ (2000) Livestock Drinking Water Guideline of 1000 mg/L.

  Sulphate values in the KLC tests were all within compliance levels. Based on these results the environmental risk from sulphate is considered low.
- Metals and Metalloids: In KLC tests, levels above compliance values were detected for aluminium, boron, copper and zinc. These exceedances were relatively low and were probably associated with adsorbed species on colloids being included in the “dissolved” analyses. As such, these exceedances are considered to display a very low to low environmental risk associated with the Agate Creek waste rock piles.

5.4 RECOMMENDATIONS

The overall risk associated with the Agate Creek waste rock material is most likely very low to possibly low. In the light of this level of risk, capping is not recommended or appropriate. Any waste rock piles developed by the mining activities should be covered with layers of sub-soil and top-soil and revegetated with a range of native plant and grass species appropriate to the soils and climate of the area.

Additionally, it is recommended that the site determine site-specific water quality objectives for the receiving environment of Agate Creek and the groundwaters of relevance to the site, with particular focus on fluoride, sulphate, aluminium, boron, copper and zinc. This will allow for appropriate monitoring of potential impacts from operations/activities associated with the proposed project.

6. REFERENCES

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Appendix A – Static Results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2203022**	Page	: 1 of 26
Client	: **C & R CONSULTING PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: ALEXANDER BARNES	Contact	: Princess Marcelo
Address	: 188 ROSS RIVER ROAD AITKENVALE QUEENSLAND 4812	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: Agate Creek Geochemistry	Date Samples Received	: 01-Feb-2022 09:00
Order number	: ----	Date Analysis Commenced	: 10-Feb-2022
C-O-C number	: ----	Issue Date	: 08-Mar-2022 16:57
Sampler	: PETER NEVILLE		
Site	: ----		
Quote number	: TV/178/21		
No. of samples received	: 56		
No. of samples analysed	: 56		

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, unless the sampling was conducted by ALS. 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*
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the 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.

- EG005T (Total Metals by ICP-AES): V33205 (EB2203022-039) shows poor duplicate results due to sample heterogeneity. This has been confirmed by visual inspection.
- EG005T (Total Metals by ICP-AES): V32485 (EB2203022-010) shows poor matrix spike recovery due to sample heterogeneity. This has been confirmed by visual inspection.
- EG005T (Total Metals by ICP-AES): V32512 (EB2203022-019) shows poor duplicate results due to sample heterogeneity. This has been confirmed by visual inspection.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32482	V32485	V32488	V32491	V32494
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-009	EB2203022-010	EB2203022-011	EB2203022-012	EB2203022-013
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.0	5.4	5.6	6.0	6.2
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	-0.5	-7.0	-6.8	-1.1
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	40	234	32	23	22
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	5.3	5.5	4.9	5.8	5.9
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	1.9	3.8	13.6	3.5	3.4
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	0.5	7.0	6.8	1.1
ANC as CaCO3	----	0.1	% CaCO3	<0.1	<0.1	0.7	0.7	0.1
Fizz Rating	----	0	Fizz Unit	0	0	1	1	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	1.7	<1.0	1.0	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	20	<10	<10	<10
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	20	330	40	100	110
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	2420	1950	1470	1740	1680
Arsenic	7440-38-2	5	mg/kg	11	33	6	26	9
Barium	7440-39-3	10	mg/kg	20	240	40	40	70
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	8	6	16	9	8
Cobalt	7440-48-4	2	mg/kg	2	<2	<2	5	5
Copper	7440-50-8	5	mg/kg	7	7	9	17	14
Iron	7439-89-6	50	mg/kg	17800	5860	6030	12000	15700
Lead	7439-92-1	5	mg/kg	7	13	10	10	14

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32482	V32485	V32488	V32491	V32494
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-009	EB2203022-010	EB2203022-011	EB2203022-012	EB2203022-013
				Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued								
Manganese	7439-96-5	5	mg/kg	**33**	<5	**5**	**481**	**120**
Nickel	7440-02-0	2	mg/kg	**4**	**5**	**9**	**5**	**6**
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	**17**	**13**	**9**	**21**	**16**
Zinc	7440-66-6	5	mg/kg	**32**	**24**	**6**	**21**	**34**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	<1	**8**	**3**	**5**	**4**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32497	V32500	V32503	V32506	V32509
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-014	EB2203022-015	EB2203022-016	EB2203022-017	EB2203022-018
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.9	7.0	7.1	7.2	7.3
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-0.6	-0.8	-0.8	-0.9	-1.2
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	36	13	20	22	47
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	5.8	6.0	5.9	6.3	7.0
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	3.6	2.5	3.2	1.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	0.6	0.8	0.8	0.9	1.2
ANC as CaCO3	----	0.1	% CaCO3	<0.1	<0.1	<0.1	<0.1	0.1
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	1.1	<1.0	<1.0	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	20	10	<10	10	30
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1700	1860	1420	2150	1390
Arsenic	7440-38-2	5	mg/kg	8	17	<5	<5	<5
Barium	7440-39-3	10	mg/kg	70	80	30	20	20
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	12	11	9	12	14
Cobalt	7440-48-4	2	mg/kg	6	14	3	30	4
Copper	7440-50-8	5	mg/kg	10	23	14	19	9
Iron	7439-89-6	50	mg/kg	22400	18100	6650	32200	9560
Lead	7439-92-1	5	mg/kg	17	16	14	13	10

