Mulga Rock Uranium Project - Public Environmental Review - December 2015
Appendix H - Rehabilitation and Decommissioning

H3

Mulga Rock Uranium Project

Preliminary Radioactive Waste Management Plan

MRUP-EMP-029

November 2015

Vimy Resources Limited

address
Ground Floor
10 Richardson Street
West Perth WA 6005
Australia

telephone
+61 8 9389 2700

fax
+61 8 9389 2722

ABN
56 120 178 949

web
vimyresources.com.au

Authorship and Review

Name	Role	Version	Date
Ed Clerk	Author	Rev 0	03.11.2015

Location on Vimy Server:

J:\Env\2015 - Environment\1540340 - Vimy PER WA\Correspondence Out\EMPs\RW MP MRUP-EMP-029\MRUP-EMP-029 Radiation Waste MP H3.docx

Table of Contents

List of Figures

List of Tables

List of Appendices

1. Introduction

1.1 Purpose and Scope

This Preliminary Radioactive Waste Management Plan (RWMP) is a conceptual plan that describes the basis by which the radioactive waste stream will be managed at the Mulga Rock Uranium Project (MRUP) as well as providing a framework for the development of radioactive waste management controls. This plan should be read in conjunction with the Conceptual Mine Closure Plan (CMCP) (MRUP-EMP-031).

The overall radioactive waste management philosophy of the Project is based on containment and encapsulation of the mining and processing waste streams, by combining processing waste streams into a secure tailings storage facility. More broadly, the Project will aim to promote the minimisation of other potentially contaminated wastes through decontamination and recycling of material where these materials may have further use.

Whilst this document is focussed on radioactive waste, it is consistent with the overall approach taken by Vimy in regards to waste. This document is structured in accordance with the specific requirements for a RWMP as outlined in document 4.2 of the Western Australian Naturally Occurring Radioactive Material (NORM) Guidelines (DMP 2010).

Radioactive waste is generally defined as material for which there is no further use, and which contains an average radionuclide concentration that exceeds 1Bq/g or is contaminated with radioactive material. Contaminated material includes plant and equipment that is contaminated with radioactive material that cannot be effectively decontaminated

This plan is a high level overview of the Company's approach to radioactive waste management. A more detailed RWMP will be developed once the Project has completed the Definitive Feasibility Study (DFS) and submitted to appropriate state regulatory authorities (Department of Mines and Petroleum and Radiological Council) for formal approval prior to operations.

The Preliminary RWMP will be subject to ongoing review during the DFS and implementation of the project to ensure its ongoing effectiveness and relevance.

The scope of the Preliminary RWMP is limited to the components of the MRUP that have the potential to generate radioactive waste.

This document is structured in accordance with the specific requirements for a RWMP as outlined in document 4.2 of the Western Australian Naturally Occurring Radioactive Material (NORM) Guidelines (DMP 2010).

1.2 Objective

This Preliminary RWMP has been developed to support the Public Environmental Review (PER).

This Preliminary RWMP aims to:

- consider the Project Key Environmental Factors (PKEFs) and demonstrate how the environmental objectives of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) Radiation Protection Series (RPS 6, RPS 9, RPS 15) and the International Atomic Energy Agency Safety Standard SSR-5 'Disposal of Radioactive Waste' (IAEA 2011) are to be achieved,
- identify and characterise the waste streams associated with the operation of the Project, in accordance with RPS 20 (ARPANSA 2010),
- identify preliminary controls and risk categories for the management of tailings, process and surface waters based on Australian National Committee on Large Dams guidelines (ANCOLD 2012) and
- consider International Atomic Energy Agency Nuclear Energy Series publications.

The project PKEFs are:

- Flora and Vegetation
- Terrestrial Fauna
- Subterranean Fauna
- Hydrological Processes
- Inland Waters Environmental Quality
- Air Quality and Atmospheric Gases
- Human Health
- Heritage
- Rehabilitation and Decommissioning
- Offsets.

A more detailed description of how the company will protect the PKEFs is provided in the PER documentation and will be considered as part of the Project approval process. This Preliminary RWMP will therefore describe the design principles for management and control of radioactive waste.

Good design in conjunction with effective management systems, based on appropriate standards, will ensure that the PKEFs will be protected.

2. Guidance Framework

ARPANSA is a Federal Government agency charged with responsibility for protecting the health and safety of people, and the environment, from the harmful effects of ionising and non-ionising radiation. ARPANSA has published codes of practice in relation to radioactive waste management and this Preliminary RWMP has been developed in accordance with these.

The key reference documents are summarised as follows.

RPS6 - National Directory for Radiation Protection

This document establishes the framework for ensuring that various radiation and nuclear safety standards and guidelines produced by ARPANSA are available for adoption within state regulations.

There are no specific additional requirements other than references to published documents.

The primary objective of this document is to "protect the health and safety of people and the environment from the harmful effects of ionizing and non-ionizing radiation".

This document establishes a regulatory framework built on the ARPANSA radiation protection documentation.

RPS 9 - Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005)

The objective of this document is consistent with that of PRS 6.

This document outlines specific requirements for a RWMP and is consistent with the requirements outlined in the Project Environmental Scoping Document (ESD). A key aspect of this document is the requirement to obtain authorisation for construction, operation and closure of a waste disposal facility from the appropriate authority.

It would be expected that the RWMP for the operation should be approved prior to the commencement of construction of waste management facilities; however, some details, for example monitoring locations and frequencies, may not be finalised.

As well as the requirements previously covered, additional aspects include providing engineering detail on the actual construction of facilities as part of the construction authorisation, which includes schedules and timetables for construction and quality assurance procedures in place during construction.

RPS 15 Safety Guide for the Management of Naturally Occurring Radioactive Material (NORM) (2008)

Note that RPS15 specifically states that it does not deal with uranium and mineral sands mining and processing because these are subject to other existing regulatory frameworks, which incorporate the ARPANSA Mining Code (RPS 9). However, the general guidance is summarised Table 2.1 in the context of the Project waste facilities.

Table 2.1 Specific Requirements of RPS15

Requirement	Applicability
Development of a Radiation Management Plan (RMP)	Will be completed and submitted for approval prior to operations commencing
Identification of potential sources of health impact on workers, members of the public and the environment	Included within the PER
Management of the health impact on workers, members of the public and the environment	The operational management system will incorporate the radiation protection requirements into job procedures and into training
Control/mitigation procedures	The PER describes the design standards and controls that will be implemented. The operations management plan will incorporate radiation safety aspects
Monitoring programs	Included as part of the RMP
Dose and safety assessment	Estimates provided in the PER and updated and reported as part of the routine monitoring program
The iterative improvement approach	Vimy Resources operates a quality management system which aims to embed continual improvement
Remediation and close-out requirements for operational sites	Included as part of the site CMCP

IAEA Safety Standard SSR-5 'Disposal of Radioactive Waste'

This document provides more prescriptive guidance on the design aspects of the establishment of a facility for the disposal of radioactive waste. The design and management aspects are aimed at "protecting people and the environment".

It is noted that the specific requirements are intended to be considered for facilities for the disposal of all types of radioactive waste. Due to the low levels of radioactivity in the tailings, in some cases, the specific requirements are not warranted when compared to the actual risk and are only partially applicable.

The specific requirements of SSR-5 are shown in Attachment 1, together with the general approach that the Company will use to address the requirement.

RPS 20 Safety Guide for the Classification of Radioactive Waste (2010)

This document sets out non-prescriptive, best practice guidance for classifying radioactive wastes and is based on the IAEA General Safety Classification of Radioactive Waste published in 2009. The Safety Guide is qualitative in nature with the intention that users will have appropriate flexibility to classify their waste in accordance with internationally accepted methods.

3. Description of the Discharge Environment

3.1 Project Summary

The Mulga Rock Uranium Project (MRUP or Project) is approximately 240km east-northeast of Kalgoorlie-Boulder in the Shire of Menzies (Figure 3.1). The area is remote, located on the western flank of the Great Victoria Desert, comprising series of large, generally parallel sand dunes, with inter-dunal swales and broad flat plains. Access to the Project area is limited and is only possible using four-wheel-drive vehicles.

The nearest residential town to the Project is Laverton which lies approximately 200km to the northwest. Other regional residential communities include Pinjin Station homestead located approximately 100km to the west, Coonana Aboriginal community situated approximately 130km to the south-southwest, Kanandah Station homestead positioned approximately 150km to the southeast and the Tropicana Gold Mine lying approximately 110km to the northeast of the Project. The nearest pastoral stations are:

- Kanandah – 150km southeast
- Pinjin – 100km west
- Coonana – 130km.

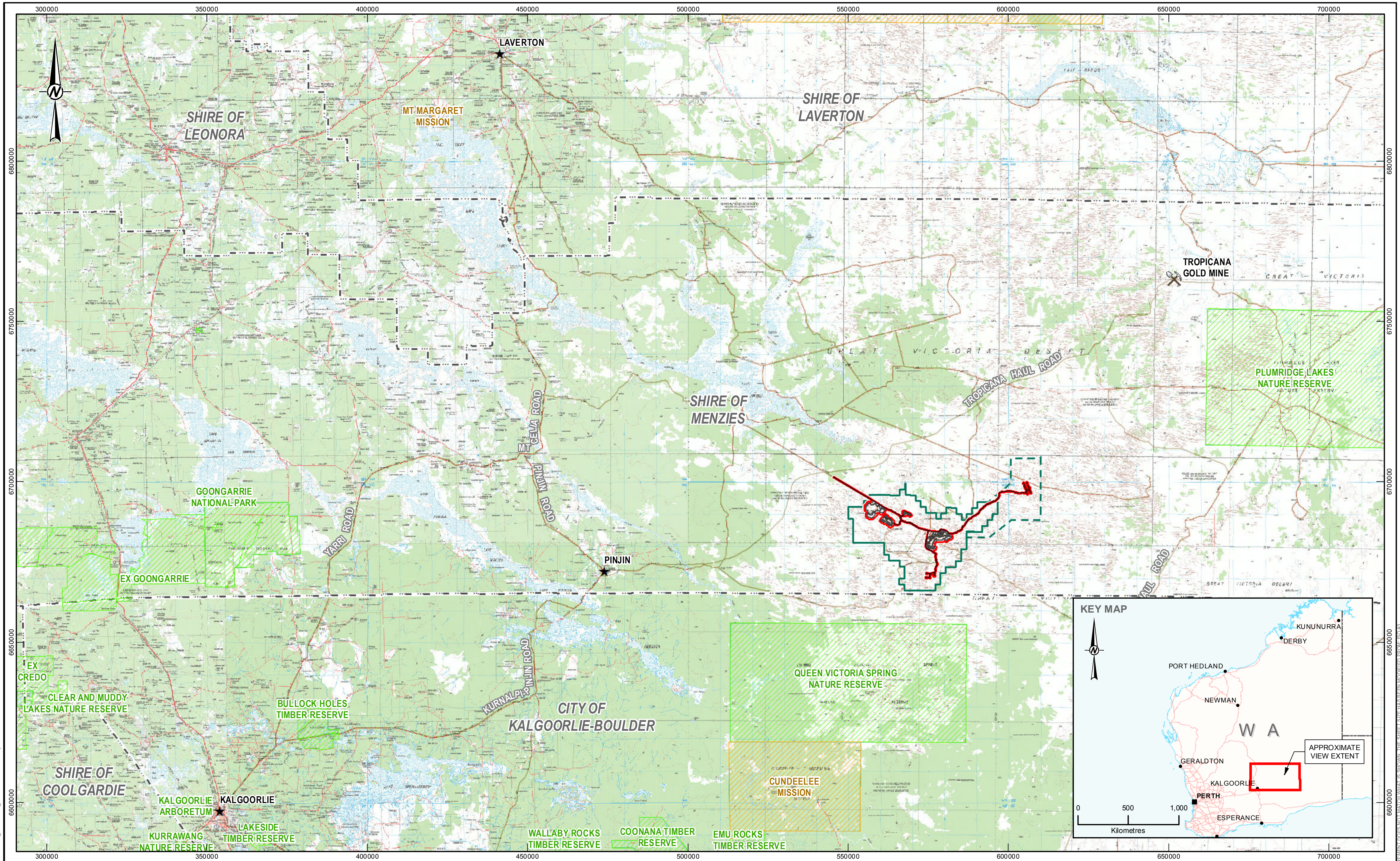
Tropicana Gold Mine is located 110km to the northeast of the MRUP.

