

# RUM JUNGLE REHABILITATION - STAGE 2A DETAILED DESIGN

## DETAILED ENGINEERING DESIGN SUMMARY REPORT

**Prepared for:**

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## BASIS OF REPORT

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## DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
680.10421.90000-R01-v1.0	19 June 2020	Various	Danielle O'Toole / Dominic Trani	Danielle O'Toole

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## EXECUTIVE SUMMARY

The Northern Territory Government (NTG), represented by the Department of Primary Industry and Resources (DPIR), proposes the rehabilitation of the former Rum Jungle Mine site (the Project), located 6 km north of Batchelor, Northern Territory (NT).

The former Rum Jungle Mine was rehabilitated in the 1980s, however recent studies indicate that the site deteriorated and needs further rehabilitation, and that the Traditional Aboriginal Owners cultural requirements have not been met. Since 2009, the NTG and the Australian Government have been working under a National Partnership arrangement to complete investigative work to inform a rehabilitation plan, deliver site maintenance and continue environmental monitoring. The results of these programs have been used to develop an improved rehabilitation strategy that is consistent with the views and interests of Traditional Aboriginal Owners and that meets contemporary environmental and mined land rehabilitation standards.

The Project's high-level objectives are two-fold and focus on environmental remediation and restoration of cultural values of the site. Full details of this are described in the Draft Environmental Impact Statement (EIS) (NT-DPIR, December 2019).

This report summarises the **Stage 2A Detailed Engineering Design** undertaken by SLR Australia Pty Ltd (SLR) to meet the engineering requirements for construction of the rehabilitation strategy (referred to as **Stage 3 Rehabilitation Construction**).

The rehabilitation strategy was developed from an understanding of current site conditions, contamination processes and a Land Use Plan goals as established with Traditional Aboriginal Owners. There are several key elements that have been incorporated in the strategy in order to satisfy the cultural needs of sacred site Custodians as far as practicable. The actions planned to address contamination processes, improve prospects of future land use and address the compromised environmental and cultural values that are not related to contamination processes are described fully in the Draft EIS (NT-DPIR, December 2019) and are summarised as follows:

- Slow down or halt the Acid and Metalliferous Drainage (AMD) production reactions from waste rock onsite by consolidating waste rock into one of three new facilities based on potential acid forming (PAF) characteristics. These facilities are:
  - Within the Main Pit backfill zone – ~1.47 Mm<sup>3</sup> storage for waste rock;
  - Within two new Waste Storage Facilities (WSFs):
    - East WSF – ~3.77 Mm<sup>3</sup> storage volume; and
    - West WSF – ~1.88 Mm<sup>3</sup> stored volume.
- Slow down or halt the future generation and transportation mechanisms for copper and other metals in the new WSFs by adopting leading practice methodology for storage of PAF waste rock.
- Treat existing groundwater sources (i.e. the Main and Intermediate WRDs) that contaminate the East Branch of the Finnis River (EBFR) by extracting and treating these impacted waters.
- Treat other AMD-impacted groundwater that does not contribute to the EBFR copper load (i.e. old ore stockpile area) by extracting and treating these impacted waters.
- Isolate radiological and AMD affected soils at the Rum Jungle site and Mt Burton from environmental and human receptors by relocating these soils to the new WSFs on site.
- Return the EBFR to its original course as far as possible.

## EXECUTIVE SUMMARY

- Restore land parcels that are poorly vegetated such as the Old Tailings Dam area and vine thicket stand.
- Revegetate new landforms to stabilise the surface and restore ecological function as far as practicable.

The Stage 2A Detailed Engineering Design for the Project has comprised reviewing, updating, refining and/or redesigning aspects of the Stage 2 Preliminary Engineering Design by others.

The scope of work and associated deliverables from Stage 2A is summarised below, including the report section references.

### Stage 2A Scope of Work and Deliverable Summary

Item	Scope and Deliverable	Report Section	Report Reference
1	Geotechnical Assessment	Section 5	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Geotechnical Investigation Waste Storage Facilities and Borrow Areas (SLR, 2020a)
2	Material Movement and Prioritisation	Section 8	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Waste Storage Facilities and General Site Civil Works Detailed Design and Construction Methodology Report (SLR, 2020g)
3	Main Pit Backfilling	Section 9	
3a	Detailed Design Report		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Main Pit Backfill Strategy (SLR, 2020b) Geotechnical Considerations (SLR, 2020bb)
3b	Technical Specifications		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Technical Specification Main Pit Backfill (SLR, 2020c)
3c	Design Drawings		680.10421-MPT Series 680.10421-GEN Series
3d	Bill of Quantities		680.10421 BOQ Main Pit Backfill Issued for Implementation.xls
4	Water Treatment Plant (WTP) (includes groundwater interception system)	Section 10	
4a	Detailed Design Report		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Water Treatment Facility Design Report (SLR, 2020d)
4b	Technical Specifications		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Technical Specification Water Treatment Plant (SLR, 2020e)
4c	Design Drawings		68010421.WTP Series 680.10421-GEN Series
4d	Bill of Quantities		680.10421 WTP Issued for Implementation V1.xls
5	General Civil and Earthworks		
5a	Waste Storage Facilities and General Site Civil Works	Section 11	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Waste Storage Facilities and General Site Civil Works Detailed Design and Construction Methodology Report (SLR, 2020g)

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Item	Scope and Deliverable	Report Section	Report Reference
5b	WSF Site Selection		WSF Technical Memo on Site Selection (SLR, 2020h)
5c	WSF Erosion Modelling		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Erosion Assessment for New Waste Storage Facilities (SLR, 2020f)
5d	WSF Growth Medium Design		Memo M06 Growth Medium for WSF Capping (SLR, 2020i)
5f	WSF Cover Options Assessment		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Waste Storage Facilities (WSF) Cover Options Analysis (SLR, 2020j)
5g	Borrow Pit Development	Section 12	Memo M03 Borrow Pit Development (SLR, 2020k)
5h	Material movement	Section 8.6.3	Appendix E of 4a. (SLR, 2020g) MEC Mining, Haulage Model, SLR Rum Jungle (MEC, 2020a)
5i	Haul Road Design	Section 16	Appendix F of 4a. (SLR, 2020g) MEC Mining, Haul Road Design, SLR Rum Jungle (MEC, 2020b) MEC Drawings Set
5j	EBFR Diversion Drain Crossing	Section 17	Appendix G of 4a. (SLR, 2020g) Pritchard Francis Drawing Set
5k	External Roads	Section 18	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Traffic Impact Assessment External Roads (SLR, 2020q)
5l	Cultural centre	Section 21	Appendix A of 4a. (SLR, 2020g) Memo M04 Cultural Centre (SLR, 2020m)
5m	Technical Specifications		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Technical Specification Waste Storage and General Site Earthworks (SLR, 2020n)
5n	Design Drawings		680.10421-GEN Series 680.1042-WSF Series 680.1042-BOR Series 680.10421-BEW Series 680.10421-RHE Series 680.10421-HR Series 680.10421-C0-C7 Series
5o	Bill of Quantities		680.10421 BoQ Civil and Earthworks v1.xls
6	Surface Water Management		
6a	Erosion and Sediment Control	Section 13	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Site Erosion and Sediment Control Measures (SLR, 2020o)
6b	Realignment of EBFR	Section 14	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design East Branch Finnis River – River Reinstatement and Flooding Design Report (SLR, 2020p)
6c	Technical Specifications		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Technical Specification Waste Storage and General Site Earthworks (SLR, 2020n)

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Item	Scope and Deliverable	Report Section	Report Reference
6d	Design Drawings		680.14021-RFR Series 680.10421-GEN Series
6e	Bill of Quantities		680.10421 E&W Issued for Implementation.xls
7	Value Engineering	Section 22	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Value Engineering Summary (SLR, 2020L)
8	Stage 3 P80 Construction Cost		
8a	Cost	Section 23.1	Turner and Townsend Rum Jungle Rehabilitation Basis of Estimate and Schedule for Stage 3
8b	Schedule	Section 23.2	
8c	Quantitative Risk Assessment (QRA)	Section 23.3	

The Basis of Design (BOD) was developed in spreadsheet format to capture the principles, assumptions and considerations used for the development of the Detailed Design. The BOD was developed iteratively between SLR and NT DPIR to ensure that not only the engineering and environmental considerations were captured, but that the cultural considerations of the Traditional Aboriginal Owners were acknowledged as well.

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## APPENDICES

Appendix A Basis of Design

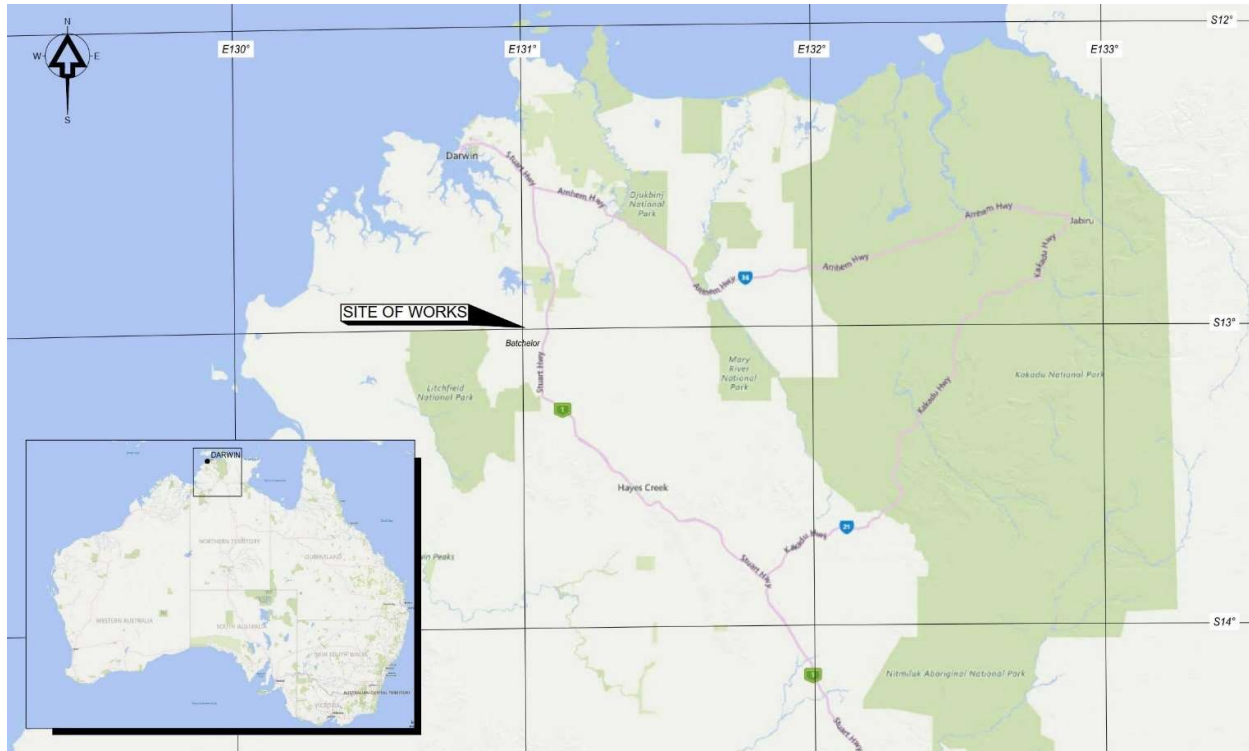
## GLOSSARY

Abbreviation/Acronym	Full form
AAPA	Aboriginal Areas Protection Authority
ABA	Acid Base Accounting
AHD	Australian Height Datum
ALRA	<i>Aboriginal Land Rights (Northern Territory) Act 1976 (Cth)</i>
AMD	Acid and Metalliferous Drainage
ANZECC	Australian and New Zealand Environment and Conservation Council
ARI	Average Recurrence Interval
bgs	Below Ground Surface
BoM	Bureau of Meteorology
CHMP	Cultural Heritage Management Plan
DPIR, the Proponent	NT Department of Primary Industry and Resources
EA Act	<i>Environmental Assessment Act 1982 (NT)</i>
EBFR	East Branch of the Finnis River
EFDC	East Finnis Diversion Channel
EIS	Environmental Impact Statement
ESCP	Erosion and Sediment Control Plan
FRALT	Finniss River Aboriginal Land Trust
LDWQO (s)	Locally Derived Water Quality Objective (s)
Mt	Mount
NAF	Non Acid Forming
NT	Northern Territory
NT EPA	Northern Territory Environment Protection Authority
NTG	Northern Territory Government
PAF	Potentially Acid Forming
Project	Rum Jungle Stage 3 Rehabilitation Project
QA/QC	Quality Assurance/Quality Control
RJ	Rum Jungle
RJCS	Rum Jungle Creek South
SIS	Seepage Interception System – installed around Intermediate and Main WRDs
TO	Traditional Aboriginal Owners
WRD	Waste Rock Dump (existing)
WSF	Waste Storage Facility (planned)
WTP	Water Treatment Plant

# 1 Introduction

## 1.1 Project Background

The Northern Territory Government (NTG), represented by the Department of Primary Industry and Resources (DPIR), proposes the rehabilitation of the former Rum Jungle Mine site (the Project), located 6 km north of Batchelor, Northern Territory (NT). The project location and regional setting are shown on **Figure 1**.



**Figure 1 Project Location**

The former Rum Jungle Mine was rehabilitated in the 1980s, however recent studies indicate that the site deteriorated and needs further rehabilitation, and that the Traditional Aboriginal Owners cultural requirements have not been met. Since 2009, the NTG and the Australian Government have been working under a National Partnership arrangement to complete investigative work to inform a rehabilitation plan, deliver site maintenance and continue environmental monitoring. The results of these programs have been used to develop an improved rehabilitation strategy that is consistent with the views and interests of Traditional Aboriginal Owners and that meets contemporary environmental and mined land rehabilitation standards.

The Project's high-level objectives are two-fold and focus on environmental remediation and restoration of cultural values of the site. Full details of this are described in the Draft Environmental Impact Statement (EIS) (NT-DPIR, December 2019) and are summarised below:

- Improve the environmental condition onsite and downstream of site within the East Branch of the Finniss River (EBFR). This includes the following key outcomes:

- 
- Improved surface water quality conditions within EBFR in accordance with locally derived water quality objectives (LDWQOs);
  - Achieve chemically and physically stable landforms;
  - Support self-sustaining vegetation systems within rehabilitated landforms; and
  - Develop physical environmental conditions supportive of the proposed Land Use Plan.
- Improve site conditions to restore cultural values. This includes the following key outcomes:
    - Restoration of the flow of the EBFR to original course as far as possible;
    - Remove culturally insensitive landforms from adjacent to sacred sites and relocate ensuring a culturally safe distance from the sacred sites;
    - Return living systems including endemic species to the remaining landforms;
    - Preserve Aboriginal cultural heritage artefacts and places;
    - Isolate sources of pollution including radiological hazards; and
    - Maximise opportunities for Traditional Aboriginal Owners to work onsite to aid reconnection to country.

This report summarises the **Stage 2A Detailed Engineering Design** undertaken to meet the engineering requirements for construction of the rehabilitation strategy (referred to as **Stage 3 Rehabilitation Construction**).

## 1.2 Detailed Engineering Design Objectives for the Project

The detailed engineering design objectives are to:

- Undertake detailed engineering design for rehabilitation components, considering latest remedial technologies. The design has built on the Stage 2 design (O'Kane Consultants Pty Ltd, 2016), recent expert geochemical studies (RGC & Jones, 2019), (RGC, November 2019)) as well as undertaking value engineering to identify where the design can be refined;
- Provide Design Drawings and Technical Specifications for all scopes that are suitable for **Stage 3** implementation<sup>1</sup>;
- Provide quantities and measurements suitable for input into **Stage 3** P80 construction cost estimate;
- Provide a **Stage 3** construction schedule; and
- Consider procurement and contracting strategies for **Stage 3** that maximise Traditional Aboriginal Owner engagement, provide adequate value for money and sufficient risk mitigation.

## 1.3 Regulatory Information

The Project is being assessed by the Northern Territory Environment Protection Authority (NT EPA) under the *Environmental Assessment Act, 1982* (EA Act). The draft EIS (NT-DPIR, December 2019) was submitted by NT DPIR in January 2020, and at the time of writing was still under assessment.

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<sup>1</sup> As per DPIR Tender D17-0252 Request for Tender, November 2017, engineering documentation is to be delivered to "Issued for Implementation"

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Detailed information on the history and development of the former Rum Jungle Mine is contained in the EIS, and where relevant, this information is repeated here for contextual reasons.

## 1.4 Cultural Heritage

The Kungarakana and Warai peoples have been found to be Traditional Aboriginal Owners (TOs) of Rum Jungle however the land claim may be resolved pending the completion of **Stage 3** works.

The engineering design considers the location of sacred sites and other Aboriginal places and objects, ensuring the end landform is culturally appropriate and that the sites will not be disturbed during the construction phase. During historic mining, several sacred sites were impacted and the scope of work for **Stage 3** includes the remediation of these landforms to the extent practicable.

### 1.4.1 Sacred Sites

Sacred sites on the Rum Jungle project area are detailed in the Aboriginal Areas Protection Authority (AAPA) Authority Certificate (C2019/082) and have been identified through consultation with sacred site Custodians. The AAPA Authority Certificate is not included in this report due to sensitive information contained in that Certificate.

### 1.4.2 Aboriginal Places and Objects

Aboriginal archaeological places and objects are afforded automatic protection under the *Heritage Act, 2011* (NT), whether their location is recorded or not. The 2010 and 2018-19 archaeological surveys identified several Aboriginal heritage objects and Aboriginal heritage places within the Rum Jungle (NT-DPIR, December 2019). The Aboriginal places have high cultural significance to the Traditional Aboriginal Owners and Custodians.

Aboriginal and archaeological places and objects are shown on relevant Design Drawings outlined in **Section 24.2**. Additionally, a Cultural Heritage Management Plan is to be prepared for the site to assist in the identification of any other artefacts that may exist within the project footprint that have not yet been identified. This is to be prepared by the project's consulting archaeologist.

### 1.4.3 Historical Places and Objects

Historical places and objects are only afforded legal protection in the NT if they have been nominated, assessed, and registered as Declared Heritage Places and Objects. There are currently no Declared Heritage Places and Objects within the project area.

However, the drill rig currently located near Main Pit, does meet the criteria to be considered a significant heritage object, and may be afforded protection from destruction, either by display at a suitable place at the Rum Jungle site or by transporting it to the grounds of the Batchelor Museum for display and interpretation (NT-DPIR, December 2019). As requested by the TOs, it is proposed to relocate the rig off site, however full details of its final location were not known at the time of reporting.

## 1.5 Previous Works

The information in the following sections has been sourced from the Draft EIS (NT-DPIR, December 2019).

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### 1.5.1 Mining

Historic mining activities occurred from 1953 to 1963 and comprised the development of several satellite pits as noted here:

- Rum Jungle main site:
  - Main Pit (uranium);
  - Dysons (uranium);
  - Intermediate (copper); and
  - Copper extraction pad.
- Mt Burton (1958) open pit;
- Mt Fitch (1966)– exploration only- small waste rock dump and pit; and
- RJCS (1961-63) – uranium. Out of scope for Stage 3 works.

The uranium ore treatment plant was constructed in 1954 and operated until 1971 when the plant was closed. The plant used a standard acid leach process to extract the uranium from the crushed and milled ores.

In addition to uranium, high-grade copper ore was treated in the plant, with lower grade ore heap leached onsite. Initially, tailings from the treatment plant were deposited informally at a 30 ha, low flat area north-west of the plant. Later known as the Old Tailings Dam, the area was subjected to annual Wet season inundation which dispersed tailings and process liquors into the EBFR and the Finnis River.

Two Copper Extraction Pad heaps comprising low-grade copper sulphide and oxide ores were constructed between the Main and Intermediate Deposits. The heaps were treated with acid to extract the copper. All overflows, including any excess barren liquor, was discharged into Copper Creek which drained into the EBFR. Copper enriched liquor was also lost to the local groundwater table from this process.

The Copper Extraction Pad experiment was deemed commercially unviable, and copper ore was left in the heap after the mine closed. Copper sulphide ore from the heap continued to oxidise and release large concentrations of copper, other heavy metals and acid into the surrounding environment after the mine closed.

### 1.5.2 Rehabilitation

Mining and mineral processing at the site created significant environmental impacts, primarily elevated dissolved copper from AMD which polluted the EBFR. The Commonwealth initiated an aesthetic clean-up of the mine site in 1977 along with review of site conditions to plan for more substantial works. The outcome of this technical assessment and planning effort was a four-year rehabilitation project funded by the Commonwealth and implemented by the NTG between 1982 and 1986.

The objectives of the 1980s Rum Jungle Rehabilitation Project were to:

Achieve a major reduction in surface water pollution, aimed at reducing the average quantities of copper, zinc and manganese as measured at the confluence of the East Branch and the Finnis River;

Reduce pollution levels in the Main and Intermediate Pits;

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Reduce public health hazards, including radiation levels at the site to at least the standards set by the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores (Commonwealth of Australia, 1980); and

Implement aesthetic improvements, including revegetation.

Four primary rehabilitation treatments were undertaken:

- A three-layer cover system was constructed over the WRDs to reduce infiltration to less than five percent of rainfall. The WRDs were also reshaped and drainage structures installed to mitigate erosion and maintain the integrity of vegetation cover. A mix of introduced pastures and legumes were used for rapid revegetation. Grass cover was the specified revegetation condition for the WRDs.
- A water treatment plant was constructed to treat heavily contaminated water from the Main Pit. Water was withdrawn from depth, with lower density treated water returned to the surface of the pit where it formed a layer of clean water overlying the untreated water at depth. Water in the Intermediate Pit was treated in situ with lime to remove heavy metals and neutralise pH. Wet season flows were then re-instated through both pits so that the system would be flushed each Wet season. Based on the results from limnological modelling, it was anticipated this process would slowly cleanse the contaminated water that remained at depth in the pits by a combination of seasonal partial vertical mixing and Wet season flushing of the surface layers. Filter cake from the water treatment process was buried in Borrow Area 5, to the north of the site and capped with a three-layer cover system.
- Dyson's Pit was partially backfilled with tailings from the tailings area and Tailings Creek. The surface of the tailings was covered with a coarse geotextile and an approximately one metre thick rock blanket drainage layer. The drainage layer was overlain with low-grade copper ore, copper launders from the Copper Extraction Pad and impacted soils from both sites. A moisture barrier, a moisture retention zone and an erosion-resistant cover were installed on top and the final surface revegetated in the same way as the WRDs.
- After the tailings were removed to Dyson's Pit, the tailings area footprint was reshaped to control drainage, limed and covered with a one-layer system (of soil) to enable revegetation with introduced pastures and native trees and shrubs.
- A sub-surface drainage system and a four-layer cover system were installed over the copper extraction area to address residual surface and sub-surface contamination. The surface was revegetated with the same methodology as the WRDs.

The rehabilitated site was considered to have successfully achieved its set engineering and environmental criteria based on the results of a 12-year monitoring program undertaken between 1986 and 1998. The rehabilitation of the Rum Jungle site was recognised as being world-leading practice at the time, especially the installation of a multi-layer cover system on the waste rock dumps. Cover system design and construction technologies were then in their infancy, so the site attracted international attention as one of the first implementations of a cover system for rehabilitation of sulfidic waste rock dumps.

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## 2 Existing Site Condition

### 2.1 Land Tenure and Land Use

The former Rum Jungle Mine is located approximately 105 km south of Darwin, and 6 km north of Batchelor, NT as shown in Figure 1. The tenures of the project components are:

- Rum Jungle proper – Section 2968 Hundred of Goyder (vacant NT Crown land recommended for grant by the Aboriginal Land Commissioner Justice Toohey on 22 May 1981);
- Mt Burton – Section 998 Hundred of Goyder (estate in fee simple held privately);
- Mt Fitch – within NT Portion 3283 (Crown Lease Perpetual 862 held by the Northern Territory Land Corporation);
- Low permeability and growth medium materials are proposed to be sourced from pre-disturbed land (Section 2830 Hundred of Goyder, being an Estate in Fee Simple, held by the Coomalie Community Government Council); and
- Granular and growth medium materials are proposed to be sourced from lands including and surrounding a former sand mining area which is now located on the FRALT (Section 2940 Hundred of Goyder, being an Estate in Fee Simple (ALRA), held by the Finnis River Aboriginal Land Trust).

The location of all components, with respect to each other and Batchelor, are shown in Figure 2.

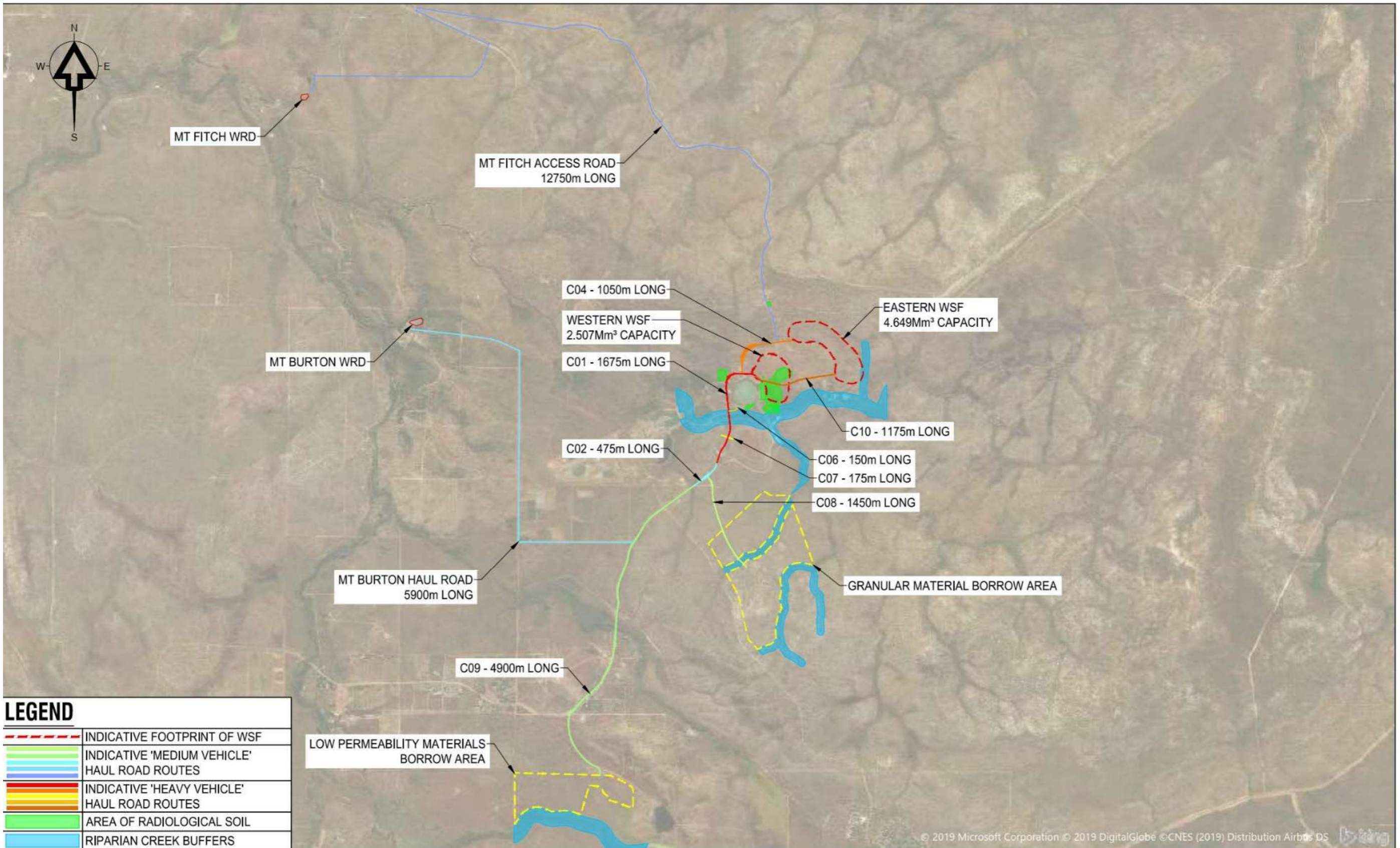


Figure 2 Existing Land Tenure and Land Use

Currently, the site is not in a condition suitable for land use activities. The site is currently fenced and only accessed for purpose of site investigations, land management and monitoring works and studies to support the future rehabilitation activities.

## 2.2 Current Site Condition

Historic mining and rehabilitation activities have altered the landscape within the former Rum Jungle Uranium Field, most prominently seen at the Rim Jungle site. Further rehabilitation will see a final landscape that, whilst still altered, has improved functionality and reduced environmental and cultural impact. The Rum Jungle complex is a typical example of an open pit legacy mining site of which there are many examples across Australia's landscape. Rum Jungle features, such as open pits and WRDs are show in **Figure 3**.

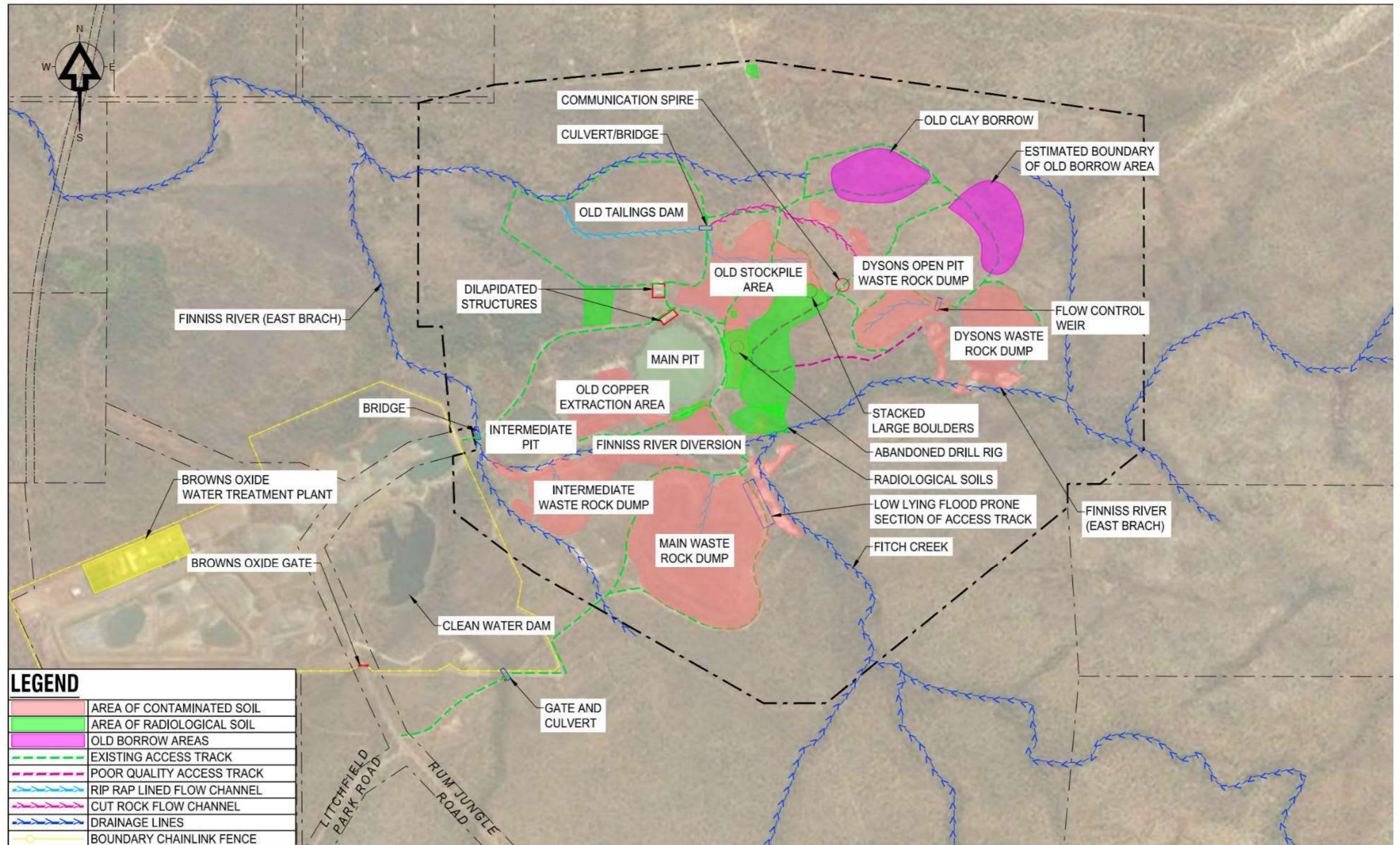


Figure 3 Existing Site Conditions and Impact Zones

Physical dimensions of all features across the Rum Jungle, Mt Burton and Mt Fitch sites are summarised in **Table 1**.

**Table 1 Mining Landscape Features (Prior to 1980s Rehabilitation), Dimensions and History**

Feature	Brief History	Horizontal Area (m <sup>2</sup> )	Maximum Height/Depth (m)	Volume (m <sup>3</sup> )
Main Pit	Open pit mined for Uranium. From 1965-1971 approx. 700,000 t of tailings was discharged into the Main Pit from the northern perimeter.	100,243	110 m to base of Pit. 47 m to top of backfilled tailings	3,530,000 *(original)
Intermediate Pit	Open pit mined for Copper.	41,882	55	1,087,000 *(original)
Dyson's Pit Overburden	Open pit mined for Uranium, then used for tailings storage (approx. 600,000 t discharged 1961-1965). During 1980s rehabilitation it was backfilled with tailings from the Tailings Dam and copper ore from the Copper Extraction Pad.	57,875	NA	917,000 (original)
Main WRD	Storage of waste rock from Main Pit.	318,275	21	4, 529,675
Main North WRD	Storage of waste rock from Main Pit.	43,525	8	119,000
Main WRD levee	Impacted soil bunds	12,950	5	68,975
Intermediate WRD	Storage of waste rock from Intermediate Pit.	84,750	13	734,900
Dyson's WRD	Storage of waste rock from Dyson's Pit.	90,250	21	1,190,250
Old Tailings Dam	During historic mining operations, un-neutralised mill tailings discharged to this area over natural surface. Area was stripped of tailings and contact soils during 1980s rehabilitation; claimed materials disposed of in Dyson's Pit.	300,000	NA	NA
Old Copper Extraction Area	Area used as copper leach pad. Ore stripped in 1980s rehabilitation and disposed of in Dyson's Pit.	70,000	NA	NA
Old Stockpile Area	Run of Mine ore stockpile - stripped and covered during 1980s rehabilitation	130,000	NA	NA
Old Borrow Area	Several on site used for 1980s rehabilitation	126,000	NA	NA
Mt Burton Pit	Open pit mined for Uranium	7,490		NA
Mt Burton WRD	Storage of waste rock from Mt Burton Pit	13,893	5	105,000
Mt Fitch Pit	Open pit explored for Uranium. No ore abstracted – overburden was stripped.	6,608	NA	NA
Mt Fitch WRD	Stockpiled overburden from Mt Fitch Pit	7,000	11	<10,000
Radiological Soils	Areas where Uranium ore was stockpiled and milled/processed	154,900	NA	NA

\*Original pit volumes (NT-DPIR, December 2019)

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Most of the environmental and cultural values within the Rum Jungle site are compromised because of historic activities that have led to present-day site conditions. These conditions are characterised by degraded environmental quality due to Acid Metalliferous Drainage (AMD) and poor ecosystem establish across the mined landscape, degraded cultural conditions due to impact to sacred sites and disruption of the EBFR from its original flow path.

### 2.2.1 Cultural Landscape

The landscapes on site and in adjacent country are the traditional lands of the Kungarakan and Warai peoples with the majority of the site being surrounded by the Finnis River Aboriginal Lands Trust which is jointly held by these two groups. The cultural views across this country differ between the two peoples and is a reflection of their diverse connections and cultural ties to various aspects of the land and water. There are several sacred sites recorded on the Rum Jungle property along with several cultural heritage objects and places. The project is designed to protect existing heritage objects and places and to improve the cultural values onsite. Site assessment and development of a rehabilitation plan has been viewed through the lens of a physical and cultural landscape that has been impacted by historic activities.

## 2.3 Conceptual Site Model – Impact Pathways

A summary Conceptual Site Model is laid out in detail within the EIS (NT-DPIR, December 2019) and is provided in tabular form below in Table 2. This model summarises the source-pathway-receptors onsite for all sources of known contamination including for AMD, radiological sources and asbestos containing materials. The most significant contamination mechanism at the Rum Jungle site is the impact to ground and surface waters by AMD. The primary AMD sources are the sulphide-bearing waste rock in the historic WRDs, leached low-grade ore and contaminated soils placed in shallow zones of Dyson's Pit during initial rehabilitation in 1984/85. Groundwater quality in some areas is further degraded by AMD from sources that were eliminated during the 1980s rehabilitation works and by metalliferous liquor lost during an experimental heap leach operation from 1965-1971 in the Copper Extraction Pad area.

