ERA Energy Resources of Australia Ltd

9 Closure implementation

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GLOSSARY

The following key terms are used in this section of the Ranger Mine Closure Plan

Key term	Definition
Bulk material movement	The movement of stockpiled waste rock for the puposes of backfill and the construction of the final landform
Capping (initial and secondary)	The placement of waste rock above the tailings in Pit 3. Capping layers provide drainage and act to dissipate the bearing pressure of construction equipment.
Closure domain	Areas with similar features, decommissioning and/or rehabilitation requirements for closure.
Conceptual Reference Ecosystem	A conceptual model of a natural reference ecosystem adjusted to accommodate changed or predicted environmental conditions, synthesised from numerous natural reference sites and modified based on evidence from research, trials, experience, benchmarking, and historical and predictive records
Digital Elevation Model	Digital representation of the land topography
Georgetown Billabong	The statutory surface water monitoring point for Georgetown Billaboing, which is located downstream of Corridor Creek and the Corridor Creek wetland filter.
Land Application Area(s)	Abbreviated to LAA. An area on the RPA used as an evapotranspiration disposal method polished and unpolished pond water from the constructed wetlands filters and, more recently, permeates from the water treatment plants. However, irrigation of unpolished pond water ceased at the end of 2009. The concept of land application is to retain metals and radionuclides in the near-surface soil profile.
Long Lived Alpha Activity	Abbreviated to LLAA. The presence, generally in airborne dust, of any of the alpha emitting radionuclides in uranium ore, except for the short-lived alpha emitting radon decay products.
Maximum Operating Level	Maximum height permitted for process water in the TSF and Pit 3. Maximum operating level also applies to the maximum deposited height of tailings in Pit 3.
Pit 1	The mined out pit of the Ranger #1 orebody, which is used as a tailings repository. Mining in Pit 1 commenced in May 1980 and was completed in December 1994, after recovering 19.78 million tonnes of ore at an average grade of 0.321%.
Pit 3	The mined out pit of the Ranger #3 orebody, which is currently being backfilled with tailings. Open cut mining in Pit 3 commenced in July 1997 and ceased in November 2012.
Processing	Processing is the mining term to describe all phases of the ore treatment from milling through to the final product packaging of uranium oxide.
Ranger Project Area	Abbreviated to RPA. The Ranger Project Area means the land described in Schedule 2 to the Commonwealth *Aboriginal Land Rights (Northern Territory) Act 1976.*

Key term	Definition
Reference level	Abbreviated to RL. Denotes a specific elevation relative to mean sea level and is regularly used to identify the height or depth of plan or mine infrastructure – e.g. the height of the tailings dam, depth of Pit 3.
Retention Pond	A large constructed storage facility that collects runoff and stores pond water for treatment (RP2 & RP6) or release water post-treatment (RP1).
Revegetation domains	Areas of disturbance, to be revegetated, differentiated on their likely physical and chemical constraints that will influence both the initial establishment and the long-term growth, development and functioning of revegetated plant communities.
Subaerial tailings deposition	Deposition of tailings in air, , e.g. from spigots or pipes above the surface of the water
Subaqueous tailings deposition	Deposition of tailings below the surface of the water
Tailings dam	Surface dam used to hold tailings and process water at Ranger. Commonly referred to as "tailings storage facility" or "TSF" in other ERA material. The tailings dam is one of currently three tailings storage facilities at Ranger, the others being Pit 1 and Pit 3.
Tailings flux/ consolidation flux	Process water squeezed from reducing pore spaces during the consolidation of tailings
Underfill	Initial fill of waste rock placed in the base of Pit 3.
U_3O_8	The most stable form of uranium oxide and the form most commonly found in nature. Uranium oxide concentrate is sometimes loosely referred to as yellowcake. It is khaki in colour and is usually represented by the empirical formula U_3O_8. Uranium is normally sold in this form.
Vadose zone	The portion of the sub-surface that lies between ground surface and the water table or saturated zone.
Vulcan	A design, modelling and planning software package that is used in mine processes, mine design, scheduling and rehabilitation.
Waste rock	The mineral waste produced in the mine but is stockpiled due to its low grade i.e. material which does not enter the processing plant. For example, 1s waste rock is typically material that has a grade of less than 0.02% U_3O_8; 2s waste rock (or low-grade ore) is typically material that has between 0.02% and 0.12% U_3O_8.
Wetland filter	A man-made system that is purpose built to emulate the ecosystem services provided by natural wetlands as a low cost, efficient means to polish/remediate/clean-up effluent.
Wicks / Prefabricated Vertical Drains	Drains inserted vertically into unconsolidated tailings material in Pit 1 and 3. The drains consist of plastic strips wrapped in geofabric with extruded channels that allow water to drain upwards from the tailings as it consolidates
XPAC	A mine scheduling software.

ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this section of the Ranger Mine Closure Plan.