The MRUP covers approximately 102,000ha on granted mining tenure (primarily M39/1080 and M39/1081) within Unallocated Crown Land (UCL). It includes two distinct mining centres, Mulga Rock East (MRE) comprising the Princess and Ambassador resources and Mulga Rock West (MRW) comprising the Emperor and Shogun resources. MRE contains over 65% of the total recoverable uranium and is of a higher grade than MRW. Mining will commence at MRE which will include the location of the processing plant.

Up to 4.5 million tonnes per annum (Mtpa) of ore will be mined using traditional open cut techniques, crushed, beneficiated and then processed at an acid leach and precipitation treatment plant to produce, on average, 1,360 tonnes of uranium oxide concentrate (UOC) per year over the life of the Project. The anticipated life of mine (LOM) is up to 16 years, based on the currently identified resource. The UOC product will be sealed in drums and transported by road from the mine site in sealed sea-containers to a suitable port (expected to be Port Adelaide) which is approved to receive and ship Class 7 materials for export.

Other metal concentrates will be extracted using sulfide precipitation after the uranium has been removed and sold separately. These metal concentrates will not be classified as radioactive.

The MRUP will require the clearing of vegetation, borefield abstraction, mine dewatering and reinjection, the creation of above ground and in-pit overburden (non-mineralised) and tailings landforms and the construction of onsite processing facilities and associated infrastructure. Key Project infrastructure will include mine administration and workshop facilities, fuel and chemical storage depots, a diesel or gas-fired power plant of up to 20MW capacity and distribution network, a saline abstraction borefield and a saline mine water reinjection borefield with associated pipelines and power supply units, an accommodation village servicing a fly-in/fly-out workforce, an airstrip, laydown areas and other supporting ancillary infrastructure including communications systems, roads, a waste water treatment plant and solid waste landfill facilities. Transport to site for consumables, bulk materials and general supply items will be via existing public road systems linked to dedicated Project site roads, branching off the Tropicana Gold Mine access road.



LEGEND

- TROPICANA GOLD MINE
- TOWN
- ROAD
- INFRASTRUCTURE
- MRUP DEVELOPMENT ENVELOPE
- PROJECT BOUNDARY (MINING TENURE)
- PROJECT BOUNDARY (MISCELLANEOUS TENURE)
- CONSERVATION RESERVE
- ABORIGINAL LAND TRUST ESTATE
- LOCAL GOVERNMENT AUTHORITY (LGA) BOUNDARY

NOTES

1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 51

REFERENCE

INFRASTRUCTURE DATA PROVIDED BY CLIENT
BASE DATA © WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2015)
IMAGE SOURCED FROM GEOSCIENCE AUSTRALIA 250K TOPO
INSET BASE DATA/ROADS SOURCED FROM STREET PRO DATA 2009

0 25 50
1:1,100,000 KILOMETRES

CLIENT
VIMY RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-30
DESIGNED	MS
PREPARED	MS
REVIEWED	EWC
APPROVED	EWC

PROJECT
MULGA ROCK URANIUM PROJECT

TITLE
REGIONAL LOCATION

PROJECT NO.	CONTROL	REV.	FIGURE
1540340	H3	0	3.1

Path: G:\Spatial_Information_Group\GIS_WORKSPACE_AUSTRALIA\01_WA\SH\15\7_MINING\1540340\Projects\APPENDIX\Rev0\1540340-H3-F003-1-Rev0.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
25mm

3.2 Mining

The Project comprises two distinct mining centres, Mulga Rock East (MRE) and Mulga Rock West (MRW), which are approximately 20km apart. Mining will commence at MRE which will include the location of the plant.

The MRUP will be mined using open cut mining techniques, and their locations are shown in Figure 3.2. Due to the large lateral extent and horizontal geometry, the deposit lends itself to strip mining techniques using truck and excavator, and dozer trap mining techniques (Figure 3.3).

3.3 Processing

3.3.1 Beneficiation Plant

Run of mine (ROM) ore feed is initially crushed and then conveyed from the pit to a modularised beneficiation plant which is comprised of a series of cyclones (similar to that used in mineral sands) to separate the materials according to grain size. The heavy coarse grained sands and gravels are generally non mineralised and the removal of this material results in a concentration of the plant feed (light carbonaceous material). The beneficiated slurry is then pumped to the mill at the main process plant. The waste sand fraction from the cyclones is pumped to the pit void, where it is dewatered and stacked as back fill in the base of the pit (AMEC Foster Wheeler 2015).

3.3.2 Main Process Plant

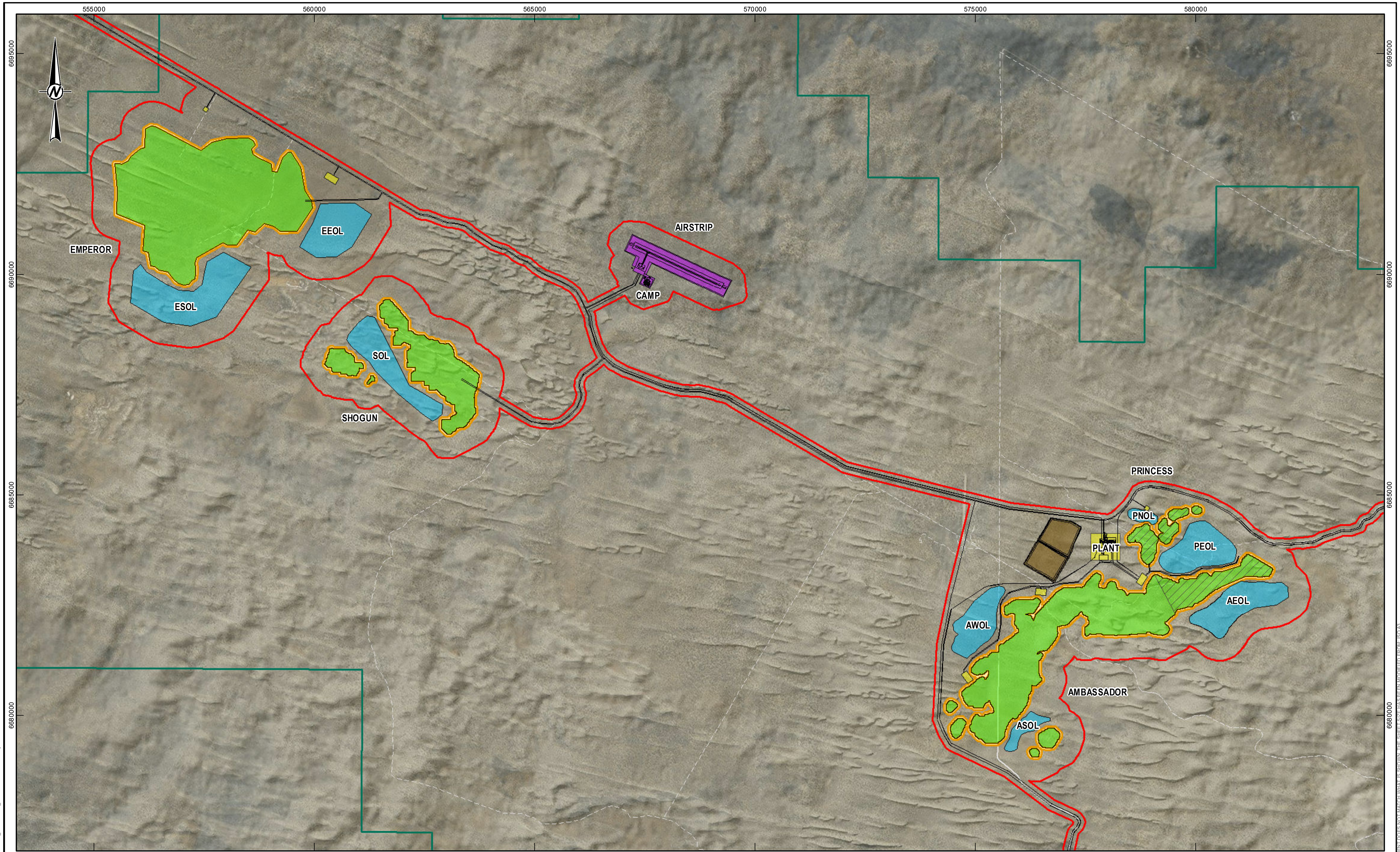
MRUP uranium mineralisation is unique in that it is either present as adsorbed uranium onto the surface of the carbonaceous material in its oxidised form, or as ultra-fine (nanometre scale) uraninite grains (UO2). This means acid can be used to simply desorb the uranium from the carbonaceous ore before resin beads are used to selectively extract uranium from solution.

The main process plant will receive beneficiated ore from the mine and then grind this feed to 80% passing a size of 150µm using a mill circuit. The milled ore is then leached for 4 hours at 40°C using sulfuric acid at an addition of 30kg acid per tonne of leach feed. Uranium is typically leached within 1-2 hours and shows very fast kinetics.

The leach discharge is then pumped to a resin-in-pulp (RIP) circuit where the slurry is contacted with an ion-exchange resin to recover the uranium present in solution. The RIP circuit has eight contact stages and is analogous to a gold carbon-in-pulp circuit except resin is used instead of activated carbon.

Uranium-loaded resin is then recovered and uranium stripped from the resin using a sodium chloride solution. The strip solution, which now contains the uranium, is further concentrated and then precipitated using concentrated caustic to generate a sodium diuranate (SDU) precipitate. The SDU precipitate is then re-dissolved using sulfuric acid and precipitated from solution using hydrogen peroxide to generate a final uranyl peroxide or “yellowcake” product. The final uranium product is washed, filtered, dried and packaged in steel drums ready for transport.

The slurry from the uranium RIP circuit has no recoverable uranium remaining but is further processed to recover the base metals still in solution. The uranium-barren leach solution is recovered using a counter current decantation circuit. The solution is neutralised to pH ~4.0 using lime. A gypsum precipitate containing iron, aluminium and other impurities is removed and sent to tails. The purified base metal solution is then contacted with sodium sulfide to produce separate copper-zinc and nickel-cobalt mixed sulphide precipitates. These products are thickened, filtered, washed and packaged in to 2 tonne bulk bags for final sale (AMEC Foster Wheeler 2015).



