FerrAus Pilbara Project

Mine Closure and Decommissioning Plan

DRAFT

Prepared for
FerrAus Limited
by Strategen

August 2011

STRATEGEN
environmental consultants

FerrAus Pilbara Project

Mine Closure and Decommissioning Plan

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Disclaimer and Limitation

Client: FerrAus Limited

Report Version	Revision No.	Purpose	Strategen author/reviewer	Submitted to Client	
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Document and Project Title	FerrAus Pilbara Project
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Mine closure plan checklist

DMP has prepared a checklist for a Mine Closure Plan which is designed to assist the proponent to ensure that all required information has been provided and to enable an efficient and accurate assessment without the need for the assessing officer to seek further information or clarification.

Q No.	Checklist	Y/N/NA	Page No.	Comments
1	Has the checklist been endorsed by a senior representative within the tenement holder/operating company? (See bottom of Checklist)	Y		See Corporate Endorsement below
2	How many copies were submitted to DMP?	Hard copies = TBD Electronic = TBD		
	Cover Page, Table of Contents			
3	Does the cover page include; • project title • company name • contact details (including telephone and email addresses) • document ID and version number • date of submission (needs to match the date of this checklist)	N	Cover Page	Information is provided in Table above.
4	Has a Table of Contents been provided?	Y		
	Scope and Project Summary			
5	Why is the MCP submitted? (as part of a Mining Proposal or a reviewed MCP or to fulfil other legal requirements)		Page 1	The MCP has been submitted to accompany an EPA referral. It will eventually replace the existing MCP for the Robertson Range Iron Ore Project.
6	Does the project summary include; • land ownership details; • location of the project; • comprehensive site plan(s); • background information on the history and status of the project.	Y	Section 2 and Section 4	Appendix 1 contains the Tenement Register. Comprehensive site plans are still in development. Indicative site plans are presented and have been used as the basis for closure planning and costing. Final changes are expected to be minor.
	Legal Obligations and Commitments			
7	Has a consolidated summary or register of closure obligations and commitments been included?	Y	Page 17	Appendix 2 contains the Legal Obligations Register.
	Data Collection and Analysis			
8	Has information relevant to mine closure been collected for each domain or feature (including pre-mining baseline studies, environmental and other data)?	Y	Section 4	A summary of the investigations and assessments conducted as part of the environmental referral is provided. The referral contains the detailed assessments and technical reports.
9	Has a gap analysis been conducted to determine if further information is required in relation to closure of each domain or feature?	Y	Section 10.3	A Rehabilitation Management Plan has been developed and incorporated into the Mine Environmental Management Plan, forming part of the EIA. Commitments have been made to undertake further assessments as required to address information gaps, as provided in 10.3.
	Stakeholder Consultation			
10	Have all stakeholders involved in closure been identified?	Y	Section 5	Stakeholder consultation is ongoing.

Q No.	Checklist	Y/N/NA	Page No.	Comments
11	Has a summary or register of stakeholder consultation been provided with details as to who has been consulted and the outcomes?	Y	Section 5	Consultation will be continued throughout the approvals process.
	Final land use(s) and Closure Objectives			
12	Does the MCP include agreed post-mining land use(s), closure objectives and conceptual landform design diagram?	Y	Section 6	Final land use concepts are provided as agreement between various stakeholders as to final land use is pending full development of options. A fully compliant Final Landform Design will be produced at the completion of Design Feasibility Studies.
13	Does the MCP identify all potential (or pre-existing) environmental legacies, which may restrict the post mining land use (including contaminated sites)?	NA	Section 7	The existing environment and all baseline information is summarised in the EIA document submitted to the EPA under Part IV of the EP Act.
	Identification and Management of Closure Issues			
14	Does the MCP identify all potential issues impacting mine closure objectives and outcomes?	Y	Section 7 & Appendix 3	
15	Does the MCP include proposed management or mitigation options to deal with these issues?	Y	Section 7 & Appendix 3	
16	Have the process, methodology, and rationale been provided to justify identification and management of the issues?	Y	Section 7 & Appendix 3	
	Closure Criteria			
17	Does the MCP include a set of specific closure criteria and / closure performance indicators?	Y	Page 59 and Page 79	The set of closure criteria includes indicative criteria that will be refined as more information becomes available over the life of the project, as per the Mine Closure guidelines.
	Closure Financial Provision			
18	Does the MCP include costing methodology, assumptions and financial provision to resource closure implementation and monitoring?	Y	Section 9	Preliminary closure cost estimates are managed internally to FerrAus and have not been included in this document.
19	Does the MCP include a process to regular review of the financial provision?	Y	Section 9	As per standard scheduled reviews of MCP
	Closure Implementation			
20	Does the reviewed MCP include a summary of closure implementation strategies and activities for the proposed operations or for the whole site?	Y	Section 10	Some information gaps exist, studies ongoing
21	Does the MCP include a closure work program for each domain or feature?	Y	Section 10	Some information gaps exist, studies ongoing. Document will be updated as studies completed, before formal submission.
22	Have the site layout plans been provided to clearly show each type of disturbance?	Y	Section 10	
23	Does the MCP contain a schedule of research and trial activities?	N	Section 10	A list is provided with a 2-year commitment to finalise the schedule.
24	Does the MCP contain a schedule of progressive rehabilitation activities?	N	Section 10	A list is provided with a 2-year commitment to finalise the schedule.

Q No.	Checklist	Y/N/NA	Page No.	Comments
25	Does the MCP include details of how unexpected closure (including care and maintenance) will be handled?	Y	Section 10	
26	Does the MCP contain a schedule of decommissioning activities?	Y	Section 10	Planned decommissioning activities are summarised in Section 10 and will be developed further throughout subsequent revisions of the closure plan
27	Does the MCP contain a schedule of closure performance monitoring and maintenance activities?	Y	Section 10	Some information gaps exist, studies ongoing. Document will be updated as studies completed, before formal submission.
	Closure Monitoring and Maintenance			
28	Does the MCP contain a framework, including methodology, quality control and remedial strategy for closure performance monitoring including post-closure monitoring and maintenance?	Y	Section 11	The preliminary closure monitoring and maintenance plan developed will be updated in subsequent revisions of the closure plan.
	Closure Information and Data Management			
29	Does the mine closure plan contain a description of management strategies including systems, and processes for the retention of mine records?	Y	Section 12	Some information gaps exist, studies ongoing. Document will be updated as studies completed, before formal submission.

Corporate Endorsement:

I hereby certify that to the best of my knowledge, the information within this Mine Closure Plan and checklist is true and correct and addresses all the requirements of the Guidelines for the Preparation of a Mine Closure Plan approved by the Director General of Mines.

Name: ___________________________________ Signed: ___________________________________

Position: __________________________________Date: ____________________________________

(NB: The corporate endorsement must be given by tenement n holder(s) or a senior representative authorised by the tenement holder(s))

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1. Introduction

FerrAus Limited (FerrAus) proposes to expand its FerrAus Pilbara Project (FPP) in the Pilbara Region of Western Australia. The FPP consists of the mining, processing and development of supporting infrastructure to produce iron ore from its Robertson Range Area (RRA) and Davidson Creek Area (DCA) deposits.

1.1 Document purpose and scope

This Mine Closure and Decommissioning Plan (Closure Plan) applies to the mining operations and associated infrastructure of the FPP. Rail, port and shipping activities associated with the FPP are outside the scope of this Closure Plan.

The Proposal was referred to the Western Australian Environmental Protection Authority (EPA) with an expectation that the EPA would set an Assessed on Proponent Information (API) level of assessment under the provisions of Part IV of the *Environmental Protection Act 1986* (EP Act).

Amendments to the Western Australian *Mining Act 1978* (Mining Act) in 2010 require that closure planning is considered at the planning stage of the Project to enable the identification and management of closure and decommissioning risks. As a result of these amendments a Closure Plan is required to support the environmental impact assessment (EIA) document and associated Mining Proposal document.

This Closure Plan has been prepared in accordance with the ANZMEC/MCA Strategic *Framework for Mine Closure* (ANZMEC/MCA 2000) and refers to methodology outlined in the DMP/EPA *Guidelines for Preparing Mine Closure Plans* (DMP /EPA 2011) and *Leading Practice Sustainable Development in Mining handbooks and the Planning for Integrated Mine Closure: Toolkit* (ICMM 2008).

This document addresses the following and is structured accordingly:

1. A brief summary of the FPP.
2. Identification of closure obligations and commitments.
3. Collection and analysis of closure data, including a directory of existing baseline data.
4. Stakeholder consultation.
5. Post-mining land use and closure objectives.
6. Identification and management of closure issues.
7. Development of completion criteria.
8. Financial provisioning processes.
9. Closure implementation, including unexpected closure.
10. Closure monitoring and maintenance.
11. Information management and reporting.

1.2 Document version and status

At this time, the FPP is in its advanced planning stage and implementation of the project is yet to commence, pending environmental and other approvals. Accordingly, this version of the Closure Plan is a conceptual document prepared with all relevant available environmental and social information considered, including assessments that have been undertaken to date at the FPP site. The Closure Plan will be subject to review and amendments throughout the life of the FPP.

1.3 Closure plan implementation

FerrAus operates in accordance with its operations-wide Environmental Policy, which is implemented through the FerrAus Environmental Management System (EMS). The EMS is structured in accordance with the principles of the *Australian Standard for Environmental Management Systems* (AS/NZS ISO 14001:2004).

2. Project summary

2.1 Purpose of this section

This section provides a brief description of the history and status of the FPP. It is presented for general information purposes only and the FPP EIA (and any subsequent referrals) can be consulted for more specific details.

2.2 Project location

The FPP is located approximately 475 km southeast of Port Hedland and lies within two shire boundaries: the Shire of Meekatharra and the Shire of East Pilbara. The town of Newman is approximately 80 km west of the project area (Figure 2-1).

The FerrAus Pilbara Project lies within the Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265 (Jigalong Aboriginal Reserve). The Jigalong community is in the northeast corner of the Reserve, approximately 30 km from the project area. The FPP is also partly located within the boundary of the Sylvania Pastoral Station. The closest pastoral station residence is the Robertson Range Homestead, which is east of the FPP and is not occupied.

The BHP Billiton Iron Ore (BHPBIO) mining operations and rail infrastructure at Jimblebar is located approximately 35 km to the west of the FPP.

2.3 Land Ownership and Tenure

The FPP tenements are held by Australian Manganese Pty Ltd, a wholly-owned subsidiary of FerrAus Limited. Mining and processing components will be located on tenements E52/1658, M52/1043, E52/1630 and M52/1034. The details of land ownership and tenure for mining and processing components are provided in Appendix 1.

2.4 Project overview

The FPP involves open pit mining of several iron ore deposits at a combined annual rate of approximately 15 Mtpa. This includes the mining of the following deposits within the Davidson Creek Area (DCA) and the Robertson Range Area (RRA):

- DCA: Python, Gwardar, Tiger, Dugite and Mirrin Mirrin deposits to below the watertable
- RRA: King Brown deposit , including the South West mineralised zone, to below the watertable

To facilitate mining of these deposits and the production of 15 Mtpa of suitable iron ore product, the FPP also involves:

- dewatering of open pits at rates up to about 11 GL/yr cumulative across operations; comprising peak annualised rates of 7 GL/yr for DCA and 4 GL/yr for RRA
- crushing, screening and beneficiation of iron ore
- storage of residue material from beneficiation; with a residue storage facility (RSF) to be located at DCA
- waste rock dumps; three at DCA and one at RRA (indicative)
- progressive rehabilitation where possible with final pit(s) void and permanent waste dumps
- establishment of a rail spur and loop enabling transport of ore to Port Hedland via either the Brockman Resources Marillana rail line or the Roy Hill rail line (outside the scope of the Closure Plan)

- water infrastructure including raw and process water dams, irrigation infrastructure, dewatering wellfield and permanent and temporary creek diversion infrastructure
- supporting infrastructure including a power station, administration buildings, mining infrastructure and workshops.

The mining of 2 mtpa from the RRA is approved under a previous mining proposal. The current (FPP) proposal under assessment relates to an additional 13 mtpa proposed to be taken from the DCA and RRA to enable the full project mining rate of 15 mtpa to be achieved.

The project layouts for the mining and processing components at DCA and RRA are presented in Figure 2-2.

2.4.1 Project schedule

Subject to obtaining State and Commonwealth approvals, the FPP is scheduled to commence operations in Quarter 2 2012 (Table 2-1). Mining of existing economic reserves will be completed in or around 2027.

Table 2-1 Indicative implementation schedules for the Proposal

FPP Milestones	Indicative Timing
Addendum to Robertson Range Mining Proposal	December 2011
Commonwealth EPBC Act Approval	December 2011
Minister for Environment approval of Part IV EP Act referral	December 2011
Mining and Processing	
Construction commences	Q2 2012
Mining preparation and pre-stripping	Q4 2012
Commissioning and start-up	Q2 2014
Ongoing operations	Q3 2014 for approximately 15 years
Rail Infrastructure	
Construction commences	Q1 of 2012
Commissioning of rail	Q2 of 2014
Ongoing operations	Approximately 15 years

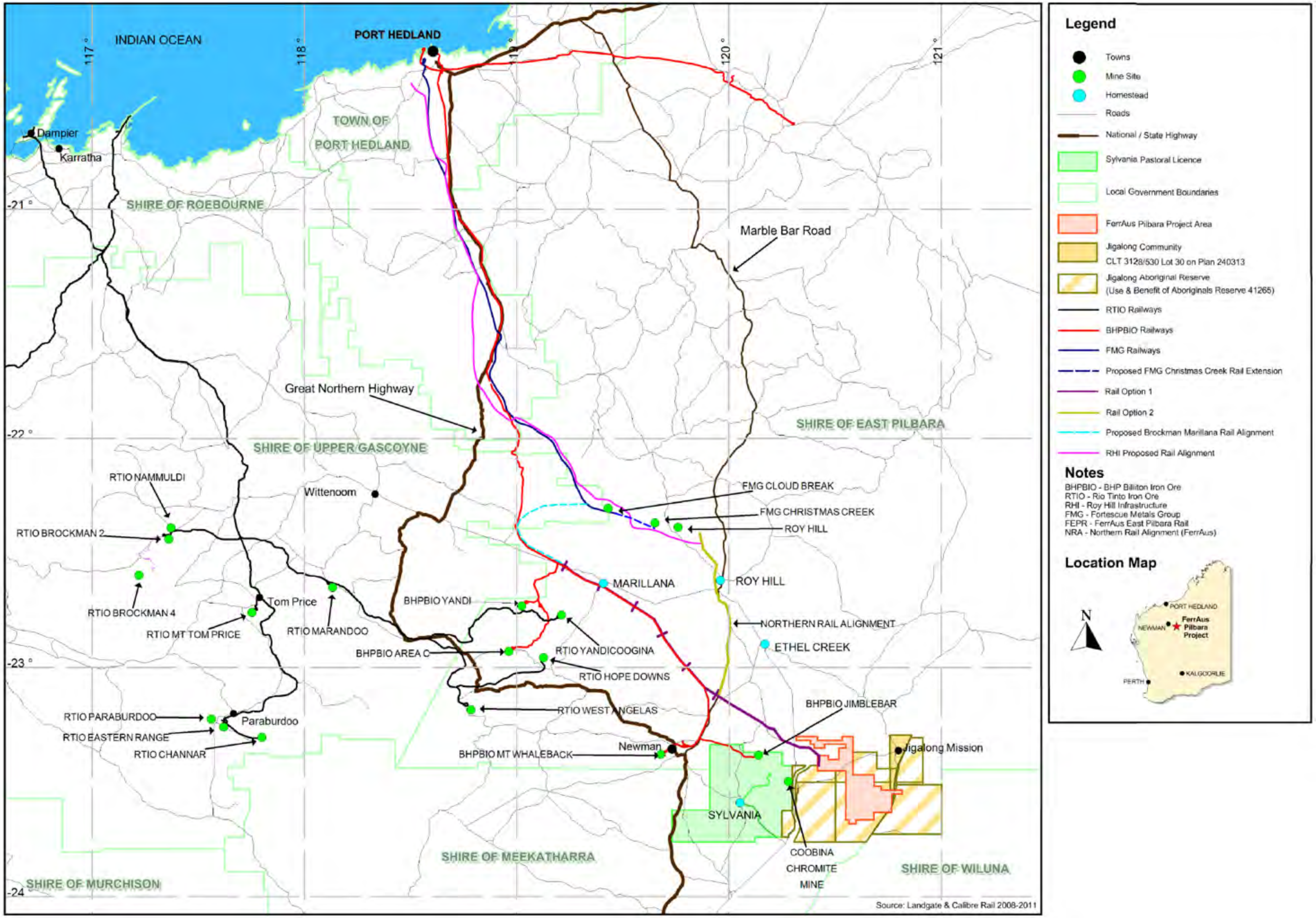

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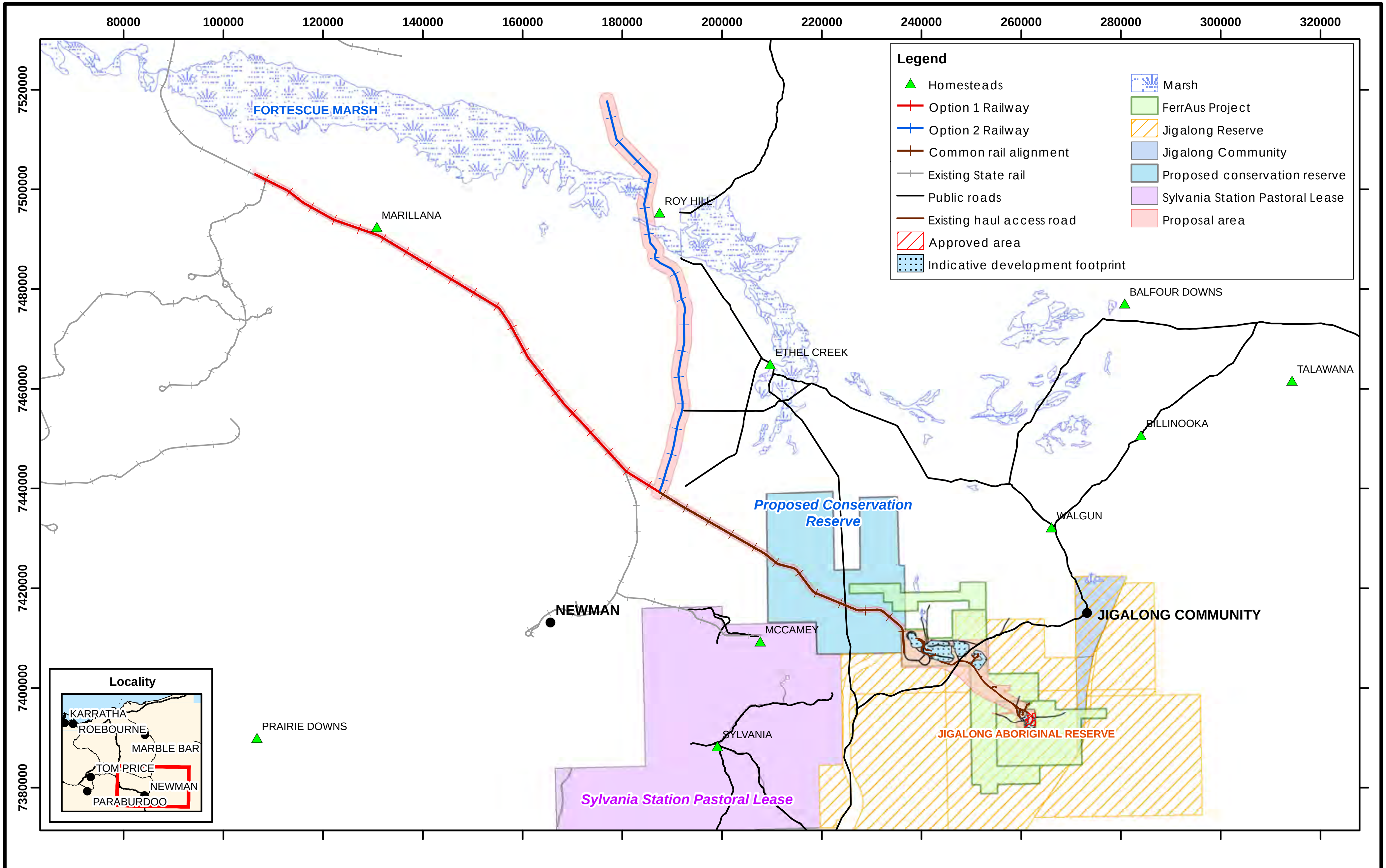
Figure 2-1 Project location and regional context

Source: JPEG from FerrAus Limited 2011

Date: 26/08/2011

Path: Q:\Consult\2011\FER\FER11084\Projects\Closure_Plan\Figure 2-1 Project location and regional context.mxd



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Scale

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Figure 2-2 Project locality

Coordinate System: GDA 1994 MGA Zone 51
Date: 26/08/2011
Author: jcrute

Scale: 1:1,000,000 at A4
Source: FerrAus Limited 2011
Note that positional errors may occur in some areas

Path: Q:\Consult\2011\FER\FER11084\Projects\Closure_Plan\Figure 2-2 Project locality.mxd

2.5 Background and Approvals history

Approval was granted for the RRA component of the FPP in November 2009, to commence development and operations in accordance with tenement conditions on Mining Lease (ML) 52/1034, General Purpose Lease (GPL) 52/281 and Miscellaneous Licence 52/103 for Australian Manganese Pty Ltd (FerrAus Limited) (Registration ID 19293). A Vegetation Clearing Permit was granted to under S.51E of the *Environmental Protection Act 1986* (Purpose permit number 2819/1) with a total allowance of up to 323.37 ha given to clear native vegetation on ML 52/1034, GPL 52/281 and Miscellaneous Licence 52/103 (ecologia 2009a).

An Addendum to the Mining Proposal (Registration ID 19263) has been submitted to the DMP to include the following:

- access/haul road between RRA and Jigalong Road (L52/129 and L52/112)
- relocation of the accommodation village (L52/130)
- airstrip (L52/131).

2.6 Summary of project components

2.6.1 Mining operations

Mining of the iron ore deposits will be conducted by conventional truck and shovel open pit mining methods, using a combination of free digging and drill and blast techniques for pre-stripping of waste and ore extraction. Material is subject to crushing, screening and processing.

Mining will be undertaken using a strip mining approach, whereby each ore body will be mined in stages to full depth. Where practicable, pits will be backfilled to the normal level of the water table to avoid the formation of mine pit lakes. Backfilling also provides the advantages of reducing waste dump area and height. At this stage it is expected that the last open section of the pits would remain open if continuation of mining is possible in the future.

Trucks then transport mined material to the appropriate destination dependent on the material type, using an excavator and mine fleet of medium to large sized equipment. Waste material is transported either to waste rock dumps or to mineralised waste stockpiles. Ore is transported to the Run of Mine (ROM) pad and either stockpiled and rehandled or directly dumped to the primary crusher.

General arrangement

Preliminary design and layout places waste rock dumps and processing infrastructure in proximity to iron ore deposits to optimise operational efficiencies. Four waste rock dumps are proposed for the DCA (Figure 2-3). For the RRA, the arrangement of the two formerly approved waste rock dumps (Figure 2-4) would now be modified.

Two mineralised waste stockpiles are also proposed with one located adjacent to the Python-Gwardar Deposit in the DCA and the other located adjacent to the King Brown deposit in the RRA.

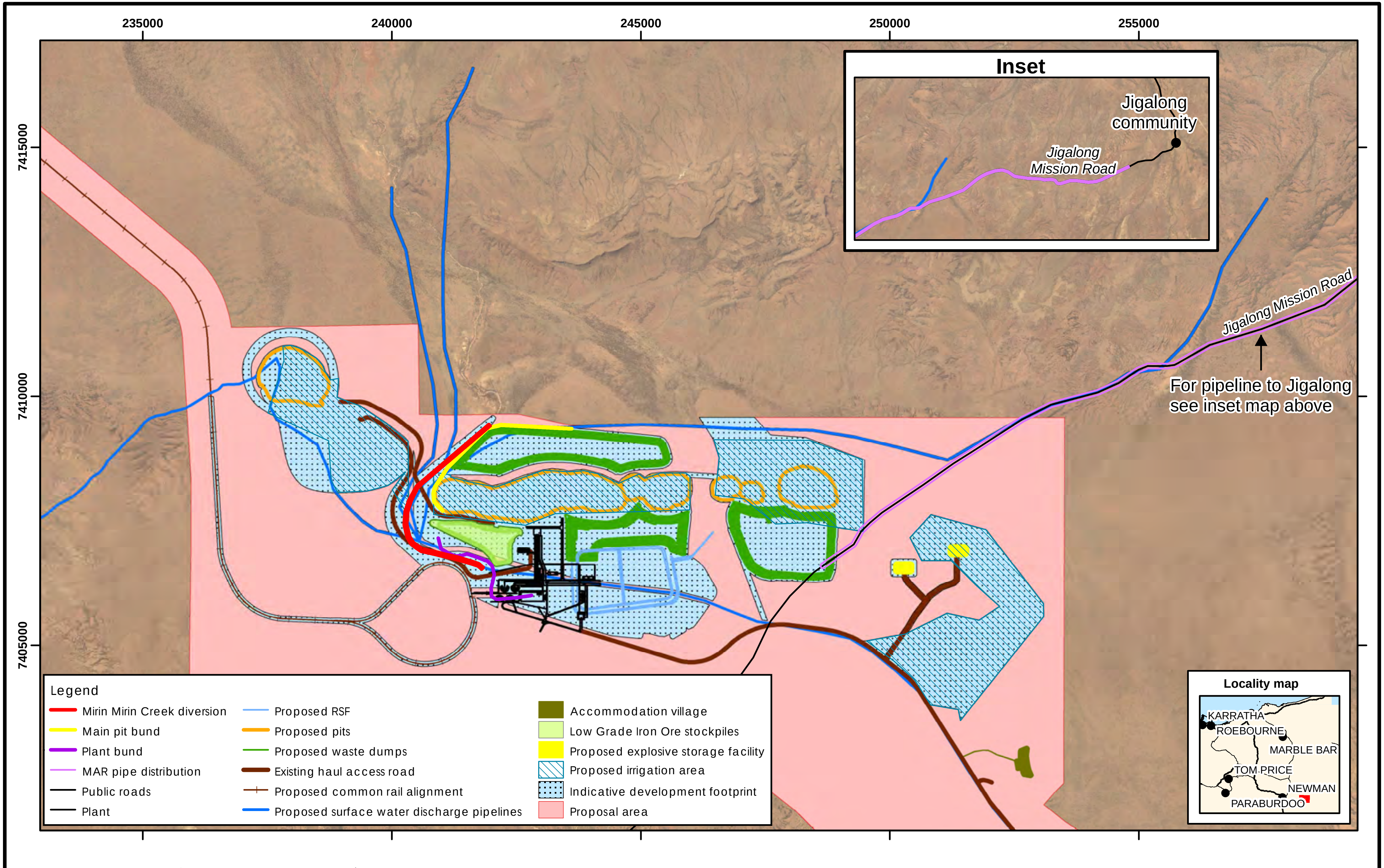

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Figure 2-3 Proposed project layout (Davidson Creek Area)

Coordinate System: GDA 1994 MGA Zone 51
Date: 30/08/2011
Author: jcrute

Scale: 1:100,000 at A4
Source: FerrAus Limited 2011
Note that positional errors may occur in some areas

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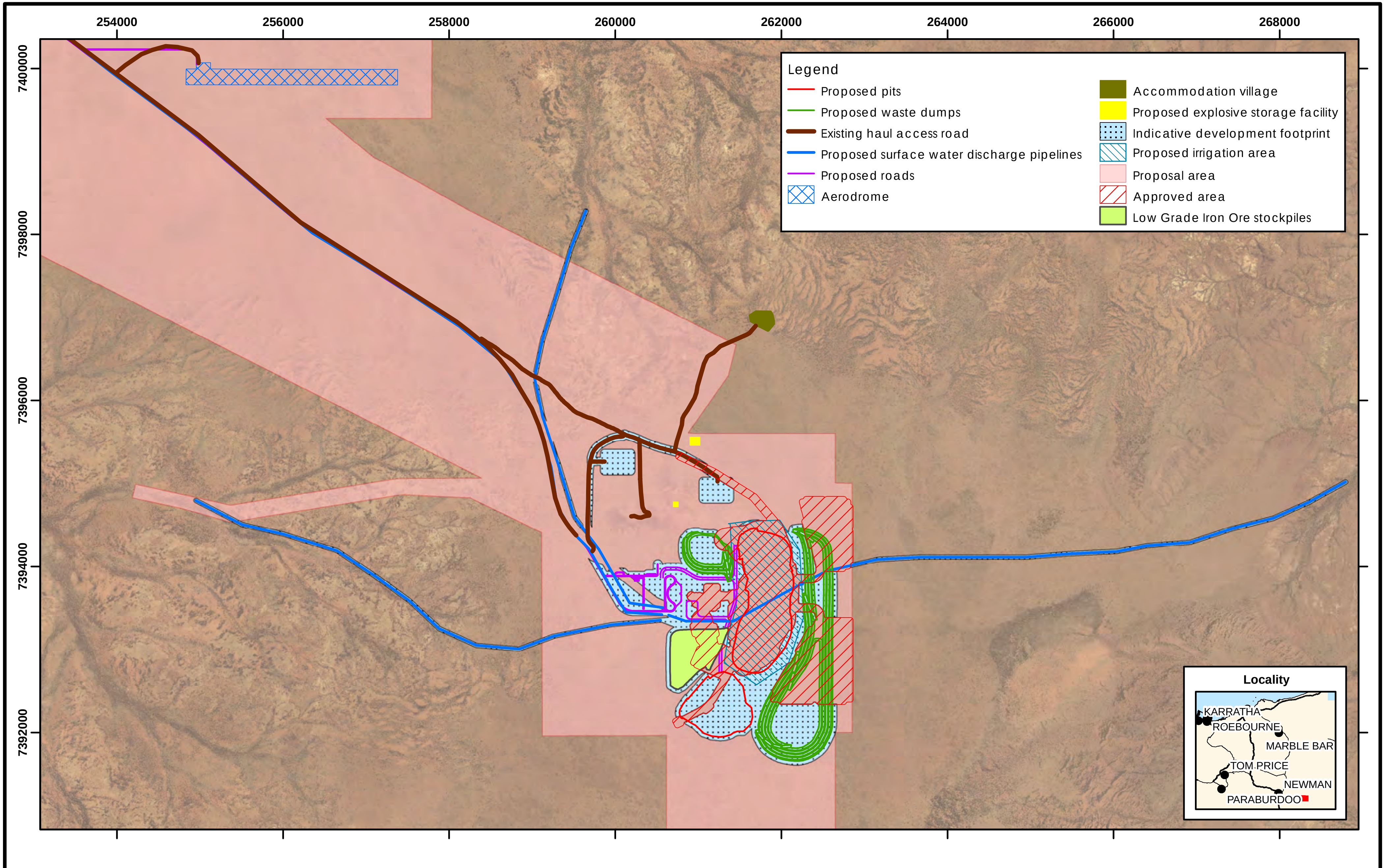

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Figure 2-4 Proposed project layout (Robertson Range Area)

Coordinate System: GDA 1994 MGA Zone 51
Date: 30/08/2011
Author: jcrute

Scale: 1:60,000 at A4
Source: FerrAus Limited 2011
Note that positional errors may occur in some areas

Path: Q:\Consult\2011\FER\FER11084\Projects\Closure_Plan\Figure 2_4_Proposed Project Layout_RR.mxd

Waste rock dumps and stockpile management

Waste dumps will be progressively rehabilitated, following the design criteria below:

- 10 m wide berms placed on each of 10 m vertical height
- batter angle dozed down to 20° between the berms
- average slope angle of dump face is approximately 16°
- berms sloped at 5° inwards to minimise rainfall run-off
- cross bunds placed on berms at 30 m spacing to break up pooled water on berms
- perimeter bunds placed on top dump surface and each berm to contain rainfall for 1-in-100 year, 72-hour event.

In addition, two medium-grade iron ore stockpiles will be developed, one at DCA and one at RRA. Perimeter bunds will be constructed such that the inner slope is minimised allowing water to be distributed evenly across the dump surface but away from the perimeter. The bunds would be broken at intervals to minimise potential impediments to surface water flow. Medium-grade iron ore stockpiles follow the same design criteria as the waste rock dumps.

The biologically active surface layer of topsoil would be stripped and stored separately during clearing activities. Topsoil would be stored in proximity to future areas requiring rehabilitation. Topsoil stockpiles (up to 2 m high) are allocated at DCA and RRA and would be located near the final pit crests (within the 100 m general exclusion zone). Where possible, stony and gravelly soils, or removed vegetation would be placed over topsoil stockpiles to assist stabilisation and control of erosion.

Mine dewatering

Mining of all ore bodies will be carried out to a depth below the watertable. Dewatering of the aquifer to lower the watertable is required to provide a safe work environment and minimise accumulation of water on pit floors. Dewatering of the ore body involves pumping from dewatering wells located both within and external to final pit perimeters. Dewatering activities will commence in advance of mining activities in order to lower the watertable to acceptable levels within the required timing to conform to the mine plan.

Raw water requirements for the FPP will be met from dewatering water sources. Water would be pumped from the dewatering system to respective raw water dams or tanks located at DCA and RRA and distributed for use as process water, raw water, fire water and potable water requirements.

Mine water disposal

Due to the high abstraction rates expected to be required to effect appropriate levels of dewatering at both mining areas, water drawn from the dewatering system will be in excess of demand requirements for the duration of the project operation. A number of potential uses for surplus mine water have been discussed with the WA Department of Water (DoW) including:

- dust control
- use in beneficiation plants
- use in the accommodation facility
- managed aquifer recharge
- irrigation to surrounding agriculture
- pumping to nearby communities or mining operations
- discharge to the environment.

The proposed disposal of mine water is based on the following prioritised system designed to conform to the DoW *Pilbara water in mining guideline* (DoW 2009).

Table 2-2: Water disposal priorities and operating rules

Priority	Disposal method	Comment	Outcome
1	On-site use as the water supply source for all activities at the mine sites.	First priority use. Variable quality sources used on a fit-for-purpose basis (e.g., high quality water for drinking, poorer quality for processing, dust suppression).	Mine site water supply met without need for development of additional sources.
2	Transferred to meet water supply demands at the Jigalong community through supplementation or replacement of the existing groundwater source.	Would meet full water demand at community, with potential to supply additional water for recreational area irrigation, to enhance community facilities.	Provide community benefit in increased supply security, with no adverse environmental effect.
3	Irrigation of Category 1* irrigation areas for growth of pastures or other crops within the mine pit disturbance footprint.	Subject to assessment and management by the DoW under water abstraction licensing regime. Subject to EP Act discharge licence conditions. Variable rates, depending on available area from time to time.	Limited to disturbed or pre-disturbed areas, with no environmental effect provided weed hygiene implemented.
4	Managed aquifer recharge back into aquifers underlying mine site through discharge into RSF and/or disused pits.	Water disposed through infiltration and evaporation. Variable rates, dependent upon available RSF/pit storage volumes.	Water discharged to the pits would be of similar quality to receiving waters. Would enhance groundwater level recoveries in the mining area.
5	Controlled release to watercourses of water in excess of that which can be disposed of by the above methods.	Would alternate between Priority 5 and 6 uses as necessary to ensure discharges are short-term and episodic to mimic local climate variability and enable alternate wetting and drying of receiving environment. Subject to assessment and management by the DoW under water abstraction licensing regime. Subject to EP Act discharge licence conditions. Variable rates, as available water would be remainder after implementation of higher priorities.	No significant adverse environmental impacts are expected as the discharges would be episodic, mimicking the variability of rainfall in the region.
6	Irrigation of Category 2** irrigation areas natural vegetation outside mine disturbance area.		No significant adverse environmental impacts are expected as the discharges would be episodic, distributed amongst five discharge locations, and would mimic the ephemeral nature of surface water flows in the region.

* Category 1 irrigation areas: areas to be disturbed by mining and areas that have been disturbed by mining activities.

** Category 2 irrigation areas: areas not expected to be disturbed by mining activities.

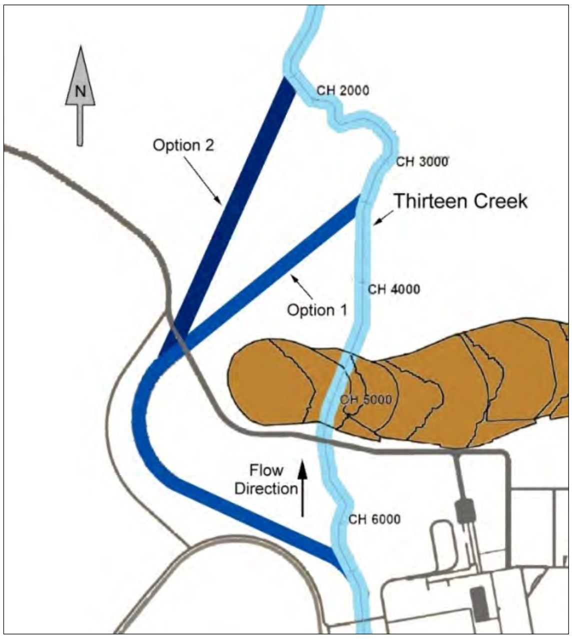
Surface drainage and stormwater management

Flood bunding and diversion channels would be established to divert surface water flows around working areas of the mine. This includes the open pits and other infrastructure. Surface water management controls required for each mining area is discussed below.

Creek diversion

Mirrin Mirrin Creek (also known as Thirteen Creek) dissects the Python-Gwardar deposit. It is proposed that the Creek be diverted around the western extent of the proposed pit (Figure 2-5). The diversion would largely comprise an excavated channel to convey the 100-year Average Return Interval (ARI) flood event, with associated bunding as required to prevent floodwaters from entering the plant and pit areas. Through the area of deepest cut, the excavation would be up to 4 m deep. The excavated channel would in the shape of a trapezoid, with a base width of around 40 m, and nominal side slopes of 1:2.5, although this may be steeper depending on ground conditions.

Figure 2-5 Mirrin Mirrin Creek diversion options (diagrammatic)



The diversion also includes a small bund on the western side of the diversion (between the Mirrin Mirrin waste dump and the diversion) necessary to ensure high flows are kept largely within the same catchment area and help maintain the current environmental regime. The creek diversion would be permanent with material from the excavation of the diversion channel used for forming of channel levees, etc.

A minor diversion of Mirrin Mirrin Creek is also required to develop the Mirrin Mirrin deposit. This diversion would take the form of a bund around the proposed waste dump and pit. The diverted flows would discharge back into its original alignment downstream of the pit area.

2.6.2 Ore processing

The majority of the King Brown and Python-Gwardar deposits is located below the water and saturated with water and wet beneficiation is consequently required to handle this material. The general process flow diagram is shown in Figure 2-6.

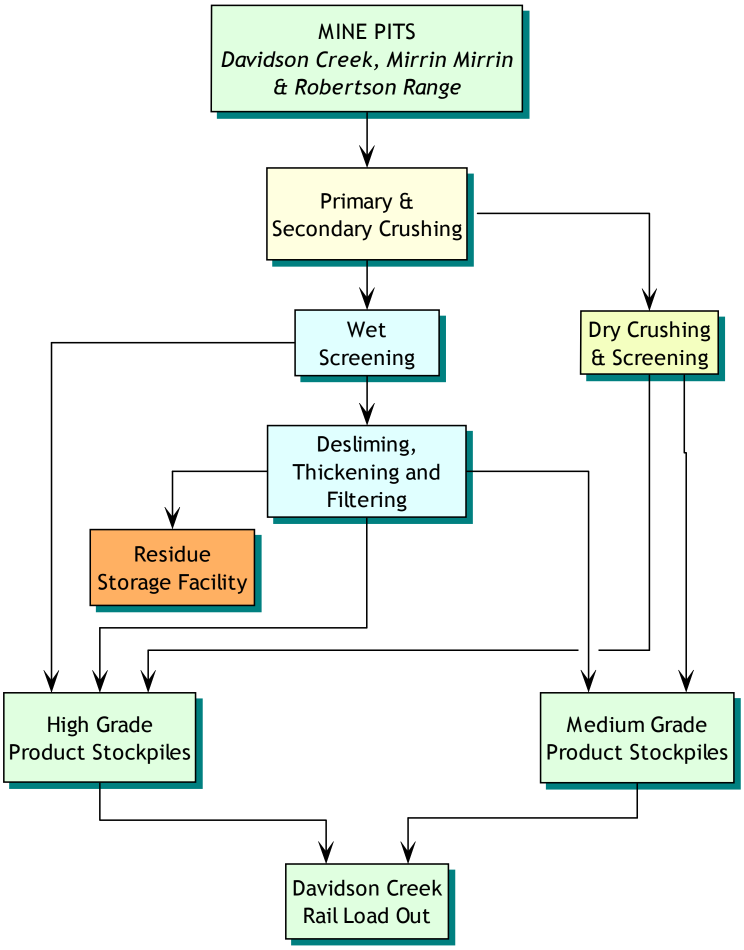
Crushing and screening is required for all ore types to produce final ore fractions between 1 and 10 mm. These fractions are then sent for stockpile and load-out. Fractions smaller than 1 mm require metallurgical upgrading or beneficiation before stockpiling and subsequent load-out.

Beneficiation

Beneficiation for High Grade (HG) ore includes de-sliming, thickening and filtration to produce a fines product. Beneficiation of Medium Grade (MG) ore involves a series of steps to separate and remove certain size fractions. This involves de-sliming and gravity (spiral) based circuits, upfront classifier to produce material fractions of 850 micrometres (µm), fine and coarse spiral circuits, dewatering on screens or belt filters before product stockpiling. During each of the processing steps, the fines fraction (<45 µm) is considered as waste. Slimes and waste would pass to the tailings thickener for discharge to the RSF while the beneficiated product would be stockpiled and reclaimed for train loading.

Blending of ore will take place at the mine, run-of-mine (ROM) stockpiles, and from product stockpiles prior to train load-out.

Figure 2-6 Processing flow diagram



2.6.3 Residue management

Thickener

The tailings thickener would receive waste fine material from beneficiation. Flocculants and coagulants would produce a thickened underflow typically made up of 48% solids. The thickened underflow and residue cyclone underflow are combined in the residue feed line tank and then pumped as slurry to the RSF.

The RSF would be established at DCA and designed as an above ground storage facility integrated with one of the waste dumps. The total area of the RSF is estimated to be about 200 ha with a separation dike/causeway in the middle to form two separate cells of approximately 100 ha each. Tailings would be deposited using a peripheral deposition scheme, with a header pipe and spigots, in both cells. During operations, each cell would be cyclically "rested" (made inactive) for about 12 months, while tailings are being deposited in the other cell. On the north side, containment for the RSF is provided by the waste dump wall with a facing of engineered fill. Containments along the other three sides are provided by engineered embankments constructed from select mine waste materials.

For start-up, a low height starter embankment would be constructed with a maximum height of 9 m at the northeast corner and progressed, during operation, be incrementally raised using the downstream method of construction. An initial starter height causeway, located in the middle of the RSF would also be constructed as part of the initial start-up operations. No basal liner or under drainage system is envisioned for the RSF as the tailings are considered to be benign.

The height of the starter embankment has been selected to provide:

- tailings deposition for the first 1.6 years of operation before erection of the embankment(s) becomes necessary
- safe containment of the 1 in 100 year ARI 72 hour flood in accordance with the DMP freeboard requirements.

Following the initial start-up phase, the perimeter embankments, including the north wall common with the waste dump, would be incrementally raised over the life of the facility. Embankment raising would be completed using the downstream method of construction using the same equipment and materials that were used for start-up construction. The causeway, separating the east and west cells, would also be incrementally raised with waste material by gradually reducing its crest width from 30 m to 6 m.

The final RSF facility will include the following design criteria:

- a concave, store-release cover with the capacity to retain 100 – 150 mm of water against gravity to aid in restricting deep infiltration by optimising evaporation of ponded water on the surface of the cover, while allowing shallow storage of water for uptake by vegetation
- typically a 1 m thick store-release cover allowing for revegetation with local provenance species
- top of the store-release cover will be ripped with 0.4 m high rip-lines approximately 1 m apart
- rock armoured outer walls to achieve an angle of led than 20°to minimise erosion
- evaporation basin floors will be 1.5 m thick
- safe containment of the 1 in 100 year ARI 72 hour flood in accordance with the DMP freeboard requirements.

The detailed design characteristics of the proposed RSF are provided in Appendix 7.

2.6.4 Support facilities

Power supply and consumption

The process plants would be supplied with electricity from a diesel power station located at DCA which would be built, owned and operated by a third party. The estimated power demand is 16 MW with a maximum demand of 20 MW. One-MW diesel generators would be installed to meet a continuous demand, providing adequate redundancy. Power would be distributed around DCA at 11 kV from the power station. A 33 kV overhead transmission line, installed within the services easement, would distribute power from DCA to the permanent accommodation village, airport and RRA.

Process water supply

A process water dam will provide the main water storage facility for each area for the respective processing plants. Process water dams have the capacity to hold approximately 3 to 3.5 days maximum storage inclusive of 1 m freeboard. Each process water dam is approximately 0.25 ha.

Raw water dams will be located at each mining area, with the capacity to hold sufficient water to meet two days of operational demand contingency of an additional one day as firewater and inclusive of 1 m freeboard. Any excess water from the Robertson Range raw water dam will be pumped to the Davidson Creek raw water dam.

Potable water supply

Preliminary investigations indicate that groundwater from dewatering would be suitable for potable use without treatment in a reverse osmosis unit, however, chlorination and softening would be required to meet the NH&MRC (2004) drinking water guidelines. Water treatment plants would be located at the DCA, RRA, permanent accommodation village and the airport. The construction campsite would also be provided with water treatment systems to ensure compliance with drinking water guidelines.

Dangerous goods storage

Hazardous materials storage

A dedicated explosives deposition and storage facility would be located between DCA and the main village. The deposition area will be approximately 120 m x 100 m and the magazine area approximately 60 m x 60 m. Explosive storage areas will be fenced and set back from any other buildings in accordance with *Dangerous Goods Safety* (Explosives) *Regulations 2007*, relevant standards, codes of practice and DMP guidelines.

In addition, there would be a radioactive store cupboard for the safe storage of low level radioactive sources for density gauges and a segregated area in the site store for detergents, solvents and other cleaning liquids. Avgas (nominally 6000 L) would be stored at the airport in a purpose built facility.

Hydrocarbons

There will be two hydrocarbon storage areas at DCA, one adjacent to the power station and another for refuelling of mobile equipment. The areas would be suitably bunded and lined to comply with AS1940. There is a high rate truck loading facility, for loading diesel for transport to a fuel store at RRA.

Fuel transfer pipelines would distribute fuel from the fuel farm to the power station, and the workshop refuelling station.

Wastewater treatment

Mine site sewage would be treated through a package treatment unit installed at DCA. Waste water discharge from the treatment system will be pumped to the residue storage facility. At RRA, some small satellite areas and the airport, septic systems with leach drains will be used to discharge the treated waste water.

DCA oily waste water and storm water from the vehicle washdown facilities, refuelling aprons and workshops will be treated via an oil - water separator, and pumped to the residue disposal circuit, ultimately reporting to the RSF. RRA oily waste water and storm water will be similarly treated and pumped to a sediment pond.

Waste management/landfill

Previous approvals obtained for RRA included provision for a landfill to be located within one of the main waste dump areas. The landfill for the project is now proposed to be located in a sterilised area adjacent and north west of the proposed Robertson Range pit. The landfill would only be used for inert material and managed in accordance with the *Environmental Protection* (Rural Landfill) *Regulations 2002*.

Administration buildings

Administration buildings and offices would be provided for the DCA and RRA. The main administration building at both locations would accommodate offices, meeting rooms, a small store room and kitchen. The buildings would be supported with a separate crib area, ablution facility, a first aid room, an emergency building and parking for the ambulance and emergency service vehicles.

Existing approved administration buildings at the RRA would remain unmodified.

Vehicle and plant workshops and washdown facility

A variety of vehicle and plant workshops inclusive of washdown facilities would be provided for both mining areas. Workshops that would handle and store hydrocarbons would have suitably bunded areas and an oily water separator. Washdown facilities would also include an oil - water separator. Waste oil storage tanks would also be provided.

Transport corridors

Main access to the FPP is via the Caramulla Creek Road. The access road would be upgraded to cater for the increased traffic. A haulage and light vehicle corridor would be established to connect DCA to RRA.

2.6.5 Rail component

The rail component of the FPP does not form part of this closure plan. Rail construction and associated progressive rehabilitation activities will be undertaken in accordance with the FPP Rail Construction Environmental Management Plan. It is anticipated that the FPP rail will form part of a State Agreement with the Western Australian government once mining activities have ceased, therefore a decommissioning plan is not required.

3. Identification of closure obligations and commitments

3.1 Legal obligations register

In addition to the applicable legislation (Section 3.1.2), there are legally binding commitments and conditions arising from the various environmental approvals and permits that will apply to the FPP. The closure objectives and completion criteria described in this management plan are derived from these commitments and conditions.

A legal obligations register has been prepared for the FPP as part of the FerrAus Limited Environmental Management System (EMS). Relevant legislation, guidance and codes of practice are summarised in the following sections. Obligations relevant to rehabilitation and closure are listed in Appendix 2.

3.1.1 Commonwealth legislation and regulations

Key Commonwealth legislation relevant to this Project includes:

- *Environment Protection Biodiversity and Conservation Act 1999* (EPBC Act)
- *National Greenhouse and Energy Reporting Act 2007*
- *Native Title Act 1993.*

3.1.2 State legislation and regulations

Key Western Australian legislation relevant to the Project includes:

- *Aboriginal Heritage Act 1972*
- *Agriculture and Related Resources Protection Act 1976*
- *Bush Fires Act 1954*
- *Conservation and Land Management Act 1984*
- *Contaminated Sites Act 2003*
- *Dangerous Goods (Transport) Act 1998*
- *Dangerous Goods Regulations 1992*
- *Dangerous Goods Safety Act 2002*
- *Environmental Protection Act 1986*
- Environmental Protection Regulations 1987
- Environmental Protection (Controlled Waste) Regulations 2004
- Environmental Protection (Noise) Regulations 1997
- Environmental Protection (Clearing of Native Vegetation) Regulations 2004
- Environmental Protection (Unauthorised Discharges) Regulations 2004
- *Explosives and Dangerous Goods Act 1961*
- *Health Act 1911*
- Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974
- *Land Administration Act 1997*
- *Mining Act 1978*
- *Mines Safety and Inspection Act 1994*
- *Pollution of Waters by Oil and Noxious Substances Act 1987*
- *Rights in Water and Irrigation Act 1914*
- *Soil and Land Conservation Act 1945*

- *Wildlife Conservation Act 1950.*

3.1.3 Guidelines and codes of practice

Guidelines and codes of practice for mine closure include the following:

- Strategic Framework for Mine Closure: Australian and New Zealand Minerals and Energy Council and the Minerals Council of Australia (ANZMEC/MCA 2000)
- Mine Closure and Completion, Leading Practice Sustainable Development Program for the Mining Industry: Department of Industry, Tourism and Resources (DITR 2006a)
- Mine Rehabilitation, Leading Practice Sustainable Development Program for the Mining Industry; Department of Industry, Tourism and Resources (DITR 2006b)
- Planning for Integrated Mine Closure: Toolkit, International Council on Mining and Metals (ICMM 2008).
- Guidelines for preparing Mine Closure Plans (DMP/EPA 2011).

4. Closure data

4.1 Purpose of this section

This section of the Closure Plan provides:

- a summary of best available data on aspects of the physical and biological environment in and around the FPP, including chemical characterisation of mine materials
- an overview of the role of the Closure Plan and EMS in regards to the identification of information gaps and the collection of new information to fill those gaps
- repositories of operational information, such as spatial datasets, scheduling information, etc.

Baseline studies for the Project first commenced in 2007 with a combined biological survey of the Robertson Range Area (ecologia 2007a). Since that time, additional local and regional biological and cultural surveys, hydrologic studies and geochemical characterisation assessments have been conducted. Several of these baseline studies are the subject of ongoing and/or additional surveys, as further details regarding potential direct and indirect impacts emerge.

Baseline and predictive assessments conducted to date are summarised below. Owing to the breadth and complexity of the baseline information, the information set is not yet complete. The Environmental Impact Assessment (EIA) (Strategen 2011) presents more detailed information on the receiving environment.

4.2 Baseline environmental studies (pre-approval)

4.2.1 Climate data

The climate of the Pilbara is characterised as arid-tropical with two distinct seasons including a hot summer (October to April) and mild winter (May to September). The Pilbara region has an extreme temperature range, rising up to 50 degrees Celsius (C) during the summer and dropping to around 0 C in winter (Bureau of Meteorology [BoM] 2011).

The nearest BoM climatic station (temperature) to the project is at Newman. Mean monthly maximum temperatures at Newman range from 39^{o}C in January to 23^{o}C in July, while mean monthly minimum temperatures range from 25^{o}C in January to 6^{o}C in July. Mean annual evaporation exceeds mean annual precipitation by 2800 mm per year (BoM 2011).

The baseline climate data presented in all reports is from the BoM weather station at the Newman aerodrome, situated approximately 75 km to the west of the FPP.

4.2.2 Geology and soils

Geology

The FPP is located on the southern portion of the Pilbara Block, known as the Hamersley Province. Specifically the FPP is located on the eastern margin of the Hamersley Province, and is dominated by the Archaean granite and greenstone of the Sylvania Dome, the mafic volcanic flows of the Fortescue Group and the cherty Banded Iron Formations (BIF) of the Hamersley Group (SKM 2011a).

The ore bodies at both RRA and DCA are contained within the Archaean age Marra Mamba Formation (Aquaterra 2007). Folding and faulting within the Hamersley Group is a common structural feature, with alluvial deposits of Cainozoic age often overlying the sequence (Aquaterra 2007).

For more detailed geological information, the FerrAus geological database should be examined (managed by the FerrAus Exploration Department).

Soils

The soils of the FPP area have been classified under a Land Classification System for Western Australia (Van Vreeswyk et al. 2004; ecologia 2007a; Phoenix 2011a). The soils of the RRA range from deep red sands and red sandy earths seen in the Divide Land System, to the stony soils with red shallow loams or sands on the higher slopes and stony soils with red loamy earths on the lower slopes which are seen in the Newman Land system (ecologia 2007a). With the exception of the outcropping Jeerinah and Marra Mamba rocks forming the east-west trending ridge, the DCA is covered with aeolian sand, recent colluvium and alluvium (Aquaterra 2010).

An assessment of soil profiles across the FPP area was undertaken by Outback Ecological Services (OES) in conjunction with Graeme Campbell and Associates (GCA) in 2010a; 2010b (Appendix 6). Three soil-landform units were identified across the site including scree slopes, flats and drainage areas. Soil properties across the FPP differ considerably which is primarily as a result of their position in the landscape, relative to various landforms (Appendix 6).

The flats soil-landform unit within both the RRA and DCA consists of soils deposited from higher in the landscape and is characterised by relatively deep, homogenous soils. The scree slope soil/landform unit comprises soils that have formed primarily via colluvial deposition of soil and rock from higher in the landscape. The drainage soils were relatively similar to the flats and scree slopes, apart from a number of characteristics including nutrient levels, soil strength and hydraulic conductivity. Specific soil characterisation results for each soil-landform unit are discussed below.

Soil texture

Soil texture describes the particle size distribution, which is determined by proportions of sand, silt and clay within a soil. Soil texture can influence a range of chemical and biological properties including soil structure, water holding capacity, hydraulic conductivity, soil strength, fertility, erodibility and susceptibility to compaction. The flat soil-landform unit soils are typically sand to sandy clay loam in texture, with a low to moderate coarse fragment content (42% at DCA and 4% at RRA). The scree slopes are in general sandy loams with high amounts of course materials (60% at RRA and 73% at DCA). Coarse material/gravel content from drainage soils has an average percentage of 9%.

High coarse fractions of the scree slope soils means that soil is suitable for placement on the outer slopes of waste landforms, providing armour against erosion by water (Appendix 6).

Soil structure and structural stability

Well structured soil typically exhibits different sized particles, with component particles bound together to give a range of pore sizes facilitating root growth and the transfer of air and water (Appendix 6). When a soil material is disturbed, a breakdown of aggregates into primary particles can lead to structural decline, which can result in hard-setting and crusting of the soil surface, potentially reducing the ability of seeds to germinate, penetration of roots and infiltration of water into the root zone.

Soil aggregates that slake and disperse indicate a weak soil structure, which can be identified through the Emerson Aggregate Test, where samples are allocated an Emerson Class (1 and 2 being the most likely to exhibit dispersive properties). None of the soils sampled from the RRA fell into Emerson Classes 1 or 2, however one sample from the DCA flat soil-landform association exhibited Emerson Class 2 (Appendix 6).

All but one of the samples from the RRA exhibited dispersion upon re-moulding, which indicates a potential to become dispersive and problematic following sever disturbance. All of the DCA samples also exhibit dispersion upon re-moulding. This indicates that handling of soils should be undertaken with caution, particularly when wet (Appendix 6).

As discussed, a number of the soils sampled indicate a potential to disperse from remoulded aggregates, which may potentially become structurally unstable and prone to erosion when disturbed as a result. However based on the high percentage of coarse material, the susceptibility of these soils to erosion is likely to be reduced by rock armouring, which also occurs naturally in the undisturbed environment (Appendix 6).

Soil strength and root growth

Soil strength is measured to identify the likelihood of soil to hard-set as a result of soil slaking and dispersion. Assessment of soil strength provides insight into the potential for layers of soils to hard-set and compact with repeated wetting and drying cycles and the ability of roots to fracture the soil and penetrate crack faces. Soil strength at RRA and DCA is below the critical level to be considered at risk of hard-setting. Therefore, the risk of hard-setting is not considered significant or problematic in terms of root penetration. Topsoil from the DCA is also considered to be in the non-problematic range, however soils from the 45 cm depth in drainage soils have the potential to be problematic in terms of root penetration (Appendix 6).

The presence of roots was observed within all soil profiles in the RRA and DCA. root abundance is dependent on proximity to plants and the number of plants present (Appendix 6).

Hydraulic conductivity

Hydraulic conductivity (measured by K_{sat} values) is the ability of water to infiltrate and drain through the soil matrix and is dependent on soil texture and structure. High K_{sat} values are generally less susceptible to surface water runoff and erosion and low K_{sat} values are generally more likely to experience water logging, increased surface runoff and erosion (Appendix 6)

The drainage classes for samples from the different soil/landforms associations were variable. The flat soil/landform samples from the RRA were classed as having moderate to moderately rapid drainage, while the flat samples from the DCA where in the moderate to moderately slow drainage classes. Samples from the drainage soils associated with Davidson Creek are classed as slow draining. Scree slope samples from the RRA ranged from moderate to moderately slow, whilst those from the DCA are moderate to moderately rapid (Appendix 6).

Soil pH and total metal concentrations

The ideal pH range for plant growth of most agricultural species is considered to be between 5.0 and 7.5 (Moore 1998). Soil samples from the RRA are within the neutral range (pH 5.8 to 7). All soil pH values from the DCA were classified as neutral to slightly acidic (pH 5 to 7.1) (Appendix 6).

Variable levels of total metal concentrations were recorded for the FPP (As, Cd, Cr, Cu, Pb, Ni, Zn and Hg). All results were below the recommended 'Ecological Investigation Levels (EILs) for soils (DEC 2010), except for one site at Davidson Creek which had a Ni concentration just over the EIL (Appendix 6).

Electrical conductivity, exchangeable cations and exchangeable sodium percentage

Saline and sodic materials have the potential to cause erosion and compromise the integrity of final landforms. The electrical conductivity (EC) of all soils sampled from the RRA is considered non-saline to slightly saline. Average EC values were slightly higher for soils from the flat soil-landform sites compared to those from the scree slopes. Soils from the DCA ranged from non-saline for drainage and scree slope soil samples to moderately saline for one of the flat soil-landform samples (Appendix 6).

Exchangeable cations are held within clay surfaces and within organic matter and act as an important source of soil fertility, which can influence the physical properties of soil. If cations are dominant on the surface, the soil will typically display increased physical structure and stability, leading to increased aeration, drainage and root growth (Moore 1998). The exchangeable sodium percentage (ESP) describes the sodium fraction of the exchangeable cations held on the soil surface. If sodium cations are dominant on the surface and exceed more than 6% of the total exchangeable cations, then the soil is considered sodic, which can lead to poor physical properties (Appendix 6).

The dominant cations for both the RRA and DCA were calcium cations, with very low ESP levels (OES 2010). No soils sampled were considered highly sodic, however one sample from the DCA was classed as sodic (Appendix 6).

Soil organic matter and plant available nutrients

Organic matter content of the soils within the FPP area was determined as a measure of the soil organic carbon (SOC) percentage. Organic matter content provides the basis for biological activity prior to and during ecosystem re-establishment (DITR 2006). The organic carbon percentage across the FPP area was low, which is consistent with most natural Western Australian soils, particularly the Pilbara region. The highest organic carbon contents were from the upper surface soils and typically decreased or remained constant with depth (Appendix 6).

Plant-available nutrients were variable across the RRA and DCA. Nitrogen concentration across the majority of sites were low, which is consistent with the typical nutrient poor arid areas of Australia, however two samples from the DCA (flat areas) exhibited high concentrations. Plant available phosphorus, potassium and sulfur across both the RRA and DCA were considered low (Appendix 6).

Assessment of closure related characteristics

Soil characterisation results indicate that no potential issues relating to the development of final landforms exist, a summary of specific closure related components of the assessment are summarised below:

- all soils from RRA and DCA are non-sodic and non-saline, therefore the likelihood of erosion is not considered to be a risk to the development of final landforms
- the suitability of soils for use in rehabilitation and closure activities varied across the site, with coarse material content varying from moderate to low in the flat soil-landform units (42% at DCA and 4% at RRA), high in scree slopes (60% at RRA and 73% at DCA) and low in drainage soils (average of 9%)
- a high proportion of soils sampled from the FPP area may potentially disperse after disturbance, however the large percentage of coarse fragment material can be used to reduce the potential for disturbance through rock armouring
- soil sampled is generally not at risk of hard-setting and is conducive to root penetration
- hydraulic conductivity of soils varies across the sites, however it is generally slow which can potentially result in ponding and erosion and water logging
- soils are generally slightly acidic and exhibit low nutrient levels, however this is typical of soils in the Pilbara. The slight acidity in the majority of soils is not considered to increase the risk of acid mine drainage.

Additional soil characterisation assessments will be undertaken prior to mine closure to allow suitable timing for completion. Soil characterisation results will be incorporated in rehabilitation trials to determine appropriate closure materials and sources to ensure closure objectives are achieved.

4.2.3 Topography and landforms

The topography of the RRA slopes gently to the south east and rises abruptly to the north-west at the northern portion of the proposed pit (Aquaterra 2007). Located 1 – 2 km to the west of the proposed pit is a predominant hill, which is the location of a telephone tower. The boundary of the Upper Fortescue catchment and the Lake Disappointment Catchment, within which the Robertson Range mine is located, lies approximately 3 – 4 km to the west of the Robertson Range mining area (Aquaterra 2007).

The topography of the Davidson Creek area is flat to gently sloping. Immediately south of the ore body runs a low east west ridge, with the land directly above the deposit sloping gently to the north. Drainage is predominantly to the north with major drainage features running through the western end (Thirteen Creek) of the proposed pit and 1 km to the east (Davidson Creek) of the pit (Aquaterra 2009).

The topography and landforms of the FPP have been investigated and described in the following report:

- *Robertson Range, Davidson Creek and Mirrin Mirrin - Soil and Waste Material Assessment* (OES 2010).

Additional information on the soils of the area can be found in the Pilbara Region Inventory and Condition Survey, conducted by the Department of Agriculture (Van Vreeswyk et al. 2004).

Assessment of closure related characteristics

Final landforms will be developed in accordance with agreed closure outcomes and final land use, to ensure consistency, as far as practicable with the pre-mining landscape. Final landforms will be developed in accordance with agreed completion and design criteria, summarised in Section 2.6.1.

4.2.4 Vegetation and flora

Vegetation

In addition to the regional vegetation and flora surveys conducted by government agencies and other mining proponents, the vegetation and flora of the FPP has been mapped at a local scale over multiple seasons and surveys since 2007.

Vegetation and flora surveys encompassing the Proposal area and surrounds have been undertaken by ecologia, G & G Environmental and APM between 2007 and 2011 and included the following:

- ecologia 2007a, Robertson Range Biological Survey
- ecologia 2007b, Robertson Range - Proposed Haul Road Biological Survey
- ecologia 2007c, Robertson Range - Short Range Endemic Desktop Review
- ecologia 2007d, Davidson Creek Targeted Priority and Rare Flora Survey
- ecologia 2009b, Robertson Range (M52/1034) Vegetation and Flora Report
- G & G Environmental 2011a, FerrAus Pilbara Project Flora And Vegetation Survey (included consolidation of the surveys previously conducted within the Proposal area [ecologia 2007a, ecologia 2007b, ecologia 2009b, G & G 2010a and G & G 2010b])
- G & G Environmental 2011b, A Flora And Vegetation Survey of the Proposed FerrAus Limited Rail Corridor
- APM 2011, Proposed Rail Corridor (Option 2) Biological Assessment.

The purpose of the surveys was to identify the vegetation and flora of the area and to record the presence of Declared Rare Flora (DRF), Priority Flora and vegetation of high conservation significance and provide regional/local context.

G & G Environmental, ecologia, and APM defined 66 vegetation communities across the FPP area, with 42 comprised of flat to undulating plains of varying soil type, five on rocky hills, six within rivers and creeks, six grove/intergrove communities, four communities within minor depressions, two on red sand dunes and one waterhole community. Of these, 20 occur within the mining area. All mapped vegetation communities are well represented in the Pilbara region and Gascoyne regions.

Vegetation condition within the mining area was recorded as Good (2.5%), Very Good (0.6%), Excellent (18.6%) with the majority of the vegetation considered to be in Pristine condition (78.3%). No Threatened Ecological Communities (TEC) or Priority Ecological Communities (PEC) were recorded from the FPP area.

Open woodlands containing *Eucalyptus camaldulensis* (River Red Gum) and/or *Eucalyptus victrix* (Coolibah) were mapped on the creek lines that occur in the Proposal area. River Red Gum and Coolibah are is considered to have a partial dependence on groundwater (partially phreatophytic) to meet their physiological moisture requirements through the use of deep, aggressive root systems (Fisher et al. 2004). River Red Gum vegetation (vegetation type 3b, 3d and 3f) covers approximately 776 ha of the surveyed areas (includes both the mine and rail survey areas) and Coolibah vegetation (vegetation type W2) covers approximately 3452 ha of the surveyed areas.

Flora

No Threatened species pursuant to the EPBC Act were located within the FPP area. In addition, no plant taxa gazetted as DRF pursuant to the WC Act have been located within the Proposal area.

Seven Priority Flora species were recorded within the Proposal area, as summarised in Table 4-1 below.

Table 4-1 Conservation significant flora recorded in the Project area

Species	Conservation status	Location
Brachyscome sp. Wanna Munna Flats	P1	Rail option 1
Gompholobium karijini	P2	Rail option 1
Goodenia nuda	P4	DCA Rail option 1 Rail option 2
Eremophila youngii subsp. *lepidota*	P4	Rail option 2
Olearia mucronata	P3	Rail option 1
Vigna sp. rockpiles (R. Butcher et al. RB 1400)	P3	Rail option 2
Vittadinia pustulata	P2	Rail option 1

An additional 49 species listed as Threatened or Priority Flora have been recorded in the vicinity of the FPP area, though were not recorded during surveys for the FPP. This species list is summarised in the EIA document.

A total of 17 weeds were recorded during surveys of the Proposal area, including one Declared Plant under the *Agriculture and Related Resources Protection Act 1976.* All other weed species were recorded occasionally, mainly in wetter areas.

Closure and rehabilitation activities will be undertaken within approved cleared areas already disturbed as a result of mining activities, therefore no further flora and vegetation surveys are required from the FPP area.

Riparian vegetation

The ephemeral nature of the two watercourses is important in providing the opportunity for vegetation to establish on the ridges and islands and mitigate the potentially aggressive erosion that could occur with the low cohesion bank systems.

Riparian vegetation is critical to the physical form of Mirrin Mirrin Creek. Ground cover is particularly important to stabilising banks and ridges. Over-storey vegetation and the shrub layer are likely to be important to the stability of banks and are critical to the initiation of in-channel ridges and the existence of a multi-channel river pattern. Wende and Nansen (1998) notes that uprooted vegetation and timber debris allow formation of zones of deposition suitable for establishment of vegetation.

Vegetation and the associated woody debris generated and transported through the system is likely to be an important component of hydraulic roughness and critical to the energy of flow in the channel and erosion, deposition and sediment transport.

Assessment of closure related characteristics

Impacts to flora and vegetation as a result of closure activities are anticipated to be negligible as all activities will be undertaken within already disturbed areas. Where practicable progressive rehabilitation will be undertaken throughout project operations and continue through mine closure and rehabilitation and eventual tenement relinquishment. It is anticipated that riparian vegetation will be well-established in creek diversion areas at the completion of mining operations. If required riparian vegetation will be monitored and rehabilitated where necessary.

No further flora and vegetation assessments will be required over the course of the FPP. The management of impacts and hazards to flora and vegetation, particularly those of conservation significance, are the scope of the FPP Flora and Vegetation Management Plan, which should be consulted in addition to the above reports.

4.2.5 Fauna and habitats

As with vegetation and flora, the vertebrate and invertebrate fauna assemblages of the FPP have been studied intensively since 2007. Vertebrate fauna assessments undertaken to date include the following:

- Level 1 survey of Robertson Range tenement (M52/1034) in 2007, herein referred to as Survey VF01 (ecologia 2007a)
- Level 1 survey of proposed haul road and associated infrastructure in 2007, herein referred to as Survey VF02 (ecologia 2007b)
- Level 2 survey of Robertson Range tenement (M52/1034) in 2008, herein referred to as Survey VF03 (ecologia 2008)
- Level 2 survey of Python Gwardar deposit, proposed haul road and associated infrastructure areas in 2010, herein referred to as Survey VF04 (Phoenix 2010a)
- Level 2 survey of proposed rail corridor, herein referred to as Survey VF05 (Phoenix 2011b)
- Targeted Mulgara and Level 1 survey of Mirrin Mirrin, Tiger/Dugite, proposed accommodation village and proposed airstrip, herein referred to as Survey VF06 (Phoenix 2011c).

Studies for short-range endemics (SREs) have been conducted over the 2007 – 2011 period, including:

- Robertson Range Iron Ore Project Short Range Endemic Desktop Review (ecologia 2007c)
- Davidson Creek Iron Ore Project Short-range Endemic Invertebrate Fauna Survey (Phoenix 2009a)
- Short-Range Endemic Invertebrate Fauna Report: FerrAus Pilbara Project (Phoenix 2010b)

Studies for Troglofauna and Stygofauna have been conducted over the 2007 – 2011 period, including:

- Phoenix Environmental Sciences (2011e) Subterranean Fauna Survey of the FerrAus Pilbara Project: Mirrin Mirrin and Tiger/Dugite
- Phoenix Environmental Sciences (2010d) Python and Gwardar Iron Ore Deposit Stygofauna Survey Final Report: FerrAus Pilbara Project
- Phoenix Environmental Sciences (2010e) Python and Gwardar Iron Ore Deposit Troglofauna Survey Final Report: FerrAus Pilbara Project
- ecologia (2009c) Robertson Range Subterranean Invertebrate Survey Stygofauna
- ecologia (2009d) Robertson Range Subterranean Invertebrate Survey Troglofauna

The studies have been consolidated into three reports for the FPP:

1. Consolidated Report on Vertebrate Fauna Surveys Conducted for the FerrAus Pilbara Project. Phoenix Environmental Sciences Pty Ltd July 2011.
2. Consolidated Report on Subterranean Fauna Surveys conducted for the FerrAus Pilbara Project. Phoenix Environmental Sciences Pty Ltd July 2011.
3. Davidson Creek Iron Ore Project Short-range Endemic Invertebrate Fauna Survey. Phoenix Environmental Sciences Pty Ltd June 2009.

A summary of the survey results is provided in the following section below:

Vertebrate fauna

Five fauna habitats have been identified across the FPP area, including the following:

Table 4-2 Fauna habitat

Fauna habitat	Habitat description
Spinifex sandplain	Sandy plains vegetated with hummock grassland (predominantly Spinifex) and scattered trees and shrubs.
Mulga woodland	Open to moderately dense woodlands occur on sandy plains and rocky slopes. Understorey can be composed of tussock or hummock grasses.
Major creeklines and floodplains	Dominant vegetation is generally *Eucalyptus* and *Corymbia* trees up to 15 m over a variably dense understorey of mixed *Acacia* species, low shrubs and tussock grasses.
Low rocky ranges and rocky slopes	Vegetation comprises sparse Mulga and eucalypt trees and small tree stands. The understorey consists of Spinifex hummock grasslands and mixed low shrubs. More open areas consist of open shrublands of Grevillea and Acacia over hummock grassland. The ground surface varies from skeletal sands to clay and rocky substrates.
Sand dunes	Spinifex and *Dolichandrone heterophylla* were the two main types of vegetation found in the dune systems of the study area.

Fifteen conservation-significant species were recorded or are considered likely to occur in the FPP area, including eight species of birds, five species of mammals and two species of reptiles.

Of the recorded conservation-significant species, the Proposal area contains important habitat for:

- Crest-tailed Mulgara (*Dasycercus cristicauda*) - Spinifex sandplain habitats on deep sandy soils in the vicinity of the proposed haul road between King Brown deposit and Python/Gwardar deposit, at the King Brown deposit, airstrip, accommodation village (lower slopes) and at some sections along the Option 1 rail corridor
- Australian Bustard (*Ardeotis australis*) – occurs regularly in the Proposal area and is actively utilising the Spinifex sandplain and low rocky range/rocky slope habitats, although it is likely to be using other habitats also
- Bush Stone-curlew (*Burhinus grallarius*) – recorded at the eastern boundary of its current distribution range
- Western Pebble-mound Mouse (*Pseudomys chapmani*) – suitable habitat occurs throughout the Proposal area near the proposed haul road, the King Brown deposit, the Option 1 rail corridor and the accommodation village.
- Rainbow Bee-eater (*Merops ornatus*) – suitable nesting habitat occurs along the numerous creek lines of the study area.

In addition, potential habitat for the Northern Marsupial Mole, Unpatterned Robust Lerista, Brush-tailed Mulgara and Greater Bilby will also be disturbed (Phoenix 2011c).

Conservation significant species of the FPP area are summarised in Table 4-3.

Table 4-3 Conservation-significant species in the Proposal area

Species	Status			Distribution and ecology	Likelihood of occurrence
	EPBC Act	WC Act	DEC		
Fork-tailed Swift (*Apus pacificus*)	Mig			A widespread migratory species that overwinters in Australia, and can be found throughout Western Australia (Phoenix 2011c). They occur in a wide range of dry or open habitats, including riparian woodlands, tea-tree swamps, low scrub, heathland, salt marsh, grassland and Spinifex sandplains, open farmland and inland and coastal sand-dunes (Phoenix 2011c). Fork-tailed Swifts are often found around in areas of updraughts around cliffs, and normally forage several hundred metres above ground level (SEWPAC 2011a).	Recorded during Survey VF05. Suitable habitat within Proposal area. *Likelihood of occurrence – likely.*
Grey Falcon (*Falco hypoluecos*)			P4	A widespread but rare species inhabiting much of the semi-arid interior of Australia. Its distribution is centred on inland drainage systems (Phoenix 2011c). It has a large foraging range extending from timbered plains, such as *Acacia* shrublands, into open grasslands (Garnett & Crowley 2000).	Not recorded. Suitable foraging and breeding habitat is available in Proposal area (species can breed on tall human infrastructures such as telecommunications towers). *Likelihood of occurrence – possible.*
Peregrine Falcon (*Falco peregrinus*)		S4		A widespread species found across Australia, and has a large foraging range (Phoenix 2011c). Preferred habitat includes cliffs and wooded watercourses (Johnstone & Storr 1998).	Single birds recorded during Survey VF04 (Python/Gwardar deposit) and Survey VF05 (Option 1 rail corridor). No suitable nesting habitat within the Proposal area. *Likelihood of occurrence –unlikely.*
Australian Bustard (*Ardeotis australis*)			P4	A large, ground-dwelling bird that favours open or lightly wooded grasslands, chenopod flats and plains, and heathlands and farming country (Johnstone & Storr 1998). Found across Australia, it is nomadic and highly mobile, and may range over large areas (Phoenix 2011c).	Recorded in a range of habitats during Survey VF06 (proposed accommodation village and Tiger/Dugite deposit), Survey VF04 (northwest of the Proposal area), Survey VF05 (Option 1 rail corridor, Survey VF02 (proposed haul road) and Survey VF03 (King Brown deposit). Suitable habitat occurs throughout Proposal area. *Likelihood of occurrence – likely.*

Species	Status			Distribution and ecology	Likelihood of occurrence
	EPBC Act	WC Act	DEC		
Bush Stone-curlew (*Burhinus grallarius*)			P4	A relatively large, ground-dwelling bird that prefers lightly wooded country near daytime shelter such as thickets or long grass (Phoenix 2011c). It can be found across much of Australia except the arid interior and southern coast (Phoenix 2011c). The species is considered sedentary (stable home range and non-migratory) (Garnett & Crowley 2000).	A single Bush Stone-curlew was recorded during nocturnal searches for Survey VF04 (northwest of the Proposal area) and Survey VF06 (near the current campsite). Suitable habitat occurs throughout Proposal area, and in particular within Survey VF06 (proposed accommodation village and the Tiger/Dugite deposit) and Survey VF05 (Option 1 rail corridor). *Likelihood of occurrence – possible.*
Oriental Plover (*Charadrius veredus*)			P4	A non-breeding visitor to Australia. It has a widespread distribution but most records are along the northwestern coast between Exmouth Gulf and Derby (SEWPAC 2011b). Inland habitats occupied by the species include sparsely vegetated plains or recently burnt open areas (Phoenix 2011c).	Not recorded. Suitable habitat occurs throughout the Proposal area. *Likelihood of occurrence – possible.*
Rainbow Bee-eater (*Merops ornatus*)	Mig			A highly-mobile migratory bird that moves between Australia and Asia (Phoenix 2011c). In Western Australia, the Rainbow Bee-eater can be found in lightly wooded, preferably sandy country near water, occurring as a resident, breeding visitor, postnuptial nomad, passage migrant or winter visitor (Johnstone & Storr 1998).	Recorded throughout Proposal area during Survey VF02 (proposed haul road), Survey VF04 (northwest of the Proposal area), Survey VF05 (Option 1 rail corridor), Survey VF06 (proposed accommodation village) and Survey VF03 (King Brown deposit). Suitable habitat occurs throughout the Proposal area. *Likelihood of occurrence – likely.*
Star Finch (*Neochmia ruficauda subclarescens*)			P4	Found in flocks of five to 20 individuals around permanent water in north-western Western Australia (Phoenix 2011c). The species can occur in arid habitat after the wet season, if the conditions are good for breeding (Phoenix 2011c).	Not recorded. Suitable habitat may be available irregularly when the climatic conditions are favorable (e.g. after the wet season). *Likelihood of occurrence – unlikely.*

Species	Status			Distribution and ecology	Likelihood of occurrence
	EPBC Act	WC Act	DEC		
Crest-tailed Mulgara (*Dasycercus cristicauda*)	Vul	S1		The current distribution map listed for the Crest-tailed Mulgara under the EPBC Act 1999 shows a wide distribution, covering most of central Australia and spreading into north-western Western Australia (SEWPAC 2011c). It is likely that both species have been included in this map, particularly as the EPBC Act currently does not accept the recent taxonomic revision of the genus (SEWPAC 2011c). Mulgara have now been recorded in Western Australia in the Great Victoria Desert, Goldfields, Gascoyne, Sandy Desert and Pilbara regions. Recent surveys in Western Australia show that Crest-tailed Mulgara are found on medium to dense Spinifex plains (Phoenix 2010a; Thompson & Thompson 2007). Mulgara burrows are generally found under dense Spinifex hummocks or in open sand away from vegetation, but they also occur under Canegrass clumps, Nitre Bush hummocks, and small shrubs including melaleuca and grevillea (Körtner et al. 2007; Masters 2003; Thompson & Thompson 2007). No home range studies have been completed for Crest-tailed Mulgara. Brush-tailed Mulgara have been reported to have home ranges from one hectare up to 25.5 hectares, with notable differences occurring between sexes and seasons. Brush-tailed Mulgara are noted as having a sedentary lifestyle, meaning that they maintain a stable home range and may live in one location for many years (Körtner et al. 2007; Masters 2003).	Crest-tailed Mulgara recorded within Survey VF04 (proposed haul road) and Survey VF05 (Option 1 rail corridor). Inactive Mulgara burrows were recorded during Survey VF01, VF03 and VF06 (King Brown deposit) and Survey VF06 (Option 1 rail corridor). Suitable habitat across Proposal area for Crest-tailed Mulgara, where spinifex plains are found (proposed airstrip, lower part of the proposed accommodation village, and the deposits at Mirrin Mirrin and Tiger/Dugite). *Likelihood of occurrence – likely.*
Brush-tailed Mulgara (*Dasycercus blythi*)			P4		Not recorded. Suitable habitat occurs throughout the Proposal area. Whilst not recorded, there is still potential for Brush-tailed Mulgara to occur within the study area as the two Mulgara species may be sympatric. *Likelihood of occurrence – possible.*
Greater Bilby (*Macrotis lagotis*)	Vul	S1		A rabbit-sized marsupial that originally occupied over 70% of the Australian mainland. It now occurs in less than 20% of its original range, with remaining Western Australian populations predominantly in the Great Sandy and Gibson Deserts (Phoenix 2011c). Habitat preferences include hummock grassland in plains and alluvial areas, open tussock grassland on uplands and hills, and mulga woodland/shrubland on ridges and rises (SEWPAC 2011d).	Not recorded. Suitable habitat occurs throughout the Proposal area. *Likelihood of occurrence – possible.*

Species	Status			Distribution and ecology	Likelihood of occurrence
	EPBC Act	WC Act	DEC		
Northern Marsupial Mole (*Notoryctes caruinus*)	End	S1		A blind marsupial adapted to living underground. It is associated with the sand-dune desert systems of inland Australia (Van Dyck & Strahan 2008; SEWPAC 2011e). In Western Australia, specimens have been collected from the Great Sandy, Little Sandy and Gibson Deserts (Benshemesh 2004).	Not recorded. Given the lack of records and the limited knowledge on the species biology, distribution and regional habitat extent it is difficult to assess the likelihood of occurrence of this species in the Proposal area. *Likelihood of occurrence –unlikely.*
Ghost Bat (*Macroderma gigas*)			P4	Restricted to northern Australia, common in the Northern Territory but limited to small or widely scattered colonies elsewhere within their range (Phoenix 2011c). This large bat roosts in shallow sandstone caves on cliff lines, under boulder piles, in deep limestone caves and within old mines (Phoenix 2011c).	A 'probable' call was recorded during Survey VF04 (Python/Gwardar deposit) No suitable roosting habitat occurs in the Proposal area. *Likelihood of occurrence – unlikely.*
Western Pebble-mound Mouse (*Pseudomys chapmani*)			P4	Widespread in the ranges of the central and southern Pilbara and extends into the Little Sandy Desert Ranges (Van Dyck & Strahan 2008). The mouse mounds are located on the gentle slopes of rocky ranges covered in rocky mulch, hard spinifex and sparse trees and shrubs (*Eucalyptus, Senna*, *Acacia* and *Ptilotus*). They are also often found near *Acacia*-dominated drainage lines (Van Dyck & Strahan 2008).	Inactive mounds recorded in Proposal area in Survey VF03 (proposed haul road). Active mounds recorded in Proposal area in Survey VF03 (King Brown deposit – possibly active mound) and Survey VF05 (Option 1 rail corridor). Suitable habitat occurs throughout Proposal area (Survey VF03 (proposed haul road), Survey VF03 (King Brown deposit – possibly active mound) and Survey VF05 (Option 1 rail corridor) and Survey VF06 (proposed accommodation village)). *Likelihood of occurrence – possible.*
Unpatterned Robust Lerista (*Lerista macropisthopus remota*)			P2	This Lerista species favours sandy to sandy loam soils which support *Acacia* shrubland or woodland (Phoenix 2011c). It inhabits loose soil under leaf litter at the base of shrubs (Wilson & Swan 2010).	Not recorded. Suitable habitat occurs in the Proposal area. *Likelihood of occurrence – possible.*

Species	Status			Distribution and ecology	Likelihood of occurrence
	EPBC Act	WC Act	DEC		
Ctenotus uber johnstonei			P2	This subspecies of *C. uber* is found at a remote location, north-east of the study area in inland WA (Storr et al. 1999).	Several recent records are located a few kilometres west of the study area (DEC 2011b). These records are a long distance away from the previously known distribution range of the species (Phoenix 2011c). Given the few data available on the sub-species biology and habitat, it is not possible to assess the likelihood of occurrence of *C. u. johnstonei* in the study area (Phoenix 2011c). Of all the specimens collected during the surveys, all were identified as *C. u. uber* (Phoenix 2011c). *Likelihood of occurrence – unlikely.*

Mig = migratory; Vul = vulnerable; End = endangered.

Short Range Endemics

According to Phoenix (2009a, 2010b, 2010c), the Proposal area contains nine potential SRE habitats, including:

- major and minor drainage lines
- spinifex sandplains – floodplains
- rocky outcrops on low stony slopes
- south-facing minor slopes on low stony hills
- *Acacia* woodland
- *Acacia* in drainage lines
- *Triodia* hummock grasslands
- low shrublands
- stony hills of moderate elevation.

Of the Land Systems located within the Proposal area, the Boolgeeda, Newman and Fortescue systems have the greatest potential to harbour SRE species (Phoenix 2010b, 2011d) (Table 4-4).

The absence of mountainous terrain within the study area drastically reduces the chances of encountering SRE fauna and fauna habitats. Mountainous habitats in the Pilbara, with their associated, southern facing slopes, gullies, gorges and water holes, typically drive short-range endemism by providing refugial habitats that retain moisture (cited in Phoenix 2010b).

Table 4-4 SRE species recorded in the Proposal area

Order	Family	Genus/Species	SRE Status	Habitat
Mygalomorphae (Trap-door spider)	Actinopodidae	*Missulena* sp.	Putative SRE	Open Grassland
	Idiopidae	*Anidiops (Gaius)* sp.	Putative SRE	Minor drainage lines/ *Acacia* woodland Low Shrubland/Open woodland
	Nemesiidae	*Aname* 'MYG001'	Putative SRE	Rocky outcrops on low stony slopes Minor drainage lines/ *Acacia* woodland Low Shrubland/Open woodland
		Aname'MYG004'	Putative SRE	Rocky outcrops on low stony slopes Major drainage lines/Floodplains Open Grassland Low Shrubland/Open woodland
Scorpiones	Buthidae	*Lychas*'*harveyi*' gp	Putative SRE	Major drainage lines/Floodplains Minor drainage lines/ *Acacia* woodland
	Urodacidae	*Urodacus*'Davidson Creek'	Putative SRE	Major drainage lines/Floodplains Minor drainage lines/ *Acacia* woodland

The recorded putative SRE species were identified from sites within the RRA, DCA and the services corridor between the two areas. No SRE species were recorded in the proposed railway corridors.

Stygofauna

Robertson Range Area

Eight stygobitic amphipods were recorded within the Robertson Range impact areas during stygofauna sampling (ecologia 2009c). The specimens were collected from five sites and all appeared to be the same species, representing a new genus of crangonyctoid amphipods from the family Paramelitidae (Dr B. Knott, University of Western Australia, pers. comm.). All other invertebrates collected during the study were not stygobitic.

Davidson Creek Area

During surveys of the DCA (Phoenix 2010c and 2011e), 14 species, representing three classes, seven orders and ten families were recorded. Eight other potential stygofauna species were also recorded in the DCA; however these species were also collected in the regional samples indicating that they are actually stygoxenes (An aquatic species which spends only part of its life cycle in subterranean waters). As such they have not been listed below and will not be discussed further.

Table 4-5 Summary of stygofauna collected from DCA

Class	Superorder/order	Family	Taxon	No. of individuals recorded	No. of bores with specimens
Malostraca	Amphipoda	Paramelitidae	*Kruptus sp. DC6*	15	4
	Syncarida/Bathynellacea	Parabathynellidae	*Billibathynella* sp. DC2	4	3
	Isopoda	Tainisopidae	*Pygolabis sp. DC11*	1	1
Oligochaeta	Tubificida	Enchytraeidae	*Enchytraeidae* sp. indet.	14	27
			Enchytraeus sp. Pilbara 2 (PSS)	>1400	38
Maxillopoda	Cyclopoida	Cyclopidae	*Fierscyclops* (pilbaracyclops) sp. 'DC'	1	1
	Harpacticoida	Parastenocarididae	*Parastenocaris* sp. *B9*	1	1

Troglofauna

Robertson Range Area

Several troglobites were collected within each of the three phases of the troglofauna survey of the RRA (ecologia 2009d):

1. Onicidean isopods (Onicidea): four specimens of the same species were collected from three sites
2. Silverfish (Thysanura): four specimens were collected in one drill hole
3. Beetle larvae (Coleoptera): three individual beetle larvae specimens were collected in a single sample. The basic body plan of the larvae was very similar to that of beetles belonging to the Carabidae. Species of troglobitic Carabidae are known to occur in other localities in Australia such as Tasmania. Further sampling for adult specimens would be required to allow species level identification.
4. Mites (Acarina): Mites were so abundant in the samples that it was impossible to identify all specimens to species level. The specimens belonged to genera which are known to be abundant in leaf litter, therefore it cannot be definitively determined if any of the species are troglobitic.
5. Davidson Creek Area

During surveys of the DCA (Phoenix 2010d and 2011e), seven putative troglofauna species, representing four classes, five orders and six families were recorded (Table 4-6).

Table 4-6 Summary of potential and confirmed troglofauna collected from DCA

Class	Superorder/order	Family	Taxon	No. of individuals recorded	No. of bores with specimens
Arachnida	Palpigradi	Palpigradi*	*Palpigradi* sp. DC8	1	1
	Pseudoscorpiones	Chthoniidae	*Tyrannochthonius* sp. DC4	2	2
Chilopoda	Scolopendromorpha	Cryptopidae	*Cryptops* sp. DC10	1	1
Entognatha	Diplura	Japygidae	*Japygidae* sp. DC14	1	1
			Japygidae sp. PG1	1	1
		Parajapygidae	*Parajapygidae* sp. DC12	1	1
Malacostraca	Isopoda	Armadillidae	*Troglarmadillo* sp. DC5	4	1

Assessment of closure related characteristics

Terrestrial fauna rely on native vegetation and physical aspects of the landscape to provide food and shelter. All clearing of terrestrial fauna habitat will be undertaken during mining activities and all closure activities will be undertaken within already disturbed areas. Potential indirect impacts to fauna may occur as a result of closure activities including vertebrate fauna death through vehicle strike, machinery operation and as a result of final landform development and introduced species in the area. Fauna management measures will be implemented in accordance with the Fauna Management Plan, which has been developed as part of the EIA.

No significant excavation activities will be undertaken during closure activities. Potential indirect impacts to subterranean fauna resulting from the legacies of mining activities, including drawdown may occur. It is considered that impacts will be managed appropriately through post-closure rehabilitation and monitoring.

No further fauna assessments will be required over the course of the FPP. The management of impacts and hazards to fauna, particularly those of conservation significance, are the scope of the FPP Fauna Management Plan, which should be consulted in addition to the above reports.

4.2.6 Local water resources and groundwater impacts

Surface water

A number of surface water studies have been conducted for the FPP between 2010 and 2011, and have been consolidated as appendices to the Mine Water Options Assessment (SKM 2011a). These studies are:

- regional hydrology assessment (SKM 2011b)
- stream diversion, Mirrin Mirrin Creek and Davidson Creek (SKM 2011c)
- receiving environment study (SKM 2011d)
- surface water quality modelling study (SKM 2011e)
- Robertson Range, Davidson Creek and Mirrin Mirrin soil and waste material assessment (OES 2010)
- mine water balance study (SKM 2011f)
- site stormwater strategy (SKM 2011f).

These studies were aligned to considering the issue of potential diversions of Mirrin Mirrin Creek and Davidson Creek within the DCA, and the watercourses proposed for disposal of surplus mine water, being Davidson Creek, Jigalong Creek and Coobina Creek. In addition to SKM 2011a, RPS Aquaterra (2011a) undertook an environmental surface water assessment to characterise and describe baseline drainage conditions, assess project impacts on natural drainage systems and project infrastructure, and develop strategies to minimise impacts on the natural drainage systems. A summary of the findings of the assessments is provided below.

Regional surface water

The DCA is located in the upper Fortescue River catchment and the RRA, is located in the upper Savory Creek catchment. Outfalls from RRA will be directed into the Fortescue River catchment. The rail component of the FPP both lie within the Fortescue catchment.

The Fortescue River is hydrologically segregated into the upper and lower Fortescue Rivers, with Fortescue Marsh forming the divide between the two reaches. The Fortescue Marsh is an area of low relief that commences near Roy Hill Station and extends 100 km west presenting a physical barrier to flow (DoW 2007). Water from the Upper Fortescue River only flows into the Lower Fortescue River in large rainfall events. The Fortescue Marsh is listed as a Priority 1 Ecological Community and is recognised as a Wetland of National Significance in the Commonwealth’s Directory of Important Wetlands in Australia (Davis et al. 2001).

As a result of pastoral grazing, the hydrology of the Fortescue catchment has been significantly altered due to higher runoff from reduced ground cover, channelling and gutter erosion. Mining infrastructure such as railways and roads has diverted creeks and dammed rivers (Rangelands NRM 2009).

Examination of flow duration curves for several gauged catchments within the area indicated that the rivers are ephemeral, and are not dependent on groundwater baseflow to maintain flows (SKM 2011b, presented as an appendix to SKM 2011a. This is consistent with the depths to watertable in the FPP area being at least 18 m below ground level.

Mirrin Mirrin Creek and Davidson Creek traverse the DCA, and flow in a northerly direction as first order streams in the upper Fortescue catchment. These watercourses will be affected by the mining and processing component of the FPP. Coobina Creek and Jigalong Creek also flow north into the upper Fortescue River.

Geomorphology

The planform of the Mirrin Mirrin Creek is classified as straight, with a low level of sinuosity, where bends have long radii of curvature. The banks are dominated by sediment with low cohesion, and bank stability is likely to be dependent on the presence of vegetation (Van Vreeswyk et al. 2004). Mirrin Mirrin Creek alternates between a single channel and multi-channelled form. Where the creek is defined by a single channel, the channel has a relatively simple trapezoidal morphology. This simple trapezoidal morphology is punctuated in sections by vegetated ridges that accrete within the bed of the creek to create a multi-channelled system; generally with up to two or three smaller channels (SKM 2011b).

Similar to Mirrin Mirrin Creek, the planform of Davidson Creek is also straight. However, there is more variability in the planform as Davidson Creek channels have scoured separately and are not the consequence of ridges subdividing a single channel. This has resulted in planform of variable morphology and hence habitat along the floodplain. The Davidson Creek parent channel is 14 m wide with nine anabranches. Four of the anabranches were channels between 3 to 8 m wide with five minor channels approximately 1 m wide. The channels have a simple trapezoidal form (SKM 2011b). The banks of Davidson Creek are dominated by silty sand sediments, of low cohesion.

The beds of both creeks are dominated by dunes; however, the presence of ripples in the dune formations forming the bed of Davidson Creek suggests that flow velocities and the rate of sediment transport are lower relative to Mirrin Mirrin Creek. The lower depth of the channels of Davidson Creek, approximately half the depth of Mirrin Mirrin Creek, may account for much of the difference in velocity and sediment transport rates.

In the lower parts of the Davidson Creek system, the drainage networks transitions into a series of low-gradient un-channelled depositional surfaces (alluvial fans).

Water quality

A number of sites under consideration for discharge of surplus mine water were assessed as part of the water quality assessment. Water quality parameters are variable across the sites. Electrical conductivity was higher at the southern sites in the headwaters of Davidson Creek, within the RRA (≈500 µS/cm) and Coobina Creek (350 µS/cm). Other sites had lower conductivities. Turbidity levels were very low at all sites except Jigalong Creek. Low dissolved oxygen levels and high temperatures (over 25 ºC) were recorded, which is typical of still, isolated pools. At the time of sampling, temporary pools were present in the area, resulting from substantial recent rains.

It is considered that the ability to respond to short duration rainfall events, given the Pilbara's highly ephemeral flow systems will be difficult. However it is considered that appropriately managed short duration discharges are unlikely to cause unacceptable fluctuations in downstream water quality, and will be mostly diluted to background levels at a distance of 20 – 30 km downstream of the DCA (SKM, 2011e). Therefore it is considered that management of discharge into surface water post-mining will be the same as that proposed for mining operations.

Assessment of closure related characteristics

After the completion of mining operations, natural drainage lines will be reinstated with the removal of water management structures no longer required. Permanent water management structures including bunding around waste rock stockpiles and the RSF facility will remain. At the time of mine closure, it is anticipated that diverted drainage lines, including Mirrin Mirrin Creek will be well-established which will prevent sediment build up and potential impacts to surface water quality post mining.

If contaminated areas exist they will be isolated and remediated in accordance with the *Contaminated Sites Act 2003* prior to reinstatement of natural drainage lines to ensure downstream contamination does not occur. In addition, the benign nature of waste rock dumps and mineralised ore stockpiles also reduces the risk of potential surface water contamination.

Ongoing water sampling will be implemented throughout project operations and into closure and rehabilitation. The monitoring program will utilise baseline parameters to determine potential changes to surface water quality and be developed based on the Water Resources Management Plan, currently in operation at the FPP.

Groundwater

RPS Aquaterra undertook the primary groundwater modelling studies to determine dewatering rates and drawdown impacts (RPS Aquaterra 2011a; 2011b).

A number of other groundwater studies have been conducted for the FPP between 2007 and 2011, and the following studies have been consolidated as appendices to the *Mine Water Options Assessment* (SKM 2011a). These studies are:

- regional hydrogeology and cumulative impacts assessment (SKM 2011g)
- Davidson Creek preliminary mine dewatering analysis (Aquaterra 2009)
- Robertson Range dewatering study (Aquaterra 2007)
- receiving environment study (SKM 2011d)
- third party consumer supply and mine water transfer study (SKM 2011h)
- mine water irrigation feasibility assessment (SKM 2011i)
- managed aquifer recharge feasibility assessment (SKM 2011j)
- Jigalong water supply preliminary desktop study (SKM 2010)a
- Jigalong water supply feasibility study (SKM 2010b)
- groundwater modelling study SKM (2011k).

These studies were aligned to evaluating the various options for disposing of surplus mine water.

URS characterised the leachates with potential to seep from the RSF into the surrounding groundwater (Appendix 8).

A conceptual groundwater monitoring network and testing program has been designed to capture information addressing groundwater quality, and aquifer hydraulic characteristics to enable refinement of the numeric groundwater model. The indicative conceptual network is included in SKM 2011a.

Local hydrogeology

The main aquifers of the Proposal area are as follows:

- surficial aquifers (comprising inter bedded alluvium and colluviums)
- Wittenoom formation (dolomitic aquifer)
- ore body aquifers (comprising the Marra Mamba Iron Formation)
- Jeerinah formation (considered the basement for this region).

The aquifer units are hydraulically connected; however, the Marra Mamba Iron Formation has a higher hydraulic conductivity than the surrounding aquifers.

The surficial aquifer comprises sequences of alluvium and colluvium. The alluvium is often clayey with inter-bedded sand and gravel lenses while the colluvium comprises cobble sized detritals within a clay matrix. The thickness of the surficial aquifers varies considerably and reaches 60 m at the DCA. The surficial sediments possibly form an unconfined aquifer that may be in hydraulic connection with the adjacent formations. Estimates of yield range from 50 to 2500 m3/day.

The Marra Mamba aquifer is characterised by secondary porosity associated with fractures and faults.

Aquifer characterisation has not been undertaken in the Proposal area. Test pumping of the Cloudbreak Marra Mamba aquifer by Fortescue Metals Group derived estimates of the following hydraulic properties (Greenhalgh et al. 2010).

- hydraulic conductivity: 10 to 140 m/d
- transmissivity: 138 to 3115 m^2/d

The Cloudbreak Marra Mamba unit is located approximately 180 km north-west of the Proposal mine site. Airlift tests within the Marra Mamba Iron Formations of the Proposal mine site indicated yields of 350 to 1900 m^3/d. This implies that hydraulic conductivities in the Proposal area are of a similar order of magnitude to those at Cloudbreak.

Recharge of groundwater in the Proposal area occurs from infiltration of rainfall and from creek systems into the surficial aquifer, and subsequently into the underlying Wittenoom and Marra Mamba Iron Formations. The RRA is up-gradient of the nearby creek system and is recharged from rainfall events only, particularly where the Marra Mamba Iron formation sub-crops.

Water levels

Groundwater levels in the proposal area generally follow the topography. Water levels within the DCA are approximately 8 mbgl to 24 mbgl on the eastern extent. Inferred groundwater level contouring on this site indicates that water levels range over about 20 m and groundwater flows towards the northwest as part of the Fortescue River catchment.

Inferred groundwater level contouring at the RRA indicates that groundwater flow direction is towards the south within the Savory Creek catchment.

Water quality

Water quality data collected from the Marra Mamba Iron Formation at the DCA during the airlift testing in 2009) indicated that TDS of the groundwater in the Marra Mamba Iron Formation is highly variable (ranging between 520 and 1700 mg/L). The pH is neutral to slightly alkaline. The water is classed as Fresh to Brackish.

Water quality data collected from the Marra Mamba Iron Formation at the RRA during test pumping activities in 2007 indicated fresh water with total dissolved solids (TDS) values ranging from 420 to 900 mg/L with a slightly alkaline pH ranging from 7.6 to 7.7.

Groundwater monitoring was commenced in August 2011. Baseline data obtained from the assessment will be used to develop criteria to assess groundwater against during mining and closure and rehabilitation activities. Monitoring will continue throughout operations and closure and rehabilitation activities until tenement relinquishment, or an agreed upon timeframe with the relevant regulators.

The outcomes of this baseline groundwater quality monitoring assessment will be used to define groundwater quality trigger levels.

A summary of the groundwater quality testing results is presented in Table 4-7.

Table 4-7 Summary of groundwater quality results

Parameter	Unit	Laboratory Detection Limit	DCA	RRA	Australian Drinking Water Guideline Values (2004)
pH	pH unit	0.1	7-8.5	7.6-7.7	6.5-8.5**
Conductivity @25℃	µS/cm	2	860-2800	800-1800	n/a
TDS	mg/L	5	520-1700	420-900	500**
Soluble Iron, Fe	mg/L	0.02	<0.02-0.03	0.02-0.13	0.3
Sodium, Na	mg/L	0.5	92-630	80-180	180**
Potassium, K	mg/L	0.1	0.1-25	26-48 9	n/a
Calcium, Ca	mg/L	0.2	4.8-140	37-73	n/a
Magnesium, Mg	mg/L	0.1	20-120	29-72	n/a
Chloride, Cl	mg/L	1	160-510	88-310	250**
Carbonate, CO_3	mg/L	1	No data	<1	n/a
Bicarbonate, HCO_3	mg/L	5	130-1000	230-270	n/a
Sulfate, SO_4	mg/L	1	No data	49-180	500*, 250**
Nitrate, NO_3	mg/L	0.2	<0.2-100	3.4-42	50*
Fluoride, F	mg/L	0.1	0.8-1.6	0.7-0.8	1.5*
Manganese, Mn	mg/L	0.005	<0.005-0.12	<0.005-0.082	0.5*, 0.1**
Silica, SiO_2	mg/L	0.05	No data	24-50	n/a

* Health based Guideline Value ** Aesthetic Guideline Value

These results show water quality varies from fresh to brackish, with some exceedances of the drinking water criteria for salinity (TDS). Some exceedance of the sodium and chloride limit also occurred in samples from the DCA, associated with the higher salinity waters. All other chemical parameters complied with the criteria.

Mine pit voids

Two pit voids will remain after mining operations have ceased. Final pit voids will be developed into, and remain as, pit void lakes as a result of surface water inflows (backfilling will be at a level above groundwater levels). Pit water modelling and geochemical analysis will be undertaken to determine anticipated groundwater level and recharge into the pit and water quality parameters. As discussed and shown in Table 4-7 above, groundwater quality parameters to date indicate fresh to brackish water within the FPP area, however the high evaporation rates of the Pilbara have the potential to progressively alter water quality, resulting in the salinisation of water through evaporation.

Assessment of closure related characteristics

After mining operations have ceased, no further dewatering activities will be required. Therefore it is considered that groundwater levels will re-establish over time. Potential impacts to groundwater post-closure can potentially occur through contamination from seepage of waste rock and mineralised waste stockpiles and the RSF facility. However based on waste and soil characterisation and the RSF feasibility assessments it is considered unlikely to occur due to the predominance of non-acid forming (NAF) materials, non-sodic and saline materials and the benign nature of residue material.

Mine pit water will be monitored to ensure salinisation is controlled and not flowing through to the existing groundwater level.

4.2.7 Waste materials characterisation

Geochemical characterisation of the RRA deposits was conducted in 2007 by Dr H.W.Carr and reported on in the 2009 Mining Proposal (ecologia 2009e). The DCA deposits have been characterised by GCA in 2010, and reported by OES (Appendix 6).

Geochemical characterisation of the waste and low-grade materials from the DCA and RRA deposits by Graeme Campbell and Associates (presented as an appendix to OES 2010) has indicated that:

- all samples of mine waste are classified as non-acid forming
- all samples of low-grade ore material are classified as non-acid forming
- samples of mine waste and low-grade have contents of major and minor elements typically below or close to the average crustal abundance
- all samples were circum-neutral in pH, with low concentrations of soluble salts.

It was concluded that the mine waste and low grade materials from the Robertson Range and Davidson Creek deposits are geochemically and physio-chemically benign. Runoff from the site consequently poses no additional risks to the receiving environment in terms of geochemistry.

The studies found that for the King Brown and Python-Gwardar deposits, the waste materials are low sulfur-bearing with Net Acid Generation (NAG) values less than 0.5 kg H_2SO_4 per tonne. However, the various lithotypes is devoid of carbonate minerals and posses a low capacity to consume acid. These findings are typical of other iron ore mines in the Pilbara.

The potential for dewatering to expose acid-generating material in non mineralised formations surrounding the mine (e.g. carbonaceous shale) has not been specifically investigated owing the following low-risk factors:

- the geological strata that contain the higher-risk materials either have very low groundwater transmissivity and yield (hanging wall) or are below the depth of mining (footwall)
- annual rainfall is sporadic and low and is significantly smaller than evaporation
- during the period of recharge, net groundwater inflows will be into the empty mine void
- the connectivity between mined and unmined aquifers and limited use of groundwater in the immediate region is low.

Groundwater and surface water monitoring will be ongoing throughout the mining and closure phases and will include indicators of sulfide oxidation and neutral mine drainage.

Geological setting

The FPP is situated in the Hamersley Iron Province. The Robertson Range, Davidson Creek and Mirrin Mirrin ore bodies are contained within the Mt Newman and MacLeod Members of the Achaean Marra Mamba Formation. This formation is part of The Hamersley Group, a regionally extensive series of interbedded banded Iron Formation (BIF), shales and cherts which were deposited in a basin covering most of the southern Pilbara.

Aquifers are associated with deformation, fracturing and iron ore mineralization – the brittle nature of these BIFs, structural movement during regional folding and faulting has created fractured zones of higher permeability

The Marra Mamba Formation is underlain by the Jerrinah Formation of the Archaean Fortescue Group. This formation is characterised by a volcanogenic sequence including massive and vesicular basalts, intermediate flows and tuffs. Sediments, minor chert and pebble conglomerate are intercalated throughout the entire sequence.

Overlying the Marra Mamba Iron Formation is the Wittenoom Formation, with the basal West Angela Member consisting of shale, manganiferous shale with minor BIF and chert. Alluvial deposits of Cainozoic age often overlie the sequence.

Acid and metalliferous drainage risk associated with the Marra Mamba formation

The Hope Downs, Marandoo, West Angelas, Mining Area C and Cloud Break deposits are also within the Marra Mamba Iron Formation. For these projects, sulfides are predominantly associated with carbonaceous shales, in particular, the McRae Shale, which unconformably overlies the Marra Mamba Formation. However, because the shales form, at most, between 0.5 and 1% of the total materials balance, the sites are managed as low to moderate risk for acid and metalliferous drainage (ADM). As such, standard measurers are used to manage the ADM risk, including:

- detailed investigation of the location and reactivity of high risk materials (shales)
- separation and/or encapsulation of potential acid forming (PAF) materials
- monitoring and treatment of stormwater run-off
- groundwater monitoring
- predictive modelling of final void.

FPP deposits

The potential for sulfidic minerals to be present within the Robertson Range Area has been assessed on three occasions since 2007, with the latest study conducted by Graeme Campbell and Associates (GCA). GCA also assessed the Python-Gwardar deposit. These studies are summarised in Table 4-8.

Table 4-8 Summary of ADM studies for FPP

Study	Findings
Preliminary Report on ADM Potential of the King Brown Ore body, Robertson Range, WA. Carr 2007.	• rocks types are low sulfur content, particularly those to be mined • samples of hanging wall, footwall and a small continuous zone in the transported cover north of the deposit returned high sulfur levels • ADM potential is low.

Study	Findings
Geochemical Characterisation of Mine-Waste and Low-Grade-Ore Samples from King-Brown Pit, and Implications for Material Management.	• samples typical of iron ore mines in Pilbara • negligible occurrence of sulfide minerals such as pyrite • less than 1% of 5210 samples returned total sulfur values >0.1% • samples pH 6-7 with low contents of soluble salts • all samples of test suite (16 samples) classified as NAF (ANC values 1-33 kg H2SO4/tonne and NAG values less than 0.5 kg H2SO4/tonne) • waste-landform design and rehabilitation will not be constrained by the physicochemical nature of the mine-waste streams.
Geochemical Characterisation of Mine-Waste and Low-Grade-Ore Samples from Python-Gwardar Pit, and Implications for Material Management.	• samples typical of iron ore mines in Pilbara • negligible occurrence of sulfide minerals such as pyrite • less than 1% of 7891 samples returned total sulfur values >0.1% • samples pH 6-7 with low contents of soluble salts • all samples of test suite (14 samples) classified as NAF (ANC values 1-14 kg H2SO4/tonne and NAG values less than 0.5 kg H2SO4/tonne) • waste-landform design and rehabilitation will not be constrained by the physicochemical nature of the mine-waste streams.

For the Mirrin Mirrin deposit, which has not been as thoroughly tested, GCA (Appendix 6) reported that the above assessments should equally apply to the mine waste and low-grade-ores streams derived from the Mirrin Mirrin Deposit. This reflects the "common-geology/mineralisation-style" shared by the Python Gwardar and Mirrin Mirrin Deposits.

To test this statement, the Mirrin Mirrin Exploration Database was queried for samples of transported cover and low-grade ore (5881 samples). As for King Brown and Python-Gwardar, less than 1% of the samples contained in excess of 0.1% total sulfur.

Note that the high-risk McRae Shale member has not been recorded atop the Marra Mamba Formation at any of the FPP deposits. However, black shale has been recorded in the Jerrinah Formation, mostly in the footwall (below depth of mining).

Final void water quality

Final void water quality will be determined by:

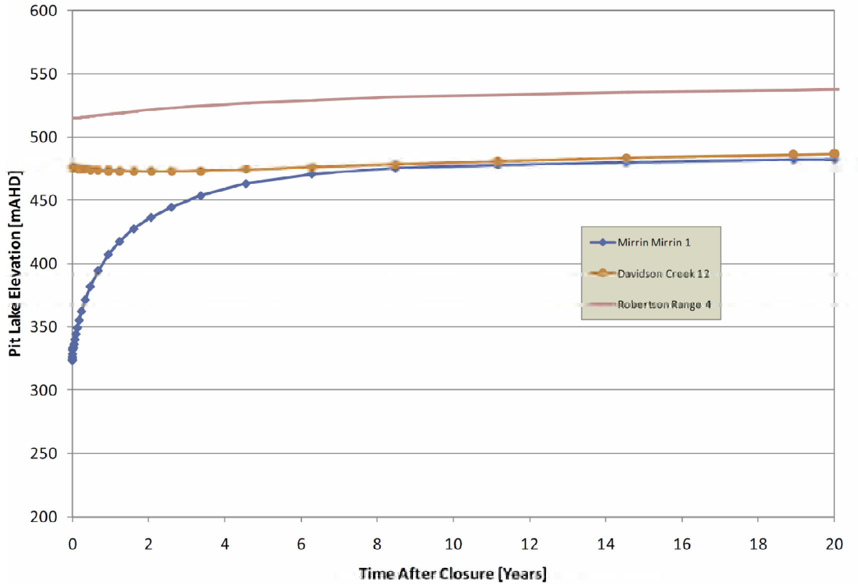
- quality and volumes of seepage from surrounding aquifers
- evapo-concentration effects
- groundwater through-flows

The Aquaterra and SKM hydrological studies do not indicate that any pit lakes that form would be part of flow through systems, based on the aquifer characteristics. Accordingly, evapo-concentration will result in the pit void lakes becoming hyper-saline waterbodies, with limited contamination potential for neighbouring aquifers. Figure 4-1 presents the predicted changes in pit lake water levels after mine closure.

This expectation is consistent with the Central Pilbara Groundwater Study conducted by the Water and Rivers Commission (WRC 2001). This study included a review of the pit lake at the Mount Goldsworthy void, where mining ceased in 1992 and has naturally refilled with groundwater. Pit water quality was found to become increasingly saline over time (4900 mg/L TDS in 1992 to 5600 mg/L TDS in 1996) and also increasingly alkaline (pH 7.6 to 8.0).

A mine closure model was developed from the Best Estimate Model (SKM 2011k). Initial conditions were extracted from the best estimate model at the end of mining. After completion of mining groundwater levels will recover towards their pre-mining levels over a period of years.

Figure 4-1 Predicted change in water level in the pit lakes following mine closure

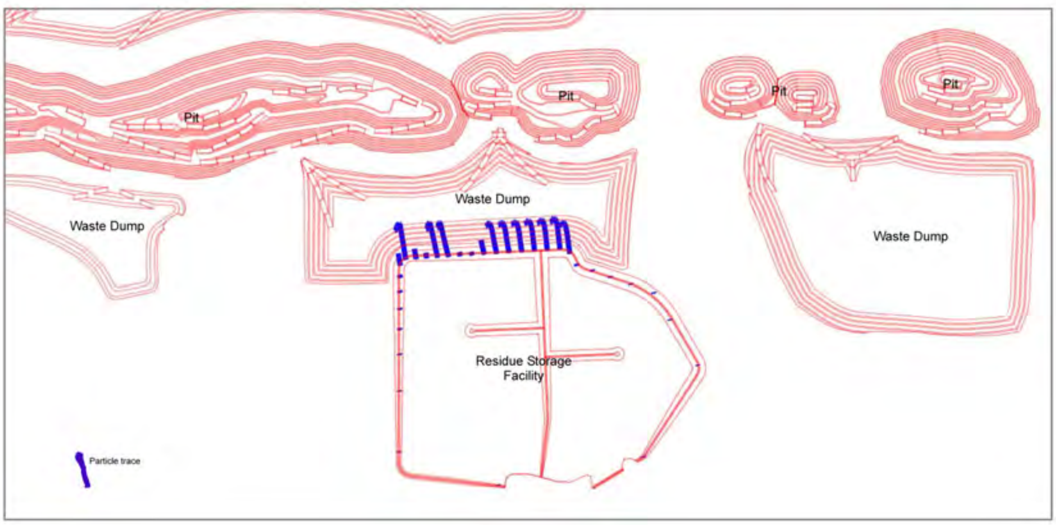


The presence of sulfide-bearing materials (shales) within the hanging walls at Robertson Range and Davidson Creek is not expected to play any significant part in the water quality of any final pit lakes, for the following reasons:

- the shales will not be exposed after mining (by virtue of their location)
- the majority of records are from shales situated above the water table and in their oxidised state
- the Jerrinah Formation in which the shales have been recorded is very low-yielding (0.005 *cf.* 0.04 for Marra Mamba), with low hydraulic conductivity (0.04 m/d *cf.* 3 m/d for Marra Mamba)
- many bioactive metals in solution become less soluble at high salinities.

Leachates from the RSF are also not expected to significantly affect the water quality of the final void. SKM (2011k) tracked groundwater particles originating from the RSF over the full 27 years of model operation. From Figure 4-2, it can be seen that only those particles defined on the northern border of the RSF are mobilised due to the relative proximity of the mining pits. The predicted travel paths are restricted and the particles travel a few hundred metres at most.

Figure 4-2 Modelled particle traces – Best Estimate Model (2013 to 2040)



Asbestiform minerals

No fibrous material has been identified on the FPP site to date. Three drill core samples were submitted for laboratory analysis in 2010, based on visual assessments of the cores. Asbestos and other respirable fibres were not detected in any of the samples (P. Brooks pers. com and MPL 2010).

4.2.8 Social environment

Aboriginal heritage and native title

The Proposal area is also located within the Jigalong Aboriginal Reserve, which is managed by the Jigalong Aboriginal Community. Negotiations are currently underway with the Jigalong community regarding mining in this reserve, and once the agreement is executed it will forwarded to the Aboriginal Land Trusts and ultimately the Minister for Indigenous Affairs. It is anticipated that agreement will be reached on or around 21 September 2011.

A search of the DIA Aboriginal Heritage Inquiry System identified 44 registered sites of Aboriginal heritage significance in the Project area (DIA 2011). The site types recorded range from modified trees, quarries, artefacts/scatter, rock shelters, engravings, camps and ceremonial sites.

Heritage surveys have been undertaken across the Proposal area since 2006, with approximately 47 heritage sites, including 39 sites within the DCA infrastructure area and 586 isolated stone artefacts located within the Proposal area (Eureka 2010).

No archaeological sites were recorded within the haul road, airstrip or in the accommodation village location (LAS 2011a).

No sites of ethnographic significance are located within the RRA (Big Island Research 2010a). “Telstra Hill” is located to the northeast of the RRA, and has significant ethnographic value related to specific regional mythology (Big Island Research 2010b), however the site does not fall within the Proposal area.

The Proposal area is located within the Nyiyaparli People (WAD6280/98; WC99/4) Federal Court Native Title Claim. Negotiations to develop a Land Access Agreement (LAA) are currently in progress with Traditional Owners.

Assessment of closure related characteristics

All activities undertaken as part of mine closure will take place on already cleared land. Closure activities will be undertaken in accordance with the provisions of the *Aboriginal Heritage Act 1972* and FPP Cultural Heritage Management Plan, to be developed in consultation with traditional owners of the area.

Dust emissions

Activities or aspects of the construction and mining operations that may result in dust emissions include:

- physical disturbance to the land surface during construction of infrastructure (removal of vegetation, blasting, earthmoving, cutting and filling) and mining activities
- haulage and light traffic on unsealed roads
- dust lift-off from dry, cleared areas and stockpiles.

These dust emissions have the potential to create a dust nuisance for workers and adjacent land users.

The generation of dust from mining operations and rail construction would depend on:

- the frequency at which a dust generating activity takes place
- meteorological conditions, such as wind speed and rain
- composition of dust, including particle size distribution, particle density and moisture content
- the condition of the source (dry or otherwise).

Dust may adversely affect health where there are nearby residences; however, the nearest residences to the mining areas, McCamey Homestead and Jigalong Aboriginal Community, are approximately 30 km and 50 km respectively from the mine areas and are not close enough to be affected by dust.

Dust may have physical effects on plants, although this is likely to be restricted to immediate peripheral vegetation and would be of a short duration as construction works move along the alignment. Intermittent rainfall events are expected to remove dust deposited on leaves.

Assessment of closure related characteristics

Dust generated from closure activities is anticipated to be minimal. Potentially dust generating activities will be reduced as mining activities cease. Dust will be controlled through a range of measures identified in the FPP Environmental Management Plan.

Visual amenity

the Proposal area is located on the Jigalong Aboriginal Reserve, 80 km east of Newman and approximately 30 km from the Jigalong Community. The topography of the RRA slopes gently to the south east and rises abruptly to the north west, with a predominant hill in the west (Aquaterra 2007). The topography of the DCA is flat to gently sloping towards the north, with a low east west ridge (Aquaterra 2009).

The most likely impact is predicted to be to local pastoralists and members of the Jigalong community. The closest pastoral station residence is the McCamey Homestead, approximately 30 km from the Proposal area. The Robertson Range Homestead, which is northeast of the RRA is not occupied. The nearest major highway (Great Northern Highway) is approximately 58 km from the proposal, with Marble Bar Rd approximately 52 km away at its nearest point. There are no DEC managed conservation parks, regional parks or national parks located in the vicinity of the Proposal area, reducing the likelihood of impact on tourism in the area.

Assessment of closure related characteristics

Final landforms of mining including the RSF, waste dumps and pit lakes will provide a visual amenity legacy for land-users including pastoralists and Aboriginal community members and traditional owners. Final landforms will be developed to be as consistent with the surrounding land-use as possible and rehabilitated to complement the existing environment. Due to distance of the closest visual receptors from the FPP area, visual amenity legacies are not anticipated to be significant, given the small number of land-users of the area.

4.3 Further studies

Further studies regarding closure aspects are either planned or underway at this stage, as part of improving on the existing understanding of the receiving environment, the FerrAus future operations and the interactions between each entity. These studies are listed in Section 10.

5. Stakeholder consultation

5.1 Purpose of this section

FerrAus has undertaken detailed consultation with relevant stakeholders in accordance with its Stakeholder Consultation Strategy. The purpose of this section is to identify the relevant stakeholders and to list inputs received to date that are relevant to the Closure Plan. This section will be continually updated as new stakeholders or concerns emerge.

5.2 Stakeholder engagement process

A consultation program was initiated in early 2010 that allowed FerrAus to inform stakeholders on details of the Proposal and to enable stakeholder comments to be considered in the preliminary engineering design. This provided the opportunity to modify the Proposal in response to the issues raised and to consider these issues in the EIA process. Stakeholders have been engaged throughout development of this EIA and an ongoing dialogue would be maintained with stakeholders as the Proposal is developed.

The primary stakeholder engagement objectives for the Proposal include:

- identifying key stakeholders
- identifying and verifying areas of stakeholder concern for social and environmental values
- establish a robust consultation approach to demonstrate that appropriate and effective consultation has been undertaken
- assessing stakeholder issues and areas of concerns so that proposed impacts are minimised to as low as reasonably practicable
- establishing collaborative relationships with stakeholders to assist with managing Proposal related expectations.

The consultation program included the following key activities:

- correspondence to potentially impacted parties to advise them regarding the Project and offer detailed briefings
- workshop meetings with representatives of decision making authorities to brief them on mine water disposal options and obtain feedback on issues and concerns
- one-on-one briefings and feedback sessions with specific stakeholders.

The following subsections identify the stakeholders that FerrAus has consulted with to date. A summary of the consultation program for the Project is presented in Table 5-1 below.

5.3 Government Agencies

Federal

- Department of Sustainability, Environment, Water, Population and Communities (SEWPaC)
- Department of Resources, Energy and Tourism,

State

- DEC (Environmental Management Branch, Pilbara Regional Office)
- Department of State Development (DSD)
- DMP
- DoW (Perth, Pilbara Regional Office)
- Department of Agriculture and Food (DAF)
- Department of Regional Development and Lands (DRDL)
- Office of the EPA (OEPA)
- Department of Indigenous Affairs (DIA)

Local

- Shire of Meekatharra
- Shire of East Pilbara.

5.4 Community

Mining Houses

- API Management
- Atlas Iron Ltd
- Warwick Resources Ltd
- BHP Billiton Iron Ore
- Brockman Exploration
- Cliffs Asia Pacific
- Coobina Chromite Mine (Consolidated Minerals)
- Digirock
- Giralia Resources
- Fortescue Metals Group Ltd
- Hancock Prospecting Pty Ltd
- Mamba Resource Management
- Norwest Mining Services
- Rio Tinto Iron Ore
- Royal Resources Ltd

Pastoralists

- Ethel Creek Pastoral Station
- Roy Hill Pastoral Station
- Sylvania Pastoral Station.

Indigenous Community

- Representatives of the Jigalong community
- Representatives of the Nyiyaparli Native Title Claimant Group.

5.5 Non-Government Organisations

- Conservation Council of Western Australia (CCWA)
- Wildflower Society of Western Australia

A summary of the consultation program for the Proposal is presented in Table 5-1.

5.6 Ongoing consultation

FerrAus would continue to consult with specific agencies as required throughout the assessment and implementation of the Proposal.

Table 5-1: Summary of consultation undertaken to date

Date	Stakeholder	Purpose	Issue	Response
April 2010	DEC (Environmental Management Branch)	To brief the agency on subterranean fauna found at the Robertson Range Area.	No issue.	No response required.
May 2010	DMP	To brief the agency on the Proposal and discuss approvals strategy.	No issue.	No response required.
July 2010	API Management	To brief the stakeholder on the Proposal and early railway works investigations.	No issue.	No response required.
	Atlas Iron and Warwick Resources Ltd	To brief the stakeholder on the Proposal and early railway works investigations.	No issue.	No response required.
	Consolidated Minerals	To brief the stakeholder on the Proposal and haul road access and maintenance.	No issue.	Haul road maintenance and access road agreement reached.
	Rio Tinto Iron Ore	To brief the stakeholder on the Proposal and discuss rail alignment.	Alignment of rail will need to avoid economic mineralised areas.	Further consultation required.
	Royal Resources Ltd	To brief the stakeholder on the Proposal early railway works investigations.	No issue.	No response required.
	Hancock Prospecting Pty Ltd	To brief the stakeholder on the Proposal and rail alignment.	No issue.	No response required.
	Sylvania Station (Brent Smoothy)	To brief the stakeholder on the Proposal and discuss road access.	No issue.	Allowance made to utilise road.

Date	Stakeholder	Purpose	Issue	Response
July 2010	DEC (Environmental Management Branch)	To discuss environmental factors and biological survey requirements for proposed project.	Does not support surface disposal of excess water down creeklines or the clearing of native vegetation for agricultural purposes. Requires that all excess water, after processing and valid alternative uses are adopted, be injected back into suitable aquifers and/or put into the sub-surface. Borrow pits would ideally be located in the area between the existing BHP railway and the new FerrAus rail spur. If this means moving the FerrAus railway further away from the BHP rail, the DEC would support this. Large, shallow and free draining borrow pits are acceptable. Environmental culverts would typically be required every 50 m in areas where there is Mulga, although these may be spaced as close as every 20 m or wider than 50 m depending on the vegetation and surface flow being crossed. For the part of the proposed rail spur adjacent to the BHP railway, FerrAus should construct the railway as close as possible to the BHP railway. It would then be sufficient to mirror the drainage in the proposed rail spur to what BHP constructed for its railway. The DEC was planning to create a new conservation reserve just north of the Proposal. The wider distribution of stygofauna need to be understood for the Proposal, and the geology of non-impact potential habitat should be understood on the basis of drill core and reverse circulation type drilling. The part of the proposed rail corridor that is adjacent to the BHP railway will only require a Level 1 type desktop assessment and targeted flora/fauna survey. Does not require constructing a vegetation map using land systems/Van Vreeswyk for this part of the proposed rail spur. Desktop assessment/habitat risk assessment would be required for the rail spur corridor, not a field survey, and that at least one place to consider for SREs would where the rail spur crosses the Fortescue River. Considers that piping excess water to Ophthalmia dam should be evaluated. Expectation that the Part IV referral will contain a formal presentation and evaluation of water use options with consideration to environmental impacts and approval requirements for each option. Assessment of potential impact on groundwater dependent ecosystems expected in Part IV referral.	A mine water options assessment was scoped to address management of mine dewater. Designs for Pre Feasibility Study to incorporate comments regarding borrow pits and culverts and rail location. Subterranean Fauna Survey Strategy developed to further assess distribution of subterranean fauna (refer to EIA). Level 1 desktop assessment and targeted flora/fauna survey undertaken for rail corridor (Rail Option 1) (refer to EIA). SRE assessment completed as identified (refer to EIA).

Date	Stakeholder	Purpose	Issue	Response
August 2010	DoW (Perth Office)	Present on the results of existing hydrogeology, groundwater investigations and future modelling proposed for the Python/Gwardar and King Brown deposits.	DOW comfortable with the model parameters being used. FerrAus should work through the DoW '*Pilbara water in mining guidelines*, and ensure that Proposal closure is considered with reference to *Mine void water resource issues in Western Australia*.	Predictive numeric groundwater modelling completed and independent peer review undertaken (refer to EIA). Mine Water Assessment report developed following DoW *Pilbara Water Mining Guidelines* (refer to EIA).
September 2010	DoW (Pilbara Regional Office)	To brief the agency on the Proposal.	No issue.	No response required.
	OEPA	To brief the agency on the Proposal.	Potential impacts related to dewatering and water disposal options. Mine closure planning.	No response required.
	DEC (Pilbara Office)	To brief the agency on the Proposal and define works completed to date.	No issue.	No response required.
October 2010	BHPBIO	To brief the stakeholder on the Proposal and discuss railway alignment.	Alignment of rail will need to avoid economic mineralised areas.	Further consultation required.
	DSD	To brief the agency on the Proposal.	No issue.	No response required.
November 2010	Shire of East Pilbara	To brief the local government on the Proposal and discuss potential concerns.	No issue.	No response required.
January 2011	DoW (Perth & Karratha offices)	Discuss status of mine water options for mine dewater.	If mine voids in closure need to consider long term groundwater quality impacts, particularly with below watertable voids. All water use options must be discussed and supported by analysis of environmental values and sensitivity of the receiving environment. Promoted use of DoW *Pilbara water in mining guidelines*, to determine acceptable hierarchy of disposal. Support high value water use in the Pilbara, but equally concerned about changes in water use required at closure – aquifer sustainable yield needs to be reinstated. Groundwater protection zone needs to be established for any community supply well(s).	Issues related to environmental aspects of dewatering management options considered at DMA workshop in April 2011. All mine dewatering options investigated within the Mine Water Options Assessment, developed in accordance with the DoW *Pilbara water in mining guidelines*. Pit void water quality post closure modelled and outcomes presented in draft Mine Closure and Decommissioning Plan (refer to EIA).

Date	Stakeholder	Purpose	Issue	Response
	DAF	To brief the agency on the Proposal and discuss prospect of irrigation as a water disposal option.	Supportive of identifying alternate uses for excess water, including for agricultural uses.	Investigation of impacts from irrigation proposal investigated in DMA workshop in April 2011 and prefeasibility study for irrigation undertaken (refer to EIA).
	DEC (Karratha)	To brief the agency on the Proposal and discuss: • potential impacts related to dewatering and water disposal options • vegetation and fauna survey results • mine closure planning.	Mine structures seepage rates and water quality impacts assessed. Seepage monitoring program to be developed around mine structures, RSF. All water use options must be discussed and supported by analysis of environmental values and sensitivity of the receiving environment. Environmental culverts to promote transfer of fauna impacted by rail Management of borrow pits for rail.	Issues related to environmental aspects of dewatering management options considered at DMA workshop in April. All mine dewatering options investigated within the Mine Water Options Assessment.
	DMP	To brief the agency on the Proposal and discuss: • potential impacts related to dewatering and water disposal options • vegetation and fauna survey results • mine closure planning.	Location of permanent creek diversions. Mine structure seepage rates and water quality of potential leachate from RSF. Final closure landforms. Legal implications of irrigation on mining act tenure.	Issues related to environmental aspects of dewatering management options considered at DMA workshop in April 2011. All mine water disposal options investigated within the Mine Water Options Assessment (refer to EIA). Leachate studies conducted and results incorporated within EIA (refer to Section EIA). Geochemical characterisation of waste rock samples undertaken to assess likelihood of generating drainage with elevated metals or other elements in acidic, neutral or alkaline drainage conditions.
February 2011	OEPA	To brief the agency on the Proposal and discuss: • proposed approvals strategy and potential level of assessment • potential aspects requiring consideration by the EPA • proposed dewatering and water disposal options • vegetation and fauna survey results.	Proposal to be better considered by EPA as one referral. Suggested peer review of hydrology and hydrogeology works and obtain advice from DoW regarding this. Continued consultation with key agencies prior to second meeting with EPA.	Mining and rail to be incorporated into single referral to EPA (this document). DoW advised no peer review for hydrogeology necessary. FerrAus conducted independent assessment of hydrogeological modelling (refer to EIA).

Date	Stakeholder	Purpose	Issue	Response
February 2011	DEC (Environmental Management Branch)	To brief the agency on the Proposal and discuss: • potential impacts related to dewatering and water disposal options • vegetation and fauna survey results • mine closure planning.	Targeted survey of marsupial mole in the dunal habitat along the Rail Option 1 alignment suggested. Proposed irrigation would need to be referred within the EIA referral document. Savory Creek catchment incorporates Savory Creek, a “Wild River”. DEC would not approve discharge of surface water to this catchment. Expect to see key understanding of ephemeral riparian species in creeks proposed for surface water discharge.	Targeted survey undertaken (refer to EIA). Discussion on environmental impacts from irrigation provided in EIA. Mine water options assessment consider no discharge to Savory Creek catchment. Assessment of receiving environment at creeks proposed for surface water discharge undertaken (refer to EIA).
April 2011	DAF, DoW, DEC, DRDL, OEPA	Workshop conducted to: • provide briefing on progress with development of options for disposal of mine water • to discuss noted divergent positions in the outcomes of previous consultations • facilitate a forum by which these differences could be addressed.	Irrigation areas, land systems, vegetation types and management of pastoral crops and weeds. Single surface water discharge versus multiple surface water discharge points Surface water expression extent during surface discharge events.	Issues considered in EIA.
	SEWPaC	To brief the agency on the Proposal and discuss potential for determination as a ‘controlled action’ under the EPBC Act.	All rail options will need to be considered Define potential and active species habitat (particularly along rail) Referral will require detailed information, mitigation measures, and discussion on offsets When completing impact assessment, illustrate that ecology is a priority motivator	Addressed within EIA.
June 2011	EPA Chairman	To brief the Chairman on the Proposal and discuss: • proposed approvals strategy and potential level of assessment • potential aspects requiring consideration by the EPA • proposed dewatering and water disposal options • vegetation and fauna survey results	Suggested referring a project envelope within which a disturbance footprint to be defined. EPA to consider providing “other advice” in relation to post-closure concerns to be addressed about water management options proposed. Offsets unlikely to be required, particularly if the Commonwealth is considering offsets for Mulgara. Acceptable to refer two rail options for assessment.	No response required.

Date	Stakeholder	Purpose	Issue	Response
	Shire of East Pilbara	To brief the local government on the Proposal and discuss potential concerns.	No issues.	No response required.
	Hancock Prospecting Pty Ltd	To brief the stakeholder on the Proposal and to discuss land issues.	Tie-in point for connection to Hancock Rail. Consideration of environmental constraints of Roy Hill Iron Ore Project layout including sheetflow reinstallation mechanisms.	Confidentiality deed signed to allow transfer of information to address rail design issues in DFS.
July 2011	Department of Resources, Energy and Tourism	To brief the agency on the Proposal and discuss opportunities regarding commonwealth programs to support implementation of Proposal.	No issues.	No response required.
	Offices of the Ministers for Resources, Energy and Tourism and Infrastructure and Transport.	To brief the Ministerial Offices on the Proposal and discuss approvals processes underway, consideration of duplication of rail alignments and ongoing consultation with stakeholders.	No issues.	No response required.
July 2011	Representatives of the Jigalong community	To brief the stakeholder on the Proposal and to discuss issues related to: • heritage • consideration of the potential impacts of mining operations on the Jigalong Aboriginal Reserve • water (surface and ground) • potential reuse of water from mine dewatering for the Jigalong community.	No issues.	No response required.

Date	Stakeholder	Purpose	Issue	Response
	CCWA and Wildflower Society of WA	To brief the stakeholder on the Proposal and to discuss issues related to: • water (surface and ground) • flora and fauna • mine water options study outcomes for management of mine dewater • mine closure planning.	Primary focus of the CCWA would be on the Mine Closure Plan, including issues such as: • non-transparency of mine closure planning approval process • feral animal control if there are residual pit lakes, or other resources that might attract ferals (camels, predators) • management of pit lakes and groundwater throughflow if connected to aquifer system (need to plan backfill to affect outcomes, not just spoil disposal) • shape of landforms, including vehicle access to top of waste rock dumps • soil management to enhance rehabilitation. Need to consider matching water abstractions with regional water demands to move towards a more integrated consideration of water management in the region. Establishment of camps causing increases in feral animal populations, increasing threats to Mulgara, etc. Groundwater: • presence of selenium if released to the environment • presence of arsenic in water may be an issue for supply to Jigalong community • impacts of groundwater drawdown on riparian phreatophytes. Commonwealth vegetation mapping needs to be ground-truthed to confirm presence of larger trees in mapped areas (potential phreatophytes). Impact of imported grasses, etc., for the irrigation proposal.	Issues accommodated in various sections of EIA.
July 2011	Representatives of the Nyiyaparli native title claimant group	To brief the stakeholder on the Proposal and to discuss issues related to: • heritage • water (surface and ground) • consideration of potential impacts of mine and rail construction on Aboriginal heritage.	No issues.	No response required.

Date	Stakeholder	Purpose	Issue	Response
	Ethel Creek Station (Barry and Bella Gratte)	To brief the stakeholder on the Proposal and to discuss issues related to: • rail alignment • water (surface and ground) • land (terrestrial).	Rail alignment intersecting grazing areas. Proposed bridges and culvert locations. Access to water.	Make good any water supply impacted by the rail or mining operations. Consideration of rail camp location to avoid pastoral holding paddock. Consideration of crossing points and fencing for cattle to avoid rail.
August 2011	Shire of Meekatharra	To brief the agency on the Proposal and discuss potential concerns.	No issues.	No response required.

6. Post mining land-use and closure objectives

6.1 Purpose of this section

Planned post-mining land-use and closure objectives establish the basis for developing completion criteria and performance indicators which in turn facilitates the development of appropriate management strategies (EPA, DMP 2011). Closure objectives must be consistent with the proposed final land use of the area to ensure the success of closure and rehabilitation activities. Once agreement is reached on post-mining land-use and closure objectives a basis on which the EPA and DMP can assess closure activities is formed.

6.2 Post-mining land-use

On completion of mining, it is anticipated that the FPP area will be returned to a pastoral land use with further mining and exploration potential. As the FPP exists within the Jigalong Aboriginal Reserve and within the Nyiyaparli People Native Title Claim, consultation is ongoing to determine final land-use consistent with all stakeholder expectations.

However, due to the conceptual nature of this Closure Plan and the preliminary stage of the project at the time of document development, final landforms and post mining land-use(s) may change over the course of the FPP.

Any proposed changes to the intended final land use will be preceded by a review of the Closure Plan, conducted in consultation with relevant stakeholders.

6.3 Closure objectives

The ANZMEC Strategic Framework on Mine Closure (ANZMEC 2000) advises that the objective of mine closure is to "*prevent or minimise adverse long-term environmental impacts, and to create a self-sustaining natural ecosystem or alternate land-use based on an agreed set of objectives*."

FerrAus has adopted this principal for its own policy objective. In addition, the ANZMEC Strategic Framework for Mine Closure includes the following general closure objectives that have been used as the basis for the FPP closure objectives, as listed below:

1. To enable all stakeholders to have their interests considered during the mine closure process.
2. To ensure the process of closure occurs in an orderly, cost effective and timely manner.
3. To ensure the cost of closure is adequately represented in company accounts and that the community is not left with a liability.
4. To ensure there is clear accountability and adequate resources for the implementation of the closure plan.
5. To establish a set of indicators that will demonstrate the successful completion of the closure process.
6. To reach a point where the company has met agreed completion criteria to the satisfaction of regulatory agencies.

7. Identification and management of closure issues

7.1 Purpose of this section

The purpose of this section is to describe the key closure risks associated with the FPP and the management priorities that have been identified to ensure the issues are managed in such a way as to not compromise the end land use of the FPP area.

7.2 Identification of closure issues

A risk assessment approach was used to identify potential hazards that might compromise the closure objectives for the FPP. Assessment criteria were derived from:

- EPA guidelines on various environmental factors
- outcomes of stakeholder consultation
- a risk assessment workshop attended by FerrAus operational and project staff and supported by professional and specialist environmental consultants.

Closure risks identified during the risk assessment workshop were determined for each closure domain and assessed according to facilities existing at the site, types of mining undertaken at the site, and DMP (2011) guidance. The complete risk assessment is detailed in Appendix 3.

To underpin the risk assessment, project-specific likelihood and consequence matrices were developed, and a risk ranking matrix established. Potential risks were ranked to determine inherent risk (the level of risk arising from a potential impact prior to the implementation of mitigation/management measures). Assumptions and potential mitigation measures were identified for each potential impact, then a residual risk rating (risk level after implementation of mitigation/management measures) and a confidence level was assigned to each risk, based on a consideration of elements such as the number and detail of studies completed and feedback from relevant authorities.

A summary of the highest ranked risks for each closure domain is summarised in the sections below. No extreme residual risks were identified.

7.2.1 ROM pad and ore stockpiles

Three aspects of closure for the ROM pad and ore stockpiles were assessed as having a medium residual risk ranking, including the following:

1. Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).
2. Contamination of groundwater (resulting in contaminated site classification by DEC).
3. Surface soil contamination around plant equipment and storage areas (resulting in contaminated site classification by DEC).

7.2.2 Processing facilities

Four aspects of closure relating to the processing facilities were assessed as having a medium residual risk ranking, including the following:

1. Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).
2. Soil contamination through hydrocarbon and chemical use on site post operations.
3. Surface water contamination post-closure.
4. Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages).

7.2.3 Residue storage facility

Three aspects of closure for the RSF were assessed as having a medium residual risk ranking, including the following:

1. Contamination of groundwater through leaching of residue material and chemicals post-mining.
2. Surface water contamination post-closure.
3. Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages).

7.2.4 Hazardous materials storage

Three aspects of closure for the hazardous materials storage area were assessed as having a medium residual risk ranking, including the following:

1. Soil contamination through hydrocarbon and chemical use on site post operations.
2. Contamination of groundwater (resulting in contaminated site classification by DEC).
3. Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages).

7.2.5 Water management infrastructure

Two aspects of closure for the water management structures were assessed as having a medium residual risk ranking, including the following:

1. Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).
2. Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages).

7.2.6 Waste dumps and mineralised waste stockpiles

One aspect of closure for the waste dumps and mineralised waste stockpiles was assessed as having a major residual risk ranking: Instability of backfilled pits and waste dumps resulting in public injury and fauna injury and/or death.

An additional four aspects were considered as having a medium residual risk ranking, including the following:

1. Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).
2. Contamination of groundwater (resulting in contaminated site classification by DEC)
3. Public injury from incorrect or incomplete decommissioning and rehabilitation.
4. Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages)
5. Contamination of groundwater downstream of backfilled pits and waste dumps through ADM

7.2.7 Mine pit voids and declines

Two aspects of closure were considered as having a major residual risk ranking, as summarised below:

1. Alteration to groundwater levels (recovery after water abstraction and dewatering activities).
2. Potential for groundwater contamination from pit lake infiltration.

An additional six aspects were considered as having a medium residual risk ranking, including the following:

1. Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).

2. Contamination of groundwater through leaching of acidic, metalliferous or saline materials.
3. Contamination of groundwater (resulting in contaminated site classification by DEC).
4. Public safety risk from open pit lakes left on site.
5. Potential fauna deaths as grazing animals are attracted to the area.
6. Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages).
7. Contamination of groundwater downstream of backfilled pits and waste dumps through ADM.

7.2.8 Supporting infrastructure

One aspect of closure relating to supporting infrastructure was considered as having a major residual risk ranking:

1. Instability of final landforms resulting in public injury and fauna injury and/or death.

An additional six aspects were considered as having a medium risk ranking, including the following:

1. Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).
2. Soil contamination through hydrocarbon and chemical use on site post operations.
3. Surface water contamination post-closure.
4. Contamination of groundwater (resulting in contaminated site classification by DEC).
5. Surface soil contamination around plant equipment and storage areas (resulting in contaminated site classification by DEC).
6. Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages).

7.2.9 Social impacts

In addition to specific closure domains, a risk assessment of other factors including social impacts was undertaken as part of the workshop.

Four aspects of closure have the potential to adversely impact upon surrounding communities and land-users if not managed appropriately, these aspects have been ranked with a residual risk of major:

1. Alteration of groundwater levels (recovery after water abstraction and dewatering activities).
2. Loss of water supply to the Jigalong community and surrounding station wells.
3. Instability of backfilled pits and waste dumps resulting in public injury and fauna injury and/or death.
4. Potential for groundwater contamination from pit lake infiltration.

In addition, five aspects are considered to have a medium level of impact on social factors, including the following:

1. Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).
2. Contamination of groundwater through leaching of residue material and chemicals post-mining.
3. Soil contamination through hydrocarbon and chemical use on site post operations.
4. Public injury from incorrect or incomplete decommissioning and rehabilitation.
5. Public safety risk from open pit lakes left on site.

Potential mitigation measures determined in this risk assessment will be incorporated in the relevant management plans for the FPP, including this Closure Plan.

8. Completion criteria

8.1 Background

Development of completion criteria and associated performance indicators are necessary to provide the basis for determining to what extent the rehabilitation and mine closure objectives have been achieved. 'Completion criteria' are defined as 'qualitative or quantitative standards of performance used to measure the success or otherwise of rehabilitation actions required for closure of a site' (EPA 2006).

Completion criteria must be sufficiently stringent to ensure that the overall objectives of rehabilitation have been met. These criteria must also be designed to allow effective reporting and auditing to define an endpoint for rehabilitation activities where sites can be handed over to a third party. It is widely accepted (e.g. ANZMEC/MCA 2000) that completion criteria should be:

- specific enough to reflect unique set of environmental, social and economic circumstances
- flexible enough to adapt to changing circumstances without compromising objectives
- include environmental indicators suitable for demonstrating that closure efforts and rehabilitation trends are heading in the right direction
- undergo periodic review resulting in modification if required due to changed circumstances or improved knowledge
- based on targeted research which results in more informed decisions.

To ensure appropriate and realistic completion criteria are developed, consultation with regulators and relevant stakeholders should be undertaken throughout project planning, development, operation and closure. Preliminary completion criteria for the FPP are presented in Table 8-1.

8.2 Development pathway

The closure criteria presented in Table 8-1 are presented in two forms:

1. Indicative Completion Criteria, which are reasonably general and are considered to be a measure of interim performance.
2. Final Completion Criteria, which replace the Indicative Completion Criteria once sufficient detail has been accrued.

8.3 Limitations and research priorities

The closure criteria presented in Table 8-1 are preliminary and it is expected they will change as the operating environment and constraints to achieving the rehabilitation objectives become better understood.