Abbreviation/ Acronym	Description
1s rock	Waste rock material that typically has a grade of less than 0.02% U_3O_8
2s rock	Waste rock (or low grade ore) material that typically has between 0.02% and 0.12% U_3O_8
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ALARA	As Low As Reasonably Achievable
BC	Brine Concentrator
BoM	Bureau of Meteorology
BMM	Bulk Material Movement
BPT	Best Practicable Technology
C&M	Care and Maintenance
CCD	Counter Current Decantation
COPC	Constituents of Potential Concern
CRE	Conceptual Reference Ecosystem
CRF	Cemented Rock Fill
CSIRO	Commonwealth Scientific, Industrial Research Organisation
DEM	Digital Elevation Model
DISER	Commonwealth Department of Industry, Science, Energy and Resources (formally DIIS)
DITT	Department of Infrastructure, Tourism and Trade
DPIR	Northern Territory Department of Primary Industry and Resources (now DITT)
ERs	Environmental Requirements
ERA	Energy Resources of Australia Ltd
ERISS	Environmental Research Institute of the Supervising Scientist
FLF	Final Landform
GAC	Gundjeihmi Aboriginal Corporation
GCMBL	Georgetown Creek median bund leveline
GIS	Geographic Information System
GPS	Global Positioning System
GTB	Georgetown Billabong
H2	Second Half
HDPE	High Density Polyethylene

Abbreviation/ Acronym	Description
HDS	High Density Sludge
LAA	Land Application Area(s)
MCP	Mine Closure Plan
MOL	Maximum Operating Level
mRL	Metres Reference Level
MTC	Minesite Technical Committee
NLC	Northern Land Council
NP	National Park
O&M	Operations and Maintenance
OPSIM	Operation Simulation Modelling
PAW	Plant Available Water
PMP	Probable Maximum Precipitation
PSD	Particle Size Distribution
PTF	Pit Tailings Flux (or expressed process water)
PVD	Prefabricated Vertical Drains (wicks)
Q1	Quarter 1, as in first quarter of the calendar year. Also Q2, Q3 & Q4
R3D	Ranger 3 Deeps
RL	Reference Level
RMV	Ranger Mine Village
RO	Reverse Osmosis
ROM	Run-of-mine
RP1	Retention Pond 1 – also denotes other retention ponds used on site – e.g. RP2, RP3, RP6
RP1WLF	Retention Pond 1 Wetland Filter
RPA	Ranger Project Area
SSB	Supervising Scientist Branch; formally the Supervising Scientist Division (SSD)
SSD	Supervising Scientist Division
SX	Solvent Extraction
TARP	Trigger, Action, Response Plan
TDS	Total Dissolved Solids
TLF	Trial Landform
TSF	Tailings Storage Facility or tailings dam
UF/MFRO	Ultrafiltration/Microfiltration and Reverse Osmosis
WLF	Wetland Filter
WTP	Water Treatment Plant

9 CLOSURE IMPLEMENTATION

9.1 Introduction

The following section presents:

- a summary of closure implementation strategies for the Ranger Mine
- a description of the closure work program for each key closure domain
- an overview of the closure activities that are required across multiple closure domains

Within the description of closure works for each domain, the status of completion for each closure activity is provided. This section details the 'what', 'where' and 'when' of closure activities at the Ranger Mine. Studies used to inform the closure strategy for a domain are the 'why' and have been previously described in Section 5.

9.2 Closure planning

Closure planning aims to meet the closure objectives and achieve the post-mining landuse goals set out in Section 8. The principle closure objective is to rehabilitate the disturbed areas of the Ranger Project Area (RPA) to establish an environment similar to the adjacent areas of Kakadu National Park (NP). The total area of disturbance within the RPA (including Land Application Areas (LAAs) and the airport) is approximately 1062 ha.

ERA has undertaken significant progressive rehabilitation works since 2012, with more than AUD$600 Million spent on rehabilitation activities including tailings transfer, process water treatment and the backfill of Pit 1. Opportunities for final revegetation of disturbed areas have so far been limited, in part due to efforts to maintain a minimum footprint and concentrate operational activities within the existing disturbed area. Despite this, over 12 ha of successful native revegetation has been completed (Table 9-2).

A detailed risk assessment has been completed for the closure of the Ranger Mine, and this is discussed in Section 7. The closure implementation plan for Ranger Mine has been designed to mitigate these identified risks. The following sections provide an outline of how this closure plan will be implemented and includes the current stages of closure across the RPA and staged closure timing. The closure plan for each domain or activity has been developed through a review of all options with the preferred option selected through a Best Practicable Technology (BPT) assessment, where appropriate (Section 6).

Closure planning is subject to continual revision as results of closure studies[1] become available, and from continual assessment of implementation activities to ensure feasibility and a best practice approach to all closure activities.

A schedule of all closure tasks is presented for each domain/activity. The schedule is indicative and subject to ongoing revision to reflect the status of closure activities. A full schedule for all closure activities is provided in Appendix 9.1. ERA is committed to completing rehabilitation by the regulated closure date of 8 January 2026 and achieving all closure obligations and environmental requirements (Section 3). The current closure schedule indicates that this can be achieved.