LEGEND

MINOR ROAD/TRACK	IN-PIT TSF
ROAD	PIT
MRUP DEVELOPMENT ENVELOPE	OVERBURDEN LANDFORM
PROJECT BOUNDARY (MINING TENURE)	PROCESSING INFRASTRUCTURE
PROJECT BOUNDARY (MISCELLANEOUS TENURE)	ABOVE GROUND TSF
PIT CLEARING (50 m BUFFER)	SUPPORTING INFRASTRUCTURE

NOTES

1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 51

REFERENCE

INFRASTRUCTURE DATA PROVIDED BY CLIENT
AERIAL IMAGERY SOURCED FROM ESRI ONLINE
TOPOGRAPHY BASED ON NATIONAL DEM 1 S SOURCED FROM GEOSCIENCE AUSTRALIA

0 1 2 3 4 5
1:80,000 KILOMETRES

CLIENT
VIMY RESOURCES LIMITED

CONSULTANT
Golder Associates

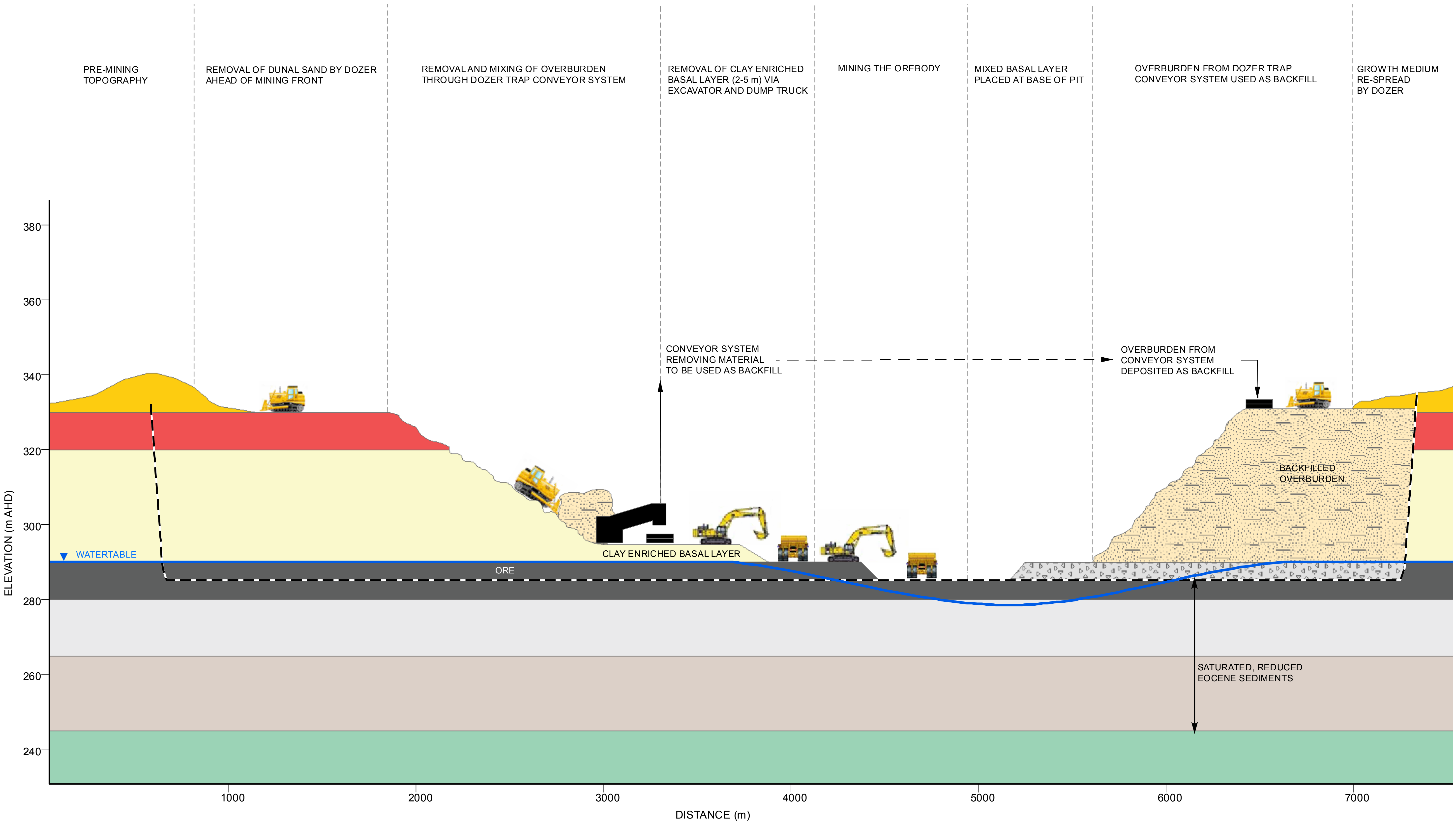
YYYY-MM-DD	2015-10-30
DESIGNED	MS
PREPARED	MS
REVIEWED	EWC
APPROVED	EWC

PROJECT
MULGA ROCK URANIUM PROJECT

TITLE
CONCEPTUAL PROJECT LAYOUT PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
1540340	H3	0	3.2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3
25mm



LEGEND

- PROPOSED MINE PIT
- QUATERNARY SEDIMENTS
- MIOCENE SEDIMENTS
- OXIDISED EOCENE SEDIMENTS
- U-ENRICHED LIGNITE, CLAY, SILT
- REDUCED EOCENE SEDIMENTS
- HIGH PERMEABILITY BASAL SAND
- PERMIAN SEDIMENTS (BASEMENT)
- MIXED BASAL OVERBURDEN & BENEFICIATED SAND PREFERENTIALLY PLACED AT BASE OF PIT
- MIXED MIOCENE AND OXIDISED EOCENE SEDIMENTS

0 10 20 30 40 50
V 1:1,000 METRES

0 200 400 600 800 1,000
H 1:20,000 METRES

CLIENT VIMY RESOURCES LIMITED		PROJECT MULGA ROCK URANIUM PROJECT	
CONSULTANT Golder Associates	YYYY-MM-DD: 2015-10-30 DESIGNED: MS PREPARED: MS REVIEWED: EWC APPROVED: EWC	TITLE **PROPOSED MINING OF THE MINE PITS AND INTERNAL MANAGEMENT OF SOIL AND OVERBURDEN MATERIALS**	
		PROJECT NO. 1540340 · CONTROL H3 · REV. 0	FIGURE **3.3**

3.4 Environmental Setting

A summary of the baseline environmental data relevant to the MRUP and the Preliminary RWMP is provided in Table 3.1.

Table 3.1 Summary of Existing Environmental Data for the MRUP

Aspect	Description
Biogeographic region	Great Victorian Desert Shield Subregion (GVD01).
Climate	The climate of the MRUP area is classified as desert with hot summers and cool – mild winters. Rainfall throughout the year does not vary considerably with 20–40mm/month falling in the summer months (November – March), often associated with cyclonic events, and 10-30mm/month in winter (April – October), with a total annual average rainfall of approximately 280mm. Pan evaporation (around 2,650mm/yr) greatly exceeds rainfall throughout the year and thus the environment exists in a water deficit condition. Daily pan evaporation rates vary from 11–12mm/day (330-360mm/month) in summer to 2-3mm/day (75-100mm/month) in winter.
Geology and geochemistry	The MRUP occurs within the Narnoo Paleodrainage channel that has been filled with a diverse mix of Eocene sediments under lacustrine and palustrine conditions. These sediments have been extensively weathered and oxidised to around 40m depth, and all sulfides and mobile metals and metalloids have been stripped from the profile leaving a geochemically inert material. Below the redox boundary, the remaining carbonaceous sediments (representing the ore) are enriched in uranium and base metals, and are classified as PAF. The potential for metalliferous drainage is limited due to the strong affinity of metals and metalloids for the organic matter.
Regolith characterisation	The land surface within the MRUP is dominated by large Quaternary dunes that have been deposited directly onto the pre-existing Miocene/Eocene sediments. This material is structurally stable, however it has a very low water holding and nutrient retention capacity and thus has limited capacity to support native vegetation, with the depth of this sand cover governing the distribution of the vegetation types.
Flora	A total of 335 vascular plant taxa, representative of approximately 140 genera and 43 families, have been recorded in numerous surveys by MCPL in the MRUP area since 2007 (MCPL 2015a). The majority of taxa recorded were representative of the Fabaceae (52 taxa), Myrtaceae (40 taxa), Goodeniaceae (25 taxa) and Proteaceae (23 taxa) families, and typical of the wider GVD flora. A total of nine annual and/or biennial species, equating to approximately 2.7% of the total number of taxa, were recorded (MCPL 2015a). Of the 89 dunes surveyed, only five dunes with *Hibbertia crispula* occur within the Project Development Envelope representing approximately 225 plants (MCPL 2015c). The 2014 fire affected 78% of the Project Disturbance Footprint and 74% of the Project Development Envelope. It is estimated that 76% (approximately 10,823 plants) were potentially impacted by this fire and that many of these individual plants will no longer exist. A total of 13 other Priority Flora species have been recorded in the MRUP area from the 2007-2015 surveys (MCPL 2015c).
Fauna	Eighteen mammal species, 38 bird species, zero amphibians and 42 species of reptile have been recorded at or near to the Project site. Four conservation significant animals may occur in the area. Sandhill dunnarts, despite concentrated trapping, were only recorded in 1985. Evidence of Southern Marsupial Moles indicated that they may have been present at very low levels at some time in the past and are restricted to yellow Aeolian sands. The Woma Python has been seen onsite on a limited number of occasions. The Malleefowl is not likely to occur in the Project habitat. No locally conservation significant SREs or stygofauna were sampled.
Conservation areas	There are no PECs or TECs or other conservation significant zones in the region of the Project.

Aspect	Description
Groundwater	Groundwater within the mining areas of the MRUP is confined within the paleodrainage channel with a level of approximately 40m below the land surface (290mAHD). Hydraulic gradient are very small (<0.002) and thus water movement in the aquifer is sluggish. This groundwater is moderately acidic and hypersaline, and enriched in Cd, Co, Cu, Ni, Pb and Zn. Groundwater in the Kakarook abstraction borefield is constrained within a graben-horst structure and is of good quality, being circum-neutral in pH, relatively non-saline and containing low solutes.
Surface water	No surface water occurs within the MRUP due to the nature of the topography and surficial sandy soils.
Land allotment	MRUP is located within the Shire of Menzies on granted Mining Tenement M39/1080 and 39/1081
Aboriginal heritage	There are no significant heritage sites located in the Disturbance Footprint, but there is one Registered Site located at the edge of the proposed Development Envelope.
European heritage	No evidence of any historic settlement in the region.