The objective of the project is to improve within water quality the EBFR and Finnis River proper to LDWQOs. Copper is the primary Contaminant of Concern as described in the Draft EIS. Impacts to the cultural landscape of historic activities are related to the course of the EBFR and the general environmental health onsite. Land access is also currently impacted by Asbestos Containing Materials and radiological soils present at surface. All works described in this Design Report are targeted at rectification of these physical, chemical and cultural aspects of the current site condition.

For comprehensive detail on the site condition, studies into the contaminating processes the reader is referred to the Draft EIS document (NT-DPIR, December 2019) and the detailed technical reporting within the Appendix of that report. Significant work has been completed over recent years to characterise site conditions and to establish an agreed future landform and land use with Traditional Aboriginal Owners. Additionally, information requested to support this Draft EIS will be provided within the Supplementary Report (NT-DPIR, June 2020).

**Table 2 Conceptual Site Contamination Model**

Source Details		Pathway Details	Receptor Details
Legacy WRDs and Operational Features (primary contamination sources)	<u>Tailings and Waste Rock Dumps</u> Intermediate WRD - PAF-I Main WRD - full range of PAF and NAF Dyson's Pit Overburden - PAF-I Dyson's WRD - predominantly NAF Main North WRD - contaminated spoil (NAF)	<u>Contamination Vectors from Waste Rock and Contaminated Soils</u> Atmospheric exchange due to cover-system absence or deterioration leading to increased acidification, sulphate and heavy metal release <i>via</i> seepage and/or leaching to groundwater. Capillary rise of contaminants through cover systems to surface soils. Seepage of impacts from landforms caused by infiltration and formation of elevated hydraulic pressure within mounded features. Salt affected soils and drainage channel / watercourse sediments (secondary source).	Surface water body and sediments (ultimately EBFR) Groundwater aquifer (and secondary source)
		<u>Surface Water and Groundwater Vectors</u> Lateral migration of impacted soils through fluvial and aeolian dispersion. Lateral migration of exposed residual contamination <i>via</i> surface water flow. Vertical or lateral seepage of contamination within groundwater.	
	<u>Rehabilitated Former Operational Areas</u> Copper Extraction Area - copper and sulphate Former Plant Site - radiological soils and asbestos containing legacy structures Old Tailings Dam Area - leached metal impacts in subsoils Old Stockpile Areas - radiological soils and isolated pocket of process liquor (in sub-surface)	<u>Radiation Vectors</u> Release of radon and radiation associated with radiological sources.	Atmospheric and dispersion
		<u>Ecological Vectors</u> Direct contact between terrestrial fauna and surface contaminants (sub-surface contaminants with burrowing fauna). Bioaccumulation in terrestrial and aquatic flora and fauna.	Terrestrial flora and fauna (within riparian zone) Aquatic flora and fauna (within surface water bodies)
		<u>Human Health Vectors</u> Ingestion of contaminated media <i>via</i> impacted flora, fauna, surface water and/or groundwater. Direct contact with contaminated soils, sediment, surface water and groundwater.	Traditional landowners / users, Site workers Other site visitors
Surface/Ground Water (secondary sources)	<u>Impacted Groundwater</u> AMD-impacted groundwater Cu liquor impacted groundwater <u>Legacy Mine Pits – Surface Waters</u> Intermediate Pit Main Pit <u>Surface Water Channels (and sediments)</u> EBFR Diversion Channel Upper EBFR Fitch Creek Former EBFR Channel (now incorporating Copper Creek)	<u>Surface Water and Sediment Vectors</u> Dispersion / migration of contaminants in surface water and sediments. Short term sinks for contaminated sediments. Concentration / settling of contaminants in slow moving or stagnant waters during dry seasons.	Surface water body and sediments
		<u>Groundwater-Surface Water Interaction (seasonally ephemeral)</u> Lateral seepage from groundwater to river in wet seasons. Vertical or lateral seepage from river to groundwater in dry seasons.	Groundwater aquifer
		<u>Ecological Vectors</u> Impacts to riparian zones from contaminated surface water, groundwater, sediment or WRD seepage. Bioaccumulation in aquatic flora and fauna.	Terrestrial flora and fauna (within riparian zone) Aquatic flora and fauna (within surface water body)
		<u>Human Health Vectors</u> Ingestion of (drinking) or direct contact with (bathing, recreational use) surface water. Ingestion of contaminated media <i>via</i> consumption of impacted flora, fauna, surface water and/or groundwater.	Traditional landowners / users, Site workers Other site visitors

### 2.3.1 Acid Metalliferous Drainage

The waste rock AMD processes at the Rum Jungle site are the most significant contributor to environmental impact, specifically Copper (Cu) both onsite and downstream EBFR via surface and groundwater pathways. Sulphide-bearing materials onsite are classified as either PAF or NAF, with PAF-I having the highest potential and PAF-III having the least, as based on conventional Acid Base Accounting (ABA).

The waste rock materials at Rum Jungle have been well characterised over time. As described by (RGC & Jones, 2019) approximately 85% of the volume of waste rock at the Rum Jungle site is PAF. Figure 4 is a graphical representation of the PAF waste rock characterisation across site by current storage location. A high proportion of all waste rock stored at the site is PAF-I. It is important to note that each pie chart represents a storage facility though stored volume at each facility varies.

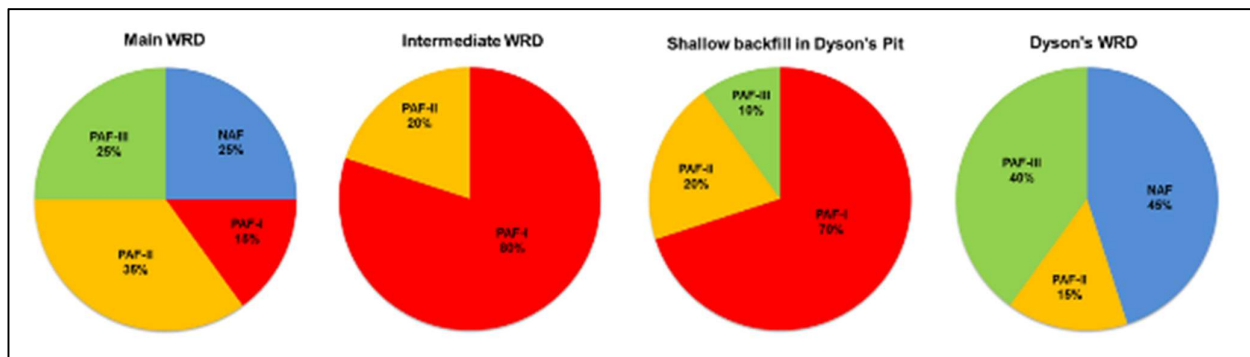


Figure 4 WRD Characterisation (RGC & Jones, 2019)

The contribution of Cu loading to the EBFR varies across the site, however the majority of this load is sourced from the Intermediate WRD and Main WRD. Figure 5 shows an example copper balance flow chart for site (2013-14 water year) that succinctly describes the movement of copper from the existing WRDs and other sources through the surface and groundwater systems to the EBFR (RGC, November 2019).

AMD impacts over time have led to the deterioration of groundwater quality below the Main and Intermediate WRDs and seepage from these two facilities along with that from Dysons Backfilled Pit and Dysons WRD contribute to surface water quality deterioration. The proportion of copper load from each of these system reaches is shown in **Figure 5** and **Figure 6**.

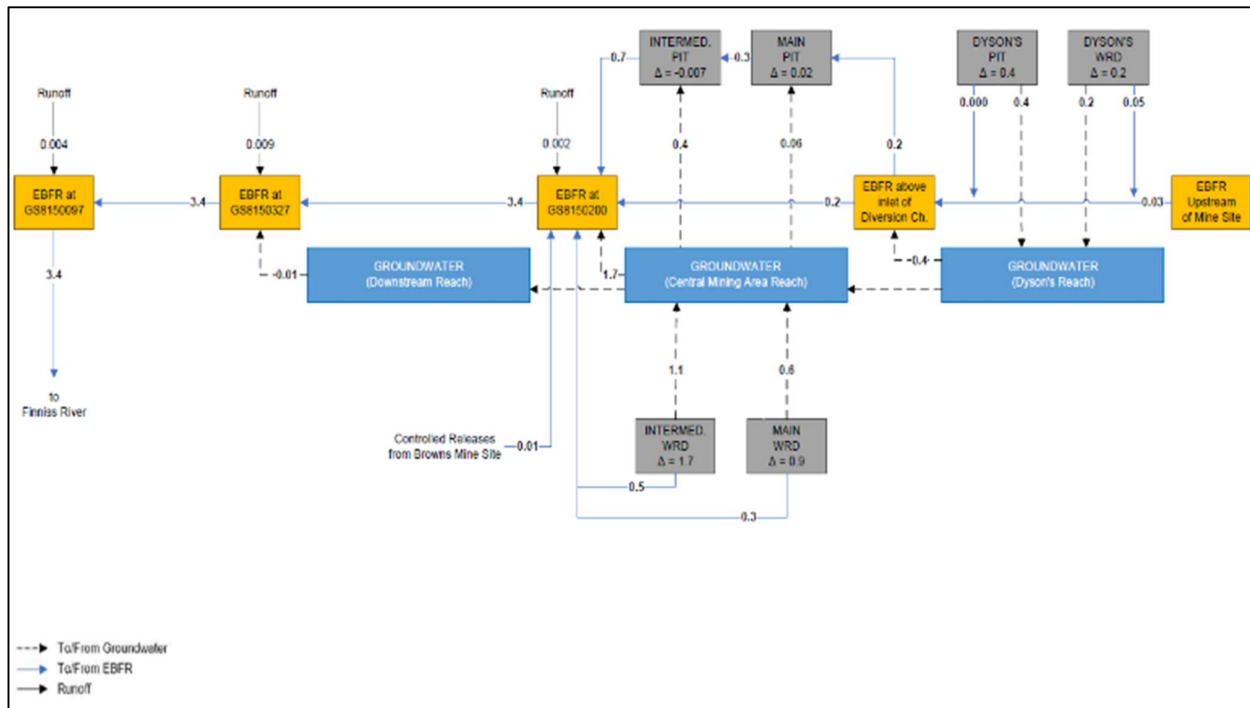


Figure 5 Copper Balance Flow Chart (RGC, November 2019)

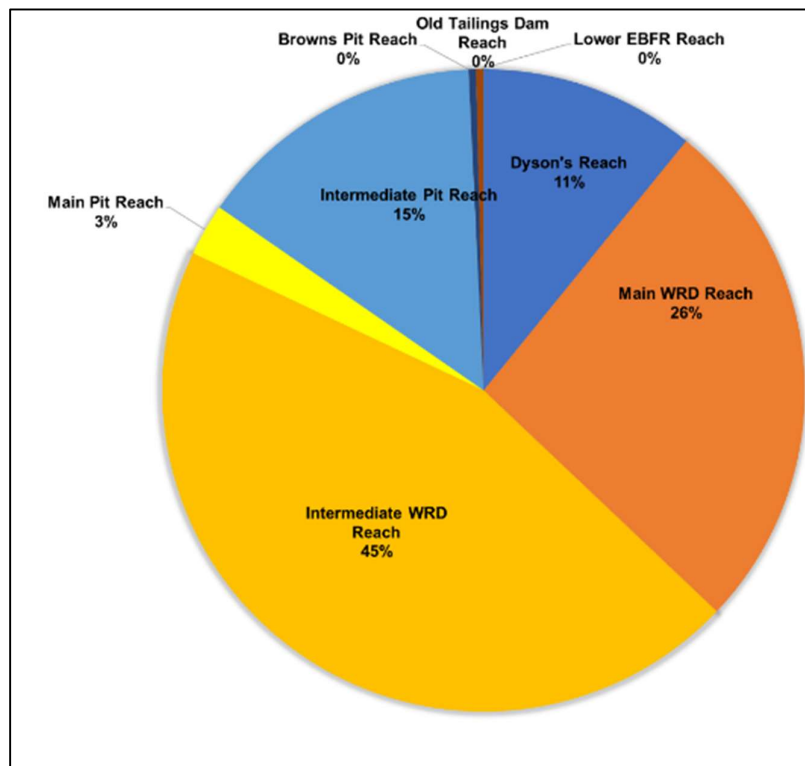


Figure 6 Contribution of Site Systems to Copper Loading

AMD processes for each facility are summarised briefly here and further detail is located in the EIS (DPIR, 2020).

- Dyson's WRD
  - Dyson's WRD contains around 55% PAF-II and PAF-III waste rock. It was constructed on or near the floodplain of the upper EBFR. The base of the dump is often inundated by the creek during the Wet season and there are multiple seepage areas where AMD reports directly to the EBFR. The top of Dyson's WRD was covered during initial rehabilitation in the 1980s but the rill slopes of the dump were not covered and remain at angle of repose. As a result, there is substantial infiltration of rainfall through the batter slopes.
  - Seepage from Dyson's WRD is acidic and is characterised by elevated  $\text{SO}_4$  and metal concentrations.
- Dyson's (backfilled) Pit
  - Dyson's Pit was mined to 47 m below ground surface (bgs) and has been backfilled with tailings to grade, and above-grade with leached, low-grade ore and copper contaminated soils from the copper leach pad. The backfilled pit was later covered, with a rock-lined drain along the centreline conveying rainfall runoff to the upper EBFR. There are uncovered rill slopes at angle of repose on this facility.
  - Shallow backfill materials in Dyson's Pit are a PAF. These materials are separated from the deeper tailings by a drainage layer, which conveys seepage to a toe drain along the southern batter of the backfilled pit and then to the upper EBFR via a surface channel. Both seepage and groundwater are acidic and characterised by elevated concentrations of  $\text{SO}_4$  and metals.
  - Tailings in deeper portions of Dyson's Pit are not considered a significant source of AMD because they are submerged year-round and therefore not oxidizing.
- The Main WRD contains up to 75% PAF. It is unlined and a cover system is in place from the 1980s rehabilitation. The physical cover was found to have deteriorated in the 1990s. Annual metal loads do not appear to be increasing over time, so the existing cover system is still having a beneficial effect.
  - Seepage from the Main WRD reports to groundwater and to an interflow seepage collection ditch along the western toe of the dump near the main access road to the site. Seepage samples from the ditch are acidic and characterised by highly elevated concentrations of  $\text{SO}_4$  and metals. Seepage from this ditch reports to Fitch Creek near the head of the EBFR diversion trench.
  - Groundwater can be characterised by very high  $\text{SO}_4$  concentration levels. Cu concentration levels are much lower than seepage values, implying attenuation in the aquifer and that Cu is not transported far beyond the perimeter of the Main WRD.
- The Intermediate WRD is 100% PAF. It is unlined and the majority was covered during the 1980s rehabilitation works. No cover was installed at the northern end where the toe of the dump terminates at the EBFR diversion channel.
  - AMD seepage from the Intermediate WRD is particularly detrimental to EBFR water quality due to its proximity to the EBFR and most of the AMD generated by the Intermediate WRD likely reports to EBFR via groundwater beneath the dump, via seepage interflow during the wet season and via the Intermediate Pit.
  - Groundwater near the Intermediate WRD is characterised by elevated  $\text{SO}_4$  but low concentrations of most metals, suggesting attenuation of metals in the unsaturated zone or saturated zone.
- Historic tailings stored within the Main Pit at depth are unlikely to be contributing load of copper and other metals to the receiving environment and are relatively well isolated below a significant column of water.

### 2.3.2 Other Impacted Groundwaters

Heap leaching operations were conducted in the Copper Extraction Pad area from 1965 to 1971. Substantial losses of metalliferous (Cu) liquor was reported during operation, primarily from an unlined storage ditch adjacent to the heap leach pad. Overflow from the ditch and excess barren liquors were also discharged to Copper Creek, which flowed northwest to the EBFR. In 2010, near-undiluted liquor was identified during a hydrogeological field investigation in this area:

- The liquor in the Copper Extraction Pad area appears to be restricted to a narrow zone of the bedrock aquifer that may correspond to a fault that is oriented east-to-west across the area between Main Pit and Intermediate Pit. It appears though that impacted water may reside in a system of cavities that may not be interconnected and could be isolated from groundwater in the surrounding bedrock aquifer. This suggests the liquor does not report to Intermediate Pit or to the EBFR and is therefore a localised groundwater quality issue. However, some load from this area (however small) cannot be completely discounted with the information available.
- Recent comprehensive testing indicates that the high Cu plume is limited to the northern side of the pad area with an approximate length of 325 m and width of 120 m, while the SO<sub>4</sub> plume is inferred to cover the full extent of the Copper Extraction Pad area.

Tailings were discharged to the Old Tailings Dam area during historic mining operations in the 1950s and 1960s. Most of the tailings that were in the Old Tailings Dam area were re-located to Dyson's Pit during rehabilitation in the 1980s and the area was subsequently covered and re-vegetated. Some small amounts of residual tailings have been identified but they are not considered a significant AMD source.

Groundwater in the Old Tailings Dam area is characterised by elevated SO<sub>4</sub> concentrations and low metal concentrations, likely due to attenuation in the Coomalie Dolostone. Groundwater in the former ore stockpile area near the Main Pit is an exception, where elevated Cu concentrations have been observed. These concentrations are attributed to seepage from a surface ore stockpile that was removed during initial rehabilitation in the 1980s and are unrelated to historic tailings.

### 2.3.3 Radiological Soils

Radiological risks to construction phase workers and potential future land users are posed by several sources onsite. An excavation plan has been developed to target removal and isolation of these sources of elevated radioactivity. For the purpose of Stage 3 worker safety, all waste rock stockpiles onsite are to be treated as a low radiological hazard as all waste rock contains Naturally Occurring Uranium Material (NORM) from the uranium (or copper) ore body from which they were mined.

### 2.3.4 EBFR Receptors

The ephemeral EBFR has been impacted by historic and current AMD processes at the Rum Jungle site.

Observed stream flows in the EBFR vary predictably in response to intra-annual variability in rainfall and typically vary by several orders-of-magnitude over the course of a year. Sustained flows in the EBFR typically start in December or January and persist until May when flows begin to substantially recede. No appreciable flows are observed from July to October.

A series of LDWQOs were established by (Hydrobiology, 2013) (Hydrobiology, 2016) to establish target quality objectives for improvement of the river condition. The purpose of this project is to improve the water quality in EBFR to meet as far as possible the LDWQOs.

The Draft EIS (NT-DPIR, December 2019) describes the following:

- 
- At present there are several locations that exceed these LDWQOs for several parameters. LDWQOs for Al, Cu, Co, and Fe are commonly exceeded in the EBFR downstream for Rum Jungle site regardless of the flow in the EBFR. This is, in part, due to naturally occurring suspended sediments that are included in total metal concentrations. LDWQOs for SO<sub>4</sub>, Mg and Zn are rarely exceeded if there are appreciable flows in the EBFR. The greatest impact from the site therefore occurs during the start of the Wet season when pools of highly contaminated (by metals and acid) water that have accumulated in the site drainage lines during the Dry are flushed out into the EBFR.
  - First flows at each gauge are observed in early December and peak flows occur in January and February before gradually receding in the subsequent months. At downstream gauge GS8150200, first flush pH values of around 4 and EC values higher than 1000 µS/cm are initially observed. Abrupt increases in flow in December 2017 are associated with higher pH values (to pH 5) and higher EC values, suggesting higher concentrations of SO<sub>4</sub>, Mg and some metals, and acidic water is being flushed from the EFDC towards gauge GS8150200 by cleaner water following high flows from the EBFR upstream. Later in the Wet season, short-term increases in flow cause lower pH and higher EC values, suggesting inputs of AMD-impacted groundwater from the site to the EBFR occurring between these flow periods. The trends at GS8150200 are generally consistent with the dilution of AMD inputs by EBFR flows from upstream, which explains the gradual increase in EC (and decrease in pH) during the late Wet season.

## 3 Rehabilitation Strategy

The scope of works for the Stage 3 Rehabilitation Project was developed from an understanding of current site conditions, contamination processes and a Land Use Plan goals as established with Traditional Aboriginal Owners. There are several key elements that have been incorporated in the strategy in order to satisfy the cultural needs of sacred site Custodians as far as practicable.

### 3.1 Remediation Action Plan

The actions planned to address contamination processes and improve prospects of future land use are described fully in the Draft EIS (NT-DPIR, December 2019) and are as follows:

- Slow down or halt the AMD production reactions from waste rock onsite by consolidating waste rock into one of three new facilities based on PAF characteristics. These facilities are:
  - Within the Main Pit backfill zone – ~1.47 Mm<sup>3</sup> storage for waste rock;
  - Within two new Waste Storage Facilities:
    - East WSF – ~3.77 Mm<sup>3</sup> storage volume; and
    - West WSF – ~1.88 Mm<sup>3</sup> stored volume.
- Slow down or halt the future generation and transportation mechanisms for copper and other metals in the new WSFs by adopting leading practice methodology for storage of PAF waste rock.
- Treat existing groundwater sources (i.e. the Main and Intermediate WRDs) that contaminate the EBFR by pumping and treating these impacted waters.
- Treat other AMD-impacted groundwater that does not contribute to the EBFR copper load (i.e. old ore stockpile area) by pumping and treating these impacted waters.
- Isolate radiological, AMD or metal impacted soils at the Rum Jungle site, Mt Burton and Mt Fitch from environmental and human receptors by relocating these soils to the new WSFs on site.

Detail on these actions are described within this Design Report.

### 3.2 Reestablishment of Cultural Values

The actions that are planned to address the compromised environmental and cultural values that are not related to contamination processes are:

- Return the EBFR to its original course as far as possible. The original course is discussed in (NT-DPIR, December 2019) and is shown representatively in **Figure 7**.
- Restore land parcels that are poorly vegetated such as the Old Tailings Dam area and vine thicket stand.
- Revegetate new landforms to stabilise the surface and restore ecological function as far as practicable.

Detail on these actions are described or referenced within this Detailed Design Report.

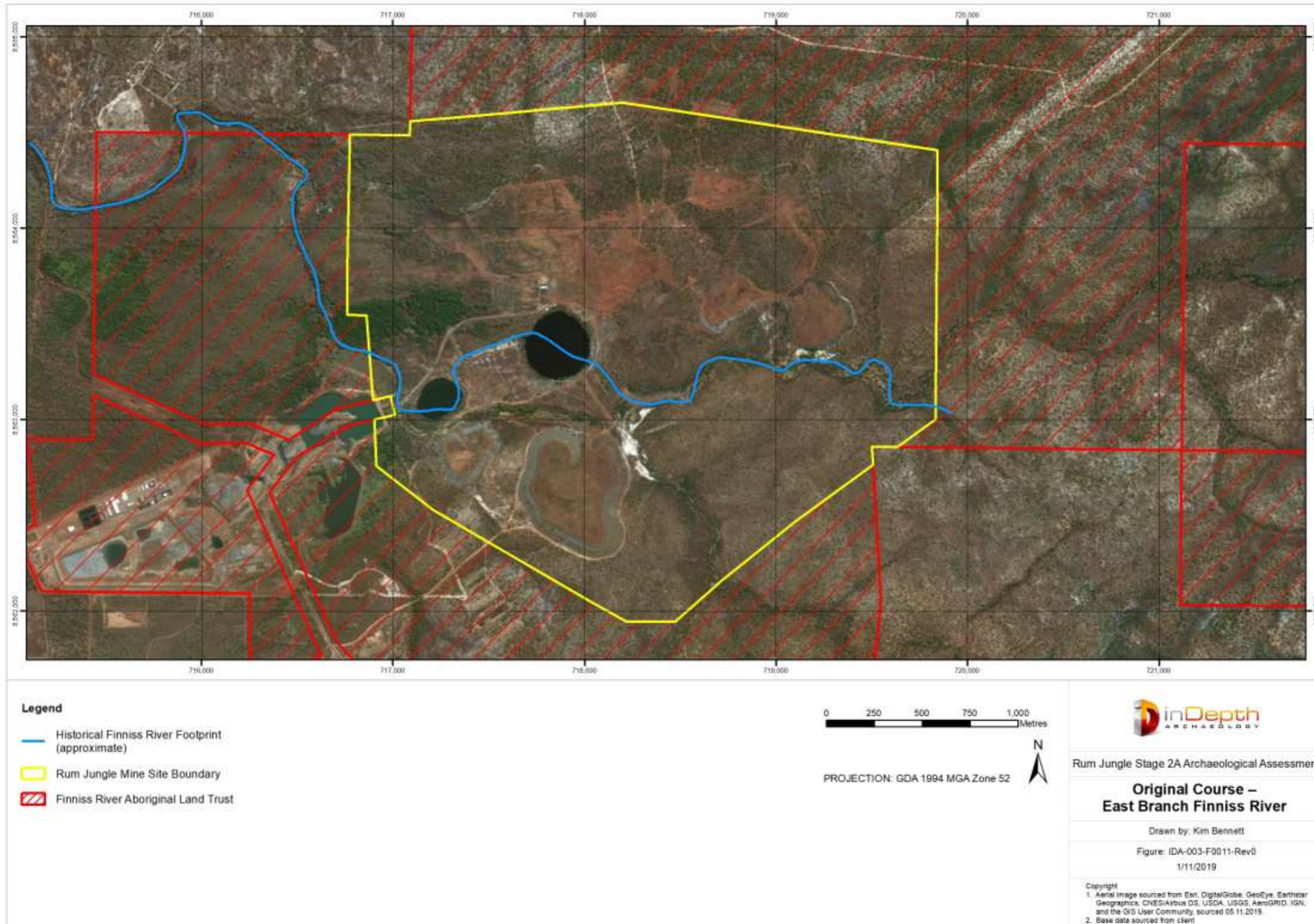


Figure 7 Estimated Original Course of the EBFR (K. Martin-Stone, 2019)

### 3.3 Final Site Condition (Land Use Plan)

A Land Use Plan has been developed by a panel of Traditional Aboriginal Owners, the NTG and Australian Government officers, which considers the traditional views across both Warai and Kungarakan related to the Rum Jungle site. The Land Use Plan is shown in **Figure 8**.

There will be little remaining post-**Stage 3** construction infrastructure retained on site however the Cultural Centre and several roads will be retained for site maintenance and monitoring activities through both **Stage 3** and in future stages.

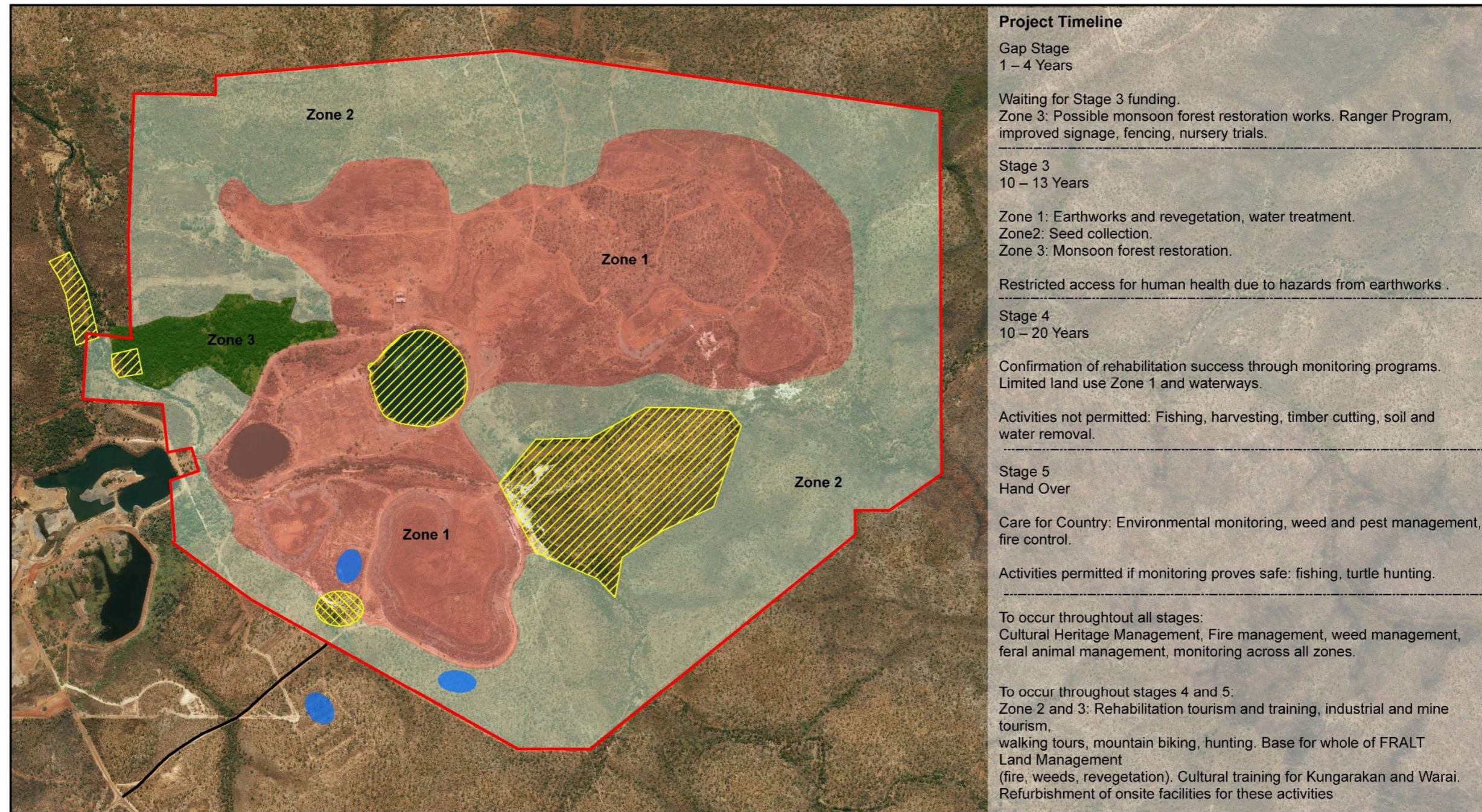


Figure 8 Land Use Management Plan (NT-DPIR, December 2019)

## 4 Stage 2A Detailed Design Scope of Works

### 4.1 Background

The Stage 2A Detailed Engineering Design for the Project has comprised reviewing, updating, refining and/or redesigning aspects of the Stage 2 Preliminary Engineering Design by others.

SLR was engaged under Contract No. D17-0252 in June 2018. The original scope of works has varied significantly over the period of engagement under a flexible arrangement with NT DPIR. The final agreed Design Scope and Stage 2A Deliverables suitable to meet the NT Partnership Agreement with the Australian Federal Government are summarised in **Section 4.2**.

### 4.2 Key Design Scope and Deliverables

The scope of work and associated deliverables from Stage 2A is summarised in **Table 3**.

**Table 3 Stage 2A Scope of Work and Deliverable Summary**

Item	Scope and Deliverable	Report Section	Report Reference
Item	Geotechnical Assessment	Section 5	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Geotechnical Investigation Waste Storage Facilities and Borrow Areas (SLR, 2020a)
1	Material Movement and Prioritisation	Section 8	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Waste Storage Facilities and General Site Civil Works Detailed Design and Construction Methodology Report (SLR, 2020g)
2	Main Pit Backfilling	Section 9	
3	Detailed Design Report		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Main Pit Backfill Strategy (SLR, 2020b) Geotechnical Considerations (SLR, 2020bb)
3a	Technical Specifications		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Technical Specification Main Pit Backfill (SLR, 2020c)
3b	Design Drawings		680.10421-MPT Series 680.10421-GEN Series
3c	Bill of Quantities		680.10421 BOQ Main Pit Backfill Issued for Implementation.xls
3d	Water Treatment Plant (WTP) (includes groundwater interception system)	Section 10	
4	Detailed Design Report		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Water Treatment Facility Design Report (SLR, 2020d)
4a	Technical Specifications		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Technical Specification Water Treatment Plant (SLR, 2020e)
4b	Design Drawings		68010421.WTP Series 680.10421-GEN Series

Item	Scope and Deliverable	Report Section	Report Reference
4c	Bill of Quantities		680.10421 WTP Issued for Implementation V1.xls
4d	General Civil and Earthworks		
5	Waste Storage Facilities and General Site Civil Works	Section 11	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Waste Storage Facilities and General Site Civil Works Detailed Design and Construction Methodology Report (SLR, 2020g)
5a	WSF Site Selection		WSF Technical Memo on Site Selection (SLR, 2020h)
5b	WSF Erosion Modelling		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Erosion Assessment for New Waste Storage Facilities (SLR, 2020f)
5c	WSF Growth Medium Design		Memo M06 Growth Medium for WSF Capping (SLR, 2020i)
5d	WSF Cover Options Assessment		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Waste Storage Facilities (WSF) Cover Options Analysis (SLR, 2020j)
5f	Borrow Pit Development	Section 12	Memo M03 Borrow Pit Development (SLR, 2020k)
5g	Material movement	Section 8.6.3	Appendix E of 4a. (SLR, 2020g) MEC Mining, Haulage Model, SLR Rum Jungle (MEC, 2020a)
5h	Haul Road Design	Section 16	Appendix F of 4a. (SLR, 2020g) MEC Mining, Haul Road Design, SLR Rum Jungle (MEC, 2020b) MEC Drawings Set
5i	EBFR Diversion Drain Crossing	Section 17	Appendix G of 4a. (SLR, 2020g) Pritchard Francis Drawing Set
5j	External Roads	Section 18	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Traffic Impact Assessment External Roads (SLR, 2020q)
5k	Cultural centre	Section 21	Appendix A of 4a. (SLR, 2020g) Memo M04 Cultural Centre (SLR, 2020m)
5l	Technical Specifications		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Technical Specification Waste Storage and General Site Earthworks (SLR, 2020n)
5m	Design Drawings		680.10421-GEN Series 680.1042-WSF Series 680.1042-BOR Series 680.10421-BEW Series 680.10421-RHE Series 680.10421-HR Series 680.10421-C0-C7 Series
5n	Bill of Quantities		680.10421 BoQ Civil and Earthworks v1.xls
5o	Surface Water Management		
6	Erosion and Sediment Control	Section 13	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Site Erosion and Sediment Control Measures (SLR, 2020o)
6a	Realignment of EBFR	Section 14	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design East Branch Finnis River – River Reinstatement and Flooding Design Report (SLR, 2020p)

Item	Scope and Deliverable	Report Section	Report Reference
6b	Technical Specifications		Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Technical Specification Waste Storage and General Site Earthworks (SLR, 2020n)
6c	Design Drawings		680.14021-RFR Series 680.10421-GEN Series
6d	Bill of Quantities		680.10421 E&W Issued for Implementation.xls
6e	Value Engineering	Section 22	Rum Jungle Rehabilitation - Stage 2A Detailed Engineering Design Value Engineering Summary (SLR, 2020L)
7	Stage 3 P80 Construction Cost		
8	Cost	Section 23.1	Turner and Townsend Rum Jungle Rehabilitation Basis of Estimate and Schedule for Stage 3
8a	Schedule	Section 23.2	
8b	Quantitative Risk Assessment (QRA)	Section 23.3	
8c			

### 4.3 Scope by Others

In order to deliver the detailed engineering design, SLR has relied on a variety of specialist design data provided by others contracted to NT DPIR, including:

- Geochemical advice, including:
  - RGC & Jones. (2019). Rum Jungle Mine Site – Physical and Geochemical Characteristics of Waste Rock and Contaminated Materials (Rev 2); and
  - RGC. (November 2019). Robertson GeoConsultants Inc. Groundwater and Surface Water Modelling Report, Rum Jungle.
- Conceptual Engineering and Environmental Design:
  - O'Kane Consultants Pty Ltd. (2016). Former Rum Jungle Mine Site; Detailed Civil Works Design for Rehabilitation - Design Report . Darwin: Northern Territory Government.
- Various specialist advice as referenced in:
  - NT-DPIR. (December 2019). Northern Territory Government, Department of Primary Industry and Resources - Draft Environmental Impact Statement, including:
    - Radiation management (EcOz, 2019a); and
    - Archeological and cultural considerations (K. Martin-Stone, 2019).
  - Hydrobiology. (2016). Rum Jungle Impact Assessment, Final Report (Issue June); and
  - Hydrobiology (2013). Environmental Values Downstream of the Former Rum Jungle Minesite – Phase 1.

## 5 Basis of Design

The Basis of Design (BOD) was developed in spreadsheet format to capture the principles, assumptions and considerations used for the development of the Detailed Design. The BOD was developed iteratively between SLR and NT DPIR to ensure that not only the engineering and environmental considerations were captured, but that the cultural considerations of the TOs were included as well.

A copy of the BOD is contained in **Appendix A**.

## 6 Geotechnical Site Conditions

A combination of desk top review of historical and recent geotechnical reports and intrusive geotechnical investigations were undertaken to assess the ground and groundwater conditions for:

- Rum Jungle Mine Site – including two proposed Waste Storage Facilities (WSFs) and haul road alignments;
- Clay and growth medium borrow area (Borrow Area A); and
- Granular and growth medium borrow area (Borrow Area B).