The Ranger Mine closure plan factors in a number of contingency options for implementation in the event that the preferred option cannot be implemented or fails to achieve the desired outcome. The majority of these options are discussed in Section 6 as part of the best practical technology assessment with some specific contingencies further outlined in this section.

9.3 Closure domains

Closure domains are areas with similar features, decommissioning and/or rehabilitation requirements for closure (DMIRS 2020). The closure domains for the Ranger Mine are provided in Figure 9-1. The name and size of each associated area of land disturbance is provided in Table 9-1.

The purpose of the implementation section is to outline all closure tasks for each closure domain or closure activity. This includes tasks already completed, currently underway or planned. The main categories discussed within each domain, where appropriate, are:

- decommissioning, including decontamination and hazardous material management
- remediation
- final landform preparation, including erosion and sediment control
- revegetation
- monitoring
- maintenance
- contingency plans

[1] ERA completed a feasibility study in 2018 to review and refine the proposed closure strategy to obtain a better level of confidence in the execution plan. The outcomes of this study have formed the basis for the closure implementation plan outlined in this section.

The closure activities that apply across more than a single domain, such as revegetation, or activities that do not fit into a specific domain, such as the treatment of the process water inventory, are discussed in Section 9.4.

Table 9-1: Land disturbance by domains

Reference No.	Domain	Disturbance (ha)	
1	Pit 1	41.40	41.40
2	Pit 3	107.12	107.12
3	Tailings Storage Facility	185.18	185.18
4	Land Application Areas		
4A	Corridor Creek LAA	13.50	
4B	Magela LAA	45.56	
4C	Djalkmarra LAA	12.50	
4D	Djalkmarra LAA ext.	5.80	
4E	Retention Pond 1 LAA	36.0	
4F	Retention Pond 1 LAA ext.	0.9	
4G	Jabiru East LAA	43.0	158.00
5	Processing plant, administration buildings and Water Treatment Plant	39.86	39.86
6	Stockpiles	268.65	268.65
7	Water Management Areas		
7A	Retention Pond 1	53.89	
7B	Retention Pond 2 & 3	21.80	
7C	Retention Pond 6	12.85	
7D	Retention Pond 1 wetland filter	11.43	
7E	Corridor Creek wetland filter	9.48	
7F	Georgetown Creek Mine Bore	13.84	
7G	Sleepy Cod Dam	2.33	125.61
8	Linear Infrastructure (tracks, service corridors)	40.79	40.79
9	Miscellaneous		
9A	Gagadju Yard	1.80	
9B	Ranger Mine Village (temp)	3.04	
9C	Nursery/Coreyard	4.05	
9D	Levee	2.82	
9Ei	Borrow Pits	2.32	
9Eii	Borrow Pits	16.40	
9Fi	Landfill Sites	3.62	
9Fii	Landfill Sites	6.79	
9G	R3 Deep Decline	2.63	
9H	Magazine	0.95	55.02

Reference No.	Domain	Disturbance (ha)	
9I	Trial Landform	10.60	
10 A & B	Airport & ERISS	44.08	44.08
Total			1062.53

Table 9-2: Area of progressive revegetation at RPA

Site	Area
Trial landform	6.38
Borrow pit	1.39
RPI Site 3	0.12
Closed track at RMV	0.31
RMV revegetation track	3.34
Drill pad east of Djalkmarra 1	0.13
Drill pad east of Djalkmarra 2	0.22
Drill pad east of Djalkmarra 3	0.19
Magela B drill pad 1	0.06
Magela B drill pad 2	0.04
Drill pad	0.16
Total	*12.34ha*