Table 8-1 FPP Completion Criteria

Factor	Objective	Indicative Completion Criteria	Final Completion Criteria	Measurement Tools
Final land use	To ensure that an agreed post-mining land use exists.	A process is in place for securing a final land use agreement and progress is being pursued.	A Final Land Use Agreement has been agreed to by all relevant stakeholders.	Not performance related.
Indigenous Heritage	To undertake activities on the site in accordance with relevant legislation and agreements with the traditional owners.	As per the TO Agreement. Compliance with the *Aboriginal Heritage Act 1972.*	A Heritage Register for the site is in place. An agreement with the Traditional Owners is in place.	Non-compliances are reported in the Annual Environmental Review.
Acid Mine Drainage/ Potential acid forming material	Ensure all identified or potentially acidic forming material is suitably contained to prevent contamination of soil, surface water and groundwater.	Waste dumps are designed to incorporate a suitable cover of non-PAF material, where necessary. PAF material on the footwalls and hanging walls of the pits is identified and suitably covered. Groundwater and surface waters, including pit void lakes, are within predicted water quality parameters and indicators of acid formation are reasonably stable. Soil quality for the upper horizon is comparable to baseline (pre-disturbance) data.	Acidic and PAF materials are contained on site. Final water quality criteria for surface and groundwater are yet to be determined. Soil quality for the upper horizon is comparable to baseline (pre-disturbance) data.	Final Landform audit, including visual assessment for common indicators of AMD. Soil, groundwater and surface water tests.
Surface water	Surface water drainage supports a safe, stable landform with low risk of erosion, consistent with the surrounding landscape. Natural ecosystems are established after permanent diversion of creek-lines. Final surface water quality (in relation to level of contamination present) is equivalent to pre-mining levels.	Final landform that ensures storm flow capability and erosion stability is suitable for final land use requirements and the receiving environment. Natural ecosystems have been rehabilitated and maintained after permanent diversion of creek-lines in accordance with floral species richness, diversity coverage, weed species number, weed density, landform and soil stability targets to be developed. No deterioration (in relation to level of sediments and contamination present) downstream of FPP area.	The design of final landforms is certified by an engineer to ensure storm flow capability and erosion stability is suitable for final land use requirements and the receiving environment. No downstream deposition and erosion of materials higher than background levels. Catchment response is not significantly affected by the proposal. Downstream surface water quality are the same as pre-mining contaminant levels.	Final Landform audit. Surface water monitoring. Rehabilitation monitoring.

Factor	Objective	Indicative Completion Criteria	Final Completion Criteria	Measurement Tools
Groundwater	Final groundwater quality (in relation to level of contaminants present) does not pose an unacceptable risk to users. No potential for off-site groundwater contamination. No potential for groundwater contamination from pit infiltration.	Any contamination of groundwater as a result of the proposal will not result in unacceptable risk to receptors.	Removal and decommissioning of groundwater wells. Groundwater quality results do not indicate unacceptable contamination, as per the *Contaminated Sites Act 2003*. Groundwater levels within the mine areas demonstrate recovery trends.	As per Contaminated Sites guidelines issued by the DEC. Groundwater monitoring.
Biodiversity	Rehabilitated ecosystems are self-sustaining with the ability to support a range of fauna species known from the site prior to disturbance.	Flora and vegetation on the rehabilitated site is representative of the target ecosystem as defined by species richness, diversity, density, weed species number and weed density targets to be developed. Floral species richness and diversity is compatible with the target ecosystem or reference sites at a level to be developed. Weed species are not present in rehabilitated areas above an agreed level of species number and density. Fauna habitat is established on the rehabilitated site and is suitable for the target ecosystem as defined by habitat targets to be developed. Native fauna species are re-established on site as defined by monitoring targets to be developed.	Flora species and vegetation communities from the targeted ecosystem have been planted on site. Suitable fauna habitat for native species, including conservation significant species is well represented across the rehabilitation site. No clearing activities outside of already disturbed areas, unless otherwise approved. Flora is the rehabilitated site are representative of surrounding vegetation communities, in terms of diversity, density and weeds satisfying agreed criteria.	Rehabilitation monitoring.
Public health, and safety	Site is left in a condition where the risk of adverse effects (to people, livestock, other fauna and the general environment) is reduced to a level acceptable to stakeholders.	All required infrastructure is removed or buried to an agreed depth to ensure the site is safe and suitable to be used by the public and fauna (both native and livestock).	Buildings and signage are removed Excavations are filled Mine voids are securely demarcated. Drill holes and wells are securely capped, filled or otherwise made safe Rubbish is removed from the site, or encapsulated within waste dumps and landfills (if environmentally appropriate to do so)	Final risk assessment.

Factor	Objective	Indicative Completion Criteria	Final Completion Criteria	Measurement Tools
Visual amenity	Final landforms are compatible with the surrounding landscape.	Final landform will integrate with the surrounding landscape, with the exception of mine voids, as defined by design specifications to be developed.	Post mining profile is integrated into the surrounding undisturbed landscape. Post mining land surface will be within 20% groundcover and species richness of rehabilitation targets	Final Landform audit with visual assessment.
Final landform and soils	Landforms are stable and able to support the agreed final land use and targeted ecosystem. The processes affecting the final landform stability are occurring at rates suitable for post mining land use.	Post-mining land is structurally stable and suitable for post-mining land use as defined by landform design and soil specifications to be developed. Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem as defined by soil specifications to be developed. Stockpiled topsoil is able to be utilised and replaced to a suitable depth as defined by stockpile management targets to be developed.	Landforms are stable and resilient to erosion. Soil parameters are consistent with pre-mining levels. Topsoil is spread to an average 100 mm depth. Topsoil used on site is comparable with the surrounding area. Ongoing management required to maintain the landform is no greater than would be required for similar properties in the area.	Formal engineering design drawing for RSF and waste dumps. Final Landform audit.
Landforms – Waste dumps	To ensure that artificial landforms are constructed to maximise stability, minimise erosion, and enable successful rehabilitation.	Waste rock dumps and mineralised waste stockpiles will be developed in accordance with the following design criteria: • 10 m wide berms placed on each of 10 m vertical height • batter angle dozed down to 20° between the berms • average slope angle of dump face is approximately 16° • berms sloped at 5° inwards to minimise rainfall run-off • cross bunds placed on berms at 30 m spacing to break up pooled water on berms • perimeter bunds placed on top dump surface and each berm to contain rainfall for 1-in-100 year, 72-hour event.		Final Landform audit.

Factor	Objective	Indicative Completion Criteria	Final Completion Criteria	Measurement Tools
Landforms – RSF	To ensure that artificial landforms are constructed to maximise stability, minimise erosion, and enable successful rehabilitation.	RSF will be developed in accordance with the following design criteria: • a concave, store-release cover with the capacity to retain 100 – 150 mm of water against gravity to aid in restricting deep infiltration by optimising evaporation of ponded water on the surface of the cover, while allowing shallow storage of water for uptake by vegetation • typically a 1 m thick store-release cover allowing for revegetation with local provenance species • top of the store-release cover will be ripped with 0.4 m high rip-lines approximately 1 m apart • rock armoured outer walls to achieve an angle of led than 20° to minimise erosion • evaporation basin floors will be 1.5 m thick • safe containment of the 1 in 100 year ARI 72 hour flood in accordance with the DMP freeboard requirements.		Final Landform audit.
Soil stability	Soils are able to support the targeted ecosystem.	Post-mining landscape is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites (specifications to be developed)	Waste dumps, RSF, batters and banks are stable and the surface vegetated. Erosion is acceptable, i.e. surface profiles are not degrading and land use objectives are not compromised.	Final Landform audit. Routine visual assessment.
Soil contamination	To ensure substances within the soil is not present at above background concentrations and potentially presents a risk of harm to human health, the environment or any environmental value.	High risk areas are managed in accordance to relevant standards, including ensuring appropriate safeguards are applied.	A Preliminary Site Investigation (PSI) has been conducted for the site, as a minimum. Compliance with the *Contaminated Sites Act 2003*.	As per Contaminated Sites guidelines issued by the DEC.

9. Financial provisions for closure

9.1 Purpose of this section

The purpose of this section is to outline the processes to be used to track the status of all closure-related liabilities so that estimates of closure costs can be kept up-to-date and that adequate funds are available for acceptable closure and rehabilitation of the FPP.

9.2 Mine closure costing methodology

Estimated bonds and estimated closure and rehabilitation costs have been calculated for activities at the FPP, as part of the Detailed Feasibility Study (DFS; in preparation. Bond calculations were based on DMP guidance (DMP 2011). The NSW Department of Primary Industry Rehabilitation Cost Calculation Tool V1.7 (DPI 2006) was utilised to estimate closure costs on a preliminary basis (in the absence of Western Australian specific cost calculation tools). A worksheet showing how preliminary costings have been estimated is provided in Table 9-1.

9.3 Closure assumptions

Significant information gaps exist around closure activities and FerrAus will update costs continually as information becomes available, in consultation with, or on advice from, relevant stakeholders.

Generalised assumptions used in the existing preliminary closure cost estimates include:

- progressive rehabilitation of disturbed areas
- the objectives and preliminary completion criteria will be implemented and achievable
- decommissioning of built infrastructure will be total.

Engineering-specific assumptions relating to earthworks, final designs and rate and scale of implementation are considered in the DFS.

9.4 Financial processes

In addition to the financial securities required under the *Mining Act 1978*, adequate financial provisions to fund the implementation of closure commitments and obligations form part of the FerrAus financial and accounting requirements under Australian legislation.

Table 9-1 Preliminary estimate of closure costs for the FerrAus Pilbara Project

Domain	Works required in domain	General works included in preliminary costing	Potential costs per unit
Tailing Storage Facility (TSF)	Structural works on banks. Source, cart and spread capping. Source, cart and spread topsoil. Seed supply, spreading and fertilising. Maintenance.	Source, cart and spread capping (capping thickness to be determined), final contouring and stabilisation. Source, cart and spread topsoil (to a minimum thickness of 10 cm). Seed supply, spreading and fertilising . Maintenance	Estimation based on NSW DPI Rehabilitation Cost Calculation Tool
Mining pit voids	Structural works (e.g. berms on edges of pits). Fencing around pits.		
Waste Landforms	Maintenance of already rehabilitated areas. Source, cart and spread topsoil, seed, fertiliser on already shaped areas. Maintenance of already shaped areas (once revegetated). Earthworks on unshaped areas (minor earthworks), followed by topsoil, seed, fertilisation and maintenance.	Earthworks on unshaped areas (minor earthworks and ripping), followed by topsoil (to to a minimum thickness of 10 cm) , seed, fertilisation and maintenance Ripping, then cart and spread topsoil (to a minimum thickness of 10 cm), seed, fertiliser on already shaped areas. Maintenance of already shaped areas (once revegetated). Maintenance of already rehabilitated areas.	Estimation based on NSW DPI Rehabilitation Cost Calculation Tool
Infrastructure and roads (including ROM pad)	Disconnection of services. Demolition of structures and buildings. Removal of footings and pads. Removal of waste material following demolition (including conveyor belts etc). Decommissioning and removal of any underground storage tanks. Removal of any contaminated material. Disposal of equipment such as vehicles. Correct removal of waste water treatment plant. Ripping of hardstand, laydown, and structure footprints. Reshaping where required. Source, cart and spread topsoil, seeds and fertilisers. Maintenance of rehabilitated areas.	Disconnection of services (process plant, workshop, administration areas, and waste water treatment plant). Ripping, then cart and spread topsoil (to a minimum thickness of 10 cm), seed and fertilisers. Final trim, rock rake & deep rip (non road areas). Reshaping of unsealed roads.	Estimation based on NSW DPI Rehabilitation Cost Calculation Tool
Cleared Areas	Ripping of hardstand and structure footprints. Reshaping where required. Source, cart and spread topsoil, seeds and fertilisers. Maintenance of rehabilitated areas.	Ripping of hardstand, laydown, and structure footprints. Source, cart and spread topsoil (to 10 cm thickness), seeds and fertilisers.	Estimation based on NSW DPI Rehabilitation Cost Calculation Tool

10. Closure Implementation

10.1 Purpose of this section

To achieve successful mine closure, specific closure implementation strategies must be developed at the preliminary stage of the project, incorporating all knowledge to date and anticipated project risks that may potentially result, to determine the most suitable and realistic approach to achieving desired final land-uses. This section describes the preliminary closure implementation strategies for each FPP closure domain.

10.2 Approach

A critical review of each FPP domain or component has been undertaken, incorporating all available knowledge and potential knowledge gaps to determine potential closure risks (Appendix 5). Investigations on measures to minimise these risks have been proposed over the life of the FPP in order to refine the closure implementation strategy for each domain. Closure domains for the FPP include the following:

1. ROM pad and ore stockpiles.
2. Open-pits.
3. RSF.
4. Hazardous materials storage.
5. Water management infrastructure.
6. Waste dumps and mineralised waste stockpiles.
7. Mine pit voids and declines.
8. Supporting infrastructure.
9. Roads and airstrip.

As information becomes available through the completion of investigations, project knowledge is increased and closure objectives and criteria will be refined where appropriate, and closure implementation strategies for each domain updated.

10.3 Decommissioning and rehabilitation strategy

As investigations continue throughout the life of the mine, closure and rehabilitation strategies are likely to be updated to reflect the increased knowledge base. Based on the current level of understanding, the closure and rehabilitation strategy of the operational area will involve the following:

- ensure risks to the environment and to safety are continually managed in accordance with the project's objectives and relevant legislation, as long as is required
- ROM pad and ore stockpile infrastructure will be dismantled on site and removed off-site by a licensed contractor and disposed of appropriately
- chemicals will be removed from site and disposed of by appropriate means by licensed contractors
- hard stand areas will be removed as will all associated infrastructure including pipes, powerlines; decommissioned areas will be ripped to address compaction
- the RSF slimes will be allowed to dry to a suitable moisture content prior to capping to an agreed thickness with a non-reactive material and a cover established (Appendix 7)
- waste rock dumps and voids will be re-contoured and other works implemented as considered necessary to meet project objectives and criteria
- the accommodation village and associated services, including the packet wastewater treatment plant, will be removed from the FPP site

- the landfill site will be decommissioned in accordance with relevant guidelines
- areas of reactive and/or dispersive materials will be identified and managed to achieve the project objectives
- contaminated soil will either be remediated on-site or removed off-site by a licensed contractor
- any remaining contamination will be reported and corrective actions taken in response to DEC or other appropriate regulatory authorities
- reshaping and re-contouring the landscape to be consistent with landform and drainage plans; ongoing management will be undertaken in accordance with the surface water management plan to be developed for post-mining activities
- surfaces will be ripped, rehabilitated with topsoil and revegetated utilising local provenance seed; rehabilitation will also add to slope stability and reduce erosion of the final landforms
- topsoils used in rehabilitation will be managed to ensure that nutrient levels are appropriate to support plant growth (e.g. fertiliser may be applied if required)
- post-closure monitoring of groundwater, surface water, landforms, soils and revegetation will continue and maintenance works conducted until final criteria have been achieved.

10.3.1 Rehabilitation management plan

A rehabilitation management plan has been developed as a component of the Mine EMP. The plan is detailed as an Appendix to the EIA document and includes the development of a rehabilitation program in consultation with DEC, to be implemented throughout operations. The program will identify the following:

- final land uses of the entire project area
- areas to be rehabilitated
- timing of rehabilitation activities
- detailed methodology by domain
- completion criteria by domain.

Rehabilitation management measures address the following:

- decommissioning of work areas
- re-contouring of final landforms to ensure stability and promote habitat regeneration through the application of topsoil and local provenance species
- management of topsoil stockpiles to minimise the loss of rehabilitation materials
- a monitoring and maintenance program, including weed and fire management.

The rehabilitation management plan will be updated throughout the course of the project to incorporate management measures and recommendations arising from additional assessments and guidance material. The revised rehabilitation management plan will include the following:

- further soil-chemical characterisation to ensure the rehabilitation potential of the site is adequately addressed
- how to address potentially dispersive or saline soils, as well as other soil criteria
- rehabilitation reviews and trials to determine the most effective rehabilitation materials, plant species and planting methods and so that rehabilitation performance and completion criteria can be established.

10.4 Closure implementation schedule

Closure timing is yet to be finalised, however it is anticipated that the FPP will operate over 15 to 20 years, with operations anticipated to commence in 2012. Based on this conceptual schedule, mine closure is anticipated to take place between 2027 and 2032. All FPP components will be closed as soon after the cessation of mining activities as possible.

Progressive rehabilitation will be undertaken throughout the FPP as components and/or cleared areas are no longer required. FerrAus proposes to implement all revegetation within two years of end of mining and monitor rehabilitation for three to five years post mining or until proven to match closure criteria.

10.5 Closure domains

10.5.1 Run of mine pad and ore stockpiles

Overview

The closure domain consists of:

- the run-of-mine (ROM) pad
- ore stockpiles
- associated infrastructure.

Once mined, ore is trucked to the ROM pad for stockpiling, rehandling or dumping directly to the primary crusher. Crushing activities involve primary and secondary crushing of ore, and tertiary crushing if necessary, prior to screening. Upon completion of primary and secondary crushing and screening and prior to transport, materials are subject to beneficiation. Product from the RRA will be delivered to a road load-out bin for the direct loading of road trains. The material is then transported to the stockpiling area of the DCA.

At the point of closure, all stockpiles will have been exhausted. Closure will focus on the decommissioning of any associated infrastructure, contouring and ripping of the site followed by revegetation, in accordance with developed procedures.

Overview of closure risks

Priority closure risks for the ROM pad and ore stockpile areas, as identified in Appendix 3, are likely to be:

- poor rehabilitation performance owing to unsuitability of substrate (soil compaction, residual ore, saline build-up from dust suppression, excessive slimes or dust)
- runoff water quality fails water quality criteria or contributes to high sediment loads (excessive slimes or dust).

Specific closure objectives and criteria

All of the objectives and completion criteria previously described apply to this domain.

Closure material sources

Closure and decommissioning of the operational area will involve dismantling all project related infrastructure and removal off site by a licensed contractor for recycling or re-use. Topsoil to be respread over the project area and will be sourced from topsoil stockpiles developed during initial vegetation clearing activities. The length of time topsoil is stockpiled will be minimised to the extent possible. Local provenance seed will be obtained from seed stocks collected during vegetation clearance and further seed may be required from other sources (in accordance with a provenance zone management strategy).

Unplanned or temporary closure

In the event of unexpected or unplanned closure, the site will be removed of all existing ore stockpiles. The ROM pad will be retained and fenced, with adequate signage to prevent access by unauthorised personnel.

10.5.2 Processing facilities

Overview

Processing facilities consist of a crushing and screening plant at both RRA and DCA and a beneficiation facility at DCA only. Once processed, ore is sent for stockpiling and load-out. Metallurgical upgrading includes de-sliming, thickening and filtration to produce a fines product. Slimes pass to the Residue Storage Facility (RSF) while the beneficiated product is stockpiled and reclaimed for train loading, or passed directly to the train load-out facility.

The RRA ore processing operations includes primary crushing, secondary crushing/screening and stockpiling of high grade and medium grade ore separately. Conventional rubber belt conveyors are used for material transport between primary crushing, secondary crushing/screening and stockpiles. Stockpiled material is loaded directly from the stockpiles by front-end loader (FEL) into road trains and hauled to the DCA plant where it is discharged into a hopper and conveyed into the DCA plant at a transfer station after the secondary crushing/screening facility for further processing.

The DCA ore processing operations consist of two processing plants for high grade and medium grade ore. The crushing plants have the same design as the RRA primary and secondary crushers. After secondary crushing and screening the crushed ore is fed to scrubbers, before being screened on secondary double deck dry screens. The ore is then subject to tertiary crushing, before being sent to product stockpiles or metallurgically upgraded, as required.

Blending of ore takes place at the mine, ROM stockpiles, and from product stockpiles prior to train load-out.

Specific closure objectives and criteria

All of the objectives and completion criteria previously described apply to this domain.

Closure material sources

Decommissioning of the process area will involve removal of buildings and structures, removal of chemicals and testing of soil and groundwater in the area for contamination. Topsoil to be used for rehabilitation will be sourced from on site and surrounds during clearing activities, to be consistent with the surrounding and target environment. Investigations and trials into rehabilitation material sources and timing will be conducted, and an appropriate rehabilitation material and strategy will be identified.

Unplanned and temporary closure

In the event of unexpected or unplanned closure, the following will occur:

- cessation of all processing activities
- isolation of all chemical and hydrocarbon storage
- erection of adequate fencing around the processing areas with appropriate and adequate signage.

10.5.3 Residue storage facility

Overview

The RSF disturbance footprint comprises an area of approximately 308 ha, located at the DCA. The DCA RSF is designed as an above ground storage facility integrated with waste dump DCWD3. The total area of the RSF is estimated to be about 200 ha with a separation dike/causeway in the middle to form two separate cells of approximately 100 ha each.

At the commencement of the Project, a low height starter embankment will be constructed with a maximum height of 9 m at the northeast corner of the facility, and be incrementally raised using the downstream method of construction. An initial starter height causeway, located in the middle of the RSF will also be constructed as part of the initial start-up operations. .

It is proposed for tailings to be spigotted from the top of the starter embankment in both cells from the west, north, and east sides of the RSF (starter embankment will not be present along majority of the south side) forming beaches draining to temporary ponds within the storage areas of each of the two cells. Two sets of stationary pumps (located on the causeway) with HDPE pipes and floating decant intakes will be used to pump water from the two decant ponds.

The height of the starter embankment has been selected to provide:

- tailings deposition for the first 1.6 years of operation before erection of the embankment(s) becomes necessary
- safe containment of the 1 in 100-year 72-hour flood in accordance with the DMP freeboard requirements.

Following the initial start-up phase, the perimeter embankments, including the north wall that is common with the waste dump, will be incrementally raised over the life of the facility.

Each facility receives thickened slurry from the process plant via a perimeter pipeline along the top of these banks. Recovery of water for return to the plant is from a central ‘overflow’ type structure.

The banks of the RSF will be up to 20 m high with <20° batter slopes from horizontal. The RSF has been designed to enable the containment of rainfall for a 1 in 100 year, 72 hour precipitation event. Waste rock and overburden will be utilised for RSF construction.

Recovery of water from the RSF for return to the process water dam is via a centralised structure designed to redirect ‘overflow’.

Specific closure objectives and criteria

All of the objectives and completion criteria previously described apply to this domain.

Closure material sources

Closure of the RSF will involve capping of the tailings material and the use of waste rock material to backfill the area to provide a geotechnically stable landform with the ability to support local provenance species. Investigations and trials into capping material sources will be conducted and an appropriate material will be identified through this process. Topsoil will be sourced on-site and surrounds during clearing activities, to ensure that rehabilitation is compatible with the surrounding environment. Investigations and trials into rehabilitation material sources and timing will be conducted, and an appropriate rehabilitation material and method will be identified through this process.

Unplanned and temporary closure

In the event of unexpected or unplanned closure, the following activities will occur:

- suspension of inflow of tailings into the RSF
- isolation and tagging of inflow lines running to the RSF
- erection of signage to identify the RSF and to inform it is not currently in use.
- Continue safety inspections and monitoring.

10.5.4 Hazardous materials storage

Overview

Explosives, chemicals and hydrocarbons will be utilised throughout Project operations. Hazardous materials including explosives and hydrocarbons will be stored at both the RRA and DCA.

Explosives

Two re-locatable explosives magazine, purchased as pre-fabricated buildings, will be provided for storage of explosives and detonators at the DCA and RRA. These building will occupy only a small area and will be fenced and set back from any other buildings in accordance with the Australian Standards for:

- explosives storage, transport and use terminology (AS2187.0)
- explosives storage, transport and use storage (AS2187.1)
- explosives storage and use, use of explosives (AS2187.2).

Hydrocarbon storage

Hydrocarbons are required for both the construction and operational phases of the Project. Prior to development of rail infrastructure, hydrocarbons will be transported to DCA via road. Following completion of the rail, diesel will be transported to the DCA via rail in dedicated wagons, with a backup provision via road. The rail wagons have a dedicated fuel spur with dispensing facilities to decant and transfer fuel to modularized double skinned storage tanks via dual containment pipeline.

Fuel is stored at designated fuel farms; two diesel fuel storage facilities are proposed for the DCA and one at the RRA. Fuel transfer pipelines distribute fuel from the fuel farm to the power station, and the workshop refuelling station. The fuel farms will be constructed from earth and be suitably bunded and lined to comply with the Australian Standard for the storage and handling of flammable and combustible liquids (AS1940).

Nominal storage capacity at the RRA fuel farm includes three 300 kL horizontal tanks. The DCA fuel farms have approximately 16 tanks distributed between the powerhouse and heavy vehicle facilities.

Vehicle workshops and wash-down facilities

Vehicle workshops and wash-down facilities are required at both DCA and RRA. At DCA, there is a dedicated road train haulage work shop, dedicated heavy mining and light vehicle work shop and a dedicated plant workshop. Wash-down, refuelling and tyre change facilities will also be at the vehicle workshop sites.

At RRA, there is a dedicated heavy/light vehicle workshop complete with wash-down refuelling and tyre change facilities.

Workshops have suitably bunded areas for hydrocarbon storage and an oily water separator. Wash down facilities also comprises an oily water separator. Waste oil storage tanks, appropriately bunded to comply with AS1940, are at the workshop facilities also. Run-off from areas potentially contaminated with hydrocarbons (for example, workshop and wash down areas) is directed to an oily-water separator for treatment.

A workshop refueling station has been developed at DCA, incorporating a high-rate truck loading facility to allow for loading of diesel for transport to RRA. Bunded double-skinned tanks provide for lubricating oils at each work shop facility at the DCA and RRA.

Specific closure objectives and criteria

All of the objectives and completion criteria previously described apply to this domain.

Closure material sources

Decommissioning of hazardous material storage areas will involve removal of buildings and structures, removal of chemicals, and testing of soil and groundwater in the area for contamination. Topsoil will be sourced from on site and surrounds during clearing activities, so that rehabilitation is compatible with the surrounding environment. Investigations and trials into rehabilitation material sources and timing will be conducted, and an appropriate rehabilitation material and method will be identified through this process.

Unplanned and temporary closure

In the event of unexpected or unplanned closure, the following will occur:

- isolation of all chemical and hydrocarbon storage
- erection of adequate fencing around storage areas with appropriate and adequate signage.

10.5.5 Water management infrastructure

Overview

Dewatering infrastructure

Dewatering rates are forecast to substantially exceed demand and be in the order of up to 11.5 GL/year. As a result, a range of options has been investigated to determine the most environmentally sound and cost-effective means of disposal of surplus water.

Dewatering is achieved by the use of dewatering wells, both in-pit and ex-pit as required. In-pit infrastructure can be easily removable, whereas the ex-pit infrastructure is a more permanent installation. A monitoring and control system is installed to monitor and record well pumping rates and pumping water levels.

Twelve dewatering wells are required at DCA and four at RRA. The dewatering infrastructure for each well consists of the following:

- electro-submersible pump and power cable
- riser column
- wellhead works (including valves, flow meter, sample tap, instrumentation, etc.)
- down-hole pressure transducer for measuring well water levels
- pump control panel
- diesel generator
- associated power and control cabling

At the DCA, the dewatering wells pump into a common dewatering collection pipeline. The dewatering pipeline discharges into the main raw water pond located at the DCA process plant. In addition to processing, dewatering water will be used for dust suppression via water stands connected off the main dewatering pipeline.

At RRA a transfer pipeline from RRA conveys water to the accommodation village, and to the main raw water pond. Water is then pumped from the dewatering system to the respective raw water dams or tanks located at DCA and RRA and distributed for use as process water, raw water, fire water and potable water.

Surface water management structures

Two dams have been developed as part of the Project; the raw water dam includes potable water and fire fighting water, the process water dam supplies water for dust suppression and plant demands. Dewatering is pumped to the respective water dams and either treated to become potable or retained for process water.

Flood bunding and diversion channels have been established to divert surface water flows around working areas of the mine. Perimeter bunding structures around the waste dumps, pits, stockpiles and RSF have been installed. Internal run-off is collected by a sediment basin to remove sediment prior to release to the receiving environment. In pit stormwater management structures have been implemented to capture and pump water to the plant for use in processing or dust suppression. Culverts have been utilised to manage surface water from the haul road.

Hydrological assessments predicting 100 yr Average Return Interval (ARI) flood levels suggest that protective flood bunding is required at both RRA and DCA.

Stormwater from the DCA and RRA plant areas is discharged into a local catchment via settlement ponds. During larger rain events, managed water release from settlement ponds takes place. In addition, a water transfer pipeline between DCA and RRA allows pit water to be managed in conjunction with mining activities and environmental disposal options.

Mirrin Mirrin Creek divides the rail loop and train load out bin from the DCA processing plant and was diverted during construction of the DCA process plant. Bunding has been designed to retain flood waters (1 in 100-year ARI level).

Creek diversion infrastructure

The project involves the permanent diversion of Mirrin Mirrin and Davidson creeks and development of permanent drainage structures to manage surface water flows. Mirrin Mirrin Creek has been diverted in a north-westerly direction around the proposed low grade waste dump and then in a northerly and then north-easterly direction around the westernmost end of the proposed pit, and back onto its original alignment downstream of the pit area.

Mirrin Mirrin Creek dissects the Python-Gwardar deposit, located at the DCA. A five km section of the creek has been diverted around the western extent of the proposed pit. The diversion largely comprises an excavated channel to convey the 100 year ARI flood event, with associated bunding as required to prevent flood waters from entering the plant and pit areas. Through the area of deepest cut, the excavation is up to 4 m deep. The excavated channel is trapezoidal in cross-section, with a base width of around 40 m, and nominal side slopes of 1:2.5, although this may be steeper depending on ground conditions (SKM 2011k). The creek diversion will be permanent due to presence of the pit void upon cessation of mining.

Irrigation infrastructure

Analysis of dewatering flows and mine water demands indicates that up to 24 ML/d would be surplus to requirements and would require disposal. A number of options were identified to dispose of surface water, including the transfer to pasture land for irrigation at Sylvania Station which involves the development of irrigation channels to transfer the water.

Specific closure objectives and criteria

All of the objectives and completion criteria previously described apply to this domain.

Unplanned and temporary closure

In the event of unexpected or unplanned closure, water management structures will remain until it is confirmed the mine will not re-open and adequate fences and signage will be erected to prevent access to the dams.

10.5.6 Waste dumps and mineralised waste stockpiles

Overview

The Project involves development of three waste rock dumps at the DCA and one at the RRA. Waste rock dumps are located adjacent to iron ore deposits to optimise operational efficiencies. Three waste rock dumps are proposed for the DCA. Two waste rock dumps were originally approved for the RRA, however, the arrangement of the two waste rock dumps formerly approved has now been modified under the revised mine proposal. The South Waste fits entirely within M52/1034. Two mineralised waste stockpiles occur at RRA, with one located adjacent to the Python-Gwardar Deposit on M52/1043 and E52/1658 and the other located adjacent to the King Brown deposit on M52/1034. Waste material is transported to either the waste rock dumps or the mineralised waste stockpiles.

Waste rock material and overburden has been utilised in several areas across the operation. The majority of material has been used to back-fill mining pits and minor quantities stockpiled as mineralised waste, utilised for the RSF or transported to the waste rock dump.

Waste rock dumps have been constructed in accordance with the following design criteria summarised below:

- 10 m wide berms placed on each of 10 m vertical height
- batter angle dozed down to 20° between the berms
- average slope angle of dump face is approximately 16°
- berms sloped at 5° inwards to minimise rainfall run-off
- cross bunds placed on berms at 30 m spacing to break up pooled water on berms
- perimeter bunds placed on top dump surface and each berm to contain rainfall for 1-in-100 year, 72-hour event.

Mineralised waste stockpiles established at the DCA and RRA follow the same design criteria as waste rock dumps discussed above. The perimeter bunds have been constructed such that the inner slope is minimised allowing water to be distributed evenly across the dump surface but away from the perimeter. Low grade iron ore stockpiles also follow the same design criteria for the waste rock dumps and mineralised waste stockpiles.

The biologically active surface layer of topsoil was stripped and stored separately during clearing activities, with topsoil depth between 10 and 20 cm (EPA/DMP 2011). The bunds are broken at intervals to minimise potential impediments to surface water flow. Topsoil is stored in proximity to future areas requiring rehabilitation. Topsoil stockpiles (up to 2m high) are allocated at DCA and RRA and located near the final pit crests (within the 100m general exclusion zone).

Waste rock characterisation was undertaken for the Project, identifying negligible concentrations of sulfides in waste rock material (Graeme Campbell 2010a; 2010b). It is considered unlikely that acid and metalliferous drainage will be an issue for the Project.

Specific closure objectives and criteria

All of the objectives and completion criteria previously described apply to this domain.

Closure material sources

Closure and rehabilitation of the waste rock dumps and mineralised waste stockpiles will involve the re-contouring of final landforms to meet the agreed completion criteria, in particular to provide geotechnically stable landforms with the ability to support revegetation targets. Topsoil will be sourced from on site and surrounds, so that rehabilitation is compatible with the surrounding environment. Investigations and trials into rehabilitation material sources and timing will be conducted, and an appropriate rehabilitation material and method will be identified based on this process.

Unplanned and temporary closure

In the event of unplanned or temporary closure waste rock dumps and mineralised waste stockpiles will be retained with adequate fencing and signage to ensure the safety of people in the area. Waste rock dumps will be inspected for safety and monitored until such time as operations re-commence.

10.5.7 Mine pit voids and declines

Overview

The Project involves strip mining of a number of pits at both DCA and RRA, which will be progressively backfilled. Backfilling to the original surface level will not be possible, so a void will remain upon completion of backfilling.

Upon project completion, two mine pit voids will remain, one at DCA and one at RRA. Final pit voids will be developed into, and remain as, pit void lakes as a result of surface water inflows (backfilling will be at a level above groundwater in-pit water level).

Borrow areas are not required for the mining component of the Project. Material from pit areas supplies high quality gravel for road construction, general fill material and suitable fill material for stabilising earth walls at the ROM pads and backfill around concrete structures. Borrow areas have been constructed as part of the rail component of the Project, which does not form part of this Closure Plan.

Drill holes and wells are located throughout the Project area from pre-mining and exploration activities, operational activities and closure and rehabilitation stages of the Project. As drill holes and wells are no longer required, they will be decommissioned and the wellfield access disturbance area rehabilitated. A number of wells will be retained on site after mining operations have ceased for use in groundwater monitoring.

Specific closure objectives and criteria

All of the objectives and completion criteria previously described apply to this domain.

Closure material sources

Waste rock will be used to backfill those pits designated for that purpose. Investigations and trials into rehabilitation materials, methods and timing will be conducted, and an appropriate rehabilitation material and method will be identified based on this process.

Unplanned and temporary closure

In the event of unplanned or temporary closure, mine pits will be left as is until further notice. An abandonment bund and adequate fencing and signage will be erected in the event of unplanned or temporary closure to ensure access from unauthorised personnel does not occur.

10.5.8 Supporting infrastructure

Overview

Accommodation and associated facilities

The existing mine exploration camp and facilities at Robertson Range was used to setup the permanent accommodation village between the RRA and DCA. Once construction of the permanent accommodation village is complete, the existing mine exploration camp can be decommissioned. The permanent accommodation village is located approximately 8 km east of the DCA and approximately 15 km north-west of the RRA. One camp is required to suit the needs of both the main construction phase and for permanent operations. The permanent village caters for 450 employees during operations.

The village has been designed around central facilities incorporating:

- dry mess and kitchen building incorporating a fully equipped kitchen to cater for the full construction content (700 personnel). After the construction period, these facilities are to be modified to cater for the permanent operational numbers and the additional space converted into training / office / function facilities
- common use and administration facilities such as office/retail, store, first aid room, ablution facilities, laundries, and maintenance compound
- sport and recreation centre (gymnasium, recreation room, multi-function sports court, swimming pool, indoor cricket, tennis, squash, small grass oval and TV/theatre room)
- car/coach parking areas and loading/unloading zones connected to the village access.

Associated infrastructure for the camp facilities include access roads, power supply, water supply and solid and liquid waste management. Power, water and waste systems are sized accordingly to cater for up to 500 personnel.

The following utilities are provided to the camp facility:

- potable water supply
- packet sewerage and waste water treatment facilities
- diesel generator for back-up power supply, fuel storage, maintenance shed, water tanks and an electrical substation, all to be located away from the building areas
- landfill area to be created away from the village for general waste.
- telecommunications.

Power supply

The Project, including process plants, accommodation and other support infrastructure, is supplied with electricity from a diesel power station located at the DCA, which is built, owned and operated by a third party. The estimated power demand is 12 MW with a maximum demand of 15 MW. Twelve 1 MW diesel generators have been installed to meet a continuous demand, providing adequate redundancy.

Power is distributed around DCA at 11 kV from the power station. A 33 kV overhead transmission line, installed within the services easement, distributes power from DCA to the permanent accommodation village, airport, the DCA explosive storage facility and RRA.

Emergency power supplies are sourced from separate automatic or manual start diesel generators, depending upon the application. Uninterruptible power supplies provide a two-hour backup for communications and control equipment should normal and emergency power supplies be interrupted.

Temporary diesel generators are used to supply power to the camp and construction activities until the main power station and aerial power reticulation is in service.

Roads and airstrip

A services corridor (SC) connects the DCA to the RRA. The SC incorporates a sealed access/haul road that covering a distance of approximately 24 km and connecting RRA and DCA to the Jigalong Road situated to the north of DCA. Water distribution pipelines, power and communication distribution infrastructure also utilise the SC. The permanent accommodation village and airstrip are located immediately east of the SC with entrances to these facilities via the SC haul road.

Existing site access is via the Coobina Chromite Mine road, which runs off the Caramulla Creek Road, and enters the DCA from the west. The road is being utilised until the permanent site access road has been constructed.

Internal roads around and connecting the plants have been designed to allow safe movement of equipment envisaged for both normal operation and during maintenance. The main roads are through the plant areas, within the SC, and to the camp and airport and are all sealed. Access roads to the RSF, dewatering wellfields and similar low traffic areas are formed but unsealed.

Waste management/ landfill

The camps require wastewater treatment systems and landfills to manage the predicted waste volumes. Water treatment plants treat waste water from site domestic sources. Sewage from the accommodation village is treated through sequencing batch reactor (SBR) type wastewater treatment plants. Other areas with human waste water including DCA, RRA and airport are treated using Biomax (or equivalent) units.

Waste water from the vehicle washdown facility and workshops is treated via an oily water separator, and pumped to adjacent storm water sediment pond.

The principles of waste minimisation will be adhered to, such that the Project has been designed to maximise re-use of materials where possible and minimise all types of waste generation. However, a range of solid and liquid waste products is generated on site throughout project activities, closure, decommissioning and rehabilitation activities. Solid and liquid waste management facilities are located at each camp at RRA and DCA. Appropriate waste receptacles are located at various points throughout the Project area including administration and workshop facilities and in particular in areas with food waste to ensure native and introduced fauna species are not attracted to the area.

Specific closure objectives and criteria

All of the objectives and completion criteria previously described apply to this domain.

Closure material sources

Closure and rehabilitation of supporting infrastructure will involve the re-contouring of final landforms to meet the agreed completion criteria, in particular to provide geotechnically stable landforms with the ability to support revegetation targets. Topsoil will be sourced from on site and surrounds, so that rehabilitation is compatible with the surrounding environment. Investigations and trials into rehabilitation material sources and timing will be conducted, and an appropriate rehabilitation material and method will be identified based on this process.

Unplanned and temporary closure

In the event of unexpected or unplanned closure, the following will be conducted:

- isolation of all chemical and hydrocarbon storage
- erection of adequate fencing and signage around areas with appropriate and adequate signage
- suspension of inflow of wastewater.

11. Closure monitoring and maintenance

11.1 Purpose of this section

The successful and timely relinquishment of the FPP tenements no longer required for the purposes of mining requires suitable demonstration that the agreed land use objective(s) has or can be met, as evidenced by records that show that closure criteria have been met. This necessitates development and implementation of a closure and rehabilitation monitoring program that tracks the status of closure implementation as well as the performance of rehabilitation, decommissioning and other closure mitigation measures.

The closure monitoring and maintenance schedules will be revised and updated every three years, to ensure that information needs are being met and that the costs of both monitoring and maintenance are regularly optimised and allowed for in budget forecasts.

11.2 Objective of the closure monitoring program

To ensure closure activities are undertaken in accordance with agreed closure objectives, criteria and implementation, closure performance monitoring throughout progressive rehabilitation and post-closure is required. Post-closure monitoring of revegetation and erosion will be undertaken 2-4 times a year, with more intensive monitoring at the start of the program becoming less intensive as information needs are gradually rationalised.

Rehabilitation monitoring forms the major component of the Annual Environmental Report (AER) required to be submitted to the DMP each year of operations through to post-closure. The primary function of the AER is to document progress against agreed completion criteria and rehabilitation targets.

A preliminary strategy for monitoring and maintenance has been developed (Table 11-1) and will be further refined throughout the assessment process, based on consultation with key stakeholders.

Table 11-1 Preliminary closure and rehabilitation monitoring program

Category	Actions	Purpose	Frequency	Location
Waste dumps and mineralised waste stockpiles	Monitor for erosion	To provide data on erosion	Quarterly	At all waste dumps
	Monitor rehabilitation status	To provide data on rehabilitation	Quarterly	At all waste dumps
RSF	Monitor groundwater for seepage	To provide data on whether seepage is occurring the RSF	Quarterly	At DCA RSF
	Monitor for erosion	To provide data on erosion	Quarterly	At DCA RSF
	Monitor rehabilitation status	To provide data on rehabilitation	Quarterly	At DCA RSF
Pit voids	Monitor bunding and fencing	To provide data on safety barriers around open pits	Quarterly	At all open pits
	Monitor pit voids for vegetation growth	To provide data on vegetation growth at open pits.	Quarterly, and after rain events	At and around open pits
	Monitor pit void geochemistry	To provide data on pit void geochemistry.	Quarterly	At pit voids
Surface drainage	Monitor surface drainage pathways for erosion and sedimentation	To provide data on surface drainage pathways	Quarterly	Across site where required
	Monitor surface water characteristics for potential contamination	To provide data on surface water geochemistry.	Quarterly	Across the site where required

Category	Actions	Purpose	Frequency	Location
Groundwater	Monitor groundwater wells for potential contamination	To provide data on groundwater geochemistry	Quarterly	Across site where required
Soil	Monitor representative soil samples across the site for potential contamination	To provide data on potential soil contamination.	Quarterly	Across the site where required.
Inspection and Monitoring	Monitor for environmental parameters as per program established during assessment process (water levels, groundwater and surface water quality, soil quality, rehabilitation)	To provide environmental data (including water levels, water quality, soil quality and vegetation growth) across the site	Quarterly	Across site where required
	Update environmental monitoring data register	To store environmental data in a central repository and ensure it is up to date	Quarterly	Across site where required

11.3 Maintenance and contingency planning

In the event that monitoring targets are not being achieved, contingency actions will be fully developed in consultation with relevant stakeholders and implemented, as summarised in Table 11-2.

Table 11-2 Preliminary contingency actions for decommissioning and closure

Category	Trigger	Action
General	As below, or exceedance of limits set in licence conditions.	General contingency response model: 1. Retest to confirm exceedance. 2. Investigate cause. 3. Determine remedial action (in consultation with relevant stakeholders/authorities as required). 4. Implement remedial action. 5. Report issue to relevant authority. 6. Monitor outcome. 7. Revise procedures as appropriate. 8. Continue from Step 1 if outcome not satisfactory.
Waste Dumps	Significant erosion noted at waste dump.	Implement erosion protection measures (e.g. bunding).
	Rehabilitation growth lower than targets.	Investigate cause (soil quality, seed viability etc) and implement corrective actions. These could include fertilisers, more seed, better quality topsoil, etc.
Residue Storage	Seepage becomes evident at RSF.	Instigate engineers to investigate cause of seepage and apply appropriate corrective.
	Significant erosion noted at RSF.	Implement erosion protection measures (e.g. bunding).
	Rehabilitation growth lower than targets.	Investigate cause (soil quality, seed viability etc) and implement corrective actions. These could include fertilisers, more seed, better quality topsoil, etc.
Pit void lakes	Fencing or bunding found to be damaged or ineffective in preventing access to pits.	Immediately repair damaged fencing or bunding.
Surface Drainage	Significant erosion or sedimentation noted.	Implement erosion protection measures (e.g. bunding).
	Contaminated surface water above baseline levels.	Remediate surface water and continue monitoring at site and downstream until surface water is no longer contaminated.

Category	Trigger	Action
Groundwater	Contaminated groundwater above baseline levels.	Remediate groundwater and continue monitoring at site and downstream wells until groundwater is no longer contaminated.
Soil	Contaminated soil on site.	Removal of soil off-site by a license contractor, followed by remediation of the site.

On completion of mining activities, an audit will be undertaken to determine the environmental condition of the site. The monitoring and maintenance regime will be updated with each successive version of the Closure Plan, as required.

12. Management of information and data

12.1 Purpose of this section

Contemporary mine closure guidelines, including the joint guidelines issued by the EPA and DMP, place a high value of the effective collection and storage of project records, including site knowledge. The guidelines emphasise that such information should be both comprehensive and easily retrieved, usually through the auspices of a dedicated information and/or knowledge management framework.

At this point in time, FerrAus does not have a single collective repository for the systematic storage and distribution of project information. However, FerrAus is committed to pursuing best practice in this regard and a strategy for the development and implementation of such is outlined in the following sections.

12.2 Current management of reports and construction details

All reports that have been prepared for FerrAus to date are stored in the FPP document management system. This includes internal studies, design parameters and detailed feasibility studies. All reports prepared as part of the ongoing development and implementation of the Closure Plan, including monitoring results and reviews, are required to be registered with the FPP document management system, through the FPP Document Controller.

12.3 Development of future information management tools

To address the recommendations of the Closure Guidelines, FerrAus will develop an operations-wide information management framework, with systems for the storage and quality assurance of environmental data as well as mine planning and operational documentation. The approach that will be adopted by FerrAus is outlined in Table 12-1.

Table 12-1 Information and data management strategy

Requirement	Description of Action
Establish	A systems audit will be undertaken to ascertain the types of information to be captured and stored. Following this audit, an electronic and hardcopy recording and filing system will be created. Electronic records allow ease of transfer into annual reporting documents and provide a backup to hardcopy records. Hardcopy records allow data to be recorded in the field, and allow a means of tracking data to electronic systems, establishing an auditable QA/QC process. The aim of this system will be to capture all data relevant to closure.
Assign responsible person	The Project environmental officer (or other delegated person) will be assigned responsibility of the dataset. This person will ensure data is updated regularly. This person must suitably qualified and knowledgeable regarding the requirements of environmental monitoring
Record data	Monitoring will be undertaken on a regular basis, with all data collected transferred into the electronic database as soon as practicable. Once the data transfer is complete, hardcopy monitoring records will be filed. Records will be categorised according to feature and monitoring activity (for example, 'waste dumps', 'residue storage facilities', 'groundwater quality' and 'revegetation').
Quality Assurance and Quality Control	After each monitoring round is completed, a Quality Assurance and Quality Control (QA/QC) check will take place. This will involve an employee of suitable qualifications and rank, who is not responsible for the database, checking that data has been transferred correctly from hardcopy to electronic form. This check will then be recorded as having taken place.
Training	Monitoring and recording of data will be explained to employees during the induction process. This will ensure personnel at site are aware of the importance of the data collection process, and will also provide a point of contact should personnel wish to report any environmental changes noted on site.
Miscellaneous	Non-regular events will also be recorded in the system. These will include, for example: seed type, provenance and volume applied to rehabilitation areas, names and volumes of reports submitted to DMP, decommissioning dates, instances of personnel leaving and entering employment at the site, etc.

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Appendix 1

FPP Tenement details

Land ownership and tenure for mining and processing components of the FerrAus Pilbara Project

Existing Lease Holders/Reserves	Existing Tenure†	FerrAus Proposed Tenure
Existing tenure		
Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	M52/1034	King Brown Deposit, King Brown South and Waste Dumps
Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	M52/1034 E52/1630	King Brown Processing Infrastructure
Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	G52/103	King Brown Camp
Sylvania Pastoral Licence	M52/1043	Python-Gwardar, Taipan, Dugite, Tiger Deposits
Sylvania Pastoral Licence, Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	E52/1658 L52/105	Python-Gwardar, Taipan, Dugite, Tiger Deposits and Waste Dumps
Sylvania Pastoral Licence, Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	E52/1658 L52/105	Python-Gwardar, Taipan, Dugite, Tiger Processing Infrastructure
Sylvania Pastoral Licence, Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	E52/1658	Mirrin Mirrin Deposit and Waste Dumps
Pending tenure		
Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	M52/1055	Mirrin Mirrin Deposit
Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	L52/112	Access Haul Road
Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	L52/130	Planned lease application for accommodation proposed on
Sylvania Pastoral Licence, Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	L52/131	Planned lease application for Airstrip
Sylvania Pastoral Licence, Nyiyaparli Native Title and Use and Benefit of Aboriginals Reserve 41265	G52/2874	General Purpose
Sylvania Pastoral Licence	E52/2542	Planned lease application for exploration activities.

*Development of the King Brown deposit to above the watertable was approved by the Department of Mines and Petroleum in November 2009. †G – General Purpose Lease; M – Mining Lease; E – Exploration Lease

Appendix 2

Legal obligations register

Table 1 Legal Obligations Register – Tenement Conditions

Tenement Conditions			
TENEMENT	**NO.**	**CONDITION**	**START DATE**
E52/1630	1	All surface holes drilled for the purpose of exploration are to be capped, filled or otherwise made safe immediately after completion.	25/08/2005
	2	All costeans and other disturbances to the surface of the land made as a result of exploration, including drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer, Department of Industry and Resources (DoIR). Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, DoIR.	
	3	All waste materials, rubbish, plastic sample bags, abandoned equipment and temporary buildings being removed from the mining tenement prior to or at the termination of exploration program.	
	4	Unless the written approval of the Environmental Officer, DoIR is first obtained, the use of drilling rigs, scrapers, graders, bulldozers, backhoes or other mechanised equipment for surface disturbance or the excavation of costeans is prohibited. Following approval, all topsoil being removed ahead of mining operations and separately stockpiled for replacement after backfilling and/or completion of operations.	
	11	The development and operation of the project being carried out in such a manner so as to create the minimum practicable disturbance to the existing vegetation and natural landform	
	13	All topsoil being removed ahead of all mining operations from sites such as pit areas, waste disposal areas, ore stockpile areas, pipeline, haul roads and new access roads and being stockpiled for later respreading or immediately respread as rehabilitation progresses	
E52/1658	1	All surface holes drilled for the purpose of exploration are to be capped, filled or otherwise made safe immediately after completion.	25/08/2005
	2	All costeans and other disturbances to the surface of the land made as a result of exploration, including drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer, Department of Industry and Resources (DoIR). Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, DoIR.	
	3	All waste materials, rubbish, plastic sample bags, abandoned equipment and temporary buildings being removed from the mining tenement prior to or at the termination of exploration program.	
	4	Unless the written approval of the Environmental Officer, DoIR is first obtained, the use of drilling rigs, scrapers, graders, bulldozers, backhoes or other mechanised equipment for surface disturbance or the excavation of costeans is prohibited. Following approval, all topsoil being removed ahead of mining operations and separately stockpiled for replacement after backfilling and/or completion of operations.	
M52/1034	2	All surface holes drilled for the purpose of exploration are to be capped, filled or otherwise made safe immediately after completion.	23/04/2009
	3	All costeans and other disturbances to the surface of the land made as a result of exploration, including drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer, Department of Mines and Petroleum (DMP). Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, DMP	
	4	All waste materials, rubbish, plastic sample bags, abandoned equipment and temporary buildings being removed from the mining tenement prior to or at the termination of exploration program.	
	5	Unless the written approval of the Environmental Officer, DMP is first obtained, the use of drilling rigs, scrapers, graders, bulldozers, backhoes or other mechanised equipment for surface disturbance or the excavation of costeans is prohibited. Following approval, all topsoil being removed ahead of mining operations and separately stockpiled for replacement after backfilling and/or completion of operations.	

Tenement Conditions			
	7	The construction and operation of the project and measures to protect the environment being carried out generally in accordance with the document titled: •"Robertson Range Iron Ore Project Mining Proposal M52/1034" (Reg ID 19293)" dated 28 July 2009 signed by John Berry and retained on Department of Mines and Petroleum File No. E0325/200901; •Re: Mining Proposal - Robertson Range - M52/1034" (Reg ID 19293) letter addressed to Jacqueline Brienne dated 5 August 2009 signed by John Berry and retained on Department of Mines and Petroleum File No. E0325/200901 Where a difference exists between the above document(s) and the following conditions, then the following conditions shall prevail.	
	9	All topsoil being removed ahead of all mining operations from sites such as pit areas, waste disposal areas, ore stockpile areas, pipeline, haul roads and new access roads and being stockpiled for later respreading or immediately respread as rehabilitation progresses.	
	10	At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Director, Environment Division, DMP.	
	11	All rubbish and scrap is to be progressively disposed of in a suitable manner.	
	13	At the completion of operations or progressively where possible, all waste dumps, residue storage facilities, stockpiles or other mining related landforms must be rehabilitated to form safe, stable, non-polluting structures which are integrated with the surrounding landscape and support self-sustaining, functional ecosystems comprising suitable, local provenance species or an alternative agreed outcome to the satisfaction of an Environmental Officer, Department of Mines and Petroleum (DMP).	
	14	Placement of waste material must be such that the final footprint after rehabilitation will not be impacted upon by pit wall subsidence and zone of instability.	
	15	The Lessee submitting to the Director, Environment Division, DMP, a brief annual report outlining the project operations, minesite environmental management and rehabilitation work undertaken in the previous 12 months and the proposed operations, environmental management plans and rehabilitation programmes for the next 12 months. This report to be submitted each year in December.	
M52/1043	2	All surface holes drilled for the purpose of exploration are to be capped, filled or otherwise made safe immediately after completion.	22/09/2010
	3	All disturbances to the surface of the land made as a result of exploration, including costeans, drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer, Department of Mines and Petroleum (DMP). Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, DMP.	
	4	All waste materials, rubbish, plastic sample bags, abandoned equipment and temporary buildings being removed from the mining tenement prior to or at the termination of exploration program.	
	5	Unless the written approval of the Environmental Officer, DMP is first obtained, the use of drilling rigs, scrapers, graders, bulldozers, backhoes or other mechanised equipment for surface disturbance or the excavation of costeans is prohibited. Following approval, all topsoil being removed ahead of mining operations and separately stockpiled for replacement after backfilling and/or completion of operations.	

Table 2 Legal Obligations Register – Robertson Range Mining Proposal (M52/1034)

Condition	Component related to closure
Land Clearing	Vegetation when removed will either be directly placed on rehabilitation areas or mulched and stockpiled in windrows for use during later rehabilitation.
	Rehabilitation will be undertaken as areas become available, and waste dump design will allow for progressive rehabilitation.
Flora and Vegetation	Rehabilitation will be undertaken as soon as practicable after land disturbance.
Vertebrate Fauna	Disturbed areas will be rehabilitated as soon as possible, with ongoing rehabilitation throughout the mine life to facilitate habitat restoration.
Topsoil and soil profiles	Topsoil will be applied as soon as possible to areas being rehabilitated. If stripped topsoil exceeds rehabilitation requirements at that time, excess topsoil will be stockpiled for later use.
Domestic and Industrial Waste products	On decommissioning of a work area, non-permanent structures and facilities will be removed and disposed of appropriately in accordance with the Conceptual Closure Plan for this project.

Table 3 Legal Obligations Register – Robertson Range Conceptual Closure Plan February 2009

Condition	Component related to closure
Contaminated sites	Known contaminated sites are remediated to agreed levels as soon as possible
	All known contaminated sites have been remediated to acceptable levels. Specific criteria will be determined for each specific contamination situation.
Decommissioning	Remove or dispose appropriately project infrastructure that will not be required for post closure land uses.
	Undertake contamination remediation and rehabilitate all sites to the agreed completion criteria.
	From the Chamber of Minerals and Energy, Mine Closure Guidelines for Mineral Operations in WA (DMP Oct 2000), the following are the desired outcomes concerning site decommissioning: • Appropriate removal and/or modification of all required infrastructure. • Stable long term structural integrity is derived. • Public and environmental health and safety is protected. • Local water characteristics are preserved. • Successful rehabilitation occurs where necessary. • The sustainability of flora and fauna is assured. • Consideration of post closure land uses is undertaken.
Development of landforms	Ensure that aesthetic values and public experience of the landscape are considered, and measures are adopted to reduce the visual impacts on the landscape.
	Maintain and protect any significant landscape, indigenous heritage and geo-heritage values.
Surface and groundwater	The quality and quantity of ground and surface waters is maintained, so that existing and potential environmental values of drainage systems interacting with the proposal are maintained.
	Any water use related infrastructure has been effectively decommissioned as per agreed post land use intentions, and natural drainage patterns are reinstated as far as possible dependent on site layout and water management scenarios.
Rehabilitation	Rehabilitation achieves a safe, stable and functioning ecosystem that meets the requirements of the post-mining land use.
Waste rock dumps	Ensure rehabilitation achieves a safe, stable, non-polluting landform consistent with the surrounding landscape.
	Rehabilitated areas have been revegetated to meet the agreed post-mining land use and vegetation communities have been assessed to be equivalent to surrounding undisturbed areas/undisturbed state using standard flora survey techniques.

Table 4 Legal Obligations Register – Robertson Range Environmental Management Plan

Condition	Component related to closure
Vegetation Clearance	All clearing activities will be scheduled to minimise the time between initial clearing and rehabilitation. Waste dump design will allow for progressive rehabilitation
	Vegetation and topsoil will be stripped ad immediately placed on areas to be rehabilitated or stockpiled for later use in rehabilitation. Topsoil management procedures will be followed.
Topsoil	Topsoil will be applied as soon as possible to areas being rehabilitated. If stripped topsoil exceeds rehabilitation requirements at that time, excess topsoil will be stockpiled for later use.

Condition	Component related to closure
Waste Dumps	Final waste dumps will have an average slope of no greater than 20° to minimise erosion and improve revegetation success.
	Dump construction will be conducted to enable early and progressive rehabilitation while topsoil viability is highest.
	Progressive rehabilitation will be conducted in accordance with Rehabilitation management strategies.
Vertebrate Fauna	Rehabilitation of disturbed areas will be conducted in accordance with Rehabilitation procedures.
	Areas that have been disturbed and are under rehabilitation will be checked for rehabilitation progress on a routine and ongoing basis by the Environmental Officer and records of progress maintained.
Rehabilitation	Rehabilitation will be undertaken as soon as practicable to facilitate fauna habitat restoration.
	Progressive rehabilitation will be conducted in accordance with Rehabilitation management strategies.
	Monitoring of each major rehabilitation area will be undertaken systematically at regular intervals 12 months after rehabilitation and again in years 2 and 5 any deficiencies will be reported using an Incident/Non Conformance Report to ensure corrective actions are implemented.
Access tracks, haul roads and borrow pits	Topsoil stockpiles will be no higher than 1 metre and will be located 2 metres from the borrow pit boundary to allow for battering during rehabilitation.
Weed and pest management	At the completion of mining rehabilitation, weed infestation surveys will be commissioned by FerrAus using suitably qualified external consultants.

Table 5 Legal Obligations Register – Vegetation Clearing Permit

Aspect	No	Condition
Type of clearing authorised	1	The Permit holder must not clear more than 323.37 ha of native vegetation. All clearing must be within the area cross-hatched yellow on attached Plan 2819/1
	2	The permit holder shall not clear native vegetation unless the purpose for which the clearing is authorised is enacted within 3 months of the clearing being undertaken.
Avoid, minimise clearing	3	In determining the amount of native vegetation to be cleared pursuant to this Permit, the Permit, the Permit Holder must have regard to the following principles, set out in order of preference: i. avoid the clearing of native vegetation ii. minimise the amount of native vegetation to be cleared iii. reduce the impact of clearing on any environmental value.
Weed control	4	When undertaking any clearing or other activity authorised under this Permit, the Permit holder must take the following steps to minimise the risk of the introduction and spread of weeds: i. clean earth-moving machinery of soil and vegetation prior to entering and leaving the area to be cleared ii. ensure that no weed-affected road building materials, mulch, fill or other material is brought into the area to be cleared iii. restrict the movement of machines and other vehicles to the limits of the areas to be cleared.
Retain vegetative material and topsoil	5	The Permit holder shall retain the vegetative material and topsoil removed by clearing authorised under this permit and stockpile the vegetative material and topsoil in an area that has already been cleared.
Records to be kept	6	The Permit holder must maintain the following records for activities done pursuant to the Permit: i. the location where the clearing occurred, recorded using a GPS unit set to Geocentric Datum Australia 1994 (GDA94), expressing the geographical coordinates in Easting's and Northing's ii. the date that the area was cleared iii. the size of the area cleared (ha) iv. purpose for which clearing was undertaken.

Aspect	No	Condition
Reporting	7	a) Permit holder shall provide a report to the Director, Environmental Division, Department of Mines and Petroleum by 31 July each year for the life of this permit, demonstrating adherence to all conditions of this permit, and setting out the records required under Condition 6 of this Permit in relation to clearing carried out between 1 July and 30 June of the previous financial year. b) Prior to 31 July 2014, the Permit holder must provide to the Director, Environment Division, Department of Mines and Petroleum a written report of records required under condition 6 of this Permit where these records have not already been provided under Condition 7(a) of this Permit.

Table 6 Legal Obligations Register – License to take water (GWL164445 (2))

Tenement	No.	Condition
M52/1034; E52/1630; L52/103 and G52/281	1	The annual water year for water taken under this license is defined as 1 November to 31 October (2009-2011)
	2	The licensee must install a cumulative water meter of a type approved under the Rights in Water and Irrigation (Approved Meters) Order 2009 to each water draw point under this license
	3	The meter(s) must be installed in accordance with the provisions of the document entitled "Guidelines for Water Meter Installation 2009" before any water is taken under this license.
	4	The licensee must take and record the reading from each meter required under this license at the beginning and another at the end of the water year defined on this license.
	5	In addition to taking and recording readings at the beginning and the end of the water year, the licensee must, as close as practicable to the end of each month (other than the month in which the water year ends), take and record the reading from each meter required under this license.
	6	The licensee must submit to the DoW the recorded meter readings and the volume of water taken within the water year by 31 December annually from each bore under this license (bores 345B, 349B and Camp Bore).
	7	The licensee is to provide salinity readings and water levels (pumping affected) taken monthly from each bore under this license (bores 345B, 349B and Camp Bore) to the DoW by 31December annually. It shall be recorded if water levels are recorded at rest or pump affected.
	8	Every year the licensee shall ensure that a comprehensive analysis of the water quality is undertaken on water samples taken from each bore under this license (bores 345B, 349B and Camp Bore) by 30 June. The analysis is to be carried out in accordance with the attached DoW State-wide Policy series Report No. 19 (May 2007) publication 'Hydrogeological reporting associated with a Groundwater License'. The report is due by 31 December each year.
	9	The licensee must ensure the installed meter(s) accuracy is maintained to within plus or minus 50% of the volume metered, in field conditions.
	10	The licensee must notify the DoW in writing of any water meter malfunction within seven days of the malfunction being noticed.
	11	The licensee must obtain authorisation from the DoW before removing, replacing or interfering with any meter required under this license.
	12	That the licensee ensure that any water supplied for drinking purposes shall not constitute a hazard to the health of those so supplied.
	13	The DoW at its discretion may direct changes to be made to the monitoring program at any time.
	14	That should the licensee's draw adversely affect the aquifer or other users in the area, the DoW may reduce the amount that may be drawn.
	15	That the licensee shall allow access, in an agreed manner, by the DoW personnel for the purposes of inspection at any time.
	16	Approval by the DoW is to be obtained prior to the construction of additional and replacement wells and the modification or refurbishment of existing wells.

Table 7 Legal Obligations Register – License to take water (GWL166913 (2))

Tenement	No.	Condition
E52/1658	1	That should the licensee's draw adversely affect the aquifer or other users in the area, the DoW may reduce the amount that may be drawn.
	2	Approval by the DoW is to be obtained prior to the construction of additional and replacement wells and the modification or refurbishment of existing wells.
	3	The licensee must install and maintain a cumulative water meter of a type authorised under the Rights in Water and Irrigation (Approved Meters) Order 2003 and the meter must be installed in accordance with the meters manufacturer's specifications.

Tenement	No.	Condition
	4	That should the drawing of water from the bore adversely affect the aquifer, and/or other users, the DoW shall direct the licensee to effect necessary action to make good the supply to affected users.

Appendix 3
Closure and decommissioning risk assessment

Table 1 ROM pad and ore stockpiles closure risk assessment

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Fauna	Direct fauna death as a result of decommissioning and rehabilitation activities (vehicle strike, fauna entrapment, contamination)	C	4	Low	Vehicle use on site after mine closure will be significantly reduced.	Enforce vehicle speed limits on site by means of appropriate signage and personnel education. Ensure all open areas including drill holes are fenced adequately, decommissioned and rehabilitated (in accordance with tenement conditions) to prevent fauna access and fenced appropriately (not with barbed wire).	C	4	Low	Speed limits are adhered to on site with adequate signage erected.	High
	Fauna decline through uncontrolled species introduction post-closure (weeds, competing fauna, pests)	D	2	Major	Introduced fauna and weeds are already present on site.	Ensure appropriate management of waste to avoid fauna being attracted to the area during closure and rehabilitation. Reduce chances of adding new weed species by ensuring revegetation stock only contains endemic native species. Undertake "weed and seed" checks during decommissioning. Weed treatment with agreed upon pesticides where required. Develop a post-closure weed monitoring program to monitor weed infestations and mitigation success.	D	3	Low		High
	Indirect impacts to terrestrial and subterranean fauna through leaching of hydrocarbons and chemicals	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater or soil contamination, remedial action will be determined based on the severity of contamination. Groundwater and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Ongoing soil and groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Flora and Vegetation	Loss of flora species and vegetation of significance due to unapproved clearing during closure and rehabilitation activities.	D	3	Low	No clearing will be conducted during decommissioning and closure. Earthworks during decommissioning and closure will be in areas that have already been disturbed.	Educate site personnel as to clearing allowances and boundaries stipulated. Any significant habitats/vegetation communities should remain clearly demarcated by means of fencing and signage during closure and rehabilitation activities	E	3	Very low	Clearing is undertaken in accordance with EIA conditions.	High.
	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	B	3	Major	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	C	3	Medium	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Death of individual plants as a result of dust deposition	C	3	Medium	Dust generating activity on site will be reduced significantly during closure, decommissioning and rehabilitation.	In times of increased activity (final landform construction) and windy conditions, water trucks will be used. In times of extreme wind and dust generation, rehabilitation activities will stop until such time as winds have decreased.	D	3	Low		High
	Vegetation decline through species introduction (weeds and introduced flora)	D	3	Major	Introduced fauna and weeds are already present on site.	Ensure appropriate management of waste to avoid fauna being attracted to the area during closure and rehabilitation. Reduce chances of adding new weed species by ensuring revegetation stock only contains endemic native species. Undertake "weed and seed" checks during decommissioning. Weed treatment with agreed upon pesticides where required. Develop a post-closure weed monitoring program to monitor weed infestations and mitigation success.	D	3	Low		High
Hydrology	Contamination of surface water sources through use of chemicals and hydrocarbons on site	C	3	Medium	Activities undertaken during closure and decommissioning will be utilising significantly reduced chemicals and hydrocarbons potentially resulting in contamination of the receiving environment.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Surface water will be monitored throughout operations and closure and rehabilitation. If contamination does occur, early detection will trigger remedial action.	D	3	Low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Soil	Erosion of topsoil and dispersive material from final landforms	C	3	Medium	Assume that regular prevailing winds affect the region.	Initial wetting to prevent wind erosion of topsoil material-allowing revegetation to occur. Apply erosion agents to waste dumps (e.g. rock armouring) Apply nutrient rich soil that can support revegetation.	D	3	Low	Assume that rehabilitation trials have been conducted.	High
	Soil compaction resulting from project operational and hardstand areas	C	3	Medium		Removal of hardstand areas followed by deep ripping of compacted soil. Nutrient rich topsoil will be re-spread over the area to facilitate revegetation of the area.	D	3	Low	Assume that rehabilitation trials have been conducted.	High
	Soil contamination through hydrocarbon and chemical use on site post operations.	D	2	Medium		Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Contaminated soil will be removed from site and disposed of by a licensed contractor. If contamination does occur, early detection will trigger remedial action.	E	2	Low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Contamination	Contamination of groundwater (resulting in contaminated site classification by DEC)	D	1	Major	Assume contamination in groundwater presents a threat to ecological health.	Ongoing groundwater monitoring throughout operations and closure and rehabilitation. Early intervention and mitigation if any breaches in criteria are observed.	D	3	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Surface soil contamination around plant equipment and storage areas (resulting in contaminated site classification by DEC)	D	1	Major	Potentially contaminating equipment will be removed from site during decommissioning and closure, so any contamination events would be isolated.	Area around plant and equipment should be checked for surface soil impacts as part of closure and decommissioning. If contamination is found, it will be removed immediately.	D	3	Medium	Any surface soil contamination around plant or plant equipment following closure will likely be easy to remove.	High
Rehabilitation	Revegetation failure due to insufficient soil type/nutrients	D	2	Medium	Assume use of topsoil where available.	Topsoil will be stripped and the area will be re-spread with adequate topsoil and fertilised where necessary.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to inadequate soil structure (high erosion and compaction vegetation unable to establish)	D	2	Medium	Assume soil has been treated following respread of topsoil.	Soil will be stripped and land will be deep ripped, prior to respread of adequate topsoil. Planting with local provenance will be undertaken.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to insufficient water availability	D	2	Medium	Assume soil has been treated following respread of topsoil.	Rehabilitated areas will be irrigated as required within the first year of planting to promote revegetation.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
Monitoring	Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages)	C	2	Major	Consultation with DMP and DEC has been undertaken throughout operational and closure activities.	Consult with DMP and DEC to receive approval of planned monitoring frequency. Ensure monitoring plan executed at stated frequency.	D	2	Medium		High

Table 2 Processing facilities closure risk assessment

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Vertebrate fauna	Direct fauna death as a result of decommissioning and rehabilitation activities (vehicle strike, fauna entrapment, contamination)	C	4	Low	Vehicle use on site after mine closure will be significantly reduced.	Enforce vehicle speed limits on site by means of appropriate signage and personnel education. Ensure all open areas including drill holes are fenced adequately, decommissioned and rehabilitated (in accordance with tenement conditions) to prevent fauna access and fenced appropriately (not with barbed wire).	C	4	Low	Speed limits are adhered to on site with adequate signage erected.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Stygofauna	Contamination of Stygofauna habitat through leaching of hydrocarbons and chemicals post-mining.	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater contamination, remedial action will be determined based on the severity of contamination. Ongoing groundwater quality monitoring will be undertaken to ensure water quality is consistent with baseline parameters. Should monitoring trigger contamination, remedial actions will be developed on a case by case basis.	E	3	Very low	Ongoing groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Troglofauna	Indirect impacts to Troglofauna through leaching of hydrocarbons and chemicals	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater or soil contamination, remedial action will be determined based on the severity of contamination. Groundwater and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Ongoing soil and groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Flora and vegetation	Death of individual plants as a result of dust deposition	C	3	Medium	Dust generating activity on site will be reduced significantly during closure, decommissioning and rehabilitation.	In times of increased activity (final landform construction) and windy conditions, water trucks will be used. In times of extreme wind and dust generation, rehabilitation activities will stop until such time as winds have decreased.	D	3	Low		High
	Soil, surface water and groundwater contamination resulting in plant deaths.	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of contamination, remedial action will be determined based on the severity of contamination. Groundwater, surface water and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Surface water	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	B	3	Major	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	C	3	Medium	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Contamination of surface water sources through use of chemicals and hydrocarbons on site	C	3	Medium	Activities undertaken during closure and decommissioning will be utilising significantly reduced chemicals and hydrocarbons potentially resulting in contamination of the receiving environment.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Surface water will be monitored throughout operations and closure and rehabilitation. If contamination does occur, early detection will trigger remedial action.	D	3	Low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Groundwater	Contamination of groundwater through leaching of residue material and chemicals post-mining	D	2	Medium	Assume RSF is constructed to contain potential leaching.	If residue leaching does occur, a remediation program will be developed in consultation with relevant authorities. Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards.	D	2	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	Reasonable
Soil	Soil compaction resulting from project operational and hardstand areas	C	3	Medium		Removal of hardstand areas followed by deep ripping of compacted soil. Nutrient rich topsoil will be re-spread over the area to facilitate revegetation of the area.	D	3	Low	Assume that rehabilitation trials have been conducted.	High
	Soil contamination through hydrocarbon and chemical use on site post operations.	D	2	Medium		Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Contaminated soil will be removed from site and disposed of by a licensed contractor. If contamination does occur, early detection will trigger remedial action.	D	2	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Contamination	Surface water contamination post-closure	D	2	Medium	Assumes that regular surface water parameters are within baseline surface water parameters.	If contaminated water levels are recorded, early detection will trigger remedial action that will be determined in consultation with DoW.	D	2	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	Reasonable
	Contamination of groundwater (resulting in contaminated site classification by DEC)	D	1	Major	Assume contamination in groundwater presents a threat to ecological health.	Ongoing groundwater monitoring throughout operations and closure and rehabilitation. Early intervention and mitigation if any breaches in criteria are observed.	D	3	Low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
	Surface soil contamination around plant equipment and storage areas (resulting in contaminated site classification by DEC)	D	1	Major	Potentially contaminating equipment will be removed from site during decommissioning and closure, so any contamination events would be isolated.	Area around plant and equipment should be checked for surface soil impacts as part of closure and decommissioning. If contamination is found, it will be removed immediately.	D	3	Low	Any surface soil contamination around plant or plant equipment following closure will likely be easy to remove.	High
Rehabilitation	Revegetation failure due to insufficient soil type/nutrients	D	2	Medium	Assume use of topsoil where available.	Topsoil will be stripped and the area will be re-spread with adequate topsoil and fertilised where necessary.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to inadequate soil structure (high erosion and compaction vegetation unable to establish)	D	2	Medium	Assume soil has been treated following respread of topsoil.	Soil will be stripped and land will be deep ripped, prior to respread of adequate topsoil. Planting with local provenance will be undertaken.	E	2	Low	Assume that rehabilitation trials have been conducted.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Revegetation failure due to insufficient water availability	D	2	Medium	Assume soil has been treated following respread of topsoil.	Rehabilitated areas will be irrigated as required within the first year of planting to promote revegetation.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
Monitoring	Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages)	C	2	Major	Consultation with DMP and DEC has been undertaken throughout operational and closure activities.	Consult with DMP and DEC to receive approval of planned monitoring frequency. Ensure monitoring plan executed at stated frequency.	D	2	Medium		High

Table 3 RSF closure risk assessment

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Vertebrate fauna	Direct fauna death as a result of decommissioning and rehabilitation activities (vehicle strike, fauna entrapment, contamination)	C	4	Low	Vehicle use on site after mine closure will be significantly reduced.	Enforce vehicle speed limits on site by means of appropriate signage and personnel education. Ensure all open areas including drill holes are fenced adequately, decommissioned and rehabilitated (in accordance with tenement conditions) to prevent fauna access and fenced appropriately (not with barbed wire).	C	4	Low	Speed limits are adhered to on site with adequate signage erected.	High
Stygofauna	Contamination of Stygofauna habitat through leaching of residue material post-mining.	D	3	Low	Assume that tailings will be dried and capped prior to closure. Assume RSF is constructed to contain potential seepage.	In the event of groundwater contamination, remedial action will be determined based on the severity of contamination. Ongoing groundwater quality monitoring will be undertaken to ensure water quality is consistent with baseline parameters. Should monitoring trigger contamination, remedial actions will be developed on a case by case basis.	E	3	Very low	Ongoing groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Troglofauna	Indirect impacts to Troglofauna through leaching of residue material	D	3	Low	Assume that tailings will be dried and capped prior to closure. Assume RSF is constructed to contain potential seepage.	In the event of groundwater or soil contamination, remedial action will be determined based on the severity of contamination. Groundwater and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Ongoing soil and groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Short Range Endemics	Degradation of SRE habitat as a result of contamination from residue material	D	3	Low	Assume that tailings will be dried and capped prior to closure. Assume RSF is constructed to contain potential seepage.	Continue environmental monitoring around tailings facilities post-closure. If seepage does occur, early detection will trigger remedial action.	E	3	Very low		High
Flora and Vegetation	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	C	3	Medium	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	D	3	Low	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High
	Soil, surface water and groundwater contamination resulting in plant deaths.	D	3	Low	Assume that tailings will be dried and capped prior to closure. Assume RSF is constructed to contain potential seepage.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of contamination, remedial action will be determined based on the severity of contamination. Groundwater, surface water and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Surface water	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	C	3	Medium	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	D	3	Low	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High
Groundwater	Contamination of groundwater through leaching of residue material and chemicals post-mining	D	2	Medium	Assume RSF is constructed to contain potential leaching.	If residue leaching does occur, a remediation program will be developed in consultation with relevant authorities. Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards.	D	2	Medium	Residue material is stored in a structurally stable landform.	Reasonable
Soil	Erosion of topsoil and dispersive material from final landforms	C	3	Medium	Assume that regular prevailing winds affect the region.	Initial wetting to prevent wind erosion of topsoil material-allowing revegetation to occur. Apply erosion agents to waste dumps (e.g. rock armouring) Apply nutrient rich soil that can support revegetation.	D	3	Low	Assume that rehabilitation trials have been conducted.	High
	Soil contamination through RSF seepage	D	2	Medium	Assume that structural stability assessments of the RSF have been undertaken	Contaminated soil will be removed from site and disposed of by a licensed contractor. If contamination does occur, early detection will trigger remedial action.	E	2	Low		High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Residue Storage Facility	Seepage of residue material from RSF post-closure (to soil to groundwater)	D	2	Medium	Assume that tailings will be dried and capped prior to closure. Assume RSF is constructed to contain potential seepage.	Continue environmental monitoring around tailings facilities post-closure. If seepage does occur, early detection will trigger remedial action.	E	3	Very Low		High
	Erosion of capping material leading to failure of capping/potential contamination/inadequate rehabilitation	D	2	Medium	Assume tailings dam is constructed to contain potential seepage.	Initial wetting to prevent wind erosion of topsoil material-allowing revegetation to occur. Apply erosion agents to waste dumps (e.g. rock armouring) Apply nutrient rich soil that can support revegetation.	E	3	Very Low	Assume that rehabilitation trials have been conducted.	High
	RSF construction failure post closure	E	2	Low	Assume regular monitoring of RSF shows that construction has not weakened, no cracks observed in RSF walls.	Continued TSF monitoring in accordance with licence conditions. Ensure tailings are dried completely before capping, and that RSF is filled only to design specifications.	E	2	Low		High
Contamination	Surface water contamination post-closure	D	2	Medium	Assumes that regular surface water parameters are within baseline surface water parameters.	If contaminated water levels are recorded, early detection will trigger remedial action that will be determined in consultation with DoW.	D	2	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	Reasonable
	Contamination of groundwater (resulting in contaminated site classification by DEC)	D	1	Major	Assume contamination in groundwater presents a threat to ecological health.	Ongoing groundwater monitoring throughout operations and closure and rehabilitation. Early intervention and mitigation if any breaches in criteria are observed.	D	3	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Rehabilitation	Revegetation failure due to insufficient soil type/nutrients	D	2	Medium	Assume use of topsoil where available.	Topsoil will be stripped and the area will be re-spread with adequate topsoil and fertilised where necessary.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to inadequate soil structure (high erosion and compaction vegetation unable to establish)	D	2	Medium	Assume soil has been treated following respread of topsoil.	Soil will be stripped and land will be deep ripped, prior to respread of adequate topsoil. Planting with local provenance will be undertaken.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to insufficient water availability	D	2	Medium	Assume soil has been treated following respread of topsoil.	Rehabilitated areas will be irrigated as required within the first year of planting to promote revegetation.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
Monitoring	Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages)	C	2	Major	Consultation with DMP and DEC has been undertaken throughout operational and closure activities.	Consult with DMP and DEC to receive approval of planned monitoring frequency. Ensure monitoring plan executed at stated frequency.	D	2	Medium		High

Table 4 Hazardous material storage closure risk assessment

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Vertebrate Fauna	Direct fauna death as a result of decommissioning and rehabilitation activities (vehicle strike, fauna entrapment, contamination)	C	4	Low	Vehicle use on site after mine closure will be significantly reduced.	Enforce vehicle speed limits on site by means of appropriate signage and personnel education. Ensure all open areas including drill holes are fenced adequately, decommissioned and rehabilitated (in accordance with tenement conditions) to prevent fauna access and fenced appropriately (not with barbed wire).	C	4	Low	Speed limits are adhered to on site with adequate signage erected.	High
Stygofauna	Contamination of Stygofauna habitat through leaching of hydrocarbons and chemicals post-mining.	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater contamination, remedial action will be determined based on the severity of contamination. Ongoing groundwater quality monitoring will be undertaken to ensure water quality is consistent with baseline parameters. Should monitoring trigger contamination, remedial actions will be developed on a case by case basis.	E	3	Very low	Ongoing groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Troglofauna	Indirect impacts to Troglofauna through leaching of hydrocarbons and chemicals	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater or soil contamination, remedial action will be determined based on the severity of contamination. Groundwater and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Ongoing soil and groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Short Range Endemics	Disturbance and/or permanent degradation of SRE habitat through contamination	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater or soil contamination, remedial action will be determined based on the severity of contamination. Groundwater and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Ongoing soil and groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Flora and Vegetation	Soil, surface water and groundwater contamination resulting in plant deaths.	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of contamination, remedial action will be determined based on the severity of contamination. Groundwater, surface water and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Surface water	Contamination of surface water sources through use of chemicals and hydrocarbons on site	C	3	Medium	Activities undertaken during closure and decommissioning will be utilising significantly reduced chemicals and hydrocarbons potentially resulting in contamination of the receiving environment.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Surface water will be monitored throughout operations and closure and rehabilitation. If contamination does occur, early detection will trigger remedial action.	D	3	Low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Groundwater	Groundwater contamination from closure and rehabilitation activities.	C	3	Medium	No dewatering and abstraction activities will be undertaken during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater contamination, remedial action will be determined based on the severity of contamination. Ongoing groundwater quality monitoring will be undertaken to ensure water quality is consistent with baseline parameters. Should monitoring trigger contamination, remedial actions will be developed on a case by case basis.	D	3	Low		High
Soil	Soil contamination through hydrocarbon and chemical use on site post operations.	D	2	Medium		Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Contaminated soil will be removed from site and disposed of by a licensed contractor. If contamination does occur, early detection will trigger remedial action.	D	2	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Contamination	Surface water contamination post-closure	D	2	Medium	Assumes that regular surface water parameters are within baseline surface water parameters.	If contaminated water levels are recorded, early detection will trigger remedial action that will be determined in consultation with DoW.	D	2	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	Reasonable
	Contamination of groundwater (resulting in contaminated site classification by DEC)	D	1	Major	Assume contamination in groundwater presents a threat to ecological health.	Ongoing groundwater monitoring throughout operations and closure and rehabilitation. Early intervention and mitigation if any breaches in criteria are observed.	D	3	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Surface soil contamination around plant equipment and storage areas (resulting in contaminated site classification by DEC)	D	1	Major	Potentially contaminating equipment will be removed from site during decommissioning and closure, so any contamination events would be isolated.	Area around plant and equipment should be checked for surface soil impacts as part of closure and decommissioning. If contamination is found, it will be removed immediately.	D	3	Very Low	Any surface soil contamination around plant or plant equipment following closure will likely be easy to remove.	High
Rehabilitation	Revegetation failure due to insufficient soil type/nutrients	D	2	Medium	Assume use of topsoil where available.	Topsoil will be stripped and the area will be re-spread with adequate topsoil and fertilised where necessary.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to inadequate soil structure (high erosion and compaction vegetation unable to establish)	D	2	Medium	Assume soil has been treated following respread of topsoil.	Soil will be stripped and land will be deep ripped, prior to respread of adequate topsoil. Planting with local provenance will be undertaken.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to insufficient water availability	D	2	Medium	Assume soil has been treated following respread of topsoil.	Rehabilitated areas will be irrigated as required within the first year of planting to promote revegetation.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
Monitoring	Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages)	C	2	Major	Consultation with DMP and DEC has been undertaken throughout operational and closure activities.	Consult with DMP and DEC to receive approval of planned monitoring frequency. Ensure monitoring plan executed at stated frequency.	D	2	Medium		High

Table 5 Water management structures closure risk assessment

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Flora and vegetation	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	B	3	Major	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	C	3	Medium	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High
Surface water	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	B	3	Major	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	C	3	Medium	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Changes to ecosystem values of irrigated lands	D	2	Major	Irrigation will be undertaken during mining operations only.	Rehabilitate irrigated areas with local provenance species. Ensure all irrigation infrastructure is removed or retained as required.	C	4	Low		High
Monitoring	Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages)	C	2	Major	Consultation with DMP and DEC has been undertaken throughout operational and closure activities.	Consult with DMP and DEC to receive approval of planned monitoring frequency. Ensure monitoring plan executed at stated frequency.	D	2	Medium		High

Table 6 Waste dumps and mineralised waste stockpiles closure risk assessment

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Vertebrate fauna	Direct fauna death as a result of decommissioning and rehabilitation activities (vehicle strike, fauna entrapment, contamination)	C	4	Low	Vehicle use on site after mine closure will be significantly reduced.	Enforce vehicle speed limits on site by means of appropriate signage and personnel education. Ensure all open areas including drill holes are fenced adequately, decommissioned and rehabilitated (in accordance with tenement conditions) to prevent fauna access and fenced appropriately (not with barbed wire).	C	4	Low	Speed limits are adhered to on site with adequate signage erected.	High
	Fauna decline through uncontrolled species introduction post-closure (weeds, competing fauna, pests)	D	2	Major	Introduced fauna and weeds are already present on site.	Ensure appropriate management of waste to avoid fauna being attracted to the area during closure and rehabilitation. Reduce chances of adding new weed species by ensuring revegetation stock only contains endemic native species. Undertake "weed and seed" checks during decommissioning. Weed treatment with agreed upon pesticides where required. Develop a post-closure weed monitoring program to monitor weed infestations and mitigation success.	D	3	Low		High
Stygofauna	Contamination of Stygofauna habitat through leaching of hydrocarbons and chemicals post-mining.	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater contamination, remedial action will be determined based on the severity of contamination. Ongoing groundwater quality monitoring will be undertaken to ensure water quality is consistent with baseline parameters. Should monitoring trigger contamination, remedial actions will be developed on a case by case basis.	E	3	Very low	Ongoing groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Troglofauna	Indirect impacts to Troglofauna through leaching of hydrocarbons and chemicals	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater or soil contamination, remedial action will be determined based on the severity of contamination. Groundwater and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Ongoing soil and groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Flora and Vegetation	Loss of flora species and vegetation of significance due to unapproved clearing during closure and rehabilitation activities.	D	3	Low	No clearing will be conducted during decommissioning and closure. Earthworks during decommissioning and closure will be in areas that have already been disturbed.	Educate site personnel as to clearing allowances and boundaries stipulated. Any significant habitats/vegetation communities should remain clearly demarcated by means of fencing and signage during closure and rehabilitation activities	E	3	Very low	Clearing is undertaken in accordance with EIA conditions.	High.
	Changes to ecosystem values and flora and vegetation composition as a result of drawdown impacts.	C	3	Medium	No dewatering and abstraction activities will be undertaken during closure and rehabilitation activities.	Ongoing groundwater level monitoring will be undertaken to ensure water level are increasing as per anticipated groundwater levels.	D	3	Low	Sufficient drawdown assessments have been completed.	High
	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	B	3	Major	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	C	3	Medium	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High
	Death of individual plants as a result of dust deposition	C	3	Medium	Dust generating activity on site will be reduced significantly during closure, decommissioning and rehabilitation.	In times of increased activity (final landform construction) and windy conditions, water trucks will be used. In times of extreme wind and dust generation, rehabilitation activities will stop until such time as winds have decreased.	D	3	Low		High
	Soil, surface water and groundwater contamination resulting in plant deaths.	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of contamination, remedial action will be determined based on the severity of contamination. Groundwater, surface water and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Vegetation decline through species introduction (weeds and introduced flora)	D	3	Major	Introduced fauna and weeds are already present on site.	Ensure appropriate management of waste to avoid fauna being attracted to the area during closure and rehabilitation. Reduce chances of adding new weed species by ensuring revegetation stock only contains endemic native species. Undertake “weed and seed” checks during decommissioning. Weed treatment with agreed upon pesticides where required. Develop a post-closure weed monitoring program to monitor weed infestations and mitigation success.	D	3	Low		High
Surface water	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	B	3	Major	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	C	3	Medium	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High
Contamination	Contamination of groundwater (resulting in contaminated site classification by DEC)	D	1	Extreme	Assume contamination in groundwater presents a threat to ecological health.	Ongoing groundwater monitoring throughout operations and closure and rehabilitation. Early intervention and mitigation if any breaches in criteria are observed.	D	3	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Rehabilitation	Revegetation failure due to insufficient soil type/nutrients	D	2	Medium	Assume use of topsoil where available.	Topsoil will be stripped and the area will be re-spread with adequate topsoil and fertilised where necessary.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to inadequate soil structure (high erosion and compaction vegetation unable to establish)	D	2	Medium	Assume soil has been treated following respread of topsoil.	Soil will be stripped and land will be deep ripped, prior to respread of adequate topsoil. Planting with local provenance will be undertaken.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to insufficient water availability	D	2	Medium	Assume soil has been treated following respread of topsoil.	Rehabilitated areas will be irrigated as required within the first year of planting to promote revegetation.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
Backfilled pits and waste dumps	Insufficient rehabilitation of waste dumps, plant area and village area (visual amenity legacy)	E	3	Very Low	Assumed appropriate geotechnical investigations have been undertaken.	Ensure that all plant and equipment are taken off site at decommissioning. Ensure revegetation of plant area is established and monitored.	E	2	Very Low	Assume soil has been treated following respread of topsoil.	High
	Public injury from incorrect or incomplete decommissioning and rehabilitation.	C	1	Major		Former pit areas should be securely fenced and signposted to restrict access.	D	2	Medium		Reasonable
	Fauna death resulting from inappropriate rehabilitation of pits.	B	4	Medium		Former pit areas should be securely fenced to restrict animal entry.	C	4	Low		Reasonable

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Instability of backfilled pits and waste dumps resulting in public injury and fauna injury and/or death.	D	1	Major	Assumed appropriate geotechnical investigations have been undertaken.	Final landforms will be re-contoured to ensure stability. Further geotechnical investigations will be undertaken to ensure stability of final landforms. Rehabilitation will follow including respreading of topsoil, deep ripping and planting with local provenance seeds.	D	1	Major		Reasonable
Monitoring	Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages)	C	2	Major	Consultation with DMP and DEC has been undertaken throughout operational and closure activities.	Consult with DMP and DEC to receive approval of planned monitoring frequency. Ensure monitoring plan executed at stated frequency.	D	2	Medium		High
Acid and metalliferous drainage	Contamination of groundwater downstream of backfilled pits and waste dumps	C	2	Major	Assume contaminated groundwater presents a threat to ecological health	Ongoing groundwater monitoring throughout operations and closure and rehabilitation. Early intervention and mitigation if any breaches in criteria are observed.	D	2	Medium	Waste rock characterisation has been implemented, indicating waste material is benign in nature. Additional characterisation will be undertaken prior to mine closure.	High

Table 7 Mine pit voids and declines closure risk assessment

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Vertebrate Fauna	Direct fauna death as a result of decommissioning and rehabilitation activities (vehicle strike, fauna entrapment, contamination)	C	4	Low	Vehicle use on site after mine closure will be significantly reduced.	Enforce vehicle speed limits on site by means of appropriate signage and personnel education. Ensure all open areas including drill holes are fenced adequately, decommissioned and rehabilitated (in accordance with tenement conditions) to prevent fauna access and fenced appropriately (not with barbed wire).	C	4	Low	Speed limits are adhered to on site with adequate signage erected.	High
	Fauna decline through uncontrolled species introduction post-closure (weeds, competing fauna, pests)	D	2	Major	Introduced fauna and weeds are already present on site.	Ensure appropriate management of waste to avoid fauna being attracted to the area during closure and rehabilitation. Reduce chances of adding new weed species by ensuring revegetation stock only contains endemic native species. Undertake "weed and seed" checks during decommissioning. Weed treatment with agreed upon pesticides where required. Develop a post-closure weed monitoring program to monitor weed infestations and mitigation success.	D	3	Low		High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Stygofauna	Contamination of Stygofauna habitat through leaching of acidic, metaliferous or saline materials	D	3	Low	Assume materials characterisation is undertaken prior to closure activities.	In the event of groundwater contamination, remedial action will be determined based on the severity of contamination. Ongoing groundwater quality monitoring will be undertaken to ensure water quality is consistent with baseline parameters. Should monitoring trigger contamination, remedial actions will be developed on a case by case basis.	E	3	Very low	Ongoing groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Troglofauna	Indirect impacts to Troglofauna through leaching of acidic, metalliferous or saline materials.	D	3	Low	Assume materials characterisation is undertaken prior to closure activities.	In the event of groundwater or soil contamination, remedial action will be determined based on the severity of contamination. Groundwater and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Ongoing soil and groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Flora and Vegetation	Changes to ecosystem values and flora and vegetation composition as a result of groundwater drawdown legacy post-mining	C	3	Medium	No dewatering and abstraction activities will be undertaken during closure and rehabilitation activities.	Ongoing groundwater level monitoring will be undertaken to ensure water level are increasing as per anticipated groundwater levels.	D	3	Low	Sufficient drawdown assessments have been completed.	High
	Soil, surface water and groundwater contamination resulting in plant deaths.	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of contamination, remedial action will be determined based on the severity of contamination. Groundwater, surface water and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
	Vegetation decline through species introduction (weeds and introduced flora)	D	3	Major	Introduced fauna and weeds are already present on site.	Ensure appropriate management of waste to avoid fauna being attracted to the area during closure and rehabilitation. Reduce chances of adding new weed species by ensuring revegetation stock only contains endemic native species. Undertake “weed and seed” checks during decommissioning. Weed treatment with agreed upon pesticides where required. Develop a post-closure weed monitoring program to monitor weed infestations and mitigation success.	D	3	Low		High
Surface water	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	B	3	Major	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	C	3	Medium	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Contamination of surface water sources through use of chemicals and hydrocarbons on site	C	3	Medium	Activities undertaken during closure and decommissioning will be utilising significantly reduced chemicals and hydrocarbons potentially resulting in contamination of the receiving environment.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Surface water will be monitored throughout operations and closure and rehabilitation. If contamination does occur, early detection will trigger remedial action.	D	3	Low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Groundwater	Alteration to groundwater levels (recovery after water abstraction and dewatering activities)	B	3	Major		Groundwater levels will be monitored throughout operations and throughout the closure, decommissioning and rehabilitation stage of the project.	B	3	Major	Groundwater modelling has been undertaken and will be updated as information comes available.	Reasonable
	Groundwater contamination from closure and rehabilitation activities.	C	3	Medium	No dewatering and abstraction activities will be undertaken during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater contamination, remedial action will be determined based on the severity of contamination. Ongoing groundwater quality monitoring will be undertaken to ensure water quality is consistent with baseline parameters. Should monitoring trigger contamination, remedial actions will be developed on a case by case basis.	D	3	Low		High
	Contamination of groundwater through leaching of acidic, metalliferous or saline materials	D	2	Medium	Assume mine pit voids are re-contoured to achieve a stable final landform consistent with the pre-mining landscape, consistent with findings of rehabilitation trials and additional geotechnical investigations have been undertaken.	If leaching to groundwater does occur, a remediation program will be developed in consultation with relevant authorities.	D	2	Medium	Final pit voids are developed in accordance with agreed design requirements.	Reasonable
Soil	Erosion of topsoil and dispersive material from final landforms	C	3	Medium	Assume that regular prevailing winds affect the region.	Initial wetting to prevent wind erosion of topsoil material-allowing revegetation to occur. Apply erosion agents (e.g. rock armouring) where required. Apply nutrient rich soil that can support revegetation.	D	3	Low	Assume that rehabilitation trials have been conducted.	High
Contamination	Contamination of groundwater (resulting in contaminated site classification by DEC)	D	1	Major	Assume contamination in groundwater presents a threat to ecological health.	Ongoing groundwater monitoring throughout operations and closure and rehabilitation. Early intervention and mitigation if any breaches in criteria are observed.	D	3	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Rehabilitation	Revegetation failure due to insufficient soil type/nutrients	D	2	Medium	Assume use of topsoil where available.	Topsoil will be stripped and the area will be re-spread with adequate topsoil and fertilised where necessary.	E	2	Low	Assume that rehabilitation trials have been conducted.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Revegetation failure due to inadequate soil structure (high erosion and compaction vegetation unable to establish)	D	2	Medium	Assume soil has been treated following respread of topsoil.	Soil will be stripped and land will be deep ripped, prior to respread of adequate topsoil. Planting with local provenance will be undertaken.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to insufficient water availability	D	2	Medium	Assume soil has been treated following respread of topsoil.	Rehabilitated areas will be irrigated as required within the first year of planting to promote revegetation.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
Mine Pit Lakes	Potential for groundwater contamination from pit lake infiltration	C	2	Major	Assume geochemical assessment of surface and groundwater.	Conduct investigations into ways to mitigate pit lakes as per DMP guidance. Possible options include backfilling to eliminate standing water, or remediating water to be of suitable quality.	C	2	Major		Low
	Public safety risk from open pit lakes left on site	C	1	Major	Final mine pits lakes will be left open.	Former pit areas will be securely fenced and signposted to restrict human entry.	D	2	Medium		Reasonable
	Potential fauna deaths as grazing animals are attracted to the area	C	2	Major		Fences will be erected to ensure safe access to the area by fauna is achieved.	D	2	Medium		High
Monitoring	Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages)	C	2	Major	Consultation with DMP and DEC has been undertaken throughout operational and closure activities.	Consult with DMP and DEC to receive approval of planned monitoring frequency. Ensure monitoring plan executed at stated frequency.	D	2	Medium		High
Acid and metalliferous drainage	Contamination of groundwater downstream of backfilled pits and waste dumps	C	2	Major	Assume contaminated groundwater presents a threat to ecological health	Ongoing groundwater monitoring throughout operations and closure and rehabilitation. Early intervention and mitigation if any breaches in criteria are observed.	D	2	Medium	Waste rock characterisation has been implemented, indicating waste material is benign in nature. Additional characterisation will be undertaken prior to mine closure.	High

Table 8 Supporting infrastructure closure risk assessment

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Vertebrate Fauna	Disturbance or degradation of habitat of significant fauna	C	2	Major	No clearing will be conducted during decommissioning and closure. Earthworks during decommissioning and closure will be in areas that have already been disturbed.	any significant habitats/vegetation communities should remain clearly demarcated by means of fencing and signage during closure and rehabilitation activities	E	2	Low	No further clearing activities are required as part of closure and rehabilitation activities.	High
	Direct fauna death as a result of decommissioning and rehabilitation activities (vehicle strike, fauna entrapment, contamination)	C	4	Low	Vehicle use on site after mine closure will be significantly reduced.	Enforce vehicle speed limits on site by means of appropriate signage and personnel education. Ensure all open areas including drill holes are fenced adequately, decommissioned and rehabilitated (in accordance with tenement conditions) to prevent fauna access and fenced appropriately (not with barbed wire).	C	4	Low	Speed limits are adhered to on site with adequate signage erected.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Fauna decline through uncontrolled species introduction post-closure (weeds, competing fauna, pests)	D	2	Major	Introduced fauna and weeds are already present on site.	Ensure appropriate management of waste to avoid fauna being attracted to the area during closure and rehabilitation. Reduce chances of adding new weed species by ensuring revegetation stock only contains endemic native species. Undertake "weed and seed" checks during decommissioning. Weed treatment with agreed upon pesticides where required. Develop a post-closure weed monitoring program to monitor weed infestations and mitigation success.	D	3	Low		High
Stygofauna	Contamination of Stygofauna habitat through leaching of hydrocarbons and chemicals post-mining.	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater contamination, remedial action will be determined based on the severity of contamination. Ongoing groundwater quality monitoring will be undertaken to ensure water quality is consistent with baseline parameters. Should monitoring trigger contamination, remedial actions will be developed on a case by case basis.	E	3	Very low	Ongoing groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Troglofauna	Indirect impacts to Troglofauna through leaching of hydrocarbons and chemicals	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater or soil contamination, remedial action will be determined based on the severity of contamination. Groundwater and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Ongoing soil and groundwater monitoring will be undertaken to determine the extent of contamination post-closure.	High
Short Range Endemics	Disturbance and/or permanent degradation of SRE habitat through ground disturbance and excavation	D	3	Low	No clearing or earthworks will be conducted during decommissioning and closure. Earthworks during decommissioning and closure will be in areas that have already been disturbed.	Educate site personnel as to clearing allowances and boundaries stipulated in EIA. Final landforms will be developed as close to the pre-mining landscape as possible.	E	3	Very low		High
Flora and Vegetation	Loss of flora species and vegetation of significance due to unapproved clearing during closure and rehabilitation activities.	D	3	Low	No clearing will be conducted during decommissioning and closure. Earthworks during decommissioning and closure will be in areas that have already been disturbed.	Educate site personnel as to clearing allowances and boundaries stipulated. Any significant habitats/vegetation communities should remain clearly demarcated by means of fencing and signage during closure and rehabilitation activities	E	3	Very low	Clearing is undertaken in accordance with EIA conditions.	High.

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	B	3	Major	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	C	3	Medium	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High
	Death of individual plants as a result of dust deposition	C	3	Medium	Dust generating activity on site will be reduced significantly during closure, decommissioning and rehabilitation.	In times of increased activity (final landform construction) and windy conditions, water trucks will be used. In times of extreme wind and dust generation, rehabilitation activities will stop until such time as winds have decreased.	D	3	Low		High
	Soil, surface water and groundwater contamination resulting in plant deaths.	D	3	Low	Use of hazardous substances on site will be significantly reduced during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of contamination, remedial action will be determined based on the severity of contamination. Groundwater, surface water and soil will be monitored to ensure contamination is not taking place. If contamination does occur, early detection will trigger remedial action to be determined on a case by case basis.	E	3	Very low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
	Vegetation decline through species introduction (weeds and introduced flora)	D	3	Major	Introduced fauna and weeds are already present on site.	Ensure appropriate management of waste to avoid fauna being attracted to the area during closure and rehabilitation. Reduce chances of adding new weed species by ensuring revegetation stock only contains endemic native species. Undertake “weed and seed” checks during decommissioning. Weed treatment with agreed upon pesticides where required. Develop a post-closure weed monitoring program to monitor weed infestations and mitigation success.	D	3	Low		High
Surface water	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	B	3	Major	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	C	3	Medium	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Contamination of surface water sources through use of chemicals and hydrocarbons on site	C	3	Medium	Activities undertaken during closure and decommissioning will be utilising significantly reduced chemicals and hydrocarbons potentially resulting in contamination of the receiving environment.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Surface water will be monitored throughout operations and closure and rehabilitation. If contamination does occur, early detection will trigger remedial action.	D	3	Low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Groundwater	Groundwater contamination from closure and rehabilitation activities.	C	3	Medium	No dewatering and abstraction activities will be undertaken during closure and rehabilitation activities.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. In the event of groundwater contamination, remedial action will be determined based on the severity of contamination. Ongoing groundwater quality monitoring will be undertaken to ensure water quality is consistent with baseline parameters. Should monitoring trigger contamination, remedial actions will be developed on a case by case basis.	D	3	Low		High
Soil	Erosion of topsoil and dispersive material from final landforms	C	3	Medium	Assume that regular prevailing winds affect the region.	Initial wetting to prevent wind erosion of topsoil material-allowing revegetation to occur. Apply erosion agents to waste dumps (e.g. rock armouring) Apply nutrient rich soil that can support revegetation.	D	3	Low	Assume that rehabilitation trials have been conducted.	High
	Soil compaction resulting from project operational and hardstand areas	C	3	Medium		Removal of hardstand areas followed by deep ripping of compacted soil. Nutrient rich topsoil will be re-spread over the area to facilitate revegetation of the area.	D	3	Low	Assume that rehabilitation trials have been conducted.	High
	Soil contamination through hydrocarbon and chemical use on site post operations.	D	2	Medium		Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Contaminated soil will be removed from site and disposed of by a licensed contractor. If contamination does occur, early detection will trigger remedial action.	D	2	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Contamination	Surface water contamination post-closure	D	2	Medium	Assumes that regular surface water parameters are within baseline surface water parameters.	If contaminated water levels are recorded, early detection will trigger remedial action that will be determined in consultation with DoW.	D	2	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	Reasonable
	Contamination of groundwater (resulting in contaminated site classification by DEC)	D	1	Major	Assume contamination in groundwater presents a threat to ecological health.	Ongoing groundwater monitoring throughout operations and closure and rehabilitation. Early intervention and mitigation if any breaches in criteria are observed.	D	3	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Surface soil contamination around plant equipment and storage areas (resulting in contaminated site classification by DEC)	D	1	Major	Potentially contaminating equipment will be removed from site during decommissioning and closure, so any contamination events would be isolated.	Area around plant and equipment should be checked for surface soil impacts as part of closure and decommissioning. If contamination is found, it will be removed immediately.	D	3	Very Low	Any surface soil contamination around plant or plant equipment following closure will likely be easy to remove.	High
	Contamination from improper decommissioning of waste water treatment plant	C	3	Medium	Assume ponds have been constructed from construction.	Undertake groundwater monitoring around WWTP. Sample soil from underneath ponds when ponds are decommissioned. If contamination (in groundwater or soil) has occurred, take remedial action.	D	3	Low		High
	Contamination from improper containment and decommissioning of landfills on site	C	2	Major	No evidence of landfill being constructed.	Capping and revegetation of landfill area will reduce influence of rainfall on leaching of contaminants. Monitoring of groundwater surrounding landfill area will allow early detection of any contamination. If contamination is detected, remedial measures will be instigated.	D	3	Low		
Rehabilitation	Revegetation failure due to insufficient soil type/nutrients	D	2	Medium	Assume use of topsoil where available.	Topsoil will be stripped and the area will be re-spread with adequate topsoil and fertilised where necessary.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to inadequate soil structure (high erosion and compaction vegetation unable to establish)	D	2	Medium	Assume soil has been treated following respread of topsoil.	Soil will be stripped and land will be deep ripped, prior to respread of adequate topsoil. Planting with local provenance will be undertaken.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to insufficient water availability	D	2	Medium	Assume soil has been treated following respread of topsoil.	Rehabilitated areas will be irrigated as required within the first year of planting to promote revegetation.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Instability of final landforms resulting in public injury and fauna injury and/or death.	D	1	Major	Assumed appropriate geotechnical investigations have been undertaken.	Final landforms will be re-contoured to ensure stability. Further geotechnical investigations will be undertaken to ensure stability of final landforms. Rehabilitation will follow including respreading of topsoil, deep ripping and planting with local provenance seeds.	D	1	Major		Reasonable
Monitoring	Monitoring frequency inadequate (resulting in potential contamination or rehabilitation failure not detected in early stages)	C	2	Major	Consultation with DMP and DEC has been undertaken throughout operational and closure activities.	Consult with DMP and DEC to receive approval of planned monitoring frequency. Ensure monitoring plan executed at stated frequency.	D	2	Medium		High

Table 9 Social impacts closure risk assessment

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
Cultural / Heritage	Disturbance of Indigenous heritage sites/values, outside of approved Section 18 specifications	D	2	Medium	Assume Section 18 covers all areas that are accessed under mining proposals. Assume closure activities would not disturb additional heritage sites/values.	Educate personnel about boundaries. Educate personnel about how to identify a heritage site	E	2	Low		High
Surface water	Changes to ecosystem values and flora and vegetation composition as a result of altered surface water regimes (reinstatement of natural surface water drainage).	B	3	Major	Diverted creeks will be diverted back to the pre-mining surface water regimes (except for 13 and Davidson creek).	Ensure all bunding and non-permanent surface water management structures are removed and/or retained as required. Ensure adequate drainage pathways are maintained during landform decommissioning. Install permanent bunds, should monitoring identify surface water pooling or significant sediment deposition.	C	3	Medium	Sufficient surface water modelling has been undertaken to assess impacts of the creek diversion.	High
	Contamination of surface water sources through use of chemicals and hydrocarbons on site	C	3	Medium	Activities undertaken during closure and decommissioning will be utilising significantly reduced chemicals and hydrocarbons potentially resulting in contamination of the receiving environment.	Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Surface water will be monitored throughout operations and closure and rehabilitation. If contamination does occur, early detection will trigger remedial action.	D	3	Low	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Groundwater	Alteration of groundwater levels (recovery after water abstraction and dewatering activities)	B	3	Major		Groundwater levels will be monitored throughout operations and throughout the closure, decommissioning and rehabilitation stage of the project.	B	3	Major	Groundwater modelling has been undertaken and will be updated as information comes available.	Reasonable
	Loss of water supply to the Jigalong Aboriginal Community and surrounding station bores	D	1	Major		A groundwater monitoring program will be developed as part of the EIA approvals process to ensure there is sufficient available groundwater.	D	1	Major	Sufficient dewatering modelling has been undertaken.	Reasonable
	Contamination of groundwater through leaching of residue material and chemicals post-mining	D	2	Medium	Assume RSF is constructed to contain potential leaching.	If residue leaching does occur, a remediation program will be developed in consultation with relevant authorities. Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards.	D	2	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	Reasonable
Soil	Erosion of topsoil and dispersive material from final landforms	C	3	Medium	Assume that regular prevailing winds affect the region.	Initial wetting to prevent wind erosion of topsoil material-allowing revegetation to occur. Apply erosion agents to waste dumps (e.g. rock armouring) Apply nutrient rich soil that can support revegetation.	D	3	Low	Assume that rehabilitation trials have been conducted.	High

Aspect	Potential impacts	Highest Likelihood	Highest Consequence	Inherent risk	Assumptions/comments	Potential mitigation	Highest Likelihood	Highest Consequence	Residual risk	Assumptions/comments	Confidence level
	Soil contamination through hydrocarbon and chemical use on site post operations.	D	2	Medium		Hydrocarbons and chemicals will be stored in lined, bunded containers and appropriate facilities consistent with the *Dangerous Goods Safety Act 2004* and Australian Standards. Contaminated soil will be removed from site and disposed of by a licensed contractor. If contamination does occur, early detection will trigger remedial action.	D	2	Medium	Hydrocarbon and chemicals are stored in accordance with site management procedures	High
Rehabilitation	Revegetation failure due to insufficient soil type/nutrients	D	2	Medium	Assume use of topsoil where available.	Topsoil will be stripped and the area will be re-spread with adequate topsoil and fertilised where necessary.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to inadequate soil structure (high erosion and compaction vegetation unable to establish)	D	2	Medium	Assume soil has been treated following respread of topsoil.	Soil will be stripped and land will be deep ripped, prior to respread of adequate topsoil. Planting with local provenance will be undertaken.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
	Revegetation failure due to insufficient water availability	D	2	Medium	Assume soil has been treated following respread of topsoil.	Rehabilitated areas will be irrigated as required within the first year of planting to promote revegetation.	E	2	Low	Assume that rehabilitation trials have been conducted.	High
Backfilled pits and waste dumps	Insufficient rehabilitation of waste dumps, plant area and village area (visual amenity legacy)	E	3	Very Low	Assumed appropriate geotechnical investigations have been undertaken.	Ensure that all plant and equipment are taken off site at decommissioning. Ensure revegetation of plant area is established and monitored.	E	2	Very Low	Assume soil has been treated following respread of topsoil.	High
	Public injury from incorrect or incomplete decommissioning and rehabilitation.	C	1	Major		Former pit areas should be securely fenced and signposted to restrict access.	D	2	Medium		Reasonable
	Instability of backfilled pits and waste dumps resulting in public injury and fauna injury and/or death.	D	1	Major	Assumed appropriate geotechnical investigations have been undertaken.	Final landforms will be re-contoured to ensure stability. Further geotechnical investigations will be undertaken to ensure stability of final landforms. Rehabilitation will follow including respreading of topsoil, deep ripping and planting with local provenance seeds.	D	1	Major		Reasonable
Mine Pit Lakes	Potential for groundwater contamination from pit lake infiltration	C	2	Major	Assume geochemical assessment of surface and groundwater.	Conduct investigations into ways to mitigate pit lakes as per DMP guidance. Possible options include backfilling to eliminate standing water, or remediating water to be of suitable quality.	C	2	Major		Low
	Public safety risk from open pit lakes left on site	C	1	Major	Final mine pits lakes will be left open.	Former pit areas will be securely fenced and signposted to restrict human entry.	D	2	Medium		Reasonable

Table 10 Measures of likelihood

Level	Descriptor	Description	Frequency
A	Almost certain	Is expected to occur in most circumstances Common repeating occurrence	Once per week
B	Likely	Will probably occur in most circumstances Known to occur	Once per month
C	Possible	Could occur Might occur at some time	Once per year
D	Unlikely	Could occur but not expected Not likely to occur	Once per ten years
E	Rare	Occurs only in exceptional circumstances Unheard of	Once in mine life

Table 11 Measures of consequence

Rating	Descriptor	Potential Areas of Impact				
		Environment	**Public Safety**	**Cultural**	**Financial**	**Corporate Reputation**
1	Catastrophic	Very significant long-term impact/s off site. Legal action taken against company Company not released from liability following operations	Fatality	Major impact to Indigenous or European cultural sites/values resulting in permanent loss of cultural value (permanent damage to one or more restricted sites, cause of cultural community outrage, breach of statutory obligations, permanent damage to cultural relationship)	Financial loss: exceeding $1 Million	Permanent damage to company reputation, outraged stakeholders, permanent damage to community values
2	Major	Serious long-term impact/s offsite License conditions breached Lengthy delay in release from liability following operations	Injury resulting in permanent disability	Major impact to Indigenous or European cultural sites/values (damage to restricted site, cause of cultural community outrage, negative media coverage, medium term damage to cultural relationship)	Financial loss: $500,000 to $1 Million	Major damage to company reputation, stakeholder mistrust, community values significantly diminished
3	Significant / Moderate	Serious, medium-term impact/s extending off site, but generally contained on site. Delay in release from liability following operations	Lost time injury	Impacts to Indigenous or European cultural sites/values requiring some management (accessing restricted site, minor deterioration in cultural relationship)	Financial loss: $100,000 to $500,000	Moderate impact to company reputation, requiring management of stakeholder and community relationship
4	Minor	Minor short-term impact/s on site only.	Minor injury, medical treatment required	Minor impact to Indigenous or European cultural sites/values (accessing restricted site)	Financial loss: $10,000 to $100,000	Minor impact to company reputation, stakeholder inconvenience
5	Negligible	Limited impact/s to minimal area on site.	Minor injury, no medical treatment required	Minimal impact to Indigenous or European cultural sites/values	Financial loss: Less than $10,000	No impacts, positive company reputation

Table 12 Risk ranking matrix

		Likelihood				
		A Almost certain	B Likely	C Possible	D Unlikely	E Rare
Consequence	1 Catastrophic					
	2 Major					
	3 Significant/Moderate					
	4 Minor					
	5 Negligible					

Risk level	Response
Very Low	Acceptable risk.
Low	Application of management measures will ensure risk level remains low.
Medium	Development of site specific management measures will be required to lower risk level. Prescription of environmental outcomes (e.g. Environmental Conditions) may be necessary.
Major	Development of site specific management measures will be required to lower risk level. Prescription of environmental outcomes (e.g. Environmental Conditions) considered necessary.
Extreme	Potentially unacceptable. Massive mitigation required.

Table 13 Confidence level definitions

High confidence	Several expert investigations/studies. Excellent survey data. Long-term monitoring results available.
Reasonably confident	Survey data available from one expert. Short-term monitoring results available. No site-specific information/data available but able to translate information/data from other similar operations.
Low certainty/confidence	No survey data. Unable to translate information/data from other similar operations.

Appendix 4
Pit schedule

Scheduled Total Tonnage

Scheduled Total Tonnage	Period Beginning	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Total	P(80%)	Description
DC1		0	0	26,324,427	49,397,977	927,640	0	0	0	0	0	0	0	0	0	0	0	76,650,044	40,168,557	DC1
DC2		0	0	4,765,299	15,612,355	16,000,000	0	0	0	0	0	0	0	0	0	0	0	36,377,654	15,844,942	DC2
DC3		0	0	0	16,951,978	62,000,000	26,609,913	0	0	0	0	0	0	0	0	0	0	105,561,890	47,843,965	DC3
DC4		0	0	0	0	10,080,555	65,038,172	25,896,927	0	0	0	0	0	0	0	0	0	101,015,654	49,381,674	DC4
DC5		0	0	0	0	893,769	10,142,311	50,000,000	21,297,921	0	0	0	0	0	0	0	0	82,334,002	32,778,753	DC5
DC6		0	0	0	0	0	0	0	0	563,801	3,348,304	65,251,632	16,903,038	9,122,645	0	0	0	95,189,421	26,572,757	DC6
DC7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DC7
DC8		0	0	0	0	0	0	0	0	0	0	0	0	11,647,778	8,508,268	0	0	20,156,046	11,019,876	DC8
DC9		0	0	0	0	0	0	0	43,670,207	23,878,522	0	0	0	0	0	0	0	67,548,729	39,711,870	DC9
DC10		0	0	0	0	0	0	0	0	0	0	0	18,928,085	0	0	0	0	18,928,085	18,928,085	DC10
DC11		0	0	0	0	0	0	0	0	0	0	0	11,529,932	0	0	0	0	11,529,932	11,529,932	DC11
DC12		0	0	0	0	0	0	0	10,933,203	50,000,000	48,299,286	10,206,498	0	0	0	0	0	119,438,988	48,979,572	DC12
DCSpare		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DCSpare
RR1		0	0	6,566,117	10,398,402	9,916,823	11,644,863	0	0	0	0	0	0	0	0	0	0	38,526,205	10,896,986	RR1
RR2		0	0	0	0	0	1,305,774	25,000,000	5,823,381	305,018	0	0	0	0	0	0	0	32,434,173	13,494,029	RR2
RR3		0	0	0	0	0	378,380	15,000,000	13,418,470	12,652,139	3,054,816	0	0	0	0	0	0	44,503,805	13,734,776	RR3
RR4		0	0	0	0	0	0	0	0	2,258,557	34,955,631	18,302,979	3,520,545	0	0	0	0	59,037,712	24,964,040	RR4
RRET		4,566,674	6,088,899	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,655,573	5,784,454	RRET
MM1		0	0	0	0	0	0	0	20,753,745	26,238,891	26,238,890	22,135,818	65,015,327	35,000,000	26,173,959	0	0	221,556,630	33,247,778	MM1
Total		**4,566,674**	**6,088,899**	**37,655,843**	**92,360,712**	**99,818,787**	**115,119,413**	**115,896,927**	**115,896,927**	**115,896,927**	**115,896,927**	**115,896,927**	**115,896,927**	**55,770,423**	**34,682,227**	**0**	**0**	**1,141,444,542**	115,896,927	Total
Total with Waste Re-Mine		**4,566,674**	**6,088,899**	**37,655,843**	**92,360,712**	**99,818,787**	**115,119,413**	**115,896,927**	**115,896,927**	**115,896,927**	**115,896,927**	**115,896,927**	**115,896,927**	**55,770,423**	**34,682,227**	**0**	**0**	**1,141,444,542**	115,896,927	Total with Waste Re-Mine

Scheduled Waste Tonnage

Scheduled Waste Tonnage	Period Beginning	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Total	P(80%)	Description
DC1		0	0	26,090,279	38,763,847	315,289	0	0	0	0	0	0	0	0	0	0	0	65,169,415	33,694,420	DC1
DC2		0	0	4,765,299	14,762,877	11,839,218	0	0	0	0	0	0	0	0	0	0	0	31,367,393	13,593,413	DC2
DC3		0	0	0	16,943,287	51,121,941	19,536,658	0	0	0	0	0	0	0	0	0	0	87,601,886	38,487,828	DC3
DC4		0	0	0	0	10,080,555	58,204,204	15,868,502	0	0	0	0	0	0	0	0	0	84,153,261	41,269,923	DC4
DC5		0	0	0	0	893,769	10,126,157	44,410,745	14,256,761	0	0	0	0	0	0	0	0	69,687,432	26,318,355	DC5
DC6		0	0	0	0	0	0	0	0	563,176	3,344,592	54,199,693	10,534,755	6,177,754	0	0	0	74,819,970	19,267,742	DC6
DC7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DC7
DC8		0	0	0	0	0	0	0	0	0	0	0	0	11,485,974	5,685,898	0	0	17,171,872	10,325,959	DC8
DC9		0	0	0	0	0	0	0	35,388,457	13,086,427	0	0	0	0	0	0	0	48,474,885	30,928,051	DC9
DC10		0	0	0	0	0	0	0	0	0	0	0	15,660,690	0	0	0	0	15,660,690	15,660,690	DC10
DC11		0	0	0	0	0	0	0	0	0	0	0	10,420,999	0	0	0	0	10,420,999	10,420,999	DC11
DC12		0	0	0	0	0	0	0	10,921,245	44,534,544	36,134,450	5,791,101	0	0	0	0	0	97,381,340	39,494,488	DC12
DCSpare		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DCSpare
RR1		0	0	5,874,783	9,118,956	7,411,444	7,260,646	0	0	0	0	0	0	0	0	0	0	29,665,828	8,094,449	RR1
RR2		0	0	0	0	0	1,302,116	22,132,541	4,002,724	103,531	0	0	0	0	0	0	0	27,540,912	11,254,651	RR2
RR3		0	0	0	0	0	378,380	13,689,268	10,836,041	8,620,842	1,692,445	0	0	0	0	0	0	35,216,977	11,406,687	RR3
RR4		0	0	0	0	0	0	0	0	2,258,557	31,959,033	13,656,359	1,962,299	0	0	0	0	49,836,248	20,977,428	RR4
RRET		3,224,812	2,355,384	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,580,197	3,050,927	RRET
MM1		0	0	0	0	0	0	0	20,753,745	26,238,891	26,238,890	21,990,718	56,908,005	19,258,355	8,818,137	0	0	180,206,741	26,238,891	MM1
Total		3,224,812	2,355,384	36,730,361	79,588,966	81,662,216	96,808,160	96,101,056	96,158,973	95,405,969	99,369,411	95,637,871	95,486,747	36,922,083	14,504,034	0	0	929,956,045	Total	Total

Scheduled Ore Tonnage

Scheduled Ore Tonnage	Period Beginning	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Total	P(80%)	Description
DC1		0	0	195,635	9,393,611	577,692	0	0	0	0	0	0	0	0	0	0	0	10,166,938	5,867,244	DC1
DC2		0	0	0	725,072	3,924,697	0	0	0	0	0	0	0	0	0	0	0	4,649,770	3,284,772	DC2
DC3		0	0	0	3,256	9,391,678	6,737,762	0	0	0	0	0	0	0	0	0	0	16,132,696	8,330,112	DC3
DC4		0	0	0	0	0	5,841,167	9,672,082	0	0	0	0	0	0	0	0	0	15,513,249	8,905,899	DC4
DC5		0	0	0	0	0	5,605	4,880,087	6,764,394	0	0	0	0	0	0	0	0	11,650,085	6,010,671	DC5
DC6		0	0	0	0	0	0	0	0	0	0	9,978,938	6,129,040	2,819,652	0	0	0	18,927,631	8,438,979	DC6
DC7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DC7
DC8		0	0	0	0	0	0	0	0	0	0	0	0	113,448	1,899,498	0	0	2,012,946	1,542,288	DC8
DC9		0	0	0	0	0	0	0	7,191,845	10,065,930	0	0	0	0	0	0	0	17,257,775	9,491,113	DC9
DC10		0	0	0	0	0	0	0	0	0	0	0	2,841,305	0	0	0	0	2,841,305	2,841,305	DC10
DC11		0	0	0	0	0	0	0	0	0	0	0	957,048	0	0	0	0	957,048	957,048	DC11
DC12		0	0	0	0	0	0	0	9,784	4,891,770	10,594,398	4,159,183	0	0	0	0	0	19,655,135	7,172,821	DC12
DCSpare		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DCSpare
RR1		0	0	580,416	1,089,494	2,260,802	4,008,459	0	0	0	0	0	0	0	0	0	0	7,939,171	2,959,865	RR1
RR2		0	0	0	0	0	2,822	2,570,920	1,672,004	191,123	0	0	0	0	0	0	0	4,436,869	2,031,571	RR2
RR3		0	0	0	0	0	0	1,107,154	2,327,996	3,808,877	1,269,169	0	0	0	0	0	0	8,513,195	2,920,348	RR3
RR4		0	0	0	0	0	0	0	0	0	2,764,036	4,231,533	1,444,508	0	0	0	0	8,440,076	3,351,035	RR4
RRET		1,165,538	3,421,367	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,586,906	2,970,202	RRET
MM1		0	0	0	0	0	0	0	0	0	0	124,115	6,550,559	14,411,255	16,534,547	0	0	37,620,476	15,260,572	MM1
Total		1,165,538	3,421,367	776,051	11,211,434	16,154,869	16,595,814	18,230,242	17,966,023	18,957,701	14,627,603	18,493,769	17,922,460	17,344,355	18,434,045	0	0	191,301,271	Total	Total

Scheduled Mineralised Waste Tonnage

Scheduled Mineralised Waste Tonnage	Period Beginning	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Total	P(80%)	Description
DC1		0	0	38,513	1,240,519	34,659	0	0	0	0	0	0	0	0	0	0	0	1,313,691	759,717	DC1
DC2		0	0	0	124,406	236,085	0	0	0	0	0	0	0	0	0	0	0	360,491	213,749	DC2
DC3		0	0	0	5,434	1,486,380	335,493	0	0	0	0	0	0	0	0	0	0	1,827,308	1,026,025	DC3
DC4		0	0	0	0	0	992,801	356,344	0	0	0	0	0	0	0	0	0	1,349,144	865,509	DC4
DC5		0	0	0	0	0	10,550	709,169	276,766	0	0	0	0	0	0	0	0	996,484	536,208	DC5
DC6		0	0	0	0	0	0	0	0	625	3,712	1,073,001	239,243	125,239	0	0	0	1,441,820	405,995	DC6
DC7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DC7
DC8		0	0	0	0	0	0	0	0	0	0	0	0	48,355	922,873	0	0	971,228	747,969	DC8
DC9		0	0	0	0	0	0	0	1,089,905	726,164	0	0	0	0	0	0	0	1,816,069	1,017,157	DC9
DC10		0	0	0	0	0	0	0	0	0	0	0	426,090	0	0	0	0	426,090	426,090	DC10
DC11		0	0	0	0	0	0	0	0	0	0	0	151,885	0	0	0	0	151,885	151,885	DC11
DC12		0	0	0	0	0	0	0	2,175	573,685	1,570,438	256,214	0	0	0	0	0	2,402,512	972,386	DC12
DCSpare		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DCSpare
RR1		0	0	110,918	189,952	244,577	375,759	0	0	0	0	0	0	0	0	0	0	921,206	297,050	RR1
RR2		0	0	0	0	0	837	296,539	148,653	10,364	0	0	0	0	0	0	0	456,392	207,807	RR2
RR3		0	0	0	0	0	0	203,579	254,433	222,419	93,202	0	0	0	0	0	0	773,633	235,225	RR3
RR4		0	0	0	0	0	0	0	0	0	232,562	415,088	113,738	0	0	0	0	761,388	305,572	RR4
RRET		176,323	312,147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	488,470	284,982	RRET

		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027			
MM1		0	0	0	0	0	0	0	0	0	0	20,985	1,556,764	1,330,390	821,275	0	0	3,729,413	1,420,940	MM1
Total		176,323	312,147	149,431	1,560,312	2,001,702	1,715,438	1,565,630	1,771,931	1,533,258	1,899,914	1,765,288	2,487,720	1,503,984	1,744,148	0	0	20,187,226	Total	Total

Schedule Pit Floor mRL	**Period Beginning**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**Minimum**	**Description**
DC1	532	532	532	496	400	388	388	388	388	388	388	388	388	388	388	388	388	388	DC1
DC2	532	532	532	520	472	400	400	400	400	400	400	400	400	400	400	400	400	400	DC2
DC3	532	532	532	532	520	448	364	364	364	364	364	364	364	364	364	364	364	364	DC3
DC4	532	532	532	532	532	520	424	340	340	340	340	340	340	340	340	340	340	340	DC4
DC5	532	532	532	532	532	532	520	436	352	352	352	352	352	352	352	352	352	352	DC5
DC6	532	532	532	532	532	532	532	532	532	532	532	448	424	364	364	364	364	364	DC6
DC7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DC7
DC8	532	532	532	532	532	532	532	532	532	532	532	532	532	496	448	448	448	448	DC8
DC9	532	532	532	532	532	532	532	532	484	424	424	424	424	424	424	424	424	424	DC9
DC10	532	532	532	532	532	532	532	532	532	532	532	532	448	448	448	448	448	448	DC10
DC11	532	532	532	532	532	532	532	532	532	532	532	532	460	460	460	460	460	460	DC11
DC12	532	532	532	532	532	532	532	532	520	496	436	376	376	376	376	376	376	376	DC12
DCSpare	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DCSpare
RR1	606	606	606	570	558	534	474	474	474	474	474	474	474	474	474	474	474	474	RR1
RR2	594	594	594	594	594	594	570	510	474	474	474	474	474	474	474	474	474	474	RR2
RR3	582	582	582	582	582	582	582	558	522	486	462	462	462	462	462	462	462	462	RR3
RR4	582	582	582	582	582	582	582	582	582	570	534	486	462	462	462	462	462	462	RR4
RRET	582	570	546	546	546	546	546	546	546	546	546	546	546	546	546	546	546	546	RRSpare
MM1	524	524	524	524	524	524	524	524	512	500	488	476	428	392	320	320	320	320	

Schedule Vertical Advance	**Period Beginning**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**Minimum**	**Description**
DC1		0	0	36	96	12	0	0	0	0	0	0	0	0	0	0	0	96	DC1
DC2		0	0	12	48	72	0	0	0	0	0	0	0	0	0	0	0	72	DC2
DC3		0	0	0	12	72	84	0	0	0	0	0	0	0	0	0	0	84	DC3
DC4		0	0	0	0	12	96	84	0	0	0	0	0	0	0	0	0	96	DC4
DC5		0	0	0	0	0	12	84	84	0	0	0	0	0	0	0	0	84	DC5
DC6		0	0	0	0	0	0	0	0	0	0	84	24	60	0	0	0	84	DC6
DC7		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DC7
DC8		0	0	0	0	0	0	0	0	0	0	0	0	36	48	0	0	48	DC8
DC9		0	0	0	0	0	0	0	48	60	0	0	0	0	0	0	0	60	DC9
DC10		0	0	0	0	0	0	0	0	0	0	0	84	0	0	0	0	84	DC10
DC11		0	0	0	0	0	0	0	0	0	0	0	72	0	0	0	0	72	DC11
DC12		0	0	0	0	0	0	0	12	24	60	60	0	0	0	0	0	60	DC12
DCSpare		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DCSpare
RR1		0	0	36	12	24	60	0	0	0	0	0	0	0	0	0	0	60	RR1
RR2		0	0	0	0	0	24	60	36	0	0	0	0	0	0	0	0	60	RR2
RR3		0	0	0	0	0	0	24	36	36	24	0	0	0	0	0	0	36	RR3
RR4		0	0	0	0	0	0	0	0	12	36	48	24	0	0	0	0	48	RR4
RRET		12	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	RRSpare
MM1		0	0	0	0	0	0	0	12	12	12	12	48	36	72	0	0	72	
	Maximum	**12**	**24**	**36**	**96**	**72**	**96**	**84**	**84**	**60**	**60**	**84**	**84**	**60**	**72**	**0**	**0**	**96**	

Schedule Pit Catchment	**Area**	**Period Beginning**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
DC1	560,291		0	0	560291	560291	560291	560291	560291	560291	560291	560291	560291	560291	560291	560291	560291	560291
DC2	205,386		0	0	205386	205386	205386	205386	205386	205386	205386	205386	205386	205386	205386	205386	205386	205386
DC3	605,280		0	0	0	605280	605280	605280	605280	605280	605280	605280	605280	605280	605280	605280	605280	605280
DC4	409,116		0	0	0	0	409116	409116	409116	409116	409116	409116	409116	409116	409116	409116	409116	409116
DC5	403,673		0	0	0	0	403673	403673	403673	403673	403673	403673	403673	403673	403673	403673	403673	403673
DC6	480,603		0	0	0	0	0	0	0	0	480603	480603	480603	480603	480603	480603	480603	480603
DC7			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DC8	223,472		0	0	0	0	0	0	0	0	0	0	0	0	223472	223472	223472	223472
DC9	522,989		0	0	0	0	0	0	0	522989	522989	522989	522989	522989	522989	522989	522989	522989
DC10	215,601		0	0	0	0	0	0	0	0	0	0	0	215601	215601	215601	215601	215601
DC11	156,204		0	0	0	0	0	0	0	0	0	0	0	156204	156204	156204	156204	156204
DC12	765,535		0	0	0	0	0	0	0	765535	765535	765535	765535	765535	765535	765535	765535	765535
DCSpare			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RR1	415,183		0	0	415183	415183	415183	415183	415183	415183	415183	415183	415183	415183	415183	415183	415183	415183
RR2	246,169		0	0	0	0	0	246169	246169	246169	246169	246169	246169	246169	246169	246169	246169	246169
RR3	288,095		0	0	0	0	0	288095	288095	288095	288095	288095	288095	288095	288095	288095	288095	288095
RR4	468,219		0	0	0	0	0	0	0	0	468219	468219	468219	468219	468219	468219	468219	468219
RRET			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MM1	1,270,461		0	0	0	0	0	0	0	1270461	1270461	1270461	1270461	1270461	1270461	1270461	1270461	1270461
Total	7,236,277		0	0	1,180,860	1,786,140	2,598,929	3,133,193	3,133,193	5,692,178	6,641,000	6,641,000	6,641,000	7,012,805	7,236,277	7,236,277	7,236,277	7,236,277

Schedule Backfill	**Area**		**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
DC1	258616	258,616	0	0	0	0	0	0	258,616	258,616	258,616	258,616	258,616	258,616	258,616	258,616	258,616	258,616
DC2	277560	277,560	0	0	0	0	0	0	277,560	277,560	277,560	277,560	277,560	277,560	277,560	277,560	277,560	277,560
DC3	254738	254,738	0	0	0	0	0	0	0	254,738	254,738	254,738	254,738	254,738	254,738	254,738	254,738	254,738
DC4	430360	430,360	0	0	0	0	0	0	0	0	0	0	0	430,360	430,360	430,360	430,360	430,360
DC5	606040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DC6	837035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DC7																		
DC8	171659	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DC9	574802	574,802	0	0	0	0	0	0	0	0	0	0	0	0	574,802	574,802	574,802	574,802
DC10	215601	215,601	0	0	0	0	0	0	0	0	0	0	0	0	0	0	215,601	215,601
DC11	156204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DC12	765535	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DCSpare																		
RR1	237,875	237,875	0	0	0	0	0	0	0	237,875	237,875	237,875	237,875	237,875	237,875	237,875	237,875	237,875
RR2	258,568	258,568	0	0	0	0	0	0	0	0	0	0	258,568	258,568	258,568	258,568	258,568	258,568
RR3	453004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RR4	468219	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RRET																		

MM1	0																
Total	5,965,816	0	0	0	0	0	0	536,176	1,028,789	1,028,789	1,028,789	1,287,357	1,717,717	2,292,519	2,292,519	2,508,120	2,508,120
Unfilled Area	1,270,461	0	0	1,180,860	1,786,140	2,598,929	3,133,193	2,597,017	4,663,389	5,612,211	5,612,211	5,353,643	5,295,088	4,943,758	4,943,758	4,728,157	4,728,157

Appendix 5
FPP Closure task register
(Implementation Strategy)

Table 1 Operational area closure ROM pad and ore stockpiles

Operational area factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Soil contamination	• To comply with the *Contaminated Sites Act 2003*.	• Revegetation failure due to insufficient soil nutrients and or/contamination. • Contamination through hydrocarbon and chemical use at the operational area. • Incorrect disposal of wastes leading to contamination of soils, surface and groundwater and a decrease in surrounding environmental values • Soil contamination resulting in infiltration to groundwater or run-off into surface water expressions. • Surface soil contamination around plant equipment and storage areas (resulting in contaminated site classification by DEC).	<u>Investigations to date:</u> • Soil-chemical characterisation of the Project area has been undertaken to determine baseline chemical parameters. Prior to the commencement of closure activities, further soil-chemical characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. • Waste rock characterisation has confirmed no potentially or acid forming material present. Prior to the commencement of closure activities additional waste rock characterisation will be undertaken to determine the acid-forming potential of material post-mining. <u>Planned Investigations/activities:</u> • Ongoing soil monitoring will be undertaken to ensure soil-chemical parameters are at baseline levels. A preliminary monitoring program will be developed and further refined and incorporated into the next revision of the Closure Plan. • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the potential contaminated nature of soil), rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Maintain a register of contamination occurring at the operational area. Areas where contamination has occurred will be remediated appropriately	• Contaminant levels in soil are at or below background concentrations, and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • No evidence of residue storage facilities, explosives storage or other potential source of contamination on site. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	As investigations continue throughout the life of the mine, closure and rehabilitation strategies are likely to be updated to reflect the increased knowledge base. Based on the current level of understanding, the closure and rehabilitation strategy of the operational area will involve the following: • ROM pad and ore stockpile infrastructure will be dismantled on site and removed off-site by a licensed contractor and disposed of appropriately • chemicals will be removed from site and disposed of by appropriate means by licensed contractors • hard stand areas will be removed and all associated infrastructure • contaminated soil will either be decontaminated on-site or removed off-site by a licensed contractor for remediation • any contamination will be reported and corrective actions taken in response to DEC or other appropriate regulatory authorities • reshaping and re-contouring the landscape to be consistent with surrounding relief and drainage. Ongoing management will be undertaken in accordance with the surface water management plan to be developed for post-mining activities • surfaces will be rehabilitated with topsoil and ripped and revegetated utilising local provenance seed in accordance with a provenance zone management strategy, rehabilitation will also add to slope stability and reduce erosion of the final landforms • local provenance seed will be used, dependent upon availability; with provenance collection management based on 'zones' according to the species characteristics (e.g. abundance, distribution, recalcitrance) • topsoils used in rehabilitation will be managed to ensure that nutrient levels are appropriate to support plant growth (e.g. fertiliser may be applied if required)
Soil stability	Erosion of soil materials does not occur at rates in excess of examples in the natural surrounding landscape.	• Revegetation failure due to inadequate soil structure (high erosion and compaction, vegetation unable to establish). • Erosion of topsoil and dispersive material from final landforms. • Soil compaction from prolonged project activities and hardstand areas. • Final landform design is ineffective in retaining local provenance seeds and therefore increasing erosion.	<u>Investigations to date:</u> • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. <u>Planned Investigations/activities:</u> • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further.	Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	

Operational area factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Surface water	• Surface water drainage is implemented to achieve a safe, stable landform with low risk of erosion, consistent with the surrounding landscape. • Natural ecosystems are maintained after permanent diversion of creek-lines.	• Contamination of surface water sources through use of chemicals and hydrocarbons on site • Increased sediment loads after re-instatement of natural surface water drainage.	Investigations to date: • Baseline surface water assessments are currently being undertaken to determine baseline drainage conditions and water quality parameters of surface water from the Project Area. • Assessment of potential stormwater flows from peak storm events at FPP are currently underway and will be incorporated into the next revisions of the Closure Plan. Planned Investigations/activities: • Water quality sampling will be undertaken throughout the life of the Project, including during rehabilitation activities. • A post-mining surface water management plan will be developed focused on maintaining re-established flows.	• Contours of the final landform reflect the contours, and drainage patterns, of the pre mining landscape (in relation to stability and geometry) as defined in design specifications to be developed. • Natural ecosystems have been re-established and maintained after permanent diversion of creek-lines in accordance with floral species richness, diversity coverage, weed species number, weed density, landform and soil stability targets to be developed. • No contamination (in relation to level of contamination present) downstream of FPP area.	
Groundwater	• Final groundwater quality (in relation to level of contaminants present) is equivalent to pre-mining levels. • No potential for off-site groundwater contamination.	• Contamination of groundwater (resulting in contaminated site classification by DEC). • Contamination of groundwater resulting in downstream impacts to the Jigalong community and the surrounding environment	Investigations to date: • Monitoring of baseline groundwater quality parameters is currently underway and will be developed further in consultation with the DoW. Planned Investigations/activities: • Baseline water quality parameters will be monitored throughout both the mining and closure and rehabilitation stages of the Project at a number of bores, to be determined in consultation with DoW. • A post-mining groundwater management plan will be developed focused on groundwater recovery. • Develop a procedure for provision of water to the Jigalong community, should there be a reduction in supply.	• Groundwater levels have returned to pre-dewatering levels, comparable to regional levels. • Contaminant levels in groundwater are at agreed levels, to be developed in consultation with DoW and DEC. Water quality parameters will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Contamination levels in groundwater downstream of the project are at or below background concentrations (in relation to contaminant present) and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Groundwater abstraction bores are decommissioned.	
Biodiversity	• Rehabilitated ecosystems are self-sustaining with the ability to support a range of fauna species known from the site prior to disturbance.	• Soil, surface water and groundwater contamination resulting in death of flora and fauna. • Increased weed species introduced on site through closure and rehabilitation activities. • Revegetation failure due to insufficient soil nutrients and or/contamination.	Investigations to date: • Flora and fauna assessments have been undertaken to identify all significant species occurring and with the potential to occur in the Project area. Where required, specific management plans will be developed as part of the EIA process and implemented on site throughout the life of the Project, including during rehabilitation activities. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials, rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Assess stockpiled topsoil, based on its capacity to be used on waste landforms, to enable the retention of seed, seed viability and chemical and physical properties.	• Flora and vegetation on the rehabilitated site is representative of the target ecosystem as defined by species richness, diversity, density, weed species number and weed density targets to be developed. • Floral species richness and diversity is compatible with the target ecosystem or reference sites at a level to be developed. • Weed species are not present in rehabilitated areas above an agreed level of species number and density. • Fauna habitat is established on the rehabilitated site and is suitable for the target ecosystem as defined by habitat targets to be developed. • Native fauna species are re-established on site as defined by monitoring targets to be developed.	
Public health and safety	• Site is left in a condition where the risk of adverse effects (to people, livestock, other fauna and the general environment) is reduced to a level acceptable to stakeholders.	• Soil and water contamination resulting in potential downstream impacts to local communities including the Jigalong community. • Inadequate rehabilitation of final land-forms resulting in injury and/or death.	Investigations to date: • Identification of stakeholders with the potential to be impacted by the Project and assessment of their concerns and anticipated management requirements. Planned Investigations/activities: • Stakeholder consultation including consultation with communities over Project concerns will continue throughout the Project and during rehabilitation activities • Ongoing soil, surface water and groundwater monitoring will be undertaken to ensure no contamination is occurring on site.	• All required infrastructure is removed or buried to an agreed depth to ensure the site is safe and suitable to be used by the public and fauna (both native and livestock).	

Operational area factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Monitoring	• Environmental monitoring is consistent with requirements of DMP/DEC and undertaken throughout closure and rehabilitation activities as required.	• Contamination of surrounding environment. • Ineffective final landform maintenance, resulting in failure of structural integrity. • Revegation failure	A preliminary closure monitoring program has been developed and provided in Table 11.1 of this Closure Plan. Specific monitoring programs will be developed as baseline environmental information comes available.	• Post-mining land-use objectives identified in the monitoring program have been met.	
Final landform	• Landforms are stable and able to support the agreed final land use and targeted ecosystem. • The processes affecting the final landform stability are occurring at rates suitable for post mining land use.	• Erosion of topsoil and dispersive material from final landforms. • Final landform design is ineffective in retaining local provenance seeds and therefore increasing erosion. • Revegetation failure due to insufficient soil nutrients and or/contamination.	Investigations to date: • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further.	• Post-mining land is structurally stable and suitable for post-mining land use as defined by landform design and soil specifications to be developed. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem as defined by soil specifications to be developed. • Stockpiled topsoil is able to be utilised and replaced to a suitable depth as defined by stockpile management targets to be developed.	