### 6.1 Desk Top Study and Ground Investigations

SLR has undertaken geotechnical ground investigations in July and October 2019 to facilitate the detailed design works required. The fieldworks comprised of a series of test pits, in-situ Dynamic Cone Penetrometer (DCP) testing, and geotechnical laboratory testing.

The results of the ground investigations are provided in SLR Report “*Geotechnical Investigation – Waste Storage Facilities and Borrow Areas*”, May 2020 (SLR, 2020a) along with the findings from the desk top review of the historical geotechnical reports.

### 6.2 Relevant Results

#### 6.2.1 Rum Jungle Mine Site

This area contains three main areas of interest:

- West WSF
- East WSF
- Haul road alignment

##### West WSF

- The footprint largely encompasses the old stockpile area (for waste rock and ore materials) and has been rehabilitated to a terraced slope by cut, waste rock fill and cover.
- General ground conditions comprise of up to 6m thick of fill (cover) underlain by waste road and natural superficial deposits (clayey gravel, sandy or gravelly clay, cobbles and boulders). Weathered rock was encountered from 1.2m to 1.8m below ground level (bgl).
- The natural soils in this area would be suitable for use as general fill materials and have potential as road construction material in terms of geotechnical properties. However, the soils are likely to be contaminated due to the previous land use and therefore, reuse of site won materials from this area might not be possible.

##### East WSF

- The footprint covers old borrow area (for low permeability soils and growth medium) and existing haul roads.
- Road base (associated with existing haul road) and filter cake (associated with rehabilitation works in 1980) materials were encountered along with other superficial deposits (clay, silt, sand and gravel). Bedrock was encountered from between 2.5 m and 3.3m bgl.

- Groundwater was encountered in some test pits in the area between 2.8 m and 4.0 m bgl during the investigation.
- The clay materials from the northern portion of this area is likely to be suitable for use as low permeability layers, with appropriate moisture content, compaction and granular materials addition.
- Water treatment waste (filter cake) was used to backfilling an old clay borrow area used in the 1980 rehabilitation. Approximately 76,000 m<sup>3</sup> filter cake material is believed to be located in a pocket located in the western portion of the proposed East WSF envelope.

### **Haul Road Alignment**

- Since the final alignment was to be optimised at the time of fieldwork, ground investigation was undertaken along the preliminary haul road alignment only.
- The laboratory test results indicate that the California Bearing Ratio (CBR) of the potential haul road subgrade ranges from 20 % to 40 %.

### **6.2.2 Borrow Area A**

- The ground conditions in this area generally comprised of up to approximately 5m thick residual fine-grained soils underlain by rock.
- The low permeability clays in this area is suitable for use in the proposed Rehabilitation works.

### **6.2.3 Borrow Area B**

- The ground conditions in this area generally comprised of up to approximately 4m thick of sand and gravel underlain by rock.
- The granular materials in this area is suitable for use in the proposed Rehabilitation works with approximately moist content and compaction.

### **6.2.4 Growth Material**

- Assessment on suitable growth materials for the waste rock capping was undertaken as part of the investigation. The results of the assessment suggest Kandosol soil would be suitable growth material for the project.
- Borrow Areas A and B are both suitable sources to create Kandosol-equivalent soil.

## **6.3 Site Materials**

Use of site won material for construction is not feasible. Previous rehabilitation works have depleted potential borrow sources. Excavation beneath the WSFs for borrow is not feasible due to the high water table (East WSF) or contaminated material (West WSF).

## **6.4 Groundwater**

Groundwater is generally found less than 12 m below existing ground surface, with an average depth to water of 4.0 m. Groundwater is nearer the surface (<3.0 m below the surface) proximal to Giant's Reef Fault on the northern side. Groundwater is strongly influenced by wet and dry season rainfall fluctuations, with groundwater level typically 5 m to 7 m higher during wet season periods.

Shallow groundwater was encountered in test pits proximal to the Giants Reef Fault near the East WSF as the fault appears to act as a sub-surface barrier to south trending groundwater flows.

Within Borrow Area B, no known groundwater studies exist, however the local topography indicates that groundwater flows in a north-easterly direction towards natural drainage channel of Eastern Branch Finnis River. The flow is likely within influenced by structural elements within the granite or deeper lying lithologies, altered by mapped faults, which are likely to act as barriers or flow paths.

Similarly, for Borrow Area A, minimal groundwater studies exist. However, based on the local topography, it is anticipated that groundwater flows in a south-westerly direction towards the tributaries of the Finnis River. Groundwater is likely influenced by seasonal variation, and in times of high rainfall it is possible that the underlying rock layer may act as a semi impervious layer resulting in a perched groundwater table at the soil/rock interface.

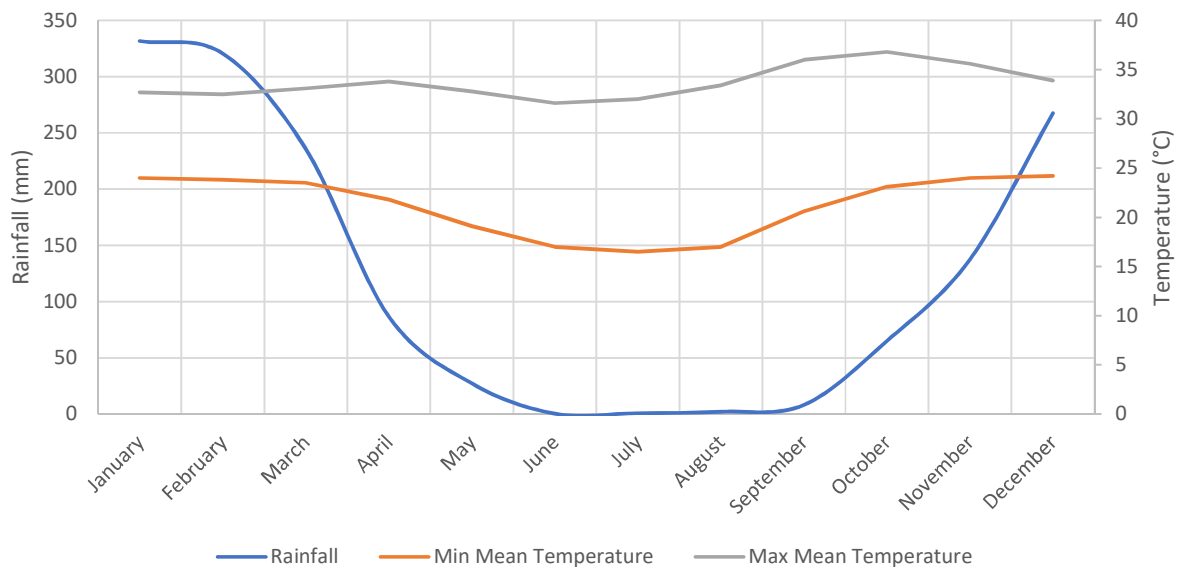
## 7 Climate

The climate of Rum Jungle area is considered to be ‘tropical savanna’ in accordance with the Köppen classification system used by the Bureau of Meteorology (BoM). The area receives approximately 1500mm of annual rainfall and is marked as ‘Summer Dominant’ climate characterised by wet summers and dry winters (Bureau of Meteorology, 2005). The great majority (>90%) of precipitation occurs between November to April with little rainfall seen between May to October. Table 4 shows the monthly average rainfall and mean minimum and mean maximum temperature as recorded at the Batchelor Airport Station (014272) (6.5km south east) from 1992 to 2019.

**Table 4 Average Rainfall and Temperature 1992-2019 (Batchelor Airport 014272)**

Aspect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>Rainfall (mm)</b>	331.7	320.6	235.8	86.8	27.3	0.4	0.8	2.1	8.1	65	137.5	267.5
<b>Min Temp (°C)</b>	24	23.8	23.5	21.8	19.1	17.0	16.5	17.0	20.6	23.1	24	24.2
<b>Max Temp (°C)</b>	32.7	32.5	33.1	33.8	32.8	31.6	32	33.4	36	36.8	35.6	33.9

As shown above, the lowest minimum mean temperature for Batchelor is 16.5°C (July) and highest maximum mean temperature is 36.8°C (October). The minimum mean monthly rainfall is 0.4mm (June) and maximum is 320.6mm (February).



**Figure 9 Climate Data**

## 8 Material Movements and Prioritisation

### 8.1 Objectives and Approach

Relocation of waste rock and impacted soils is to be scheduled so as to:

- Limit worker health and safety by minimising exposure to radiological materials during construction;
- Limit open faces of both the existing WRDs (during deconstruction) and the new WSFs (during construction) during wet season to minimise potentially contaminated runoff; and
- Worst PAF (PAF I and II) are stored below the groundwater level in the Main Pit.

### 8.2 Impacted Material Sources

Identification of impacted material sources has been undertaken by others as part of the Stage 2 Engineering Design. SLR has determined the volumes of materials based on the advised Stage 2 footprints of impacted materials and height determined by LiDAR (2016).

Figure 10 shows the locations and volumes of the impacted material sources.

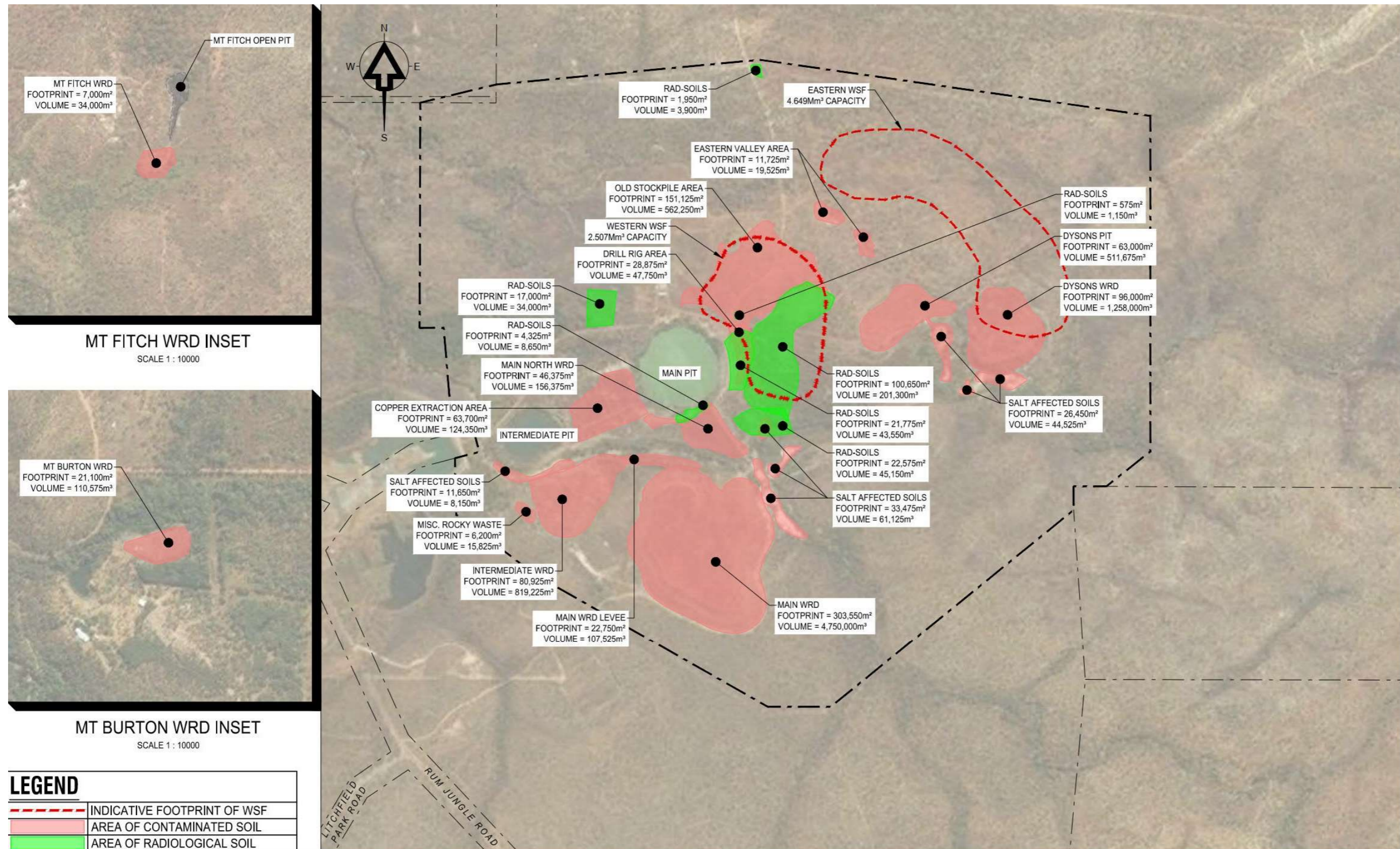


Figure 10 Impacted Material Locations

### 8.3 Material Prioritisation

Material prioritisation to the WSFs is based on limiting human health and environmental impacts, as well as practical constructability requirements, and is recommended to be as follows:

1. All radiological soils must be relocated to the WSFs and covered as first priority.
2. Intermediate WRD and Dysons Pit Overburden are to be first priority to the Main Pit.
3. While Main WRD is to be given preference for relocation to the WSFs (ahead of other WRD and impacted soils) it is essential that sufficient volume is retained for relocation to Main Pit (after the Intermediate WRD and Dysons Pit Overburden), as storage in the Main Pit is preferred for this higher PAF material.
4. Dyson's WRD material, which is generally NAF to very low PAF, will be used to form starter embankments for the WSFs and also be placed as an oxygen scavenging beneath the formal cover system.
5. Main North WRD to be relocated as soon as practical (preferably Year 1) to allow room for the Main Pit backfill activities to be undertaken.
6. Mt Burton WRD material should be the next priority.
7. Relocation of the copper extraction area, Main WRD levee, metal and salt impacted soils and miscellaneous rocky waste may occur in any order, to optimise construction timing.
8. Mt Fitch WRD is to be relocated to the adjacent Mt Fitch open pit.

### 8.4 Material Characterisation

The total in-situ volume of impacted materials to be moved is 7,563,525 m<sup>3</sup>. The volumetric breakdown of materials is as shown in **Table 5**.

**Table 5 Total Impacted Volume to Move**

Source	Reason for Relocation <sup>1</sup>	Volume m <sup>3</sup>	Relocated to:
Radiological Soils	Radiological	135,725	WSF
Intermediate WRD	PAF I	734,900	Main Pit
Dysons Pit Overburden	PAF I	443,425	Main Pit
Main WRD	PAF II and III	4,529,675	WSF
Main North WRD	PAF II and III	119,000	WSF
Dysons WRD	PAF III and NAF	1,190,250	WSF
Main WRD Levee	Landform shaping	68,975	WSF
Copper Extraction Area	High copper levels	143,050	WSF
Old Stockpile Area	Trace uranium ore	62,700	WSF
Salt and metal impacted soils	Salts and metals	12,400	WSF
Miscellaneous rocky piles	Landform shaping	2,850	WSF
Mt Burton WRD	Trace uranium ore	110,575	WSF
Mt Fitch WRD	Landform shaping	10,000	Mt Fitch open pit

Note: 1. From (NT-DPIR, December 2019), (EcOz, 2019b) and (RGC & Jones, 2019)

In addition to the above, clean borrow materials for WSF capping and Main Pit bedding and capping will be required from offsite. These material movements will be in parallel with the impacted material movement to ensure that the WSFs are capped progressively.

## 8.5 Material Volumes

### 8.5.1 Main Pit Volume

The total capacity of the Main Pit, based on 2015 Bathymetry, is 2,173,228m<sup>3</sup>. The volumetric breakdown of materials to the pit is provided in Table 6.

**Table 6 Main Pit Volumetric Breakdown**

Layer	Volume of Material m <sup>3</sup>
Available Capacity	2,173,228
Sand bedding layers	80,196
Inert Capping Layer	176,692
Capacity available for waste rock (before bulking and lime treatment) <sup>1</sup>	1,916,340
Waste rock to be relocated to Main Pit (after bulking and lime treatment)	<b>1,474,108</b>

Note: 1. Assumed bulking and liming factors as per (SLR, 2020b)

### 8.5.2 New WSF Volumes

The total volume capacity required from the new WSFs is therefore 7,553,525m<sup>3</sup> less 1,474,108m<sup>3</sup> which is **6,079,417m<sup>3</sup>**.

### 8.5.3 Borrow Material Volumes

Derivation of borrow material volumes are discussed in the WSFs and Main Pit Backfill detailed design sections (Sections 10 and 9 respectively). The volumes are summarised here in Table 7 for completeness.

**Table 7 Borrow Material Volumes**

Material Type	Volume m <sup>3</sup>
Sand for bedding layer in Main Pit Backfill	76,178
Clean fill for capping of Main Pit after backfilling	158,124
Low permeability material for WSF cover system	381,569
Growth medium for WSF cover system and backfill of excavated footprints	2,887,445

## 8.6 Material Movement Schedule

### 8.6.1 Movement Rates

Through consultation with NT DPIR, SLR design team and experienced construction personnel, the material movement rates (BOD) for movement of all waste rock and impacted soil have been developed as shown in Table 8.

**Table 8 Material Movement Rates Basis of Design**

Parameter	Value	Comments
Dry Season	01 May – 30 November (approx. 30 weeks)	
Wet Season	1 December – 30 April (approx. 17 weeks)	Includes a 4-week break over Christmas period
Operational hours/days for WSF construction	12 hours per day, 7 days per week	Typical efficiency of 70% means 8.4 hours of working per day
Waste rock bulking factor in WSF (allowing for addition of lime)	0.9	
Haulage bulking factor (all materials, from in-situ to truck)	15%	
Radiation soils, salts etc bulking factor in WSF	0.9	No lime addition
Dry season WSF construction rate (PAF soils)	5000 m <sup>3</sup> /day	These may be varied if all Geotech and Geochem quality requirements are met
Wet season WSF construction rate (PAF soils)	3000 m <sup>3</sup> /day	
Dry season WSF construction rate (salt, radiation, miscellaneous soils)	7500 m <sup>3</sup> /day	
Wet season WSF construction rate (salt, radiation, miscellaneous soils)	5000 m <sup>3</sup> /day	
Dry Season Borrow Materials – Borrow Area A (Clay & Growth Medium)	5000 m <sup>3</sup> /day	Clay materials for low permeability WSF cover. Growth Medium for WSF slopes.
Wet Season Borrow Materials – Borrow Area A (Clay & Growth Medium)	3000 m <sup>3</sup> /day	
Dry Season Borrow Materials – Borrow Area B (Growth Medium)	7500 m <sup>3</sup> /day	Growth Medium for WSF plateaus and excavated footprints.
Wet Season Borrow Materials – Borrow Area B (Granular Material & Growth Medium)	5000 m <sup>3</sup> /day	

### 8.6.2 Movement Schedule

Material source priority to the WSFs is as follows:

**Table 9 WSF Source Material Priority**

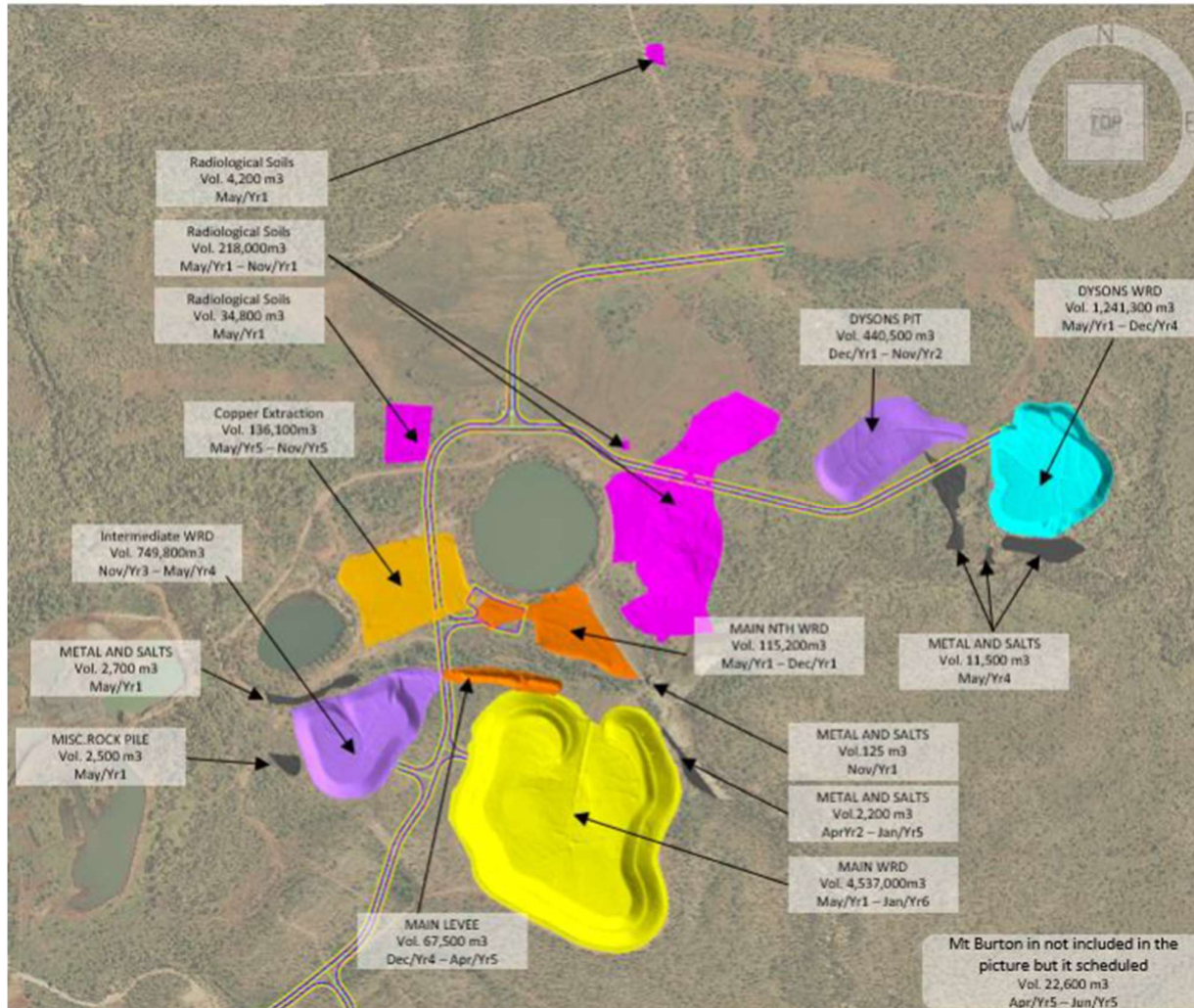
Source	Location	Year 1		Year 2		Year 3		Year 4		Year 5	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Intermediate WRD	Main Pit										
Radiological Soils	WSF										
Main WRD	WSF										
Main WRD	Main Pit										
Dyson's Overburden	Main Pit										
Dyson's WRD	WSF										
Main North WRD	WSF										
Metal and Salt Impacted Soils	WSF										
Miscellaneous Waste Rock Piles	WSF										
Main WRD Levee	WSF										
Mt Burton WRD	WSF										
Copper Extraction Pad	WSF										

### 8.6.3 Block Modelling

In order to optimise the material movement and construction sequencing, preliminary block modelling using Deswik has been undertaken (MEC, 2020). Key points to note are:

- The block modelling is a reference design / model and has been used to inform optimal vehicle movements.
- Material movement has been based on the production rates and movement order provided by SLR. The WSF siting report (SLR, 2020h), recommended that the West WSF be developed first followed by the East WSF. In initial discussions MEC recommended that developing the East WSF might be more optimal for access and haulage, hence the decision was made to develop the block model in the configuration as follows:
  - East WSF from north to south; then

- West WSF from north to south.
- The schedule of deconstruction of WRDs and impacted soils is shown in **Figure 11**.



**Figure 11 WRD and Impacted Soil Relocation Schedule**

- The schedule of construction of the new WSFs is shown in **Figure 12**.

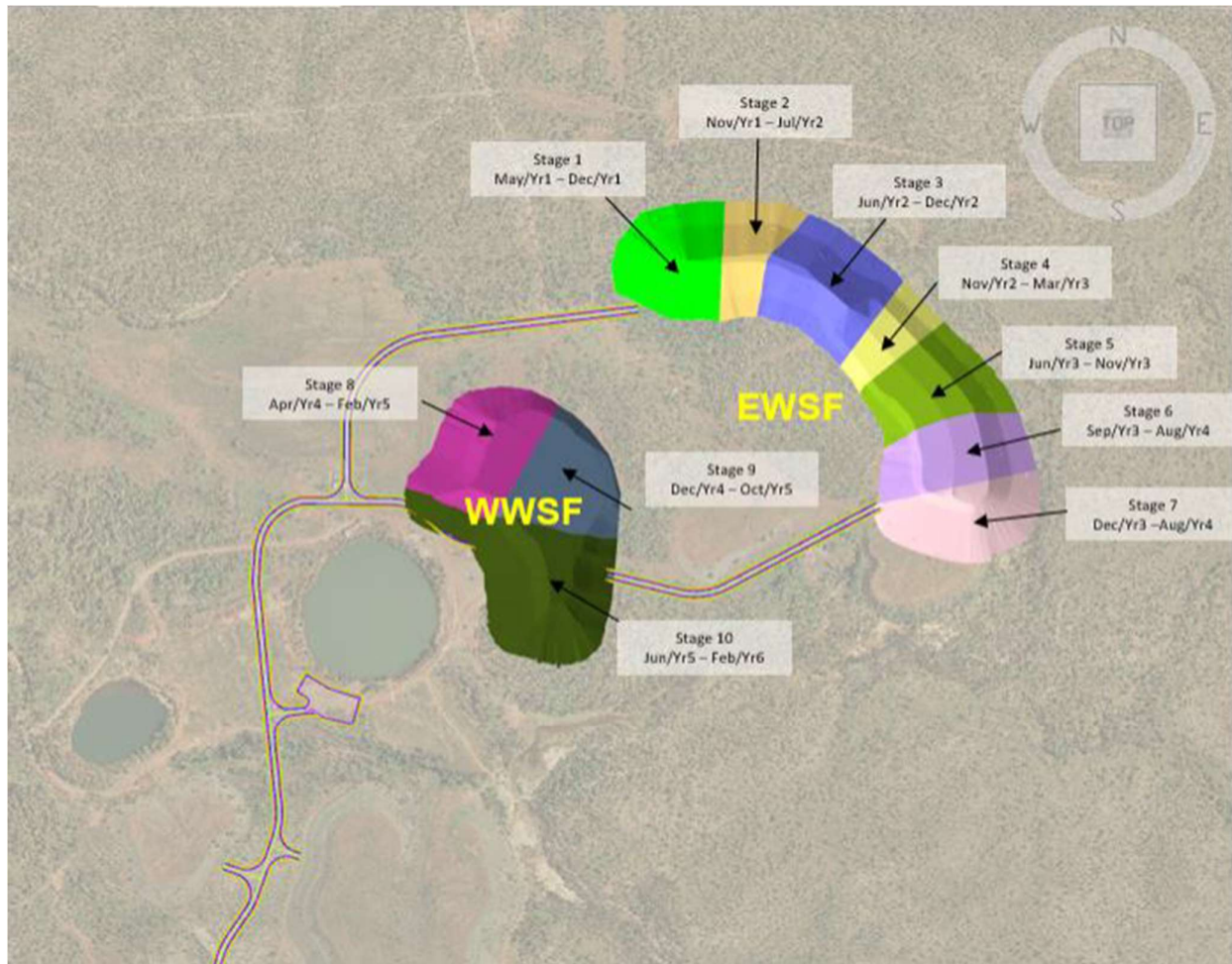
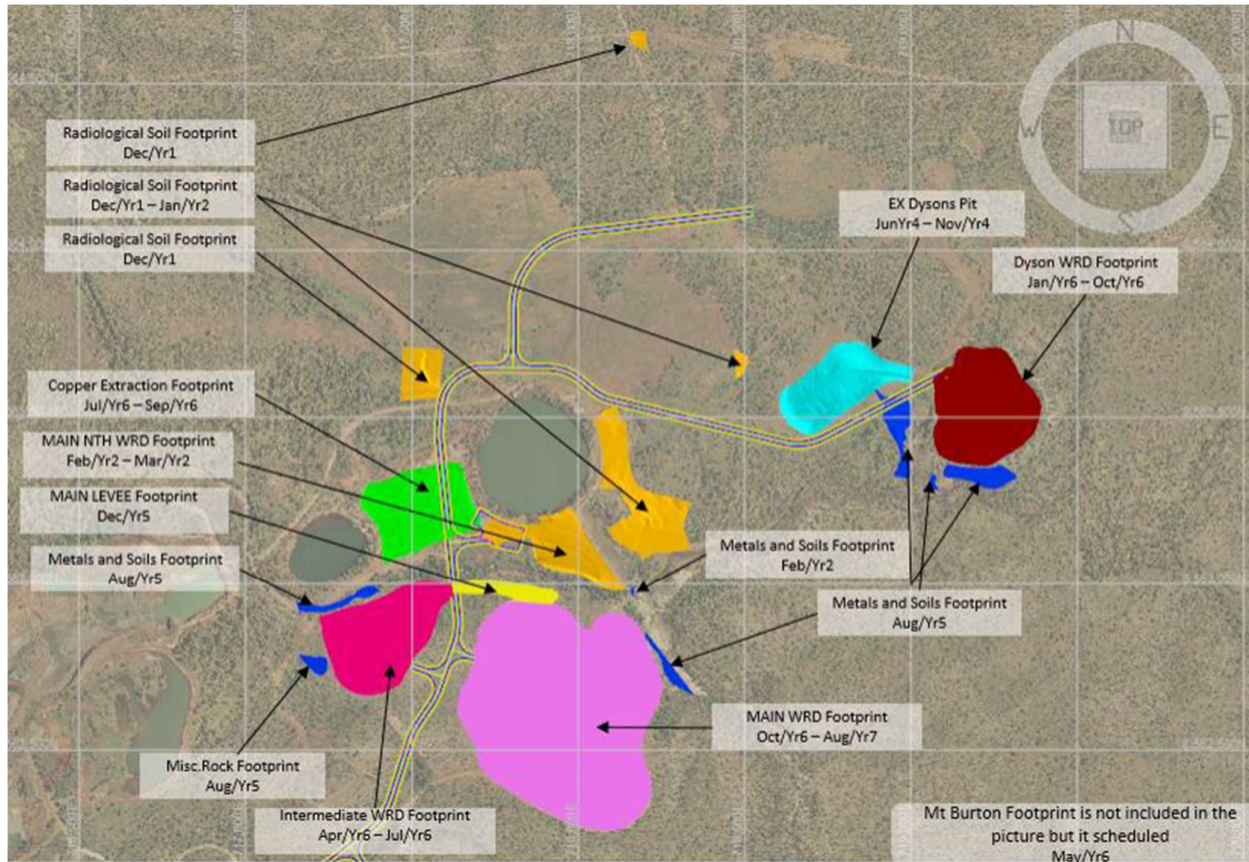


Figure 12 Waste Storage Facilities Construction Sequence

- The schedule for backfilling excavated footprints (after any lime treatment and flushing if required) is shown in **Figure 13**.



**Figure 13 Excavated Footprint Backfill Schedule**

Additional to the above, the output of the modelling includes truck numbers and hours.

It is the intention that the Deswik block modelling be updated by the Construction Contractor on award of the Project work in order to optimise material movements.

---

## 9 Main Pit Backfill Strategy

Full details of the design and strategy for the Main Pit backfill are given in SLR Report “*Main Pit Backfill Strategy*”, (SLR, 2020b) and “*Main Pit Backfill Strategy – Geotechnical Considerations*” (SLR, 2020bb). Key points are summarised here.

It is important to note that this is a reference design that has been developed by SLR in conjunction with advice from specialist barge operators. Provided the key constraints identified in Section 9.5.1 are met, the actual backfill methodology may be varied.

### 9.1 Objectives

At the end of its mine life, the Main Pit was reported to be approximately 105 m deep with a base at RL -35m. Following rehabilitation works in the 1980s, uranium tailings were disposed of within the pit to an elevation of +14.18m RL. Groundwater has naturally stabilised within the Main Pit at levels ranging from +58.95m RL (Minimum dry season level) to RL +61.59m (Maximum wet season level). An impacted water layer, or chemocline, is present from RL 22.0m (as per 2008 monitoring data).

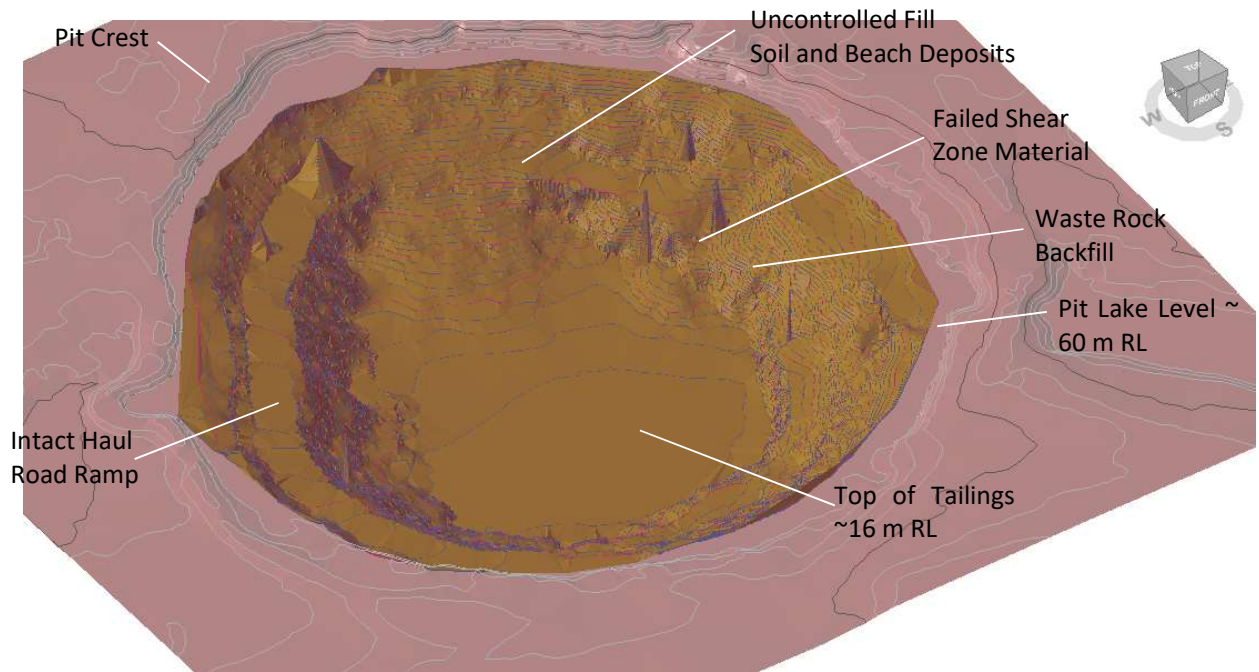
The aim of the remediation strategy is to allow the:

- Backfill of the Main Pit with the highest-grade PAF. The backfilling strategy is to be aimed at:
  - Preventing bearing capacity failure of the in-situ tailings (i.e. ensure that placement of fill on tailings do not cause the tailings to displace, which can mobilise further contaminants);
  - Minimising disturbance of the chemocline layer, which can mobilise further contaminants;
  - Mitigating and minimising slope instability risk inherent within the Pit walls during and following construction;
  - Backfilling at rates conducive to the treatment of displaced Main Pit water by the WTP; and
  - Ensuring the safety of people and equipment during construction.
- Development of a long-term shallow pit lake. To allow this backfill approach should allow for:
  - PAF placed to a final level no greater than RL 56.0m AHD (after allowing for potential settlement of the in-situ tailings and placed backfill); and
  - Finished capping level placed to a level no greater than RL 58m AHD.
- Realignment of East Branch Finnis River (EBFR) back to its original course.
- Stabilisation and amelioration of the Pit crest and upper batters to a landform suitable for revegetation and safe future access.

### 9.2 Description of Main Pit

The profile of the Main Pit has been established based on a variety of sources, including bathymetry (2015), historical photographs, the results of an over-water geotechnical investigation conducted by others (SRK Consulting, 2018) and recent laboratory testing commissioned on samples from the SRK investigation (ATC Williams, 2019).

An oblique view of the Main Pit is shown in **Figure 14** and some historical photographs are given in **Figure 15**.



**Figure 14 Oblique View of Main Pit 2015 Bathymetry Survey**



White's Open Cut and Rum Jungle treatment Plant, during the late 1960's. Completed to a depth of 350 feet in 1958.