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32497	V32500	V32503	V32506	V32509
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-014	EB2203022-015	EB2203022-016	EB2203022-017	EB2203022-018
				Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued								
Manganese	7439-96-5	5	mg/kg	**62**	**312**	**84**	**376**	**191**
Nickel	7440-02-0	2	mg/kg	**11**	**14**	**8**	**25**	**10**
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	**11**	**9**	<5	**8**	**5**
Zinc	7440-66-6	5	mg/kg	**36**	**38**	**37**	**120**	**38**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	**6**	**6**	**4**	**5**	**5**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32512	V32515	V32518	V32521	V32524
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-019	EB2203022-020	EB2203022-021	EB2203022-022	EB2203022-023
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.4	7.6	7.4	7.3	7.2
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	-0.8	-6.7	-6.7	-1.1
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	28	30	35	30	47
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.9	6.5	6.4	6.9	8.0
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	1.6	1.2	0.2	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	0.8	6.7	6.7	1.1
ANC as CaCO3	----	0.1	% CaCO3	<0.1	<0.1	0.7	0.7	0.1
Fizz Rating	----	0	Fizz Unit	0	0	1	1	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	1.0	1.0	1.0	<1.0	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	20	20	20	40
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1920	1240	1370	1450	1450
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	<5
Barium	7440-39-3	10	mg/kg	70	20	40	10	100
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	11	14	12	18	8
Cobalt	7440-48-4	2	mg/kg	10	4	3	2	<2
Copper	7440-50-8	5	mg/kg	9	11	<5	9	12
Iron	7439-89-6	50	mg/kg	27100	10900	9370	7860	8500
Lead	7439-92-1	5	mg/kg	6	8	20	11	10

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V32512	V32515	V32518	V32521	V32524
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203022-019	EB2203022-020	EB2203022-021	EB2203022-022	EB2203022-023
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**456**	**161**	**104**	**219**	**128**
Nickel	7440-02-0	2	mg/kg		**19**	**13**	**10**	**10**	**10**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**6**	<5	<5	<5	<5
Zinc	7440-66-6	5	mg/kg		**72**	**38**	**34**	**35**	**39**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**4**	**3**	**3**	**4**	**4**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32527	V32530	V32533	V32536	V32539
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-024	EB2203022-025	EB2203022-026	EB2203022-027	EB2203022-028
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.3	6.5	7.8	7.6	7.6
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-1.6	-1.0	-1.2	-0.7	-0.8
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	41	96	69	46	65
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	8.0	6.8	7.6	7.4	7.2
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	1.0	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	1.6	1.3	1.5	1.0	1.4
ANC as CaCO3	----	0.1	% CaCO3	0.2	0.1	0.2	0.1	0.1
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	<1.0	<1.0	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	10	110	90	40	70
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.01	0.01	0.01	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	20	120	10	10	20
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1240	1780	1190	3330	3170
Arsenic	7440-38-2	5	mg/kg	<5	21	5	<5	7
Barium	7440-39-3	10	mg/kg	130	290	50	50	80
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	9	8	10	14	13
Cobalt	7440-48-4	2	mg/kg	6	45	18	7	7
Copper	7440-50-8	5	mg/kg	15	22	6	12	8
Iron	7439-89-6	50	mg/kg	8470	16400	9940	25600	26200
Lead	7439-92-1	5	mg/kg	11	18	19	9	17

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V32527	V32530	V32533	V32536	V32539
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203022-024	EB2203022-025	EB2203022-026	EB2203022-027	EB2203022-028
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**325**	**52**	**562**	**515**	**738**
Nickel	7440-02-0	2	mg/kg		**10**	**43**	**18**	**14**	**12**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		<5	**5**	**6**	**14**	**11**
Zinc	7440-66-6	5	mg/kg		**42**	**185**	**83**	**94**	**63**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	**0.3**	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**5**	**3**	**4**	**4**	**4**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32542	V33151	V33154	V33157	V33189
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-029	EB2203022-030	EB2203022-031	EB2203022-032	EB2203022-033
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.3	6.9	7.2	4.7	5.0
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-3.0	-0.6	<0.5	6.4	0.6
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	44	21	23	278	57
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.2	5.4	6.9	3.4	5.9
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	2.4	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	2.8	1.0	5.2	1.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	3.3	0.6	<0.5	0.6	<0.5
ANC as CaCO3	----	0.1	% CaCO3	0.3	<0.1	<0.1	<0.1	<0.1
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	<1.0	1.5	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	30	<10	<10	670	110
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.01	<0.01	<0.01	0.23	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	10	<10	<10	100	30
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	5820	750	610	8800	2410
Arsenic	7440-38-2	5	mg/kg	<5	19	6	37	18
Barium	7440-39-3	10	mg/kg	40	<10	<10	<10	10
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	13	13	5	33	12
Cobalt	7440-48-4	2	mg/kg	7	2	<2	48	20
Copper	7440-50-8	5	mg/kg	10	25	25	155	48
Iron	7439-89-6	50	mg/kg	48100	6850	1010	46100	28500
Lead	7439-92-1	5	mg/kg	10	<5	<5	<5	9

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Sample ID	V32542	V33151	V33154	V33157	V33189
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
					EB2203022-029	EB2203022-030	EB2203022-031	EB2203022-032	EB2203022-033
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**903**	**36**	**6**	**589**	**187**
Nickel	7440-02-0	2	mg/kg		**18**	**10**	**3**	**118**	**6**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**10**	**10**	**8**	**64**	**57**
Zinc	7440-66-6	5	mg/kg		**120**	**15**	<5	**215**	**16**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**4**	**5**	**8**	**2**	**2**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V33192	V33195	V33198	V33201	V33202
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-034	EB2203022-035	EB2203022-036	EB2203022-037	EB2203022-038
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.3	5.7	6.7	7.0	5.4
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-5.3	-1.8	-5.6	-15.6	-8.3
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	242	334	429	446	296
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	5.2	7.2	6.9	7.2	7.1
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	5.3	<0.1	0.2	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	5.9	2.7	6.8	16.8	8.9
ANC as CaCO3	----	0.1	% CaCO3	0.6	0.3	0.7	1.7	0.9
Fizz Rating	----	0	Fizz Unit	1	0	0	1	1
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	1.0	1.7	2.9	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	420	630	820	910	530
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.03	0.04	0.04	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	90	130	180	160	120
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1190	1460	6370	14500	3050
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	13	18
Barium	7440-39-3	10	mg/kg	60	20	20	<10	20
Beryllium	7440-41-7	1	mg/kg	<1	1	<1	1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	6	7	16	32	20
Cobalt	7440-48-4	2	mg/kg	4	37	39	53	31
Copper	7440-50-8	5	mg/kg	38	68	142	125	44
Iron	7439-89-6	50	mg/kg	14400	38500	40900	71800	40900
Lead	7439-92-1	5	mg/kg	<5	<5	<5	<5	10