Table 2 Processing facilities closure implementation strategy

Processing facilities factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Soil contamination	• Final soil quality (in relation to level of contamination present) is equivalent to pre-mining levels. • Residue storage facilities, waste rock dumps and explosives facilities sites are free from contamination.	• Incorrect disposal of wastes (including process chemicals and hydrocarbons) resulting in contamination of soils, surface and groundwater and a decrease in surrounding environmental values • Soil contamination resulting in infiltration to groundwater or run-off into surface water resulting in an increased risk to health of surrounding biological communities • Surface soil contamination around plant equipment and storage areas (resulting in contaminated site classification by DEC)	<u>Investigations to date:</u> • Soil-chemical characterisation of the Project area has been undertaken to determine baseline chemical parameters. Prior to the commencement of closure activities, further soil-chemical characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. • Waste rock characterisation has confirmed no potentially or acid forming material present. Prior to the commencement of closure activities additional waste rock characterisation will be undertaken to determine the acid-forming potential of material post-mining. <u>Planned Investigations/activities:</u> • Ongoing soil monitoring will be undertaken to ensure soil-chemical parameters are at baseline levels. A preliminary monitoring program will be developed and further refined and incorporated into the next revision of the Closure Plan. • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the potential contaminated nature of soil), rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. Maintain a register of contamination occurring at the processing facilities. Areas where contamination has occurred will be remediated appropriately.	• Contaminant levels in soil are at or below background concentrations, and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • No evidence of residue storage facilities, explosives storage or other potential source of contamination on site. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	As investigations continue throughout the life of the mine, closure and rehabilitation strategies are likely to be updated to reflect the increased knowledge base. Based on the current level of understanding, the closure and rehabilitation strategy of the processing facilities will involve the following: • removal of chemicals of site by appropriate means by a licensed contractor • processing infrastructure, including the crushing and screening plants and beneficiation facility, will be cleaned to remove residual chemicals and chemicals before being dismantled by an approved licensed contractor and either disposed of or re-used as appropriate • removal of associated facilities including conveyors, load-out facilities, buried pipes, buildings etc. • contaminated waste from the facility will be disposed of appropriately in accordance with the *Dangerous Goods Safety Act 2004* and *Contaminated Sites Act 2003* by a licensed waste contractor • after all processing infrastructure is removed; the soil will be decontaminated on site or disposed of off-site by an approved waste contractor, licensed to remove and dispose of chemicals, hydrocarbons and hazardous substances • the site will be re-contoured where possible to restore natural drainage and be compatible with the surrounding environment • compacted soil will be ripped to promote germination prior to the application of topsoil to a minimum depth to be determined in consultation with key stakeholders • local provenance seed will be used, dependent upon availability; with provenance collection management based on 'zones' according to the species characteristics (e.g. abundance, distribution, recalcitrance) • topsoils used in rehabilitation will be managed to ensure that nutrient levels are appropriate to support plant growth (e.g. fertiliser may be applied if required) • any reports of contamination and corrective actions taken in response will be reported to DEC or other appropriate regulatory authority
Soil stability	Soils are able to support the targeted ecosystem.	• Revegetation failure due to inadequate soil structure (high erosion and compaction, vegetation unable to establish). • Erosion of topsoil and dispersive material from final landforms. • Final landform design is ineffective in retaining local provenance seeds and therefore increasing erosion.	<u>Investigations to date:</u> • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. <u>Planned Investigations/activities:</u> • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further.	Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	

Processing facilities factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Surface water	• Surface water drainage is implemented to achieve a safe, stable landform with low risk of erosion, consistent with the surrounding landscape. • Natural ecosystems are maintained after permanent diversion of creek-lines.	• Contamination of surface water sources through use of chemicals and hydrocarbons at the processing facilities • Increased sediment loads after re-instatement of natural surface water drainage	Investigations to date: • Baseline surface water assessments are currently being undertaken to determine baseline drainage conditions and water quality parameters of surface water from the Project Area. • Assessment of potential stormwater flows from peak storm events at RRA and DCA are currently underway and will be incorporated into the next revisions of the Closure Plan. Planned Investigations/activities: • Water quality sampling will be undertaken throughout the life of the Project, including during rehabilitation activities. • A post-mining surface water management plan will be developed focused on maintaining re-established flows.	• Contours of the final landform reflect the contours, and drainage patterns, of the pre mining landscape (in relation to stability and geometry) as defined in design specifications to be developed. • Natural ecosystems have been re-established and maintained after permanent diversion of creek-lines in accordance with floral species richness, diversity coverage, weed species number, weed density, landform and soil stability targets to be developed. • No contamination (in relation to level of contamination present) downstream of FPP area.	
Groundwater	• Groundwater levels are at pre-mining levels. • Final groundwater quality (in relation to level of contaminants present) is equivalent to pre-mining levels. • No potential for off-site groundwater contamination.	• Contamination of groundwater (resulting in contaminated site classification by DEC). • Contamination of groundwater resulting in downstream impacts to the Jigalong community and the surrounding environment	Investigations to date: • Monitoring of baseline groundwater quality parameters is currently underway and will be developed further in consultation with the DoW. Planned Investigations/activities: • Baseline water quality parameters will be monitored throughout both the mining and closure and rehabilitation stages of the Project at a number of bores, to be determined in consultation with DoW. • A post-mining groundwater management plan will be developed focused on groundwater recovery. • Develop a procedure for provision of water to the Jigalong community, should there be a reduction in supply.	• Groundwater levels have returned to pre-dewatering levels, comparable to regional levels. • Contaminant levels in groundwater are at agreed levels, to be developed in consultation with DoW and DEC. Water quality parameters will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Contamination levels in groundwater downstream of the project are at or below background concentrations (in relation to contaminant present) and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Groundwater abstraction bores are decommissioned.	
Biodiversity	• Rehabilitated ecosystems are self-sustaining with the ability to support a range of fauna species known from the site prior to disturbance.	• Soil, surface water and groundwater contamination resulting in death of flora and fauna • Increased weed species introduced on site through closure and rehabilitation activities • Revegetation failure due to insufficient soil nutrients and or/contamination	Investigations to date: • Flora and fauna assessments have been undertaken to identify all significant species occurring and with the potential to occur in the Project area. Where required, specific management plans will be developed as part of the EIA process and implemented on site throughout the life of the Project, including during rehabilitation activities. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials, rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Assess stockpiled topsoil, based on its capacity to be used on waste landforms, to enable the retention of seed, seed viability and chemical and physical properties.	• Flora and vegetation on the rehabilitated site is representative of the target ecosystem as defined by species richness, diversity, density, weed species number and weed density targets to be developed. • Floral species richness and diversity is compatible with the target ecosystem or reference sites at a level to be developed. • Weed species are not present in rehabilitated areas above an agreed level of species number and density. • Fauna habitat is established on the rehabilitated site and is suitable for the target ecosystem as defined by habitat targets to be developed. • Native fauna species are re-established on site as defined by monitoring targets to be developed.	
Public health and safety	• Site is left in a condition where the risk of adverse effects (to people, livestock, other fauna and the general environment) is reduced to a level acceptable to stakeholders.	• Soil and water contamination resulting in potential downstream impacts to local communities including the Jigalong community • Insufficient rehabilitation of final land-forms resulting in injury.	Investigations to date: • Identification of stakeholders with the potential to be impacted by the Project and assessment of their concerns and anticipated management requirements. Planned Investigations/activities: • Stakeholder consultation including consultation with communities over Project concerns will continue throughout the Project and during rehabilitation activities • Ongoing soil, surface water and groundwater monitoring will be undertaken to ensure no contamination is occurring on site.	• All required infrastructure is removed or buried to an agreed depth to ensure the site is safe and suitable to be used by the public and fauna (both native and livestock).	

Processing facilities factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Monitoring	• Environmental monitoring is consistent with requirements of DMP/DEC and undertaken throughout closure and rehabilitation activities as required.	• Contamination of surrounding environment. • Ineffective final landform maintenance, resulting in failure of structural integrity. • Revegation failure	A preliminary closure monitoring program has been developed and provided in Table 11.1 of this Closure Plan. Specific monitoring programs will be developed as baseline environmental information comes available.	• Post-mining land-use objectives identified in the monitoring program have been met.	
Final landform	• Landforms are stable and able to support the agreed final land use and targeted ecosystem. • The processes affecting the final landform stability are occurring at rates suitable for post mining land use.	• Erosion of topsoil and dispersive material from final landforms. • Final landform design is ineffective in retaining local provenance seeds and therefore increasing erosion. • Revegetation failure due to insufficient soil nutrients and or/contamination.	Investigations to date: • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further.	• Post-mining land is structurally stable and suitable for post-mining land use as defined by landform design and soil specifications to be developed. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem as defined by soil specifications to be developed. • Stockpiled topsoil is able to be utilised and replaced to a suitable depth as defined by stockpile management targets to be developed.	

Table 3 RSF closure implementation strategy

RSF factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Soil contamination	• Final soil quality (in relation to level of contamination present) is equivalent to pre-mining levels. • Residue storage facilities, waste rock dumps and explosives facilities sites are free from contamination.	• Seepage of residue material from RSF post-closure (to soil to groundwater) • RSF construction failure post-closure • Contamination due to unexpected chemical composition of tailings samples.	<u>Investigations to date:</u> • Soil-chemical characterisation of the Project area has been undertaken to determine baseline chemical parameters. Prior to the commencement of closure activities, further soil-chemical characterisation is required to ensure the rehabilitation potential of the site is adequately addressed, with particular focus on areas of potential contamination including the RSF. • A RSF pilot plant has been developed to assess chemical parameters of residue material from Robertson Range and Mirrin Mirrn. Further geochemical assessment will be undertaken for inclusion in the MP and EIA document and the next revision of the Closure Plan. • A seepage analysis was undertaken as a component of the RSF pilot plant assessment. <u>Planned Investigations/activities:</u> • Ongoing soil monitoring will be undertaken to ensure soil-chemical parameters are at baseline levels. A preliminary monitoring program will be developed and further refined and incorporated into the next revision of the Closure Plan. • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the potential contaminated nature of soil), rehabilitation techniques and local provenance species. • Maintain a register of contamination occurring at the RSF. Areas where contamination has occurred will be remediated appropriately	• Contaminant levels in soil are at or below background concentrations, and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • No evidence of residue storage facilities, explosives storage or other potential source of contamination on site. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	As investigations continue throughout the life of the mine, closure and rehabilitation strategies are likely to be updated to reflect the increased knowledge base. Based on the current level of understanding, the closure and rehabilitation strategy of the RSF will involve the following: • drying of the residue material, prior to capping of the RSF with an agreed capping material to ensure geotechnical stability of the facility • installation of a store release cover system that restricts infiltration into the RSF and potentially impacts on surface water sources • the RSF will be developed with a concave, duplex cover-profile with the capacity to retain 100-150 mm of water, in evaporation basins • all potentially contaminated soil associated with the facility will be remediated on-site or transported off site for disposal by appropriate means by a licensed contractor • geotechnical assessments of the final landform will be undertaken prior to re-contouring, deep ripping and respreading of topsoil • the RSF will undergo backfilling and re-contouring of the area where possible to restore natural drainage • flood protection bunds will remain post-closure as required to redirect surface water flows • the facility will be ripped with 0.4 m rip lines approximately 1 m apart, spread with topsoil and revegetated to promote germination and further increase the stability of the final landform • revegetation will be undertaken utilising local provenance seed (in accordance with a provenance zone management strategy) to facilitate rehabilitation • a post-closure groundwater monitoring schedule will be detailed in subsequent revisions of the Closure Plan • a post-closure surface water monitoring schedule will be detailed in the subsequent revisions of the Closure Plan • any reports of contamination and corrective actions taken in response will be reported to DEC or other appropriate regulatory authority.
Soil stability	• Soils are able to support the targeted ecosystem.	• Erosion of capping material leading to failure of RSF capping. • Inadequate soil structure (high erosion and compaction vegetation unable to establish). • Erosion of topsoil and dispersive material from final landforms.	<u>Investigations to date:</u> • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. • A RSF feasibility assessment has been undertaken incorporating a geotechnical investigation of the proposed facility under static and seismic loading conditions. <u>Planned Investigations/activities:</u> • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • It is anticipated that waste rock will be used as capping material for the RSF, however detailed cover material assessments are required prior to closure. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further. • Initiate a geotechnical monitoring program throughout project operations to assess geochemical performance of the perimeter embankment. After operations have ceased and residue material has dried a final geotechnical investigation of the RSF will be undertaken prior to rehabilitation.	• Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	

RSF factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Surface water	• Surface water drainage is implemented to achieve a safe, stable landform with low risk of erosion, consistent with the surrounding landscape. • Natural ecosystems are maintained after permanent diversion of creek-lines.	• Contamination of surface water sources through use of chemicals and hydrocarbons at the RSF. • Increased sediment loads after re-instatement of natural surface water drainage	Investigations to date: • Baseline surface water assessments are currently being undertaken to determine baseline drainage conditions and water quality parameters of surface water from the Project Area. • Assessment of potential stormwater flows from peak storm events at RRA and DCA are currently underway and will be incorporated into the next revisions of the Closure Plan. • A RSF pilot plant has been developed to assess chemical parameters of residue material from Robertson Range and Mirrin Mirrn. Further geochemical assessment will be undertaken for inclusion in the MP and EIA document and the next revision of the Closure Plan. • A seepage analysis was undertaken as a component of the RSF pilot plant assessment. Planned Investigations/activities: • Water quality sampling will be undertaken throughout the life of the Project, including during rehabilitation activities. A post-mining surface water management plan will be developed focused on maintaining re-established flows. • Investigate the potential impacts of flood breakthrough the RSF and associated impacts to surface water. • A RSF design and management strategy will be developed, incorporating a surface water management component that minimises the potential for surface water to be released to the environment during rainfall events.	• Contours of the final landform reflect the contours, and drainage patterns, of the pre mining landscape (in relation to stability and geometry) as defined in design specifications to be developed. • Natural ecosystems have been re-established and maintained after permanent diversion of creek-lines in accordance with floral species richness, diversity coverage, weed species number, weed density, landform and soil stability targets to be developed. • No contamination (in relation to level of contamination present) downstream of FPP area.	
Groundwater	• Groundwater levels are at pre-mining levels. • Final groundwater quality (in relation to level of contaminants present) is equivalent to pre-mining levels. • No potential for off-site groundwater contamination.	• Contamination of groundwater through leaching of residue material and chemicals • Contamination of groundwater (resulting in contaminated site classification by DEC) • Contamination of groundwater resulting in downstream impacts to the Jigalong community and the surrounding environment	Investigations to date: • Monitoring of baseline groundwater quality parameters is currently underway and will be developed further in consultation with the DoW. • A RSF pilot plant has been developed to assess chemical parameters of residue material from Robertson Range and Mirrin Mirrn. Further geochemical assessment will be undertaken for inclusion in the MP and EIA document and the next revision of the Closure Plan. • A seepage analysis was undertaken as a component of the RSF pilot plant assessment. Planned Investigations/activities: • Baseline water quality parameters will be monitored throughout both the mining and closure and rehabilitation stages of the Project at a number of bores, to be determined in consultation with DoW. Post-mining monitoring will focus on areas with greater potential for contamination, such as the RSF. • A post-mining RSF management plan will be developed. • Results from leachate testing from the RSF should be reviewed against baseline groundwater parameters.	• Groundwater levels have returned to pre-dewatering levels, comparable to regional levels. • Contaminant levels in groundwater are at agreed levels, to be developed in consultation with DoW and DEC. Water quality parameters will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Contamination levels in groundwater downstream of the project are at or below background concentrations (in relation to contaminant present) and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Groundwater abstraction bores are decommissioned.	

RSF factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Biodiversity	• Rehabilitated ecosystems are self-sustaining with the ability to support a range of fauna species known from the site prior to disturbance.	• Soil, surface water and groundwater contamination from the RSF resulting in death of flora and fauna	Planned Investigations/activities: • Undertake a study of tailings material to confirm chemical and physical parameters relating to plant development and the potential for residue material to form effective rehabilitation soil profiles. • Initiate rehabilitation trials to determine the most effective rehabilitation materials, rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Assess stockpiled topsoil, based on its capacity to be used on waste landforms, to enable the retention of seed, seed viability and chemical and physical properties.	• Flora and vegetation on the rehabilitated site is representative of the target ecosystem as defined by species richness, diversity, density, weed species number and weed density targets to be developed. • Floral species richness and diversity is compatible with the target ecosystem or reference sites at a level to be developed. • Weed species are not present in rehabilitated areas above an agreed level of species number and density. • Fauna habitat is established on the rehabilitated site and is suitable for the target ecosystem as defined by habitat targets to be developed. • Native fauna species are re-established on site as defined by monitoring targets to be developed.	
Public health and safety	• Site is left in a condition where the risk of adverse effects (to people, livestock, other fauna and the general environment) is reduced to a level acceptable to stakeholders.	• Soil and water contamination resulting in potential downstream impacts to local communities including the Jigalong community • Insufficient rehabilitation of final land-forms resulting in injury	Investigations to date: • Identification of stakeholders with the potential to be impacted by the Project and assessment of their concerns and anticipated management requirements. Planned Investigations/activities: • Stakeholder consultation including consultation with communities over Project concerns will continue throughout the Project and during rehabilitation activities • Ongoing soil, surface water and groundwater monitoring will be undertaken to ensure no contamination is occurring on site.	• All required infrastructure is removed or buried to an agreed depth to ensure the site is safe and suitable to be used by the public and fauna (both native and livestock).	
Visual amenity	• Final landforms are compatible with the surrounding landscape.	• Final RSF facility developed outside of agreed upon final landform	Planned Investigations/activities: • ongoing stakeholder liaison will continue as part of the Project operations, to ensure final landforms are complementary to the surrounding environment and agreed upon and by all relevant stakeholders	• Final landform will integrate with the surrounding landscape, with the exception of mine voids, as defined by design specifications to be developed.	
Monitoring	• Environmental monitoring is consistent with requirements of DMP/DEC and undertaken throughout closure and rehabilitation activities as required.	• Contamination of surrounding environment. • Ineffective final landform maintenance, resulting in failure of structural integrity. • Revegation failure	A preliminary closure monitoring program has been developed and provided in Table 11.1 of this Closure Plan. Specific monitoring programs will be developed as baseline environmental information comes available.	• Post-mining land-use objectives identified in the monitoring program have been met.	

RSF factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Final landform	• Landforms are stable and able to support the agreed final land use and targeted ecosystem. • The processes affecting the final landform stability are occurring at rates suitable for post mining land use.	• Geotechnical failure of RSF. • Erosion of topsoil and dispersive material from final landforms. • Final landform design is ineffective in retaining local provenance seeds and therefore increasing erosion. • Revegetation failure due to insufficient soil nutrients and or/contamination.	Investigations to date: • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. • Preliminary assessment of RSF stability was undertaken in static and seismic loading conditions to determine RSF design criteria. • It is anticipated that waste rock will be used as capping material for the RSF, however detailed cover material assessments are required prior to closure. • Initiate a geotechnical monitoring program throughout project operations to assess geochemical performance of the perimeter embankment. After operations have ceased and residue material has dried a final geotechnical investigation of the RSF will be undertaken prior to rehabilitation. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further. • Initiate a geotechnical monitoring program of the RSF to determine geotechnical performance of the RSF and perimeter embankments. • A RSF design and management strategy will be developed, incorporating a surface water management component that minimises the potential for surface water to be released to the environment during rainfall events.	• Post-mining land is structurally stable and suitable for post-mining land use as defined by landform design and soil specifications to be developed. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem as defined by soil specifications to be developed. • Stockpiled topsoil is able to be utilised and replaced to a suitable depth as defined by stockpile management targets to be developed.	

Table 4 Hazardous materials storage closure implementation strategy

Hazardous materials storage factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Soil contamination	• Final soil quality (in relation to level of contamination present) is equivalent to pre-mining levels. • Residue storage facilities, waste rock dumps and explosives facilities sites are free from contamination.	• Contamination of surface water and groundwater through use of hazardous materials on site. • Site contamination resulting in contaminated sites classification by DEC).	Investigations to date: • Soil-chemical characterisation of the Project area has been undertaken to determine baseline chemical parameters. Prior to the commencement of closure activities, further soil-chemical characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. Planned Investigations/activities: • Ongoing soil monitoring will be undertaken to ensure soil-chemical parameters are at baseline levels. A preliminary monitoring program will be developed and further refined and incorporated into the next revision of the Closure Plan. • Initiate rehabilitation trials to determine the most effective rehabilitation materials (given the potential contaminated nature of soil), rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Maintain a register of contamination occurring at hazardous materials storage areas. Areas where contamination has occurred will be remediated appropriately.	• Contaminant levels in soil are at or below background concentrations, and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • No evidence of residue storage facilities, explosives storage or other potential source of contamination on site. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	As investigations continue throughout the life of the mine, closure and rehabilitation strategies are likely to be updated to reflect the increased knowledge base. Based on the current level of understanding, the closure and rehabilitation strategy of hazardous materials storage will involve the following: • hazardous materials will be removed off site, with small quantities required for closure activities retained on site in suitably sized and appropriately bunded containment • dismantling and removal of infrastructure for re-use or disposal by a licensed contractor in accordance with *Dangerous Goods Safety Act 2004* and Dangerous Goods Safety (Explosives) Regulations 2007 • storage structures will be decommissioned, including remediation to remove all residual hazardous materials • site remediation and decontamination of hazardous material storage areas will then be undertaken either on-site (soil) or off-site, removed by a licensed contractor • the area will be backfilled and re-contoured, prior to ripping and re-spread of topsoil to a minimum depth to be determined in consultation with key stakeholders • revegetation will be undertaken to further increase the stability of the final landform utilising local provenance seed (in accordance with a provenance zone management strategy) • a post-closure groundwater monitoring schedule will be detailed in subsequent revisions of the Closure Plan • a post-closure surface water monitoring schedule will be detailed in the subsequent revisions of the Closure Plan • any reports of contamination and corrective actions taken in response will be reported to DEC or other appropriate regulatory authority.
Soil stability	• Soils are able to support the targeted ecosystem.	• Inadequate soil structure (high erosion and compaction vegetation unable to establish). • Erosion of topsoil and dispersive material from final landforms.	Investigations to date: • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further.	• Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	
Surface water	• Surface water drainage is implemented to achieve a safe, stable landform with low risk of erosion, consistent with the surrounding landscape. • Natural ecosystems are maintained after permanent diversion of creek-lines.	• Contamination of surface water sources through use of hazardous materials on site. • Increased sediment loads after re-instatement of natural surface water drainage.	Investigations to date: • Baseline surface water assessments are currently being undertaken to determine baseline drainage conditions and water quality parameters of surface water from the Project Area. • Assessment of potential stormwater flows from peak storm events at RRA and DCA are currently underway and will be incorporated into the next revisions of the Closure Plan. Planned Investigations/activities: • Water quality sampling will be undertaken throughout the life of the Project, including during rehabilitation activities. • A post-mining surface water management plan will be developed focused on maintaining re-established flows.	• Contours of the final landform reflect the contours, and drainage patterns, of the pre mining landscape (in relation to stability and geometry) as defined in design specifications to be developed. • Natural ecosystems have been re-established and maintained after permanent diversion of creek-lines in accordance with floral species richness, diversity coverage, weed species number, weed density, landform and soil stability targets to be developed. • No contamination (in relation to level of contamination present) downstream of FPP area.	

Hazardous materials storage factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Groundwater	• Groundwater levels are at pre-mining levels. • Final groundwater quality (in relation to level of contaminants present) is equivalent to pre-mining levels. • No potential for off-site groundwater contamination.	• Contamination of groundwater through leaching of hazardous materials and chemicals • Contamination of groundwater (resulting in contaminated site classification by DEC) • Contamination of groundwater resulting in downstream impacts to the Jigalong community and the surrounding environment	Investigations to date: • Monitoring of baseline groundwater quality parameters is currently underway and will be developed further in consultation with the DoW. Planned Investigations/activities: • Baseline water quality parameters will be monitored throughout the mining and closure and rehabilitation stages of the Project at a number of bores, to be determined in consultation with DoW. • A post-mining groundwater management plan will be developed.	• Groundwater levels have returned to pre-dewatering levels, comparable to regional levels. • Contaminant levels in groundwater are at agreed levels, to be developed in consultation with DoW and DEC. Water quality parameters will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Contamination levels in groundwater downstream of the project are at or below background concentrations (in relation to contaminant present) and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Groundwater abstraction bores are decommissioned.	
Biodiversity	• Rehabilitated ecosystems are self-sustaining with the ability to support a range of fauna species known from the site prior to disturbance.	• Soil, surface water and groundwater contamination from hazardous materials resulting in death of flora and fauna.	Investigations to date: • Flora and fauna assessments have been undertaken to identify all significant species occurring and with the potential to occur in the Project area. Where required, specific management plans will be developed as part of the EIA process and implemented on site throughout the life of the Project, including during rehabilitation activities. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials, rehabilitation techniques and local provenance species. • Assess capacity of stockpiled topsoil with respect to suitability for use on waste landforms, including biological function, retained seed, seed viability, and basic chemical and physical properties.	• Flora and vegetation on the rehabilitated site is representative of the target ecosystem as defined by species richness, diversity, density, weed species number and weed density targets to be developed. • Floral species richness and diversity is compatible with the target ecosystem or reference sites at a level to be developed. • Weed species are not present in rehabilitated areas above an agreed level of species number and density. • Fauna habitat is established on the rehabilitated site and is suitable for the target ecosystem as defined by habitat targets to be developed. • Native fauna species are re-established on site as defined by monitoring targets to be developed.	
Monitoring	• Environmental monitoring is consistent with requirements of DMP/DEC and undertaken throughout closure and rehabilitation activities as required.	• Contamination of surrounding environment. • Ineffective final landform maintenance, resulting in failure of structural integrity. • Revegation failure	A preliminary closure monitoring program has been developed and provided in Table 11.1 of this Closure Plan. Specific monitoring programs will be developed as baseline environmental information comes available.	• Post-mining land-use objectives identified in the monitoring program have been met.	
Public health and safety	• Site is left in a condition where the risk of adverse effects (to people, livestock, other fauna and the general environment) is reduced to a level acceptable to stakeholders.	• Soil and water contamination resulting in potential downstream impacts to local communities including the Jigalong community. • Insufficient rehabilitation of final land-forms resulting in injury.	Planned Investigations/activities: • Stakeholder consultation including consultation with communities over Project concerns will continue throughout the Project and during rehabilitation activities. • Ongoing soil, surface water and groundwater monitoring will be undertaken to ensure no contamination is occurring on site and downstream. • Review groundwater monitoring to include potential sources of contamination such as saline waters, treated sewage effluent, hydrocarbons, and elevated metals for all areas of heavy industrial infrastructure.	• All required infrastructure is removed or buried to an agreed depth to ensure the site is safe and suitable to be used by the public and fauna (both native and livestock).	

Table 5 Water management structures closure implementation strategy

Water management structures factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy

Surface water	• Surface water drainage is implemented to achieve a safe, stable landform with low risk of erosion, consistent with the surrounding landscape.
	• Natural ecosystems are maintained after permanent diversion of creek-lines.
		• Changes to surface water flow patterns as a result of increased or decreased sediment loads upstream and downstream from creek diversions
		• Contamination to surface and groundwater through increased sediment loads and/or contaminants present post mining
		• Increased sediment loads after re-instatement of natural surface water drainage
		• Changes to surface water flow patterns (sheet flow)
			<u>Investigations to date:</u>
			• Baseline surface water assessments are currently being undertaken to determine baseline drainage conditions and water quality parameters of surface water from the Project Area.
			• Assessment of potential stormwater flows from peak storm events at RRA and DCA are currently underway and will be incorporated into the next revisions of the Closure Plan.
			• Initiate trials to assess what treatments are required to effectively re-establish major drainage pathways over void backfill, with a focus on basement treatments.
			• A mine water options assessment was undertaken to determine the preferred alignment and develop concept designs for the diversion of the creeks (SKM 2011).
			<u>Planned Investigations/activities:</u>
			• To progress the concept designs detailed in the mine water options assessment, to detailed designs of the creek diversions a number of assessments are required including the following:
			  • detailed LiDAR/ALS or feature survey of the existing and proposed creek alignments
			  • geotechnical assessment of the site to allow the detailed design of levees of suitable strength to withstand large flow events
			  • hydraulic assessment to determine flows larger than 100 year and up to the 200 year ARI flood event.
			• Water quality sampling will be undertaken throughout the life of the Project, including during rehabilitation activities.
			• A post-mining surface water management plan will be developed focused on maintaining re-established flows.
			• Develop a plan to maintain and re-establish sheet flow to downstream communities on and around proposed mine disturbance.
				• Contours of the final landform reflect the contours, and drainage patterns, of the pre mining landscape (in relation to stability and geometry) as defined in design specifications to be developed.
				• Natural ecosystems have been re-established and maintained after permanent diversion of creek-lines in accordance with floral species richness, diversity coverage, weed species number, weed density, landform and soil stability targets to be developed.
				• No contamination (in relation to level of contamination present) downstream of FPP area.
					As investigations continue throughout the life of the mine, closure and rehabilitation strategies are likely to be updated to reflect the increased knowledge base. Based on the current level of understanding, the closure and rehabilitation strategy of water management infrastructure will involve the following:
					• dismantling and removal of perimeter bunding, sediment basins, in pit stormwater management structures, culverts, piping, redundant groundwater bores and associated infrastructure by a licensed contractor
					• delivery and re-use of excess water from process and raw water dams to a recipient to be determined through the EIA process
					• final landforms will be backfilled and re-contoured to produce landforms consistent with the surrounding environment, and as close to pre-mining drainage lines as possible
					• re-spreading of topsoil and deep ripping of compacted soil will be undertaken to promote re-growth and revegetation
					• revegetation will be undertaken to further increase the stability of the final landform utilising local provenance seed (in accordance with a provenance zone management strategy)
					• during period of inundation monitor creek flows for levels of transported suspended sediment to ensure sediment load transported
					• ongoing monitoring of surface water flows through permanent creek diversion to ensure flows are retained
					• any reports of surface water contamination or changes to surface water flows, including erosion and deposition, and corrective action taken, will be reported to DoW.

Groundwater	• Groundwater levels are at pre-mining levels. • Final groundwater quality (in relation to level of contaminants present) is equivalent to pre-mining levels. • No potential for off-site groundwater contamination.	• Contamination of groundwater through use of hazardous materials and chemicals on site. • Contamination of groundwater (resulting in contaminated site classification by DEC). • Contamination of groundwater/over-abstraction resulting in downstream impacts to the Jigalong community and the surrounding environment.	<u>Investigations to date:</u> • Monitoring of baseline groundwater quality parameters is currently underway and will be developed further in consultation with the DoW. <u>Planned Investigations/activities:</u> • Baseline water quality parameters will be monitored throughout both the mining and closure and rehabilitation stages of the Project at a number of bores, to be determined in consultation with DoW. • A post-mining groundwater management plan will be developed focused on groundwater recovery. • Develop a procedure for provision of water to the Jigalong community, should there be a reduction in supply.	• Groundwater levels have returned to pre-dewatering levels, comparable to regional levels. • Contaminant levels in groundwater are at agreed levels, to be developed in consultation with DoW and DEC. Water quality parameters will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Contamination levels in groundwater downstream of the project are at or below background concentrations (in relation to contaminant present) and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Groundwater abstraction bores are decommissioned.	

Water management structures factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Biodiversity	• Rehabilitated ecosystems are self-sustaining with the ability to support a range of fauna species known from the site prior to disturbance.	• Downstream impacts to ecological communities resulting from installation of inadequate water management structures. • Contamination to surface and groundwater through increased sediment loads and/or contaminants present. • Revegetation failure due to inadequate soil structure (high erosion and compaction vegetation unable to establish). • Incorrect capping of redundant groundwater bores resulting in fauna death and/or injury.	Planned Investigations/activities: • Investigate requirements to successfully reinstate and reestablishment communities in re-established drainage areas. • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials, rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Assess stockpiled topsoil, based on its capacity to be used on waste landforms, to enable the retention of seed, seed viability and chemical and physical properties.	• Flora and vegetation on the rehabilitated site is representative of the target ecosystem as defined by species richness, diversity, density, weed species number and weed density targets to be developed. • Floral species richness and diversity is compatible with the target ecosystem or reference sites at a level to be developed. • Weed species are not present in rehabilitated areas above an agreed level of species number and density. • Fauna habitat is established on the rehabilitated site and is suitable for the target ecosystem as defined by habitat targets to be developed. • Native fauna species are re-established on site as defined by monitoring targets to be developed.	
Public health and safety	• Site is left in a condition where the risk of adverse effects (to people, livestock, other fauna and the general environment) is reduced to a level acceptable to stakeholders.	• Permanent creek diversions are subject to erosion over time providing an unsafe environment. • Previous bunding sites are not rehabilitated to agreed standards resulting in a risk to human health. • Soil and water contamination resulting in potential downstream impacts to local communities including the Jigalong community.	Planned Investigations/activities: • Stakeholder consultation including consultation with communities over Project concerns will continue throughout the Project and during rehabilitation activities • Ongoing soil, surface water and groundwater monitoring will be undertaken to ensure no contamination is occurring on site.	• All required infrastructure is removed or buried to an agreed depth to ensure the site is safe and suitable to be used by the public and fauna (both native and livestock).	
Visual amenity	• Final landforms are compatible with the surrounding landscape.	• Final stormwater management structures developed outside of agreed upon final landform.	Planned Investigations/activities: • Ongoing stakeholder consultation will continue throughout the Project life to ensure adequate final landforms will be produced upon completion of mining activities.	• Final landform will integrate with the surrounding landscape, with the exception of mine voids, as defined by design specifications to be developed.	
Monitoring	• Environmental monitoring is consistent with requirements of DMP/DEC and undertaken throughout closure and rehabilitation activities as required.	• Contamination of surrounding environment. • Ineffective final landform maintenance, resulting in failure of structural integrity. • Revegation failure	A preliminary closure monitoring program has been developed and provided in Table 11.1 of this Closure Plan. Specific monitoring programs will be developed as baseline environmental information comes available.	• Post-mining land-use objectives identified in the monitoring program have been met.	
Final landform	• Landforms are stable and able to support the agreed final land use and targeted ecosystem. • The processes affecting the final landform stability are occurring at rates suitable for post mining land use.	• Re-instaled drainage is ineffective in minimising sediment loads and maintenance of re-instated catchments. • Final landform design is ineffective in retaining local provenance seeds and therefore increasing erosion.	Investigations to date: • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further.	• Post-mining land is structurally stable and suitable for post-mining land use as defined by landform design and soil specifications to be developed. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem as defined by soil specifications to be developed. • Stockpiled topsoil is able to be utilised and replaced to a suitable depth as defined by stockpile management targets to be developed.	

Table 6 Waste dumps and mineralised waste stockpiles closure implementation strategy

Waste dump and mineralised ore stockpile factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy

Soil contamination	• Final soil quality (in relation to level of contamination present) is equivalent to pre-mining levels.
	• Residue storage facilities, waste rock dumps and explosives facilities sites are free from contamination.
		• Generation of acid forming material in waste dumps and mineralised waste stockpiles resulting in soil groundwater contamination.	Investigations to date:
			• Soil-chemical characterisation of the Project area has been undertaken to determine baseline chemical parameters. Prior to the commencement of closure activities, further soil-chemical characterisation is required to ensure the rehabilitation potential of the site is adequately addressed.
			• Waste rock characterisation has confirmed no potentially or acid forming material present. Prior to the commencement of closure activities additional waste rock characterisation will be undertaken, including kinetic testing to determine the acid-forming potential of material post-mining.
			Planned Investigations/activities:
			• Ongoing soil monitoring will be undertaken to ensure soil-chemical parameters are at baseline levels. A preliminary monitoring program will be developed and further refined and incorporated into the next revision of the Closure Plan.
			• Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the potential contaminated nature of soil), rehabilitation techniques and local provenance species.
			• A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy.
			• Maintain a register of contamination occurring at the waste dump and stockpile areas. Areas where contamination has occurred will be remediated appropriately.
			• Kinetic testing of waste rock will be undertaken and results provided in the next revision of this closure plan.
				• Contaminant levels in soil are at or below background concentrations, and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern.
				• No evidence of residue storage facilities, explosives storage or other potential source of contamination on site.
				• Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.
					As investigations continue throughout the life of the mine, closure and rehabilitation strategies are likely to be updated to reflect the increased knowledge base. Based on the current level of understanding, the closure and rehabilitation strategy of the waste dumps and mineralised ore stockpiles will involve the following:
					• removing and disposing of any contaminated soil of site by a licensed contractor, followed by remediation of the affected area
					• re-contouring of waste rock dumps and mineralised waste stockpiles in accordance with design criteria: (concave to reduce linear flow and reduce erosion)
					  • 10 m wide berms placed on each of 10 m vertical height
					  • batter angle dozed down to 20° between the berms
					  • average slope angle of dump face is approximately 16°
					  • berms sloped at 5° inwards to minimise rainfall run-off
					  • cross bunds placed on berms at 30 m spacing to break up pooled water on berms
					  • perimeter bunds placed on top dump surface and each berm to contain rainfall for 1-in-100 year, 72 hour event.
					• consideration of potential for provision of a tourist access track to the summit(s) to provide for lookouts.
					• further waste characterisation will be undertaken to determine the erodability of the waste material and to maximise the locations of bunds and berms post-mining
					• geotechnical assessment of final waste rock dumps and mineralised waste rock stockpiles to determine stability of final landforms
					• deep ripping of surface prior to the respread of topsoil and seeding with local provenance seeds
					• acid and metalliferous drainageis not anticipated, however in the event that acid forming or potentially acid forming materials are identified in waste rock, appropriate management measures will be developed and implemented, incorporating a monitoring program
					• soil, groundwater and surface water monitoring against baseline conditions will be undertaken throughout mining and closure and rehabilitation activities to ensure compliance with ANZECC Guidelines for Water Quality Monitoring and Reporting 2000 (ANZECC 2000a) and ANZECC Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (ANZECC 2000b)
					• any reports of contamination and corrective action undertaken will be reported to DEC or other appropriate regulatory authority

Soil stability	• Soils are able to support the targeted ecosystem.	• Inadequate soil structure (high erosion and compaction vegetation unable to establish). • Erosion of topsoil and dispersive material from final landforms.	Investigations to date: • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Assess and categorise specific overburden types for potential use in rehabilitation. • Assess water retaining potential of materials within waste landforms. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further.	• Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	

Waste dump and mineralised ore stockpile factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Acid Mine Drainage/Potential acid forming material	Ensure all identified or potentially acidic forming material is contained to prevent contamination of soil, surface water and groundwater.	• generation of acid forming material in waste dumps and mineralised waste stockpiles resulting in soil groundwater contamination	Investigations to date: • Waste rock characterisation of the Project area has been undertaken, identifying no potentially or acid forming material. Further waste rock characterisation is not required until after the cessation of mining activities. Information from the assessment will form the basis of waste material placement and final landform design. Planned Investigations/activities: • Ongoing soil, surface water and groundwater monitoring will be undertaken to ensure chemicals are at baseline levels. A detailed monitoring program will be developed and incorporated into the next revision of the closure plan	• All known acidic or PAF areas have been contained and rehabilitated to a geotechnical stable landform.	
Surface water	• Surface water drainage is implemented to achieve a safe, stable landform with low risk of erosion, consistent with the surrounding landscape. • Natural ecosystems are maintained after permanent diversion of creek-lines.	• increased sediment loads after re-instatement of natural surface water drainage • erosion of final waste dumps and stockpiles resulting in changes to local hydrology • a reduction in surface water runoff volume and water quality downstream • increased surface water flows upstream of waste dumps and mineralised ore stockpiles.	Investigations to date: • Baseline surface water assessments are currently being undertaken to determine baseline drainage conditions and water quality parameters of surface water from the Project Area. • Assessment of potential stormwater flows from peak storm events at RRA and DCA are currently underway and will be incorporated into the next revisions of the Closure Plan. Planned Investigations/activities: • Water quality sampling will be undertaken throughout the life of the Project, including during rehabilitation activities. • Investigate the anticipated and actual quantities of sediment run-off from waste landforms based on particle size, slope profile and rainfall events to establish requirements for sediment control. • A post-mining surface water management plan will be developed focused on maintaining re-established flows.	• Contours of the final landform reflect the contours, and drainage patterns, of the pre mining landscape (in relation to stability and geometry) as defined in design specifications to be developed. • Natural ecosystems have been re-established and maintained after permanent diversion of creek-lines in accordance with floral species richness, diversity coverage, weed species number, weed density, landform and soil stability targets to be developed. • No contamination (in relation to level of contamination present) downstream of FPP area.	
Groundwater	• Groundwater levels are at pre-mining levels. • Final groundwater quality (in relation to level of contaminants present) is equivalent to pre-mining levels. • No potential for off-site groundwater contamination.	• contamination of groundwater through leaching of residue material and chemicals	Investigations to date: • Monitoring of baseline groundwater quality parameters is currently underway and will be developed further in consultation with the DoW. Planned Investigations/activities: • Baseline water quality parameters will be monitored throughout both the mining and closure and rehabilitation stages of the Project at a number of bores, to be determined in consultation with DoW. • A post-mining groundwater management plan will be developed focused on groundwater recovery.	• Groundwater levels have returned to pre-dewatering levels, comparable to regional levels. • Contaminant levels in groundwater are at agreed levels, to be developed in consultation with DoW and DEC. Water quality parameters will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Contamination levels in groundwater downstream of the project are at or below background concentrations (in relation to contaminant present) and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Groundwater abstraction bores are decommissioned.	

Waste dump and mineralised ore stockpile factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Biodiversity	• Rehabilitated ecosystems are self-sustaining with the ability to support a range of fauna species known from the site prior to disturbance.	• Fauna death resulting from inappropriate rehabilitation of pits • Soil, surface water and groundwater contamination from acid forming material, resulting in death of flora and fauna • Fauna death resulting from inappropriate rehabilitation of waste dumps	Investigations to date: • Flora and fauna assessments have been undertaken to identify all significant species occurring and with the potential to occur in the Project area. Where required, specific management plans will be developed as part of the EIA process and implemented on site throughout the life of the Project, including during rehabilitation activities. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials, rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Assess stockpiled topsoil, based on its capacity to be used on waste landforms, to enable the retention of seed, seed viability and chemical and physical properties.	• Flora and vegetation on the rehabilitated site is representative of the target ecosystem as defined by species richness, diversity, density, weed species number and weed density targets to be developed. • Floral species richness and diversity is compatible with the target ecosystem or reference sites at a level to be developed. • Weed species are not present in rehabilitated areas above an agreed level of species number and density. • Fauna habitat is established on the rehabilitated site and is suitable for the target ecosystem as defined by habitat targets to be developed. • Native fauna species are re-established on site as defined by monitoring targets to be developed.	
Public health and safety	• Site is left in a condition where the risk of adverse effects (to people, livestock, other fauna and the general environment) is reduced to a level acceptable to stakeholders.	• Soil and water contamination resulting in potential downstream impacts to local communities including the Jigalong community. • Public injury from incorrect or incomplete decommissioning and rehabilitation.	Investigations to date: • Identification of stakeholders with the potential to be impacted by the Project and assessment of their concerns and anticipated management requirements. Planned Investigations/activities: • Stakeholder consultation including consultation with communities over Project concerns will continue throughout the Project and during rehabilitation activities • Ongoing soil, surface water and groundwater monitoring will be undertaken to ensure no contamination is occurring on site. • Geotechnical investigations of waste dumps will be undertaken to ensure stability of the final landforms is achieved.	• All required infrastructure is removed or buried to an agreed depth to ensure the site is safe and suitable to be used by the public and fauna (both native and livestock).	
Visual amenity	• Insufficient rehabilitation of waste dumps and mineralised ore stockpiles (visual amenity legacy)	• insufficient rehabilitation of waste dumps (visual amenity legacy)	Planned Investigations/activities: • Ongoing stakeholder consultation including consultation with communities in respect to visual amenity of waste landforms and end land use.	• Final landform will integrate with the surrounding landscape, with the exception of mine voids, as defined by design specifications to be developed.	
Monitoring	• Environmental monitoring is consistent with requirements of DMP/DEC and undertaken throughout closure and rehabilitation activities as required.	• Contamination of surrounding environment. • Ineffective final landform maintenance, resulting in failure of structural integrity. • Revegation failure	A preliminary closure monitoring program has been developed and provided in Table 11.1 of this Closure Plan. Specific monitoring programs will be developed as baseline environmental information comes available.	• Post-mining land-use objectives identified in the monitoring program have been met.	

Waste dump and mineralised ore stockpile factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Final landform	• Landforms are stable and able to support the agreed final land use and targeted ecosystem. • The processes affecting the final landform stability are occurring at rates suitable for post mining land use.	• Erosion of topsoil and dispersive material from final landforms. • Final landform design is ineffective in retaining local provenance seeds and therefore increasing erosion. • Revegetation failure due to insufficient soil nutrients and or/contamination.	Investigations to date: • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. Planned Investigations/activities: • Geotechnical investigations of waste dumps will be undertaken to ensure stability of the final landforms is achieved. • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further.	• Post-mining land is structurally stable and suitable for post-mining land use as defined by landform design and soil specifications to be developed. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem as defined by soil specifications to be developed. • Stockpiled topsoil is able to be utilised and replaced to a suitable depth as defined by stockpile management targets to be developed.	

Table 7 Mine pit voids and declines closure implementation strategy

Mine pit void and decline aspect	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Soil contamination	• Final soil quality (in relation to level of contamination present) is equivalent to pre-mining levels. • Residue storage facilities, waste rock dumps and explosives facilities sites are free from contamination.	• Generation of acid forming material in pit voids resulting in soil contamination. • Incorrect disposal of wastes leading to contamination of soil in pit void and declines.	Investigations to date: • Soil-chemical characterisation of the Project area has been undertaken to determine baseline chemical parameters. Prior to the commencement of closure activities, further soil-chemical characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. • Waste rock characterisation has confirmed no potentially or acid forming material present. Prior to the commencement of closure activities additional waste rock characterisation will be undertaken to determine the acid-forming potential of material post-mining. Planned Investigations/activities: • Ongoing soil monitoring will be undertaken to ensure soil-chemical parameters are at baseline levels. A preliminary monitoring program will be developed and further refined and incorporated into the next revision of the Closure Plan. • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the potential contaminated nature of soil), rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Maintain a register of contamination occurring on site. Areas where contamination has occurred will be remediated appropriately.	• Contaminant levels in soil are at or below background concentrations, and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • No evidence of residue storage facilities, explosives storage or other potential source of contamination on site. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	As investigations continue throughout the life of the mine, closure and rehabilitation strategies are likely to be updated to reflect the increased knowledge base. Based on the current level of understanding, the closure and rehabilitation strategy of the mine pit voids and declines will involve the following: • removal of drainage structures no longer required to restore natural drainage and/or drainage patterns compatible with the surrounding landscape where to be as compatible with the surrounding topography as possible. Natural drainage will be restored where possible • pits no longer required during mining operations will be backfiled to ensure geotechnical stability, in accordance with the pit backfiling schedule (Appendix 4). • after mining activities have ceased, pits to be retained as pit voids, will be left open and securely fenced to prevent human and ecological access. Adequate signage will be erected to notify the public and personnel using the site • the base of the pit voids will be retained above the level of the long-term watertable to allow the natural groundwater level to return post-mining • where required bunding will be established around the perimeter of the pit to control erosion and water flow • pits will be deep ripped prior to being spread with topsoil to promote revegetation. Topsoil depth will be determined with consultation with relevant stakeholders • revegetation of pit walls (where possible) and pit base will be undertaken to further increase the stability of the final landform and achieve vegetation targets • local provenance seed will be used in revegetation in accordance with a provenance zone management strategy • geotechnical assessment of backfilled pit areas to will be undertaken ensure stability of the final landform • monitoring of pit water quality will be undertaken and additional information regarding pit water remediation, if required, will be included in subsequent revisions of this Closure Plan • groundwater will be monitored both at the site and downstream of the site to ensure leaching of contaminants is not occurring. A post-closure groundwater monitoring schedule will be determined in the next revision of the closure plan • surface water monitoring downstream of pit areas to ensure contamination from stormwater does not occur. A post-closure surface water monitoring schedule will be detailed in subsequent revisions of the Closure Plan • any reports of contamination and corrective actions undertaken will be reported to DEC or other appropriate regulatory authority.
Acid Mine Drainage/Potential acid forming material	Ensure all identified or potentially acidic forming material is contained to prevent contamination of soil, surface water and groundwater.	• Generation of acid forming material in waste dumps and mineralised waste stockpiles resulting in soil groundwater contamination.	Investigations to date: • Waste rock characterisation of the Project area has been undertaken, identifying no potentially or acid forming material. Further waste rock characterisation is not required until after the cessation of mining activities. Information from the assessment will form the basis of waste material placement and final landform design. Planned Investigations/activities: • Ongoing soil, surface water and groundwater monitoring will be undertaken to ensure chemicals are at baseline levels. A detailed monitoring program will be developed and incorporated into the next revision of the closure plan	• All known acidic or PAF areas have been contained and rehabilitated to a geotechnical stable landform.	

Mine pit void and decline aspect	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Soil stability	• Soils are able to support the targeted ecosystem.	• Final pit void design is ineffective, resulting in sediment travelling into the local drainage system. • Inadequate soil structure (high erosion and compaction vegetation unable to establish). • Erosion of topsoil and dispersive material from pit voids.	Investigations to date: • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further. • Initiate geotechnical investigation of the site to ensure stability of final landforms post-operations.	• Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	
Surface water	• Surface water drainage is implemented to achieve a safe, stable landform with low risk of erosion, consistent with the surrounding landscape. • Natural ecosystems are maintained after permanent diversion of creek-lines.	• Increased sediment loads after re-instatement of natural surface water drainage. • Erosion of pit voids and stockpiles resulting in changes to local hydrology. • A reduction in surface water runoff volume and water quality downstream. • Increased surface water flows upstream of pit voids.	Investigations to date: • Baseline surface water assessments are currently being undertaken to determine baseline drainage conditions and water quality parameters of surface water from the Project Area. • Assessment of potential stormwater flows from peak storm events at RRA and DCA are currently underway and will be incorporated into the next revisions of the Closure Plan. Planned Investigations/activities: • Water quality sampling will be undertaken throughout the life of the Project, including during rehabilitation activities. Sampling will incorporate contaminants and sediment loads. • A post-mining surface water management plan will be developed focused on maintaining re-established flows. • A water quality sampling program and management plan will be developed for post-mining monitoring of pit lakes. • Water quality sampling will be undertaken throughout the life of the Project, including during rehabilitation activities.	• Contours of the final landform reflect the contours, and drainage patterns, of the pre mining landscape (in relation to stability and geometry) as defined in design specifications to be developed. • Natural ecosystems have been re-established and maintained after permanent diversion of creek-lines in accordance with floral species richness, diversity coverage, weed species number, weed density, landform and soil stability targets to be developed. • No contamination (in relation to level of contamination present) downstream of FPP area.	
Groundwater	• Groundwater levels are at pre-mining levels. • Final groundwater quality (in relation to level of contaminants present) is equivalent to pre-mining levels. • No potential for off-site groundwater contamination.	• Contamination of groundwater through leaching of residue material and chemicals from pit voids. • Contamination of local groundwater sources through infiltration of contaminated pit lake water.	Investigations to date: • Monitoring of baseline groundwater quality parameters is currently underway and will be developed further in consultation with the DoW. Planned Investigations/activities: • Baseline water quality parameters will be monitored throughout both the mining and closure and rehabilitation stages of the Project at a number of bores, to be determined in consultation with DoW. • A post-mining groundwater management plan will be developed focused on groundwater recovery. • A water quality sampling program and management plan will be developed for post-mining monitoring of pit lakes.	• Groundwater levels have returned to pre-dewatering levels, comparable to regional levels. • Contaminant levels in groundwater are at agreed levels, to be developed in consultation with DoW and DEC. Water quality parameters will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Contamination levels in groundwater downstream of the project are at or below background concentrations (in relation to contaminant present) and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Groundwater abstraction bores are decommissioned.	

Mine pit void and decline aspect	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Biodiversity	• Rehabilitated ecosystems are self-sustaining with the ability to support a range of fauna species known from the site prior to disturbance.	• Fauna death resulting from inappropriate rehabilitation of pits. • Soil, surface water and groundwater contamination from acid forming material, resulting in death of flora and fauna. • Contaminated pit lake water resulting in fauna and flora death. • Rehabilitation does not develop final landforms into stable, self sustaining ecosystem.	Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials, rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Assess stockpiled topsoil, based on its capacity to be used on waste landforms, to enable the retention of seed, seed viability and chemical and physical properties. • Final land-form design will incorporate geotechnical investigations to ensure stability and address potential erosion issues.	• Flora and vegetation on the rehabilitated site is representative of the target ecosystem as defined by species richness, diversity, density, weed species number and weed density targets to be developed. • Floral species richness and diversity is compatible with the target ecosystem or reference sites at a level to be developed. • Weed species are not present in rehabilitated areas above an agreed level of species number and density. • Fauna habitat is established on the rehabilitated site and is suitable for the target ecosystem as defined by habitat targets to be developed. • Native fauna species are re-established on site as defined by monitoring targets to be developed.	
Public health and safety	• Site is left in a condition where the risk of adverse effects (to people, livestock, other fauna and the general environment) is reduced to a level acceptable to stakeholders.	• Soil and water contamination resulting in potential downstream impacts to local communities including the jigalong community. • Public injury from incorrect or incomplete decommissioning and rehabilitation. • Public injury from insufficient signage or fencing of final pit voids and pit lakes.	Investigations to date: • Identification of stakeholders with the potential to be impacted by the Project and assessment of their concerns and anticipated management requirements. Planned Investigations/activities: • Stakeholder consultation including consultation with communities over Project concerns will continue throughout the Project and during rehabilitation activities • Ongoing soil, surface water and groundwater monitoring will be undertaken to ensure no contamination is occurring on site. • A water quality sampling program and management plan will be developed for post-mining monitoring of pit lakes. • Geotechnical investigations will be undertaken post-mining and rehabilitation to ensure stability of the final landforms is achieved. • Post-closure landforms will be monitored to ensure required fencing and signs are maintained. • Stakeholder consultation is ongoing throughout project activities.	• All required infrastructure is removed or buried to an agreed depth to ensure the site is safe and suitable to be used by the public and fauna (both native and livestock).	
Visual amenity	• Insufficient rehabilitation of waste dumps and mineralised ore stockpiles (visual amenity legacy)	• Insufficient rehabilitation of pit voids and lakes (visual amenity legacy).	Planned Investigations/activities: • Ongoing stakeholder consultation including consultation with communities in respect to visual amenity of waste landforms and end land use.	• Final landform will integrate with the surrounding landscape, with the exception of mine voids, as defined by design specifications to be developed.	
Monitoring	• Environmental monitoring is consistent with requirements of DMP/DEC and undertaken throughout closure and rehabilitation activities as required.	• Contamination of surrounding environment. • Ineffective final landform maintenance, resulting in failure of structural integrity. • Revegation failure	A preliminary closure monitoring program has been developed and provided in Table 11.1 of this Closure Plan. Specific monitoring programs will be developed as baseline environmental information comes available.	• Post-mining land-use objectives identified in the monitoring program have been met.	

Mine pit void and decline aspect	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Final landform	• Landforms are stable and able to support the agreed final land use and targeted ecosystem. • The processes affecting the final landform stability are occurring at rates suitable for post mining land use.	• Erosion of topsoil and dispersive material from final landforms. • Final landform design is ineffective in retaining local provenance seeds and therefore increasing erosion. • Revegetation failure due to insufficient soil nutrients and or/contamination.	Investigations to date: • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. Planned Investigations/activities: • Geotechnical investigations of areas surrounding pit voids and declines to ensure stability of the final landforms is achieved. • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further.	• Post-mining land is structurally stable and suitable for post-mining land use as defined by landform design and soil specifications to be developed. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem as defined by soil specifications to be developed. • Stockpiled topsoil is able to be utilised and replaced to a suitable depth as defined by stockpile management targets to be developed.	

Table 8 Supporting infrastructure closure implementation strategy

Supporting infrastructure factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Soil contamination	• Final soil quality (in relation to level of contamination present) is equivalent to pre-mining levels. • Residue storage facilities, waste rock dumps and explosives facilities sites are free from contamination.	• Incorrect disposal of wastes leading to contamination of soil, surface water and groundwater. • Contamination of soil through incorrect handling of hazardous materials • Soil contamination resulting from seepage from landfill facility.	Investigations to date: • Soil-chemical characterisation of the Project area has been undertaken to determine baseline chemical parameters. Prior to the commencement of closure activities, further soil-chemical characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. • Waste rock characterisation has confirmed no potentially or acid forming material present. Prior to the commencement of closure activities additional waste rock characterisation will be undertaken to determine the acid-forming potential of material post-mining. Planned Investigations/activities: • Ongoing soil monitoring will be undertaken to ensure soil-chemical parameters are at baseline levels. A preliminary monitoring program will be developed and further refined and incorporated into the next revision of the Closure Plan. • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the potential contaminated nature of soil), rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Maintain a register of contamination occurring on site. Areas where contamination has occurred will be remediated appropriately.	• Contaminant levels in soil are at or below background concentrations, and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • No evidence of residue storage facilities, explosives storage or other potential source of contamination on site. • Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	As investigations continue throughout the life of the mine, closure and rehabilitation strategies are likely to be updated to reflect the increased knowledge base. Based on the current level of understanding, the closure and rehabilitation strategy of supporting infrastructure will involve the following: • removal of all infrastructure including accommodation, messing, administration and storage facilities, waste water treatment and landfill infrastructure and roads • landfill areas are to be capped within 2 metres of inert material • material other than soil requiring bioremediation will be removed off site by a licensed contractor and disposed of appropriately • soil will be remediated on site and monitored until the bioremediation cycle is complete. Alternatively soil may be removed off-site and disposed of at an appropriately classed landfill facility (as required) • ripping up of hardstand areas including the road and airstrip, prior to rehabilitation • final landforms will be re-contoured and deep ripped, before being spread with topsoil to promote revegetation • revegetation of all disturbance areas utilising local provenance seed in accordance with a provenance zone management strategy • a post-closure groundwater monitoring schedule will be determined in following revisions of the Closure Plan • a post-closure surface water monitoring schedule will be determined in following revisions of the Closure Plan • any reports of contamination and corrective action taken will be reported to DEC or other appropriate regulatory authority • geotechnical investigations will be undertaken as required to ensure stability of final landforms.
Soil stability	Soils are able to support the targeted ecosystem.	• inadequate soil structure (high erosion and compaction vegetation unable to establish) • erosion of topsoil and dispersive material from final landforms	Investigations to date: • Soil characterisations of the Project area has been undertaken to determine the dispersive nature of baseline soils. Prior to the commencement of closure activities, further soil characterisation is required to ensure the rehabilitation potential of the site is adequately addressed. Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials (given the dispersive nature of soils), rehabilitation techniques and local provenance species. Final land-form design will be developed to address potential dispersive nature of soils used for rehabilitation. • Develop a provenance zone management strategy to develop the Project rehabilitation strategy further. • Initiate geotechnical investigation of the site to ensure stability of final landforms (as required)	• Post-mining soil is conducive to native flora and vegetation growth in accordance with the target ecosystem or reference sites as defined in soil specifications to be developed.	

Supporting infrastructure factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Surface water	• Surface water drainage is implemented to achieve a safe, stable landform with low risk of erosion, consistent with the surrounding landscape. • Natural ecosystems are maintained after permanent diversion of creek-lines.	• Increased sediment loads after re-instatement of natural surface water drainage. • A reduction in surface water runoff volume and water quality downstream. • Increased surface water flows upstream of final landforms. • Contamination of surface water resulting from incorrect disposal of wastes. • Contamination of surface water through incorrect handling of hazardous materials. • Surface water contamination resulting from seepage from landfill facility.	Investigations to date: • Baseline surface water assessments are currently being undertaken to determine baseline drainage conditions and water quality parameters of surface water from the Project Area. • Assessment of potential stormwater flows from peak storm events at RRA and DCA are currently underway and will be incorporated into the next revisions of the Closure Plan. Planned Investigations/activities: • Water quality sampling will be undertaken throughout the life of the Project, including during rehabilitation activities. • A post-mining surface water management plan will be developed focused on maintaining re-established flows.	• Contours of the final landform reflect the contours, and drainage patterns, of the pre mining landscape (in relation to stability and geometry) as defined in design specifications to be developed. • Natural ecosystems have been re-established and maintained after permanent diversion of creek-lines in accordance with floral species richness, diversity coverage, weed species number, weed density, landform and soil stability targets to be developed. • No contamination (in relation to level of contamination present) downstream of FPP area.	
Groundwater	• Groundwater levels are at pre-mining levels. • Final groundwater quality (in relation to level of contaminants present) is equivalent to pre-mining levels. • No potential for off-site groundwater contamination.	• contamination of groundwater through leaching of waste material from the landfill facility • contamination of local groundwater sources through incorrect handling of hazardous materials and wastes	Investigations to date: • Monitoring of baseline groundwater quality parameters is currently underway and will be developed further in consultation with the DoW. Planned Investigations/activities: • Baseline water quality parameters will be monitored throughout both the mining and closure and rehabilitation stages of the Project at a number of bores, to be determined in consultation with DoW. • A post-mining groundwater management plan will be developed focused on groundwater recovery.	• Groundwater levels have returned to pre-dewatering levels, comparable to regional levels. • Contaminant levels in groundwater are at agreed levels, to be developed in consultation with DoW and DEC. Water quality parameters will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Contamination levels in groundwater downstream of the project are at or below background concentrations (in relation to contaminant present) and will include pH, salinity, heavy metals, hydrocarbons and other contaminants of concern. • Groundwater abstraction bores are decommissioned.	
Biodiversity	• Rehabilitated ecosystems are self-sustaining with the ability to support a range of fauna species known from the site prior to disturbance.	• fauna death resulting from inappropriate rehabilitation supporting infrastructure • soil, surface water and groundwater contamination from incorrect handling of hazardous materials and inappropriate disposal of wastes, resulting in death of flora and fauna • rehabilitation does not develop final landforms into stable, self sustaining ecosystem.	Planned Investigations/activities: • Initiate rehabilitation trials in consultation with a relevant provenance specialist to determine the most effective rehabilitation materials, rehabilitation techniques and local provenance species. • A provenance zone management strategy will be developed to be incorporated into the Project rehabilitation strategy. • Assess stockpiled topsoil, based on its capacity to be used on waste landforms, to enable the retention of seed, seed viability and chemical and physical properties. • Final land-form design will incorporate geotechnical investigations to ensure stability and address potential erosion issues.	• Flora and vegetation on the rehabilitated site is representative of the target ecosystem as defined by species richness, diversity, density, weed species number and weed density targets to be developed. • Floral species richness and diversity is compatible with the target ecosystem or reference sites at a level to be developed. • Weed species are not present in rehabilitated areas above an agreed level of species number and density. • Fauna habitat is established on the rehabilitated site and is suitable for the target ecosystem as defined by habitat targets to be developed. • Native fauna species are re-established on site as defined by monitoring targets to be developed.	
Public health and safety	• Site is left in a condition where the risk of adverse effects (to people, livestock, other fauna and the general environment) is reduced to a level acceptable to stakeholders.	• Soil and water contamination resulting in potential downstream impacts to local communities including the Jigalong community. • Public injury from incorrect or incomplete decommissioning and rehabilitation. • Public injury from insufficient signage or fencing of final land forms.	Investigations to date: • Identification of stakeholders with the potential to be impacted by the Project and assessment of their concerns and anticipated management requirements. Planned Investigations/activities: • Stakeholder consultation including consultation with communities over Project concerns will continue throughout the Project and during rehabilitation activities • Ongoing soil, surface water and groundwater monitoring will be undertaken to ensure no contamination is occurring on site.	• All required infrastructure is removed or buried to an agreed depth to ensure the site is safe and suitable to be used by the public and fauna (both native and livestock).	

Supporting infrastructure factor	Closure objectives	Potential closure risks	Investigations to minimise risk to closure (both complete and required)	Preliminary closure criteria	Rehabilitation/Closure Strategy
Monitoring	• Environmental monitoring is consistent with requirements of DMP/DEC and undertaken throughout closure and rehabilitation activities as required.	• Contamination of surrounding environment. • Ineffective final landform maintenance, resulting in failure of structural integrity. • Revegation failure	A preliminary closure monitoring program has been developed and provided in Table 11.1 of this Closure Plan. Specific monitoring programs will be developed as baseline environmental information comes available.	• Post-mining land-use objectives identified in the monitoring program have been met.	
Visual amenity	• Insufficient rehabilitation of waste dumps and mineralised ore stockpiles (visual amenity legacy)	• Insufficient rehabilitation and development of final landforms (visual amenity legacy).	Planned Investigations/activities: • Ongoing stakeholder consultation including consultation with communities in respect to visual amenity of waste landforms and end land use.	• Final landform will integrate with the surrounding landscape, with the exception of mine voids, as defined by design specifications to be developed.	

Appendix 6
Soil and Waste Material Assessment, Outback Ecological Services, 2010

FerrAus Limited

Robertson Range, Davidson Creek and Mirrin Mirrin - Soil and Waste Material Assessment

December 2010

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Robertson Range, Davidson Creek and Mirrin Mirrin – Soil and Waste Material Assessment

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	T. O'Keeffe			
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Executive Summary

Outback Ecology Services (OES) was commissioned by FerrAus Limited to conduct an assessment of soil and waste material at the Robertson Range, Davidson Creek and Mirrin Mirrin Projects. This information is required to develop a greater understanding of the chemical and physical properties of the surface soil and waste materials, to identify potentially problematic materials, and to develop associated recommendations for soil and waste handling and rehabilitation. The outcomes of this assessment aim to meet the DoIR Guidelines for Mining Proposals (2006). This report was prepared in conjunction with an assessment of the geochemical characteristics of waste materials by Graeme Campbell and Associates (Appendix E).

Surface soils

'Surface' soils (to approximately 100cm depth) were collected from 15 sites across the Robertson Range and Davidson Creek Project areas, with information extrapolated to the adjacent Mirrin Mirrin Project area, located approximately 5km from the Davidson Creek Project area. The soil survey and laboratory analyses of 'surface' soils indicated a range of existing soil properties between, and in some instances within, the various soil / landform associations investigated ('Scree slope', 'Flat' and 'Drainage') within the Robertson Range and Davidson Creek Project areas. The greatest variations in soil profile morphology and measured characteristics appear to be between soils from contrasting positions within the landscape.

Table ES1 is a summary of the chemical and physical characteristics of the soils sampled. The Flats soil-landform unit within both the Robertson Range and Davidson Creek study areas consists of soils deposited from higher in the landscape and is characterised by relatively deep, homogenous soils. These soils are typically sand to sandy clay loam in texture, with a low to moderate coarse fragment content. They are typically non-saline and slightly acidic in pH, are non-sodic and non-hardsetting and have a 'moderately slow' to 'moderate' drainage class.

The Scree slope soil / landform unit comprises soils that have formed primarily via colluvial deposition of soil and rock from higher in the landscape. These soils are, in general, slightly acidic sandy loams with high amounts of coarse material and a low nutrient status. Compared to the Flats soils unit, this unit has a higher hydraulic conductivity, with a drainage class of 'moderate' to 'rapid'. The Scree slope soils are also non-saline and non-sodic.

The Drainage soils were relatively similar to the soils from the Flats, apart from higher soil strength upon drying, a lower hydraulic conductivity and slightly higher nutrient status.

Given the close proximity, geological and landform similarity of the Mirrin Mirrin Project area to that of the Davidson Creek Project area, it is considered reasonable that the characteristics of the surface soils measured within the Davidson Creek area can be extrapolated to include those likely to be found within the Mirrin Mirrin Project area.

Mine Waste Materials

The waste materials that are to be generated from the mining operations within the Robertson Range, Davidson Creek and Mirrin Mirrin Projects are dominated by transported sediments comprising clays, detrital and surficial materials. Other waste lithologies associated with the deposits are the Lower West Angela, Mt Newman and MacLeod / Nammuldi members.

The majority of the waste materials assessed indicated that the soil fraction (i.e. <2mm) of all waste lithologies are non-saline, non-hardsetting, non-sodic, structurally stable (i.e. limited clay dispersion upon saturation), and have a neutral to slightly alkaline pH.

Geochemical characterisation by Graeme Campbell and Associates has indicated that the mine waste and low-grade materials from the Robertson Range and Davidson Creek deposits are also geochemically and physiochemically benign.

The geological and lithological similarity of the Davidson Creek and Mirrin Mirrin Projects indicates that the information derived from the characterisation of the Davidson Creek waste materials can be extrapolated to the waste from the Mirrin Mirrin Project with a high level of confidence.

Conclusions and Recommendations

The successful construction and rehabilitation of waste landforms associated with the mining activities necessitates the creation of a stable surface and sufficient medium to support plant growth. Given the geochemically benign nature of the waste materials, there is unlikely to be any material specific requirements for waste placement within the constructed landforms. While this simplifies the design requirements for the waste landforms, the final design will have the potential to influence the success of rehabilitation operations and impact on the surrounding environment.

The placement of salvage topsoils material on the waste landform will depend, to some degree, on the design of the waste landform. It may be beneficial to target specific areas of the waste landforms for selective placement of rehabilitation resources and have rehabilitation prescriptions (e.g. seed mixes) which are targeted for certain positions within the reconstructed landforms.

It is likely that the separate collection and stockpiling of topsoil materials from the Scree slopes and Flats / Drainage areas will be required. This would preserve the seed store, and the chemical, physical and biological attributes of the soil profiles on which the individual vegetation communities in these areas are located. The high coarse fraction within the Scree slope soils means that these soils will be suitable for placement on the outer slopes of waste landforms, with enough coarse material to provide armour against erosion by water. The design of the waste landforms should aim to minimise the concentration of surface water where applicable. The adoption of concave slopes for the final landform shape (if practicable), at a minimum angle possible (dictated by waste landform footprint and landform height), is likely to further minimise erosion, promote successful rehabilitation and blend in with surrounding landforms. Ripping of the surface following topsoil application will result in some mixing of the topsoil with underlying waste rock, and further increase surface stability.

Table ES1: Physical and chemical characteristics for surface soil materials. The data presented represent average values, with broad ratings of good, moderate and poor for each parameter relative to suitability for plant growth and/or overall material stability, relative to the FerrAus Pilbara Project study area

Prospect	Landform	Physical properties					Chemical properties						
		Soil Texture [1]	Gravel content [2] (%)	Emerson Class [3]	Modulus Of Rupture (kPa)	Saturated Hydraulic conductivity (kSat)	pH	Salinity Class (dS/m)	Organic Carbon (%)	Nutrient status	Effective Cation Exchange Capacity (meq/100g)	Exchangeable Sodium Percentage (%)	Total metal concentrations [4]
Robertson Range	**Flat**	Sand to loamy sand	4	3b	Low (11.9)	Moderate drainage (45.7)	Slightly acidic (6.4)	Non-saline (0.03)	Extremely low (0.13)	Low	Low (0.82)	Non-sodic (5.7)	Variable Cr
	Scree Slope	Sandy loam to loamy sand	60	3a, 3b and 6	Low (25.5)	Moderately slow drainage (18.9)	Slightly acidic (6.3)	Non-saline (0.01)	Low (0.18)	Low	Low (1.04)	Non-sodic (4.9)	Variable Cr
Davidson Creek	**Drainage**	Sandy loam to sandy clay loam	9	3a	Very high (108.0)	Slow drainage (3.1)	Neutral (6.5)	Non-saline (0.01)	Medium (0.44)	Medium	Medium (3.6)	Non-sodic (1.9)	Low
	Flat	Sandy loam to sandy clay loam	42	2, 3 and 6	Medium (42.2)	Moderately slow drainage (17.8)	Slightly acidic (6.1)	Non-saline (0.09)	Low (0.18)	Low	Low (2.0)	Non-sodic (2.9)	Low
	Scree Slope	Sandy loam to sandy clay loam	73	3a and 3b	Low (33.9)	Rapid drainage (169.3)	Slightly acidic (6.3)	Non-saline (0.01)	Low (0.18)	Low	Low (1.4)	Non-sodic (3.9)	Variable Cr

1. Based on the <2 mm size fraction
2. Determined for all coarse fragments >2 mm in size
3. See Appendix B for Emerson Classes.
4. 'High' metal concentrations indicate results above Ecological Investigation Levels (EILs) (Department of Environment and Conservation, 2010).

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1. INTRODUCTION

1.1 Background

Outback Ecology Services (OES) was commissioned by FerrAus Limited to conduct a programme of soil and waste material assessment for the FerrAus Pilbara Project in August 2010. The Project comprises the Robertson Range, Davidson Creek and Mirrin Mirrin Project areas located approximately 100km southeast of Newman in the Pilbara region of Western Australia (**Figure 1**). The soil and waste characterisation (physical and chemical characteristics) was performed in conjunction with a geochemical assessment of mine waste materials by Graeme Campbell and Associates (Appendix E).

Many soil, regolith and waste rock materials, once disturbed and brought to the surface during mining operations, will behave differently to how they would in their natural setting. Such materials often have intrinsic properties that make their management and incorporation into rehabilitation designs difficult. The difficulties faced in the restoration of functioning ecosystems on such landforms, often under extreme ranges of temperature and rainfall, is often exacerbated by the properties of the waste material. The way in which these materials are likely to weather and develop over time should also be taken into account when planning final landform designs. In order to obtain an idea of how materials may behave they need to be assessed and characterised.

It must be remembered that the findings presented within this report are based on analysis of samples from a relatively small number of sites. Further investigations may be required if different soil and / or waste materials are identified in the future, to facilitate rehabilitation / revegetation practices.

1.2 Report scope and objectives

The soil survey was designed to meet the DoIR Guidelines for Mining Proposals in Western Australia (DoIR, 2006) and the Leading Practice Sustainable Development Program for the Mining Industry (Dept. of Industry, Tourism and Resources, 2006).

The objectives of the soil and waste material assessment were to:

- Assess the baseline physical and chemical properties of ‘surface’ soils (to max. 1.0m depth), and mine waste materials from drill samples as appropriate;
- Identify potentially problematic soil and waste material characteristics;
- Identify characteristics which may influence rehabilitation practices;
- Develop broad recommendations for soil and waste material handling and placement in waste landforms.

Soil sample sites were chosen to encompass the range of soil / landform associations present within the Robertson Range and Davidson Creek study areas, with representative samples of soil and waste materials collected by FerrAus personnel. This report documents the results of this survey and provides the following:

- descriptions of soil profile morphology, based on Australian Soil Classification Standards (McDonald *et al.,* 1998);
- evaluation of soil physical parameters (soil structural stability [Emerson Aggregate Test], soil texture / particle size distribution, hard-setting characteristics [modified Modulus of Rupture test], hydraulic conductivity;
- measurement of soil chemical parameters (soil pH, electrical conductivity, plant-available nutrient concentrations, organic carbon, exchangeable cations and total metals concentration); and
- examination of possible correlations between measured soil properties and landform associations.

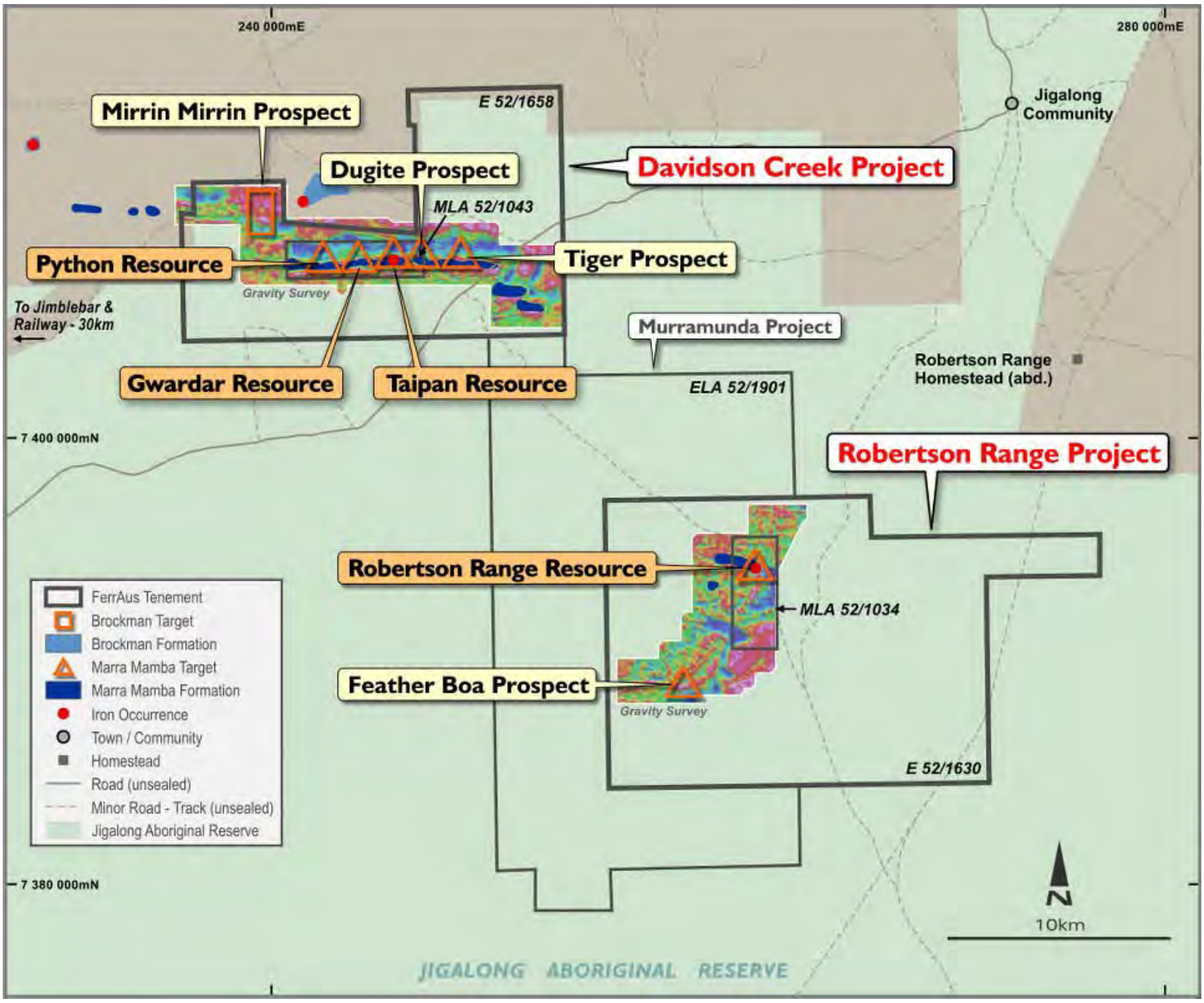

Figure 1 Location of Davidson Creek, Mirrin Mirrin and Robertson Range Project areas (FerrAus, 2010)

2. MATERIALS AND METHODS

2.1 Sampling regime

A total of 15 ‘surface’ soil sites were investigated / sampled. Nine sites were located within the Davidson Creek study area, and 6 within the Robertson Range study area (**Table 1**). The collection of field samples was performed by FerrAus personnel using sampling protocols supplied by Outback Ecology.

Sample sites were chosen to represent the range of landforms present with the two study areas, namely the flats and scree slopes within the Robertson Range study area, and the flats, scree slope, drainage area and creek bed within the Davidson Creek study area.

Soil pits were excavated at all 15 locations by FerrAus staff, as deep as possible, to a maximum depth of approximately 1.0 m. At some sites however, high soil strength or competent rock restricted excavation to approximately 0.5 m depth. The soil profile was described (soil profile morphology, soil structure, root distribution) based on the Australian Soil and Land Survey Handbook (McDonald *et al.,* 1998). Samples were taken from three to four depth intervals within each profile for analyses of chemical and physical parameters.

Table 1: Summary of soil sampling sites and locations.

Site #	Site description	Coordinates (Projection: UTM Zone 51J, Datum: GDA94)	
		Easting (mE)	Northing (mN)
Robertson Range Sites			
RR 001	Robertson Range, flat	261845	7394103
RR 002	Robertson Range, flat	261951	7393315
RR 003	Robertson Range, flat	261632	7393112
RR 004	Robertson Range, scree slope	261694	7394185
RR 005	Robertson Range, scree slope	261688	7394105
RR 006	Robertson Range, scree slope	261801	7394309
Davidson Creek Sites			
DC001	Davidson Creek, drainage – creek bed	241796	7408185
DC 002	Davidson Creek, flat	242386	7408093
DC 003	Davidson Creek, flat	242687	7407645

Site #	Site description	Coordinates (Projection: UTM Zone 51J, Datum: GDA94)	
		Easting (mE)	Northing (mN)
DC 004	Davidson Creek, flat	244485	7407070
DC 005	Davidson Creek, flat	243773	7406264
DC 006	Davidson Creek, scree slope	244132	7407747
DC 007	Davidson Creek, drainage	246147	7407884
DC 008	Davidson Creek, scree slope	242688	7407695
DC 009	Davidson Creek, drainage	241681	7407828

Samples of representative mine waste drill samples from the Robertson Range deposit (**Table 2** and **Figure 2**) and the Davidson Creek deposit (**Table 3** and **Figure 3**) were selected by FerrAus personnel and sent to Outback Ecology for analysis.

Table 2 Sample ID's, descriptions and locations of waste material drill samples from the Robertson Range deposit

Waste Type	Hole ID	Sample Depth	Geological Description
Transported Clay	RRDD0037G	23.9m - 24.2m	Pale clay with minor maghemite gravel
	RRDD0038G	27.7m - 28.0m	Pale puggy lacustrine clay
Transported Surficial Material	RRDD0037G	1.7m - 2.0m	Loamy soil and fine gravel/quartz
	RRDD0038G	4.1m - 4.4m	Brown loamy soil and minor fine gravel
	RRDD0029T	4.6m - 4.9m	Sand, clay, maghemite pisolites
Transported Detritals	RRDD0037G	28.0m - 28.3m	Clay matrix supported detrital zone; 30% ferruginous frags
	RRDD0038G	36.0m - 36.3m	Haematite hardcap fragments in clay matrix
	RRDD0021G	27.5m - 27.8m	Coarse maghemite and goethite
Lower West Angela Low Mn	RRDD0036G	30.0m - 30.3m	Brown, weakly Manganiferous clay
	RRDD0040G	65.0m - 65.3m	Weathered shale
	RRDD0028T	33.8m - 34.1m	Clay after weathered shale
Lower West Angela +3% Mn	RRDD0036G	18.0m - 18.3m	Manganiferous clay
	RRDD0027	90.7m - 91.0m	Strongly manganiferous clay/shale
Mt Newman/McLeod Member	RRDD0036G	71.0m - 71.35m	BIF +/- chert
	RRDD0018G	123.8m - 124.1m	Interbedded shale/chert

Table 3 Sample ID's, descriptions and locations of waste material drill samples from the Davidson Creek deposit

Waste Rock Type	Hole ID	Sample Depth	Geological Description
Transported Clay	DCDD0037G	31.1m - 31.4m	Transported clay with minor sandy grits
	DCDD0039G	78.7m - 79.0m	Quartz sand in transported clay
	DCRC0987	68m - 69m	Transported clay
Transported Surficial Material	DCDD0037G	4.2m - 4.5m	Soil/sand with 20% ferruginous and maghemite fragments
	DCDD0039G	4.3m - 4.6m	Clay with gravels and quartz fragments
	DCRC0987	4m - 5m	Sand, soil, quartz and ferruginous fragments
Transported Detritals	DCDD0033G	20.7m - 21.0m	BIF/goethite fragments in light brown clay matrix
	DCDD0037G	48.1m - 48.4m	Pisolites and goethite fragments in clay matrix
	DCDD0043G	40.1m - 40.4m	Maghemite clasts in clay matrix
Lower West Angela Low Mn	DCDD0037G	64.4m - 64.7m	Weakly manganiferous clay after weathered shale
	DCRC0973	84m - 85m	Clay + goethite, trace Manganese
Lower West Angela +3% Mn	DCDD0039G	96.3m - 96.6m	Manganiferous shales / clays
	DCRC0973	94m - 95m	Manganiferous shale and clay
Mt Newman/McLeod Member	DCDD0038G	107.0m - 107.3m	Finely laminated chert / shale
	DCDD0033G	52.7m - 53.0m	Bedded chert and ferruginous shale
	DCDD0042G	64.0m - 64.3m	Biffy cherts and minor haematitic shale

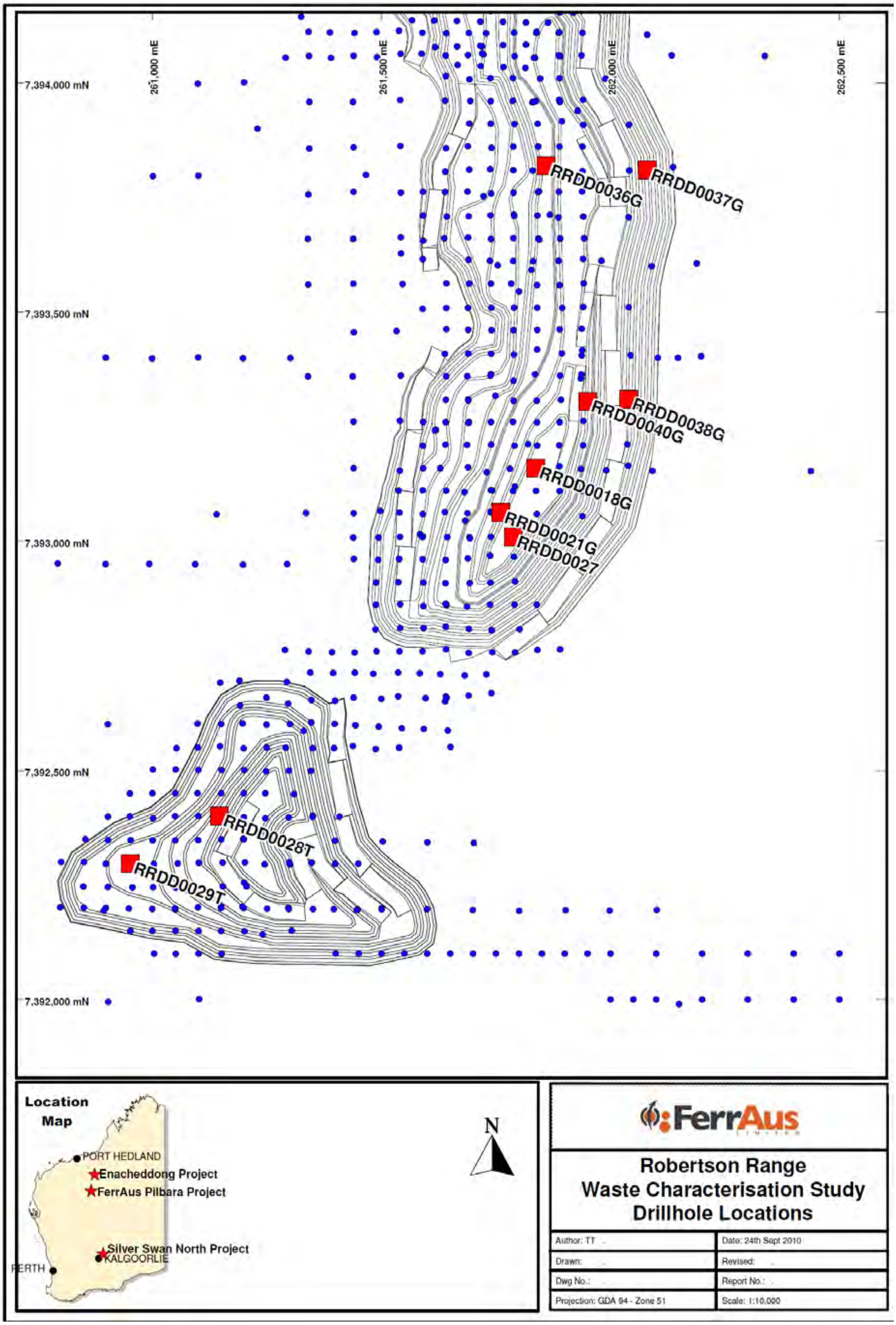

Figure 2: Location of waste material drillhole sites at Robertson Range, FerrAus Pilbara Project

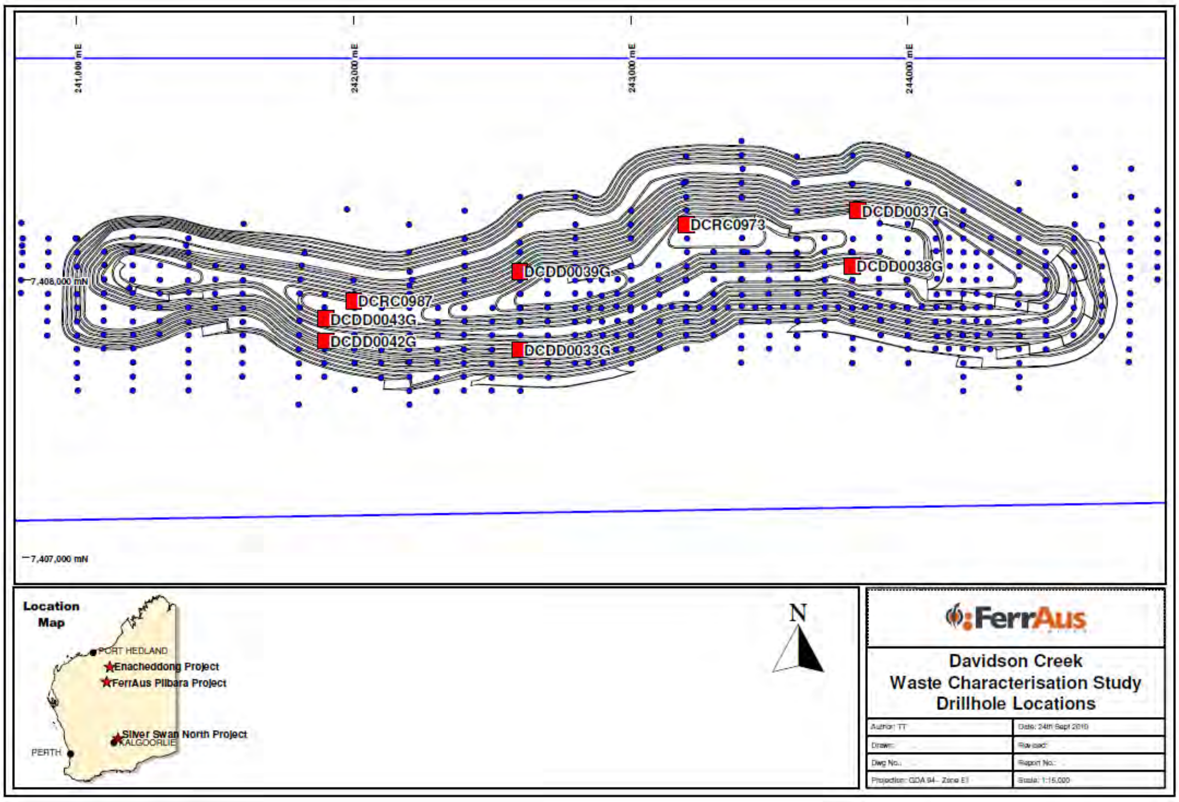

Figure 3 Location of waste material drillhole sites at Davidson Creek, FerrAus Pilbara project.

2.2 Test work and procedures

The various analyses, methods and sample numbers for the chemical and physical analysis of soil and waste materials are detailed in **Table 4**.

CSBP Soil and Plant Laboratory conducted analyses on the selected samples from the Robertson Range and Davidson Creek sites for ammonium and nitrate (Scarle 1984), extractable phosphorus and potassium (Colwell 1965, Rayment and Higginson 1992), extractable sulphur (Blair *et al.* 1991), total phosphorus (Allen and Jeffrey 1990), and organic carbon (Walkley and Black 1934). Analysis of total nitrogen was conducted by combustion at 950°C in oxygen using a Leco FP-428 Nitrogen Analyser. Measurements of electrical conductivity (1:5 H_2O), soil pH (1:5 H_2O and 1:5 $CaCl_2$), of soil and waste materials were conducted using the methods described in Rayment and Higginson (1992). Exchangeable cations Ca^{2+}, Mg^{2+}, Na^+ and K^+ (Rayment and Higginson, 1992) and particle size (McKenzie *et al.* 2002) was also assessed on selected samples of soil and waste materials..

ALS Environmental Laboratory analysed selected surface soil samples for total concentrations of metals including arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), nickel (Ni), zinc (Zn) and mercury (Hg). CV/FIMS was used to analyse for Hg, while ICPAES was used for the other elements.

Soil texture was assessed by OES staff using the procedure described in McDonald *et al.* (1998). A measure of soil slaking and dispersive properties (Emerson Aggregate Test) of soil and waste materials was conducted as described in McKenzie *et al.* (2002). Soil strength and the resulting tendency of each material to hardset was assessed by OES staff using a modified Modulus of Rupture test (Aylmore and Sills 1982, Harper and Gilkes 1994).

Table 4: Summary of analyses conducted on Robertson Range and Davidson Creek soil and mine waste samples.

Soil parameter	Measurement method	Conducted by	Number of samples analysed		Sample selection criteria
			Surface soils	Mine waste	
Chemical properties					
Total Metals (As, Cd, Cr, Cu, Pb, Ni and Zn)	Inductively coupled plasma atomic emission spectroscopy (ICP-AES) method	ALS	55	-	All surface soil samples
Total Metals (Hg)	Cold vapour/ Flow injection mercury system (CV/FIMS method)	ALS	55	-	All surface soil samples
Soil pH	pH measured in 1:5 soil:water and 1:5 Soil:$CaCl_2$ (Rayment and Higginson, 1992)	CSBP	55	31	All surface soil and mine waste samples
Electrical conductivity	Measured in 1:5 soil:water (Rayment and Higginson, 1992)	CSBP	55	31	All surface soil and mine waste samples
Plant-available nitrogen (ammonium and nitrate)	Scarle (1984)	CSBP	26	-	Soil samples from 2 depths (0-5cm and 40-50cm) at 13 sites, selected to represent the 3 landforms types and 2 areas.
Exchangeable cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+})	Rayment and Higginson (1992)	CSBP	55	-	All surface soil samples
Plant-available phosphorus and potassium	Colwell (1965); Rayment and Higginson (1992)	CSBP	26	-	Soil samples from 2 depths (0-5cm and 40-50cm) at 13 sites, selected to represent the 3 landforms types and 2 areas.
Organic carbon percentage	Walkley and Black (1934)	CSBP	55	-	All surface soil samples
Physical properties					
Particle size distribution	Pipette method (Day, 1965)	CSBP	55	-	All surface soil samples
Saturated hydraulic conductivity (K_{sat})	Measured on materials packed to their respective field bulk densities, using a constant-head of pressure technique (Hunt and Gilkes, 1992)	Outback Ecology	12	-	Surface soil (0-5cm) samples from 12 sites selected to represent the 3 landforms types and 2 areas.
Soil slaking and dispersive properties	Emerson Aggregate Test (McKenzie *et al.*, 2002)	Outback Ecology	30	31	2 depths (0-5cm and 40-50cm) from all surface soil sites, plus all mine waste samples
Soil strength	Modified Modulus of Rupture test (Aylmore and Sills, 1982; Harper and Gilkes, 1994)	Outback Ecology	30	31	2 depths (0-5cm and 40-50cm) from all surface soil sites, plus all mine waste samples
Soil texture	McDonald *et al.*, (1998)	Outback Ecology	30	-	2 depths (0-5cm and 40-50cm) from all surface soil sites, plus all mine waste samples

3. RESULTS AND DISCUSSION - SURFACE SOILS

3.1 Soil profile descriptions

A description of the soil profile morphology at each site has been documented, with a summary of the measured physical, chemical and morphological parameters tabulated for each site (Sections 3.1.1 – 3.1.15). Individual soil characteristics are then discussed in further detail (Sections 3.2 – 3.3). The vegetation descriptions given for each site are based on photographs and observations made in the field by FerrAus personnel at the time of sampling.

3.1.1 Site RR 001

Site description: Robertson Range, Site 1

Soil/Landform Association Flat

Plate 1: Soil profile at RR 001

Soil profile description

0 - 50cm: Homogenous reddish orange soil material, few coarse fragments. Sparse roots present in top 40cm

50 – 100cm: Sharp transition to homogenous soil with high percentage (>75%) coarse fragments.

Vegetation: Spinifex plain with widely scattered *Eucalyptus sp.* over moderately dense mixed *Acacia sp.*.

Plate 2: Vegetation at RR 001

3.1.2 Site RR 002

Site description: Robertson Range, Site 2

Soil/Landform Association Flat

Plate 3: Soil profile at RR 002

Soil profile description

0 – 100 cm: Homogenous, massive soil to base of pit at 100cm. Few coarse fragments. Few roots to approximately 65cm depth.

Vegetation: Spinifex plain with widely scattered *Eucalyptus sp.* over moderately dense mixed *Acacia.*

Plate 4: Vegetation at RR 002

3.1.3 Site RR 003

Site description:	Robertson Range, Site 3
Soil/Landform Association	Flat

Plate 5: Soil profile at RR 003

Soil profile description

0 – 100 cm: Soft surface crust, homogenous dark red soil with gradual change to lighter brown with depth. Roots present to approximately 70cm.

Vegetation: Spinifex plain with widely scattered *Eucalyptus sp.* over moderately dense mixed *Acacia.*

Plate 6: Vegetation at RR 003

3.1.4 Site RR 004

Site description: Robertson Range, Site 4

Soil/Landform Association Scree Slope

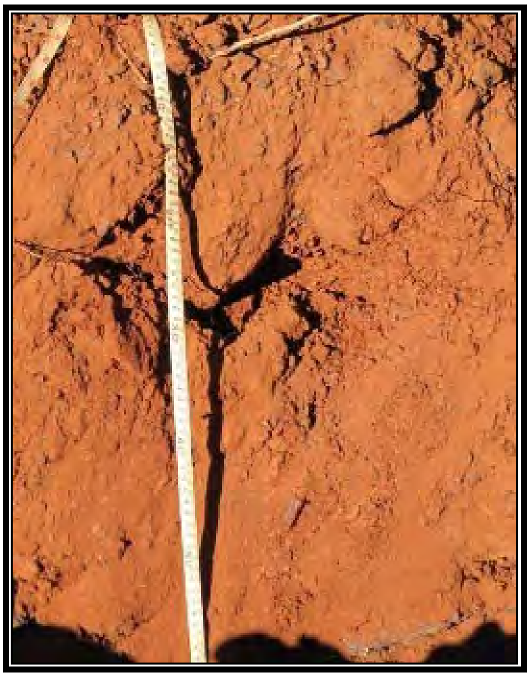

Plate 7: Soil profile at RR 004

Soil profile description

0 – 50 cm: Dark red gravelly soil material, high coarse material content throughout profile, sparse roots to 30cm.

50 cm+: Dense gravelly soil with massive structure.

Vegetation: Spinifex plain with widely scattered *Eucaluptus sp.* over moderately dense mixed *Acacia.*

Plate 8: Vegetation at RR 004

3.1.5 Site RR 005

Site description: Robertson Range, Site 5

Soil/Landform Association Scree slope

Plate 9: Soil profile at RR 005

Soil profile description

0 – 50 cm: Dark red gravelly soil material, high coarse material content throughout profile, sparse roots to 40cm.

50 cm+: Dense gravelly soil with massive structure.

Vegetation: *Mulga*, over low shrubs and *Spinifex.*

Plate 10: Vegetation at RR 005

3.1.6 Site RR 006

Site description: Robertson Range, Site 6

Soil/Landform Association Scree slope

Plate 11: Soil profile at RR 006

Soil profile description

0 – 50 cm: Dark red gravelly soil material, high coarse material content throughout profile, sparse roots to 30cm.

50 cm+: Dense gravelly soil with massive structure. Large coarse fragments present from approximately 40cm depth.

Vegetation: *Mulga*, over low shrubs and *Spinifex.*

Plate 12: Vegetation at RR 006

3.1.7 Site DC 001

Site description: Davidson Creek, Site 1

Soil/Landform Association Drainage – creek bed

Plate 13: Soil profile at DC 001

Soil profile description

0 – 100 cm: Weak surface crust. Homogenous soil to base of pit at 100cm. Coarse fragments increasing with depth. Many roots to base of pit.

Vegetation: Scattered *Eucalyptus sp.* and grasses.

Plate 14: Vegetation at DC 001

3.1.8 Site DC 002

Site description: Davidson Creek, Site 2

Soil/Landform Association Flat

Plate 15: Soil profile at DC 002

Soil profile description

0 – 100 cm: Dark reddish orange soil progressing to light red with depth, calcareous coarse material from approximately 20 to 40cm deep, large rock fragments present throughout profile.

Vegetation: Mostly small grasses with a few larger trees within 10m of site.

Plate 16: Vegetation at DC 002

3.1.9 Site DC 003

Site description: Davidson Creek, Site 3

Soil/Landform Association Flat

Plate 17: Soil profile at DC 003

Soil profile description

0 – 70 cm: Consolidated gravelly soil with strong consistence. Few roots to approximately 30cm.

Vegetation: Mainly *Spinifex* with some small trees.

Plate 18: Vegetation at DC 003

3.1.10 Site DC 004

Site description: Davidson Creek, Site 4

Soil/Landform Association Flat

Plate 19: Soil profile at DC 004

Soil profile description

0 – 90 cm: Rocky surface. Consolidated gravelly soil with strong consistence. Large rock fragments present throughout profile. Few roots to approximately 30cm.

Vegetation: Mainly *Spinifex* with some small trees.

Plate 20: Vegetation at DC 004

3.1.11 Site DC 005

Site description: Davidson Creek, Site 5

Soil/Landform Association Flat

Plate 21: Soil profile at DC 005

Soil profile description

0 – 80 cm: Soft surface, increasing soil strength with depth from approximately 40cm, many rock fragments at depth. Roots common to approximately 70cm depth.

Vegetation: Mostly small trees with some *Spinifex.*

Plate 22: Vegetation at DC 005

3.1.12 Site DC 006

Site description: Davidson Creek, Site 6

Soil/Landform Association Scree slope

Plate 23: Soil profile at DC 006

Soil profile description

0 – 80 cm: Loose rocky surface. Loose gravelly soil with strength increasing with depth. Large rock fragments present throughout profile. Some roots present to approximately 70cm depth

80 cm+: Massive soil structure.

Vegetation: Abundant *Spinifex* with some small trees.

Plate 24: Vegetation at DC 006

3.1.13 Site DC 007

Site description: Davidson Creek, Site 7

Soil/Landform Association Drainage area

Plate 25: Soil profile at DC 007

Soil profile description

0 – 100 cm: Loose sandy material at surface progressing to homogenous dark brown massive soil with depth, root abundance classified as 'many' and present to approximately 80cm depth.

Vegetation: Abundant grasses and medium-sized trees.

Plate 26: Vegetation at DC 007

3.1.14 Site DC 008

Site description: Davidson Creek, Site 8

Soil/Landform Association Scree slope

Plate 27: Soil profile at DC 008

Soil profile description

0 – 90 cm: Loose rocky surface. Loose gravelly soil with strength increasing with depth. Large rock fragments present throughout profile. Some roots present to approximately 50cm depth

Vegetation: Hard *Spinifex*, with few trees.

Plate 28: Vegetation at DC 008

3.1.15 Site DC 009

Site description: Davidson Creek, Site 9

Soil/Landform Association Drainage area

Plate 29: Soil profile at DC 009

Soil profile description

0 – 100 cm: Loose sandy material at surface progressing to homogenous, massive soil with depth, gravel content increasing with depth. Many roots to base of pit.

.

Vegetation:

Some grasses with scattered small trees.

Plate 30: Vegetation at DC 009

3.2 Soil physical properties

3.2.1 Soil texture

Soil texture describes the proportions of sand, silt and clay (the particle size distribution) within a soil. The particle size distribution and resulting textural class of soils is an important factor influencing most physical and many chemical and biological properties. Soil structure, water holding capacity, hydraulic conductivity, soil strength, fertility, erodibility and susceptibility to compaction are some of the factors closely linked to soil texture.

There were a range of particle size distributions exhibited throughout the Robertson Range (**Figure 4**) and Davidson Creek (**Figure 5**) study areas and within the individual soil profiles, with soil textures ranging from loamy sand (approximately 5 % clay) to sandy clay loam (approximately 20% clay). The majority of soil materials were classed as sandy loams, loamy sands or sandy clay loams, (**Table 5** and **Table 6**).

Coarse material / gravel contents were highest in scree slope samples for both sites, averaging 60% at Robertson Range and 73% at Davidson Creek. The Flat site samples at Davidson Creek had much higher gravel contents than those from the Flat sites at Robertson Range with 42% and 4 % respectively. Surface soils at Drainage site samples had an average gravel content of 9%.

Gravel contents increased with depth in the Scree samples but changed little with depth in the Flat samples from Robertson Range (**Figure 6**). Gravel contents typically increased with depth in samples from all landforms at Davison Creek (**Figure 7**).

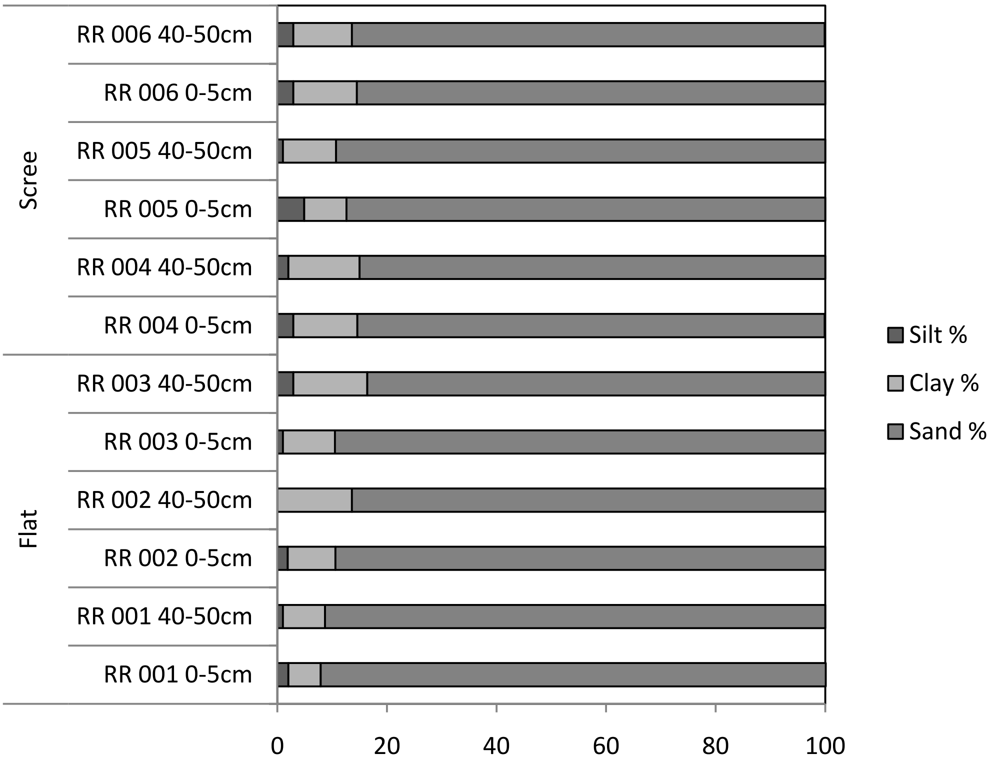

Figure 4: Particle size distribution of selected Robertson Range soil samples.

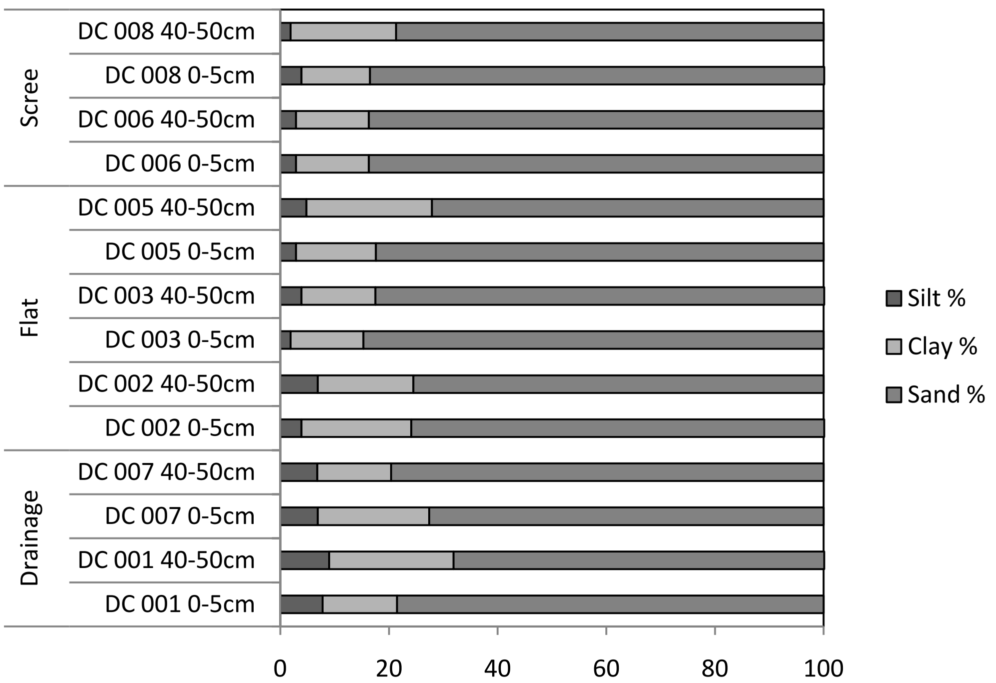

Figure 5: Particle size distribution of selected Davidson Creek soil samples.

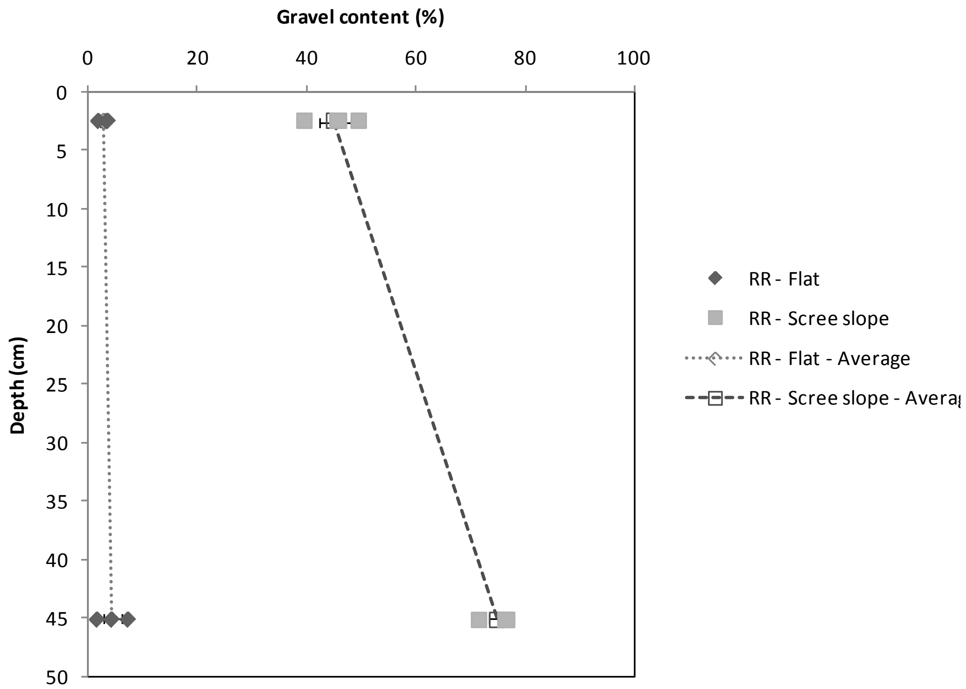

Figure 6: Individual and average coarse material / gravel content (%) values grouped into landform associations at Robertson Range (error bars represent standard error).

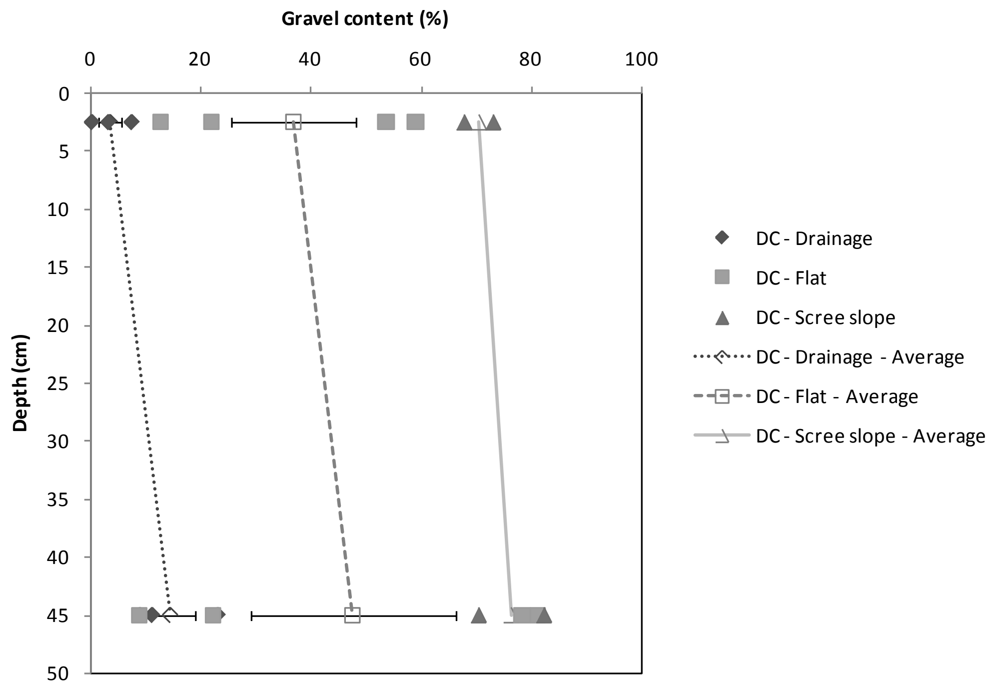

Figure 7: Individual and average coarse material / gravel content (%) values grouped into landform associations at Davidson Creek (error bars represent standard error).

Table 5: Soil physical characteristics for Robertson Range soil samples

Site	Depth Interval (cm)	Field Texture (of <2 mm fraction)	Emerson Test Class[1]	MOR (kPa)	% Coarse Fragments (>2mm)	Particle Size Distribution (<2mm fraction)			
						% Coarse sand	% Fine sand	% Clay	% Silt
RR 001	**0 to 5**	Sand	3b	12.84	3.26	74.5	17.6	5.9	2
	40 to 50	Sand	3b	9.71	7.26	69.6	21.7	7.7	1
RR 002	**0 to 5**	Sand	3b	20.27	1.74	66.9	22.4	8.7	1.9
	40 to 50	Loamy Sand	3b	9.23	1.50	54.7	31.8	13.6	<0.01
RR 003	**0 to 5**	Sandy Loam	3b	10.61	3.50	61.7	27.8	9.5	1
	40 to 50	Sandy Loam	3b	8.54	4.23	59.8	23.8	13.5	2.9
RR 004	**0 to 5**	Sandy Loam	3b	21.27	45.85	35.6	49.7	11.7	2.9
	40 to 50	Sandy Loam	3b	19.31	71.54	43.2	41.8	13	2
RR 005	**0 to 5**	Loamy Sand	3b	13.53	39.69	37.3	50.1	7.7	4.9
	40 to 50	Loamy Sand	3a	35.81	76.69	42.2	47.1	9.7	1
RR 006	**0 to 5**	Sandy Loam	6	42.97	49.55	26.6	58.9	11.6	2.9
	40 to 50	Sandy Loam	3a	20.00	76.56	59.4	26.9	10.7	2.9

1. See Appendix B for Emerson Test class categories.

Table 6: Soil physical characteristics for Davidson Creek soil samples

Site	Depth Interval (cm)	Field Texture (of <2 mm fraction)	Emerson Test Class[1]	MOR (kPa)	% Coarse Fragments (>2mm)	Particle Size Distribution (<2mm fraction)			
						% Coarse sand	% Fine sand	% Clay	% Silt
DC 001	**0 to 5**	Sandy Loam	3a	27.48	3.12	39.6	38.9	13.7	7.8
	40 to 50	Sandy Clay Loam	3a	254.86	23.14	19.7	48.5	22.9	9
DC 002	**0 to 5**	Sandy Clay Loam	2	50.13	21.91	53.9	22	20.2	3.9
	40 to 50	Sandy Loam	2	69.13	22.23	54.7	20.9	17.6	6.9
DC 003	**0 to 5**	Sandy Loam	3b	31.14	53.54	40.2	44.4	13.4	1.9
	40 to 50	Sandy Loam	3b	36.87	80.90	52	30.6	13.6	3.9
DC 004	**0 to 5**	-	3b	36.87	58.84	-	-	-	-
	40 to 50	-	6	45.90	78.11	-	-	-	-
DC 005	**0 to 5**	Sandy Loam	3a	36.71	12.85	52.3	30.1	14.7	2.9
	40 to 50	Sandy Clay Loam	6	71.14	8.99	53.4	18.7	23.1	4.8
DC 006	**0 to 5**	Sandy Loam	3a	32.31	67.75	48	35.7	13.4	2.9
	40 to 50	Sandy Loam	3a	20.00	70.37	53.6	30.1	13.4	2.9
DC 007	**0 to 5**	Sandy Clay Loam	3a	60.27	7.38	39.2	33.5	20.5	6.9
	40 to 50	Sandy Loam	3a	60.74	11.12	48.8	30.8	13.6	6.8
DC 008	**0 to 5**	Sandy Loam	3b	47.27	73.00	43.7	39.9	12.6	3.9
	40 to 50	Sandy Clay Loam	3b	35.97	82.20	44.5	34.2	19.4	1.9
DC 009	**0 to 5**	-	3a	17.83	0.09	-	-	-	-
	40 to 50	-	3a	226.90	8.90	-	-	-	-

1. See Appendix B for Emerson Test class categories.

3.2.2 Soil structure and structural stability

Soil structure describes the arrangement of solid particles and void space in a soil. It is an important factor influencing the ability of soil to support plant growth, store and transmit water and resist erosional processes. A well-structured soil is one with a range of different sized aggregates, with component particles bound together to give a range of pore sizes facilitating root growth and the transfer of air and water. When a soil material is disturbed, the breakdown of aggregates into primary particles can lead to structural decline (Needham *et al.,* 1998). This can result in hard-setting and crusting at the soil surface and a 'massive' soil structure at depth, potentially reducing the ability of seeds to germinate, roots to penetrate the soil matrix and water to infiltrate to the root zone.

The structural stability of a soil and its susceptibility to structural decline is complex and depends on the net effect of a number of properties, including the amount and type of clay present, organic matter content, soil chemistry and the nature of disturbance. Soil aggregates that slake and disperse indicate a weak soil structure that is easily degraded. The Emerson Aggregate Test identifies the potential slaking and dispersive properties of soil aggregates under a worst case scenario, where severe stress is applied to the soil material. Generally samples allocated to Emerson Classes 1 and 2 are those most likely to exhibit dispersive properties. These soils should be seen as potentially problematic when used for the reconstruction of soil profiles for rehabilitation, particularly if left exposed at the surface. None of the soil samples tested from Robertson Range fell into either Emerson Class 1 or 2 (**Table 5**). Of the samples from Davidson Creek, only one sample from the 'Flat' soil / landform association (DC002) was categorised as Emerson Class 2 in both the 0-5cm and 40-50cm depth intervals (**Table 6**).

All but one of the samples tested from Robertson Range exhibited dispersion upon re-moulding (Emerson Class 3a and 3b), (**Table 5**). This indicates a potential to become dispersive and problematic following severe disturbance. Care should be taken to minimise the handling of soil materials where possible, particularly when wet. All of the Davidson Creek samples (with the exception of DC002) also fell into Emerson Class 3a and 3b for the topsoil (0-5cm) samples, and with the exception of two 40-50cm samples, (DC004 and DC005) all subsoil samples also fell into these categories (**Table 6**).

3.2.3 Soil strength

A modified Modulus of Rupture (MOR) test was conducted on all samples collected (**Figure 8**). This test is a measure of soil strength and identifies the tendency of a soil to hard-set as a direct result of soil slaking and dispersion. A modulus of rupture of over 60 kPa has been described as the critical value for distinguishing potentially problematic soils in agricultural scenarios (Cochrane and Aylmore, 1997). Restricted root penetration into the soil matrix is a likely consequence of a high modulus of rupture. In reconstructed soil profiles, materials normally deep within the profile that may have a high MOR can often be re-deposited closer to the surface, leading to germination / emergence and root penetration problems.

As this test is conducted on reconstructed soil blocks composed of the < 2 mm soil fraction, it does not take into account the effect of gravel content or soil structure on soil strength, nor any degree of compaction that may be present in the field. It does, however, provide insight into the potential for layers to hard-set and compact with repeated wetting and drying cycles, and the ability of roots to fracture the soil and penetrate crack faces.

All soils tested from Robertson Range had MOR values below the critical level and thus are not considered to be at risk of hard setting nor problematic in terms of root penetration (Figure 7). Topsoils at Davidson Creek were also in the non-problematic range (**Figure 8**). However, soils from the 45cm depth in the 'Drainage' samples at Davidson Creek are over 60kPa and could potentially cause problems for root penetration.

It should also be noted that an increase in dispersive properties, as salt is leached from saline soils may result in an increase in the tendency of some materials to hard-set over time. Although not currently a problem this should be monitored given some of the higher salinity readings from some 'Flat' soil samples at Davidson Creek (Section 3.2.2).

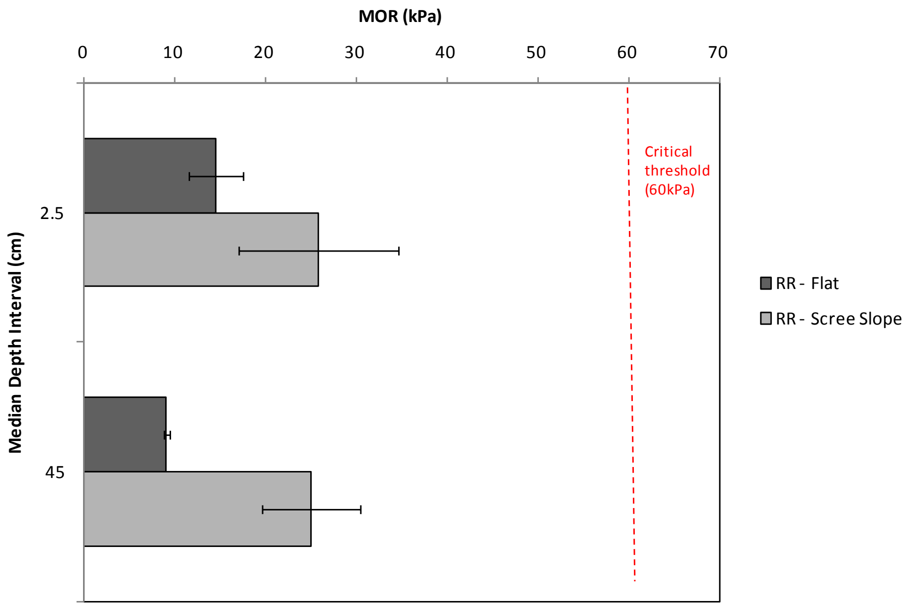

Figure 8: Average modulus of rupture (kPa) values for soils grouped into soil / landform associations (error bars represent standard error) at Robertson Range. Red line indicates potential restrictions to plant and root development (Cochrane and Aylmore, 1997).

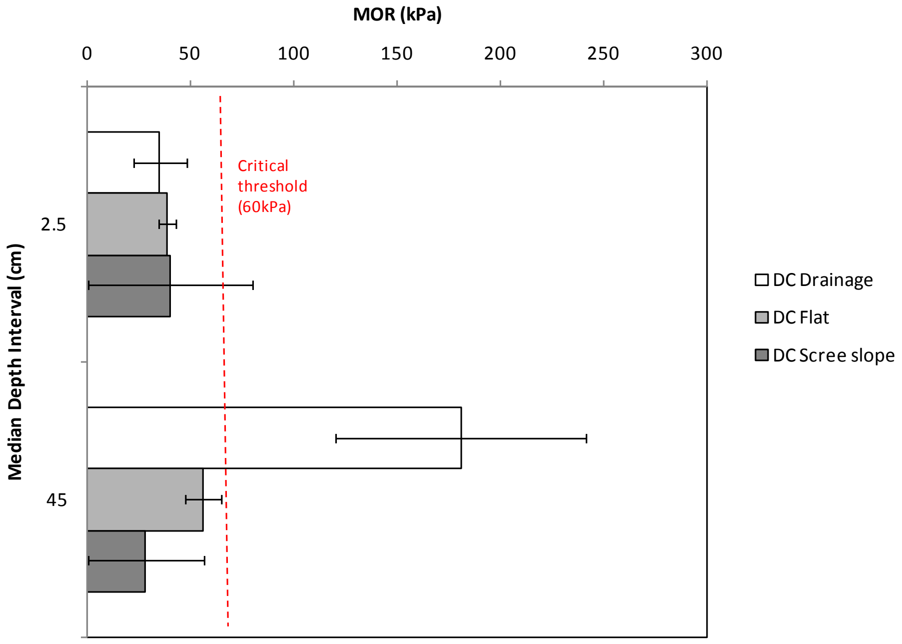

Figure 9: Average modulus of rupture (kPa) values for soils grouped into landform associations at Davidson Creek (error bars represent standard error). Red line indicates potential restrictions to plant and root development (Cochrane and Aylmore, 1997).

3.2.4 Hydraulic conductivity

Hydraulic conductivity (K_{sat}) refers to the permeability of soil, or the ability of water to infiltrate and drain through the soil matrix, and is dependant on soil properties such as texture and structure (Hunt and Gilkes 1992; Hazelton and Murphy 2007; Moore 1998). Freely draining soils with high K_{sat} values will generally be less susceptible to surface runoff and erosion. Slow draining soils with low K_{sat} values, are more likely to experience water logging, increased surface runoff and erosion.

Saturated hydraulic conductivity was determined on 12 samples representing the 3 landform types and 2 study areas. Samples were collected in the field and repacked to their approximate bulk densities. Drainage classes were determined for each core according to their K_{sat} (Hunt and Gilkes,1992) (**Table 8**).

The drainage classes for samples from the different soil / landforms associations were variable. The 'Flat' soil / landform samples from the Robertson Range study area were classed as having 'moderate' to 'moderately rapid' drainage, while the Flat samples from Davidson Creek where in the 'moderate' to 'moderately slow' drainage classes (**Table 8**). Samples from within the Drainage soil / landform association at Davison Creek where both classed as 'slow draining'. Scree slope samples from the Robertson Range study area ranged from 'moderate' to 'moderately slow' draining while those at Davidson Creek fell into the 'moderate' to 'moderately rapid' drainage class (**Table 8**).

Table 7: Saturated hydraulic conductivity (Ksat) values, soil texture and drainage class for selected soil samples at Robertson Range and Davidson Creek.

Landform	Site ID	Depth (cm)	Field Texture	k_{sat} (mm/hr)	Drainage class[1.]
Robertson Range Samples					
Flat	RR 001	40-50	Sand	59.55	Moderately rapid
	RR 002	40-50	Sand	51.78	Moderately rapid
	RR 003	40-50	Sandy Loam	25.69	Moderate
Scree slope	RR 004	10-20	Sandy Loam	18.60	Moderately slow
	RR 005	10-20	Loamy sand	13.42	Moderately slow
	RR 006	10-20	Sandy Loam	24.55	Moderate
Davidson Creek Samples					
Drainage	DC 001	40-50	Sandy Clay Loam	3.70	slow
	DC 007	40-50	Sandy Loam	2.49	Slow
Flat	DC 003	10-20	Sandy Loam	21.60	Moderate
	DC 005	40-50	Sandy Clay Loam	13.93	Moderately slow
Scree slope	DC 006	10-20	Sandy Loam	87.01	Moderately rapid
	DC 008	10-20	Sandy Loam	251.52	Rapid

1. Based on categories described in Hunt and Gilkes (1992)

3.2.5 Root growth

The presence of roots was observed within all soil profiles in the Robertson Range and Davidson Creek study areas (Section 3.1). Root abundance ranged from ‘sparse’ to ‘many’ and was obviously dependant on proximity to plants and the number of plants present. The full extent of root penetration into the underlying soil / regolith profile, beyond the depth of the soil pits, is unknown.

3.3 Soil chemical properties

3.3.1 Soil pH

The soil pH gives a measure of the soil acidity or alkalinity. The ideal pH range for plant growth of most agricultural species is considered to be between 5.0 and 7.5 (Moore 1998). Outside this range, the plant-availability of some nutrients is affected, while various metal toxicities (e.g. Al and Mn) can become limiting at low pH. For native species, which are known to be tolerant of wider ranges in soil pH, preferred pH ranges are best inferred from the soil in which they are observed to occur.

Samples from the Robertson Range study area indicate a narrow range of soil pH values, with all soil pH values within the neutral range (Table 8, Figure 10).

All soil pH values from Davidson Creek samples were classed as neutral to slightly acidic (Table 9, Figure 11). There was slightly higher degree of variability in pH within the soils from the Flat soil / landform sites compared to the Drainage and Scree slope soils. However, on average, pH values from the three soil / landform associations were relatively similar.

Table 8: Soil chemical characteristics for Robertson Range soil samples

Site	Depth Interval (cm)	Soil pH (H_2O)	EC (dS/m)	Organic Carbon (%)	Plant-available Nutrients (mg/kg)					Exchangeable Cations (meq/100 g)				ESP (%)
					Nitrate (NO_3^-)	Ammonium (NH_4^+)	P	K	S	Ca^{2+}	Mg^{2+}	Na^+	K^+	
RR 001	**0-5**	5.8	0.016	0.19	3	1	4	56	1.05	0.42	0.11	<0.01	0.05	4.92
	10-20	6.5	0.031	0.15	2	0	2	75	6.44	0.45	0.11	<0.01	0.07	4.55
	40-50	6.4	0.018	0.14	1	3	3	68	3.59	0.36	0.36	<0.01	0.09	5.81
	90-100	6.7	0.026	0.09	3	4	4	56	2.62	0.41	0.27	<0.01	0.06	3.27
RR 002	**0-5**	6.5	0.035	0.19	8	3	4	129	5.79	0.69	0.19	<0.01	0.12	2.44
	10-20	6.6	0.045	0.13	2	1	2	138	11.9	0.6	0.18	<0.01	0.16	5.05
	40-50	6.8	0.039	0.09	2	14	11	80	9.49	0.48	0.5	<0.01	0.12	4.35
	90-100	7	0.055	0.05	11	0	2	77	10.5	0.54	0.45	<0.01	0.08	4.46
RR 003	**0-5**	6.2	0.015	0.15	3	1	2	57	1.16	0.36	0.16	<0.01	0.04	4.27
	10-20	6.2	0.01	0.09	1	0	2	74	2.67	0.36	0.16	<0.01	0.06	4.13
	40-50	6	0.015	0.22	0	0	9	73	4.84	0.43	0.17	<0.01	0.08	3.55
	90-100	6.4	<0.01	0.05	0	0	3	74	5.81	0.37	0.17	<0.01	0.05	4.07
RR 004	**0-5**	6.2	<0.01	0.24	3	0	4	98	1.56	0.79	0.16	<0.01	0.12	4.46
	10-20	6.5	0.015	0.22	3	0	13	120	3	0.87	0.22	<0.01	0.16	3.85
	40-50	6.4	0.012	0.18	1	0	3	100	1.85	0.83	0.2	<0.01	0.12	4.17
RR 005	**0-5**	6.4	<0.01	0.22	2	1	3	77	1.39	0.6	0.16	<0.01	0.08	5.62
	10-20	6.4	0.014	0.15	3	0	16	113	2.38	0.55	0.15	<0.01	0.13	5.68

Site	Depth Interval (cm)	Soil pH (H_2O)	EC (dS/m)	Organic Carbon (%)	Plant-available Nutrients (mg/kg)					Exchangeable Cations (meq/100 g)				ESP (%)
					Nitrate (NO_3^-)	Ammonium (NH_4^+)	P	K	S	Ca^{2+}	Mg^{2+}	Na^+	K^+	
	40-50	6.4	<0.01	0.14	1	1	3	64	1.43	0.6	0.21	<0.01	0.05	5.49
RR 006	**0-5**	6	<0.01	0.13	1	0	8	75	2.22	0.64	0.21	<0.01	0.08	5.10
	10-20	6.4	0.011	0.09	2	0	3	84	3.29	0.63	0.15	<0.01	0.1	5.38
	40-50	6.1	<0.01	0.24	1	1	6	64	1.53	0.82	0.18	<0.01	0.08	4.42

Table 9: Soil chemical characteristics for Davidson Creek soil samples

Site	Depth Interval (cm)	Soil pH (H_2O)	EC (dS/m)	Organic Carbon (%)	Plant-available Nutrients (mg/kg)					Exchangeable Cations (meq/100 g)				ESP (%)
					Nitrate (NO_3^-)	Ammonium (NH_4^+)	P	K	S	Ca^{2+}	Mg^{2+}	Na^+	K^+	
DC 001	**0 to 5**	6.3	0.074	0.79	28	8	7	248	2.63	2.94	1.25	<0.1	0.29	1.10
	10 to 20	6.7	0.055	0.54	19	2	9	141	2.79	3.07	1.16	<0.1	0.17	1.12
	40 to 50	6.4	0.05	0.52	10	6	4	68	4.1	3.49	1.6	<0.1	0.1	0.95
	90 to 100	7.1	0.028	0.35	1	5	4	106	2.98	2.15	0.92	<0.1	0.1	1.55
DC 002	**0 to 5**	6.3	<0.010	0.21	1	1	3	125	1.16	1.69	0.9	<0.1	0.17	1.78
	10 to 20	7	0.033	0.14	3	1	5	148	6.4	1.4	0.87	<0.1	0.15	2.02
	40 to 50	6	0.018	0.14	3	<1	2	126	6.1	1.15	0.6	<0.1	0.13	2.59
DC 003	**0 to 5**	5.9	0.018	0.19	4	<1	3	111	3.81	0.68	0.24	<0.1	0.13	4.55
	10 to 20	6.8	0.016	0.11	1	<1	2	112	6.41	0.82	0.24	<0.1	0.13	4.03

Site	Depth Interval (cm)	Soil pH (H_2O)	EC (dS/m)	Organic Carbon (%)	Plant-available Nutrients (mg/kg)					Exchangeable Cations (meq/100 g)				ESP (%)
					Nitrate (NO_3^-)	Ammonium (NH_4^+)	P	K	S	Ca^{2+}	Mg^{2+}	Na^+	K^+	
	40 to 50	6.4	0.012	0.18	2	<1	3	129	4.06	1	0.42	<0.1	0.19	3.01
	90 to 100	7	0.021	0.07	2	1	3	118	2.04	1.59	0.79	<0.1	0.11	1.97
DC 004	**0 to 5**	6.2	0.052	0.21	12	4	6	120	8.14	1.2	0.42	<0.1	0.11	2.81
	10 to 20	5.9	0.72	0.28	201	15	4	163	121	2.4	0.66	<0.1	0.19	1.52
	40 to 50	6.3	0.215	0.2	69	2	3	143	25.1	2.42	1.17	<0.1	0.2	1.30
DC 005	**0 to 5**	5.9	0.024	0.36	5	6	5	204	1.16	0.92	0.42	<0.1	0.25	3.05
	10 to 20	5	0.019	0.25	7	<1	3	163	4.11	1	0.28	<0.1	0.14	3.40
	40 to 50	5.5	0.014	0.12	2	1	3	110	10.7	0.7	0.33	<0.1	0.11	4.20
	70 to 80	5.3	0.015	0.11	1	1	6	80	9.8	0.49	0.51	<0.1	0.1	4.35
DC 006	**0 to 5**	6.2	0.011	0.17	1	<1	4	110	3.72	0.89	0.37	<0.1	0.14	3.52
	10 to 20	6.4	<0.010	0.17	1	1	3	99	2.52	0.76	0.39	<0.1	0.13	3.76
	40 to 50	6.4	0.011	0.24	1	<1	4	98	1.78	0.64	0.24	<0.1	0.13	4.72
	90 to 100	6.5	0.01	0.2	1	1	4	86	3.91	0.72	0.34	<0.1	0.13	4.03
DC 007	**0 to 5**	6.5	0.041	0.71	6	5	7	302	2.6	2.71	0.53	<0.1	0.45	1.34
	10 to 20	6.4	0.033	0.46	11	<1	3	173	2.28	2.26	1.06	<0.1	0.18	1.41
	40 to 50	6.7	0.015	0.23	5	<1	4	134	0.98	1.46	0.5	<0.1	0.12	2.35
	90 to 100	6.5	<0.010	0.06	1	<1	4	78	0.64	0.57	0.15	<0.1	0.03	6.25
DC 008	**0 to 5**	5.7	0.011	0.18	3	2	5	104	2.72	0.55	0.19	<0.1	0.11	5.56
	10 to 20	6.4	0.01	0.17	3	<1	2	131	1.85	0.88	0.41	<0.1	0.18	3.29

Site	Depth Interval (cm)	Soil pH (H_2O)	EC (dS/m)	Organic Carbon (%)	Plant-available Nutrients (mg/kg)					Exchangeable Cations (meq/100 g)				ESP (%)
					Nitrate (NO_3^-)	Ammonium (NH_4^+)	P	K	S	Ca^{2+}	Mg^{2+}	Na^+	K^+	
	40 to 50	6	<0.010	0.15	4	<1	2	103	3.07	0.97	0.45	<0.1	0.14	3.11
	90 to 100	6.4	0.014	0.14	3	<1	4	100	5.76	1.06	0.52	<0.1	0.14	2.82
DC 009	**0 to 5**	6.6	0.037	0.6	12	5	7	263	1.99	2.27	0.98	<0.1	0.25	1.41
	10 to 20	6.2	0.038	0.51	15	2	3	135	2.53	2.91	1.22	<0.1	0.13	1.16
	40 to 50	6.3	0.062	0.42	26	1	6	95	1.5	3.71	1.72	<0.1	0.12	0.89
	90 to 100	6.5	0.017	0.14	6	2	40	128	0.91	1.06	0.45	<0.1	0.03	3.14

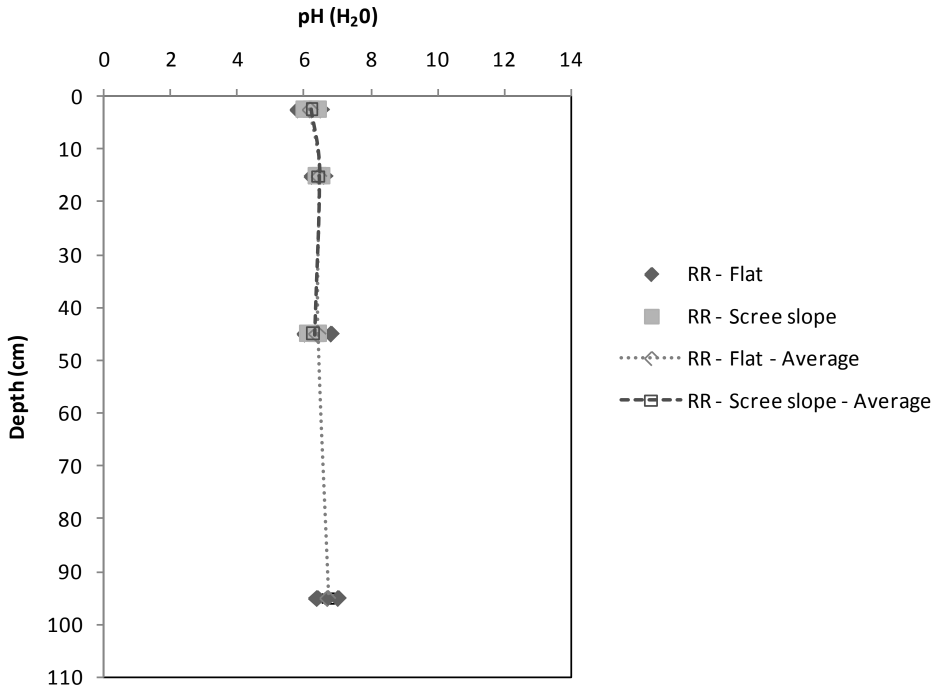

Figure 10: Individual and average soil pH (H_2O) values grouped into soil / landform associations at Robertson Range (error bars represent standard error).

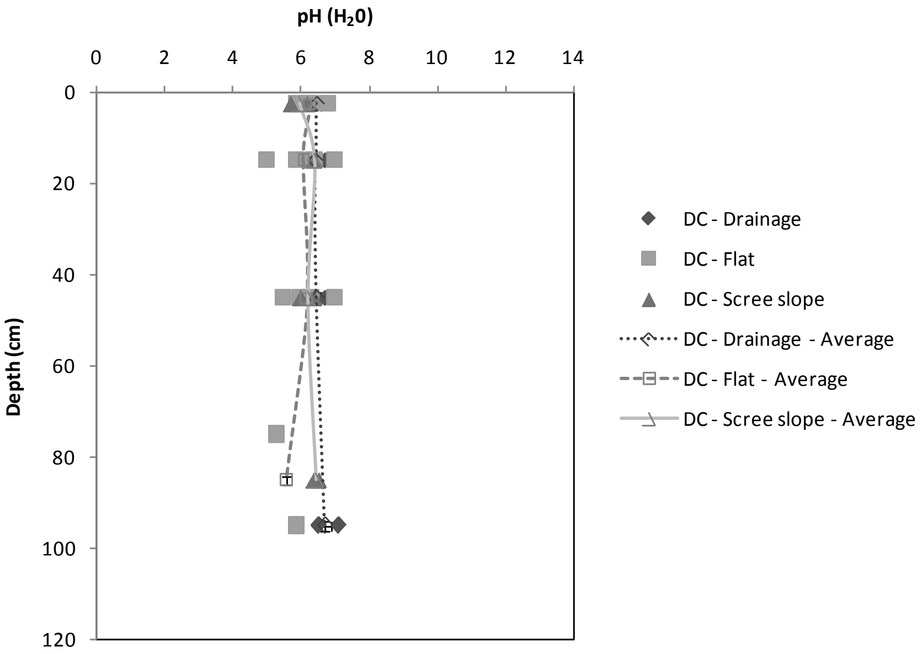

Figure 11: Individual and average soil pH (H_2O) values grouped into soil / landform associations at Davidson Creek (error bars represent standard error).

3.3.2 Electrical conductivity

Electrical conductivity (EC) is a measurement of the soluble salts in soils or water. Soil salinity results from natural processes of landscape evolution, hydrological processes and rainfall (Hunt and Gilkes, 1992).

The electrical conductivity (EC) of all soils sampled from the Robertson Range area is considered to be non saline (0 – 0.2 dS/m) to slightly saline (0.2 – 0.44 dS/m) (**Table 8, Figure 12**), based on the standard USDA and CSIRO categories (Appendix B). Average EC values were slightly higher for the soils from the Flat soil / landform sites, compared to those from the Scree slopes.

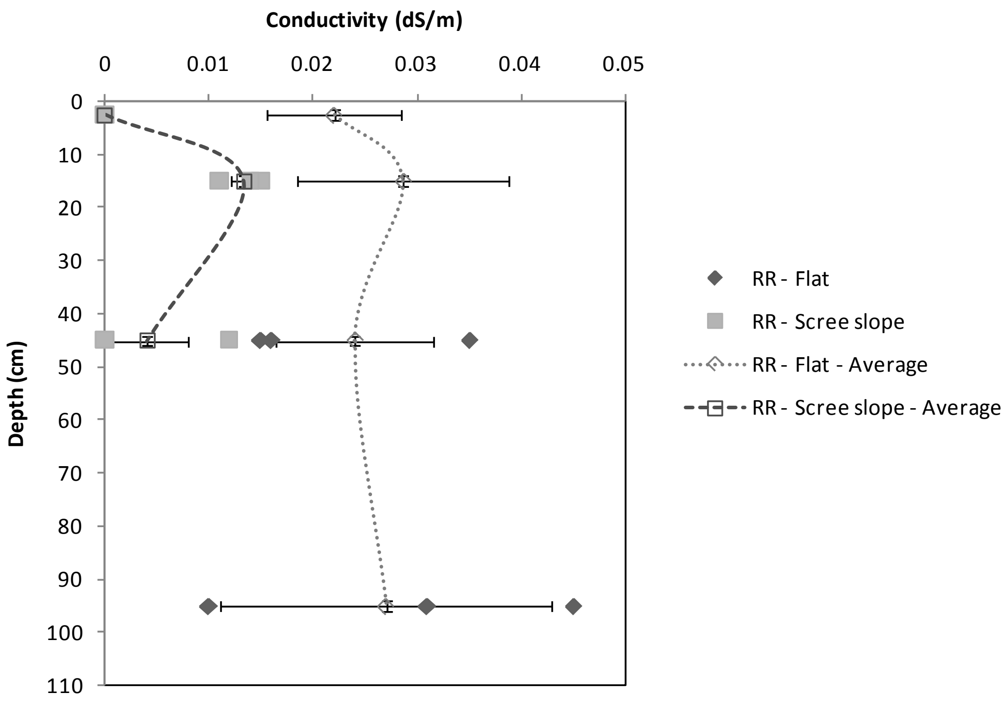

Figure 12: Individual and average electrical conductivity (EC 1:5 H_2O) values grouped into soil / landform associations at Robertson Range (error bars represent standard error).

Soils from the Davidson Creek area ranged from non-saline for the Drainage and Scree slope soil samples to moderately saline for one of the 'Flat' soil / landform samples (**Table 9, Figure 13**).

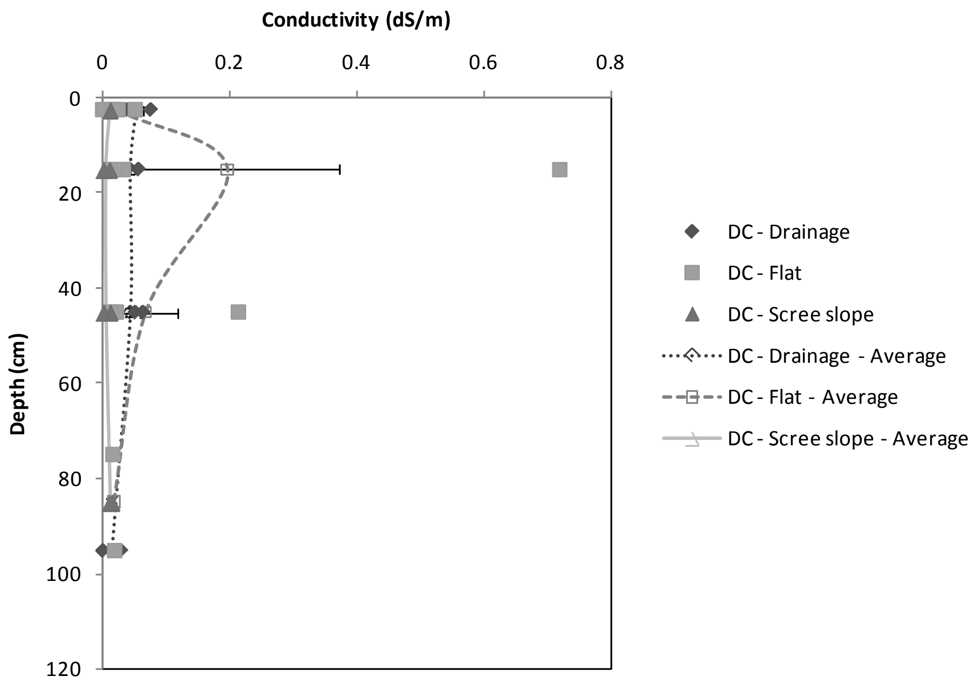

Figure 13: Individual and average electrical conductivity (EC 1:5 H_2O) values grouped into soil / landform associations at Davidson Creek (error bars represent standard error).

3.3.3 Soil organic matter

The organic matter content of soil is an important factor influencing many physical, chemical and biological soil characteristics. Directly derived from plants and animals, its functions in soil include supporting the micro and macro fauna and flora populations in the soil, increasing the water retention capacity, buffering pH and improving soil structure. The organic matter content of the soils within the study area was determined as a measure of the soil organic carbon (SOC) percentage.

The organic carbon percentage within all of the soils sampled was low (< 1% SOC) (Purdie 1998), as is the case in most natural Western Australian soils (**Figures 14 and 15**). The highest organic carbon contents were measured in the upper surface soils, and typically decreased or remained constant with depth. The highest concentrations of SOC were measured in the soils from the Drainage soil / landform sites in the Davidson Creek study area (**Figure 15**).

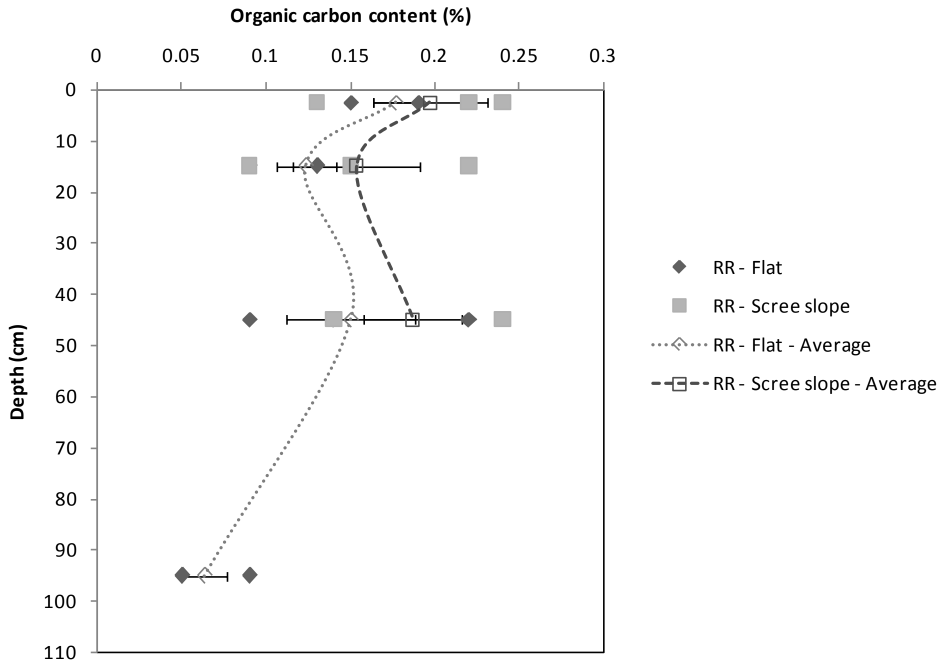

Figure 14: Individual and average soil organic carbon (%) values grouped into soil / landform associations at Robertson Range (error bars represent standard error).