Completed Main Pit 1960s Looking South East

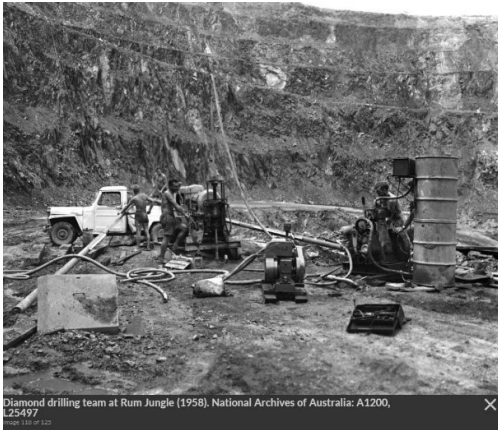
Image Courtesy: World Nuclear Association, <https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/appendices/australia-s-former-uranium-mines.aspx>. Accessed 19 Feb 2020



White's open cut pit, Rum Jungle (1958), National Archives of Australia: A1200, L25494

Main Pit 1958 Looking South East

Image Courtesy: DPIR, <https://dpir.nt.gov.au/mining-and-energy/mine-rehabilitation-projects/rum-jungle-mine/photo-gallery>. Accessed 19 Feb 2020.



Pit Wall Conditions Near Pit Completion in 1958

Image Courtesy: DPIR, <https://dpir.nt.gov.au/mining-and-energy/mine-rehabilitation-projects/rum-jungle-mine/photo-gallery>. Accessed 19 Feb 2020.



Pit Wall Conditions Looking West (estimated)

Image Courtesy: DPIR, <https://dpir.nt.gov.au/mining-and-energy/mine-rehabilitation-projects/rum-jungle-mine/photo-gallery>. Accessed 19 Feb 2020.

### Figure 15 Historical Photographs

## 9.3 Design Strategy

The conceptual backfill strategy developed by SLR in consultation with NT DPIR, aimed at meeting the objectives includes:

- Sub-aqueous (i.e. placement below water) placement of a bedding layer to facilitate the backfilling of waste rock materials and prevent the remobilisation of contaminate materials within the tailings and chemocline;
- Sub-aqueous placement of waste rock;
- Consideration of placement methods and their impacts on contaminate mobilisation risk, WTP rates and Main Pit geological features;
- Placement of clean, inert cover materials over backfilled waste rock;
- Placement of erosion protections; and
- Recontouring of Main Pit crest to meet final landform objectives and facilitate revegetation.

The generalised final profile of the Main Pit after backfilling is shown in **Figure 16**.

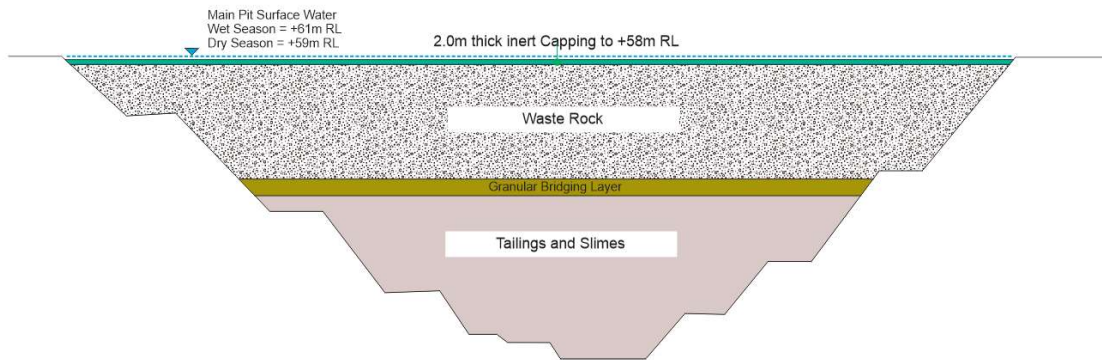


Figure 16 Generalised Main Pit Backfill Profile

Detailed geotechnical modelling including stability, kinematic and consolidation analyses together with a risk assessment has been undertaken to inform the rate of material placement within the Main Pit and the recommended final profile of the pit rim.

## 9.4 Geochemical Requirements

As a means of long-term geochemical mitigation lime dosage and mixing is required in backfilled materials.

- Sand Bedding Layers shall be mixed with hydrated lime at 1.7% w/w rate and placed sub-aqueously; and
- Waste rock layers shall be dosed and mixed with granulated lime at rate dictated by the waste rock source:
  - Intermediate WRD source; 24 kg CaCO<sub>3</sub> / tonne of waste rock;
  - Dyson's Overburden WRD; 24 kg CaCO<sub>3</sub> / tonne of waste rock; and
  - Main Pit WRD; 15 kg CaCO<sub>3</sub> / tonne of waste rock.

## 9.5 Proposed Backfill Methodology

Slow, uniform application that allows the capping material to accumulate in layers is necessary to avoid displacement of or mixing with the underlying sediment and if possible, chemocline. Uncontrolled placement of the capping material can also result in the resuspension of adverse suspended solids and/or contaminants into the water column and the creation of a fluid mud wave that results in problematic build up.

During reference design development, a literature review was undertaken, and discussions were held with a specialist marine contractor to identify suitable material handling and placement techniques.

### 9.5.1 Key Constraints

Key constraints considered when assessing a preferred placement methodology include:

- Limiting rate of water treatment plant treating pit lake water which is displaced by backfill materials: The maximum filling rate is based on a limiting water treatment capacity of 80 L/S which governs the fill placement rate. This equates to a limiting maximum placement rate of 6,900m<sup>3</sup> per day.

- Material supply rates (barge, conveyor, pipeline): Discussions with specialist contractors have been undertaken to verify appropriate placement rates at various stages of filling. Typical rates are as follows:
  - Floating line to barge with sub-aqueous placement of fluidized sand slurry by spreader pontoon with diffuser for careful and controlled placement of basal sand and intermediate sand bedding layers: 60-80 m<sup>3</sup> per hour (600-800 m<sup>3</sup> per day considering 10 hours production);
  - Split Barge or pontoon for careful and controlled placement of wet or dry basal sand bedding layer and waste rock: 120-150 m<sup>3</sup> per hour (1,200-1,500 m<sup>3</sup> per day considering 10 hours production). Multiple barges may be used;
  - Conveyor: Up to 1,000 m<sup>3</sup> per hour (10,000 m<sup>3</sup> per day) for land-based transport of dry basal sand bedding layer and waste rock. The system could either deliver to receiving stockpiles at pit rim (for to hoppers for loading on to barges) or be connected to floating pontoons for use over water; and
  - Side cast by Dozer: Placement rates of up to 1,000 m<sup>3</sup> per hour are achievable for a large (CAT D10+) dozer operating short haul distances.
- There is a need to place backfill material into the pit lake very carefully to avoid disturbance of the chemocline.
- Stability of capping: Sub aqueous placement of predominantly granular materials will result in a very loose to loose matrix which may exhibit creep settlement over time, could undergo bearing or slope stability failure on very soft tailings and may be prone to liquefaction.
- Chemical suitability of backfill materials: PAF waste rock must be kept submerged below the lowest (dry season) water level which is taken to be RL 59 m AHD. For this reason, the final layer of PAF waste rock is placed no higher than **RL +56m AHD** below a 2.0m thick inert capping material (**RL 58m AHD**) with a minimum **1.0 m** water cover at the peak of dry season. Settlement analyses show that the upper surface of the PAF material will settle several metres over a period of decades which provides risk mitigation against oxidization of these materials (i.e. the amount of favourable water coverage over oxidizable materials will increase with time).
- The final landform of the backfill will be profiled to maintain stream flow, minimum channel depth, operational surface drainage (to avoid ponding), appropriate landscaping and erosion management.

### 9.5.2 Recommended Backfill Strategy (Reference Design)

Taking into consideration these constraints, various placement methods and strategies have been considered and the following key outcomes of the design development are summarised below:

- A suitable borrow and placement technique could utilise bulk (dry) excavation of sand borrow material, processing (screening), stockpiling, then fluidisation by end tipping into receivals bin, pumping using a wet placement process through floating line and discharge from near water surface via spreader pontoon. An alternative to this would be to utilise a dry transport process involving land and floating conveyor systems instead of a slurry filled pipeline to transport material to a spreader pontoon (barge) for controlled sub-aqueous placement.

- For wet placement methods (involving slurry/pipeline) a relatively fine grading of bedding layer material is preferred ( $D_{50} \leq 1\text{mm}$ ) to reduce impeller wear and pump maintenance. On this basis, it would be necessary to screen and stockpile oversize material for later barge placement as intermediate grade fill before placing waste rock. As shown in grading plots, the approximate split of borrow material between sand bedding ( $D_{50} \leq 1\text{mm}$ ) and intermediate sand fill ( $D_{50} \geq 1\text{mm}$ ) is about 50/50, and so this can be used to balance stockpile volumes for 1mm minus, unscreened and 1mm plus bedding materials.
- The rate of placement is effectively governed by the capacity of the water treatment plant which extracts and treats pit lake water as it is displaced by capping and backfill. The maximum water treatment (and therefore fill placement) rate is understood to be 80-90L/s.
- Target filling levels are such that that PAF waste rock must remain submerged under the lowest expected dry season water level of RL 59 m AHD. Adding the nominal 2m thickness of inert (non-PAF) surface capping layer material, results in a target landform surface level of RL +58m AHD. Further consideration of the landform design is required which needs to take into consideration post construction total and differential settlements, grade of submerged waterways and finished landform (considering erosion, etc).
- Placement of first 1000 mm of bedding sand may result in 500mm lost into surface of tailings.
- Hydraulic fill placement has the potential to disturb and displace a liquid / slurry chemocline layer where this exists. Further assessment of the type and thickness of potential chemocline layer is discussed above.
- Following sampling, testing and characterisation of chemocline baseline conditions, then regular construction stage monitoring should be undertaken to confirm that chemocline disturbance is being managed to achieve acceptable groundwater quality levels.
- Regular multibeam survey (intense initially) is required to confirm placement coverage, check for instability and mud-waving. Periodic CPT validation testing should also be undertaken to confirm settlement of the capping/tailing interface and confirm excess pore pressure and strength gain assumptions at critical staging.

**Figure 17** shows a schematic of the proposed backfill strategy.

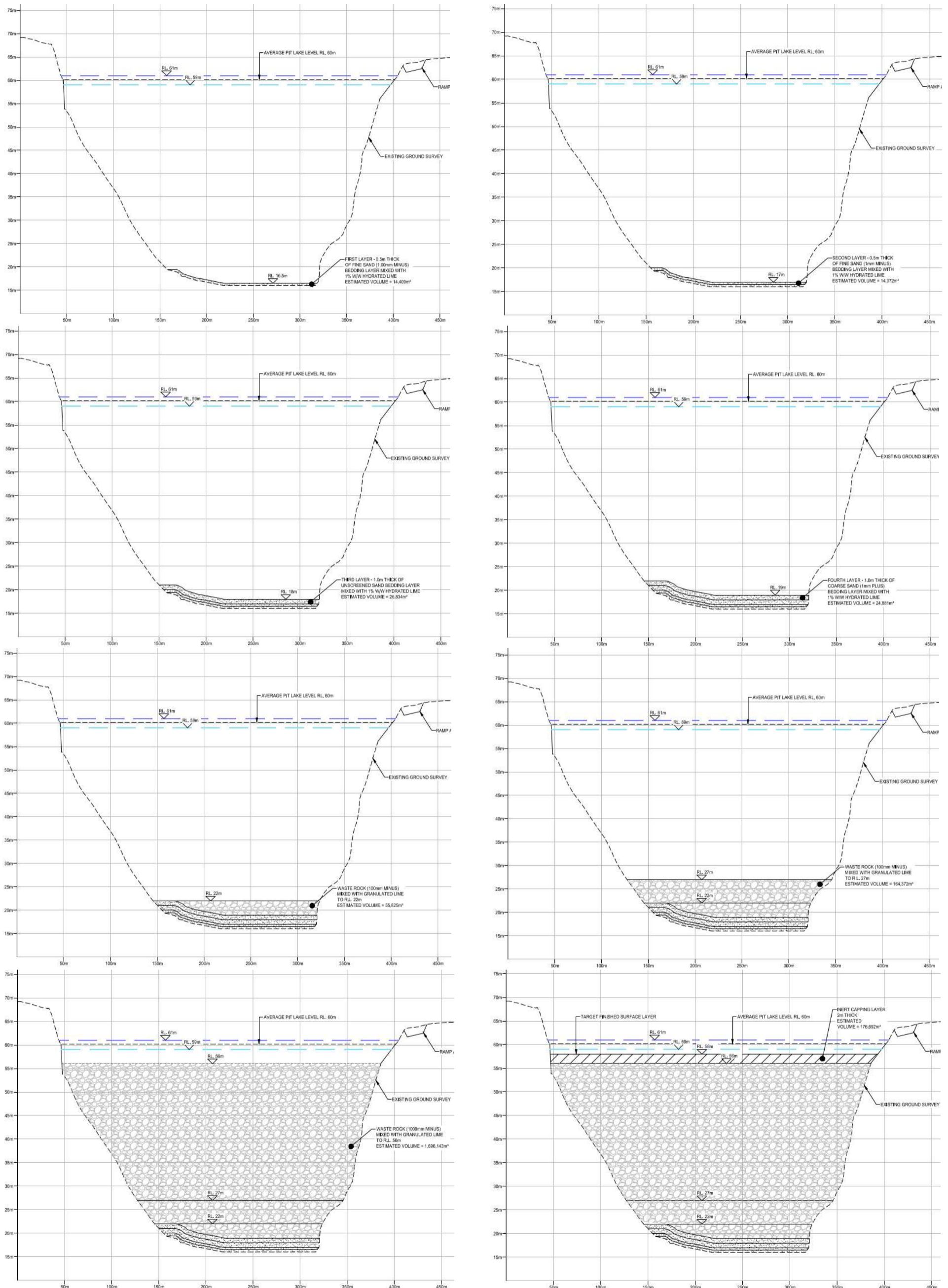


Figure 17 Main Pit Backfill Schematic

## 9.6 Backfill Scheduling

**Table 10** outlines the estimated backfill schedule.

**Table 10 Main Pit Backfill Program**

Layer	Source	Volume in Main Pit (m <sup>3</sup> )									
		Year 1		Year 2		Year 3		Year 4		Year 5	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Establishing Works		Site Establishment. No Placement									
Sand Bedding Layer SBL-1	Borrow Area B										
Sand Bedding Layer U/S											
Sand Bedding Layer SBL+1	Screened Stockpile from SBL-1										
WR Lens Up to RL 22m AHD	Dyson's Overburden WRD										
Waste Rock Up to RL 27m AHD	Dyson's Overburden WRD										
Waste Rock Up to RL 56m AHD	Dyson's Overburden WRD										
Waste Rock Up to RL 56m AHD	Intermediate WRD										
Waste Rock Up to RL 56m AHD	Main WRD										
Inert Capping Up to RL 58m AHD	Borrow Area B (FRALT)										
Closing Works											Final landform recontouring, demobilisation and ongoing monitoring.

## 9.7 Pit Wall Stability and Landform Creation

A number of geohazards have been identified to be present with risk relevant to the various backfill concept approaches. The hazards relevant to the pit wall stability included:

- 
- Steep backfill/scree cones founded on tailings in a meta-stable condition which could potentially be exacerbated by dewatering;
  - Compressible materials which could take many years to consolidate;
  - Tailings susceptible to liquefaction and sudden loss of strength;
  - Unstable, low strength and highly fractured (in shear zones) pit wall materials since softened from pit flooding, susceptible to sliding and slumping;
  - Clayey pit wall skin impeding dewatering of the walls leading to wall pressurization and instability; and
  - High decay rate and possible solution channelling/undercutting in the Coomalie Dolostone exposed in the pit.

Construction activities, specifically in relation end dumping over the pit crest were identified as likely to present instability created by the backfill material sliding on the pit wall as well as basal failure of the tailings. Additionally, surcharge loading of the pit crest from waste rock piles and earthworks machinery would act to destabilise the crest and could cause failure of the walls. This is particularly a problem if the walls have softened or weathered.

As a means of addressing Pit Wall stability concerns, backfilling preferred approach is to place material sub-aqueously with minimal dewatering of the Main Pit water body.

In addition to above, prior to commencement of backfill works and site establishment, stability assessment of the Main Pit crest will be performed by a suitably qualified geotechnical engineer. The Engineer will assess the site for suitable laydown, stockpile, office, processing and crane launch areas. As a minimum, a 40 m off-set exclusion zone from the Pit crest will be observed for all non-essential equipment and infrastructure throughout the construction works.

Following completion of backfilling to RL 58 m AHD. The Main Pit crest will be re-contoured at select locations by backfilling against the crest down to the top of the backfilled inert cap (RL 58 m AHD) at 1V:6H slope with clean, inert, non-dispersive materials, as shown in **Figure 18**.

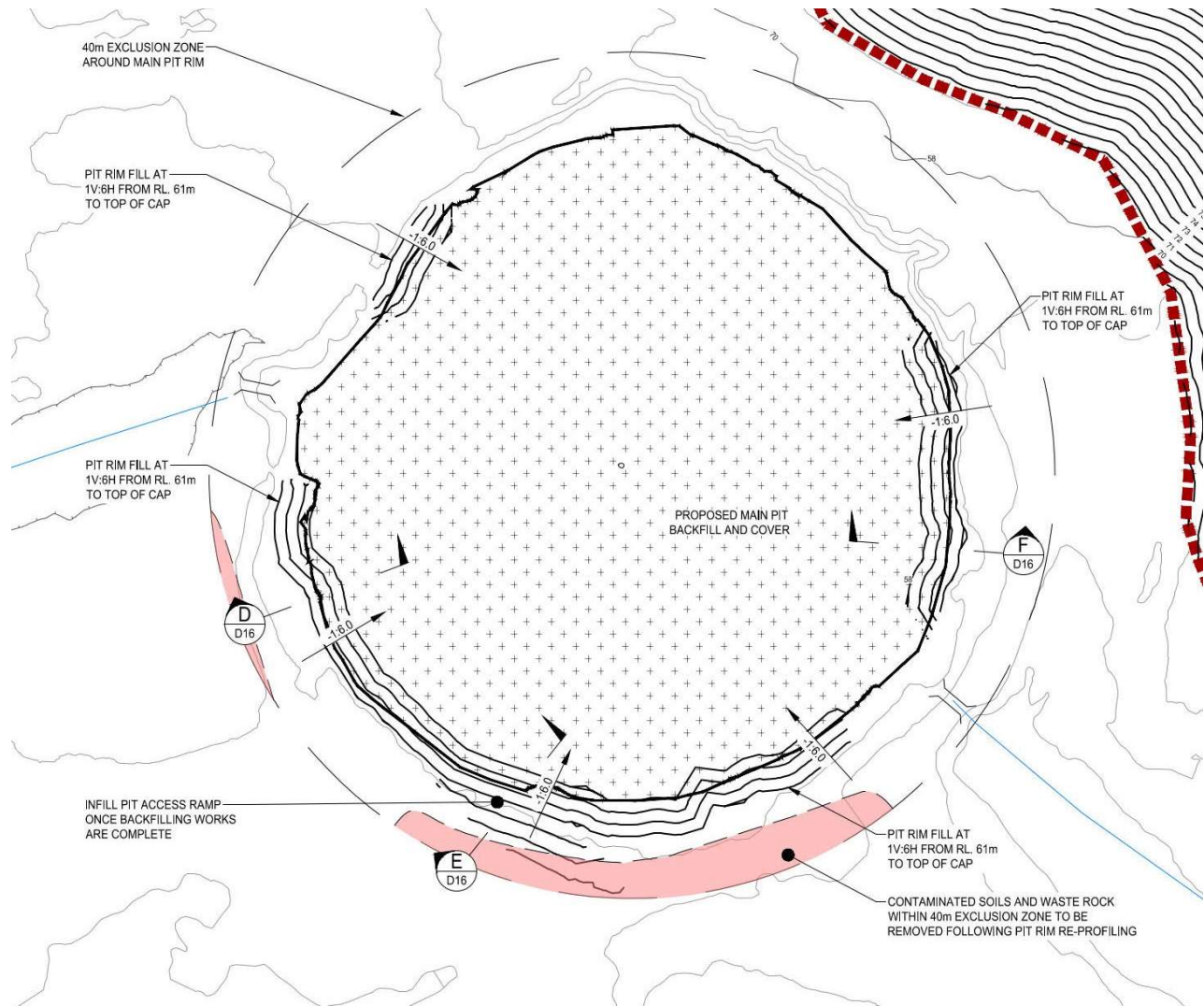


Figure 18 Areas for Contouring

## 9.8 Quality Assurance Requirements

The quality assurance requirements for the Main Pit backfill activities include:

- Regular bathymetry;
- Cone Penetrometer Testing (CPTs); and
- Geotechnical conformance of materials to be placed.

Full details of the quality assurance and quality control (QA/QC) requirements are outlined in the SLR “*Main Pit Backfill, Technical Specifications*” (SLR, 2020c).

## 9.9 Design Drawings

Issued for Implementation design drawings specific to the Main Pit Backfill are summarised in **Table 11**.

**Table 11 Main Pit Backfill Issued for Implementation Drawings**

Drawing No.	Title
<b>MAIN PIT BACKFILL</b>	
680.10421.MPS.D01	EXISTING MAIN PIT SITE CONDITIONS
680.10421.MPS.D02	MAIN PIT REHABILITATION PLAN
680.10421.MPS.D03	MAIN PIT ACCESS AND LAYDOWN AREA
680.10421.MPS.D04	MAIN PIT ENTRY RAMP DETAIL
680.10421.MPS.D05	MAIN PIT REHABILITATION SECTIONS
680.10421.MPS.D06	TYPICAL MAIN PIT BACKFILL SECTION - SHEET 1 OF 8
680.10421.MPS.D07	TYPICAL MAIN PIT BACKFILL SECTION - SHEET 2 OF 8
680.10421.MPS.D08	TYPICAL MAIN PIT BACKFILL SECTION - SHEET 3 OF 8
680.10421.MPS.D09	TYPICAL MAIN PIT BACKFILL SECTION - SHEET 4 OF 8
680.10421.MPS.D10	TYPICAL MAIN PIT BACKFILL SECTION - SHEET 5 OF 8
680.10421.MPS.D11	TYPICAL MAIN PIT BACKFILL SECTION - SHEET 6 OF 8
680.10421.MPS.D12	TYPICAL MAIN PIT BACKFILL SECTION - SHEET 7 OF 8
680.10421.MPS.D13	TYPICAL MAIN PIT BACKFILL SECTION - SHEET 8 OF 8
680.10421.MPS.D14	MAIN PIT BACKFILL METHODOLOGY DETAILS
680.10421.MPS.D15	RE-PROFILING INFILL LAYOUT PLAN
680.10421.MPS.D16	RE-PROFILING INFILL - TYPICAL SECTIONS

## 10 Water Treatment

A water treatment plant will be required to treat contaminated water before it can be released off-site to the EBFR. The water treatment plant will need to treat contaminated:

- Groundwater, which is to be extracted from nominated locations by a series of groundwater bores and sumps;
- Main Pit water displaced by the backfilling described in Section 9;
- Intermediate Pit water that needs to be displaced prior to each wet season to allow for contaminated surface water runoff capture from the catchment area associated with the Main and Intermediate Pits; and
- Surface water pumped from other disturbed catchment areas during construction.

As a result of the above, the Water Treatment Plant (WTP) will be required to treat two specific types of contaminated water:

- High volume, low contamination concentration (i.e. Main and Intermediate Pits; surface water); and
- Low volume, high contamination concentration (i.e. groundwater).

Full details of the design and strategy for the WTP and associated infrastructure are given in SLR Report “*Water Treatment Facility, Design Report*”, (SLR, 2020d). Key points are summarised here.

It is important to note that this is a reference design that has been developed by SLR and is not fully detailed in all aspects. The Contractor is responsible for additional detailing of elements as required to facilitate a fully functional plant which achieves the Performance Objectives. The Contractor may enhance or modify the design only if any proposed alternative arrangements or systems result in a facility that meets the Performance Objectives.

### 10.1 Objectives

#### 10.1.1 EBFR Release Limits

Hydrobiology (Hydrobiology, 2016) was engaged by the NT DPIR to develop site specific Locally Derived Water Quality Objectives (LDWQOs), in accordance with the methodologies of the ANZECC/ARMCANZ guidelines, to establish release limits for water to the EBFR. Table 12 compares the general ANZECC limits to the Project LDWQOs.

**Table 12 Water Quality Objectives**

Analyte	Project LDWQOs (mg/L) (Hydrobiology, 2016)	95% ANZECC Limit (mg/L)
Arsenic	0.013	0.013
Aluminium	0.236	0.055
Cadmium	0.0002	0.0002
Cobalt	0.089	ID
Copper	0.060	0.0014
Iron (2+ and 3+)	0.300	ID
Manganese	0.759	1.7
Nickel	0.130	0.011

Analyte	Project LDWQOs (mg/L) (Hydrobiology, 2016)	95% ANZECC Limit (mg/L)
Magnesium	86.6	15
Lead	0.003	0.0034
Zinc	0.210	0.008
EC ( $\mu\text{S}/\text{cm}$ )	2,985	ND
Sulphates	1,192	2,000
pH	7-8.5	6.5-8.0

Notes: ID – Insufficient data, ND – no data

### 10.1.2 Groundwater Treatment

Robertson GeoConsultants (RGC) were engaged by NT DPIR to prepare a MODFLOW/MT3D groundwater model to simulate groundwater flow across site and the interactions of ground and surface waters (RGC, November 2019). The model was enhanced through calibration over a period of 9 years. As Copper was considered a key indicator of riparian health and regularly breaches LDWQOs, the project team sought to identify a solution which would reduce copper loads in EBFR downstream of the site to levels below the Project LDWQOs. The solution provided by RGC involved the establishment of a network of groundwater extraction bores in strategic locations that would draw groundwater from a depth of up to 30m at a rate between 1 and 2L/s on a 24hour basis for a period of 10 years minimum.

## 10.2 Strategy to Meet the Project Water Quality Objectives

The Project water quality objectives are to be met by:

- Relocating waste rock and other impacted soils to new waste storage facilities (WSFs) to minimise further AMD production and release of solutes from already existing oxidation product;
- Backfilling the highest Potentially Acid Forming (PAF) waste rock into the Main Pit to submerge material in an anoxic environment and reduce further AMD production; and
- Extracting impacted groundwater from beneath the existing WRDs area and treating before release.

Additional groundwater extraction at the old Copper Extraction Pad and former Stockpile area will improve local groundwater conditions however these groundwaters do not substantially report to the EBFR.

In parallel, the cultural objectives are to be met by relocating EBFR back through Main and Intermediate Pits and leaving these as ‘lakes’ along the realignment.

## 10.3 Inflow Regime

A comprehensive WTP will be required to treat the range of AMD affected surface water and groundwater for a period of 10 years. As the backfilling operation will take less than one third of a possible ten years treatment duration, it is proposed to selectively manage the inflow sources on site so as not to over design the WTP. The groundwater sources from the Intermediate Pit WRD will be the only inflow from the groundwater network to be treated during the backfilling operation. The remaining groundwater sources will be activated at the conclusion of backfilling.

**Table 13** and **Table 14** summarise the approximate inflow rates to the WTP from the groundwater bores, seepage interception systems (SIS), groundwater recharge and surface water sources.

**Table 13 WTP Inflow from Groundwater and SIS sources**

Source	Dry season flow rate (L/s)	Wet season flow rate (L/s)
<b>Groundwater and Seepage Interception Sources</b>		
Main WRD (east), 6 groundwater bores	6	12
Main WRD (east), SIS sump pump	1-6 (with an equivalent reduction in groundwater cluster)	1-12 (with an equivalent reduction in groundwater cluster)
Main WRD (west), 3 groundwater bores	3	6
Main WRD (west), SIS sump pump contingency	1-3 (with an equivalent reduction in groundwater cluster)	1-6 (with an equivalent reduction in groundwater cluster)
Intermediate WRD (north), 4 groundwater bores	4	8
Intermediate WRD (north), SIS sump pump contingency	1-4 (with an equivalent reduction in groundwater cluster)	1-8 (with an equivalent reduction in groundwater cluster)
Heap Leach, three groundwater bores	3	6
Old tailings, one groundwater bore	1	2
<b>Subtotal Groundwater &amp; SIS</b>	<b>Approximately 17L/s</b>	<b>Approximately 34L/s</b>

**Table 14 Surface Water & Groundwater Recharge Rates to the WTP**

WTP Input	Dry season flow rate (L/s)	Wet season flow rate (L/s)
<b>Groundwater Ingress and Surface Water Sources</b>		
Rainfall contribution to the Main Pit	1	13
Evaporation from the Main Pit	-7	-6
Rainfall contribution to the Intermediate Pit	1	8
Evaporation from the Intermediate Pit	-2	-2
Groundwater recharge into the Intermediate Pit during construction	18	31
Groundwater recharge into the Main Pit	0	0
Waste Storage Facility sediment basins	1	15
<b>Subtotal Groundwater &amp; SIS</b>	<b>Approximately 12L/s</b>	<b>Approximately 59L/s</b>

### 10.3.1 Main Pit Water Quality

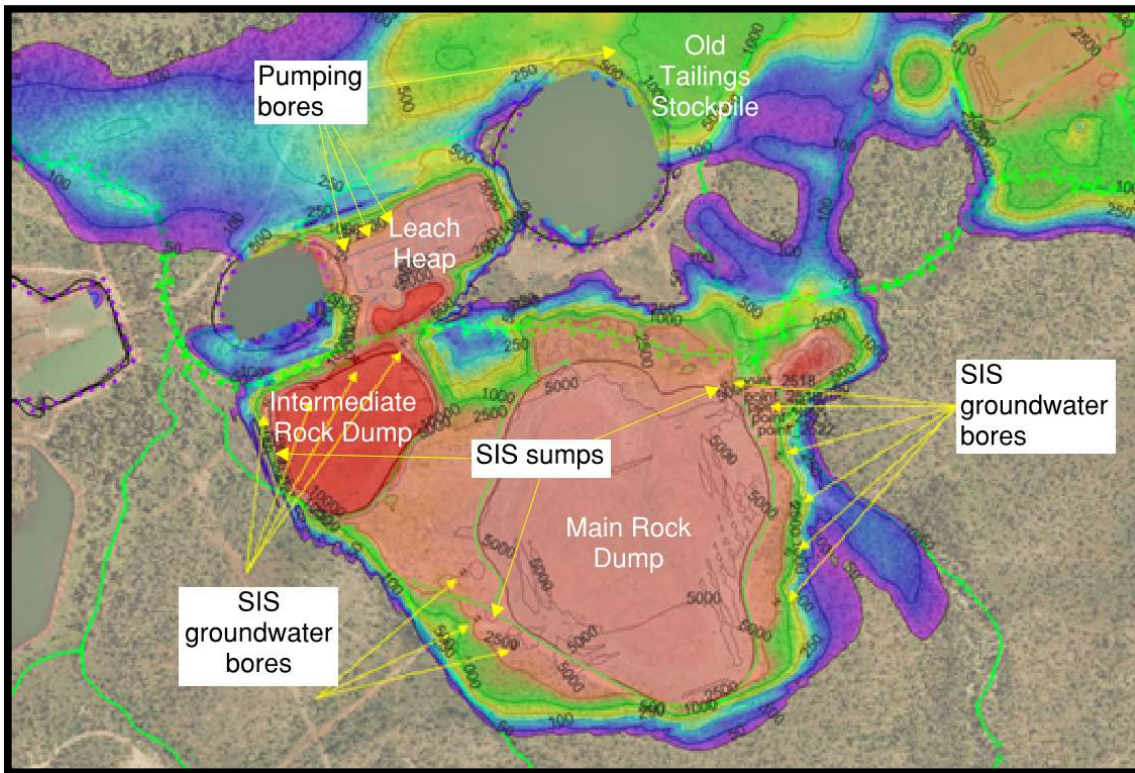
The water quality in the Main Pit will vary during the backfilling operations from the disturbance of the chemocline and the placement of waste rock materials. To both reduce the load on the WTP and to provide an alkaline environment around the waste rock placement, an operational strategy will be implemented to blend finely crushed limestone with the waste rock material during the backfill operation. To further reduce the incidence of AMD release during the placement, a hydrated lime slurry would be on standby to dispense if the local pH falls below neutral.

### 10.3.2 Groundwater

RGC (RGC, November 2019) have identified five strategic locations from which groundwater is to be extracted and treated over the Rum Jungle site. These include:

1. Main WRD (East).
2. Main WRD (West).
3. Intermediate WRD (North).
4. Heap Leaching Area.
5. Old Tailings Stockpile Area.

**Figure 19** shows the recommended locations to extract groundwater over the Rum Jungle site. Groundwater modelling has confirmed that the extraction regime will need to persist for over 9.5 years before aqueous metal concentrations are considered safe for the downstream biology in the EBFR.



**Figure 19** Location of Groundwater and Surface Water Extraction

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## 10.4 Design

### 10.4.1 Physical Process Requirements

The treatment technology has been developed in response to the variable nature of the system, with fluctuating flowrates, contaminants and low pH. The treatment plant is required to be modular, temporary with readily available, cost effective chemical inputs and proven technology to produce water quality which satisfies the LDWQOs.

### 10.4.2 Chemical Process Requirements

The concentration of metals in the groundwater exceed those in the surface water by one to two magnitudes. The concentration of metals within the waste rock will be buffered by the addition of crushed limestone and precipitated by the addition of hydrated lime in the Main Pit during the backfilling operation. The volumes extracted from the pits are two to three times those from the groundwater bores.

The basic treatment method will be to control the pH, oxidise, allow time to react and force settle the metal hydroxides with the aid of polymers on a clarifier. A proportion of the sludge would be recirculated to enhance the sludge settlement process. Waste sludge would either be released with the waste rock to aid settlement of metals, dewatered and buried on site or pumped to Brown's treatment facility for ore processing.

### 10.4.3 Treatment Sequence

The following outlines the expected remediation and treatment sequence:

1. Year 1 wet season – Achieving pit operating levels & activating Intermediate Pit WRD groundwater bores;
2. Years 2 to 4 – Main Pit backfill with Intermediate Pit WRD bores operational;
3. Year 5 – Main Pit capped;
4. Years 5 to 10 – Pits open to the EBFR, site wide groundwater network established; then
5. Year 6 and year 10 – Decommissioning.

## 10.5 Water Treatment Process

A High-Density Sludge (HDS) two-staged 'Geco' hydroxide precipitation with oxidation, Ion exchange and Greensands/DMI65 catalytic filtration media water treatment process has been proposed to satisfy the LDWQO for the range and blending of influents. The process subjects the influent to a range of pH streams with aeration, flocculation, clarification, pH correction, recirculation of clarified sludge (Aubé, B., & Zinck, J., 2003) and final polishing through ion exchange and catalytic filtration (**Figure 20**).

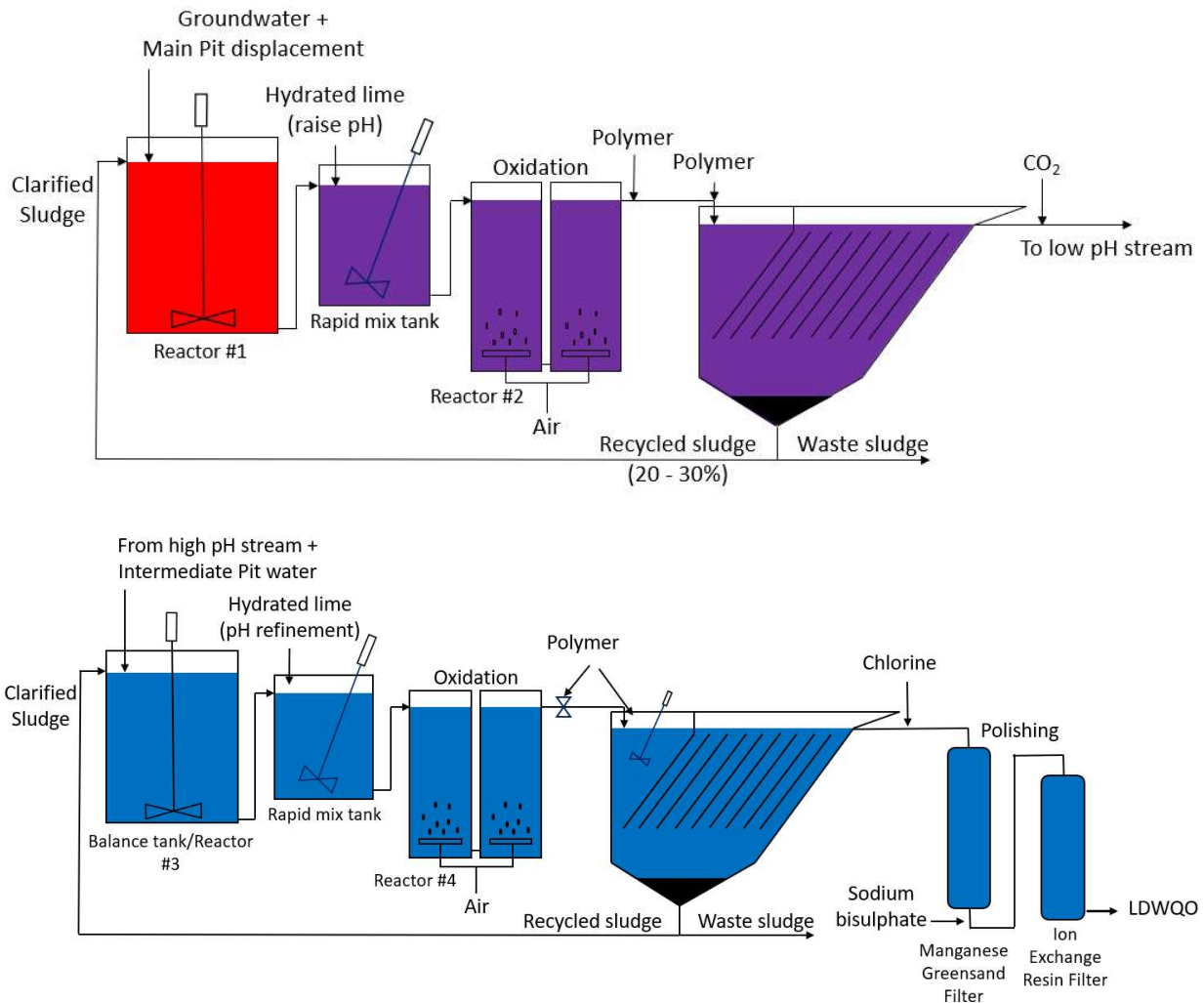


Figure 20 WTP Process Schematic, High and Neutral pH 'Geco' HDS process With Polishing

## 10.6 Chemicals Used

The following chemicals are required during the water treatment process:

- Flocculant Praestol;
- Lime;
- Carbon Dioxide;
- Hydrochloric Acid;
- Chlorine; and
- Sodium Bisulphate.