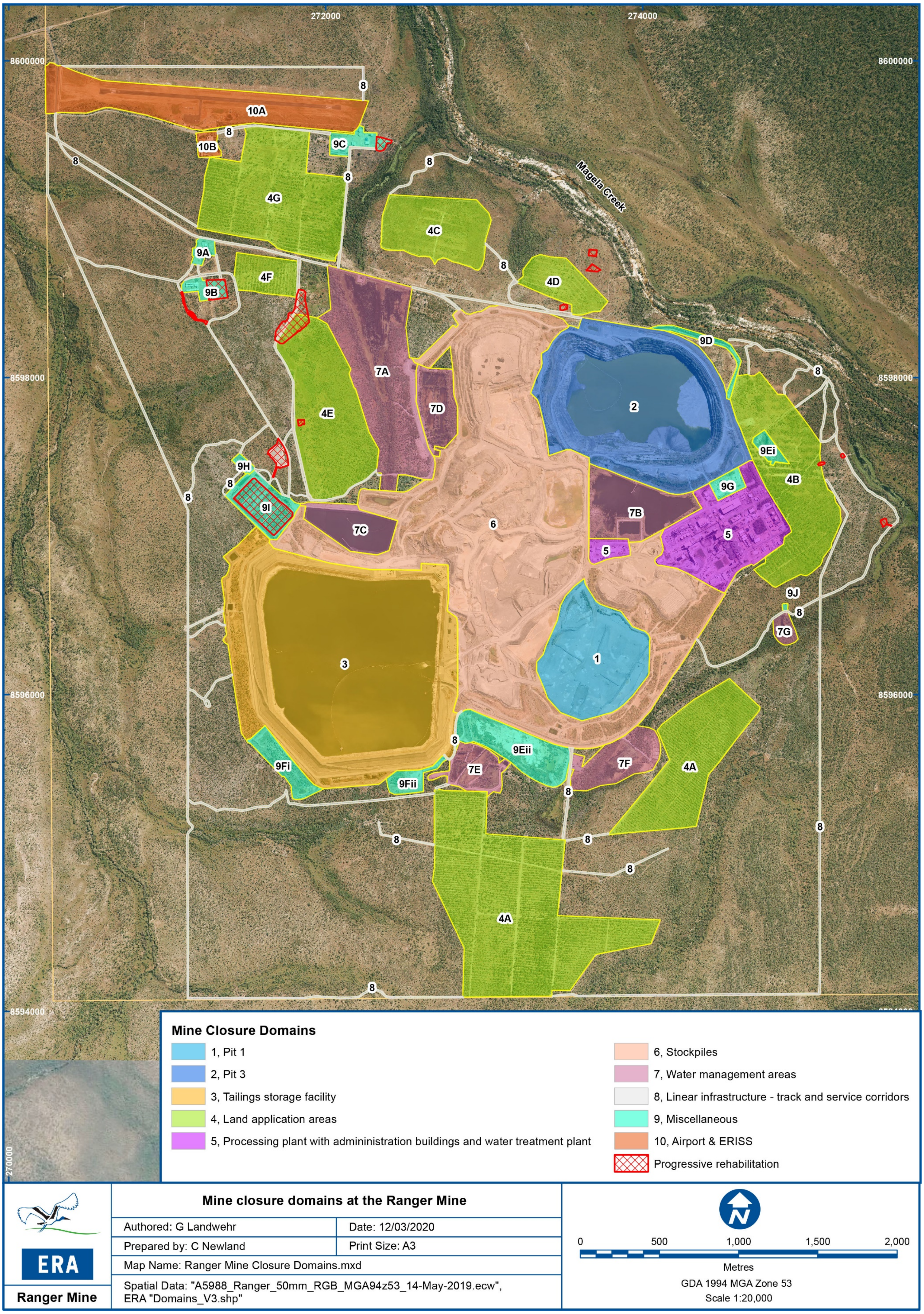


Figure 9-1: Ranger Mine closure domains (aerial 2019)

9.3.1 Pit 1

Figure 9-2: Pit 1 (August 2020)

With due consideration given to the outcomes of the relevant risk assessments, in particular the range of existing and proposed controls required to eliminate or mitigate the identified risks, a robust plan was developed for the execution of Pit 1 closure and the construction of the final landform. This is now in the final stages.

Key elements of Pit 1 closure are:

- construction of an underdrain across the floor of the pit
- deposition of 25.6 M tonnes (unconsolidated) tailings in the base of the pit between 1996 and 2008
- installation of vertical wick drains to assist with dewatering
- installation of an initial capping layer of geotextile and waste rock
- ongoing removal of pit tailings flux during tailings consolidation to reduce the risk of contaminants entering groundwater or surface waters and potentially impacting the RPA or offsite aquatic ecosystems
- placement of Grade 2 (2s) waste rock material below the water table to reduce the risk of contaminants impacting RPA or offsite aquatic ecosystems, and below a layer of Grade 1 (1s) material to ensure any gamma radiation from the 2s material is sufficiently attenuated (refer to Section 9.3)

- construction of a surface layer of non-mineralised Grade 1 (1s) material, with consideration given to the physical characteristics and thickness of the material required to support a self-sustaining native ecosystem similar to target reference ecosystems
- construction of drainage channels within the surface layer to manage erosion for the Pit 1 catchment and reduce the risk of mobilised sediments or other contaminants impacting RPA or offsite aquatic ecosystems (to be discussed under Section 9.4.5)
- revegetation to initiate the establishment of a self-sustaining ecosystem
- monitoring and research to continue to improve on the trials and modelling already completed. This will further reduce the risks associated with aspects of the Pit 1 closure and inform the closure planning for the rest of the final landform. This is discussed further within Section 5 and Section 10 of the MCP

9.3.1.1 Completed rehabilitation

ERA commenced the deposition of tailings within the mined-out Pit 1 in August 1996. Between 1996 and December 2008, ERA deposited approximately 18.9 Mm3 (25.6 Mt) of tailings into the pit (ATC 2012, CSIRO 2014). Concurrent with tailings deposition, Pit 1 was also used to store process water.

The backfill and rehabilitation activities that have taken place in Pit 1 from 1995 to present are provided in Table 9-4.

Figure 9-3: A view of some of the 7,554 vertical wick drains installed in Pit 1 in 2012

Backfill

The two types of waste rock used in rehabilitation are termed 1s and 2s (Table 9-3). Waste characterisation is further discussed in Section 9.4.2.