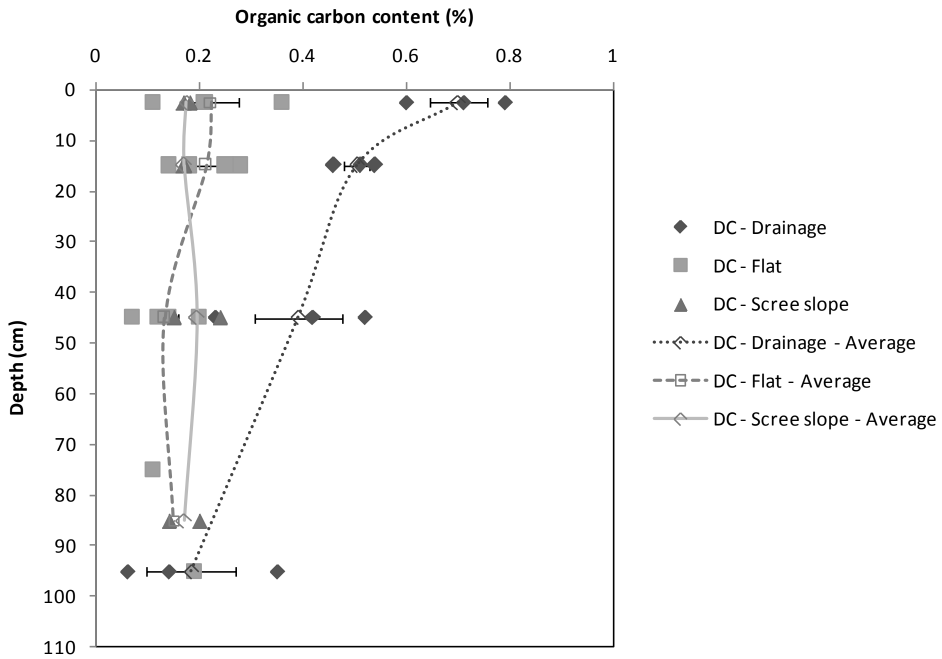

Figure 15: Individual and average soil organic carbon (%) values grouped into soil / landform associations at Davidson Creek (error bars represent standard error).

3.3.4 Exchangeable cations and exchangeable sodium percentage (ESP)

Exchangeable cations are held on clay surfaces and within organic matter and are an important source of soil fertility which can influence the physical properties of soil. Generally, if cations such as Ca^{2+}, Mg^{2+} and K^{+} are dominant on the clay exchange surfaces, the soil will typically display increased physical structure and stability, leading to increased aeration, drainage and root growth (Moore, 1998). The exchangeable sodium percentage (ESP) describes the sodium fraction of the exchangeable cations held on the soil surfaces. If sodium cations (Na^{+}) are dominant on exchange surfaces (as determined by calculating the exchangeable sodium percentage (ESP) and exceed more than 6 % of the total exchangeable cations, then the soil is considered to be *sodic*, which can lead to poor physical properties (i.e. dispersion, hard-setting and erosion in clay-rich soils).

If the ESP exceeds more than 15 %, then the soil is considered to be *highly sodic* (Moore, 1998). Sodic soils have an increased tendency to disperse upon wetting and are therefore more prone to hardsetting at the soil surface, and erosion when placed on the slopes of constructed landforms.

Calcium cations (Ca^{2+}) were the dominant cation in all of the Robertson Range (**Table 8**) and Davidson Creek (**Table 9**) samples. Exchangeable sodium levels were very low (<0.1 meq / 100g) for all samples tested (**Tables 8 and 9**). None of the soils sampled from either study area were considered to be highly sodic (i.e. ESP > 15%) (**Figures 16 and 17**), with only one sample (DC007, 90-100cm) classed as sodic.

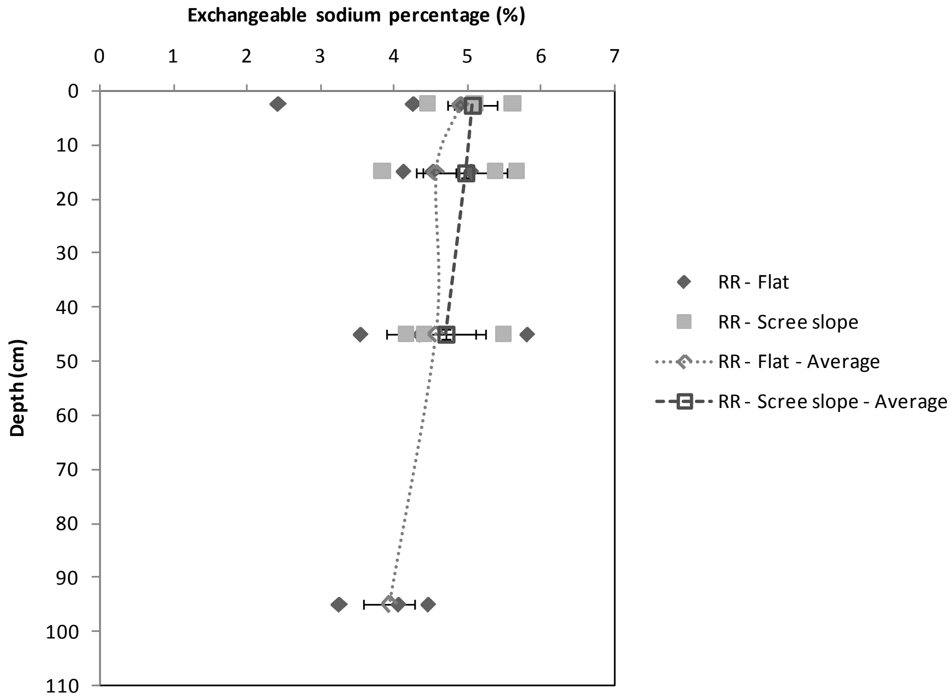

Figure 16: Individual and average exchangeable sodium percentage (%) values grouped into soil / landform associations at Robertson Range (error bars represent standard error).

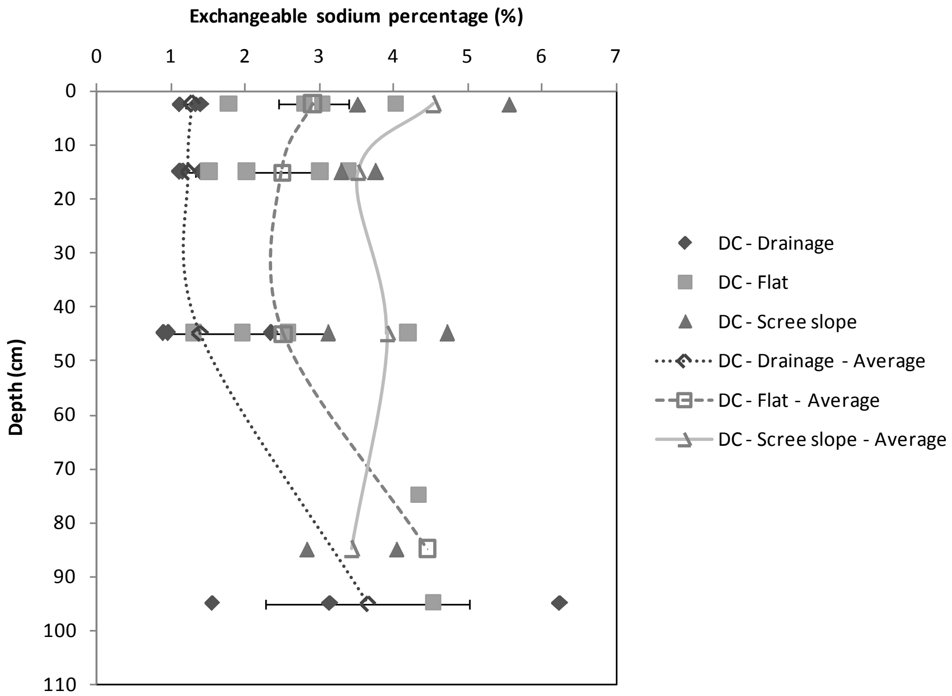

Figure 17: Individual and average exchangeable sodium percentage (%) values grouped into soil / landform associations at Davidson Creek (error bars represent standard error).

3.3.5 Plant-available nutrients

The most important macro-nutrients for plant growth are nitrogen (N), phosphorus (P), potassium (K), and sulphur (S). These nutrients are largely derived from the soil mineral component and organic matter. While the definition of adequate levels of these nutrients are well known for agricultural plant species, relatively little information is available for the nutrient requirements of native species.

The amount of plant-available nutrients held within the soils sampled form the Robertson Range and Davidson Creek study areas was variable (**Tables 8 and 9**). For nitrogen, concentrations for most sites were low (nitrogen < 30 mg/kg,), which is characteristic of native arid Australian soils (**Figure 18 and 19**). Two samples from the Flat soil / landform association in the Davidson Creek study area had nitrogen concentrations classed as high (Figure 19).

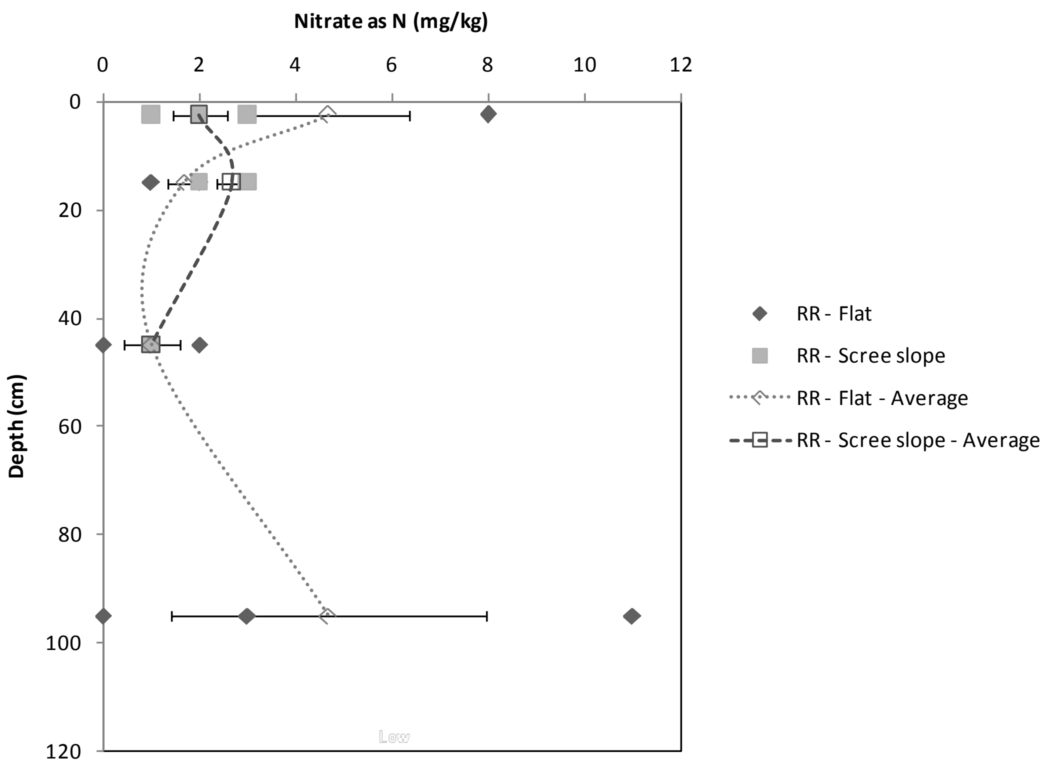

Figure 18: Individual and average nitrate N (mg/kg) values grouped into soil / landform associations at Robertson Range (error bars represent standard error).

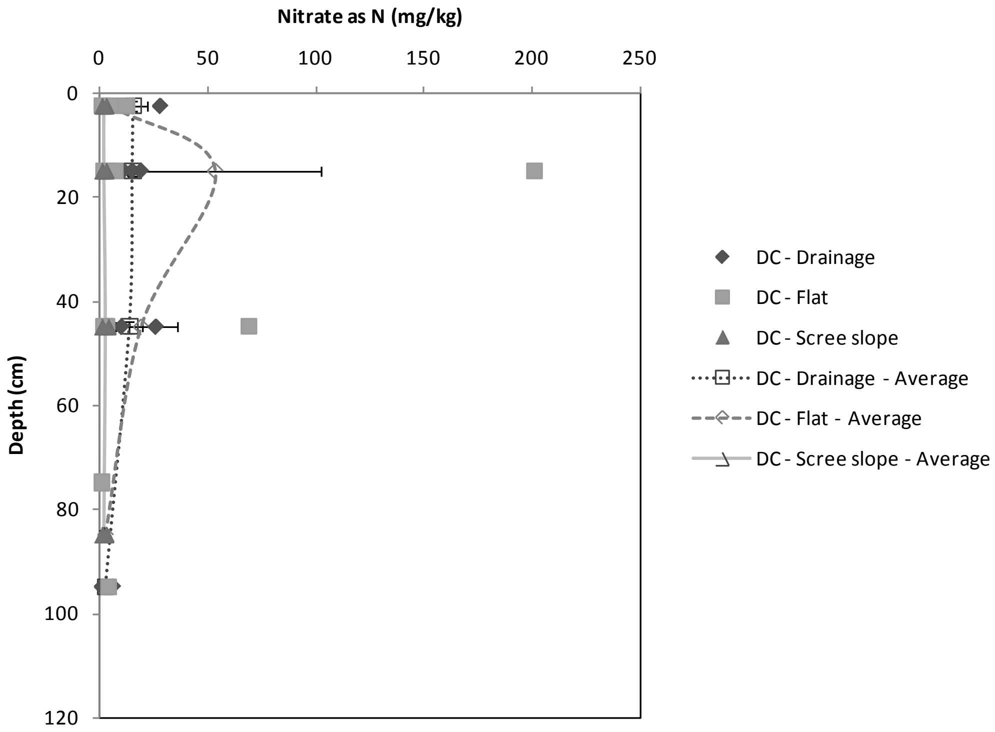

Figure 19: Individual and average nitrate N (mg/kg) values grouped into soil / landform associations at Davidson Creek (error bars represent standard error).

The levels of plant-available phosphorus (Figure 20 and 21), plant-available potassium (Figures 22 and 23), and plant-available sulphur (Figures 24 and 25) in samples from both the Robertson Range and Davidson Creek study areas were considered low, with little consistent trend with sample depth or position within the landscape.

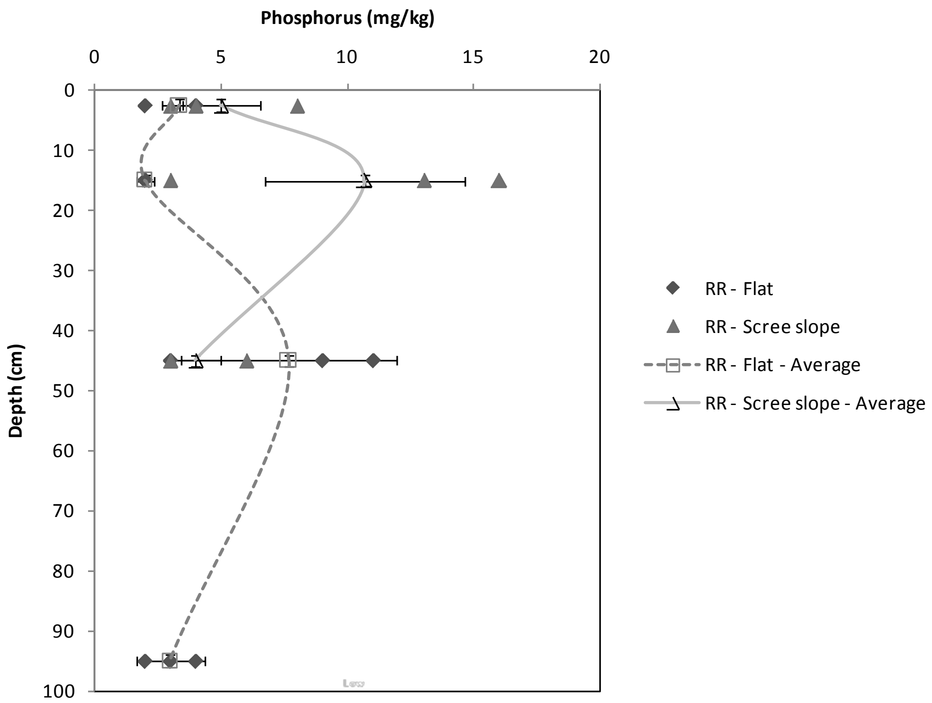

Figure 20: Individual and average plant-available phosphorus (P) (mg/kg) values grouped into soil / landform associations at Robertson Range (error bars represent standard error).

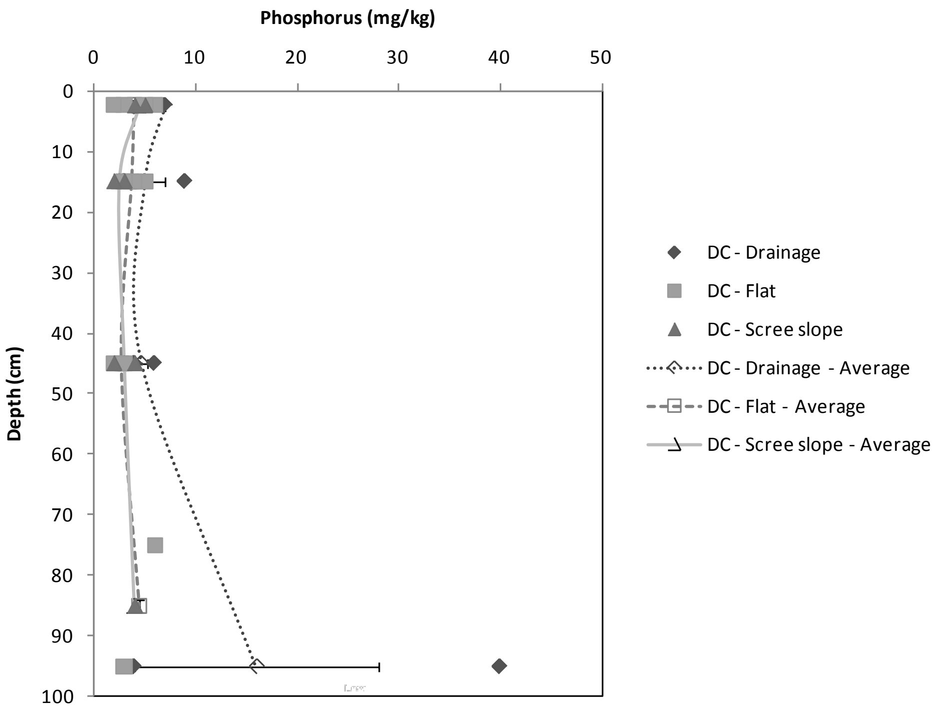

Figure 21: Individual and average plant-available phosphorus (P) (mg/kg) values grouped into soil / landform associations at Davidson Creek (error bars represent standard error).

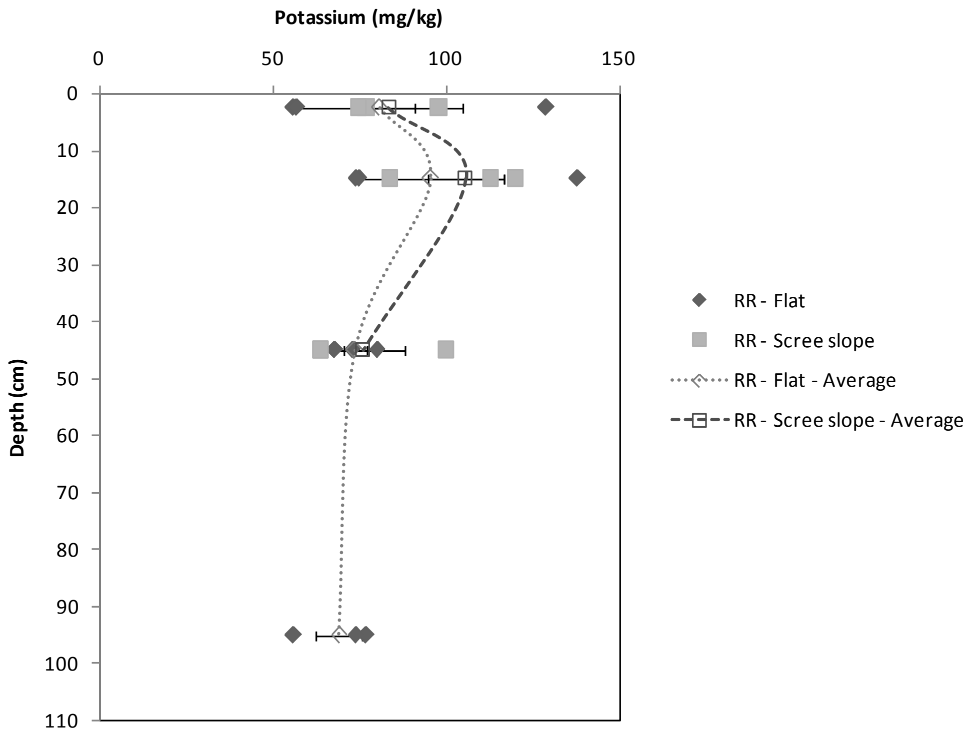

Figure 22: Individual and average plant-available potassium (K) (mg/kg) values grouped into soil / landform associations at Robertson Range (error bars represent standard error).

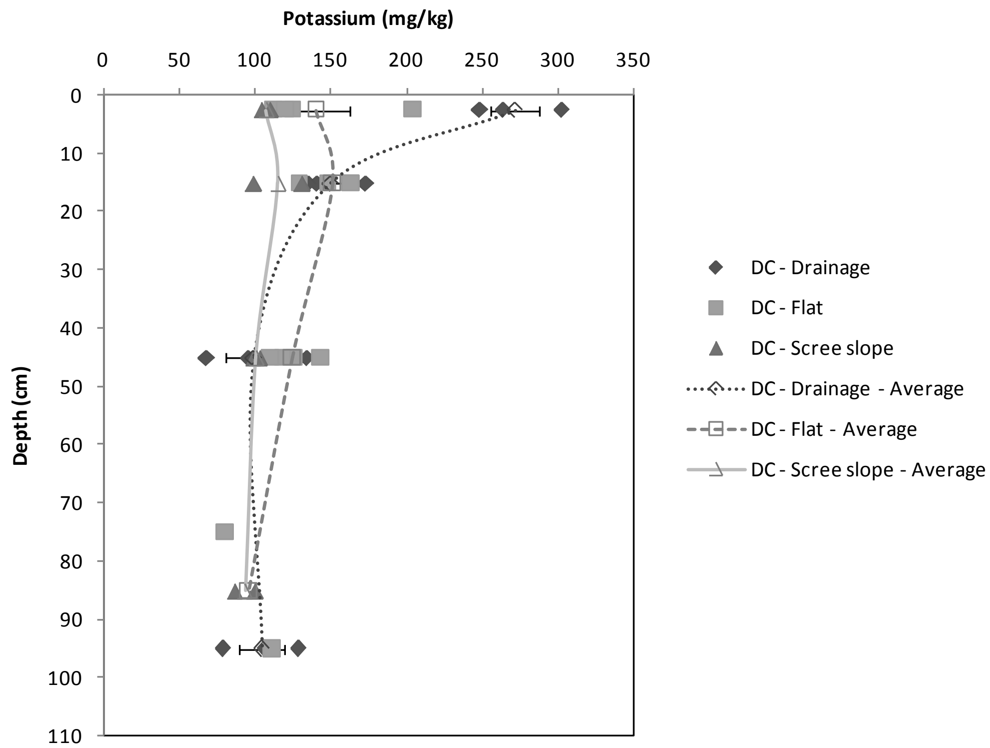

Figure 23: Individual and average plant-available potassium (K) (mg/kg) values grouped into soil / landform associations at Davidson Creek (error bars represent standard error).

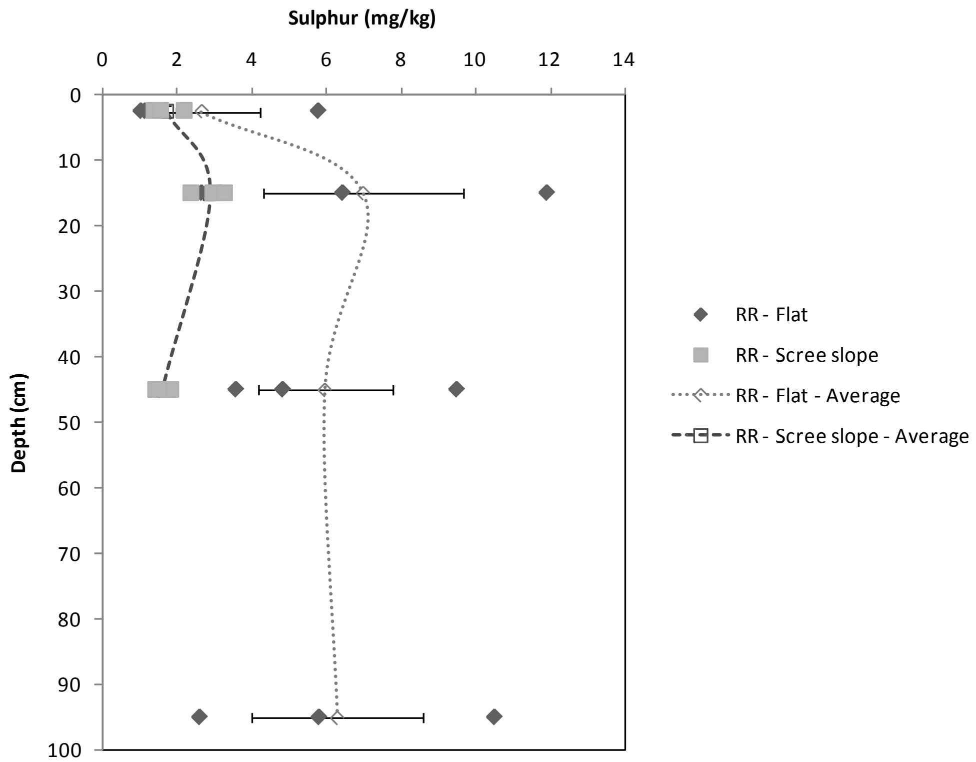

Figure 24: Individual and average plant-available sulphur (S) (mg/kg) values grouped into soil / landform associations at Robertson Range (error bars represent standard error).

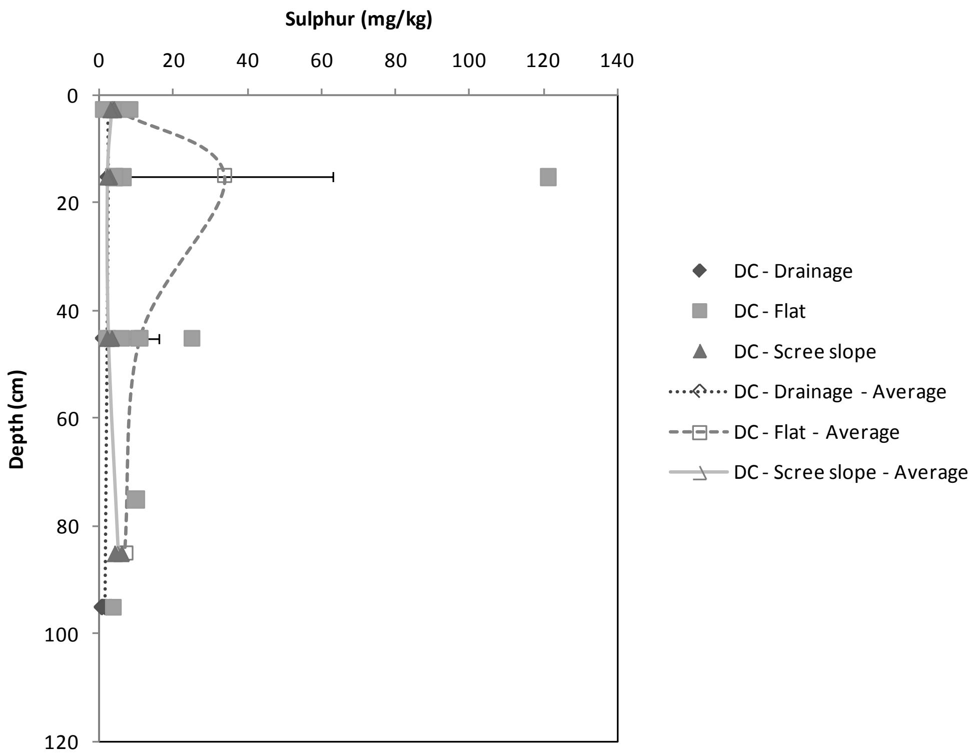

Figure 25: Individual and average plant-available sulphur (S) (mg/kg) values grouped into soil / landform associations at Davidson Creek (error bars represent standard error).

3.3.6 Total metal concentrations

Measurements of total metal concentrations in the soil samples indicated that variable levels of As, Cd, Cr, Cu, Pb, Ni, Zn and Hg were present (**Table 10**). All results were compared with ‘Ecological Investigation Levels’ (EILs) for soils (Department of Environment and Conservation (DEC), 2010). The EILs are intended as a guide only, as higher EIL values may be acceptable for some metal concentrations, such as As, Cr, Cu, Ni, Pb and Zn, in areas where soils naturally have high background concentrations of these substances (DEC, 2010).

All materials sampled were below the detectable limit for As, Cd, and Hg, however Cr, Cu, Pb, Ni and Zn were regularly detected at a reportable levels (**Table 10**). All total metal concentration were below the recommended ‘Ecological Investigation Levels (EILs) for soils (DEC, 2010) with the exception of the 80-90cm depth sample from Davidson Creek, at Site DC008, which had a Ni concentration just over the EIL.

Table 10: Individual total metal concentrations (mg/kg) for selected soil samples, and limits of reporting (LOR)

Site	Depth	Landform	Analyte (mg/kg)							
			Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Robertson Range samples										
RR 001	0-5	Flat	<5	<1	**59**	<5	<5	**2**	**5**	<0.1
	10-20	Flat	<5	<1	**56**	<5	<5	<2	<5	<0.1
	40-50	Flat	<5	<1	**58**	<5	<5	<2	<5	<0.1
	90-100	Flat	<5	<1	**125**	<5	**7**	**2**	**6**	<0.1
RR 002	0-5	Flat	<5	<1	**73**	<5	<5	**3**	<5	<0.1
	10-20	Flat	<5	<1	**88**	<5	<5	**2**	<5	<0.1
	40-50	Flat	<5	<1	**75**	<5	**5**	**3**	<5	<0.1
	90-100	Flat	<5	<1	**111**	<5	**6**	**3**	<5	<0.1
RR 003	0-5	Flat	<5	<1	**136**	<5	<5	**2**	<5	<0.1
	10-20	Flat	<5	<1	**98**	<5	**5**	**2**	<5	<0.1
	40-50	Flat	<5	<1	**103**	<5	**6**	**3**	<5	<0.1
	90-100	Flat	<5	<1	**116**	<5	**8**	**3**	<5	<0.1
RR 004	0-5	Scree Slope	<5	<1	**52**	**7**	**21**	**8**	**5**	<0.1
	10-20	Scree Slope	<5	<1	**36**	**5**	**10**	**13**	<5	<0.1
	40-50	Scree Slope	<5	<1	**40**	**6**	**20**	**13**	<5	<0.1
RR 005	0-5	Scree Slope	<5	<1	**41**	<5	**7**	**3**	**6**	<0.1
	10-20	Scree Slope	<5	<1	**61**	**5**	<5	**3**	**6**	<0.1
	40-50	Scree Slope	<5	<1	**58**	**5**	**7**	**6**	**8**	<0.1
RR 006	0-5	Scree Slope	<5	<1	**45**	**7**	**6**	**4**	**7**	<0.1
	10-20	Scree Slope	<5	<1	**42**	<5	<5	**3**	**8**	<0.1

	40-50	Scree Slope	<5	<1	**58**	**8**	**12**	**16**	<5	<0.1
Davidson Creek samples										
DC 001	0-5	Drainage, Creek bed	<5	<1	**35**	**7**	**11**	**4**	**11**	<0.1
	10-20	Drainage	<5	<1	**35**	**9**	**12**	**6**	**12**	<0.1
	40-50	Drainage	<5	<1	**35**	**9**	**10**	**6**	**10**	<0.1
	90-100	Drainage	<5	<1	**41**	**9**	**11**	**5**	**10**	<0.1
DC 002	0-5	Flat	<5	<1	**36**	**9**	**10**	**4**	**8**	<0.1
	10-20	Flat	<5	<1	**38**	**8**	**8**	**3**	**10**	<0.1
	40-50	Flat	<5	<1	**30**	**6**	**7**	**3**	**8**	<0.1
	90-100	Flat	<5	<1	**30**	**8**	**12**	**4**	**6**	<0.1
DC 003	0-5	Flat	<5	<1	**54**	**10**	**7**	**4**	**5**	<0.1
	10-20	Flat	<5	<1	**89**	**8**	**8**	**4**	<5	<0.1
	40-50	Flat	<5	<1	**90**	**15**	**19**	**23**	<5	<0.1
DC 004	0-5	Flat	<5	<1	**44**	**12**	**10**	**9**	**8**	<0.1
	10-20	Flat	<5	<1	**33**	**11**	**8**	**6**	**8**	<0.1
	40-50	Flat	<5	<1	**48**	**18**	**19**	**15**	**8**	<0.1
DC 005	0-5	Flat	<5	<1	**37**	**7**	**6**	**3**	**11**	<0.1
	10-20	Flat	<5	<1	**37**	**7**	**6**	**2**	<5	<0.1
	40-50	Flat	<5	<1	**39**	**7**	**5**	**2**	<5	<0.1
	70-80	Flat	<5	<1	**41**	**7**	**6**	**3**	<5	<0.1
DC 006	0-5	Scree Slope	<5	<1	**62**	**8**	**8**	**10**	**7**	<0.1
	10-20	Scree Slope	<5	<1	**67**	**9**	**10**	**15**	**5**	<0.1
	40-50	Scree Slope	<5	<1	**84**	**8**	**15**	**8**	**6**	<0.1
	80-90	Scree Slope	<5	<1	**94**	**38**	**47**	**44**	**10**	<0.1

DC 007	0-5	Drainage	<5	<1	**40**	**12**	**18**	**8**	**17**	<0.1
	10-20	Drainage	<5	<1	**34**	**12**	**18**	**7**	**16**	<0.1
	40-50	Drainage	<5	<1	**36**	**10**	**14**	**6**	**10**	<0.1
	90-100	Drainage	<5	<1	**29**	**11**	**17**	**4**	**13**	<0.1
DC 008	0-5	Scree Slope	<5	<1	**78**	**9**	**13**	**5**	**6**	<0.1
	10-20	Scree Slope	<5	<1	**108**	**10**	**16**	**28**	<5	<0.1
	40-50	Scree Slope	<5	<1	**92**	**21**	**13**	**56**	<5	<0.1
	80-90	Scree Slope	<5	<1	**93**	**52**	**30**	**62**	<5	<0.1
DC 009	0-5	Drainage	<5	<1	**38**	**8**	**9**	**6**	**10**	<0.1
	10-20	Drainage	<5	<1	**36**	**8**	**10**	**5**	**10**	<0.1
	40-50	Drainage	<5	<1	**36**	**11**	**13**	**7**	**14**	<0.1
	90-100	Drainage	<5	<1	**53**	<5	**9**	**3**	**6**	<0.1
LOR (mg/kg)		-	**5**	**1**	**2**	**5**	**5**	**2**	**5**	**0.1**
EIL (mg/kg)		-	**20**	**3**	**400**	**100**	**600**	**60**	**200**	**1**

Note: Values in bold indicate levels detected above Limits of Reporting (LOR), levels above the Ecological Investigation Levels (EIL) (DEC, 2010) are highlighted in yellow.

4. RESULTS AND DISCUSSION – MINE WASTE MATERIALS

4.1 Waste material physical properties

The waste materials that are to be generated from the mining operations within the Robertson Range Davidson Creek and Mirrin Mirrin Project areas are dominated by transported sediments comprising clays, detrital and surficial materials. Other waste lithologies associated with the deposits are the Lower West Angela, Mt Newman and MacLeod / Nammuldi members. The approximate volumes and tonnages of the various waste lithologies from the two Projects are detailed in **Table 11**.

Table 11: Approximate volumes and tonnage of waste materials to be derived from the Robertson Range, Davidson Creek and Mirrin Mirrin Projects

Project Area	Waste Type	Volume (bcm)	Tonnage (t)
Robertson Range	Transported	104,536,641	240,434,273
	Lower West Angela	29,324,219	61,381,513
	Mt Newman	19,659,141	53,666,183
	MacLeod / Nammuldi	14,005,625	37,815,188
	Total	**167,525,625**	**393,297,157**
Davidson Creek	Transported	31,850,586	75,509,657
	Lower West Angela	12,626,875	28,453,651
	Mt Newman	7,104,883	20,019,530
	MacLeod / Nammuldi	2,070,586	4,845,171
	Total	**53,652,930**	**128,828,009**
Mirrin Mirrin	Transported	63,238,125	125,327,113
	Lower West Angela	1,058,203	2,211,645
	Mt Newman	10,637,500	28,181,019
	MacLeod / Nammuldi	267,500	722,250
	Dolerite	1,471,016	2,736,089
	Total	**76,672,344**	**128,828,009**

4.1.1 Structural Stability

As discussed in Section 3.2.2, the Emerson aggregate test identifies the potential slaking and dispersive properties of soil aggregates. Generally, samples that are allocated into Emerson Classes 1 or 2 are those most likely to exhibit dispersive properties and therefore be the most problematic.

While most of the waste materials tested from the Robertson Range and Davidson Creek deposits were not categorised as Emerson Class 5 or 6 (Table 12), four of the waste material samples from Robertson range and two from Davidson Creek fell into Emerson Class 1 or 2. All four of the waste samples from Robertson Range were samples of transported detrital material collected from depths ranging from 27.5 to 36.3. The two waste samples from Davidson Creek were of transported clay waste (depth 4-5m) and a sample of lower west Angela low Mn material, (depth 31.1-31.4m).

Table 12: Summary of slaking/dispersion properties (Emerson Test) results, indicating structural stability for Robertson Range and Davidson Creek waste samples. Emerson Test classes are included in Appendix B

Site	Waste type	Depth (m)	Emerson class (24 hour)	Description
Robertson Range waste samples				
RRDD 0018G	Mt Newman / MacLeod	123.8-124.1	-	-
RRDD 0021G	Transported detritals	27.5-27.8	1	Slaked, completely dispersed
RRDD 0027	Lower West Angela	90.7-91.0	6	Slaked, no dispersion, flocculated suspension
RRDD 0028T	Lower West Angela	33.8-34.1	6	Slaked, no dispersion, flocculated suspension
RRDD 0029T	Transported Surficial Material	4.6-4.9	5	Slaked, no dispersion, dispersed suspension
RRDD 0036G	Lower West Angela	18.0-18.3	6	Slaked, no dispersion, flocculated suspension
RRDD 0036G	Lower West Angela	30.0-30.3	6	Slaked, no dispersion, flocculated suspension
RRDD 0036G	Mt Newman / MacLeod	71.0-71.35	5	Slaked, no dispersion, dispersed suspension

Site	Waste type	Depth (m)	Emerson class (24 hour)	Description
RRDD 0037G	Transported Surficial Material	1.7-2.0	5	Slaked, no dispersion, dispersed suspension
RRDD 0037G	Transported Clay	23.9-24.2	5	Slaked, no dispersion, dispersed suspension
RRDD 0037G	Transported detritals	28.0-28.3	2	Slaked, partially dispersed
RRDD 0038G	Transported Surficial Material	4.1-4.4	5	Slaked, no dispersion, dispersed suspension
RRDD 0038G	Transported Clay	27.7-28.0	1	Slaked, completely dispersed
RRDD 0038G	Transported detritals	36.0-36.3	2	Slaked, partially dispersed
RRDD 0040G	Lower West Angela	65.0-65.3	6	Slaked, no dispersion, flocculated suspension
Davidson Creek waste samples				
DCDD 0033G	Transported detritals	20.7-21.0	6	Slaked, no dispersion, flocculated suspension
DCDD 0033G	Mt Newman / MacLeod	52.7-53.0	5	Slaked, no dispersion, dispersed suspension
DCDD 0037G	Transported Surficial Material	4.2-4.5	5	Slaked, no dispersion, dispersed suspension
DCDD 0037G	Transported Clay	31.1-31.4	1	Slaked, completely dispersed
DCDD 0037G	Transported detritals	48.1-48.4	6	Slaked, no dispersion, flocculated suspension
DCDD 0037G	Lower West Angela	64.4-64.7	6	Slaked, no dispersion, flocculated suspension
DCDD 0038G	Mt Newman / MacLeod	107.0-107.3	5	Slaked, no dispersion, dispersed suspension
DCDD 0039G	Transported Surficial Material	4.3-4.6	5	Slaked, no dispersion, dispersed suspension
DCDD	Transported Clay	78.-79.0	6	Slaked, no dispersion, flocculated

Site	Waste type	Depth (m)	Emerson class (24 hour)	Description
0039G				suspension
DCDD 0039G	Lower West Angela	96.3-96.6	6	Slaked, no dispersion, flocculated suspension
DCDD 042G	Mt Newman / MacLeod	64.0-64.3	6	Slaked, no dispersion, flocculated suspension
DCDD 0043G	Transported detritals	40.1-40.4	6	Slaked, no dispersion, flocculated suspension
DCRC 0973	Lower West Angela	84.0-85.0	5	Slaked, no dispersion, dispersed suspension
DCRC 0973	Lower West Angela	94.0-95.0	6	Slaked, no dispersion, flocculated suspension
DCRC 0987	Transported Surficial Material	4.0-5.0	1	Slaked, completely dispersed
DCRC 0987	Transported Clay	68.0-69.0	5	Slaked, no dispersion, dispersed suspension

4.1.2 Soil Strength

As discussed in Section 3.2.3, a modified modulus of rupture (MOR) test result of over 60kPa indicates a tendency for the soil sized fraction to hardset upon wetting and drying which can be problematic as it can restrict root penetration, or impede seedling germination / emergence if left at the surface.

The majority of waste materials from both the Robertson Range and Davidson Creek deposits had MOR values below the critical value of 60kPa (**Figure 26**). Four of the waste samples from Davidson Creek reported MOR values above 60kPa. Two of these samples were Transported clay, one was Transported surficial material and the other was a sample of Lower West Angela waste. There was no apparent trend between soil strength, waste type or sample depth (**Figure 26**).

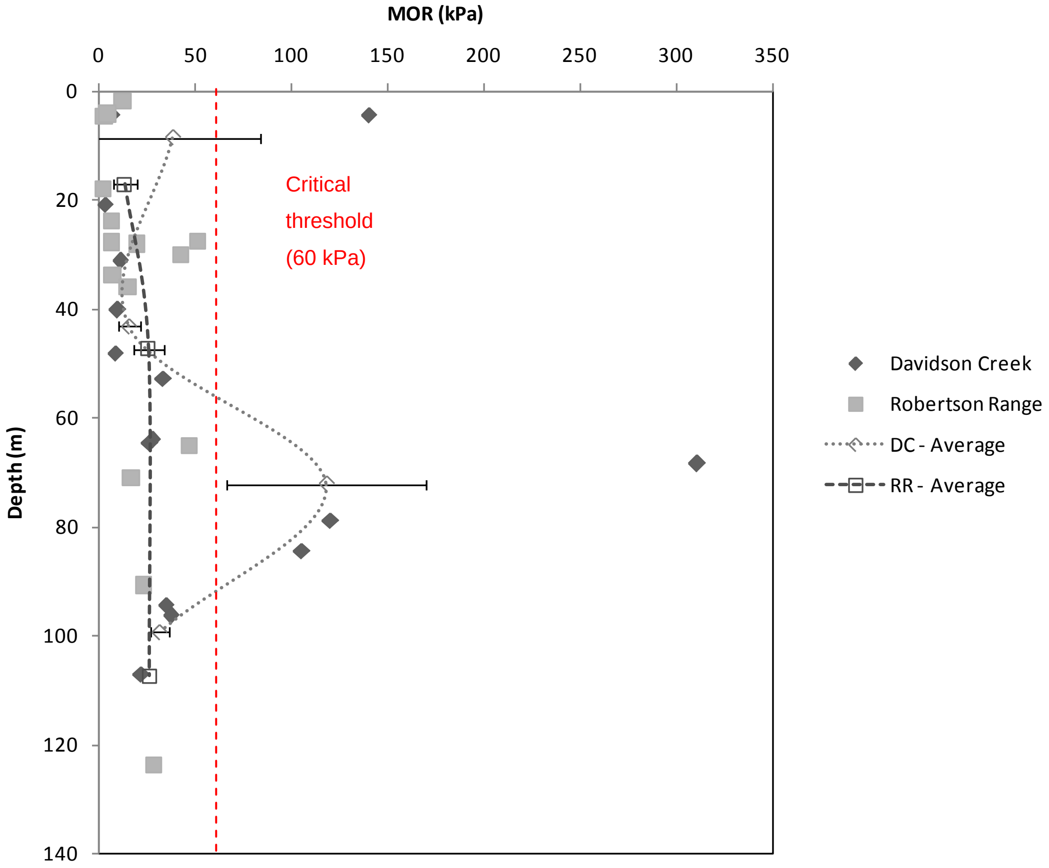

Figure 26: Average modulus of rupture (kPa) values of the soil (<2mm) fraction of waste samples from Robertson Range and Davidson Creek (error bars represent standard error). Red line indicates potential restrictions to plant and root development (Cochrane and Aylmore, 1997).

4.2 Waste material chemical properties

4.2.1 Waste material pH

The waste material pH values were relatively consistent, ranging from pH 6.4 to pH 8.5 (H_2O) (Figure 27). There was no apparent trend between waste material pH, waste material type or depth of sample from either the Robertson Range or Davidson Creek deposits.

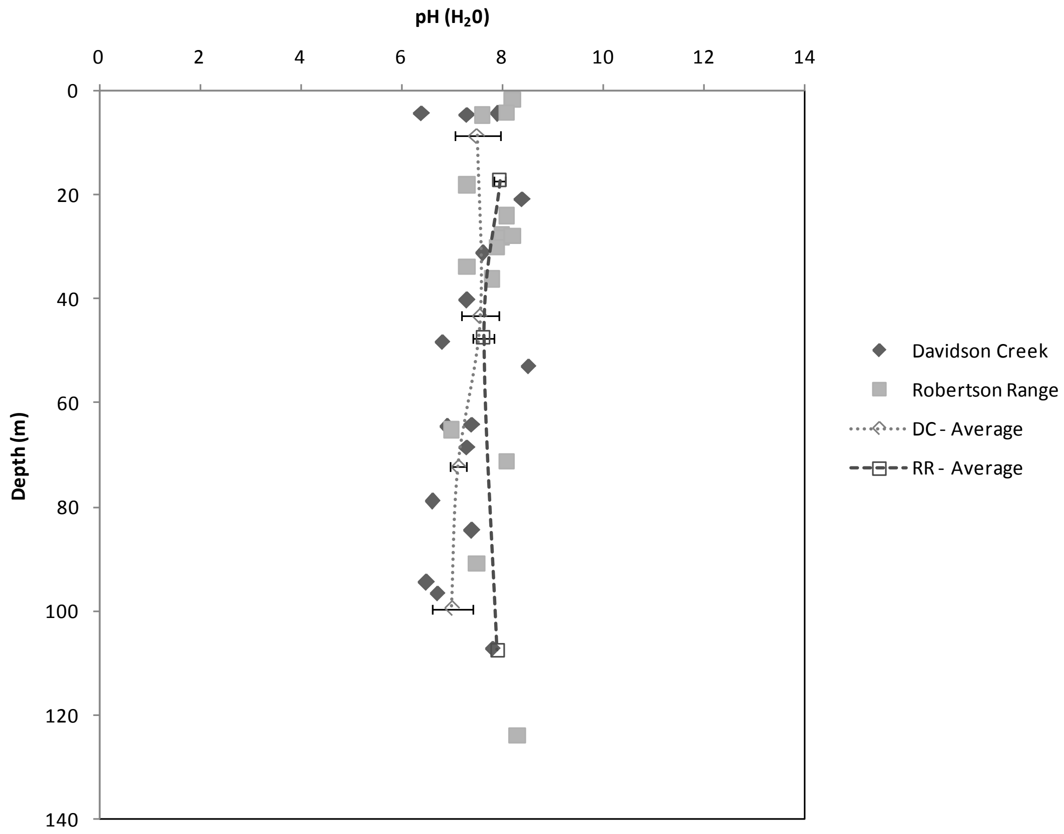

Figure 27: Individual and average waste pH (H_2O) values for samples from the Robertson Range and Davidson Creek deposits (error bars represent standard error).

4.2.2 Electrical conductivity

Electrical conductivity (EC) is a measurement of the soluble salts in soils or water. Soil salinity results from natural processes of landscape evolution, hydrological processes and rainfall (Hunt and Gilkes 1992).

The electrical conductivity (EC) of waste materials sampled from the Robertson Range and Davidson Creek deposits were variable ranging from non-saline (0 – 0.2 dS/m) to moderately saline (0.2 – 0.44 dS/m) (**Figure 28**), based on the standard USDA and CSIRO categories (Appendix B). There was no apparent trend between waste material EC, waste material type or depth of sample from either the Robertson Range or Davidson Creek deposits.

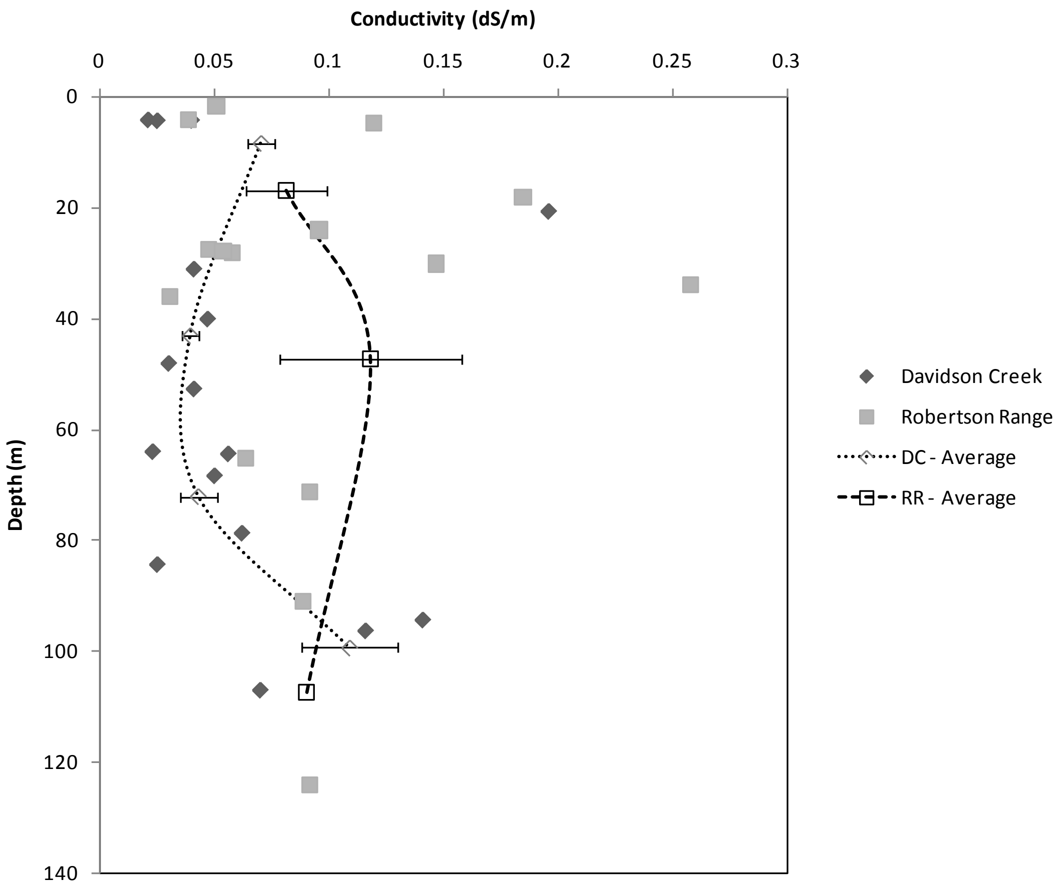

Figure 28: Individual and average electrical conductivity (EC 1:5 H_2O) values of waste samples at Robertson Range and Davidson Creek (error bars represent standard error).

4.2.3 Exchangeable cations and exchangeable sodium percentage (ESP)

As discussed in Section 3.3.4, an ESP value over 6% is considered sodic. If the ESP exceeds more than 15 %, then the soil is considered to be highly sodic (Moore, 1998). Sodic soils have an increased tendency to disperse upon wetting and are therefore more prone to hardsetting at the soil surface, and erosion when placed on the slopes of constructed landforms.

None of the waste materials from the Robertson Range and Davidson Creek deposits were classed as highly sodic (Figure 29). Only three of the waste samples tested had ESP values higher than 6%. All three sodic samples were from the Lower West Angela waste unit.

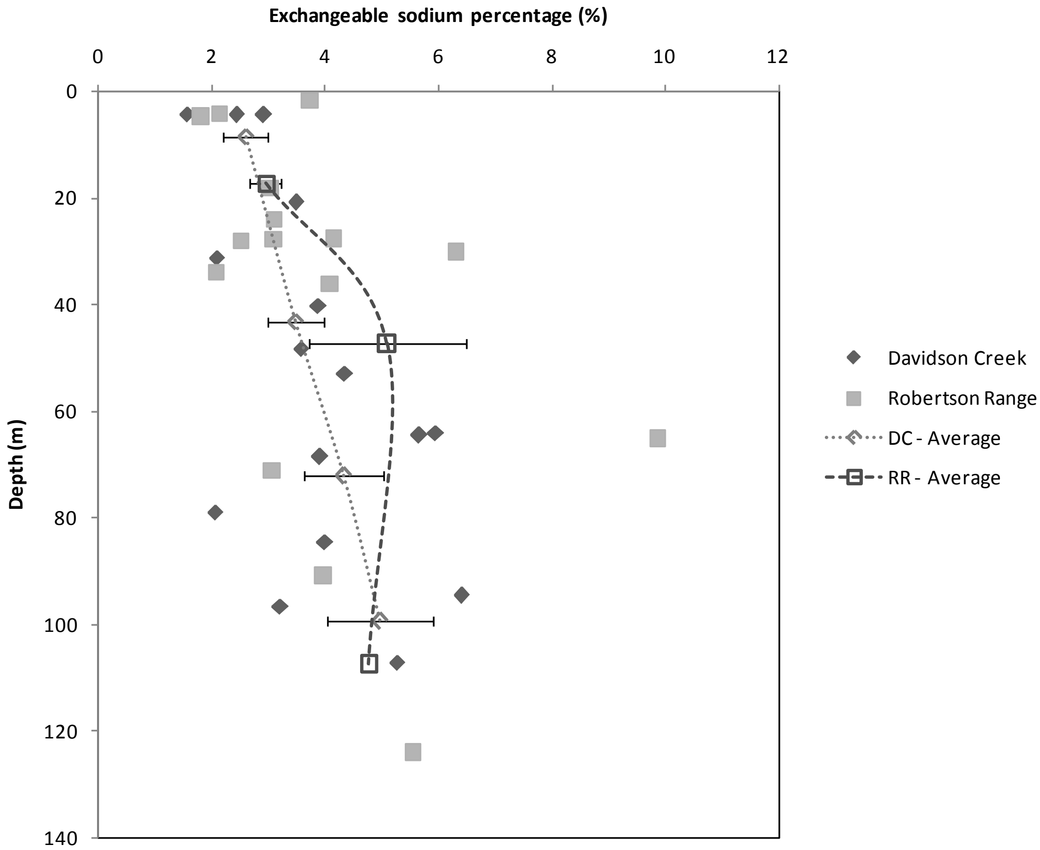

Figure 29: Individual and average exchangeable sodium percentage (%) values of waste samples at Robertson Range and Davidson Creek (error bars represent standard error).

4.3 Waste Material Geochemistry

The geochemical characterisation of the waste and low-grade materials from the Robertson Range and Davidson Creek deposits, performed by Graeme Campbell and Associates (Appendix E) has indicated that:

- All samples of mine waste are classified as non-acid forming (NAF);
- All samples of low-grade ore material are classified as NAF;
- The samples of mine waste and low-grade have contents of major and minor elements typically below or close to the average crustal abundance;
- All samples were circum-neutral in pH, with low concentrations of soluble salts.

It was concluded by Graeme Campbell and Associates that the mine waste and low-grade materials from the Robertson Range and Davidson Creek deposits are geochemically and physiochemically benign.

It has been indicated that, given the similarity in geology, lithology and mineralisation characteristics between the Davidson Creek deposits and the Mirrin Mirrin deposit, the geochemical characteristics of the waste and low grade material from Davidson Creek can be extrapolated to the waste and low grade from Mirrin Mirrin with a high level of confidence (Appendix E).

5. CONCLUSIONS AND RECOMMENDATIONS

Results from the physical and chemical characterisation of surface soils suggest that there some variations in soil characteristics present across the study areas. The differences in soil properties are typically related to their position within the landscape (i.e. the Scree slope, Flats and Drainage areas).

The Flats soil-landform unit within both the Robertson Range and Davidson Creek study areas consists of soils deposited from higher in the landscape and is characterised by relatively deep, homogenous soils. These soils are typically sand to sandy clay loam in texture, with a low to moderate coarse fragment content. They are typically non-saline and slightly acidic in pH, are non-sodic and non-hardsetting and have a ‘moderately slow’ to ‘moderate’ drainage class.

The Scree slope soil / landform unit comprises soils that have formed primarily via colluvial deposition of soil and rock from higher in the landscape. These soils are, in general, slightly acidic sandy loams with high amounts of coarse material and a low nutrient status. Compared to the Flats soils unit, this unit has a higher hydraulic conductivity, with a drainage class of ‘moderate’ to ‘rapid’. The Scree slope soils are also non-saline and non-sodic.

The Drainage soils were relatively similar to the other soils, apart from higher soil strength upon drying, a lower hydraulic conductivity and slightly higher nutrient status.

The greatest variations in soil profile morphology and measured characteristics appear to be between soils from contrasting positions within the landscape. It is likely that the separate collection and stockpiling of topsoil materials from the Scree slopes and Flats / Drainage areas will be required. This would preserve the seed store, and the chemical, physical and biological attributes of the soil profiles on which the individual vegetation communities in these areas are located. The high coarse fraction within the Scree slope soils means that these soils will be suitable for placement on the outer slopes of waste landforms, with enough coarse material to provide armour against erosion by water.

5.1 Potentially problematic soil properties

5.2.1 Surface soils

The soil survey conducted across the Robertson Range and Davidson Creek study area identified three main soil / landform associations; namely the Flats, the Scree slopes, and the Drainage associations. The soils present within these associations tend to have very low fertility. However the native vegetation in this region is well adapted to soils that are low in nutrients.

Many of the surface soils sampled indicated a potential to disperse from remoulded aggregates, and may therefore become structurally unstable and prone to erosion when disturbed. However, taking the high percentage of coarse material into account, particularly for the Scree slope soils, the susceptibility of these soils to erosion is likely to be reduced by rock armouring, as is the case in the undisturbed environment, where the coarse fragments protect the soil surface against erosion.

5.2.2 Waste Material

The majority of the waste materials sampled are likely to pose no major problems from a physical or chemical perspective. The sodic ESP results measured for the <2 mm soil fraction of some of the waste materials suggests that these materials may be susceptible to erosion if handled and deposited inappropriately. It should be recognised however, that the <2mm soil fraction of the waste materials is likely to constitute a relatively small component of the majority of the waste materials. Emerson test results for the waste materials indicate similar levels of structural stability to the surface soils in the area. Erosion of waste materials is therefore considered unlikely to be a major issue. Nevertheless, minimal handling of waste materials, particularly when wet, and armouring of the soil surface will assist in the surface stabilisation of constructed landforms.

Geochemical characterisation of the mine waste and low-grade waste materials by Graeme Campbell and Associates has indicated that the materials are geochemically benign from an acid formation and multi-element composition perspective.

5.3 Soil stripping and management of surface soil

Topsoil refers to the fraction of surface soil which is enriched in organic matter, nutrients, seed and has a high degree of microbial activity. In agriculture, the topsoil traditionally refers to the 0 – 10 cm depth of soil profile. However, in Australia, topsoils from undisturbed soil profiles, may extend to depths between 5 and 20 cm.

Separate collection, stockpiling and re-application of topsoil will be an important component of the successful rehabilitation of target vegetation communities. Differences in soil properties and vegetation characteristics between areas constituting different habitats, can often complicate the requirements for material handling. Soil stripping and handling guidelines however, must be broad enough to fit into logistical operations of earthworks and mining activities, and tailored to suit the characteristics of landforms / soils of the Project.

Three soil-landform associations were identified within the Robertson Range and Davidson Creek Project areas, with little variation in the majority of the chemical and physical characteristics measured for the soils from different positions in the landscape. The major difference between the soils from the Drainage and Flats landform association and those soils from higher in the landscape (i.e. the Scree slope soils), is the amount of competent rock material (>2mm) present. The high percentage of rock within the Scree slope soils mean that this material will be a valuable resource for placement on the outer slopes of reconstructed landforms, due to its ability to resist erosion. It is therefore recommended that the topsoils from the Scree slopes be collected and stockpiled separately to the soils from the areas of disturbance, lower in the landscape.

As a general guide it is recommended that, where possible, the top 0.2 m of soil (plus any existing vegetation) from within disturbance footprints be stripped and stockpiled as topsoil. The use / placement of the salvaged topsoil on the waste landforms should be considered carefully, with strategic placement in particular areas of the waste landforms likely to be a key to successful rehabilitation.

Topsoil stockpiles should be kept as low as practicable (ideally < 2 m) to preserve biological activity and viable seed reserves. 'Paddock-dumping' of topsoil, to a maximum depth of 2 m, achieved by placing successive truckloads of soil sufficiently far apart to create depressions between loads, is one method of creating shallow stockpiles with minimal compaction. The soil mounds created by paddock dumping maximises the overall surface area of the stockpile, promoting biological activity and plant cover. Topsoil stockpiles should be seeded as soon as possible to promote early plant establishment and surface stabilisation, and to restore biological functions and the viable seed count of the soil.

5.4 Management of waste material and associated waste landform construction

The successful rehabilitation of waste landforms associated with the mining activities necessitates the creation of a stable surface and sufficient medium to support plant growth. Given the geochemically benign nature of the waste materials, there is unlikely to be any material specific requirements for waste placement within the constructed landforms. While this simplifies the design requirements for the waste landforms, the final design will have the potential to influence the success of rehabilitation operations and impact on the surrounding environment.

The design of the waste landforms should aim to minimise the concentration of surface water where applicable. The adoption of concave slopes for the final landform shape (if practicable), at a minimum angle possible (dictated by waste landform footprint and landform height), is likely to further minimise erosion, promote successful rehabilitation and blend in with surrounding landforms. Ripping of the surface following topsoil application will result in some mixing of the topsoil with underlying waste rock, and further increase surface stability.

The placement of salvage topsoils material on the waste landform will depend, to some degree, on the design of the waste landform. It may be beneficial to target specific areas of the waste landforms for selective placement of rehabilitation resources and have rehabilitation prescriptions (e.g. seed mixes) which are targeted for certain positions within the reconstructed landforms.

5.5 Future monitoring and assessment

The final design and rehabilitation prescription for constructed landforms associated with the Robertson Range, Mirrin Mirrin and Davidson Creek Projects should be considered carefully, with an assessment of potential landform design options and associated risks / benefits recommended.

Monitoring of rehabilitated areas including waste landforms, should be considered to monitor vegetation growth and surface erosion, and evaluate the success of rehabilitation protocols over time.

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Appendix A

Glossary of terms

Glossary of terms

Aggregate (or ped)	A cluster of primary particles separated from adjoining peds by natural planes of weakness, voids (cracks) or cutans.
Bulk density	Mass per unit volume of undisturbed soil, dried to a constant weight at 105°C.
Clay	The fraction of mineral soil finer than 0.002 mm (2 µm).
Coarse fragments	Particles greater than 2 mm in size.
Consistence	The strength of cohesion and adhesion in soil.
Dispersion	The process whereby the structure or aggregation of the soil is destroyed, breaking down into primary particles.
Electrical conductivity	How well a soil conducts an electrical charge, related closely to the salinity of a soil.
Hydrophobicity	Description of hydrophobic or water repellent characteristics in soil. Primarily caused by hydrophobic organic residues derived from decomposing plant materials, which alter the contact angle between water droplets and the soil surface, in turn affecting the ability of water to infiltrate into the soil.
Massive soil structure	Coherent soil, no soil structure, separates into fragments when displaced. Large force often required to break soil matrix.
Modulus of Rupture (MOR)	This test is a measure of soil strength and identifies the tendency of a soil to hard-set as a direct result of soil slaking and dispersion.
Organic Carbon	Carbon residue retained by the soil in humus form. Can influence many physical, chemical and biological soil properties. Synonymous with organic matter (OM).
Plant-available water	The ability of a soil to hold that part of the water that can be absorbed by plant roots. Available water is the difference between field capacity and permanent wilting point.

Regolith	The unconsolidated rock and weathered material above bedrock, including weathered sediments, saprolites, organic accumulations, soil, colluvium, alluvium and aeolian deposits.
Single grain structure	Loose, incoherent mass of individual particles. Soil separates into individual particles when displaced.
Slaking	The partial breakdown of soil aggregates in water due to the swelling of clay and the expulsion of air from pore spaces.
Soil horizon	Relatively uniform materials that extend laterally, continuously or discontinuously throughout the profile, running approximately parallel to the surface of the ground and differs from the related horizons in chemical, physical or biological properties.
Soil pH	The negative logarithm of the hydrogen ion concentration of a soil solution. The degree of acidity or alkalinity of a soil expressed in terms of the pH scale, from 2 to 10.
Soil structure	The distinctness, size, shape and arrangement of soil aggregates (or peds) and voids within a soil profile. Can be classed as *'apedal'*, having no observable peds, or *'pedal'*, having observable peds.
Soil strength	The resistance of a soil to breaking or deformation. '*Hardsetting'* refers to a high soil strength upon drying.
Soil texture	The size distribution of individual particles of a soil.
Subsoil	The layer of soil below the topsoil or A horizons, often of finer texture (i.e. more clayey), denser and stronger in colour. Generally considered to be the 'B-horizon' above partially weathered or un-weathered material.
Topsoil	Soil consisting of various mixtures of sand, silt, clay and organic matter; considered to be the nutrient-rich top layer of soil – The 'A-horizon'.

Appendix B

Outback Ecology Soil Analysis Methods

1. Soil texturing

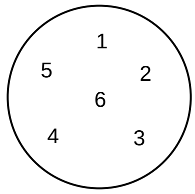
Soils were worked by hand, and the texture, shearing capacity, particle size and ribbon length were observed according to methods described in McDonald *et al.* (1998) as follows.

Texture grade	Behaviour of moist bolus	Approximate clay content	Code
Sand	Nil to very slight coherence; cannot be moulded; single sand grains adhere to fingers	<5 %	S
Loamy sand	Slight coherence; can be sheared between thumb and forefinger to give minimal ribbon of about 5 mm	5 %	LS
Clayey sand	Slight coherence; sticky when wet; many sand grains stick to fingers; discolours fingers with stain; forms minimal ribbon of 5 – 15 mm	5 - 10 %	CS
Sandy loam	Bolus coherent but very sandy to touch; dominant sand grains of medium size and readily visible ; ribbon of 15 – 25 mm	10 – 20 %	SL
Loam	Bolus coherent and rather spongy; no obvious sandiness or silkiness; forms ribbon of about 25 mm	25 %	L
Sandy clay loam	Strongly coherent bolus; sandy to touch; ribbon of 25 – 40 mm	20 - 30 %	SCL
Clay loam	Coherent plastic bolus, smooth to touch, ribbon of 25 mm to 40 mm	30 – 35 %	CL
Clay loam, sandy	Coherent plastic bolus, sand grains visible in finer matrix, ribbon of 40 - 50 mm; sandy to touch	30 - 35 %	CLS
Light clay	Plastic bolus, smooth to touch; slight resistance to shearing; ribbon of 50 – 75 mm	35 – 40 %	LC
Light medium clay	Ribbon of about 75 mm, slight to moderate resistance to ribboning shear	40 - 45 %	LMC
Medium clay	Smooth plastic bolus, handles like plasticine and can be moulded into rods without fracture; moderate resistance to ribboning shear, ribbon of 75 mm or longer	45 – 55 %	MC
Medium heavy clay	Ribbon of 75 mm or longer, handles like plasticine, moderate to firm resistance to ribboning shear	>50 %	MHC
Heavy Clay	Handles like stiff plasticine; firm resistance to ribboning shear, ribbon of 75 mm or longer	>50 %	HC

2. Emerson Dispersion Test

Emerson dispersion tests were carried out on all samples according to the following procedure:

1. A petri dish was labelled 1 to 6. eg.



2. The petri dish was filled with DI water.
3. A 3-5mm soil aggregate is taken from each sample and gently placed into the labelled petri dish (3 per dish).
4. Additional aggregates, remoulded by hand, are placed into the labelled petri dish (3 per dish).
5. Observations are made of the dispersivity or slaking nature of the sample according to the following table:

Emerson Aggregate test classes (Moore 1998)

Class	**Description**
Class 1	Dry aggregate slakes and completely disperses
Class 2	Dry aggregate slakes and partly disperses
Class 3a	Dry aggregate slakes but does not disperse; remoulded soil disperses completely
Class 3b	Dry aggregate slakes but does not disperse; remoulded soil partly disperses
Class 4	Dry aggregate slakes but does not disperse; remoulded soil does not disperse; carbonates and gypsum are present
Class 5	Dry aggregate slakes but does not disperse; remoulded soil does not disperse; carbonates and gypsum are absent; 1:5 suspension remains dispersed
Class 6	Dry aggregate slakes but does not disperse; remoulded soil does not disperse; carbonates and gypsum are absent; 1:5 suspension remains flocculated
Class 7	Dry aggregate does not slake; aggregate swells
Class 8	Dry aggregate does not slake; aggregate does not swell

The samples were left in the dish for a 24 hour period, after which the samples were observed again and rated according to the above Table.

3. Soil Electrical Conductivity classes

(Based on standard USDA and CSIRO categories)

EC (1:5) (dS/m)						
Salinity Class	**Sand**	**Sandy loam**	**Loam**	**Clay loam**	**Light/Medium Clay**	**Heavy Clay**
Non-saline	<0.13	<0.17	<0.20	<0.22	<0.25	<0.33
Slightly Saline	0.13-0.26	0.17-0.33	0.20-0.40	0.22-0.44	0.25-0.50	0.33-0.67
Moderately Saline	0.26-0.52	0.33-0.67	0.40-0.80	0.44-0.89	0.50-1.00	0.67-1.33
Very Saline	0.52-1.06	0.67-1.33	0.80-1.60	0.89-1.78	1.00-2.00	1.33-2.67
Extremely Saline	>1.06	>1.33	>1.60	>1.78	>2.00	>2.67

4. General soil pH ratings

These ratings area based on the Land Evaluation Standards for Land Resource Mapping categories, (Van Gool *et. al*. 2005).

The pH of a soil measures its acidity or alkalinity. The standard method for measuring pH in WA is 1:5 0.01M $CaCl_2$ (pH_{Ca}). However, in most land resource surveys it has been measured in a 1:5 soil:water suspension (pH_w). It is preferable to record actual data rather than derived data, therefore pH should be recorded according to the method used. The pH measured using different methods should not be compared directly for site investigations. For general land interpretation purposes, the relationship between pH_w and pH_{Ca} can be estimated by the equation:

$$pH_{Ca} = 1.04\ pH_w - 1.28$$ (Van Gool *et. al*., 2005)

The most widely available pH measurement is for the surface layer. However, the pH of the topsoil varies dramatically, and based on a comparison of map unit and soil profile data, estimated mean values for topsoil pH is commonly underestimated. Hence it is suggested that only an estimate of subsoil pH should be attempted. Even for subsoil the value can only be used as an indicator because pH varies dramatically with land use and minor soil variations.

Soil depth

The pH should be recorded for each soil group layer (see Section 1.6 and Figure 6). It is then reported at the following predefined depths:

- 0 - 10 cm (the surface layer);
- 20 cm (used for assessing subsoil acidity); and
- 50 - 80 cm. If there is a layer boundary within this depth use the higher value (used for assessing subsoil alkalinity).

	Soil pH rating						
	Very strongly acid (Vsac)	**Strongly acid (Sac)**	**Moderately acid (Mac)**	**Slightly acid (Slac)**	**Neutral (N)**	**Moderately alkaline (Malk)**	**Strongly alkaline (Salk)**
pH_w	< 5.3	5.3 - 5.6	5.6 - 6.0	6.0 - 6.5	6.5 - 8.0	8.0 - 9.0	> 9.0
pH_{Ca}	< 4.2	4.2 - 4.5	4.5 - 5.0	5.0 - 5.5	5.5 - 7.0	7.0 - 8.0	> 8.0

Appendix C

Outback Ecology soil analysis results

Summary of Outback Ecology results for field texture, gravel content, soil strength (modulus of rupture), Emerson Class and saturated conductivity and salinity class.

Site	Sample Depth Interval (cm)	Field Texture (<2 mm fraction)	% Coarse Fragments (>2 mm)	Emerson Test Class	MOR (kPa)	Saturated Conductivity (kSat)	Salinity Class
Robertson Range soil samples							
RR 001	0-5	Sand	3.26	3b	12.84	-	Non saline
	40-50	Sand	7.26	3b	9.71	59.55	Non saline
RR 002	0-5	Sand	1.74	3b	20.27	-	Non saline
	40-50	Sand	1.50	3b	9.23	51.78	Non saline
RR 003	0-5	Loamy Sand	3.50	3b	10.61	-	Non saline
	40-50	Sandy Loam	4.23	3b	8.54	25.69	Non saline
RR 004	0-5	Sandy Loam	45.85	3b	21.27	-	Non saline
	10-20	-	-	-	-	18.60	-
	40-50	Sandy Loam	71.54	3b	19.31	-	Non saline
RR 005	0-5	Loamy Sand	39.69	3b	13.53	-	Non saline
	10-20	-	-	-	-	13.42	-
	40-50	Loamy Sand	76.69	3a	35.81	-	Non saline
RR 006	0-5	Sandy Loam	49.55	6	42.97	-	Non saline
	10-20	-	-	-	-	24.55	-
Davidson Creek soil samples							
DC 001	0-5	Sandy Loam	3.12	3a	27.48	-	Non saline
	40-50	Sandy Clay Loam	23.14	3a	254.86	3.70	Non saline
DC 002	0-5	Sandy Clay Loam	21.91	2	50.13	-	Non saline
	40-50	Sandy Loam	22.23	2	69.13	-	Non saline
	90-100	Sandy Loam	-	-	-	-	Non saline
DC 003	0-5	Sandy Loam	53.54	3b	31.14	-	Non saline
	10-20	-	-	-	-	21.60	-
	40-50	-	80.90	-	36.87	-	-
DC 004	0-5	-	58.84	3b	36.87	-	-
	40-50	-	78.11	6	45.90	-	-
DC 005	0-5	Sandy Loam	12.85	3a	36.71	-	Non saline
	40-50	Sandy Clay Loam	8.99	6	71.14	13.93	Non saline
DC 006	0-5	Sandy Loam	67.75	3a	32.31	-	Non saline
	10-20	-	-	-	-	87.01	-
	40-50	Sandy Loam	70.37	3a	20.00	-	Non saline
DC 007	0-5	Sandy Clay Loam	7.38	3a	60.27	-	Non saline
	40-50	Sandy Loam	11.12	3a	60.74	2.49	Non saline
DC 008	0-5	Sandy Loam	73.00	3b	47.27	-	Non saline
	10-20	-	-	-	-	251.51	-
	40-50	Sandy Clay Loam	82.20	3b	35.97	-	Non saline
DC 009	0-5	-	0.09	3a	17.83	-	-
	40-50	-	8.90	3a	226.90	-	-

Appendix D
CSBP analysis results

Summary of CSBP analyses

SAMPLE ID		TEXTURE	GRAVEL	COLOUR	Ammonium Nitrogen	Nitrate Nitrogen	Phosphorus Colwell	Potassium Colwell	Sulphur	Organic Carbon	Conductivity	pH Level (CaCl2)	pH Level (H2O)	% Clay	% Course Sand	% Fine Sand	% Sand	% Silt	Prewash exch. Ca	Prewash exch. K	Prewash exch. Mg	Prewash exch. Na
					mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	%	dS/m	pH	pH	%	%	%	%	%	meq/100g	meq/100g	meq/100g	meq/100g
DC 001	0-5	2.0	0	BROR	8	28	7	248	2.63	0.79	0.074	5.5	6.3	13.7	39.6	38.9	78.5	7.8	2.94	0.29	1.25	0.05
DC 001	10-20	2.5	0	BROR	2	19	9	141	2.79	0.54	0.055	5.8	6.7	-	-	-	-	-	3.07	0.17	1.16	0.05
DC 001	40-50	3.5	0	BRRD	6	10	4	68	4.1	0.52	0.05	5.5	6.4	22.9	19.7	48.5	68.2	9	3.49	0.1	1.6	0.05
DC 001	90-100	2.0	0	BROR	5	1	4	106	2.98	0.35	0.028	5.9	7.1	-	-	-	-	-	2.15	0.1	0.92	0.05
DC 002	0-5	3.0	5	BROR	1	1	3	125	1.16	0.21	< 0.01	5.1	6.3	20.2	53.9	22	76	3.9	1.69	0.17	0.9	0.05
DC 002	10-20	2.5	5	BROR	1	3	5	148	6.4	0.14	0.033	5.9	7	-	-	-	-	-	1.4	0.15	0.87	0.05
DC 002	40-50	3.5	5	BROR	< 1	3	2	126	6.1	0.14	0.018	5	6	17.6	54.7	20.9	75.5	6.9	1.15	0.13	0.6	0.05
DC 002	90-100	2.5	0	BROR	1	2	3	118	2.04	0.07	0.021	5.9	7	-	-	-	-	-	1.59	0.11	0.79	0.05
DC 003	0-5	3.0	5	BROR	< 1	4	3	111	3.81	0.19	0.018	4.9	5.9	13.4	40.2	44.4	84.7	1.9	0.68	0.13	0.24	0.05
DC 003	10-20	2.5	5	BROR	< 1	1	2	112	6.41	0.11	0.016	5.9	6.8	-	-	-	-	-	0.82	0.13	0.24	0.05
DC 003	40-50	2.5	25-30	BRRD	< 1	2	3	129	4.06	0.18	0.012	5.4	6.4	13.6	52	30.6	82.6	3.9	1	0.19	0.42	0.05
DC 004	0-5	3.0	5-10	BROR	4	12	6	120	8.14	0.21	0.052	5.4	6.2	-	-	-	-	-	1.2	0.11	0.42	0.05
DC 004	10-20	3.0	5-10	BROR	15	201	4	163	121	0.28	0.72	5.7	5.9	-	-	-	-	-	2.4	0.19	0.66	0.05
DC 004	40-50	3.5	5-10	BROR	2	69	3	143	25.1	0.2	0.215	5.7	6.3	-	-	-	-	-	2.42	0.2	1.17	0.05
DC 005	0-5	3.0	5	BROR	6	5	5	204	1.16	0.36	0.024	4.9	5.9	14.7	52.3	30.1	82.4	2.9	0.92	0.25	0.42	0.05
DC 005	10-20	3.5	5	BROR	< 1	7	3	163	4.11	0.25	0.019	4.3	5	-	-	-	-	-	1	0.14	0.28	0.05
DC 005	40-50	3.0	5	BROR	1	2	3	110	10.7	0.12	0.014	4.4	5.5	23.1	53.4	18.7	72.1	4.8	0.7	0.11	0.33	0.05
DC 005	70-80	3.5	5	BROR	1	1	6	80	9.8	0.11	0.015	4.1	5.3	-	-	-	-	-	0.49	0.1	0.51	0.05

DC 006	0-5	3.5	5	BRRD	< 1	1	4	110	3.72	0.17	0.011	5	6.2	13.4	48	35.7	83.7	2.9	0.86	0.14	0.37	0.05
DC 006	10-20	3.0	15-20	BROR	1	1	3	99	2.52	0.17	< 0.01	5.6	6.4	-	-	-	-	-	0.76	0.13	0.39	0.05
DC 006	40-50	2.5	5-10	BRRD	< 1	1	4	98	1.78	0.24	0.011	5.4	6.4	13.4	53.6	30.1	83.7	2.9	0.64	0.13	0.24	0.05
DC 006	80-90	2.5	25-30	BRRD	1	1	4	86	3.91	0.2	0.01	5.8	6.5	-	-	-	-	-	0.72	0.13	0.34	0.05
DC 007	0-5	3.5	0	BROR	5	6	7	302	2.6	0.71	0.041	5.7	6.5	20.5	39.2	33.5	72.6	6.9	2.71	0.45	0.53	0.05
DC 007	10-20	3.0	0	BR	< 1	11	3	173	2.28	0.46	0.033	5.5	6.4	-	-	-	-	-	2.26	0.18	1.06	0.05
DC 007	40-50	2.0	0	BRRD	< 1	5	4	134	0.98	0.23	0.015	5.6	6.7	13.6	48.8	30.8	79.6	6.8	1.46	0.12	0.5	0.05
DC 007	90-100	2.0	5	BR	< 1	1	4	78	0.64	0.06	< 0.010	5.6	6.5	-	-	-	-	-	0.57	0.03	0.15	0.05
DC 008	0-5	2.5	25-30	BROR	2	3	5	104	2.72	0.18	0.011	4.7	5.7	12.6	43.7	39.9	83.6	3.9	0.55	0.11	0.19	0.05
DC 008	10-20	2.5	5-10	BRRD	< 1	3	2	131	1.85	0.17	0.01	5.4	6.4	-	-	-	-	-	0.88	0.18	0.41	0.05
DC 008	40-50	2.5	35-40	BRRD	< 1	4	2	103	3.07	0.15	< 0.010	5.3	6	19.4	44.5	34.2	78.7	1.9	0.97	0.14	0.45	0.05
DC 008	90-100	2.5	15-20	BRRD	< 1	3	4	100	5.76	0.14	0.014	5.5	6.4	-	-	-	-	-	1.06	0.14	0.52	0.05
DC 009	0-5	2.0	0	BROR	5	12	7	263	1.99	0.6	0.037	5.8	6.6	-	-	-	-	-	2.27	0.25	0.98	0.05
DC 009	10-20	2.5	0	BROR	2	15	3	135	2.53	0.51	0.038	5.4	6.2	-	-	-	-	-	2.91	0.13	1.22	0.05
DC 009	40-50	3.5	0	BROR	1	26	6	95	1.5	0.42	0.062	5.4	6.3	-	-	-	-	-	3.71	0.12	1.72	0.05
DC 009	90-100	2.0	5	BROR	2	6	40	128	0.91	0.14	0.017	5.6	6.5	-	-	-	-	-	1.06	0.03	0.45	0.05
RR 001	0-5	1.5	0	BROR	1	3	4	56	1.05	0.19	0.016	5.1	5.8	5.9	74.5	17.6	92.2	2	0.42	0.05	0.11	0.03
RR 001	10-20	1.5	0	BROR	< 1	2	2	75	6.44	0.15	0.031	5.7	6.5	-	-	-	-	-	0.45	0.07	0.11	0.03
RR 001	40-50	1.5	5	BRRD	3	1	3	68	3.59	0.14	0.018	5.9	6.4	7.7	69.6	21.7	91.3	1	0.36	0.09	0.36	0.05
RR 001	90-100	2.0	25-30	BRRD	4	3	4	56	2.62	0.09	0.026	6.1	6.7	-	-	-	-	-	0.41	0.06	0.27	0.05
RR 002	0-5	2.0	5	BRRD	3	8	4	129	5.79	0.19	0.035	6	6.5	8.7	66.9	22.4	89.4	1.9	0.69	0.12	0.19	0.05
RR 002	10-20	1.5	0	BROR	1	2	2	138	11.9	0.13	0.045	5.8	6.6	-	-	-	-	-	0.6	0.16	0.18	0.05
RR 002	40-50	2.0	0	BRRD	14	2	11	80	9.49	0.09	0.039	6.3	6.8	13.6	54.7	31.8	86.4	< 0.01	0.48	0.12	0.5	0.05
RR 002	90-100	3.0	0	BRRD	< 1	11	2	77	10.5	0.05	0.055	6.4	7	-	-	-	-	-	0.54	0.08	0.45	0.05
RR 003	0-5	1.5	0	BRRD	1	3	2	57	1.16	0.15	0.015	5.5	6.2	9.5	61.7	27.8	89.5	1	0.36	0.04	0.16	0.05

RR 003	10-20	2.0	0	BROR	< 1	1	2	74	2.67	0.09	0.01	5.4	6.2	-	-	-	-	-	0.36	0.06	0.16	0.05
RR 003	40-50	2.5	0	BRRD	< 1	< 1	9	73	4.84	0.22	0.015	5.2	6	13.5	59.8	23.8	83.6	2.9	0.43	0.08	0.17	0.05
RR 003	90-100	2.5	5	BROR	< 1	< 1	3	74	5.81	0.05	< 0.010	5.6	6.4	-	-	-	-	-	0.37	0.05	0.17	0.05
RR 004	0-5	2.5	5-10	BROR	< 1	3	4	98	1.56	0.24	< 0.010	5.2	6.2	11.7	35.6	49.7	85.3	2.9	0.79	0.12	0.16	0.05
RR 004	10-20	1.5	25-30	BRRD	< 1	3	13	120	3	0.22	0.015	5.6	6.5	-	-	-	-	-	0.87	0.16	0.22	0.05
RR 004	40-50	3.0	5	BRRD	< 1	1	3	100	1.85	0.18	0.012	5.7	6.4	13	43.2	41.8	85	2	0.83	0.12	0.2	0.05
RR 005	0-5	1.5	5-10	BROR	1	2	3	77	1.39	0.22	< 0.010	5.6	6.4	7.7	37.3	50.1	87.4	4.9	0.6	0.08	0.16	0.05
RR 005	10-20	1.5	5	BRRD	< 1	3	16	113	2.38	0.15	0.014	5.4	6.4	-	-	-	-	-	0.55	0.13	0.15	0.05
RR 005	40-50	1.5	15-20	BRRD	1	1	3	64	1.43	0.14	< 0.010	5.7	6.4	9.7	42.2	47.1	89.3	1	0.6	0.05	0.21	0.05
RR 006	0-5	1.5	15-20	BROR	< 1	1	8	75	2.22	0.13	< 0.010	5	6	11.6	26.6	58.9	85.5	2.9	0.64	0.08	0.21	0.05
RR 006	10-20	2.0	15-20	BRRD	< 1	2	3	84	3.29	0.09	0.011	5.4	6.4	-	-	-	-	-	0.63	0.1	0.15	0.05
RR 006	40-50	1.5	15-20	BRRD	1	1	6	64	1.53	0.24	< 0.010	5.3	6.1	10.7	59.4	26.9	86.3	2.9	0.82	0.08	0.18	0.05

Appendix E

Davidson Creek and Robertson Range Geochemical Characterisation

Graeme Campbell and Associates

GRAEME CAMPBELL & ASSOCIATES PTY LTD
Specialists in Mine-Waste Geochemistry,
& Soil-Moisture-Retention Testing

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1018/1

COMPANY: FerrAus Limited

ATTENTION: Todd Tuffin

FROM: Graeme Campbell

SUBJECT: FerrAus Pilbara Project: Geochemical Characterisation of Mine-Waste and Low-Grade-Ore Samples from King-Brown Pit, and Implications for Material Management -

DRAFT-REPORT

NO. PAGES (including this page): 67 DATE: 20th December 2010

Todd,

The occurrences of S, and associated univariate-statistics, for the waste-zone of the King-Brown Pit are presented in Attachment I.

Geological-cross-sections, and the locations of the samples tested in this study, are also presented in Attachment I.

Details of the testwork methods employed are presented in Attachment II. Classification criteria in terms of Acid-Formation Potential (AFP) are summarised in Attachment III. Copies of the laboratory reports are presented in Attachment IV.

1.0 APPRAISAL OF SULPHUR-OCCURRENCES

The Exploration-Database from which the univariate-statistics of S-occurrences are derived correspond to the determination of Total-S at intervals of 2-m.

The occurrence of sulphide-minerals is therefore defined at a "fine-spatial-resolution". This "metre-scale-resolution" of S-occurrences is small compared with the likely "mining-resolution" of *c.* 5 m, as controlled by the large equipment to be employed during open-pit mining.

In terms of assessing the potential for the formation of Acid-Rock Drainage (ARD), a "S-threshold/cutoff" of 0.3 % (as S) is employed herein. Although Sulphide-S values less than 0.3 % may result in acidification through sulphide-oxidation, this is restricted to "end-member" mineralogies for sulphide- and groundmass-mineral suites. In particular, it applies to lithotypes for which both the sulphide-minerals include hyper-reactive varieties (e.g. framboidal-pyrite), and the groundmass comprises simply quartz, soil-clays, and sesquioxides (i.e. devoid of reactive-carbonates, and primary-rock-silicates).[1] However, this "type-mineralogy" is not characteristic of the mine-wastes and low-grade-ores to be produced from the King-Brown Pit.

The negligible occurrence of sulphide-minerals (e.g. pyrite) is shown by the distribution of S-occurrences for all lithotypes (Attachment I).

Essentially all of the mine-waste and low-grade-ore streams should be characterised by Total-S values less than 0.3 %, and the majority should have Total-S values well below 0.1-0.2 %. This paucity of sulphide-minerals is consistent with both the styles of mineralisation, and the depths of *in-situ*-weathering, of iron-ore deposits, and associated country-rocks, as generally observed in the Pilbara.

All mine-waste and low-grade-ore streams to be produced from the King-Brown Pit should be classified as Non-Acid Forming (NAF).

Acidification of mine-wastes, and low-grade-ores, should therefore not be an issue for mine-waste management to contend with for the Project.

2.0 GEOCHEMISTRY OF MINE-WASTE SAMPLES

Sixteen (16) samples of mine-wastes were subjected to static-testing (Tables 1-5).

2.1 Acid-Forming Characteristics, and Salinity

The samples were characterised by (Table 1):

- Total-S values of 0.01-0.05 %;
- Acid-Neutralisation-Capacity (ANC) values of 1-33 kg H_2SO_4/tonne;
- Net-Acid-Generation (NAG) values less than 0.5 kg H_2SO_4/tonne, and NAG-pH values of 5.8-6.9; and,
- pH-(1:2) values of 5.8-7.3, and EC-(1:2) values of 0.037-0.28 mS/cm.[2]

The testwork results indicate that all samples are classified as NAF, as expected from the assessment of S-occurrences (Section 1.0, and Attachment I). The groundmass of the various lithotypes is devoid of carbonate-minerals, and so possesses a low capacity to consume acid.

[1] References:
Price W, 2005, "Criteria Used in Material Characterization and the Prediction of Drainage Chemistry: "Screaming Criteria"", Presentation B.1 in "Proceedings of the 12th Annual British Columbia – MEND ML/ARD Workshop on "Challenges in the Prediction of Drainage Chemistry", November 30 to December 1, 2005, Vancouver, British Columbia.
Price WA, Morin K and Hutt N, 1997, "Guidelines for the Prediction of Acid Rock Drainage and Metal Leaching for Mines in British Columbia: Part II. Recommended Procedures for Static and Kinetic Testing", pp. 15-30 in "Proceedings of the Fourth International Conference on Acid Rock Drainage", Volume I, Vancouver.
Campbell GD, unpublished results since the late-1980s.

[2] EC = Electrical-Conductivity. Refer Attachment II for a description of the pH-(1:2) and EC-(1:2) testwork, and other testwork.

The samples were circum-neutral (viz. pH 6-7) with low contents of soluble-salts. Such pH and salinity regimes are typical of mine-waste streams produced at iron-ore-mines in the Pilbara.[3]

2.2 Multi-Element Composition

The samples subjected to multi-element analyses had contents of major- and minor-elements typically below, or close to, those recorded for soils, regoliths, and bedrocks derived from unmineralised terrain (Table 2). Although variously enriched in As, Sb, Se, Bi, and Mn, the degree of enrichment was not marked. However, the Mn content of 10.7 % in the WAMN sample (GCA8894) was an exception, as expected.

In addition to the samples subjected to multi-element analyses, the remaining samples were assayed for a restricted suite of minor-elements (viz. As, Sb, Se, Mo and B). These minor-elements occur as oxyanions (e.g. arsenates) in natural systems, and their pH-solubility relationships are such that their concentrations can potentially be within the mg/L+ range at circum-neutral-pH. The analysis results for this restricted-minor-element suite are presented in Table 3.

The ranges in contents of these minor-elements were:

- 11-47 mg/kg for As;
- 0.99-9.7 mg/kg for Sb;
- 0.06-1.7 mg/kg for Se;
- 0.70-5.9 mg/kg for Mo; and,
- less than 50 mg/kg, to 51 mg/kg for B.

The minor-element contents above fall within the range generally recorded for mine-waste samples derived from other iron-ore mines on the Pilbara block, especially for lithotypes located above the Base-of-Oxidation (BoX).[4]

2.3 Minor-Element Solubility

To assess the stability of major/minor-elements, a range of samples was subjected to Water-Extraction Tests (Table 4). In this testwork, pulped samples (nominal 75 µm) were extracted for *c.* 1 day via the bottle-roll technique, employing slurries prepared from deionised-water, at a solid:solution ratio of *c.* 1:2 (w/w). The resulting water-extracts were filtered (0.45-µm-membrane), and preserved, as appropriate, for specific analyses (see Attachment II).

> Note: To assist interpretation of the Water-Extraction-Test results, a broad comparison may be made between the testwork conditions, and elution of solutes from the surficial-zone of the waste-dumps by rainfall. The solid:solution ratio employed in the testing was *c.* 1:2 (w/w). If the Dry-Bulk-Density (DBD) of the mixture of the fine-earth (viz. -2 mm) fraction, and clasts, is *c.* 2.0 t/m^3, then for an annual rainfall of *c.* 300-400 mm, the "equivalent" solid:solution ratio experienced by the top 0.1 m may be taken as *c.* 1:2 (w/w). Therefore, the testwork results broadly correspond to the efficient leaching of the top 0.1 m of a mine-waste-profile by a year's worth of rainfall, and where all drainage-waters are collected in a dam without any mixing with

[3] Campbell, unpublished results.
[4] Campbell, unpublished results.

runoff-waters derived from up-catchment areas. Although approximate, this comparison assists in placing the testwork results into broad perspective in terms of potential water-quality for the downstream environs. However, sight must not be lost of the testwork conditions employed (viz. samples as powders in suspensions that are continuously agitated). The Water-Extraction Tests herein serves simply to identify any weakly-bound forms of solutes which are susceptible to release to solution upon contact with meteoric-waters.

The concentration of minor-elements in the water-extracts were either below, or close to, the respective detection-limits (viz. typically within the range 0.1-10 µg/L) [Table 4]. These results are consistent with the hydrogeochemical expectation of a sparingly-low solubility of minor-elements (at circum-neutral-pH) for mine-wastes which are Fe-rich, weakly-mineralised, and devoid of sulphide- and carbonate-minerals.

The Se concentrations in the present water-extracts ranged from less than 0.5 µg/L, to 1.7 µg/L, and correspond to test-slurries with a solid:solution ratio of *c.* 1:2 (w/w). In related water-extraction testwork on ferruginous-overburden samples from the Yandi Iron-Ore Mine, Gardiner (2003) reported Se concentrations of *c.* 21-43 µg/L (see Tables 3.11-3.13 in Gardiner [2003]), corresponding to test-slurries with a solid:solution ratio of *c.* 1:20 (w/w).[5] When expressed in terms of µg of Se extracted per kg of dry-solids, the mine-waste samples tested herein had Water-Extractable-Se contents ranging up to *c.* 2 µg Se/kg, whereas Gardiner (2003) reported Water-Extractable-Se contents within the range *c.* 400-900 µg Se/kg. There is therefore a 100-fold difference in the Water-Extractable-Se contents between this study, and that of Gardiner (2003).[6] The latter results lead to the conclusion that *inter alia* elevated Se solubility could be a water-quality issue for pit-lakes following cessation of pit-dewatering at closure. However, there are a number of inconsistencies in the results reported by Gardiner (2003). Given the potential implications of such apparent Se-solubility behaviour to the iron-ore-mining industry generally, it is justified to critique these analysis anomalies.

Anomalous-Results from Gardiner (2003): Sample LAET-908 had a Total-Se content less than 0.01 mg/kg (Table 3.7), yet its Water-Extractable-Se content (calculated from the Water-Extract-Se concentration of 31.5 µg/L in Table 3.12) is 0.63 mg/kg. Related discrepancies occur for the Zn results. For example, sample LAET-898 had a Total-Zn content of 12.4 mg/kg (Table 3.7), and an apparent Water-Extractable-Zn content of 25 mg/kg (calculated from Table 3.12). Water-Extract-Fe concentrations ranged up to 13.2 mg/L (Table 3.13) which are untenable for "true" Soluble-Fe forms at circum-neutral-pH, and the oxic-redox conditions of the test-slurries employed in the water-extraction testwork. Finally, several water-extracts had alkalinities greater than 1,000 mg/L (as $CaCO_3$), and Ca concentrations within the range *c.* 200-800 mg/L, but the corresponding EC values were only *c.* 80-150 µS/cm (Tables 3.11-3.13). These anomalous results can be explained by the occurrence of ultra-fine (i.e. sub-µm-sized) forms of carbonate-minerals (e.g. calcites), clays and Fe/Al-sesquioxides which passed through the 0.45µm-membrane, and then released bound forms of minor-elements (e.g. Se and Zn) to solution when the filtrates were preserved for analysis by acidifying with HNO_3.[7]

Whatever the exact reason(s) for the analysis anomalies above, the net outcome is that the stability of Se (and other minor-elements) in NAF varieties of mine-wastes at iron-ore-mines in the Pilbara is likely considerably greater than reported by Gardiner (2003).

[5] Gardiner SJ, 2003, "Impacts of Mining and Mine Closure on Water Quality and the Nature of the Shallow Aquifer, Yandi Iron Ore Mine", MSc Thesis, Department of Applied Geology, Curtin University of Technology, Drs R Watkins and C Evans as Supervisors.

[6] The Total-Se contents of the samples tested herein were 0.06-1.7 mg/kg (Table 3), whereas those recorded by Gardiner (2003) ranged up to 1.24 mg/kg (Tables 3.6, 3.7, and 3.8).

[7] Water-Extract-Al concentrations were not reported by Gardiner (2003).

In the present study, the WAMN sample (GCA8894) with a Total-Mn content of 10.7 % had a Water-Extract-Mn concentration of 1.2 mg/L (Table 4). The Mn in the WAMN sample therefore corresponds to stable forms of low solubility.

2.4 Clay-Mineralogy and Clay-Surface-Chemistry

The clay-mineral suite of the tested samples was dominated by kaolinites (c.f. "high-activity" smectites which exhibit marked shrink-swell behaviour under wetting and drying conditions).

The Effective-Cation-Exchange-Capacity (eCEC) values of the tested samples were 1.2-8.9 cmol (p+)/kg, and the Exchangeable-Sodium-Percentage (ESP) values were *c.* 6-17 % (Table 5). The samples were therefore variously sodic.

3.0 GEOCHEMISTRY OF LOW-GRADE-ORE SAMPLES

Seven (7) samples of low-grade-ores were subjected to static-testing (Tables 6-9).

In essence, the geochemical character of the low-grade-ore samples is indistinguishable from that of the mine-waste samples above. Given the nature of iron-ore-mineralisation within the King-Brown Deposit, this is to be expected.

All low-grade-ore samples are classified as NAF, and were circum-neutral (viz. pH 6-7) with low contents of soluble-salts (Table 6).

The samples subjected to multi-element analyses had contents of major- and minor-elements typically below, or close to, those recorded for soils, regoliths, and bedrocks derived from unmineralised terrain (Tables 7 and 8).

The concentration of minor-elements in the water-extracts were either below, or close to, the respective detection-limits (Table 9).

4.0 MANAGEMENT IMPLICATIONS

The management implications outlined below reflect a working-model of mine-waste geochemistry for the King-Brown Deposit developed from the testwork results obtained in this study (and Appendix I), as well as experience with other deposits on the Pilbara block which share a related geology, and style of mineralisation.

4.1 Mine-Wastes

Geochemically, the various mine-waste units should be benign (i.e. extremes in pH and/or salinity should <u>not</u> place constraints on how such materials are managed). The 'ex-pit' streams of the mine-waste units should be circum-neutral, and of low-to-moderate salinity. Such pH and salinity regimes should prevail over the longer-term during weathering on the waste-dumps, as governed by the frequency, and penetration-depth, of the seasonal wetting-front.[8]

[8] Campbell GD, 2008, "Mine-Waste Geochemistry, Rainfall Seasonality, and Coincidence of the Wetting/Oxidation-Fronts: A Conceptual Arid-Zone Weathering Model", PowerPoint-presentation delivered at the May 2008 Workshop of the Goldfields Environmental Management Group, Kalgoorlie. Campbell GD, 2007, "Isolation of Reactive Mine-Wastes in the WA Goldfields: How Arid-Zone Weathering and Hydroecology Simplify Cover-Design Studies", Section 8 in "Planning for Mine-Closure Seminar", Australian Centre for Geomechanics, 14-15 June 2007, 40 pp.

Since the remnant "chalcophyle-signature" reflecting mineralisation is weak, minor-element enrichments should pose no concerns to water-quality, or uptake by plant-roots. The abundance of Fe-oxyhydroxides should ensure that minor-elements are retained by sorption reactions of the "high-affinity/poorly-reversible" type, as have occurred *in situ* over the eons.

Since the majority of the lithotypes produced during mining are competent, chunky and durable, they are well suited to applications where exposure occurs over the longer-term (e.g. rock-armouring, construction of pit-safety-bund, etc.). Where earthy, friable lithotypes are produced, their susceptibility to erosion should be dampened by the expected abundance of clasts, and the fact that their "fine-earth" fraction (viz. -2 mm) should not be enriched in smectites (i.e. "high-activity" clays that exhibit marked shrink-swell behaviour). Together with topsoils, such lithotypes should be earmarked for use in constructing the outermost-sections of the waste-landforms, so that water-retention capacities, in particular, are favourable to vegetation. However, since friable materials are susceptible to erosion, a balance needs to be struck between creating a profile which is both texturally suitable as a rooting-medium for plant growth, and physically stable. These challenges are generic to mine-waste management at hard-rock mines.

In brief, waste-landform design and rehabilitation should not be constrained by the physicochemical nature of the mine-waste streams. Planning for waste-landform decommissioning should integrate industry best-practice concepts for rehabilitation and mine-site closure (DITR 2006a,b), and the practical know-how from other Pilbara iron-ore mines.[9]

4.2 Low-Grade-Ores

Since the physicochemical character of the low-grade-ores is similar to that for the mine-waste streams, the same generic remarks apply to the rehabilitation of the stockpiles of low-grade-ores in the event that such stockpiles remain at closure.

5.0 CLOSURE

I trust the above is useful to you.

Regards,

Dr GD Campbell
Director

Encl. Tables 1-9.
Attachments I-IV.

[9] Department of Industry, Tourism and Resources, 2006a, "Mine Closure and Completion", Leading Practice Sustainable Development Program for the Mining Industry, Canberra.
Department of Industry, Tourism and Resources, 2006b, "Mine Rehabilitation", Leading Practice Sustainable Development Program for the Mining Industry, Canberra.

TABLES

Table 1: Acid-Base-Analysis and Net-Acid-Generation Results for Mine-Waste Samples

GCA-SAMPLE NO.	SITE-SAMPLE NO.	DRILLHOLE & DOWN-HOLE INTERVAL (m)	LITHOTYPE	pH-(1:2)	EC-(1:2) [mS/cm]	TOTAL-S (%)	TOTAL-C (%)	CO_3-C (%)	ANC	NAPP	NAG	NAG-pH	AFP CATEGORY
									kg H_2SO_4/tonne				
GCA8884	RRWC0001	RRRC0658, 4-8	TW	7.3	0.15	0.05 (0.05)	0.08 (0.08)	nm	2 (1)	nc	<0.5	6.9	NAF
GCA8885	RRWC0002	RRRC0149, 10-12	TW	6.4	0.12	0.05	0.10	nm	3	nc	<0.5	6.8	NAF
GCA8886	RRWC0013	RRRC0180, 32-36	TW	6.0	0.16	0.01	0.05	nm	4	nc	<0.5	6.6	NAF
GCA8887	RRWC0014	RRRC0408, 36-40	TW	6.5	0.14	0.01	0.35	0.04	1	nc	<0.5	6.8	NAF
GCA8888	RRWC0015	RRRC0724, 34-38	TW	6.7	0.037	0.02	0.06	nm	4	nc	<0.5	6.9	NAF
GCA8889	RRWC0016	RRRC0354, 34-38	TW	6.7	0.054	0.01	0.17	nm	2	nc	<0.5	6.6	NAF
GCA8890	RRWC0003	RRRC0659, 14-18	WAW	6.4	0.18	0.04	0.13	nm	27	nc	<0.5	6.6	NAF
GCA8891	RRWC0017	RRRC0354, 78-82	WAW	6.3	0.13	0.02	0.73	0.07	33	nc	<0.5	6.5	NAF
GCA8892	RRWC0018	RRRC0164, 46-50	WAW	6.5	0.058	0.01	0.06	nm	3	nc	<0.5	6.7	NAF
GCA8893	RRWC0008	RRRC0149, 90-94	WAMN	6.3	0.066	0.02	0.04	nm	5	nc	<0.5	6.8	NAF
GCA8894	RRWC0021	RRRD0401, 92-96	WAMN	5.9 (5.8)	0.15 (0.16)	0.02	0.64	0.09	9	nc	<0.5	5.9	NAF
GCA8895	RRWC0022	RRRC0354, 112-116	WAMN	6.6	0.28	0.02	0.79	0.17	10	nc	<0.5	6.6	NAF
GCA8896	RRWC0009	RRRC0655, 0-4	MMW	6.8	0.12	0.05	0.15	nm	1	nc	<0.5	6.6	NAF
GCA8897	RRWC0010	RRRC0656, 0-4	MMW	7.0	0.057	0.05	0.08	nm	2	nc	<0.5	6.6	NAF
GCA8898	RRWC0023	RRRC0230, 4-8	MMW	6.9	0.048	0.05	0.11	nm	2	nc	<0.5	6.6	NAF
GCA8899	RRWC0024	RRRC0235, 18-22	MMW	6.5	0.046	0.03	0.07	nm	1	nc	<0.5	5.8	NAF

Notes:

EC = Electrical Conductivity; ANC = Acid-Neutralisation-Capacity; NAPP = Net-Acid-Producing-Potential; AFP = Acid-Formation-Potential; NAF = Non-Acid-Forming; NAG = Net-Acid Generation; nm = not measured; nc = not calculated.
pH-(1:2) and EC-(1:2) values correspond to pH and EC measured on sample slurries prepared with deionised-water, and a solid:solution ratio of *c.* 1:2 (w/w).
All results expressed on a dry-weight basis, except for pH-(1:2), EC-(1:2), and NAG-pH.
Values in parentheses represent duplicates.

N.B. **TW** = Transported **WAW** = Lower-West-Angela **WAMN** = Lower-West-Angela-[Mn-Bearing] **MMW** = Mt-Newman/McLeod

Table 2: Multi-Element-Analysis Results for Mine-Waste Samples

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)				AVERAGE-CRUSTAL-ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)			
	TW (GCA8884)	TW (GCA8887)	WAW (GCA8891)	WAMN (GCA8894)		TW (GCA8884)	TW (GCA8887)	WAW (GCA8891)	WAMN (GCA8894)
Al	5.2%	13%	3.9%	3.7%	8.2%	0	0	0	0
Fe	45.1%	10.4%	35.5%	25.0%	4.1%	**3**	1	**3**	2
Na	0.043%	0.051%	0.015%	0.031%	2.3%	0	0	0	0
K	0.12%	0.030%	0.033%	0.097%	2.1%	0	0	0	0
Mg	0.094%	0.13%	0.26%	0.15%	2.3%	0	0	0	0
Ca	0.076%	0.087%	0.045%	0.052%	4.1%	0	0	0	0
Ag	0.7	0.4	0.2	0.3	0.07	**3**	2	1	2
Cu	21	70	140	86	50	0	0	1	0
Zn	66	26	480	330	75	0	0	2	2
Cd	<0.1	<0.1	<0.1	0.5	0.11	0	0	0	2
Pb	46	25	35	11	14	1	0	1	0
Cr	220	220	44	25	100	1	1	0	0
Ni	18	25	110	76	80	0	0	0	0
Co	9.5	3.6	46	35	20	0	0	1	0
Mn	3,300	78	8,300	10.7%	950	1	0	**3**	**6**
Hg	0.01	0.12	0.07	0.30	0.05	0	1	0	2
Sn	4.3	10	1.2	1.3	2.2	0	2	0	0
Sr	14	11	5.4	48	370	0	0	0	0
Ba	180	38	38	1,400	500	0	0	0	1
Th	19	15	6.3	6.8	12	0	0	0	0
U	3.7	2.7	1.9	1.6	2.4	0	0	0	0
Tl	0.53	0.04	0.13	7.4	0.6	0	0	0	**3**
V	210	90	63	58	160	0	0	0	0
As	34	12	38	18	1.5	**4**	2	**4**	**3**
Bi	0.59	0.95	0.22	0.51	0.048	**3**	**4**	2	**3**
Sb	4.3	3.3	3.0	0.99	0.2	**4**	**3**	**3**	2
Se	0.13	0.30	0.06	0.05	0.05	1	2	0	0
Mo	3.2	1.8	1.5	0.7	1.5	1	0	0	0
B	<50	<50	<50	<50	10	0	0	0	0
P	380	<50	1,100	780	1,000	0	0	0	0
F	200	340	310	420	950	0	0	0	0

Note:
Average-crustal abundance of elements based on Bowen (1979), and the Geochemical-Abundance Index (GAI) is based on Förstner *et al.* (1993). Refer Attachment II.

Table 2 (Cont'd): Multi-Element-Analysis Results for Mine-Waste Samples

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)		AVERAGE-CRUSTAL ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)	
	MMW (GCA8896)	MMW (GCA8898)		MMW (GCA8896)	MMW (GCA8898)
Al	4.3%	5.7%	8.2%	0	0
Fe	47.0%	39.8%	4.1%	**3**	**3**
Na	0.028%	0.028%	2.3%	0	0
K	0.14%	0.23%	2.1%	0	0
Mg	0.11%	0.12%	2.3%	0	0
Ca	0.12%	0.086%	4.1%	0	0
Ag	0.5	0.5	0.07	2	2
Cu	27	35	50	0	0
Zn	140	42	75	0	0
Cd	<0.1	<0.1	0.11	0	0
Pb	53	52	14	1	1
Cr	220	410	100	1	1
Ni	40	18	80	0	0
Co	19	5.1	20	0	0
Mn	4,000	360	950	1	0
Hg	0.03	0.01	0.05	0	0
Sn	3.1	3.9	2.2	0	0
Sr	25	22	370	0	0
Ba	650	150	500	0	0
Th	17	21	12	0	0
U	5.4	3.0	2.4	1	0
Tl	0.92	0.23	0.6	0	0
V	190	330	160	0	0
As	38	51	1.5	**4**	**5**
Bi	0.50	0.73	0.048	**3**	**3**
Sb	3.3	8.3	0.2	**3**	**5**
Se	1.7	0.54	0.05	**5**	**3**
Mo	3.4	3.6	1.5	1	1
B	<50	<50	10	0	0
P	490	380	1,000	0	0
F	360	300	950	0	0

Table 3: Total-Contents of As, Sb, Se, Mo and B in Mine-Waste Samples

GCA-SAMPLE NO.	SITE-SAMPLE NO.	DRILLHOLE & DOWN-HOLE INTERVAL (m)	LITHOTYPE	As (mg/kg)	Sb (mg/kg)	Se (mg/kg)	Mo (mg/kg)	B (mg/kg)
GCA8884	RRWC0001	RRRC0658, 4-8	TW	34	4.3	0.13	3.2	<50
GCA8885	RRWC0002	RRRC0149, 10-12	TW	43	7.6	0.35	3.9	<50
GCA8886	RRWC0013	RRRC0180, 32-36	TW	13	5.0	0.07	1.5	51
GCA8887	RRWC0014	RRRC0408, 36-40	TW	12	3.3	0.30	1.8	<50
GCA8888	RRWC0015	RRRC0724, 34-38	TW	47	9.7	0.26	2.6	<50
GCA8889	RRWC0016	RRRC0354, 34-38	TW	32	4.0	0.45	2.0	<50
GCA8890	RRWC0003	RRRC0659, 14-18	WAW	31	4.5	1.1	5.9	<50
GCA8891	RRWC0017	RRRC0354, 78-82	WAW	38	3.0	0.06	1.5	<50
GCA8892	RRWC0018	RRRC0164, 46-50	WAW	28	1.9	0.30	1.7	<50
GCA8893	RRWC0008	RRRC0149, 90-94	WAMN	26	1.8	0.11	5.1	<50
GCA8894	RRWC0021	RRRD0401, 92-96	WAMN	18	0.99	0.05	0.70	<50
GCA8895	RRWC0022	RRRC0354, 112-116	WAMN	11	1.7	0.04	0.80	<50
GCA8896	RRWC0009	RRRC0655, 0-4	MMW	38	3.3	1.7	3.4	<50
GCA8897	RRWC0010	RRRC0656, 0-4	MMW	33	3.5	0.80	3.0	<50
GCA8898	RRWC0023	RRRC0230, 4-8	MMW	51	8.3	0.54	3.6	<50
GCA8899	RRWC0024	RRRC0235, 18-22	MMW	11	0.99	0.26	1.6	<50

Table 4: Water-Extraction-Testwork Results for Mine-Waste Samples

Note: All results in mg/L, except for pH and Electrical-Conductivity (EC).

ELEMENT/ PARAMETER	TW (GCA8887)	WAW (GCA8891)	WAMN (GCA8893)	WAMN (GCA8894)	WAMN (GCA8895)	MMW (GCA8898)
Major-Parameters						
pH	7.3 (7.3)	6.7	6.6	7.3	6.8	6.6
EC [µS/cm]	180 (180)	260	140	380	670	120
Major-Ions						
Na	28	21	18	26	34	15
K	3.9	7.7	1.6	7.7	22	7.1
Mg	5.1	12	4.6	20	33	2.1
Ca	6.1	9.7	4.5	22	54	3.7
Cl	8 (8)	48	24	54	93	6.0
SO_4	8.1	14	3.3	12	38	16

ELEMENT/ PARAMETER	TW (GCA8887)	WAW (GCA8891)	WAMN (GCA8893)	WAMN (GCA8894)	WAMN (GCA8895)	MMW (GCA8898)
Minor-Ions						
Fe	0.02	0.02	0.01	0.03	0.02	0.01
Cu	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ni	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Zn	0.01	<0.01	0.03	0.03	0.01	<0.01
Co	0.0002	0.0003	0.0007	0.0011	0.0016	0.0002
Al	0.04	<0.01	<0.01	0.03	<0.01	0.08
Cd	0.00002	0.00002	<0.00002	0.00003	<0.00002	<0.00002
Pb	0.0011	0.0006	0.0011	0.0030	0.0006	0.0016
Cr	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hg	0.0002	<0.0001	0.0010	0.0002	0.0002	0.0003
As	0.0025	0.0019	0.0009	0.0012	0.0013	0.0006
Sb	0.0001	0.00003	0.00005	0.00024	0.00006	0.00004
Bi	0.00027	0.00015	0.000078	0.00028	0.000037	0.00052
Se	<0.0005	0.0017	0.0010	0.00013	0.0017	0.0012
B	0.16	0.07	0.07	0.05	<0.01	0.07
Mo	0.00038	<0.00005	0.00006	<0.00005	<0.00005	<0.00005
P	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Si	14	3.8	4.2	3.2	1.6	6.9
Ag	<0.00001	<0.00001	0.00001	0.00004	<0.00001	<0.00001
Ba	0.012	0.012	0.0026	0.012	0.0055	0.078
Sr	0.046	0.046	0.018	0.23	0.37	0.047
Tl	0.00001	0.00004	<0.00001	0.00002	0.00006	0.00001
V	<0.01	<0.000005	<0.01	<0.01	<0.01	<0.01
Sn	0.0003	0.0002	0.0006	0.0003	0.0002	0.0002
U	0.000018	<0.000005	<0.000005	0.000007	<0.000005	0.000023
Th	0.000005	<0.000005	<0.000005	0.000005	<0.000005	<0.000005
Mn	0.01	<0.01	<0.01	1.20	0.52	0.01

Notes: Water-Extraction Testwork employed pulped-samples (nominal 75-µm), and slurries prepared using deionised-water, and a solid:solution ratio of *c.* 1:2 (w/w). Slurries were bottle-rolled for *c.* 1 day, prior to obtaining water-extracts (via vacuum-filtration) for analysis. Values in parentheses represent duplicates.

Table 5: Clay-Mineralogical and Clay-Surface-Chemistry Results for Mine-Waste Samples

TW (GCA8884)					TW (GCA8887)					WAW (GCA8891)				
hematite			dominant		kaolinite			dominant		goethite				dominant
kaolinite			major							kaolinite				major
goethite			minor		quartz			minor		quartz				minor
quartz			accessory		goethite			accessory		hematite				accessory
					hematite									
eCEC [cmol (p+)/kg]	%-Proportion of eCEC				eCEC [cmol (p+)/kg]	%-Proportion of eCEC				eCEC [cmol (p+)/kg]	%-Proportion of eCEC			
	Na	K	Mg	Ca		Na	K	Mg	Ca		Na	K	Mg	Ca
4.1 (4.0)	17.1 (16.8)	20.9 (20.8)	26.3 (26.2)	35.7 (36.2)	8.9	6.5	4.1	48.9	40.5	1.2	10.9	26.6	36.5	26.0

Notes:
eCEC = effective-Cation-Exchange Capacity
dominant = greater than 50 %; major = 20-50 %; minor = 10-20 %; and, accessory = 2-10 %

WAMN (GCA8894)					MMW (GCA8898)				
goethite			major		kaolinite			major	
					hematite				
kaolinite			minor		goethite			minor	
pyrolusite					quartz				
quartz									
hematite			accessory						
microcline			trace		microcline			trace	
eCEC [cmol (p+)/kg]	%-Proportion of eCEC				eCEC [cmol (p+)/kg]	%-Proportion of eCEC			
	Na	K	Mg	Ca		Na	K	Mg	Ca
2.2	8.3	8.6	43.4	39.7	3.4	8.3	16.1	30.5	45.1

Notes:
eCEC = effective-Cation-Exchange Capacity
major = 20-50 %; minor = 10-20 %; accessory = 2-10 %; and, trace = less than 2 %

Table 6: Acid-Base-Analysis and Net-Acid-Generation Results for Low-Grade-Ore Samples

GCA-SAMPLE NO.	SITE-SAMPLE NO.	DRILLHOLE & DOWN-HOLE INTERVAL (m)	LITHOTYPE	pH-(1:2)	EC-(1:2) [mS/cm]	TOTAL-S (%)	SO_4-S (%)	SULPHIDE-S (%)	TOTAL-C (%)	ANC	NAPP	NAG	NAG-pH	AFP CATEGORY
										kg H_2SO_4/tonne				
GCA8900	RRWC0005	RRRC0124, 26-30	WALG	6.0	0.051	0.01	nm	0.01	0.03	2	nc	<0.5	5.8	NAF
GCA8901	RRWC0019	RRRC0158, 16-18	WALG	6.1	0.055	0.09	nm	0.09	0.19	2	nc	<0.5	6.2 (6.3)	NAF
GCA8902	RRWC0020	RRRC0353, 74-76	WALG	6.2	0.081	<0.01	nm	<0.01	0.04	4	nc	<0.5	6.9	NAF
GCA8903	RRWC0025	RRRC0235, 24-26	MMLG	6.3	0.054	0.03	nm	0.03	0.08	1	nc	<0.5	5.8	NAF
GCA8904	RRWC0026	RRRC0230, 34-38	MMLG	6.1	0.043	0.01 (0.01)	nm	0.01	0.09	1 (1)	nc	<0.5	6.1	NAF
GCA8905	RRWC0011	RRRC0213, 6-10	MMLG	5.7	0.056	0.10	0.02	0.08	0.12	2	nc	1.2	4.3	NAF
GCA8906	RRWC0012	RRRC0657, 10-14	MMLG	5.8 (5.8)	0.13 (0.13)	0.05	nm	0.05	0.14	1	nc	<0.5 (<0.5)	5.9 (5.9)	NAF

Notes:

EC = Electrical Conductivity; ANC = Acid-Neutralisation-Capacity; NAPP = Net-Acid-Producing-Potential; AFP = Acid-Formation-Potential; NAF = Non-Acid-Forming; NAG = Net-Acid Generation;
nm = not measured; nc = not calculated.
pH-(1:2) and EC-(1:2) values correspond to pH and EC measured on sample slurries prepared with deionised-water, and a solid:solution ratio of *c.* 1:2 (w/w).
All results expressed on a dry-weight basis, except for pH-(1:2), EC-(1:2), and NAG-pH.
Values in parentheses represent duplicates.

N.B. **WALG** = Lower-West-Angela-Low-Grade **MMLG** = Mt-Newman/McLeod-Low-Grade

Table 7: Multi-Element-Analysis Results for Low-Grade-Ore Samples

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)		AVERAGE-CRUSTAL ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)	
	WALG (GCA8901)	MMLG (GCA8904)		WALG (GCA8901)	MMLG (GCA8904)
Al	4.6%	2.1%	8.2%	0	0
Fe	50.9%	54.6%	4.1%	**3**	**3**
Na	0.018%	0.0083%	2.3%	0	0
K	0.046%	0.0078%	2.1%	0	0
Mg	0.16%	0.10%	2.3%	0	0
Ca	0.069%	0.032%	4.1%	0	0
Ag	0.3	0.7	0.07	2	**3**
Cu	48	130	50	0	1
Zn	110	120	75	0	0
Cd	<0.1	<0.1	0.11	0	0
Pb	36	32	14	1	1
Cr	110	31	100	0	0
Ni	48	38	80	0	0
Co	17	16	20	0	0
Mn	400	450	950	0	0
Hg	0.07	0.14	0.05	0	1
Sn	2.2	1.0	2.2	0	0
Sr	17	3.4	370	0	0
Ba	32	18	500	0	0
Th	9.7	2.0	12	0	0
U	5.0	4.3	2.4	0	0
Tl	0.06	0.08	0.6	0	0
V	110	31	160	0	0
As	43	15	1.5	**4**	**3**
Bi	0.38	0.10	0.048	2	0
Sb	3.3	0.96	0.2	**3**	2
Se	0.45	0.27	0.05	**3**	2
Mo	4.2	2.0	1.5	1	0
B	<50	<50	10	0	0
P	600	1,100	1,000	0	0
F	390	320	950	0	0

<u>Note</u>:
Average-crustal abundance of elements based on Bowen (1979), and the Geochemical-Abundance Index (GAI) is based on Förstner *et al.* (1993). Refer Attachment II.

Table 8: Total-Contents of As, Sb, Se, Mo and B in Low-Grade-Ore Samples

GCA-SAMPLE NO.	SITE-SAMPLE NO.	DRILLHOLE & DOWN-HOLE INTERVAL (m)	LITHOTYPE	As (mg/kg)	Sb (mg/kg)	Se (mg/kg)	Mo (mg/kg)	B (mg/kg)
GCA8900	RRWC0005	RRRC0124, 26-30	WALG	29	1.4	0.02	1.3	<50
GCA8901	RRWC0019	RRRC0158, 16-18	WALG	43	3.3	0.45	4.2	<50
GCA8902	RRWC0020	RRRC0353, 74-76	WALG	28	1.2	0.04	1.9	<50
GCA8903	RRWC0025	RRRC0235, 24-26	MMLG	29	1.7	0.20	3.4	<50
GCA8904	RRWC0026	RRRC0230, 34-38	MMLG	15	0.96	0.27	2.0	<50
GCA8905	RRWC0011	RRRC0213, 6-10	MMLG	31	5.2	1.6	4.4	<50
GCA8906	RRWC0012	RRRC0657, 10-14	MMLG	34	3.9	0.35	3.9	<50

Table 9: Water-Extraction-Testwork Results for Low-Grade-Ore Samples

Note: All results in mg/L, except for pH and Electrical-Conductivity (EC).

ELEMENT/ PARAMETER	WALG (GCA8901)	MMLG (GCA8904)	ELEMENT/ PARAMETER	WALG (GCA8901)	MMLG (GCA8904)
Major-Parameters			***Minor-Ions***		
pH	6.3	6.1	Fe	0.02	0.03
EC [µS/cm]	120	86	Cu	<0.01	<0.01
			Ni	<0.01	<0.01
			Zn	0.02	0.02
Major-Ions			Co	0.0001	0.013
			Al	<0.01	0.16
Na	18	8.7	Cd	<0.00002	0.0006
K	4.1	4.3	Pb	0.0018	0.026
Mg	2.2	3.4	Cr	<0.01	<0.01
Ca	2.4	3.4	Hg	0.0003	0.0003
Cl	15	7	As	0.0013	0.0008
SO_4	9.9	0.6	Sb	0.00007	0.0003
			Bi	0.000052	0.00073
			Se	0.0013	<0.0005
			B	0.08	0.06
			Mo	0.0001	<0.00005
			P	<0.1	<0.1
			Si	5.0	4.7
			Ag	<0.00001	0.00002
			Ba	0.018	0.031
			Sr	0.019	0.027
			Tl	<0.00001	0.00012
			V	<0.01	<0.01
			Sn	0.0002	0.0002
			U	0.000009	0.000021
			Th	<0.000005	0.000005
			Mn	<0.01	0.01

Notes: Water-Extraction Testwork employed pulped-samples (nominal 75-µm), and slurries prepared using deionised-water, and a solid:solution ratio of *c.* 1:2 (w/w). Slurries were bottle-rolled for *c.* 1 day, prior to obtaining water-extracts (via vacuum-filtration) for analysis. Values in parentheses represent duplicates.

ATTACHMENT I

STATISTICAL ASSESSMENT OF SULPHUR OCCURRENCES AND DETAILS OF SAMPLING PROGRAMME

Suite 10, 100 Mill Point Rd, South Perth WA 6151
Tel: (08) 9474 3770
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Memo

To: Graeme Campbell

From: Todd Tuffin

cc:

Date: 20-Dec-10 **Ref No:**

Re: King Brown Pit - Preliminary Waste and Low Grade Stockpile Sulphur Geochemistry Study

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Preliminary work has been carried out on determining the likelihood of acid forming material (both waste and low grade) to accumulate on stockpiles during the mining of the King Brown deposit. This first phase of work involved extracting “in-pit” sulphur assays from the database and analyzing the assays with respect to different geological/grade domains of waste and low grade material that are likely to be stockpiled separately during the mining phase. All extracted assays were 2m downhole composite samples taken during RC or core drilling programs.

Files Used to Domain Data

The following 3D solids, DTM’s and Surpac^{TM} string files were used to group the samples into their domains. All files are found on the Perth server in P:\Geology\Exploration\SURPAC\Waste Characterisation Study Jul2010\King Brown and were modeled in December 2009 at the time of the most recent resource calculation for the King Brown deposit.

rrkb_pd_stg3_oma1.dtm – pit design
detore.dtm – 3D solid of detrital Fe ore
bot2.dtm – dtm of the base of transported cover
mn.dtm – dtm of the upper contact of the Mt Newman Member
mnhc.dtm – 3D solid of Mt Newman Member hardcap Fe mineralisation
mnmin.dtm – 3D solid of Mt Newman Member high grade / low impurity primary Fe mineralization
wahc.dtm – 3D solid of Lower West Angela Member hardcap Fe mineralisation
wamin.dtm – 3D solid of Lower West Angela Member hardcap Fe mineralisation

Database

The drilling information was contained in the access database *Ferraus_SURPAC.mdb.* All S assays below detection limit (-0.01) changed to half detection (0.005), -0.005 to 0.0025, -0.001 to 0.0005, -0.0004 to 0.0002.

Domaining

In consultation with Graeme Campbell of Graeme Campbell & Associates Pty Ltd, six different domains (3 x waste and 3 x low grade) were classified as those potentially most likely to form discreet stockpiles during mining. These are as follows:

1. Waste – Transported cover.
2. Waste – Lower West Angela Member.
3. Waste – Mt Newman / McLeod Members (combined).
4. Low Grade Mn – Mn bearing Lower West Angela Member.
5. Low Grade Fe – Lower West Angela Member.
6. Low Grade Fe – Mt Newman / McLeod Member (combined).

Data Coding

The process of assay extraction from the database involved initially coding all drillholes within the database according to their position relative to all of the above modeled dtm's and 3D solid files. A separate table was created in the database called "Intersect" to contain the coded drillhole data, with codes placed in three different fields to represent:

a. Whether drillhole data was inside or outside the pit design dtm.
b. Whether drillhole data was transported, Lower West Angela or Mt Newman / McLeod Member material.
c. Whether drillhole data was within or outside modeled mineralisation 3D solids.

Data Compositing

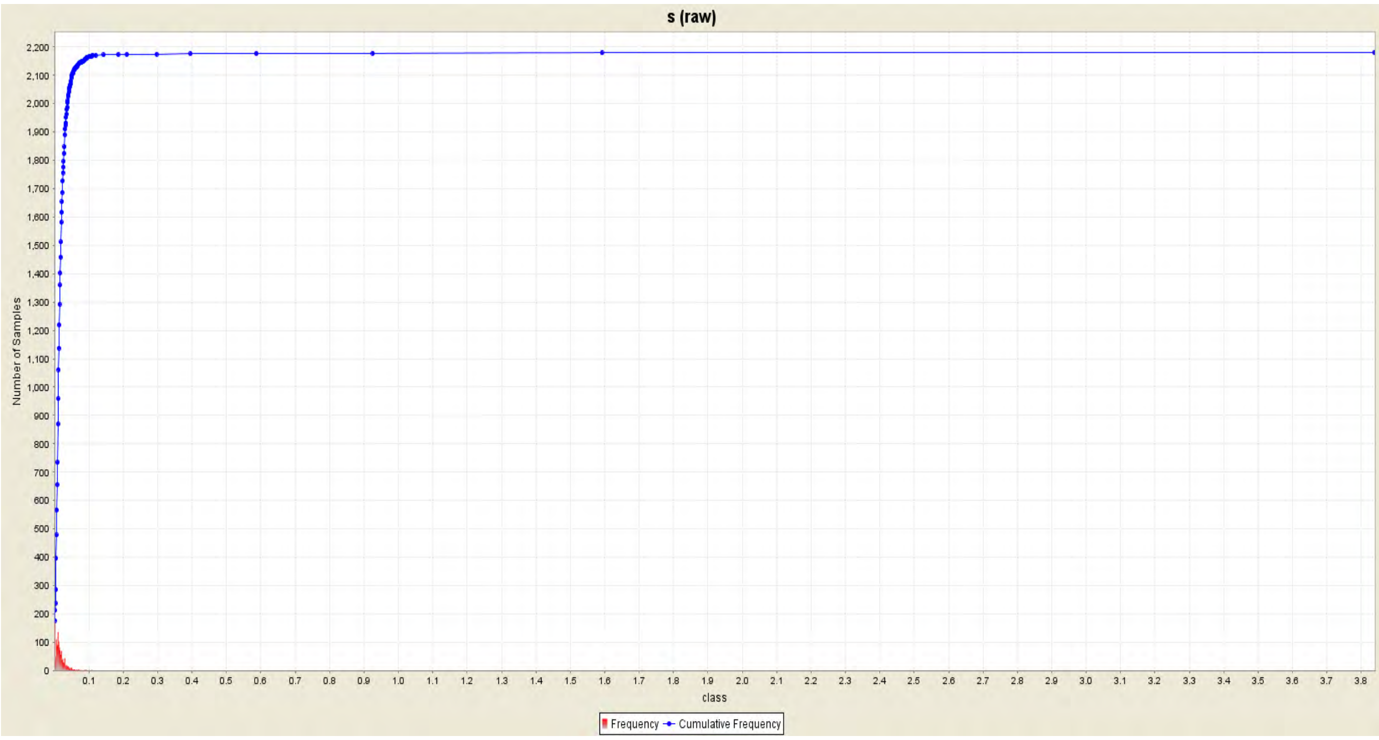
Once the data was coded, all drillhole records composites outside of the pit design and within mineralized solids were deleted from the Intersect table, leaving only in-pit waste and low-grade samples in the table. From this resultant table, data was composited into the six separate domains into the following Surpac^{TM} string files:

1. *kb_waste_trans1.str*; Samples above bot2.dtm and outside of detore.dtm.
2. *kb_waste_lwa1.str;* Samples between bot2.dtm and mn.dtm, outside of wahc.dtm and wamin.dtm mineralisation solids and are <50% Fe and <5% Mn.
3. *kb_waste_mnmc1.*str; Samples below mn.dtm, outside mnhc.dtm and mnmin.dtm mineralisation solids and <50% Fe.
4. *kb_mang_lwa1.str;* Samples between bot2.dtm and mn.dtm, outside of wahc.dtm and wamin.dtm mineralisation solids and are >5% Mn regardless of Fe grade.
5. *kb_lowgrade_lwa1.str;* Samples between bot2.dtm and mn.dtm, outside of wahc.dtm and wamin.dtm mineralisation solids and are >50% Fe and <5% Mn.
6. *kb_lowgrade_mnmc1.str;* Samples below mn.dtm, outside mnhc.dtm and mnmin.dtm mineralisation solids and >50% Fe.

Statistical Summary

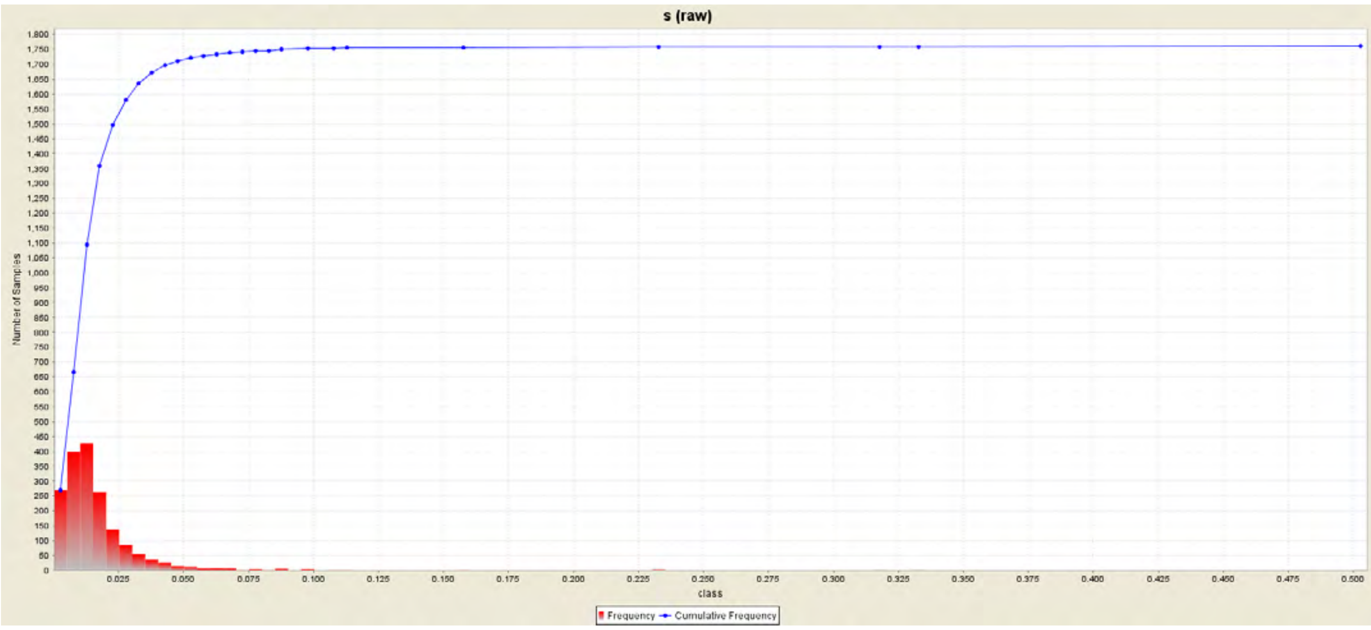
Transported cover - waste material (Fe<50%)

kb_waste_trans1.str	
Sulphur %	**Sample Count**
<0.0202	1581
0.0202-0.1002	584
0.1002-0.50	11
>0.50	4
Total	**2180**
Basic Stats	
Number of samples	2180
Minimum value	0.0002
Maximum value	3.8387
Mean	0.020493
Median	0.013
Geometric Mean	0.010766
Variance	0.008725
Standard Deviation	0.093407
Coefficient of variation	4.5579



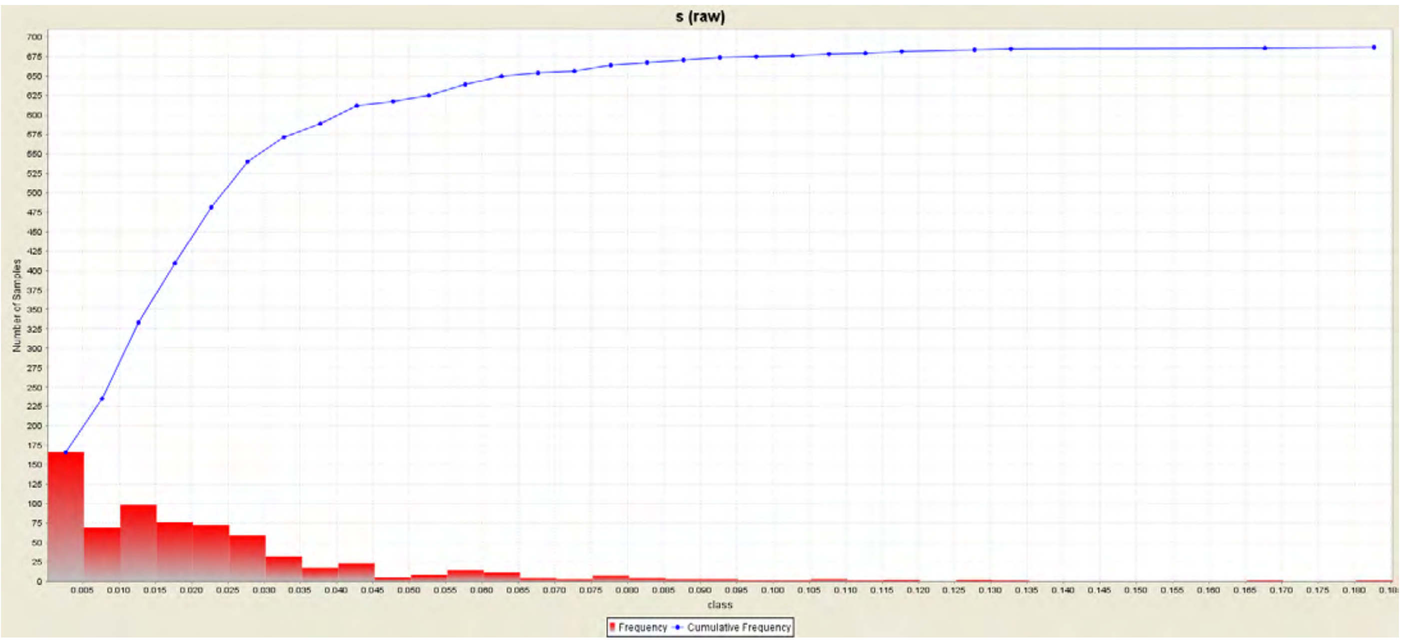
Lower West Angela Member – waste material (Fe <50%, Mn <5%)

kb_waste_lwa1.str	
Sulphur %	**Sample Count**
<0.0202	1358
0.0202-0.1002	395
0.1002-0.50	7
>0.50	1
Total	**1761**
Basic Stats	
Number of samples	1761
Minimum value	0.0002
Maximum value	0.5014
Mean	0.016584
Median	0.013
Geometric Mean	0.010925
Variance	0.000481
Standard Deviation	0.02193
Coefficient of variation	1.322343



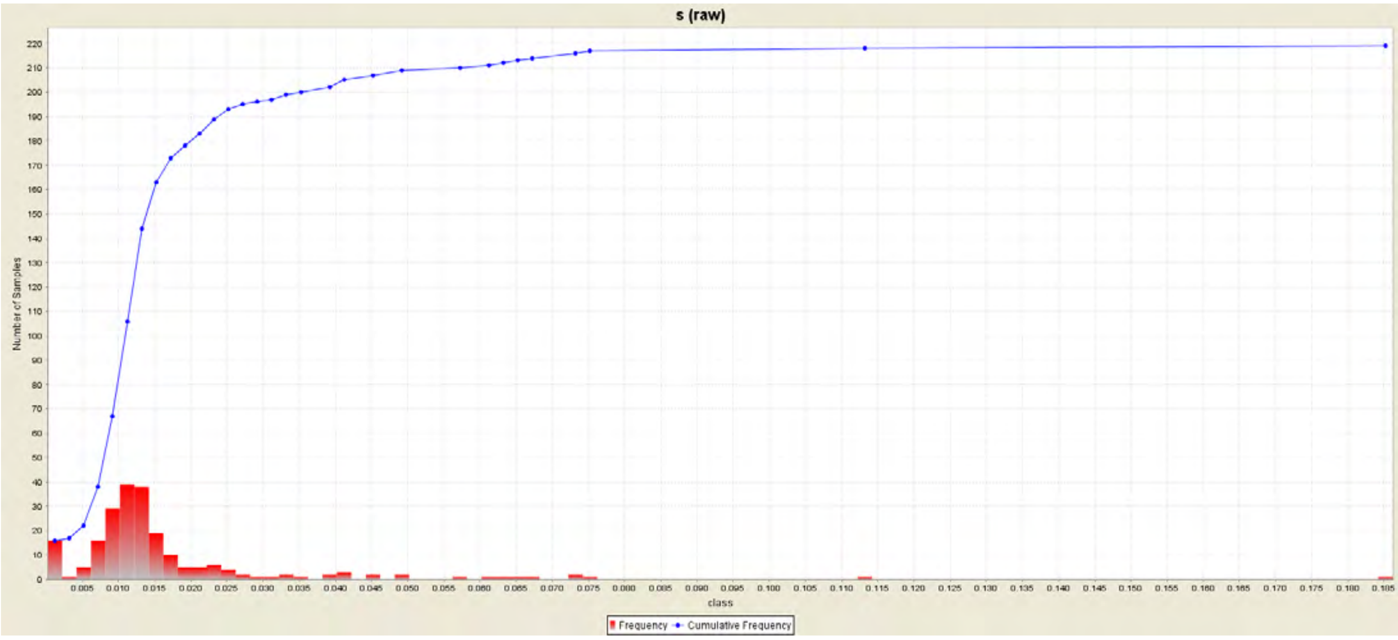
Mt Newman / Mc Leod Members – waste material (Fe <50%)

kb_waste_mnmc1.str	
Sulphur %	**Sample Count**
<0.0202	409
0.0202-0.1002	266
0.1002-0.50	12
>0.50	0
Total	**687**
Basic Stats	
Number of samples	687
Minimum value	0.0002
Maximum value	0.181
Mean	0.021741
Median	0.0156
Geometric Mean	0.009746
Variance	0.000556
Standard Deviation	0.023574
Coefficient of variation	1.084305



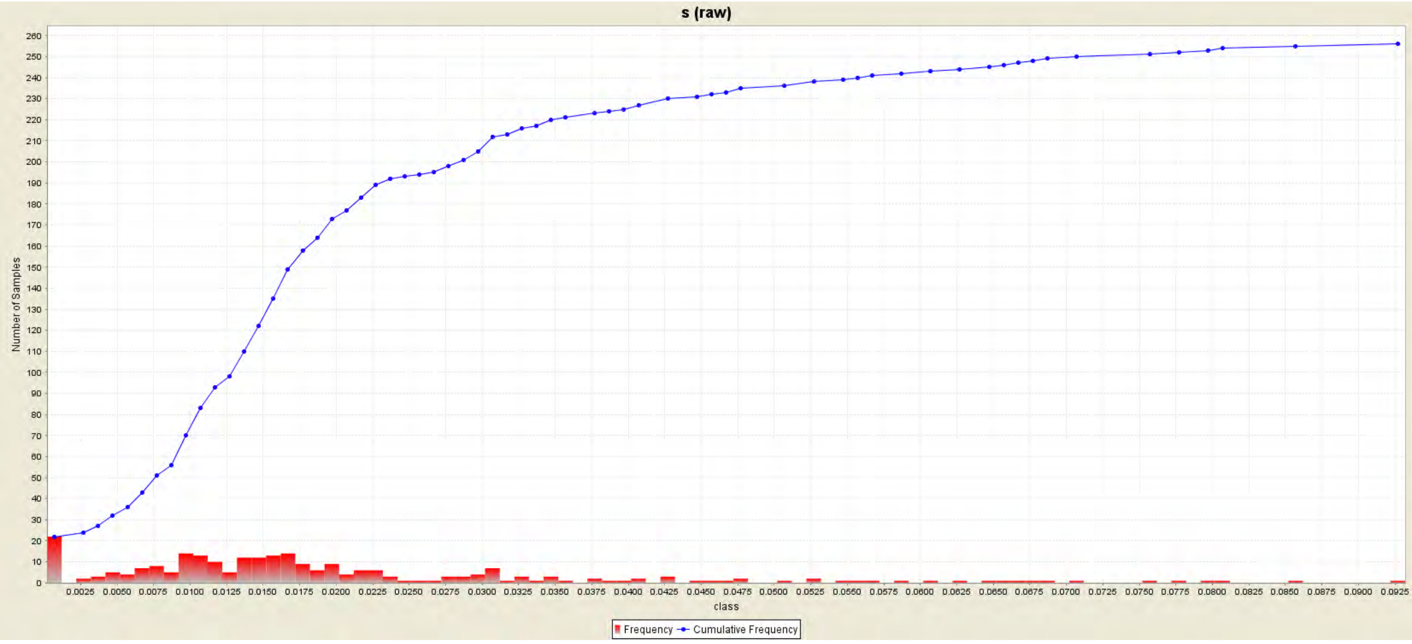
Lower West Angela Member – Manganese bearing material (Mn >5% irrespective of Fe)

kb_mang_lwa1.str	
Sulphur %	**Sample Count**
<0.0202	178
0.0202-0.1002	39
0.1002-0.50	2
>0.50	0
Total	**219**
Basic Stats	
Number of samples	219
Minimum value	0.0002
Maximum value	0.1861
Mean	0.017167
Median	0.0126
Geometric Mean	0.011393
Variance	0.000352
Standard Deviation	0.018774
Coefficient of variation	1.093625



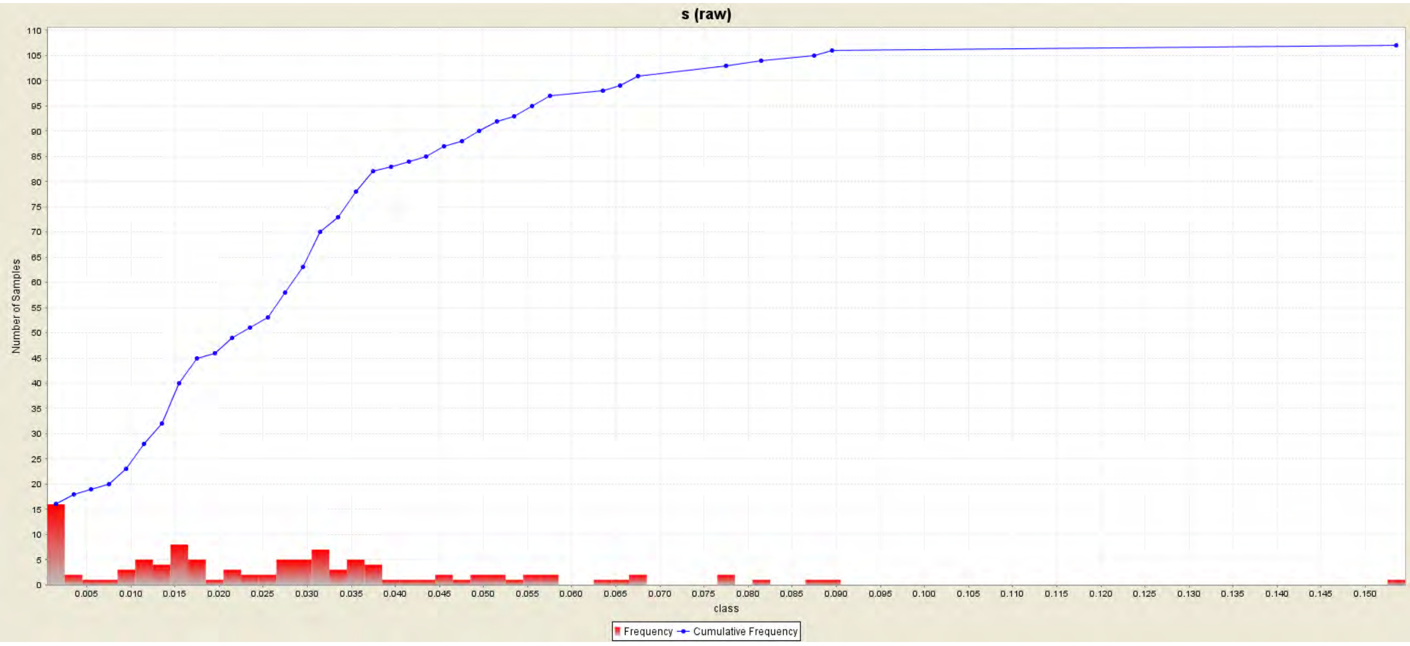
Lower West Angela Member – low grade material (Fe; 50-55%, Mn <5%)

kb_lowgrade_lwa1.str	
Sulphur %	**Sample Count**
<0.0202	173
0.0202-0.1002	83
0.1002-0.50	0
>0.50	0
Total	**256**
Basic Stats	
Number of samples	256
Minimum value	0.0002
Maximum value	0.0926
Mean	0.0205
Median	0.0159
Geometric Mean	0.012956
Variance	0.000308
Standard Deviation	0.017549
Coefficient of variation	0.856084



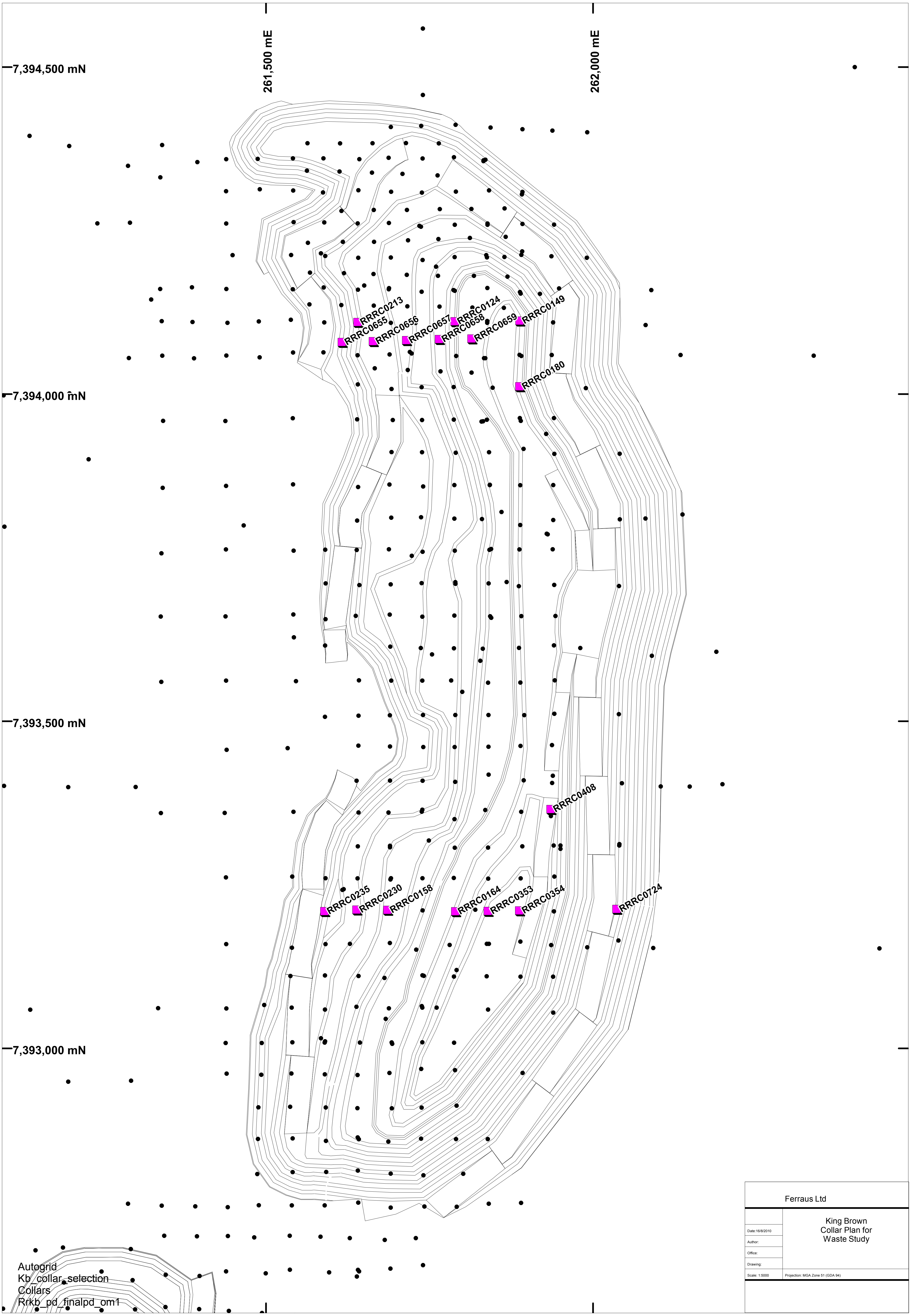
Mt Newman / Mc Leod Members – low grade material (Fe; 50-55%)

kb_lowgrade_mnmc1.str	
Sulphur %	**Sample Count**
<0.0205	46
0.0205-0.1002	60
0.1002-0.50	1
>0.50	0
Total	**107**
Basic Stats	
Number of samples	107
Minimum value	0.0005
Maximum value	0.1535
Mean	0.028815
Median	0.028
Geometric Mean	0.015111
Variance	0.000599
Standard Deviation	0.024468
Coefficient of variation	0.849132



Summary

A total of 5210 in-pit samples made up the six different domains used in this preliminary study with the vast majority coming (as expected) from the Transported waste and Lower West Angela waste domains. Of these, 38 samples (0.73% of the total) were of material greater than 0.10% sulphur, with a peak of 3.84%.