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## 10.7 Optioneering

A new technology option is provided whereby the process uses electrified Titanium Oxide plates to apply a charge to the metals in the water causing them to coagulate and drop out of solution. The process does not use chemicals, apart from pH correction, and runs on very little power. Most installations are solar powered due to the remote locations.

## 10.8 Design Drawings

Issued for Implementation design drawings specific to the Main Pit Backfill are summarised in Table 15.

**Table 15 WTP Issued for Implementation Drawings**

Drawing No.	Title
<b>MAIN PIT BACKFILL</b>	
680.10421.WTP.D01	Water Treatment Plant Layout
680.10421.WTP.D02	Water Treatment Plant Plan
680.10421.WTP.D03	Water Treatment Plant Schedule
680.10421.PIP.D01	Site Wide Pipelines – Ground & Surface Water Extraction & Treated Water Discharge

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## 11 New Waste Storage Facilities

Full details of the design of the new WSFs are given in SLR Report “*Waste Storage Facilities and General Site Civil Works, Detailed Design and Construction Methodology*”, dated May 2020 (SLR, 2020g). Key points are summarised here.

### 11.1 Objectives

The primary purposes of the development of the WSFs is to encapsulate PAF waste rock and impacted soils that can't be accommodated within the Main Pit, with the aim of preventing AMD from the WSFs and ongoing contamination impacts to the groundwater and surface water systems.

The material to be relocated to the WSFs includes:

- Radiological soils (that sit outside the WSFs);
- Remainder of the Main WRD;
- Main North WRD;
- Main WRD Levee;
- Mt Burton WRD;
- Copper impacted heap leach soils;
- Old stockpile area soils (that sit outside the WSFs); and
- Miscellaneous salt and metal impacted soils.

In addition to the above, waste rock at Mt Fitch is to be relocated to the Mt Fitch open pit.

To prevent AMD from the WSFs, the waste rock materials are to be placed and treated in line with strict geotechnical and geochemical quality requirements. Similarly, the radiological and impacted soils will require specific quality treatments. The excavated footprints of the existing WRDs and impacted soils will also require treatment to prevent surface and groundwater contamination impact.

### 11.2 Design Strategy

The design involved consideration of landform modelling, capping requirements and constructability to meet strict quality control requirements.

#### 11.2.1 Siting

SLR undertook a siting study to determine the WSF footprints that would meet the following criteria:

- Are not prone to flooding in a 1:1,000 Average Recurrence Interval (ARI) event;
- Have suitable foundation geotechnical stability;
- Require minimal clearing of established vegetation;
- Minimise re-handling of radiological soils by covering the major remnants *in situ*;
- Do not disturb Aboriginal places, objects or artefacts; and
- Do not present unacceptable visual amenity impacts.

The recommendation was for the development of the East WSF and West WSF, with block modelling to be undertaken to optimise material haulage and thus reduce costs.

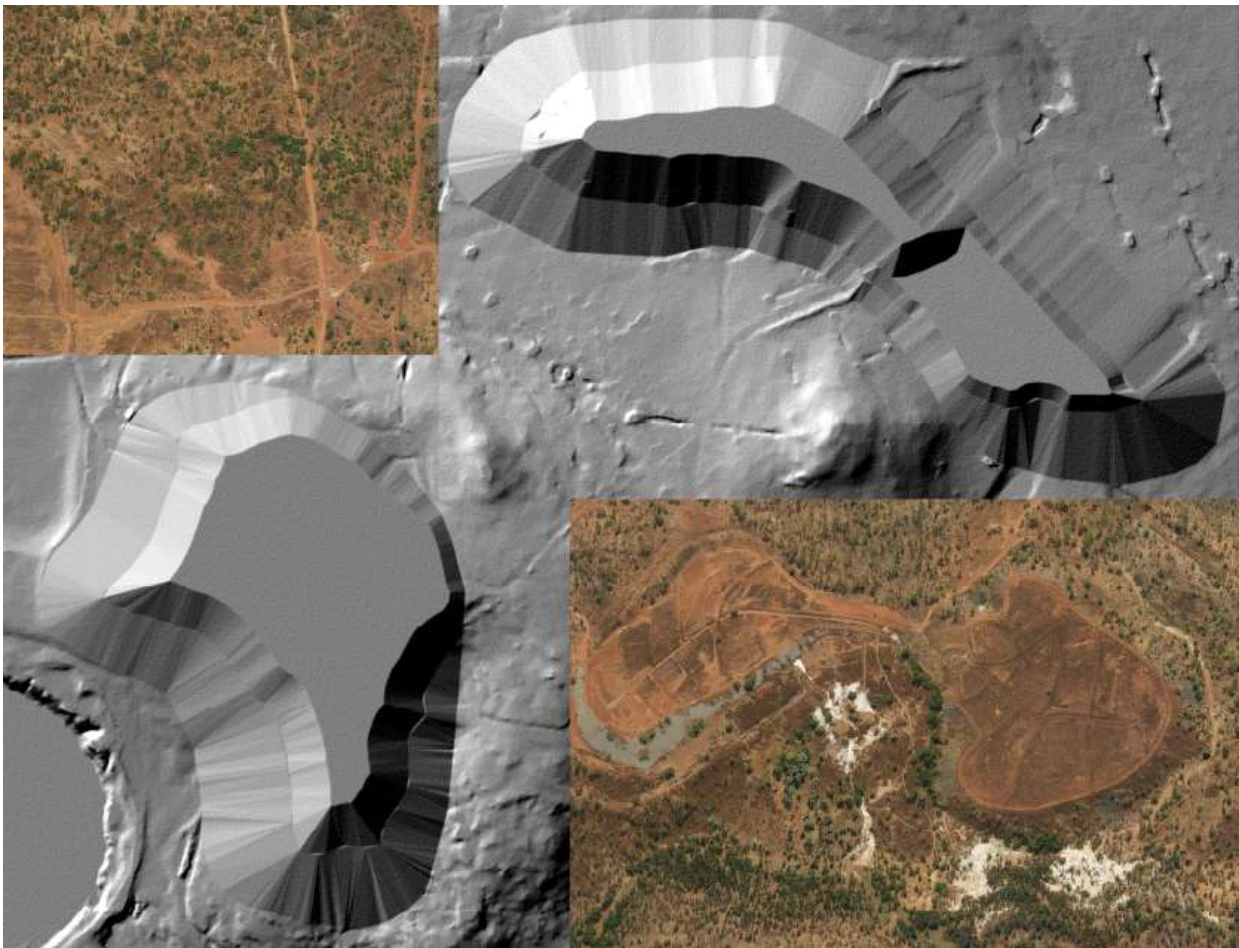
### 11.2.2 Landform Modelling

Landform modelling has included consideration of:

- Volume of material to be placed;
- Maximum height; and
- Side slope angle and configuration.

**Figure 10** previously shows the footprints of the WRDs and impacted soil areas to be relocated together with the proposed WSF footprints.

**Figure 21** shows a 3D model of the proposed WSF landforms (note that these were developed for the erosion assessment, hence do not represent the final 3D format, but are relevant to this discussion).



**Figure 21** 3D Rendering of the Proposed East WSF and West WSF

#### 11.2.2.1 Volume

As per **Section 8.5.2** the required volume to be stored in the WSFs is **6,079,417** m<sup>3</sup> excluding capping materials.

#### 11.2.2.2 Maximum Height

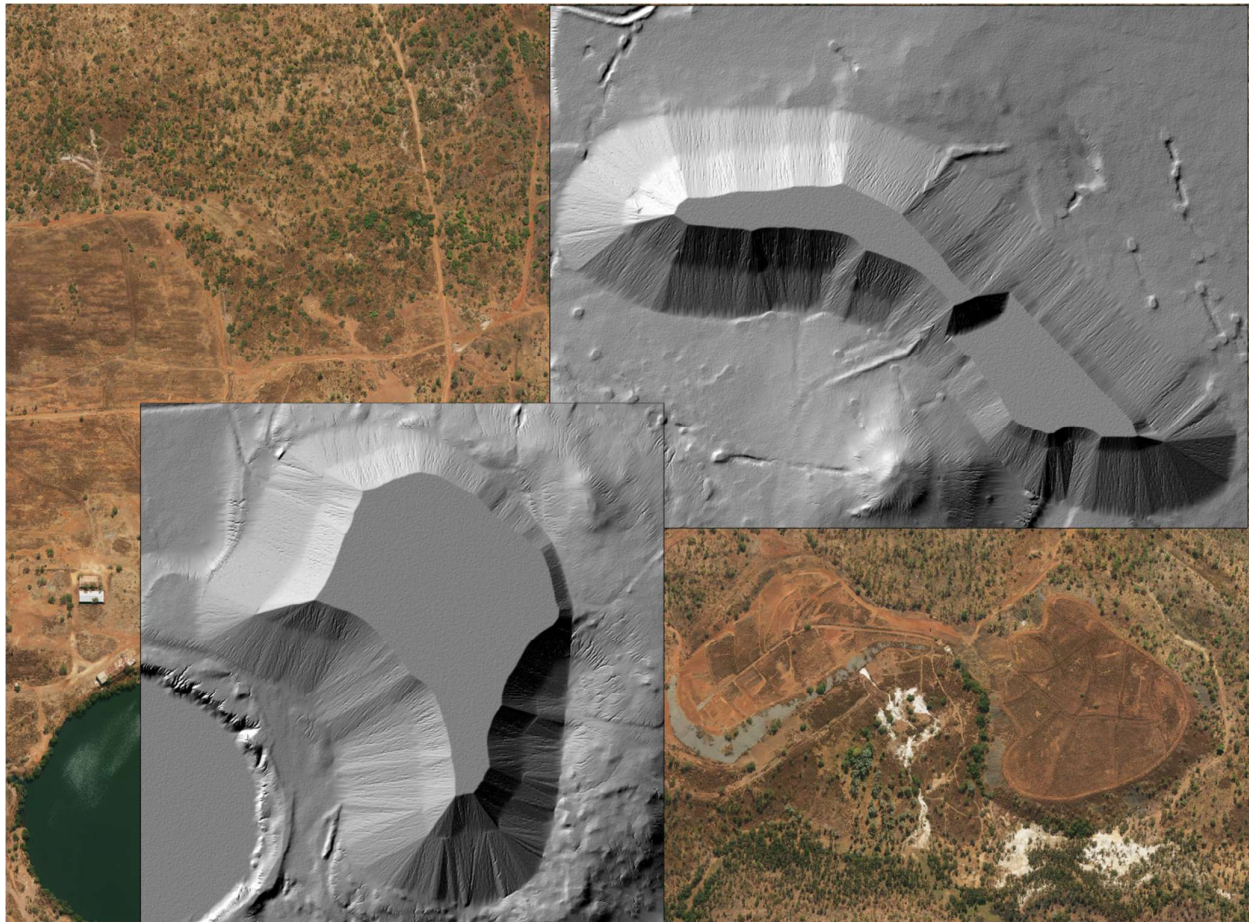
To maintain sight lines for cultural requirements, the maximum height of the WSFs between the sacred sites nominated on the AAPA certification is RL98m. This applies to all of the West WSF and the southern section for the East WSF.

#### 11.2.2.3 Side Slopes

The angles of the side slopes have been established to ensure overall slope stability and minimise erosion of the proposed capping.

Detailed erosion modelling has been undertaken based on flume laboratory testing and using the commercially available SIBERIA modelling software. The aim was to establish optimal side slopes that would minimise the likelihood of the 2.5m deep capping eroding, via either sheet erosion or gullying, leaving the waste rock exposed. Full details of the flume testing and SIBERIA modelling are given in the Erosion Modelling Report (SLR, 2020f) and are shown graphically in the 3D rendering in **Figure 22**.

Stability modelling has previously been undertaken for the side slopes at a greater angle that adopted here (O'Kane Consultants Pty Ltd, 2016) hence additional modelling has not been undertaken.



**Figure 22 3D Rendering of WSFs after 500 Years of Erosion**

Based on the SIBERIA modelling, the recommended batter slope to prevent excessive erosion/gully incision into the capping materials is 9° to 14° dual-slope. Vegetated cover models predict that the proposed cover depth of 2.50 m is not likely to be reached after 500 years.

### 11.2.3 Capping Requirements

SLR conducted an options analysis using the Multi-Criteria Analysis (MCA) approach to assess if any variations to the preferred capping design developed in Stage 2 by (O'Kane Consultants Pty Ltd, 2016) should be considered. The MCA (SLR, 2020j) indicated:

- Capping for the WSFs crest should include:
  - Topsoil; overlying
  - 2m growth medium; then
  - 1.5mm LLDPE with and overlying protection geotextile; then
  - 0.5m compacted clay liner.
- Capping for the WSFs batter slopes should include:
  - Topsoil; overlying

- 2m growth medium; then
- 0.5m compacted clay liner.
- Revegetation for all areas should include:
  - Broadcast native cover (the details of which are to be further developed by NT DPIR in consultation with their vegetation experts).

Figure 23 shows the recommended cover design.

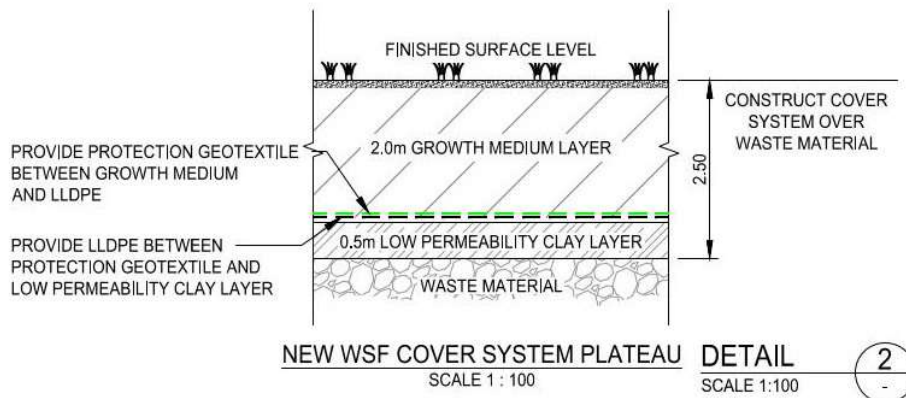


Figure 23 Cover Design

#### 11.2.4 Oxygen Scavaging Layer

Starter bunds are to be formed around the circumference of the WSFs to provide stability and a competent platform on which to form the cover system. As recommended by (RGC & Jones, 2019) an oxygen scavenging layer is also to be formed over PAF material and beneath the formal cover system if sufficient material is available. This oxygen scavenging layer provides an additional barrier to reduce oxygen influx to the PAF material.

Dysons WRD material is generally considered non-acid forming (NAF) to very low PAF and has been identified as oxygen scavenging. It is therefore proposed to use it to form the starter bunds as well as beneath the formal cover system on the plateau of the WSFs.

Modelling has been undertaken to distribute the available Dysons WRD between the 2m cover and starter bunds. The final profiles are shown in **Figure 24**.

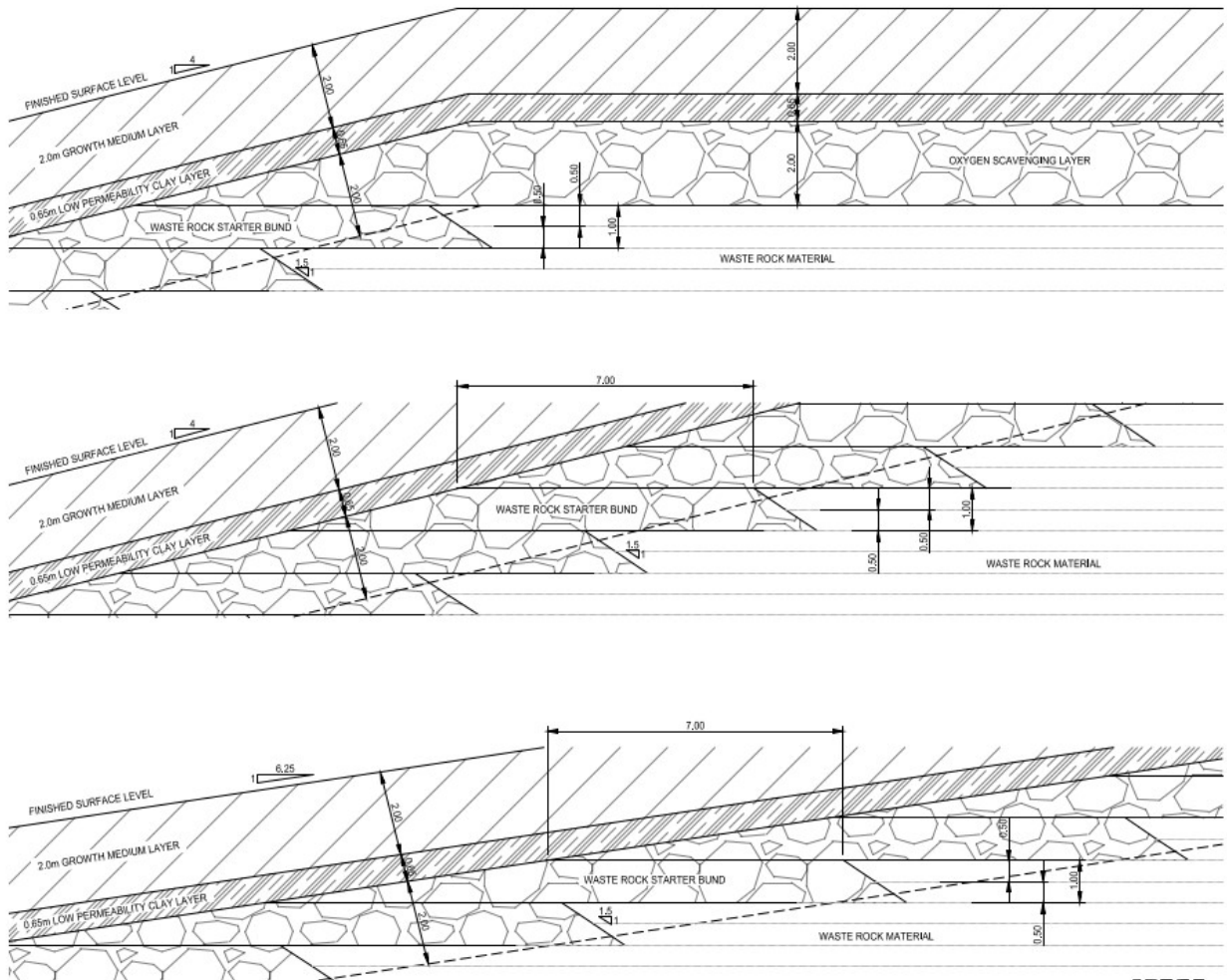


Figure 24 Starter Bund Geometry and Oxygen Scavenging Layer

## 11.3 Monitoring Requirements

### 11.3.1 Erosion Monitoring

The first 20 years after construction of the WSF's are vital to ensure that erosion performs according to the modelled predictions. It is recommended to develop a monitoring program for the first 7 years until vegetation establishment has achieved a minimum of 90% soil cover, with field checks every 6 months and/or after any storm event that produces runoff. In parallel, two DEM (LiDAR) checks are also required to assess whether there are any signs of deviation from the modelled predictions/normality developing that may not be readily visible in the field. These are required at the following frequency: one at 3.5 years and the second at 7 years.

From 7 to 20 years, provided vegetation has established to provide a soil cover greater than 90%, the majority of monitoring will be performed by DEM (LiDAR) monitoring in parallel with ground-truthing in the field. One DEM (LiDAR) check every 4 years and field checks every 12 months.

Should the aforementioned monitoring activities indicate the WSFs are presenting dissimilar behaviour compared to the modelled predictions, it is critical that immediate investigations are undertaken to identify the root causes of failure to design and implement appropriate maintenance works as early as possible.

The procedure to follow in order to determine possible issues, their causes and the corrective actions, if required, is provided in (SLR, 2020f) in Appendix C and will be included in the Owners Team Monitoring and Management Plan.

### 11.3.2 Capping Performance

Field performance monitoring systems are required to demonstrate that the facilities are meeting closure objectives. Assessment of oxygen and water ingress (during construction and post-construction), and water levels and quality are required to assess performance of the WSFs in terms of reducing net percolation and thus, the reduction in the formation and transport of oxidation products from the waste rock into the surface water and groundwater. The designed monitoring system consists of elements to measure surface water balance, net percolation, internal conditions of the waste rock (pore-gas concentrations, temperature and moisture conditions) and groundwater levels and quality (inside and outside the footprint of the facility). The proposed monitoring system includes a series of lysimeters and soil moisture monitoring stations as shown on **Drawings 680.10421.WSF.D12 to D14**. Typical details are given in **Figure 25** and **Figure 26**.

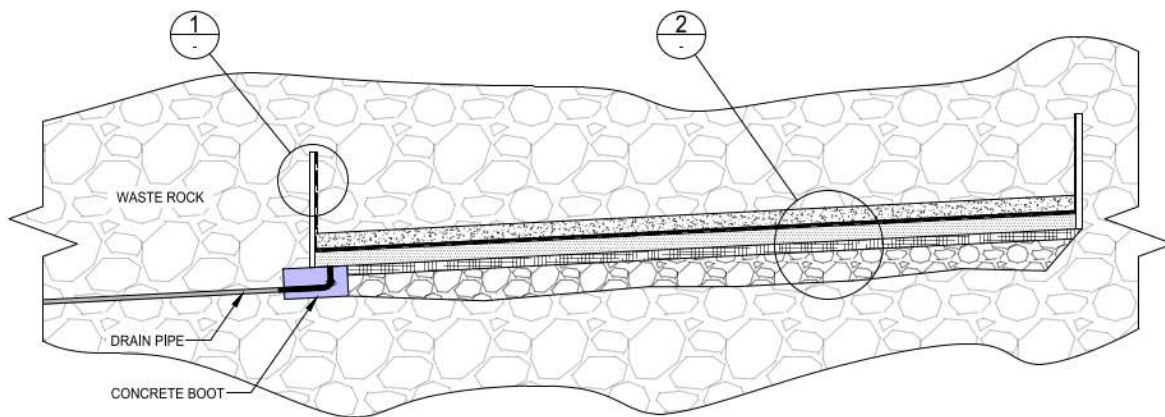


Figure 25 Typical Lysimeter Details

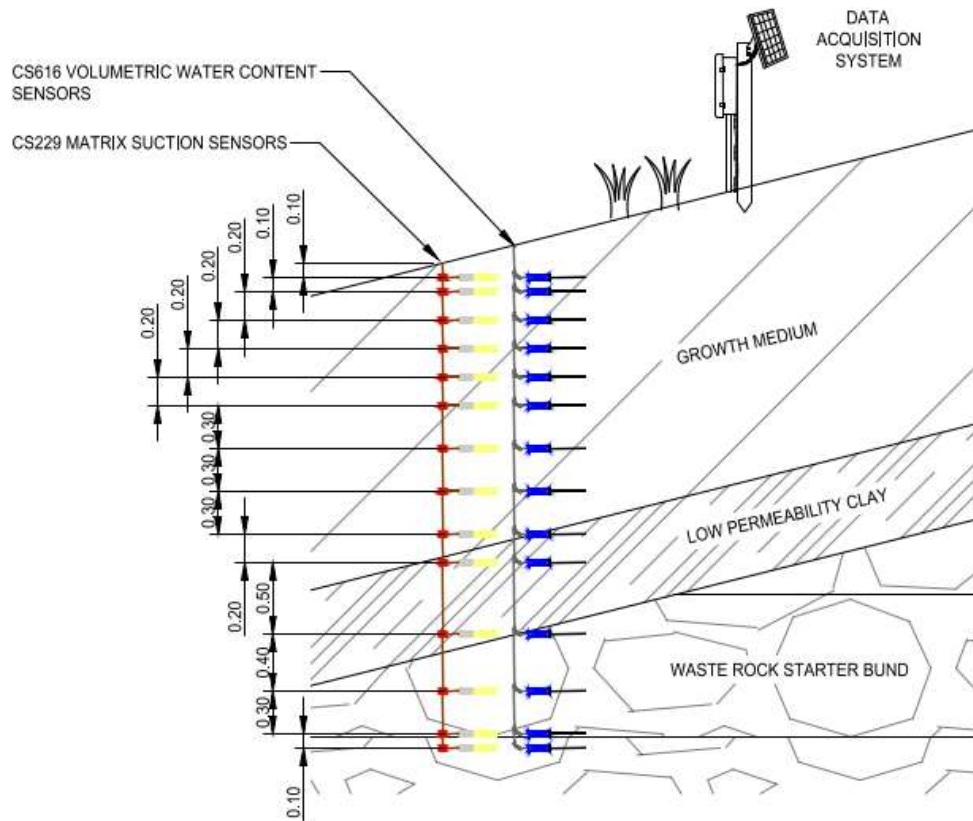


Figure 26 Typical Soil Monitoring Station Details

## 11.4 Detailed Design Drawings

Issued for Implementation design drawings specific to the WSF are summarised Table 16.

Table 16 WSF Issued for Implementation Drawings

Drawing No.	Title
<b>WASTE STORAGE FACILITY</b>	
680.10421.WSF.D01	WSF General Arrangement Plan
680.10421.WSF.D02	EWSF Foundation Plan
680.10421.WSF.D03	EWSF Layout Plan
680.10421.WSF.D04	EWSF Fill Elevation Plan
680.10421.WSF.D05	EWSF Sections
680.10421.WSF.D06	WWSF Foundation Plan Radiological Soil Treatment
680.10421.WSF.D07	WWSF Foundation Plan
680.10421.WSF.D08	WWSF Layout Plan

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Drawing No.	Title
680.10421.WSF.D09	WWSF Fill Elevation Plan
680.10421.WSF.D10	WWSF Sections
680.10421.WSF.D11	Typical Details
680.10421.WSF.D12	WSF Lysimeter Layout Plan
680.10421.WSF.D13	Lysimeter Details
680.10421.WSF.D14	Soil Monitoring Stations Details

## 12 Borrow Pit Development

Full details of the borrow pit development are contained in SLR Memo “*Borrow Area Development*”, dated April 2020 (SLR, 2020k).

### 12.1 Design Strategy

Borrow material is required for:

- Capping of WSFs;
- Capping of Dysons Pit Overburden;
- Backfill of excavated footprints; and
- Main Pit backfill bedding layer and clean capping layer.

The following type and quantity of materials are required:

- Low permeability clay material (420,250m<sup>3</sup>);
- Bedding sand (98,800m<sup>3</sup>);
- Clean capping material (155,850m<sup>3</sup>); and
- Growth material (1,486,358m<sup>3</sup>).

No suitable borrow material has been identified on site. Two borrow areas have been identified (**Figure 27**):

- Borrow Area A on Coomalie Council land; and
- Borrow Area B on Finnis River Aboriginal Land Trust (FRALT).

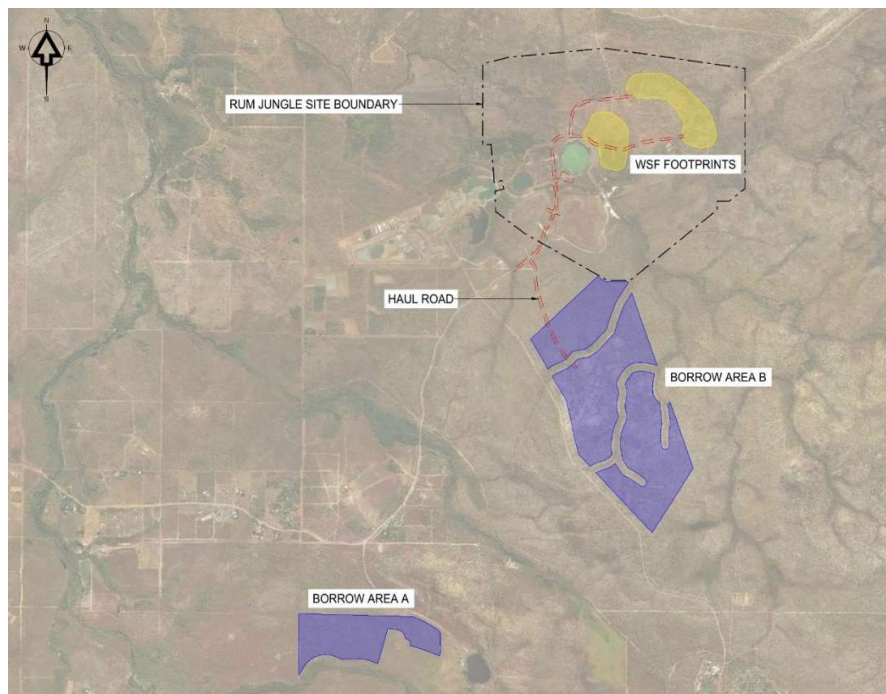


Figure 27 Borrow Area Locations

The estimated extent, depth and volumes of the available borrow materials are shown on the Design Drawings and in summary are:

- Borrow Area A
  - Clays: 607,250m<sup>3</sup>; and
  - Growth Medium: 1,558,075m<sup>3</sup>.
- Borrow Area B
  - Clean Sand (For Main Pit Backfill): 98,800m<sup>3</sup>;
  - Clean Capping Material (For Main Pit Backfill): 155,850m<sup>3</sup>; and
  - Growth Medium: 2,166,750m<sup>3</sup>.

## 12.2 Detailed Design Drawings

Issued for Implementation design drawings specific to the borrow areas are summarised in **Table 17**.

**Table 17 Borrow Areas Issued for Implementation Drawings**

Drawing No.	Title
<b>BORROW PITS</b>	
680.10421.BOR.D01	BORROW AREA 'A' COOMALIE COUNCIL FREE-HOLD MATERIAL TYPES PLAN
680.10421.BOR.D02	BORROW AREA 'A' COOMALIE COUNCIL FREE-HOLD TYPICAL SECTIONS
680.10421.BOR.D03	BORROW AREA 'B' FRLT - MATERIAL TYPES PLAN
680.10421.BOR.D04	BORROW AREA 'B' FRLT - TYPICAL SECTIONS

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## 13 Erosion and Sediment Control

This study indicates the erosion and sediment control measures required for the proposed rehabilitation works during both the construction phase and for longer term after site works. Full details of the design are given in SLR Report “*Site Erosion and Sediment Control Measures*” dated June 2020 (SLR, 2020o). Key points extracted from the report are summarised here.

### 13.1 Design Strategy

- **General Strategy.** The site has been divided into number of sub-catchments as shown in **Figure 28**. The ESC strategy for the various catchments is summarised in the following sections.
  - **Catchment 1:** located just north of the main site. Using the Revised Universal Soil Loss Equation (RUSLE) for soil loss estimation as per the IECA Guidelines (IECA, 2008), Catchment 1 runoff can be managed using sediment fencing downstream of the proposed works without the need for a sediment dam. A clean water diversion is also proposed directly upstream of the proposed works to redirect runoff from upslope catchments.
  - **Catchment 2:** located west of the main site. Using the RUSLE equation for soil loss estimation as per the IECA Guidelines, Catchment 2 runoff can be managed using sediment fencing downstream of the proposed works (annual soil loss < 150m<sup>3</sup>) without the need for a sediment dam. In order to satisfy the IECA requirements, Catchment 2 will require mulching over the entire catchment. A clean water diversion is also proposed directly upstream of the proposed works to redirect runoff from upslope catchments.
  - **Catchment 3:** associated to the Water Treatment Plant (WTP), this catchment is designed to be self-contained and ESC measures for this catchment constitute of sediment fencing and hydro-mulching (as required) of the batters.
  - **Catchment 4:** located between the Main and Intermediate Pits. Due to the close proximity of Main Pit, it is proposed to build a conveyance structure to the north of Catchment 4 which would discharge into Main Pit. Further ESC measures as such as mulching should be used over the proposed disturbance area to reduce potential erosion risks.
  - **Catchment 5:** located directly south of Main Pit and it is proposed to let the catchment discharge straight into Main Pit. Further ESC measures as such as mulching should be used over the proposed disturbance area to reduce potential erosion risks.
- **West WSF Catchment Area:** located directly east of the main pit and it is proposed to use two toe drains (around the north and south of the west WSF) to direct the generated runoff towards Main Pit.
- **East WSF Catchment Areas:** has been divided into a north and a south sub-catchment and is proposed to be managed as follows:
  - The north sub-catchment runoff will be managed by two toe drains redirecting flow to the proposed sediment dam SD1.
  - The south sub-catchment, Dysons Pit Overburden and Dysons WRD runoff will be managed using a system of sediment dams (SD2, SD3 and SD4) and conveyance channels. Where runoff can't be redirected towards a sediment dam, it is proposed to use sediment fencing and mulching of the disturbed areas as required. Further ESC measures as such as mulching should be used over the proposed disturbance area to reduce potential erosion risks where typical ESC measures aren't adequate.

- 
- **Main Waste Rock Dump Catchment Area:** located directly south of the EBFR diversion. This catchment will be managed by sediment dam SD5 using two conveyance channels to redirect runoff as well as sediment fencing and mulching where runoff can't be directed to SD5. A clean water diversion drain is also proposed to redirect flows from upslope catchments.
  - **Intermediate Waste Rock Dump Catchment Areas:** located just south of the Intermediate Pit separated by the EBFR diversion. This catchment will be managed by sediment dam SD6 using two conveyance channels to redirect runoff as required. A clean water diversion drain is also proposed to redirect flows from upslope catchments.
  - **Mt Burton Waste Rock Dump:** located approximately 2.5km west of the main Rum jungle mine site. The site is not large enough to warrant a sediment basin for erosion control. A clean water diversion drain is required to divert run-on from the work area.
  - **Mt Fitch Waste Rock Dump:** also remote from the main Rum jungle mine site. Clean water diversion drains are required to divert run-on from entering the work site, or in the longer term eroding the final landform. Sediment control will include two conveyance channels to convey water from the WRD site to a sediment basin located immediately downslope.