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V33192	V33195	V33198	V33201	V33202
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203022-034	EB2203022-035	EB2203022-036	EB2203022-037	EB2203022-038
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**29**	**1580**	**1070**	**4260**	**453**
Nickel	7440-02-0	2	mg/kg		**4**	**17**	**47**	**62**	**14**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**28**	**32**	**66**	**126**	**70**
Zinc	7440-66-6	5	mg/kg		**15**	**68**	**68**	**108**	**33**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**2**	**3**	**4**	**6**	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V33205	V33208	V33211	V33214	V33217
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-039	EB2203022-040	EB2203022-041	EB2203022-042	EB2203022-043
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	8.2	7.4	7.2	8.4	7.7
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-12.9	-8.9	-16.8	-9.3	-23.8
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	143	52	342	147	55
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	8.0	7.4	6.9	7.6	7.4
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	0.2	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	13.2	9.2	17.4	9.6	23.8
ANC as CaCO3	----	0.1	% CaCO3	1.3	0.9	1.8	1.0	2.4
Fizz Rating	----	0	Fizz Unit	1	1	1	1	1
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.0	<1.0	2.0	<1.0	2.6
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	110	60	580	170	20
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.01	0.01	0.02	0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	90	20	140	60	20
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	2780	1140	27000	2470	22300
Arsenic	7440-38-2	5	mg/kg	<5	<5	9	11	<5
Barium	7440-39-3	10	mg/kg	80	20	<10	<10	20
Beryllium	7440-41-7	1	mg/kg	2	<1	<1	<1	2
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	12	28	31	13	26
Cobalt	7440-48-4	2	mg/kg	23	49	58	9	53
Copper	7440-50-8	5	mg/kg	73	56	60	9	80
Iron	7439-89-6	50	mg/kg	49000	9310	56000	6440	55400
Lead	7439-92-1	5	mg/kg	<5	<5	<5	21	9

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V33205	V33208	V33211	V33214	V33217
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203022-039	EB2203022-040	EB2203022-041	EB2203022-042	EB2203022-043
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**2090**	**852**	**973**	**212**	**1560**
Nickel	7440-02-0	2	mg/kg		**12**	**31**	**162**	**20**	**135**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**50**	**14**	**111**	**9**	**106**
Zinc	7440-66-6	5	mg/kg		**59**	**24**	**114**	**17**	**121**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**18**	**8**	**12**	**11**	**20**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V33220	V33223	V33226	V33246	V33249
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-044	EB2203022-045	EB2203022-046	EB2203022-047	EB2203022-048
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.4	7.2	7.2	5.6	7.7
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-26.0	-25.1	-28.0	-9.2	-4.5
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	58	51	46	42	221
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.8	7.4	7.4	6.3	7.5
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	0.8	<0.1	<0.1	0.9	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	27.8	25.1	28.0	9.2	4.8
ANC as CaCO3	----	0.1	% CaCO3	2.8	2.6	2.8	0.9	0.5
Fizz Rating	----	0	Fizz Unit	1	1	1	1	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.1	5.4	5.0	1.7	1.4
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	70	<10	<10	30	100
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.06	<0.01	<0.01	<0.01	0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	10	20	20	30	200
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	21800	27200	25400	5320	2570
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	6	<5
Barium	7440-39-3	10	mg/kg	10	60	30	80	510
Beryllium	7440-41-7	1	mg/kg	1	2	2	<1	1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	26	27	30	9	8
Cobalt	7440-48-4	2	mg/kg	40	62	50	3	6
Copper	7440-50-8	5	mg/kg	51	109	120	5	6
Iron	7439-89-6	50	mg/kg	46500	57400	51100	14600	8610
Lead	7439-92-1	5	mg/kg	<5	<5	<5	7	7

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Sample ID	V33220	V33223	V33226	V33246	V33249
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
					EB2203022-044	EB2203022-045	EB2203022-046	EB2203022-047	EB2203022-048
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**2040**	**3200**	**1400**	**28**	**416**
Nickel	7440-02-0	2	mg/kg		**102**	**136**	**132**	**4**	**9**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**86**	**137**	**130**	**17**	**6**
Zinc	7440-66-6	5	mg/kg		**57**	**78**	**75**	**19**	**38**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**14**	**18**	**16**	**6**	**21**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V33252	V33255	V33258	V33261	V33264
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-049	EB2203022-050	EB2203022-051	EB2203022-052	EB2203022-053
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.1	7.2	8.0	7.7	7.6
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-2.6	-2.9	-12.4	-8.2	-17.8
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	175	189	78	28	21
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.0	6.2	7.5	7.4	7.2
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	3.0	1.4	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	2.6	2.9	12.4	8.2	17.8
ANC as CaCO3	----	0.1	% CaCO3	0.3	0.3	1.2	0.8	1.8
Fizz Rating	----	0	Fizz Unit	0	0	1	0	1
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	1.1	<1.0	1.1	<1.0	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	120	140	40	<10	<10
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	140	150	60	20	10
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1290	760	3840	6740	7000
Arsenic	7440-38-2	5	mg/kg	7	5	<5	<5	<5
Barium	7440-39-3	10	mg/kg	190	30	90	60	40
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	7	17	11	21	21
Cobalt	7440-48-4	2	mg/kg	<2	<2	7	12	11
Copper	7440-50-8	5	mg/kg	8	8	19	12	8
Iron	7439-89-6	50	mg/kg	4170	2930	16700	19000	18200
Lead	7439-92-1	5	mg/kg	7	6	11	8	6