Ferraus Ltd

King Brown
Collar Plan for
Waste Study

Date:16/8/2010
Author:
Office:
Drawing:
Scale: 1:5000
Projection: MGA Zone 51 (GDA 94)

Hole ID	From(m)	To(m)	Sample Numbers	Code	Sample No
RRRC0658	4	8	RR59870, RR59871	TW	RRWC0001
RRRC0149	10	12	DC0607	TW	RRWC0002
RRRC0180	32	36	DC4457, DC4458	TW	RRWC0013
RRRC0408	36	40	RR10571, RR10572	TW	RRWC0014
RRRC0724	34	38	RR43567, RR43568	TW	RRWC0015
RRRC0354	34	38	RR9900, RR9901	TW	RRWC0016
RRRC0659	14	18	RR59897, RR59898	WAW	RRWC0003
RRRC0354	78	82	RR9923, RR9924	WAW	RRWC0017
RRRC0164	46	50	DC1235, DC1236	WAW	RRWC0018
RRRC0149	90	94	DC0649, DC0650	WAMN	RRWC0008
RRRD0401	92	96	RR10022, RR10023	WAMN	RRWC0021
RRRC0354	112	116	RR9941, RR9942	WAMN	RRWC0022
RRRC0655	0	4	RR59812, RR59813	MMW	RRWC0009
RRRC0656	0	4	RR59829, RR59830	MMW	RRWC0010
RRRC0230	4	8	DC3156, DC3157	MMW	RRWC0023
RRRC0235	18	22	DC3381, DC3382	MMW	RRWC0024
RRRC0124	26	30	RRRC124/028, RRRC124/030	WALG	RRWC0005
RRRC0158	16	18	DC0942	WALG	RRWC0019
RRRC0353	74	76	RR9832	WALG	RRWC0020
RRRC0235	24	26	DC3384	MMLG	RRWC0025
RRRC0230	34	38	DC3171, DC3172	MMLG	RRWC0026
RRRC0213	6	10	DC2459, DC2460	MMLG	RRWC0011
RRRC0657	10	14	RR59851, RR59852	MMLG	RRWC0012

Stratigraphy	Stockpile	Criteria	Code
Transported	Waste	<50% Fe	TW
Lower West Angela	Waste	<50% Fe, <5% Mn	WAW
Lower West Angela	Manganese bearing	>5% Mn	WAMN
Mt Newman/McLeod	Waste	<50% Fe	MMW
Lower West Angela	Low Grade	50-55% Fe, <5% Mn	WALG
Mt Newman/McLeod	Low Grade	50-55% Fe	MMLG

ATTACHMENT II

TESTWORK METHODS

ATTACHMENT II

TESTWORK METHODS

The testwork methods outlined below are proven approaches to 'static-testing' within the Australian, and international mining-industries (e.g. Price 2009; Stewart *et al.* 2006; AMIRA 2002; Morin and Hutt 1997).[1] The MEND-document prepared by Price (2009), and *c.* 10-20 years in the making by an experienced practitioner, is an invaluable source of information on testing methods on mine-waste geochemistry. There is also the Global-Acid-Rock-Drainage-Guide (GARD Guide) which is an INAP initiative (go to: www.gardguide.com). However, in terms of comprehensiveness, structure, and clarity, the document by Price (2009) is recommended.

Part of the acid-base-account (ABA) testing, and all of the multi-element analyses, and clay-surface-chemical determinations, are carried out by Genalysis Laboratory Services Pty Ltd [GLS] (Maddington). Specialised ABA-testing is undertaken by GCA (Bridgetown), and characterisation of rock- and clay-mineralogy is carried out by Roger Townend & Associates (Malaga), and CSIRO (Bentley), respectively.

Samples are crushed to 2mm (nominal) in a jaw/rolls-crusher, and pulverised to 75µm (nominal), for specific tests, as required. These sample-splits are referred to herein as "crushings" and "pulps", respectively.

It should be noted that the testwork methods described below are routinely employed in work programmes undertaken by GCA. However, the testwork methods described are generic, and specific tests may not necessarily be undertaken in a given study.

1.0 ACID-BASE-CHEMISTRY AND SALINITY TESTWORK

Acid-base chemistry and salinity are assessed by determining:

- pH and Electrical-Conductivity (EC) on sample slurries;
- Total-Sulphur (Total-S), and Sulphate-Sulphur (SO_4-S);
- Acid-Neutralisation-Capacity (ANC), and CO_3-C;
- pH-buffering properties;
- Net-Acid-Producing-Potential (NAPP); and,
- Net-Acid-Generation (NAG).

Relevant details of the testwork methods employed are discussed below. Further details are presented in the laboratory reports.

[1] 'Static'-testing' corresponds to "whole-rock" analyses and tests.

1.1 pH-(1:2) and EC-(1:2) Tests

Measurements of pH and EC are performed on slurries prepared using deionised-water, and a solid:water ratio of *c.* 1:2 (w/w). The slurries are allowed to age for *c.* 24 hours, prior to measuring pH and EC.[2] These tests are performed on the crushings.

pH-(1:2) and EC-(1:2) values provide a measure of the inherent acidity/alkalinity and salinity.[3]

1.2 Total-S and SO_4-S

Total-S is determined by Leco combustion (@ 1300 ^{o}C) with detection of evolved $SO_{2(g)}$ by infra-red spectroscopy. SO_4-S is determined by the Na_2CO_3-Extraction Method (Berigari and Al-Any 1994; Lenahan and Murray-Smith 1986).[4] The difference between Total-S and SO_4-S indicates the Sulphide-S (strictly Non-Sulphate-S) value. The Total-S and SO_4-S tests are performed on pulps.

1.3 Acid-Consuming Properties

1.3.1 ANC

ANC is determined by a procedure based on that of Sobek *et al.* (1978) which is the "standard" ANC-testing method (AMIRA 2002; Morin and Hutt 1997).

Samples (as crushings) are reacted with dilute HCl for *c.* 2 hours at 80-90 ^{o}C, followed by back-titration with NaOH to a pH=7 end-point to determine the amount of acid consumed.[5] The simmering step for *c.* 2 hours differs from the Sobek *et al.* procedure wherein test-mixtures are heated to near boiling until reaction is deemed to be complete, followed by boiling for one minute. In terms of the dissolution of carbonate- and primary-silicate-minerals, this variation to the Sobek *et al.* method is inconsequential.

The Sobek *et al.* (1978) procedure subjects samples to both strongly-acidic conditions (e.g. pH of 1-2), and a near-boiling temperature. Provided excess acid is added, the dissolution of carbonate-minerals is near-quantitative, and traces of primary-silicates

[2] The slurries are stirred at the beginning of the testwork, and once again immediately prior to measuring pH and EC.

[3] The pH-(1:2) values approximate the "Abrasion-pH" values for identifying minerals in the field (e.g. Stevens and Carron 1948).

[4] The Na_2CO_3-reagent extracts SO_4 which occurs as soluble sulphates, and calcium sulphates (e.g. gypsum and anhydrite). It also extracts SO_4 sorbed to the surfaces of sesquioxides, clays and primary-silicates. However, SO_4 present as barytes ($BaSO_4$) is not extracted, and SO_4 associated with jarositic-type and alunitic-type compounds is incompletely extracted.

[5] A few drops of 30 % (w/w) H_2O_2 are added to the test mixtures as the pH=7 end-point is approached, so that Fe(II) forms released by the acid-attack of ferroan-carbonates (and -silicates) are oxidised to Fe(III) forms (which then hydrolyse to "$Fe(OH)_3$"). This step ensures that the resulting ANC values are not unduly biased "on-the-high-side", due to the release of Fe(II) during the acid-digestion step (AMIRA 2002), provided that the ferroan-carbonate content is not excessive (e.g. siderite-C values less than 1.5 % [Stewart *et al.* 2006]).

also dissolve. However, at circum-neutral-pH (viz. pH 6-8) relevant to mine-waste and environmental management, the dissolution of primary-silicates is kinetically limiting (e.g. see review-monograph by White and Brantley [1995]).

In the absence of inhibiting alteration-rims, dissolution rates of mafic/felsic-silicates generally equate to H_2SO_4-consumption rates 'of-the-order' 10^{-11}-10^{-12} moles/m^2/s. Accordingly, for particle-sizes within the sub-mm range, circum-neutral-dissolution rates of primary-silicates correspond to Sulphide-Oxidation Rates (SORs) 'of-the-order' 1-10 mg SO_4/kg/week (= *c.* 0.1-1.0 kg H_2SO_4/tonne/year).[6] In practice, circum-neutral buffering through the surface-hydrolysis/dissolution of primary-silicates is therefore restricted to both particle-gradings akin to "rock-flour" (viz. sub-mm), and slow rates of sulphide-oxidation (e.g. as exhibited by "trace-sulphides" which are not atypically reactive).[7]

Despite aggressive-digestion conditions, the ANC values determined by the Sobek *et al.* (1978) method allow an informed "screening" of acid-consuming properties, especially when due regard is given to groundmass-mineralogy (Morin and Hutt 1997). Jambor *et al.* (2005, 2002, 2000) list 'Sobek-ANC' values for different types of primary-silicates which assists interpretation of ANC-testwork results.

That the ANC value is not an intrinsic property of a sample of geologic media, but rather the outcome of the particular ANC-testwork method employed, is shown by Morin and Hutt (2009).

1.3.2 CO_3-C

CO_3-C is the difference between the Total-C and Total-Organic-C (TOC). Total-C is measured by Leco combustion (@ 1300 ^oC) with detection of evolved $CO_{2(g)}$ by infra-red spectroscopy. TOC is determined by Leco combustion on a sub-sample which had been treated with strong HCl to decompose carbonate-minerals. Pulps are used for these determinations.

1.3.3 pH-Buffering Properties

pH-Buffering properties are determined via a Metrohm® 736 Titrino auto-titrator, and 0.05 M-H_2SO_4. Auto-titrations comprise regular addition of H_2SO_4 to decrease the pH values of the test-suspensions (prepared using pulps) to 3.0 typically over the course of

6 SORs of this magnitude (at circum-neutral-pH) would typically only be recorded for the oxidation of "trace-sulphides" (e.g. Sulphide-S contents less than *c.* 0.5 %) which are not hyper-reactive, and so excludes *inter alia* framboidal-pyrite, and marcasite.

7 Primary-particle-sizes within the "rock-flour" range is a given for process-tailings-solids. In the case of mine-wastes, despite its usually small weight-based abundance, this size-fraction is invariably the main seat of geochemical-weathering reactions within waste-dumps, and thereby the main "source-term" for solute generation (e.g. Price and Kwong 1997). Such "rock-flour" occurs in two forms: that obtained via dry-sieving, and that associated with the surfaces of clasts of wide-ranging sizes, and which can only be obtained via wet-sieving.

c. 1 day.[8] Despite taking up to 1 day to complete, the H_2SO_4-addition rates employed in the auto-titrations are 'orders-of-magnitude' faster than the sulphide-oxidation rates typically observed under "ambient-weathering" conditions.

1.4 NAPP Calculations

NAPP values are calculated from Total-S, SO_4-S and ANC values, assuming that **all** of the Sulphide-S occurs in the form of pyrite, and/or pyrrhotite. NAPP values facilitate assessment of Acid-Formation Potential (AFP).

The complete-oxidation of pyrite (and/or marcasite) may be described by:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O = 2H_2SO_4 + \text{"}Fe(OH)_3\text{"}$$

The complete-oxidation of pyrrhotite may be described by:

$$\text{"}FeS\text{"} + 9/2O_2 + 5/2H_2O = H_2SO_4 + \text{"}Fe(OH)_3\text{"}$$

Since pyrrhotite is non-stoichiometric, expressing it as "FeS" is approximate (Janzen *et al.* 2000). Elemental-S may also be produced during pyrrhotite weathering (Nicholson and Scharer 1994), especially at low-pH. However, Elemental-S is ultimately oxidised to H_2SO_4.

It may be shown that, if the Sulphide-S (in %S) occurs as pyrite/pyrrhotite, then the amount of acid (in kg H_2SO_4/tonne) produced through complete-oxidation is given by **30.6 x %S**. That is, the same conversion-factor of 30.6 applies for both pyrite-, and pyrrhotite-oxidation.

> Note: The above treatment of oxidation-reaction stoichiometry is restricted to oxidation by 'atmospheric-O_2' which is the dominant oxidant at circum-neutral-pH. A different oxidation-stoichiometry applies under acidic conditions (e.g. pH less than 3-4) where soluble-Fe(III) forms prevail, and then function as the chief oxidant (e.g. Rimstidt and Newcomb 1993).

Mechanistic aspects of pyrite- and pyrrhotite-oxidation were reviewed by Rimstidt and Vaughan (2003), and Belzile *et al.* (2004), respectively.

1.5 NAG Tests

The NAG Test is a direct measure of the potential for acid-production through sulphide-oxidation, and also provides an indication of the reactivity of the sulphide-minerals, and the availability of alkalinity-forms (AMIRA 2002; Miller *et al.* 1997, 1994). Since this test is performed on pulps, sulphide-grains are fully liberated, and available for reaction.

[8] In titrating to a pH=3.0 end-point, any Fe(II) released through acid attack of ferroan-carbonates and -silicates is not quantitatively oxidised to Fe(III), and subsequently hydrolysed/precipitated to "$Fe(OH)_3$". The equivalent of *c.* 0.5 kg H_2SO_4/tonne is generally required to decrease the pH of the "solution-only" to pH=3.0. No correction is made for this "electrolyte-consumption" of H_2SO_4.

The sample is reacted with H_2O_2 to oxidise sulphide-minerals, and allow the produced acid to react with the acid-neutralising components (chiefly carbonate-minerals). The results from NAG testwork supplement the NAPP-based assessment of AFP (Stewart *et al.* 2006; Shaw 2005; Morin and Hutt 1997).

The NAG-testing methodology used by GCA is the 'Static-NAG Test' in its "single-addition" mode, with NaOH-titration to a pH=7 end-point (AMIRA 2002; Miller *et al.* 1994, 1997). The Start-pH of the 15 % (v/v) H_2O_2 solution (prepared from A.R.-grade H_2O_2) is adjusted to pH=4.5 using 0.1 M-NaOH. The boiling treatment to decompose residual, unreacted-H_2O_2 following overnight reaction is carried out in two stages (viz. boiling for *c.* 2 hours initially, cooling and addition of 1 mL of 0.02 M-$CuSO_4$, followed by boiling for a further *c.* 2 hours). The addition of Cu(II) catalyses the decomposition of unreacted-H_2O_2, and thereby prevents "positive-blank" values (O'Shay *et al.* 1990).[9]

Prior to the boiling steps, the pH values of the test-suspensions are measured. Such pH values reflect buffering under ambient conditions without accelerated dissolution of groundmass-minerals through boiling. In the interpretation of NAG-testwork results, it is important to note the pH values prior to the boiling steps, especially for lithotypes characterised by "trace-sulphides" (e.g. Sulphide-S within the sub-% range), and ANC values less than *c.* 10-20 kg H_2SO_4/tonne (e.g. a groundmass devoid of carbonate-minerals). The rates of "peroxide-oxidation" are orders-of-magnitude faster than those of "ambient-oxidation" (viz. SORs recorded in kinetic-testing employing Weathering-Columns). If circum-neutral-pH is to prevail during NAG testwork, then the rate of acid-consumption must be proportionately faster than that for "ambient-oxidation", and is essentially restricted to buffering by reactive-carbonate-minerals (e.g. calcites, dolomites, and ankerites). This aspect must be borne in mind when interpreting NAG-testwork results, especially for samples that contain "trace-sulphides" in a carbonate-deficient groundmass.

2.0 MULTI-ELEMENT ANALYSES

The total content of a wide range of major- and minor-elements are determined through the use of various digestion and analytical techniques. The respective detection-limits are appropriate for environmental investigations.

Element enrichments are identified using the *Geochemical Abundance Index (GAI)*.[10] The GAI quantifies an assay result for a particular element in terms of the average-

[9] Where samples contain sufficient Cu(II), then Cu(II) forms will be released to solution during reaction with H_2O_2, especially at low-pH.

[10] The GAI was developed by Förstner *et al* (1993), and is defined as:

$$GAI = \log_2 [C_n/(1.5 \times B_n)]$$

where:

C_n = measured content of n-th element in the sample.

B_n = "background" content of the n-th element in the sample.

crustal-abundance of that element.[11] The latter corresponds to the typical composition of soils, regoliths and bedrocks derived from unmineralised terrain.

The GAI (based on a log-2 scale) is expressed in 7 integer increments (viz. 0 to 6). A GAI of 0 indicates that the content of the element is less than, or similar to, the average-crustal-abundance; a GAI of 3 corresponds to a 12-fold enrichment above the average-crustal-abundance; and so forth, up to a GAI of 6 which corresponds to a 96-fold, or greater, enrichment above average-crustal-abundances.

3.0 MINERALOGY AND CLAY-SURFACE CHEMISTRY

The semi-quantitative mineralogy, and clay-surface chemistry (generally restricted to waste-regoliths, oxide-ores, and/or soils), are determined using methods routinely used in geology, and soil science.

Indicative abundances of mineral fall into one of the following broad classes, viz.

- dominant — greater than 50 %
- major — 20-50 %
- minor — 10-20 %
- accessory — 2-10 %
- trace — less than 2 %

Randomly- and preferentially-oriented specimens are prepared, and variously treated with sodium-hexametaphosphate (dispersant), ethylene-glycol, and heating, to quantify non-expansive, and expansive (e.g. smectites), varieties of clay-minerals.

The Effective-Cation-Exchange Capacity (eCEC), and suite of Exchangeable-Cations, are determined by different methods for samples (as crushings) of non-calcareous and calcareous materials (Rengasamy and Churchman 1999). In both cases, soluble-salts are initially removed via pre-washing using a "mixed-organic-solvent" (viz. ethylene-glycol and ethanol). Method 15A2 in Rayment and Higginson (1992) is then employed for non-calcareous samples to determine eCEC, and Exchangeable-Sodium Percentage (ESP). In the case of calcareous samples, a method based on that described by Pierce and Morris (2004) is used, and prevents the dissolution of carbonate-minerals (e.g. calcites and dolomites).[12] After the initial pre-washing step above, extraction is carried out with 1 M-NH_4Cl buffered at pH=8.5 in an ethanolic-aqueous solution. Without such precautions to suppress dissolution of carbonate-minerals, the eCEC is biased "on-the-high-side", and ESP biased "on-the-low-side". Depending on the abundance and nature of the carbonate-minerals, the magnitude of this bias can be marked.

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[11] The average-crustal-abundances of the elements for the GAI calculations are based on the values listed in Bowen (1979).

[12] The procedure described by Pierce and Morris (2004) is closely related to that originally developed by Tucker (1974).

4.0 WATER-EXTRACTION TESTWORK

The contents of water-extractable solutes in selected samples were determined via bottle-roll testwork employing the crushings, and deionised-water. The test-slurries had a solid:solution ratio of *c.* 1:2 (w/w), and were bottle-rolled for *c.* 1 day before being left to "still-stand" for *c.* 1 day to allow suspended mineral-fines to settle. The resulting supernatants were then decanted, vacuum-filtered (0.45µm-membrane), and preserved, as appropriate, for specific analyses. Where required, centrifuging at *c.* 4,000 G for 30 minutes was undertaken to expedite solid-solution separation for vacuum-filtration. The Water-Extraction Testwork was performed in the GCA-Testing Laboratory.

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ATTACHMENT III

ACID-FORMATION POTENTIAL (AFP):

CALCULATED PARAMETERS AND CLASSIFICATION CRITERIA

ATTACHMENT III

ACID-FORMATION POTENTIAL (AFP):

CALCULATED PARAMETERS AND CLASSIFICATION CRITERIA

Notes: The geochemically-based parameters, and AFP-classification criteria, indicated below apply equally to samples of mine-wastes (e.g. waste-regoliths and waste-bedrocks), low-grade-ores, and process-tailings-solids. The generic descriptor "test-sample" is employed below.

1.0 CALCULATED PARAMETERS

Maximum-Potential-Acidity (MPA) values (in kg H_2SO_4/tonne) of test-samples are typically calculated by multiplying the Sulphide-S values (in %) by 30.6. The multiplication-factor of 30.6 reflects both the reaction stoichiometry for the complete-oxidation of pyrite, by O_2 to "$Fe(OH)_3$" and H_2SO_4, and the different weight-based units of %, and kg H_2SO_4/tonne.

Net-Acid-Producing-Potential (NAPP) values (in kg H_2SO_4/tonne) are calculated from the corresponding MPA and Acid-Neutralisation-Capacity (ANC) values (i.e. NAPP = MPA - ANC).

2.0 CLASSIFICATION CRITERIA

In terms of AFP, test-samples may be classified into one of the following categories, viz.

- Non-Acid Forming (NAF)
- Potentially-Acid Forming (PAF)

There are **no** unifying, "standard" criteria for classifying the AFP of test-samples (e.g. Price 2009; AMIRA 2002), and reflects the diversity of sulphide- and gangue-mineral assemblages within (un)mineralised-lithotypes of varying weathering- and alteration-status. Rather, criteria for classifying AFP may need to be tailored to deposit-specific geochemistry, mineralogy, and site-specific climate.

The AFP-classification criteria often employed at mining-operations worldwide are:

- **NAF**: Sulphide-S < 0.3 %. For Sulphide-S ≥ 0.3 %, both a negative NAPP value, and an ANC/MPA ratio ≥ 2.0
- **PAF**: For Sulphide-S ≥ 0.3 %, any positive-NAPP value; negative-NAPP value with an ANC/MPA ratio < 2.0

In assessing AFP, lithotypes from hard-rock mines with Sulphide-S values less than 0.3 % are unlikely to acidify (e.g. pH less than 4-5) through sulphide-oxidation. This position holds especially where the groundmass hosting the "trace-sulphides" is not simply quartz, soil-clays, and/or sesquioxides (Price *et al.* 1997), and where the sulphide-minerals are not hyper-reactive varieties (e.g. framboidal-pyrite). A "cut-off" of 0.3 % for Sulphide-S also accords with the findings of kinetic-testing, since the late-1980s, by Dr. Graeme Campbell for test-samples of diverse mineralogy in terms of sulphide-weathering dynamics, and solubility behaviour.

The risk posed by PAF-lithotypes during the active-mine-life is governed primarily by the duration of the lag-phase (i.e. the period during which sulphide-oxidation occurs, but acidification does not develop, due to circum-neutral buffering by gangue-phases [chiefly reactive-carbonate-minerals]).[1] Although the duration of the lag-phase for mine-wastes at field-scale cannot be accurately predicted *a priori*, estimates may still be needed to identify threshold exposure-times for the safe handling of PAF-lithotypes. Lag-phase duration may be estimated via kinetic-testing (viz. Weathering-Columns), and consideration of the moisture/aeration/thermal-regimes of exposed (i.e. uncovered) mine-wastes under the site's climatic conditions. In the absence of results from kinetic-testing, experience permits "first-pass" estimates of sulphide-oxidation rates and lag-phase duration to be made from the results of static-testing, and thereby classify PAF-lithotypes into **PAF-[Short-Lag]** and **PAF-[Long-Lag]** sub-categories. Such "first-pass" estimations are necessarily provisional, and subject to revision, in the light of the outcomes of kinetic-testing, and field observations.

3.0 REFERENCES

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[1] SO_4 is still produced by sulphide-oxidation during the lag-phase, and appreciable amounts of soluble-forms of certain minor-elements (e.g. Ni and As) may be released at circum-neutral-pH during lag-phase weathering. However, in the latter case, the mine-wastes would need to be sufficiently enriched in Total-Ni and Total-As to begin with.

ATTACHMENT IV

LABORATORY REPORTS

Dr G Campbell
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	143/1011293
No. of SAMPLES	13
CLIENT O/N	GCA1018/1
PROJECT	King Brown
STATE	Mine waste
DATE RECEIVED	23/08/2010
DATE COMPLETED	30/09/2010

The samples were originally received as mine waste as pulps

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
( ) = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
> = Value beyond Limit of Method

Results of analysis on:

Element		S	S-SO4	C	TOC+C	C-CO3
Method		Ind/IR	Na2CO3/GRAV	Ind/IR	HotAcidInd/IR	/CALC
Detection		0.01	0.01	0.01	0.01	0.01
Units		%	%	%	%	%
Sample Name						
Control Blank		X		X		
GCA8884		0.05		0.08		
GCA8884	check	0.05		0.08		
GCA8885		0.05		0.1		
GCA8886		0.01		0.05		
GCA8887		0.01		0.35	0.31	0.04
GCA8888		0.02		0.06		
GCA8889		0.01		0.17		
GCA8890		0.04		0.13		
GCA8891		0.02		0.73	0.66	0.07
GCA8892		0.01		0.06		
GCA8893		0.02		0.04		
GCA8894		0.02		0.64	0.55	0.09
GCA8895		0.02		0.79	0.62	0.17
GCA8896		0.05		0.15		
GCA8897		0.04		0.08		
GCA8898		0.05		0.11		
GCA8899		0.03		0.07		
GCA8900		0.01		0.03		
GCA8901		0.09		0.19		
GCA8902		X		0.04		
GCA8903		0.03		0.08		
GCA8904		0.01		0.09		
GCA8904	check	0.01		0.08		
GCA8905		0.1	0.02	0.12		
GCA8906		0.05		0.14		
SO-3		0.02		6.47		
CD-1		3.37		0.23		
S_SO4_A			0.55			
S_SO4_B			1.26			
PD-1			1.06			

Notes:
1. The C, S results were determined from the pulverised portion
2. The Carbon and Sulphur was determined according to Genalysis method number MPL_W043
3. S-SO4 was determined by precipitation of BaSO4 according to Genalysis method number ENV_W039
4. TOC+C (acid insoluble carbon compounds and elemental carbon) by a C&S analyser after removal of carbonates and soluble organic carbon according to Genalysis method number MPL_W046. This method is not covered by the NATA scope of accreditation

Results of analysis on:

sample		Fizz	volume	HCl	NaOH	Colour	ANC	pH	ANC
name		Rate	HCl	M	M	Change	soln pH	Drop	(kgH2SO4/t)
GCA8884		0	8	0.50	0.20	N	1.3		2
GCA8884	check	0	8	0.50	0.20	N	1.5		1
GCA8885		0	8	0.50	0.20	N	1.3		3
GCA8886		0	8	0.50	0.20	N	1.5		4
GCA8887		0	8	0.50	0.20	N	1.2		1
GCA8888		0	8	0.50	0.20	N	1.3		4
GCA8889		0	8	0.50	0.20	N	1.3		2
GCA8890		0	8	0.50	0.20	N	1.4		27
GCA8891		0	8	0.50	0.20	N	1.6		33
GCA8892		0	8	0.50	0.20	N	1.4		3
GCA8893		0	8	0.50	0.20	N	1.3		5
GCA8894		0	8	0.50	0.20	N	1.3		9
GCA8895		0	8	0.50	0.20	N	1.7		10
GCA8896		0	8	0.50	0.20	N	1.6		1
GCA8897		0	8	0.50	0.20	N	1.6		2
GCA8898		0	8	0.50	0.20	N	1.5		2
GCA8899		0	8	0.50	0.20	N	1.7		1
GCA8900		0	8	0.50	0.20	N	1.5		2
GCA8901		0	8	0.50	0.20	N	1.6		2
GCA8902		0	8	0.50	0.20	N	1.6		4
GCA8903		0	8	0.50	0.20	N	1.6		1
GCA8904		0	8	0.50	0.20	N	1.7		1
GCA8904	check	0	8	0.50	0.20	N	1.5		1
GCA8905		0	8	0.50	0.20	N	1.5		2
GCA8906		0	8	0.50	0.20	N	1.5		1

Notes:

1. ANC was determined on 2g of pulp. Acid concentrations are as stated.
2. Colour change: Y indicates the appearance of a green colouration as the pH=7 endpoint was approached. N no change. Two drops of hydrogen peroxide are added to each sample as the endpoint is approached to oxidise any ferrous iron
3. pH drop : Result reported when the pH drops to a value below 4 on addition of peroxide
4. This procedure according to Genalysis method number ENV_W035

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Company Accreditation Number 3244
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NATA Signatory: Ann Evers

Ann Evers

Date: 30/09/2010

This document is issued in accordance with NATA accreditation requirements.

Graeme Campbell & Associates Pty Ltd

Laboratory Report

pH-(1:2) & EC-(1:2) TESTWORK

SAMPLE NO.	SAMPLE WEIGHT (g)	SAMPLE + DEION.-W WEIGHT (g)	pH-(1:2)	EC-(1:2) (µS/cm)
GCA8884	30.0	60.0	7.3	150
GCA8885	30.0	60.0	6.4	120
GCA8886	30.0	60.0	6.0	160
GCA8887	30.0	60.0	6.5	140
GCA8888	30.0	60.0	6.7	37
GCA8889	30.0	60.0	6.7	54
GCA8890	30.0	60.0	6.4	180
GCA8891	30.0	60.0	6.3	130
GCA8892	30.0	60.0	6.5	58
GCA8893	30.0	60.0	6.3	66
GCA8894	30.0	60.0	5.9	150
GCA8894-1	30.0	60.0	5.8	160
GCA8895	30.0	60.0	6.6	280
GCA8896	30.0	60.0	6.8	120
GCA8897	30.0	60.0	7.0	57
GCA8898	30.0	60.0	6.9	48
GCA8899	30.0	60.0	6.5	46
GCA8900	30.0	60.0	6.0	51
GCA8901	30.0	60.0	6.1	55
GCA8902	30.0	60.0	6.2	81
GCA8903	30.0	60.0	6.3	54
GCA8904	30.0	60.0	6.1	43
GCA8905	30.0	60.0	5.7	56
GCA8906	30.0	60.0	5.8	130
GCA8906-1	30.0	60.0	5.8	130

Note: EC = Electrical-Conductivity.
Testwork performed on the as-supplied 'pulp' samples (nominal -75 µm).
pH-(1:2) and EC-(1:2) values correspond to pH and EC values of suspensions with a solid:solution ratio of *c.* 1:2 (w/w) prepared using deionised-water.
Drift in pH-glass-electrode less than 0.1 pH unit between commencement, and completion, of testwork.
Drift in EC-electrode less than 5 µS/cm between commencement, and completion, of testwork.
Testwork performed in a constant-temperature room (viz. 21 +/- 2-3 ^{o}C).

Dr GD Campbell
17th September 2010

Graeme Campbell & Associates Pty Ltd

Laboratory Report

NET-ACID-GENERATION (NAG) TESTWORK

Sample Number	Sample Weight (g)	Comments	pH of Test Mixture Before Boiling Step	Test Mixture After Boiling Step		Titre [0.1 M-NaOH] (mL)	NAG (kg H_2SO_4/ tonne)
				pH	EC (µS/cm)		
GCA8884	3.0	Reaction peaked overnight	6.4	6.9	30	0.10	<0.5
GCA8885	3.0	No observed reaction	6.0	6.8	28	0.10	<0.5
GCA8886	3.0	No observed reaction	5.2	6.6	29	0.10	<0.5
GCA8887	3.0	No observed reaction	5.4	6.8	26	0.10	<0.5
GCA8888	3.0	No observed reaction	5.7	6.9	23	0.10	<0.5
GCA8889	3.0	No observed reaction	5.7	6.6	21	0.20	<0.5
GCA8890	3.0	No observed reaction	5.6	6.6	15	0.10	<0.5
GCA8891	3.0	No observed reaction	4.5	6.5	34	0.20	<0.5
GCA8892	3.0	No observed reaction	5.4	6.7	25	0.10	<0.5
GCA8893	3.0	Reaction peaked within 5 minutes	8.3	6.8	35	0.10	<0.5
GCA8894	3.0	Reaction peaked within 5 minutes	7.0	5.9	38	0.10	<0.5
GCA8895	3.0	Reaction peaked within 1 minute	6.9	6.6	54	0.20	<0.5
GCA8896	3.0	Reaction peaked overnight	6.8	6.6	28	0.10	<0.5
GCA8897	3.0	Reaction peaked overnight	6.8	6.6	27	0.10	<0.5
GCA8898	3.0	No observed reaction	5.2	6.6	26	0.10	<0.5
GCA8899	3.0	No observed reaction	4.8	5.8	15	0.20	<0.5
GCA8900	3.0	Reaction peaked overnight	6.2	5.8	20	0.20	<0.5
GCA8901	3.0	No observed reaction	5.3	6.2	29	0.10	<0.5
GCA8901-1	3.0	No observed reaction	5.3	6.3	30	0.10	<0.5
BLANK1	3.0	Reaction peaked overnight	5.6	7.1	43	-	<0.5

Notes: Test conditions based on those described by Miller *et al.* (1997), and AMIRA (2002) for the 'Static-NAG-Test' in its "Single-Additon-Mode". The pH of the 15 % (v/v) H_2O_2 solution was adjusted to 4.5 using 0.1 M-NaOH prior to commencing the NAG Tests. Following an overnight-reaction period, the test-mixtures were boiled for *c.* 2 hours. Then, after allowing the test-mixtures to cool, *c.* 1.0 mL of 0.016 M-$CuSO_4$ solution was added, and the test-mixtures again boiled for *c.* 2 hours. The addition of Cu(II) catalyses the decomposition of any residual, unreacted-H_2O_2 in the test-mixtures (McElnea and Ahern 2004; O'Shay *et al.* 1990). K-Feldspar was employed for the Blank.

Dr GD Campbell
27th September 2010

Graeme Campbell & Associates Pty Ltd

Laboratory Report

NET-ACID-GENERATION (NAG) TESTWORK

Sample Number	Sample Weight (g)	Comments	pH of Test Mixture Before Boiling Step	Test Mixture After Boiling Step		Titre [0.1 M-NaOH] (mL)	NAG (kg H_2SO_4/ tonne)
				pH	EC (µS/cm)		
GCA8902	3.0	No observed reaction	5.9	6.9	51	0.10	<0.5
GCA8903	3.0	No observed reaction	5.2	5.8	18	0.10	<0.5
GCA8904	3.0	No observed reaction	5.2	6.1	19	0.10	<0.5
GCA8905	3.0	No observed reaction	3.7	4.3	59	0.70	1.2
GCA8906	3.0	No observed reaction	5.3	5.9	25	0.20	<0.5
GCA8906-1	3.0	No observed reaction	5.3	5.9	28	0.10	<0.5
BLANK2	3.0	No observed reaction	6.0	7.2	37	-	<0.5

Notes: Test conditions based on those described by Miller *et al.* (1997), and AMIRA (2002) for the 'Static-NAG-Test' in its "Single-Additon-Mode". The pH of the 15 % (v/v) H_2O_2 solution was adjusted to 4.5 using 0.1 M-NaOH prior to commencing the NAG Tests. Following an overnight-reaction period, the test-mixtures were boiled for *c.* 2 hours. Then, after allowing the test-mixtures to cool, *c.* 1.0 mL of 0.016 M-$CuSO_4$ solution was added, and the test-mixtures again boiled for *c.* 2 hours. The addition of Cu(II) catalyses the decomposition of any residual, unreacted-H_2O_2 in the test-mixtures (McElnea and Ahern 2004; O'Shay *et al.* 1990). K-Feldspar was employed for the Blank.

Dr GD Campbell
27th September 2010

ANALYTICAL REPORT

Dr G. CAMPBELL
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PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE	:	143.0/1013711
No. of SAMPLES	:	23
No. of ELEMENTS	:	32
CLIENT O/N	:	GCA 1018/1 (Job 1 of 1)
SAMPLE SUBMISSION No.	:	
PROJECT	:	King Brown Deposit
STATE	:	Ex-Pulp
DATE RECEIVED	:	01/10/2010
DATE COMPLETED	:	09/11/2010
DATE PRINTED	:	10/11/2010
PRIMARY LABORATORY	:	Genalysis Main Laboratory

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method
OV	= Value over-range for Package

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SAMPLE DETAILS

DISCLAIMER

Genalysis Laboratory Services Pty Ltd wishes to make the following disclaimer pertaining to the accompanying analytical results.

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It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that the third, fourth and subsequent figures may be real or significant.

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SAMPLE STORAGE DETAILS

GENERAL CONDITIONS

SAMPLE STORAGE OF SOLIDS

Bulk Residues and Pulps will be stored for 60 DAYS without charge. After this time all Bulk Residues and Pulps will be stored at a rate of $3.30 per cubic metre per day until your written advice regarding collection or disposal is received. Expenses related to the return or disposal of samples will be charged to you at cost. Current disposal cost is charged at $100.00 per cubic metre.

SAMPLE STORAGE OF SOLUTIONS

Samples received as liquids, waters or solutions will be held for 60 DAYS free of charge then disposed of, unless written advice for return or collection is received.

NOTES

*** NATA ENDORSED DOCUMENT ****

Company Accreditation Number 3244

The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.

The analysis results reported herein have been obtained using the following methods and conditions:

The 23 samples, as listed in the report, were received as being 'Mine-Waste' which had been dried, mixed,crushed and pulverised as per job referance 143.0/1011293.

The results have been determined according to Genalysis methods codes :
Digestions : MPL_W001 (A/), SL_W007 (BP/), ENV_W012 (DH/SIE), MPL_W011 (D/), MPL_W008 (CM/).
Analytical Finishes: ICP_W004 (/OES), ICP_W003 (/MS) and and AAS_W008 (/AAS).

The results included the assay of blanks and international reference standards OREAS 45P,STSD-2 and Genalysis in-house standards OREAS 97.01 and HgSTD-3.

The results are expressed as parts per million or percent by mass in the dried and prepared material.

NATA Signatory: A Evers
Chief Chemist

Date: 09th November 2010

This document is issued in accordance with NATA’s accreditation requirements.

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.2	50	2	50	0.1	0.01	50	0.1	0.1	5
DIGEST	A/	A/	A/	D/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	MS	OES	MS	OES	MS	MS	OES	MS	MS	OES
SAMPLE NUMBERS										
0001 GCA8884	0.7	5.14%	34	X	176.7	0.59	754	X	9.5	215
0002 GCA8885			43	X						
0003 GCA8886			13	51						
0004 GCA8887	0.4	12.78%	12	X	37.4	0.95	866	X	3.6	215
0005 GCA8888			47	X						
0006 GCA8889			32	X						
0007 GCA8890			31	X						
0008 GCA8891	0.2	3.83%	38	X	37.8	0.22	441	X	46.0	44
0009 GCA8892			28	X						
0010 GCA8893			26	X						
0011 GCA8894	0.3	3.62%	18	X	1362.5	0.51	515	0.5	34.4	25
0012 GCA8895			11	X						
0013 GCA8896	0.5	4.26%	38	X	644.3	0.50	1146	X	19.0	212
0014 GCA8897			33	X						
0015 GCA8898	0.5	5.62%	51	X	146.3	0.73	857	X	5.1	406
0016 GCA8899			11	X						
0017 GCA8900			29	X						
0018 GCA8901	0.3	4.52%	43	X	31.5	0.38	687	X	16.1	106
0019 GCA8902			28	X						
0020 GCA8903			29	X						
0021 GCA8904	0.7	2.09%	15	X	17.7	0.10	314	X	15.4	31
0022 GCA8905			31	X						
0023 GCA8906			34	X						
CHECKS										
0001 GCA8884	0.7	5.41%	34	X	170.7	0.55	747	X	9.2	212
0002 GCA8904	0.7	2.17%	16	X	17.2	0.10	299	X	15.8	31
STANDARDS										
0001 HgSTD-3										
0002 OREAS 45P				X						
0003 OREAS 45P	0.5	6.48%	14		285.1	0.20	3067	X	115.6	1150
0004 OREAS 97.01										
0005 STSD-2										
BLANKS										
0001 Control Blank	X	X	X	X	0.4	0.01	X	X	X	X
0002 Control Blank										
0003 Control Blank				X						
0004 Acid Blank	X	X	X		X	0.01	X	X	X	X

ANALYSIS

ELEMENTS	Cu	F	Fe	Hg	K	Mg	Mn	Mo	Na	Ni
UNITS	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	1	50	0.01	0.01	20	20	1	0.1	20	1
DIGEST	A/	DH/	D/	CM/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	SIE	OES	CVAP	OES	OES	OES	MS	OES	OES
SAMPLE NUMBERS										
0001 GCA8884	21	200	45.05	0.01	1116	937	3252	3.2	423	18
0002 GCA8885								3.9		
0003 GCA8886								1.5		
0004 GCA8887	70	338	10.39	0.12	298	1214	78	1.8	502	25
0005 GCA8888								2.6		
0006 GCA8889								2.0		
0007 GCA8890								5.9		
0008 GCA8891	136	309	35.50	0.07	330	2523	8238	1.5	145	108
0009 GCA8892								1.7		
0010 GCA8893								5.1		
0011 GCA8894	86	418	24.91	0.30	961	1481	10.73%	0.7	303	76
0012 GCA8895								0.8		
0013 GCA8896	27	353	46.02	0.03	1319	1021	3983	3.4	275	40
0014 GCA8897								3.0		
0015 GCA8898	35	296	39.76	0.01	2246	1164	351	3.6	276	18
0016 GCA8899								1.6		
0017 GCA8900								1.3		
0018 GCA8901	48	385	50.84	0.07	460	1505	399	4.2	172	48
0019 GCA8902								1.9		
0020 GCA8903								3.4		
0021 GCA8904	125	320	54.59	0.14	78	996	448	2.0	83	38
0022 GCA8905								4.4		
0023 GCA8906								3.9		
CHECKS										
0001 GCA8884	19	228	45.62	X	1063	917	3099	3.2	426	15
0002 GCA8904	117	240	54.81	0.13	83	970	439	1.9	81	37
STANDARDS										
0001 HgSTD-3				0.37						
0002 OREAS 45P			19.16							
0003 OREAS 45P	764				3659	2198	1287	2.1	852	389
0004 OREAS 97.01										
0005 STSD-2		1090								
BLANKS										
0001 Control Blank	2	80	X	X	X	X		X	X	2
0002 Control Blank										
0003 Control Blank			X							
0004 Acid Blank	X				X	X	X	X	X	1

ANALYSIS

ELEMENTS	P	Pb	S	Sb	Se	Sn	Sr	Th	Tl	U
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	50	2	50	0.05	0.01	0.1	0.05	0.01	0.02	0.01
DIGEST	A/	A/	A/	A/	BP/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	MS	OES	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 GCA8884	378	46	385	4.28	0.13	4.3	13.92	18.88	0.53	3.70
0002 GCA8885				7.60	0.35					
0003 GCA8886				4.96	0.07					
0004 GCA8887	X	25	79	3.29	0.30	10.0	10.33	14.23	0.04	2.62
0005 GCA8888				9.66	0.26					
0006 GCA8889				3.97	0.45					
0007 GCA8890				4.46	1.09					
0008 GCA8891	1023	35	182	2.98	0.06	1.2	5.40	6.24	0.13	1.87
0009 GCA8892				1.85	0.30					
0010 GCA8893				1.75	0.11					
0011 GCA8894	771	11	188	0.99	0.05	1.3	47.43	6.79	7.38	1.59
0012 GCA8895				1.65	0.04					
0013 GCA8896	483	53	398	3.27	1.62	3.1	24.45	16.35	0.92	5.31
0014 GCA8897				3.41	0.80					
0015 GCA8898	372	52	389	8.24	0.54	3.9	21.77	20.75	0.23	2.99
0016 GCA8899				0.99	0.26					
0017 GCA8900				1.38	0.02					
0018 GCA8901	596	36	770	3.26	0.45	2.2	16.60	9.70	0.06	4.99
0019 GCA8902				1.13	0.04					
0020 GCA8903				1.69	0.20					
0021 GCA8904	1025	32	157	0.96	0.27	1.0	3.40	1.93	0.08	4.26
0022 GCA8905				5.14	1.55					
0023 GCA8906				3.83	0.35					

CHECKS										
0001 GCA8884	329	42	387	3.99	1.11	4.0	13.97	18.11	0.48	3.69
0002 GCA8904	1015	32	151	0.92	0.17	1.0	3.47	1.95	0.07	4.16

STANDARDS										
0001 HgSTD-3										
0002 OREAS 45P										
0003 OREAS 45P	454	21	308	0.88		3.0	32.60	9.12	0.22	2.01
0004 OREAS 97.01					0.68					
0005 STSD-2										

BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	0.01	X	X
0002 Control Blank					0.02					
0003 Control Blank										
0004 Acid Blank	X	X	X	X		0.6	X	X	X	0.03

ANALYSIS

ELEMENTS	V	Zn
UNITS	ppm	ppm
DETECTION LIMIT	2	1
DIGEST	A/	A/
ANALYTICAL FINISH	OES	OES
SAMPLE NUMBERS		
0001 GCA8884	205	66
0002 GCA8885		
0003 GCA8886		
0004 GCA8887	90	26
0005 GCA8888		
0006 GCA8889		
0007 GCA8890		
0008 GCA8891	63	479
0009 GCA8892		
0010 GCA8893		
0011 GCA8894	58	329
0012 GCA8895		
0013 GCA8896	182	134
0014 GCA8897		
0015 GCA8898	323	42
0016 GCA8899		
0017 GCA8900		
0018 GCA8901	110	108
0019 GCA8902		
0020 GCA8903		
0021 GCA8904	31	120
0022 GCA8905		
0023 GCA8906		

CHECKS		
0001 GCA8884	203	59
0002 GCA8904	29	113

STANDARDS		
0001 HgSTD-3		
0002 OREAS 45P		
0003 OREAS 45P	286	147
0004 OREAS 97.01		
0005 STSD-2		

BLANKS		
0001 Control Blank	X	2
0002 Control Blank		
0003 Control Blank		
0004 Acid Blank	X	X

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.2	50	2	50	0.1	0.01	50	0.1	0.1	5
DIGEST	A/	A/	A/	D/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	MS	OES	MS	OES	MS	MS	OES	MS	MS	OES
BLANKS										
0005 Acid Blank				X						

ANALYSIS

ELEMENTS	Cu	F	Fe	Hg	K	Mg	Mn	Mo	Na	Ni
UNITS	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	1	50	0.01	0.01	20	20	1	0.1	20	1
DIGEST	A/	DH/	D/	CM/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	SIE	OES	CVAP	OES	OES	OES	MS	OES	OES
BLANKS										
0005 Acid Blank			X							

ANALYSIS

ELEMENTS	P	Pb	S	Sb	Se	Sn	Sr	Th	Tl	U
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	50	2	50	0.05	0.01	0.1	0.05	0.01	0.02	0.01
DIGEST	A/	A/	A/	A/	BP/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	MS	OES	MS	MS	MS	MS	MS	MS	MS
BLANKS										
0005 Acid Blank										

ANALYSIS

ELEMENTS	V	Zn
UNITS	ppm	ppm
DETECTION LIMIT	2	1
DIGEST	A/	A/
ANALYTICAL FINISH	OES	OES
BLANKS		
0005 Acid Blank		

METHOD CODE DESCRIPTION

A/MS Genalysis Main Laboratory

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Mass Spectrometry.

A/OES Genalysis Main Laboratory

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

BP/MS Genalysis Main Laboratory

Aqua-Regia digest followed by Precipitation and Concentration. Specific for Selenium. Analysed by Inductively Coupled Plasma Mass Spectrometry.

D/OES Genalysis Main Laboratory

Sodium peroxide fusion (Zirconium crucibles) and Hydrochloric acid to dissolve the melt. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

DH/SIE Genalysis Main Laboratory

Alkaline fusion (Nickel crucible) specific for Fluorine. Analysed by Specific Ion Electrode.

CM/CVAP Genalysis Main Laboratory

Low temperature Perchloric acid digest specific for Mercury. Analysed by Cold Vapour Generation Atomic Absorption Spectrometry.

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JOB INFORMATION

JOB CODE	143/1014065
No. of SAMPLES	18
CLIENT O/N	GCA1018/1
PROJECT	Ferraus King Brown
STATE	Water extracts
DATE RECEIVED	1/10/2010
DATE COMPLETED	21/10/2010

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method

18 solutions were received.

pH, EC, Cl were measured on each “Green” sample
Genalysis method codes ENV_W001, ENV_W002, ENV_W013

“Red” solutions were received as nitric acid dosed filtered solutions which were analysed for the requested element suite by ICPOES and ICPMS Genalysis method codes (ICP_W004,ICP_W003)

Results of analysis on:

Element		Cl	EC	/METER
Method		/VOL	/METER	0.1
Detection		2	10	NONE
Units		mg/l	uS/cm	
Sample Name				( )
Control Blank		X	( )	7.3
GCA8887 Raw		8	175	7.3
GCA8887 Raw	check	8	173	7.3
GCA8891 Raw		48	252	6.7
GCA8893 Raw		24	131	6.6
GCA8894 Raw		54	374	7.3
GCA8895 Raw		93	665	6.8
GCA8898 Raw		6	113	6.6
GCA8901 Raw		15	115	6.3
GCA8904 Raw		7	86	
N191		95		

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Element	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
Method	/MS	/OES	/MS	/OES	/MS	/MS	/OES	/MS	/MS	/OES
Detection	0.01	0.01	0.1	0.01	0.05	0.005	0.01	0.02	0.1	0.01
Units	ug/l	mg/l	ug/l	mg/l	ug/l	ug/l	mg/l	ug/l	ug/l	mg/l
Sample Name										
Control Blank	X	X	X	X	X	X	X	X	X	X
GCA8887 HNO3	X	0.04	2.5	0.16	11.33	0.268	6.06	0.02	0.2	X
GCA8891 HNO3	X	X	1.9	0.07	11.38	0.143	9.61	0.02	0.3	X
GCA8893 HNO3	0.01	X	0.9	0.07	2.54	0.078	4.46	X	0.7	X
GCA8894 HNO3	0.04	0.03	1.2	0.05	11.95	0.277	21.96	0.03	1.1	X
GCA8895 HNO3	X	X	1.3	X	5.47	0.037	53.98	X	1.6	X
GCA8898 HNO3	X	0.08	0.6	0.07	77.06	0.52	3.65	X	0.2	X
GCA8901 HNO3	X	X	1.3	0.08	17.22	0.052	2.4	X	0.1	X
GCA8904 HNO3	0.02	0.16	0.8	0.06	30.75	0.726	3.38	0.6	12.9	X
Blank-(WET)	0.01	X	3.1	X	0.28	0.035	0.07	X	X	X
DW-(WET)	0.01	X	0.1	X	0.32	0.021	0.07	X	X	X
Alcoa-High3-MS	21.05		108.8		22.22	19.976		21.12	1094.2	
AlcoaHi2-OES		46.31		19.68			974.43			19.76

Element	Cu	Fe-Sol	Hg	K	Mg	Mn	Mo	Na	Ni	P
Method	/OES	/OES	/MS	/OES	/OES	/OES	/MS	/OES	/OES	/OES
Detection	0.01	0.01	0.1	0.1	0.01	0.01	0.05	0.1	0.01	0.1
Units	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l
Sample Name										
Control Blank	X	X	X	0.1	X	X	X	X	X	X
GCA8887 HNO3	X	0.02	0.2	3.9	5.04	0.01	0.38	27.7	X	X
GCA8891 HNO3	X	0.02	0.3	7.7	11.24	X	X	20.5	X	X
GCA8893 HNO3	X	0.01	1	1.6	4.54	X	0.06	17.9	0.01	X
GCA8894 HNO3	X	0.03	0.2	7.7	19.8	1.13	X	25.1	X	X
GCA8895 HNO3	X	0.02	0.2	21.1	32.71	0.52	X	33.6	X	X
GCA8898 HNO3	X	0.01	0.3	7.1	2.04	0.01	X	14.3	X	X
GCA8901 HNO3	X	0.02	0.3	4.1	2.14	X	0.1	17.1	X	X
GCA8904 HNO3	X	0.03	0.3	4.3	3.32	0.01	X	8.7	X	X
Blank-(WET)	X	X	0.3	0.2	0.07	X	X	0.3	X	X
DW-(WET)	X	X	0.1	0.2	X	X	X	X	X	X
Alcoa-High3-MS			22.5				20.94			
AlcoaHi2-OES	2.67	96.5		482.9	199.2	19.3		1951.3	20.62	46.2

Element	Pb	S	SO4	Sb	Se	Si	Sn	Sr	Th	Tl
Method	/MS	/OES	/CALC	/MS	/MS	/OES	/MS	/MS	/MS	/MS
Detection	0.5	0.1	0.3	0.01	0.5	0.05	0.1	0.02	0.005	0.01
Units	ug/l	mg/l	mg/l	ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l
Sample Name										
Control Blank	X	X		X	X	X	X	X	X	X
GCA8887 HNO3	1.1	2.7	8.1	0.1	X	13.28	0.3	45.74	0.005	0.01
GCA8891 HNO3	0.6	4.5	13.5	0.03	1.7	3.77	0.2	45.96	X	0.04
GCA8893 HNO3	1.1	1.1	3.3	0.05	1	4.19	0.6	17.49	X	X
GCA8894 HNO3	3	3.8	11.4	0.24	1.3	3.2	0.3	221.52	0.005	0.02
GCA8895 HNO3	0.6	12.6	37.8	0.06	1.7	1.59	0.2	366.62	X	0.06
GCA8898 HNO3	1.6	5.2	15.6	0.04	1.2	6.83	0.2	46.7	X	0.01
GCA8901 HNO3	1.8	3.3	9.9	0.07	1.3	4.98	0.2	18.97	X	X
GCA8904 HNO3	25.9	0.2	0.6	0.3	X	4.68	0.2	26.41	0.005	0.12
Blank-(WET)	1.1	X		0.04	X	0.05	0.1	0.08	X	X
DW-(WET)	1.2	X		X	X	X	X	X	X	X
Alcoa-High3-MS	21.3		0	21.99	107.5		22.1	1095.88	22.224	20.34
AlcoaHi2-OES		244	732			95.91				

Element	U	V	Zn
Method	/MS	/OES	/OES
Detection	0.005	0.01	0.01
Units	ug/l	mg/l	mg/l
Sample Name			
Control Blank	X	X	X
GCA8887 HNO3	0.018	X	0.01
GCA8891 HNO3	X	X	X
GCA8893 HNO3	X	X	0.03
GCA8894 HNO3	0.007	X	0.03
GCA8895 HNO3	X	X	0.01
GCA8898 HNO3	0.023	X	X
GCA8901 HNO3	0.009	X	0.02
GCA8904 HNO3	0.021	X	0.02
Blank-(WET)	X	X	X
DW-(WET)	X	X	X
Alcoa-High3-MS	21.854		
AlcoaHi2-OES		19.77	21.02

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NATA Signatory: Ann Evers

Ann Evers

Date: 21/10/2010

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JOB INFORMATION

JOB CODE	143.0/1013712
No. of SAMPLES	5
CLIENT O/N	GCA1018/1
PROJECT	King Brown
STATE	pulps
DATE RECEIVED	1/10/2010
DATE COMPLETED	25/10/2010

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
( ) = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
> = Value beyond Limit of Method

The samples were received as pulps and were indicated to be non calcareous

Results of analysis on:

Element	Method	Units	GCA8884	GCA8884	GCA8887	GCA8891
				check		
Ca	NH4Cl7/OES	cmol(+)/kg	1.46	1.43	3.59	0.31
K	NH4Cl7/OES	cmol(+)/kg	0.86	0.82	0.37	0.32
Mg	NH4Cl7/OES	cmol(+)/kg	1.08	1.04	4.34	0.44
Na	NH4Cl7/OES	cmol(+)/kg	0.70	0.67	0.58	0.13
ECEC	/CALC		4.09	3.95	8.87	1.19
Exchangeable Ca	/CALC	%	35.7	36.2	40.5	26.0
Exchangeable K	/CALC	%	20.9	20.8	4.1	26.6
Exchangeable Mg	/CALC	%	26.3	26.2	48.9	36.5
Exchangeable Na (ESP)	/CALC	%	17.1	16.8	6.5	10.9

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Element	Method	Units	GCA8894	GCA8898	ASPAC33
Ca	NH4Cl7/OES	cmol(+)/kg	0.85	1.51	38.77
K	NH4Cl7/OES	cmol(+)/kg	0.18	0.54	1.41
Mg	NH4Cl7/OES	cmol(+)/kg	0.93	1.02	32.28
Na	NH4Cl7/OES	cmol(+)/kg	0.18	0.28	1.77
ECEC	/CALC		2.14	3.34	74.23
Exchangeable Ca	/CALC	%	39.7	45.1	52.2
Exchangeable K	/CALC	%	8.6	16.1	1.9
Exchangeable Mg	/CALC	%	43.4	30.5	43.5
Exchangeable Na (ESP)	/CALC	%	8.3	8.3	2.4

2g of each of the samples were weighed into a centrifuge tube and pre- washed with 2x 25ml 10 % (v/v) deionised ethylene glycol in 90 % (v/v) ethanol which has been previously deionised by passing through Amberlite resin
After the centrifuge stage there may be finely dispersed material in suspension. If this is the case a few drops of PVA may be necessary. The PVA aqueous solution is 0.05 % (w/v) polyvinyl alcohol. Addition of PVA was made to samples GCA8891 and 8894. This did not result in flocculation of the samples and the fine material was filtered off and extracted separately. The exchangeable bases in solution when included in the total did not raise the eCEC above 5 and were not included in the total. The values in solution were below the detection limit

<u>Extraction step for Exchangeable cations</u>
After decanting following completion of the 2nd pre-wash, the residue in centrifuge tube is subjected to 2 x 30-minute extractions via end-over-end tumbling at approx. 10 rpm. Each extraction uses 20 mL of 1 M-NH_4Cl buffered at pH 7.0 using ammonia solution 28 % (w/w). At the completion of each extraction, the suspensions are centrifuged and the supernatants decanted and collected into a communal extract. After this extraction is completed (under same conditions as before), the suspension is centrifuged, and the supernatant combined with the communal extract above. The final communal extract is brought to 50 mL with 4 M-HCl.
Sample analysed for Ca,Mg,K and Na by OES

Reference:
Based on procedure 15B2
Australian laboratory handbook of soil and water chemical methods / G.E. Rayment and F.R. Higginson 1992 Inkata Press

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Semi Quantitative XRD Report – JN1018/1

1. Sample Preparation:

The samples received were the -2mm fraction and pulps (-75µm nominal) of waste regolith material from the Ferraus-King-Brown Iron Ore project. Sub samples of the pulps weighing approximately 3g were back loaded into a standard X-Ray Diffraction (XRD) sample holder for semi-quantitative analysis. A sub sample of the -2mm fraction was also taken for clay separation and identification.

The samples for clay separation were mixed with a 0.6% calgon (sodium hexametaphosphate) solution and allowed to settle. The clay fraction was then removed by pipette and placed on a ceramic disk for XRD.

2. Experimental Method:

Pack packed random orientated samples:
Data was collected using a Bruker D8 XRD fitted with a Cu tube operated at 40kV, 40mA and a Ni filter; using the following settings:
2-theta range = 6–80^o, Step size = 0.021^o, Divergence slit = 1mm Fixed

Clay samples:
Data was collected using a Philips X'pert XRD fitted with a Co tube operated at 40kV, 40mA and an Fe filter; using the following settings:
2-theta range = 4–32^o, Step size = 0.035^o, Step time = 0.8s, Divergence slit = 15mm ADS
Receiving slit = 0.8mm.

The XRD measurements for the clay samples with evidence of expanding clays were repeated after the samples were expanded with ethylene glycol.

3. Diffraction Data files:

Diffraction data files in the original binary format (with the file extension .rd) and ASCII format (with extension .txt) are available on request.

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Semi Quantitative XRD Report – JN1018/1

4. Semi-quantitative results:
The semi-quantitative results are based on the XRD pattern obtained from a “randomly” orientated sub sample. However, orientated clay samples are used to aid in identification of the clays.

	GCA8884	**GCA8887**	**GCA8891**	**GCA8894**	**GCA8898**
Quartz	Accessory	Minor	Minor	Minor	Minor
Goethite	Minor	Accessory	Dominant	Major	Minor
Hematite	Dominant	Accessory	Accessory	Accessory	Major
Kaolinite	Major	Dominant	Major	Minor	Major
Pyrolusite				Minor	
Microcline				Trace	Trace

Nominal abundance
Trace <2%
Accessory 2-10%
Minor 10-20%
Major 20-50%
Dominant >50%

Notes:

The amounts indicated are a guide only and are based on rough Rietveld refinements of the diffraction patterns from the “randomly” orientated samples and previous work of this nature; however the variations in clay properties, sample preparation, and the degree of orientation in the “random” orientated samples will all affect the peak heights and the estimates of the amount present.

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1018/2

COMPANY: FerrAus Limited

ATTENTION: Todd Tuffin

FROM: Graeme Campbell

SUBJECT: FerrAus Pilbara Project: Geochemical Characterisation of Mine-Waste and Low-Grade-Ore Samples from Python-Gwardar Pit, and Implications for Material Management -

NO. PAGES (including this page): 69 DATE: 3rd February 2011

Todd,

The occurrences of S, and associated univariate-statistics, for the waste-zone of the Python-Gwardar Pit are presented in Attachment I. Geological-cross-sections, and the locations of the samples tested in this study, are also presented in Attachment I. In addition, a summary of the geology of the nearby Mirrin Mirrin Deposit is presented in Attachment I.

Details of the testwork methods employed are presented in Attachment II. Classification criteria in terms of Acid-Formation Potential (AFP) are summarised in Attachment III. Copies of the laboratory reports are presented in Attachment IV.

1.0 APPRAISAL OF SULPHUR-OCCURRENCES

The Exploration-Database from which the univariate-statistics of S-occurrences are derived correspond to the determination of Total-S at intervals of 2-m.

The occurrence of sulphide-minerals is therefore defined at a "fine-spatial-resolution". This "metre-scale-resolution" of S-occurrences is small compared with the likely "mining-resolution" of *c.* 5 m, as controlled by the large equipment to be employed during open-pit mining.

In terms of assessing the potential for the formation of Acid-Rock Drainage (ARD), a "S-threshold/cutoff" of 0.3 % (as S) is employed herein. Although Sulphide-S values less than 0.3 % may result in acidification through sulphide-oxidation, this is restricted to "end-member" mineralogies for sulphide- and groundmass-mineral suites. In particular, it applies to lithotypes for which both the sulphide-minerals include hyper-reactive varieties (e.g. framboidal-pyrite), and the groundmass comprises simply quartz, soil-clays, and sesquioxides (i.e. devoid of reactive-carbonates, and primary-rock-silicates).[1] However, this "type-mineralogy" is not characteristic of the mine-wastes and low-grade-ores to be produced from the Python-Gwardar Pit.

The negligible occurrence of sulphide-minerals (e.g. pyrite) is shown by the distribution of S-occurrences for all lithotypes (Attachment I).

Essentially all of the mine-waste and low-grade-ore streams should be characterised by Total-S values less than 0.3 %, and the majority should have Total-S values well below 0.1-0.2 %. This paucity of sulphide-minerals is consistent with both the styles of mineralisation, and the depths of *in-situ*-weathering, of iron-ore deposits, and associated country-rocks, as generally observed in the Pilbara.

All mine-waste and low-grade-ore streams to be produced from the Python-Gwardar Pit should be classified as Non-Acid Forming (NAF).

Acidification of mine-wastes, and low-grade-ores, should therefore not be an issue for mine-waste management to contend with for the Project.

2.0 GEOCHEMISTRY OF MINE-WASTE SAMPLES

Fourteen (14) samples of mine-wastes were subjected to static-testing (Tables 1-5).

2.1 Acid-Forming Characteristics, and Salinity

The samples were characterised by (Table 1):

- Total-S values that ranged from less than 0.01 %, to 0.15 %%;
- Acid-Neutralisation-Capacity (ANC) values of 1-14 kg H_2SO_4/tonne;
- Net-Acid-Generation (NAG) values less than 0.5 kg H_2SO_4/tonne, and NAG-pH values of 5.2-8.1; and,
- pH-(1:2) values of 5.4-6.5, and EC-(1:2) values of 0.017-0.18 mS/cm.[2]

The testwork results indicate that all samples are classified as NAF, as expected from the assessment of S-occurrences (Section 1.0, and Attachment I). The groundmass of the various lithotypes is devoid of carbonate-minerals, and so possesses a low capacity to consume acid.

[1] References:
Price W, 2005, "Criteria Used in Material Characterization and the Prediction of Drainage Chemistry: "Screaming Criteria"", Presentation B.1 in "Proceedings of the 12th Annual British Columbia – MEND ML/ARD Workshop on "Challenges in the Prediction of Drainage Chemistry", November 30 to December 1, 2005, Vancouver, British Columbia.
Price WA, Morin K and Hutt N, 1997, "Guidelines for the Prediction of Acid Rock Drainage and Metal Leaching for Mines in British Columbia: Part II. Recommended Procedures for Static and Kinetic Testing", pp. 15-30 in "Proceedings of the Fourth International Conference on Acid Rock Drainage", Volume I, Vancouver.
Campbell GD, unpublished results since the late-1980s.

[2] EC = Electrical-Conductivity. Refer Attachment II for a description of the pH-(1:2) and EC-(1:2) testwork, and other testwork.

The samples were circum-neutral (viz. pH 6-7) with low contents of soluble-salts. Such pH and salinity regimes are typical of mine-waste streams produced at iron-ore-mines in the Pilbara.[3]

2.2 Multi-Element Composition

The samples subjected to multi-element analyses had contents of major- and minor-elements typically below, or close to, those recorded for soils, regoliths, and bedrocks derived from unmineralised terrain (Table 2). Although variously enriched in As, Sb, Bi, Cd, and Mn, the degree of enrichment was not marked. However, the Mn content of 6.2 % in the WAMN sample (GCA8916) was an exception, as expected.

In addition to the samples subjected to multi-element analyses, the remaining samples were assayed for a restricted suite of minor-elements (viz. As, Sb, Se, Mo and B). These minor-elements occur as oxyanions (e.g. arsenates) in natural systems, and their pH-solubility relationships are such that their concentrations can potentially be within the mg/L+ range at circum-neutral-pH. The analysis results for this restricted-minor-element suite are presented in Table 3.

The ranges in contents of these minor-elements were:

- 4.0-48 mg/kg for As;
- 0.57-6.4 mg/kg for Sb;
- 0.04-2.4 mg/kg for Se;
- 0.40-2.9 mg/kg for Mo; and,
- less than 50 mg/kg for B.

The minor-element contents above fall within the range generally recorded for mine-waste samples derived from other iron-ore mines on the Pilbara block, especially for lithotypes located above the Base-of-Oxidation (BoX).[4]

2.3 Minor-Element Solubility

To assess the stability of major/minor-elements, a range of samples was subjected to Water-Extraction Tests (Table 4). In this testwork, pulped samples (nominal 75 µm) were extracted for *c.* 1 day via the bottle-roll technique, employing slurries prepared from deionised-water, at a solid:solution ratio of *c.* 1:2 (w/w). The resulting water-extracts were filtered (0.45-µm-membrane), and preserved, as appropriate, for specific analyses (see Attachment II).

> Note: To assist interpretation of the Water-Extraction-Test results, a broad comparison may be made between the testwork conditions, and elution of solutes from the surficial-zone of the waste-dumps by rainfall. The solid:solution ratio employed in the testing was *c.* 1:2 (w/w). If the Dry-Bulk-Density (DBD) of the mixture of the fine-earth (viz. -2 mm) fraction, and clasts, is *c.* 2.0 t/m^3, then for an annual rainfall of *c.* 300-400 mm, the "equivalent" solid:solution ratio experienced by the top 0.1 m may be taken as *c.* 1:2 (w/w). Therefore, the testwork results broadly correspond to the efficient leaching of the top 0.1 m of a mine-waste-profile by a year's worth of rainfall, and where all drainage-waters are collected in a dam without any mixing with

[3] Campbell, unpublished results.
[4] Campbell, unpublished results.

runoff-waters derived from up-catchment areas. Although approximate, this comparison assists in placing the testwork results into broad perspective in terms of potential water-quality for the downstream environs. However, sight must not be lost of the testwork conditions employed (viz. samples as powders in suspensions that are continuously agitated). The Water-Extraction Tests herein serves simply to identify any weakly-bound forms of solutes which are susceptible to release to solution upon contact with meteoric-waters.

The concentration of minor-elements in the water-extracts were either below, or close to, the respective detection-limits (viz. typically within the range 0.1-10 µg/L) [Table 4]. These results are consistent with the hydrogeochemical expectation of a sparingly-low solubility of minor-elements (at circum-neutral-pH) for mine-wastes which are Fe-rich, weakly-mineralised, and devoid of sulphide- and carbonate-minerals.

The Se concentrations in the present water-extracts were 0.6-2.0 µg/L, and correspond to test-slurries with a solid:solution ratio of *c.* 1:2 (w/w). In related water-extraction testwork on ferruginous-overburden samples from the Yandi Iron-Ore Mine, Gardiner (2003) reported Se concentrations of *c.* 21-43 µg/L (see Tables 3.11-3.13 in Gardiner [2003]), corresponding to test-slurries with a solid:solution ratio of *c.* 1:20 (w/w).[5] When expressed in terms of µg of Se extracted per kg of dry-solids, the mine-waste samples tested herein had Water-Extractable-Se contents ranging up to *c.* 4 µg Se/kg, whereas Gardiner (2003) reported Water-Extractable-Se contents within the range *c.* 400-900 µg Se/kg. There is therefore a 100-fold difference in the Water-Extractable-Se contents between this study, and that of Gardiner (2003).[6] The latter results lead to the conclusion that *inter alia* elevated Se solubility could be a water-quality issue for pit-lakes following cessation of pit-dewatering at closure. However, there are a number of inconsistencies in the results reported by Gardiner (2003). Given the potential implications of such apparent Se-solubility behaviour to the iron-ore-mining industry generally, it is justified to critique these analysis anomalies.

Anomalous-Results from Gardiner (2003): Sample LAET-908 had a Total-Se content less than 0.01 mg/kg (Table 3.7), yet its Water-Extractable-Se content (calculated from the Water-Extract-Se concentration of 31.5 µg/L in Table 3.12) is 0.63 mg/kg. Related discrepancies occur for the Zn results. For example, sample LAET-898 had a Total-Zn content of 12.4 mg/kg (Table 3.7), and an apparent Water-Extractable-Zn content of 25 mg/kg (calculated from Table 3.12). Water-Extract-Fe concentrations ranged up to 13.2 mg/L (Table 3.13) which are untenable for "true" Soluble-Fe forms at circum-neutral-pH, and the oxic-redox conditions of the test-slurries employed in the water-extraction testwork. Finally, several water-extracts had alkalinities greater than 1,000 mg/L (as $CaCO_3$), and Ca concentrations within the range *c.* 200-800 mg/L, but the corresponding EC values were only *c.* 80-150 µS/cm (Tables 3.11-3.13). These anomalous results can be explained by the occurrence of ultra-fine (i.e. sub-µm-sized) forms of carbonate-minerals (e.g. calcites), clays and Fe/Al-sesquioxides which passed through the 0.45µm-membrane, and then released bound forms of minor-elements (e.g. Se and Zn) to solution when the filtrates were preserved for analysis by acidifying with HNO_3.[7]

Whatever the exact reason(s) for the analysis anomalies above, the net outcome is that the stability of Se (and other minor-elements) in NAF varieties of mine-wastes at iron-ore-mines in the Pilbara is likely considerably greater than reported by Gardiner (2003).

In the present study, the WAMN sample (GCA8916) with a Total-Mn content of 6.2 % had a Water-Extract-Mn concentration of 0.11 mg/L (Table 4). The Mn in the WAMN sample therefore corresponds to stable forms of low solubility.

[5] Gardiner SJ, 2003, "Impacts of Mining and Mine Closure on Water Quality and the Nature of the Shallow Aquifer, Yandi Iron Ore Mine", MSc Thesis, Department of Applied Geology, Curtin University of Technology, Drs R Watkins and C Evans as Supervisors.

[6] The Total-Se contents of the samples tested herein were 0.06-1.7 mg/kg (Table 3), whereas those recorded by Gardiner (2003) ranged up to 1.24 mg/kg (Tables 3.6, 3.7, and 3.8).

[7] Water-Extract-Al concentrations were not reported by Gardiner (2003).

2.4 Clay-Mineralogy and Clay-Surface-Chemistry

The clay-mineral suite of the tested samples was dominated by kaolinites (c.f. "high-activity" smectites which exhibit marked shrink-swell behaviour under wetting and drying conditions).

The Effective-Cation-Exchange-Capacity (eCEC) values of the tested samples were 0.7-13.5 cmol (p+)/kg, and the Exchangeable-Sodium-Percentage (ESP) values were *c.* 5-15 % (Table 5). The samples were therefore variously sodic.

3.0 GEOCHEMISTRY OF LOW-GRADE-ORE SAMPLES

Eight (8) samples of low-grade-ores were subjected to static-testing (Tables 6-9).

In essence, the geochemical character of the low-grade-ore samples is indistinguishable from that of the mine-waste samples above. Given the nature of iron-ore-mineralisation within the Python-Gwardar Deposit, this is to be expected.

All low-grade-ore samples are classified as NAF, and were circum-neutral (viz. pH 6) with low contents of soluble-salts (Table 6).

The samples subjected to multi-element analyses had contents of major- and minor-elements typically below, or close to, those recorded for soils, regoliths, and bedrocks derived from unmineralised terrain (Tables 7 and 8).

The concentration of minor-elements in the water-extracts were either below, or close to, the respective detection-limits (Table 9).

4.0 MANAGEMENT IMPLICATIONS

The management implications outlined below reflect a working-model of mine-waste geochemistry for the Python-Gwardar Deposit developed from the testwork results obtained in this study (and Appendix I), as well as experience with other deposits on the Pilbara block which share a related geology, and style of mineralisation.

4.1 Mine-Wastes

Geochemically, the various mine-waste units should be benign (i.e. extremes in pH and/or salinity should <u>not</u> place constraints on how such materials are managed). The 'ex-pit' streams of the mine-waste units should be circum-neutral, and of low-to-moderate salinity. Such pH and salinity regimes should prevail over the longer-term during weathering on the waste-dumps, as governed by the frequency, and penetration-depth, of the seasonal wetting-front.[8]

Since the remnant "chalcophyle-signature" reflecting mineralisation is weak, minor-element enrichments should pose no concerns to water-quality, or uptake by plant-roots. The abundance of Fe-oxyhydroxides should ensure that minor-elements are retained by

[8] Campbell GD, 2008, "Mine-Waste Geochemistry, Rainfall Seasonality, and Coincidence of the Wetting/Oxidation-Fronts: A Conceptual Arid-Zone Weathering Model", PowerPoint-presentation delivered at the May 2008 Workshop of the Goldfields Environmental Management Group, Kalgoorlie. Campbell GD, 2007, "Isolation of Reactive Mine-Wastes in the WA Goldfields: How Arid-Zone Weathering and Hydroecology Simplify Cover-Design Studies", Section 8 in "Planning for Mine-Closure Seminar", Australian Centre for Geomechanics, 14-15 June 2007, 40 pp.

sorption reactions of the "high-affinity/poorly-reversible" type, as have occurred *in situ* over the eons.

Since the majority of the lithotypes produced during mining are competent, chunky and durable, they are well suited to applications where exposure occurs over the longer-term (e.g. rock-armouring, construction of pit-safety-bund, etc.). Where earthy, friable lithotypes are produced, their susceptibility to erosion should be dampened by the expected abundance of clasts, and the fact that their "fine-earth" fraction (viz. -2 mm) should not be enriched in smectites (i.e. "high-activity" clays that exhibit marked shrink-swell behaviour). Together with topsoils, such lithotypes should be earmarked for use in constructing the outermost-sections of the waste-landforms, so that water-retention capacities, in particular, are favourable to vegetation. However, since friable materials are susceptible to erosion, a balance needs to be struck between creating a profile which is <u>both</u> texturally suitable as a rooting-medium for plant growth, <u>and</u> physically stable. These challenges are generic to mine-waste management at hard-rock mines.

In brief, waste-landform design and rehabilitation should not be constrained by the physicochemical nature of the mine-waste streams. Planning for waste-landform decommissioning should integrate industry best-practice concepts for rehabilitation and mine-site closure (DITR 2006a,b), and the practical know-how from other Pilbara iron-ore mines.[9]

4.2 Low-Grade-Ores

Since the physicochemical character of the low-grade-ores is similar to that for the mine-waste streams, the same generic remarks apply to the rehabilitation of the stockpiles of low-grade-ores in the event that such stockpiles remain at closure.

4.3 Mirrin Mirrin Deposit

Although samples of mine-wastes derived from the waste-zone of the proposed Pit for this Deposit were not tested, the above assessment should equally apply to the mine-waste and low-grade-ores streams derived from the Mirrin Mirrin Deposit. This reflects the "common-geology/mineralisation-style" shared by the Python Gwardar and Mirrin Mirrin Deposits.

5.0 CLOSURE

I trust the above is useful to you.

Regards,

Dr GD Campbell
Director

Encl. Tables 1-9.
Attachments I-IV.

[9] Department of Industry, Tourism and Resources, 2006a, "Mine Closure and Completion", Leading Practice Sustainable Development Program for the Mining Industry, Canberra.
Department of Industry, Tourism and Resources, 2006b, "Mine Rehabilitation", Leading Practice Sustainable Development Program for the Mining Industry, Canberra.

TABLES

Table 1: Acid-Base-Analysis and Net-Acid-Generation Results for Mine-Waste Samples

GCA-SAMPLE NO.	SITE-SAMPLE NO.	DRILLHOLE & DOWN-HOLE INTERVAL (m)	LITHOTYPE	pH-(1:2)	EC-(1:2) [mS/cm]	TOTAL-S (%)	SO4-S (%)	SULPHIDE-S (%)	TOTAL-C (%)	CO_3-C (%)	ANC	NAPP	NAG	NAG-pH	AFP CATEGORY
											kg H_2SO_4/tonne				
GCA8907	DCWC0001	DCRC0706, 68-72	TW	5.8	0.078	<0.01 (<0.01)	nm	<0.01	0.06 (0.05)	nm	2 (2)	nc	<0.5	6.0	NAF
GCA8908	DCWC0002	DCRC0704, 40-44	TW	5.4	0.039	0.15	0.10	0.05	0.22	0.09	2	nc	<0.5	5.2	NAF
GCA8909	DCWC0013	DCRC0833, 12-16	TW	6.0	0.017	<0.01	nm	<0.01	0.02	nm	4	nc	<0.5	6.5	NAF
GCA8910	DCWC0014	DCRC0830, 14-18	TW	5.9	0.082	<0.01	nm	<0.01	0.04	nm	4	nc	<0.5	6.4	NAF
GCA8911	DCWC0003	DCRC0698, 16-20	WAW	6.0	0.16	0.04	nm	0.04	0.15	nm	3	nc	<0.5	6.7	NAF
GCA8912	DCWC0004	DCRC0706, 82-86	WAW	6.0	0.060	<0.01	nm	<0.01	0.19	nm	1	nc	<0.5	6.1	NAF
GCA8913	DCWC0015	DCRC0828, 14-18	WAW	6.0	0.075	0.03	nm	0.03	0.11	nm	4	nc	<0.5	6.4	NAF
GCA8914	DCWC0016	DCRC0831, 24-28	WAW	6.1	0.059	0.03	nm	0.03	0.17	nm	3	nc	<0.5	6.5	NAF
GCA8915	DCWC0007	DCRC0705, 134-138	WAMN	6.6	0.18	0.01	nm	0.01	0.18	nm	14	nc	<0.5	8.1	NAF
GCA8916	DCWC0008	DCRC0706, 104-108	WAMN	6.4	0.10	<0.01	nm	<0.01	0.09	nm	10	nc	<0.5	7.3	NAF
GCA8917	DCWC0009	DCRC0704, 160-164	MMW	6.5 (6.5)	0.043 (0.042)	<0.01	nm	<0.01	0.03	nm	1	nc	<0.5	6.4	NAF
GCA8918	DCWC0010	DCRC0699, 34-38	MMW	6.5	0.028	<0.01	nm	<0.01	0.09	nm	4	nc	<0.5	6.0	NAF
GCA8919	DCWC0021	DCRC0833, 92-96	MMW	6.4	0.031	<0.01	nm	<0.01	0.04	nm	1	nc	<0.5	5.9	NAF
GCA8920	DCWC0022	DCRC0829, 32-36	MMW	6.3	0.036	<0.01	nm	<0.01	0.05	nm	4	nc	<0.5	6.3	NAF

Notes:

EC = Electrical Conductivity; ANC = Acid-Neutralisation-Capacity; NAPP = Net-Acid-Producing-Potential; AFP = Acid-Formation-Potential; NAF = Non-Acid-Forming; NAG = Net-Acid Generation;
nm = not measured; nc = not calculated.
pH-(1:2) and EC-(1:2) values correspond to pH and EC measured on sample slurries prepared with deionised-water, and a solid:solution ratio of *c.* 1:2 (w/w).
All results expressed on a dry-weight basis, except for pH-(1:2), EC-(1:2), and NAG-pH.
Values in parentheses represent duplicates.

N.B. **TW** = Transported **WAW** = Lower-West-Angela **WAMN** = Lower-West-Angela-[Mn-Bearing] **MMW** = Mt-Newman/McLeod

Table 2: Multi-Element-Analysis Results for Mine-Waste Samples

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)				AVERAGE-CRUSTAL-ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)			
	TW (GCA8907)	TW (GCA8909)	WAW (GCA8912)	WAW (GCA8913)		TW (GCA8907)	TW (GCA8909)	WAW (GCA8912)	WAW (GCA8913)
Al	10.8%	9.7%	6.0%	6.9%	8.2%	0	0	0	0
Fe	18.1%	14.7%	4.4%	41.6%	4.1%	2	1	0	**3**
Na	0.019%	0.039%	0.014%	0.032%	2.3%	0	0	0	0
K	1.4%	0.38%	0.69%	0.048%	2.1%	0	0	0	0
Mg	0.35%	0.25%	0.18%	0.13%	2.3%	0	0	0	0
Ca	0.031%	0.15%	0.024%	0.091%	4.1%	0	0	0	0
Ag	<0.2	<0.2	<0.2	<0.2	0.07	0	0	0	0
Cu	46	50	30	44	50	0	0	0	0
Zn	44	37	36	110	75	0	0	0	0
Cd	<0.1	<0.1	<0.1	<0.1	0.11	0	0	0	0
Pb	22	27	18	25	14	0	0	0	0
Cr	160	370	120	260	100	0	1	0	1
Ni	58	28	45	8	80	0	0	0	0
Co	17	7.7	11	3	20	0	0	0	0
Mn	1,800	530	300	66	950	0	0	0	0
Hg	0.02	<0.01	0.02	0.06	0.05	0	0	0	0
Sn	3.8	3.1	2.1	4.0	2.2	0	0	0	0
Sr	21	22	13	12	370	0	0	0	0
Ba	93	200	45	51	500	0	0	0	0
Th	19	17	11	16	12	0	0	0	0
U	6.2	4.4	3.0	5.3	2.4	1	0	0	1
Tl	0.17	0.52	0.10	0.08	0.6	0	0	0	0
V	130	410	61	180	160	0	1	0	0
As	24	9	20	30	1.5	**3**	2	**3**	**4**
Bi	0.91	0.32	0.65	0.67	0.048	**4**	2	**3**	**3**
Sb	3.8	1.4	3.1	6.7	0.2	**4**	2	**3**	**4**
Se	0.27	0.35	0.07	0.30	0.05	2	2	0	2
Mo	1.9	1.4	2.4	2.9	1.5	0	0	0	0
B	<50	<50	<50	<50	10	0	0	0	0
P	950	77	630	290	1,000	0	0	0	0
F	430	370	370	280	950	0	0	0	0

Note:
Average-crustal abundance of elements based on Bowen (1979), and the Geochemical-Abundance Index (GAI) is based on Förstner *et al.* (1993). Refer Attachment II.

Table 2 (Cont'd): Multi-Element-Analysis Results for Mine-Waste Samples

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)		AVERAGE-CRUSTAL ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)	
	WAMN (GCA8916)	MMW (GCA8918)		WAMN (GCA8916)	MMW (GCA8918)
Al	4.6%	1.1%	8.2%	0	0
Fe	28.7%	24.6%	4.1%	2	2
Na	0.021%	0.013%	2.3%	0	0
K	0.47%	0.017%	2.1%	0	0
Mg	0.29%	0.052%	2.3%	0	0
Ca	0.079%	0.018%	4.1%	0	0
Ag	<0.2	0.2	0.07	0	1
Cu	44	34	50	0	0
Zn	200	140	75	1	0
Cd	1.0	<0.1	0.11	**3**	0
Pb	43	10	14	1	0
Cr	42	28	100	0	0
Ni	45	25	80	0	0
Co	27	2.8	20	0	0
Mn	6.2%	82	950	**6**	0
Hg	0.05	0.02	0.05	0	0
Sn	1.6	0.7	2.2	0	0
Sr	140	2.5	370	0	0
Ba	790	14	500	0	0
Th	7.9	0.96	12	0	0
U	4.0	0.91	2.4	0	0
Tl	2.4	0.03	0.6	1	0
V	72	13	160	0	0
As	12	4	1.5	2	1
Bi	0.56	0.07	0.048	**3**	0
Sb	1.9	1.7	0.2	**3**	**3**
Se	0.08	0.12	0.05	0	1
Mo	0.6	1.5	1.5	0	0
B	<50	<50	10	0	0
P	1,100	340	1,000	0	0
F	230	160	950	0	0

Table 3: Total-Contents of As, Sb, Se, Mo and B in Mine-Waste Samples

GCA-SAMPLE NO.	SITE-SAMPLE NO.	DRILLHOLE & DOWN-HOLE INTERVAL (m)	LITHOTYPE	As (mg/kg)	Sb (mg/kg)	Se (mg/kg)	Mo (mg/kg)	B (mg/kg)
GCA8907	DCWC0001	DCRC0706, 68-72	TW	24	3.8	0.27	1.9	<50
GCA8908	DCWC0002	DCRC0704, 40-44	TW	31	3.5	2.4	2.4	<50
GCA8909	DCWC0013	DCRC0833, 12-16	TW	9.0	1.4	0.35	1.4	<50
GCA8910	DCWC0014	DCRC0830, 14-18	TW	22	2.6	0.20	1.3	<50
GCA8911	DCWC0003	DCRC0698, 16-20	WAW	22	6.4	0.37	1.9	<50
GCA8912	DCWC0004	DCRC0706, 82-86	WAW	20	3.1	0.07	2.4	<50
GCA8913	DCWC0015	DCRC0828, 14-18	WAW	30	6.7	0.30	2.9	<50
GCA8914	DCWC0016	DCRC0831, 24-28	WAW	48	4.1	0.59	1.3	<50
GCA8915	DCWC0007	DCRC0705, 134-138	WAMN	7.0	0.87	0.04	0.40	<50
GCA8916	DCWC0008	DCRC0706, 104-108	WAMN	12	1.9	0.08	0.60	<50
GCA8917	DCWC0009	DCRC0704, 160-164	MMW	7.0	0.67	0.13	1.5	<50
GCA8918	DCWC0010	DCRC0699, 34-38	MMW	4.0	1.7	0.12	1.5	<50
GCA8919	DCWC0021	DCRC0833, 92-96	MMW	7.0	0.57	0.24	2.1	<50
GCA8920	DCWC0022	DCRC0829, 32-36	MMW	15	1.2	0.33	1.6	<50

Table 4: Water-Extraction-Testwork Results for Mine-Waste Samples

Note: All results in mg/L, except for pH and Electrical-Conductivity (EC).

ELEMENT/ PARAMETER	TW (GCA8907)	WAW (GCA8912)	WAMN (GCA8915)	WAMN (GCA8916)	MMW (GCA8918)
Major-Parameters					
pH	6.7 (6.7)	6.9	7.0	6.6	6.6
EC [µS/cm]	160 (170)	140	580	280	55
Major-Ions					
Na	14	14	37	20	7.8
K	13	7.7	21	15	1.6
Mg	4.7	5.2	31	14	1.9
Ca	6.4	6.3	61	21	1.8
Cl	29 (29)	20	57	34	5.0
SO_4	14	15	31	13	4.5

ELEMENT/ PARAMETER	TW (GCA8907)	WAW (GCA8912)	WAMN (GCA8915)	WAMN (GCA8916)	MMW (GCA8918)
Minor-Ions					
Fe	0.02	0.44	0.03	0.08	<0.01
Cu	<0.01	<0.01	<0.01	<0.01	<0.01
Ni	<0.01	<0.01	<0.01	<0.01	<0.01
Zn	0.03	<0.01	0.01	0.01	0.01
Co	0.0003	0.0009	0.0004	0.0004	0.0003
Al	0.02	<0.01	<0.01	<0.01	<0.01
Cd	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Pb	0.0057	0.0007	0.0019	0.0006	0.0008
Cr	<0.01	<0.01	<0.01	<0.01	<0.01
Hg	<0.0001	<0.0001	0.0006	0.0003	<0.0001
As	0.0016	0.0006	0.011	0.0008	<0.0001
Sb	0.00043	0.00009	0.00004	0.00009	0.00011
Bi	0.00016	0.000017	0.00028	0.000011	<0.000005
Se	0.0012	0.0010	0.0020	0.0008	0.0006
B	0.06	0.05	<0.01	0.03	0.07
Mo	0.00009	0.0012	<0.00005	<0.00005	<0.00005
P	<0.1	<0.1	<0.1	<0.1	<0.1
Si	8.5	3.9	1.8	4.2	5.7
Ag	0.00002	<0.00001	<0.00001	<0.00001	<0.00001
Ba	0.015	0.0071	0.0029	0.0021	0.012
Sr	0.039	0.036	0.17	0.052	0.014
Tl	0.00003	0.00001	0.00001	0.00001	0.00001
V	<0.01	<0.01	<0.01	<0.01	<0.01
Sn	0.0002	0.0002	0.0002	0.0002	0.0002
U	0.000012	0.00002	0.000012	<0.000005	<0.000005
Th	0.00003	0.000009	0.000012	0.000008	0.000008
Mn	0.01	0.16	0.07	0.11	0.03

Notes: Water-Extraction Testwork employed pulped-samples (nominal 75-µm), and slurries prepared using deionised-water, and a solid:solution ratio of *c.* 1:2 (w/w). Slurries were bottle-rolled for *c.* 1 day, prior to obtaining water-extracts (via vacuum-filtration) for analysis. Values in parentheses represent duplicates.

Table 5: Clay-Mineralogical and Clay-Surface-Chemistry Results for Mine-Waste Samples

TW (GCA8909)		WAW (GCA8913)		WAMN (GCA8916)	
kaolinite	dominant	goethite	dominant	goethite	dominant
	major	kaolinite	major	kaolinite	major
quartz	minor	hematite	minor	quartz	minor
hematite					
goethite	accessory			hematite	accessory
K-feldspar				muscovite	
		quartz	trace	K-feldspar	trace

TW (GCA8909)					WAW (GCA8913)					WAMN (GCA8916)				
eCEC [cmol (p+)/kg]	**%-Proportion of eCEC**				**eCEC [cmol (p+)/kg]**	**%-Proportion of eCEC**				**eCEC [cmol (p+)/kg]**	**%-Proportion of eCEC**			
	Na	**K**	**Mg**	**Ca**		**Na**	**K**	**Mg**	**Ca**		**Na**	**K**	**Mg**	**Ca**
13.4 (13.5)	5.4 (5.0)	3.2 (3.2)	47.3 (47.7)	44.1 (44.1)	4.3	13.5	7.5	33.7	45.4	2.7	5.6	1.4	32.7	51.2

Notes:
eCEC = effective-Cation-Exchange Capacity
dominant = greater than 50 %; major = 20-50 %; minor = 10-20 %; accessory = 2-10 %; and, trace = less than 2 %

MMW (GCA8918)	
quartz	dominant
goethite	major
hematite	accessory
kaolinite	trace

eCEC [cmol (p+)/kg]	**%-Proportion of eCEC**			
	Na	**K**	**Mg**	**Ca**
0.7	15.4	25.4	34.4	24.8

Notes:
eCEC = effective-Cation-Exchange Capacity
dominant = greater than 50 %; major = 20-50 %; minor = 10-20 %; accessory = 2-10 %; and, trace = less than 2 %

Table 6: Acid-Base-Analysis and Net-Acid-Generation Results for Low-Grade-Ore Samples

GCA-SAMPLE NO.	SITE-SAMPLE NO.	DRILLHOLE & DOWN-HOLE INTERVAL (m)	LITHOTYPE	pH-(1:2)	EC-(1:2) [mS/cm]	TOTAL-S (%)	TOTAL-C (%)	ANC	NAPP	NAG	NAG-pH	AFP CATEGORY
								kg H_2SO_4/tonne				
GCA8921	DCWC0023	DCRC0830, 52-56	MMLG	6.2	0.03	<0.01	0.07	4	nc	<0.5	6.2	NAF
GCA8922	DCWC0024	DCRC0703, 126-128	MMLG	6.2	0.035	<0.01	0.05	2	nc	<0.5	6.3	NAF
GCA8923	DCWC0011	DCRC0705, 184-186	MMLG	6.1	0.053	<0.01	0.03	2	nc	<0.5	6.1	NAF
GCA8924	DCWC0012	DCRC0700, 82-86	MMLG	6.2	0.037	<0.01	0.06	2	nc	<0.5 (<0.5)	6.2 (6.1)	NAF
GCA8925	DCWC0005	DCRC0706, 164-168	WALG	6.1	0.072	<0.01	0.08	4	nc	<0.5	6.6	NAF
GCA8926	DCWC0006	DCRC0698, 44-46	WALG	6.3	0.10	0.02	0.06	3	nc	<0.5	6.5	NAF
GCA8927	DCWC0017	DCRC0829, 16-18	WALG	5.9	0.098	0.03 (0.02)	0.17 (0.11)	3 (3)	nc	<0.5	5.9	NAF
GCA8928	DCWC0018	DCRC0828, 20-22	WALG	5.9 (5.9)	0.058 (0.059)	0.03	0.09	2	nc	<0.5 (<0.5)	5.6 (5.6)	NAF

Notes:

EC = Electrical Conductivity; ANC = Acid-Neutralisation-Capacity; NAPP = Net-Acid-Producing-Potential; AFP = Acid-Formation-Potential; NAF = Non-Acid-Forming; NAG = Net-Acid Generation; nm = not measured; nc = not calculated.
pH-(1:2) and EC-(1:2) values correspond to pH and EC measured on sample slurries prepared with deionised-water, and a solid:solution ratio of *c.* 1:2 (w/w).
All results expressed on a dry-weight basis, except for pH-(1:2), EC-(1:2), and NAG-pH.
Values in parentheses represent duplicates.

N.B. **WALG** = Lower-West-Angela-Low-Grade **MMLG** = Mt-Newman/McLeod-Low-Grade

Table 7: Multi-Element-Analysis Results for Low-Grade-Ore Samples

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)		AVERAGE-CRUSTAL ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)	
	MMLG (GCA8923)	WALG (GCA8925)		MMLG (GCA8923)	WALG (GCA8925)
Al	0.81%	2.9%	8.2%	0	0
Fe	51.1%	53.1%	4.1%	**3**	**3**
Na	0.0094%	0.013%	2.3%	0	0
K	0.0068%	0.18%	2.1%	0	0
Mg	0.077%	0.27%	2.3%	0	0
Ca	0.025%	0.044%	4.1%	0	0
Ag	<0.2	0.2	0.07	0	1
Cu	20	77	50	0	0
Zn	120	310	75	0	1
Cd	<0.1	0.4	0.11	0	1
Pb	23	43	14	0	1
Cr	10	31	100	0	0
Ni	2.0	49	80	0	0
Co	3.7	20	20	0	0
Mn	0.11	1.4%	950	0	**6**
Hg	0.01	0.04	0.05	0	0
Sn	0.3	0.9	2.2	0	0
Sr	5.2	38	370	0	0
Ba	11	190	500	0	0
Th	0.59	3.6	12	0	0
U	0.45	2.2	2.4	0	0
Tl	0.11	1.9	0.6	0	1
V	10	45	160	0	0
As	4.0	24	1.5	1	**3**
Bi	0.06	0.46	0.048	0	**3**
Sb	0.87	2.1	0.2	2	**3**
Se	0.02	0.08	0.05	0	0
Mo	1.7	1.0	1.5	0	0
B	<50	<50	10	0	0
P	300	820	1,000	0	0
F	140	250	950	0	0

Note:
Average-crustal abundance of elements based on Bowen (1979), and the Geochemical-Abundance Index (GAI) is based on Förstner *et al.* (1993). Refer Attachment II.

Table 8: Total-Contents of As, Sb, Se, Mo and B in Low-Grade-Ore Samples

GCA-SAMPLE NO.	SITE-SAMPLE NO.	DRILLHOLE & DOWN-HOLE INTERVAL (m)	LITHOTYPE	As (mg/kg)	Sb (mg/kg)	Se (mg/kg)	Mo (mg/kg)	B (mg/kg)
GCA8921	DCWC0023	DCRC0830, 52-56	MMLG	9.0	1.2	0.03	1.5	<50
GCA8922	DCWC0024	DCRC0703, 126-128	MMLG	10	0.63	0.24	2.0	<50
GCA8923	DCWC0011	DCRC0705, 184-186	MMLG	4.0	0.87	0.02	1.7	<50
GCA8924	DCWC0012	DCRC0700, 82-86	MMLG	10	1.6	0.25	2.3	<50
GCA8925	DCWC0005	DCRC0706, 164-168	WALG	24	2.1	0.08	1.0	<50
GCA8926	DCWC0006	DCRC0698, 44-46	WALG	110	3.5	0.76	4.3	<50
GCA8927	DCWC0017	DCRC0829, 16-18	WALG	26	5.8	0.19	6.0	<50
GCA8928	DCWC0018	DCRC0828, 20-22	WALG	11	1.6	0.29	1.2	<50

Table 9: Water-Extraction-Testwork Results for Low-Grade-Ore Samples

Note: All results in mg/L, except for pH and Electrical-Conductivity (EC).

ELEMENT/ PARAMETER	MMLG (GCA8923)	WALG (GCA8925)	ELEMENT/ PARAMETER	MMLG (GCA8923)	WALG (GCA8925)
Major-Parameters			***Minor-Ions***		
pH	6.4	6.6	Fe	0.21	0.02
EC [µS/cm]	130	210	Cu	<0.01	<0.01
			Ni	<0.01	<0.01
			Zn	0.01	0.01
Major-Ions			Co	0.0002	0.0002
			Al	0.04	<0.01
Na	15.0	17	Cd	0.00003	0.00005
K	1.4	7.7	Pb	<0.0005	0.0006
Mg	4.0	8.0	Cr	<0.01	<0.01
Ca	4.5	8.1	Hg	<0.0001	<0.0001
Cl	25	29	As	0.0002	0.0006
SO_4	5.1	11.0	Sb	0.00002	0.00003
			Bi	<0.000005	<0.000005
			Se	0.0008	0.0012
			B	0.12	0.05
			Mo	<0.00005	<0.00005
			P	<0.1	<0.1
			Si	3.8	3.8
			Ag	<0.00001	<0.00001
			Ba	0.0054	0.0049
			Sr	0.040	0.069
			Tl	0.00001	0.00002
			V	<0.01	<0.01
			Sn	0.0002	0.0002
			U	<0.000005	0.000005
			Th	0.000005	0.000006
			Mn	0.06	0.02

Notes: Water-Extraction Testwork employed pulped-samples (nominal 75-µm), and slurries prepared using deionised-water, and a solid:solution ratio of *c.* 1:2 (w/w). Slurries were bottle-rolled for *c.* 1 day, prior to obtaining water-extracts (via vacuum-filtration) for analysis. Values in parentheses represent duplicates.

ATTACHMENT I

STATISTICAL ASSESSMENT OF SULPHUR OCCURRENCES AND DETAILS OF SAMPLING PROGRAMME

Suite 10, 100 Mill Point Rd, South Perth WA 6151
Tel: (08) 9474 3770
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Memo

To: Graeme Campbell

From: Todd Tuffin

cc:

Date: 20-Dec-10 **Ref No:**

Re: Davidson Creek (Python-Gwardar Pit) - Preliminary Waste and Low Grade Stockpile Sulphur Geochemistry Study

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Preliminary work has been carried out on determining the likelihood of acid forming material (both waste and low grade) to accumulate on stockpiles during the mining of the Python-Gwardar pit at Davidson Creek. This first phase of work involved extracting “in-pit” (using the latest pit designs) sulphur assays from the database and analyzing the assays with respect to different geological/grade domains of waste and low grade material that are likely to be stockpiled separately during the mining phase. All extracted assays were 2m downhole composite samples taken during RC or core drilling programs.

Files Used to Domain Data

The following 3D solids, DTM’s and Surpac^{TM} string files were used to group the samples into their domains. All files are found on the Perth server in P:\Geology\Exploration\SURPAC\Waste Characterisation Study Jul2010\Python_Gwardar and were modeled in April and May 2010 at the time of the most recent resource calculation for the Davidson Creek deposits.

dcpgt_pd_stg6_oma1.dtm – pit design
detore.dtm – 3D solid of detrital Fe ore
bot_dc.dtm – dtm of the base of transported cover
mn.dtm – dtm of the upper contact of the Mt Newman Member
mnhc.dtm – 3D solid of Mt Newman Member hardcap Fe mineralisation
mnmin.dtm – 3D solid of Mt Newman Member high grade / low impurity primary Fe mineralization
wahc.dtm – 3D solid of Lower West Angela Member hardcap Fe mineralisation
wamin.dtm – 3D solid of Lower West Angela Member hardcap Fe mineralisation

Database

The drilling information was contained in the access database *Ferraus_SURPAC.mdb.* All S assays below detection limit (-0.01) changed to half detection (0.005), -0.005 to 0.0025, -0.001 to 0.0005, -0.0004 to 0.0002.

Domaining

In consultation with Graeme Campbell of Graeme Campbell & Associates Pty Ltd, six different domains (3 x waste and 3 x low grade) were classified as those potentially most likely to form discreet stockpiles during mining. These are as follows:

1. Waste – Transported cover.
2. Waste – Lower West Angela Member.
3. Waste – Mt Newman / McLeod Members (combined).
4. Low Grade Mn – Mn bearing Lower West Angela Member.
5. Low Grade Fe – Lower West Angela Member.
6. Low Grade Fe – Mt Newman / McLeod Member (combined).

Data Coding

The process of assay extraction from the database involved initially coding all drillholes within the database according to their position relative to all of the above modeled dtm's and 3D solid files. A separate table was created in the database called "Intersect" to contain the coded drillhole data, with codes placed in three different fields to represent:

a. Whether drillhole data was inside or outside the pit design dtm.
b. Whether drillhole data was transported, Lower West Angela or Mt Newman / McLeod Member material.
c. Whether drillhole data was within or outside modeled mineralisation 3D solids.

Data Compositing

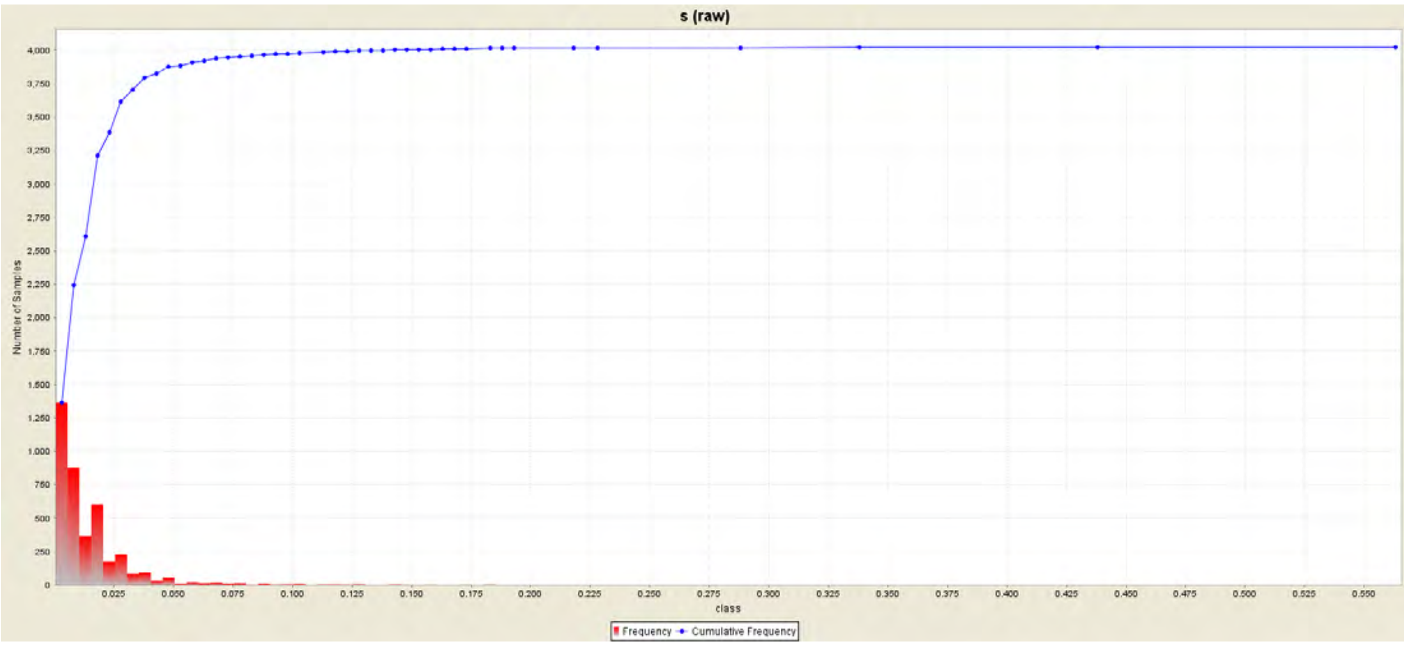
Once the data was coded, all drillhole records composites outside of the pit design and within mineralized solids were deleted from the Intersect table, leaving only in-pit waste and low-grade samples in the table. From this resultant table, data was composited into the six separate domains into the following Surpac™ string files:

1. *pg_waste_trans1.str*; Samples above bot_dc.dtm and outside of detore.dtm.
2. *pg_waste_lwa1.str;* Samples between bot_dc.dtm and mn.dtm, outside of wahc.dtm and wamin.dtm mineralisation solids and are <50% Fe and <5% Mn.
3. *pg_waste_mnmc1.*str; Samples below mn.dtm, outside mnhc.dtm and mnmin.dtm mineralisation solids and <50% Fe.
4. *pg_mang_lwa1.str;* Samples between bot_dc.dtm and mn.dtm, outside of wahc.dtm and wamin.dtm mineralisation solids and are >5% Mn regardless of Fe grade.
5. *pg_lowgrade_lwa1.str;* Samples between bot_dc.dtm and mn.dtm, outside of wahc.dtm and wamin.dtm mineralisation solids and are >50% Fe and <5% Mn.
6. *pg_lowgrade_mnmc1.str;* Samples below mn.dtm, outside mnhc.dtm and mnmin.dtm mineralisation solids and >50% Fe.

Statistical Summary

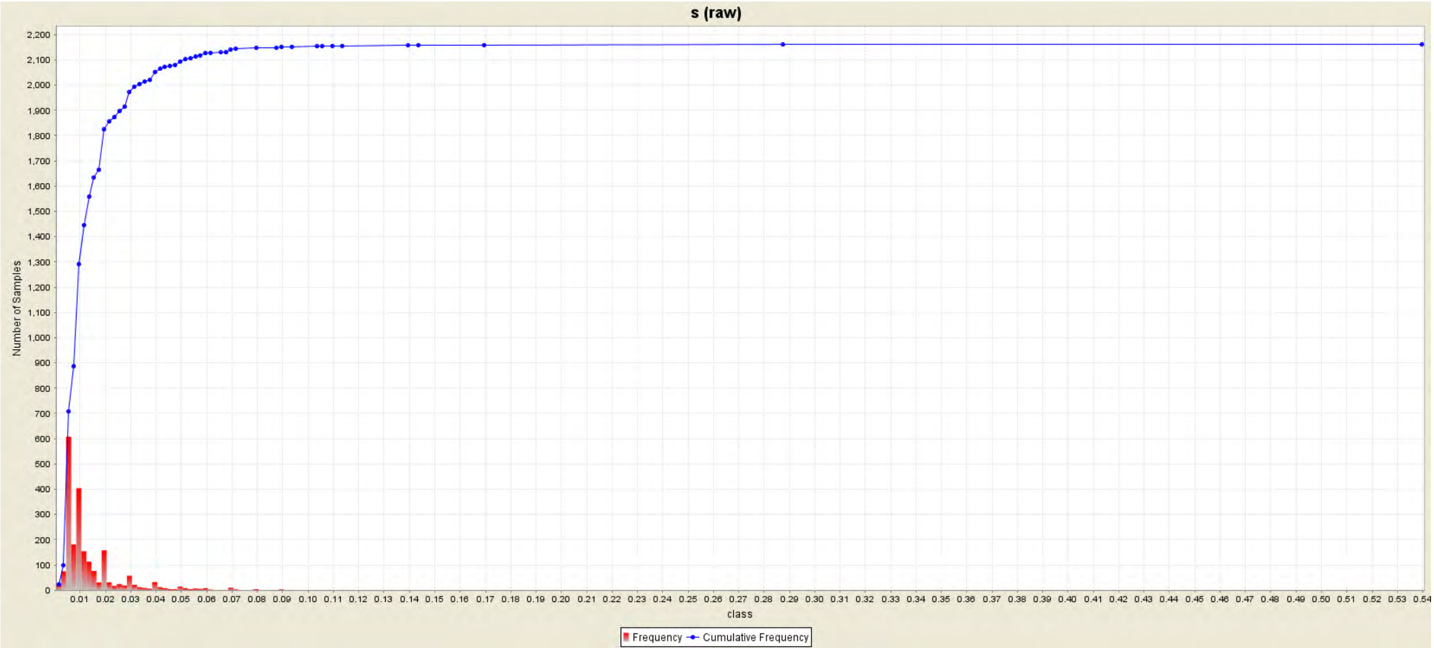
Transported cover - waste material (Fe<50%)

pg_waste_trans1.str	
Sulphur %	**Sample Count**
<0.0205	3209
0.0205-0.1005	764
0.1005-0.50	47
>0.50	1
Total	**4021**
Basic Stats	
Number of samples	4021
Minimum value	0.0005
Maximum value	0.564
Mean	0.016251
Median	0.01
Geometric Mean	0.01051
Variance	0.000532
Standard Deviation	0.023072
Coefficient of variation	1.419698



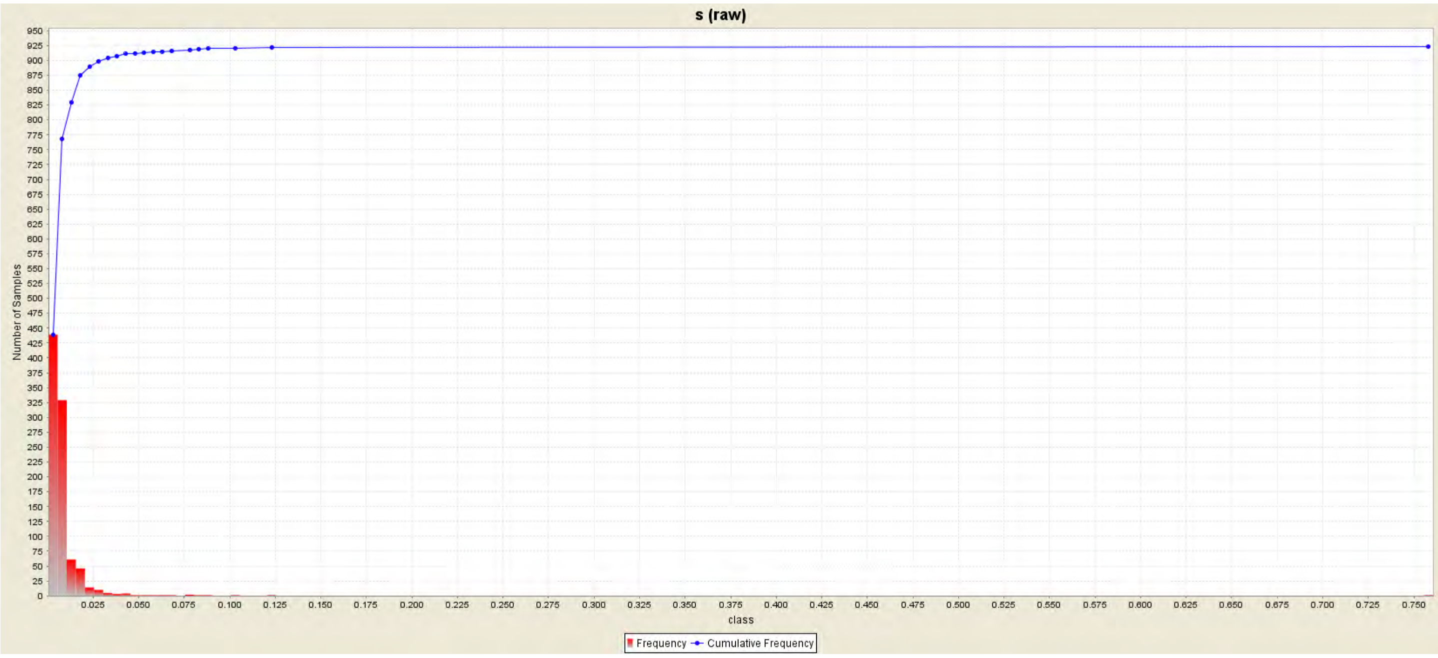
Lower West Angela Member – waste material (Fe <50%, Mn <5%)

pg_waste_lwa1.str	
Sulphur %	**Sample Count**
<0.0205	1824
0.0205-0.10	328
0.10-0.50	8
>0.50	1
Total	**2161**
Basic Stats	
Number of samples	2161
Minimum value	0.0005
Maximum value	0.54
Mean	0.014379
Median	0.01
Geometric Mean	0.010325
Variance	0.000363
Standard Deviation	0.019049
Coefficient of variation	1.324759



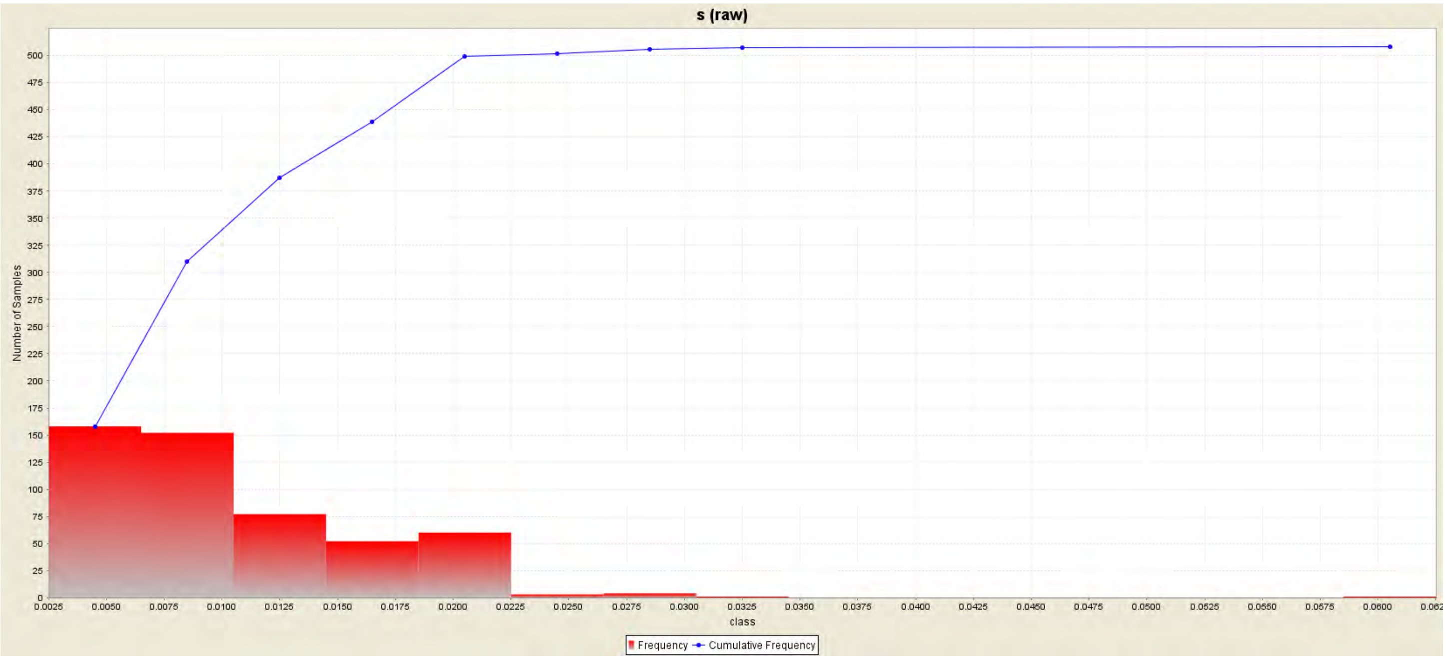
Mt Newman / Mc Leod Members – waste material (Fe <50%)

pg_waste_mnmc1.str	
Sulphur %	**Sample Count**
<0.0205	875
0.0205-0.10	45
0.10-0.50	2
>0.50	1
Total	**923**
Basic Stats	
Number of samples	923
Minimum value	0.0005
Maximum value	0.7601
Mean	0.00934
Median	0.006
Geometric Mean	0.006255
Variance	0.000708
Standard Deviation	0.026617
Coefficient of variation	2.849641



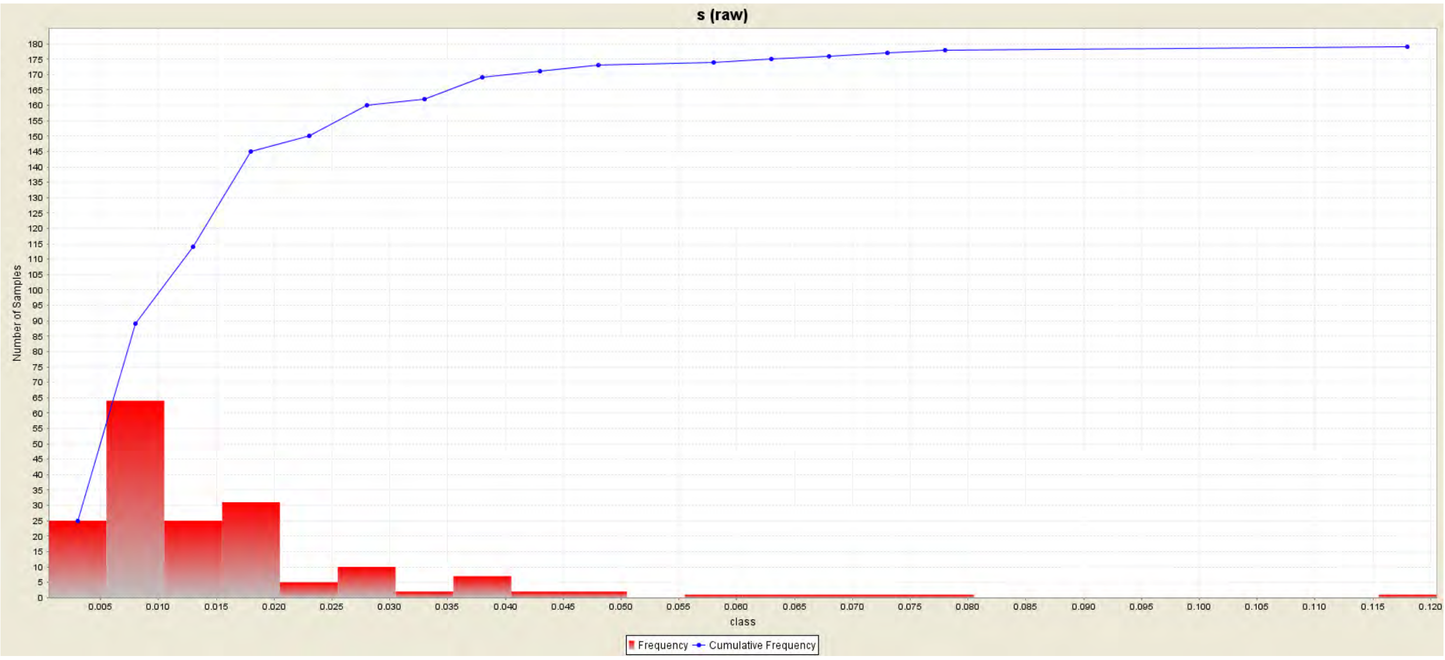
Lower West Angela Member – Manganese bearing material (Mn >5% irrespective of Fe)

pg_mang_lwa1.str	
Sulphur %	**Sample Count**
<0.0185	439
0.0185-0.1002	69
0.1002-0.50	0
>0.50	0
Total	**508**
Basic Stats	
Number of samples	508
Minimum value	0.0025
Maximum value	0.062
Mean	0.010712
Median	0.01
Geometric Mean	0.00937
Variance	3.50E-05
Standard Deviation	0.005915
Coefficient of variation	0.552174



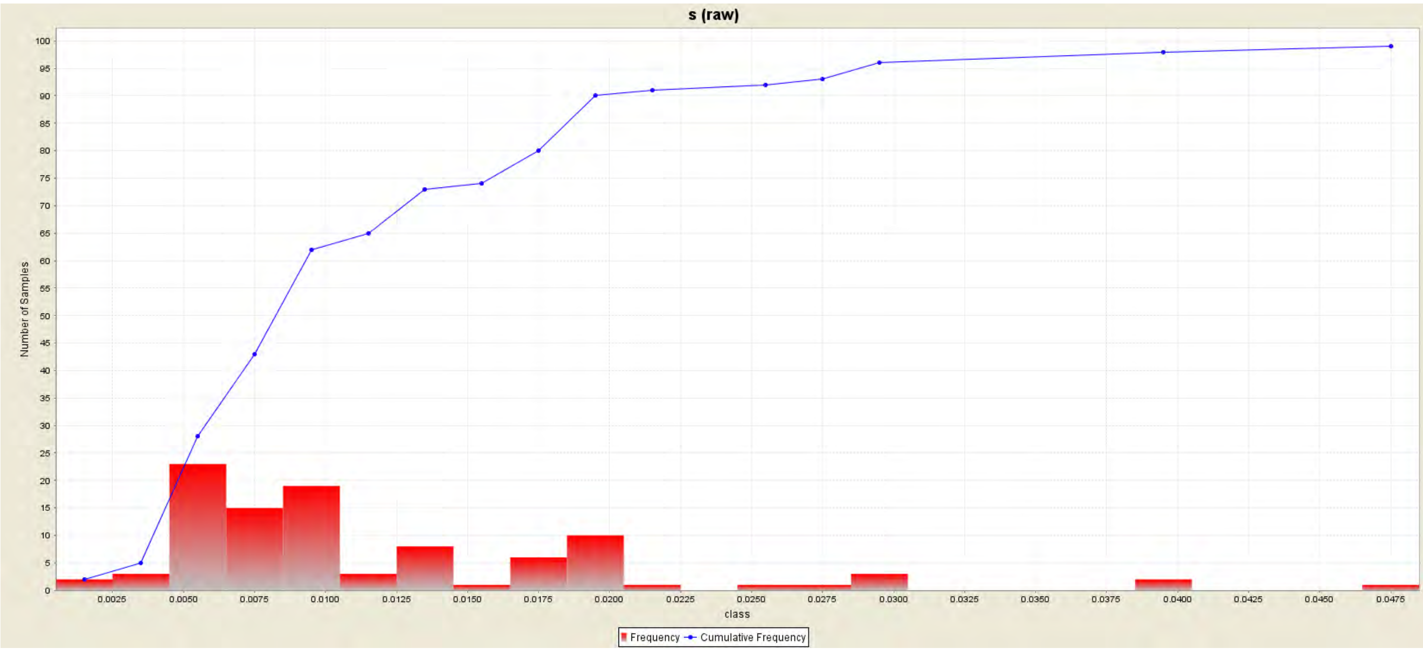
Lower West Angela Member – low grade material (Fe; 50-55%, Mn <5%)

pg_lowgrade_lwa1.str	
Sulphur %	**Sample Count**
<0.0205	145
0.0205-0.1002	33
0.1002-0.50	1
>0.50	0
Total	**179**
Basic Stats	
Number of samples	179
Minimum value	0.0005
Maximum value	0.118
Mean	0.016555
Median	0.0105
Geometric Mean	0.012378
Variance	0.000235
Standard Deviation	0.015342
Coefficient of variation	0.926748



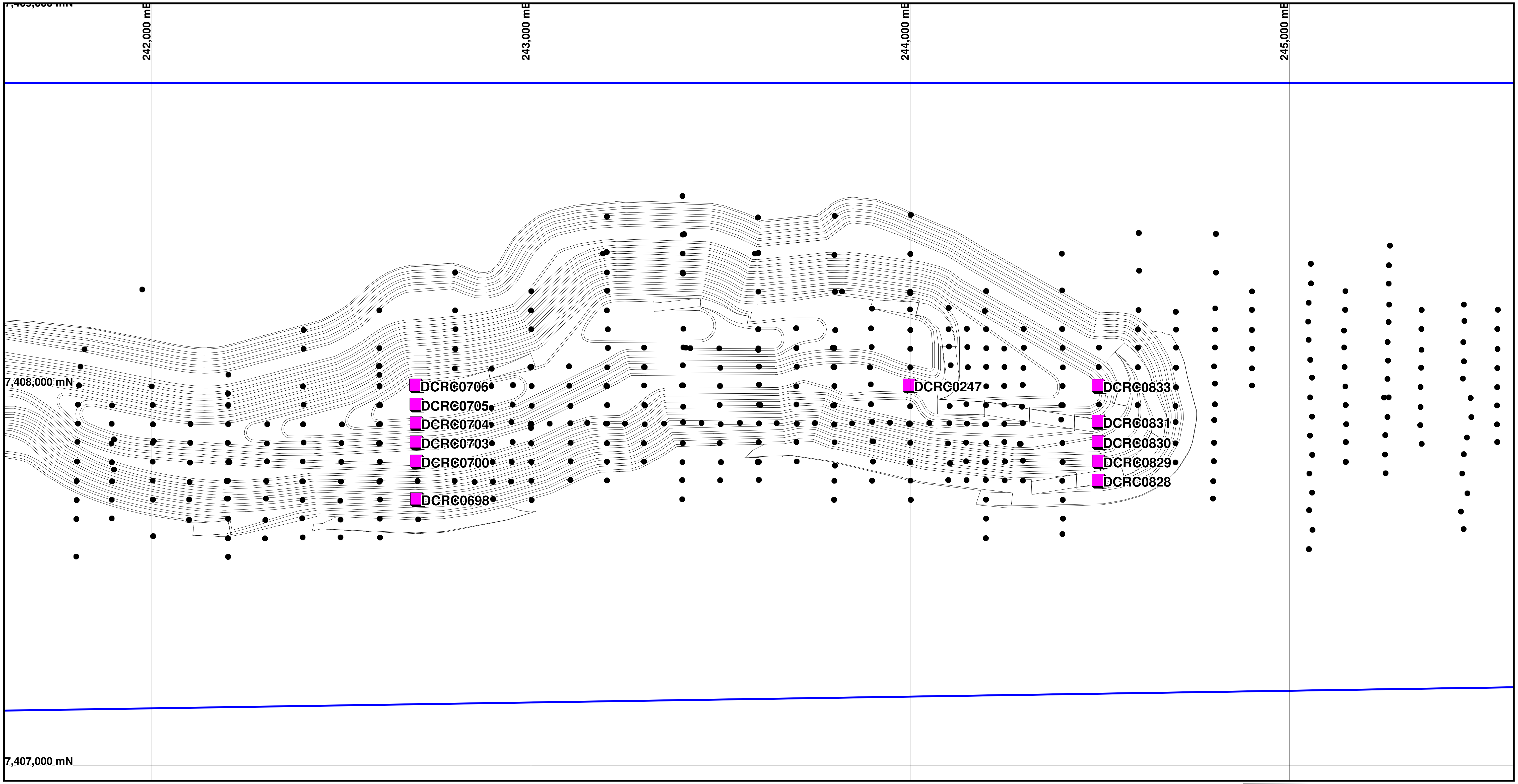
Mt Newman / Mc Leod Members – low grade material (Fe; 50-55%)

pg_lowgrade_mnmc1.str	
Sulphur %	**Sample Count**
<0.0205	90
0.0205-0.1002	9
0.1002-0.50	0
>0.50	0
Total	**99**
Basic Stats	
Number of samples	99
Minimum value	0.0005
Maximum value	0.047
Mean	0.012075
Median	0.0099
Geometric Mean	0.009762
Variance	7.05E-05
Standard Deviation	0.008396
Coefficient of variation	0.695334

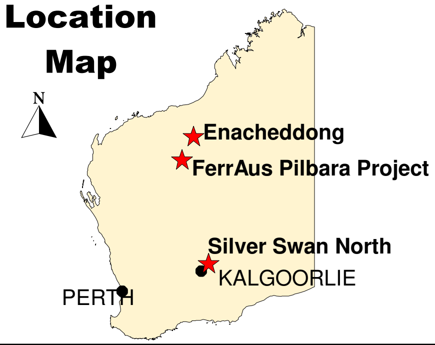


Summary

A total of 7891 in-pit samples made up the six different domains used in this preliminary study with the vast majority coming (as expected) from the Transported waste and Lower West Angela waste domains. Of these, 61 samples (0.77% of the total) were of material greater than 0.10% sulphur, with a peak of 0.76%.



Location Map



Davidson Creek Project
Python-Gwardar Pit
Waste Characterisation
Sample Locations

Author: T.Tuffin	Date: 13th August 2010
Drawn: .	Revised: .
Dwg No.: .	Report No.: .
Projection: GDA 94 (Zone 51)	Scale: 1:10,000

Hole ID	From(m)	To(m)	Sample Numbers	Code	Sample No
DCRC0706	68	72	RR75923, RR75924	TW	DCWC0001
DCRC0704	40	44	RR75706, RR75707	TW	DCWC0002
DCRC0833	12	16	RR82171, RR82172	TW	DCWC0013
DCRC0830	14	18	RR82025, RR82026	TW	DCWC0014
DCRC0698	16	20	RR75260, RR75261	WAW	DCWC0003
DCRC0706	82	86	RR75930, RR75931	WAW	DCWC0004
DCRC0828	14	18	RR81974, RR81975	WAW	DCWC0015
DCRC0831	24	28	RR82069, RR82070	WAW	DCWC0016
DCRC0705	134	138	RR75845, RR75846	WAMN	DCWC0007
DCRC0706	104	108	RR75942, RR75943	WAMN	DCWC0008
DCRC0704	160	164	RR75769, RR75770	MMW	DCWC0009
DCRC0699	34	38	RR75291, RR75292	MMW	DCWC0010
DCRC0833	92	96	RR82212, RR82213	MMW	DCWC0021
DCRC0829	32	36	RR82005, RR82006	MMW	DCWC0022
DCRC0830	52	56	RR82045, RR82046	MMLG	DCWC0023
DCRC0703	126	128	RR75673	MMLG	DCWC0024
DCRC0705	184	186	RR75871	MMLG	DCWC0011
DCRC0700	82	86	RR90072, RR90073	MMLG	DCWC0012
DCRC0706	164	168	RR75973, RR75974	WALG	DCWC0005
DCRC0698	44	46	RR90061	WALG	DCWC0006
DCRC0829	16	18	RR81997	WALG	DCWC0017
DCRC0828	20	22	RR81977	WALG	DCWC0018

Stratigraphy	Stockpile	Criteria	Code
Transported	Waste	<50% Fe	TW
Lower West Angela	Waste	<50% Fe, <5% Mn	WAW
Lower West Angela	Manganese bearing	>5% Mn	WAMN
Mt Newman/McLeod	Waste	<50% Fe	MMW
Lower West Angela	Low Grade	50-55% Fe, <5% Mn	WALG
Mt Newman/McLeod	Low Grade	50-55% Fe	MMLG

ATTACHMENT II

TESTWORK METHODS

ATTACHMENT II

TESTWORK METHODS

The testwork methods outlined below are proven approaches to 'static-testing' within the Australian, and international mining-industries (e.g. Price 2009; Stewart *et al.* 2006; AMIRA 2002; Morin and Hutt 1997).[1] The MEND-document prepared by Price (2009), and *c.* 10-20 years in the making by an experienced practitioner, is an invaluable source of information on testing methods on mine-waste geochemistry. There is also the Global-Acid-Rock-Drainage-Guide (GARD Guide) which is an INAP initiative (go to: www.gardguide.com). However, in terms of comprehensiveness, structure, and clarity, the document by Price (2009) is recommended.

Part of the acid-base-account (ABA) testing, and all of the multi-element analyses, and clay-surface-chemical determinations, are carried out by Genalysis Laboratory Services Pty Ltd [GLS] (Maddington). Specialised ABA-testing is undertaken by GCA (Bridgetown), and characterisation of rock- and clay-mineralogy is carried out by Roger Townend & Associates (Malaga), and CSIRO (Bentley), respectively.

Samples are crushed to 2mm (nominal) in a jaw/rolls-crusher, and pulverised to 75µm (nominal), for specific tests, as required. These sample-splits are referred to herein as "crushings" and "pulps", respectively.

It should be noted that the testwork methods described below are routinely employed in work programmes undertaken by GCA. However, the testwork methods described are generic, and specific tests may not necessarily be undertaken in a given study.

1.0 ACID-BASE-CHEMISTRY AND SALINITY TESTWORK

Acid-base chemistry and salinity are assessed by determining:

- pH and Electrical-Conductivity (EC) on sample slurries;
- Total-Sulphur (Total-S), and Sulphate-Sulphur (SO_4-S);
- Acid-Neutralisation-Capacity (ANC), and CO_3-C;
- pH-buffering properties;
- Net-Acid-Producing-Potential (NAPP); and,
- Net-Acid-Generation (NAG).

Relevant details of the testwork methods employed are discussed below. Further details are presented in the laboratory reports.

[1] 'Static'-testing' corresponds to "whole-rock" analyses and tests.

1.1 pH-(1:2) and EC-(1:2) Tests

Measurements of pH and EC are performed on slurries prepared using deionised-water, and a solid:water ratio of *c.* 1:2 (w/w). The slurries are allowed to age for *c.* 24 hours, prior to measuring pH and EC.[2] These tests are performed on the crushings.

pH-(1:2) and EC-(1:2) values provide a measure of the inherent acidity/alkalinity and salinity.[3]

1.2 Total-S and SO_4-S

Total-S is determined by Leco combustion (@ 1300 ^oC) with detection of evolved $SO_{2(g)}$ by infra-red spectroscopy. SO_4-S is determined by the Na_2CO_3-Extraction Method (Berigari and Al-Any 1994; Lenahan and Murray-Smith 1986).[4] The difference between Total-S and SO_4-S indicates the Sulphide-S (strictly Non-Sulphate-S) value. The Total-S and SO_4-S tests are performed on pulps.

1.3 Acid-Consuming Properties

1.3.1 ANC

ANC is determined by a procedure based on that of Sobek *et al.* (1978) which is the "standard" ANC-testing method (AMIRA 2002; Morin and Hutt 1997).

Samples (as crushings) are reacted with dilute HCl for *c.* 2 hours at 80-90 ^oC, followed by back-titration with NaOH to a pH=7 end-point to determine the amount of acid consumed.[5] The simmering step for *c.* 2 hours differs from the Sobek *et al.* procedure wherein test-mixtures are heated to near boiling until reaction is deemed to be complete, followed by boiling for one minute. In terms of the dissolution of carbonate- and primary-silicate-minerals, this variation to the Sobek *et al.* method is inconsequential.

The Sobek *et al.* (1978) procedure subjects samples to both strongly-acidic conditions (e.g. pH of 1-2), and a near-boiling temperature. Provided excess acid is added, the dissolution of carbonate-minerals is near-quantitative, and traces of primary-silicates

[2] The slurries are stirred at the beginning of the testwork, and once again immediately prior to measuring pH and EC.
[3] The pH-(1:2) values approximate the "Abrasion-pH" values for identifying minerals in the field (e.g. Stevens and Carron 1948).
[4] The Na_2CO_3-reagent extracts SO_4 which occurs as soluble sulphates, and calcium sulphates (e.g. gypsum and anhydrite). It also extracts SO_4 sorbed to the surfaces of sesquioxides, clays and primary-silicates. However, SO_4 present as barytes ($BaSO_4$) is not extracted, and SO_4 associated with jarositic-type and alunitic-type compounds is incompletely extracted.
[5] A few drops of 30 % (w/w) H_2O_2 are added to the test mixtures as the pH=7 end-point is approached, so that Fe(II) forms released by the acid-attack of ferroan-carbonates (and -silicates) are oxidised to Fe(III) forms (which then hydrolyse to "$Fe(OH)_3$"). This step ensures that the resulting ANC values are not unduly biased "on-the-high-side", due to the release of Fe(II) during the acid-digestion step (AMIRA 2002), provided that the ferroan-carbonate content is not excessive (e.g. siderite-C values less than 1.5 % [Stewart *et al.* 2006]).

also dissolve. However, at circum-neutral-pH (viz. pH 6-8) relevant to mine-waste and environmental management, the dissolution of primary-silicates is kinetically limiting (e.g. see review-monograph by White and Brantley [1995]).

In the absence of inhibiting alteration-rims, dissolution rates of mafic/felsic-silicates generally equate to H_2SO_4-consumption rates 'of-the-order' 10^{-11}-10^{-12} moles/m^2/s. Accordingly, for particle-sizes within the sub-mm range, circum-neutral-dissolution rates of primary-silicates correspond to Sulphide-Oxidation Rates (SORs) 'of-the-order' 1-10 mg SO_4/kg/week (= *c.* 0.1-1.0 kg H_2SO_4/tonne/year).[6] In practice, circum-neutral buffering through the surface-hydrolysis/dissolution of primary-silicates is therefore restricted to both particle-gradings akin to "rock-flour" (viz. sub-mm), and slow rates of sulphide-oxidation (e.g. as exhibited by "trace-sulphides" which are not atypically reactive).[7]

Despite aggressive-digestion conditions, the ANC values determined by the Sobek *et al.* (1978) method allow an informed "screening" of acid-consuming properties, especially when due regard is given to groundmass-mineralogy (Morin and Hutt 1997). Jambor *et al.* (2005, 2002, 2000) list 'Sobek-ANC' values for different types of primary-silicates which assists interpretation of ANC-testwork results.

That the ANC value is not an intrinsic property of a sample of geologic media, but rather the outcome of the particular ANC-testwork method employed, is shown by Morin and Hutt (2009).

1.3.2 CO_3-C

CO_3-C is the difference between the Total-C and Total-Organic-C (TOC). Total-C is measured by Leco combustion (@ 1300 ^oC) with detection of evolved $CO_{2(g)}$ by infra-red spectroscopy. TOC is determined by Leco combustion on a sub-sample which had been treated with strong HCl to decompose carbonate-minerals. Pulps are used for these determinations.

1.3.3 pH-Buffering Properties

pH-Buffering properties are determined via a Metrohm® 736 Titrino auto-titrator, and 0.05 M-H_2SO_4. Auto-titrations comprise regular addition of H_2SO_4 to decrease the pH values of the test-suspensions (prepared using pulps) to 3.0 typically over the course of

[6] SORs of this magnitude (at circum-neutral-pH) would typically only be recorded for the oxidation of "trace-sulphides" (e.g. Sulphide-S contents less than *c.* 0.5 %) which are not hyper-reactive, and so excludes *inter alia* framboidal-pyrite, and marcasite.