3.5 Geology

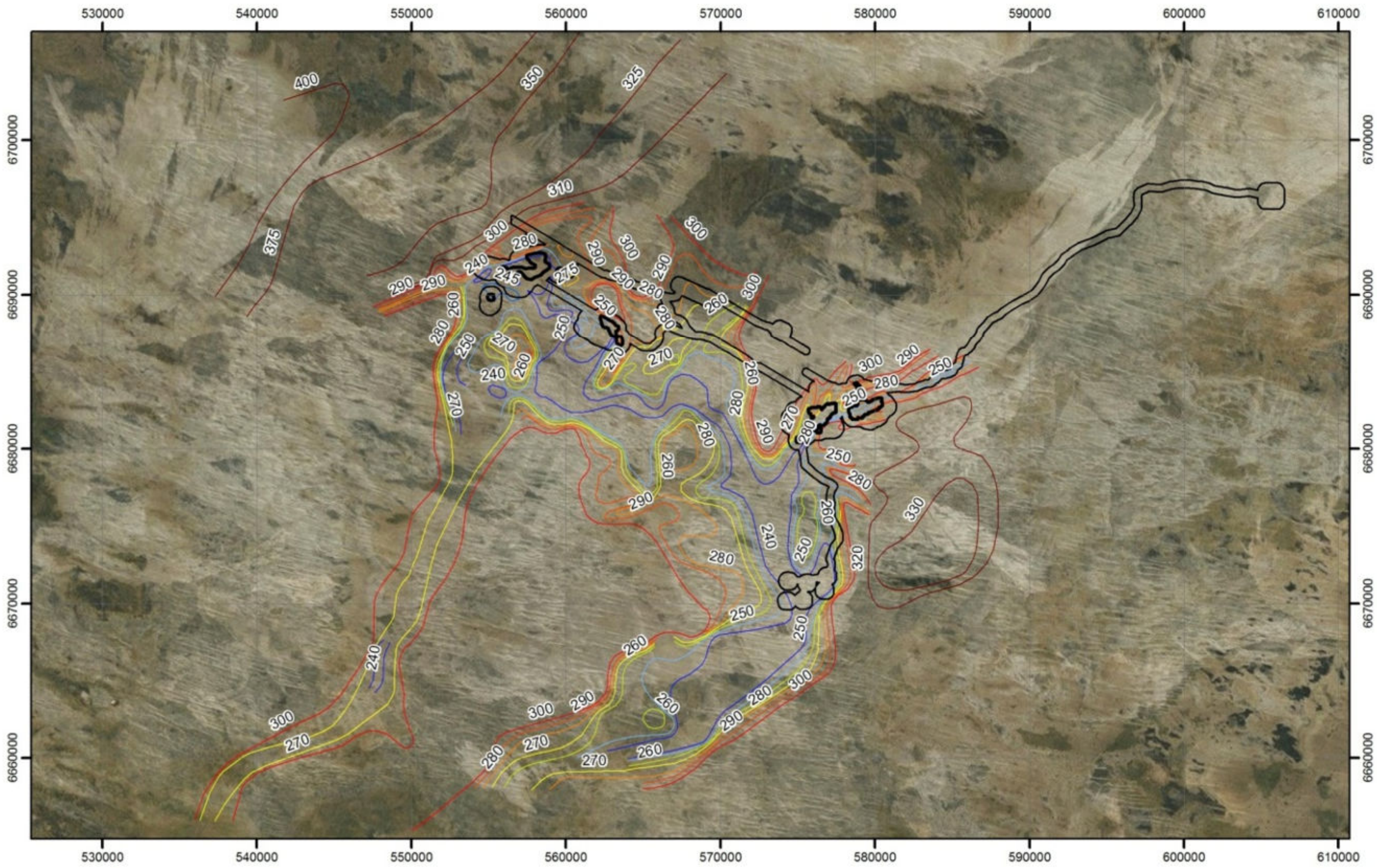
The MRUP occurs within an Eocene paleodrainage channel that was incised into the Cretaceous – Eocene Narnoo Basin. Given the geomorphic nature of the paleovalley during deposition (i.e. slow meandering oxbow shaped stream) the Eocene sediments experienced extensive lacustrine and palustrine conditions, and consequently they became enriched in organic matter (up to 40%; ANSTO, 2015), with Total Organic Carbon (TOC) contents varying from 2 to 25% (Soilwater Consultants (SWC), 2015a). Widespread peneplanation of the Archean and Proterozoic granitic rocks of the adjacent Yilgarn Craton and Albany Fraser Province (AFP) resulted in the release and mobilisation of uranium from the parent minerals, and subsequent deposition within the Narnoo paleodrainage channel. Given the carbonaceous nature of the Eocene sediments and the prevailing geochemical conditions, the released uranium was strongly absorbed onto the surface of the organic matter, either through ion exchange or functional-group complexation (Douglas et al., 1996), and effectively immobilised it from the aquifer, forming the MRUP orebody. In addition, base metals were also strongly complexed with the organic matter and associated sulphides.

Following the Paleocene-Eocene Thermal Maximum, drying of the global climate resulted in a lowering of groundwater levels to their current level of approximately 40m (around 290mAHD) below the land surface (Figure 3.4). This drop in water table, resulted in the oxidation of the overlying Eocene sediments, and subsequent oxidation of sulfides contained within the organic matter. The associated release of acidity caused the pH of the sediments to drop (most likely to pH < 3) resulting in a destruction of the clay mineral lattice and organic matter and stripping and remobilisation of the uranium and the majority of the base metals. This accelerated and intense weathering of the overlying unsaturated Eocene sediments has resulted in them becoming geochemically benign.

Uranium (U) precipitation is strongly controlled by redox conditions, such that it effectively becomes immobile under reducing conditions. Consequently, the uranium which is to be mined at the MRUP is confined to and immediately below the current redox boundary (water table). The uranium orebody is therefore constrained to 2-5m below the current groundwater level, and thus the base of the pit will be at most 5m below the water level.

A schematic diagram showing the geology of the MRUP is provided in (Figure 3.5), whilst the morphological characteristic of the sedimentary sequence is shown in (Figure 3.6). During the Miocene the entire region was blanketed in a transported cover (Miocene sediments), which has subsequently been covered by a Quaternary Aeolian Sand.

Path: G:\Spatial_Information_Group\GIS_WORKSPACE_AUSTRALIA\01_WA\SH5107_MINIGWAL\1540340\Projects\APPENDIX\Rev0\1540340-H3-F003.4-Rev0.mxd



NOTES

1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 51

REFERENCE

MAP SUPPLIED BY CLIENT

0 10 20

1:400,000 KILOMETERS

CLIENT
VIMY RESOURCES LIMITED

VIMY RESOURCES

CONSULTANT

Golder Associates

YYYY-MM-DD	2015-11-01
DESIGNED	SAR
PREPARED	SAR
REVIEWED	DCR
APPROVED	DCR

PROJECT
MULGA ROCK URANIUM PROJECT

TITLE
MAP SHOWING THE BASEMENT DEPTHS OF THE PALEODRAINAGE CHANNEL

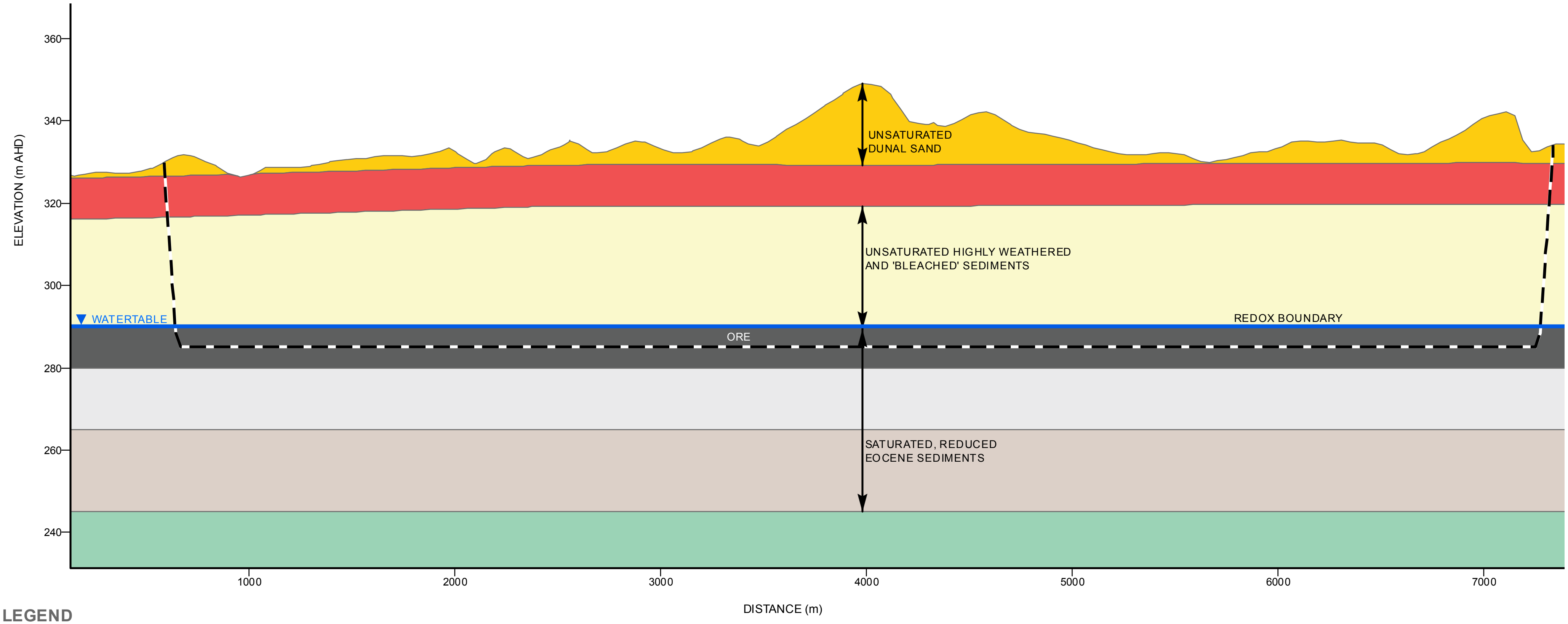
PROJECT NO.	CONTROL	REV.	FIGURE
1540340	H3	0	**3.4**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ISO A4

25mm

0

Path: G:\Spatial_Information_Group\GIS_WORKSPACE_AUSTRALIA\01_WA\SH5107_MINIGWAL\1540340\Projects\APPENDIX\Rev0\1540340-H3-F003.5-Rev0.mxd



LEGEND

PROPOSED MINE PIT	U-ENRICHED LIGNITE, CLAY, SILT
QUATERNARY SEDIMENTS	REDUCED EOCENE SEDIMENTS
MIOCENE SEDIMENTS	HIGH PERMEABILITY BASAL SAND
OXIDISED EOCENE SEDIMENTS	PERMIAN SEDIMENTS (BASEMENT)

0 10 20 30 40 50
V 1:1,400 METRES

0 200 400 600 800 1,000
H 1:28,000 METRES

CLIENT
VIMY RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-30
DESIGNED	MS
PREPARED	MS
REVIEWED	EWC
APPROVED	EWC

PROJECT
MULGA ROCK URANIUM PROJECT

TITLE
SCHEMATIC DIAGRAM OF THE GEOLOGY WITHIN MRUP

PROJECT NO.	CONTROL	REV.	FIGURE
1540340	H3	0	**3.5**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM: ISO A4
25mm
0