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V33252	V33255	V33258	V33261	V33264
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203022-049	EB2203022-050	EB2203022-051	EB2203022-052	EB2203022-053
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**16**	**13**	**199**	**359**	**407**
Nickel	7440-02-0	2	mg/kg		**6**	**12**	**17**	**18**	**18**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		<5	<5	**9**	**19**	**19**
Zinc	7440-66-6	5	mg/kg		**15**	**12**	**72**	**64**	**59**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**13**	**8**	**11**	**7**	**4**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V33327	V33330	V33333	V33336	V33339
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-054	EB2203022-055	EB2203022-056	EB2203022-057	EB2203022-058
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.2	7.4	7.5	6.8	7.4
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-5.5	-16.4	-9.5	-5.2	-3.0
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	19	100	133	256	58
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.7	7.5	7.1	7.1	7.8
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	0.8	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	5.8	16.4	9.5	5.5	3.0
ANC as CaCO3	----	0.1	% CaCO3	0.6	1.7	1.0	0.6	0.3
Fizz Rating	----	0	Fizz Unit	0	1	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	1.0	<1.0	1.1	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	10	60	130	280	40
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.01	<0.01	<0.01	0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	10	60	100	170	40
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	6940	6440	7330	6200	1580
Arsenic	7440-38-2	5	mg/kg	6	7	6	<5	8
Barium	7440-39-3	10	mg/kg	90	90	40	160	90
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	13	10	20	10	11
Cobalt	7440-48-4	2	mg/kg	10	10	12	14	5
Copper	7440-50-8	5	mg/kg	<5	6	10	14	10
Iron	7439-89-6	50	mg/kg	20200	16000	22300	18800	5040
Lead	7439-92-1	5	mg/kg	10	11	10	7	12

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Sample ID	V33327	V33330	V33333	V33336	V33339
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
					EB2203022-054	EB2203022-055	EB2203022-056	EB2203022-057	EB2203022-058
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**158**	**857**	**287**	**111**	**219**
Nickel	7440-02-0	2	mg/kg		**13**	**12**	**19**	**23**	**10**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**24**	**15**	**28**	**16**	**7**
Zinc	7440-66-6	5	mg/kg		**48**	**36**	**64**	**129**	**38**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**2**	**24**	**9**	**9**	**8**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V33342	V33345	V33348	V33351	V33354
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203022-059	EB2203022-060	EB2203022-061	EB2203022-062	EB2203022-063
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.9	6.8	8.0	7.4	7.6
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	-11.8	-8.3	-13.7	-7.1
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	22	20	46	40	45
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.2	7.5	7.3	7.2	6.7
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	0.9
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	11.8	8.3	13.7	7.1
ANC as CaCO3	----	0.1	% CaCO3	<0.1	1.2	0.8	1.4	0.7
Fizz Rating	----	0	Fizz Unit	0	1	0	1	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	<1.0	<1.0	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	10	<10	10	40	20
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	10	<10	<10
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	2360	2530	8260	5420	9800
Arsenic	7440-38-2	5	mg/kg	10	<5	<5	<5	<5
Barium	7440-39-3	10	mg/kg	80	60	60	20	50
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	7	6	11	10	14
Cobalt	7440-48-4	2	mg/kg	6	7	22	6	8
Copper	7440-50-8	5	mg/kg	11	9	14	12	17
Iron	7439-89-6	50	mg/kg	7770	7810	27400	18500	26500
Lead	7439-92-1	5	mg/kg	8	9	10	10	13

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V33342	V33345	V33348	V33351	V33354
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203022-059	EB2203022-060	EB2203022-061	EB2203022-062	EB2203022-063
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**180**	**138**	**278**	**240**	**63**
Nickel	7440-02-0	2	mg/kg		**11**	**8**	**45**	**10**	**12**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**6**	**7**	**14**	**12**	**15**
Zinc	7440-66-6	5	mg/kg		**52**	**39**	**122**	**51**	**73**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**4**	**4**	**4**	**4**	**4**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V33357	----	----	----	----
			Sampling date / time	01-Feb-2022 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB2203022-064	--------	--------	--------	--------
				Result	----	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**8.0**	----	----	----	----
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**-1.0**	----	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**80**	----	----	----	----
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**3.4**	----	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	**4.0**	----	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	**6.3**	----	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**8.3**	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	**0.8**	----	----	----	----
Fizz Rating	----	0	Fizz Unit	**0**	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	**110**	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.24**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	----	----	----	----
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**8370**	----	----	----	----
Arsenic	7440-38-2	5	mg/kg	**7**	----	----	----	----
Barium	7440-39-3	10	mg/kg	**160**	----	----	----	----
Beryllium	7440-41-7	1	mg/kg	<1	----	----	----	----
Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg	**20**	----	----	----	----
Cobalt	7440-48-4	2	mg/kg	**13**	----	----	----	----
Copper	7440-50-8	5	mg/kg	**9**	----	----	----	----
Iron	7439-89-6	50	mg/kg	**29600**	----	----	----	----
Lead	7439-92-1	5	mg/kg	**11**	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V33357	----	----	----	----
				Sampling date / time	01-Feb-2022 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB2203022-064	--------	--------	--------	--------
					Result	----	----	----	----
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**401**	----	----	----	----
Nickel	7440-02-0	2	mg/kg		**17**	----	----	----	----
Selenium	7782-49-2	5	mg/kg		<5	----	----	----	----
Vanadium	7440-62-2	5	mg/kg		**25**	----	----	----	----
Zinc	7440-66-6	5	mg/kg		**55**	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	----	----	----	----
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**2**	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2203026**	Page	: 1 of 4
Amendment	: **1**		
Client	: **C & R CONSULTING PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: ALEXANDER BARNES	Contact	: Princess Marcelo
Address	: 188 ROSS RIVER ROAD AITKENVALE QUEENSLAND 4812	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: Agate Creek Geochemistry	Date Samples Received	: 01-Feb-2022 09:00
Order number	: ----	Date Analysis Commenced	: 15-Feb-2022
C-O-C number	: ----	Issue Date	: 10-Mar-2022 15:27
Sampler	: PETER NEVILLE		
Site	: ----		
Quote number	: TV/178/21		
No. of samples received	: 1		
No. of samples analysed	: 1		

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, unless the sampling was conducted by ALS. 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*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the 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.