[7] Primary-particle-sizes within the "rock-flour" range is a given for process-tailings-solids. In the case of mine-wastes, despite its usually small weight-based abundance, this size-fraction is invariably the main seat of geochemical-weathering reactions within waste-dumps, and thereby the main "source-term" for solute generation (e.g. Price and Kwong 1997). Such "rock-flour" occurs in two forms: that obtained via dry-sieving, and that associated with the surfaces of clasts of wide-ranging sizes, and which can only be obtained via wet-sieving.

c. 1 day.[8] Despite taking up to 1 day to complete, the H_2SO_4-addition rates employed in the auto-titrations are 'orders-of-magnitude' faster than the sulphide-oxidation rates typically observed under "ambient-weathering" conditions.

1.4 NAPP Calculations

NAPP values are calculated from Total-S, SO_4-S and ANC values, assuming that **all** of the Sulphide-S occurs in the form of pyrite, and/or pyrrhotite. NAPP values facilitate assessment of Acid-Formation Potential (AFP).

The complete-oxidation of pyrite (and/or marcasite) may be described by:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O = 2H_2SO_4 + \text{"}Fe(OH)_3\text{"}$$

The complete-oxidation of pyrrhotite may be described by:

$$\text{"}FeS\text{"} + 9/2O_2 + 5/2H_2O = H_2SO_4 + \text{"}Fe(OH)_3\text{"}$$

Since pyrrhotite is non-stoichiometric, expressing it as "FeS" is approximate (Janzen *et al.* 2000). Elemental-S may also be produced during pyrrhotite weathering (Nicholson and Scharer 1994), especially at low-pH. However, Elemental-S is ultimately oxidised to H_2SO_4.

It may be shown that, if the Sulphide-S (in %S) occurs as pyrite/pyrrhotite, then the amount of acid (in kg H_2SO_4/tonne) produced through complete-oxidation is given by **30.6 x %S**. That is, the same conversion-factor of 30.6 applies for both pyrite-, and pyrrhotite-oxidation.

> Note: The above treatment of oxidation-reaction stoichiometry is restricted to oxidation by 'atmospheric-O_2' which is the dominant oxidant at circum-neutral-pH. A different oxidation-stoichiometry applies under acidic conditions (e.g. pH less than 3-4) where soluble-Fe(III) forms prevail, and then function as the chief oxidant (e.g. Rimstidt and Newcomb 1993).

Mechanistic aspects of pyrite- and pyrrhotite-oxidation were reviewed by Rimstidt and Vaughan (2003), and Belzile *et al.* (2004), respectively.

1.5 NAG Tests

The NAG Test is a direct measure of the potential for acid-production through sulphide-oxidation, and also provides an indication of the reactivity of the sulphide-minerals, and the availability of alkalinity-forms (AMIRA 2002; Miller *et al.* 1997, 1994). Since this test is performed on pulps, sulphide-grains are fully liberated, and available for reaction.

[8] In titrating to a pH=3.0 end-point, any Fe(II) released through acid attack of ferroan-carbonates and -silicates is not quantitatively oxidised to Fe(III), and subsequently hydrolysed/precipitated to "$Fe(OH)_3$". The equivalent of *c.* 0.5 kg H_2SO_4/tonne is generally required to decrease the pH of the "solution-only" to pH=3.0. No correction is made for this "electrolyte-consumption" of H_2SO_4.

The sample is reacted with H_2O_2 to oxidise sulphide-minerals, and allow the produced acid to react with the acid-neutralising components (chiefly carbonate-minerals). The results from NAG testwork supplement the NAPP-based assessment of AFP (Stewart *et al.* 2006; Shaw 2005; Morin and Hutt 1997).

The NAG-testing methodology used by GCA is the 'Static-NAG Test' in its "single-addition" mode, with NaOH-titration to a pH=7 end-point (AMIRA 2002; Miller *et al.* 1994, 1997). The Start-pH of the 15 % (v/v) H_2O_2 solution (prepared from A.R.-grade H_2O_2) is adjusted to pH=4.5 using 0.1 M-NaOH. The boiling treatment to decompose residual, unreacted-H_2O_2 following overnight reaction is carried out in two stages (viz. boiling for *c.* 2 hours initially, cooling and addition of 1 mL of 0.02 M-$CuSO_4$, followed by boiling for a further *c.* 2 hours). The addition of Cu(II) catalyses the decomposition of unreacted-H_2O_2, and thereby prevents "positive-blank" values (O'Shay *et al.* 1990).[9]

Prior to the boiling steps, the pH values of the test-suspensions are measured. Such pH values reflect buffering under ambient conditions without accelerated dissolution of groundmass-minerals through boiling. In the interpretation of NAG-testwork results, it is important to note the pH values prior to the boiling steps, especially for lithotypes characterised by "trace-sulphides" (e.g. Sulphide-S within the sub-% range), and ANC values less than *c.* 10-20 kg H_2SO_4/tonne (e.g. a groundmass devoid of carbonate-minerals). The rates of "peroxide-oxidation" are orders-of-magnitude faster than those of "ambient-oxidation" (viz. SORs recorded in kinetic-testing employing Weathering-Columns). If circum-neutral-pH is to prevail during NAG testwork, then the rate of acid-consumption must be proportionately faster than that for "ambient-oxidation", and is essentially restricted to buffering by reactive-carbonate-minerals (e.g. calcites, dolomites, and ankerites). This aspect must be borne in mind when interpreting NAG-testwork results, especially for samples that contain "trace-sulphides" in a carbonate-deficient groundmass.

2.0 MULTI-ELEMENT ANALYSES

The total content of a wide range of major- and minor-elements are determined through the use of various digestion and analytical techniques. The respective detection-limits are appropriate for environmental investigations.

Element enrichments are identified using the *Geochemical Abundance Index (GAI)*.[10] The GAI quantifies an assay result for a particular element in terms of the average-

[9] Where samples contain sufficient Cu(II), then Cu(II) forms will be released to solution during reaction with H_2O_2, especially at low-pH.

[10] The GAI was developed by Förstner *et al* (1993), and is defined as:

$$GAI = \log_2 [C_n/(1.5 \times B_n)]$$

where:

C_n = measured content of n-th element in the sample.

B_n = "background" content of the n-th element in the sample.

crustal-abundance of that element.[11] The latter corresponds to the typical composition of soils, regoliths and bedrocks derived from unmineralised terrain.

The GAI (based on a log-2 scale) is expressed in 7 integer increments (viz. 0 to 6). A GAI of 0 indicates that the content of the element is less than, or similar to, the average-crustal-abundance; a GAI of 3 corresponds to a 12-fold enrichment above the average-crustal-abundance; and so forth, up to a GAI of 6 which corresponds to a 96-fold, or greater, enrichment above average-crustal-abundances.

3.0 MINERALOGY AND CLAY-SURFACE CHEMISTRY

The semi-quantitative mineralogy, and clay-surface chemistry (generally restricted to waste-regoliths, oxide-ores, and/or soils), are determined using methods routinely used in geology, and soil science.

Indicative abundances of mineral fall into one of the following broad classes, viz.

- dominant — greater than 50 %
- major — 20-50 %
- minor — 10-20 %
- accessory — 2-10 %
- trace — less than 2 %

Randomly- and preferentially-oriented specimens are prepared, and variously treated with sodium-hexametaphosphate (dispersant), ethylene-glycol, and heating, to quantify non-expansive, and expansive (e.g. smectites), varieties of clay-minerals.

The Effective-Cation-Exchange Capacity (eCEC), and suite of Exchangeable-Cations, are determined by different methods for samples (as crushings) of non-calcareous and calcareous materials (Rengasamy and Churchman 1999). In both cases, soluble-salts are initially removed via pre-washing using a "mixed-organic-solvent" (viz. ethylene-glycol and ethanol). Method 15A2 in Rayment and Higginson (1992) is then employed for non-calcareous samples to determine eCEC, and Exchangeable-Sodium Percentage (ESP). In the case of calcareous samples, a method based on that described by Pierce and Morris (2004) is used, and prevents the dissolution of carbonate-minerals (e.g. calcites and dolomites).[12] After the initial pre-washing step above, extraction is carried out with 1 M-NH_4Cl buffered at pH=8.5 in an ethanolic-aqueous solution. Without such precautions to suppress dissolution of carbonate-minerals, the eCEC is biased "on-the-high-side", and ESP biased "on-the-low-side". Depending on the abundance and nature of the carbonate-minerals, the magnitude of this bias can be marked.

[11] The average-crustal-abundances of the elements for the GAI calculations are based on the values listed in Bowen (1979).

[12] The procedure described by Pierce and Morris (2004) is closely related to that originally developed by Tucker (1974).

4.0 WATER-EXTRACTION TESTWORK

The contents of water-extractable solutes in selected samples were determined via bottle-roll testwork employing the crushings, and deionised-water. The test-slurries had a solid:solution ratio of *c.* 1:2 (w/w), and were bottle-rolled for *c.* 1 day before being left to "still-stand" for *c.* 1 day to allow suspended mineral-fines to settle. The resulting supernatants were then decanted, vacuum-filtered (0.45µm-membrane), and preserved, as appropriate, for specific analyses. Where required, centrifuging at *c.* 4,000 G for 30 minutes was undertaken to expedite solid-solution separation for vacuum-filtration. The Water-Extraction Testwork was performed in the GCA-Testing Laboratory.

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ATTACHMENT III

ACID-FORMATION POTENTIAL (AFP):

CALCULATED PARAMETERS AND CLASSIFICATION CRITERIA

ATTACHMENT III

ACID-FORMATION POTENTIAL (AFP):

CALCULATED PARAMETERS AND CLASSIFICATION CRITERIA

Notes: The geochemically-based parameters, and AFP-classification criteria, indicated below apply equally to samples of mine-wastes (e.g. waste-regoliths and waste-bedrocks), low-grade-ores, and process-tailings-solids. The generic descriptor "test-sample" is employed below.

1.0 CALCULATED PARAMETERS

Maximum-Potential-Acidity (MPA) values (in kg H_2SO_4/tonne) of test-samples are typically calculated by multiplying the Sulphide-S values (in %) by 30.6. The multiplication-factor of 30.6 reflects both the reaction stoichiometry for the complete-oxidation of pyrite, by O_2 to "$Fe(OH)_3$" and H_2SO_4, and the different weight-based units of %, and kg H_2SO_4/tonne.

Net-Acid-Producing-Potential (NAPP) values (in kg H_2SO_4/tonne) are calculated from the corresponding MPA and Acid-Neutralisation-Capacity (ANC) values (i.e. NAPP = MPA - ANC).

2.0 CLASSIFICATION CRITERIA

In terms of AFP, test-samples may be classified into one of the following categories, viz.

- Non-Acid Forming (NAF)
- Potentially-Acid Forming (PAF)

There are **no** unifying, "standard" criteria for classifying the AFP of test-samples (e.g. Price 2009; AMIRA 2002), and reflects the diversity of sulphide- and gangue-mineral assemblages within (un)mineralised-lithotypes of varying weathering- and alteration-status. Rather, criteria for classifying AFP may need to be tailored to deposit-specific geochemistry, mineralogy, and site-specific climate.

The AFP-classification criteria often employed at mining-operations worldwide are:

- **NAF**: Sulphide-S < 0.3 %. For Sulphide-S ≥ 0.3 %, both a negative NAPP value, and an ANC/MPA ratio ≥ 2.0
- **PAF**: For Sulphide-S ≥ 0.3 %, any positive-NAPP value; negative-NAPP value with an ANC/MPA ratio < 2.0

In assessing AFP, lithotypes from hard-rock mines with Sulphide-S values less than 0.3 % are unlikely to acidify (e.g. pH less than 4-5) through sulphide-oxidation. This position holds especially where the groundmass hosting the "trace-sulphides" is not simply quartz, soil-clays, and/or sesquioxides (Price *et al.* 1997), and where the sulphide-minerals are not hyper-reactive varieties (e.g. framboidal-pyrite). A "cut-off" of 0.3 % for Sulphide-S also accords with the findings of kinetic-testing, since the late-1980s, by Dr. Graeme Campbell for test-samples of diverse mineralogy in terms of sulphide-weathering dynamics, and solubility behaviour.

The risk posed by PAF-lithotypes during the active-mine-life is governed primarily by the duration of the lag-phase (i.e. the period during which sulphide-oxidation occurs, but acidification does not develop, due to circum-neutral buffering by gangue-phases [chiefly reactive-carbonate-minerals]).[1] Although the duration of the lag-phase for mine-wastes at field-scale cannot be accurately predicted *a priori*, estimates may still be needed to identify threshold exposure-times for the safe handling of PAF-lithotypes. Lag-phase duration may be estimated via kinetic-testing (viz. Weathering-Columns), and consideration of the moisture/aeration/thermal-regimes of exposed (i.e. uncovered) mine-wastes under the site's climatic conditions. In the absence of results from kinetic-testing, experience permits "first-pass" estimates of sulphide-oxidation rates and lag-phase duration to be made from the results of static-testing, and thereby classify PAF-lithotypes into **PAF-[Short-Lag]** and **PAF-[Long-Lag]** sub-categories. Such "first-pass" estimations are necessarily provisional, and subject to revision, in the light of the outcomes of kinetic-testing, and field observations.

3.0 REFERENCES

AMIRA International Ltd, 2002, "ARD Test Handbook", Prepared by Ian Wark Research Institute, and Environmental Geochemistry International Pty Ltd

Price W, 2009, "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials", MEND Report 1.20.1

Price WA, Morin K and Hutt N, 1997, "Guidelines for the Prediction of Acid Rock Drainage and Metal Leaching for Mines in British Columbia: Part II. Recommended Procedures for Static and Kinetic Testing", pp. 15-30 in "Proceedings of the Fourth International Conference on Acid Rock Drainage", Volume I, Vancouver

[1] SO_4 is still produced by sulphide-oxidation during the lag-phase, and appreciable amounts of soluble-forms of certain minor-elements (e.g. Ni and As) may be released at circum-neutral-pH during lag-phase weathering. However, in the latter case, the mine-wastes would need to be sufficiently enriched in Total-Ni and Total-As to begin with.

ATTACHMENT IV

LABORATORY REPORTS

Intertek

GENALYSIS LABORATORY SERVICES

Dr G Campbell
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	143/1011294
No. of SAMPLES	22
CLIENT O/N	GCA1018/2
PROJECT	Python Gwarda Deposit
STATE	Mine waste
DATE RECEIVED	23/08/2010
DATE COMPLETED	30/09/2010

The samples were received as pulps

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
( ) = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
> = Value beyond Limit of Method

Results of analysis on:

Element		S	S-SO4	C	TOC+C	C-CO3
Method		Ind/IR	Na2CO3/GRAV	Ind/IR	HotAcidInd/IR	/CALC
Detection		0.01	0.01	0.01	0.01	0.01
Units		%	%	%	%	%
Sample Name						
Control Blank		X		0.02		
GCA8907		X		0.06		
GCA8907	check	X		0.05		
GCA8908		0.15	0.1	0.22	0.13	0.09
GCA8909		X		0.02		
GCA8910		X		0.04		
GCA8911		0.04		0.15		
GCA8912		X		0.19		
GCA8913		0.03		0.11		
GCA8914		0.03		0.17		
GCA8915		0.01		0.18		
GCA8916		X		0.09		
GCA8917		X		0.03		
GCA8918		X		0.09		
GCA8919		X		0.04		
GCA8920		X		0.05		
GCA8921		X		0.07		
GCA8922		X		0.05		
GCA8923		X		0.03		
GCA8924		X		0.06		
GCA8925		X		0.08		
GCA8926		0.02		0.06		
GCA8927		0.03		0.17		
GCA8927	check	0.02		0.11		
GCA8928		0.03		0.09		
CD-1		3.25		0.19		
OREAS 45P		0.02		2.27		
PD-1			1.06			
S_SO4_B			1.26			
S_SO4_A			0.55			

Notes:
1. The C, S results were determined from the pulverised portion
2. The Carbon and Sulphur was determined according to Genalysis method number MPL_W043
3. S-SO4 was determined by precipitation of BaSO4 according to Genalysis method number ENV_W039
4. TOC+C (acid insoluble carbon compounds and elemental carbon) by a C&S analyser after removal of carbonates and soluble organic carbon according to Genalysis method number MPL_W046. This method is not covered by the NATA scope of accreditation

Results of analysis on:

sample		Fizz	volume	HCl	NaOH	Colour	ANC	pH	ANC
name		Rate	HCl	M	M	Change	soln pH	Drop	(kgH2SO4/t)
GCA8907		0	8	0.50	0.20	N	1.7		2
GCA8907	check	0	8	0.50	0.20	N	1.7		2
GCA8908		0	8	0.50	0.20	N	1.6		2
GCA8909		0	8	0.50	0.20	N	1.7		4
GCA8910		0	8	0.50	0.20	N	1.6		4
GCA8911		0	8	0.50	0.20	N	1.8		3
GCA8912		0	8	0.50	0.20	N	1.6		1
GCA8913		0	8	0.50	0.20	N	1.6		4
GCA8914		0	8	0.50	0.20	N	1		3
GCA8915		0	8	0.50	0.20	N	1.8		14
GCA8916		0	8	0.50	0.20	N	1.5		10
GCA8917		0	8	0.50	0.20	N	1.6		1
GCA8918		0	8	0.50	0.20	N	1.5		4
GCA8919		0	8	0.50	0.20	N	1.4	3.3	1
GCA8920		0	8	0.50	0.20	N	1.7		4
GCA8921		0	8	0.50	0.20	N	1.7		4
GCA8922		0	8	0.50	0.20	N	1.6		2
GCA8923		0	8	0.50	0.20	N	1.7		2
GCA8924		0	8	0.50	0.20	N	1.7		2
GCA8925		0	8	0.50	0.20	N	1.6		4
GCA8926		0	8	0.50	0.20	N	1.7		3
GCA8927		0	8	0.50	0.20	N	1.8		3
GCA8927	check	0	8	0.50	0.20	N	1.8		3
GCA8928		0	8	0.50	0.20	N	1.7		2

Notes:

1. ANC was determined on 2g of the pulp. Acid concentrations are as stated.
2. Colour change: Y indicates the appearance of a green colouration as the pH=7 endpoint was approached. N no change. Two drops of hydrogen peroxide are added to each sample as the endpoint is approached to oxidise any ferrous iron
3. pH drop : Result reported when the pH drops to a value below 4 on addition of peroxide
4. This procedure according to Genalysis method number ENV_W035

NATA ENDORSED DOCUMENT
Company Accreditation Number 3244
The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.

NATA Signatory: Ann Evers

Ann Evers

Date: 30/09/2010

This document is issued in accordance with NATA accreditation requirements.

Graeme Campbell & Associates Pty Ltd

Laboratory Report

pH-(1:2) & EC-(1:2) TESTWORK

SAMPLE NO.	SAMPLE WEIGHT (g)	SAMPLE + DEION.-W WEIGHT (g)	pH-(1:2)	EC-(1:2) (µS/cm)
GCA8907	30.0	60.0	5.8	78
GCA8908	30.0	60.0	5.4	39
GCA8909	30.0	60.0	6.0	17
GCA8910	30.0	60.0	5.9	82
GCA8911	30.0	60.0	6.0	160
GCA8912	30.0	60.0	6.0	60
GCA8913	30.0	60.0	6.0	75
GCA8914	30.0	60.0	6.1	59
GCA8915	30.0	60.0	6.6	180
GCA8916	30.0	60.0	6.4	100
GCA8917	30.0	60.0	6.5	43
GCA8917-1	30.0	60.0	6.5	42
GCA8918	30.0	60.0	6.5	28
GCA8919	30.0	60.0	6.4	31
GCA8920	30.0	60.0	6.3	36
GCA8921	30.0	60.0	6.2	30
GCA8922	30.0	60.0	6.2	35
GCA8923	30.0	60.0	6.1	53
GCA8924	30.0	60.0	6.2	37
GCA8925	30.0	60.0	6.1	72
GCA8926	30.0	60.0	6.3	100
GCA8927	30.0	60.0	5.9	98
GCA8928	30.0	60.0	5.9	58
GCA8928-1	30.0	60.0	5.9	59

Note: EC = Electrical-Conductivity.
Testwork performed on the as-supplied 'pulp' samples (nominal -75 µm).
pH-(1:2) and EC-(1:2) values correspond to pH and EC values of suspensions with a solid:solution ratio of *c.* 1:2 (w/w) prepared using deionised-water.
Drift in pH-glass-electrode less than 0.1 pH unit between commencement, and completion, of testwork.
Drift in EC-electrode less than 5 µS/cm between commencement, and completion, of testwork.
Testwork performed in a constant-temperature room (viz. 21 +/- 2-3 ^{o}C).

Dr GD Campbell
17th September 2010

Graeme Campbell & Associates Pty Ltd

Laboratory Report

NET-ACID-GENERATION (NAG) TESTWORK

Sample Number	Sample Weight (g)	Comments	pH of Test Mixture Before Boiling Step	Test Mixture After Boiling Step		Titre [0.1 M-NaOH] (mL)	NAG (kg H_2SO_4/ tonne)
				pH	EC (µS/cm)		
GCA8907	3.0	No observed reaction	5.1	6.0	42	0.20	<0.5
GCA8908	3.0	No observed reaction	4.0	5.2	18	0.40	<0.5
GCA8909	3.0	No observed reaction	5.9	6.5	19	0.20	<0.5
GCA8910	3.0	No observed reaction	5.6	6.4	34	0.20	<0.5
GCA8911	3.0	No observed reaction	5.5	6.7	28	0.10	<0.5
GCA8912	3.0	No observed reaction	4.4	6.1	17	0.10	<0.5
GCA8913	3.0	No observed reaction	5.4	6.4	22	0.20	<0.5
GCA8914	3.0	No observed reaction	5.5	6.5	20	0.10	<0.5
GCA8915	3.0	Boiled in 10 seconds!!	7.7	8.1	43	-	<0.5
GCA8916	3.0	No observed reaction	7.2	7.3	34	-	<0.5
GCA8917	3.0	No observed reaction	5.1	6.4	19	0.10	<0.5
GCA8918	3.0	No observed reaction	4.9	6.0	15	0.20	<0.5
GCA8919	3.0	No observed reaction	5.0	5.9	13	0.20	<0.5
GCA8920	3.0	No observed reaction	5.4	6.3	20	0.20	<0.5
GCA8921	3.0	No observed reaction	5.3	6.2	17	0.20	<0.5
GCA8922	3.0	No observed reaction	5.2	6.3	16	0.10	<0.5
GCA8923	3.0	Reaction peaked overnight	6.1	6.1	19	0.20	<0.5
GCA8924	3.0	No observed reaction	5.3	6.2	17	0.20	<0.5
GCA8924-1	3.0	No observed reaction	5.3	6.1	17	0.10	<0.5
BLANK3	3.0	Reaction peaked overnight	5.6	7.1	36	-	<0.5

Notes: Test conditions based on those described by Miller *et al.* (1997), and AMIRA (2002) for the 'Static-NAG-Test' in its "Single-Additon-Mode". The pH of the 15 % (v/v) H_2O_2 solution was adjusted to 4.5 using 0.1 M-NaOH prior to commencing the NAG Tests. Following an overnight-reaction period, the test-mixtures were boiled for *c.* 2 hours. Then, after allowing the test-mixtures to cool, *c.* 1.0 mL of 0.016 M-$CuSO_4$ solution was added, and the test-mixtures again boiled for *c.* 2 hours. The addition of Cu(II) catalyses the decomposition of any residual, unreacted-H_2O_2 in the test-mixtures (McElnea and Ahern 2004; O'Shay *et al.* 1990). K-Feldspar was employed for the Blank.

Dr GD Campbell
27th September 2010

NET-ACID-GENERATION (NAG) TESTWORK

Sample Number	Sample Weight (g)	Comments	pH of Test Mixture Before Boiling Step	Test Mixture After Boiling Step		Titre [0.1 M-NaOH] (mL)	NAG (kg H_2SO_4/ tonne)
				pH	EC (µS/cm)		
GCA8925	3.0	Reaction peaked within 15 minutes	7.8	6.6	38	0.10	<0.5
GCA8926	3.0	No observed reaction	5.7	6.5	28	0.10	<0.5
GCA8927	3.0	No observed reaction	5.4	5.9	29	0.10	<0.5
GCA8928	3.0	No observed reaction	5.6	6.3	24	0.10	<0.5
GCA8928-1	3.0	No observed reaction	5.6	6.4	22	0.10	<0.5
BLANK4	3.0	No observed reaction	6.0	7.2	37	-	<0.5

Notes: Test conditions based on those described by Miller *et al.* (1997), and AMIRA (2002) for the 'Static-NAG-Test' in its "Single-Additon-Mode". The pH of the 15 % (v/v) H_2O_2 solution was adjusted to 4.5 using 0.1 M-NaOH prior to commencing the NAG Tests. Following an overnight-reaction period, the test-mixtures were boiled for *c.* 2 hours. Then, after allowing the test-mixtures to cool, *c.* 1.0 mL of 0.016 M-$CuSO_4$ solution was added, and the test-mixtures again boiled for *c.* 2 hours. The addition of Cu(II) catalyses the decomposition of any residual, unreacted-H_2O_2 in the test-mixtures (McElnea and Ahern 2004; O'Shay *et al.* 1990). K-Feldspar was employed for the Blank.

Dr GD Campbell
27th September 2010

ANALYTICAL REPORT

Dr G. CAMPBELL
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE	:	143.0/1013714
No. of SAMPLES	:	22
No. of ELEMENTS	:	32
CLIENT O/N	:	GCA1018/2 (Job 1 of 1)
SAMPLE SUBMISSION No.	:	
PROJECT	:	Pythod Gwadar Deposit
STATE	:	Ex-Pulp
DATE RECEIVED	:	01/10/2010
DATE COMPLETED	:	15/11/2010
DATE PRINTED	:	15/11/2010
PRIMARY LABORATORY	:	Genalysis Main Laboratory

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
( )	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method
OV	= Value over-range for Package

MAIN OFFICE AND LABORATORY

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SAMPLE DETAILS

DISCLAIMER

Genalysis Laboratory Services Pty Ltd wishes to make the following disclaimer pertaining to the accompanying analytical results.

Genalysis Laboratory Services Pty Ltd disclaims any liability, legal or otherwise, for any inferences implied from this report relating to either the origin of, or the sampling technique employed in the collection of, the submitted samples.

SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that the third, fourth and subsequent figures may be real or significant.

Genalysis Laboratory Services Pty Ltd accepts no responsibility whatsoever for any interpretation by any party of any data where more than two or three significant figures have been reported.

SAMPLE STORAGE DETAILS

GENERAL CONDITIONS

SAMPLE STORAGE OF SOLIDS

Bulk Residues and Pulps will be stored for 60 DAYS without charge. After this time all Bulk Residues and Pulps will be stored at a rate of $3.30 per cubic metre per day until your written advice regarding collection or disposal is received. Expenses related to the return or disposal of samples will be charged to you at cost. Current disposal cost is charged at $100.00 per cubic metre.

SAMPLE STORAGE OF SOLUTIONS

Samples received as liquids, waters or solutions will be held for 60 DAYS free of charge then disposed of, unless written advice for return or collection is received.

NOTES

*** NATA ENDORSED DOCUMENT ****

Company Accreditation Number 3244

The contents of this report have been prepared in accordance with the
terms of NATA accreditation and as such should only be reproduced in full.

The analysis results reported herein have been obtained using the
following methods and conditions:

The 22 samples, as listed in the report, were received as being 'Mine-Waste'
which had been dried, mixed,crushed and pulverised as per job referance 143.0/1011294.

The results have been determined according to Genalysis methods codes :
Digestions : MPL_W001 (A/), SL_W007 (BP/), ENV_W012 (DH/SIE), MPL_W011 (D/),
MPL_W008 (CM/).
Analytical Finishes: ICP_W004 (/OES), ICP_W003 (/MS) and and AAS_W008 (/AAS).

The results included the assay of blanks and international reference standards
OREAS 45P,STSD-2 and Genalysis in-house standards OREAS 97.01 and HgSTD-3.

The results are expressed as parts per million or percent by mass in the dried and
prepared material.

NATA Signatory: A Evers
Chief Chemist

Date: 15th November 2010

This document is issued in accordance with NATA’s accreditation requirements.

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.2	50	2	50	0.1	0.01	50	0.1	0.1	5
DIGEST	A/	A/	A/	D/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	MS	OES	MS	OES	MS	MS	OES	MS	MS	OES
SAMPLE NUMBERS										
0001 GCA8907	X	10.75%	24	X	92.1	0.91	303	X	16.4	153
0002 GCA8908			31	X						
0003 GCA8909	X	9.65%	9	X	192.5	0.32	1448	X	7.7	366
0004 GCA8910			22	X						
0005 GCA8911			22	X						
0006 GCA8912	X	5.92%	20	X	44.4	0.65	238	X	10.2	117
0007 GCA8913	X	6.85%	30	X	50.7	0.67	908	X	3.0	254
0008 GCA8914			48	X						
0009 GCA8915			7	X						
0010 GCA8916	X	4.52%	12	X	785.3	0.56	785	1.0	26.3	42
0011 GCA8917			7	X						
0012 GCA8918	0.2	1.08%	4	X	13.3	0.07	178	X	2.8	28
0013 GCA8919			7	X						
0014 GCA8920			15	X						
0015 GCA8921			9	X						
0016 GCA8922			10	X						
0017 GCA8923	X	8070	4	X	10.9	0.06	245	X	3.7	10
0018 GCA8924			10	X						
0019 GCA8925	0.2	2.82%	24	X	187.9	0.46	432	0.4	19.2	31
0020 GCA8926			110	X						
0021 GCA8927			26	X						
0022 GCA8928			11	X						
CHECKS										
0001 GCA8907	X	11.26%	23	X	95.2	0.99	316	0.1	15.9	152
0002 GCA8927			26	X						
STANDARDS										
0001 HgSTD-3										
0002 OREAS 45P				X						
0003 OREAS 45P	0.4	6.57%	11		306.4	0.22	3137	0.1	113.1	1206
0004 OREAS 97.01										
0005 STSD-2										
BLANKS										
0001 Control Blank	X	X	X	X	0.2	0.02	X	X	X	X
0002 Control Blank	X	X	X		0.5	0.02	X	X	0.2	X
0003 Control Blank										
0004 Control Blank				X						
0005 Acid Blank	X	X	X		X	X	X	X	X	X

ANALYSIS

ELEMENTS	Cu	F	Fe	Hg	K	Mg	Mn	Mo	Na	Ni
UNITS	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	1	50	0.01	0.01	20	20	1	0.1	20	1
DIGEST	A/	DH/	D/	CM/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	SIE	OES	CVAP	OES	OES	OES	MS	OES	OES
SAMPLE NUMBERS										
0001 GCA8907	46	427	18.02	0.02	1.38%	3423	1702	1.9	187	58
0002 GCA8908								2.4		
0003 GCA8909	50	364	14.64	X	3729	2473	523	1.4	387	28
0004 GCA8910								1.3		
0005 GCA8911								1.9		
0006 GCA8912	30	364	4.44	0.02	6837	1736	294	2.4	139	45
0007 GCA8913	44	275	41.60	0.06	477	1204	66	2.9	320	8
0008 GCA8914								1.3		
0009 GCA8915								0.4		
0010 GCA8916	44	225	28.68	0.05	4627	2802	6.17%	0.6	203	45
0011 GCA8917								1.5		
0012 GCA8918	34	151	24.57	0.02	164	514	82	1.5	127	25
0013 GCA8919								2.1		
0014 GCA8920								1.6		
0015 GCA8921								1.5		
0016 GCA8922								2.0		
0017 GCA8923	20	133	51.10	0.01	68	763	1082	1.7	94	2
0018 GCA8924								2.3		
0019 GCA8925	77	244	53.02	0.04	1772	2602	1.35%	1.0	123	49
0020 GCA8926								4.3		
0021 GCA8927								6.0		
0022 GCA8928								1.2		
CHECKS										
0001 GCA8907	47	482	18.73	0.02	1.48%	3606	1706	1.9	197	58
0002 GCA8927								5.9		
STANDARDS										
0001 HgSTD-3				0.37						
0002 OREAS 45P			19.16							
0003 OREAS 45P	771				3813	2320	1304	2.2	882	395
0004 OREAS 97.01										
0005 STSD-2		1074								
BLANKS										
0001 Control Blank	1	X	0.01	X	X	X	X	X	X	X
0002 Control Blank	2				X	X	X	X	X	X
0003 Control Blank										
0004 Control Blank			0.02							
0005 Acid Blank	1				X	X	X	X	X	X

ANALYSIS

ELEMENTS	P	Pb	S	Sb	Se	Sn	Sr	Th	Tl	U
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	50	2	50	0.05	0.01	0.1	0.05	0.01	0.02	0.01
DIGEST	A/	A/	A/	A/	BP/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	MS	OES	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 GCA8907	949	22	90	3.79	0.27	3.8	20.03	18.62	0.17	6.16
0002 GCA8908				3.49	2.34					
0003 GCA8909	77	27	81	1.35	0.35	3.1	21.05	16.35	0.52	4.39
0004 GCA8910				2.58	0.20					
0005 GCA8911				6.31	0.37					
0006 GCA8912	622	18	X	3.09	0.07	2.1	12.08	10.38	0.10	2.98
0007 GCA8913	288	25	501	6.68	0.30	4.0	11.45	15.84	0.08	5.30
0008 GCA8914				4.01	0.59					
0009 GCA8915				0.87	0.04					
0010 GCA8916	1069	43	97	1.89	0.08	1.6	137.09	7.88	2.36	4.00
0011 GCA8917				0.67	0.13					
0012 GCA8918	333	10	72	1.62	0.12	0.7	2.48	0.96	0.03	0.91
0013 GCA8919				0.57	0.24					
0014 GCA8920				1.13	0.33					
0015 GCA8921				1.16	0.03					
0016 GCA8922				0.63	0.24					
0017 GCA8923	292	23	81	0.87	0.02	0.3	5.14	0.59	0.11	0.45
0018 GCA8924				1.53	0.25					
0019 GCA8925	819	43	160	2.03	0.08	0.9	37.51	3.54	1.85	2.12
0020 GCA8926				3.44	0.76					
0021 GCA8927				5.72	0.19					
0022 GCA8928				1.54	0.29					
CHECKS										
0001 GCA8907	918	22	90	4.02	0.24	4.2	20.35	19.95	0.18	6.40
0002 GCA8927				5.18	0.13					
STANDARDS										
0001 HgSTD-3										
0002 OREAS 45P										
0003 OREAS 45P	438	24	315	0.89		2.8	34.54	10.35	0.24	2.39
0004 OREAS 97.01					0.67					
0005 STSD-2										
BLANKS										
0001 Control Blank	X	X	X	X	X	0.2	X	X	X	X
0002 Control Blank	X	X	X	X		0.2	0.14	0.02	X	0.08
0003 Control Blank					X					
0004 Control Blank										
0005 Acid Blank	X	X	X	X		X	X	X	X	X

ANALYSIS

ELEMENTS	V	Zn
UNITS	ppm	ppm
DETECTION LIMIT	2	1
DIGEST	A/	A/
ANALYTICAL FINISH	OES	OES
SAMPLE NUMBERS		
0001 GCA8907	130	44
0002 GCA8908		
0003 GCA8909	408	37
0004 GCA8910		
0005 GCA8911		
0006 GCA8912	61	36
0007 GCA8913	179	106
0008 GCA8914		
0009 GCA8915		
0010 GCA8916	72	193
0011 GCA8917		
0012 GCA8918	13	137
0013 GCA8919		
0014 GCA8920		
0015 GCA8921		
0016 GCA8922		
0017 GCA8923	10	116
0018 GCA8924		
0019 GCA8925	45	305
0020 GCA8926		
0021 GCA8927		
0022 GCA8928		

CHECKS		
0001 GCA8907	137	44
0002 GCA8927		

STANDARDS		
0001 HgSTD-3		
0002 OREAS 45P		
0003 OREAS 45P	297	149
0004 OREAS 97.01		
0005 STSD-2		

BLANKS		
0001 Control Blank	X	2
0002 Control Blank	X	2
0003 Control Blank		
0004 Control Blank		
0005 Acid Blank	X	2

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	0.2	50	2	50	0.1	0.01	50	0.1	0.1	5
DIGEST	A/	A/	A/	D/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	MS	OES	MS	OES	MS	MS	OES	MS	MS	OES
BLANKS										
0006 Acid Blank				X						

ANALYSIS

ELEMENTS	Cu	F	Fe	Hg	K	Mg	Mn	Mo	Na	Ni
UNITS	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	1	50	0.01	0.01	20	20	1	0.1	20	1
DIGEST	A/	DH/	D/	CM/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	SIE	OES	CVAP	OES	OES	OES	MS	OES	OES
BLANKS										
0006 Acid Blank			X							

ANALYSIS

ELEMENTS	P	Pb	S	Sb	Se	Sn	Sr	Th	Tl	U
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION LIMIT	50	2	50	0.05	0.01	0.1	0.05	0.01	0.02	0.01
DIGEST	A/	A/	A/	A/	BP/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	MS	OES	MS	MS	MS	MS	MS	MS	MS
BLANKS										
0006 Acid Blank										

ANALYSIS

ELEMENTS	V	Zn
UNITS	ppm	ppm
DETECTION LIMIT	2	1
DIGEST	A/	A/
ANALYTICAL FINISH	OES	OES
BLANKS		
0006 Acid Blank		

METHOD CODE DESCRIPTION

A/MS Genalysis Main Laboratory

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Mass Spectrometry.

A/OES Genalysis Main Laboratory

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

BP/MS Genalysis Main Laboratory

Aqua-Regia digest followed by Precipitation and Concentration. Specific for Selenium. Analysed by Inductively Coupled Plasma Mass Spectrometry.

D/OES Genalysis Main Laboratory

Sodium peroxide fusion (Zirconium crucibles) and Hydrochloric acid to dissolve the melt. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

DH/SIE Genalysis Main Laboratory

Alkaline fusion (Nickel crucible) specific for Fluorine. Analysed by Specific Ion Electrode.

CM/CVAP Genalysis Main Laboratory

Low temperature Perchloric acid digest specific for Mercury. Analysed by Cold Vapour Generation Atomic Absorption Spectrometry.

Intertek GENALYSIS LABORATORY SERVICES

Dr G Campbell
CAMPBELL, GRAEME and ASSOCIATES PTY LTD
PO Box 247
BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	143/1014066
No. of SAMPLES	16
CLIENT O/N	GCA1018/1
PROJECT	Ferraus Python Gwardar
STATE	Water extracts
DATE RECEIVED	8/10/2010
DATE COMPLETED	21/10/2010

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
( ) = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
> = Value beyond Limit of Method

16 solutions were received.

pH, EC, Cl were measured on each “Green” sample
Genalysis method codes ENV_W001, ENV_W002, ENV_W013

“Red” solutions were received as nitric acid dosed filtered solutions which were analysed for the requested element suite by ICPOES and ICPMS Genalysis method codes (ICP_W004,ICP_W003)

Results of analysis on:

Element		Cl	EC	pH
Method		/COL	/METER	/METER
Detection		2	10	0.1
Units		mg/l	uS/cm	NONE
Sample Name				
Control Blank				
GCA8907 Raw		29	158	6.7
GCA8907 Raw	check	29	169	6.7
GCA8912 Raw		20	132	6.9
GCA8915 Raw		57	573	7
GCA8916 Raw		34	278	6.6
GCA8918 Raw		5	55	6.6
GCA8923 Raw		25	128	6.4
GCA8925 Raw		29	203	6.6

Element	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
Method	/MS	/OES	/MS	/OES	/MS	/MS	/OES	/MS	/MS	/OES
Detection	0.01	0.01	0.1	0.01	0.05	0.005	0.01	0.02	0.1	0.01
Units	ug/l	mg/l	ug/l	mg/l	ug/l	ug/l	mg/l	ug/l	ug/l	mg/l
Duplicates										
Sample Name										
Control Blank	X	X	0.2	X	X	X	0.01	X	X	X
GCA8907 HNO3	0.02	0.02	1.6	0.06	14.5	0.152	6.4	X	0.3	X
GCA8912 HNO3	X	X	0.6	0.05	7.05	0.017	6.22	X	0.9	X
GCA8915 HNO3	X	X	1.1	X	2.85	0.275	60.46	X	0.4	X
GCA8916 HNO3	X	X	0.8	0.03	2.01	0.011	20.35	X	0.4	X
GCA8918 HNO3	X	X	X	0.07	11.11	X	1.79	X	0.3	X
GCA8923 HNO3	X	0.04	0.2	0.12	5.38	X	4.48	0.03	0.2	X
GCA8925 HNO3	X	X	0.6	0.05	4.87	X	8.04	0.05	0.2	X
Blank-(WET-1)	X	X	0.3	X	0.52	X	0.1	X	X	X
DW-(WET-1)	X	X	X	X	0.69	X	0.11	X	X	X
Alcoa-High3-MS	20.54		108.4		21.7	19.974		20.78	1068.2	
AlcoaHi2-OES		46.47		19.88			983.5			20.47

Element	Cu	Fe-Sol	Hg	K	Mg	Mn	Mo	Na	Ni	P
Method	/OES	/OES	/MS	/OES	/OES	/OES	/MS	/OES	/OES	/OES
Detection	0.01	0.01	0.1	0.1	0.01	0.01	0.05	0.1	0.01	0.1
Units	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l
Duplicates										
Sample Name										
Control Blank	X	X	X	0.1	0.02	X	X	X	X	X
GCA8907 HNO3	X	0.02	X	12.9	4.67	0.01	0.09	13.7	X	X
GCA8912 HNO3	X	0.44	X	7.7	5.15	0.16	1.14	13.2	X	X
GCA8915 HNO3	X	0.03	0.6	20.1	30.56	0.07	X	36.5	X	X
GCA8916 HNO3	X	0.08	0.3	14.9	13.1	0.11	X	19.8	X	X
GCA8918 HNO3	X	X	X	1.6	1.89	0.03	X	7.8	X	X
GCA8923 HNO3	X	0.21	X	1.4	3.94	0.06	X	14.5	X	X
GCA8925 HNO3	X	0.02	X	7.7	8	0.02	X	16.8	X	X
Blank-(WET-1)	X	X	X	0.1	0.04	X	X	0.2	X	X
DW-(WET-1)	X	X	X	X	X	X	X	X	X	X
Alcoa-High3-MS			21.8				20.57			
AlcoaHi2-OES	2.71	96.36		485.1	197.99	19.25		1969.7	20.56	46.7

Element	Pb	S	SO4	Sb	Se	Si	Sn	Sr	Th	Tl
Method	/MS	/OES	/CALC	/MS	/MS	/OES	/MS	/MS	/MS	/MS
Detection	0.5	0.1	0.3	0.01	0.5	0.05	0.1	0.02	0.005	0.01
Units	ug/l	mg/l	mg/l	ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l
Duplicates										
Sample Name										
Control Blank	X	X		X	X	X	X	X	X	X
GCA8907 HNO3	5.7	4.5	13.5	0.43	1.2	8.42	0.2	38.22	0.03	0.03
GCA8912 HNO3	0.7	4.7	14.1	0.09	1	3.88	0.2	35.75	0.009	0.01
GCA8915 HNO3	1.9	10.2	30.6	0.04	2	1.79	0.2	169.82	0.012	0.01
GCA8916 HNO3	0.6	4.3	12.9	0.09	0.8	4.19	0.2	51.11	0.008	0.01
GCA8918 HNO3	0.8	1.5	4.5	0.11	0.6	5.63	0.2	13.99	0.008	0.01
GCA8923 HNO3	X	1.7	5.1	0.02	0.8	3.77	0.2	39.82	0.005	0.01
GCA8925 HNO3	0.6	3.4	10.2	0.03	1.2	3.76	0.2	68.69	0.006	0.02
Blank-(WET-1)	X	X		X	X	0.09	X	0.39	X	X
DW-(WET-1)	X	X		X	X	X	X	0.1	X	X
Alcoa-High3-MS	19.8		0	21.9	106		21.6	1077.72	21.891	20.49
AlcoaHi2-OES		241.7	725.1			95.42				

Element	U	V	Zn
Method	/MS	/OES	/OES
Detection	0.005	0.01	0.01
Units	ug/l	mg/l	mg/l
Duplicates			
Sample Name			
Control Blank	X	X	X
GCA8907 HNO3	0.012	X	0.03
GCA8912 HNO3	0.02	X	X
GCA8915 HNO3	0.012	X	0.01
GCA8916 HNO3	X	X	0.01
GCA8918 HNO3	X	X	0.01
GCA8923 HNO3	X	X	0.01
GCA8925 HNO3	0.005	X	0.01
Blank-(WET-1)	X	X	X
DW-(WET-1)	X	X	X
Alcoa-High3-MS	21.746		
AlcoaHi2-OES		20.31	20.86

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NATA Signatory: Ann Evers

Ann Evers

Date: 21/10/2010

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Semi Quantitative XRD Report – JN1018/2

1. Sample Preparation:

The samples received were the pulps (-75µm nominal) of waste regolith material from the Ferraus-King-Brown Iron Ore project. Sub samples of the pulps weighing approximately 3g were back loaded into a standard X-Ray Diffraction (XRD) sample holder for semi-quantitative analysis. A sub sample was also taken for clay separation and identification.

The samples for clay separation were mixed with a 0.6% calgon (sodium hexametaphosphate) solution and allowed to settle. The clay fraction was then removed by pipette and placed on a ceramic disk for XRD.

2. Experimental Method:

Pack packed random orientated samples:
Data was collected using a Bruker D8 XRD fitted with a Cu tube operated at 40kV, 40mA and a Ni filter; using the following settings:
2-theta range = 6–80^{o}, Step size = 0.021^{o}, Divergence slit = 1mm Fixed

Clay samples:
Data was collected using a Philips X'pert XRD fitted with a Co tube operated at 40kV, 40mA and an Fe filter; using the following settings:
2-theta range = 4–32^{o}, Step size = 0.035^{o}, Step time = 0.8s, Divergence slit = 15mm ADS
Receiving slit = 0.8mm.

The XRD measurements for the clay samples with evidence of expanding clays were repeated after the samples were expanded with ethylene glycol.

3. Diffraction Data files:

Diffraction data files in the original binary format (with the file extension .rd) and ASCII format (with extension .txt) are available on request.

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Semi Quantitative XRD Report – JN1018/2

4. Semi-quantitative results:
The semi-quantitative results are based on the XRD pattern obtained from a "randomly" orientated sub sample. However, orientated clay samples are used to aid in identification of the clays.

	GCA8909	**GCA8913**	**GCA8916**	**GCA8918**
Quartz	Minor	Trace	Minor	Dominant
Goethite	Accessory	Dominant	Dominant	Major
Hematite	Minor	Minor	Accessory	Accessory
Kaolinite	Dominant	Major	Major	Trace
K-Feldspar	Accessory		Trace	
Muscovite			Accessory	

Nominal abundance
Trace <2%
Accessory 2-10%
Minor 10-20%
Major 20-50%
Dominant >50%

Notes:

The amounts indicated are a guide only and are based on rough Rietveld refinements of the diffraction patterns from the "randomly" orientated samples and previous work of this nature; however the variations in clay properties, sample preparation, and the degree of orientation in the "random" orientated samples will all affect the peak heights and the estimates of the amount present.

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JOB INFORMATION

JOB CODE	143.0/1013715
No. of SAMPLES	4
CLIENT O/N	GCA1018/2
PROJECT	Python Gwardar
STATE	pulps
DATE RECEIVED	1/10/2010
DATE COMPLETED	25/10/2010

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
( ) = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
> = Value beyond Limit of Method

The samples were received as pulps and were indicated to be non calcareous

Results of analysis on:

Element	Method	Units	GCA8909	GCA8909	GCA8913	GCA8916	GCA8918	ASPAC33
				check				
Ca	NH4Cl7/OES	cmol(+)/kg	5.9	6.0	2.0	1.4	0.2	40.4
K	NH4Cl7/OES	cmol(+)/kg	0.4	0.4	0.3	0.3	0.2	1.5
Mg	NH4Cl7/OES	cmol(+)/kg	6.4	6.4	1.4	0.9	0.2	33.5
Na	NH4Cl7/OES	cmol(+)/kg	0.7	0.7	0.6	0.2	0.1	1.8
ECEC			13.4	13.5	4.3	2.7	0.7	77.2
Exchangeable Ca	/CALC	%	44.1	44.1	45.4	51.2	24.8	52.3
Exchangeable K	/CALC	%	3.2	3.2	7.5	10.4	25.4	1.9
Exchangeable Mg	/CALC	%	47.3	47.7	33.7	32.7	34.4	43.4
Exchangeable Na (ESP)	/CALC	%	5.4	5.0	13.5	5.6	15.4	2.3

2g of each of the samples were weighed into a centrifuge tube and pre- washed with 2x 25ml 10 % (v/v) deionised ethylene glycol in 90 % (v/v) ethanol which has been previously deionised by passing through Amberlite resin
After the centrifuge stage there may be finely dispersed material in suspension. If this is the case a few drops of PVA may be necessary. The PVA aqueous solution is 0.05 % (w/v) polyvinyl alcohol. Addition of PVA was made to sample GCA8916. This did not result in flocculation of the samples and the fine material was filtered off and extracted separately. The exchangeable bases in solution when included in the total did not raise the eCEC above 5 and were not included in the total. The values in solution were below the detection limit

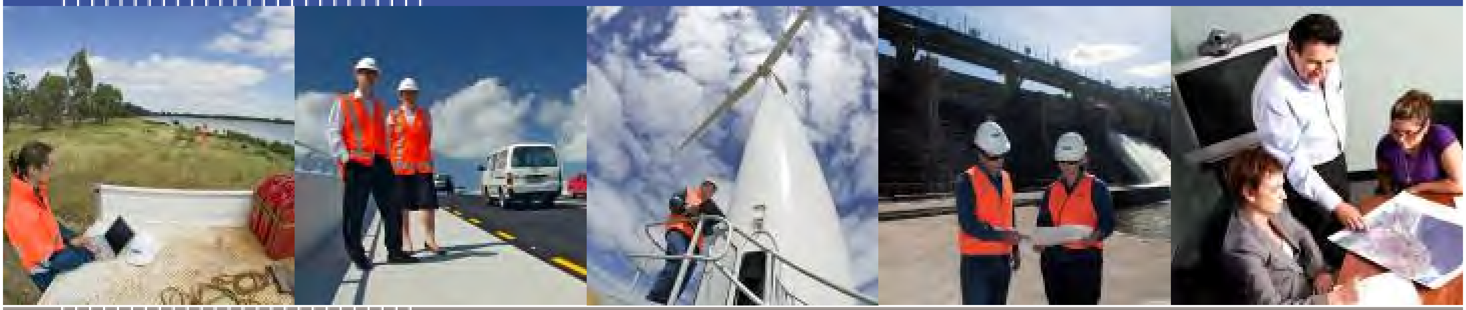
Extraction step for Exchangeable cations

After decanting following completion of the 2nd pre-wash, the residue in centrifuge tube is subjected to 2 x 30-minute extractions via end-over-end tumbling at approx. 10 rpm. Each extraction uses 20 mL of 1 M-NH_4Cl buffered at pH 7.0 using ammonia solution 28 % (w/w). At the completion of each extraction, the suspensions are centrifuged and the supernatants decanted and collected into a communal extract. After this extraction is completed (under same conditions as before), the suspension is centrifuged, and the supernatant combined with the communal extract above. The final communal extract is brought to 50 mL with 4 M-HCl.
Sample analysed for Ca,Mg,K and Na by OES

Reference:
Based on procedure 15B2
Australian laboratory handbook of soil and water chemical methods / G.E. Rayment and F.R. Higginson 1992
Inkata Press

Ann Evers

Appendix 7
Feasibility Design of Residue Storage Facility, FerrAus Pilbara Project, Davidson Creek Mine Site, Pilbara Region, Western Australia, URS, 2011



Draft Report

Feasibility Design of Residue Storage Facility

FerrAus Pilbara Project, Davidson Creek Mine Site

Pilbara Region, Western Australia

25 AUGUST 2011

Prepared for

FerrAus Limited

Suite 10, 100 Mill Point Road
South Perth, WA 6151

42907769

URS

Project Manager:	.... Ajitha Wanninayake Associate Geotechnical Engineer	**URS Australia Pty Ltd** **Level 4, 226 Adelaide Terrace** **Perth WA 6000** **PO Box 6004, East Perth, 6892** **Australia** **T: 61 8 9326 0100** **F: 61 8 9326 0296**
Principal-In-Charge:	.... Imran Gillani Principal Engineer	
Reviewer:	.... Elio Novello Senior Principal Geotechnical Engineer	
Independent Technical Reviewer:	.... Neil Mattes Senior Principal	Date: **25 August 2011** Reference: 42907769/001/1 Status: DRAFT

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Executive Summary

A single Residue Storage Facility (RSF) is planned to be constructed at FerrAus' Davidson Creek Area (DCA) mine site to cater for both DCA and Robertson Range Area (RRA) operations. The location of the RSF has been identified to be south of pits DC5 and DC6 (Python-Gwardar deposit) and pits DC8 and DC9 (Taipan deposit), adjacent to waste dump DCWD3 and east of the DC4 plant. The RSF is planned to handle a tailings production rate of 2.2 Million tonnes per annum (Mtpa) for a 15 year project life (expandable at a later date). The tailings are expected to have predominantly minus 45 microns (μ) material with some [minus 1 millimetre (mm)] spiral reject material. The percent solids, prior to deposition, are expected to be between 40% and 50% solids by weight.

FerrAus Limited (FerrAus) is in the process of completing the Feasibility Study for the FerrAus Pilbara Project (FPP). URS Australia Pty Ltd (URS) has been tasked by FerrAus to complete the feasibility design of the RSF.

Before deciding upon the preferred design concept for the RSF, an options evaluations study was completed to explore various options for constructing the RSF. Options included constructing the RSF embankments from borrow material and/or from the mine waste material. Conceptual layouts and sections of the viable options were discussed with FerrAus in a meeting to select the preferred design concept.

The option to integrate the RSF with waste dump DCWD3 and to use the waste material to construct the embankments was mutually selected by URS and FerrAus as the preferred design concept for the DCA RSF. The RSF is designed as an above ground storage facility that is integrated with the mine waste dump. The total area of the RSF is estimated to be about 200 hectares (ha) with a separation dike/causeway in the middle to form two separate cells of 100 ha each. Tailings will be deposited using a peripheral deposition scheme, with a header pipe and spigots, in both cells. During operations, each cell will be cyclically "rested" (made inactive) for about 12 months, while tailings are being deposited in the other cell. No basal liner or underdrainage system is envisioned for the RSF at this stage.

For start-up, a low height starter embankment will be constructed which would later-on, during operation, be incrementally raised using the downstream method of construction. The geotechnical performance of the perimeter embankment, during operations, will be monitored with the aid of a geotechnical monitoring program. During closure, the RSF will be closed and rehabilitated in-situ in accordance with the relevant regulatory guidelines.

During operations, if conditions change and there is a need to change the embankment raising methodology, the downstream method of embankment raising could be changed/switched to either an upstream or a centreline raise methodology. The upstream raise methodology (and to some extent the centreline raise methodology) could lead to significant savings in the material required for future embankment raises. However, before switching to either one of these approaches, the strength and loading behaviour of the beach tailings would need to be studied and verified in advance of changing the design.

At the start of the project, it was envisaged to complete field investigations and geotechnical testing of tailings in support of the RSF design. However, because of unanticipated delays in the approval process and unavailability of representative tailings samples, the field and laboratory test work could not be undertaken in a timely manner to provide input to the RSF feasibility design presented in this report. It was mutually agreed by FerrAus and URS to go ahead and complete the RSF feasibility design using the available data and information with the understanding that after the field work and

laboratory testing of tailings obtained from the pilot program are complete, URS would be given another opportunity to review the data and update the RSF design, if needed.

Introduction

1.1 Project Description

The FerrAus Pilbara Project (FPP) incorporates mining and processing at two proposed minesite areas identified as the Davidson Creek Area (DCA) and the Robertson Range Area (RRA). The FPP is located in the interzone between the Pilbara and Gascoyne biogeographic regions, approximately 400 kilometres (km) southeast of Port Hedland and 100 km southeast of the town of Newmon. Open strip mining, via a series of cut and fill pits, is proposed for the Mirrin Mirrin, Python-Gwardar, Taipan, Dugite and Tiger iron ore deposits at DCA and the King Brown and South Zone deposits at RRA.

Cumulative annual ore production is approximated at 15 Million tonnes (Mt) (wet) for the ore deposits at the DCA and RRA over a perod of up to 15 years. A single Residue Storage Facility (RSF) is planned for construction at DCA to cater to mining operations at both DC and RRA. The proposed RSF is designed to abut against waste dump DCWD3 to the south. Waste dump DCWD3 is located immediately south of pits DC5 and DC6 (Python-Gwardar deposit) and pits DC9 and DC10 (Taipan deposit).

From a dam safety perspective, there is little difference, if any, between a tailings storage facility (TSF) and a residue storage facility (RSF). Australian National Committee on Large Dams' (ANCOLD) guidelines on tailings dam design defines "Tailings" as "a waste product or residue from a process". From process engineering perspective, tailings are defined as a fine-grained material remaining after the recoverable metals and minerals have been extracted from crushed and ground mined ore. Tailings solids are embedded in process water and are typically produced by a hydrometallurgical processing plant, such as a floatation plant. The term residue, on the other hand, is used in a broader sense to define waste material from both hydrometallurgical as well as pyrometallurgical (smeltering) processes. Furthermore, unlike tailings, residues need not be water slurries.

In the alumina, iron ore, and coal industries, the term residue is more commonly used. On the other hand, in the copper, gold, and uranium industries, the term tailings is more commonly used. URS agrees with FerrAus to adopt the residue and RSF terminology as opposed to the tailings and TSF terminology for their Pilbara project.

The RSF is planned to be designed for a tailings production rate of 2.2 Million tons per annum (Mtpa) for a 15 year project life (expandable at a later date). The tailings circuit includes a bank of cyclones and a thickener. The cyclone overflow passes to the tailings thickener and the underflow from the cyclones is blended into the thickener underflow prior to pumping to the RSF. The tailings are expected to have predominantly minus 45 microns (μ) material with some [minus 1 millimetre (mm)] spiral reject material. The percent solids, prior to deposition, is expected to be between 40% and 50% solids by weight.

A Pre-Feasibility Study (PFS) for the FPP has been completed by Sinclair Knight Merz Pty. Ltd (SKM) and others and currently FerrAus is in the process of organising and completing the Detailed Feasibility Study (DFS) for the project. URS Australia Pty Ltd (URS) has been tasked by FerrAus to complete the feasibility design of the RSF.

1.2 Purpose and Scope

The purpose of this report is to present the feasibility level design of the DCA RSF. More specifically, URS' scope of work included the following:

- Complete an options study to select the preferred design concept.

1 Introduction

- Facilitate and supervise field investigations and assist with laboratory testing.
- Develop feasibility level design drawings for the RSF including material quantities – civil/earthworks components only.
- Develop construction and operational notes and closure guidelines.
- Summarise and document results from all supporting analyses including field and laboratory investigations.

URS' scope of work is limited to the RSF design and does not address the following:

- Tailings/residue transport system (pump and pipe) design from the thickener to the RSF.
- Groundwater modelling and environmental impact assessment from ground and/or surface waters.
- Decant water return system design to transport the decant water from the RSF back to the plant.

Design Criteria and Design Basis

2.1 Key Project Objectives

Key project objectives include:

- Provide safe and efficient storage of tailings.
- Design for successful closure.
- Strive for Aim for Zero Harm Approach (ZHA) for environmental impacts associated with the following:
  - Off site discharge
  - Seepage
  - Disturbance footprint
  - Dust generation
- Use Health Safety and Environment (HSE) and sustainability mindset.
- Satisfy Australian National Committee on Large Dams (ANCOLD) Criteria as identified in Guidelines on Tailings Dam Design, Construction and Operation (ANCOLD, 1999).
- Satisfy Department of Minerals and Energy (DME) Criteria as identified in Guidelines on the Safe Design and Operating Standards for Tailings Storage (DME, 1999).
- Work towards project commissioning date of January, 2014.

2.2 Design Criteria

2.2.1 General

- Safely store inflow corresponding to 1 in 100 year Average Recurrence Interval (ARI), 72-hour precipitation event on top of the RSF with the intent of preventing discharge to ground surface as per DME Guidelines (DME, 1999); Include strategy for preventing overtopping of embankment under Probable Maximum Precipitation (PMP) conditions from dam safety standpoint.
- Utilize (As Low As Reasonably Practicable (ALARP) approach to minimize risk to fauna (birds).
- Maximize use of on-site materials.
- Use the anticipated average tailings production rate, assumed to be constant throughout the mine life, for RSF design. Provide allowance for 25% increase in production rate.
- Design RSF for the mine life.

2.2.2 RSF Design

- Satisfy ANCOLD (1999) guidelines considering the Significant Hazard category rating.
- Satisfy DME's "Safe Design and Operating Standards for Tailings Storage Guidelines" (DME, 1999).
- Employ observational approach design philosophy with monitoring program.
- Design Basis Earthquake (DBE) is a 1 in 5,000 year event (leading practice).
- Operating Basis Earthquake (OBE) is a 1 in 1,000 year event.
- Use average value of percent solids for the RSF design.
- Provide flood protection for 1 in 500 years, 72-hour flood event.
- Provide surface water diversion for 1 in 100 years critical duration storm event [DoIR Feb. 2006]
- Provide initial Start-up capacity for first 1.5 to 2 years.

2.2.3 Tailings Deposition System

- Maximize evaporation - Minimise return water from the decant system.

2.3 Design Basis

2.3.1 Mine / Process Data

Parameter	Value	Reference
Mine Life	15 years	FerrAus provided
Average tailings production rate	2.2 Mtpa	FerrAus provided
Percent solids from the tailings/residue storage tank	Average value= 45% Likely range= 40% to 50%	FerrAus and SKM provided

2.3.2 Tailings Properties

Parameter	Value	Reference
Specific Gravity (SG)	3.3	URS estimate based on Outotec test results.
Permeability	TBA (Rowe cell tests need to be conducted)	
Gradation	99 to 100% Fines (<0.075 mm) 43 to 47% Clay (<0.002 mm)	Test results on RRA and Mirrin Mirrin pilot trial samples
Atterberg limits	PI=16; LL=43 – average values	Test results on RRA and Mirrin Mirrin pilot trial samples
Final inplace dry density (average over depth)	1.19 tons per cubic meter (t/m^3)	URS estimation (Conservative)
Final inplace solids content (average over depth)	65%	URS estimation (Conservative)
Beach angle	1%	FerrAus estimation
ARD potential	Not Likely – to be confirmed	Test results on RRA and Mirrin Mirrin pilot trial samples

2.3.3 Tailings Liquor Properties

Parameter	Value	Reference
Specific Gravity (SG)	1.05	FerrAus
pH	7 to 8	FerrAus
Temperature	20 to 30^{o} C	FerrAus

2 Design Criteria and Design Basis

2.3.4 Tailings Deposition System

Parameter	Value	Reference
Hydraulic properties of Tailings Slurry	Yield stress = 59 to 156 Pascal (Pa)	SKM Prefeasibility Report

2.3.5 Geotechnical Design

Parameter	Value	Reference
RSF embankment raising	Consider Downstream and Centreline raise methodologies	URS
Employ observational approach for RSF embankment design	N/A	
Design Basis Earthquake (DBE)	Peak Ground Accel. (PGA) of 0.13g [g is gravitational acceleration = 9.81 metres per square second (m/s^2)], Magnitude of earthquake (M_W)~7.5 – 1 in 5,000 yrs event	Sinadinovski et al (2005), Gaull et al. (1990), AS1170.4, ANCOLD (1998)
Operating Basis Earthquake (OBE)	PGA of 0.08g – 1 in 1,000 yrs event	Sinadinovski et al (2005), Gaull et al. (1990), AS1170.4, ANCOLD (1998)
Static long-term drained Factor of Safety (FoS)	1.5	ANCOLD (1999)
Static Undrained FoS	1.3	ANCOLD (1999)
Pseudo Static Seismic FoS	1.1	ANCOLD (1999)
Post Seismic FoS	1.1	ANCOLD (1999)
Maximum rate of rise	2 m/year	URS

2.3.6 Climate Data

Parameter	Value	Reference
Annual Mean Minimum Temp	17^{o} C	RPS Aquaterra (2011)
Monthly Mean Minimum Temp	25^{o} C (Jan) to 7^{o} C (Jul)	RPS Aquaterra(2011), BOM (2011)
Annual Mean Maximum Temp.	31.6^{o} C	RPS Aquaterra (2011)
Monthly Mean Maximum Temp	39^{o} C (Jan) to 23^{o} C (Jul)	RPS Aquaterra (2011), BOM (2011)
Annual average rainfall	261 mm – Sylvania Station 268 mm – Ethel Creek 319 mm – Newman Aerodrome	RPS Aquaterra (2011), BOM (2011)
Probable Maximum Precipitation (PMP) for 72 hr storm	1746 mm	RPS Aquaterra (2011)
1 in 100 yrs for 72 hr storm 1 in 500 yrs for 72 hr storm 1 in 1000 yrs for 72 hr storm 1 in 2000 yrs for 72 hr storm	300 mm 329 mm 367 mm 406 mm	RPS Aquaterra (2011)
Evaporation (pan) – mean monthly	339 mm – Jigalong 311 mm – Newman Aerodrome	RPS Aquaterra (2011)

2.3.7 Closure

Parameter	Value	Reference
Soil/Rock cover for RSF	1.0 m	URS
Final landform for RSF	< 20^{o} batter	Mineral Council of Australia Mine Rehabilitation Handbook (1998)
Topsoil/growth medium stockpile	Required	
Cover type	Shedding	

Field and Laboratory Investigations

3.1 Field Investigations

The field investigation of the RSF area is currently being carried out and expected to be completed by 27 August 2011. The findings from this field investigation will be reported separately. Preliminary studies that have been carried out by Sinclair Knight Merz Pty Ltd. (SKM) (SKM 2010a and 2010b) and Snowden (Snowden 2010) in the past have been used in planning the field investigations.

3.2 Laboratory Testing of Field Samples

[to be completed following completion of the field investigations and testing of field samples]

3.3 Laboratory Testing of Tailings Samples

Laboratory testing of tailings samples is required to provide pertinent data, such as dry/wet unit weight of deposited tailings, which in turn are used to support the RSF design. FerrAus provided a couple of tailings samples from some previous/old metallurgical test work. These samples represented only the finer fraction of tailings and did not include the coarser fraction to represent the spiral reject material that is anticipated to be mixed with the finer fraction before being deposited within the RSF. These tailings samples, even though not fully representative of the tailings material that will be deposited in the RSF, were sent to the SGS laboratory in Welshpool, Perth for some basic geotechnical testing. Results from this test work are presented in Appendix E.

To get more representative properties of the material that will be deposited within the RSF, a second round of testing is planned following availability of tailings samples from the pilot test program that is scheduled to commence during the first week of July 2011.

The RSF design presented in this report was based on the available data and information coupled with our judgement and experience from working with similar materials. It is understood that, following completion of the above mentioned tailings test work, URS would be given another opportunity to review the data and update the RSF design, if needed.

Residue Storage Facility Design

4.1 General

The proposed Residue Storage Facility (RSF) at the DCA is designed to abut against waste dump DCWD3 to the south. Waste dump DCWD3 is located immediately south of pits DC5 and DC6 (Python-Gwardar deposit) and pits DC9 and DC10 (Taipan deposit). Considering the ground topography and other project requirements, the storage facility is envisaged to be an above ground ring dike type facility with perimeter deposition. The total surface area of this facility is estimated to be approximately 200 ha. Design Basis Criteria for the RSF is presented in Section 2.0.

4.2 Options Study

Before deciding upon the preferred design concept for the RSF, an options evaluations study was completed to explore various design/storage options that are available for constructing the RSF. Conceptual layouts and sections were developed for several viable design options as listed in Table 4.1. The developed conceptual layouts and sections under options study are presented in Appendix A.

Table 4-1 Viable Design Options for RSF

Basic Concept	Variation	Variation	Figures
Construct perimeter embankment from borrow Material	Win borrow material from within the RSF footprint		Figure 2, Figure 3 (Appendix A)
	Assume external borrow source		Figure 2, Figure 4 (Appendix A)
Construct perimeter embankment from waste material	Keep RSF separate from the waste dump (DCWD3)		
	Integrate RSF with the waste dump (DCWD3)	Construct part of embankment with waste material and the remaining with borrow material	Figure 8
		Construct all of the embankment with waste material	Figure 7 with modifications
In-pit disposal			

The concept of constructing the perimeter embankment from borrow material has the following key advantages and disadvantages:

Advantages of constructing the embankment from borrow material:

- Construction of the RSF can be completed independent of the waste production schedule – flexibility in operations.
- Waste dump could be located and sized independent of the RSF layout and location – added flexibility in mine plan.

Disadvantages of constructing the embankment from borrow material:

- Added cost for winning the borrow material.
- If availability of borrow material limited and hence rely more on upstream method of raising the embankment, it could cause less redundancy in design.
- Limited capacity to store major precipitation events above the 1 in 100 years, 72 hour event if upstream raising is adopted.
- May be viewed less favourably by the regulators – added disturbance area for winning borrow if borrow is external to storage.

The concept of constructing the perimeter embankment from waste material has the following advantages and disadvantages:

Advantages of constructing the embankment from waste material:

- No need to identify and develop borrow source(s).
- The embankment could be raised with the down-stream method of construction – less reliance on the tailings properties and added redundancy in design.
- Would be viewed more favourably by the regulators – more sustainable (smart utilisation of waste) and robust design.
- Added capacity to store major precipitation events without release.
- More economical to future expansions, both for increases in tailings production rates and total storage capacity.
- Could be cost effective.

Disadvantages of constructing the embankment from waste material:

- High reliance on waste production schedule – construction of embankment and its raising is intimately tied with the waste production schedule.
- May impose limitations on the mine plan.

The conceptual layouts/sections and the above listed pros and cons were discussed first internally within URS and then with the FerrAus project team during the Options Selection Meeting on April 29, 2011. Following these discussions and input from FerrAus team members the preferred design concept for the RSF was selected, as described below.

4.3 Selection of Preferred Design Concept

The option to integrate the RSF with the waste dump and to use the waste material to construct the embankment(s) was mutually selected by URS and FerrAus as the preferred option/design for the DCA RSF. This option was selected for the following key reasons:

- Integrated use of the mine waste dump (DCWD3) and material to contain the tailings provides a sustainable (environmentally friendly) solution for waste disposal – using HSE and sustainability mindset is one of the key project objectives.
- The mine plan indicates that ample quantity of select waste material will be available during the initial stages of the project to construct the RSF starter dike. Therefore, use of waste material to construct the RSF embankment is envisaged to be more cost effective as compared to using borrow material.
- The ability to store a major precipitation event above the stipulated 1 in 100 year, 72 hour event would be viewed favourably by the regulators.

- With the downstream method of embankment raising, reliance on the tailings properties (especially strength) is substantially reduced thus providing greater flexibility in design. Higher rates of rise, changes in rheology and gradations etc. could be more easily accommodated with the downstream method of embankment raising as compared to the upstream method.

The preferred design concept was developed to a feasibility level RSF design and the design drawings are presented in Appendix B.

4.4 RSF Design Overview

The RSF is designed as an above ground storage facility that is integrated with the mine waste dump. The total area of the RSF is estimated to be about 200 ha with a separation dike/causeway in the middle to form two separate cells of 100 ha each. Tailings will be deposited using a peripheral deposition scheme, with a header pipe and spigots, in both cells. During operations, each cell will be cyclically "rested" (made inactive) for about 12 months covering dry and wet seasons of an year, while tailings are being deposited in the other cell. On the north side, containment for the RSF is provided by the waste dump wall with a facing of engineered fill, as shown on drawings C-004 and C-006. Containments along the other three sides are provided by engineered embankments constructed from select mine waste materials.

For start-up, a low height starter embankment will be constructed which would during operation, be incrementally raised using the downstream method of construction. Based on the information available to date, we do not believe that the RSF needs to be a lined facility. Hence, no basal liner or underdrainage system is envisioned for the RSF at this stage. In future, based on any additional testing, such as leachate testing and/or change in process, if it is concluded that the RSF needs to be lined, then a basal liner with or without a leachate collection system could be included without significantly altering the RSF design.

During operations the geotechnical performance of the perimeter embankment will be monitored with the aid of a geotechnical monitoring program.

During closure, the RSF will be closed and rehabilitated in-situ in accordance with the relevant regulatory guidelines. Guidelines for the development of the closure plan for the RSF are presented in Section 7.

4.4.1 Start-up Phase

For start-up, a low height starter embankment will be constructed with a maximum height of 9 m at the northeast corner. An initial starter height causeway, located in the middle of the RSF, will also be constructed as part of the initial start-up operations.

Tailings would be spigotted from the top of the starter embankment in both cells from the west, north, and east sides of the RSF (starter embankment will not be present along majority of the south side) forming beaches draining to temporary ponds within the storage areas of each of the two cells.

The height of the starter embankment has been selected to provide:

1. Tailings deposition for the first 1.6 years of operation before raising of the embankment(s) is needed.
2. Safe containment of the 1 in 100 year, 72 hour flood in accordance with the DME freeboard requirements (DME, 1999).

4.4.2 Post Start-up Phase

Following the initial start-up phase, the perimeter embankments, including the north wall that is common with the waste dump, will be incrementally raised over the life of the facility. Embankment raising will be completed using the downstream method of construction using the same equipment and materials that were used for the start-up construction.

The causeway, separating the east and west cells, will also be incrementally raised with Zone 2 (Refer to Drawing No. C-004 in Appendix B) waste material by gradually reducing its crest width from 30 m to 6 m. Smaller compacting equipment needs to be used for the construction of causeway during post start-up phase.

After the first embankment raise, tailings will be spigotted from top of the embankment from all four sides of the RSF. With this peripheral tailings deposition scheme, two decant ponds, in the east and west cells, will be created in the middle of the RSF on both sides of the causeway. Two sets of stationary pumps (located on the causeway) with High-density polyethylene (HDPE) pipes and floating decant intakes will be used to pump water from the two decant ponds.

The final design elevation of the embankment is estimated to be to at (Reduced Level) RL 552 m, which will involve a total of 13 m of downstream lifting. For the present study it has been assumed that this will be achieved in three, 4 to 5 m high stages over the life of the facility.

4.4.3 Opportunity to Switch to Upstream/Centreline Embankment Raise Methodology

As discussed earlier, downstream method of embankment raising was selected for the Davidson Creek RSF to reduce reliance on the tailings properties (especially strength) and to provide greater redundancy in design. With the downstream method, higher rates of rise, changes in rheology and gradations etc. could be more easily accommodated without requiring significant changes in design.

The drawback with the downstream method is that it requires the most amount of embankment material for embankment raises and the toe of the embankment keeps on moving out as the crest of the embankment is raised. For the RSF, since the embankments are envisioned to be constructed from mine waste material and there does not appear to be any real restrictions on the extents of the RSF, the downstream method of embankment raising is judged to be quite appropriate, especially for the initial years.

In future (during operations), if conditions change and there is a need to change the embankment raising methodology, the downstream method of embankment raising could be changed/switched to either an upstream or a centreline raise methodology. The upstream raise methodology (and to some extent the centreline raise methodology) could lead to significant savings in the material required for future embankment raises. However, before switching to either one of these approaches, the strength and loading behaviour of the beach tailings would need to be studied and verified in advance of changing the design.

4.5 Feasibility Level Design Drawings

A List of the drawings prepared for the feasibility level design of the RSF is given in Table 4-2 and the drawings are presented in Appendix B.

Table 4-2 List of Design Drawings

Drawing No.	Title
C-001	General Site Location & Cover Sheet
C-002	Site Layout
C-003	Residue Storage Facility Start-up Layout Plan
C-004	Starter Embankment Typical Cross Sections
C-005	Residue Storage Facility Final Layout Plan
C-006	Final Embankment Typical Cross Sections
C-007	Perimeter Road and Drainage Channels Details

4.5.1 Key Design/Construction Features

Following are the key design features of the RSF feasibility level design.

Surface Water Management System:

The surface water management system is designed to intercept, collect, and safely divert surface run-off around the RSF. In accordance with the DME requirements (DME, 1999). , the surface water diversion system is designed to accommodate a 1 in 100 year critical duration storm event. The design of the surface water management system for the RSF is discussed in detail in Section 5 of this report. The layout plan and sections of the drainage channels and associated structures are included in the design drawings.

Foundation Preparation:

Foundation preparation for the RSF includes removal of vegetation, stripping of topsoil, and removal of loose sacrificial materials, if needed, from within the footprint of the perimeter embankments and the causeway. The minimum depth of excavation required for foundation preparation is estimated to be 500 mm. Following stripping of vegetation and topsoil from entire width of the embankment, the surface will be inspected by an engineer to nominate areas of excessively loose or weak material that would need to be removed or compacted.

Starter Embankment:

The starter embankment with a maximum height of 9 m at the northeast corner, will be constructed using two zones of select waste material.

- Zone 1, located along the upstream/inside face of the embankment, consists of select waste material with a substantial fines content and rocks no greater than 200 mm size. This zone will be placed in maximum 500 mm thick layers and compacted to form a low permeability engineered fill.

- Zone 2, located behind Zone 1, consists of select waste material with rocks no greater than 1000 mm size. This zone will be placed in 2000 mm layers and compacted by trafficking and track rolling, as a minimum.

With a constant crest elevation at 539 m, the starter embankment will not be required along most of the south side of the RSF, where the natural ground is at or higher than EL 539m. The crest width of the starter embankment has been kept as 35 m to accommodate large haulage plant, which is envisioned to be used for its construction.

Cut-off Trench:

A 5 m wide and 1 m deep cut-off trench will be constructed along the inside toe of the starter embankment all around the RSF. The depth of the cut-off trench was selected based on the average depth to the hard soil layer as reported by the previous subsurface investigations done by others. The cut-off trench is backfilled with compacted Zone 1 waste material and is an integral part of the starter embankment.

Causeway:

A causeway will be constructed to sub-divide the 200 ha RSF into two cells of 100 ha each. Access to the decant system/pumps is also provided via the causeway.

An initial height starter causeway, with a maximum height of about 6 m, will first be constructed as part of the initial start-up operations. Compacted Zone 2 material will be used for the causeway construction. The crest width of the starter causeway has been kept as 30 m to accommodate large haulage plant, which is envisioned to be used for its construction.

Future raises of the causeway are envisioned to be completed by smaller plant by gradually reducing its crest width from 30 m to 6 m.

The decant causeway has been designed for the full width of the RSF dividing it in to two cells. At the start-up phase this facilitates the storage of design flood event. However, at subsequent stages of construction of RSF the decant causeway might not be required for the full width of the RSF. However, this design change could be accommodated in the final design of the RSF.

Downstream Embankment Raises:

The perimeter embankments along the east, south, and west sides of the RSF will be raised with the downstream method of construction using the same equipment and materials that were used for the start-up construction – large haul plants and select waste material Zones 1 and 2. For this reason, as shown on the drawings, a minimum crest width of 35 m is maintained for the raises.

Downstream embankment raises totalling about 13 m would be needed following start-up and before achieving the final design elevation of 552 m. For the present study it has been assumed that this would be achieved via three 4 to 5 m high stages of downstream construction. However, if it is intended to use 30 – 35 m wide working areas which allow the use of large mine trucks for material delivery, the augmentation will need to be carried out in two, 6 to 7 m high stages.

4 Residue Storage Facility Design

Raising of the North Wall:

Similar to the raising of the east, south, and west walls, the north wall of the RSF will be incrementally raised over the life of the facility. Construction for this wall raise will proceed by placing and compacting Zone 1 and Zone 2 waste material against the slope of the waste dump. With a crest width of 35 m, the raising of the north wall is also envisioned to be completed with the large plant.

Perimeter Tailings Deposition System:

A peripheral deposition scheme, with a header pipe and spigots, will be used to deposit tailings within the two cells of the RSF. Spigot spacing of about 20 m has been assumed for this stage of the design. During initial start-up, tailings will deposited from the top of the starter embankment in both cells from the west, north, and east sides of the RSF. However, following the first embankment raise, tailings will be deposited from all four sides of the RSF. Tailings are not envisaged to be deposited from top of the causeway.

It is envisioned that after depositing tailings in a cell for about 12 months, the cell will be “rested” (made inactive) for about 12 months while tailings are being deposited in the other cell. This on and off cycle will be continued through out the operating life of the facility primarily for the following three reasons:

- Maximize evaporation;
- Maximize desiccation and consolidation of tailings; and
- Facilitate embankment and header pipe raises.

Decant System:

A stationary pump with HDPE pipes and floating decant intakes are envisioned for each cell of the RSF – two sets in total for the two cells. Access to the decant pumps will be provided via the causeway.

Instrumentation Program:

The stability analyses completed in support of the RSF design have assumed a design phreatic surface through the RSF embankment. The estimate for the design phreatic surface was based on the results from the seepage analyses coupled with our knowledge/experience from similar projects. It represents a reasonably conservative phreatic surface that is expected to develop within the RSF embankment. If the actual phreatic surface and the associated pore water pressures are observed to be less/lower than the design estimate, the geometry of the embankment could potentially be optimized to realise cost savings. In contrast, if the phreatic surface and the associated pore water pressures are observed to be more/higher than the design estimate, the geometry and design of the RSF would need to be re-evaluated to ensure compliance with the design criteria.

To monitor the actual pore water pressures, and indirectly the phreatic surface, within the RSF embankment, two rows of nested vibrating wire piezometers will be installed along three study sections along the RSF embankment. The locations of the three study sections and typical cross-sections indicating the recommended positions of the piezometers will be provided in the final phase of the RSF design. Readings from these piezometers will be monitored on a monthly basis and the interpreted results will be compared with the design estimates – design verification.

4.6 Residue Stage Storage Capacity

Residue storage capacity in each stage of RSF construction was calculated using digital terrain models and 3-D surfaces created for the RSF. AutoCAD Civil 3D 2010 software together with manual calculations were used for the volume calculations. The stage storage capacity of tailings is presented in Table 4-3.

Table 4-3 Stage Storage Capacity of Tailings

Storage volume required for 1 year = 1,848,739 m^3			
Stage	Tailings Storage Capacity (m^3)		No. of Years that tailings could be deposited in each stage (Years)
	Stage Tailings Capacity	Cumulative Capacity	
Starter	2,768,027	2,768,027	1.5
Raise 1	8,463,806	11,231,833	4.6
Raise 2	10,531,583	21,763,416	5.7
Raise 3	6,498,299	28,261,715	3.5
		Total	**15.3 Years**

Surface Water Management and Water Balance Study

5.1 Surface Water Management

5.1.1 Climate

The Pilbara region is characterised by an arid-tropical climate resulting from the influence of tropical maritime and tropical continental air masses, receiving summer rainfall. Cyclones can occur during this period, bringing heavy rain, causing potential destruction to coastal and inland towns. (RPS Aquaterra 2011)

5.1.2 Rainfall

The Pilbara region has a highly variable rainfall, which is dominated by the occurrence of tropical cyclones mainly from January to March. The moist tropical cyclones from the north bring sporadic and drenching rainfall events. With the exception of these large events, rainfall can be erratic, and localised, due to thunderstorm activity. Therefore, rainfall from a single site may not be representative of the spatial variability of rainfall over a wider area.

During winter, cold fronts move in an easterly direction across Western Australia and sometimes reach the Pilbara region producing light winter rains.

The nearest rainfall gauging stations to the project area are at Sylvania (Site Number 007079 – approximately 49 km to the south-west) and at Ethel Creek (Site Number 005003, – approximately 68 km to the north-west). The annual average rainfall recorded at Sylvania and Ethel Creek is 261 mm and 268 mm respectively (Bureau of Meteorology, BOM, 2011).

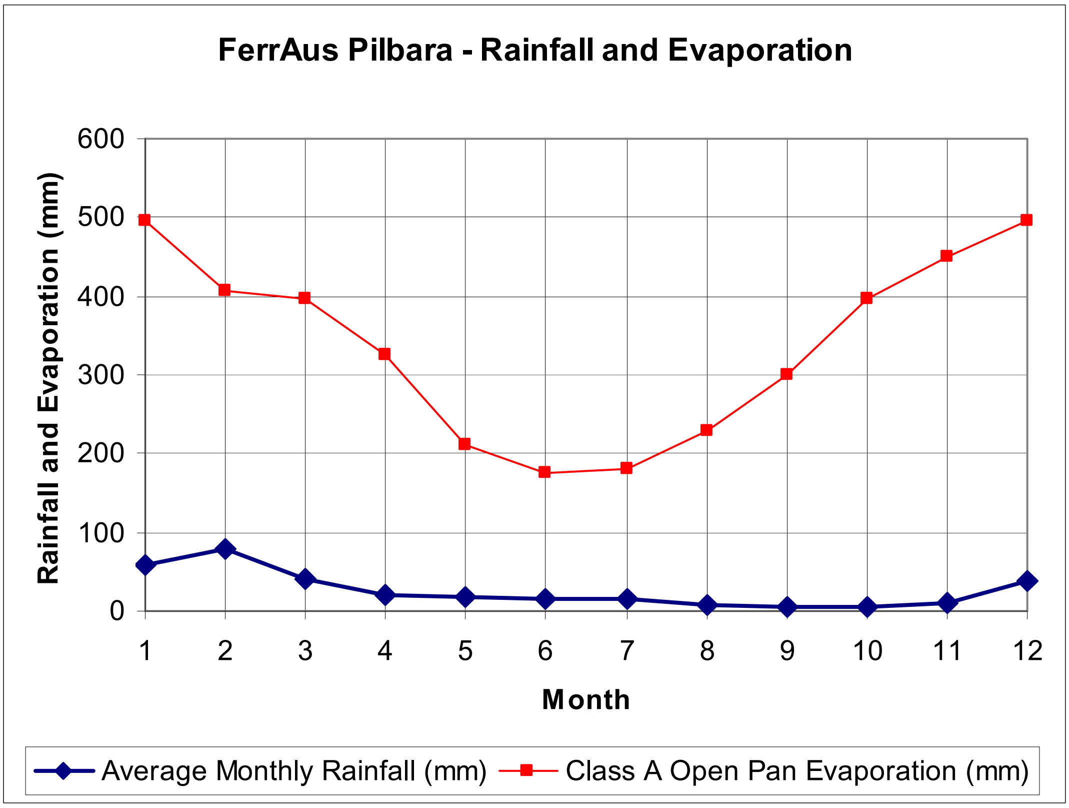
This is slightly lower than at Newman Aerodrome, which has an annual average rainfall of 319 mm (BOM, 2011). Average monthly rainfall totals for Newman Aerodrome are shown in Table 5-1. On average the driest period is August to November, with September and October historically being the driest months. Typically, January and February are the wettest months. However, variability is high with recorded annual rainfall at Newman varying between 153 mm (1976) and 619 mm (1999). The highest recorded annual rainfall at Sylvania and Ethel Creek was 713 mm (1998) and 814 mm (1942) respectively (RPS Aquaterra, 2011).

Average rainfall data at the Newman Aerodrome is available from BoM and is shown in Table 5-1 and Chart 5-1.

Table 5-1 Average monthly rainfall and evaporation

Month	Average Monthly Rainfall (mm)	Class A Open Pan Evaporation (mm)
Jan	57.3	497
Feb	78.8	406
Mar	40.3	397
Apr	19.6	326
May	18.1	211
Jun	14.2	176
Jul	14.9	180
Aug	8	229
Sep	4.6	301
Oct	4.9	396
Nov	10.3	450
Dec	37.6	497
Annual Total	**314.2**	**4066**

Chart 5-1 Rainfall and Evaporation



5.1.3 Evaporation

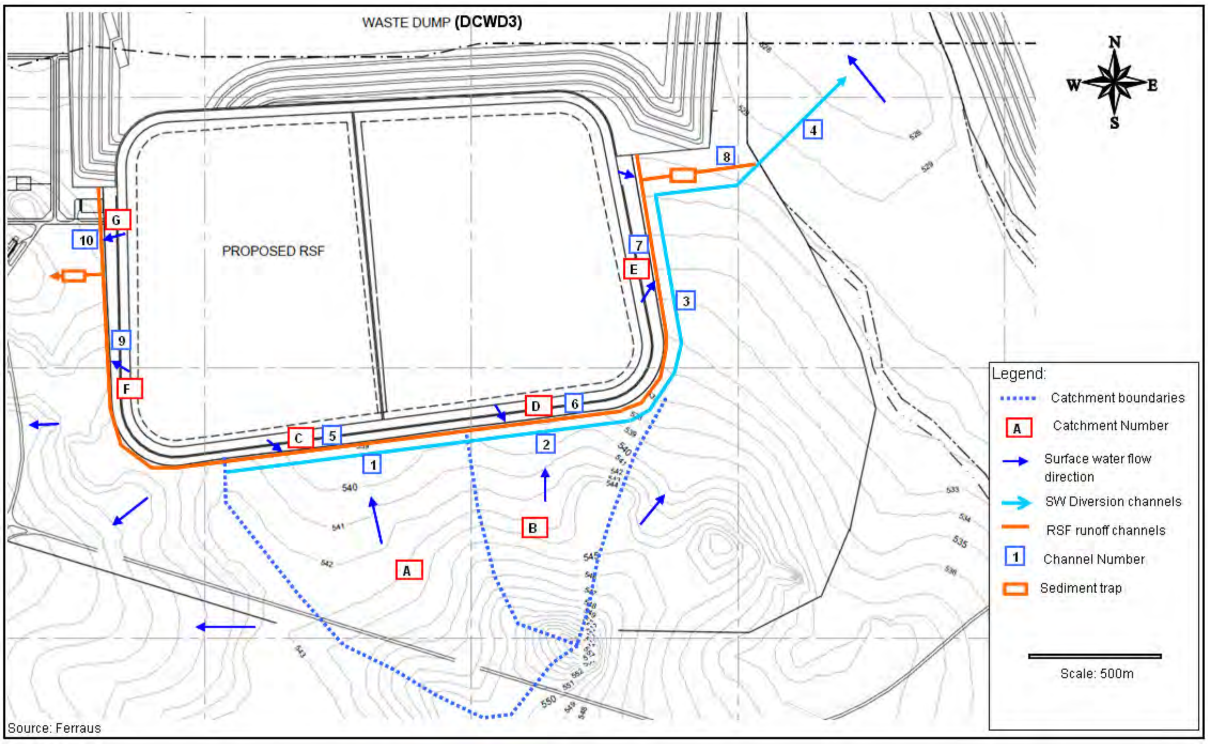
The mean annual pan evaporation rate as measured by a Class A pan at Jigalong (around 34 km to the east) is 4,066 mm and at Newman is 3,733 mm. These average evaporation rates at Jigalong vary between 176 mm in June and 497 mm in January/December. The average monthly pan evaporation rates for Jigalong are shown in Table 5-1. Evaporation rates at the project site would be expected to be similar to the evaporation averages at Jigalong. (RPS Aquaterra, 2011)

5.1.4 Description of the Catchment Area

The catchment area that drains towards the proposed RSF is located to the south of the RSF. The catchment slopes from south to north towards the RSF and the catchment area is 1.18 km^2. This catchment is divided in a western and eastern catchment, i.e. Catchment A and Catchment B respectively, for design purposes (Figure 5-1)

The RSF embankment drain will intercept water from the outer edge of the initial embankment and will include the perimeter road. The width of this area is approximately 60 m wide alround the RSF except for the perimeter to the north of the RSF at wastedump DCWD3 .. It has been assumed that the wastedump DCWD3 will be designed to prevent any runoff towards the RSF.

Figure 5-1 Catchment areas



5.1.5 Estimation of Peak Runoff

The Rational Method for the Pilbara Region as described in Book IV of ARR97 has been used to estimate the peak runoff flows.

The equation for the time of concentration (t_c) is: $t_c = 0.56A^{0.38}$ (Equation 1.29),

where A is the catchment area in square kilometres.

The runoff coefficient (C_2) for the 2 year event is: $C_2 = 3.07 \times 10^{-1} L^{-0.20}$ (Equation 1.30)

where L is the mainstream length (km).

The frequency factors (C_y/C_2) is:

ARI (years)	2	20	50	100
(C_y/C_2)	1.00	3.60	5.20	6.3 *

* extrapolated

The calculated runoff coefficient adjusted with the frequency factor for the 20 to 100 year storm events often results in a runoff factor higher than 1.0 for catchments with short stream length. The maximum value for the effective runoff coefficient in this case has been limited to 1.0.

The runoff estimation is based on the rainfall Intensity Frequency Duration (IFD) data as sourced from the Bureau of Meteorology (BOM). The IFD data is presented in Table 5-2, giving the rainfall intensity in mm/hr for rainfall events of different Average Recurrence Intervals (ARI) and durations.

Table 5-2 Rainfall Intensity Frequency Duration (IFD) data

	Average Recurrence Interval / Rainfall Intensity (mm/hr)						
DURATION	1 year	2 years	5 years	10 years	20 years	50 years	100 years
5Mins	54.8	72.1	98.3	114	135	163	184
6Mins	51	67.2	91.8	107	126	152	173
10Mins	41.9	55.2	75.6	88.1	104	126	143
20Mins	31.4	41.3	56.3	65.5	77.3	93.2	106
30Mins	25.7	33.8	46.1	53.7	63.4	76.4	86.5
1Hr	17.1	22.5	31.2	36.5	43.3	52.6	59.8
2Hrs	10.4	13.9	19.9	23.7	28.6	35.2	40.5
3Hrs	7.62	10.3	15.1	18.2	22.2	27.7	32.1
6Hrs	4.38	6.03	9.28	11.5	14.3	18.3	21.6
12Hrs	2.58	3.6	5.76	7.28	9.2	12	14.3
24Hrs	1.59	2.23	3.62	4.61	5.86	7.68	9.2
48Hrs	0.989	1.38	2.24	2.85	3.61	4.73	5.66
72Hrs	0.708	1	1.63	2.08	2.64	3.47	4.16

The catchment areas and surface water diversion channels are indicated on Figure 5-1.

The estimated runoff for each catchment and diversion channel is shown in Table 5-3.

Table 5-3 Runoff for each catchment and diversion channel

Catchment Number	Channel Number	Catchment area, A (km2)	Mainstream length, L (km)	Time of concentration t_c (min)	C_Y for ARI (years)			$I_{tc,Y}$ for ARI (years), (mm/hr)			*Peak runoff* (Q_Y) for ARI (years), (m^3/s)		
					2	**20**	**100**	**2**	**20**	**100**	**2**	**20**	**100**
A	1	0.788	1.4	31	0.29	1.00	1.00	34	63	86	2.11	13.80	18.84
B		0.397	0.8	24	0.32	1.00	1.00	38	71	97	1.33	7.84	10.71
A+B	2,3,4	1.185	2.2	36	0.26	0.94	1.00	30	58	79	2.63	18.04	26.02
C	5	0.048	0.8	11	0.32	1.00	1.00	53	101	137	0.23	1.35	1.83
C+D	6	0.084	1.4	13	0.29	1.00	1.00	50	94	128	0.33	2.20	2.99
C+D+E	7,8	0.132	2.2	16	0.26	0.94	1.00	45	85	117	0.44	2.94	4.29
F	9	0.054	0.9	11	0.31	1.00	1.00	53	101	137	0.25	1.52	2.06
G	10	0.018	0.3	7	0.39	1.00	1.00	62	117	160	0.12	0.59	0.80
F+G											0.37	2.10	2.86
For the estimation of t_c is derived from ARR97 Book IV, Formula 1.29													
The coeffisient C_2 is derived from ARR97 Book IV, Formula 1.30													

5.1.6 Engineering of Surface Water Diversion Drains

Open drains will be sized to convey the 100 year ARI peak flows while the erosion protection will be designed for the 20 year ARI peak flows.

Erosion protection will be in the form of check dams where the flow velocity during the 20 year ARI event would normally exceed 1.0 m/s.

The open drain for the RSF runoff has been designed with an additional depth of 300 mm to allow for silt build-up. The channels have been sized as shown in Table 5-4.

Table 5-4 Drainage Channel Sizes

Description	Units	Channel	Channel	Channel	Channel	Channel	Channel	Channel	Channel	Channel	Channel
Refer to map for channel numbers		1	2	3 ***	4***	5**	6**	7***	8	9**	10**
Design flow (100 yr ARI)	m^3/s	18.84	26.02	26.02	30.32	1.83	2.99	4.29	4.29	2.06	0.80
Manning's "n", max roughness		0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
channel longitudinal slope %	%	0.075	0.070	0.07	0.07	0.075	0.07	0.10	0.10	0.10	0.67
side slope - vertical dimension		1	1	1	1	1	1	1	1	1	1
side slope - horisontal dimension		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
depth of flow, perp to slope	m	1.8	1.8	1.8	1.8	0.8	0.8	0.8	1.1	0.8	0.3
Channel depth with 0.2m freeboard	**m**	**2.0**	**2.0**	*2.0*	*2.0*	*1.0*	*1.0*	*1.0*	**1.3**	*1.0*	*0.5*
** Channel depth with 0.2m freeboard and 0.3m spare depth for silt build-up						**1.3**	**1.3**			**1.3**	**0.8**
*** Channel depth with 0.5m check dams and 0.2m freeboard				**2.5**	**2.5**			**1.5**			
Base width	m	6.0	9.0	9.0	10.0	2.0	4.0	5.0	2.0	2.0	2.0
Top channel width for 0.2m freeboard	**m**	**16.0**	**19.0**						**8.5**		
** Top of channel width with 0.2m freeboard and 0.3m spare depth for silt build-up						**8.5**	**10.5**			**8.5**	**6.0**
*** Top channel width for 0.5m check dams and 0.2m freeboard				**21.5**	**22.5**			**12.5**			

* Note: Install Rip-Rap to prevent erosion for channels with flow velocities above 1 m/s and at sudden direction changes.
** Allow 300mm additional depth for silt buildup for dirty water drains on flat gradient
*** Rock check dams need to be installed at regular intervals (approx 50m to 100m) to prevent channel erosion.

The sediment trap has been designed to trap coarse silt particles (0.05mm diameter) for the peak 2 year ARI event using the guidelines of Alderson (Alderson, Allan, 2006),. Allowance has been made for sediment collection in the trap by adding 300 mm to the design depth. The sediment trap will need to be approximately 21 m wide, 63m long and a total depth of 1.6m. The sides slopes has been assumed to be a gradient of 1 in 3 and the weir overflow level is 0.9m above the pond floor level.

5.2 Water Balance Study

5.2.1 Scope

A preliminary water balance analysis has been completed for the RSF using monthly rainfall, evaporation data and seepage losses. The aim for the water balance study is to:

- Estimate the quantity of excess water which may be generated in a wet year, and the required additional storage capacity to safely retain this water within the system.
- Freeboard assessment and the need for an emergency spillway.
- Estimate the need for additional make-up water in a dry year and during the dry season.

5.2.2 RSF Description and Operation

The RSF is divided into two cells each with a surface area of approximately 950,000m^2 (Drawing 42907769-C-004.dwg).

The top of the embankment/crest area is approximately 35 m wide and slopes to the inside of the RSF. This area will route rainfall to the RSF. The total area for rainwater collection includes the RSF area and the top of the embankment/crest area. The surface water catchment area for each cell is approximately 1,150,000 m^2.

The cells will alternate in operation. A cell will receive tailings for a period of 12 months at a time.

The tailings will be routed to the cell in operation via a slurry line with spigots that will stretch around the outer perimeter of the RSF, but not on the dividing wall. It has been assumed that 20 percent of the surface area of each cell will be wet with water at a time, either as sheet flow or water ponding at the decant pump station. The surface of the cell in operation will only be covered with more water than 20 percent of the area during the wettest months. The effective evaporation from the beach area of the RSF is estimated to be 1.2 times Class A Open Pan Evaporation.

The RSF will be designed for an ore capacity of 2.2 Mtpa. The tailings pumped to the RSF will contain 45 percent solid particles by weight. The SG of the solids is 3 times that of water therefore the water in the tailings flow is 0.224 GL/month.

It is estimated that the final tailings will contain 65 percent solids by weight...The solids in the tailings flow will be 0.183 Mt/month, while the water retained in the RSF will be 0.099 Mt/month. This equal to 0.099gigalitre/month (GL/month).

It has been assumed that the tailings water will be pumped back to the process plant for reuse. The volume of decant water will be equal to the volume of tailings water minues the volumes lost to evaporation, seepage and retention. The maximum volume of water that can be returned to the process plant is equal to the water component in the tailings flow (0.224GL/month).

5.2.3 Estimated Seepage

The average seepage rate through the bottom of the RSF is estimated to vary from 100 mm to 10 mm per month. (0.1 to 0.01 cubic meters/month per square metre). The higher end value is more representative of the start up conditions which could include the first couple of months. Following that, the seepage rate would steadily decline to the lower end value as the RSF is raised.

For the purpose of this study the lower value (10 mm/month) is used, because this will be more representative of the long term condition.

5.2.4 Net Water Loss

Average Net Water Loss

In order to estimate the average water demand for the operations, the net water loss and decant return has been estimated for each month using the average monthly rainfall. (Table 5-5)

The total annual water loss is estimated to be 1.87 GL. This also represents the average annual water demand for the operation of the RSF.

Table 5-5 Net water loss for the average monthly rainfall

Month	Average Monthly Rainfall (mm)	Class A Open Pan Evaporation (mm)	Effective Evaporation (mm) *	Seepage (mm/month)	Tailings water retention (GL/month)	Net Water Loss (GL/month)	Decant return (GL/month)
Jan	57.3	497	596.4	10	0.099	0.156	0.068
Feb	78.8	406	487.2	10	0.099	0.110	0.114
Mar	40.3	397	476.4	10	0.099	0.152	0.072
Apr	19.6	326	391.2	10	0.099	0.160	0.064
May	18.1	211	253.2	10	0.099	0.136	0.088
Jun	14.2	176	211.2	10	0.099	0.132	0.092
Jul	14.9	180	216	10	0.099	0.132	0.092
Aug	8	229	274.8	10	0.099	0.151	0.073
Sep	4.6	301	361.2	10	0.099	0.172	0.052
Oct	4.9	396	475.2	10	0.099	0.193	0.031
Nov	10.3	450	540	10	0.099	0.199	0.025
Dec	37.6	497	596.4	10	0.099	0.178	0.046
Annual Total	**308.6**	**4066**	**4879.2**	**120**	**1.185**	**1.871**	**0.817**

Note * The evaporation is calculated for a water surface covering 20 percent of the surface area of the cell in operation, and an effective evaporation factor of 1.2 the Class A Open Pan Evaporation

Effective Water Loss for the driest months and year on record

The lowest monthly rainfall for the period 1971 to 2010 is zero for all months except for December when it was 0.6 mm. (Table 5-6).

Based on the lowest annual rainfall of 36.6mm, which occurred in 1996, the net annual water loss is estimated to be 2.09 GL.

The month with the highest net water loss is January with 0.222 GL.

5 Surface Water Management and Water Balance Study

Table 5-6 Net water loss according to the lowest monthly rainfall on record

Month	Lowest Monthly Rainfall (mm)	Class A Open Pan Evaporation (mm)	Effective Evaporation (mm) *	Seepage (mm/month)	Tailings water retention (GL/month)	Net Water Loss (GL/month)	Decant return (GL/month)
Jan	0	497	596.4	10	0.099	0.222	0.002
Feb	0	406	487.2	10	0.099	0.201	0.023
Mar	0	397	476.4	10	0.099	0.199	0.025
Apr	0	326	391.2	10	0.099	0.183	0.041
May	0	211	253.2	10	0.099	0.156	0.068
Jun	0	176	211.2	10	0.099	0.148	0.076
Jul	0	180	216	10	0.099	0.149	0.075
Aug	0	229	274.8	10	0.099	0.160	0.064
Sep	0	301	361.2	10	0.099	0.177	0.047
Oct	0	396	475.2	10	0.099	0.199	0.025
Nov	0	450	540	10	0.099	0.211	0.013
Dec	0.6	497	596.4	10	0.099	0.221	0.003
Lowest Annual Rainfall	**36.6**	**4066**	**4879.2**	**120**	**1.185**	**2.184**	**0.504**

Note * The evaporation is calculated for a water surface covering 20 percent of the surface area of the cell in operation, and an effective evaporation factor of 1.2 the Class A Open Pan Evaporation

Net Water Loss – Wet period

The highest rainfall for each month for the period 1971 to 2010 and the estimated net water loss is shown in Table 5-7.

Based on the highest annual rainfall of 619.2 mm, the net annual water loss is estimated to be 1.514 GL.

As shown in Table 5-7 there are a few months where the estimated net water loss has a negative value. In these cases the operating pond volume and therefore also the surface area will increase. The increased pond area will cause additional evaporation that will cause the net water loss to be zero. This is demonstrated in Table 5-8 for the case where the surface of the RSF is fully covered with water. In this case there will be a net water loss for each month.

5 Surface Water Management and Water Balance Study

Table 5-7 Effective water loss for the wettest months and year on record

Month	Highest Monthly Rainfall (mm)	Class A Open Pan Evaporation (mm)	Effective Evaporation (mm) *	Seepage (mm/month)	Tailings water retention (GL/month)	Net Water Loss (GL/month)	Decant return (GL/month)
Jan	239.8	497	596.4	10	0.099	-0.054	0.278
Feb	305.6	406	487.2	10	0.099	-0.151	0.375
Mar	214.2	397	476.4	10	0.099	-0.048	0.272
Apr	89.6	326	391.2	10	0.099	0.080	0.144
May	110.3	211	253.2	10	0.099	0.029	0.195
Jun	77.8	176	211.2	10	0.099	0.059	0.165
Jul	139.8	180	216	10	0.099	-0.012	0.236
Aug	79.6	229	274.8	10	0.099	0.069	0.155
Sep	44.6	301	361.2	10	0.099	0.126	0.098
Oct	34.8	396	475.2	10	0.099	0.158	0.066
Nov	65.2	450	540	10	0.099	0.136	0.088
Dec	236	497	596.4	10	0.099	-0.050	0.274
Highest Annual Rainfall	**619.2**	**4066**	**4879.2**	**120**	**1.185**	**1.514**	**1.174**

Note * The evaporation is calculated for a water surface covering 20 percent of the surface area of the cell in operation, and an effective evaporation factor of 1.2 the Class A Open Pan Evaporation

Table 5-8 Effective water loss in case the RSF is covered with water

Month	Highest Monthly Rainfall (mm)	Class A Open Pan Evaporation (mm)	Lake Evaporation (mm) **	Seepage (mm/month)	Tailings water retention (GL/month)	Net Water Loss (GL/month)	Decant return (GL/month)
Jan	239.8	497	347.9	10	0.099	0.163	0.061
Feb	305.6	406	284.2	10	0.099	0.027	0.197
Mar	214.2	397	277.9	10	0.099	0.126	0.098
Apr	89.6	326	228.2	10	0.099	0.222	0.002
May	110.3	211	147.7	10	0.099	0.122	0.102
Jun	77.8	176	123.2	10	0.099	0.136	0.088
Jul	139.8	180	126	10	0.099	0.067	0.157
Aug	79.6	229	160.3	10	0.099	0.169	0.055
Sep	44.6	301	210.7	10	0.099	0.257	-0.033
Oct	34.8	396	277.2	10	0.099	0.332	-0.108
Nov	65.2	450	315	10	0.099	0.332	-0.108
Dec	236	497	347.9	10	0.099	0.167	0.057

Note ** The evaporation is calculated for a water surface covering 100 percent of the surface area of the cell in operation, and an effective evaporation factor of 0.7 the Class A Open Pan Evaporation

5.2.5 Freeboard Assessment

Total Freeboard is defined as the vertical height between the lowest point on the crest of the perimeter embankment of the RSF and the normal operating pond level plus an allowance for an inflow corresponding to the 1:100 year 72-hour duration rainfall event falling in the catchment of the pond, assuming that no uncontrolled discharge takes place for the duration of the rainfall event.

For a RSF with a water pond normally located away from any perimeter embankment the total freeboard is the sum of the operational freeboard and the beach freeboard. In this case the minimum operational freeboard is 300 mm while the minimum beach freeboard is 200 mm for a minimum total freeboard of 500mm (DME, 1999).

The required freeboard above the normal operating water level must be sufficient to contain the 72 hour duration rainfall for the 100 year ARI plus a freeboard of 500 mm, for the case where the tailings pond is normally away from the embankment (DME, 1999).

The rainfall IFD data for the site is shown in Table 5-2. The table indicates the rainfall intensity in mm/hr for rainfall events of different average recurrence interval (ARI) and duration. The total rainfall for the 72 hour duration is 300 mm.

This rainfall event would likely be accommodated within the cone of depression of the tailings with very little likelihood for the flood water to rise up to the top edge of the tailings beach. In that case, the required freeboard would be close to 500mm. Since, predicting the beach slope at this stage is difficult, as a conservative estimate, the required freeboard is assumed to be 800 mm – sum of 500 mm and 300mm. This freeboard estimate could be further refined during the final design stage of the project.

Supporting Analyses

6.1 Slope Stability Analyses

6.1.1 General

The stability of the RSF final embankment was evaluated under static and seismic loading conditions. The stability analyses were conducted using GeoStudio 2007 SLOPE/W, a commercially available computer program developed by Geo-Slope International Ltd. (Geo-Slope, 2007a) and the input parameters are presented herein. For all failure mechanisms considered in the analyses, slope stability was evaluated using limit equilibrium methods based on Morgenstern-Price's method of analysis (Morgenstern-Price, 1965). Morgenstern-Price's method is a method of slices (referencing the analysis' consideration of potential failure masses as rigid bodies divided into adjacent regions or "slices," separated by vertical boundary planes). For each failure mode, the program iterates through a variety of failure surfaces to determine the surface with the minimum safety factor, otherwise referred to as the critical surface. Design static and seismic stability analyses were conducted using circular surface search routines for failures in the embankment.

6.1.2 Design Sections

For the stability analyses, a typical cross section was developed through the RSF embankment at the critical location. This critical location occurs at the north-east corner of the RSF where the embankment has the maximum height (see drawing Nos. C-005 and C-006 in Appendix B).

6.1.3 Load Cases

Static and seismic stability analyses were carried out under undrained conditions for the following loading cases:

1. Upstream stability without tailings;
2. Downstream stability with tailings at maximum embankment height of 21 m.

In case 1, no phreatic surface was considered in the analysis. But, a worst case phreatic surface was considered in case 2.

6.1.4 Material Properties

Material properties were developed based on best judgement by taking into consideration the soil types at site as reported by previous site investigations conducted by others. The properties used for the analyses are presented in Table 6-1. The impounded tailings were modelled as a surcharge load conservatively assuming no shear strength is mobilised in the tailings.

Table 6-1 Assumed Material Properties

Material	Unit Weight, kN/m^3	Cohesion, kPa	Friction Angle, deg	Permeability, m/sec
Zone 1	18	43	21	1×10^{-9}
Zone 2	18	43	21	1×10^{-8}
Zone 3	19	40	31	1×10^{-3}
Sand Foundation	17	0	30	1×10^{-6}
Hard Foundation	20	50	40	1×10^{-11}
Tailings	14	-	-	-

6.1.5 Analyses Results

Results of the stability analyses are presented in Table 6-2. The figures with critical slip surfaces are presented in Appendix C. It is important to note that the factor of safety values shown, are for failure surfaces that would result in significant (global) failure of the RSF embankment. Smaller, localized slope failures may occur at the face of the embankment, however these localized failures are not considered significant for the stability of the entire RSF embankment. As indicated, the stability analyses show that the critical failure surfaces all have factors of safety greater than the minimum values set forth in the design criteria.

Table 6-2 Slope Stability Analyses Results

	Factor of Safety (FoS)		
Case	Static	OBE (Operating Basis Earthquake)	DBE (Design Basis Earthquake)
1 – Upstream Stability	1.72	1.45	1.31
2 – Downstream Stability	1.66	1.32	1.15
Minimum Values	1.5	1.3	1.1

6.2 Seepage Analyses

Two-dimensional seepage analyses were performed with the finite element program GeoStudio 2007 SEEP/W developed by Geo-Slope International (Geo-Slope, 2007b) All analyses were completed for steady-state flow conditions with no consideration of time. Both saturated and unsaturated flow conditions were evaluated in the same model using conductivity functions, which define the variation in material conductivity with negative and positive pressure. The analyses section of the RSF described in Section 6.1 under slope stability analyses was used for the seepage analyses. The material hydraulic conductivities used for the analyses are presented in Table 6-1 above. The results of the seepage analyses that include the seepage profile of the RSF final embankment is presented in Appendix C.

6.3 Seismic Study

A seismic study for the proposed RSF at the DCA was undertaken.

The Operating Basis Earthquake was taken to be the 1,000 year return period event (following ANCOLD, 1998) and the assessed peak ground acceleration is 0.079g.

The Design Basis Earthquake was taken to be the 5,000 year return period event (following ANCOLD, 1998) and the assessed peak ground acceleration is 0.13g.

The details of the seismic study are presented in Appendix C.

Preliminary Closure Considerations

7.1 General

As of 30 June 2011, the RSF will require a mine closure plan to be developed and approved in accordance with the *Guideline for Preparing Mine Closure Plans (DMP, 2011).* under Part IV of the *Environmental Protection and Biodiversity and Conservation Act 1986.* This requirement specifies the identification of a final land use, definable criteria and measurable parameters to enable the accomplishment of achievable closure outcomes. Although this section discusses closure considerations for the RSF, its content should be inclusive of a whole of site mine closure plan for the operation. It is recommended that the above mentioned guideline be utilised when preparing the mine closure plan for the RSF.

Closure outcomes need to be specific to the RSF, achievable and realistic, but they must also incorporate the following to ensure that ecologically sustainable closure can be achieved:

- Corporate policy requirements;
- Corporate financial provisioning;
- Tenement and/or Ministerial Conditions imposed upon FerrAus as an outcome of environmental impact assessment;
- Early stakeholder consultation; and
- Physical and biological data analysis.

In particular, the RSF will be required to adhere to the *Safe Design and Operations Standard for Tailings Storage (DME, 1999)* in which it states that the final structure must be safe*,* stable and non-polluting.

7.2 Basis for Closure Design

Based on regulatory requirements, baseline data provided, climatic conditions and vegetation characteristics of the arid tropical zone, the implementation of a store-release cover system is preferable. The primary function of a store-release cover is to aid in maintaining a stable non-polluting landform by restricting deep infiltration of rainfall into the structure by optimising evaporation of ponded water on the surface of the cover, while allowing shallow storage of water for uptake by vegetation (evapo-transpiration). It is also recognised that the final landform must be geotechnically stable and able to withstand erosion over the short, medium and long term.

Although not all data has been viewed, conceptual design of the store release cover system has been assumed to require the following:

- A concave, duplex cover-profile with the capacity to retain 100-150 mm of water, in evaporation basins, against gravity;
- Minimisation of the penetration of water into surface-zone tailings to limit sulphide oxidation and prevent deep root uptake of heavy metals; and
- Re-vegetation with shrubs, grasses and perennial/annual varieties of plants.

Cover materials located at the RSF site was categorised as three types; “scree slope”, “flats” and “drainage”. Each of these were generally described, as being suitable for use on the surface of the RSF and the “scree” slope particularly suitable for outer embankments due to its high coarse fraction size and low potential for dispersion (Outback Ecology, 2010) and Graham Campbell and Associates, 2010). However; based on the information reviewed, volumes of these materials available have not been calculated. The Environmental Protection Authority will require FerrAus to clearly articulate where cover materials may be derived and if adequate volumes are available in the event of unplanned closure and upon planned closure of the RSF.

On the surface of the RSF, it is anticipated that FerrAus would seek to grow provenance species and that vegetation plots at the nearby Mirrin Mirrin ore deposit could be used to fast track trajectory closure criteria, as materials available at the surface of the DCA ore deposit sites are similar to those found at the Mirrin Mirrin ore deposit.

7.3 Geotechnical and Geochemical characteristics

The overall geotechnical stability of the RSF structure in the long-term depends on a combination of the construction of the RSF, physical stability and saturation of tailings, the physical parameters of the proposed capping material and an assessment of long-term settlement trends. These components need to be considered in an assessment of the proposed cover design. Maintenance of the stability of the structure will help achieve key closure objectives including:

- Prevention of erosion of the surface due to wind or surface run-off;
- Prevention of erosion of the embankments; and
- Minimisation of post-closure maintenance of the cover or embankments due to mass movement of the tailings.

Calculations for the RSF and its requirement for waste materials for structural embankments and capping are required.

With regards to geochemical characteristics, initial assessments of the mine waste rock and low grade materials at both the DCA and RRA minesites indicate that the materials are geochemically and physiochemically benign (Graeme Campbell and Associates, 2010); however it is understood further testing is currently being conducted. The Graeme Campbell and Associates study of 2010 would be adequate for use in developing closure criteria for a closure plan submitted in the early phases of the mine life.

7.4 Monitoring

Based on the review of brief information, it was clear that FerrAus are currently compiling a pre-feasibility approvals document with attached closure plan. The closure objectives, design and outcome criteria were not assessed as a part of this review. In order to determine if closure criteria are being achieved an ongoing monitoring program should be developed. This shall assist FerrAus in assessing performance of leading indicators and subsequently striving towards achieving the closure objective.

Monitoring requirements need to be specific, measurable, achievable, realistic and associated with a time period. Each monitoring requirement will be different and appropriate for each closure criteria, for example, in order to assess and record rehabilitation progress and final landform, monitoring may revolve around the point where adequate trajectory completion criteria have been achieved or a designated completion point, based on trials or analogue data, has been reached. The timeline associated with monitoring will depend upon the information at hand and the resources available.

7.5 Conceptual Criteria

The conceptual criteria (Table D-2 of Appendix D) for closure of the RSF are based on the requirement that the final landform must be geotechnically stable and able to withstand erosion over the short, medium and long term. The conceptual criteria provide FerrAus with a high level guide to the expected requirement for a closure plan to be submitted with the future Mining Proposal (specific to the RSF domain), however, a more thorough review of documentation and interaction with FerrAus to determine corporate policy and objectives, stakeholder requirements and commitments, and detailed design is required for completeness.

A detailed discussion on the Preliminary Closure Considerations summarised above is presented in Appendix D.

Material Quantity Estimate

8.1 General

Earthwork quantities have been estimated with digital terrain models prepared for the original ground topography and the feasibility-level design using AutoCAD Civil 3D 2010 computer program. The original ground topography data was provided by FerrAus.

Data reported by others based on their previous site investigations in the general project area was used as the basis for characterising the subsurface conditions at the site. This information was used to quantify the expected level of earthworks required to develop the RSF site. Descriptions and specifications of materials used in different zones of RSF embankments are included in design drawings presented in Appendix B.

Earthwork quantities for the proposed RSF are presented in Table 8-1.

Table 8-1 Estimated Material Quantities

Stage	Material Volume (m^3)		
	Zone 1	Zone 2	Zone 3 (minimum)
Starter	134,859	1,102,381	-
Raise 1	186,272	670,541	1,308,255
Raise 2	161,681	660,091	1,827,338
Raise 3	62,821	377,025	1,270,015
Total	545,633	2,810,038	4,405,608

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10

Limitations

10.1 Geotechnical & Hydrogeological Report

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of FerrAus Limited and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal No. 3091278 dated 8 March 2011.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between April and June 2011 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

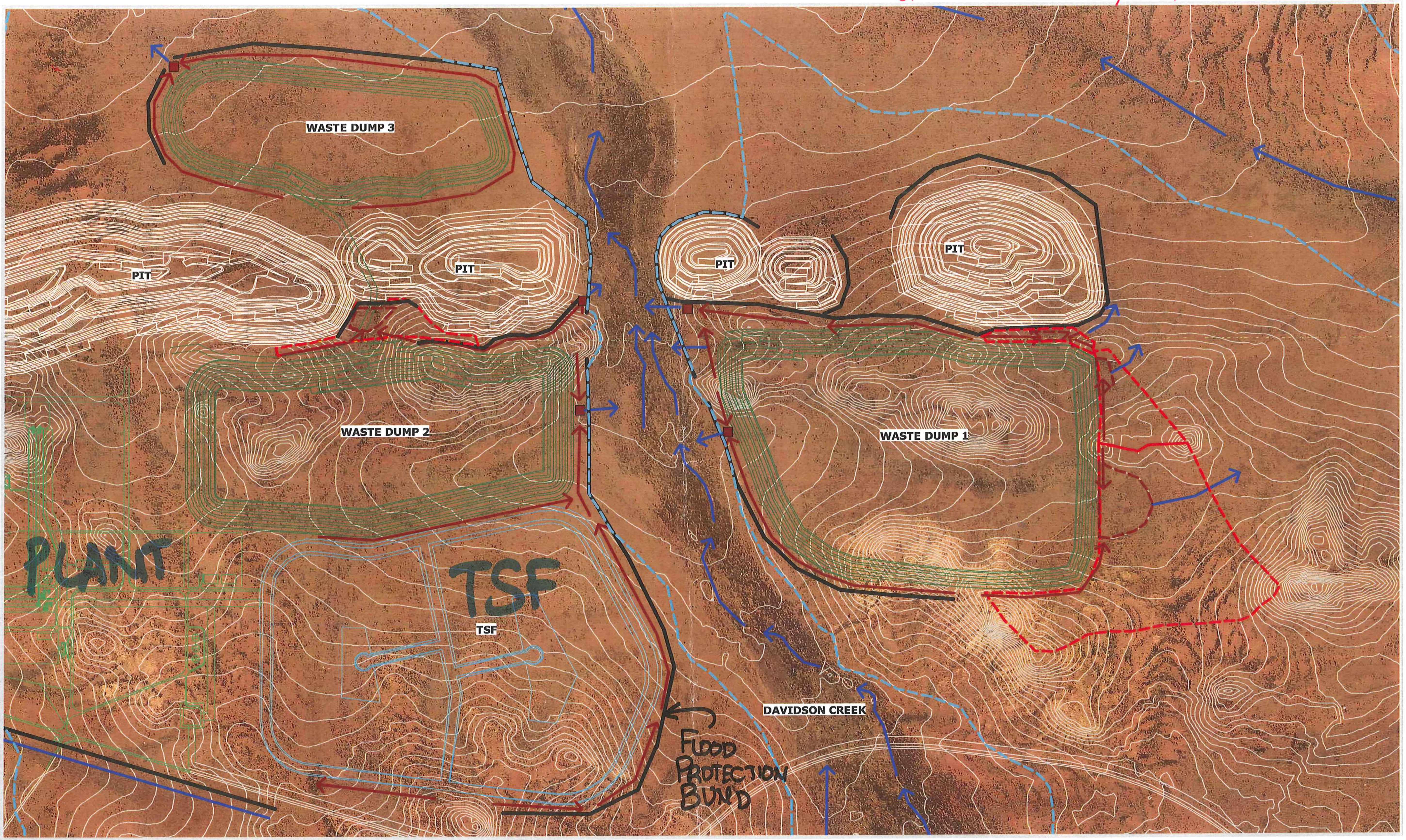
This report contains information obtained by inspection, sampling, testing or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. The borehole logs indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of conditions as constrained by the project budget limitations. The behaviour of groundwater and some aspects of contaminants in soil and groundwater are complex. Our conclusions are based upon the analytical data presented in this report and our experience. Future advances in regard to the understanding of chemicals and their behaviour, and changes in regulations affecting their management, could impact on our conclusions and recommendations regarding their potential presence on this site.

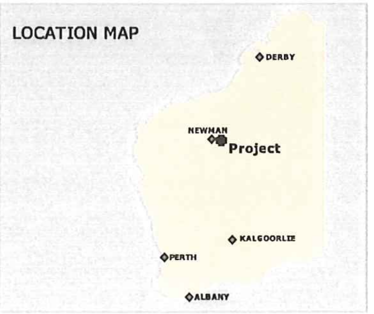
Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, URS must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

Appendix A RSF Options Study

GENERAL LAYOUT





Location: 1297B/REPORTING/SURFACE WATER/014

0 400 800
Meters
Scale: 1:20,000 @A3
GDA 1994 Zone 51

AUTHOR:	DM	REPORT NO:	014
DRAWN:	DM	REVISION:	a
DATE:	15/02/2011	JOB NO:	1297B

LEGEND

- Dirty Water Flow
- Clean Water Flow
- Diversion Bunding
- Sediment Trap
- Trapped Surface Water Area
- Estimated 100 Year ARI Floodline

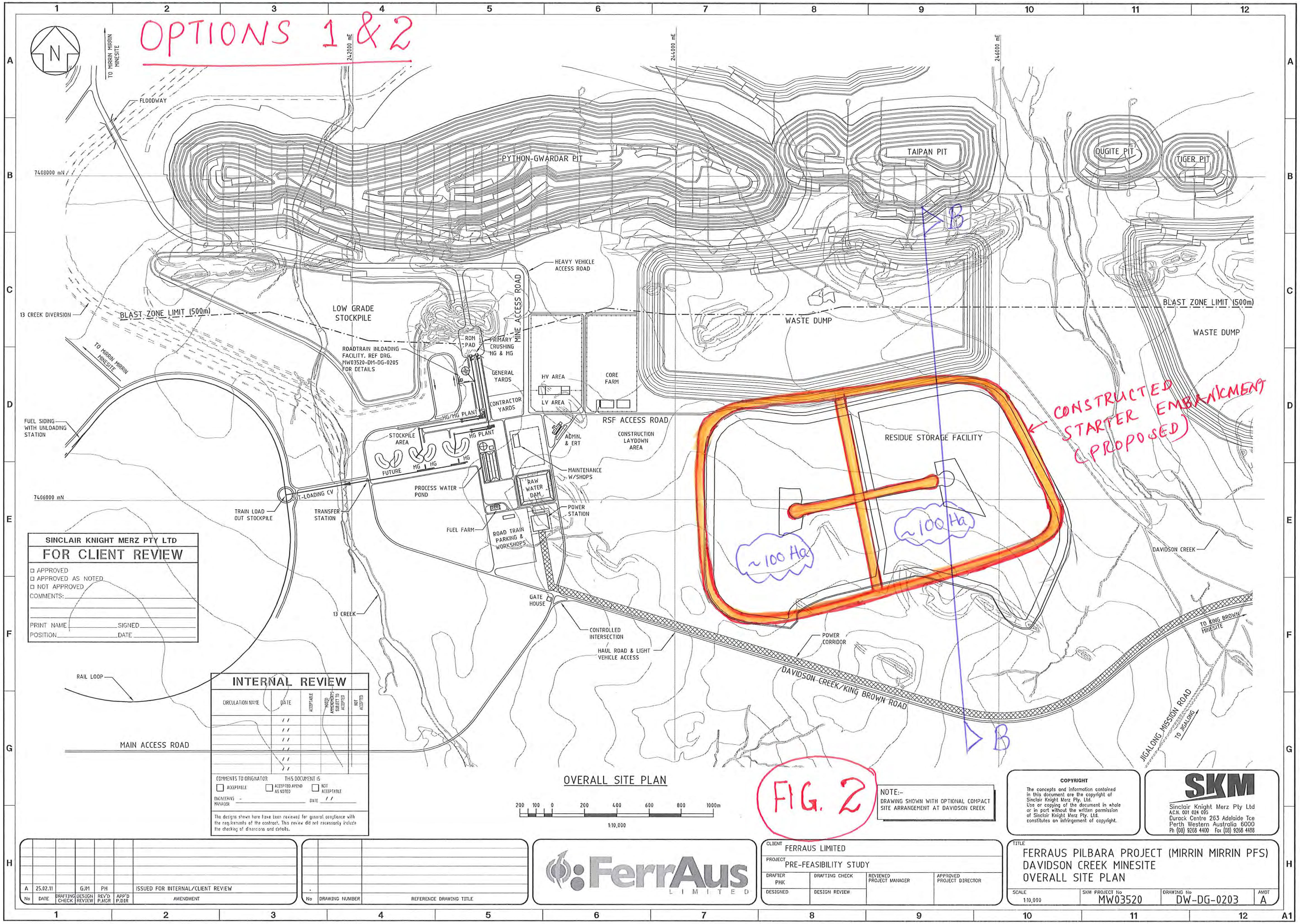
DATA SOURCES:
Client supplied aerial photography and 1m contours

RPS Aquaterra

FIGURE 6

DAVIDSON CREEK AREA: SURFACE WATER MANAGEMENT

FIG. 1


OPTIONS 1 & 2
TO MIRRIN MIRRIN MINESITE
FLOODWAY
PYTHON-GWARDAR PIT
TAIPAN PIT
DUGITE PIT
TIGER PIT
7408000 mN
242000 mE
244000 mE
246000 mE
13 CREEK DIVERSION
BLAST ZONE LIMIT (500m)
LOW GRADE STOCKPILE
HEAVY VEHICLE ACCESS ROAD
MINE ACCESS ROAD
WASTE DUMP
ROM PAD
PRIMARY CRUSHING HG & MG
ROADTRAIN INLOADING FACILITY. REF DRG. MW03520-DM-DG-0205 FOR DETAILS
GENERAL YARDS
HV AREA
LV AREA
CORE FARM
CONTRACTOR YARDS
HG/MG PLANT
HG PLANT
RSF ACCESS ROAD
FUEL SIDING WITH UNLOADING STATION
STOCKPILE AREA
FUTURE
MG
HG
ADMIN. & ERT
CONSTRUCTION LAYDOWN AREA
RESIDUE STORAGE FACILITY
CONSTRUCTED STARTER EMBANKMENT (PROPOSED)
MAINTENANCE W/SHOPS
PROCESS WATER POND
RAW WATER DAM
POWER STATION
7406000 mN
T-LOADING CV
TRAIN LOAD OUT STOCKPILE
TRANSFER STATION
FUEL FARM
ROAD TRAIN PARKING & WORKSHOPS
~100 Ha
~100 Ha
DAVIDSON CREEK
SINCLAIR KNIGHT MERZ PTY LTD
FOR CLIENT REVIEW
☐ APPROVED
☐ APPROVED AS NOTED
☐ NOT APPROVED
COMMENTS:
PRINT NAME
SIGNED
POSITION
DATE
GATE HOUSE
13 CREEK
CONTROLLED INTERSECTION
HAUL ROAD & LIGHT VEHICLE ACCESS
POWER CORRIDOR
TO KING BROWN MINESITE
DAVIDSON CREEK/KING BROWN ROAD
RAIL LOOP
INTERNAL REVIEW
CIRCULATION NAME
DATE
ACCEPTABLE
NOT ACCEPTED
COMMENTS TO ORIGINATOR
THIS DOCUMENT IS
ACCEPTABLE
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NOT ACCEPTABLE
ENGINEERING MANAGER
The designs shown here have been reviewed for general compliance with the requirements of the contract. This review did not necessarily include the checking of dimensions and details.
MAIN ACCESS ROAD
B
B
JIGALONG MISSION ROAD
TO JIGALONG
OVERALL SITE PLAN
200 100 0 200 400 600 800 1000m
1:10,000
FIG. 2
NOTE:- DRAWING SHOWN WITH OPTIONAL COMPACT SITE ARRANGEMENT AT DAVIDSON CREEK
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No DRAWING NUMBER REFERENCE DRAWING TITLE
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CLIENT FERRAUS LIMITED
PROJECT PRE-FEASIBILITY STUDY
DRAFTER PHK
DRAFTING CHECK
REVIEWED PROJECT MANAGER
APPROVED PROJECT DIRECTOR
DESIGNED
DESIGN REVIEW
TITLE FERRAUS PILBARA PROJECT (MIRRIN MIRRIN PFS) DAVIDSON CREEK MINESITE OVERALL SITE PLAN
SCALE 1:10,000
SKM PROJECT No MW03520
DRAWING No DW-DG-0203
AMDT A
A1

OPTION 1

- LIMITED CAPACITY TO STORE PMP.
(PMP = 1.75m)

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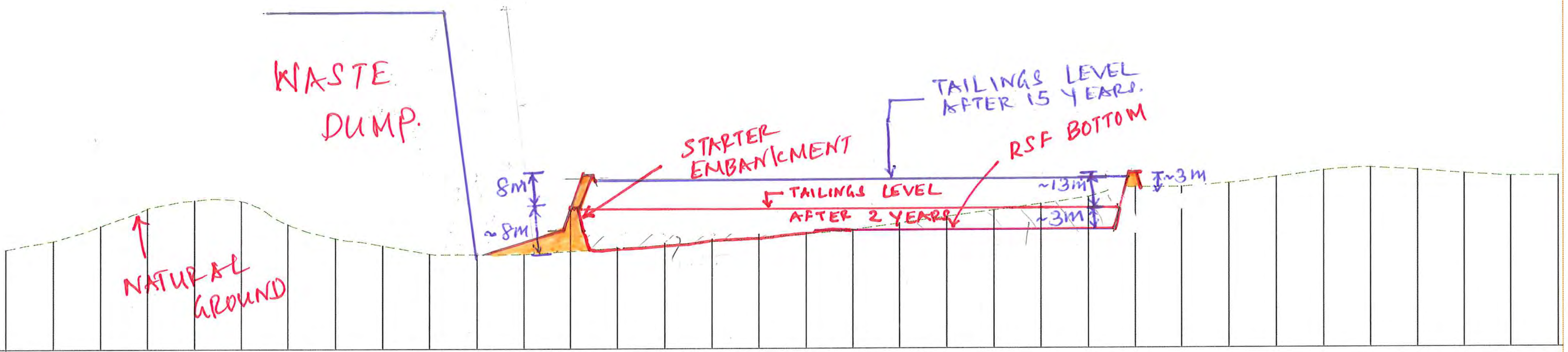

Datum 510.000

Design Surface											
Natural Surface	533.004	536.114	539.823	541.540	541.373	536.444	533.445	531.902	530.162	529.998	530.059
Chainage	100.000	200.000	300.000	400.000	500.000	600.000	700.000	800.000	900.000	1000.000	1100.000

Design Surface	539.332	535.000	535.000	535.000	535.000	535.000	535.000	535.000	535.000	535.000	535.000
Natural Surface	530.649	531.281	531.939	532.638	533.414	534.235	535.100	536.468	537.832	539.180	540.499
Chainage	1200.000	1300.000	1400.000	1500.000	1600.000	1700.000	1800.000	1900.000	2000.000	2100.000	2200.000

Design Surface	535.000										
Natural Surface	541.978	544.003	544.009	544.817	546.037	547.361	548.016	547.447	546.717	546.171	546.195
Chainage	2300.000	2400.000	2500.000	2600.000	2700.000	2800.000	2900.000	3000.000	3100.000	3200.000	3300.000

SECTION B-B.

VERTICAL EXAGGERATION =10

Fig 3

OPTION 2

- LIMITED CAPACITY TO STORE PMP
(PMP = 1.75 m)

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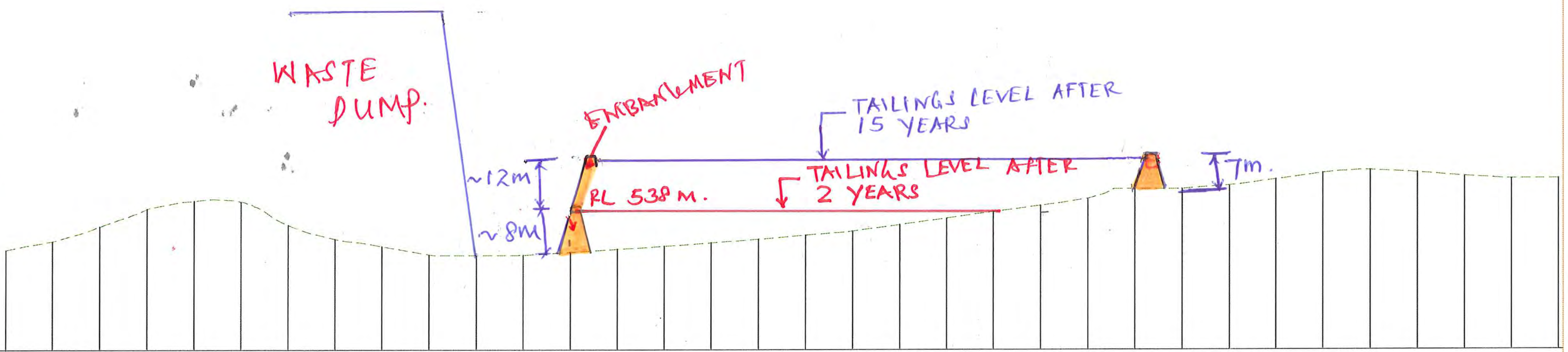

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Design Surface	533.004	536.114	539.823	541.540	541.373	536.444	533.445	531.902	530.162	529.998	530.059
Natural Surface	533.004	536.114	539.823	541.540	541.373	536.444	533.445	531.902	530.162	529.998	530.059
Chainage	100.000	200.000	300.000	400.000	500.000	600.000	700.000	800.000	900.000	1000.000	1100.000

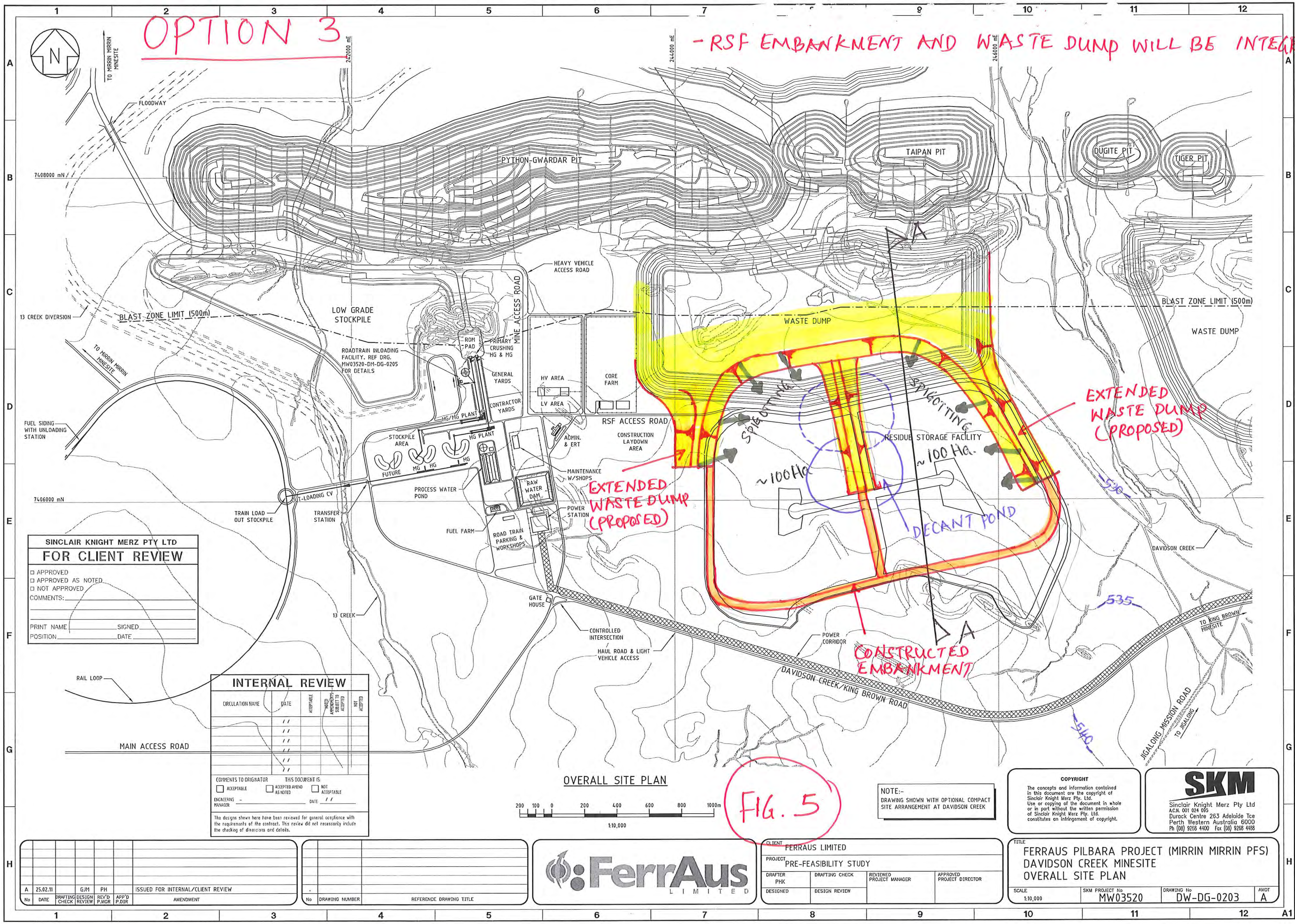
Design Surface	530.649	531.281	531.939	532.638	533.414	534.235	535.100	536.468	537.832	539.180	540.499
Natural Surface	530.649	531.281	531.939	532.638	533.414	534.235	535.100	536.468	537.832	539.180	540.499
Chainage	1200.000	1300.000	1400.000	1500.000	1600.000	1700.000	1800.000	1900.000	2000.000	2100.000	2200.000

Design Surface	541.978	544.003	544.009	544.817	546.037	547.361	548.016	547.447	546.717	546.171	546.195
Natural Surface	541.978	544.003	544.009	544.817	546.037	547.361	548.016	547.447	546.717	546.171	546.195
Chainage	2300.000	2400.000	2500.000	2600.000	2700.000	2800.000	2900.000	3000.000	3100.000	3200.000	3300.000

SECTION B-B

VERTICAL EXAGGERATION =10.

FIG. 4



OPTION 3
- RSF EMBANKMENT AND WASTE DUMP WILL BE INTEGRATED.
N
TO MIRRIN MIRRIN MINESITE
FLOODWAY
PYTHON-GWARDAR PIT
TAIPAN PIT
DUGITE PIT
TIGER PIT
7408000 mN
242000 mE
244000 mE
246000 mE
HEAVY VEHICLE ACCESS ROAD
MINE ACCESS ROAD
LOW GRADE STOCKPILE
13 CREEK DIVERSION
BLAST ZONE LIMIT (500m)
WASTE DUMP
ROM PAD
PRIMARY CRUSHING HG & MG
ROADTRAIN UNLOADING FACILITY. REF DRG. MW03520-DM-DG-0205 FOR DETAILS
GENERAL YARDS
HV AREA
CORE FARM
LV AREA
CONTRACTOR YARDS
HG/HG PLANT
HG PLANT
STOCKPILE AREA
FUTURE
MG
HG
FUEL SIDING WITH UNLOADING STATION
TO MIRRIN MIRRIN MINESITE
RSF ACCESS ROAD
ADMIN. & ERT
CONSTRUCTION LAYDOWN AREA
MAINTENANCE W/SHOPS
RESIDUE STORAGE FACILITY
SPIGOTTING
~100 Ha
~100 Ha.
DECANT POND
EXTENDED WASTE DUMP (PROPOSED)
EXTENDED WASTE DUMP (PROPOSED)
CONSTRUCTED EMBANKMENT
A
A
530
535
540
7406000 mN
LOADING CV
TRAIN LOAD OUT STOCKPILE
TRANSFER STATION
PROCESS WATER POND
RAW WATER DAM
POWER STATION
FUEL FARM
ROAD TRAIN PARKING & WORKSHOPS
GATE HOUSE
13 CREEK
CONTROLLED INTERSECTION
HAUL ROAD & LIGHT VEHICLE ACCESS
POWER CORRIDOR
DAVIDSON CREEK
DAVIDSON CREEK/KING BROWN ROAD
TO KING BROWN MINESITE
JIGALONG MISSION ROAD
TO JIGALONG
RAIL LOOP
MAIN ACCESS ROAD
SINCLAIR KNIGHT MERZ PTY LTD
FOR CLIENT REVIEW
☐ APPROVED
☐ APPROVED AS NOTED
☐ NOT APPROVED
COMMENTS:
PRINT NAME
SIGNED
POSITION
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ENGINEERING MANAGER
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OVERALL SITE PLAN
200 100 0 200 400 600 800 1000m
1:10,000
FIG. 5
NOTE:-
DRAWING SHOWN WITH OPTIONAL COMPACT SITE ARRANGEMENT AT DAVIDSON CREEK
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CLIENT FERRAUS LIMITED
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DRAFTING CHECK
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APPROVED PROJECT DIRECTOR
DESIGNED
DESIGN REVIEW
TITLE
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DAVIDSON CREEK MINESITE
OVERALL SITE PLAN
SCALE 1:10,000
SKM PROJECT No MW03520
DRAWING No DW-DG-0203
AMDT A
A1
CLIENT REVIEW

OPTION 3

– ADEQUATE CAPACITY TO STORE PMP.