Table 9-3: Type of waste rock used in rehabilitation

Type	Term	Uranium oxide grade (U_3O_8) %wt
Non-mineralised waste rock	1s (Grade 1)	Less than 0.02
Mineralised waste rock	2s (Grade 2)	0.02 – 0.05

The key to the backfill design of Pit 1 is to place fill to an elevation so that, after the potential settlement due to tailings consolidation, the 2s material is below the height of 20 mRL with minimal need for modification of the surface levels. However, it was also desirable to maximise the volume of 2s material placed under the 1s layer (Fitton 2015).

The bulk backfill design also aims to minimise the potential disturbance to the decant towers, settlement plate upstands and future drainage patterns. ERA placed the 2s waste rock in seven stages using three metre paddock-dumped layers. This dumping method allowed for the raising of the settlement standpipes and decant wells, and therefore more accurate monitoring of fill depths (Fitton 2015) (Section 5.4.1.5). The settlement standpipes continue to provide this data.

The final level of 2s waste rock was completed in 2018. Surveys demonstrated that the level of 2s is below the 20 mRL, achieving the desired design parameters (Fitton 2018). The conservatism built into the design allows for additional tailings settlement induced by the weight of the final waste rock cover.

Table 9-4: Completed Pit 1 rehabilitation

Year	Closure activity
1995-96:	Preparation of the pit to receive tailings included the construction of an underdrain in the base of the pit of approximately 10,000 m2 in area, and construction of a horizontal rock-filled adit from the base of the pit to intercept a vertical dewatering bore. Tailings deposition into the pit began in August 1996.
2005	Installation of a seepage limiting barrier in the south-eastern part of the pit occurred to seal permeable wall zones and ensure the effective containment of process water.
2006	Grouting and ongoing monitoring of the seepage limiting barrier.
2008	Tailings deposition in Pit 1 ceased in Q4. The void volume of Pit 1 is 24.0 Mm3. The volume of unconsolidated tailings in Pit 1 was approximately 18.9 Mm3 and the average level of the tailings was less than 12 mRL, in accordance with the interim approval to store tailings in Pit 1 (Marshall 2014).
2012	The installation of 7,554 prefabricated vertical wick drains occurred to assist with dewatering the pit prior of capping and rehabilitation (Figure 9-3). The wicks were installed within the top 40 m of the tailings mass. The purpose of the wicks was to dewater the upper level of the tailings and promote tailings consolidation, thus establishing a stable surface upon which to commence backfill activities.

Year	Closure activity
2013-14	Installation of a geotextile layer occurred across the exposed tailings surface area and, subsequently, a 2.5 m thick rock initial capping was placed across 209,116 m2 (70%) of the pit. The rock placement was designed to activate the vertical wick drains and porewater expression. A 0.5 m – 1.0 m cover of laterite was placed over the northern half the pit to form the pond water interception layer as part of the Ranger Mine operational water management (to prevent rainwater adding to the process water inventory). Prior to the placement of the initial capping layer in the fourth quarter of 2013 and in 2014, 28 settling monitoring plates were installed across the pit to enable regular verification and updating of the consolidation model.
2015	A geotextile layer was installed across the remaining exposed tailings surface (30% of total surface).
2016	Jan - A 2.5 m thick rock initial capping layer and placement of 0.5-1 m laterite across the entire pit surface was completed. Two decant towers were installed to remove the expressed process water from the pit. A subsequent decant well was installed in 2017. May - Bulk backfill of Pit 1 commenced following regulatory approval of the final average tailings level of 7 mRL mRL (Pugh et al. 2016).
2018	July – Bulk backfill was halted pending regulatory approval for further works.
2019	May – Final backfill commenced following regulatory approval of the final landform design.
2020	August – Final backfill and landform contouring completed.

Note: the initial capping layer was previously termed 'preload'.