- Amendment (10/3/22): This report has been amended and re-released to allow the reporting of additional analytical data, specifically Thorium that was missed at the log-in stage.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V34048 to V34117 Composite	----	----	----	----
			Sampling date / time	01-Feb-2022 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB2203026-001	--------	--------	--------	--------
				Result	----	----	----	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	**5.3**	----	----	----	----
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**-3.3**	----	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	**19**	----	----	----	----
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	**7.1**	----	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	----	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	----	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**3.3**	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	**0.3**	----	----	----	----
Fizz Rating	----	0	Fizz Unit	**0**	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	----	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	**20**	----	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	<10	----	----	----	----
Magnesium	7439-95-4	10	mg/kg	<10	----	----	----	----
Sodium	7440-23-5	10	mg/kg	<10	----	----	----	----
Potassium	7440-09-7	10	mg/kg	**20**	----	----	----	----
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	**710**	----	----	----	----
Arsenic	7440-38-2	5	mg/kg	<5	----	----	----	----
Barium	7440-39-3	10	mg/kg	<10	----	----	----	----
Beryllium	7440-41-7	1	mg/kg	<1	----	----	----	----
Boron	7440-42-8	50	mg/kg	<50	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V34048 to V34117 Composite	----	----	----	----
				Sampling date / time	01-Feb-2022 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB2203026-001	--------	--------	--------	--------
					Result	----	----	----	----
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Cadmium	7440-43-9	1	mg/kg		<1	----	----	----	----
Chromium	7440-47-3	2	mg/kg		**5**	----	----	----	----
Cobalt	7440-48-4	2	mg/kg		<2	----	----	----	----
Copper	7440-50-8	5	mg/kg		<5	----	----	----	----
Iron	7439-89-6	50	mg/kg		**5180**	----	----	----	----
Lead	7439-92-1	5	mg/kg		<5	----	----	----	----
Manganese	7439-96-5	5	mg/kg		**78**	----	----	----	----
Nickel	7440-02-0	2	mg/kg		<2	----	----	----	----
Selenium	7782-49-2	5	mg/kg		<5	----	----	----	----
Vanadium	7440-62-2	5	mg/kg		**6**	----	----	----	----
Zinc	7440-66-6	5	mg/kg		**14**	----	----	----	----
EG020T: Total Metals by ICP-MS									
Thorium	7440-29-1	0.1	mg/kg		**0.8**	----	----	----	----
Molybdenum	7439-98-7	0.1	mg/kg		**2.4**	----	----	----	----
Antimony	7440-36-0	0.1	mg/kg		**0.5**	----	----	----	----
Uranium	7440-61-1	0.1	mg/kg		**0.4**	----	----	----	----
Tellurium	22541-49-7	0.5	mg/kg		<0.5	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2203029**	Page	: 1 of 32
Client	: **C & R CONSULTING PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: ALEXANDER BARNES	Contact	: Princess Marcelo
Address	: 188 ROSS RIVER ROAD AITKENVALE QUEENSLAND 4812	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: Agate Creek Geochemistry	Date Samples Received	: 01-Feb-2022 09:00
Order number	: ----	Date Analysis Commenced	: 10-Feb-2022
C-O-C number	: ----	Issue Date	: 10-Mar-2022 15:31
Sampler	: PETER NEVILLE		
Site	: ----		
Quote number	: TV/178/21		
No. of samples received	: 73		
No. of samples analysed	: 73		

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- Analytical Results

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Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

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^ = 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.

- **SPLIT WORK ORDER: It should be noted that ALS has split this work order over the following work orders (EB2203032, EB2203029) due to the size of the sample numbers. For any further information regarding this processing of samples please contact ALS client services division on ALSEnviro.Brisbane@alsglobal.com**
- EG005T (Total Metals by ICP-AES): V33031 (EB2203029-046) shows poor matrix spike recovery due to sample heterogeneity. This has been confirmed by visual inspection.
- EG005T (Total Metals by ICP-AES): V31908 (EB2203029-005) and V320030 (EB2203029-015) shows poor duplicate results due to sample heterogeneity. This has been confirmed by visual inspection.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V31900	V31903	V31905	V31906	V31908
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-001	EB2203029-002	EB2203029-003	EB2203029-004	EB2203029-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	4.9	5.0	5.0	5.0	4.9
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-0.7	-1.1	-0.7	-2.0	-1.6
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	10	10	13	10	13
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	5.6	5.6	5.5	5.8	5.8
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	4.4	6.1	4.2	3.3	4.4
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	0.7	1.1	0.7	2.0	1.6
ANC as CaCO3	----	0.1	% CaCO3	<0.1	0.1	<0.1	0.2	0.2
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	<1.0	<1.0	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	<10
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1000	980	1300	740	920
Arsenic	7440-38-2	5	mg/kg	<5	6	13	<5	<5
Barium	7440-39-3	10	mg/kg	10	10	10	<10	<10
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	5	2	3	<2	<2
Cobalt	7440-48-4	2	mg/kg	<2	<2	<2	<2	<2
Copper	7440-50-8	5	mg/kg	<5	<5	8	<5	<5
Iron	7439-89-6	50	mg/kg	2240	4760	10700	2000	810
Lead	7439-92-1	5	mg/kg	<5	<5	<5	<5	<5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V31900	V31903	V31905	V31906	V31908
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203029-001	EB2203029-002	EB2203029-003	EB2203029-004	EB2203029-005
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		<5	<5	**6**	**5**	<5
Nickel	7440-02-0	2	mg/kg		**3**	<2	<2	<2	<2
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**10**	**6**	**6**	<5	<5
Zinc	7440-66-6	5	mg/kg		<5	<5	**8**	<5	<5
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V31910	V31912	V31914	V31916	V31918
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-006	EB2203029-007	EB2203029-008	EB2203029-009	EB2203029-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.2	5.4	5.5	5.4	5.6
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	-1.6	-1.9	-2.4	-2.5
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	10	10	11	13	15
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	5.8	5.6	5.9	6.6	6.1
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	3.6	4.2	2.7	0.8	2.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	1.6	1.9	2.4	2.5
ANC as CaCO3	----	0.1	% CaCO3	<0.1	0.2	0.2	0.2	0.2
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	1.0	1.0	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	<10	<10	<10	<10
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	10	10	<10
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1000	790	1080	1010	760
Arsenic	7440-38-2	5	mg/kg	<5	<5	5	8	9
Barium	7440-39-3	10	mg/kg	10	20	40	60	10
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	<2	2	3	2	<2
Cobalt	7440-48-4	2	mg/kg	<2	<2	<2	<2	<2
Copper	7440-50-8	5	mg/kg	<5	<5	6	7	13
Iron	7439-89-6	50	mg/kg	380	4920	5820	5600	3400
Lead	7439-92-1	5	mg/kg	<5	<5	7	10	6