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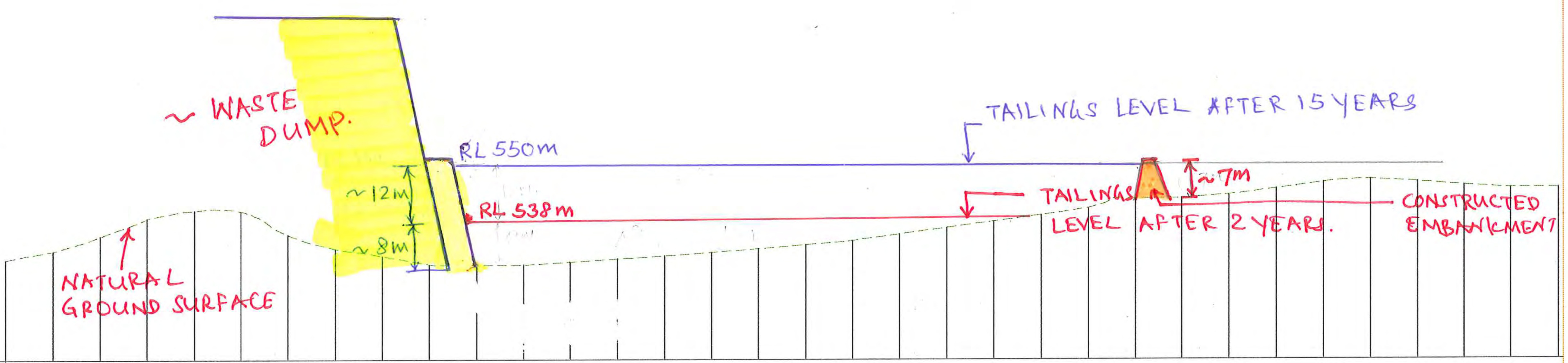

Datum 510.000

Chainage	100.000	200.000	300.000	400.000	500.000	600.000	700.000	800.000	900.000	1000.000	1100.000
Design Surface	533.004	536.114	539.823	541.540	541.373	536.444	533.445	531.902	530.162	529.998	530.059
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Chainage	1200.000	1300.000	1400.000	1500.000	1600.000	1700.000	1800.000	1900.000	2000.000	2100.000	2200.000
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Natural Surface	541.978	544.003	544.009	544.817	546.037	547.361	548.016	547.447	546.717	546.171	546.195

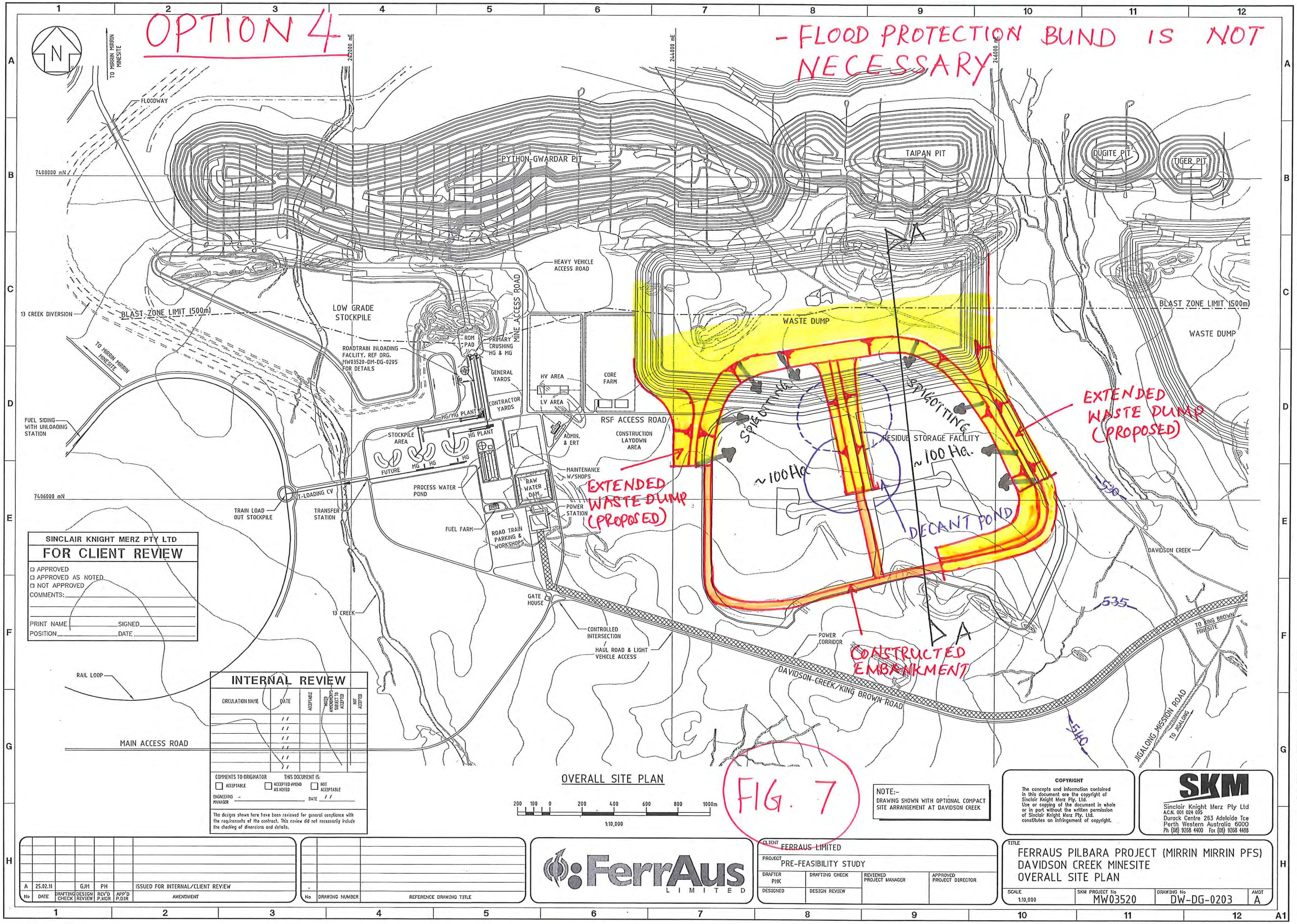
SECTION A–A.

VERTICAL EXAGGERATION = 10.

FIG. 6

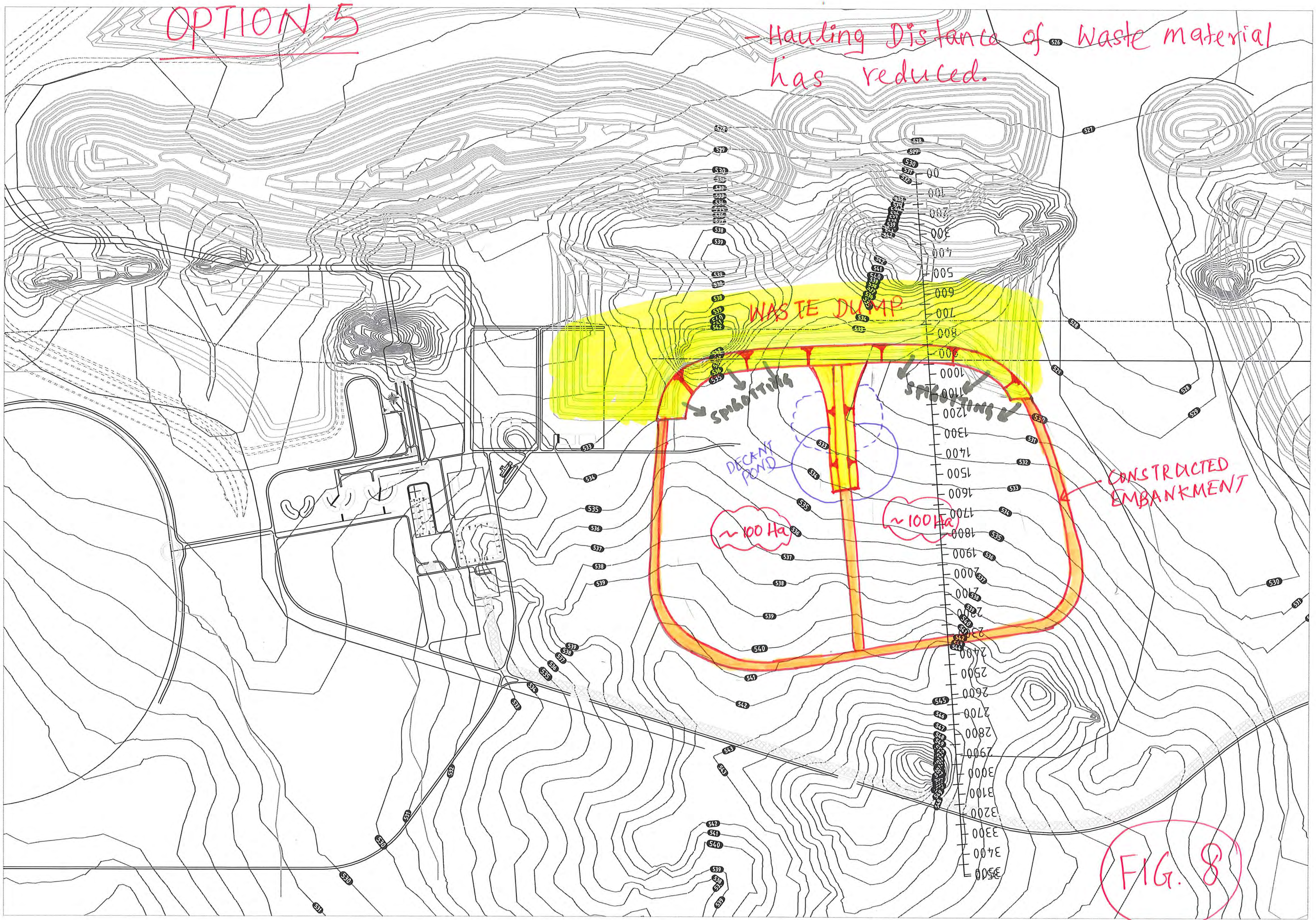
CLIENT REVIEW

CLIENT REVIEW



CLIENT REVIEW

CLIENT REVIEW

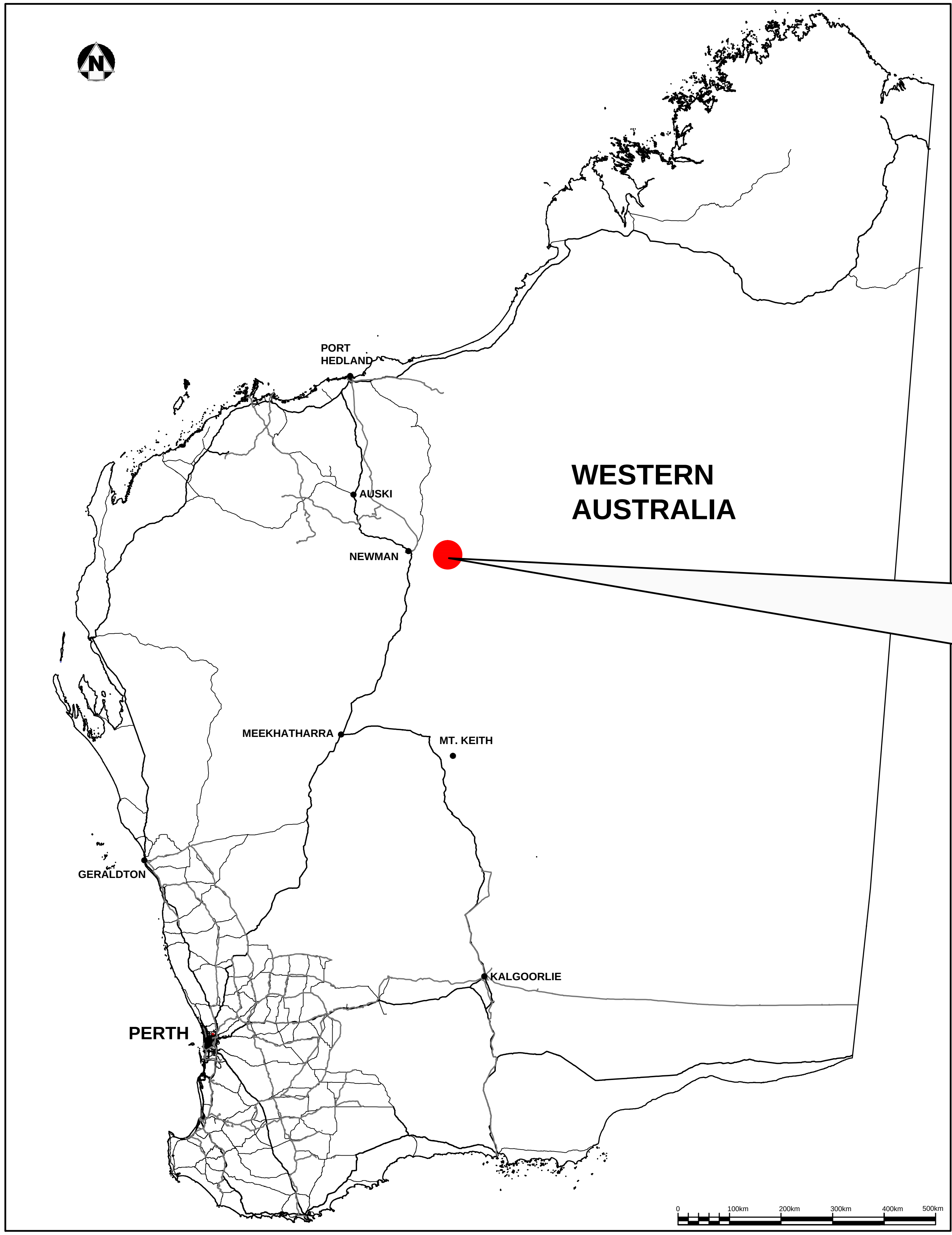


OPTION 5
- Hauling Distance of Waste material has reduced.
WASTE DUMP
SPIGOTTING
SPIGOTTING
DECANT POND
~100 Ha
~100 Ha
CONSTRUCTED EMBANKMENT

FIG. 8

Appendix B RSF Feasibility Design Drawings

THIS DRAWING TO BE READ IN CONJUNCTION WITH THE COMPLETE PROJECT DOCUMENTATION SET.

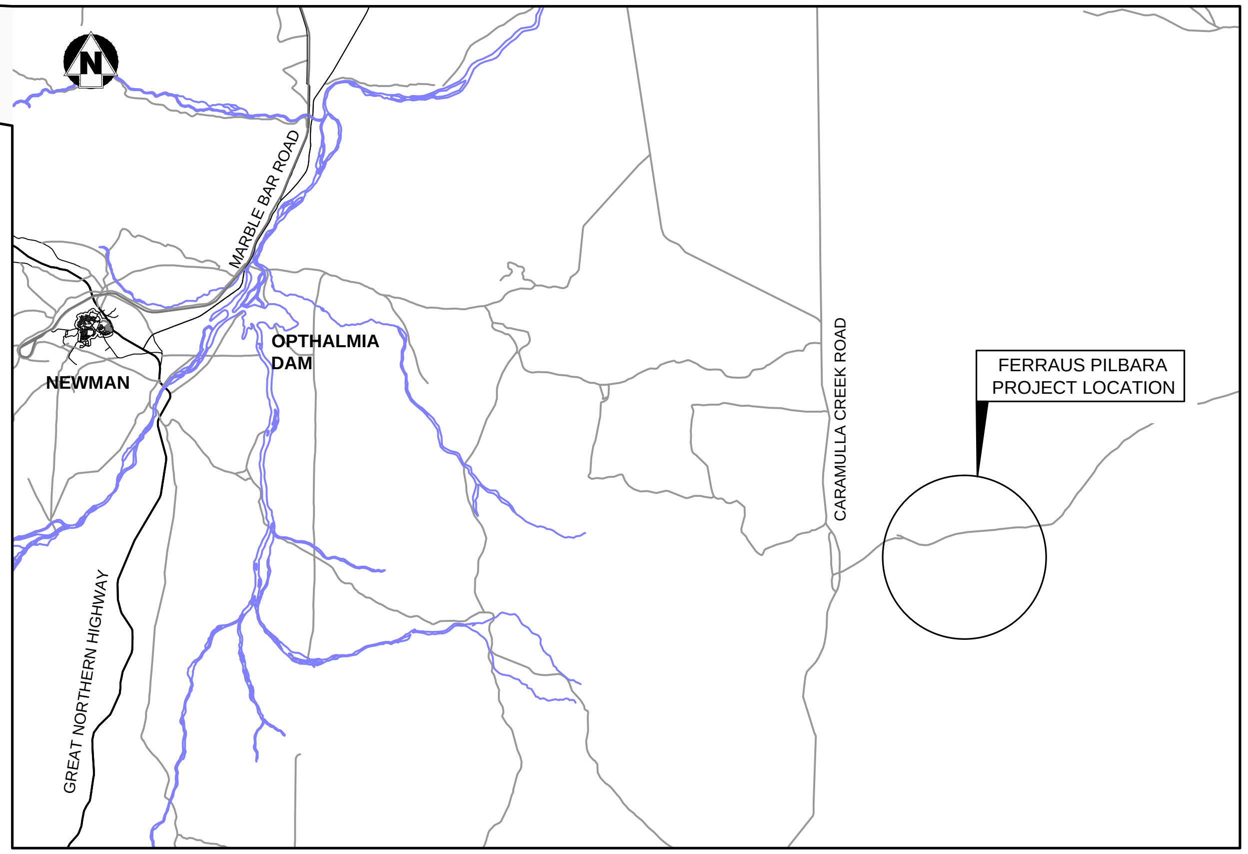


LOCALITY PLAN

1:5 000 000 @ A1

LIST OF DRAWINGS

DRAWING No	ABBREVIATED TITLE	REVISION
C-001	GENERAL SITE LOCATION & COVER SHEET	0
C-002	SITE LAYOUT	0
C-003	RESIDUE STORAGE FACILITY START-UP LAYOUT PLAN	0
C-004	STARTER EMBANKMENT TYPICAL CROSS SECTIONS	0
C-005	RESIDUE STORAGE FACILITY FINAL LAYOUT PLAN	0
C-006	FINAL EMBANKMENT TYPICAL CROSS SECTIONS	0
C-007	PERIMETER ROAD AND DRAINAGE CHANNELS DETAILS	0



SITE LOCATION

1: 1 30 000 @ A1

Rev	Drawn	Design	Date	REVISION RECORD
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Plotted: 6/27/2011 5:01:25 PM File Name: U:\Jobs\42907769\AMaster\42907769-C-001_0.dwg

CLIENT: FerrAus LIMITED

FERRAUS PILBARA PROJECT
RESIDUE STORAGE FACILITY
FEASIBILITY DESIGN

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

DRAWING TITLE:
GENERAL SITE LOCATION
AND COVER SHEET

Status: FINAL DRAFT

Datum: MGA 94 ZONE 51

Date: 27.06.11

URS

PROJECT MANAGER: AW

URS Australia Pty. Ltd. Perth, Western Australia 6000 Tel: +61 8 9326 0100 Fax: +61 8 9326 0296

Designed By: AW Date: 01.06.11

Drawn By: SVR Date: 08.06.11

Checked By: IG Date: 15.06.11

Approved By: EAN Date: 27.06.11

42907769-C-001_0.dwg

Drawing: C-001

REV. 0

THIS DRAWING TO BE READ IN CONJUNCTION WITH THE COMPLETE PROJECT DOCUMENTATION SET.

Legend:

- Railway
- 100 Year Floodline
- 500 Year Floodline
- Flood Protection Bunds (Designed by Others)
- Blast Limit

NOTES:

1. TOPOGRAPHIC CONTOURS PROVIDED BY FERRAUS ON 01.04.2011.
2. PITS, WASTE DUMPS AND PROCESS PLANT LOCATION AND GEOMETRIES PROVIDED BY FERRAUS IN APRIL 2011.
3. 100 YEAR AND 500 YEAR FLOODLINES PROVIDED BY RPS AQUATERRA IN APRIL 2011.
4. DATUM USED IS MGA 94 ZONE 51.
5. GROUND CONTOUR LABELS ARE ELEVATIONS IN METERS.
6. LAYOUT/LOCATION OF WASTE DUMP(S) AND PROCESS PLANT TO BE UPDATED FOLLOWING INPUT FROM FERRAUS.

Rev	Drawn	Design	Date	REVISION RECORD
0	SVR	AW	27.06.11	ISSUED FOR APPROVAL

CLIENT: FerrAus LIMITED

FERRAUS PILBARA PROJECT
RESIDUE STORAGE FACILITY
FEASIBILITY DESIGN

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

DRAWING TITLE: SITE LAYOUT

Status: FINAL DRAFT

Datum: MGA 94 ZONE 51

Date: 27.06.11

URS

PROJECT MANAGER: AW

Designed By: AW — Date: 01.06.11

Drawn By: SVR — Date: 08.06.11

Checked By: IG — Date: 15.06.11

Approved By: EAN — Date: 27.06.11

Drawing: C-002

REV. 0

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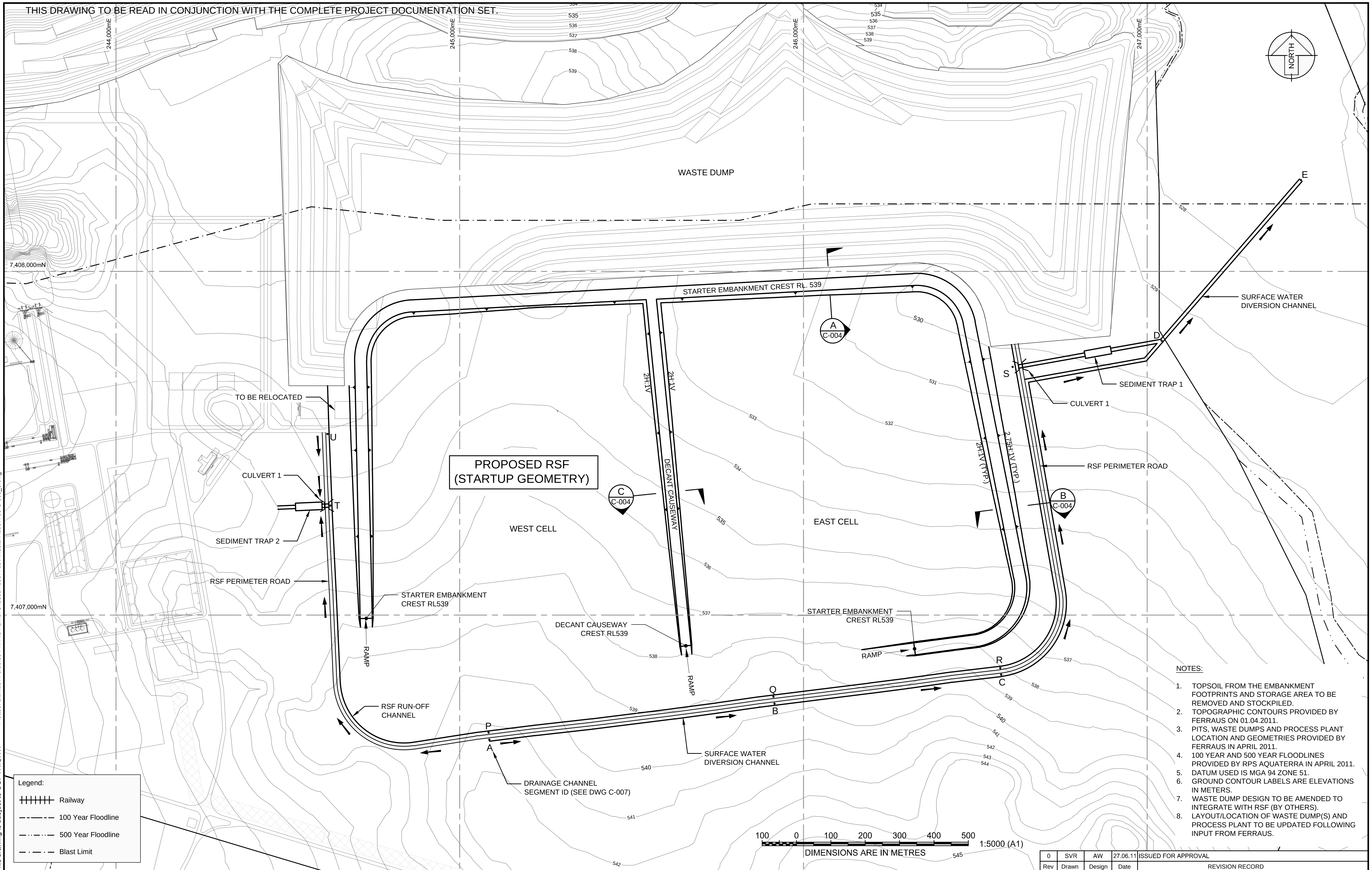

NOTES:

1. TOPSOIL FROM THE EMBANKMENT FOOTPRINTS AND STORAGE AREA TO BE REMOVED AND STOCKPILED.
2. TOPOGRAPHIC CONTOURS PROVIDED BY FERRAUS ON 01.04.2011.
3. PITS, WASTE DUMPS AND PROCESS PLANT LOCATION AND GEOMETRIES PROVIDED BY FERRAUS IN APRIL 2011.
4. 100 YEAR AND 500 YEAR FLOODLINES PROVIDED BY RPS AQUATERRA IN APRIL 2011.
5. DATUM USED IS MGA 94 ZONE 51.
6. GROUND CONTOUR LABELS ARE ELEVATIONS IN METERS.
7. WASTE DUMP DESIGN TO BE AMENDED TO INTEGRATE WITH RSF (BY OTHERS).
8. LAYOUT/LOCATION OF WASTE DUMP(S) AND PROCESS PLANT TO BE UPDATED FOLLOWING INPUT FROM FERRAUS.

Rev	Drawn	Design	Date	REVISION RECORD
0	SVR	AW	27.06.11	ISSUED FOR APPROVAL

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CLIENT: FerrAus LIMITED

FERRAUS PILBARA PROJECT
RESIDUE STORAGE FACILITY
FEASIBILITY DESIGN

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

DRAWING TITLE:
RESIDUE STORAGE FACILITY
START-UP LAYOUT PLAN

Status: FINAL DRAFT
Datum: MGA 94 ZONE 51
Date: 27.06.11

URS

PROJECT MANAGER: AW

Designed By: AW | Drawn By: SVR | Checked By: IG | Approved By: EAN

Date: 01.06.11 | Date: 08.06.11 | Date: 15.06.11 | Date: 27.06.11

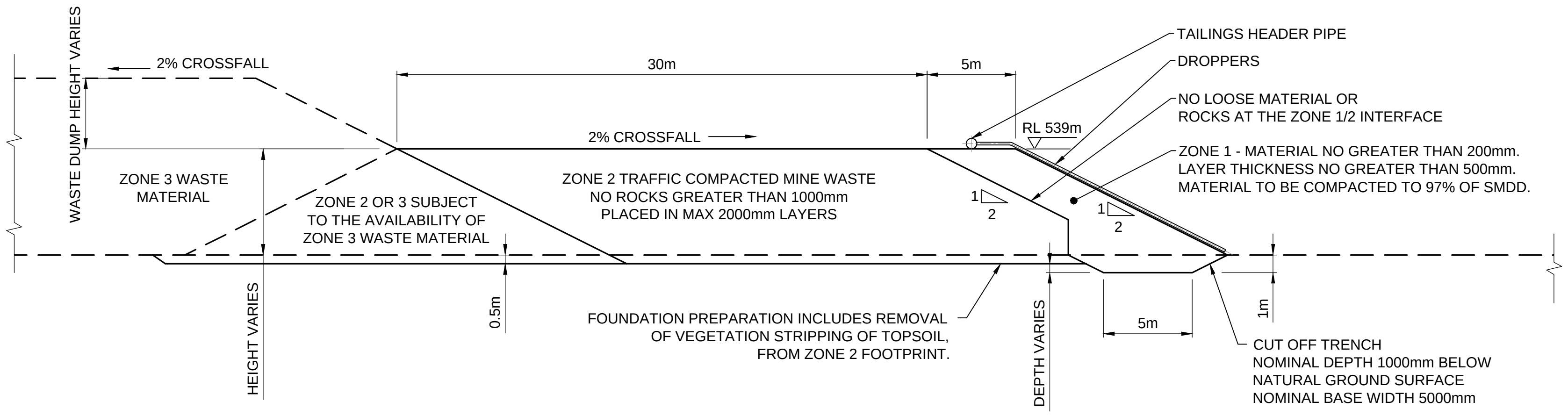
URS Australia Pty. Ltd. Perth, Western Australia 6000 Tel: +61 8 9326 0100 Fax: +61 8 9326 0296

42907769-C-003_0.dwg

Drawing: C-003

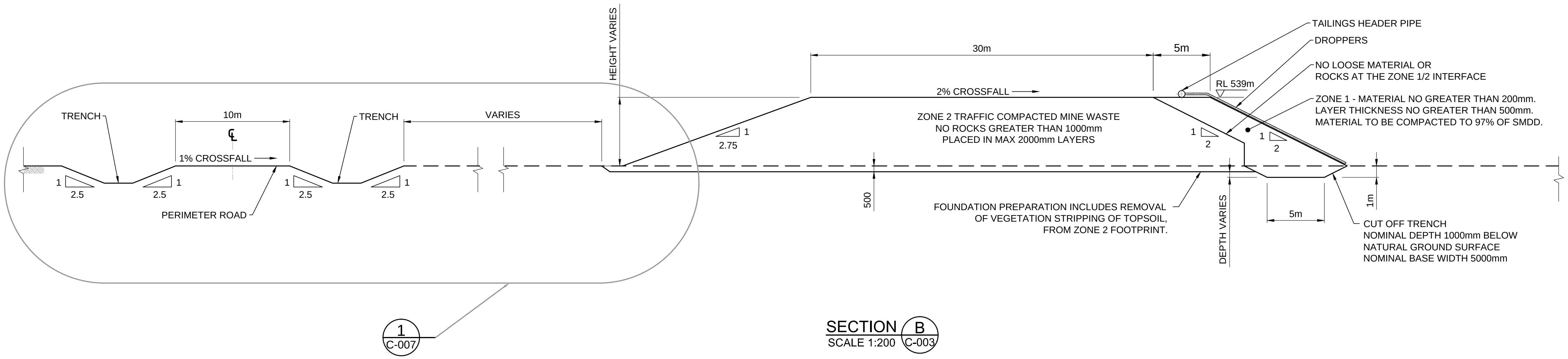
REV. 0

THIS DRAWING TO BE READ IN CONJUNCTION WITH THE COMPLETE PROJECT DOCUMENTATION SET.



SECTION A (C-003)
SCALE 1:200

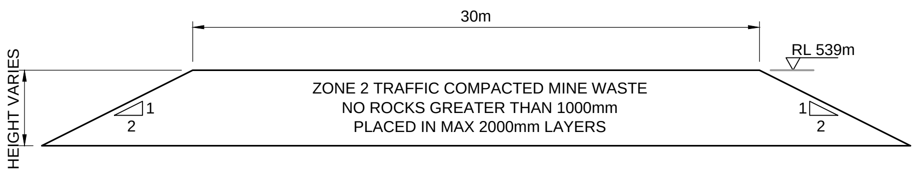
STARTER EMBANKMENT SECTION AGAINST WASTE DUMP



SECTION B (C-003)
SCALE 1:200

STARTER EMBANKMENT SECTION (TYP.)

	CONSTRUCTION MATERIAL
ZONE 1	SELECT MINE WASTE WITH SUBSTANTIAL FINES CONTENT, CLASIFICATION: GC, SC, CL, CI, CH, MAX. PARTICLE SIZE 200mm, PLACED IN MAX. 500mm LAYERS, COMPACTED TO MIN. 97% SMDD.
ZONE 2	MINE WASTE WITH MAX. PARTICLE SIZE OF 1000mm PLACED IN MAX. 2000mm LAYERS AND TRAFFIC COMPACTED.
ZONE 3	GENERAL MINE WASTE MATERIAL.



SECTION C (C-003)
SCALE 1:200

DECANT CAUSEWAY - STARTER EMBANKMENT

NOTES:
1. DO NOT SCALE FROM THIS DRAWING

4 0 4 8 12 16 20 1:200 (A1)
DIMENSIONS ARE IN METRES

Plotted: 6/27/2011 5:08:53 PM File Name: U:\Jobs\42907769\AMaster\42907769_C-004 006 And 007_0.dwg

Rev	Drawn	Design	Date	REVISION RECORD
0	AS	AW	27.06.11	ISSUED FOR INFORMATION

CLIENT: FerrAus LIMITED

FERRAUS PILBARA PROJECT
RESIDUE STORAGE FACILITY
FEASIBILITY DESIGN

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

DRAWING TITLE:
STARTER EMBANKMENT
TYPICAL CROSS SECTIONS

Status: FINAL DRAFT
Datum: -
Date: 27.06.11

URS

PROJECT MANAGER: AW
Designed By: AW — Date: 01.06.11
Drawn By: AS — Date: 08.06.11
Checked By: IG — Date: 15.06.11
Approved By: EAN — Date: 27.06.11

URS Australia Pty. Ltd. Perth, Western Australia 6000 Tel: +61 8 9326 0100 Fax: +61 8 9326 0296

Drawing: C-004
42907769_C-004 006 and 007_0.dwg
REV. 0

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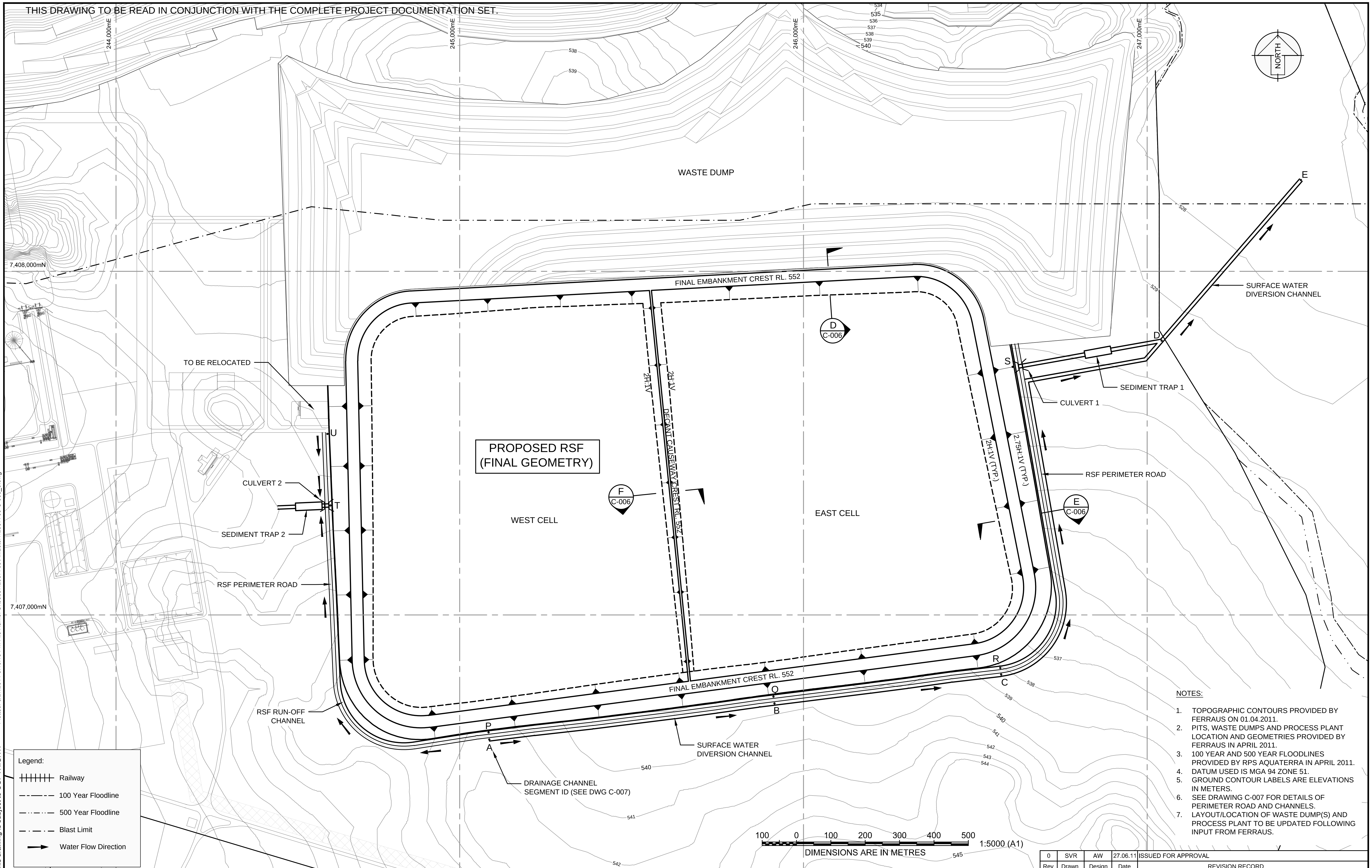

NOTES:

1. TOPOGRAPHIC CONTOURS PROVIDED BY FERRAUS ON 01.04.2011.
2. PITS, WASTE DUMPS AND PROCESS PLANT LOCATION AND GEOMETRIES PROVIDED BY FERRAUS IN APRIL 2011.
3. 100 YEAR AND 500 YEAR FLOODLINES PROVIDED BY RPS AQUATERRA IN APRIL 2011.
4. DATUM USED IS MGA 94 ZONE 51.
5. GROUND CONTOUR LABELS ARE ELEVATIONS IN METERS.
6. SEE DRAWING C-007 FOR DETAILS OF PERIMETER ROAD AND CHANNELS.
7. LAYOUT/LOCATION OF WASTE DUMP(S) AND PROCESS PLANT TO BE UPDATED FOLLOWING INPUT FROM FERRAUS.

Rev	Drawn	Design	Date	REVISION RECORD
0	SVR	AW	27.06.11	ISSUED FOR APPROVAL

CLIENT: FerrAus LIMITED

FERRAUS PILBARA PROJECT
RESIDUE STORAGE FACILITY
FEASIBILITY DESIGN

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DRAWING TITLE: RESIDUE STORAGE FACILITY FINAL LAYOUT PLAN

Status: FINAL DRAFT

Datum: MGA 94 ZONE51

Date: 27.06.11

URS

PROJECT MANAGER: AW

URS Australia Pty. Ltd. Perth, Western Australia 6000 Tel: +61 8 9326 0100 Fax: +61 8 9326 0296

Designed By: AW	Drawn By: SVR	Checked By: IG	Approved By: EAN
Date: 01.06.11	Date: 08.06.11	Date: 15.06.11	Date: 27.06.11

Drawing: C-005

42907769-C-005_0.dwg

REV. 0

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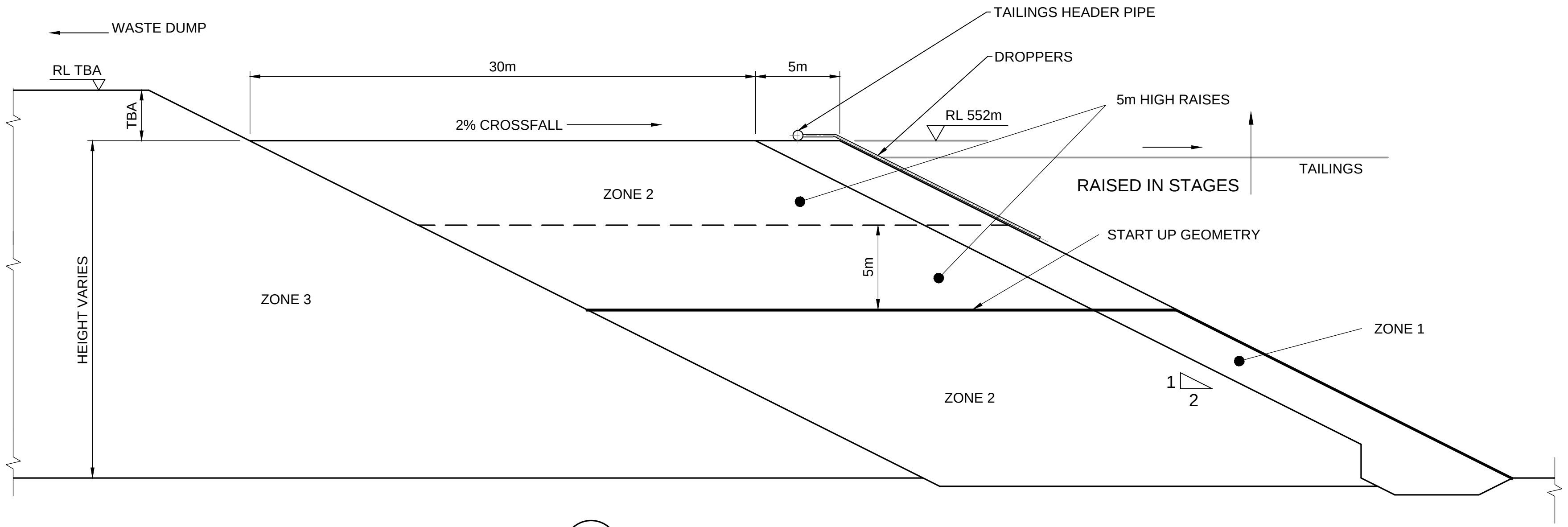
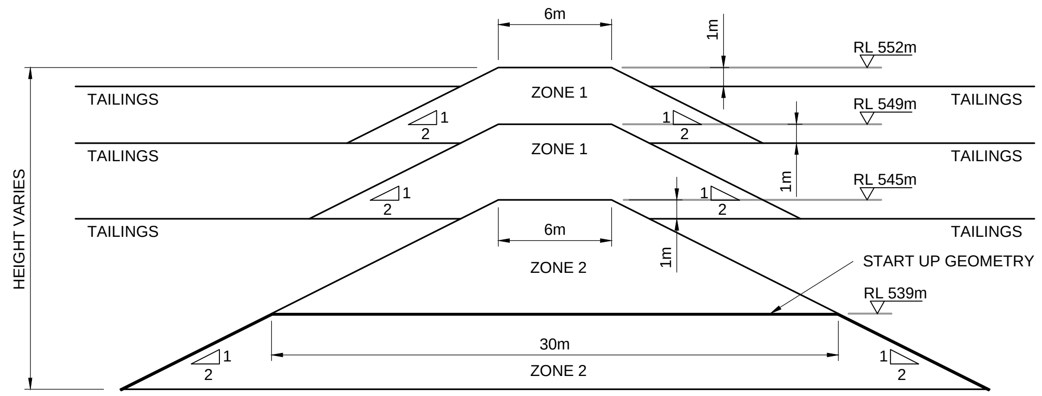


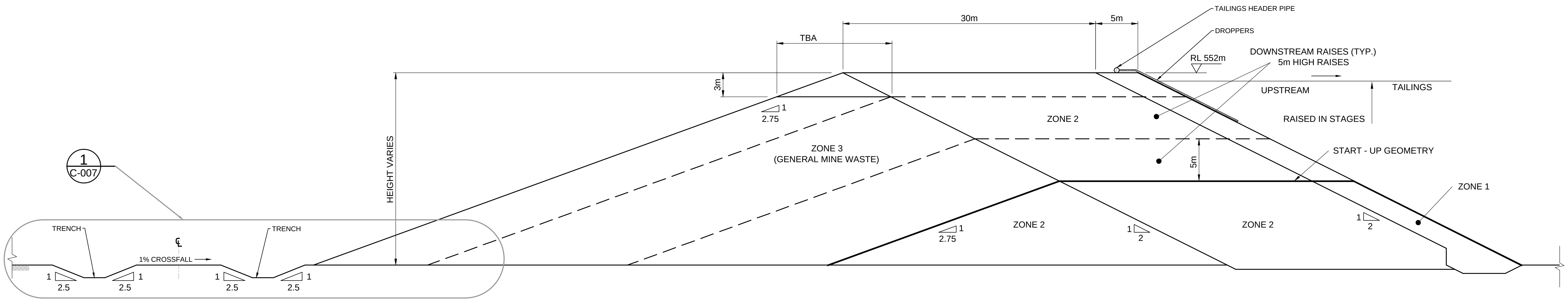
SECTION D
SCALE 1:200 C-005

FUTURE RAISING OF EMBANKMENT AGAINST WASTE DUMP (TYP.)



SECTION F
SCALE 1:200 C-005

DECANT CAUSEWAY - FINAL EMBANKMENT



SECTION E
SCALE 1:250 C-005

FINAL EMBANKMENT SECTION (TYP.)

5 0 5 10 15 20 25 1:250 (A1)
DIMENSIONS ARE IN METRES

4 0 4 8 12 16 20 1:200 (A1)
DIMENSIONS ARE IN METRES

NOTES:

1. DO NOT SCALE FROM THIS DRAWING

Rev	Drawn	Design	Date	REVISION RECORD
0	AS	AW	27.06.11	ISSUED FOR INFORMATION

CLIENT: FerrAus LIMITED

FERRAUS PILBARA PROJECT
RESIDUE STORAGE FACILITY
FEASIBILITY DESIGN

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

DRAWING TITLE:
FINAL EMBANKMENT
TYPICAL CROSS SECTIONS

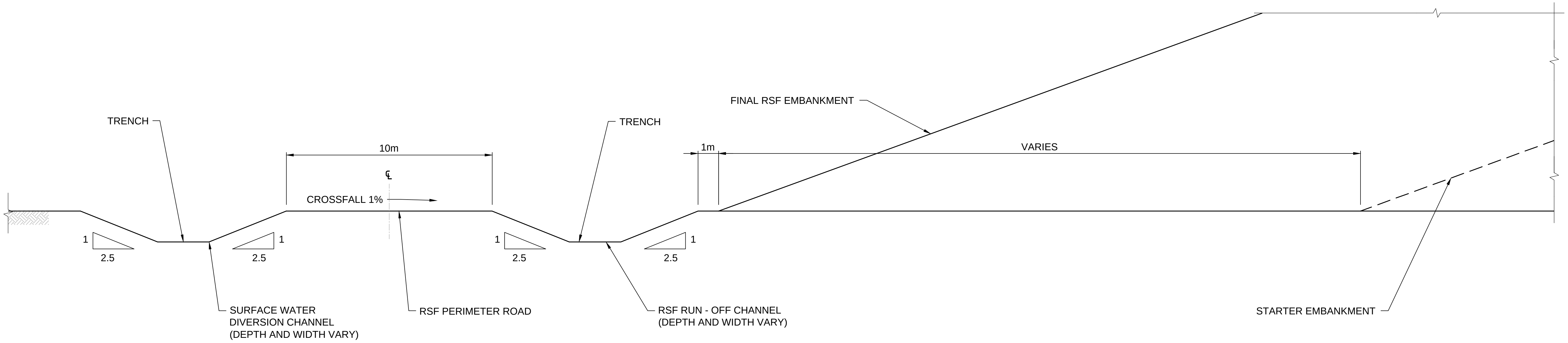
Status: FINAL DRAFT
Datum: -
Date: 27.06.11

URS
PROJECT MANAGER: AW
URS Australia Pty. Ltd. Perth, Western Australia 6000 Tel: +61 8 9326 0100 Fax: +61 8 9326 0296

Designed By: AW Date: 01.06.11
Drawn By: AS Date: 08.06.11
Checked By: IG Date: 15.06.11
Approved By: EAN Date: 27.06.11

Drawing: C-006
42907769_C-004 006 and 007_0.dwg REV. 0

THIS DRAWING TO BE READ IN CONJUNCTION WITH THE COMPLETE PROJECT DOCUMENTATION SET.

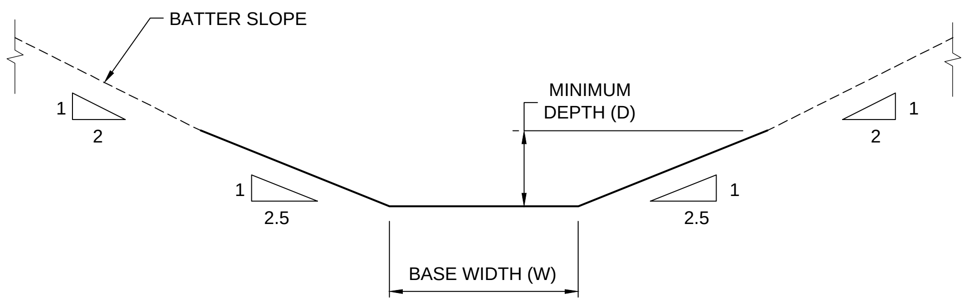


DETAIL 1 C-005 /C-006
SCALE 1:100

PERIMETER ROAD AND CHANNELS TYPICAL CROSS SECTION

DRAINAGE CHANNEL DETAILS

CHANNEL SECTION	POINT		MINIMUM DEPTH (m)	BASE WIDTH (m)
	FROM	TO		
C01	A	B	2.00	6.0
C02	B	C	2.00	9.0
C03	C	D	2.50	9.0
C04	D	E	2.50	10.0
C05	P	Q	1.30	2.0
C06	Q	R	1.30	4.0
C07	R	S	1.50	5.0
C08	S	D	1.30	2.0
C09	P	T	1.30	2.0
C10	U	T	0.80	2.0



TYPICAL CHANNEL CROSS SECTION
SCALE: 1:50

1 0 1 2 3 4 5 1:50 (A1)
DIMENSIONS ARE IN METRES

2 0 2 4 6 8 10 1:100 (A1)
DIMENSIONS ARE IN METRES

NOTES:

1. REFER URS REPORT - FEASIBILITY DESIGN OF RSF FOR EROSION PROTECTION REQUIREMENTS OF CHANNELS.
2. DO NOT SCALE FROM THIS DRAWING

Rev	Drawn	Design	Date	REVISION RECORD
0	AS	AW	27.06.11	ISSUED FOR INFORMATION

Plotted: 6/27/2011 5:06:52 PM File Name: U:\Jobs\42907769\AMaster\42907769_C-004 006 And 007_0.dwg

CLIENT: FerrAus LIMITED

FERRAUS PILBARA PROJECT
RESIDUE STORAGE FACILITY
FEASIBILITY DESIGN

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

DRAWING TITLE:
PERIMETER ROAD
AND DRAINAGE CHANNELS
DETAILS

Status: FINAL DRAFT
Datum: -
Date: 27.06.11

URS

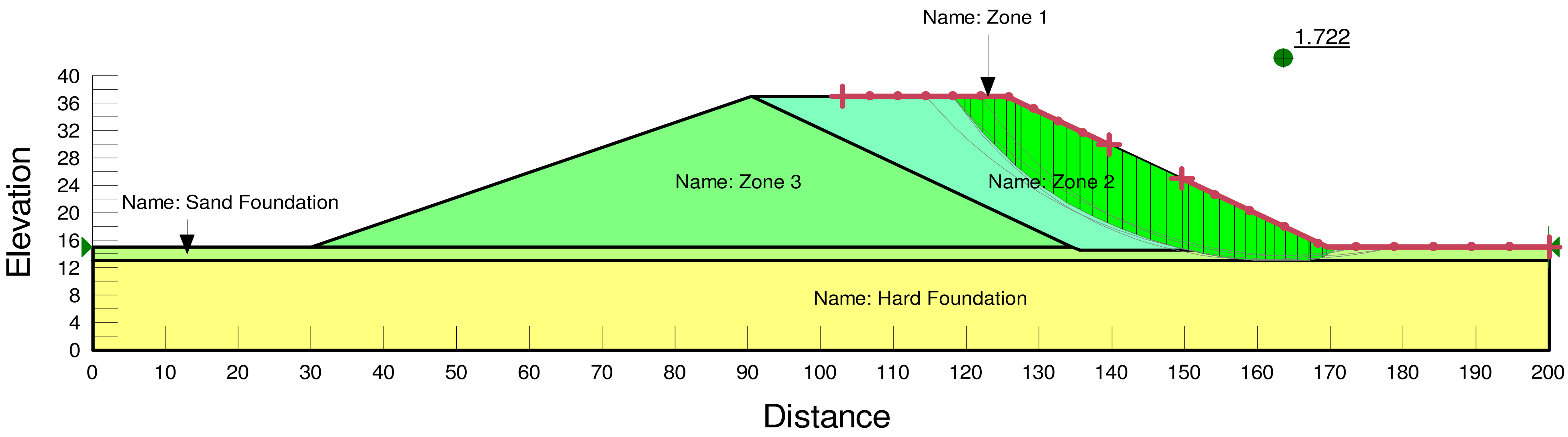
PROJECT MANAGER: AW
URS Australia Pty. Ltd. Perth, Western Australia 6000 Tel: +61 8 9326 0100 Fax: +61 8 9326 0296

Designed By: AW Date: 01.06.11
Drawn By: AS Date: 08.06.11
Checked By: IG Date: 15.06.11
Approved By: EAN Date: 27.06.11

Drawing: C-007
42907769_C-004 006 and 007_0.dwg REV. 0

C

Appendix C Supporting Analyses



Name: Zone 1
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 2
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 3
Unit Weight: 19 kN/m³
Cohesion: 40 kPa
Phi: 31 °

Name: Sand Foundation
Unit Weight: 17 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Hard Foundation
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 40 °

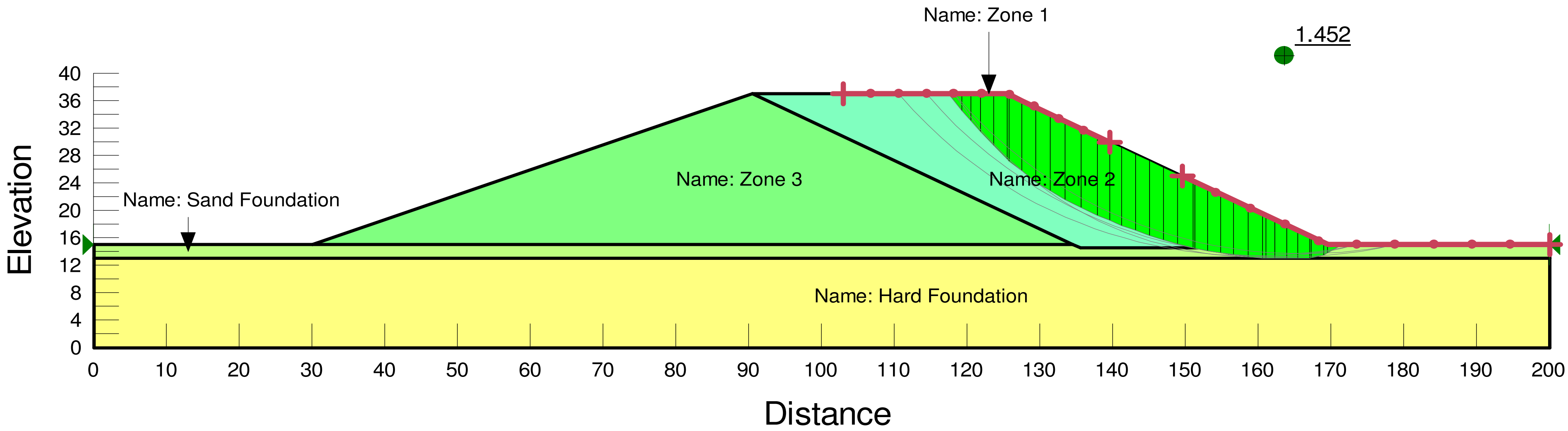
Job No.	42907769	
Prep. By	JT	21 Jun. '11
Chk'd By	AW	21 Jun. '11
Revision No.		0

FerrAus Pilbara Project

Upstream Stability
Static Case

Figure 1

URS



Name: Zone 1
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 2
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 3
Unit Weight: 19 kN/m³
Cohesion: 40 kPa
Phi: 31 °

Name: Sand Foundation
Unit Weight: 17 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Hard Foundation
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 40 °

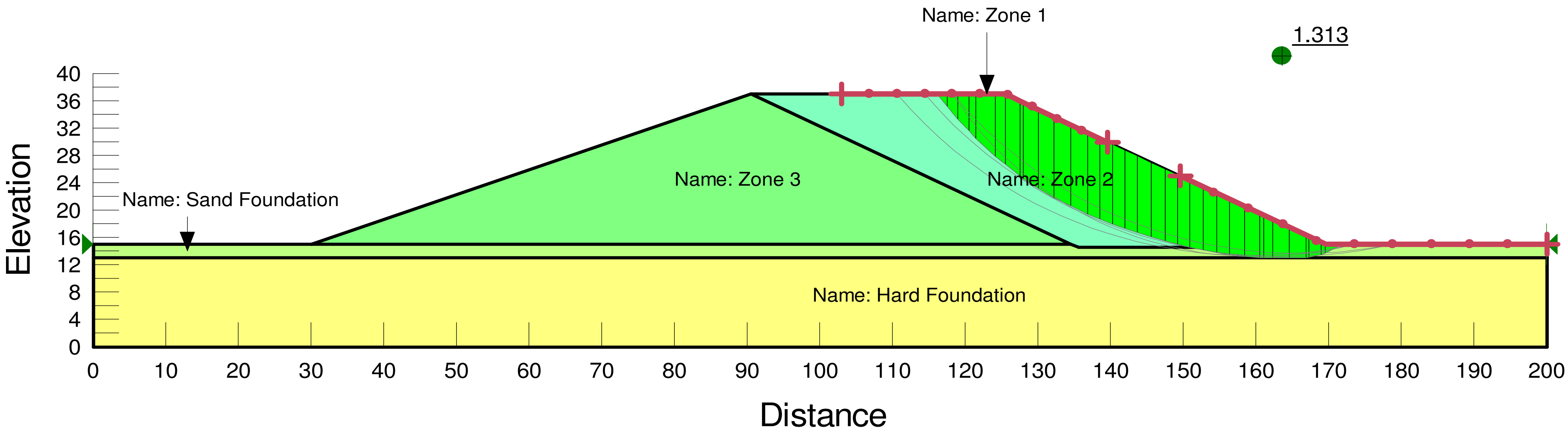
Job No.	42907769	
Prep. By	JT	21 Jun. '11
Chk'd By	AW	21 Jun. '11
Revision No.		0

FerrAus Pilbara Project

Upstream Stability Under Earthquake
OBE Case (0.079g)

Figure 2

URS



Name: Zone 1
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 2
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 3
Unit Weight: 19 kN/m³
Cohesion: 40 kPa
Phi: 31 °

Name: Sand Foundation
Unit Weight: 17 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Hard Foundation
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 40 °

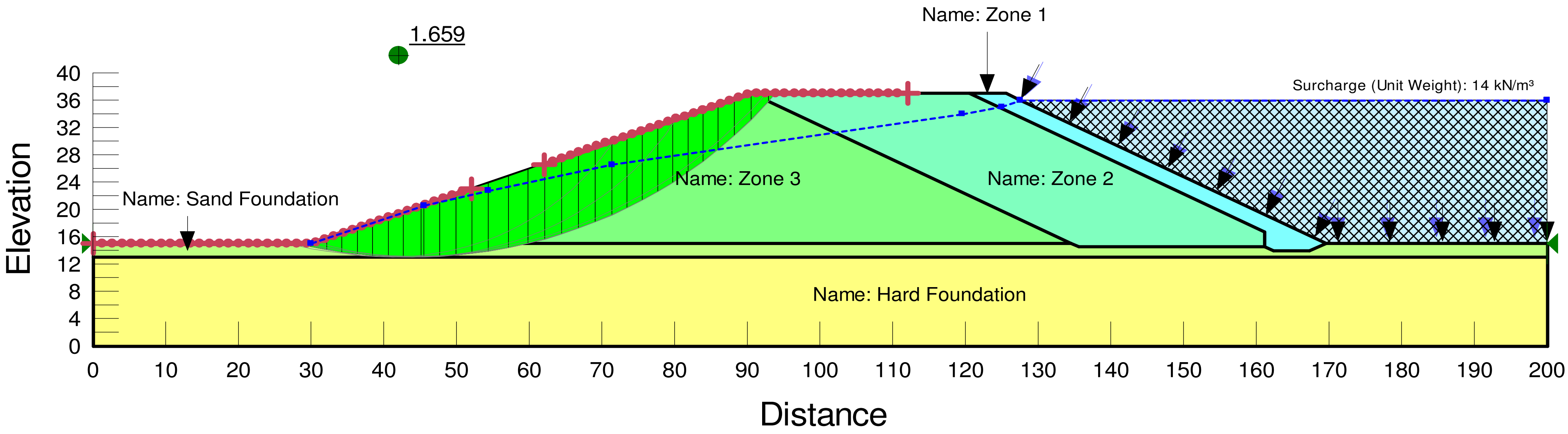
Job No.	42907769	
Prep. By	JT	21 Jun. '11
Chk'd By	AW	21 Jun. '11
Revision No.		0

FerrAus Pilbara Project

Upstream Stability Under Earthquake
DBE Case (0.13g)

Figure 3

URS



Name: Zone 1
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 2
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 3
Unit Weight: 19 kN/m³
Cohesion: 40 kPa
Phi: 31 °

Name: Sand Foundation
Unit Weight: 17 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Hard Foundation
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 40 °

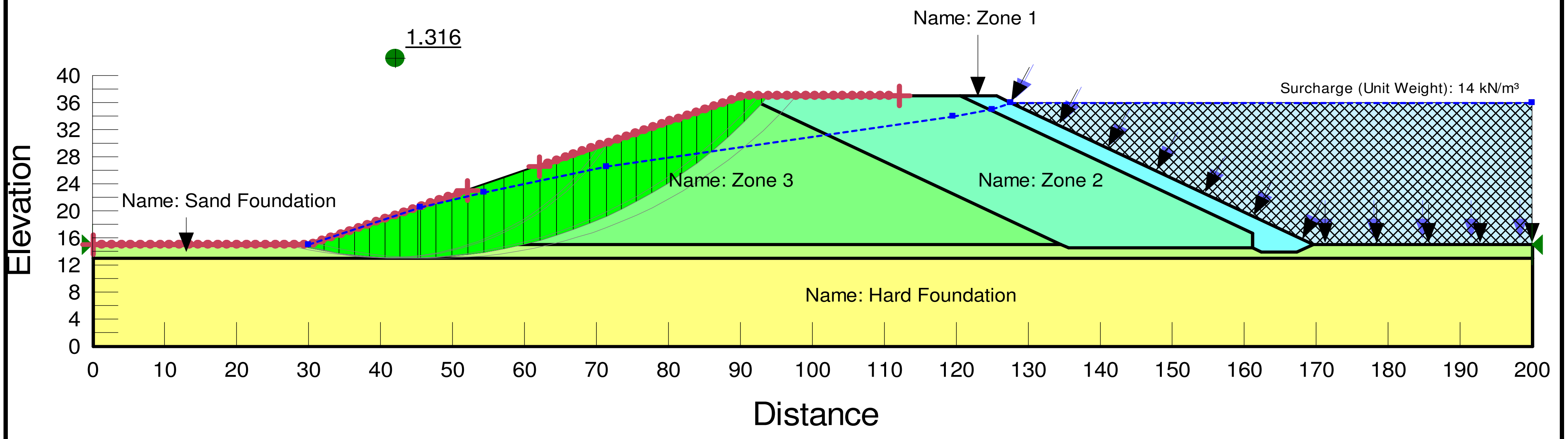
Job No.	42907769	
Prep. By	JT	21 Jun. '11
Chk'd By	AW	21 Jun. '11
Revision No.		0

FerrAus Pilbara Project

Downstream Stability
Static Case

Figure 4

URS



Name: Zone 1
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 2
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 3
Unit Weight: 19 kN/m³
Cohesion: 40 kPa
Phi: 31 °

Name: Sand Foundation
Unit Weight: 17 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Hard Foundation
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 40 °

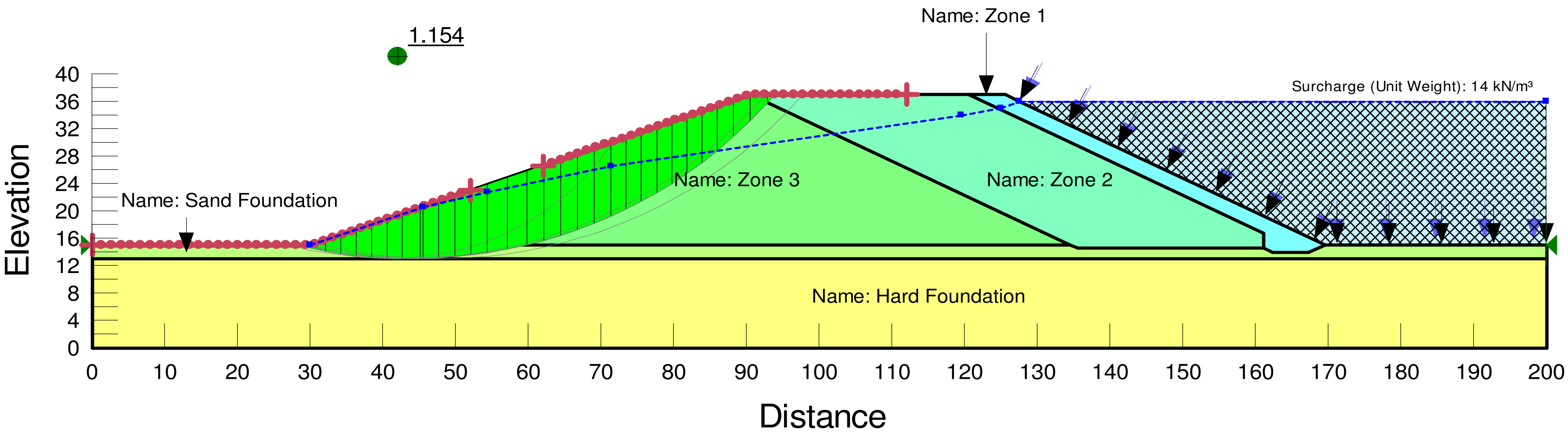
Job No.	42907769	
Prep. By	JT	21 Jun. '11
Chk'd By	AW	21 Jun. '11
Revision No.	0	

FerrAus Pilbara Project

Upstream Stability Under Earthquake
OBE Case (0.079g)

Figure 5

URS



Name: Zone 1
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 2
Unit Weight: 18 kN/m³
Cohesion: 43 kPa
Phi: 21 °

Name: Zone 3
Unit Weight: 19 kN/m³
Cohesion: 40 kPa
Phi: 31 °

Name: Sand Foundation
Unit Weight: 17 kN/m³
Cohesion: 0 kPa
Phi: 30 °

Name: Hard Foundation
Unit Weight: 20 kN/m³
Cohesion: 50 kPa
Phi: 40 °

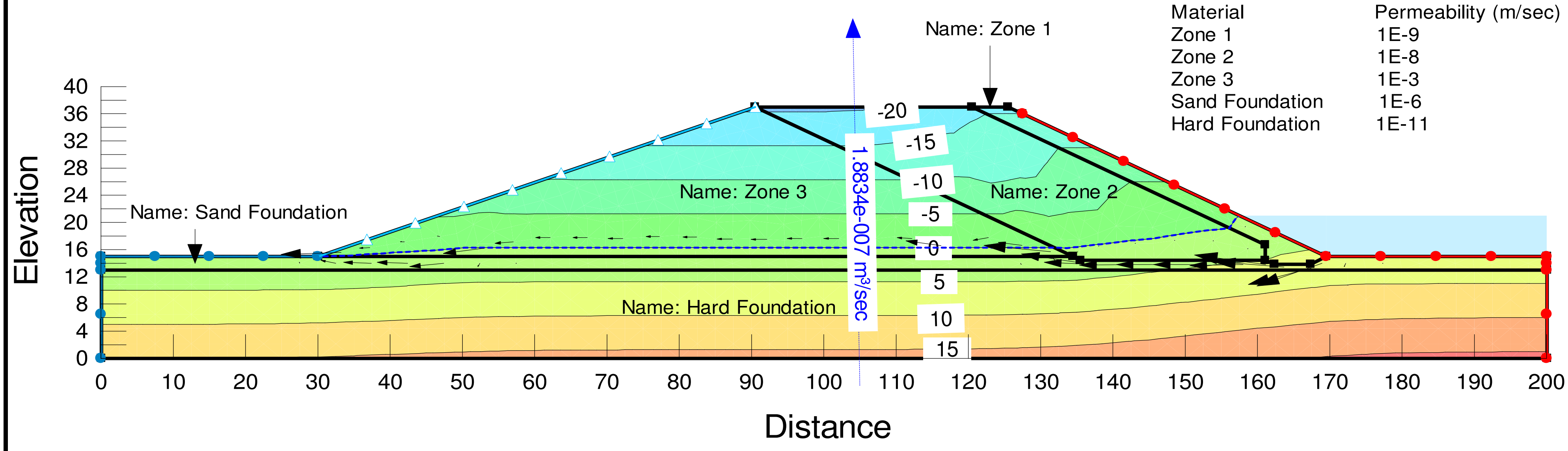
Job No.	42907769	
Prep. By	JT	21 Jun. '11
Chk'd By	AW	21 Jun. '11
Revision No.	0	

FerrAus Pilbara Project

Upstream Stability Under Earthquake DBE Case (0.13g)

Figure 6

URS



Job No.	42907769	
Prep. By	JT	21 Jun. '11
Chk'd By	AW	21 Jun. '11
Revision No.		0

FerrAus Pilbara Project

Seepage Analysis - Pressure Head Profile

Figure 7

URS

URS

Technical Note

Date: 25 August 2011

To: Ajitha Wanninayake

From: Elio Novello

Subject: FerrAus Tailing Storage – Seismic study

Executive Summary

A seismic study has been undertaken for the proposed Residue Storage Facility (RSF) located within the DCA minesite of the FerrAus Pilbara Project (FPP).

The Operating Basis Earthquake was taken to be the 1,000 year return period event (following ANCOLD, 1998) and the assessed peak ground acceleration is 0.079g.

The Design Basis Earthquake was taken to be the 5,000 year return period event (following ANCOLD, 1998) and the assessed peak ground acceleration is 0.13g.

1. Introduction

This technical note presents the results of a seismic study for the FerrAus Pilbara Project. The study site is the proposed Residue Storage Facility (RSF) at the DCA. The aims of the study are to:

- review and establish available information derived from the various references related to the seismic activity of WA with regard to the Davidson Creek Area;
- analyse peak ground acceleration of the project area using available models; and
- select seismic parameters (Operating Basis Earthquake, OBE, and Design Basis Earthquake, DBE) to use in RSF slope stability analysis and assessment.

The FerrAus Pilbara Project site is situated 100km from Newman. WA. Seismic risk assessment is required in order to analyse the tailing storage facilities construction and safety based on the ANCOLD – Guidelines for design of dams for earthquake (1998). In particular the risk from closer smaller earthquakes (background seismicity) needs to be considered.

Peak ground acceleration is the most important design seismic parameter in embankment dam slope stability analysis. Therefore, an important part of risk assessment is to predict the potential ground motion caused by an earthquake at a particular distance from the site. Ground motion attenuation models are used to evaluate the peak ground acceleration (PGA) due to the seismic activity affecting the site.

The OBE has been selected as the 1,000 year return period event and the DBE has been selected as the 5,000 year return period event (ANCOLD, 1998).

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2. Basis for Assessment

The study makes use of the results of the following two important seismic risks studies:

- Gaull et al (1990) - which characterised the seismic risk for Australia, and developed peak bedrock acceleration and peak ground velocity contours for Australia. Gaull et al (1990) was the basis for the seismic risk incorporated in the Australian Structural Loading Code AS1170.4 for earthquake actions.
- Sinadinovski et al (2005) – which characterised the seismic risk for Perth as part of a larger natural hazards risk study for the Greater Perth urban area, and extending north and south of Perth

The following information from these studies was used to characterise the seismic risk at the site, with the more recent (2005) study giving a higher seismic risk:

- earthquake source zones;
- expected number of earthquakes (and their magnitude) for these source zones; and
- seismic attenuation models, giving the bedrock acceleration at the site knowing the distance of the earthquakes from the site.

3. Earthquake Base Data

The Australian earthquake loadings standard, AS1170.4-1993, presents earthquake hazard in terms of an “acceleration coefficient” that has a 10% chance of being exceeded in 50 years. This acceleration coefficient is often considered to be equivalent to the PGA. The Davidson Creek Area (DCA) falls within the contour of 0.08. This estimate is considered very crude. Therefore, analysis of PGA related to earthquake source zone and magnitude is required.

3.1 Earthquake Source Zones

The following source zones from Gaull et al (1990) were used:

- Zone 8, Carnarvon Basin
- Zone 9, Pilbara
- Zone 10A, Canning Basin Fitzroy Trough
- Zone 11, Northwestern Continental Shelf
- Western Background

Each source zone is characterised by its area, and the number and size of its earthquakes.

Gaull et al (1990) selected its zones based on:

- satisfying the requirements of the computer program for the zones to be made up of a series of quadrilaterals;
- the areal distribution of epicentres up to the end of 1986; and
- using relevant geological and tectonic factors.

3.2 Number of Earthquakes

For each source, the number of earthquakes is represented by a Gutenberg-Richter type recurrence relationship, relating the number of earthquakes and their magnitude by a single straight line in log-linear space using the equation below:

$$\text{Log } N = a - b M$$

N = cumulative number of earthquakes, greater than or equal to magnitude M per year

M = Earthquake magnitude

a, b = constants related to the total number of earthquakes above a certain size and the frequency relation between small and large earthquakes

3.3 Earthquake Magnitude

Earthquake magnitude for the source zones is taken from Gaull et al (1990), with updated values taken from Sinadinovski et al (2005).

Upper bound and lower bound values of earthquake magnitude are given for each source zone.

3.4 Seismic Source Zone Summary

The earthquake source zones and zone parameters used in the seismic assessment of the site are presented in Table 1. The Western Background source zone in Table 1 reflects the seismicity effects at the site from background closer and predominantly smaller earthquakes.

Table 1: Source Zone and Seismic Parameters adopted in Gaull et al model

Source zone	Area (km^2)	h (km)	M_{Lmin}	M_{Lmax}	b	A_{min}
Zone 8	135,700	5	4.0	7.7	0.94	3.60
Zone 9*	84,200	5	3.9	7.5	1.0	1.809
Zone 10A	165,100	5	4.0	7.5	1.0	9.65
Zone 11	67,850	5	4.0	8.0	0.98	4.00
Western Background*	10,000	5	3.9	7.5	1.0	.044

Note:

h = average focal depth

M_{Lmin} = lower bound Richter magnitude from completeness tests

M_{Lmax} = upper bound Richter magnitude (largest known ML for source zone +0.5)

b = slope of Gutenberg & Richter magnitude-frequency relationship (Section 3.2)

A_{min} = number of earthquakes per year with ML ≥ ML_{min}, = intercept of Gutenberg & Richter equation (Section 3.2) at ML = ML_{min}

* updated from Sinadinovski et al (2005)

4. Attenuation Models

Attenuation models relate the potential ground motion caused by an earthquake to its distance from the site. In this study, the Gaull at al (1990) model was used to determine peak ground (bedrock) acceleration for the site.

The attenuation relation adopted by Gaull et al (1990) is given below:

$$PGA = 0.025\ \exp(1.1\ ML) / R^{1.03}$$

PGA = peak ground acceleration

R = hypocentral distance given by $R = \left(\Delta^2 + h^2 + Co^2\right)^{1/2}$

Δ = epicentral distance (km)

h = focal depth (km) = 5 km for Gaull et al (1990)

Co = the depth adjusting constant = 0 for Gaull et al (1990)

This model and its corresponding companion relation for peak ground velocity (PGV) are used in the present Australian earthquake loading code (AS1170.4).

5. Analysis of Bedrock Acceleration

Analysis of the peak ground acceleration (bedrock) at the site was undertaken using the Gaull et al (1990) seismic setting and parameters, with updated Western Background seismic setting using Sinadinovski et al (2005).

The analysis adopted the following methodology and calculation sequence:

1. Divide each seismic source zone into subareas
2. Determine the distance of each subarea to the site
3. Determine the annualised number (N_L) of earthquakes of a given magnitude (M) for the subarea – Section 3.2
4. Determine the bedrock acceleration (a_{max}) at the site due to that earthquake of magnitude M using the attenuation relationships – Section 4
5. From steps 3 and 4, the annualised number of occurrences (N_L) of a particular value of a_{max} has been determined
6. Repeat steps 2 to 4 for every subarea in every seismic source zone
7. List the paired values of N_L and a_{max}
8. Sort the paired values in order of decreasing a_{max}
9. Perform a cumulative sum of the N_L values in the sorted list
10. The cumulative summation of N_L represents the annualised number of occurrences of a bedrock acceleration at the site greater than a_{max}
11. The inverse of the cumulative summation of N_L gives the return period of that a_{max} at the site

6. Bedrock Acceleration Results

6.1 Analysis Results

Results of the analysis of the bedrock acceleration for the site are summarised in Table 3, and presented as peak ground bedrock acceleration values (in units of g) for different return periods.

Table 3: Summary of bedrock acceleration results

Return Period Years	Bedrock Acceleration (g) Gaull et al (1990)
66,666	0.285
33,333	0.203
10,000	0.129
5,000	0.100
2,000	0.082
1,000	0.056
500	0.039
100	0.019
50	0.015

7. Lateral Seismic Coefficient

Slope stability assessment of earthen embankments can be undertaken using pseudo-static analyses where the effects of dynamic loading (seismic shaking) can be approximated by applying an equivalent static lateral acceleration in the analysis. The equivalent static lateral acceleration coefficient, k, is typically taken to 0.5 a^*_{max}., where a^*_{max} is the peak ground acceleration allowing for the effects of site amplification of the bedrock seismic shaking.

For the present seismic assessment, site amplification was taken into account by applying the Idriss amplification factor for a soil site intermediate between a “Soft Soil” site and a purely “Bedrock” site., based on the methodology in Elias et al (1992).

The peak ground accelerations (a^*_{max}) after Idriss site amplification corresponding lateral seismic coefficient (k) values are presented in Table 4 in units of g.

Table 4: Summary of peak ground acceleration after Idriss amplification

Return Period Years	Peak Ground Acceleration, a^*_{max} (g) after Idriss amplification	Lateral Seismic Acceleration Coefficient, k (in units of g)
66,666	0.298	0.149
33,333	0.227	0.114
10,000	0.160	0.080
5,000	0.130	0.065
2,000	0.110	0.055
1,000	0.079	0.039
500	0.058	0.029
100	0.029	0.015
50	0.024	0.012

8. Design Seismic Events

Based on return periods of 1,000 year and 5,000 year for the respective OBE and DBE (ANCOLD, 1998), the following design accelerations have been assessed.

The probable maximum magnitude for an earthquake affecting the site is an M value of 7.5.

Table 5: Summary of design seismic accelerations

Design Event	Design Acceleration (in units of g)		
	Bedrock	Peak Ground Acceleration	Lateral Seismic Acceleration, k
OBE	0.056	0.079	0.04
DBE	0.10	0.13	0.065

REFERENCES

ANCOLD (1998) – Guidelines for design of dams for earthquake. Australian National Committee on large dams, August 1998.

Elias, D.C., Novello, E.A., Glenister, D. (1992). Design procedure for the seismic analysis of earth structures. Geotechnical Risk – Identification, Evaluation and Solutions. 6th Australia-New Zealand Conference on Geomechanics, Christchurch, New Zealand, 3-7 February 1992.

Gaull, B. A. Michael-Leiba, M. O. and Rynn, M. W. (1990). Probabilistic earthquake risk maps of Australia. Australian Journal of Earth Sciences, 1990.

Idriss, I.M. (1991). Response of soft soil sites during earthquakes. Proceedings H. B. Seed Memorial Symposium. UC Berkeley California., Vol. 2, 1991, pp. 273-289.

Sinadinovski et al (2005). Earthquake risk. In: Jones T., Middelmann M. and Corby N., Editors. Natural hazard risk in Perth, Western Australia. Canberra: Geoscience Australia – Australian Government; Cat No. 63527.

Standard Australia – AS1170.4 – Structural design actions – Part 4: Earthquake actions in Australia.

Appendix D Preliminary Closure Considerations

D.1 General

This section provides a summary of requirements relevant to the closure and capping of the Residue Storage Facilities (RSF) that is planned at Davidson Creek.

This section has been undertaken primarily to summarise:

- Closure requirements for a RSF in Western Australia;
- The data required to satisfy these requirements;
- Provide a preliminary closure design concepts; and
- Make recommendations on key data gaps and the requirements (if any) to enable the final design and specification of the RSF closure to be completed and approved by the regulator.

D.2 Post Mining Land Use – Closure Outcomes

The type of closure activities conducted on a site will depend on several factors. The most important of these, that will mould strategic closure planning and activities, is the determination of the final land use, and each closure outcome should be related to this land use. The Davidson Creek RSF closure outcomes should directly relate to:

- Corporate policy requirements;
- Corporate financial provisioning;
- Tenement and/or Ministerial Conditions imposed upon FerrAus as an outcome of the Mining Proposal;
- Early stakeholder consultation;
- Meteorological conditions;
- Geotechnical baseline data;
- Geochemical baseline data;
- Hydrological quality and quantity baseline data;
- Vegetation data; and
- Fauna data.

D.3 Regulatory Considerations for Closure

As specified by DOIR (1999) the primary function of any RSF is to be a safe and economical short term storage of fine grained mined wastes to minimise environmental impacts and for this receptacle to be erosion resistant, non polluting structure which is stable in the long term.

Recent amendments to the Mining Act 1978 require proponents to now submit closure plans as part of the Mining Proposal application process. Closure plans submitted after 30 June 2011, must be prepared and written in accordance with the Guidelines for Preparing Mine Closure Plans, jointly compiled by the Department of Mines and Petroleum (DMP) and the Environmental Protection Authority (EPA). As FerrAus seek to submit a Mining Proposal late 2011, these guidelines will apply and a revision of the site closure plan, in which the RSF should be considered as its own domain, will be required triennially.

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With specific reference to a closure of the planned RSF, the following documents outline the key state and federal regulatory requirements:

- DME Environment Division Report (Mining Environmental Management Guidelines) – Safe Design and Operations Standard for Tailings Storage;
- DME Environment Division Report (Mining Environmental Management Guidelines) – Development of an Operating Manual for Tailings Storage;
- Department of Industry, Tourism and Resources – Leading Practice Sustainable Development Program for the Mining Industry: Tailings Management; and
- Department of Industry, Tourism and Resources – Leading Practice Sustainable Development Program for the Mining Industry: Acid and Metalliferous Drainage.

In particular, the Safe Design and Operations Standard for Tailings Storage document outlines the consideration for pre-decommissioning review to attain closure specifying the following requirements.

Requirement
SAFE
Decommissioned RSFs shall be left in a manner that protects embankment integrity.
Decant systems shall be fully decommissioned and made safe so that inclement weather shall not undermine the integrity of the embankment.
The structure shall be designed so embankment walls are not heavily eroded by surface run-off.
Outer embankments are to be protected against erosion effects that could undercut embankments or outer walls upstream.
The groundwater or surface water shall not be adversely impacted as a result of liquor or metals leaching from the structure.
STABLE
Decommissioned RSFs shall not erode at an excessive rate, but be similar to that of surrounding areas.
The proponent shall utilise erosion control methods.
AESTHETICS
The decommissioned RSF should blend in with the surrounding landscape.
Visible portions of the RSF should be covered by a suitable self sustaining vegetative cover.

D.3.1 Data Requirements

In submitting a conceptual RSF closure plan to the EPA, FerrAus will be required to demonstrate that the environmental issues have been identified and the management measures presented can provide confidence to the assessing office "... that environmentally sustainable closure can be achieved" (DMP and EPA 2011). As such, the following table identifies data observed for preliminary closure considerations and highlights gaps that FerrAus will be required to develop prior to submitting a closure plan to the EPA.

The following is a list of all the documents sighted by URS, which were relevant to the RSF and its closure.

Appendix D

Table D-1 Data Sources

Document Name	Materials Balance and Construction	Geotechnical	Geochemical	Hydrology and Flood Analysis
FerrAus Pilbara Project Environmental Surface Water Assessment (Section 2: RPS Aquaterra 2011)				√
Mirrin Mirrin/Davidson Creek Project: 13 Creek Diversion & Surface Water Management – Revised Memo (RPS Aquaterra 2011)				√
Robertson Range, Davidson Creek and Mirrin Mirrin - Soil and Waste Material Assessment December 2010 (Outback Ecology 2010)	Materials assessment, no balance		√	
Australian Manganese: Davidson Creek Geotechnical Study Project No. 00934 September 2010 (Snowden 2010)		√		
Graham Campbell and Associates: Davidson Creek and Robertson Range Geochemical Characterisation – Draft Report Appendix E, Outback Ecology Services (2010)			√	

The brief overview of documentation has been utilised to extrapolate the following closure concepts.

D.4 Closure Concepts

D.4.1 Basis for Closure Design

Davidson Creek is located approximately 100 km from Newman in the Pilbara region. The area is characteristic of an arid tropical climate comprising high rainfall variability including cyclonic seasons and extremes in temperature as described in Section 5 of the main report. The average evaporation rate exceeds the average rainfall every month by an average of 3,700 mm (RPS Aquaterra).

The climate and vegetation characteristics of the arid tropical zone are favourable to the implementation of store-release cover systems. The primary function of a store-release cover is to aid in maintaining a stable non-polluting landform by restricting deep infiltration of rainfall into the structure by optimising evaporation of ponded water on the surface of the cover, and allowing shallow storage of water for uptake by vegetation (evapo-transpiration). It is also recognised that the final landform must be geotechnically stable and able to withstand erosion over the short, medium and long term.

D.4.2 Design Description

The conceptual design of the RSF store-release cover system requires:

- A concave, duplex cover-profile with the capacity to retain 100-150 mm of water, in evaporation basins, against gravity;

- Minimisation of the penetration of water into surface-zone tailings to limit sulphide oxidation and prevent deep root uptake of heavy metals; and
- Re-vegetation with shrubs, forbs and perennial/annual varieties of plants.

The cover is usually designed with a total thickness of 1 m, subject to site specific conditions. This material has been observed to be available from the “scree”, “drainage” and “flats” materials. The top surface could be ripped with 0.4 m high rip-lines spaced approximately 1 m apart. The outer walls of the RSF are to be rock armoured to achieve an angle of <20° to minimise erosion as specified in Table D-2.

The floors of the evaporation basins are proposed to be 1.5 m thick although the minimum areas of the sub-catchment basins, thickness of the floor and level of compaction required has not yet been outlined. Following the Australian National Committee on Large Dams (ANCOLD) guidelines, it is recommended that the sub-catchment areas and evaporation basins be designed to manage a 1 in 100 year, 72 hour storm event (302 mm) (RPS Aquaterra, 2011) to protect against erosion and flood overspill.

Following construction, the cover is proposed to be revegetated with a combination of native species. The vegetation surveys carried out at the nearby prior to and during mining activities, and revegetation trials at the nearby Mirrin Mirrin project will assist in recognising suitable species.

D.4.3 Cover Materials

The waste-rock material at Davidson’s Creek, including soil and waste material was assessed by Outback Ecology Services and Graham Campbell and Associates in 2010. As described in the Outback Ecology report, surface material was categorised as three types; “scree slope”, “flats” and “drainage”.

The physical parameters of each of these surface soils indicated that “scree” slope material was slightly acidic sandy loams, non saline, non sodic course material with low nutrient status and low hydraulic conductivity. This material is suitable for use on outer embankments due to the high coarse fraction size and is considered a class 3a and 3b Emerson Class (i.e. will not disperse unless remoulded).

Materials characterised as “flats” were generally sandy to sandy clay loam, moderate course material, non-saline and slightly acidic, are non-sodic and non-hardsetting and have a ‘moderately slow’ to ‘moderate’ drainage class.

The “drainage” soils were relatively similar to the soils from the flats, but have higher soil strength upon drying, a lower hydraulic conductivity and slightly higher nutrient content.

Based on the information reviewed, volumes of these materials available have not been calculated. The EPA will require FerrAus to clearly articulate where cover materials may be derived and if adequate volumes are available in the event of unplanned closure and upon planned closure of the RSF.

Conceptually, vegetation grown on top of the RSF should be provenance species. This information was not provided to URS, however it is assumed that FerrAus has access to this baseline information. It is understood that the Mirrin Mirrin project located close by could be used to fast track trial plots as materials available at Davison’s Creek are similar to those found at the Mirrin Mirrin project.

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D.4.4 Studies

Geotechnical

The overall geotechnical stability of the RSF structure in the long-term depends on a combination of the construction of the RSF, physical stability and saturation of tailings, the physical parameters of the proposed capping material, and an assessment of long-term settlement trends. These components need to be considered in an assessment of the proposed cover design. Maintenance of the stability of the structure will help achieve key closure objectives including:

- Prevention of erosion of the surface due to wind or surface run-off;
- Prevention of erosion of the embankments; and
- Minimisation of post-closure maintenance of the cover or embankments due to mass movement of the tailings.

Physical properties of waste materials produced from the Davidson Creek mining operation are dominated by transported sediments comprising clays, detrital and surficial materials. These lithologies include Lower West Angela, Mt Newman and MacLeod / Nammuldi and transported material. The approximate volumes and tonnages from the project are supplied by Outback Ecology (2011).

Calculations for the RSF and its requirement for waste materials for structural embankments and capping are required.

Geochemical

Initial assessments of the mine waste rock and low grade materials at both the Robertson's Range and Davidson's Creek projects indicate that the materials are geochemically and physiochemically benign (Graeme Campbell and Associates, 2010).

In general, waste materials indicated that the soil fraction (i.e. <2mm) of all waste lithologies are non-saline, non-hardsetting, non-sodic, structurally stable, with a neutral to slightly alkaline pH (Outback Ecology, 2011). This information is adequate for a conceptual closure plan and can be used in the setting of conceptual closure criterion as specified in Table D-2.

It is understood that tailings materials are currently undergoing testing to determine geochemical properties.

D.4.5 Monitoring

Monitoring must occur on a routine basis and is required to provide the assessing regulator enough information to provide confidence that the outcome can be achieved. It is recommended that the Davidson Creek RSF closure objectives and associated outcomes be based on an analogue site nearby. It is understood that the Mirrin Mirrin project, located 5 km away, may be of some assistance in this regard. The analogue would need to be of similar terrain, slope and directional orientation as the RSF.

An ongoing monitoring program should be developed in order to assess and record rehabilitation progress and final landform, until the point where adequate trajectory completion criteria have been achieved or a designated completion point, based on trials or analogue data, is reached.

D.5 Conceptual Closure Criteria

As mentioned, several components of the closure planning journey need to be considered prior to developing closure criteria. Criteria developed will depend upon the closure outcomes.

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Table D-2 Conceptual Closure Criteria

Domain 1 – Residue Storage Facility			
Criterion No.	**Conceptual Criteria**	**Specification**	**Measurable Parameters**
1.	Plan and execute closure in a timely manner that makes efficient use of resources.	• Refer to closure schedule	a) Timelines as specified in closure schedule
2.	All internal and external stakeholders have been given appropriate opportunities for involvement in the closure planning process.	**Short Term** • Provide design information to the EPA for approval. • Provide design information and negotiate closure outcomes with final land use holder. **At least two years prior to RSF closure** • Advise the EPA in writing of intentions to close RSF. • Inform pastoral lessee of site closure • Inform indigenous and non indigenous land owners of tenders for land forming/ seeding of the area.	**Closure Completion** b) Final EPA audit for lease relinquishment. c) Close out RSF component of Licence to Operate.
3.	Control public access and install signage to assist in preventing injury to third parties.	**Post Closure** • Close or bund all site access tracks. • Establish warning signage. • Undertake regular security inspections	**Closure Process** d) Signage to be installed as per AS1319-1994. e) Signage inspection to be carried out on a quarterly basis.

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Domain 1 – Residue Storage Facility			
Criterion No.	**Conceptual Criteria**	**Specification**	**Measurable Parameters**
4.	Maintain safety programs and standards consistent with operational standards.	**Short Term / during operations** • Contractor H&S and environmental plans and systems to be reviewed for acceptability prior to start. • Incorporate environmental and H&S expectations into submissions for RSF works tender. • H&S and environment inductions to be developed that are activity specific where required. • All contractors to be fully inducted to project H&S and environment requirements prior to initiation of work onsite.	**Closure Process** f) All contractors registered as inducted and records retained. g) The relevant JSA and scope of work to be signed off by necessary personnel and available on the job. h) All safety and environment hazards and near misses to be reported. i) Maintain an injury rate <1.
5.	All drill holes, wells and other holes in the ground, made either during exploration or operations, to be rehabilitated.	**Post Closure** • Bores utilised for monitoring be removed at completion of the RSF.	**Closure Process** j) Maintain sampling bores until Criterion 10 is satisfied. **Closure Completion** k) Bore surface capped from 5 m depth to 300 mm to surface with concrete, cement grout or bentonite grout and topped with compacted native soil. l) Rehabilitation - Refer Criterion 14.
6.	Remove all waste materials and rubbish.	**During operations/ Post Closure** • Ensure compliance with Waste Management Plan.	**Closure Completion** m) All waste materials and equipment to be removed from the surface of the RSF.
7.	Create minimum practical disturbance to the natural landform.	**During operations/ Post Closure** • Final landform to be completed as per Criterion 8. • Final Landform to be in accordance with specification agreed by stakeholders.	**Closure Completion** n) Maximum height of Area (RSF) is 25 m (AGL). o) Rehabilitation - Refer Criterion 14.

Appendix D

Domain 1 – Residue Storage Facility			
Criterion No.	**Conceptual Criteria**	**Specification**	**Measurable Parameters**
8.	Batter down RSF out-slopes to < 20° to horizontal and profile top surface.	**During operations/ Post Closure** • Batter out-slopes < 20° from horizontal.	**Closure Completion** p) Slope angle of final landform to be < 20° from horizontal.
9.	Batter down out-slopes to < 20° from the horizontal. Cover slopes with competent rock and re-vegetate.	**During operations/ Post Closure** • Submit engineering specifications and design for final landform to the State Mining Engineer prior to commencement of works.	**Closure Completion** q) Capping as per Section D.4 of this plan Top surface: r) Perimeter bund – 500 mm to 1000 mm in height s) Final landform - concave 2° – 3° from the bund. t) Profile with cap-rock. Slopes: u) <20° degrees from the horizontal. v) Rock armour to 300 mm on slopes w) Topsoil to 100 mm
10.	No impairment of surface or underground waters relative to background conditions.	**During operations/ Post Closure** • Groundwater quality to be maintained within pre-determined regulatory criteria. • Tailings cover design to be refined to manage environmental risks.	**Closure Process** x) Comparison of groundwater laboratory results to DEC fresh waters (FW) guidelines. **Closure Completion** y) Sample results to plateau to less than the specified parameters of (x). z) Engineer toe drains to capture sediment run-off.

Appendix D

Domain 1 – Residue Storage Facility			
Criterion No.	**Conceptual Criteria**	**Specification**	**Measurable Parameters**
11.	No impairment of surface or underground soils relative to background conditions.	**During operations/ Post Closure** • No discernable seepage through capping material or wall lining. • No remaining tailings waste outside of RSF, or walls or along tailings distribution line.	**Closure Process** aa) Comparison of soil laboratory results to the DEC ecological investigation levels (EIL). **Closure Completion** bb) Sample results to plateau to less than the specified parameters of (aa).
12.	Replace topsoil on disturbed areas.	**During operations/ Post Closure** • Engineer a stable structure that minimises erosion and is visibly aesthetic.	**Closure Process** cc) Topsoil to be placed approximately 100 mm thick.
13.	Disturbed areas are deep ripped (sloped areas are ripped on the contour).	**During operations/ Post Closure** • Surface water flow to be captured upon structure without undermining surface stability.	**Closure Process** dd) Ripping to 120 mm on the RSF horizontal cap at 1000 mm spacing. ee) Ripping to occur at to 120 mm deep and 3000 mm spacing for sloped areas.
14.	Disturbed areas are revegetated with local native grasses, shrubs and trees which are self supporting.	**During operations/ Post Closure** • Engineer a stable structure that minimises erosion and is visibly aesthetic. • Area will be seeded with local provenance species to blend with surrounding habitat. • Seeding rate will be 10 kg/ha. • LFA monitoring over a two year period (post closure).	**Closure Completion** ff) Flora density 3 stems per 10 m^2 gg) Flora diversity of 20 % species from provenance species list hh) Rhyzosphere development.
15.	Close all site access tracks.	**Post Closure** • Retain adjacent tracks for monitoring and inspection access. • Retain tracks as agreed with pastoral lessee.	**Closure Completion** ii) Access tracks removed once RSF monitoring is in accordance with Criterion 10.

Appendix D

Domain 1 – Residue Storage Facility			
Criterion No.	**Conceptual Criteria**	**Specification**	**Measurable Parameters**
16.	Control erosion.	**During operations/ Post Closure** • Rock armouring to 100 mm on slopes to prevent loss of vegetation to rilling or gullying. • Final landform to incorporate inward sloping (2^o-3^o) top surfaces. • 1000 mm bund to be constructed along the outer perimeter of top surface.	**Closure Completion** jj) Gullying and rilling to be inactive for at least 3 years. kk) Embankment movement to be inactive for at least 3 years
17.	Remove all pipelines except those stipulated to remain by regulators.	**Post Closure** • Remove all pipeline and pumping infrastructure from site and rehabilitate disturbed areas.	**Closure Completion** ll) Remove tailings pipeline from site. mm) All pipe-work less than 300 mm below ground level is to be removed.
18.	Enhance groundwater recovery.	**During operations/ Post Closure** • Determine acceptable groundwater recovery rates as agreed with pastoral lessee.	**Closure Process** nn) Report provided to relevant stakeholders. **Closure Completion** oo) Finalise stakeholder agreement.

D.6 Summary

As of 30 June 2011, the Davidson's Creek RSF will require a mine closure plan to be developed and approved in accordance with the Guidelines for Preparing Mine Closure Plans under the Mining Act 1978 in which requirements are specified for inclusion within a whole site mine closure plan for the operation. It is recommended that this guideline be utilised when preparing the mine closure plan for the RSF.

FerrAus has conducted many baseline studies to date. Based on a brief assessment of data made available, it was noted that flora and fauna baseline data, and calculations of availability of cover material were not provided. Additionally, high level strategic planning, corporate policy and objectives and stakeholder consultation information were not reviewed. Assuming this data is available to FerrAus, a RSF closure plan could be developed with adequate detail (of a Project Approval Stage Assessment) to gain the required regulator approval.

Based on regulatory requirements, baseline data provided and climatic conditions of the area, a store-release cover design concept for the RSF is recommended. This system functions by optimising the potential for evaporation of ponded water on the surface from the cover and utilises vegetation up-take of water, retaining a shallow water storage level.

The conceptual criterion (Table D-2) for closure of the RSF is based on the requirement that the final landform must be geotechnically stable and able to withstand erosion over the short, medium and long term. The conceptual criterion provides FerrAus a high level guide to the criteria required in their closure plan to be submitted with the future RSF Mining Proposal, however, a more thorough review of documentation and interaction with FerrAus to determine corporate policy and objectives, stakeholder requirements and commitments, and detailed design is required for completeness.

Appendix E Laboratory Test Reports

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TEST CERTIFICATE

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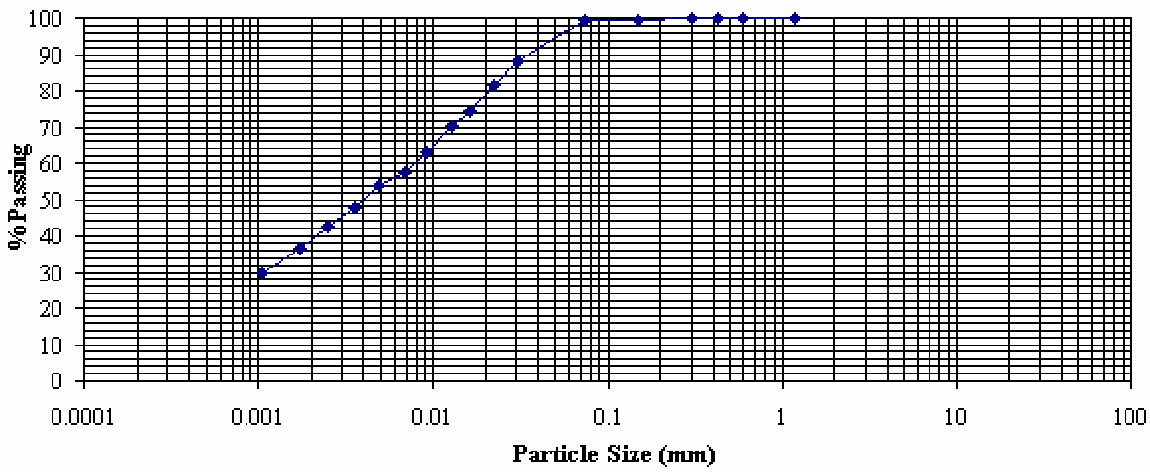
36 Railway Parade
Welshpool WA 6106

Client:	URS Australia Limited	Client Job No:	42907769
Order No:		Project:	Pilbara Tailings Testing
Tested Date:	11/07/2011	Location:	
SGS Job Number:	11-01-840	Sample No:	11-MT-5846
Lab:	Welshpool	Sample ID:	Sample 1

PARTICLE SIZE DISTRIBUTION - SIEVING AND HYDROMETER ANALYSIS

AS1289.3.6.1 & AS1289.3.6.3



SIEVING	(AS1289.3.6.1)	HYDROMETER	(AS1289.3.6.3)
Sieve Size	Passing	Particle Diameter	Finer
(mm)	%	(mm)	%
53.0		0.0308	88
37.5		0.0225	81
19.0		0.0164	74
9.5		0.0128	70
4.75		0.0091	63
2.36	100	0.0069	58
1.18	100	0.0049	54
0.600	100	0.0035	48
0.425	100	0.0025	43
0.300	100	0.0017	36
0.150	100	0.0010	30
0.075	99		

Method of Dispersion : Mechanical ; Hydrometer Used : Glass, -5 to 60g/l soil Colloids

Loss after Pretreatment: No Pretreatment

Note: Sample supplied by client.

Approved Signatory: (John.Reid) Date: 4/08/2011

This document is issued in accordance with NATA's accreditation requirements

Accreditation No.: 2418

Site No.: 2411

Client Address: L4, 226 Adelaide Tce Perth WA 6000

TEST CERTIFICATE

ABN: 44 000 964 278
ph: 1300 781 744
fx: (08) 9458 3700

SGS Australia Pty Ltd
PO Box 219 Bentley WA 6982
36 Railway Parade
Welshpool WA 6106

Client:	URS Australia Limited	Client Job No:	42907769
Order No:		Project:	Pilbara Tailings Testing
Tested Date:	25/07/2011	Location:	
SGS Job Number:	11-01-840	Sample No:	11-MT-5846
Lab:	Welshpool	Sample ID:	Sample 1

PLASTICITY INDEX

AS 1289.3.9.2(Single Point Cone Method), 3.2.1(Plastic Limit), 3.3.2(Plasticity Index), 3.4.1(Linear Shrinkage)

AS 1289.3.9.2	
Liquid Limit (%)	**37**
AS 1289.3.2.1	
Plastic Limit (%)	**22**
AS 1289.3.3.2	
Plasticity Index (%)	**15**
AS 1289.3.4.1	
Linear Shrinkage (%)	**9.0**
History of Sample	Oven Dried at <50ºC
Method of preparation	Dry Sieved
Nature of Shrinkage	Flat
Length of mould (mm)	125

Note: Sample supplied by client.

Approved Signatory: (John.Reid) Date: 4/08/2011

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Accreditation No.: 2418 Form No.PF-(AU)-[IND(MTE)]-TE-S324.LCER/D/02.09.09

Site No.: 2411
Cert No.: 11-MT-5846-S324

Client Address: L4, 226 Adelaide Tce Perth WA 6000

TEST CERTIFICATE

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PO Box 219 Bentley WA 6982
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Welshpool WA 6106

Client:	URS Australia Limited	Client Job No:	42907769
Order No:		Project:	Pilbara Tailings Testing
Tested Date:	14/07/2011	Location:	
SGS Job Number:	11-01-840	Sample No:	11-MT-5846
Lab:	Welshpool	Sample ID:	Sample 1

FINE PARTICLE DENSITY

AS1289.3.5.1

FINE FRACTION

SOIL APPARENT
PARTICLE DENSITY (g/cc) **3.76**

at temperature 25 º C

Note: Sample supplied by client.

Approved Signatory: (John.Reid) Date: 4/08/2011

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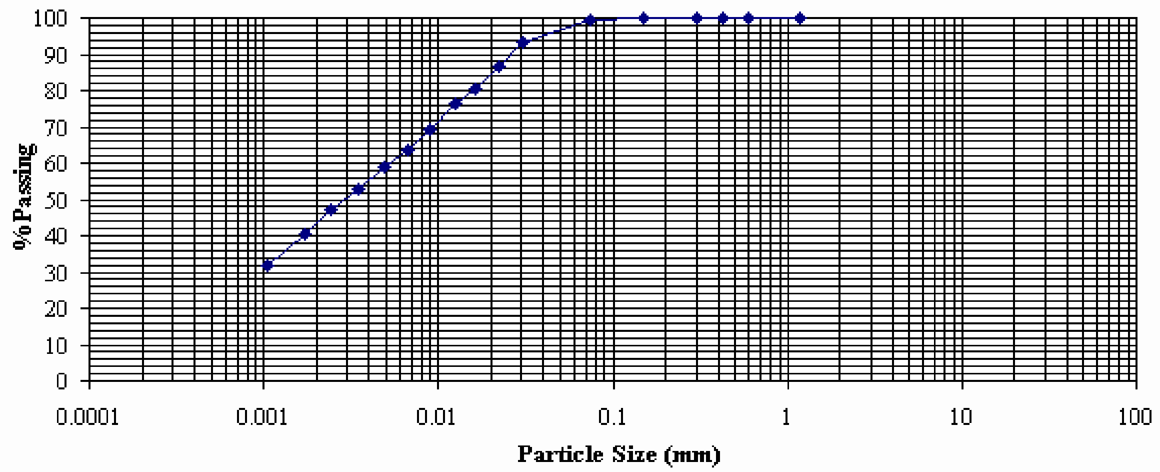
Client:	URS Australia Limited	Client Job No:	42907769
Order No:		Project:	Pilbara Tailings Testing
Tested Date:	11/07/2011	Location:	
SGS Job Number:	11-01-840	Sample No:	11-MT-5847
Lab:	Welshpool	Sample ID:	Sample 2

PARTICLE SIZE DISTRIBUTION - SIEVING AND HYDROMETER ANALYSIS

AS1289.3.6.1 & AS1289.3.6.3



SIEVING	(AS1289.3.6.1)	HYDROMETER	(AS1289.3.6.3)
Sieve Size	Passing	Particle Diameter	Finer
(mm)	%	(mm)	%
53.0		0.0303	94
37.5		0.0221	87
19.0		0.0161	80
9.5		0.0126	77
4.75		0.0089	69
2.36	100	0.0068	64
1.18	100	0.0049	59
0.600	100	0.0035	53
0.425	100	0.0024	47
0.300	100	0.0017	40
0.150	100	0.0010	32
0.075	100		

Method of Dispersion : Mechanical ; Hydrometer Used : Glass, -5 to 60g/l soil Colloids

Loss after Pretreatment: No Pretreatment

Note: Sample supplied by client.

Approved Signatory: (John.Reid) Date: 4/08/2011

This document is issued in accordance with NATA's accreditation requirements

TEST CERTIFICATE

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Client:	URS Australia Limited	Client Job No:	42907769
Order No:		Project:	Pilbara Tailings Testing
Tested Date:	25/07/2011	Location:	
SGS Job Number:	11-01-840	Sample No:	11-MT-5847
Lab:	Welshpool	Sample ID:	Sample 2

PLASTICITY INDEX

AS 1289.3.9.2(Single Point Cone Method), 3.2.1(Plastic Limit), 3.3.2(Plasticity Index), 3.4.1(Linear Shrinkage)

AS 1289.3.9.2	
Liquid Limit (%)	**49**
AS 1289.3.2.1	
Plastic Limit (%)	**33**
AS 1289.3.3.2	
Plasticity Index (%)	**16**
AS 1289.3.4.1	
Linear Shrinkage (%)	**9.0**
History of Sample	Oven Dried at <50ºC
Method of preparation	Dry Sieved
Nature of Shrinkage	Curling
Length of mould (mm)	125

Note: Sample supplied by client.

Approved Signatory: (John.Reid) Date: 4/08/2011

This document is issued in accordance with NATA's accreditation requirements

Accreditation No.: 2418 Form No.PF-(AU)-[IND(MTE)]-TE-S324.LCER/D/02.09.09

Client Address: L4, 226 Adelaide Tce Perth WA 6000

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TEST CERTIFICATE

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Client:	URS Australia Limited	Client Job No:	42907769
Order No:		Project:	Pilbara Tailings Testing
Tested Date:	14/07/2011	Location:	
SGS Job Number:	11-01-840	Sample No:	11-MT-5847
Lab:	Welshpool	Sample ID:	Sample 2

FINE PARTICLE DENSITY

AS1289.3.5.1

FINE FRACTION

SOIL APPARENT
PARTICLE DENSITY (g/cc) **3.76**

at temperature 25 º C

Note: Sample supplied by client.

Approved Signatory: (John.Reid) Date: 4/08/2011

This document is issued in accordance with NATA's accreditation requirements

Accreditation No.: 2418 Form No.PF-(AU)-[IND(MTE)]-TE-S415.LCER/A/01.01.2009

Site No.: 2411
Cert No.: 11-MT-5847-S415

Client Address: L4, 226 Adelaide Tce Perth WA 6000

SGS

DETERMINATION OF SETTLING & BEACH DRYING OF SLURRY

according to: Client Instructions

Job No.: 11 - 01 - 840 **Lab No.:** **11-MT-5846**
Client: URS Australia Limited Sample ID
Project: Pilbara Tailings Testing Sample No.:
Location: Depth:
Date Tested: 20/7/11

SLURRY DETAILS:	Red Tailings	Red Tailings	Red Tailings
PERCENT SLURRY:	35%	45%	55%
WET DENSITY t/m3 (after decantation):	1.99 at 60% moisture	1.988 at 55% Moisture	1.83 at 60% moisture
DRY DENSITY t/m3:	1.29 at 0% moisture	1.22 at 0% moisture	1.20 at 0% moisture
BEACH DENSITY t/m3:	1.82 at 34% moisture	1.83 at 27% moisture	1.63 at 35% moisture

Notes.
1 Samples mixed to the reported percentage on a dry basis in a 200mm diameter tin.
2 Wet Density reported at the moisture content where sample had settled and decantation was no longer possible.
3 Beach Density reported after 24 hours air-drying and 24 hours assisted drying in a 45 degree oven.
4 Dry Density reported after constant mass achieved in a 110 degree oven.
5 Sample density recorded using height as the variable value. This method does not take into account sample cracking due to a high shrinkage factor.

Signatory: ____ ____(A. Harrap) Date: 20/08/2011

SGS

DETERMINATION OF SETTLING & BEACH DRYING OF SLURRY

according to: Client Instructions

Job No.: 11 - 01 - 840
Client: URS Australia Limited
Project: Pilbara Tailings Testing
Location:
Date Tested: 20/7/11

Lab No.: **11-MT-5847**
Sample ID
Sample No.:
Depth:

SLURRY DETAILS:	Yellow Tailings	Yellow Tailings	Yellow Tailings
PERCENT SLURRY:	35%	45%	55%
WET DENSITY t/m3 (after decantation):	1.90 at 70% moisture	1.78 at 71% moisture	1.850 at 58: moisture
DRY DENSITY t/m3:	1.01 at 0% moisture	0.91 at 0% moisture	1.02 at 0% moisture
BEACH DENSITY t/m3:	1.50 at 39% moisture	1.545 at 24% moisture	1.49 at 27% moisture

Notes.
1 Samples mixed to the reported percentage on a dry basis in a 200mm diameter tin.
2 Wet Density reported at the moisture content where sample had settled and decantation was no longer possible.
3 Beach Density reported after 24 hours air-drying and 24 hours assisted drying in a 45 degree oven.
4 Dry Density reported after constant mass achieved in a 110 degree oven.
5 Sample density recorded using height as the variable value. This method does not take into account sample cracking due to a high shrinkage factor.

Signatory: ____ (A. Harrap) Date: 4/08/2011

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Appendix 8
Phase 1 Geochemical assessment of Pilot Trial Residue Tailings, FerrAus Pilbara Project, Western Australia, URS, 2011

26 July 2011
Project No. 42907769

FerrAus Limited
Level 10, 233 Adelaide Terrace
Perth, WA 6000

Attention: Rudolph van Niekerk/Barbara Heemink

Subject: Phase 1 Geochemical assessment of Pilot Trial Residue Tailings, FerrAus Pilbara Project, Western Australia

1 Introduction

FerrAus Limited (FerrAus) is planning to construct a single Residue Storage Facility (RSF) at their FerrAus Pilbara Project (FPP) site located in the inter-zone of the Pilbara and Gascoyne bio-geographic regions in Western Australia. The FPP site encompasses two mining areas identified as the Davidson Creek Area (DCA) and the Robertson Range Area (RRA). The proposed RSF will be situated in the DCA abutting waste rock dump DCWD3 to the south. The DCA incorporates five iron ore deposits, namely Mirrin Mirrin, Python, Gwandar, Tiger, Dugite and Taipan. The RRA incorporates two iron ore deposits, namely King Brown and South Zone.

The RSF is currently in feasibility design stage of development, and it is planned to hold residue tailings from the DCA and RRA mining operations. The FPP is currently in approvals stage of development.

The RSF is planed to handle an average tailings production rate of 2.2 million tons per annum (Mtpa) for a planned project life of 15 years. The tailings are expected to have predominantly less than 45 microns material with some [less than 1 millimetre (mm)] spiral reject material. The percent solids, prior to deposition, are expected to be between 40% and 50% solids by weight.

URS Australia Pty Ltd (URS) is currently undertaking the feasibility study for the provision of the design of the RSF. As a component of the design, URS have been asked to undertake an assessment of the residue tailings geochemistry, for the purpose of characterising the chemical properties of the residue tailings as part of the first phase (Phase 1) geochemical assessment.

The objective of the assessment of the residue tailings geochemistry is to provide information to refine the design of the RSF and to assist in the environmental approvals process for the FPP, where possible.

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1.1 Scope of Works

To meet the primary objectives outlined above, the following scope of work was identified:

- Task management and consultation – provision of regular project update reports on the geochemical assessment task, and consultation and meetings with the FerrAus engineering and approvals team.
- Laboratory analytical programme – Management of the sub-contracted laboratory including laboratory program design, and management of reporting of analytical results.
- Data review and analysis – Review of existing information on geochemical testing of materials for the FPP, validation of the laboratory data, and assessment and analysis of results in accordance with standard industry practice.
- Phase 1 Report preparation for refinement of the RSF design and environmental approvals – Preparation of a Memorandum report providing laboratory analytical results, key findings of the data assessment and recommendations for ongoing assessment as part of the FPP approvals process.
- Phase 2 report preparation for Mining Proposal – This task will be completed within a separate scope of work following the submission of the Memorandum report. This scope will include the detailed analytical requirements and reporting to be conducted as part of the Mining Proposal document.

1.2 Background

The requirement for tailings geochemical characterisation is detailed in the Department of Industry and Resources (DoIR) [currently identified as the Department of Mines and Petroleum (DMP)].1999 guideline identified as the *Mining Environmental Management Guidelines - Safe Design and Operating Standards for Tailings Storage* (DoIR, 1999) that provide guidance under the Western Australian legislation governing safety and environmental issues of Tailings Storage Facilities (TSF). For the purposes of clarity, there is no significant difference between a TSF and RSF as they are both designed for the safe, long term storage of fine-grained waste material generated in the production of ore. As such the terms TSF and RSF should be treated as one and the same entity.

For any of the category 1, 2, or 3 TSFs, physical and chemical characterisation of the tailings is required to understand possible environmental issues relating to water quality, dust, revegetation, rehabilitation and closure requirements. The chemical characterisation component includes acid and metalliferous drainage (AMD), but also includes metals, salts and mineralogical characteristics (such as asbestiform fibres) that also need to be considered in the design and operation of the TSF.

The Phase 1 geochemical assessment forms part of a greater geochemical assessment program that is integrated within the life of mine plan (**Figure 1**). The other components of the life of mine plan include approvals documentation, mine plan and impact and/or receptor assessments that are included as part of the greater environmental approvals process for the FPP. The geochemical assessment components and activities that are planned as part of the life of mine plan are described in **Figure 1**.

It is intended that this Phase 1 geochemical assessment be incorporated into the proposed Part IV s38 environmental approvals document. This approvals document is currently anticipated to be assessed as an Assessment on Proponent Information (API) level of assessment. The Phase 2 detailed geochemical assessment will be conducted as part of the ongoing environmental requisite assessments to be included within the FPP Mining Proposal.

The recommendations section of this report outlines the activities that are proposed for the Phase 2 detailed geochemical assessment to be conducted prior to preparation of the FPP Mining Proposal.

2 Existing Information

Geochemical characterisation of the mine-waste materials and low-grade-ore from the King-Brown ore deposit of the DCA was carried out by Graeme Campbell and Associates in December 2010. The report *Geochemical Characterisation of Mine-Waste and Low-Grade-Ore Samples* (GCA, 2010) contains details of the assessment. Key findings have been summarised below.

Sixteen (16) mine-waste samples and seven (7) low-grade-ore samples were selected for geochemical analysis. Acid-base chemistry, salinity and multi-element composition were assessed using the following analytical techniques:

- pH and Electrical-Conductivity (EC) on sample slurries;
- Total-Sulphur (Total-S), and Sulphate-Sulphur (SO4-S);
- Acid-Neutralisation-Capacity (ANC), and CO_3-C;
- pH-buffering properties;
- Net-Acid-Producing-Potential (NAPP);
- Net-Acid-Generation (NAG);
- Geochemical Abundance Index (GAI); and
- Multi-element Analysis.

The mine-waste samples comprised sediments (clay, detrital and surficial materials) that were classified as non-acid forming (NAF), with low total sulfur concentrations. The samples were circum-neutral (pH 6-7) with low contents of soluble-salts as is consistent with typical mine-waste streams produced at iron ore mines in the Pilbara. The multi-element analyses results showed the mine-waste samples had contents of major and minor elements typically below, or close to, those recorded for soils, regoliths, and bedrocks derived from unmineralised terrain. Although variously enriched in As, Sb, Se, Bi, and Mn, the degree of enrichment was not marked.

The low-grade-ores were classified as NAF, and were circum-neutral (pH 6-7) with low contents of soluble-salts. The multi-element analyses showed that the low-grade-ores had contents of major and minor elements typically below, or close to, those recorded for soils, regoliths, and bedrocks derived from unmineralised terrain.

In the management recommendations it was noted that the waste-landform design and rehabilitation should not be constrained by the physicochemical nature of the mine-waste streams. It was recommended that planning for waste-landform decommissioning should integrate industry best-practice concepts for rehabilitation and mine-site closure and the practical know-how gained from the experiences of other Pilbara iron ore mines.

It was noted that only materials from DCA and RRA sites were tested; however, results may be extrapolated to waste from the Mirrin Mirrin ore deposit with a high level of confidence.

The Outback Ecology report *Robertson Range, Davidson Creek and Mirrin Mirrin – Soil and Waste Material* Assessment (Outback Ecology, 2010) indicated that there were unlikely to be any material specific requirements for waste placement within constructed landforms. It was recommended that waste landform designs should aim to minimise the ponding of surface water where applicable.

3 Methodology

FerrAus is undertaking pilot plant process studies to assess the chemical and physical characteristics of the reside waste from the FPP. To date, pilot plant reside samples have been collected for the RRA ore deposits and the Mirrin Mirrin ore deposit. The most recent pilot plant trial represented the Detailed Feasibility Stage Pilot Plant Evaluation. Two tailings residue samples from the RRA ore deposit (RR High grade and RR medium grade) and two samples from the Mirrin Mirrin ore deposit (MM high grade and MM medium grade) were selected for analysis.

This section describes the analysis process undertaken to assess the chemical properties of the samples.

3.1 Classification Criteria

The geochemical assessment and analysis of laboratory analytical results is conducted in accordance with the *Global Acid Rock Drainage (GARD) Guide* (INAP, 2011), and Department of Industry, Tourism and Resources – *Leading Practice Sustainable Development Program for the Mining Industry: Acid and Metalliferous Drainage* (DITR, 2007), that are the current standard industry practice for the analysis and reporting of data relevant to potential acid and metalliferous drainage and/or geochemical assessments.

3.1.1 Acid Base Accounting

A number of procedures have been developed to assess the AMD characteristics of mine waste materials. However, ultimately the overall acid generation assessments for mine materials are mainly carried out using the following static testing methods:

- Acid Base Accounting (ABA); and/or
- Net Acid Generation (NAG).

The testwork carried out for the FPP follows the ABA methodology. It calculates the acid generation capacity of the sample material by determining the maximum potential acidity (MPA) that can be generated from the oxidation of sulfide minerals relative to its acid neutralising capacity (ANC) due mainly to the presence of carbonate minerals and to lesser extent silicate minerals. The difference between the MPA and ANC value is referred to as net acid producing potential (NAPP).

For the purposes of this assessment, total sulfur concentration (%S) has been used to calculate maximum potential acidity (MPA) on the basis that all sulfur present is in the mineral form of pyrite (FeS_2). It is noted that this represents a conservative approach to the estimation of NAPP and is likely to over-estimate the MPA produced from the residue tailings materials. This is supported by the comment given in the *Geochemical Characterisation of Mine-Waste and Low-Grade-Ore Samples* (GCA, 2010) from the FPP, which stated that it is likely that negligible occurrences of sulphide minerals (e.g. pyrite) would occur at the FPP, as is consistent with the style of iron-ore mineralisation at the FPP and the depths of in-situ weathering observed at the site and around the Pilbara.

The use of a conservative approach enables the assessment to be undertaken as a reasonable worst case scenario. As the objective of this assessment is to test preliminary pilot trial residue tailings samples for the purpose of highlighting any potential gaps in data and identifying any potential impacts from the storage of residue tailings, an assessment based on a reasonable worst case scenario is considered appropriate to enable this objective to be fulfilled.

On the basis of the ABA and NAG results samples may be classified into one of the following categories (AMIRA, 2002):

- **Barren**: where samples have minimal acid neutralising capacity and low total sulfur content (generally <0.1 %S). This category mostly applies to highly weathered materials and criteria may vary between sites.
- **Non-acid Forming (NAF)**: where samples may have significant sulfur content, but acid neutralising capacity is present and is able to neutralise the potential acidity that could be produced by oxidising sulfur. In general NAF materials have negative NAPP and final NAG pH of >4.5.
- **Potentially Acid Forming (PAF)**: where samples have significant sulfur content and the potential to general acidity in exceedence of the available acid neutralising capacity. In general PAF materials have positive NAPP and a final NAG pH <4.5.
- **Uncertain**: where the NAPP and NAG results are not in agreement. Further kinetic testwork or field oxidation trials are usually recommended to determine the acid forming characteristics of these materials.

3.1.2 Multi-element Composition

To assess the potential for elemental enrichment, tailings solid samples were tested for multi-element composition. The results are compared to standard median soil abundance values (Bowen, 1979) to evaluate the extent of elemental enrichment, which is reported as a geochemical abundance index (GAI) value. In general, a GAI of 3 or greater is considered as enrichment to a level that may warrant further examination to assess their environmental significance.

In addition to the GAI, multi-element analyses for the total metals concentration of waste materials have been compared to Department of Environment and Conservation (DEC) Contaminated Sites Management Series Guidelines – *Assessment Levels for Soil, Sediment and Water* (DEC, 2010). The criteria chosen are the interim sediment quality guideline values (ISQG) for both low and high probability of causing biological effects. The trigger values are tabulated in **Table 2-1**.

Table 2-1 DEC Assessment Levels for Soils and Sediment (DEC, 2010)

Element	ISQG – Low[1] (mg/kg)	ISQG – High[2] (mg/kg)
Ag	1.0	3.7
As	20	70
Cd	1.5	10
Cr	80	370
Cu	65	270
Hg	0.15	1.0
Ni	21	52
Pb	50	220
Sb	2.0	25
Zn	200	410

Notes:
[1] ISQG – Low: probable effects concentrations above which biological effects rarely occur.
[2] ISQG – High: probable effects concentrations above which biological effects would possibly occur.

Static leach test methodology for multi-element analysis varies widely. The method used for the two samples subjected to multi-element leach testing involved a singe leach of the solid material with deionised water (utilising the Australian Standard Leaching Procedure). The resulting leachate is generally analysed for major ions and a selected suite of metals. The leachate values have been compared to the Australian and New Zealand Environment and Conservation Council (ANZECC) *Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000). The trigger values have been chosen appropriate to the likely receiving environment, as outlined in the *FerrAus Pilbara Project Mine Water Options Assessment – Receiving Environment Study* (SKM, 2011). This study utilised the ANZECC *Upland Rivers* in Tropical Australia (includes North-West Western Australia) trigger levels for 95% protection of species.

The ANZECC trigger values have been utilised for this Phase 1 assessment as the baseline groundwater quality data for the FPP is currently being collected and analysed for the purpose of future impact assessments. The assessment of potential impact based on these trigger levels is to be used as a guideline only. The Phase 2 detailed geochemistry assessment will utilise the final baseline water quality objectives determined for the FPP.

To aid with the assessment of leachate quality against site specific water quality objective, the draft objectives proposed in the *FerrAus Pilbara Project Mine Water Options Assessment – Receiving Environment Study* (SKM, 2011) have also been utilised for identification of potential impact for the purposes of guiding future work in the Phase 2 detailed geochemistry assessment. These represent draft objectives for waterways that have the potential to be impacted by mine discharges. Some of these waterways may also receive a limited amount of groundwater discharge.

The values for both the ANZECC trigger values and the Draft objectives (SKM, 2011) are tabulated in (**Table 2-2**).

Table 2-2 Assessment Levels for Leachate (ANZECC, 2000; and SKM, 2011)

Element	ANZECC trigger value (mg/L)[1]	Draft Objective (mg/L)[2]
Ag	0.0005	0.005
Al	0.055	0.055
As	0.024	0.024
Bi	No guideline	1
Cd	0.0002	0.0002
Cu	0.0014	0.0014
Fe	0.3	0.3
Mn	1.9	0.5
Pb	0.0034	0.0034
Se	0.011	0.011
Sb	No guideline	0.05
Zn	0.008	0.02

Note:
[1]ANZECC trigger level for Upland Rivers in Tropical Australia (includes North-West WA) 95% Protection level
[2] Draft Objectives for waterways with the potential to be impacted by FPP mine discharges (surface water and groundwater)

4 Quality Assurance and Quality Control

4.1 Data Validation Techniques and Elements

For quality assurance and quality control (QAQC) purposes, validation of analytical data was used to assess whether the data gathered were in compliance with method requirements and project specifications. The primary objectives of this process were to ensure that: (i) data of known quality are reported; and (ii) the data can be used to fulfil the overall project objectives.

The data validation guidelines used are based on guidance documents published by the United States Environmental Protection Agency (US EPA). These include:

- *Contract Laboratory Program for Organic Data Review* (October 1999);
- *Contract Laboratory Program for Inorganic Data Review* (July 2002); and
- *Guidance on Environmental Data Verification and Data Validation* (November 2002).

The validation process, for both the field sampling procedures and the laboratory analytical programmes, involves checking the compliance of analytical procedures and assessing the accuracy and precision of analytical data from a range of quality control measurements.

Tailing samples were produced, by FerrAus, in a pilot process plant and as such validation of field sampling procedures was not required and have not been included in this data assessment.

The data validation protocols employed by URS are compliant with and exceed those specified in the National Environment Protection (assessment of site contamination) Measure (NEPC, 1999), with additional reference to the quality control specifications detailed in section 5 of the Australian and New Zealand Standard (AS/NZS) 5667.1.1998. *Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples* (AS/NZS, 1998).

Specific elements of the analytical programmes checked and assessed for this project include:

- Sample holding times;
- Use of appropriate analytical procedures;
- Required limits of reporting (LOR);
- Frequency of conducting quality control measurements;
- Laboratory blank results;
- Precision [(Relative Percent Difference (RPD)] of laboratory duplicate results; and
- Matrix spike results.

All quality assurance reports received from the laboratory are included in Appendix A. The contracted laboratory [Australian Laboratory Services (ALS) Environmental Division] is National Association of Testing Authorities (NATA) accredited for all analyses conducted as part of this analytical program.

The X-ray Fluorescence (XRF) testing was conducted by ALS – Minerals Division. This XRF analysis is not covered under the NATA accreditation process.

4.2 Laboratory Analysis Validation

Laboratory data validation consists of four types of QAQC samples:

- Laboratory duplicate - to determine the reproducibility of results (intra-laboratory precision);
- Laboratory control sample - to indicate the potential for bias within the analysis method, or due to analytical equipment;
- Method blank - to assess the potential for cross-contamination during the analytical process; and
- Matrix spike - to indicate the potential bias within the sample results due to the interferences within the sample matrix.

The assessment of these types of QAQC samples allows an overall determination of the quality of laboratory analytical data.

Laboratory data validation also includes the assessment of sample preservation and storage parameters, and compliance with maximum recommended holding times.

Detailed laboratory QAQC data (reported by the laboratory) are presented in the analytical reports in Appendix A. The validation of the laboratory data carried out as part of this assessment is presented in tables in Appendix B.

Based on validation of laboratory QAQC data, the overall quality of the analytical results is considered to be generally acceptable for interpretive use.

Exceptions are discussed below.

4.2.1 Frequency of Laboratory QAQC - Non Compliances

A sufficient frequency of laboratory QAQC was completed to generally confirm the accuracy and precision of laboratory reporting processes, except:

- Laboratory duplicate and laboratory control spikes for physio-chemical parameters (pH).

4.2.2 Sample Handling and Preservation – Non Compliances

- Samples were received by the laboratory at 23.7ºC, above the recommended temperature. However, this will not affect data interpretation as no volatile analytes were included within the analytical suite.
- Sample containers do not comply with preservation standards as tailings samples are usually expected to be delivered as wet samples stored in a plastic bottle with nitric acid preservation. It is not expected that this will influence data interpretation of these samples as no volatile analytes were included in the analytical suite and materials were delivered as dry samples in an unpreserved glass jar.

4.2.3 Holding Time – Exceedences

Holding time exceedence for RRPT01 occurred for pH (6 hour holding time exceeded by 2 days), soluble sulphate (extraction time exceeded by 4 days) and chloride (extraction time exceeded by 4 days).

4.2.4 Laboratory Control Sample

Iron had a recovery (137%) which marginally exceeded the upper control limit (130%).

4.2.5 Matrix Spikes

Manganese (Mn) recovery in RRPT01 was not determined due to background concentrations greater than 4 times the spike level.

4.2.6 Summary of Laboratory QAQC Results

The majority of QAQC issues outlined above are unlikely to have a significant effect on the precision and accuracy of reported results for the following reasons:

- Generally, laboratory QA/QC was reported at an appropriate frequency to indicate that the data has been generated with acceptable accuracy and precision.
- No volatile compounds were analysed, therefore it is unlikely that the excessive sample temperature will affect the reported analyte concentrations.
- The exceedence of holding time for analysis of some parameters (pH, soluble sulfate and chloride) is not considered to affect the interpretation of the results as the parameters are not considered to be of high importance in assessing the overall potential of impact from the residue materials.
- The assessment of Mn recovery was not able to be carried out as concentrations of Mn in the residue samples were higher than the spike concentration. This is not considered to have an affect on the interpretation of any results

The purpose of this Phase 1 geochemical assessment is to highlight a potential for environmental impact, and to establish technically appropriate protocols for ongoing detailed geochemical assessment at the FPP to address identified data gaps. On the basis of the assessment objectives and the laboratory analytical data validation, the overall quality of the analytical results is considered to be acceptable for interpretive use.

5 Results

As part of the most recent pilot plant trial, the Detailed Feasibility Stage Pilot Plant Evaluation, two samples from the RRA ore deposit (RR high grade and RR medium grade) and two samples from the Mirrin Mirrin ore deposit (MM high grade and MM medium grade) were selected for analysis.

The high and medium grade samples were combined in ratios to approximate the conditions under which the residue material will be generated. The combination ratios and sample names selected are:

- RRPT01: RRA ore deposit - 29% high grade and 71% medium grade; and
- MMPT01: Mirrin Mirrin ore deposit - 57% high grade and 43% medium grade.

Laboratory reports and QAQC results are presented in Appendices A and B respectively.

5.1 Acid Forming Characteristics

Acid producing potential of the residue materials have been assessed using total sulfur (%S) content of the residue tailings samples. The predicted MPA generation based on the maximum %S values, and ANC for each residue sample is presented in **Table 1**.

Total sulfur values for both the RRA (RRPT01) and Mirrin Mirrin (MMPT01) samples were below the 0.1 %S, and as such both samples are categorised as Barren. NAPP values for both samples are negative (-40.7 kg H_2SO_4/t for MMPT01 and -1.2 kg H_2SO_4/t for RRPT01) which indicates that the residue tailings are classified as Non-acid Forming (NAF).

In general NAPP values of +/- 20 kg H_2SO_4/tonne (applicable to RRPT01) are considered to be uncertain of generating acid. In the absence of the complete suite of NAPP and NAG testing, the exact acid producing potential of the ore and waste materials cannot be determined. However, given the oxidised nature and the low total sulfur content (<0.1 %S) of the residue material tested from RRA (RRPT01), it is unlikely that acid production potential will be significant and samples are likely to be classified as NAF. In order to confirm the acid producing characteristics of the waste it is recommended that final pilot trial residue materials are tested for the full NAPP and NAG testing suites.

6 Multi-Element Composition of Waste Materials

6.1.1 Geochemical Abundance Index

The results of the GAI analysis, for both the RRA and Mirrin Mirrin residue samples (RRPT01 and MMPT01) are presented in **Table 2**.The results indicate that the elements present in enriched concentrations in both RRA (RRPT01) and Mirrin Mirrin (MMPT01) residue materials are:

- Arsenic (As), iron (Fe) and zinc (Zn) (both RRPT01 and MMPT01); and
- Manganese (Mn) (RRPT01).

Arsenic enrichment is higher in the RRPT01 compare to MMPT01. The only element that has a GAI that equals or exceeds 3 is As in the RRA residue sample (RRPT01).

As the proposed mine is located in the Pilbara region, where Fe and some metals are preferentially enriched in soils and rock, elevated Fe in the Mirrin Mirrin and RRA residue materials is considered to be representative of background conditions. Therefore, it is unlikely to have substantial environmental impact risks.

6.1.2 Multi-element solids

Screening of residue tailings analytical results was undertaken by initially comparing the results with the ISQG low and high values. **Table 3** presents a summary of the RRA and Mirrin Mirrin residue samples (RRPT01 and MMPT01) compared against the adopted DEC guideline criteria.

Both of the residue samples reported metal concentrations below the ISQG criteria for both low and high probability for causing biological effects, with the exception of silver (Ag) concentrations, which were reported above ISQG low trigger value in MMPT01 and RRPT01. All of the metal concentrations were reported above limit of reporting (LOR). The exceptions were boron (B), mercury (Hg), selenium (Se) for both the residue samples (RRPT01 and MMPT01) and cadmium (Cd) for the Mirrin Mirrin residue sample (MMPT01).

6.1.3 Multi-element leachate

While the NAG and NAPP values (and ANC/MPA ratio and ABCC tests) provide an indication of the potential for acid generation from a sample, additional test work is required to predict the potential for metalliferous or saline drainage. . In view of this, metal leachability tests (deionised water extractions) were conducted. The results of the multi-element leachate analysis of the RRA and Mirrin Mirrin residue samples (RRPT01 and MMPT01) are presented in **Table 4**.

The LOR was higher than the criteria values for Ag. This may lead to an inaccurate determination of potential impacts from leachate. The analyses that were below detection limit for this element have not been highlighted; however results have been interpreted with caution.

In general leachate from both RRA and Mirrin Mirrin residue samples (RRPT01 and MMPT01) had low salinity (electrical conductivity measurements of 196 uS/cm and 115 uS/cm respectively) and had neutral pH (pH 7.22 and 7.34 respectively). Most metals were below detection limit with the exception of:

- Aluminium (Al), Barium (Ba), Boron (B), Lithium (Li), Mn, Molybdenum (Mo) and Strontium (Sr) for both RRPT01 and MMPT01; and
- Chromium (Cr) and Tungsten (W) for RRPT01.

Concentrations of some metals exceeded both of the ANZECC and draft objective assessment criteria in the following samples:

- Copper (Cu) and Zn for both RRPT01 and MMPT01;
- Cadmium (Cd) for MMPT01;
- Aluminium (Al) and Fe[1] for RRPT01.

It is noted that the ANZECC and draft objective trigger values are equivalent for Fe, Cd and Al.

7 Summary

Two residue samples from the recent FPP Detailed Feasibility Stage Pilot Plant Evaluation of materials from the RRA and Mirrin Mirrin ore deposits were subjected for ABA and multi-element solids and leachate analysis as part of the Phase 1 geochemical assessment of the residue materials intended to be stored in the RSF at the FPP.

Both the RRA and Mirrin Mirrin residue samples (RRPT01 and MMPT01) were classified as NAF. Both samples had total sulfur vales below 0.1 %S indicating that they may also be classified as Barren.

Based on the review of the analytical results for ABA for the two samples tested, the residue tailings from RRA and Mirrin Mirrin ore deposits is considered tested is unlikely to generate acid or saline drainage; however, they may be problematic with regards to the potential generation of metal (Cu, Zn, Cd, Al and Fe) drainage if not managed appropriately.

It is recommended that the geochemical testing of residue materials from the DCA ore deposit be included in the Phase 2 detailed geochemical assessment and be considered for the detailed design phase of the RSF development.

Both the RRA and Mirrin Mirrin residue samples (RRPT01 and MMPT01) are enriched in some metals (As, Fe and Zn). Residue materials from the RRA ore deposit (RRPT01) are also enriched in Mn. The GAI results found that the only element enriched at a GAI of 3 or above was As, which was enriched in the RRA residue material (RRPT01). The results of the multi-element testing of the RRPT01 sample show that the RRA residue sample did not exceed the DEC ISQG low or ISQG high trigger values for As and that As did not leach from the RRPT01 residue material in elevated concentrations (As concentration of RRPT01 <LOR).

Therefore, although the GAI indicated that As is present in the RRA residue material at concentrations that may require further investigation, it is considered unlikely that release of residue solids (for example from dust generation on the surface of the RSF) or leaching of the RRA residue materials will cause adverse impact to soils or water quality if managed appropriately. It is

[1] Australian Drinking Water Guideline (aesthetic) value for iron has been adopted based on water quality objectives identified for the FPP (SKM, 2011)

recommended that As be included in the analytical suite of any further geochemical assessments and water quality testing at FPP.

The RRA and Mirrin Mirrin residue samples (RRPT01 and MMPT01) did not exceed DEC ISQG low or ISQG high trigger values for soils and sediments for the majority of metals. The only exception was exceedence of the ISQG low trigger value for Ag for both the RRA and Mirrin Mirrin samples. An exceedence of the ISQG low trigger value indicates that there is the potential for biological effects to occur is rare. The leachate testing was carried out using a method that resulted in the LOR of Ag being higher than the ANZECC (2000) trigger value. This means that the results require interpretation with caution. It is recommended that Ag be included within the analytical suite of any further geochemical assessments and water quality testing at FPP, and that the analytical methodology be adjusted to achieve a smaller LOR and enable a more thorough assessment of the potential impacts associated with Ag in the residue samples.

The results of the leachate testing indicated that the RRA and Mirrin Mirrin residue samples (RRPT01 and MMPT01) exceeded the ANZECC and draft water quality objectives for the following parameters:

- Copper (Cu) and Zinc (Zn) (both RRPT01 and MMPT01);
- Cadmium (Cd) (MMPT01); and
- Aluminium (Al) and Iron (Fe) (RRPT01).

This indicates that leachate generated within the RSF due to interaction of the residue material with rainfall or process liquids has the potential to impact groundwater and/or surface water based in the interim screening trigger values (ANZECC and draft water quality objectives). The presence of Fe and Al in the leachate and in the residue materials is likely to limit the mobility of metals such as Cu, Zn and Cd through sorption reactions with iron-hydroxide minerals. It is recommended that kinetic leach testing be carried out on residue materials from the RRA, Mirrin Mirrin and DCA ore deposits to determine the leachable concentrations under conditions that approximate the climatic conditions of the FPP.

As the draft water quality objectives and ANZECC trigger values relate to the protection of ecosystems in surface water bodies that may be affected by mine discharges, it is recommended that, as a precautionary measure, the RSF be designed and managed so that the potential risk of run-off (and seepage) to cause significant water quality impacts is minimised.

It is understood that draft groundwater quality objectives will be proposed as part of the baseline groundwater quality study that is currently in progress for the FPP. It is recommended that the results of the leachate testing be reviewed against the baseline groundwater quality data to assess the potential for seepage from the base of the RSF to cause impact to groundwater quality in the region.

It is also recommended that a closure strategy be developed to minimise the infiltration of rainfall into the RSF at closure of the FPP. This strategy may include the design and installation of a suitable cover system on the RSF.

8 Recommendations

It is understood that as part of the Phase 2 detailed geochemical assessment, the outcomes of this Phase 1 geochemical assessment of residue tailings materials from RRA and Mirrin Mirrin operations will be combined with other existing information on waste, ore and low-grade materials and placed into context within the greater mine plan and infrastructure planned for the Project (as is illustrated in **Figure 1**). It is suggested that a Mine Waste Management Plan (MWMP) be developed specific to the level of risk of acid or metalliferous drainage (AMD) potential that each of the residue tailings and waste rock materials from the RRA, Mirrin Mirrin and DCA ore deposits have.

At this stage it is not expected that any specific requirements are needed for the placement or management of waste materials, for the purposes of prevention of AMD. It is recommended that waste landforms be constructed to minimise the ponding of surface water (Outback Ecology, 2010).

As part of the Phase 2 detailed geochemical assessment detailed geochemical testing is recommended for all new or existing pilot trial residue tailings samples for RRA, Mirrin Mirrin and DCA ore deposits. This testing may include but not be limited to:

- Residue Tailings solids
  - Acid Base Accounting (static testing e.g. NAPP and NAG);
  - Kinetic Leach Testing;
  - Mineralogy (X-ray diffraction)
  - Multi-element solids (total and leachable); and
  - Major ions.
- Residue Tailings liquor
  - pH, electrical conductivity, total dissolved solids;
  - major ions; and
  - multi elements.

Testing will be repeated throughout mine life where residue tailings composition changes due to change in mining or process conditions.

The results of this Phase 1 geochemical assessment indicate that the residue materials are unlikely to be acid forming; therefore, ABA and detailed testing around acid generation mechanisms is considered to be of lower importance compared to the potential for the residue materials to release metals in leachate. Based on this outcome it is recommended that the detailed testing focus on the potential release of metals from residue materials.

The potential for the release of metals in leachate from the residue tailings material from the RRA and Mirrin Mirrin ore deposits, indicate that additional design parameters may need to be included in the detailed design phase of the RSF development. The final recommendations are subject to comparison of the leachate results to the findings baseline groundwater quality studies. It is understood that these results will be available as part of the proposed Part IV s38 environmental approvals document.

It is recommended that the following be considered in the detailed design of the RSF:

- A surface water management plan that minimises the potential for surface water to be released to the environment during rainfall events;
- Installation of a clay liner to minimise seepage from the base of the RSF; and
- The design of a store and release cover system to minimise infiltration of surface water into the residue tailings materials at closure.

9 Close

We trust that this Phase 1 geochemical assessment meets the requirements of the objectives outlined in Section 1. Please contact the undersigned on 08 9326 0100 if there are any queries on the information contained in this letter.