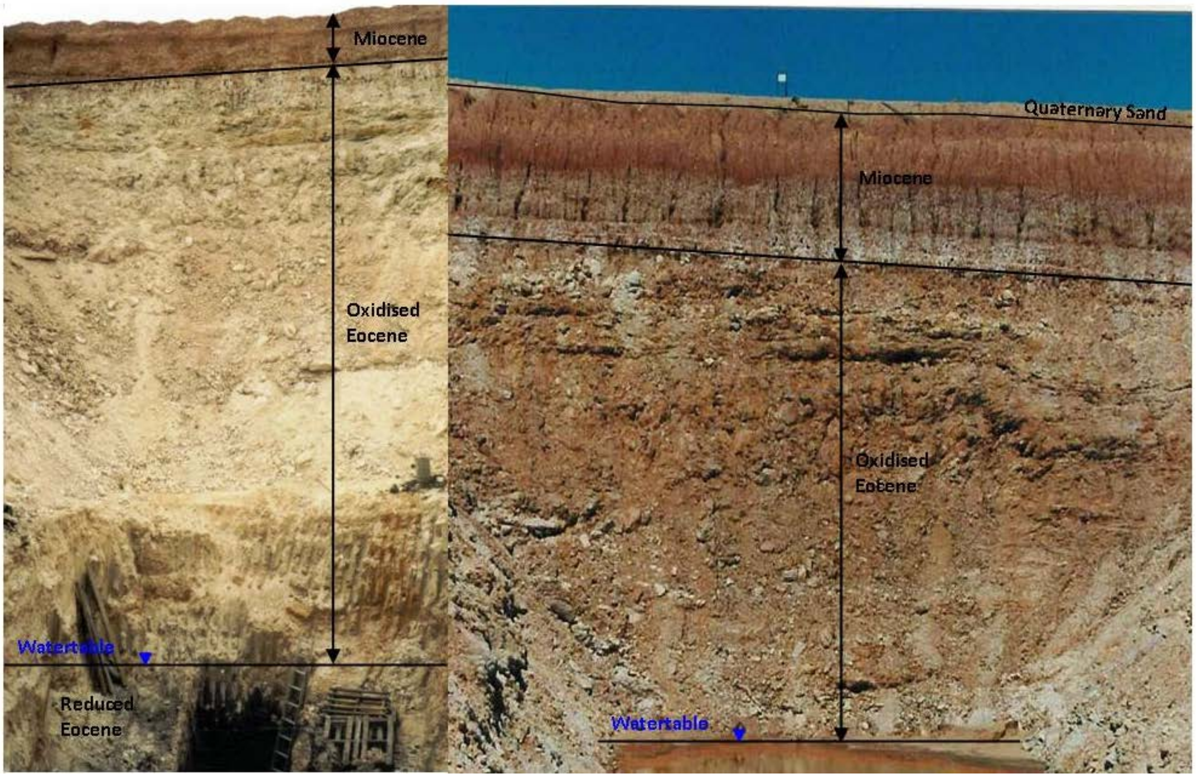


Figure 3.6 Morphological characteristic of the sedimentary sequence overlying the orebody

4. Waste Generating Processes

The main waste streams that are generated from operations that require management are:

- Approximately 40 to 50mtpa of non-radioactive inert overburden and surficial soil materials will be mined.
- Approximately 1.2-1.5mtpa of non-radioactive course silica sands which will be separated via in-pit beneficiation process and mixed with the basal portion (2-5m) of the oxidised Eocene sediments (overburden) and preferentially placed at the base of the mined pit.
- Approximately 1.2-1.3mtpa of processing plant tailings will be produced and disposed in the TSFs. Three TSFs are proposed for the MRUP, one above ground TSF and two in-pit TSFs (Princess Pit and the Ambassador In-pit TSFs). The tailings are the processing residue that has passed through the processing plant and had uranium extracted, leaving the remaining radionuclides in the uranium decay series.
- Water that may have come into contact with radioactive materials from areas which may contain uranium bearing materials, including surface run off, and leachate that has infiltrated materials such as tailings.
- Miscellaneous wastes that may have become contaminated through contact with ores and process residues (referred to as contaminated waste), including discarded conveyor belts, rubber lining material, pipes, filter media and used personal protective equipment.

Further details on the management of the wastes are provided below.

Inert Material and Overburden Management

This material is non-radioactive and will either be backfilled into the mine void (preferred option) or stored in out of pit overburden landforms. The mining method and geology of the ore body facilitates the overall waste management approach developed by Vimy by enabling a significant portion of mining and processing waste to be internally managed, with the majority of the overburden placed back into mined out sections of the mine. This equates to approximately 50-75% of waste being backfilled. By the end of mine life all pits will be backfilled (to the surface or to a depth of not less than 10m above the water table).

Coarse Silica Sands Management

The mined ore will be partially beneficiated within the mine using a two staged beneficiation plant located within the perimeter of the pit. This process is used to separate coarse silicate sands from the ore which make up approximately 50% of the ore that is mined. The coarse sands do not contain elevated concentrations of uranium and will be mixed with the basal portion (2-5m above the ore zone) of the oxidised Eocene sediments (overburden) and preferentially placed at the base of the mined pit.

Tailings Management

Tailings are the waste product from the process plant which consists primarily of the ore that has been finely ground and with the majority of the target minerals, such as uranium and base metals such as nickel, cobalt, zinc and copper, removed.

During the processing of ore at the Project, a number of solid waste streams will be generated that will be combined to produce a final stream that is thickened (to approximately 40% solids). Waste streams occur from the uranium and base metals leach circuits and various intermediate and final neutralisation processes.

In the current mining schedule tailings will be placed initially into a constructed above ground tailings storage facility (TSF) for approximately 18 months of operations prior to the Princess Pit resource being been mined out and ready to receive tailings. At around year 8 tailings deposition into the Princess In-pit TSF will cease and further in-pit deposition will commence in the Ambassador in-pit TSF. Tailings deposition in this TSF will continue until the planned life of mine (LOM; 16 years). The TSFs will be capped with a 1m capillary layer and a maximum 1m layer of growth medium.

The general tailings disposal philosophy is to dispose of them in-pit. Overall, approximately 90% of the tailings will be replaced into in-pit TSFs with 10% deposited into the above ground facility.

Above-ground TSF

A single, above-ground TSF with two cells is proposed. It is likely to have a construction footprint of around 106ha and be positioned to coincide with a large topographic depression immediately to the north of Ambassador Pit. This placement ensures that the single lift, approximately 8-10m high TSF, will not protrude higher than the surrounding dune crests.

TSF has been designed to minimise the opportunity for seepage through engineered clay walls and bases.

After the first year to 18 months of tailings disposal in the above-ground facility, the disposal method will shift to in-pit disposal. Tailings in the surface facility will be allowed to dry, with the surface forming a competent chloride-based crust. Once sufficiently dried and consolidated, the surface will be capped with a 1m capillary layer and 1m layer of Quaternary sands (growth medium) with a layer of inert cover material obtained from mine overburden removal.

In Pit Tailings Disposal

After the first year to 18 months of operations, the tailings will be disposed of in the mined out Princess Pit and allowed to drain. Modelling has shown that no special base preparation is required and that sidewall excursion of tailings leachate is unlikely (SWC 2015).

The radionuclide analysis of tailings (ANSTO 2015) indicates that the majority of the remnant radionuclides remain in the tailings solids and, therefore, radionuclides are not available to migrate with any seepage that may occur.

Fate and transport modelling of groundwater in the wider region has been conducted for the in pit tailings disposal which indicates that over a period of 1,000 years, soluble uranium in groundwater does not extend more than 700m from the main tailings disposal area, well within the boundary of mining lease M39/1080 (GHD 2015).

Waste Water Management

The operations will be designed to manage and contain water that has been in contact with mineralised material. This includes stormwater runoff from ore stockpiles, water from the processing plant area and water from mine dewatering. This water does not become radioactive, but may contain entrained radioactive dusts and sediments. Implemented drainage structures and controls will be designed to retain surface water runoff from a 1-in-100 year, 72 hour storm event on site. Sedimentation/settling dams and evaporations ponds with collection bunds and channels will be used for water management, where required

A design feature of the processing facility will be secondary containment around tanks to collect and contain spillages as specified in the Chemical and Hydrocarbon Management Plan (MRUP-EMP-037). The secondary containment volume will be sufficient to contain contents of tanks in a catastrophic failure event and be designed for ease of clean up.

Excess process water will be co-disposed of in the active tailings facility.

Water that is used for decontamination, such as wash-down water, would be either reused in the treatment plant or disposed into tailings.

Miscellaneous Waste Control

During operations, various wastes will be generated and disposed of in an approved manner. The overall approach is to minimise waste and recycle, where possible. However, waste will be generated and require on site disposal and some of this waste will be contaminated by radioactive material such as ore or process materials.

Contaminated waste will include tyres, process plant equipment, vehicles and general wastes such as personal protective equipment. This waste will be disposed of at the site waste disposal area in separately constructed trenches that will be progressively covered by local inert overburden material reclaimed from mining operations on the MRUP and covered by Quaternary sediments and growth medium.

Process material wastes, such as collected spillage or slimes from sedimentation dams, will be disposed of with the tailings.

All miscellaneous waste will be disposed of in accordance with relevant waste disposal legislation and onsite waste classification will account for other hazards that may be present with the waste. For example, all oil and fuels will be drained from vehicles prior to those being retired or removed from site.

In all cases, records of the disposal of potentially contaminated items, including type of material/equipment, quantities and location of disposal will be kept according to Vimy's document control procedures.

5. Radiological Characteristics of Tailings

Physicochemical Characterisation

A detailed physicochemical characterisation of tailings from the MRUP is reported separately (SWC 2015). The work mainly focusses on the acid forming potential and metalliferous drainage potential of those tailings. However, the following conclusions are relevant to the behaviour of radionuclides in the waste streams identified:

- The carbonaceous material hosting the ore represents a metal and metalloid sink whereby these constituents are effectively removed from the water column and strongly bound to the organic material.
- The carbonaceous material can, therefore, be considered as a Passive or Permeable Reactive Barrier (PRB) effectively acting as a filter stripping contaminants out of the groundwater. Following processing, the organic material will be placed back in the pit as tailings and continue to act as a sink.
- Given the strength at which metals and metalloids are bound to the carbonaceous material, it is unlikely that metalliferous (and therefore radionuclide) drainage will occur from stockpiles.
- The carbonaceous ore is classified as Potentially Acid Forming (PAF); however geochemical conditions likely to exist in the TSFs will not be conducive to sulfide oxidation, and thus the likelihood of acidic drainage occurring is consider low.

Radon Emission

Radon emanation rates were measured from dry samples for two different ore types (lignitic and sandy) using charcoal canisters backed by continuous radon and thoron emanation rates measured using a Durridge RAD 7 unit (Sonter et al., 2015). Tests were also carried out with samples saturated with site water and capped with Eocene clay material to assess their respective emanation attenuation potential. Results were as follow:

- Radon emanation rates from saturated vs. dry ore decreased by greater than 95% to less than 0.1Bq/m2/s. This is due to the diffusion coefficient of radon being much lower in water than in air. That attenuation factor achieved in a genuine sub-aqueous configuration is likely to be greater than that achieved through a mere saturated medium.
- A 35cm Eocene sand clay cap achieved greater than 99% attenuation of radon attenuation rate. Given the thickness of the capillary break, and growth medium considered for both the surface and in-pit tailings disposal facilities, similar attenuation factors are expected from the reconstructed final landform capping structure, following drainage of the tailings leachate.

Further test-work will be undertaken to establish the efficacy of various cover or capping systems to reduce radon emanation rates and identify the key drivers influencing these rates. Following the completion of two geotechnical investigation trenches at the Ambassador deposit in late 2015-early 2016, Vimy intends on conducting further radon and thoron emanation test-work on loose bulk mineralised samples excavated from the base of the trench to confirm previous radon emanation rates obtained from small-scale canisters. These ore samples will undergo processing in a pilot plant, and similar measurements will be taken over the tailings generated and rate assumptions for various landforms updated accordingly.

Given the very short half-life of thoron (55s), it was not considered relevant for closure.

This supports the concept of benign radon emanation rates associated with the final MRUP tailings reconstructed landforms, decreasing in a logarithmic manner over time with the decay of radium left in those tailings.