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Sample ID	V31910	V31912	V31914	V31916	V31918
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
					EB2203029-006	EB2203029-007	EB2203029-008	EB2203029-009	EB2203029-010
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		<5	<5	**20**	**93**	**39**
Nickel	7440-02-0	2	mg/kg		<2	<2	**2**	**3**	**2**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		<5	**6**	**7**	**8**	<5
Zinc	7440-66-6	5	mg/kg		<5	<5	**10**	**11**	**14**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		<1	**1**	**1**	**2**	**2**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V31920	V31922	V31997	V32000	V32003
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-011	EB2203029-012	EB2203029-013	EB2203029-014	EB2203029-015
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.8	5.8	5.5	5.8	6.2
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	-3.0	-1.0	-1.7	-2.9
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	15	26	16	23	29
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.1	7.1	6.1	6.4	7.6
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	3.4	<0.1	1.5	1.3	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	3.0	1.0	1.7	2.9
ANC as CaCO3	----	0.1	% CaCO3	<0.1	0.3	<0.1	0.2	0.3
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	1.2	1.4	<1.0	<1.0	1.1
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	10	20	10	10
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	230	<10	<10	<10
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	980	990	410	620	990
Arsenic	7440-38-2	5	mg/kg	14	11	19	<5	11
Barium	7440-39-3	10	mg/kg	40	10	40	20	80
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	2	<2	5	8	5
Cobalt	7440-48-4	2	mg/kg	3	6	<2	<2	8
Copper	7440-50-8	5	mg/kg	11	9	12	<5	9
Iron	7439-89-6	50	mg/kg	9380	14700	4630	2510	13800
Lead	7439-92-1	5	mg/kg	8	5	<5	<5	7

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V31920	V31922	V31997	V32000	V32003
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203029-011	EB2203029-012	EB2203029-013	EB2203029-014	EB2203029-015
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**188**	**66**	**23**	**22**	**307**
Nickel	7440-02-0	2	mg/kg		**4**	**5**	**4**	**4**	**8**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**5**	**6**	**8**	<5	<5
Zinc	7440-66-6	5	mg/kg		**18**	**25**	**10**	<5	**29**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**3**	**4**	**1**	**3**	**6**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32006	V32009	V32012	V32015	V32018
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-016	EB2203029-017	EB2203029-018	EB2203029-019	EB2203029-020
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.4	6.8	6.8	6.9	7.0
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-1.5	-3.4	-3.7	-2.0	10.7
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	33	29	25	30	112
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.2	6.5	7.8	6.5	2.9
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	9.9
NAG (pH 7.0)	----	0.1	kg H2SO4/t	3.3	1.6	<0.1	1.2	12.2
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	1.8	3.4	3.7	2.0	5.2
ANC as CaCO3	----	0.1	% CaCO3	0.2	0.4	0.4	0.2	0.5
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	1.3	1.1	1.1	1.4	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	30	<10	<10	10	190
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.01	<0.01	<0.01	<0.01	0.52
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	<10	<10
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1200	900	1320	1020	4250
Arsenic	7440-38-2	5	mg/kg	14	7	27	15	59
Barium	7440-39-3	10	mg/kg	210	40	70	20	10
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	4	5	6	4	7
Cobalt	7440-48-4	2	mg/kg	3	<2	7	4	15
Copper	7440-50-8	5	mg/kg	7	<5	12	6	12
Iron	7439-89-6	50	mg/kg	4940	7590	17700	11700	22900
Lead	7439-92-1	5	mg/kg	9	8	14	6	8

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Sample ID	V32006	V32009	V32012	V32015	V32018
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
					EB2203029-016	EB2203029-017	EB2203029-018	EB2203029-019	EB2203029-020
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**54**	**77**	**462**	**103**	**506**
Nickel	7440-02-0	2	mg/kg		**7**	**6**	**7**	**8**	**29**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		<5	<5	**5**	<5	**11**
Zinc	7440-66-6	5	mg/kg		**34**	**22**	**26**	**27**	**126**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**7**	**8**	**8**	**9**	**7**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32021	V32024	V32027	V32137	V32140
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-021	EB2203029-022	EB2203029-023	EB2203029-024	EB2203029-025
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.9	7.6	7.7	4.8	5.4
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-3.1	-5.5	-2.2	-1.7	-2.7
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	67	63	59	39	276
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.4	7.3	6.0	5.8	5.7
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	1.2	1.3	1.2
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	3.4	5.5	2.2	1.7	2.7
ANC as CaCO3	----	0.1	% CaCO3	0.3	0.6	0.2	0.2	0.3
Fizz Rating	----	0	Fizz Unit	0	1	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	<1.0	<1.0	1.6
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	30	30	30	30	20
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	<10	<10	<10	20	310
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1560	1000	1060	2360	1800
Arsenic	7440-38-2	5	mg/kg	<5	<5	9	10	11
Barium	7440-39-3	10	mg/kg	40	20	40	30	120
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	4	3	2	6	11
Cobalt	7440-48-4	2	mg/kg	7	6	4	<2	3
Copper	7440-50-8	5	mg/kg	6	<5	12	<5	9
Iron	7439-89-6	50	mg/kg	22000	26400	18100	13200	11000
Lead	7439-92-1	5	mg/kg	8	5	8	<5	5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V32021	V32024	V32027	V32137	V32140
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203029-021	EB2203029-022	EB2203029-023	EB2203029-024	EB2203029-025
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**365**	**428**	**382**	**19**	**25**
Nickel	7440-02-0	2	mg/kg		**11**	**6**	**7**	**3**	**8**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**7**	**7**	**6**	**17**	**12**
Zinc	7440-66-6	5	mg/kg		**78**	**61**	**46**	**14**	**21**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**12**	**10**	**10**	<1	**11**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32143	V32146	V32149	V32152	V32155
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-026	EB2203029-027	EB2203029-028	EB2203029-029	EB2203029-030
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.0	5.3	6.0	6.7	7.2
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-2.2	-2.3	-2.9	-3.4	-3.6
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	270	279	186	162	180
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	5.9	6.0	6.8	6.3	7.7
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	2.0	1.9	0.9	2.3	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	2.2	2.3	2.9	3.4	3.6
ANC as CaCO3	----	0.1	% CaCO3	0.2	0.2	0.3	0.4	0.4
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	1.6	1.5	<1.0	1.1	1.1
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	50	40	20	30	20
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	370	350	210	140	200
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1830	1410	1220	1460	1200
Arsenic	7440-38-2	5	mg/kg	29	14	8	12	7
Barium	7440-39-3	10	mg/kg	70	30	20	130	20
Beryllium	7440-41-7	1	mg/kg	1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	9	21	17	17	19
Cobalt	7440-48-4	2	mg/kg	4	3	4	8	4
Copper	7440-50-8	5	mg/kg	9	8	8	11	8
Iron	7439-89-6	50	mg/kg	20500	5580	6080	10200	8550
Lead	7439-92-1	5	mg/kg	8	6	10	13	12