Yours sincerely
URS Australia Pty Ltd

Tracey Hassell
Senior Geochemist

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Attachments:

Tables

Table 1 Acid Base Accounting Results - FerrAus Pilbara Project Tailings Residue

Table 2a XRF Results - FerrAus Pilbara Project Tailings Residue

Table 2b Geochemical Abundance Index Results - FerrAus Pilbara Project Tailings Residue

Table 3 Soil Analytical Results - FerrAus Pilbara Project Tailings Residue

Table 4 Leachate Analytical Results - FerrAus Pilbara Project Tailings Residue

Figure

Figure 1 Geochemical Assessment – Life of Mining Plan

Appendices

Appendix A Laboratory Reports

Appendix B Data Validation

References

AMIRA International (AMIRA), 2002. *ARD Test Handbook – Project P387A Prediction and Kinetic Control of Acid Mine Drainage*. Ian Wark Research Institute and Environmental Geochemistry International Pty Ltd. May 2002

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Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of FerrAus Limited and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Variation Request dated 9 June 2011.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between June 2011 and July 2011 is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Tables

Table 1
Acid Base Accounting Results - FerrAus Pilbara Project Tailings Residue
FerrAus Limited

Sample ID	Sample Type	pH[1]	Acidity (to pH 8.3)	Alkalinity (to pH 5.5)	EC[1]	Total Sulfur	Sulfate Sulfur	MPA[2]	ANC[2]	NAPP[2]	Sample Classification[3]
			(kg H_2SO_4/t)		(µS/cm)	(%)		(kg H_2SO_4/t)			
MMPT01	Tailings	NA	NA	NA	NA	0.04	NA	1.2	41.9	-40.7	Non-acid forming (Barren)
RRPT01	Tailings	NA	NA	NA	NA	0.03	NA	0.9	2.1	-1.2	Non-acid forming (Barren)

Notes:
1. Natural pH and EC provided for 1:5 sample:water extracts
2. MPA = Maximum potential acidity; ANC = Acid neutralising capacity; NAPP = Net acid producing potential.
3. Samples generally classified as PAF if NAPP is positive and NAF if NAPP is negative (NAF-Barren if Total Sulfur is <0.10%). Refer to text for further details.
4. NA denoted not analysed

Table 2a
XRF Results - FerrAus Pilbara Project Tailings Residue
FerrAus Limited

Location	Sample ID	Date Sampled	Sample Type	Analyte	Al2O3	As	BaO	CaO	Cl	Co	Cr2O3	Cu	Fe2O3	K2O	MgO	MnO	Mo	Na2O	Ni	P2O5	Pb	SO3	SiO2	TiO	V2O5	Zn
				Units	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
				LOR	0.01	0.001	0.001	0.01	0.001	0.001	0.001	0.0021	0.01	0.001	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01	0.001	0.001
Mirrin Mirrin	MMPT01	24/06/2011	Tailing		**7.52**	**0.005**	<0.001	**0.07**	**0.062**	<0.001	<0.001	**0.002**	**72.1**	<0.001	**0.15**	**0.231**	<0.001	**0.082**	**0.002**	**0.233**	<0.001	**0.043**	**9.42**	**0.21**	<0.001	**0.024**
Robertson Range	RRPT01	24/06/2011	Tailing		**7.58**	**0.006**	<0.001	**0.1**	**0.37**	<0.001	<0.001	**0.003**	**68.4**	**0.027**	**0.12**	**0.297**	<0.001	**0.058**	**0.003**	**0.17**	<0.001	**0.076**	**14.25**	**0.33**	<0.001	**0.021**

Table 2b
Geochemical Abundance Index Results - FerrAus Pilbara Project Tailings Residue
FerrAus Limited

Element	**TOTAL-ELEMENT CONTENT (mg/kg or %)** MMPT01	RRPT01	**AVERAGE CRUSTAL ABUNDANCE[1] (mg/kg or %)**	**GEOCHEMICAL ABUNDANCE INDEX (GAI)** MMPT01	RRPT01
Al2O3%	7.52	7.58	7.10	0	0
As	50	60	6	**2**	**3**
Ba	<LOR	<LOR	500	<LOR	<LOR
CaO%	0.07	0.1	1.50	0	0
Co	<LOR	<LOR	8	<LOR	<LOR
Cr	<LOR	<LOR	70	<LOR	<LOR
Cu	20	30	30	0	0
Fe%	25.21	23.92	4	**2**	**2**
K2O%	<LOR	0.027	1.40	<LOR	0
MgO%	0.15	0.12	0.50	0	0
Mn	1789	2300.27	1000	0	**1**
Na%	0.061	0.043	0.50	0	0
Ni	20	30	50	0	0
P	1016.58	741.71	800	0	0
Pb	<LOR	<LOR	35	<LOR	<LOR
S%	0.0172	0.0304	0.07	0	0
Si%	4.4	6.66	33	0	0
TiO2%	0.21	0.33	0.50	0	0
V	<LOR	<LOR	90	<LOR	<LOR
Zn	240	210	90	**1**	**1**

notes
Total element content values are median concentrations (calculated form Table B-1 - Appendix B)
<LOR - element below analytical limit of reporting, effective GAI is 0
[1] from Enviromental Chemistry of the Elements (Bowen, 1979)

Table 3
Soil Analytical Results - FerrAus Pilbara Project Tailings Residue
FerrAus Limited

Location					Mirrin Mirrin	Robertson Range
Sample ID					MMPT01	RRPT01
Date Sampled					24/06/2011	24/06/2011
Sample Type					Primary Sample	Primary Sample
Analyte	**LOR**	**Units**	**ISQG-Low**	**ISQG-High**		
Moisture Content						
Moisture Content	1	%	-	-	**1.1**	<1
Metals (Total)						
Lithium	0.1	mg/kg	-	-	**4.4**	**1.2**
Uranium	0.1	mg/kg	-	-	**9**	**1.2**
Aluminium	50	mg/kg	-	-	**7280**	**4400**
Antimony	0.1	mg/kg	2	25	**0.5**	**0.5**
Arsenic	0.1	mg/kg	20	70	**0.8**	**1.7**
Barium	0.1	mg/kg	-	-	**40.2**	**94.7**
Beryllium	0.1	mg/kg	-	-	**0.4**	**0.3**
Boron	50	mg/kg	-	-	<50	<50
Cadmium	0.1	mg/kg	1.5	10	<0.1	**0.1**
Chromium	0.1	mg/kg	80	370	**19.9**	**28.6**
Cobalt	0.1	mg/kg	-	-	**6.2**	**15.9**
Copper	0.1	mg/kg	65	270	**26.9**	**18.9**
Iron	50	mg/kg	-	-	**198000**	**126000**
Lead	0.1	mg/kg	50	220	**12.4**	**13.7**
Manganese	0.1	mg/kg	-	-	**1550**	**1620**
Mercury	0.1	mg/kg	0.15	1	<0.1	<0.1
Molybdenum	0.1	mg/kg	-	-	**0.6**	**1**
Nickel	0.1	mg/kg	21	52	**15.6**	**10.2**
Selenium	1	mg/kg	-	-	<1	<1
Silver	0.1	mg/kg	1	3.7	**2.7**	**2.4**
Strontium	0.1	mg/kg	-	-	**7.7**	**6.3**
Thallium	0.1	mg/kg	-	-	**0.2**	**0.4**
Vanadium	1	mg/kg	-	-	**12**	**17**
Zinc	0.1	mg/kg	200	410	**114**	**72.7**
Bismuth	0.1	mg/kg	-	-	**0.1**	**0.1**
Thorium	0.1	mg/kg	-	-	**1.7**	**1.8**
Tungsten	0.1	mg/kg	-	-	**0.3**	**0.3**
Yttrium	0.1	mg/kg	-	-	**3**	**1.9**
Major Ions						
Calcium	10	mg/kg	-	-	**60**	**20**
Chloride	10	mg/kg	-	-	**700**	**270**
Magnesium	10	mg/kg	-	-	**20**	<10
Potassium	10	mg/kg	-	-	**30**	**20**
Sodium	10	mg/kg	-	-	**480**	**220**
Sulfur as S	10	mg/kg	-	-	**50**	**30**
Sulfate as SO4 2-	10	mg/kg	-	-	**160**	**80**
Acid Neutralising Capacity						
ANC as CaCO3	0.1	% caco3	-	-	**4.3**	**0.2**
ANC as H2SO4	0.5	kg h2so4 e	-	-	**41.9**	**2.1**
Fizz Rating		fizz unit	-	-	**2**	**1**
Sulfur						
Sulfur - Total as S (LECO)	0.01	%	-	-	**0.04**	**0.03**

Legend:
Exceeds the WA DEC, 2010, ISQG-Low (Trigger value)
Exceeds the WA DEC, 2010, ISQG-High (Trigger Value)
- Not analysed / not calculated

Table 4
Leachate Analytical Results - FerrAus Pilbara Project Tailings Residue
FerrAus Limited

Location				Mirrin Mirrin	Robertson Range
Sample ID				MMPT01	RRPT01
Date Sampled				24/06/2011	24/06/2011
Sample Type				Primary sample	Primary sample
Analyte	**LOR**	**Units**	**ANZECC trigeer level**		
Physico-Chemical Parameters					
pH	0.01	ph unit	6.0 - 7.5	7.22	7.34
Total Dissolved Solids	5	mg/L	20 - 250	111	64
Electrical Conductivity @ 25°C	1	µs/cm	20-250	196	115
Metals (Leachable)					
Bismuth	0.001	mg/L	-	<0.001	<0.001
Iron	0.05	mg/L	0.3**	<0.05	1.39
Lithium	0.001	mg/L	-	0.002	0.003
Strontium	0.001	mg/L	-	0.053	0.017
Thallium	0.001	mg/L	-	<0.001	<0.001
Thorium	0.001	mg/L	-	<0.001	<0.001
Uranium	0.001	mg/L	-	<0.001	<0.001
Yttrium	0.001	mg/L	-	<0.001	<0.001
Arsenic	0.001	mg/L	0.024	0.003	<0.001
Antimony	0.001	mg/L	-	<0.001	<0.001
Beryllium	0.001	mg/L	-	<0.001	<0.001
Cadmium	0.0001	mg/L	0.0002	0.0005	<0.0001
Chromium	0.001	mg/L	-	<0.001	0.001
Cobalt	0.001	mg/L	-	<0.001	<0.001
Copper	0.001	mg/L	0.0014	0.003	0.002
Lead	0.001	mg/L	0.0034	<0.001	<0.001
Mercury	0.0001	mg/L	-	<0.0001	<0.0001
Molybdenum	0.001	mg/L	-	0.016	0.032
Nickel	0.001	mg/L	-	<0.001	<0.001
Silver	0.001	mg/L	0.0005	<0.001*	<0.001*
Vanadium	0.01	mg/L	-	<0.01	<0.01
Zinc	0.005	mg/L	0.008	0.096	0.085
Aluminium	0.01	mg/L	0.055	0.04	0.23
Barium	0.001	mg/L	-	0.186	0.592
Boron	0.05	mg/L	-	0.1	0.25
Manganese	0.001	mg/L	1.9	0.003	0.013
Tungsten	0.001	mg/L	-	<0.001	0.002
Selenium	0.01	mg/L	0.011	<0.01	<0.01
Major Ions					
Calcium	1	mg/L	-	5	3
Chloride	1	mg/L	250	32	14
Magnesium	1	mg/L	-	1	<1
Potassium	1	mg/L	-	1	<1
Sodium	1	mg/L	180	27	18
Total Anions	0.01	meq/l	-	1.31	0.78
Total Cations	0.01	meq/l	-	1.53	0.93
Sulfate as SO4 - Turbidimetric	1	mg/L	250	11	5
Sulfur as S	1	mg/L	-	3	2
Alkalinity					
Hydroxide Alkalinity as CaCO3	1	mg/L	-	<1	<1
Carbonate Alkalinity as CaCO3	1	mg/L	-	<1	<1
Bicarbonate Alkalinity as CaCO3	1	mg/L	-	9	14
Total Alkalinity as CaCO3	1	mg/L	-	9	14

Legend:

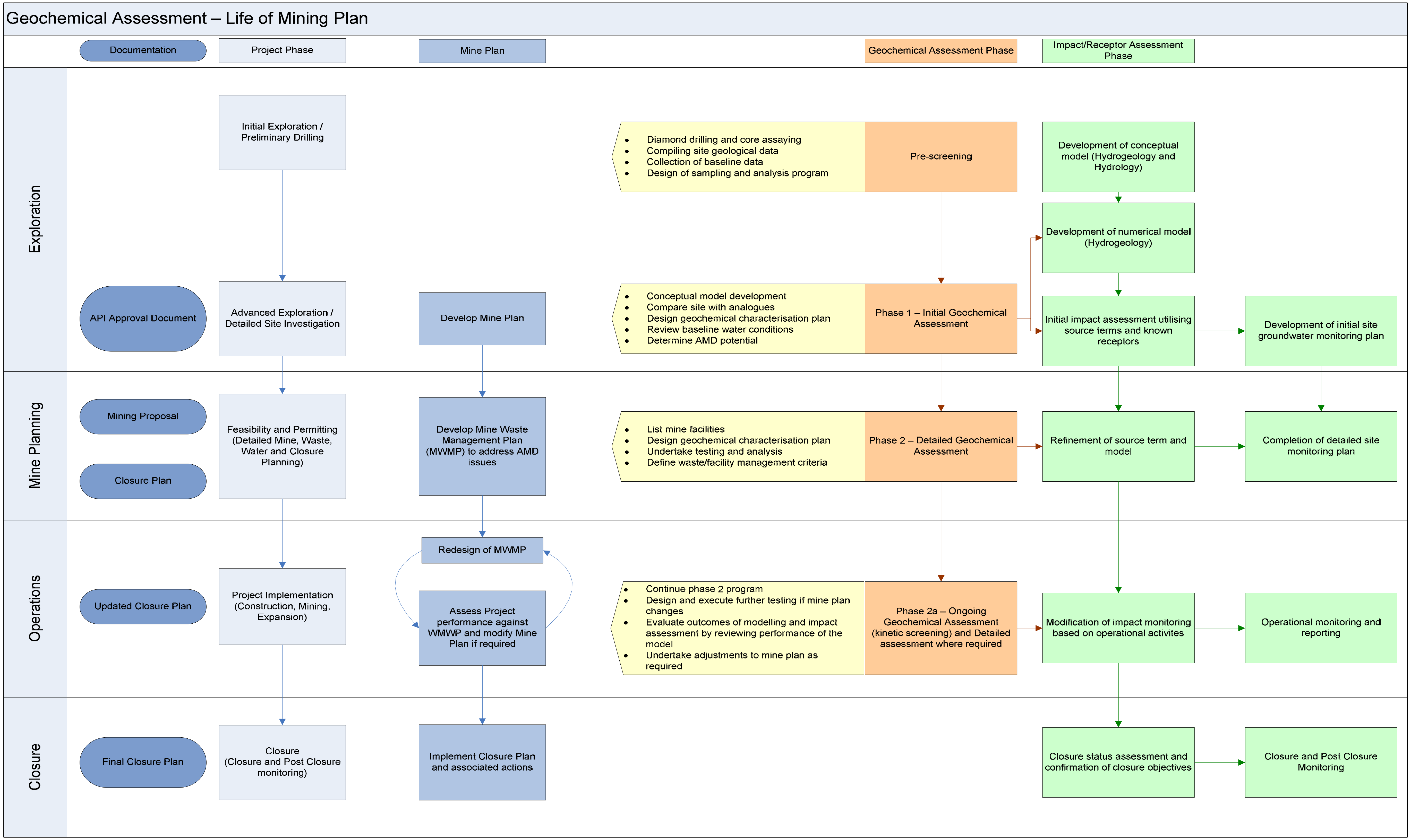
Exceeds the ANZECC trigger level for Upland Rivers in Tropical Australia (includes North-West WA) 95% Protection level

- Not analysed / not calculated

* LOR Exceeds Guideline Trigger Value

** Australian Drinking Water Guidelines - aesthetic value adopted

Figures



Notes:
AMD = Acid metalliferous drainge
MWPW = Mine Waste Management Plan

FerrAus Limited

Geochemical Assessment of Pilot Trial Tailings

Life of Mine Plan

Appendix A
Laboratory Reports

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: URS AUSTRALIA

OFFICE: LEVEL 4, 226 ADELAIDE TERRACE, PERTH WA 6000

PROJECT: 42907769 PROJECT NO.:

ORDER NUMBER: PER-11-7070E1 PURCHASE ORDER NO.:

PROJECT MANAGER: Tracy Hassell CONTACT PH: 9326 0100

SAMPLER: Client SAMPLER MOBILE:

COC Emailed to ALS? (YES / NO) EDD FORMAT (or default):

Email Reports to (will default to PM if no other addresses are listed): Elena_Chin@urscorp.com & tracey_hassell@urscorp.com

Email Invoice to (will default to PM if no other addresses are listed):

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.: EP/361/11

COUNTRY OF ORIGIN:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: 23.7 °C
Other comment:

RELINQUISHED BY:	RECEIVED BY: Joh Rees	RELINQUISHED BY:	RECEIVED BY:
DATE/TIME:	DATE/TIME: 24/6/11 14:58	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Please hold the un-use materials and send back to us when analysis is done. The leachate is to be generated by ASLP please.

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	Tailings Analysis	Leachate Analysis	XRF Analysis						Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	MMPT01	24th June 2011	S		1	x	x	x						Combine Mirrin Mirrin samples with the ratio: 57%High grade and 43%Medium grade.
2	RRPT01	24th June 2011	S		1	x	x	x						Combine Robertson Range samples with the ratio: 29%High grade and 71%Medium grade
3	MMHigh	↓	↓											
4	MMMedium													
5	RRHigh													
6	RRMedium													
				TOTAL										

Environmental Division Perth
Work Order
EP1104006
Telephone : +61-8-9209 7655

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

Linda Willis

From: Josh Rees
Sent: Friday, 24 June 2011 2:24 PM
To: Samples Perth
Cc: Lauren Ockwell
Subject: FW: Example COC Form
Attachments: 42907769 COC.pdf

Importance: High

Follow Up Flag: Follow up
Flag Status: Flagged

Hi SR,

Please see attached and below for specific instructions on some incoming URS samples.

It might be best to pre-log these as these may be fast TAT samples.

Can someone please get on this?

Thanks,

How was your customer experience? Please send us your feedback (Click the link)

Joshua Rees
Client Services Officer - Perth

ALS Environmental Division

Address
10 Hod Way, Malaga, WA, 6090

PHONE +61 8 9209 7655
DIRECT +61 8 9209 7617
FAX +61 8 9209 7600

www.alsglobal.com

From: Elena_Chin@URSCorp.com [mailto:Elena_Chin@URSCorp.com]
Sent: Friday, 24 June 2011 12:47 PM
To: Josh Rees
Cc: Lauren Ockwell; Tracey_Hassell@URSCorp.com
Subject: Re: Example COC Form

Hi Josh,

We have sorted out the problem as I discussed with you before about the combination of samples.

I will send 4 samples today into the lab, 2 samples from Mirrin Mirrin (both high and medium grade) and 2 samples from Robertson Range (both high and medium grade). Please combine the high and medium grade samples from each site according the the ratio mentioned on the COC. And please label the combined sample from Mirrin Mirrin as MMPT01 and combined sample from Robertson Range as RRPT01. I have attached the COC for your reference.

Please contact me if you have any questions.

Kind regards,

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

SAMPLE RECEIPT NOTIFICATION (SRN)

Comprehensive Report

Work Order	: **EP1104006**		
Client	: **URS AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: ELENA CHIN	Contact	: Lauren Ockwell
Address	: LEVEL 4, 226 ADELAIDE TERRACE PERTH WA, AUSTRALIA 6000	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: elena_chin@urscorp.com	E-mail	: lauren.ockwell@alsenviro.com
Telephone	: +61 08 9326 0100	Telephone	: 08 9209 7606
Facsimile	: +61 08 9326 0296	Facsimile	: 08 9209 7600
Project	: 42907769	Page	: 1 of 3
Order number	: PER-11-7070E1		
C-O-C number	: ----	Quote number	: EP2011URSWA0322 (EP/361/11)
Site	: ----		
Sampler	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Dates

Date Samples Received	: 27-JUN-2011	Issue Date	: 27-JUN-2011 15:24
Client Requested Due Date	: 05-JUL-2011	Scheduled Reporting Date	: **05-JUL-2011**

Delivery Details

Mode of Delivery	: Carrier	Temperature	: 23.7
No. of coolers/boxes	: 1 medium foam esky	No. of samples received	: 6
Security Seal	: Intact.	No. of samples analysed	: 2

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Requested Deliverables
- Sample containers do not comply to pretreatment / preservation standards (AS, APHA, USEPA). Please refer to the Sample Container(s)/Preservation Non-Compliance Log at the end of this report for details.
- Please see scanned COC for sample discrepencies: extra samples , samples not received etc.
- **Sample containers do not comply to pretreatment / preservation standards (AS, APHA, USEPA). Please refer to the Sample Container(s)/Preservation Non-Compliance Log at the end of this report for details.**
- **Please see attached Spreadsheet "Sample Weights" for weights used in Composites.**
- **pH analysis should be conducted within 6 hours of sampling.**
- Analytical work for this work order will be conducted at ALS Environmental Perth.
- Please direct any turnaround / technical queries to the laboratory contact designated above.
- Please direct any queries related to sample condition / numbering / breakages to Sample Receipt (SamplesPerth@alsenviro.com)
- Sample Disposal - Aqueous (14 days), Solid (90 days) from date of completion of Work Order.

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

Method / *Client sample ID*	Sample Container Received	Preferred Sample Container for Analysis
EG035W : Water Leachable Mercury by FIMS		
MMPT01	- Soil Glass Jar - Unpreserved	- Clear Plastic Bottle - Nitric Acid; Unfiltered
RRPT01	- Soil Glass Jar - Unpreserved	- Clear Plastic Bottle - Nitric Acid; Unfiltered

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process neccessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

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.

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	(On Hold) SOIL No analysis requested	SOIL - Balance Suite Balance Suite with DA Chloride	SOIL - EA005P pH (PC)	SOIL - EA010 Conductivity	SOIL - EA013 Acid Neutralising Capacity (ANC)	SOIL - EA015H Total Dissolved Solids - High Level	SOIL - ED040F Dissolved Major Anions	SOIL - ED040S Soluble Major Anions
EP1104006-001	24-JUN-2011 14:58	MMPT01		✓	✓	✓	✓	✓	✓	✓
EP1104006-002	24-JUN-2011 14:58	RRPT01		✓	✓	✓	✓	✓	✓	✓
EP1104006-003	24-JUN-2011 14:58	MM High	✓							
EP1104006-004	24-JUN-2011 14:58	MM Medium	✓							
EP1104006-005	24-JUN-2011 14:58	RR High	✓							
EP1104006-006	24-JUN-2011 14:58	RR Medium	✓							

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - ED042T Sulfur - Total as S (LECO)	SOIL - ED045G (solids) Chloride Soluble by Discrete Analyser	SOIL - EG005T (solids) Total Metals by ICP-AES	SOIL - EG020T (solids) Total Metals by ICP-MS	SOIL - EG020W Water Leachable Metals by ICPMS	SOIL - EG035T (solids) Total Mercury by FIMS	SOIL - EG035W Water Leachable Mercury by FIMS	SOIL - EN60-DI Suite Deionised Water Leach
EP1104006-001	24-JUN-2011 14:58	MMPT01	✓	✓	✓	✓	✓	✓	✓	✓
EP1104006-002	24-JUN-2011 14:58	RRPT01	✓	✓	✓	✓	✓	✓	✓	✓

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - MIS-SOL (Subcontracted) Miscellaneous Subcontracted Analysis (Solid)	SOIL - NT-1S Major Cations (Ca, Mg, Na, K)
EP1104006-001	24-JUN-2011 14:58	MMPT01	✓	✓
EP1104006-002	24-JUN-2011 14:58	RRPT01	✓	✓

Requested Deliverables

ELENA CHIN

- *AU Certificate of Analysis - NATA	Email	elena_chin@urscorp.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep)	Email	elena_chin@urscorp.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA	Email	elena_chin@urscorp.com
- A4 - AU Sample Receipt Notification - Environmental	Email	elena_chin@urscorp.com
- Attachment - Report	Email	elena_chin@urscorp.com
- Chain of Custody (CoC)	Email	elena_chin@urscorp.com
- EDI Format - ENMRG	Email	elena_chin@urscorp.com
- EDI Format - ESDAT	Email	elena_chin@urscorp.com
- EDI Format - MRED	Email	elena_chin@urscorp.com
- EDI Format - XTab	Email	elena_chin@urscorp.com

THE ACCOUNTS PAYABLE

- A4 - AU Tax Invoice (INV)	Email	Perth_Accounts@urscorp.com

TRACY HASSELL

- *AU Certificate of Analysis - NATA	Email	tracey_hassell@urscorp.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep)	Email	tracey_hassell@urscorp.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA	Email	tracey_hassell@urscorp.com
- A4 - AU Sample Receipt Notification - Environmental	Email	tracey_hassell@urscorp.com
- Attachment - Report	Email	tracey_hassell@urscorp.com
- Chain of Custody (CoC)	Email	tracey_hassell@urscorp.com
- EDI Format - ENMRG	Email	tracey_hassell@urscorp.com
- EDI Format - ESDAT	Email	tracey_hassell@urscorp.com
- EDI Format - MRED	Email	tracey_hassell@urscorp.com
- EDI Format - XTab	Email	tracey_hassell@urscorp.com

CERTIFICATE OF ANALYSIS

Work Order	: **EP1104006**	Page	: 1 of 6
Client	: **URS AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: ELENA CHIN	Contact	: Lauren Ockwell
Address	: LEVEL 4, 226 ADELAIDE TERRACE PERTH WA, AUSTRALIA 6000	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: elena_chin@urscorp.com	E-mail	: lauren.ockwell@alsenviro.com
Telephone	: +61 08 9326 0100	Telephone	: 08 9209 7606
Facsimile	: +61 08 9326 0296	Facsimile	: 08 9209 7600
Project	: 42907769	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: PER-11-7070E1		
C-O-C number	: ----	Date Samples Received	: 27-JUN-2011
Sampler	: ----	Issue Date	: 06-JUL-2011
Site	: ----		
		No. of samples received	: 6
Quote number	: EP/361/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Chas Tucker	Inorganic Chemist	Perth Inorganics
Cicelia Bartels	Metals Instrument Chemist	Perth Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Stafford Minerals - AY
Leanne Cooper	Acid Sulfate Soils Supervisor	Perth ASS

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: DI WATER LEACHATE			Client sample ID	MMPT01	RRPT01	----	----	----
			Client sampling date / time	29-JUN-2011 12:00	29-JUN-2011 12:00	----	----	----
Compound	CAS Number	LOR	Unit	EP1104006-001	EP1104006-002	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.22	7.34	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	196	115	----	----	----
EA015: Total Dissolved Solids								
^ Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	111	64	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	9	14	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	9	14	----	----	----
ED040F: Dissolved Major Anions								
^ Sulfur as S	63705-05-5	1	mg/L	3	2	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	11	5	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	32	14	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	5	3	----	----	----
Magnesium	7439-95-4	1	mg/L	1	<1	----	----	----
Sodium	7440-23-5	1	mg/L	27	18	----	----	----
Potassium	7440-09-7	1	mg/L	1	<1	----	----	----
EG020T: Total Metals by ICP-MS								
Tungsten	7440-33-7	0.001	mg/L	<0.001	0.002	----	----	----
EG020W: Water Leachable Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.04	0.23	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.003	<0.001	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L	0.186	0.592	----	----	----
Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	0.0005	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	0.001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	0.003	0.002	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Lithium	7439-93-2	0.001	mg/L	0.002	0.003	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.003	0.013	----	----	----

Analytical Results

Sub-Matrix: **DI WATER LEACHATE**

Compound	CAS Number	LOR	Unit	MMPT01	RRPT01	----	----	----
			Client sampling date / time	29-JUN-2011 12:00	29-JUN-2011 12:00	----	----	----
				EP1104006-001	**EP1104006-002**	**----**	**----**	**----**
EG020W: Water Leachable Metals by ICP-MS - Continued								
Molybdenum	7439-98-7	0.001	mg/L	**0.016**	**0.032**	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	----	----	----
Strontium	7440-24-6	0.001	mg/L	**0.053**	**0.017**	----	----	----
Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	----	----	----
Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	----	----	----
Yttrium	7440-65-5	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.096**	**0.085**	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.10**	**0.25**	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	**1.39**	----	----	----
EN055: Ionic Balance								
^ Total Anions	----	0.01	meq/L	**1.31**	**0.78**	----	----	----
^ Total Cations	----	0.01	meq/L	**1.53**	**0.93**	----	----	----

Analytical Results

Sub-Matrix: SOIL			Client sample ID	MMPT01	RRPT01	----	----	----
			Client sampling date / time	24-JUN-2011 14:58	24-JUN-2011 14:58	----	----	----
Compound	CAS Number	LOR	Unit	EP1104006-001	EP1104006-002	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	41.9	2.1	----	----	----
^ ANC as CaCO3	----	0.1	% CaCO3	4.3	0.2	----	----	----
Fizz Rating	----	0	Fizz Unit	2	1	----	----	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	1.1	<1.0	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	160	80	----	----	----
^ Sulfur as S	63705-05-5	10	mg/kg	50	30	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.03	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	700	270	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	60	20	----	----	----
Magnesium	7439-95-4	10	mg/kg	20	<10	----	----	----
Sodium	7440-23-5	10	mg/kg	480	220	----	----	----
Potassium	7440-09-7	10	mg/kg	30	20	----	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	7280	4400	----	----	----
Boron	7440-42-8	50	mg/kg	<50	<50	----	----	----
Iron	7439-89-6	50	mg/kg	198000	126000	----	----	----
EG020T: Total Metals by ICP-MS								
Arsenic	7440-38-2	0.1	mg/kg	0.8	1.7	----	----	----
Selenium	7782-49-2	1	mg/kg	<1	<1	----	----	----
Silver	7440-22-4	0.1	mg/kg	2.7	2.4	----	----	----
Barium	7440-39-3	0.1	mg/kg	40.2	94.7	----	----	----
Thallium	7440-28-0	0.1	mg/kg	0.2	0.4	----	----	----
Beryllium	7440-41-7	0.1	mg/kg	0.4	0.3	----	----	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.1	----	----	----
Bismuth	7440-69-9	0.1	mg/kg	0.1	0.1	----	----	----
Cobalt	7440-48-4	0.1	mg/kg	6.2	15.9	----	----	----
Chromium	7440-47-3	0.1	mg/kg	19.9	28.6	----	----	----
Uranium	7440-61-1	0.1	mg/kg	9.0	1.2	----	----	----
Copper	7440-50-8	0.1	mg/kg	26.9	18.9	----	----	----
Thorium	7440-29-1	0.1	mg/kg	1.7	1.8	----	----	----
Manganese	7439-96-5	0.1	mg/kg	1550	1620	----	----	----

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	MMPT01	RRPT01	----	----	----
			Client sampling date / time	24-JUN-2011 14:58	24-JUN-2011 14:58	----	----	----
				EP1104006-001	**EP1104006-002**	**----**	**----**	**----**
EG020T: Total Metals by ICP-MS - Continued								
Strontium	7440-24-6	0.1	mg/kg	**7.7**	**6.3**	----	----	----
Tungsten	7440-33-7	0.1	mg/kg	**0.3**	**0.3**	----	----	----
Molybdenum	7439-98-7	0.1	mg/kg	**0.6**	**1.0**	----	----	----
Nickel	7440-02-0	0.1	mg/kg	**15.6**	**10.2**	----	----	----
Lead	7439-92-1	0.1	mg/kg	**12.4**	**13.7**	----	----	----
Antimony	7440-36-0	0.1	mg/kg	**0.5**	**0.5**	----	----	----
Uranium	7440-61-1	0.1	mg/kg	**9.0**	**1.2**	----	----	----
Zinc	7440-66-6	0.1	mg/kg	**114**	**72.7**	----	----	----
Lithium	7439-93-2	0.1	mg/kg	**4.4**	**1.2**	----	----	----
Vanadium	7440-62-2	1	mg/kg	**12**	**17**	----	----	----
Thorium	7440-29-1	0.1	mg/kg	**1.7**	**1.8**	----	----	----
Yttrium	7440-65-5	0.1	mg/kg	**3.0**	**1.9**	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	----	----	----
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EN60: Bottle Leaching Procedure								
Final pH	----	0.1	pH Unit	<0.1	<0.1	----	----	----

Australian Laboratory Services Pty. Ltd.
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Finalized Date: 30-JUN-2011
Account: ALSENV

CERTIFICATE PH11116871

Project: EP1104006
P.O. No.: 295856
This report is for 2 Pulp samples submitted to our lab in Perth, WA, Australia on 27-JUN-2011.

The following have access to data associated with this certificate:

SUB RESULTS		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
LEV-01	Waste Disposal Levy
LOG-24	Pulp Login - Rcd w/o Barcode

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-XRF12	Whole rock XRF	XRF
OA-GRA05t	Multi-temperature LOI	TGA

To: **ALS ENVIRONMENTAL**
ATTN: SUB RESULTS
10 HOD WAY
MALAGA WA 6090

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

Signature: W. Abbott
Wayne Abbott, Operations Manager, Western Australia

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Finalized Date: 30-JUN-2011
Account: ALSENV

Project: EP1104006

CERTIFICATE OF ANALYSIS PH11116871

Sample Description	Method Analyte Units LOR	ME-XRF12 Al2O3 % 0.01	ME-XRF12 As % 0.001	ME-XRF12 BaO % 0.001	ME-XRF12 CaO % 0.01	ME-XRF12 Cl % 0.001	ME-XRF12 Co % 0.001	ME-XRF12 Cr2O3 % 0.001	ME-XRF12 Cu % 0.001	ME-XRF12 Fe2O3 % 0.01	ME-XRF12 K2O % 0.001	ME-XRF12 MgO % 0.01	ME-XRF12 MnO % 0.001	ME-XRF12 Mo % 0.001	ME-XRF12 Na2O % 0.001	ME-XRF12 Ni % 0.001
MMPT01		7.52	0.005	<0.001	0.07	0.062	<0.001	<0.001	0.002	72.1	<0.001	0.15	0.231	<0.001	0.082	0.002
RRPT01		7.58	0.006	<0.001	0.10	0.037	<0.001	<0.001	0.003	68.4	0.027	0.12	0.297	<0.001	0.058	0.003

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ALS Minerals

Finalized Date: 30-JUN-2011
Account: ALSENV

Project: EP1104006

CERTIFICATE OF ANALYSIS PH11116871

Sample Description	Method Analyte Units LOR	ME-XRF12 P2O5 % 0.001	ME-XRF12 Pb % 0.001	ME-XRF12 SO3 % 0.001	ME-XRF12 SiO2 % 0.01	ME-XRF12 TiO2 % 0.01	ME-XRF12 V2O5 % 0.001	ME-XRF12 Zn % 0.001	OA-GRA05t LOI 1000 % 0.01
MMPT01		0.233	<0.001	0.043	9.42	0.21	<0.001	0.024	9.87
RRPT01		0.170	<0.001	0.076	14.25	0.33	<0.001	0.021	8.48

QUALITY CONTROL REPORT

Work Order	: **EP1104006**	Page	: 1 of 11
Client	: **URS AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: ELENA CHIN	Contact	: Lauren Ockwell
Address	: LEVEL 4, 226 ADELAIDE TERRACE PERTH WA, AUSTRALIA 6000	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: elena_chin@urscorp.com	E-mail	: lauren.ockwell@alsenviro.com
Telephone	: +61 08 9326 0100	Telephone	: 08 9209 7606
Facsimile	: +61 08 9326 0296	Facsimile	: 08 9209 7600
Project	: 42907769	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 27-JUN-2011
Sampler	: ----	Issue Date	: 06-JUL-2011
Order number	: PER-11-7070E1		
		No. of samples received	: 6
Quote number	: EP/361/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

WORLD RECOGNISED ACCREDITATION

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Chas Tucker	Inorganic Chemist	Perth Inorganics
Cicelia Bartels	Metals Instrument Chemist	Perth Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Stafford Minerals - AY
Leanne Cooper	Acid Sulfate Soils Supervisor	Perth ASS

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient 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.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	**Client sample ID**	**Method: Compound**	**CAS Number**	**LOR**	**Unit**	**Original Result**	**Duplicate Result**	**RPD (%)**	**Recovery Limits (%)**
EA013: Acid Neutralising Capacity (QC Lot: 1847759)									
EP1104006-001	MMPT01	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equ	41.9	41.9	0.0	0% - 20%
EA055: Moisture Content (QC Lot: 1858768)									
EP1104006-001	MMPT01	EA055-103: Moisture Content (dried @ 103°C)	----	1.0	%	1.1	1.1	0.0	No Limit
ED040S: Soluble Major Anions (QC Lot: 1858623)									
EP1104006-001	MMPT01	ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	160	160	0.0	0% - 50%
ED042T: Total Sulfur by LECO (QC Lot: 1856956)									
EP1104006-001	MMPT01	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.04	0.0	No Limit
ED045G: Chloride Discrete analyser (QC Lot: 1858625)									
EP1104006-001	MMPT01	ED045G: Chloride	16887-00-6	10	mg/kg	700	690	1.4	0% - 20%
ED093S: Soluble Major Cations (QC Lot: 1858624)									
EP1104006-001	MMPT01	ED093S: Calcium	7440-70-2	10	mg/kg	60	60	0.0	No Limit
		ED093S: Magnesium	7439-95-4	10	mg/kg	20	20	0.0	No Limit
		ED093S: Sodium	7440-23-5	10	mg/kg	480	470	0.0	0% - 20%
		ED093S: Potassium	7440-09-7	10	mg/kg	30	30	0.0	No Limit
EG005T: Total Metals by ICP-AES (QC Lot: 1858539)									
EP1104006-001	MMPT01	EG005T: Aluminium	7429-90-5	50	mg/kg	7280	7220	0.8	0% - 20%
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.0	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	198000	203000	2.5	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 1858541)									
EP1104006-001	MMPT01	EG020X-T: Arsenic	7440-38-2	0.1	mg/kg	0.8	0.8	0.0	No Limit
		EG020X-T: Barium	7440-39-3	0.1	mg/kg	40.2	35.6	12.2	0% - 20%
		EG020X-T: Beryllium	7440-41-7	0.1	mg/kg	0.4	0.4	0.0	No Limit
		EG020X-T: Cobalt	7440-48-4	0.1	mg/kg	6.2	5.8	5.6	0% - 20%
		EG020X-T: Chromium	7440-47-3	0.1	mg/kg	19.9	18.7	6.3	0% - 20%
		EG020X-T: Copper	7440-50-8	0.1	mg/kg	26.9	26.0	3.4	0% - 20%
		EG020X-T: Manganese	7439-96-5	0.1	mg/kg	1550	1520	1.9	0% - 20%
		EG020X-T: Molybdenum	7439-98-7	0.1	mg/kg	0.6	0.6	0.0	No Limit
		EG020X-T: Nickel	7440-02-0	0.1	mg/kg	15.6	15.2	2.5	0% - 20%
		EG020X-T: Lead	7439-92-1	0.1	mg/kg	12.4	11.7	5.8	0% - 20%
		EG020X-T: Antimony	7440-36-0	0.1	mg/kg	0.5	0.5	0.0	No Limit
		EG020X-T: Uranium	7440-61-1	0.1	mg/kg	9.0	8.8	2.3	0% - 20%
		EG020X-T: Zinc	7440-66-6	0.1	mg/kg	114	113	1.0	0% - 20%
		EG020X-T: Lithium	7439-93-2	0.1	mg/kg	4.4	4.7	6.9	0% - 20%
		EG020X-T: Vanadium	7440-62-2	1	mg/kg	12	12	0.0	0% - 50%

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	***Client sample ID***	***Method: Compound***	***CAS Number***	***LOR***	***Unit***	***Original Result***	***Duplicate Result***	***RPD (%)***	***Recovery Limits (%)***
EG020T: Total Metals by ICP-MS (QC Lot: 1858542)									
EP1104006-001	MMPT01	EG020Y-T: Thallium	7440-28-0	0.1	mg/kg	0.2	0.2	0.0	No Limit
		EG020Y-T: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020Y-T: Bismuth	7440-69-9	0.1	mg/kg	0.1	0.1	0.0	No Limit
		EG020Y-T: Uranium	7440-61-1	0.1	mg/kg	9.0	8.8	2.3	0% - 20%
		EG020Y-T: Thorium	7440-29-1	0.1	mg/kg	1.7	1.7	0.0	0% - 50%
		EG020Y-T: Strontium	7440-24-6	0.1	mg/kg	7.7	7.2	5.8	0% - 20%
		EG020Y-T: Selenium	7782-49-2	1	mg/kg	<1	<1	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 1858544)									
EP1104006-001	MMPT01	EG020Z-T: Silver	7440-22-4	0.1	mg/kg	2.7	2.6	0.0	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 1858546)									
EP1104006-001	MMPT01	EG020R-T: Thorium	7440-29-1	0.1	mg/kg	1.7	1.7	0.0	0% - 50%
		EG020R-T: Yttrium	7440-65-5	0.1	mg/kg	3.0	2.9	0.0	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 1858540)									
EP1104006-001	MMPT01	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	***Client sample ID***	***Method: Compound***	***CAS Number***	***LOR***	***Unit***	***Original Result***	***Duplicate Result***	***RPD (%)***	***Recovery Limits (%)***
EA005P: pH by PC Titrator (QC Lot: 1854373)									
EP1104127-002	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.98	7.89	1.1	0% - 20%
EP1104118-005	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.75	7.77	0.2	0% - 20%
EA010: Conductivity (QC Lot: 1854649)									
EP1104006-001	MMPT01	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	196	196	0.0	0% - 20%
EA015: Total Dissolved Solids (QC Lot: 1854642)									
EP1104006-001	MMPT01	EA015H: Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	111	115	3.5	0% - 20%
EP1104080-001	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	734	715	2.6	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 1854372)									
EP1103773-004	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	21	23	5.9	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	21	23	8.4	0% - 20%
EP1104127-002	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	271	268	1.2	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	271	268	1.2	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 1854635)									
EP1103773-004	Anonymous	ED040F: Sulfur as S	63705-05-5	1	mg/L	<1	<1	0.0	No Limit
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 1854638)									
EP1103773-004	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	0.0	No Limit
ED045G: Chloride Discrete analyser (QC Lot: 1854637)									

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED045G: Chloride Discrete analyser (QC Lot: 1854637) - continued									
EP1103773-004	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	3	4	0.0	No Limit
EP1104069-002	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	331	331	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 1854636)									
EP1103773-004	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	5	6	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	3	4	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
EP1104069-002	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	6	6	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	20	20	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	155	151	2.4	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	3	3	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 1855155)									
EP1104006-001	MMPT01	EG020E-W: Tungsten	7440-33-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 1855152)									
EP1104006-001	MMPT01	EG020A-W: Cadmium	7440-43-9	0.0001	mg/L	0.0005	0.0001	119	No Limit
		EG020A-W: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Arsenic	7440-38-2	0.001	mg/L	0.003	0.004	0.0	No Limit
		EG020A-W: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Barium	7440-39-3	0.001	mg/L	0.186	0.192	3.4	0% - 20%
		EG020A-W: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Copper	7440-50-8	0.001	mg/L	0.003	0.002	0.0	No Limit
		EG020A-W: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Lithium	7439-93-2	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-W: Manganese	7439-96-5	0.001	mg/L	0.003	0.002	0.0	No Limit
		EG020A-W: Molybdenum	7439-98-7	0.001	mg/L	0.016	0.016	0.0	0% - 50%
		EG020A-W: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Zinc	7440-66-6	0.005	mg/L	0.096	0.103	6.7	0% - 20%
		EG020A-W: Aluminium	7429-90-5	0.01	mg/L	0.04	0.04	0.0	No Limit
		EG020A-W: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-W: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-W: Boron	7440-42-8	0.05	mg/L	0.10	0.11	0.0	No Limit
		EG020A-W: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 1855153)									
EP1104006-001	MMPT01	EG020B-W: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-W: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-W: Strontium	7440-24-6	0.001	mg/L	0.053	0.054	2.2	0% - 20%
		EG020B-W: Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 1855153) - continued									
EP1104006-001	MMPT01	EG020B-W: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 1855154)									
EP1104006-001	MMPT01	EG020D-W: Yttrium	7440-65-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG035W: Water Leachable Mercury by FIMS (QC Lot: 1855908)									
EP1104006-001	MMPT01	EG035W: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EA013: Acid Neutralising Capacity (QCLot: 1847759)								
EA013: ANC as H2SO4	----	0.5	kg H2SO4 equ	----	49 kg H2SO4 equ	100	80.4	118
		0.5	kg H2SO4 equiv./t	<0.5	----	----	----	----
EA013: ANC as CaCO3	----	0.1	% CaCO3	<0.1	----	----	----	----
ED040S: Soluble Major Anions (QCLot: 1858623)								
ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	250 mg/kg	102	86	116
ED042T: Total Sulfur by LECO (QCLot: 1856956)								
ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	100 %	100	70	130
ED045G: Chloride Discrete analyser (QCLot: 1858625)								
ED045G: Chloride	16887-00-6	10	mg/kg	<10	5000 mg/kg	94.5	82	126
ED093S: Soluble Major Cations (QCLot: 1858624)								
ED093S: Calcium	7440-70-2	10	mg/kg	<10	----	----	----	----
ED093S: Magnesium	7439-95-4	10	mg/kg	<10	----	----	----	----
ED093S: Sodium	7440-23-5	10	mg/kg	<10	----	----	----	----
ED093S: Potassium	7440-09-7	10	mg/kg	<10	----	----	----	----
EG005T: Total Metals by ICP-AES (QCLot: 1858539)								
EG005T: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005T: Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
EG005T: Iron	7439-89-6	50	mg/kg	<50	14257 mg/kg	# 137	79	130
EG020T: Total Metals by ICP-MS (QCLot: 1858541)								
EG020X-T: Arsenic	7440-38-2	0.1	mg/kg	<0.1	13.11 mg/kg	113	74	130
EG020X-T: Barium	7440-39-3	0.1	mg/kg	<0.1	137.41 mg/kg	102	78	130
EG020X-T: Beryllium	7440-41-7	0.1	mg/kg	<0.1	5.51 mg/kg	106	70	130
EG020X-T: Cobalt	7440-48-4	0.1	mg/kg	<0.1	24.49 mg/kg	97.7	75	130
EG020X-T: Chromium	7440-47-3	0.1	mg/kg	<0.1	60.93 mg/kg	101	70	130
EG020X-T: Copper	7440-50-8	0.1	mg/kg	<0.1	54.68 mg/kg	97.1	70	123
EG020X-T: Manganese	7439-96-5	0.1	mg/kg	<0.1	135.60 mg/kg	98.6	70	130
EG020X-T: Molybdenum	7439-98-7	0.1	mg/kg	<0.1	6.86 mg/kg	126	70	130
EG020X-T: Nickel	7440-02-0	0.1	mg/kg	<0.1	55.23 mg/kg	99.0	86	130
EG020X-T: Lead	7439-92-1	0.1	mg/kg	<0.1	54.76 mg/kg	102	79	124
EG020X-T: Antimony	7440-36-0	0.1	mg/kg	<0.1	----	----	----	----
EG020X-T: Uranium	7440-61-1	0.1	mg/kg	<0.1	----	----	----	----
EG020X-T: Zinc	7440-66-6	0.1	mg/kg	<0.1	103.88 mg/kg	101	85	123
EG020X-T: Lithium	7439-93-2	0.1	mg/kg	<0.1	----	----	----	----
EG020X-T: Vanadium	7440-62-2	1	mg/kg	<1	34.03 mg/kg	105	70	130

Sub-Matrix: **SOIL**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020T: Total Metals by ICP-MS (QCLot: 1858542)								
EG020Y-T: Selenium	7782-49-2	1	mg/kg	<1	----	----	----	----
EG020Y-T: Thallium	7440-28-0	0.1	mg/kg	<0.1	----	----	----	----
EG020Y-T: Cadmium	7440-43-9	0.1	mg/kg	<0.1	2.76 mg/kg	99.0	86	123
EG020Y-T: Bismuth	7440-69-9	0.1	mg/kg	<0.1	----	----	----	----
EG020Y-T: Uranium	7440-61-1	0.1	mg/kg	<0.1	----	----	----	----
EG020Y-T: Thorium	7440-29-1	0.1	mg/kg	<0.1	----	----	----	----
EG020Y-T: Strontium	7440-24-6	0.1	mg/kg	<0.1	60.42 mg/kg	105	75	130
EG020T: Total Metals by ICP-MS (QCLot: 1858544)								
EG020Z-T: Silver	7440-22-4	0.1	mg/kg	<0.1	5.60 mg/kg	88.4	79	130
EG020T: Total Metals by ICP-MS (QCLot: 1858545)								
EG020V-T: Tungsten	7440-33-7	0.1	mg/kg	<0.1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 1858546)								
EG020R-T: Thorium	7440-29-1	0.1	mg/kg	<0.1	----	----	----	----
EG020R-T: Yttrium	7440-65-5	0.1	mg/kg	<0.1	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1858540)								
EG035T: Mercury	7439-97-6	0.10	mg/kg	<0.1	1.34 mg/kg	86.0	73	127

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EA005P: pH by PC Titrator (QCLot: 1854373)								
EA005-P: pH Value	----	0.01	pH Unit	----	7.00 pH Unit	100	70	130
EA010: Conductivity (QCLot: 1854649)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	100	70	130
EA015: Total Dissolved Solids (QCLot: 1854642)								
EA015H: Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	<5	2000 mg/L	108	79.8	116
ED037P: Alkalinity by PC Titrator (QCLot: 1854372)								
ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	----	----	----	----
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	200 mg/L	96.9	79	113
ED040F: Dissolved Major Anions (QCLot: 1854635)								
ED040F: Sulfur as S	63705-05-5	1	mg/L	<1	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1854638)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	99.9	85	130
ED045G: Chloride Discrete analyser (QCLot: 1854637)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	94.9	78	130

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
ED093F: Dissolved Major Cations (QCLot: 1854636)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	99.9	88	112
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	97.4	88	112
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	98.0	85	111
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	97.9	84	114
EG020T: Total Metals by ICP-MS (QCLot: 1855155)								
EG020E-W: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020W: Water Leachable Metals by ICP-MS (QCLot: 1855152)								
EG020A-W: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	98.5	80	124
EG020A-W: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	99.5	93	126
EG020A-W: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	91.6	80	124
EG020A-W: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	107	90	130
EG020A-W: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-W: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	91.8	90	130
EG020A-W: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	100	70	128
EG020A-W: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	100	87	117
EG020A-W: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	98.8	78	121
EG020A-W: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	102	86	116
EG020A-W: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-W: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	102	72	122
EG020A-W: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	103	91	130
EG020A-W: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	101	83	126
EG020A-W: Selenium	7782-49-2	0.01	mg/L	<0.01	0.100 mg/L	89.0	75	121
EG020A-W: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	99.8	89	122
EG020A-W: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	92.6	84	115
EG020A-W: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	95.0	75	129
EG020A-W: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	108	75	130
EG020A-W: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	99.0	89	130
EG020W: Water Leachable Metals by ICP-MS (QCLot: 1855153)								
EG020B-W: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	108	92	116
EG020B-W: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	96.8	70	130
EG020B-W: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	101	87	115
EG020B-W: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-W: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020W: Water Leachable Metals by ICP-MS (QCLot: 1855154)								
EG020D-W: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG035W: Water Leachable Mercury by FIMS (QCLot: 1855908)								
EG035W: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.010 mg/L	105	84	117

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED045G: Chloride Discrete analyser (QCLot: 1858625)							
EP1104006-002	RRPT01	ED045G: Chloride	16887-00-6	1250 mg/kg	113	70	130
EG020T: Total Metals by ICP-MS (QCLot: 1858541)							
EP1104006-002	RRPT01	EG020X-T: Arsenic	7440-38-2	10 mg/kg	103	70	130
		EG020X-T: Barium	7440-39-3	50 mg/kg	111	70	130
		EG020X-T: Beryllium	7440-41-7	4 mg/kg	82.3	70	130
		EG020X-T: Cobalt	7440-48-4	50 mg/kg	83.4	70	130
		EG020X-T: Chromium	7440-47-3	50 mg/kg	78.8	70	130
		EG020X-T: Copper	7440-50-8	50 mg/kg	75.2	70	130
		EG020X-T: Manganese	7439-96-5	50 mg/kg	# Not Determined	70	130
		EG020X-T: Nickel	7440-02-0	50 mg/kg	75.0	70	130
		EG020X-T: Lead	7439-92-1	50 mg/kg	81.8	70	130
		EG020X-T: Zinc	7440-66-6	50 mg/kg	80.4	70	130
		EG020X-T: Vanadium	7440-62-2	50 mg/kg	74.0	70	130
EG020T: Total Metals by ICP-MS (QCLot: 1858542)							
EP1104006-002	RRPT01	EG020Y-T: Cadmium	7440-43-9	25 mg/kg	89.4	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1858540)							
EP1104006-002	RRPT01	EG035T: Mercury	7439-97-6	5.0 mg/kg	78.9	70	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1854638)							
EP1103773-004	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	100 mg/L	116	70	130
ED045G: Chloride Discrete analyser (QCLot: 1854637)							
EP1103773-004	Anonymous	ED045G: Chloride	16887-00-6	250 mg/L	112	70	130
EG020W: Water Leachable Metals by ICP-MS (QCLot: 1855152)							
EP1104006-002	RRPT01	EG020A-W: Arsenic	7440-38-2	1.000 mg/L	86.0	70	130
		EG020A-W: Beryllium	7440-41-7	0.100 mg/L	83.1	70	130
		EG020A-W: Barium	7440-39-3	1.000 mg/L	85.4	70	130
		EG020A-W: Cadmium	7440-43-9	0.500 mg/L	80.6	70	130
		EG020A-W: Chromium	7440-47-3	1.000 mg/L	84.6	70	130
		EG020A-W: Cobalt	7440-48-4	1.000 mg/L	86.2	70	130
		EG020A-W: Copper	7440-50-8	1.000 mg/L	85.1	70	130
		EG020A-W: Lead	7439-92-1	1.000 mg/L	87.3	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
				Concentration	MS	Low	High
EG020W: Water Leachable Metals by ICP-MS (QCLot: 1855152) - continued							
EP1104006-002	RRPT01	EG020A-W: Manganese	7439-96-5	1.000 mg/L	83.3	70	130
		EG020A-W: Nickel	7440-02-0	1.000 mg/L	87.4	70	130
		EG020A-W: Vanadium	7440-62-2	1.000 mg/L	82.6	70	130
		EG020A-W: Zinc	7440-66-6	1.000 mg/L	82.1	70	130
EG035W: Water Leachable Mercury by FIMS (QCLot: 1855908)							
EP1104006-002	RRPT01	EG035W: Mercury	7439-97-6	0.010 mg/L	118	70	130

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ALS Minerals

Finalized Date: 30-JUN-2011
Account: ALSENV

QC CERTIFICATE PH11116871

Project: EP1104006
P.O. No.: 295856
This report is for 2 Pulp samples submitted to our lab in Perth, WA, Australia on 27-JUN-2011.

The following have access to data associated with this certificate:

SUB RESULTS		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
LEV-01	Waste Disposal Levy
LOG-24	Pulp Login - Rcd w/o Barcode

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-XRF12	Whole rock XRF	XRF
OA-GRA05t	Multi-temperature LOI	TGA

To: **ALS ENVIRONMENTAL**
ATTN: SUB RESULTS
10 HOD WAY
MALAGA WA 6090

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

Signature: W. Abbott
Wayne Abbott, Operations Manager, Western Australia

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Finalized Date: 30-JUN-2011
Account: ALSENV

Project: EP1104006

QC CERTIFICATE OF ANALYSIS PH11116871

Sample Description	Method	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12	ME-XRF12
	Analyte	Al2O3	As	BaO	CaO	Cl	Co	Cr2O3	Cu	Fe2O3	K2O	MgO	MnO	Mo	Na2O	Ni
	Units	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
	LOR	0.01	0.001	0.001	0.01	0.001	0.001	0.001	0.001	0.01	0.001	0.01	0.001	0.001	0.001	0.001
STANDARDS																
JS1																
JS1																
Target Range - Lower Bound																
Upper Bound																
SARM-39		4.33	<0.001	0.194	9.80	0.052	0.008	0.218	0.006	9.34	1.075	25.5	0.171	<0.001	0.602	0.102
Target Range - Lower Bound		4.07	<0.001	0.180	9.20	0.032	0.007	0.180	0.006	8.82	0.987	24.9	0.161	<0.001	0.588	0.093
Upper Bound		4.51	0.003	0.201	10.20	0.038	0.009	0.201	0.008	9.76	1.095	27.5	0.180	0.002	0.652	0.105
SARM-45		26.4	0.002	0.095	0.77	0.007	0.005	0.036	0.002	12.40	3.12	3.48	0.096	0.003	0.757	0.008
Target Range - Lower Bound		24.9	0.002	0.089	0.73	0.006	0.003	0.034	<0.001	11.95	3.02	3.21	0.094	<0.001	0.797	0.007
Upper Bound		27.5	0.004	0.101	0.83	0.008	0.005	0.040	0.002	13.25	3.34	3.57	0.106	0.002	0.883	0.009
BLANKS																
BLANK		<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.003	<0.001	<0.01	<0.001	0.02	<0.001	<0.001	0.141	<0.001
Target Range - Lower Bound		<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001
Upper Bound		0.02	0.002	0.002	0.02	0.002	0.002	0.002	0.002	0.02	0.002	0.02	0.002	0.002	0.002	0.002
DUPLICATES																
MMPT01																
DUP																
Target Range - Lower Bound																
Upper Bound																
RRPT01		7.58	0.006	<0.001	0.10	0.037	<0.001	<0.001	0.003	68.4	0.027	0.12	0.297	<0.001	0.058	0.003
DUP		7.75	0.006	<0.001	0.10	0.032	<0.001	<0.001	<0.001	68.4	0.032	0.10	0.295	<0.001	0.062	<0.001
Target Range - Lower Bound		7.46	0.005	<0.001	0.09	0.033	<0.001	<0.001	<0.001	66.7	0.028	0.10	0.288	<0.001	0.058	<0.001
Upper Bound		7.87	0.007	0.002	0.11	0.036	0.002	0.002	0.003	70.1	0.031	0.12	0.304	0.002	0.063	0.003

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Account: ALSENV

Project: EP1104006

QC CERTIFICATE OF ANALYSIS PH11116871

Sample Description	Method / Analyte / Units / LOR	ME-XRF12 P2O5 % 0.001	ME-XRF12 Pb % 0.001	ME-XRF12 SO3 % 0.001	ME-XRF12 SiO2 % 0.01	ME-XRF12 TiO2 % 0.01	ME-XRF12 V2O5 % 0.001	ME-XRF12 Zn % 0.001	OA-GRA05t LOI 1000 % 0.01
STANDARDS									
JS1									7.80
JS1									7.84
Target Range - Lower Bound									6.95
Upper Bound									8.51
SARM-39		1.440	<0.001	0.789	34.2	1.66	0.020	0.007	
Target Range - Lower Bound		1.385	0.002	0.719	31.7	1.49	0.017	0.006	
Upper Bound		1.535	0.004	0.797	35.1	1.67	0.021	0.008	
SARM-45		0.077	0.003	0.116	49.5	1.85	0.048	0.009	
Target Range - Lower Bound		0.075	0.002	0.118	47.1	1.72	0.045	0.006	
Upper Bound		0.085	0.004	0.132	52.1	1.92	0.051	0.008	
BLANKS									
BLANK		<0.001	<0.001	<0.001	97.1	<0.01	<0.001	<0.001	
Target Range - Lower Bound		<0.001	<0.001	<0.001	<0.01	<0.01	<0.001	<0.001	
Upper Bound		0.002	0.002	0.002	0.02	0.02	0.002	0.002	
DUPLICATES									
MMPT01									9.87
DUP									9.90
Target Range - Lower Bound									9.38
Upper Bound									10.40
RRPT01		0.170	<0.001	0.076	14.25	0.33	<0.001	0.021	
DUP		0.170	<0.001	0.078	14.10	0.35	<0.001	0.019	
Target Range - Lower Bound		0.165	<0.001	0.074	13.80	0.32	<0.001	0.019	
Upper Bound		0.175	0.002	0.080	14.55	0.36	0.002	0.022	

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EP1104006**	Page	: 1 of 11
Client	: URS AUSTRALIA PTY LTD	Laboratory	: Environmental Division Perth
Contact	: ELENA CHIN	Contact	: Lauren Ockwell
Address	: LEVEL 4, 226 ADELAIDE TERRACE PERTH WA, AUSTRALIA 6000	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: elena_chin@urscorp.com	E-mail	: lauren.ockwell@alsenviro.com
Telephone	: +61 08 9326 0100	Telephone	: 08 9209 7606
Facsimile	: +61 08 9326 0296	Facsimile	: 08 9209 7600
Project	: 42907769	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 27-JUN-2011
Sampler	: ----	Issue Date	: 06-JUL-2011
Order number	: PER-11-7070E1		
		No. of samples received	: 6
Quote number	: EP/361/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA005P: pH by PC Titrator								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	---	29-JUN-2011	----	**01-JUL-2011**	29-JUN-2011	×
EA010: Conductivity								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	----	----	----	**01-JUL-2011**	27-JUL-2011	✓
EA013: Acid Neutralising Capacity								
Pulp Bag								
MMPT01,	RRPT01	**24-JUN-2011**	**27-JUN-2011**	23-JUN-2012	✓	**04-JUL-2011**	24-DEC-2011	✓
EA015: Total Dissolved Solids								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	----	----	----	**01-JUL-2011**	06-JUL-2011	✓
EA055: Moisture Content								
Soil Glass Jar - Unpreserved								
MMPT01,	RRPT01	**24-JUN-2011**	----	----	----	**05-JUL-2011**	08-JUL-2011	✓
ED037P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	---	13-JUL-2011	----	**01-JUL-2011**	13-JUL-2011	✓
ED040F: Dissolved Major Anions								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	---	27-JUL-2011	----	**01-JUL-2011**	27-JUL-2011	✓
ED040S : Soluble Sulfate by ICPAES								
Soil Glass Jar - Unpreserved								
MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	01-JUL-2011	×	**05-JUL-2011**	02-AUG-2011	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	---	27-JUL-2011	----	**04-JUL-2011**	27-JUL-2011	✓
ED042T: Total Sulfur by LECO								
Pulp Bag								
MMPT01,	RRPT01	**24-JUN-2011**	**04-JUL-2011**	21-DEC-2011	✓	**04-JUL-2011**	21-DEC-2011	✓

Work Order : EP1104006
Client : URS AUSTRALIA PTY LTD
Project : 42907769

Matrix: **SOIL**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method / *Container / Client Sample ID(s)*		*Sample Date*	*Extraction / Preparation*			*Analysis*		
			Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
ED045G: Chloride Discrete analyser								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	---	27-JUL-2011	----	**04-JUL-2011**	27-JUL-2011	✓
Soil Glass Jar - Unpreserved								
MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	01-JUL-2011	✗	**05-JUL-2011**	02-AUG-2011	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	---	06-JUL-2011	----	**01-JUL-2011**	06-JUL-2011	✓
ED093S: Soluble Major Cations								
Soil Glass Jar - Unpreserved								
MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	21-DEC-2011	✓	**05-JUL-2011**	21-DEC-2011	✓
EG005T: Total Metals by ICP-AES								
Soil Glass Jar - Unpreserved								
MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	21-DEC-2011	✓	**05-JUL-2011**	21-DEC-2011	✓
EG020T: Total Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Unfiltered								
MMPT01,	RRPT01	**29-JUN-2011**	**04-JUL-2011**	26-DEC-2011	✓	**04-JUL-2011**	26-DEC-2011	✓
Soil Glass Jar - Unpreserved								
MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	21-DEC-2011	✓	**05-JUL-2011**	21-DEC-2011	✓
EG020W: Water Leachable Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Unfiltered								
MMPT01,	RRPT01	**29-JUN-2011**	**04-JUL-2011**	26-DEC-2011	✓	**04-JUL-2011**	26-DEC-2011	✓
EG035T: Total Recoverable Mercury by FIMS								
Soil Glass Jar - Unpreserved								
MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	22-JUL-2011	✓	**05-JUL-2011**	22-JUL-2011	✓
EG035W: Water Leachable Mercury by FIMS								
Soil Glass Jar - Unpreserved								
MMPT01,	RRPT01	**24-JUN-2011**	----	----	----	**04-JUL-2011**	22-JUL-2011	✓
EN60: Bottle Leaching Procedure								
LabSplit: Leach for organics and other tests								
MMPT01,	RRPT01	**24-JUN-2011**	---	08-JUL-2011	----	**30-JUN-2011**	08-JUL-2011	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		*Count*		*Rate (%)*			*Quality Control Specification*
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Total Metals by ICP-MS - Suite R	EG020R-T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Acid Neutralising Capacity (ANC)	EA013	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Cations - soluble by ICP-AES	ED093S	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride Soluble By Discrete Analyser	ED045G	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Soluble	ED040S	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Moisture Content	EA055-103	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfur - Total as S (LECO)	ED042T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite X	EG020X-T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Y	EG020Y-T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Z	EG020Z-T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Acid Neutralising Capacity (ANC)	EA013	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride Soluble By Discrete Analyser	ED045G	2	2	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Soluble	ED040S	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfur - Total as S (LECO)	ED042T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite X	EG020X-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Y	EG020Y-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Z	EG020Z-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Total Metals by ICP-MS - Suite R	EG020R-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Acid Neutralising Capacity (ANC)	EA013	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Cations - soluble by ICP-AES	ED093S	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride Soluble By Discrete Analyser	ED045G	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Soluble	ED040S	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfur - Total as S (LECO)	ED042T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite V	EG020V-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite X	EG020X-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Y	EG020Y-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Z	EG020Z-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Chloride Soluble By Discrete Analyser	ED045G	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS) - Continued							
Total Metals by ICP-MS - Suite X	EG020X-T	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Total Metals by ICP-MS - Suite Y	EG020Y-T	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Total Metals by ICP-MS - Suite Z	EG020Z-T	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity	EA010	1	9	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Dissolved	ED040F	1	8	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH by PC Titrator	EA005-P	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**10.0**	×	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Mercury by FIMS	EG035W	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity	EA010	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Dissolved	ED040F	1	8	**12.5**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH by PC Titrator	EA005-P	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Mercury by FIMS	EG035W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Alkalinity by PC Titrator	ED037-P	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity	EA010	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Dissolved	ED040F	1	8	**12.5**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Mercury by FIMS	EG035W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Water Leachable Mercury by FIMS	EG035W	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH by PC Titrator	EA005-P	SOIL	APHA 21st ed. 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Conductivity	EA010	SOIL	APHA 21st ed., 2510 B Conductivity is determined by ISE, either manually or automated measurement. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Acid Neutralising Capacity (ANC)	EA013	SOIL	USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquanititatively estimate the likely reactivity. The soil is then reacted with an known excess quanitity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Total Dissolved Solids (High Level)	EA015H	SOIL	APHA 21st ed., 2540C A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Moisture Content	EA055-103	SOIL	A gravimetric procedure based on weight loss over a 12 hour drying period at 103-105 degrees C. This method is compliant with NEPM (2010 Draft) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Alkalinity by PC Titrator	ED037-P	SOIL	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Major Anions - Dissolved	ED040F	SOIL	APHA 21st ed., 3120. The 0.45um filtered samples are determined by ICP/AES for Sulfur and/or Silcon content and reported as Sulfate and/or Silica after conversion by gravimetric factor.
Major Anions - Soluble	ED040S	SOIL	In-house. Soluble Anions are determined off a 1:5 soil / water extract by ICPAES.
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	SOIL	APHA 21st ed., 4500-SO4 Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Sulfur - Total as S (LECO)	ED042T	SOIL	In-house. Dried and pulverised sample is combusted in a LECO furnace at 1350C in the presence of strong oxidants / catalysts. The evolved S (as SO2) is measured by infra-red detector
Chloride by Discrete Analyser	ED045G	SOIL	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	SOIL	APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Cations - soluble by ICP-AES	ED093S	SOIL	APHA 21st ed., 3120; USEPA SW 846 - 6010 (ICPAES) Water extracts of the soil are analyzed for major cations by ICPAES. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (1999) Schedule B(3)
Total Metals by ICP-AES	EG005T	SOIL	(APHA 21st ed., 3120; USEPA SW 846 - 6010) (ICPAES) Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (1999) Schedule B(3)

Analytical Methods	Method	Matrix	Method Descriptions
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite R	EG020R-T	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020) (ICPMS) Metals in solids are determined following an appropriate acid digestion. The ICPMS technique ionizes selected elements. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass / charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (1999) Schedule B(3)
Total Metals by ICP-MS - Suite V	EG020V-T	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Metals in solids are determined following an appropriate acid digestion. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite X	EG020X-T	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite Y	EG020Y-T	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite Z	EG020Z-T	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Mercury by FIMS	EG035T	SOIL	AS 3550, APHA 21st ed., 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3)

Analytical Methods	Method	Matrix	Method Descriptions
Water Leachable Mercury by FIMS	EG035W	SOIL	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the TCLP solution. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ionic Balance by PCT DA and ICPAES	EN055 - PG	SOIL	APHA 21st Ed. 1030F. The Ionic Balance is calculated based on the major Anions and Cations. The major anions include Alkalinity, Chloride and Sulfate which determined by PCT and DA. The Cations are determined by ICPAES. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Miscellaneous Subcontracted Analysis	MIS-SOL	SOIL	Miscellaneous Subcontracted Analysis conducted by Subcontracting Laboratory

Preparation Methods	Method	Matrix	Method Descriptions
Sample Compositing	EN020	SOIL	Equal weights of each original soil are taken, then mixed and homogenised. The combined mixture is labelled as a new sample.
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house
Digestion for Total Recoverable Metals in DI Water Leachate	EN25W	SOIL	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of distilled water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Deionised Water Leach	EN60-DIa	SOIL	AS4439.3 Preparation of Leachates
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	USEPA 200.2 Mod. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (1999) Schedule B(3) (Method 202)

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Laboratory Control Spike (LCS) Recoveries							
EG005T: Total Metals by ICP-AES	2190594-003	----	**Iron**	7439-89-6	137 %	79-130%	**Recovery greater than upper control limit**
Matrix Spike (MS) Recoveries							
EG020T: Total Metals by ICP-MS	EP1104006-002	RRPT01	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **SOIL**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural MMPT01,	RRPT01	----	----	----	01-JUL-2011	29-JUN-2011	2
ED040S : Soluble Sulfate by ICPAES							
Soil Glass Jar - Unpreserved MMPT01,	RRPT01	05-JUL-2011	01-JUL-2011	4	----	----	----
ED045G: Chloride Discrete analyser							
Soil Glass Jar - Unpreserved MMPT01,	RRPT01	05-JUL-2011	01-JUL-2011	4	----	----	----

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	1	20	5.0	10.0	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Appendix B
Data Validation

URS DATA VALIDATION SUMMARY REPORT

Site:	FerrAus Tailing, Pilbara	**Validation Conducted by:** (Data Manager)	Elena Chin	**Date:**	8 7 11
Project No.:	42907769	**Signed:**			
Project Manager:	Tracey Hassell				
Matrix:	solid and liquid	**Validation Verified by:** (Data Validator)	Wesu Ndilila-Barnes	**Date:**	21 7 2011
No of Primary Samples:	4				
Laboratory:	ALS	**Signed:**			
Lab Batch No.:	EP1104006				
		Reviewed by: (Project Manager)	Tracey Hassell	**Date:**	21 7 2011
		Signed:			

Data Quality Objectives

Anomalous Field Data Comparison (Anomalous Results)	Samples were provided by client from laboratory testing. No field work was conducted as part of this scope of work
Frequency of field QA/QC (ie field duplicates/triplicates, rinsate/field/trip blanks, etc)	Field QA/QC was not required in this investigation.
Frequency of laboratory QA/QC (ie laboratory duplicates, matrix spikes, laboratory control samples, method blanks, etc)	Lab duplicates and LCS were reported less than the required frequency for pH (solid tailing samples). Therefore, only a limited assessment of the precision and accuracy of the sample matrix can be performed for this method. However, URS considers this is acceptable as this batch only contained two samples analysed for this analytes.
Number of tests requested/reported	Samples were analysed and reported as requested on the COC.
Limits of Reporting	Limits of reporting were sufficiently low to enable a meaningful comparison with adopted guideline values, with the exception of silver (leacahte analysis), however, this analyte was below the LOR for both samples.

Sample Management

Sample handling/preservation (ie Temp received by laboratory etc.)	Samples were received by the laboratory at 23.7ºC with ice present, above the recommended temperature. However, this will not affect data interpretation as no volatile analytes were required to analyse.
Sample holding times	Analysis holding times failed by 2 days for the following samples: • RRPT01 for pH Extraction holding times failed by 4 days for the following samples: • RRTP01 for soluble sulfate and chloride

Data Precision

Field duplicate RPDs (Primary Laboratory)	Field duplicate was not required as samples were provided by client.
Laboratory duplicate RPDs	All RPDs were within control limits.

Data Accuracy

Laboratory Control Samples	Iron had a recovery (137%) which marginally exceeded the upper control limit (130%).
Data Transcription	A 10% check of the laboratory results identified no anomalies between the electronic data, the laboratory report, and the tables generated by URS.
Matrix Spike Recoveries	Manganese recovery was not determined due to background concentrations greater than 4 times the spike level.
Surrogate Recoveries	Surrogates were within recovery limits.

Data Comparability

Changes in sampling personnel	Samples provided by client
Changes in methodologies	Samples provided by client

Blank Monitoring

Rinsate Blank	N/A
Trip Blank	N/A
Method blank	Concentrations were reported below the LOR.

Chromatograms

Chromatograms	N/A
Other observations	N/A

Data Verification: COPY OF EP1104006_MRED

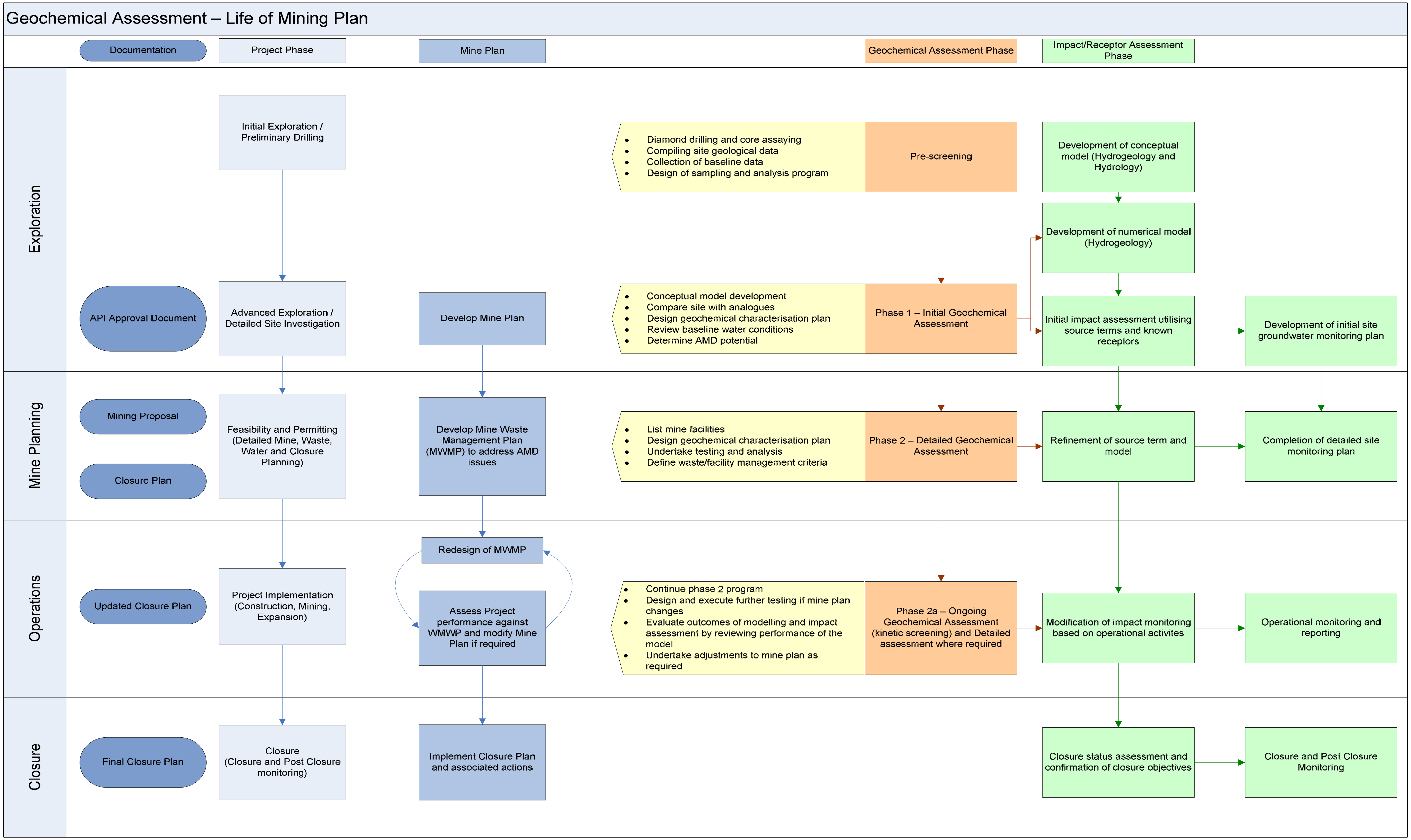
Site Name	**FerrAus Tailings Geochemical Assessment**
Project No.	**42907769**
Project Manager	**Tracey Hassell**
Matrix	**liquid**
Laboratory	**ALS-BRISBANE**
Batch File Name	**EP1104006**

Analytical Parameter	Number of Tests Requested	Number of Tests Reported	Holding Times (a)	Limits of Reporting	LAB_DUPLICATE		LCS		MATRIX_SPIKE		METHOD_BLANK	
					Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported
Acid Neutralising Capacity	2	2	✓	✓	1	1	1	1	0	0	1	1
Sulfur	2	2	✓	✓	1	1	1	1	0	0	1	1
Major Ions	2	2	☒	✓	1	3	1	3	1	1	1	3
Metals (Total)	2	2	✓	✓	1	2	1	5	1	3	1	5
Moisture Content	2	2	✓	✓	1	1	**1**	**0**	0	0	0	0
Physico-Chemical Parameters	2	2	☒	✓	1	1	1	0	0	0	0	0

Leachate

Analytical Parameter	Number of Tests Requested	Number of Tests Reported	Holding Times (a)	Limits of Reporting	LAB_DUPLICATE		LCS		MATRIX_SPIKE		METHOD_BLANK	
					Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported
Alkalinity	2	2	✓	✓	1	2	1	1	0	0	1	1
Major Ions	2	2	☒	✓	1	5	1	4	1	2	1	4
Metals (Leachable)	2	2	✓	✓	1	5	1	4	1	2	1	4
Physico-Chemical Parameters	2	2	☒	✓	1	3	1	3	0	0	1	2

Initial ________ Date ____/____/_______



Notes:
AMD = Acid metalliferous drainge
MWPW = Mine Waste Management Plan

FerrAus Limited

Geochemical Assessment of Pilot Trial Tailings

Life of Mine Plan

URS

FerrAus Pilbara Project

File No: Figure 1.vsd   Drawn: TMH   Approved: TMH   Date: 21-07-2011

Figure: 1   Rev: A   A3

Table 1
Acid Base Accounting Results - FerrAus Pilbara Project Tailings Residue
FerrAus Limited

Sample ID	Sample Type	pH[1]	Acidity (to pH 8.3)	Alkalinity (to pH 5.5)	EC[1]	Total Sulfur	Sulfate Sulfur	MPA[2]	ANC[2]	NAPP[2]	Sample Classification[3]
			(kg H_2SO_4/t)		(µS/cm)	(%)		(kg H_2SO_4/t)			
MMPT01	Tailings	NA	NA	NA	NA	0.04	NA	1.2	41.9	-40.7	Non-acid forming (Barren)
RRPT01	Tailings	NA	NA	NA	NA	0.03	NA	0.9	2.1	-1.2	Non-acid forming (Barren)

Notes:
1. Natural pH and EC provided for 1:5 sample:water extracts
2. MPA = Maximum potential acidity; ANC = Acid neutralising capacity; NAPP = Net acid producing potential.
3. Samples generally classified as PAF if NAPP is positive and NAF if NAPP is negative (NAF-Barren if Total Sulfur is <0.10%). Refer to text for further details.
4. NA denoted not analysed

Table 2a
XRF Results - FerrAus Pilbara Project Tailings Residue
FerrAus Limited

Location	Sample ID	Date Sampled	Sample Type	Analyte	Al2O3	As	BaO	CaO	Cl	Co	Cr2O3	Cu	Fe2O3	K2O	MgO	MnO	Mo	Na2O	Ni	P2O5	Pb	SO3	SiO2	TiO	V2O5	Zn
				Units	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
				LOR	0.01	0.001	0.001	0.01	0.001	0.001	0.001	0.0021	0.01	0.001	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.01	0.001	0.001
Mirrin Mirrin	MMPT01	24/06/2011	Tailing		**7.52**	**0.005**	<0.001	**0.07**	**0.062**	<0.001	<0.001	**0.002**	**72.1**	<0.001	**0.15**	**0.231**	<0.001	**0.082**	**0.002**	**0.233**	<0.001	**0.043**	**9.42**	**0.21**	<0.001	**0.024**
Robertson Range	RRPT01	24/06/2011	Tailing		**7.58**	**0.006**	<0.001	**0.1**	**0.37**	<0.001	<0.001	**0.003**	**68.4**	**0.027**	**0.12**	**0.297**	<0.001	**0.058**	**0.003**	**0.17**	<0.001	**0.076**	**14.25**	**0.33**	<0.001	**0.021**

Table 2b
Geochemical Abundance Index Results - FerrAus Pilbara Project Tailings Residue
FerrAus Limited

	TOTAL-ELEMENT CONTENT (mg/kg or %)		AVERAGE CRUSTAL ABUNDANCE[1] (mg/kg or %)	GEOCHEMICAL ABUNDANCE INDEX (GAI)	
Element	MMPT01	RRPT01		MMPT01	RRPT01
Al2O3%	7.52	7.58	7.10	0	0
As	50	60	6	**2**	**3**
Ba	<LOR	<LOR	500	<LOR	<LOR
CaO%	0.07	0.1	1.50	0	0
Co	<LOR	<LOR	8	<LOR	<LOR
Cr	<LOR	<LOR	70	<LOR	<LOR
Cu	20	30	30	0	0
Fe%	25.21	23.92	4	**2**	**2**
K2O%	<LOR	0.027	1.40	<LOR	0
MgO%	0.15	0.12	0.50	0	0
Mn	1789	2300.27	1000	0	**1**
Na%	0.061	0.043	0.50	0	0
Ni	20	30	50	0	0
P	1016.58	741.71	800	0	0
Pb	<LOR	<LOR	35	<LOR	<LOR
S%	0.0172	0.0304	0.07	0	0
Si%	4.4	6.66	33	0	0
TiO2%	0.21	0.33	0.50	0	0
V	<LOR	<LOR	90	<LOR	<LOR
Zn	240	210	90	**1**	**1**

notes
Total element content values are median concentrations (calculated form Table B-1 - Appendix B)
<LOR - element below analytical limit of reporting, effective GAI is 0
[1] from Enviromental Chemistry of the Elements (Bowen, 1979)

Table 3
Soil Analytical Results - FerrAus Pilbara Project Tailings Residue
FerrAus Limited

Location					Mirrin Mirrin	Robertson Range
Sample ID					MMPT01	RRPT01
Date Sampled					24/06/2011	24/06/2011
Sample Type					Primary Sample	Primary Sample
Analyte	**LOR**	**Units**	**ISQG-Low**	**ISQG-High**		
Moisture Content						
Moisture Content	1	%	-	-	**1.1**	<1
Metals (Total)						
Lithium	0.1	mg/kg	-	-	**4.4**	**1.2**
Uranium	0.1	mg/kg	-	-	**9**	**1.2**
Aluminium	50	mg/kg	-	-	**7280**	**4400**
Antimony	0.1	mg/kg	2	25	**0.5**	**0.5**
Arsenic	0.1	mg/kg	20	70	**0.8**	**1.7**
Barium	0.1	mg/kg	-	-	**40.2**	**94.7**
Beryllium	0.1	mg/kg	-	-	**0.4**	**0.3**
Boron	50	mg/kg	-	-	<50	<50
Cadmium	0.1	mg/kg	1.5	10	<0.1	**0.1**
Chromium	0.1	mg/kg	80	370	**19.9**	**28.6**
Cobalt	0.1	mg/kg	-	-	**6.2**	**15.9**
Copper	0.1	mg/kg	65	270	**26.9**	**18.9**
Iron	50	mg/kg	-	-	**198000**	**126000**
Lead	0.1	mg/kg	50	220	**12.4**	**13.7**
Manganese	0.1	mg/kg	-	-	**1550**	**1620**
Mercury	0.1	mg/kg	0.15	1	<0.1	<0.1
Molybdenum	0.1	mg/kg	-	-	**0.6**	**1**
Nickel	0.1	mg/kg	21	52	**15.6**	**10.2**
Selenium	1	mg/kg	-	-	<1	<1
Silver	0.1	mg/kg	1	3.7	**2.7**	**2.4**
Strontium	0.1	mg/kg	-	-	**7.7**	**6.3**
Thallium	0.1	mg/kg	-	-	**0.2**	**0.4**
Vanadium	1	mg/kg	-	-	**12**	**17**
Zinc	0.1	mg/kg	200	410	**114**	**72.7**
Bismuth	0.1	mg/kg	-	-	**0.1**	**0.1**
Thorium	0.1	mg/kg	-	-	**1.7**	**1.8**
Tungsten	0.1	mg/kg	-	-	**0.3**	**0.3**
Yttrium	0.1	mg/kg	-	-	**3**	**1.9**
Major Ions						
Calcium	10	mg/kg	-	-	**60**	**20**
Chloride	10	mg/kg	-	-	**700**	**270**
Magnesium	10	mg/kg	-	-	**20**	<10
Potassium	10	mg/kg	-	-	**30**	**20**
Sodium	10	mg/kg	-	-	**480**	**220**
Sulfur as S	10	mg/kg	-	-	**50**	**30**
Sulfate as SO4 2-	10	mg/kg	-	-	**160**	**80**
Acid Neutralising Capacity						
ANC as CaCO3	0.1	% caco3	-	-	**4.3**	**0.2**
ANC as H2SO4	0.5	kg h2so4 e	-	-	**41.9**	**2.1**
Fizz Rating		fizz unit	-	-	**2**	**1**
Sulfur						
Sulfur - Total as S (LECO)	0.01	%	-	-	**0.04**	**0.03**

Legend:

Exceeds the WA DEC, 2010, ISQG-Low (Trigger value)

Exceeds the WA DEC, 2010, ISQG-High (Trigger Value)

- Not analysed / not calculated

Table 4
Leachate Analytical Results - FerrAus Pilbara Project Tailings Residue
FerrAus Limited

Analyte	LOR	Units	ANZECC trigeer level		
Location				Mirrin Mirrin	Robertson Range
Sample ID				MMPT01	RRPT01
Date Sampled				24/06/2011	24/06/2011
Sample Type				Primary sample	Primary sample
Physico-Chemical Parameters					
pH	0.01	ph unit	6.0 - 7.5	7.22	7.34
Total Dissolved Solids	5	mg/L	20 - 250	111	64
Electrical Conductivity @ 25°C	1	µs/cm	20-250	196	115
Metals (Leachable)					
Bismuth	0.001	mg/L	-	<0.001	<0.001
Iron	0.05	mg/L	0.3**	<0.05	1.39
Lithium	0.001	mg/L	-	0.002	0.003
Strontium	0.001	mg/L	-	0.053	0.017
Thallium	0.001	mg/L	-	<0.001	<0.001
Thorium	0.001	mg/L	-	<0.001	<0.001
Uranium	0.001	mg/L	-	<0.001	<0.001
Yttrium	0.001	mg/L	-	<0.001	<0.001
Arsenic	0.001	mg/L	0.024	0.003	<0.001
Antimony	0.001	mg/L	-	<0.001	<0.001
Beryllium	0.001	mg/L	-	<0.001	<0.001
Cadmium	0.0001	mg/L	0.0002	0.0005	<0.0001
Chromium	0.001	mg/L	-	<0.001	0.001
Cobalt	0.001	mg/L	-	<0.001	<0.001
Copper	0.001	mg/L	0.0014	0.003	0.002
Lead	0.001	mg/L	0.0034	<0.001	<0.001
Mercury	0.0001	mg/L	-	<0.0001	<0.0001
Molybdenum	0.001	mg/L	-	0.016	0.032
Nickel	0.001	mg/L	-	<0.001	<0.001
Silver	0.001	mg/L	0.0005	<0.001*	<0.001*
Vanadium	0.01	mg/L	-	<0.01	<0.01
Zinc	0.005	mg/L	0.008	0.096	0.085
Aluminium	0.01	mg/L	0.055	0.04	0.23
Barium	0.001	mg/L	-	0.186	0.592
Boron	0.05	mg/L	-	0.1	0.25
Manganese	0.001	mg/L	1.9	0.003	0.013
Tungsten	0.001	mg/L	-	<0.001	0.002
Selenium	0.01	mg/L	0.011	<0.01	<0.01
Major Ions					
Calcium	1	mg/L	-	5	3
Chloride	1	mg/L	250	32	14
Magnesium	1	mg/L	-	1	<1
Potassium	1	mg/L	-	1	<1
Sodium	1	mg/L	180	27	18
Total Anions	0.01	meq/l	-	1.31	0.78
Total Cations	0.01	meq/l	-	1.53	0.93
Sulfate as SO4 - Turbidimetric	1	mg/L	250	11	5
Sulfur as S	1	mg/L	-	3	2
Alkalinity					
Hydroxide Alkalinity as CaCO3	1	mg/L	-	<1	<1
Carbonate Alkalinity as CaCO3	1	mg/L	-	<1	<1
Bicarbonate Alkalinity as CaCO3	1	mg/L	-	9	14
Total Alkalinity as CaCO3	1	mg/L	-	9	14

Legend:

Exceeds the ANZECC trigger level for Upland Rivers in Tropical Australia (includes North-West WA) 95% Protection level

- Not analysed / not calculated

* LOR Exceeds Guideline Trigger Value

** Australian Drinking Water Guidelines - aesthetic value adopted

ALS

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney:** 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle:** 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ **Brisbane:** 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville:** 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ **Melbourne:** 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide:** 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ **Perth:** 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston:** 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: URS AUSTRALIA
OFFICE: LEVEL 4, 226 ADELAIDE TERRACE, PERTH WA 6000
PROJECT: 42907769 PROJECT NO.:
ORDER NUMBER: PER-11-7070E1 PURCHASE ORDER NO.:
PROJECT MANAGER: Tracy Hassell CONTACT PH: 9326 0100
SAMPLER: Client SAMPLER MOBILE:
COC Emailed to ALS? (YES / NO) EDD FORMAT (or default):
Email Reports to (will default to PM if no other addresses are listed): Elena_Chin@urscorp.com & tracey_hassell@urscorp.com
Email Invoice to (will default to PM if no other addresses are listed):

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):
ALS QUOTE NO.: EP/361/11
COUNTRY OF ORIGIN:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes (circled) No N/A
Free ice / frozen ice bricks present upon receipt? Yes No (circled) N/A
Random Sample Temperature on Receipt: 23.7 °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
	John Rees		
DATE/TIME:	DATE/TIME: 24/6/11 14:58	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: Please hold the un-use materials and send back to us when analysis is done. The leachate is to be generated by ASLP please.

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	Tailings Analysis	Leachate Analysis	XRF Analysis						Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	MMPT01	24th June 2011	S		1	x	x	x						Combine Mirrin Mirrin samples with the ratio: 57%High grade and 43%Medium grade.
2	RRPT01	24th June 2011	S		1	x	x	x						Combine Robertson Range samples with the ratio: 29%High grade and 71%Medium grade
3	MMHigh	↓	↓											
4	MMMedium	↓	↓											
5	RRHigh	↓	↓											
6	RRMedium	↓	↓											
				TOTAL										

Environmental Division
Perth
Work Order
EP1104006
Telephone : +61-8-9209 7655

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

Linda Willis

From: Josh Rees
Sent: Friday, 24 June 2011 2:24 PM
To: Samples Perth
Cc: Lauren Ockwell
Subject: FW: Example COC Form
Attachments: 42907769 COC.pdf

Importance: High

Follow Up Flag: Follow up
Flag Status: Flagged

Hi SR,

Please see attached and below for specific instructions on some incoming URS samples.

It might be best to pre-log these as these may be fast TAT samples.

Can someone please get on this?

Thanks,

How was your customer experience? **Please send us your feedback** (Click the link)

Joshua Rees
Client Services Officer - Perth

ALS Environmental Division

Address
10 Hod Way, Malaga, WA, 6090

PHONE +61 8 9209 7655
DIRECT +61 8 9209 7617
FAX +61 8 9209 7600

www.alsglobal.com

From: Elena_Chin@URSCorp.com [mailto:Elena_Chin@URSCorp.com]
Sent: Friday, 24 June 2011 12:47 PM
To: Josh Rees
Cc: Lauren Ockwell; Tracey_Hassell@URSCorp.com
Subject: Re: Example COC Form

Hi Josh,

We have sorted out the problem as I discussed with you before about the combination of samples.

I will send 4 samples today into the lab, 2 samples from Mirrin Mirrin (both high and medium grade) and 2 samples from Robertson Range (both high and medium grade). Please combine the high and medium grade samples from each site according the the ratio mentioned on the COC. And please label the combined sample from Mirrin Mirrin as MMPT01 and combined sample from Robertson Range as RRPT01. I have attached the COC for your reference.

Please contact me if you have any questions.

Kind regards,

SAMPLE RECEIPT NOTIFICATION (SRN)

Comprehensive Report

Work Order : **EP1104006**

Client	: **URS AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: ELENA CHIN	Contact	: Lauren Ockwell
Address	: LEVEL 4, 226 ADELAIDE TERRACE PERTH WA, AUSTRALIA 6000	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: elena_chin@urscorp.com	E-mail	: lauren.ockwell@alsenviro.com
Telephone	: +61 08 9326 0100	Telephone	: 08 9209 7606
Facsimile	: +61 08 9326 0296	Facsimile	: 08 9209 7600
Project	: 42907769	Page	: 1 of 3
Order number	: PER-11-7070E1		
C-O-C number	: ----	Quote number	: EP2011URSWA0322 (EP/361/11)
Site	: ----		
Sampler	: ----	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Dates

Date Samples Received	: 27-JUN-2011	Issue Date	: 27-JUN-2011 15:24
Client Requested Due Date	: 05-JUL-2011	Scheduled Reporting Date	: **05-JUL-2011**

Delivery Details

Mode of Delivery	: Carrier	Temperature	: 23.7
No. of coolers/boxes	: 1 medium foam esky	No. of samples received	: 6
Security Seal	: Intact.	No. of samples analysed	: 2

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Requested Deliverables
- Sample containers do not comply to pretreatment / preservation standards (AS, APHA, USEPA). Please refer to the Sample Container(s)/Preservation Non-Compliance Log at the end of this report for details.
- Please see scanned COC for sample discrepencies: extra samples , samples not received etc.
- **Sample containers do not comply to pretreatment / preservation standards (AS, APHA, USEPA). Please refer to the Sample Container(s)/Preservation Non-Compliance Log at the end of this report for details.**
- **Please see attached Spreadsheet "Sample Weights" for weights used in Composites.**
- **pH analysis should be conducted within 6 hours of sampling.**
- Analytical work for this work order will be conducted at ALS Environmental Perth.
- Please direct any turnaround / technical queries to the laboratory contact designated above.
- Please direct any queries related to sample condition / numbering / breakages to Sample Receipt (SamplesPerth@alsenviro.com)
- Sample Disposal - Aqueous (14 days), Solid (90 days) from date of completion of Work Order.

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

Method Client sample ID	Sample Container Received	Preferred Sample Container for Analysis
EG035W : Water Leachable Mercury by FIMS		
MMPT01	- Soil Glass Jar - Unpreserved	- Clear Plastic Bottle - Nitric Acid; Unfiltered
RRPT01	- Soil Glass Jar - Unpreserved	- Clear Plastic Bottle - Nitric Acid; Unfiltered

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process neccessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
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.

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	(On Hold) SOIL No analysis requested	SOIL - Balance Suite Balance Suite with DA Chloride	SOIL - EA005P pH (PC)	SOIL - EA010 Conductivity	SOIL - EA013 Acid Neutralising Capacity (ANC)	SOIL - EA015H Total Dissolved Solids - High Level	SOIL - ED040F Dissolved Major Anions	SOIL - ED040S Soluble Major Anions
EP1104006-001	24-JUN-2011 14:58	MMPT01		✓	✓	✓	✓	✓	✓	✓
EP1104006-002	24-JUN-2011 14:58	RRPT01		✓	✓	✓	✓	✓	✓	✓
EP1104006-003	24-JUN-2011 14:58	MM High	✓							
EP1104006-004	24-JUN-2011 14:58	MM Medium	✓							
EP1104006-005	24-JUN-2011 14:58	RR High	✓							
EP1104006-006	24-JUN-2011 14:58	RR Medium	✓							

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - ED042T Sulfur - Total as S (LECO)	SOIL - ED045G (solids) Chloride Soluble by Discrete Analyser	SOIL - EG005T (solids) Total Metals by ICP-AES	SOIL - EG020T (solids) Total Metals by ICP-MS	SOIL - EG020W Water Leachable Metals by ICPMS	SOIL - EG035T (solids) Total Mercury by FIMS	SOIL - EG035W Water Leachable Mercury by FIMS	SOIL - EN60-DI Suite Deionised Water Leach
EP1104006-001	24-JUN-2011 14:58	MMPT01	✓	✓	✓	✓	✓	✓	✓	✓
EP1104006-002	24-JUN-2011 14:58	RRPT01	✓	✓	✓	✓	✓	✓	✓	✓

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - MIS-SOL (Subcontracted) Miscellaneous Subcontracted Analysis (Solid)	SOIL - NT-1S Major Cations (Ca, Mg, Na, K)
EP1104006-001	24-JUN-2011 14:58	MMPT01	✓	✓
EP1104006-002	24-JUN-2011 14:58	RRPT01	✓	✓

Requested Deliverables

ELENA CHIN

- *AU Certificate of Analysis - NATA	Email	elena_chin@urscorp.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep)	Email	elena_chin@urscorp.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA	Email	elena_chin@urscorp.com
- A4 - AU Sample Receipt Notification - Environmental	Email	elena_chin@urscorp.com
- Attachment - Report	Email	elena_chin@urscorp.com
- Chain of Custody (CoC)	Email	elena_chin@urscorp.com
- EDI Format - ENMRG	Email	elena_chin@urscorp.com
- EDI Format - ESDAT	Email	elena_chin@urscorp.com
- EDI Format - MRED	Email	elena_chin@urscorp.com
- EDI Format - XTab	Email	elena_chin@urscorp.com

THE ACCOUNTS PAYABLE

- A4 - AU Tax Invoice (INV)	Email	Perth_Accounts@urscorp.com

TRACY HASSELL

- *AU Certificate of Analysis - NATA	Email	tracey_hassell@urscorp.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep)	Email	tracey_hassell@urscorp.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA	Email	tracey_hassell@urscorp.com
- A4 - AU Sample Receipt Notification - Environmental	Email	tracey_hassell@urscorp.com
- Attachment - Report	Email	tracey_hassell@urscorp.com
- Chain of Custody (CoC)	Email	tracey_hassell@urscorp.com
- EDI Format - ENMRG	Email	tracey_hassell@urscorp.com
- EDI Format - ESDAT	Email	tracey_hassell@urscorp.com
- EDI Format - MRED	Email	tracey_hassell@urscorp.com
- EDI Format - XTab	Email	tracey_hassell@urscorp.com

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP1104006**	Page	: 1 of 6
Client	: **URS AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: ELENA CHIN	Contact	: Lauren Ockwell
Address	: LEVEL 4, 226 ADELAIDE TERRACE PERTH WA, AUSTRALIA 6000	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: elena_chin@urscorp.com	E-mail	: lauren.ockwell@alsenviro.com
Telephone	: +61 08 9326 0100	Telephone	: 08 9209 7606
Facsimile	: +61 08 9326 0296	Facsimile	: 08 9209 7600
Project	: 42907769	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: PER-11-7070E1		
C-O-C number	: ----	Date Samples Received	: 27-JUN-2011
Sampler	: ----	Issue Date	: 06-JUL-2011
Site	: ----		
		No. of samples received	: 6
Quote number	: EP/361/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Chas Tucker	Inorganic Chemist	Perth Inorganics
Cicelia Bartels	Metals Instrument Chemist	Perth Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Stafford Minerals - AY
Leanne Cooper	Acid Sulfate Soils Supervisor	Perth ASS

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: DI WATER LEACHATE			Client sample ID	MMPT01	RRPT01	----	----	----
			Client sampling date / time	29-JUN-2011 12:00	29-JUN-2011 12:00	----	----	----
Compound	CAS Number	LOR	Unit	EP1104006-001	EP1104006-002	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.22**	**7.34**	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**196**	**115**	----	----	----
EA015: Total Dissolved Solids								
^ Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	**111**	**64**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**9**	**14**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**9**	**14**	----	----	----
ED040F: Dissolved Major Anions								
^ Sulfur as S	63705-05-5	1	mg/L	**3**	**2**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**11**	**5**	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**32**	**14**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**5**	**3**	----	----	----
Magnesium	7439-95-4	1	mg/L	**1**	<1	----	----	----
Sodium	7440-23-5	1	mg/L	**27**	**18**	----	----	----
Potassium	7440-09-7	1	mg/L	**1**	<1	----	----	----
EG020T: Total Metals by ICP-MS								
Tungsten	7440-33-7	0.001	mg/L	<0.001	**0.002**	----	----	----
EG020W: Water Leachable Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.04**	**0.23**	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.003**	<0.001	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.186**	**0.592**	----	----	----
Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0005**	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	**0.001**	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.003**	**0.002**	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.002**	**0.003**	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.003**	**0.013**	----	----	----

Analytical Results

Sub-Matrix: DI WATER LEACHATE			Client sample ID	MMPT01	RRPT01	----	----	----
			Client sampling date / time	29-JUN-2011 12:00	29-JUN-2011 12:00	----	----	----
Compound	CAS Number	LOR	Unit	EP1104006-001	EP1104006-002	----	----	----
EG020W: Water Leachable Metals by ICP-MS - Continued								
Molybdenum	7439-98-7	0.001	mg/L	**0.016**	**0.032**	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	----	----	----
Strontium	7440-24-6	0.001	mg/L	**0.053**	**0.017**	----	----	----
Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	----	----	----
Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	----	----	----
Yttrium	7440-65-5	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.096**	**0.085**	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.10**	**0.25**	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	**1.39**	----	----	----
EN055: Ionic Balance								
^ Total Anions	----	0.01	meq/L	**1.31**	**0.78**	----	----	----
^ Total Cations	----	0.01	meq/L	**1.53**	**0.93**	----	----	----

Analytical Results

Sub-Matrix: SOIL			Client sample ID	MMPT01	RRPT01	----	----	----
			Client sampling date / time	24-JUN-2011 14:58	24-JUN-2011 14:58	----	----	----
Compound	CAS Number	LOR	Unit	EP1104006-001	EP1104006-002	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	41.9	2.1	----	----	----
^ ANC as CaCO3	----	0.1	% CaCO3	4.3	0.2	----	----	----
Fizz Rating	----	0	Fizz Unit	2	1	----	----	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	1.1	<1.0	----	----	----
ED040S : Soluble Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	160	80	----	----	----
^ Sulfur as S	63705-05-5	10	mg/kg	50	30	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.03	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	10	mg/kg	700	270	----	----	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	60	20	----	----	----
Magnesium	7439-95-4	10	mg/kg	20	<10	----	----	----
Sodium	7440-23-5	10	mg/kg	480	220	----	----	----
Potassium	7440-09-7	10	mg/kg	30	20	----	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	7280	4400	----	----	----
Boron	7440-42-8	50	mg/kg	<50	<50	----	----	----
Iron	7439-89-6	50	mg/kg	198000	126000	----	----	----
EG020T: Total Metals by ICP-MS								
Arsenic	7440-38-2	0.1	mg/kg	0.8	1.7	----	----	----
Selenium	7782-49-2	1	mg/kg	<1	<1	----	----	----
Silver	7440-22-4	0.1	mg/kg	2.7	2.4	----	----	----
Barium	7440-39-3	0.1	mg/kg	40.2	94.7	----	----	----
Thallium	7440-28-0	0.1	mg/kg	0.2	0.4	----	----	----
Beryllium	7440-41-7	0.1	mg/kg	0.4	0.3	----	----	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.1	----	----	----
Bismuth	7440-69-9	0.1	mg/kg	0.1	0.1	----	----	----
Cobalt	7440-48-4	0.1	mg/kg	6.2	15.9	----	----	----
Chromium	7440-47-3	0.1	mg/kg	19.9	28.6	----	----	----
Uranium	7440-61-1	0.1	mg/kg	9.0	1.2	----	----	----
Copper	7440-50-8	0.1	mg/kg	26.9	18.9	----	----	----
Thorium	7440-29-1	0.1	mg/kg	1.7	1.8	----	----	----
Manganese	7439-96-5	0.1	mg/kg	1550	1620	----	----	----

Analytical Results

Sub-Matrix: SOIL			Client sample ID	MMPT01	RRPT01	----	----	----
			Client sampling date / time	24-JUN-2011 14:58	24-JUN-2011 14:58	----	----	----
Compound	CAS Number	LOR	Unit	EP1104006-001	EP1104006-002	----	----	----
EG020T: Total Metals by ICP-MS - Continued								
Strontium	7440-24-6	0.1	mg/kg	7.7	6.3	----	----	----
Tungsten	7440-33-7	0.1	mg/kg	0.3	0.3	----	----	----
Molybdenum	7439-98-7	0.1	mg/kg	0.6	1.0	----	----	----
Nickel	7440-02-0	0.1	mg/kg	15.6	10.2	----	----	----
Lead	7439-92-1	0.1	mg/kg	12.4	13.7	----	----	----
Antimony	7440-36-0	0.1	mg/kg	0.5	0.5	----	----	----
Uranium	7440-61-1	0.1	mg/kg	9.0	1.2	----	----	----
Zinc	7440-66-6	0.1	mg/kg	114	72.7	----	----	----
Lithium	7439-93-2	0.1	mg/kg	4.4	1.2	----	----	----
Vanadium	7440-62-2	1	mg/kg	12	17	----	----	----
Thorium	7440-29-1	0.1	mg/kg	1.7	1.8	----	----	----
Yttrium	7440-65-5	0.1	mg/kg	3.0	1.9	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	----	----	----
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EN60: Bottle Leaching Procedure								
Final pH	----	0.1	pH Unit	<0.1	<0.1	----	----	----

ALS Minerals

Australian Laboratory Services Pty. Ltd.
32 Shand Street
Stafford
Brisbane QLD 4053
Phone: +61 (7) 3243 7222 Fax: +61 (7) 3243 7218
www.alsglobal.com

Finalized Date: 30-JUN-2011
Account: ALSENV

CERTIFICATE PH11116871

Project: EP1104006

P.O. No.: 295856

This report is for 2 Pulp samples submitted to our lab in Perth, WA, Australia on 27-JUN-2011.

The following have access to data associated with this certificate:

SUB RESULTS		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
LEV-01	Waste Disposal Levy
LOG-24	Pulp Login - Rcd w/o Barcode

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-XRF12	Whole rock XRF	XRF
OA-GRA05t	Multi-temperature LOI	TGA

To: **ALS ENVIRONMENTAL**
ATTN: SUB RESULTS
10 HOD WAY
MALAGA WA 6090

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

Signature: W. Abbott

Wayne Abbott, Operations Manager, Western Australia

ALS Minerals

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www.alsglobal.com

Finalized Date: 30-JUN-2011
Account: ALSENV

Project: EP1104006

CERTIFICATE OF ANALYSIS PH11116871

Sample Description	Method Analyte Units LOR	ME-XRF12 Al2O3 % 0.01	ME-XRF12 As % 0.001	ME-XRF12 BaO % 0.001	ME-XRF12 CaO % 0.01	ME-XRF12 Cl % 0.001	ME-XRF12 Co % 0.001	ME-XRF12 Cr2O3 % 0.001	ME-XRF12 Cu % 0.001	ME-XRF12 Fe2O3 % 0.01	ME-XRF12 K2O % 0.001	ME-XRF12 MgO % 0.01	ME-XRF12 MnO % 0.001	ME-XRF12 Mo % 0.001	ME-XRF12 Na2O % 0.001	ME-XRF12 Ni % 0.001
MMPT01		7.52	0.005	<0.001	0.07	0.062	<0.001	<0.001	0.002	72.1	<0.001	0.15	0.231	<0.001	0.082	0.002
RRPT01		7.58	0.006	<0.001	0.10	0.037	<0.001	<0.001	0.003	68.4	0.027	0.12	0.297	<0.001	0.058	0.003

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Finalized Date: 30-JUN-2011
Account: ALSENV

Project: EP1104006

CERTIFICATE OF ANALYSIS PH11116871

Sample Description	Method / Analyte / Units / LOR	ME-XRF12 P2O5 % 0.001	ME-XRF12 Pb % 0.001	ME-XRF12 SO3 % 0.001	ME-XRF12 SiO2 % 0.01	ME-XRF12 TiO2 % 0.01	ME-XRF12 V2O5 % 0.001	ME-XRF12 Zn % 0.001	OA-GRA05t LOI 1000 % 0.01
MMPT01		0.233	<0.001	0.043	9.42	0.21	<0.001	0.024	9.87
RRPT01		0.170	<0.001	0.076	14.25	0.33	<0.001	0.021	8.48

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EP1104006**	Page	: 1 of 11
Client	: **URS AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: ELENA CHIN	Contact	: Lauren Ockwell
Address	: LEVEL 4, 226 ADELAIDE TERRACE PERTH WA, AUSTRALIA 6000	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: elena_chin@urscorp.com	E-mail	: lauren.ockwell@alsenviro.com
Telephone	: +61 08 9326 0100	Telephone	: 08 9209 7606
Facsimile	: +61 08 9326 0296	Facsimile	: 08 9209 7600
Project	: 42907769	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 27-JUN-2011
Sampler	: ----	Issue Date	: 06-JUL-2011
Order number	: PER-11-7070E1		
		No. of samples received	: 6
Quote number	: EP/361/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Chas Tucker	Inorganic Chemist	Perth Inorganics
Cicelia Bartels	Metals Instrument Chemist	Perth Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Stafford Minerals - AY
Leanne Cooper	Acid Sulfate Soils Supervisor	Perth ASS

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient 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.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
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
RPD = Relative Percentage Difference
\# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **SOIL**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA013: Acid Neutralising Capacity (QC Lot: 1847759)									
EP1104006-001	MMPT01	EA013: ANC as H2SO4	----	0.5	kg H2SO4 equ	41.9	41.9	0.0	0% - 20%
EA055: Moisture Content (QC Lot: 1858768)									
EP1104006-001	MMPT01	EA055-103: Moisture Content (dried @ 103°C)	----	1.0	%	1.1	1.1	0.0	No Limit
ED040S: Soluble Major Anions (QC Lot: 1858623)									
EP1104006-001	MMPT01	ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	160	160	0.0	0% - 50%
ED042T: Total Sulfur by LECO (QC Lot: 1856956)									
EP1104006-001	MMPT01	ED042T: Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.04	0.0	No Limit
ED045G: Chloride Discrete analyser (QC Lot: 1858625)									
EP1104006-001	MMPT01	ED045G: Chloride	16887-00-6	10	mg/kg	700	690	1.4	0% - 20%
ED093S: Soluble Major Cations (QC Lot: 1858624)									
EP1104006-001	MMPT01	ED093S: Calcium	7440-70-2	10	mg/kg	60	60	0.0	No Limit
		ED093S: Magnesium	7439-95-4	10	mg/kg	20	20	0.0	No Limit
		ED093S: Sodium	7440-23-5	10	mg/kg	480	470	0.0	0% - 20%
		ED093S: Potassium	7440-09-7	10	mg/kg	30	30	0.0	No Limit
EG005T: Total Metals by ICP-AES (QC Lot: 1858539)									
EP1104006-001	MMPT01	EG005T: Aluminium	7429-90-5	50	mg/kg	7280	7220	0.8	0% - 20%
		EG005T: Boron	7440-42-8	50	mg/kg	<50	<50	0.0	No Limit
		EG005T: Iron	7439-89-6	50	mg/kg	198000	203000	2.5	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 1858541)									
EP1104006-001	MMPT01	EG020X-T: Arsenic	7440-38-2	0.1	mg/kg	0.8	0.8	0.0	No Limit
		EG020X-T: Barium	7440-39-3	0.1	mg/kg	40.2	35.6	12.2	0% - 20%
		EG020X-T: Beryllium	7440-41-7	0.1	mg/kg	0.4	0.4	0.0	No Limit
		EG020X-T: Cobalt	7440-48-4	0.1	mg/kg	6.2	5.8	5.6	0% - 20%
		EG020X-T: Chromium	7440-47-3	0.1	mg/kg	19.9	18.7	6.3	0% - 20%
		EG020X-T: Copper	7440-50-8	0.1	mg/kg	26.9	26.0	3.4	0% - 20%
		EG020X-T: Manganese	7439-96-5	0.1	mg/kg	1550	1520	1.9	0% - 20%
		EG020X-T: Molybdenum	7439-98-7	0.1	mg/kg	0.6	0.6	0.0	No Limit
		EG020X-T: Nickel	7440-02-0	0.1	mg/kg	15.6	15.2	2.5	0% - 20%
		EG020X-T: Lead	7439-92-1	0.1	mg/kg	12.4	11.7	5.8	0% - 20%
		EG020X-T: Antimony	7440-36-0	0.1	mg/kg	0.5	0.5	0.0	No Limit
		EG020X-T: Uranium	7440-61-1	0.1	mg/kg	9.0	8.8	2.3	0% - 20%
		EG020X-T: Zinc	7440-66-6	0.1	mg/kg	114	113	1.0	0% - 20%
		EG020X-T: Lithium	7439-93-2	0.1	mg/kg	4.4	4.7	6.9	0% - 20%
		EG020X-T: Vanadium	7440-62-2	1	mg/kg	12	12	0.0	0% - 50%

Sub-Matrix: **SOIL**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG020T: Total Metals by ICP-MS (QC Lot: 1858542)									
EP1104006-001	MMPT01	EG020Y-T: Thallium	7440-28-0	0.1	mg/kg	0.2	0.2	0.0	No Limit
		EG020Y-T: Cadmium	7440-43-9	0.1	mg/kg	<0.1	<0.1	0.0	No Limit
		EG020Y-T: Bismuth	7440-69-9	0.1	mg/kg	0.1	0.1	0.0	No Limit
		EG020Y-T: Uranium	7440-61-1	0.1	mg/kg	9.0	8.8	2.3	0% - 20%
		EG020Y-T: Thorium	7440-29-1	0.1	mg/kg	1.7	1.7	0.0	0% - 50%
		EG020Y-T: Strontium	7440-24-6	0.1	mg/kg	7.7	7.2	5.8	0% - 20%
		EG020Y-T: Selenium	7782-49-2	1	mg/kg	<1	<1	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 1858544)									
EP1104006-001	MMPT01	EG020Z-T: Silver	7440-22-4	0.1	mg/kg	2.7	2.6	0.0	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 1858546)									
EP1104006-001	MMPT01	EG020R-T: Thorium	7440-29-1	0.1	mg/kg	1.7	1.7	0.0	0% - 50%
		EG020R-T: Yttrium	7440-65-5	0.1	mg/kg	3.0	2.9	0.0	0% - 20%
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 1858540)									
EP1104006-001	MMPT01	EG035T: Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EA005P: pH by PC Titrator (QC Lot: 1854373)									
EP1104127-002	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.98	7.89	1.1	0% - 20%
EP1104118-005	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.75	7.77	0.2	0% - 20%
EA010: Conductivity (QC Lot: 1854649)									
EP1104006-001	MMPT01	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	196	196	0.0	0% - 20%
EA015: Total Dissolved Solids (QC Lot: 1854642)									
EP1104006-001	MMPT01	EA015H: Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	111	115	3.5	0% - 20%
EP1104080-001	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	734	715	2.6	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 1854372)									
EP1103773-004	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	21	23	5.9	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	21	23	8.4	0% - 20%
EP1104127-002	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	271	268	1.2	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	271	268	1.2	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 1854635)									
EP1103773-004	Anonymous	ED040F: Sulfur as S	63705-05-5	1	mg/L	<1	<1	0.0	No Limit
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 1854638)									
EP1103773-004	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	0.0	No Limit
ED045G: Chloride Discrete analyser (QC Lot: 1854637)									

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
ED045G: Chloride Discrete analyser (QC Lot: 1854637) - continued									
EP1103773-004	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	3	4	0.0	No Limit
EP1104069-002	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	331	331	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 1854636)									
EP1103773-004	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	5	6	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	3	4	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
EP1104069-002	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	6	6	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	20	20	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	155	151	2.4	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	3	3	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 1855155)									
EP1104006-001	MMPT01	EG020E-W: Tungsten	7440-33-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 1855152)									
EP1104006-001	MMPT01	EG020A-W: Cadmium	7440-43-9	0.0001	mg/L	0.0005	0.0001	119	No Limit
		EG020A-W: Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Arsenic	7440-38-2	0.001	mg/L	0.003	0.004	0.0	No Limit
		EG020A-W: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Barium	7440-39-3	0.001	mg/L	0.186	0.192	3.4	0% - 20%
		EG020A-W: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Copper	7440-50-8	0.001	mg/L	0.003	0.002	0.0	No Limit
		EG020A-W: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Lithium	7439-93-2	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-W: Manganese	7439-96-5	0.001	mg/L	0.003	0.002	0.0	No Limit
		EG020A-W: Molybdenum	7439-98-7	0.001	mg/L	0.016	0.016	0.0	0% - 50%
		EG020A-W: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Thallium	7440-28-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-W: Zinc	7440-66-6	0.005	mg/L	0.096	0.103	6.7	0% - 20%
		EG020A-W: Aluminium	7429-90-5	0.01	mg/L	0.04	0.04	0.0	No Limit
		EG020A-W: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-W: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-W: Boron	7440-42-8	0.05	mg/L	0.10	0.11	0.0	No Limit
		EG020A-W: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 1855153)									
EP1104006-001	MMPT01	EG020B-W: Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-W: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020B-W: Strontium	7440-24-6	0.001	mg/L	0.053	0.054	2.2	0% - 20%
		EG020B-W: Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 1855153) - continued									
EP1104006-001	MMPT01	EG020B-W: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020W: Water Leachable Metals by ICP-MS (QC Lot: 1855154)									
EP1104006-001	MMPT01	EG020D-W: Yttrium	7440-65-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG035W: Water Leachable Mercury by FIMS (QC Lot: 1855908)									
EP1104006-001	MMPT01	EG035W: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **SOIL**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA013: Acid Neutralising Capacity (QCLot: 1847759)								
EA013: ANC as H2SO4	----	0.5	kg H2SO4 equ	----	49 kg H2SO4 equ	100	80.4	118
		0.5	kg H2SO4 equiv./t	<0.5	----	----	----	----
EA013: ANC as CaCO3	----	0.1	% CaCO3	<0.1	----	----	----	----
ED040S: Soluble Major Anions (QCLot: 1858623)								
ED040S: Sulfate as SO4 2-	14808-79-8	10	mg/kg	<10	250 mg/kg	102	86	116
ED042T: Total Sulfur by LECO (QCLot: 1856956)								
ED042T: Sulfur - Total as S (LECO)	----	0.01	%	<0.01	100 %	100	70	130
ED045G: Chloride Discrete analyser (QCLot: 1858625)								
ED045G: Chloride	16887-00-6	10	mg/kg	<10	5000 mg/kg	94.5	82	126
ED093S: Soluble Major Cations (QCLot: 1858624)								
ED093S: Calcium	7440-70-2	10	mg/kg	<10	----	----	----	----
ED093S: Magnesium	7439-95-4	10	mg/kg	<10	----	----	----	----
ED093S: Sodium	7440-23-5	10	mg/kg	<10	----	----	----	----
ED093S: Potassium	7440-09-7	10	mg/kg	<10	----	----	----	----
EG005T: Total Metals by ICP-AES (QCLot: 1858539)								
EG005T: Aluminium	7429-90-5	50	mg/kg	<50	----	----	----	----
EG005T: Boron	7440-42-8	50	mg/kg	<50	----	----	----	----
EG005T: Iron	7439-89-6	50	mg/kg	<50	14257 mg/kg	# 137	79	130
EG020T: Total Metals by ICP-MS (QCLot: 1858541)								
EG020X-T: Arsenic	7440-38-2	0.1	mg/kg	<0.1	13.11 mg/kg	113	74	130
EG020X-T: Barium	7440-39-3	0.1	mg/kg	<0.1	137.41 mg/kg	102	78	130
EG020X-T: Beryllium	7440-41-7	0.1	mg/kg	<0.1	5.51 mg/kg	106	70	130
EG020X-T: Cobalt	7440-48-4	0.1	mg/kg	<0.1	24.49 mg/kg	97.7	75	130
EG020X-T: Chromium	7440-47-3	0.1	mg/kg	<0.1	60.93 mg/kg	101	70	130
EG020X-T: Copper	7440-50-8	0.1	mg/kg	<0.1	54.68 mg/kg	97.1	70	123
EG020X-T: Manganese	7439-96-5	0.1	mg/kg	<0.1	135.60 mg/kg	98.6	70	130
EG020X-T: Molybdenum	7439-98-7	0.1	mg/kg	<0.1	6.86 mg/kg	126	70	130
EG020X-T: Nickel	7440-02-0	0.1	mg/kg	<0.1	55.23 mg/kg	99.0	86	130
EG020X-T: Lead	7439-92-1	0.1	mg/kg	<0.1	54.76 mg/kg	102	79	124
EG020X-T: Antimony	7440-36-0	0.1	mg/kg	<0.1	----	----	----	----
EG020X-T: Uranium	7440-61-1	0.1	mg/kg	<0.1	----	----	----	----
EG020X-T: Zinc	7440-66-6	0.1	mg/kg	<0.1	103.88 mg/kg	101	85	123
EG020X-T: Lithium	7439-93-2	0.1	mg/kg	<0.1	----	----	----	----
EG020X-T: Vanadium	7440-62-2	1	mg/kg	<1	34.03 mg/kg	105	70	130

Sub-Matrix: **SOIL**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	High
EG020T: Total Metals by ICP-MS (QCLot: 1858542)								
EG020Y-T: Selenium	7782-49-2	1	mg/kg	<1	----	----	----	----
EG020Y-T: Thallium	7440-28-0	0.1	mg/kg	<0.1	----	----	----	----
EG020Y-T: Cadmium	7440-43-9	0.1	mg/kg	<0.1	2.76 mg/kg	99.0	86	123
EG020Y-T: Bismuth	7440-69-9	0.1	mg/kg	<0.1	----	----	----	----
EG020Y-T: Uranium	7440-61-1	0.1	mg/kg	<0.1	----	----	----	----
EG020Y-T: Thorium	7440-29-1	0.1	mg/kg	<0.1	----	----	----	----
EG020Y-T: Strontium	7440-24-6	0.1	mg/kg	<0.1	60.42 mg/kg	105	75	130
EG020T: Total Metals by ICP-MS (QCLot: 1858544)								
EG020Z-T: Silver	7440-22-4	0.1	mg/kg	<0.1	5.60 mg/kg	88.4	79	130
EG020T: Total Metals by ICP-MS (QCLot: 1858545)								
EG020V-T: Tungsten	7440-33-7	0.1	mg/kg	<0.1	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 1858546)								
EG020R-T: Thorium	7440-29-1	0.1	mg/kg	<0.1	----	----	----	----
EG020R-T: Yttrium	7440-65-5	0.1	mg/kg	<0.1	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1858540)								
EG035T: Mercury	7439-97-6	0.10	mg/kg	<0.1	1.34 mg/kg	86.0	73	127

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	High
EA005P: pH by PC Titrator (QCLot: 1854373)								
EA005-P: pH Value	----	0.01	pH Unit	----	7.00 pH Unit	100	70	130
EA010: Conductivity (QCLot: 1854649)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1412 µS/cm	100	70	130
EA015: Total Dissolved Solids (QCLot: 1854642)								
EA015H: Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	<5	2000 mg/L	108	79.8	116
ED037P: Alkalinity by PC Titrator (QCLot: 1854372)								
ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	----	----	----	----
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	<1	200 mg/L	96.9	79	113
ED040F: Dissolved Major Anions (QCLot: 1854635)								
ED040F: Sulfur as S	63705-05-5	1	mg/L	<1	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1854638)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	99.9	85	130
ED045G: Chloride Discrete analyser (QCLot: 1854637)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	94.9	78	130

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High
ED093F: Dissolved Major Cations (QCLot: 1854636)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	99.9	88	112
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	97.4	88	112
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	98.0	85	111
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	97.9	84	114
EG020T: Total Metals by ICP-MS (QCLot: 1855155)								
EG020E-W: Tungsten	7440-33-7	0.001	mg/L	<0.001	----	----	----	----
EG020W: Water Leachable Metals by ICP-MS (QCLot: 1855152)								
EG020A-W: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	98.5	80	124
EG020A-W: Antimony	7440-36-0	0.001	mg/L	<0.001	0.100 mg/L	99.5	93	126
EG020A-W: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	91.6	80	124
EG020A-W: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	107	90	130
EG020A-W: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-W: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	91.8	90	130
EG020A-W: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	100	70	128
EG020A-W: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	100	87	117
EG020A-W: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	98.8	78	121
EG020A-W: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	102	86	116
EG020A-W: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-W: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	102	72	122
EG020A-W: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	103	91	130
EG020A-W: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	101	83	126
EG020A-W: Selenium	7782-49-2	0.01	mg/L	<0.01	0.100 mg/L	89.0	75	121
EG020A-W: Thallium	7440-28-0	0.001	mg/L	<0.001	0.100 mg/L	99.8	89	122
EG020A-W: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	92.6	84	115
EG020A-W: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	95.0	75	129
EG020A-W: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	108	75	130
EG020A-W: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	99.0	89	130
EG020W: Water Leachable Metals by ICP-MS (QCLot: 1855153)								
EG020B-W: Bismuth	7440-69-9	0.001	mg/L	<0.001	0.100 mg/L	108	92	116
EG020B-W: Silver	7440-22-4	0.001	mg/L	<0.001	0.100 mg/L	96.8	70	130
EG020B-W: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	101	87	115
EG020B-W: Thorium	7440-29-1	0.001	mg/L	<0.001	----	----	----	----
EG020B-W: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020W: Water Leachable Metals by ICP-MS (QCLot: 1855154)								
EG020D-W: Yttrium	7440-65-5	0.001	mg/L	<0.001	----	----	----	----
EG035W: Water Leachable Mercury by FIMS (QCLot: 1855908)								
EG035W: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.010 mg/L	105	84	117

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **SOIL**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED045G: Chloride Discrete analyser (QCLot: 1858625)							
EP1104006-002	RRPT01	ED045G: Chloride	16887-00-6	1250 mg/kg	113	70	130
EG020T: Total Metals by ICP-MS (QCLot: 1858541)							
EP1104006-002	RRPT01	EG020X-T: Arsenic	7440-38-2	10 mg/kg	103	70	130
		EG020X-T: Barium	7440-39-3	50 mg/kg	111	70	130
		EG020X-T: Beryllium	7440-41-7	4 mg/kg	82.3	70	130
		EG020X-T: Cobalt	7440-48-4	50 mg/kg	83.4	70	130
		EG020X-T: Chromium	7440-47-3	50 mg/kg	78.8	70	130
		EG020X-T: Copper	7440-50-8	50 mg/kg	75.2	70	130
		EG020X-T: Manganese	7439-96-5	50 mg/kg	# Not Determined	70	130
		EG020X-T: Nickel	7440-02-0	50 mg/kg	75.0	70	130
		EG020X-T: Lead	7439-92-1	50 mg/kg	81.8	70	130
		EG020X-T: Zinc	7440-66-6	50 mg/kg	80.4	70	130
		EG020X-T: Vanadium	7440-62-2	50 mg/kg	74.0	70	130
EG020T: Total Metals by ICP-MS (QCLot: 1858542)							
EP1104006-002	RRPT01	EG020Y-T: Cadmium	7440-43-9	25 mg/kg	89.4	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 1858540)							
EP1104006-002	RRPT01	EG035T: Mercury	7439-97-6	5.0 mg/kg	78.9	70	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 1854638)							
EP1103773-004	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	100 mg/L	116	70	130
ED045G: Chloride Discrete analyser (QCLot: 1854637)							
EP1103773-004	Anonymous	ED045G: Chloride	16887-00-6	250 mg/L	112	70	130
EG020W: Water Leachable Metals by ICP-MS (QCLot: 1855152)							
EP1104006-002	RRPT01	EG020A-W: Arsenic	7440-38-2	1.000 mg/L	86.0	70	130
		EG020A-W: Beryllium	7440-41-7	0.100 mg/L	83.1	70	130
		EG020A-W: Barium	7440-39-3	1.000 mg/L	85.4	70	130
		EG020A-W: Cadmium	7440-43-9	0.500 mg/L	80.6	70	130
		EG020A-W: Chromium	7440-47-3	1.000 mg/L	84.6	70	130
		EG020A-W: Cobalt	7440-48-4	1.000 mg/L	86.2	70	130
		EG020A-W: Copper	7440-50-8	1.000 mg/L	85.1	70	130
		EG020A-W: Lead	7439-92-1	1.000 mg/L	87.3	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report			
				Spike	Spike Recovery (%)	Recovery Limits (%)	
				Concentration	MS	Low	High
EG020W: Water Leachable Metals by ICP-MS (QCLot: 1855152) - continued							
EP1104006-002	RRPT01	EG020A-W: Manganese	7439-96-5	1.000 mg/L	83.3	70	130
		EG020A-W: Nickel	7440-02-0	1.000 mg/L	87.4	70	130
		EG020A-W: Vanadium	7440-62-2	1.000 mg/L	82.6	70	130
		EG020A-W: Zinc	7440-66-6	1.000 mg/L	82.1	70	130
EG035W: Water Leachable Mercury by FIMS (QCLot: 1855908)							
EP1104006-002	RRPT01	EG035W: Mercury	7439-97-6	0.010 mg/L	118	70	130

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Finalized Date: 30-JUN-2011
Account: ALSENV

QC CERTIFICATE PH11116871

Project: EP1104006
P.O. No.: 295856
This report is for 2 Pulp samples submitted to our lab in Perth, WA, Australia on 27-JUN-2011.
The following have access to data associated with this certificate:

SUB RESULTS		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
LEV-01	Waste Disposal Levy
LOG-24	Pulp Login - Rcd w/o Barcode

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-XRF12	Whole rock XRF	XRF
OA-GRA05t	Multi-temperature LOI	TGA

To: **ALS ENVIRONMENTAL**
ATTN: SUB RESULTS
10 HOD WAY
MALAGA WA 6090

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

Signature: W. Abbott
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Finalized Date: 30-JUN-2011
Account: ALSENV

Project: EP1104006

QC CERTIFICATE OF ANALYSIS PH11116871

Sample Description	Method / Analyte / Units / LOR	ME-XRF12 Al2O3 % 0.01	ME-XRF12 As % 0.001	ME-XRF12 BaO % 0.001	ME-XRF12 CaO % 0.01	ME-XRF12 Cl % 0.001	ME-XRF12 Co % 0.001	ME-XRF12 Cr2O3 % 0.001	ME-XRF12 Cu % 0.001	ME-XRF12 Fe2O3 % 0.01	ME-XRF12 K2O % 0.001	ME-XRF12 MgO % 0.01	ME-XRF12 MnO % 0.001	ME-XRF12 Mo % 0.001	ME-XRF12 Na2O % 0.001	ME-XRF12 Ni % 0.001
STANDARDS																
JS1																
JS1																
Target Range - Lower Bound																
Upper Bound																
SARM-39		4.33	<0.001	0.194	9.80	0.052	0.008	0.218	0.006	9.34	1.075	25.5	0.171	<0.001	0.602	0.102
Target Range - Lower Bound		4.07	<0.001	0.180	9.20	0.032	0.007	0.180	0.006	8.82	0.987	24.9	0.161	<0.001	0.588	0.093
Upper Bound		4.51	0.003	0.201	10.20	0.038	0.009	0.201	0.008	9.76	1.095	27.5	0.180	0.002	0.652	0.105
SARM-45		26.4	0.002	0.095	0.77	0.007	0.005	0.036	0.002	12.40	3.12	3.48	0.096	0.003	0.757	0.008
Target Range - Lower Bound		24.9	0.002	0.089	0.73	0.006	0.003	0.034	<0.001	11.95	3.02	3.21	0.094	<0.001	0.797	0.007
Upper Bound		27.5	0.004	0.101	0.83	0.008	0.005	0.040	0.002	13.25	3.34	3.57	0.106	0.002	0.883	0.009
BLANKS																
BLANK		<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	0.003	<0.001	<0.01	<0.001	0.02	<0.001	<0.001	0.141	<0.001
Target Range - Lower Bound		<0.01	<0.001	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.01	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001
Upper Bound		0.02	0.002	0.002	0.02	0.002	0.002	0.002	0.002	0.02	0.002	0.02	0.002	0.002	0.002	0.002
DUPLICATES																
MMPT01																
DUP																
Target Range - Lower Bound																
Upper Bound																
RRPT01		7.58	0.006	<0.001	0.10	0.037	<0.001	<0.001	0.003	68.4	0.027	0.12	0.297	<0.001	0.058	0.003
DUP		7.75	0.006	<0.001	0.10	0.032	<0.001	<0.001	<0.001	68.4	0.032	0.10	0.295	<0.001	0.062	<0.001
Target Range - Lower Bound		7.46	0.005	<0.001	0.09	0.033	<0.001	<0.001	<0.001	66.7	0.028	0.10	0.288	<0.001	0.058	<0.001
Upper Bound		7.87	0.007	0.002	0.11	0.036	0.002	0.002	0.003	70.1	0.031	0.12	0.304	0.002	0.063	0.003

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Finalized Date: 30-JUN-2011
Account: ALSENV

Project: EP1104006

QC CERTIFICATE OF ANALYSIS PH11116871

Sample Description	Method / Analyte / Units / LOR	ME-XRF12 P2O5 % 0.001	ME-XRF12 Pb % 0.001	ME-XRF12 SO3 % 0.001	ME-XRF12 SiO2 % 0.01	ME-XRF12 TiO2 % 0.01	ME-XRF12 V2O5 % 0.001	ME-XRF12 Zn % 0.001	OA-GRA05t LOI 1000 % 0.01
STANDARDS									
JS1									7.80
JS1									7.84
Target Range - Lower Bound									6.95
Upper Bound									8.51
SARM-39		1.440	<0.001	0.789	34.2	1.66	0.020	0.007	
Target Range - Lower Bound		1.385	0.002	0.719	31.7	1.49	0.017	0.006	
Upper Bound		1.535	0.004	0.797	35.1	1.67	0.021	0.008	
SARM-45		0.077	0.003	0.116	49.5	1.85	0.048	0.009	
Target Range - Lower Bound		0.075	0.002	0.118	47.1	1.72	0.045	0.006	
Upper Bound		0.085	0.004	0.132	52.1	1.92	0.051	0.008	
BLANKS									
BLANK		<0.001	<0.001	<0.001	97.1	<0.01	<0.001	<0.001	
Target Range - Lower Bound		<0.001	<0.001	<0.001	<0.01	<0.01	<0.001	<0.001	
Upper Bound		0.002	0.002	0.002	0.02	0.02	0.002	0.002	
DUPLICATES									
MMPT01									9.87
DUP									9.90
Target Range - Lower Bound									9.38
Upper Bound									10.40
RRPT01		0.170	<0.001	0.076	14.25	0.33	<0.001	0.021	
DUP		0.170	<0.001	0.078	14.10	0.35	<0.001	0.019	
Target Range - Lower Bound		0.165	<0.001	0.074	13.80	0.32	<0.001	0.019	
Upper Bound		0.175	0.002	0.080	14.55	0.36	0.002	0.022	

Environmental Division

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EP1104006**	Page	: 1 of 11
Client	: URS AUSTRALIA PTY LTD	Laboratory	: Environmental Division Perth
Contact	: ELENA CHIN	Contact	: Lauren Ockwell
Address	: LEVEL 4, 226 ADELAIDE TERRACE PERTH WA, AUSTRALIA 6000	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: elena_chin@urscorp.com	E-mail	: lauren.ockwell@alsenviro.com
Telephone	: +61 08 9326 0100	Telephone	: 08 9209 7606
Facsimile	: +61 08 9326 0296	Facsimile	: 08 9209 7600
Project	: 42907769	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 27-JUN-2011
Sampler	: ----	Issue Date	: 06-JUL-2011
Order number	: PER-11-7070E1		
		No. of samples received	: 6
Quote number	: EP/361/11	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **SOIL**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method		*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)			*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA005P: pH by PC Titrator								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	---	29-JUN-2011	----	**01-JUL-2011**	29-JUN-2011	×
EA010: Conductivity								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	----	----	----	**01-JUL-2011**	27-JUL-2011	✓
EA013: Acid Neutralising Capacity								
Pulp Bag								
MMPT01,	RRPT01	**24-JUN-2011**	**27-JUN-2011**	23-JUN-2012	✓	**04-JUL-2011**	24-DEC-2011	✓
EA015: Total Dissolved Solids								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	----	----	----	**01-JUL-2011**	06-JUL-2011	✓
EA055: Moisture Content								
Soil Glass Jar - Unpreserved								
MMPT01,	RRPT01	**24-JUN-2011**	----	----	----	**05-JUL-2011**	08-JUL-2011	✓
ED037P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	---	13-JUL-2011	----	**01-JUL-2011**	13-JUL-2011	✓
ED040F: Dissolved Major Anions								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	---	27-JUL-2011	----	**01-JUL-2011**	27-JUL-2011	✓
ED040S : Soluble Sulfate by ICPAES								
Soil Glass Jar - Unpreserved								
MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	01-JUL-2011	×	**05-JUL-2011**	02-AUG-2011	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Clear Plastic Bottle - Natural								
MMPT01,	RRPT01	**29-JUN-2011**	---	27-JUL-2011	----	**04-JUL-2011**	27-JUL-2011	✓
ED042T: Total Sulfur by LECO								
Pulp Bag								
MMPT01,	RRPT01	**24-JUN-2011**	**04-JUL-2011**	21-DEC-2011	✓	**04-JUL-2011**	21-DEC-2011	✓

Matrix: **SOIL**

Evaluation: ✘ = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED045G: Chloride Discrete analyser								
Clear Plastic Bottle - Natural MMPT01,	RRPT01	**29-JUN-2011**	---	27-JUL-2011	----	**04-JUL-2011**	27-JUL-2011	✓
Soil Glass Jar - Unpreserved MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	01-JUL-2011	✘	**05-JUL-2011**	02-AUG-2011	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Natural MMPT01,	RRPT01	**29-JUN-2011**	---	06-JUL-2011	----	**01-JUL-2011**	06-JUL-2011	✓
ED093S: Soluble Major Cations								
Soil Glass Jar - Unpreserved MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	21-DEC-2011	✓	**05-JUL-2011**	21-DEC-2011	✓
EG005T: Total Metals by ICP-AES								
Soil Glass Jar - Unpreserved MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	21-DEC-2011	✓	**05-JUL-2011**	21-DEC-2011	✓
EG020T: Total Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Unfiltered MMPT01,	RRPT01	**29-JUN-2011**	**04-JUL-2011**	26-DEC-2011	✓	**04-JUL-2011**	26-DEC-2011	✓
Soil Glass Jar - Unpreserved MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	21-DEC-2011	✓	**05-JUL-2011**	21-DEC-2011	✓
EG020W: Water Leachable Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Unfiltered MMPT01,	RRPT01	**29-JUN-2011**	**04-JUL-2011**	26-DEC-2011	✓	**04-JUL-2011**	26-DEC-2011	✓
EG035T: Total Recoverable Mercury by FIMS								
Soil Glass Jar - Unpreserved MMPT01,	RRPT01	**24-JUN-2011**	**05-JUL-2011**	22-JUL-2011	✓	**05-JUL-2011**	22-JUL-2011	✓
EG035W: Water Leachable Mercury by FIMS								
Soil Glass Jar - Unpreserved MMPT01,	RRPT01	**24-JUN-2011**	----	----	----	**04-JUL-2011**	22-JUL-2011	✓
EN60: Bottle Leaching Procedure								
LabSplit: Leach for organics and other tests MMPT01,	RRPT01	**24-JUN-2011**	---	08-JUL-2011	----	**30-JUN-2011**	08-JUL-2011	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Total Metals by ICP-MS - Suite R	EG020R-T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Acid Neutralising Capacity (ANC)	EA013	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Cations - soluble by ICP-AES	ED093S	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride Soluble By Discrete Analyser	ED045G	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Soluble	ED040S	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Moisture Content	EA055-103	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfur - Total as S (LECO)	ED042T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite X	EG020X-T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Y	EG020Y-T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Z	EG020Z-T	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Acid Neutralising Capacity (ANC)	EA013	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride Soluble By Discrete Analyser	ED045G	2	2	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Soluble	ED040S	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfur - Total as S (LECO)	ED042T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite X	EG020X-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Y	EG020Y-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Z	EG020Z-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Total Metals by ICP-MS - Suite R	EG020R-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Acid Neutralising Capacity (ANC)	EA013	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Cations - soluble by ICP-AES	ED093S	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride Soluble By Discrete Analyser	ED045G	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Soluble	ED040S	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfur - Total as S (LECO)	ED042T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite V	EG020V-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite X	EG020X-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Y	EG020Y-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite Z	EG020Z-T	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Chloride Soluble By Discrete Analyser	ED045G	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Total Metals by ICP-AES	EG005T	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement

Matrix: **SOIL**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type / *Analytical Methods*	*Method*	*Count QC*	*Count Regular*	***Rate (%) Actual***	***Rate (%) Expected***	*Evaluation*	*Quality Control Specification*
Matrix Spikes (MS) - Continued							
Total Metals by ICP-MS - Suite X	EG020X-T	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Total Metals by ICP-MS - Suite Y	EG020Y-T	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Total Metals by ICP-MS - Suite Z	EG020Z-T	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type / *Analytical Methods*	*Method*	*Count QC*	*Count Regular*	***Rate (%) Actual***	***Rate (%) Expected***	*Evaluation*	*Quality Control Specification*
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity	EA010	1	9	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Dissolved	ED040F	1	8	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH by PC Titrator	EA005-P	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**10.0**	×	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Mercury by FIMS	EG035W	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	1	2	**50.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity	EA010	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Dissolved	ED040F	1	8	**12.5**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH by PC Titrator	EA005-P	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Mercury by FIMS	EG035W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Alkalinity by PC Titrator	ED037-P	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity	EA010	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Dissolved	ED040F	1	8	**12.5**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Mercury by FIMS	EG035W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Water Leachable Mercury by FIMS	EG035W	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	1	2	**50.0**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH by PC Titrator	EA005-P	SOIL	APHA 21st ed. 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Conductivity	EA010	SOIL	APHA 21st ed., 2510 B Conductivity is determined by ISE, either manually or automated measurement. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Acid Neutralising Capacity (ANC)	EA013	SOIL	USEPA 600/2-78-054, I. Miller (2000). A fizz test is done to semiquanititatively estimate the likely reactivity. The soil is then reacted with an known excess quanitity of an appropriate acid. Titration determines the acid remaining, and the ANC can be calculated from comparison with a blank titration.
Total Dissolved Solids (High Level)	EA015H	SOIL	APHA 21st ed., 2540C A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Moisture Content	EA055-103	SOIL	A gravimetric procedure based on weight loss over a 12 hour drying period at 103-105 degrees C. This method is compliant with NEPM (2010 Draft) Schedule B(3) Section 7.1 and Table 1 (14 day holding time).
Alkalinity by PC Titrator	ED037-P	SOIL	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Major Anions - Dissolved	ED040F	SOIL	APHA 21st ed., 3120. The 0.45um filtered samples are determined by ICP/AES for Sulfur and/or Silcon content and reported as Sulfate and/or Silica after conversion by gravimetric factor.
Major Anions - Soluble	ED040S	SOIL	In-house. Soluble Anions are determined off a 1:5 soil / water extract by ICPAES.
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	SOIL	APHA 21st ed., 4500-SO4 Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Sulfur - Total as S (LECO)	ED042T	SOIL	In-house. Dried and pulverised sample is combusted in a LECO furnace at 1350C in the presence of strong oxidants / catalysts. The evolved S (as SO2) is measured by infra-red detector
Chloride by Discrete Analyser	ED045G	SOIL	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	SOIL	APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Cations - soluble by ICP-AES	ED093S	SOIL	APHA 21st ed., 3120; USEPA SW 846 - 6010 (ICPAES) Water extracts of the soil are analyzed for major cations by ICPAES. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (1999) Schedule B(3)
Total Metals by ICP-AES	EG005T	SOIL	(APHA 21st ed., 3120; USEPA SW 846 - 6010) (ICPAES) Metals are determined following an appropriate acid digestion of the soil. The ICPAES technique ionises samples in a plasma, emitting a characteristic spectrum based on metals present. Intensities at selected wavelengths are compared against those of matrix matched standards. This method is compliant with NEPM (1999) Schedule B(3)

Analytical Methods	Method	Matrix	Method Descriptions
Water Leachable Metals by ICP-MS - Suite A	EG020A-W	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Water Leachable Metals by ICP-MS - Suite B	EG020B-W	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Water Leachable Metals by ICP-MS - Suite C	EG020D-W	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Water Leachable Metals by ICP-MS - Suite E	EG020E-W	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite R	EG020R-T	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020) (ICPMS) Metals in solids are determined following an appropriate acid digestion. The ICPMS technique ionizes selected elements. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass / charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM (1999) Schedule B(3)
Total Metals by ICP-MS - Suite V	EG020V-T	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Metals in solids are determined following an appropriate acid digestion. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite X	EG020X-T	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite Y	EG020Y-T	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite Z	EG020Z-T	SOIL	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Mercury by FIMS	EG035T	SOIL	AS 3550, APHA 21st ed., 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. Mercury in solids are determined following an appropriate acid digestion. Ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3)

Analytical Methods	Method	Matrix	Method Descriptions
Water Leachable Mercury by FIMS	EG035W	SOIL	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the TCLP solution. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ionic Balance by PCT DA and ICPAES	EN055 - PG	SOIL	APHA 21st Ed. 1030F. The Ionic Balance is calculated based on the major Anions and Cations. The major anions include Alkalinity, Chloride and Sulfate which determined by PCT and DA. The Cations are determined by ICPAES. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Miscellaneous Subcontracted Analysis	MIS-SOL	SOIL	Miscellaneous Subcontracted Analysis conducted by Subcontracting Laboratory

Preparation Methods	Method	Matrix	Method Descriptions
Sample Compositing	EN020	SOIL	Equal weights of each original soil are taken, then mixed and homogenised. The combined mixture is labelled as a new sample.
Drying at 85 degrees, bagging and labelling (ASS)	EN020PR	SOIL	In house
Digestion for Total Recoverable Metals in DI Water Leachate	EN25W	SOIL	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
1:5 solid / water leach for soluble analytes	EN34	SOIL	10 g of soil is mixed with 50 mL of distilled water and tumbled end over end for 1 hour. Water soluble salts are leached from the soil by the continuous suspension. Samples are settled and the water filtered off for analysis.
Deionised Water Leach	EN60-DIa	SOIL	AS4439.3 Preparation of Leachates
Hot Block Digest for metals in soils sediments and sludges	EN69	SOIL	USEPA 200.2 Mod. Hot Block Acid Digestion 1.0g of sample is heated with Nitric and Hydrochloric acids, then cooled. Peroxide is added and samples heated and cooled again before being filtered and bulked to volume for analysis. Digest is appropriate for determination of selected metals in sludge, sediments, and soils. This method is compliant with NEPM (1999) Schedule B(3) (Method 202)

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **SOIL**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Laboratory Control Spike (LCS) Recoveries							
EG005T: Total Metals by ICP-AES	2190594-003	----	**Iron**	7439-89-6	137 %	79-130%	**Recovery greater than upper control limit**
Matrix Spike (MS) Recoveries							
EG020T: Total Metals by ICP-MS	EP1104006-002	RRPT01	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **SOIL**

Method		*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural MMPT01,	RRPT01	----	----	----	01-JUL-2011	29-JUN-2011	**2**
ED040S : Soluble Sulfate by ICPAES							
Soil Glass Jar - Unpreserved MMPT01,	RRPT01	05-JUL-2011	01-JUL-2011	**4**	----	----	----
ED045G: Chloride Discrete analyser							
Soil Glass Jar - Unpreserved MMPT01,	RRPT01	05-JUL-2011	01-JUL-2011	**4**	----	----	----

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	1	20	5.0	10.0	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

URS DATA VALIDATION SUMMARY REPORT

Site:	FerrAus Tailing, Pilbara	**Validation Conducted by:** (Data Manager)	Elena Chin	**Date:**	8/7/11
Project No.:	42907769	**Signed:**			
Project Manager:	Tracey Hassell				
Matrix:	solid and liquid	**Validation Verified by:** (Data Validator)	Wesu Ndilila-Barnes	**Date:**	21/7/2011
No of Primary Samples:	4				
Laboratory:	ALS	**Signed:**			
Lab Batch No.:	EP1104006				
		Reviewed by: (Project Manager)	Tracey Hassell	**Date:**	21/7/2011
		Signed:			

Data Quality Objectives

Anomalous Field Data Comparison (Anomalous Results)	Samples were provided by client from laboratory testing. No field work was conducted as part of this scope of work
Frequency of field QA/QC (ie field duplicates/triplicates, rinsate/field/trip blanks, etc)	Field QA/QC was not required in this investigation.
Frequency of laboratory QA/QC (ie laboratory duplicates, matrix spikes, laboratory control samples, method blanks, etc)	Lab duplicates and LCS were reported less than the required frequency for pH (solid tailing samples). Therefore, only a limited assessment of the precision and accuracy of the sample matrix can be performed for this method. However, URS considers this is acceptable as this batch only contained two samples analysed for this analytes.
Number of tests requested/reported	Samples were analysed and reported as requested on the COC.
Limits of Reporting	Limits of reporting were sufficiently low to enable a meaningful comparison with adopted guideline values, with the exception of silver (leacahte analysis), however, this analyte was below the LOR for both samples.

Sample Management

Sample handling/preservation (ie Temp received by laboratory etc.)	Samples were received by the laboratory at 23.7ºC with ice present, above the recommended temperature. However, this will not affect data interpretation as no volatile analytes were required to analyse.
Sample holding times	Analysis holding times failed by 2 days for the following samples: • RRPT01 for pH Extraction holding times failed by 4 days for the following samples: • RRTP01 for soluble sulfate and chloride

Data Precision

Field duplicate RPDs (Primary Laboratory)	Field duplicate was not required as samples were provided by client.
Laboratory duplicate RPDs	All RPDs were within control limits.

Data Accuracy

Laboratory Control Samples	Iron had a recovery (137%) which marginally exceeded the upper control limit (130%).
Data Transcription	A 10% check of the laboratory results identified no anomalies between the electronic data, the laboratory report, and the tables generated by URS.
Matrix Spike Recoveries	Manganese recovery was not determined due to background concentrations greater than 4 times the spike level.
Surrogate Recoveries	Surrogates were within recovery limits.

Data Comparability

Changes in sampling personnel	Samples provided by client
Changes in methodologies	Samples provided by client

Blank Monitoring

Rinsate Blank	N/A
Trip Blank	N/A
Method blank	Concentrations were reported below the LOR.

Chromatograms

Chromatograms	N/A
Other observations	N/A

Data Verification: COPY OF EP1104006_MRED

Site Name	**FerrAus Tailings Geochemical Assessment**
Project No.	**42907769**
Project Manager	**Tracey Hassell**
Matrix	**liquid**
Laboratory	**ALS-BRISBANE**
Batch File Name	**EP1104006**

Analytical Parameter	Number of Tests Requested	Number of Tests Reported	Holding Times (a)	Limits of Reporting	LAB_DUPLICATE		LCS		MATRIX_SPIKE		METHOD_BLANK	
					Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported
Acid Neutralising Capacity	2	2	✓	✓	1	1	1	1	0	0	1	1
Sulfur	2	2	✓	✓	1	1	1	1	0	0	1	1
Major Ions	2	2	☒	✓	1	3	1	3	1	1	1	3
Metals (Total)	2	2	✓	✓	1	2	1	5	1	3	1	5
Moisture Content	2	2	✓	✓	1	1	**1**	**0**	0	0	0	0
Physico-Chemical Parameters	2	2	☒	✓	1	1	1	0	0	0	0	0

Leachate

Analytical Parameter	Number of Tests Requested	Number of Tests Reported	Holding Times (a)	Limits of Reporting	LAB_DUPLICATE		LCS		MATRIX_SPIKE		METHOD_BLANK	
					Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported	Number Required	Number Reported
Alkalinity	2	2	✓	✓	1	2	1	1	0	0	1	1
Major Ions	2	2	☒	✓	1	5	1	4	1	2	1	4
Metals (Leachable)	2	2	✓	✓	1	5	1	4	1	2	1	4
Physico-Chemical Parameters	2	2	☒	✓	1	3	1	3	0	0	1	2

Initial ________ Date ____/____/_______