9.3.1.2 Current rehabilitation

Tailings consolidation and removal of pit tailings flux

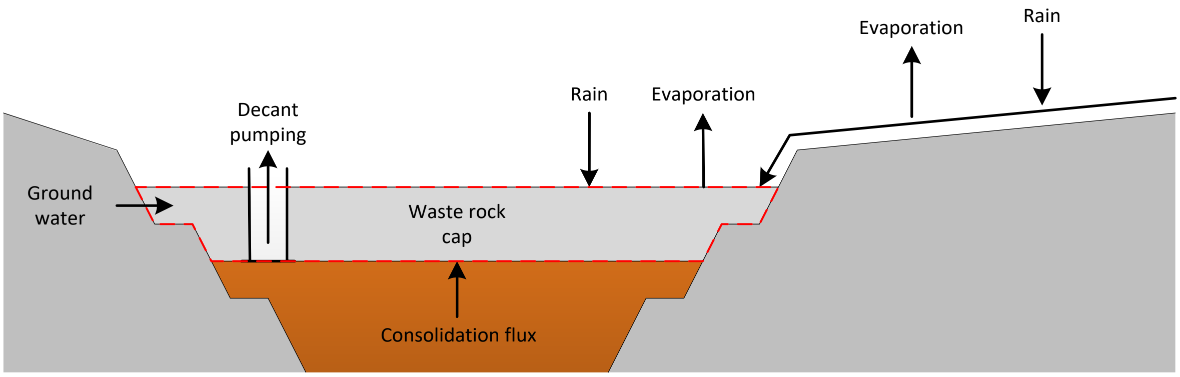


Figure 9-4: Pit 1 water balance schematic

Water from various sources contributes to the water balance of Pit 1. Rainfall is collected both on the immediate surface of Pit 1, and indirectly via overland flow from nearby catchments that report to the pit. The bottom of the pit is filled with tailings that are undergoing consolidation. The pore spaces between the tailings solids contain process water and, as the tailings consolidate, that process water is squeezed up as a consolidation flux (pit tailings flux). Groundwater from surrounding rock formations may also enter the pit. Phreatic surfaces in the pit are currently lower than surfaces in the surrounding rock formations, meaning that flow from the pit to its surrounds is not possible whilst this head difference remains. Above the tailings are several layers of waste rock backfill. Most layers of the waste rock backfill are porous and, as such, can accumulate water from the various sources.

Decant wells have been installed and extend from the surface of the waste rock backfill down to near to the top of the tailings. Tailings consolidation during the backfilling of Pit 1 steadily drives contained process water both towards the vertical drains (wicks) installed in the tailings and up into the waste rock. At any given time, it is planned that one of the decant towers is fitted with a pump that can extract solution accumulated within the waste rock, and direct it to the process water storages.

The purpose of the decant wells is thus to allow for the removal of process water derived from:

- water expressed during consolidation
- rainfall infiltration through waste rock
- groundwater ingress from the surrounding formation whilst the pit remains as a hydrologic sink

Through to late July 2019, the expressed water pumped from the southern decant used to feed the High Density Sludge (HDS) plant during its trial phase. From late July through to mid-November 2019, the decant system was offline due to low water level and to permit bulk backfill activities in the area of the decants. During this time pump and pipeline infrastructure were removed, additional concrete rings were installed on top of each of the two towers, waste rock was then placed around the decants up to the planned backfill level and the pump and pipeline infrastructure was re-installed. Once the backfil in the area of the decants was completed, pumps were installed into the northern decant (as it was the deeper of the two decants) and the system restarted in November 2019 and operated through to the end of capping activities. The decants, though currently offline, have been retained as a contingency for managing future tailings consolidation flux (Section 5.4.1.5).

Landform

The backfill of Pit 1 and contouring of the final landform was completed in August 2020 (Figure 9-6). The pit surface will now be ripped in preparation for revegetation and further trials (Section 9.3.1.3) and the interim water management works completed in preparation for the 2020/21 wet season. These works include the installation of a drain around the edges of Pit 1 to capture rainfall runoff (Figure 9-5), the extension of the existing sump (called CRS) to a sufficient capacity to collect this rainfall runoff and the installation of pumping and piping infrastructure.

These interim water management structures will remain in place until the remainder of the corridor creek catchment has been rehabilitated, at which time the final erosion and sediment control features will be installed. The ongoing management, maintenance and monitoring of the interim water management structures will be described in the latest version of the Ranger Water Management Plan.

Figure 9-5: Construction of the drain at the southeast edge of Pit 1 (July 2020)

Figure 9-6: Backfill progress at Pit 1 (view northwest) (July 2020)

9.3.1.3 Planned rehabilitation

Surface preparation & revegetation

Pit 1 is available for revegetation two years before other sections of the final landform, therefore it provides an opportunity to further ERA's understanding of the behaviour and attributes of water, radiation exposure and ecosystem establishment as the landform matures. Pit 1 will be divided into four areas to trial different methods of ripping, irrigation and revegetation. The revegetation activities at Pit 1 will include 'conceptual reference ecosystem' (CRE) trial planting based on reference ecosystem surveys, and targeted revegetation trials.

Initial plant establishment and early development is essential for successful revegetation. Although adaptive management can be used to progress an ecosystem towards a desirable state, it is the initial ecosystem establishment phase that sets the trajectory for subsequent ecosystem development. The initial establishment stage has the highest rate of 'change', which means a relatively high risk of deviation but also a greater opportunity for corrective actions. Lessons learned from a series of re-establishment activities in different aspects of the ecosystem re-establishment will inform subsequent activity in other sectors of Ranger Mine.

Initial revegetation of waste rock landforms can be difficult due to harsh field conditions, including high temperatures, irradiance and surface reflectance. The substrate can have relatively low water holding capacity, and low or no organic matter, nutrients or microbial activity. Ranger Mine waste rock has proven to be highly variable in quality and texture, and it is likely that different substrate types will yield different plant responses.