Tailings Composition

Tailings will be deposited subaqueously. Following the completion of deposition, partially saturated tailings are expected to crust within a matter of weeks due to the relatively high chloride content, therefore, limiting their potential for dust generation.

ANSTO Minerals undertook process development work and radionuclide behaviour characterisation for the various streams identified in the proposed process flowsheet. The work concluded that the radionuclide behaviour is identical to radionuclides in similar uranium extraction plants around the world. The work also identified that there appears to be disequilibrium in the 238U chain with the 226Ra activity being consistently less than the uranium activity.

Table 5.1 Radionuclide behaviour during processing

Element (Includes all isotopes)	Standard Leach (metals into solution)	Resin-in-Leach (Selective uranium leach)[1]	Neutralisation (of leach solution to remove remnant radionuclides)
Uranium	Full leach	Full leach	Remnant precipitates
Thorium	Full leach	Does not extract – remains in solution	Precipitates
Radium	Does not leach – remains in solids	Does not extract – remains in solution	Remnant precipitates
Lead	Partial leach	Does not extract – remains in solution	Precipitates
Polonium	Does not leach – remains in solids	Does not extract – remains in solution	Remnant precipitates
Actinium	Partial leach	Does not extract – remains in solution	Precipitates

Notes 1: As a proxy for the resin-in-pulp configuration proposed for the MRUP processing plant

The ANSTO Minerals work demonstrates that the primary leaching removes the majority of uranium and other metals to solution. The resin-in-pulp will then selectively remove the uranium for further precipitation. The remaining leach solution is neutralised and remnant radionuclides precipitate. Table 5.2 shows the fate of radionuclides.

The final tailings stream consists of the solids from the leach residues, precipitated materials and minor process streams, such as gypsum generated during neutralisation steps. The tailings liquor is effectively a barren process liquor, with the majority of the remaining radionuclides within the solids phase of the tailings. Table 5.2 shows the radionuclide concentration in various process streams.

Table 5.2 Radionuclide Concentrations in Process Streams (derived from ANSTO 2015) in Bq/g

	U238	U234	Th230	Ra226	Pb210	Po210	Ac227	Th232
Ore[1]	8.3	8.3	8.2	6.5	8.0	5.8	0.1	0.4
Tailings (Solids – leach residue)[2]	4.0	4.0	7.0	8.0	7.5	6.4	0.3	0.1
Tailings (Solids – resin leach residue)[3]	1.5	1.5	8.2	7.7	7.6	6.3	0.33	0.1
Tailings (Solids – neutralisation)[4]	3.1	3.1	23	0.03	20	0	0.13	0.21
Tailings (Liquid) (Bq/mL)[5]	0.061	0.061	<0.002	0.003	0.036	0	0.036	<0.001
Uranium Product[6]	8,700	8,700	-	-	-	-	-	-
Base Metal Concentrate[7]	< 1	< 1	< 1	< 1	< 1	< 1	< 1	<1

Notes 1: Assumes ore containing approximately 670ppmU.
2: Solids residue following standard leach
3: Solids residue following resin leach
4: Solids residue following neutralisation
5: Units are Bq/mL for comparison with other mass units (Bq/g)
6: Assumes final product is uranyl peroxide (UO_42H_2O)
7: Testwork demonstrates this as achievable

Further testwork on radionuclide concentration and deportment into various process and waste stream will be carried out by Vimy Resources prior to finalisation of the detailed design phase of the project.

Vimy has conducted an assessment as part of the PER and shown that potential doses to workers, the public and the environment are very low.

6. Preliminary Waste Classification

The ARPANSA RPS 20 provides information on the different types of radioactive waste and the control requirements. The proposed waste classification methodology will been adapted from ARPANSA RPS 20 and is summarised in Figure 6.1 and Figure 6.2. Initial waste classifications indicate that radioactive waste for the Project are likely to be classified as very low level waste (Very LLW) or low level waste (LLW). ARPANSA RPS 20 notes that facilities for disposal of Very LLW or LLW should:

- have sufficient capacity so that the radioactive waste only occupies a small percentage of the total volume
- have 2m or so of soil or clean fill cover over the radioactive waste
- have leachate control
- be suitable for any other of the waste characteristics e.g. it will need to be able to cater for clinical waste or radioactive waste containing nonradioactive hazardous constituents, if applicable and
- take into account land use restrictions post-closure.

Project tailings would be classified as low level waste (LLW), thereby allowing disposal in engineered surface landfill type facilities. The assessment is based on the radiological characteristics of the tailings material described in Section 5 and the local environment and disposal methods discussed in Section 3 and 4. The relatively low radionuclide activity from the waste streams identified for the MRUP, along with their ease of classification, segregation and disposal and encapsulation options identified combined with the discharge environment and natural processes controlling solids and liquid transfers support the classification of the tailings as being a low level NORM waste.

Contaminated waste will include tyres, process plant equipment, vehicles and general wastes such as personal protective equipment. This will be disposed of at the site waste disposal area in constructed trenches that will be progressively covered by inert overburden material reclaimed from mining operations and covered by Quaternary sediments and growth medium.

Process material wastes, such as collected spillage or slimes from the sedimentation dams will be disposed of with the tailings. The MRUP will have surface tailings disposal facilities and in-pit tailings disposal facilities and the operation of these facilities is addressed in Chapter 11 Inland Waters Environmental Quality.

Upon completion of the detailed design of the MRUP, the Conceptual RWMP will be revised to include detailed waste registers and classifications for all radioactive waste streams for the Project (including intermediate processing waste). The revision will detail controls and determine risk categories for the management of tailings, process and surface waters based on the ANCOLD (May 2012) guidelines.

ARPANSA RPS20 notes that disposal will need to consider other non-radiological hazard associated with the radioactive waste, which may invoke other national waste disposal standards.

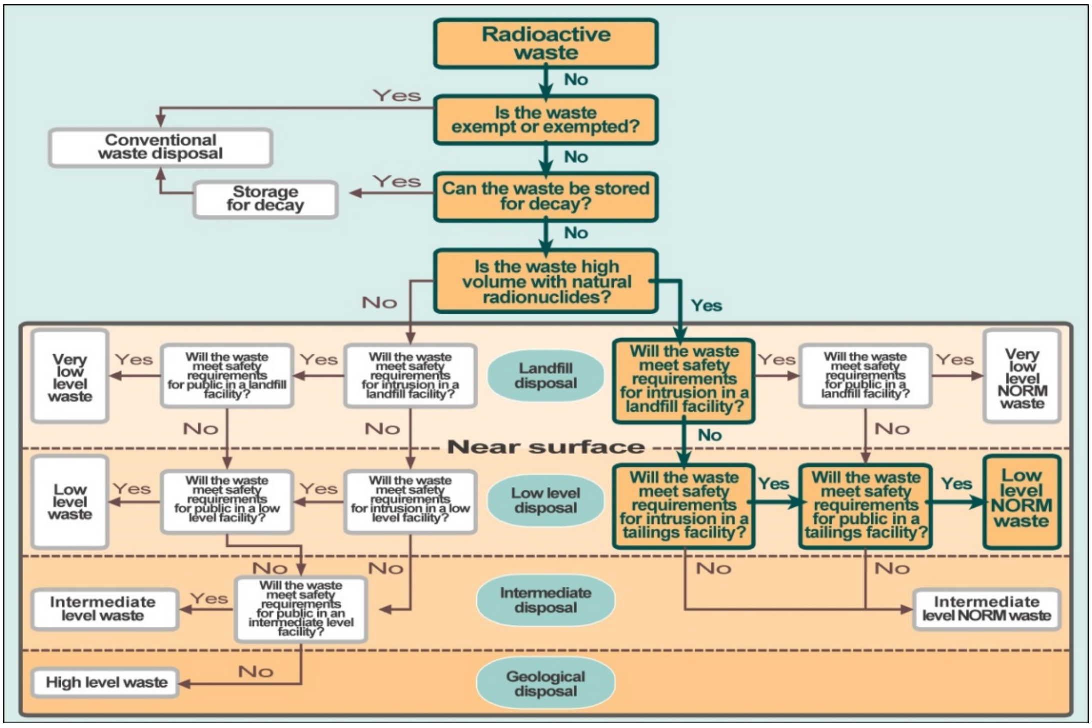


Figure 6.1 Proposed MRUP radioactive waste classification scheme (from ARPANSA RPS 20)

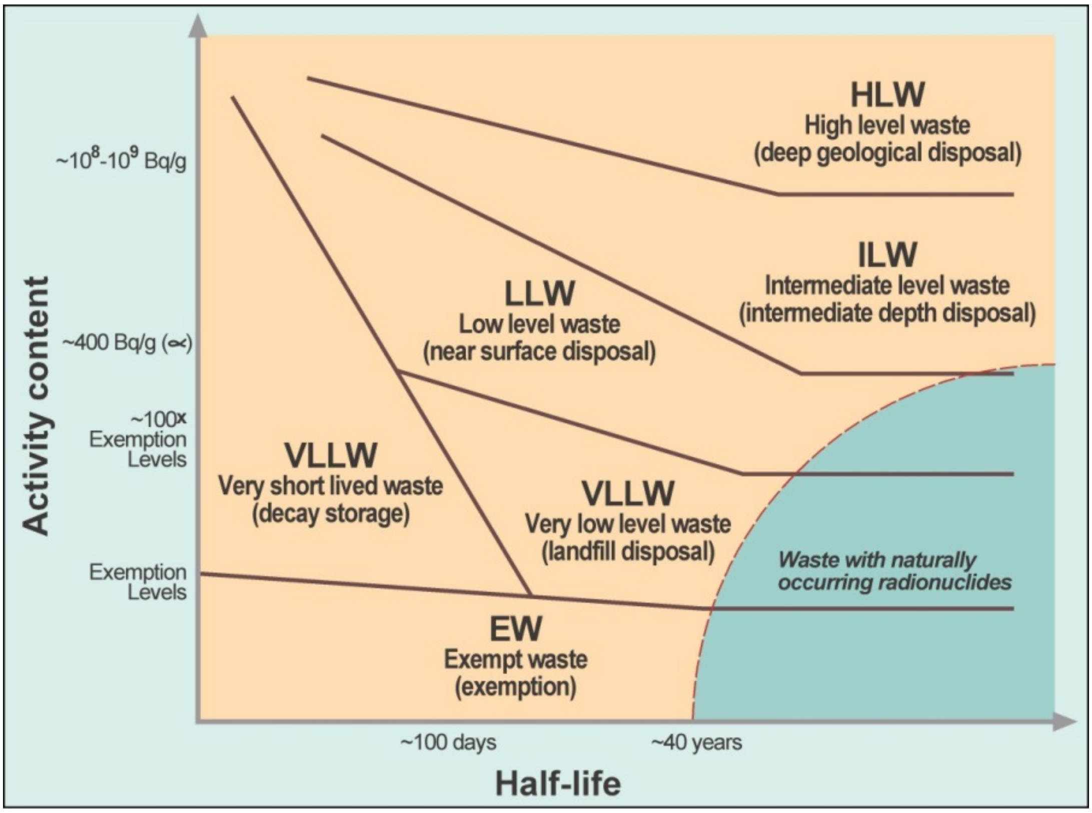


Figure 6.2 Proposed application of the waste classification scheme (adapted from ARPANSA RPS 20)

7. Description of Waste Management Systems

7.1 Background

Hazards and risks associated with radioactive waste are most effectively controlled through good design decisions. Vimy Resources will undertake a risk assessment of all waste management facilities to identify areas and situations where radiation controls may be required.