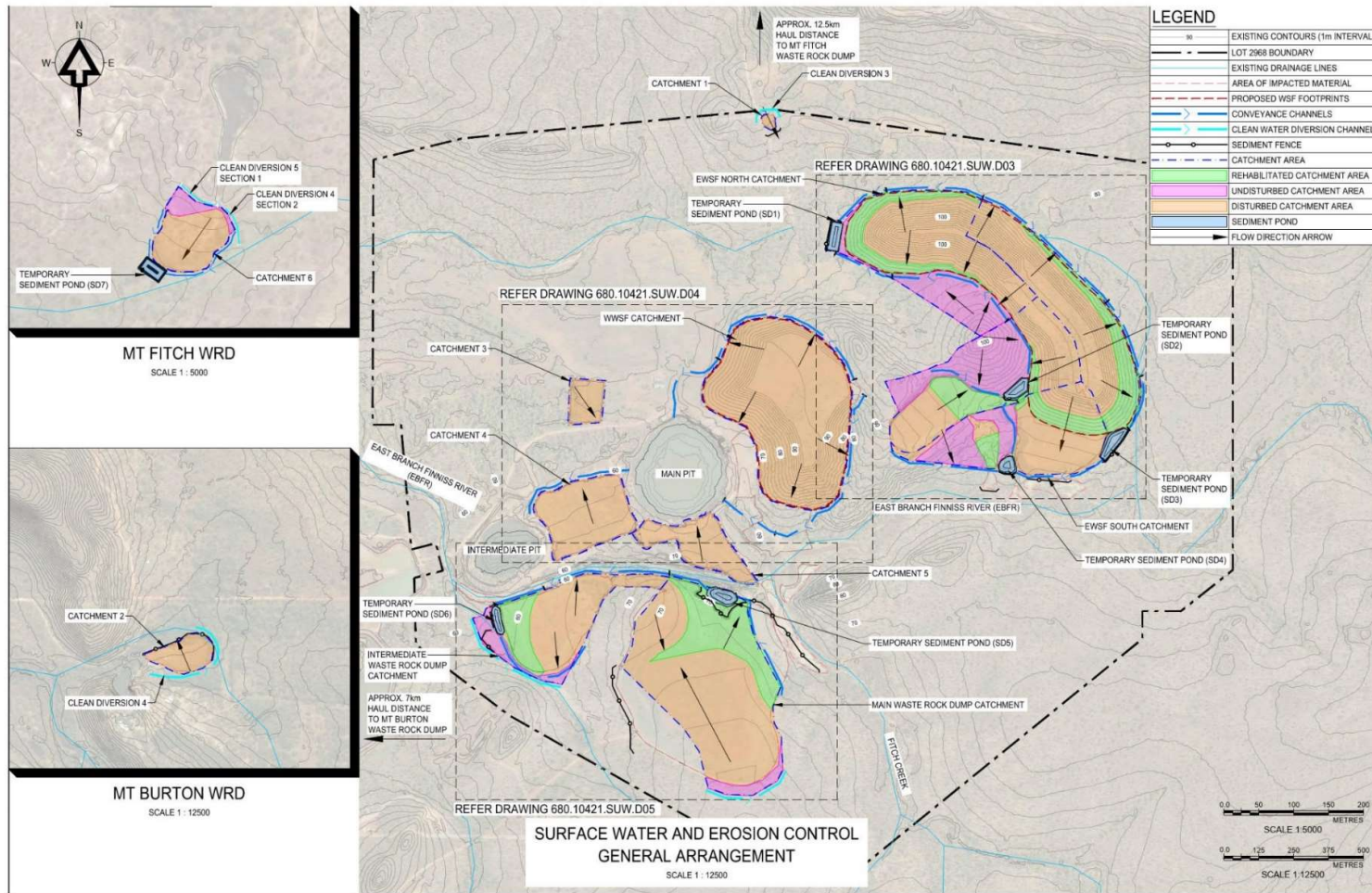


Figure 28 Overall ESCP scheme

- Sediment Dams: Due to the extent of the proposed disturbance areas, several sediment dams will be required to manage dirty water runoff, following the next design criteria and assumptions:
  - Capacity calculations based on a 5 day, 85th percentile rainfall depth of 46.7 mm derived from Equation B8 of the IECA Guideline;
  - The respective catchment areas have been assumed to be approximately 25% rehabilitated for this assessment;
  - Type F/D dams;
  - Disturbed runoff coefficient of 0.69 in accordance with Table B7 of the IECA guideline for a type D hydrological group with rainfall between 40 – 50 mm;
  - ‘Clean’ water runoff coefficient from undisturbed areas of 0.3;
  - The sediment storage zone determined based on a management period of 12 months (i.e. the sediment dam would be desilted once a year);
  - Sediment dams will be constructed with suitably designed spillways to manage overflows during significant storm events. The dams will also be constructed such that they are safe to people, vehicles and wildlife during their operation; and
  - For construction purposes, it was assumed that the sediment dams will be cut in the natural surface allowing for an embankment above the dam spill levels (i.e.: freeboard).

## 13.2 Detailed Design Drawings

Issued for Implementation design drawings specific to the surface water and flood modelling are summarised in **Table 18**.

**Table 18 Surface Water Issued for Implementation Drawings**

Drawing No.	Title
<b>SURFACE WATER</b>	
680.10421.SUW.D01	CONSTRUCTION NOTES
680.10421.SUW.D02	SURFACE WATER AND EROSION CONTROL GENERAL ARRANGEMENT
680.10421.SUW.D03	SURFACE WATER AND EROSION CONTROL OVERVIEW PLAN 1 OF 3
680.10421.SUW.D04	SURFACE WATER AND EROSION CONTROL OVERVIEW PLAN 2 OF 3
680.10421.SUW.D05	SURFACE WATER AND EROSION CONTROL OVERVIEW PLAN 3 OF 3
680.10421.SUW.D06	SEDIMENT DAM DETAILED PLANS - SHEET 1 OF 4
680.10421.SUW.D07	SEDIMENT DAM DETAILED PLANS - SHEET 2 OF 4
680.10421.SUW.D08	SEDIMENT DAM DETAILED PLANS - SHEET 3 OF 4
680.10421.SUW.D09	SEDIMENT DAM DETAILED PLANS - SHEET 4 OF 4
680.10421.SUW.D10	SEDIMENT DAM - TYPICAL DETAILS
680.10421.SUW.D11	CONVEYANCE CHANNELS - TYPICAL SECTIONS
680.10421.SUW.D12	SURFACE WATER AND EROSION CONTROL PROPOSED EBFR REALIGNMENT

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## 14 Realignment of the EBFR

A cornerstone cultural objective for rehabilitation of the former Rum Jungle Mine site is to restore the EBFR to its pre mining alignment, which runs through the Main and Intermediate Pits and fill the current manmade EBFR diversion which is not long term stable and geometrically uncharacteristic of the EBFR.

Full details of the realignment design are provided in SLR Report “*East Branch Finniss River – River Reinstatement and Flooding Design Report*” dated June 2020 (SLR, 2020p).

Key points extracted from the report are summarised here.

### 14.1 Objectives

Remedial solutions for the site have been developed in consultation with the Traditional Aboriginal Owners and involving a multi-disciplinary consultant team. The agreed collective objectives are as follows:

- Ensure no increase in flood levels upstream of the Main Pit;
- Convert the Main Pit into a permanent shallow lake;
- Retain the Intermediate Pit as a deep lake;
- Remove the manmade concrete culverts from each of the pits;
- Facilitate aquatic organism passage by ensuring zones of low velocity along the flood fringes at varying flood heights and resting places at intervals with zero velocity;
- Inclusion of a defined low flow alignment which follows the original alignment for which can be successfully revegetated and have the appearance of nearby natural creeks, while avoiding highly geometric engineered channel forms; and
- Work towards backfilling the existing manmade EBFR diversion channel to restore the EBFR to its original alignment through the Main and Intermediate Pits.

The following design specific aspects are to be complied with:

- Provide a naturalistic watercourse which is long term stable;
- Include very shallow slopes along the floodplain where slow moving water will allow for aquatic organism utilisation and passage; and
- Design the surface with an erosion potential to safely withstand a 1% AEP (1 in 100-year ARI) flood event without bed scour.

It is critical to note that the purpose of this design is to provide a suitable foundation design for construction purposes. It is recognised that this EBFR restoration process on site will require monitoring, maintenance and management over a timeframe that extends beyond the scope of the project construction phase. The rationale for the design elements provided here must be considered in the context of the dynamic watercourse processes of erosion and sedimentation, water flow and flooding regime, the seasonal cyclic nature of aquatic organism utilisation and the vegetation cycles that respond to the physical processes mentioned here.

The design presented here corrects the alignment of the water course, describes a stream bed and flood plain design that has low erosion rates and suitable flow rates to allow revegetation and aquatic organism utilisation. It is recognised that the Main Pit lake will act as a sediment trap for some time therefore isolating the downstream channels from receiving the majority of the available sediment loading. The lack of sediment

replenishment is recognised as a long-term landform risk and as such, the Project owner's management framework will need to incorporate appropriate monitoring of this element and committed to an Adaptive Management approach to mitigating future impacts.

Figure 29 shows a representation of the pre-mining alignment of the EBFR (K. Martin-Stone, 2019).



Figure 29 Pre-Mining EBFR Alignment

## 14.2 Flood Modelling

Flood behaviour over the site has been determined using Surface Water Management Modelling (SWMM) software. SWMM incorporates an interconnected one-dimensional (1D) and two-dimensional (2D) analysis of flows. Due to the large catchment, the 2D analysis has been restricted to upstream of the Main Pit and downstream to the site boundary.

Peak flooding depths of inundation for the 1% AEP event are shown in for:

- The existing site (note the bathymetry of the pits to the floor was excluded in the modelling); and
- The rehabilitated site with design river reinstatement in place (note the final pit bathymetry was included in the modelling).

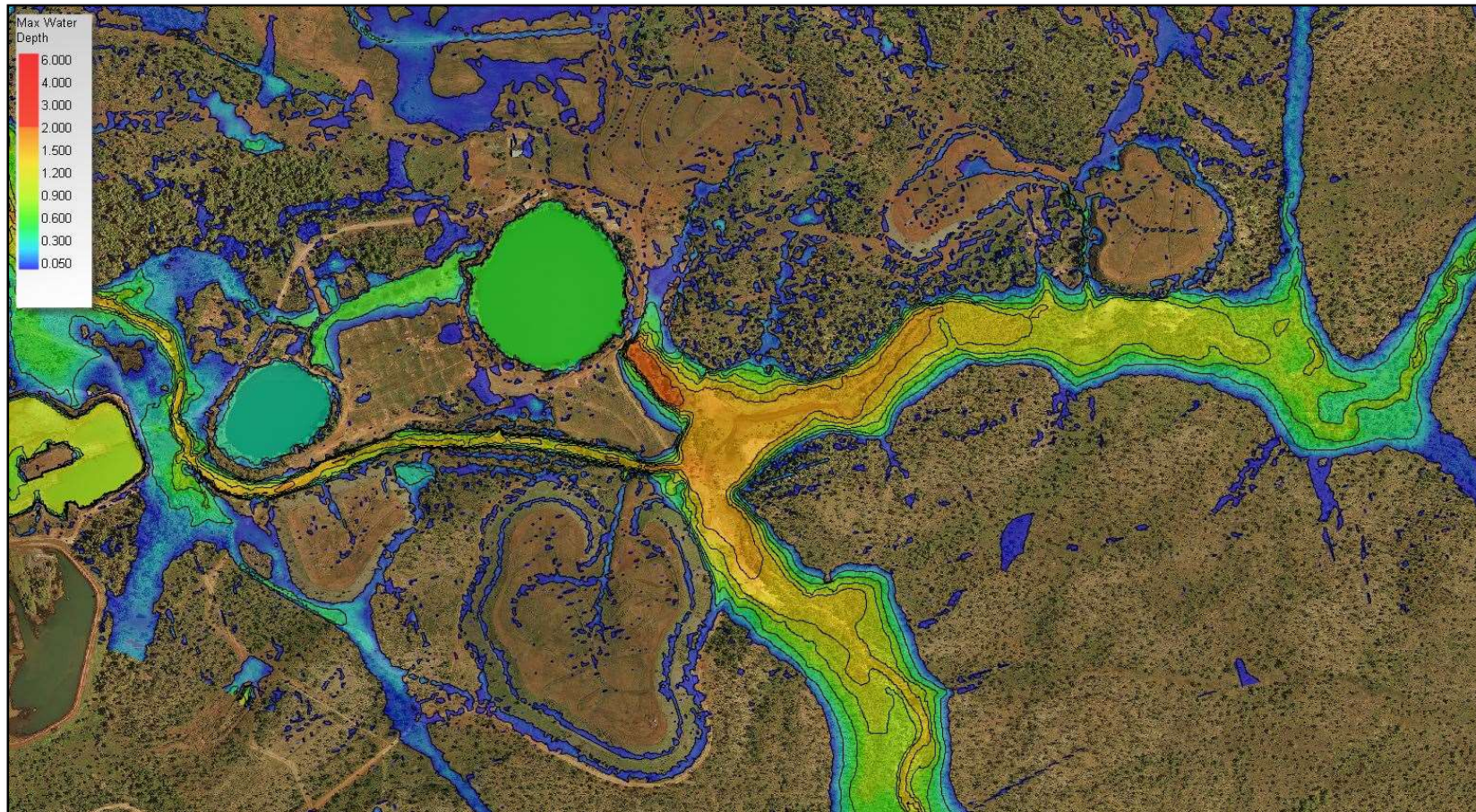


Figure 30 1% AEP Flood Extent on the Existing Site (Depths in Metres & Scale Excludes Depth to Pit Floors)

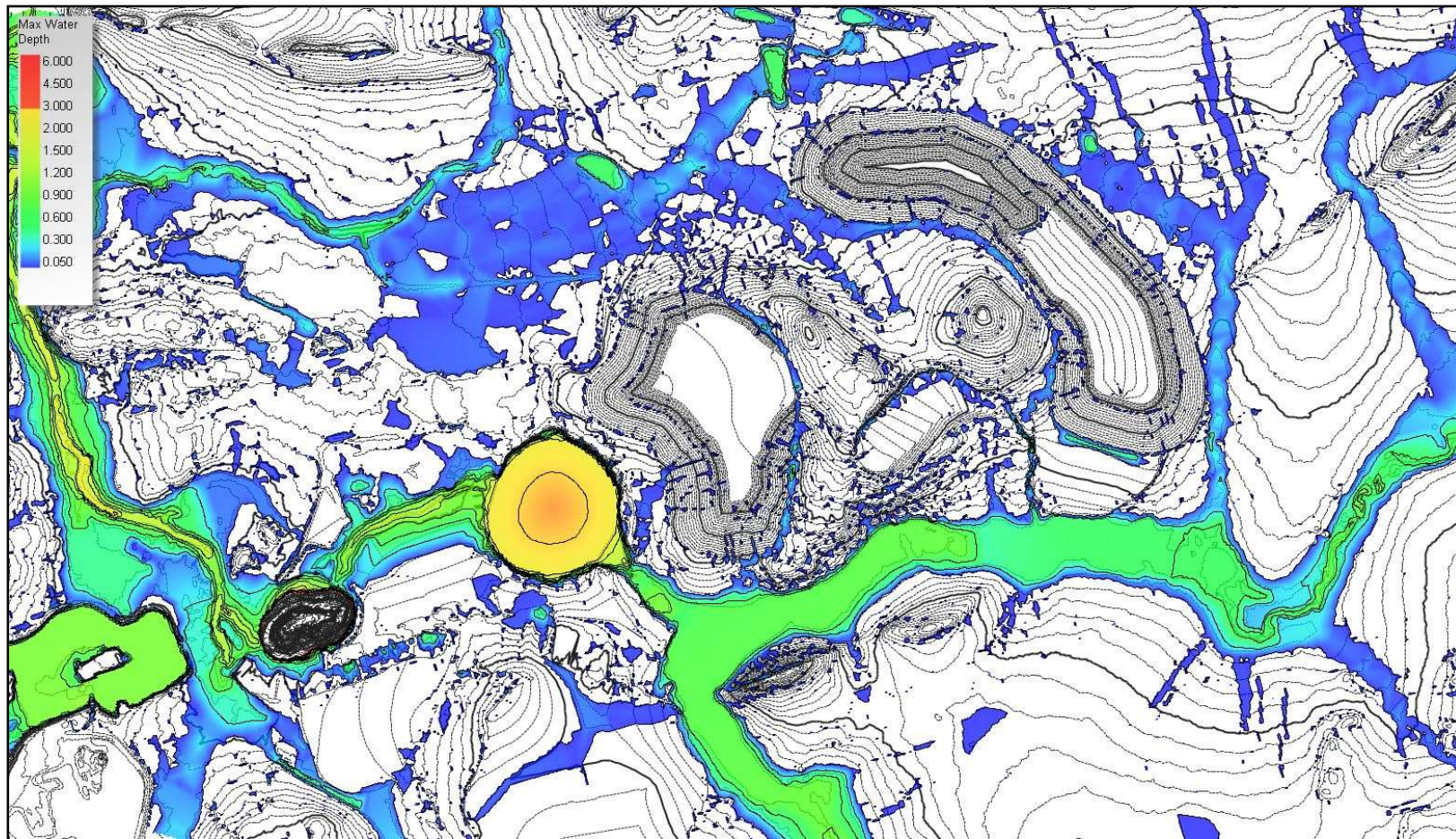


Figure 31 1% AEP Flood Extent Post Reinstatement Works (Depths Greater than 6m Excluded from Display for Clarity)

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## 14.3 River Realignment Design

### 14.3.1 Stream Bed Alignment and Form

The designed form of the watercourse includes a low flow channel which seeks to replicate stream beds in surrounding 'reference' watercourses, which have bed widths of 3 to 5m of granular material comprising gravels sand and humus.

The bed is intended to be a slightly sinuous channel lightly incised into the surrounding floodplain. The channel geometry does not have a fixed dimension or constant slopes.

### 14.3.2 Stream Bed – Materials Selection

The selection of stream bed materials seeks to provide a surface which is not dissimilar to adjoining creeks which have areas of coarse sand deposits interspersed with stone, and areas of exposed bed rock

The long-term establishment of vegetation in areas of higher shear stress will bind the finer material between the larger rip rap stone. The root matter surrounding the rip rap will serve as a robust matrix to shear stresses when exposed to flood flows.

The distribution of different materials is based on predicted shear stresses during a 1% AEP flood when the channel is in an unvegetated state. There has also been some rationalisation of zones and increase in rip-rap sizing near the entry to pit lakes.

The low flow area of the river diversion has increased thickness of growth medium to encourage the establishment of denser vegetation along the watercourse and its banks.

All site revegetation works are the responsibility of the Owner and this includes the riparian and aquatic revegetation needs for the EBFR restoration works. The Owner is to engage a locally experienced revegetation expert who will co-ordinate with TOs, project aquatic ecologists and other specialists to establish the revegetation needs for the EBFR restoration works. Priorities will include:

1. Provision of suitable rest points, habitat and nutrition for aquatic organisms;
2. Provision of suitable habitat and nutrition for riparian organisms; and
3. Culturally and ecologically appropriate plant species.

### 14.3.3 Floodplain Form

The shape of the floodplain has been set at low grades so that overbank flows are wide and slow moving. This seeks to replicate the existing landform.

### 14.3.4 Fish Passage 'Furniture'

Details around installation of natural features designed as rest points within the topography including boulders, banks, pools, logs and snags and revegetation works are to be established by the Owner Team in consultation with experienced hydrobiological personnel during the Stage 3 Construction Phase.

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## 14.4 Detailed Design Drawings

Issued for Implementation design drawings specific to the surface water and flood modelling are summarised in **Table 19**.

**Table 19 Surface Water Issued for Implementation Drawings**

Drawing No.	Title
<b>REINSTATEMENT OF EAST BRANCH FINNISS RIVER</b>	
680.10421.RFR.D01	GENERAL ARRANGEMENT
680.10421.RFR.D02	EXISTING AND FINAL CONTOURS PLAN
680.10421.RFR.D03	SECTIONS SHEET 1 OF 2
680.10421.RFR.D04	SECTIONS SHEET 2 OF 2
680.10421.RFR.D05	DETAILS SHEET 1
680.10421.RFR.D06	DETAILS SHEET 2
680.10421.RFR.D07	FLOOD INUNDATION AND WSF POSITION

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## 15 Remediation of Excavation Footprints

Excavated footprints for the waste rock and soils are to be treated to ensure no ongoing surface or groundwater contamination. Full details of the design are given in SLR Report “*Waste Storage Facilities and General Site Civil Works, Detailed Design and Construction Methodology*”, dated May 2020 (SLR, 2020g). Key points are summarised here.

### 15.1 Design Strategy

- The following areas will be excavated to 2m below assumed natural ground, treated with lime at the rate matched to that landform, allowed to flush for a minimum of 1 wet season and then backfilled with growth medium to a depth of 3m, i.e. 1m above assumed natural grade. This will allow for treatment of AMD in the unsaturated below the footprint and ensure the final landform considers potential settlement so that it remains self-shedding:
  - Intermediate WRD;
  - Main WRD; and
  - Copper Extraction Area.
- For the copper heap leach area:
  - This area is to be excavated to a depth 2 m below the current surface elevation, and the excavated material relocated to the WSF. The top 0.2 m of substrate will be grid sampled, tested for paste soil pH and dosed accordingly with lime to achieve an approximate paste pH of 8; and
  - A backfilled layer of growth substrate over the footprint will be placed to bring the final surface up to approximately 1 m above grade to result in a final landform that is water shedding for the purpose of slowing down any future release of final copper loads and will support revegetation. Total backfill thickness will therefore range from 2-3m allowing for natural fall.
- The following areas will be excavated to 2m below assumed natural ground then backfilled with growth medium to a depth of 3m, i.e. 1m above assumed natural grade. This will allow for settlement and ensure that the footprint areas remain self-shedding:
  - Main WRD levee; and
  - Main North WRD.
- Radiological soils:
  - Those soils within the footprint of the West WSF are to be left in-situ and covered by relocated radiological waste then a 0.5m low permeability cover; and
  - Areas outside the West WSF will be excavated to 2m and relocated. It should be noted though this may be as shallow as 0.4m depending on quality testing undertaken during excavation.
- The following areas will be excavated and backfilled with growth medium to natural grade to depths as specified:
  - Dysons WRD (2m);
  - Mt Burton WRD (0.3m);
  - Salt and metal impacted areas (0.3m); and
  - Miscellaneous rocky piles (stripped to natural grade, no backfill required).

The designs for the excavated footprint have been based on the following considerations:

- The base of the excavation will not be compacted prior to liming (if applicable) or backfill. The intent is to allow vertical flushing of the unsaturated zone toward the groundwater interception bore;
- There is no requirement for rock mulch or other erosion measures as the backfilled landforms are relatively flat slopes. Appropriate surface water management and erosion and sediment control will be implemented during vegetation establishment phases (SLR, 2020o); and
- Vegetation will be as per the Project Revegetation Plan, to be developed by NT DPIR.

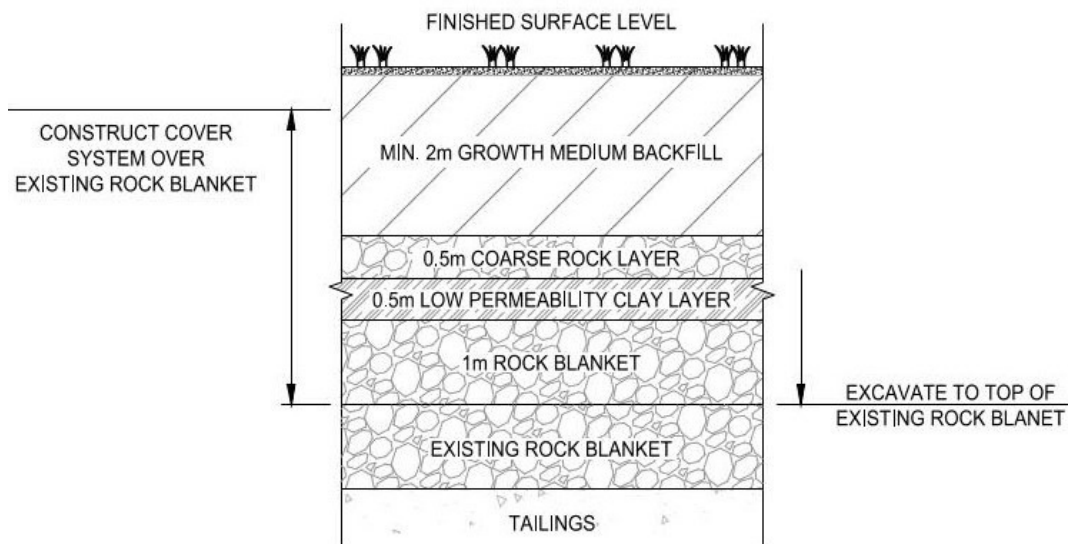
## 15.2 Dysons Pit Overburden

The capping system for Dysons Pit Overburden was developed by (O'Kane Consultants Pty Ltd, 2016) and review and update of this design was not part of the SLR Stage 2A design scope as it is considered leading industry standard.

The capping design is understood to be as follows:

- The overburden is to be excavated down to the top of existing rock blanket;
- Surface rip-rap material is to be scavenged for reuse;
- A 1m rock layer is to be placed over the existing rock blanket; and
- A new cap is to be constructed over this including:
  - 0.5m low permeability layer;
  - 0.5m coarse rock layer; and
  - 2m growth medium layer.

The proposed capping (O'Kane Consultants Pty Ltd, 2016) is shown in **Figure 32**.



**Figure 32 Dysons Overburden Cover System**

Appropriate surface water management and erosion and sediment control will be implemented during vegetation establishment phases (SLR, 2020o).

### 15.3 Detailed Design Drawings

Issued for Implementation design drawings specific to the excavated footprints areas are summarised in Table 20.

**Table 20 Excavated Footprints Issued for Implementation Drawings**

Drawing No.	Title
<b>EXCAVATED FOOTPRINTS</b>	
680.10421.REH.D01	DETAILED REHABILITATION PLAN - SHEET 1 OF 4
680.10421.REH.D02	DETAILED REHABILITATION PLAN - SHEET 2 OF 4
680.10421.REH.D03	DETAILED REHABILITATION PLAN - SHEET 3 OF 4
680.10421.REH.D04	DETAILED REHABILITATION PLAN - SHEET 4 OF 4
680.10421.REH.D05	DETAILED REHABILITATION SECTIONS - SHEET 1 OF 4
680.10421.REH.D06	DETAILED REHABILITATION SECTIONS - SHEET 2 OF 4
680.10421.REH.D07	DETAILED REHABILITATION SECTIONS - SHEET 3 OF 4
680.10421.REH.D08	DETAILED REHABILITATION SECTIONS - SHEET 4 OF 4
680.10421.REH.D09	NEW LOW FLOW CHANNEL EXCAVATION SECTIONS

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## 16 Internal Haul Roads

### 16.1 Design Details

SLR commissioned MEC Mining to undertake the design of the internal haul roads, including the haul road to the FRALT borrow area.

The scope of design included:

- Road geometry;
- Pavement thickness design;
- Superelevation design;
- Intersection design and signage;
- Speed limit designation;
- Cut and fill volumes;
- Drainage control; and
- Construction plans.

The purpose of this work is to design a haulage network that will be constructed and used during the rehabilitation project at Rum Jungle. **Figure 33** provides the proposed haul road alignment. Full details of the design development can be found in (MEC, 2020b) and (SLR, 2020g).

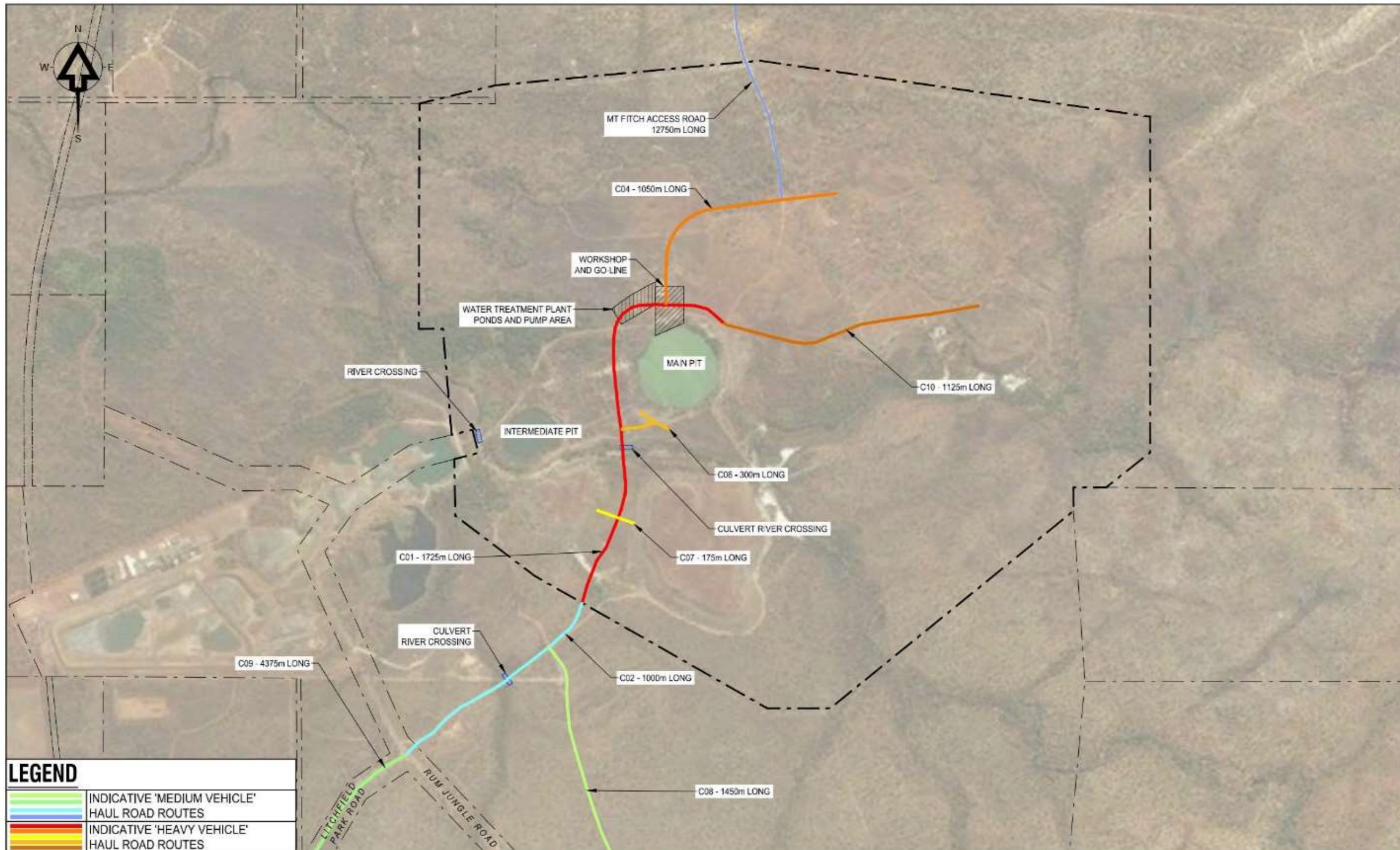
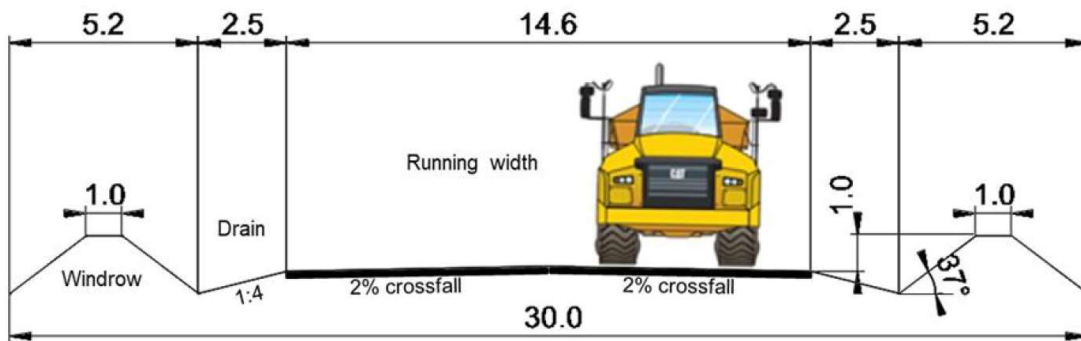


Figure 33 Haul Road Alignment

The basis of design for the haul roads includes:

- The largest haul truck assumed for the haul road design is the articulated CAT745C. This haul truck has a maximum width of 4.17m and wheel height of 1.9m. The running width of the haul road is required to be 3.5 times the maximum width of the largest truck, 14.6m. The windrow height is required to be half the wheel height of the largest haul truck, 1.0m. **Figure 34** shows the design specifications of the haul road geometry.



**Figure 34 Haul Road Geometry**

- Pavement thickness design has been based on CBR values supplied by (SLR, 2020a).
- Design is for up to 10 years.
- Design specifications have been based on:
  - Recognised Standard 19: Design and construction of mine roads August 2019. Available at: [https://www.dnrme.qld.gov.au/data/assets/pdf\\_file/0008/1453175/recognised-standard-19-mine-roads.pdf](https://www.dnrme.qld.gov.au/data/assets/pdf_file/0008/1453175/recognised-standard-19-mine-roads.pdf);
  - Guidelines for Mine Haul Road Design, by Dwayne D. Tannant and Bruce Regensburg, 2001. Available at: [https://www.researchgate.net/publication/277759950\\_Guidelines\\_for\\_Mine\\_Haul\\_Road\\_Design](https://www.researchgate.net/publication/277759950_Guidelines_for_Mine_Haul_Road_Design)
  - Various standard internal mining company specifications.

## 16.2 Detailed Design Drawings

Issued for Implementation design drawings specific to the internal haul roads are summarised in **Table 21**.

**Table 21 Internal Haul Roads Issued for Implementation Drawings**

Drawing No.	Title
<b>INTERNAL HAUL ROADS</b>	
680.10421.HR.D00	Haul Roads – Cover Sheet
680.10421.HR.D01	Haul Roads – Drawing List
680.10421.HR.D02	Haul Roads – Overview

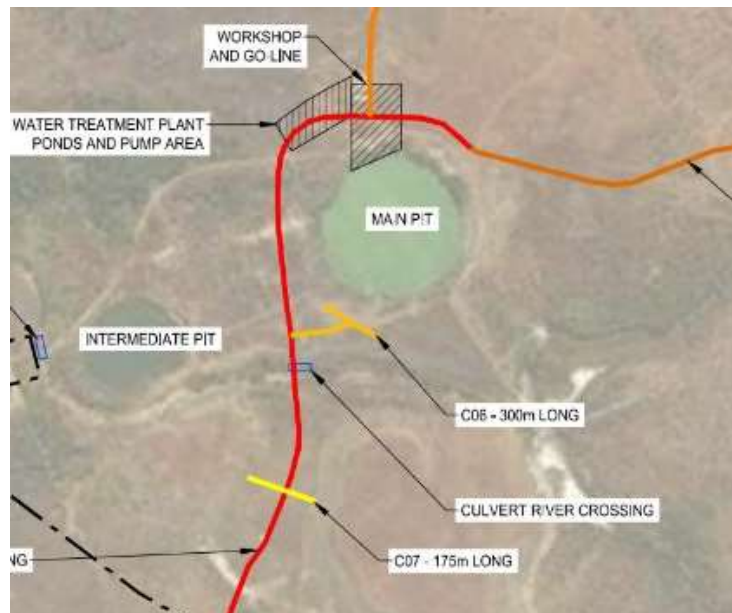
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Drawing No.	Title
680.10421.HR.D00	Haul Roads – Section A1 – Long Section
680.10421.HR.D01	Haul Roads – Section A1 – Cross Sections
680.10421.HR.D02	Haul Roads – Section A2 – Long Section
680.10421.HR.D03	Haul Roads – Section A2 – Cross Sections
680.10421.HR.D04	Haul Roads – Section A3 – Long Section
680.10421.HR.D05	Haul Roads – Section A3 – Cross Sections
680.10421.HR.D06	Haul Roads – Section A4 – Long Section
680.10421.HR.D07 and D08	Haul Roads – Section A4 – Cross Sections
680.10421.HR.D09 and D10	Haul Roads – Section A5 – Long Section
680.10421.HR.D11	Haul Roads – Section A5 – Cross Sections
680.10421.HR.D12 and D13	Haul Roads – Section A6 – Long Section
680.10421.HR.D14	Haul Roads – Section A6 – Cross Sections
680.10421.HR.D15	Haul Roads – Section A7 – Long Section
680.10421.HR.D16	Haul Roads – Section A7 – Cross Sections
680.10421.HR.D17	Haul Roads – Section A8 – Long Section
680.10421.HR.D21	Haul Roads – Section A8 – Cross Sections
680.10421.HR.D22 and D23	Haul Roads – Section A9 – Long Section
680.10421.HR.D24 to D26	Haul Roads – Section A9 – Cross Sections
680.10421.CUL.D01	Reinstatement of East Branch Finniss River Haul Road Additional Culvert Detail

## 17 EBFR Diversion Drain Crossing Design

### 17.1 Design Details

An all-weather haul road crossing is required at the EBFR Diversion Channel to allow waste rock to be hauled from the Intermediate WRD, Main WRD and various other impacted sites. The crossing will also support the delivery of materials to site. The location of the crossing (and general haul road alignment) is shown in **Figure 35** and the typical environment at the crossing location is shown in **Figure 36**.