Pit 1 provides the opportunity to test and evaluate a range of aspects related to early revegetation activities. Opportunistic, small-scale tubestock trials were conducted at Stage 13.1, adjacent to Pit 1 as a precursor for the Pit 1 revegetation. These pilot trials allowed ERA to explore a range of methodologies and techniques, and has highlighted treatments that warrant further, large-scale investigation at Pit 1.

The total surface area of Pit 1 will be close to 40 hectares; the shape will be roughly circular and have a radius of approximately 300 – 400 metres (Figure 9-7). Some sections of Pit 1 will not be available for immediate revegetation due to future works such as access and the removal of decant wells and water management features (e.g. drains, sumps).

Pit 1 will be divided into four areas to trial different methods of ripping, irrigation and revegetation (Figure 9-7). The naming convention for the areas across the pit have been based on the catchment names provided by the board of the Gundjeihmi Aboriginal Corporation (GAC). The corridor creek catchment that drains south to Georgetown Billabong is known as Walem Madjawulu. Based on this the locations have been named WM-1 though WM-4. The revegetation activities at Pit 1 will include "Research revegetation trials" and "Operational revegetation trials". The research revegetation trials will be targeted, manipulative trials investigating different potting, propagation and/or sowing methods with the aim of improving initial plant survival and establishment. Operational research trials will investigate different approaches for the operational aspects of revegetation, including irrigation and land preparation.

Table 9-5: Revegetation trial areas of Pit 1

Area	Size (Ha)	Revegetation trial type	Surface preparation
WM-1	5.3	Operational	Reefinator surface roughness
WM-2	9.9	Operational	Single shank on back of grader (up to 300mm) along contours, up to 4 m apart
WM-3	14.5	Research	Shallow scarification (200-300 mm) along contours, small distances between lines
WM-4	6.2	Operational	No ripping

The following sections describe the final landform and ecosystem establishment plans in more details.

Figure 9-7: Area of planned revegetation for Pit 1 showing trial areas

Surface preparation trial

The different ripping/scarification methods to be applied in the four areas of Pit 1 are intended to create a natural appearance on the Pit 1 surface topography while providing an opportunity to trial their impact on revegetation outcomes. Ripping methods are also in line with the principle of reducing erosion in final landform by creating roughness at the surface which slows the rate of rainwater run-off.

The objective of the Pit 1 landform configuration is to, firstly, trial multiple surface preparation methods for Pit 1 revegetation activity, in this case establishment of key species from potential conceptual reference ecosystems. Secondly, the shallow-scarified area will provide an area for a series of revegetation trials for improved revegetation methods for subsequent site-wide implementation.

A plan of the surface landform is proposed as four trials in the Pit 1 as shown in Figure 9-7. Four different surface ripping options are proposed, each separated with interim windrows. Each area has a different topography and surface micro-topography conditions. The four different surface preparation options are listed against each trial area in Table 9-5. The assessment of each ripping trial will be completed in consultation with stakeholders and used to inform the final landform ripping plan.

Irrigation trials

Irrigation infrastructure will be installed and operational prior to planting. Different configurations of irrigation system may be trialled, however all will be capable of up to 8 mm delivered over the entire planting area during a 12-hour period. Irrigation will be applied at a rate that does not cause soil displacement, surface runoff, significant water pooling or damage to young plants. All irrigation treatments shall remain consistent within each of the four trial areas. Irrigation will be operated and maintained for up to six months following planting.

Revegetation trial

The standard revegetation implementation activities are described in Section 9.4.6 including herbicide application and the tubestock planting method. Only those aspects of revegetation being investigated as part of the Pit 1 trials shall be discussed here.

ERA has recently proposed a series of four 'conceptual reference ecosystems' that could form the basis of revegetation communities most likely to be suited to the challenges posed by the rehabilitated landform (Section 5.5.4.1). Pit 1 provides a good opportunity to plant out these different CREs so that their suitability for revegetating waste rock landforms can be assessed. The conceptual reference ecosystem trial plantings will also visually demonstrate the different ecosystem types to Traditional Owners and external stakeholders prior to finalising the revegetation plan for the Ranger final landform.

Three of the four conceptual reference ecosystems will be used to revegetate Pit 1 (Table 9-6). The full species lists and their exact planting densities are to be confirmed, as the conceptual reference ecosystems are part of ongoing discussions with the Supervising Scientist Branch.

However, overall planting densities will range between 800 – 1200 stems per hectare, with an average of 1000 stems per hectare.