This will involve:

- reviewing the initial plans of plant and equipment to determine where radiation protection may be required
- quantifying the potential radiation impacts and
- determining options for control measures.

A risk-based approach will be used in the development of management systems and operating procedures.

7.2 Beneficiation

The heavy coarse grained sands and gravels removed in the beneficiation process are generally non mineralised will be pumped to the pit void, where it will be dewatered and stacked as back fill in the base of the pit with the backfilled 2-5m basal layer of overburden.

7.3 Tailings

Based on water leachability testing completed by ANSTO, primary contaminating metals, metalloids and radionuclides of concern include copper, cobalt, uranium and zinc. Once deposited in the in-pit TSFs, the entrained process water within the tailings, which is likely to have leachable concentrations of heavy metals including uranium, will primarily leach vertically and seep into the underlying groundwater.

Loss of water from the tailings will occur in three ways:

- evaporation
- vertical drainage through the base of the pit and
- leakage laterally through the walls of the pit.

The nature of the tailings confers a low hydraulic conductivity and, therefore, an expected low rate of movement of liquor from the tailings into the surrounding groundwater environment.

The specific design for the surface tailings facility is yet to be finalised, however, the design standards outlined by the WA DMP (1998, 1999) and ANCOLD (2012) will be adhered to and the established objectives for the surface tailings facility are:

- a maximum of three years capacity, split across two cells
- permanent and secure containment of solid waste materials
- optimise tailings densities
- minimisation of seepage
- containment of extreme storm events within the TSF (e.g. sufficient freeboard)
- ease of operation and

- effective final landform design and construction promoting sustainable regrowth.

The design and operation of the above-ground TSF will comply with the requirements of:

- DME (now DMP) Guidelines on the Safe Design and Operating Standards for Tailings Storage, May 1999
- DME (now DMP) Guidelines on the Development of an Operating Manual for Tailings Storage, October 1998
- ANCOLD Guidelines on Tailings Dams, Planning, Design, Construction, Operation and Closure. May 2012
- ANCOLD Guidelines on the Consequence Categories for Dams. October 2012 and
- DMP Code of Practice – Tailings Storage Facilities in Western Australia 2013.

A summary of the design considerations are as follows:

<u>Freeboard</u>

Freeboard requirements are specified within the DME Guidelines (DME (WA) 1999) and in the ANCOLD guidelines (ANCOLD 2012).

<u>Surface water and runoff</u>

There is a requirement to minimise upstream rainfall catchment areas and to divert natural runoff, expected to be very minimal at MRUP.

<u>Seismic Setting</u>

An assessment of the seismic risk on final design will be undertaken, prior to application for State Works Approval (Part 5 EP Act).

<u>Climate (Rainfall)</u>

Current practice is to use the 1 in 100-year, 72 hour duration flood event for the design storm storage, and the probable maximum flood (PMF) for the sizing of the emergency spillway.

<u>Foundation Characteristics</u>

ANCOLD has identified in-pit disposal as a preferred approach to reduce the risk of uncontrolled post-closure release of tailings into the environment by surface erosion. For the surface facility, a clay lined base will be used.

<u>Embankment Stability</u>

Embankments with an impervious core and / or internal drains help control the phreatic surface and promote stability.

<u>Embankment Raise Method</u>

Designed as a combination of excavation and raised perimeter walls, configured to blend and utilise as far as practicable the surrounding dunal landscape, minimising cut and fill.

7.4 Closure and Decommissioning

The MRUP has developed a CMCP that addresses decommissioning of the process plant and the closure and rehabilitation of the pits and overburden landforms. The CMCP will be reviewed periodically and updated accordingly for currency with legislation, standards, guidelines and operational requirements. This Plan together with the CMCP provides the framework for identify, managing and disposing of radioactive waste streams generated by the project. The CMCP is provided in Appendix H1.

The overall mining plan for the MRUP will see the landforms and mining pits progressively rehabilitated during the mining operations. The TSFs and the pits are likely to be used for the managed disposal of radioactive waste materials generated during decommissioning.

7.4.1 Closure Objectives

The overall objective of closure as stated in the CMCP, is to construct safe, stable, non-polluting landforms that demonstrate sustainable closure land uses. In order to achieve this objective Vimy will:

- ensure the interests of relevant stakeholders are considered during all stages of closure planning,
- establish and refine rehabilitation objectives and completion criteria, based on the findings of monitoring and research, that are appropriate to the agreed post-mine land use,
- construct safe, stable, non-polluting landforms that are geomorphologically and functionally consistent with the surrounding landscape and capable of sustaining agreed post-operational land use, and do not impact on surrounding environmental values or uses,
- rehabilitate disturbed areas to meet agreed post-operational land use objectives and completion criteria and
- develop indicators to demonstrate (through monitoring) when rehabilitation activities meet the established objectives and completion criteria.

Through the implementation of the above closure objectives, it is anticipated that:

- no significant long term physical offsite impacts will occur as a result of operations,
- no significant long term impact on baseline surface or groundwater flow patterns and quality will occur as a result of operations,
- no unsafe areas will remain after closure whereby members of the general public and animals could be harmed and
- rehabilitated and closed operational areas will be aesthetically consistent with the surrounding landform and consider stakeholder expectations.

Following cessation of mining, and subsequent rehabilitation and closure of post-mine landforms, the land use of the area will be self-sustaining native ecosystems of regional relevance.

7.4.2 Decommissioning Plan

Decommissioning will need to consider radiation and this will be managed through the development of an inventory of all materials and equipment at the site, nominating final disposal location for each item on the inventory. The plan will also have a schedule to assist the operation to be carried out in an efficient manner.

A strict protocol will be developed to segregate equipment that has been potentially exposed to radioactive contamination from other equipment.

The decommissioning and deconstruction of the infrastructure facilities may result in three main types of materials, namely:

- materials that can be sold or otherwise passed on to third parties
- other materials not contaminated by uranium and
- materials that have been contaminated by uranium that exhibit a surface radioactivity above a trigger level.

Material that cannot be re-used or is uneconomic to re-use shall be disposed of as waste in accordance with the Preliminary RWMP and other legislative requirements. This includes but is not limited to:

- the use of appropriate radiometric and other testing, removal and sorting procedures
- the use of registered, licensed contractors
- the selection of appropriate disposal techniques and
- tracking of volumes and materials.

All materials not removed from site will be buried in designated areas, one accommodating all the uncontaminated materials and the other all materials contaminated by uranium.

7.4.3 Post-closure

The closure and rehabilitation of the mine will be subject to compliance with an agreed CMCP (Appendix H1). The above-ground tailings facility will be capped, covered and rehabilitated in a manner that prevents radon emanation. The majority of the tailings (approximately 90%) will be deposited back in-pit and covered with sufficient overburden to control radon emanation.

Plant and equipment will be cleaned and any radioactive material captured and disposed of in a suitable manner. Once rehabilitation has been fully implemented there will be no alpha-emitting dust or radioactive gas emanations that are predicted to be above background levels.

Radioactive material that is potentially mobilised into the groundwater system from tailings will be naturally captured and retained by the carbonaceous material that occurs downstream of the in-pit TSFs.

There will be no further transport of uranium concentrate and therefore no further gamma emissions from transport. The radiological dose assessment on all members of the public and the environment post closure, once rehabilitation has been completed, is predicted to return to background levels.

8. Monitoring Program

Vimy Resources will establish an Environmental Radiation Monitoring Program. The program aims to monitor the offsite environmental impacts of operations by measuring changes in environmental radiation concentrations. This will include potential impacts of waste management infrastructure. The monitoring program will also be used to verify the effectiveness of management measures and controls. A monitoring programme for human health aspects will be addressed within the Radiation Management Plan ((MRUP-EMP-028).

The proposed monitoring is shown in Table 8.1. This monitoring program will be part of the overall Environmental Monitoring Program referring to waste management and the final program will be submitted for regulatory approval when seeking operating licences.

Table 8.1 Conceptual environmental radiation management programme

Source/Pathway	Measurement Method	Location and Frequency
Direct (external) gamma	Handheld environmental gamma monitor	Annual survey at perimeter of operational area.
Radon Decay Product Concentrations	Track etch monitors	Monitors will rotate between offsite locations.
Dispersion of dust containing long-lived, alpha-emitting radionuclides	High volume samplers	Monitors will rotate between approved offsite locations.
Dispersion of dust containing long-lived, alpha-emitting radionuclides	Dust deposition gauges	Sampling at identified locations. Samples composited for one year then radiometrically analysed.
Seepage of contaminated water	Groundwater sampling from monitoring bores	A network of monitoring bores will be sampled quarterly and analysed for radionuclides and other constituents.
Run off of contaminated water	Surface water sampling	Opportunistic surface water sampling will occur following significant rainfall events.
Radionuclides in potable water supplies	Sampling and radiometric analysis	Annually

9. Contingency Plans

9.1 Accidents, Incidents and Reporting

It is not expected that radiological emergencies associated with waste would arise. This is due to the very low specific activity of the waste streams. However, plans for any incidents or accidents that may result in exposure to radiation or loss of containment of radioactive material will be prepared as part of the overall site emergency response plan and include:

- immediate response to medical conditions
- evacuation of non-essential personnel
- stabilisation of the source(s) of radiation
- assessment of the likely source(s) of radiation exposure and the types of radiation and
- decontamination of the person(s) and the area.

The plan will include requirements for post-incident response, including counselling of all people involved or affected by the incident, detailed investigation of the incident, including root-cause analysis to prevent recurrence and procedures for estimating any radiation doses that may have arisen.

As part of the Project's emergency response plan, reporting triggers for solid and liquid wastes will be established, in compliance with existing regulatory guidelines and conditions, after consultation with relevant Decision Making Authorities.

9.2 Suspension of Operations

The mining operations may be forced to close prematurely, or to "suspended operations and place under care and maintenance". The Company would remain bound to complying with all environmental obligations. Specific issues associated with waste management during a suspension of operations will be detailed in a Care and Maintenance Plan, based on the CMCP.

10. References

ANCOLD — Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure (May 2012)

ARPANSA 2005 (RPS 9) — The Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing. Radiation Protection Series Publication No 9. ARPANSA.

ARPANSA 2008 (RPS15) — Safety Guide - Management of Naturally Occurring Radioactive Material (NORM), Radiation Protection Series Publication No. 15. ARPANSA

ARPANSA 2010 (RPS20) — Safety Guide Classification of Radioactive Waste, Radiation Protection Series Publication No. 20. ARPANSA.

ARPANSA 2014 (RPS 6) — National Directory for Radiation Protection), Radiation Protection Series Publication No. 6. ARPANSA

Barton and Cowan (2001) — Barton, B., and Cowan, M (2001). Great Victoria Desert (GVD1) – Shield Subregion CALM 2001. A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002. Department of Conservation and Land Management, Kensington WA.

DMP 2010 — Managing naturally occurring radioactive material (NORM) in mining and mineral processing - guideline. Department of Mines and Petroleum, Western Australia

DMP and EPA 2015 — Department of Mines and Petroleum (DMP) & Environmental Protection Authority (EPA), 2015, Guidelines for Preparing Mine Closure Plans, May 2015

IAEA 2011 — Disposal of radioactive waste. — Vienna, International Atomic Energy Agency, 2011, IAEA safety standards series no. SSR-5

Ishimori *et al.* 2014 — Ishimori Y., Lange K., Martin P., Mayya Y.S., Phaneuf M. (2013) Measurement and Calculation of Radon Releases from NORM residues, IAEA Technical Reports Series no. 474.