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32143	V32146	V32149	V32152	V32155
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-026	EB2203029-027	EB2203029-028	EB2203029-029	EB2203029-030
				Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued								
Manganese	7439-96-5	5	mg/kg	**14**	**9**	**85**	**63**	**162**
Nickel	7440-02-0	2	mg/kg	**11**	**14**	**12**	**21**	**15**
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	**9**	**10**	**7**	**7**	**6**
Zinc	7440-66-6	5	mg/kg	**35**	**21**	**16**	**64**	**17**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble								
Fluoride	16984-48-8	1	mg/kg	**2**	**3**	**7**	**18**	**7**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32158	V32161	V32164	V32167	V32967
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-031	EB2203029-032	EB2203029-033	EB2203029-034	EB2203029-035
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.6	7.1	7.2	7.2	5.6
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-2.8	-3.9	-2.9	-4.5	-2.6
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	130	198	129	157	64
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.8	7.5	7.7	7.8	7.0
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	2.8	3.9	2.9	4.5	2.9
ANC as CaCO3	----	0.1	% CaCO3	0.3	0.4	0.3	0.4	0.3
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	1.4	1.3	<1.0	1.1	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	30	40	40	40	90
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	110	210	110	160	20
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1110	1230	1300	3060	3170
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	6
Barium	7440-39-3	10	mg/kg	20	20	100	20	30
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	15	14	11	12	20
Cobalt	7440-48-4	2	mg/kg	4	5	10	18	29
Copper	7440-50-8	5	mg/kg	7	7	12	12	70
Iron	7439-89-6	50	mg/kg	17400	45200	33500	47900	31900
Lead	7439-92-1	5	mg/kg	13	15	15	11	28

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V32158	V32161	V32164	V32167	V32967
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203029-031	EB2203029-032	EB2203029-033	EB2203029-034	EB2203029-035
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**217**	**814**	**1100**	**451**	**405**
Nickel	7440-02-0	2	mg/kg		**13**	**11**	**11**	**24**	**17**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**6**	**9**	**11**	**8**	**53**
Zinc	7440-66-6	5	mg/kg		**28**	**46**	**40**	**140**	**47**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**7**	**6**	**6**	**7**	**2**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32970	V32973	V32976	V32979	V32982
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-036	EB2203029-037	EB2203029-038	EB2203029-039	EB2203029-040
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.1	4.8	4.7	4.6	5.0
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-0.2	-1.0	-0.6	-0.9	-1.4
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	64	170	287	362	256
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.1	6.0	6.3	6.2	6.3
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	5.3	3.2	2.4	1.0	1.0
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	0.8	2.2	3.0	2.1	2.3
ANC as CaCO3	----	0.1	% CaCO3	<0.1	0.2	0.3	0.2	0.2
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	<1.0	1.0	<1.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	70	250	490	640	460
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.04	0.08	0.04	0.03
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	40	60	60	70	40
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1070	1000	1210	1510	1130
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	13
Barium	7440-39-3	10	mg/kg	30	<10	<10	<10	10
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	1	1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	10	10	9	13	10
Cobalt	7440-48-4	2	mg/kg	<2	<2	<2	4	<2
Copper	7440-50-8	5	mg/kg	8	11	19	66	62
Iron	7439-89-6	50	mg/kg	29100	15700	16600	44500	31100
Lead	7439-92-1	5	mg/kg	<5	<5	<5	34	24

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V32970	V32973	V32976	V32979	V32982
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203029-036	EB2203029-037	EB2203029-038	EB2203029-039	EB2203029-040
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		<5	<5	<5	**27**	**6**
Nickel	7440-02-0	2	mg/kg		**3**	**5**	**3**	**6**	**4**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**11**	**13**	**21**	**83**	**34**
Zinc	7440-66-6	5	mg/kg		<5	**7**	**5**	**24**	**12**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		<1	<1	<1	<1	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V32985	V32988	V32991	V33025	V33028
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-041	EB2203029-042	EB2203029-043	EB2203029-044	EB2203029-045
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.4	6.2	6.2	5.0	4.5
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-1.7	-0.7	-0.4	-1.8	1.2
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	233	82	168	60	394
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	5.6	6.1	5.8	5.2	5.7
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	4.4	3.3	5.7	2.6	1.4
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	2.6	1.0	1.0	2.1	<0.5
ANC as CaCO3	----	0.1	% CaCO3	0.3	0.1	<0.1	0.2	<0.1
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	<1.0	<1.0	<1.0	<1.0	1.6
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	410	120	300	10	440
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.01	0.02	0.01	0.04
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	30	20	20	60	230
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	1380	880	840	1400	1470
Arsenic	7440-38-2	5	mg/kg	22	18	26	<5	<5
Barium	7440-39-3	10	mg/kg	10	<10	<10	10	30
Beryllium	7440-41-7	1	mg/kg	<1	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	14	12	9	7	9
Cobalt	7440-48-4	2	mg/kg	<2	<2	2	2	8
Copper	7440-50-8	5	mg/kg	38	29	123	13	23
Iron	7439-89-6	50	mg/kg	31500	31600	23500	15600	33100
Lead	7439-92-1	5	mg/kg	14	10	31	<5	<5