**Figure 35** Location of EBFR Diversion Channel Crossing



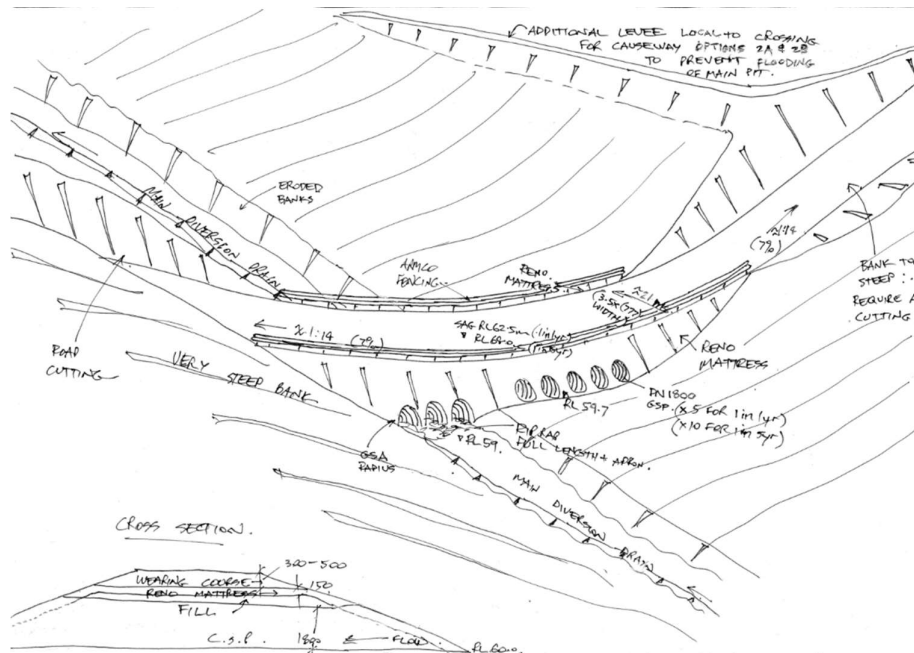
**Figure 36** Conditions at the EBFR Diversion Channel Crossing

The Stage 2 rehabilitation strategy identified that a bridge with a flood immunity of 1 in 100 year Annual Return Interval (ARI) was the preferred crossing solution, however no details of how this was selected or any design details were available. As part of Stage 2A, a Multi-Criteria Analysis (MCA) options assessment was undertaken to identify the optimal crossing type and flood immunity required (SLR, 2019).

The results, and ultimate agreement with NT DPIR, were:

- Culvert crossing; and
- 1:5 year ARI flood immunity.

An indicative design was developed by SLR (**Figure 37**) to undertake hydraulic analyses to ensure that there would be no impact on upstream culturally significant sites during flood events due to the presence of the crossing.



**Figure 37 Indicative Culvert Crossing**

Geotechnical assessment of the crossing area was undertaken to confirm foundation conditions (SLR, 2020a) and detailed survey carried out.

Pritchard Francis were commissioned by SLR to undertake the detailed design of the culvert crossing based on the supplied data. The crossing design was developed in conjunction with input data from MEC regarding the haul road design (refer **Section 16**). **Figure 38** gives an indication of the detailed design by Pritchard Francis.

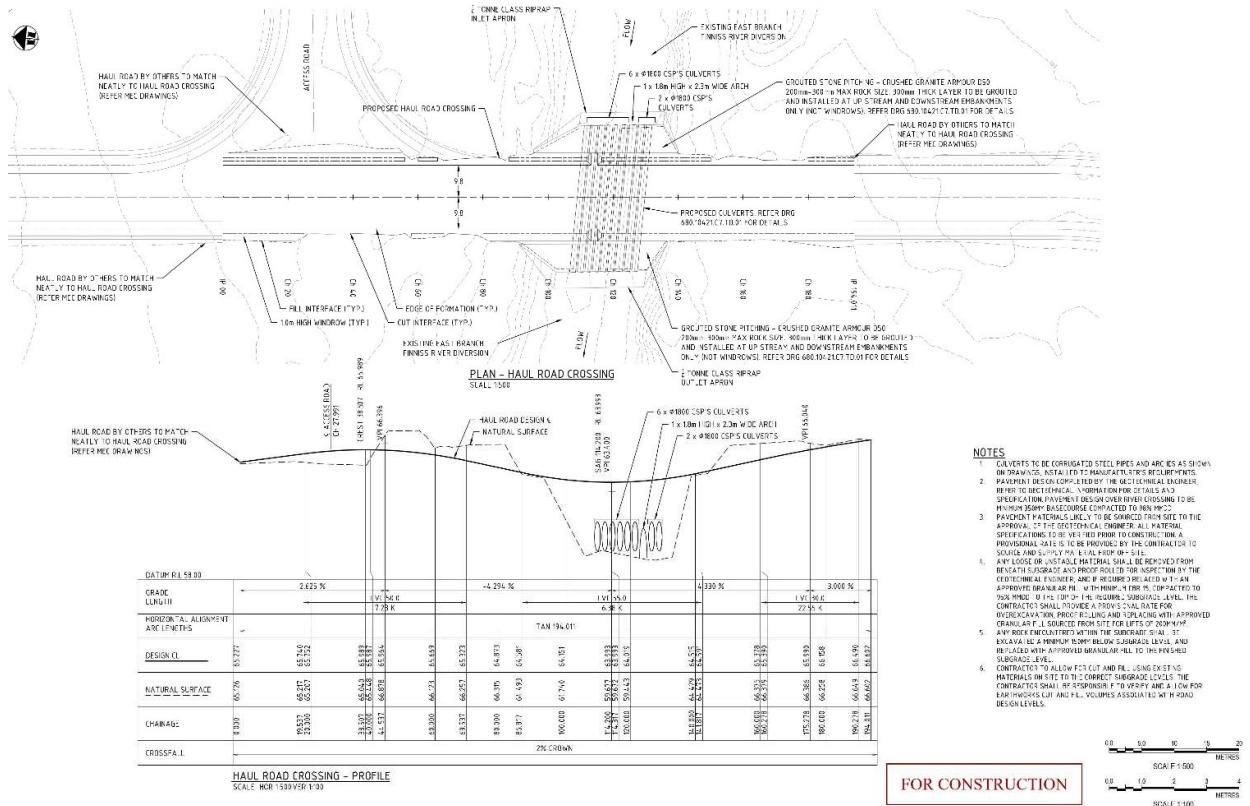


Figure 38 Pritchard Francis Culvert River Crossing Design

The culvert is to be removed at the end of the construction works.

## 17.2 Design Drawings

Issued for Implementation design drawings specific to the river crossing are summarised in **Table 22**.

Table 22 River Crossing Issued for Implementation Drawings

Drawing No.	Title
<b>DIVERSION DRAIN CROSSING</b>	
680.10421.C0.CS.01	Haul Road Crossing – Cover Sheet and Drawing List
680.10421.C1.BD.01	Haul Road Crossing – Basis of Design
680.10421.C1.GN.01	Haul Road Crossing – General Arrangement
680.10421.C5.RP.01	Haul Road Crossing – Plan and Profile
680.10421.C7.TD.01	Haul Road Crossing – Sections and Details

## 18 External Access Roads

### 18.1 Key Constraints

The key constraints are associated with the rural nature of the road environment. Being a rural road network, the existing traffic demands are relatively low, leading to the following characteristics:

- The intersection forms tend to be relatively basic;
- The pavement cross sections tend to be relatively informal, especially missing pavement shoulders and formalised kerbs; and
- The traffic demands consist of higher than typical heavy vehicle proportions, and subsequently the condition of the line marking is often poor.

A traffic impact assessment (TIA) has been undertaken on the external road network to determine the impact of the Project and the develop mitigation and management strategies.

### 18.2 Vehicle Types

The external vehicle fleet anticipated to be associated with the Project are:

- Private vehicles (workforce);
- Coach (workforce);
- Heavy rigid vehicles (material deliveries);
- Truck and dog (borrow material movement);
- B-double (fuel delivery); and
- Floats (mobilisation and demobilisation).

#### 18.2.1 Vehicle Movements

The (conservatively high) quantities of material that have been adopted for the traffic generation forecasts are as follows:

- Low permeability cover material – 500,000m<sup>3</sup>;
- Growth medium cover material – 1,200,000m<sup>3</sup>; and
- Lime – 300,000 tonnes.

The TIA indicates that the peak daily traffic generation and peak hour traffic generation will be as shown in **Table 23**.

**Table 23 External Peak Daily Traffic Generation**

Project Element	Forecast Daily Return Trips
Low permeability cover material	31
Growth medium cover material	31
Lime	15

Project Element	Forecast Daily Return Trips
Workforce	17
Fuel deliveries	1
Waste removal	1
Miscellaneous deliveries	1
Equipment deliveries	0
<b>Total</b>	<b>97 daily trips</b>

### 18.3 Traffic Impact Study

The TIA identified the following mitigation strategies to support the traffic demands generated by the Project:

- Undertake the following intersection upgrade works:
  - Rum Jungle Road / Litchfield Park Road:
    - Construct a short auxiliary left turn lane AUL(S) on the southern approach (Rum Jungle Road).
  - Litchfield Park Road / Poett Road:
    - Construct a short auxiliary left turn lane AUL(S) on the eastern approach (Litchfield Park Road).
- Obtain approval from NHVR to utilise Crater Lake as a haulage route for lime material being sourced from the south on Stuart Highway;
- The Project will assume responsibility for the pavement maintenance of roads on the external network that will be used for material haulage and other heavy vehicle activity;
- Prepare a Road Use Management Plan:
  - Summarise and update the latest condition of the road network and estimates of the Project's traffic generation potential considering the finalised workforce, procurement and logistics arrangements based upon advice from the construction contractor;
  - Update the analysis presented herein where either the underlying road conditions or assumed traffic generating characteristics of the Project have changed;
  - Identify any known over-dimension movements and the associated logistics strategy and required approvals; and
  - Detail proposed impact mitigation strategies, both "soft" strategies (for example, bussing workers, variable message signs / media notices about increased project traffic and road-use management strategies such as avoiding peak hour traffic, fatigue management) and "hard" infrastructure strategies (for example, upgrading an intersection or contributing to maintenance).
- A Traffic Management Plan (TMP) will be required for construction activities on the external road network (e.g. intersection upgrades) and is a separate document to the Road Use Management Plan.

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## 18.4 Design Strategy

### 18.4.1 Road Design

The proposed routes are public roads and given the intent for longer term use (i.e. 5 years), their design should accord with relevant public road design guidelines including NT Gov's *Standard Road Cross Section Policy* (Cross Section Policy) and where relevant the more extensive guidance presented within the Austroads design series.

The Cross Section Policy identifies Rural Arterial and Secondary Roads should be constructed with the following seal widths dependent on the forecast vehicles per day (vpd) technically at a 20-year design horizon:

- Greater than 1,000 vpd - 8.0m seal width including 2 x 3.5m lanes; and
- Less than 500vpd - 7.0m seal width including 2 x 3.0m lanes.

### 18.4.2 Litchfield Park Road

Based on the anticipated traffic demands on Litchfield Park Road with the addition of the anticipated Project traffic it is considered that the existing road cross- would be appropriate for single articulated and B double trucks.

The Project is anticipated to assume responsibility for the maintenance of Litchfield Park Road given the increase in pavement loadings as a result of the Project.

### 18.4.3 Poett Road

The future traffic demands on Poett Road are assumed to be almost entirely associated with the Project.

The Project is anticipated to assume full responsibility for the maintenance and management of Poett Road for the duration of haulage activity. Retaining the road with an unsealed treatment would not place any additional burden on the local road authority after completion of Project works.

### 18.4.4 Rum Jungle Road & Batchelor Road

The traffic demands on Rum Jungle Road and Batchelor Road are anticipated to be rather modest, at approximately 35 movements per day during the busiest period of the Project lifespan, with approximately half of these associated with staff movements. Given the modest heavy vehicle movements associated with the Project on these roads, no specific cross-sectional works are anticipated to be required.

The Project is anticipated to assume responsibility for the maintenance of Rum Jungle Road and Batchelor Road.

Whilst the use of Batchelor Road passes through Batchelor township the modest heavy vehicle traffic volumes are not expected to generate significant amenity impacts that will require infrastructure solutions.

### 18.4.5 Crater Lake Road

The traffic demands on Crater Lake Road are anticipated to be rather modest, at approximately 15 movements per day during the busiest period of the Project lifespan. Therefore, given these modest heavy vehicle movements associated with the Project on this road, no specific cross-sectional works are anticipated to be required with the exception of maintenance.

The Project is anticipated to assume responsibility for the maintenance of Crater Lake Road.

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## 19 Construction Works Layout

### 19.1 Constraints

Registered Aboriginal Sacred Sites and Objects are marked on the AAPA Authority Certificate (not included in this report due to sensitive information contained in that Certificate). All designs have been developed to avoid these areas.

Exclusion zones are these areas will be put in place by the Principal prior to commencement of construction.

### 19.2 Infrastructure

Construction infrastructure to be provided by the Contractor in conjunction with carrying out the works, as defined within the Civil and Earthworks Technical Specification (SLR, 2020n) is as follows:

- A fuel farm to meet the requirements of the Australian Standard for The Storage and Handling of Flammable and Combustible Liquids (AS1940:2017);
- Appropriate NATA laboratories;
- Offices;
- Telecommunications;
- Owners Team (Principal) offices;
- Car parking;
- Electricity supply;
- Drinking water supply;
- First aid treatment room;
- Perimeter fencing and visual screens;
- Change rooms:
  - must have wash in wash out for when working around Radiological Soils;
  - compostable toilets if possible.
- Crib sheds.

Requirements include:

- Located more than 50 m away from a waterway;
- Have ready access to road network;
- Be sited on relatively level land;
- Require minimal vegetation clearing (preferably none);
- Be above the 20 ARI Flood level unless a contingency plan to manage flooding is prepared and implemented;
- Provide sufficient area for the storage of raw materials to minimise, to the greatest extent practical, the number of deliveries outside standard construction hours; and

- Located at least 100 m from any aboriginal significant sites.

On closure all facilities and access points shall be rehabilitated to at least their pre-construction condition or better unless otherwise agreed by the Principal.

### 19.3 Vehicle Decontamination Area

The Contractor shall note that in order to avoid excessive decontamination works, vehicle movement on and off site will therefore be limited to 'Public Access Zone' and 'Construction Only Access Zone' as follows:

- The Construction Only Zone will be everything inside the Rum Jungle Boundary and the Finnis River Aboriginal Land Trust (FRALT) borrow area (Borrow Area B). This would include all construction equipment, including light vehicles and trucks that bring material from the FRALT borrow area; and
- The Public Access Zone will include areas outside the Rum Jungle Boundary and the Coomalie Council borrow area (Borrow Area A). This would include all personnel vehicles and trucks bringing material from the Coomalie Council borrow area.

To facilitate the restricted vehicle movements, a staging area will be required near the access to the Rum Jungle Mine site. The location of this staging area, which will involve vehicle parking either side of the boundary, will need to be agreed with the Principal.

The exception to the above restrictions would be delivery vehicles, specifically fuel and lime supply. These vehicles would need to undergo decontamination after every delivery. It is understood (DPIR communication) that this process takes approximately 3 hours.

### 19.4 Construction Water

During the course of the works, the Contractor is required to minimise inconvenience to local residents and site workers on or near the site of the Works by avoiding or controlling noise, vibration, dust, mud and any other nuisance.

Water for dust suppression will be sourced from sediment dams (if available), groundwater bores and the adjacent Brown's Oxide site (subject to a suitable water use agreement). Water from potable water sources (i.e. trucked-in) would only be used as a last resort. Both the Main and Intermediate Pit quality is not suitable for use as dust suppression, though may be suitable for WSF construction water.

### 19.5 Demolition and Demobilisation

The Contractor shall demolish and remove all existing buildings, including concrete footings to a facility licenced to dispose of such wastes. The Contractor is also required to isolate any asbestos materials at the Rum Jungle site from environmental and human receptors by removing and relocating to the new WSFs or by another approved means offsite.

Once the Contractor has demobilised, rehabilitation of the Contractor compound area will be carried out.

### 19.6 Quality Assurance and Quality Control

Construction Quality Control (CQC) and Construction Quality Assurance (CQA) will be required by the CQA Consultant to ensure all materials used in the Works meet the material requirements and the Works are carried out and completed in accordance with the Contract Documents and Specification.

Contractor requirements include preparing management plans, preparing work method statements, CQC material testing, surveying, hold point witness and work as executed documentation as specified in the General Site Civil and Earthworks Package Technical Specification.

### **19.6.1 Construction Quality Control**

All CQC testing shall be arranged by the Contractor at the direction of the CQA Consultant and shall be carried out by appropriately qualified personnel during the course of the works. Copies of all test results are to be sent to the Superintendent for review. The minimum testing frequencies shall be as nominated within the various parts of the Specification.

### **19.6.2 Construction Quality Assurance**

A CQA Plan will be developed prior to construction and will be implemented to ensure that the Works are undertaken in a manner that demonstrates compliance with the Contract Documents and with this Specification. The Principal shall appoint a CQA Consultant to undertake all aspects of quality assurance for the Works.

## 20 Management Plans

Numerous management plans are under development for inclusion in the Stage 3 Construction. An example of the likely management plans is shown in **Table 24**.

**Table 24 Management Plans to be Implemented During Construction**

Management Plan	Application
Radiation Management Plan, Rum Jungle Mine Rehabilitation (ECOZ, 2019)	<p>The intent of the document is to ensure the Rum Jungle rehabilitation project meets all of its regulatory obligations for the management of radiation and radioactive materials at the site during the construction and excavation project.</p> <p>Compliance with this plan will ensure that radiation exposure to contractors and members of the public is minimised and kept as low as reasonably achievable (ALARA), as defined by the International Commission on Radiological Protection (ICRP) – the premier international body for radiation protection.</p>
Erosion and Sediment Control Plan	<p>The Erosion and Sediment Control Plan (ESCP) has been prepared to manage potential ESC impacts of the proposed works in accordance with the ‘Best Practice Erosion and Sediment Control’ guideline (IECA, 2008), the Project Draft Environmental Impact Statement (NT-DPIR, December 2019) and best practice.</p> <p>The ESCP report and the associated design drawings provide a preliminary strategy and detail for implementation of erosion and sediment controls during the construction works at Rum Jungle, and document minimum requirements. It is assumed that the Construction Contractor(s) will refine and update details of progressive ESCP’s as the works take place.</p>
Cultural Heritage Engagement and Management Plan	To be developed by Principal prior to construction
Asbestos Management Plan	To be prepared by Contractor
Waste Management Plan	To be prepared by Contractor
Traffic Management Plan	To be prepared by Contractor
Weed Management Plan	To be developed by Principal prior to construction
Fire Management Plan	To be developed by Principal prior to construction
Feral Animal Management Plan	To be developed by Principal prior to construction
Revegetation Management Plan	To be developed by Principal prior to construction
Vegetation Clearance and Cycad Salvaging Plan	To be developed by Principal prior to construction

## 21 Cultural Centre

The Traditional Aboriginal Owners (TOs) have expressed a strong interest in the construction of a cultural centre. The cultural centre will communicate the history of Kungarakan and Warai peoples, and the importance of Rum Jungle to them: their displacement during mining, details of mining itself and the Rehabilitation Project. In addition, if artefacts require relocation during construction, they will be managed as per the Cultural Heritage Management Plan (CHMP) and potentially displayed within the cultural centre as per TO requirements. The cultural centre is planned for construction in Stage 3, and the final location and layout for this facility will be determined in consultation with TOs.

A conceptual layout and list of minimum centre requirements are contained in the Cultural Centre design memo (SLR, 2020m).

The Cultural Centre is proposed to remain on site as a permanent structure.

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## 22 Value Engineering Summary

In developing the detailed design, SLR undertook, or participated in jointly with DPIR, a series of value engineering assessments to determine if the Stage 2 rehabilitation approach met the Project environmental objectives and requirements of the Traditional Aboriginal Owners.

Full details of the value engineering assessments are detailed in the various design reports produced by SLR (refer Bibliography), and a memo and spreadsheet developed to summarise the various assessment (SLR, 2020L).

The key value engineering assessments carried out revolved around the following areas:

- Development of the Main Pit backfill methodology to:
  - Move from Stage 2 design of full pit dewatering, tailings dredging, dry backfill, development of a proud landform and alignment of the EBFR around the pit rim; to
  - Stage 2A design of leaving tailings insitu, depositing over water, a shallow lake final landform and realignment of the EBFR back through the Main Pit.
- Development of the design and operation of a flexible, modular water treatment plant (WTP) and groundwater interception bores for surface water and groundwater treatment and discharge;
- Optimisation of material movement and scheduling to minimise health risks and optimise environmental impact from AMD during construction;
- Reassessment of the siting of the new WSFs to meet geotechnical, environmental and traditional owner requirements;
- Design and construction of the new WSFs, including, landform design, erosion assessment and detailed constructability instructions aimed at meeting strict geochemical and geotechnical quality requirements;
- Consideration of traffic and haulage, including an external traffic impact assessment and optimisation of the EBFR diversion drain crossing and haul road sizing and alignment;
- Development of numerous alternative borrow pits;
- Inclusion of revegetation considerations;
- Power supply considerations;
- Community benefits;
- Traditional Aboriginal Owner engagement during construction; and
- Contracting and procurement opportunities.

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## 23 Stage 3 P80 Construction Cost and Schedule

SLR engaged Turner and Townsend (T&T) to develop a P80<sup>2</sup> rehabilitation construction cost estimate and associated schedule based on the SLR design (Turner Townsend, 2020). This includes for Principals Owners Costs during construction and the ongoing environmental and land management costs for 20 years post commissioning of the final works on site, i.e. after decommissioning of the WTP.

The details of this work are not available for public distribution however a high level outline of the approach is given here for completeness. DPIR has undertaken an independent peer review of the cost estimate, which found the following details as appropriate.

### 23.1 Cost

The rehabilitation estimate was compiled based on the following key parameters:

- Estimate base date of May 2020;
- The estimate in accordance with a Class 3 Cost Estimate with an intended accuracy range of -15% to +20% based on AACE 56R-08 classification for General Construction Industries;
- Unit rates based on a combination of basic estimates on commonly known items, budget quotes and historical data;
- Owners costs provided by DPIR;
- Construction labour rates based on past agreements;
- Works assumed to be performed by a local Tier 2 contractor;
- Escalation based on a factor of 2.5% per annum against the expected expenditure of the cost in accordance to the current schedule developed, based on historical long term Australian Consumer Price Index; and
- Contingency calculated probabilistically through a Quantitative Risk Analysis (QRA).

### 23.2 Schedule

**Figure 39** outlines the estimated rehabilitation schedule. The rehabilitation schedule has been developed based on the following key parameters:

- Preliminary contract procurement and WTP pilot plant activities, earthworks construction activities, water treatment and ongoing land management;
- The project execution delivered through three main works packages – Earthworks, Main Pit backfill and Water Treatment Facilities – approximately 8 years following 2½ years of preliminary contract activities;
- Construction duration is primarily driven by material placement rate in Main Pit whilst maintaining water quality, and material movement to waste storage facilities (WSFs) within quality control guidelines;
- Water treatment commences prior to Main Pit backfill and continues for a total period of 18 years (i.e. up to 5 years after completion of construction works); and
- Environmental monitoring is expected to continue up to 20 years following completion of water treatment.

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<sup>2</sup> P80 is the level of confidence for cost and schedule, indicating an 80% confidence that the actual cost and timeframe outcome will be achieved. In other words there is only a 20% chance of cost or schedule overrun.

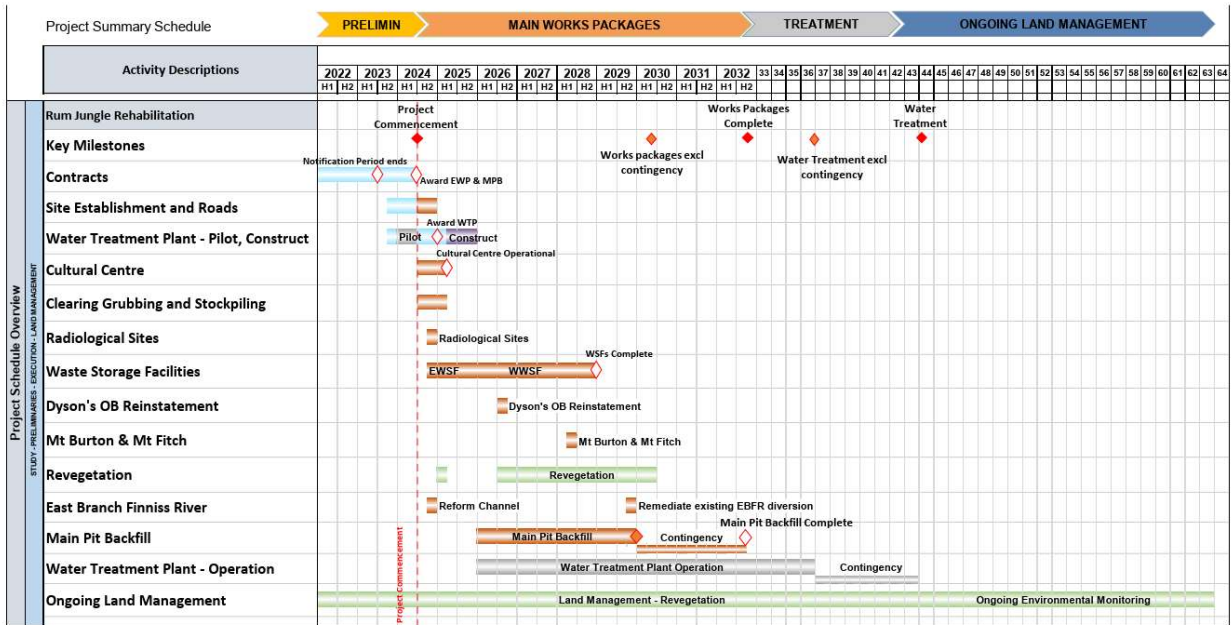


Figure 39 Rehabilitation Schedule

### 23.3 Qualitative Risk Assessment

Contingency for cost and schedule was calculated based on an Integrated Cost-Schedule-Risk Analysis for the project. The output from the analysis have been used to assist in recommending the appropriate levels of risk provision and contingency to be included in the project schedule and cost estimate. The Project has elected P80 as the level of confidence for cost and schedule.

## 24 List of Supporting Documentation

### 24.1 Design Reports

This design document is a summary of the various design reports and memos prepared by SLR and its sub-consultants prepared to support the rehabilitation strategy for Rum Jungle and it is recommended that it be read in conjunction with the documentation listed in the Bibliography.

### 24.2 Design Drawings

A summary of drawings associated with these design works is given in **Table 25**.

**Table 25 Supporting Design Drawings**

Drawing No.	Title
<b>GENERAL</b>	
680.10421.GEN.D00	Locality Plan and Schedule of Drawings
680.10421.GEN.D01	Existing Site Conditions
680.10421.GEN.D02	Site Construction Works Layout
680.10421.GEN.D03	Rehabilitation General Arrangement Plan
680.10421.GEN.D04	Site Exclusion Zones
<b>WASTE STORAGE FACILITY</b>	
680.10421.WSF.D01	WSF General Arrangement Plan
680.10421.WSF.D02	EWSF Foundation Plan
680.10421.WSF.D03	EWSF Layout Plan
680.10421.WSF.D04	EWSF Fill Elevation Plan
680.10421.WSF.D05	EWSF Sections
680.10421.WSF.D06	WWSF Foundation Plan Radiological Soil Treatment
680.10421.WSF.D07	WWSF Foundation Plan
680.10421.WSF.D08	WWSF Layout Plan
680.10421.WSF.D09	WWSF Fill Elevation Plan
680.10421.WSF.D10	WWSF Sections
680.10421.WSF.D11	Typical Details
680.10421.WSF.D12	WSF Lysimeter Layout Plan
680.10421.WSF.D13	Lysimeter Details
680.10421.WSF.D14	Soil Monitoring Stations Details
<b>BULK EARTHWORKS</b>	
680.10421.BEW.D01	Material Excavation Summary
680.10421.BEW.D02	Rip-Rap Scavenging Plan Summary
680.10421.BEW.D03	Detailed Excavation Plan – Sheet 1 of 4

Drawing No.	Title
680.10421.BEW.D04	Detailed Excavation Plan – Sheet 2 of 4
680.10421.BEW.D05	Detailed Excavation Plan – Sheet 3 of 4
680.10421.BEW.D06	Detailed Excavation Plan – Sheet 4 of 4
680.10421.BEW.D07	Detailed Excavation Sections – Sheet 1 of 4
680.10421.BEW.D08	Detailed Excavation Sections – Sheet 2 of 4
680.10421.BEW.D09	Detailed Excavation Sections – Sheet 3 of 4
680.10421.BEW.D10	Detailed Excavation Sections – Sheet 4 of 4
<b>SITE REHABILITATION</b>	
680.10421.REH.D01	Detailed Rehabilitation Plan – Sheet 1 of 4
680.10421.REH.D02	Detailed Rehabilitation Plan – Sheet 2 of 4
680.10421.REH.D03	Detailed Rehabilitation Plan – Sheet 3 of 4
680.10421.REH.D04	Detailed Rehabilitation Plan – Sheet 4 of 4
680.10421.REH.D05	Detailed Rehabilitation Sections – Sheet 1 of 4
680.10421.REH.D06	Detailed Rehabilitation Sections – Sheet 2 of 4
680.10421.REH.D07	Detailed Rehabilitation Sections – Sheet 3 of 4
680.10421.REH.D08	Detailed Rehabilitation Sections – Sheet 4 of 4
<b>HAUL ROADS</b>	
680.10421.HR.D00	Haul Roads – Cover Sheet
680.10421.HR.D01	Haul Roads – Drawing List
680.10421.HR.D02	Haul Roads – Overview
680.10421.HR.D03	Haul Roads – Section A1 – Long Section
680.10421.HR.D04	Haul Roads – Section A1 – Cross Sections
680.10421.HR.D05	Haul Roads – Section A2 – Long Section
680.10421.HR.D06	Haul Roads – Section A2 – Cross Sections
680.10421.HR.D07 and D08	Haul Roads – Section A3 – Long Section
680.10421.HR.D09 and D10	Haul Roads – Section A3 – Cross Sections
680.10421.HR.D11	Haul Roads – Section A4 – Long Section
680.10421.HR.D12 and D13	Haul Roads – Section A4 – Cross Sections
680.10421.HR.D14	Haul Roads – Section A5 – Long Section
680.10421.HR.D15	Haul Roads – Section A5 – Cross Sections
680.10421.HR.D16	Haul Roads – Section A6 – Long Section
680.10421.HR.D17	Haul Roads – Section A6 – Cross Sections
680.10421.HR.D18	Haul Roads – Section A7 – Long Section
680.10421.HR.D19	Haul Roads – Section A7 – Cross Sections
680.10421.HR.D20	Haul Roads – Section A8 – Long Section
680.10421.HR.D21	Haul Roads – Section A8 – Cross Sections

Drawing No.	Title
680.10421.HR.D22 and D23	Haul Roads – Section A9 – Long Section
680.10421.HR.D24 to D26	Haul Roads – Section A9 – Cross Sections
680.10421.CUL.D01	Reinstatement of East Branch Finnis River Haul Road Additional Culvert Detail
<b>DIVERSION DRAIN CROSSING</b>	
680.10421.C0.CS.01	Haul Road Crossing – Cover Sheet and Drawing List
680.10421.C1.BD.01	Haul Road Crossing – Basis of Design
680.10421.C1.GN.01	Haul Road Crossing – General Arrangement
680.10421.C5.RP.01	Haul Road Crossing – Plan and Profile
680.10421.C7.TD.01	Haul Road Crossing – Sections and Details
<b>SURFACE WATER</b>	
680.10421.SUW.D01	Construction Notes
680.10421.SUW.D02	Surface Water and Erosion Control General Arrangement
680.10421.SUW.D03	Surface Water and Erosion Control Overview Plan 1 of 3
680.10421.SUW.D04	Surface Water and Erosion Control Overview Plan 2 of 3
680.10421.SUW.D05	Surface Water and Erosion Control Overview Plan 3 of 3
680.10421.SUW.D06	Sediment Dam Detailed Plans Sheet 1 of 4
680.10421.SUW.D07	Sediment Dam Detailed Plans Sheet 2 of 4
680.10421.SUW.D08	Sediment Dam Detailed Plans Sheet 3 of 4
680.10421.SUW.D09	Sediment Dam Detailed Plans Sheet 4 of 4
680.10421.SUW.D10	Sediment Dam Typical Sections
680.10421.SUW.D11	Conveyance Channel Typical Sections
680.10421.SUW.D12	Surface Water and Erosion Control Proposed EBFR Realignment
<b>WATER TREATMENT PLANT</b>	
680.10421.WTP.D01	Water Treatment Plant Layout
680.10421.WTP.D02	Water Treatment Plant Schematic
680.10421.WTP.D03	Water Treatment Plant Schedule
680.10421.PIP.D01	Site Wide Pipelines – Ground & Surface Water Extraction & Treated Water Discharge

## 24.3 Construction Documentation

In summary, the construction documentation that supports the design and drawings includes the following:

- Water Treatment Plant:
  - Technical Specifications (SLR, 2020e); and
  - Bill of Quantities (680.10421 WTP Issued for Implementation V1.xls).
- Main Pit Backfill:

- Technical Specifications (SLR, 2020c); and
  - Bill of Quantities (680.10421 BOQ Main Pit Backfill Issued for Implementation.xls).
- Earthworks:
    - Technical Specifications (SLR, 2020n); and
    - Bill of Quantities (680.10421 BoQ Civil and Earthworks v1.xls).