Luke *et al.*, (1987) — Luke, G.J., Burke, K.L., O'Brien, T.M., 1987, Evaporation data for Western Australia, Resource Management Technical Report no. 65, Department of Agriculture

Sonter *et al.*, 2015 — Sonter M., Moreau X., Wu M. (2015) Mulga Rock Uranium Project Radon Test-work: Technical Note in: Radiation Protection in Australasia Vol 32 (1): 15-21

Appendix A

Assessment against the IAEA Safety Standard SSR-5 'Disposal of Radioactive Waste'

Assessment against the IAEA Safety Standard SSR-5 'Disposal of Radioactive Waste'

(It is noted that the specific requirements are intended to be considered for facilities for the disposal of all types of radioactive waste. Die to the low levels of radioactivity in the tailings, in some cases, the specific requirements are not warranted when compared to the actual risk and are only partially applicable.)

Specific Requirements	Details	Applicability to MRUP
Requirement 1: Government Responsibilities		Not applicable
Requirement 2: Responsibilities of the regulatory body		Not applicable
Requirement 3: Responsibilities of the operator	The operator of a disposal facility for radioactive waste shall be responsible for its safety. The operator shall carry out safety assessment and develop and maintain a safety case, and shall carry out all the necessary activities for site selection and evaluation, design, construction, operation, closure and, if necessary, surveillance after closure, in accordance with national strategy, in compliance with the regulatory requirements and within the legal and regulatory infrastructure.	Applicable. As part of the design of the tailings disposal facility, a safety assessment will be conducted by the design consultant. The assessment will inform design and be part of the authorisation to construct submission to the appropriate regulators prior to construction.
Requirement 4: Importance of safety in the process of development and operation of a disposal facility	Throughout the process of development and operation of a disposal facility for radioactive waste, an understanding of the relevance and the implications for safety of the available options for the facility shall be developed by the operator. This is for the purpose of providing an optimized level of safety in the operational stage and after closure.	Applicable. It is intended that a Tailings Management Plan be developed which will incorporate all aspects of operations and safety. The Tailings Management Plan (operational strategy) will be referred to in the final RWMP.
Requirement 5: Passive means for the safety of the disposal facility	The operator shall evaluate the site and shall design, construct, operate and close the disposal facility in such a way that safety is ensured by passive means to the fullest extent possible and the need for actions to be taken after closure of the facility is minimized.	Applicable. The tailings disposal facility will be designed in accordance with the nationally recognised ANCOLD standards, which incorporate passive safety measured and redundancy.
Requirement 6: Understanding of a disposal facility and confidence in safety	The operator of a disposal facility shall develop an adequate understanding of the features of the facility and its host environment and of the factors that influence its safety after closure over suitably long time periods, so that a sufficient level of confidence in safety can be achieved.	Applicable. As part of the PER, Vimy Resources has described the key environmental aspects in the region of the MRUP. The safety assessment will also consider the potential long term impacts of the facility following closure.
Requirement 7: Multiple safety functions	The host environment shall be selected, the engineered barriers of the disposal facility shall be designed and the facility shall be operated to ensure that safety is provided by means of multiple safety functions. Containment and isolation of the waste shall be provided by means of a number of physical barriers of the disposal system. The performance of these physical barriers shall be achieved by means of diverse physical and chemical processes together with various operational controls. The capability of the individual barriers and controls together with that of the overall disposal system to perform as assumed in the safety case shall be demonstrated. The overall performance of the disposal system shall not be unduly dependent on a single safety function.	Applicable. The design and safety assessment will consider these aspects.

Specific Requirements	Details	Applicability to MRUP
Requirement 8: Containment of radioactive waste	The engineered barriers, including the waste form and packaging, shall be designed, and the host environment shall be selected, so as to provide containment of the radionuclides associated with the waste. Containment shall be provided until radioactive decay has significantly reduced the hazard posed by the waste. In addition, in the case of heat generating waste, containment shall be provided while the waste is still producing heat energy in amounts that could adversely affect the performance of the disposal system.	Applicable. The design and safety assessment will consider these aspects. However, the waste is classified as low level and therefore the controls will be commensurate with the level of risk.
Requirement 9: Isolation of radioactive waste	The disposal facility shall be sited, designed and operated to provide features that are aimed at isolation of the radioactive waste from people and from the accessible biosphere. The features shall aim to provide isolation for several hundreds of years for short lived waste and at least several thousand years for intermediate and high level waste. In so doing, consideration shall be given to both the natural evolution of the disposal system and events causing disturbance of the facility.	Applicable. The design and safety assessment will consider these aspects. However, the waste is classified as low level and therefore the controls will be commensurate with the level of risk.
Requirement 10: Surveillance and control of passive safety features	An appropriate level of surveillance and control shall be applied to protect and preserve the passive safety features, to the extent that this is necessary, so that they can fulfil the functions that they are assigned in the safety case for safety after closure.	Applicable. The Tailings Management Plan (within the Operational Strategy) shall consider these aspects.
Requirement 11: Step by step development and evaluation of disposal facilities	Disposal facilities for radioactive waste shall be developed, operated and closed in a series of steps. Each of these steps shall be supported, as necessary, by iterative evaluations of the site, of the options for design, construction, operation and management, and of the performance and safety of the disposal system.	Applicable. The Tailings Management Plan (within the Operational Strategy) will consider these aspects and it is noted that this is consistent with the authorisation requirements of the ARPANSA Mining Code.
Requirement 12: Preparation, approval and use of the safety case and safety assessment for a disposal facility	A safety case and supporting safety assessment shall be prepared and updated by the operator, as necessary, at each step in the development of a disposal facility, in operation and after closure. The safety case and supporting safety assessment shall be submitted to the regulatory body for approval. The safety case and supporting safety assessment shall be sufficiently detailed and comprehensive to provide the necessary technical input for informing the regulatory body and for informing the decisions necessary at each step.	Generally Applicable. The Tailings Disposal Facility will undergo a safety assessment as part of design.
Requirement 13: Scope of the safety case and safety assessment	The safety case for a disposal facility shall describe all safety relevant aspects of the site, the design of the facility and the managerial control measures and regulatory controls. The safety case and supporting safety assessment shall demonstrate the level of protection of people and the environment provided and shall provide assurance to the regulatory body and other interested parties that safety requirements will be met.	See Requirement 12
Requirement 14: Documentation of the safety case and safety assessment	The safety case and supporting safety assessment for a disposal facility shall be documented to a level of detail and quality sufficient to inform and support the decision to be made at each step and to allow for independent review of the safety case and supporting safety assessment.	See Requirement 12
Requirement 15: Site characterization for a disposal facility	The site for a disposal facility shall be characterized at a level of detail sufficient to support a general understanding of both the characteristics of the site and how the site will evolve over time. This shall include its present condition, its probable natural evolution and possible natural events, and also human plans and actions in the vicinity that may affect the safety of the facility over the period of interest. It shall also include a specific understanding of the impact on safety of features, events and processes associated with the site and the facility.	Applicable. As part of the safety assessment, a radiological risk assessment will be conducted in a manner similar to a features, events and processes assessment.

Specific Requirements	Details	Applicability to MRUP
Requirement 16: Design of a disposal facility	The disposal facility and its engineered barriers shall be designed to contain the waste with its associated hazard, to be physically and chemically compatible with the host geological formation and/or surface environment, and to provide safety features after closure that complement those features afforded by the host environment. The facility and its engineered barriers shall be designed to provide safety during the operational period.	Applicable. As part of the safety assessment, a radiological risk assessment will be conducted in a manner similar to a features, events and processes assessment.
Requirement 17: Construction of a disposal facility	The disposal facility shall be constructed in accordance with the design as described in the approved safety case and supporting safety assessment. It shall be constructed in such a way as to preserve the safety functions of the host environment that have been shown by the safety case to be important for safety after closure. Construction activities shall be carried out in such a way as to ensure safety during the operational period.	Applicable. As part of the safety assessment, a radiological risk assessment will be conducted in a manner similar to a features, events and processes assessment.
Requirement 18: Operation of a disposal facility	The disposal facility shall be operated in accordance with the conditions of the licence and the relevant regulatory requirements so as to maintain safety during the operational period and in such a manner as to preserve the safety functions assumed in the safety case that are important to safety after closure.	Applicable. The Tailings Management Plan within the Operational Strategy) shall consider these aspects.
Requirement 19: Closure of a disposal facility	A disposal facility shall be closed in a way that provides for those safety functions that have been shown by the safety case to be important after closure. Plans for closure, including the transition from active management of the facility, shall be well defined and practicable, so that closure can be carried out safely at an appropriate time.	Applicable. The closure of the TSF will be included as part of the overall site closure plan.
Requirement 20: Waste acceptance in a disposal facility	Waste packages and unpackaged waste accepted for emplacement in a disposal facility shall conform to criteria that are fully consistent with, and are derived from, the safety case for the disposal facility in operation and after closure.	Not applicable.
Requirement 21: Monitoring programmes at a disposal facility	A programme of monitoring shall be carried out prior to, and during, the construction and operation of a disposal facility and after its closure, if this is part of the safety case. This programme shall be designed to collect and update information necessary for the purposes of protection and safety. Information shall be obtained to confirm the conditions necessary for the safety of workers and members of the public and protection of the environment during the period of operation of the facility. Monitoring shall also be carried out to confirm the absence of any conditions that could affect the safety of the facility after closure.	Applicable. Environmental monitoring will be conducted as outlined in the RWMP
Requirement 22: The period after closure and institutional controls	Plans shall be prepared for the period after closure to address institutional control and the arrangements for maintaining the availability of information on the disposal facility. These plans shall be consistent with passive safety features and shall form part of the safety case on which authorization to close the facility is granted.	Applicable. This will form part of the site Tailings Operation Strategy
Requirement 23: Consideration of the State system of accounting for, and control of, nuclear material	In the design and operation of disposal facilities subject to agreements on accounting for, and control of, nuclear material, consideration shall be given to ensuring that safety is not compromised by the measures required under the system of accounting for, and control of, nuclear material	Not Applicable. Nuclear material will not be disposed within the TSF
Requirement 24: Requirements in respect of nuclear security measures	Measures shall be implemented to ensure an integrated approach to safety measures and nuclear security measures in the disposal of radioactive waste.	Not Applicable. Nuclear material will not be disposed of within the TSF

Specific Requirements	Details	Applicability to MRUP
Requirement 25: Management systems	Management systems to provide for the assurance of quality shall be applied to all safety related activities, systems and components throughout all the steps of the development and operation of a disposal facility. The level of assurance for each element shall be commensurate with its importance to safety.	Applicable All management plans (RWMP, tailings management and closure) will be subject to Vimy Resources quality control management system
Requirement 26: Existing disposal facilities	The safety of existing disposal facilities shall be assessed periodically until termination of the licence. During this period, the safety shall also be assessed when a safety significant modification is planned or in the event of changes with regard to the conditions of the authorization. In the event that any requirements set down in this Safety Requirements publication are not met, measures shall be put in place to upgrade the safety of the facility, economic and social factors being taken into account.	Applicable. The Tailings Management Plan (as part of the Operational Strategy) shall consider these aspects.