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Sample ID	V32985	V32988	V32991	V33025	V33028
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
					EB2203029-041	EB2203029-042	EB2203029-043	EB2203029-044	EB2203029-045
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**12**	**25**	**77**	**25**	**230**
Nickel	7440-02-0	2	mg/kg		**6**	**6**	**7**	**2**	**7**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**104**	**10**	**10**	**15**	**32**
Zinc	7440-66-6	5	mg/kg		**16**	**10**	**24**	**7**	**27**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**3**	**3**	**4**	<1	**2**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V33031	V33034	V33037	V33040	V33043
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-046	EB2203029-047	EB2203029-048	EB2203029-049	EB2203029-050
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	4.6	5.4	6.7	7.4	7.6
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-0.7	0.6	-12.2	-16.6	-8.6
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	347	158	194	286	177
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	5.3	5.8	7.1	7.2	7.2
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	2.2	4.2	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	1.6	<0.5	12.8	17.2	9.2
ANC as CaCO3	----	0.1	% CaCO3	0.2	<0.1	1.3	1.8	0.9
Fizz Rating	----	0	Fizz Unit	0	0	1	1	1
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.0	<1.0	1.4	2.7	2.0
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	390	190	280	420	300
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.02	0.02	0.02	0.02
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	200	90	70	90	40
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	2180	3170	11600	41000	32400
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	<5
Barium	7440-39-3	10	mg/kg	60	<10	10	10	<10
Beryllium	7440-41-7	1	mg/kg	<1	<1	1	2	2
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	16	13	17	71	90
Cobalt	7440-48-4	2	mg/kg	10	17	67	182	85
Copper	7440-50-8	5	mg/kg	35	26	27	74	75
Iron	7439-89-6	50	mg/kg	28900	27700	36700	94500	68200
Lead	7439-92-1	5	mg/kg	7	<5	<5	15	8

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Sample ID	V33031	V33034	V33037	V33040	V33043
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
					EB2203029-046	EB2203029-047	EB2203029-048	EB2203029-049	EB2203029-050
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**186**	**97**	**218**	**871**	**741**
Nickel	7440-02-0	2	mg/kg		**8**	**25**	**55**	**101**	**68**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**32**	**17**	**29**	**176**	**151**
Zinc	7440-66-6	5	mg/kg		**37**	**63**	**129**	**216**	**165**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		<1	**1**	**7**	**9**	**6**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V33046	V33049	V33052	V33055	V33133
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-051	EB2203029-052	EB2203029-053	EB2203029-054	EB2203029-055
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.5	7.4	7.3	7.3	5.3
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-18.0	-15.7	-15.5	-19.3	2.8
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	238	200	190	157	169
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.2	7.5	7.5	6.9	4.7
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	0.2	2.2
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	18.6	16.0	16.1	19.6	0.6
ANC as CaCO3	----	0.1	% CaCO3	1.9	1.6	1.6	2.0	<0.1
Fizz Rating	----	0	Fizz Unit	1	1	1	1	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.3	1.8	2.2	3.0	1.6
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	390	350	340	250	320
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.01	0.02	0.01	0.11
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	40	30	20	20	30
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	34900	28700	29500	38000	5080
Arsenic	7440-38-2	5	mg/kg	<5	<5	<5	<5	60
Barium	7440-39-3	10	mg/kg	<10	10	20	10	40
Beryllium	7440-41-7	1	mg/kg	2	2	2	2	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	2	<1
Chromium	7440-47-3	2	mg/kg	27	38	28	60	26
Cobalt	7440-48-4	2	mg/kg	107	118	100	82	33
Copper	7440-50-8	5	mg/kg	96	100	99	134	71
Iron	7439-89-6	50	mg/kg	95800	91500	94100	107000	44400
Lead	7439-92-1	5	mg/kg	11	12	26	94	16

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	V33046	V33049	V33052	V33055	V33133
				Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit		EB2203029-051	EB2203029-052	EB2203029-053	EB2203029-054	EB2203029-055
					Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued									
Manganese	7439-96-5	5	mg/kg		**785**	**1490**	**1150**	**1170**	**632**
Nickel	7440-02-0	2	mg/kg		**75**	**92**	**70**	**102**	**31**
Selenium	7782-49-2	5	mg/kg		<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg		**198**	**165**	**181**	**240**	**91**
Zinc	7440-66-6	5	mg/kg		**187**	**234**	**317**	**395**	**55**
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
EK040S: Fluoride Soluble									
Fluoride	16984-48-8	1	mg/kg		**8**	**8**	**9**	**20**	<1

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	V33136	V33139	V33142	V33145	V33148
			Sampling date / time	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00	01-Feb-2022 00:00
Compound	CAS Number	LOR	Unit	EB2203029-056	EB2203029-057	EB2203029-058	EB2203029-059	EB2203029-060
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.5	7.5	7.8	8.0	7.6
EA009: Net Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-19.8	-16.8	-16.8	-12.2	-5.4
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	177	1680	236	114	59
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.5	7.2	7.2	7.2	7.7
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	20.4	19.2	18.0	12.5	5.4
ANC as CaCO3	----	0.1	% CaCO3	2.1	2.0	1.8	1.3	0.5
Fizz Rating	----	0	Fizz Unit	1	1	1	1	0
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	8.4	6.6	3.2	2.5	1.5
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	130	1780	210	50	20
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.08	0.04	0.01	<0.01
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	10	mg/kg	120	750	120	30	10
EG005(ED093)T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	24200	25300	24800	18700	2320
Arsenic	7440-38-2	5	mg/kg	7	8	50	8	44
Barium	7440-39-3	10	mg/kg	290	280	270	270	90
Beryllium	7440-41-7	1	mg/kg	3	6	6	6	3
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	37	33	28	23	11
Cobalt	7440-48-4	2	mg/kg	63	89	91	190	24
Copper	7440-50-8	5	mg/kg	99	129	74	89	246
Iron	7439-89-6	50	mg/kg	60700	72400	65400	69500	50600
Lead	7439-92-1	5	mg/kg	6	5	7	<5	<5