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## 25 Bibliography

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# APPENDIX A

## Basis of Design

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
<b>GENERAL</b>					
<b>Land use plan</b>					
1.1	Final Land Use Plan (FLUP)	Agreed by Traditional Owners	-	Refer NT DPIR - EIS (December 2019)	
<b>Authority for Works</b>					
1.2	Sacred cultural heritage and other sites	Aboriginal Areas Protection Authority Certificate (AAPA)	-	Obtained 23 September 2019. Key points to drive project design: - backfilling of Main Pit is allowed - salt impacted areas in Restricted Areas should also be relocated to WSF, provided TO are present during excavation	DPIR to provide Cultural Heritage MP.
1.3	Coomalie Council	Agreement to use Coomalie Council borrow pit	-	Include standard DPIL royalty rate in WBS and cost estimate	
1.4	Finniss River Aboriginal Land Trust (FRALT)	S19 Agreement for use of FRLT borrow areas	-	Include S19 agreement cost and standard DPIL royalty rate in WBS and cost estimate	
1.5	Licencing	Adherence to EIS Waste discharge licence for WTP Waste licence from AAPANZA	-	Owners Team costs	
<b>Site compound</b>					
1.6	Office compound				
1.6.1	Site offices		-	Assume Rum Jungle site based (to north of Main Pit, near existing buildings).	DBC to identify opportunity of locating this at Browns Oxide which will require contractual agreement, and update of connecting bridge. Not required for SLR base design.
1.6.2	Site access compound	Front gate access control Land management facilities (to keep away from active work areas)	-	Front access gate to double as long term Cultural Centre Owners team to undertake land management activities	
1.6.3	Clean in / Clean out facilities	Limit radiation contamination from going off site		Create work zone and clean zone, so work zone vehicles do not leave site. Exception to be delivery vehicles which will need to be decontaminated after each visit	
1.6.4	Ablutions		-	Preference is to be compostable Must have shower in / shower out to deal with radiation decontamination Grey water pumped fresh to the WTP	
1.6.5	Hard stand		-	Contractor to nominate	
1.6.6	Fuel farm		-	Assume Rum Jungle site based (to north of Main Pit, near existing buildings).	DBC to identify opportunity of locating this at Browns Oxide which will require contractual agreement, and update of connecting bridge. Not required for SLR base design.
1.7	Maintenance (HV, MV and LV)			Assume Rum Jungle site based (to north of Main Pit, near existing buildings).	
1.8	First aid station			To be provided by Head Contractor	
1.9	Fire response			Owners Team costs	
1.10	Bulk spill response			To be provided by Head Contractor	

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
<b>Project Management</b>					
1.11	Project Delivery				
1.11.1	Contracting strategy		-	Individual work packages to be developed for: Earthworks Works Package (all civils and earthmoving) WTP Main Pit backfill Traditional Owner opportunities to be identified	DPIR has provided Indigenous Participation Plan
1.11.2	TO opportunities		-		DPIR has provided Indigenous Participation Plan
1.11.3	Engineering design		-	Identify and cost what may be needed in Stage 3	Include teams, software etc.
1.11.4	Cultural heritage engagement		-	Allowance for this and other Management Plans to be included in BoQ	
1.11.5	Radiation management plan		-	To be included in all BoQ as a consideration for how works are done - monitoring, equipment modification (i.e.. filtered air conditioner units) This may expanded to all works (not just radiation soils) given that there may be uranium in the waste rock dumps that are to be moved	DPIR has provided Radiation MP.
1.11.6	Asbestos management plan		-	To be Developed in Stage 3 by Contractor. Limited to removal of existing infrastructure	
1.11.7	Waste management plan (Scrap etc.)		-	To be Developed in Stage 3 by Contractor. Limited to removal of existing infrastructure	
<b>WASTE ROCK DUMPS, NEW WASTE STORAGE FACILITIES AND BORROW DETAILS</b>					
<b>Decontamination Approach</b>					
2.1	Areas to be excavated				
2.1.1	Intermediate WRD	734,900	m <sup>3</sup>	Assumes 2m basal excavation and replacement with growth medium back to 1m above natural grade. Excavated footprint to be flushed and treated with lime prior to backfill.	
2.1.2	Main WRD	4,529,675	m <sup>3</sup>	Assumes 2m basal excavation and replacement with growth medium back to 1m above natural grade. Excavated footprint to be flushed and treated with lime prior to backfill.	
2.1.3	Main North WRD	119,000	m <sup>3</sup>	Assumes 2m basal excavation and replacement with growth medium back to 1m above natural grade	
2.1.4	Dysons Overburden	443,425	m <sup>3</sup>	Assumes excavation to top of existing rock blanket then cover system comprising 1m rock blanket, 0.5m low permeability layer and 2m growth medium	
2.1.5	Dysons WRD	1,190,250	m <sup>3</sup>	Will be covered by the new East WSF. The whole Footprint will have 2m of excavation and any area not covered by the new WSF, lime and flush then replace with growth medium to 1m above natural grade	
2.1.6	Main WRD levee	68,975	m <sup>3</sup>	Assumes 2m basal excavation and replacement with growth medium back to 1m above natural grade	
2.1.7	Copper extraction area	143,050	m <sup>3</sup>	Assumes 2m excavation, lime and flush and replacement with growth medium back to natural grade. River diversion may require widening to cross this area. Excavated footprint to be flushed and treated with lime prior to backfill	

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ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
2.1.8	Miscellaneous rocky piles	2,850	m <sup>3</sup>	Remove down to natural ground level	
2.1.9	Rad soils (1)	135,725	m <sup>3</sup>	Rad soils outside of WSF footprint to be relocated on top of rad soils (2) i.e. within WSF footprint. Excavated down to 2m (as per EIS) and backfilled with growth medium to original grade.	
2.1.10	Metal and salt impacted soils (7 x individual areas)	12,400	m <sup>3</sup>	Remove down to 0.3m below ground level and replace with 0.3m growth medium	
2.1.11	Mt Burton	110,575	m <sup>3</sup>	Remove down to 0.3m below ground level and replace with 0.3m growth medium	
2.1.12	<b>TOTAL MATERIAL MOVEMENT</b>	<b>7,490,825</b>	<b>m<sup>3</sup></b>		
2.2	Treat insitu (lime, bury, cover)				
2.2.1	Old stockpile area (2)	112,000	m <sup>3</sup>	Strip any existing cover from beneath new WSF and use to cover these. Waste material to remain in place (RGC confirmed geochemically sound and SLR confirmed geotechnically sound)	
2.2.2	Finniss River new excavation	-	m <sup>3</sup>	Reshape for safety after EBFR is realigned.	
2.2.3	Rad soils (2)	86,350	m <sup>3</sup>	Leave in situ and cap with nominal 0.5m compacted low permeability layer in situ to separate from low pH infiltration from overlying waste rock and lime.	
2.2.4	Intermediate WRD (waste and footprint)	24	kg/t of waste	Lime dose rate - Based on non-segregation of PAF types scenario as discussed in 2019 RGC report. The lime dose rate for footprint was calculated per tonne of soil over top 0.2m of substrate.	
2.2.5	Dyson's overburden (waste and footprint)	24	kg/t of waste	Lime dose rate - Based on non-segregation of PAF types scenario as discussed in 2019 RGC report. The lime dose rate for footprint was calculated per tonne of soil over top 0.2m of substrate.	
2.2.6	Main WRD & Main North WRD (waste and footprint)	15	kg/t of waste	Lime dose rate - Based on non-segregation of PAF types scenario as discussed in 2019 RGC report. The lime dose rate for footprint was calculated per tonne of soil over top 0.2m of substrate.	
2.2.7	Dyson's WRD (waste and footprint)	4.9	kg/t of waste	Lime dose rate - Based on non-segregation of PAF types scenario as discussed in 2019 RGC report. The lime dose rate for footprint was calculated per tonne of soil over top 0.2m of substrate.	
2.2.8	Copper extraction area	8	kg/t of soil	lime dose rate: 8kg/t of soil over top 0.2m of substrate (assumed same rate as for Dyson's WRD)	
2.3	Areas not to be treated				
2.3.1	Old Tailings Dam	-	-	Does not contribute to water quality in EBFR so does not need treatment in terms of contamination. However, it does not meet environmental values (ecology) so may need topsoiling and reseedling and lime and tilling. Undertaken by Owners Team	DPIR to manage rehabilitation of this area
2.3.2	Intermediate Levees	-	-	Does not contribute to water quality in EBFR. Can be used as clean fill if required.	Reclaim if cap/backfill materials needed.

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
<b>Borrow Material Requirements</b>					
2.4	Low Permeability				
2.4.1	West WSF capping	147,902	m <sup>3</sup>	0.5m thick on plateau, 0.65 on slopes (extra 0.15m on slopes to allow for scarification of slopes for bonding of layers)	
2.4.2	East WSF capping	243,449	m <sup>3</sup>	0.5m thick on plateau, 0.65 on slopes (extra 0.15m on slopes to allow for scarification of slopes for bonding of layers)	
2.4.3	Dysons Overburden	57,875	m <sup>3</sup>	0.5m thick	
2.4.4	Rad soils (2) cover (0.5m)	45,700	m <sup>3</sup>	Excavated from beneath WWSF and relocated on-top of rad soils, so does not form part of material balance for borrow areas, but will be required in BoQ	
	<b>TOTAL LOW PERM. MATERIAL REQUIRED</b>	<b>494,926</b>	<b>m<sup>3</sup></b>		
	<b>Excavation volume available from below WSFs</b>	<b>-</b>	<b>m<sup>3</sup></b>	High, fluctuating, groundwater levels mean that PAF material may not be stored below ground level, therefore there will be no excavation beneath the WSFs for borrow	
2.5	Growth medium				
2.5.1	West WSF capping - Plateau	186,100	m <sup>3</sup>	2m thick	
	West WSF capping - Slope	311,930	m <sup>3</sup>	2m thick	
2.5.2	East WSF capping - Plateau	132,500	m <sup>3</sup>	2m thick	
	East WSF capping - Slopes	647,150	m <sup>3</sup>	2m thick	
2.5.3	Rad soils (1)	148,575	m <sup>3</sup>	2m thick	
2.5.4	Dysons WRD	270,750	m <sup>3</sup>	3m thick	
2.5.5	Dysons Overburden	115,750	m <sup>3</sup>	2m thick	
2.5.6	Metal and salt impacted soils (7 x individual are	17,505	m <sup>3</sup>	0.3m thick	
2.5.7	Main WRD	954,825	m <sup>3</sup>	3m thick	
2.5.8	Intermediate WRD	254,250	m <sup>3</sup>	3m thick	
2.5.9	Copper extraction area	140,000	m <sup>3</sup>	2m thick	
2.5.10	Main North WRD	130,575	m <sup>3</sup>	2m thick	
2.5.11	Mt Burton	6,330	m <sup>3</sup>	0.3m thick	
2.5.12	Main WRD levee	25,900	m <sup>3</sup>	2m thick	
2.5.13	Eastern Valley	4,230	m <sup>3</sup>	0.3m thick	
2.5.14	Old stockpile area	5,723	m <sup>3</sup>	0.3m thick	
	<b>TOTAL GROWTH MEDIUM REQUIRED</b>	<b>3,352,093</b>	<b>m<sup>3</sup></b>		
2.6	New Rock Blanket				
2.6.1	Dysons Overburden	57,875	m <sup>3</sup>	1m thick. Scavenged rip rap or from off site	
2.7	Main Pit				
2.7.1	Sand bridging layers	85,442	m <sup>3</sup>	Refer Main Pit Backfill strategy - geotechnical requirement	
2.7.2	Clean cap	176,692	m <sup>3</sup>	Refer Main Pit Backfill strategy - geotechnical requirement	
2.8	Rock mulch/rip rap				
2.8.1	East WSF capping	-	m <sup>3</sup>	Not required for design, to be stockpiled and used in remediation of erosion if required	
2.8.2	West WSF capping	-	m <sup>3</sup>	Not required for design, to be stockpiled and used in remediation of erosion if required	

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
<b>Borrow Material Sources</b>					
2.9	Low Permeability				
2.9.1	Volume required	494,926	m <sup>3</sup>		
2.9.2	Coomalie Council Borrow Area	> 494926	m <sup>3</sup>	Geotechnical Investigation has confirmed sufficient quality and quantity	
2.9.3	Access			Refer Traffic Impact Assessment	
2.10	Growth medium				
2.10.1	FRLAT Borrow Area	2,393,013	m <sup>3</sup>	FRLT (old sand mining area) immediately south of Rum Jungle access. To be used everywhere except WSF slopes (see item 2.17.5)	
2.10.2	Coomalie Council Borrow Area	959,080	m <sup>3</sup>	To be used on WSF slopes (see item 2.17.5)	
2.11	Sand bridging layer for Main Pit Cap				
2.11.1	FRLAT Borrow Area	85,442	m <sup>3</sup>		
2.12	Clean fill for Main Pit Cap				
2.12.1	FRLAT Borrow Area	176,692	m <sup>3</sup>		
	<b>TOTAL FROM COOMALIE COUNCIL BORROW AREA</b>	<b>959,080</b>	<b>m<sup>3</sup></b>		
	<b>TOTAL FROM FRLAT BORROW AREA</b>	<b>2,655,147</b>	<b>m<sup>3</sup></b>		
2.13	Rip Rap				
2.13.1	Volume available on site	23,080	m <sup>3</sup>	Lower bound Existing rip rap scavenged and cleaned	
2.13.2	Excess volume required from external quarry	-		Not required for design, to be stockpiled and used in remediation of erosion if required	
2.14	Road base material			Will use in-situ materials. CBR testing completed and varies along road length.	
<b>Waste Storage Facilities (West - WWSF, East - EWSF)</b>					
2.15	Siting and footprint				
2.15.1	Groundwater			Avoid areas where groundwater expression at surface is known to occur, i.e. the old tailings dam area	
2.15.2	Cultural heritage sites			Cultural heritage sites (objects and places) identified in 2010 and 2018 are to remain in place and must not be disturbed by the footprint	
2.15.3	Flooding			Flood modelling to be undertaken to confirm surface shear stress, conveyance capacity of designed flow paths	
2.15.4	vegetation disturbance			Minimise the disturbance of mature vegetation	
2.15.5	culturally significant plants			Avoid as much as possible culturally significant plants	Relocation plan in EIS for mulitstem cycads.
2.15.6	Foundation and lithology			Preference to locate away from Coomalie Dolostone	
2.15.7	volume requirements			Must accept all waste from Rum Jungle and Mount Burton. Mt Fitch is to be treated on-site, i.e. not transported to Rum Jungle	
2.15.8	Creek offsets			In compliance with Section 3.3.6 of the Land Clearing Guidelines for a 3rd order stream, a buffer of 100m from the edge of the riparian is to be adopted. For 2nd order streams, a buffer of 50m is required. The EBFR Diversion does not require a buffer as there is no riparian vegetation	

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
2.15.9	Protection of ridge line and vegetation			Protect the ridge line immediately to east of Main Pit where there is undisturbed vegetation	
2.15.10	Radiation soils			Footprint to cover as much of the rad soils area as possible	
2.15.11	Maximum height			WWSF is to be at a maximum of RL97m, i.e. 3m below maximum height of adjacent ridge, in keeping with Traditional Owners request to maintain sightlines from Giants Reef ridge and the Main Pit. No restriction on height of EWSF	
2.15.12	Offset from Main Pit Crest			A qualitative minimum distance of 40m from the Pit Rim is required, based on allowing access, surface water treatment etc. Barge contractor has indicated a nominal 100m setback to allow for anchors Manual clearance of waste at north end. Minimise disturbance of vegetation. For access, minimum slope of 1:6 (safe egress). Approach is access that is suitable for wet and dry season - therefore should be to south/ to south/west of pit, so we don't have to cross river in wet. Aesthetic approach on east embankment where old fill is placed only - and reveg. this could be 1:4. For heavy equipment access to be located within offset (exclusion zone) clearance must be sought from geotech engineer prior to installation/placement.	
2.16	Geotechnical stability				
2.16.1	Side slopes	Minimum 1:4 slopes		Slope to be established by erosion modelling, but no steeper than 1:4 to meet geotechnical stability requirements	
2.17	Cover system				
2.17.1	Low permeability layer	LLDPE plus geotextile on plateau		Options analysis done to consider use of HDPE, LLDPE or BGM, drainage, revegetation materials etc.	
2.17.2	Drainage layer	No		Options analysis done to consider use of HDPE, LLDPE or BGM, drainage, revegetation materials etc.	
2.17.3	Cover design	0.5m low permeability then 2m growth medium. No rock mulch		Options analysis done to consider use of HDPE, LLDPE or BGM, drainage, revegetation materials etc.	
2.17.4	Radiological aspect			Dysons WRD and Main WRD came from the uranium pit and may still have uranium present. Must be treated as radiological in that they must have a minimum 0.5m low permeability cover, plus 2m overall. Safety aspects of this to be considered	
2.17.5	Growth Medium			Growth Medium on WSF slopes to be sourced from Coomalie Council Borrow Area (Borrow A). Growth Medium on plateaus of WSF to be sourced from FRALT Borrow (Borrow Area B). Growth medium on slopes to grade from granular to clay with depth to mitigate erosion and support reveg.	
2.17.6	Oxygen scavenging layer			Dysons WRD generally performs as NAF, can be used as an oxygen scavenging layer beneath the cover. Can therefore be used as starter embankments, rather than importing clean fill for these	

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
2.18	Basal Lining				
2.18.1	Lining of base of WSFs			Adopt Managed Natural Attenuation based on recommendation by RGC	Refer Chapters 7 and 10 of EIS for MNA. No lining needed
2.19	Surface water management				
2.19.1	Revise AEP			Revise annual exceedance probability of catchment storms following the 2016 Australian Rainfall & Runoff (ARR) revision. It is noted that the design AEP will be different for long term water conveyance structures (e.g. creek diversion works) compared to temporary conveyance structures during construction which are to be designed based a 10% AEP in accordance with Table 4.3.1 of the IECA guideline (IECA, 2008).	
2.19.2	Sediment & erosion control			Design measures to be implemented progressively to capture and contain sediment during the WSF construction	This might need pH adjustment dosing as the risk will be sediment plus low pH waters
2.19.3	Surface water conveyance & erosion protection			Design drainage structures to safely convey surface water from the WSF to the EBFR without erosion for all storms to the 1% AEP. It is noted that the design AEP will be different for long term water conveyance structures (e.g. creek diversion works) compared to temporary conveyance structures during construction which are to be designed based a 10% AEP in accordance with Table 4.3.1 of the IECA guideline (IECA, 2008). Outfall from Intermediate Pit and Main Pit to be designed for 0.2% ARI	
2.20	Scheduling				
2.20.1	Order of waste rock and contaminated soils movement	PAF-I limit as much as practical to movement during dry season only		Proposed order: - Radiological soils (to prevent exposure) - Intermediate WRD and Dysons Overburden - deepest in Main Pit - Main WRD - Main North WRD and Levee - Copper extraction area - Dysons WRD (to be used as oxygen scavenging layer)	
2.20.2	Staging	Progressive cover to be placed on slopes and top surface of WSFs as they are built			
2.21	Revegetation				
2.21.1	Revegetation			Owners Team responsibility	.
2.22	QA/QC				
2.22.1	QA/QC			Technical Specifications to include: - geotechnical (compaction, survey etc.) and geochemical (lime etc.) specifications. - radiological soils (by others) - contaminated soils (by others)	

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
<b>Intermediate WRD</b>					
2.23	Intermediate WRD				
2.23.1	Area	84750	m <sup>2</sup>		
2.23.2	Volume	734,900	m <sup>3</sup>		
2.23.3	Rip Rap	3,705	m <sup>3</sup>	Scavenged. Progressively as needed so that protection remains for wet season on remaining surfaces	
2.23.4	Excavation depth below grade	2	m	Leave foundation open for 1-2 years prior to backfilling to allow the 'flushing' of unsaturated zone metals contamination to move into the saturated zone and be captured within the SIS. Lime treatment of excavated footprint to pH 7 (EIS) prior to backfilling. Backfilled growth medium to be backfilled to 1m above natural grade and shaped to ensure shedding.	
2.23.5	Deconstruction methodology		-	To be the first removed and placed entirely in the Main Pit Preference to start in dry season as there is insufficient room around the footprint to install ESCP if work started in the wet	
2.23.6	QA/QC		-	No specific requirements above normal civil works	
<b>Dysons Overburden</b>					
2.24	Dysons Overburden				
2.24.1	Area	57,875	m <sup>2</sup>		
2.24.2	Volume	443,425	m <sup>3</sup>		
2.24.3	Rip Rap	1,190	m <sup>3</sup>	Scavenged. Progressively as needed so that protection remains for wet season on remaining surfaces	
2.24.4	Excavation depth below grade	2	m	Excavation to top of rock blanked. Based on limited information from one borehole	
2.24.5	Deconstruction methodology		-	Second priority for removal to the Main Pit. Anticipated full volume can be accommodated. Priority is to shed runoff waters away from the tailings media to reduce seepage out of the tailings media. Tailings are radiological and contact to be avoided.	
2.24.6	QA/QC			No specific requirements above normal civil works	
<b>Main WRD</b>					
2.25	Main WRD				
2.25.1	Area	318,275	m <sup>2</sup>		
2.25.2	Volume	4,529,675	m <sup>3</sup>		
2.25.3	Rip Rap	14,650	m <sup>3</sup>	Scavenged. Progressively as needed so that protection remains for wet season on remaining surfaces	
2.25.4	Excavation depth below grade	2	m	Leave foundation open for 1-2 years prior to backfilling to allow the 'flushing' of unsaturated zone metals contamination to move into the saturated zone and be captured within the SIS. Lime treatment of excavated footprint to pH 7 (EIS) prior to backfilling. Backfilled growth medium to be backfilled to 1m above natural grade and shaped to ensure shedding.	

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
2.25.5	Deconstruction methodology		-	To be moved to both WSF (in parallel with Intermediate WRD and Dysons Overburden going to Main Pit) then the Main Pit (after the above)	
2.25.6	QA/QC		-	No specific requirements above normal civil works	
<b>Dysons WRD</b>					
2.26	Dysons WRD				
2.26.1	Area	90,250	m <sup>2</sup>		
2.26.2	Volume	1,190,250	m <sup>3</sup>		
2.26.3	Rip Rap	3,535	m <sup>3</sup>	Scavenged. Progressively as needed so that protection remains for wet season on remaining surfaces	
2.26.4	Excavation depth below grade	2	m	Leave foundation open for 1-2 years prior to backfilling to allow the 'flushing' of unsaturated zone metals contamination to move into the saturated zone and be captured within the SIS. Lime treatment of excavated footprint to pH 7 (EIS) prior to backfilling. Backfilled growth medium to be backfilled to 1m above natural grade and shaped to ensure shedding.	
2.26.5	Deconstruction methodology		-	Use as NAF and oxygen scavenging layer for staging bunds and plateau of WSFs	
2.26.6	QA/QC		-	No specific requirements above normal civil works	
<b>Main North WRD</b>					
2.27	Main North WRD				
2.27.1	Area	43,525	m <sup>2</sup>		
2.27.2	Volume	119,000	m <sup>3</sup>		
2.27.3	Rip Rap	2,100	m <sup>3</sup>	None	
2.27.4	Excavation depth below grade	2	m	Backfilled growth medium to be shaped to ensure shedding	
2.27.5	Deconstruction methodology		-	Needs to be relocated to make room for Main Pit backfill laydown operations	
2.27.6	QA/QC		-	No specific requirements above normal civil works	
<b>Main Waste Rock Levee</b>					
2.28	Main Waste Rock Levee				
2.28.1	Area	12,950	m <sup>2</sup>		
2.28.2	Volume	68,975	m <sup>3</sup>		
2.28.3	Rip Rap	-	m <sup>3</sup>	Nil	
2.28.4	Excavation depth below grade	2	m	Backfilled growth medium to be shaped to ensure shedding	
2.28.5	Deconstruction methodology		-	All relocated to WSFs, properties to be checked as it may be clean and useful as growth medium on excavated footprints, construction levees etc.	
2.28.6	QA/QC		-	No specific requirements above normal civil works	
<b>Miscellaneous rocky piles</b>					
2.29	Miscellaneous rocky piles				
2.29.1	Area	4,550	m <sup>2</sup>		
2.29.2	Volume	2,850	m <sup>3</sup>		
2.29.3	Rip Rap	-	m <sup>3</sup>	Nil	
2.29.4	Excavation depth below grade	0	m	Removed to natural surface only	
2.29.5	Deconstruction methodology		-	All to relocate to WSFs	
2.29.6	QA/QC		-	No specific requirements above normal civil works	

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
<b>Salt and Metal Impacted Areas</b>					
2.30	Salt and Metal Impacted Areas				
2.30.1	Area	58,350	m <sup>2</sup>		
2.30.2	Volume	13,325	m <sup>3</sup>		
2.30.3	Rip Rap	-	m <sup>3</sup>	Nil	
2.30.4	Excavation depth below grade	0.3	m	Backfilled growth medium to be shaped to ensure shedding	
2.30.5	Deconstruction methodology		-	Relocate to WSFs to suit schedule. River works in dry season only. Need Custodian present for river works	
2.30.6	QA/QC		-	No specific requirements above normal civil works	
<b>Copper Extraction Area</b>					
2.31	Salt and Metal Impacted Areas				
2.31.1	Area	70,000	m <sup>2</sup>		
2.31.2	Volume	143,050	m <sup>3</sup>		
2.31.3	Excavation depth below grade	2	m	Backfilled growth medium to be shaped to ensure shedding Note: the flow channel from Main Pit to Intermediate Pit will need to expand over this area, so either more excavation may be required to meet this requirement. If material is not contaminated it can be opportunistically used for capping, bunds etc.	
2.31.4	Deconstruction methodology		-	Relocate to WSFs to suit schedule	
2.31.5	QA/QC		-	Land Quality and Rehabilitation Plan (by others)	
<b>HAULAGE RATES AND OTHER ASSUMPTIONS</b>					
2.32	Placement Rate - WSFs				
2.32.1	Dry Season - Waste Rock/Contaminated Soils/R	5,000	m <sup>3</sup> /day	Haulage and equipment to meet placement requirement.	
2.32.2	Wet Season - Waste Rock/Contaminated Soils/R	3,000	m <sup>3</sup> /day		
2.32.3	Dry Season - Low Permeability	5,000	m <sup>3</sup> /day		
2.32.4	Wet Season - Low Permeability	3,000	m <sup>3</sup> /day		
2.32.5	Dry Season - Growth Medium	7,500	m <sup>3</sup> /day		
2.32.6	Wet Season - Growth Medium	5,000	m <sup>3</sup> /day		
2.32.7	WSF Construction Working Hours	10	hours/day		
2.32.8	WSF Construction Working Days per Week	7	days / week		
2.33	Placement Rate - Main Pit Backfill				
2.33.1	Year 1	No backfill			
2.33.2	Year 2	306 to 1,948	m <sup>3</sup> /day	Slow rates for sand bedding.	
2.33.3	Year 3	1,948 to 3,896	m <sup>3</sup> /day	Increased rates as strength increases and risk to contaminate mobilisation reduces	
2.33.4	Year 4	3,896	m <sup>3</sup> /day	Full rates of reference design capacity (barge)	
2.33.5	Year 5	3,896	m <sup>3</sup> /day	Full rates of reference design capacity (barge)	
2.33.6	Main Pit Construction Work Hours	8	hours / day	10 hr per day working. Assume start and end 1-hour are used to prep and pack down.	
2.33.7	Main Pit Construction Work Days per Week	5	days / week	2-days to perform maintenance and allow WTP to catch up on displaced water	
2.34	Placement Rates - Remediation Footprints				
2.34.1	Dry Season - Growth Medium	7,500	m <sup>3</sup> /day		
2.34.2	Wet Season - Growth Medium	5,000	m <sup>3</sup> /day		
2.34.3	Footprint remediation Construction Working Hours	10	hours/day		
2.34.4	Footprint remediation Working Days per Week	7	days / week		

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
<b>MAIN PIT</b>					
<b>MAIN PIT CONSIDERATIONS</b>					
3.1	Dewatering				
3.1.1	Main Pit Water Level	Maintain between RL58 to RL59	m	Continually monitor. Pit backfill to stop if limits breached.	
3.1.2	Intermediate Pit Water Level	Maintain between RL49 to RL50	m	Tolerance for Intermediate Pit can be relaxed during the dry season at discretion of Superintendent.	
3.2	Geochemical				
3.2.1	Backfilling - Main Pit Water Body	To remain neutral	pH		
3.2.2	Sand Bedding Layers	Sand Bedding Layers to be dosed and mixed with 1.7% w/w hydrated lime	kg	Purpose is to neutralise the top layers of tailings and the chemocline which are acidic. This will reduce the risk of acidic water releasing heavy metals into the water column above. Hydrated lime dosing is to be introduced within the processing phase (Crush/screen/conveying)	
3.2.3	Waste Rock Layers	Dose and mix Waste Rock with granulated lime. Rate dependent on source of waste rock.	kg CaCO <sub>3</sub> /t waste rock	Chemical stabilisation of the waste rock for long term storage. Granulated lime dosing is to be introduced within the processing phase (Crush/screen/conveying)	
3.2.4	Maximum Waste rock fill height	56 RL	m	Ensure a minimum of 2.0m aqueous cover at dry season lowest Main Pit water level.	
3.2.5	Inert Capping Layer	2	m	Table 4-4 Hydrobiology, Rum Jungle Impact Assessment - Final Report, June 2016	
3.2.6	Trigger Action Response Plan	15% w/w hydrated lime slurry	kg	Chemical stabilisation of the waste rock for long term storage. Hydrated lime to be introduced if pH levels drop below thresholds.	
3.3	Geotechnical				
3.3.1	Sand bedding layer (bridging layer)		-	To manage the potential for instability or failure within the tailings temporary slopes formed within the Bedding Layer .	
3.3.2	Waste Rock Lens to RL 22m		-	The rate of placement shall be such that significant impact or disturbance of the chemocline is minimised and where practicable, impact to the water treatment process and downstream groundwater monitoring bores minimised.	
3.3.3	Waste Rock RL 22m to RL 56m		-	Rate dictated by available water treatment plant rate	
3.3.4	Inert Capping Layer RL 56m to RL 58m		-	The Inert Capping Layer material shall be deposited over water using the Contractor's chosen method(s) which achieve a controlled and accurate placement, in accordance with the following requirements: * Minimum Inert Capping Layer thickness of 2.0 m; * Minimum elevation of RL 58 m AHD; and * Temporary slopes no steeper than 25°; * Non-dispersive	

BASIS OF DESIGN					
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3.3.5	Crest Recontouring / final landform	* backfill Main Pit access ramp with inert, non-dispersive materials * backfill from Main Pit crest to surface of inert capping layer at 1V:6H batters with clean inert fill - only in designated areas * install erosion protection to re-profiled side slopes	-	Final landform design, improve aesthetics, mitigate crest instabilities	
3.4	Pit Wall Instability				
3.4.1	Slope Risk Assessment (SRA) performed around Pit crest.		-	Demarcate exclusion zone around crest. Assess suitability of proposed Main Pit Backfill operations area, including assessment of stability with anticipated loading conditions (e.g. crane loading, conveyor systems etc.)	
3.4.2	Backfill materials via sub-aqueous backfilling.	Main Pit Water Level to be minimum of RL 58m. No side casting	-	Minimise dewatering to mitigate against exposure of saturated pit wall slopes and prevent instability through drawdown and slope unravelling. No side casting due to unstable slopes	
3.4.3	Re-contouring/profiling Pit crest at low vegetated areas.	Fill from pit crest to top of inert capping (RL58 m) with clean, inert, non-dispersive fill at 1V:6H batter, buttressed against crest. Cover with erosion protection.	-	Designated zones of Pit Crest re-contouring detailed in design drawings. Crest zones to be reprofiled dictated by lack of vegetation.	
<b>GROUNDWATER AND SURFACE WATER DETAILS</b>					
<b>Groundwater Treatment</b>					
4.1	Groundwater bores				
4.1.1	Install borehole wells to accommodate bore hole pumps to a depth of 30m in locations identified in the WTP design report and EIS	17	No.		
4.1.2	Supply and install variable speed drive bore hole pumps with flow capacities from 1 to 2 L/s at the following total heads (m). Construction must be 316SS to withstand pH 4 raw water.			Will require sump pumps, staging tanks, generators, compressors etc.	
4.1.3	34	1	No		
4.1.4	38	1	No		
4.1.5	39	1	No		
4.1.6	44	1	No		
4.1.7	46	1	No		
4.1.8	47	1	No		
4.1.9	55	1	No		
4.1.10	58	1	No		
4.1.11	59	1	No		
4.1.12	61	2	No		
4.1.13	62	1	No		
4.1.14	64	2	No		

BASIS OF DESIGN					
ITEM	DESIGN ASPECT	CRITERIA	UNITS	SLR /DPIR AGREEMENT COMMENT	DPIR ADDITIONAL COMMENT
4.1.15		73	2	No	
4.1.16		86	1	No	
4.1.17	Seepage interception trenches		4	No	4 x Seepage Interception Grated Pits (the trenches are already there and the pit is at the end of the trench) each containing a high flow Air Displacement Pump
<b>Surface Water</b>					
4.2	Flood modelling of Main Pit				
4.2.1	Modelling to determine if minimum 2.5m pit lake depth during dry season (and 6m during wet season) will not disturb sediments or water quality	-	-	Perform two dimensional hydraulic modelling to calculate surface shear stresses and velocities and confirm evidence of turbulence and potential erosion. Advise on preferred lake depth and/or surface treatments.	Install surface water diversion bunding to the N of the Main Pit to direct surface water flows away from Pits.
4.2.2	Design of Main Pit inlet and outlets for during construction	-	-	Ensure Main pit inlet remains closed and the outlet remains open during the period of construction.	
4.2.3	Design of final inlets and outlets	-	-	Utilise two dimensional hydraulic modelling to design naturalised inlet and outlets with a modified topography to divert base flow through the Main Pit and major storm flows around the Main diversion drain.	
4.3	Site flood modelling				
4.3.1	Channel from Main Pit to Intermediate Pit	-	-	Channel receives inflow from northern catchment through embankment pipework and Main Pit when inlet and outlets are open. Verify geometry to mimic pre mine flows and establish erosion protection requirements to support design flows	
4.3.2	Intermediate Pit inlets and outlets	-	-	Ensure Intermediate pit outlet remains closed and inlet remains open during the period of construction. Design diversion bunds where possible to divert surface runoff away from the inlet.	
4.3.3	Whole of site - diversion levees, intersections with EBFR and other creeks	-	-	Utilise two dimensional hydraulic modelling to design naturalised Intermediate Pit inlet and outlets. with a modified topography to divert base flow through the Main Pit and major storm flows around the Main diversion drain.	
4.4	Diversion channel/EBFR Reconstruction				
4.4.1	Modelling to determine ability to take all storm flow during construction	-	-	Utilise 2D hydraulic modelling to determine geometric changes to the confluence of the Main Diversion drain and the inlet to the Main Pit to safely convey all floods up to the 1% AEP through the Main Diversion drain during construction.	
4.4.2	Design works to meet above capability	-	-	Design topography and erosion protection to achieve 100% diversion during construction	
4.4.3	Rehabilitation design works for after construction	-	-	Design final confluence, Main Pit entrance and naturalised diversion infrastructure to channel low flows through the pit and high flows through the diversion drain.	Please work with Hydrobiology on these design elements
4.4.4	Closure of diversion drain			Will be dictated by long term EBFR performance	
4.5	ESCP works				
4.5.1	Construction	-	-	Design ESCP sequential management measures during construction.	
4.5.2	Short term rehabilitation	-	-	Formulate ESC amelioration measures for a range of ad hoc site requirements where required.	ESCP structures may need to deal with low pH values
4.5.3	Long term works (requiring little, or preferably no maintenance)	-	-	Design ESCP measures across the site to safely pass the 1% AEP flood without erosion.	

BASIS OF DESIGN					
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<b>Dewatering Plan</b>					
4.6	Discharge to EBFR				
4.6.1	Hydrobiology considerations	-	-	LDWQOs to meet once backfilling commences. Wet season only preferred.	
4.7	Live storage				
4.7.1	Main Pit Water Level	Maintain between RL58 to RL59	RL, m		
4.7.2	Intermediate Pit Water Level	Maintain between RL49 to RL50	RL, m		
4.8	Construction Water			Construction water for WSF may be sourced directly from pits	
<b>Water Treatment Plant</b>					
4.9	Groundwater treatment rates (low flow, high concentration)				
4.9.1	Wet season	34	l/s	By RGC	
4.9.2	Dry season	17	l/s	By RGC	
4.10	Waste rock displacement volumes (low flow, high concentration)				
4.10.1	Wet season		l/s	Dictated by water treatment plant rate, less groundwater rate	
4.10.2	Dry season		l/s	Dictated by water treatment plant rate, less groundwater rate	
4.11	Surface water inflow to Main Pit and Intermediate Pit				
4.11.1	Wet season	59	l/s	By RGC Consideration of diversion options to be assessed by SLR	
4.11.2	Dry season	12	l/s	By RGC Consideration of diversion options to be assessed by SLR	
4.12	Discharge from WTP				
4.12.1	To EBFR			Refer EIS	
4.12.2	Dust suppression			Dust suppression demand to be calculated	
4.12.3	Construction water			Construction water demands to be calculated	
4.13	Reagents				
4.13.1	High concentration, low flow	60	l/s	For groundwater and waste rock displacement volumes	
4.13.2	Low concentration, high flow	100	l/s	For surface water inflows	
4.13.3	Sludge	33	m <sup>3</sup> /day	To be sent to Main Pit, then dewatered to send to WSF then on-site landfill will need to be developed. Location to be nominated and designed in Construction Phase after full extent of WSFs are understood	
<b>TRAFFIC, INTERNAL AND EXTERNAL HAUL ROADS</b>					
<b>Traffic Management</b>					
5.1	Traffic Impact Assessment				
5.1.1	Road safety audit				
5.1.2	Prepare TIA				
5.1.3	Prepare TMP				
5.1.4	Construction MP				
<b>Internal Haul Roads</b>					
5.2	Haul Roads			To be removed at end of construction	
5.2.1	equipment type			Cat 777 2/3/20 Equipment type changed to Moxy 40t. This is driven by safety considerations while building berms and also the placement and treatment is so low, it does not justify 777's.	
5.2.2	equipment frequency			TBA	
5.2.3	Crossfall	2 - 3	%		
5.2.4	Running Width	14.6	m		

BASIS OF DESIGN					
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5.2.5	Drain Width		2.5 m		
5.2.6	Drain Slope		1:4 -	1:4 side batters. Maximum grade	
5.2.7	Windrow Width		5.2 m		
5.2.8	Window Flat Top Width		1 m		
5.2.9	Window Height above road		1 m		
5.2.10	Windrow Slope		37 deg		
5.2.11	maximum slope				
5.2.12	Pavement Design		m		
5.2.13	CBR	10 - 40	%		
5.2.14	Base	0.10 - 0.25	m		
5.2.15	Wearing Surface	0.10 - 0.15	m		
5.2.16	maximum speed limit	50	km/hr	50km/hr with reductions to 45km/hr around intersections	
5.2.17	Design life	10	year	Removed at end of construction phase as required	
5.3	Culvert Crossing (South)				
5.3.1	ARI	1:5 year		Culvert crossing, as agreed from Options analysis	
5.3.2	Location	Midway between Intermediate and Main WRDs		To be removed at end of construction	
5.4	River Crossing (West)			Dependant on contractual approval with Browns Oxide to use the office/ablution/fuel/water treatment facilities. Get quote to upgrade bridge, but design and costs associated with this and construction to be moved to Phase 3 (Construction). Include costs as opportunity (i.e. offset of site compound facilities) in DBC.	
<b>Site Access</b>					
5.5	Alignment			Does not need to be tarred. May even need to be removed at end depending on TO requirements	
<b>External Haul Roads from Borrow</b>					
5.5.1	FRLAT Borrow Area			Internal haul road, inside the 'Construction Zone'	
5.5.2	Coomalie Council Borrow Area			External haul road on public roads. Haul trucks will remain outside of Construction Zone. This will mean double handling of external borrow material	
5.5					
<b>CLOSURE AND REHABILITATION OF CONSTRUCTION WORKS</b>					
<b>Infrastructure</b>					
6.1	Cultural Centre			To remain on site	
6.2	Demolition			All existing infrastructure (buildings, drill rig, concrete foundations etc.) and any new construction infrastructure (including roads, culvert crossing etc.) to be removed from site at completion of construction phase.	
6.3	Water Treatment Plant			To remain on site for minimum of 5 years after end of WSF construction phase, then decommissioned and removed from site	Landfill requirements for WTP sludge post-pit backfill to be determined in Stage 3.

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