Table 9-6: Example of overstorey and midstorey tree and shrubs species compositions for the different Conceptual Reference Ecosystems, listing the 18 highest density species listed in descending order of dominance

ICRE	ACREv1	ACREv2	ACREv3
Acacia mimula	*Acacia mimula*	*Acacia mimula*	*Acacia mimula*
Eucalyptus tetrodonta	*Eucalyptus tetrodonta*	*Eucalyptus miniata*	*Eucalyptus tetrodonta*
Eucalyptus miniata	*Corymbia porrecta*	*Eucalyptus tetrodonta*	*Corymbia foelscheana/ latifolia*
Corymbia bleeseri	*Livistona humilis*	*Xanthostemon paradoxus*	*Xanthostemon paradoxus*
Corymbia porrecta	*Eucalyptus miniata*	*Corymbia porrecta*	*Terminalia pterocarya*
Livistona humilis	*Xanthostemon paradoxus*	*Corymbia bleeseri*	*Corymbia porrecta*
Xanthostemon paradoxus	*Corymbia bleeseri*	*Terminalia ferdinandiana*	*Terminalia ferdinandiana*
Erythrophleum chlorostachys	*Erythrophleum chlorostachys*	*Livistona humilis*	*Corymbia disjuncta*
Terminalia ferdinandiana	*Terminalia ferdinandiana*	*Erythrophleum chlorostachys*	*Eucalyptus miniata*
Persoonia falcata	*Planchonia careya*	*Melaleuca viridiflora*	*Buchanania obovata*
Acacia lamprocarpa	*Buchanania obovata*	*Planchonia careya*	*Corymbia bleeseri*
Buchanania obovata	*Persoonia falcata*	*Corymbia foelscheana/ latifolia*	*Calytrix exstipulata*
Acacia oncinocarpa	*Acacia lamprocarpa*	*Corymbia dunlopiana*	*Cochlospermum fraseri*
Brachychiton megaphyllus	*Syzygium eucalyptoides bleeseri*	*Persoonia falcata*	*Eucalyptus tectifica*
Pandanus spiralis	*Brachychiton megaphyllus*	*Syzygium eucalyptoides bleeseri*	*Planchonella arnhemica*
Cochlospermum fraseri	*Acacia oncinocarpa*	*Calytrix exstipulata*	*Gardenia megasperma*
Planchonella arnhemica	*Jacksonia dilatata*	*Corymbia chartacea*	*Planchonia careya*
Stenocarpus acaciodes	*Planchonella arnhemica*	*Buchanania obovata*	*Grevillea mimosoides*

There will be transect monitoring of the CRE planting areas to assess tubestock survival as per the *Pit 1 Ecosystem Rehabilitation Monitoring Plan*, to be developed under the *Pit 1 Progressive Rehabilitation Monitoring Framework* and further discussed in Section 10.

Monitoring methods utilising the efficiencies of remote sensing, for example drone surveys for overall survival, will be explored.

Where high levels of mortality are observed, a remediation plan will be considered including review of potential causes, adjustment of species mix, and opportunities to infill plant.

Tubestock trials

ERA has considerable knowledge and experience regarding revegetation of waste rock using tubestock planting. The Ranger Trial Landform (TLF) has demonstrated many of the target overstorey and midstorey species can successfully establish on waste rock, despite relatively high levels of early mortality. Modifications to ERA's revegetation approach since the TLF, such as the assembly of reliable irrigation prior to planting, have already resulted in significant improvements to initial survival rates (e.g. Stage 13.1 early survival). Some propagation changes, as outlined in Table 9-8, may yield further improvements in early tubestock establishment.

The overall objective of the tubestock trials is to investigate different potting and propagation techniques with the aim of improving tubestock survival and health during the first two years after planting. This study will also provide an opportunity to:

- Gather species-specific data to fine-tune nursery propagation methods, such as germination rates, required growing times, irrigation requirements etc.;
- Obtain baseline performance data for species that have not been grown on FLF media previously; and
- Propagate and plant tubestock during different times of the year.

Species selected for tubestock trials are listed in Table 9-7. These were selected based on the following considerations:

- species which are most important to optimise establishment. e.g. Culturally significant species, species which occur at high densities etc.
- species which have historically been difficult to establish on waste rock
- species ERA has limited or no experience establishing on waste rock
- species not suitable for initial planting, either because the conditions are too harsh or because they may be too aggressive

Table 9-7: Tubestock trial species (may change slightly depending on seed collection / availability)

Species	Lifeform	Family	Seed Quantity Status
Overstorey and Midstorey			
Acacia lamprocarpa	Tree	Fabaceae	Sufficient
Acacia mimula	Shrub	Fabaceae	Sufficient
Brachychiton megaphyllus	Shrub	Malvaceae	Sufficient
Buchanania obovata	Shrub	Anacardiaceae	Collect Sep - Nov
Calytrix exstipulata	Shrub	Myrtaceae	Collect Aug - Oct
Corymbia bleeseri	Tree	Myrtaceae	Sufficient
Corymbia chartacea	Tree	Myrtaceae	Sufficient
Corymbia disjuncta	Tree	Myrtaceae	Sufficient
Corymbia dunlopiana	Tree	Myrtaceae	Sufficient
Corymbia foelscheana	Tree	Myrtaceae	Sufficient
Corymbia polysciada	Tree	Myrtaceae	Sufficient
Corymbia porrecta	Tree	Myrtaceae	Sufficient
Erythrophleum chlorostachys	Tree	Fabaceae	Sufficient
Eucalyptus miniata	Tree	Myrtaceae	Sufficient
Eucalyptus tectifica	Tree	Myrtaceae	Sufficient
Eucalyptus tetrodonta	Tree	Myrtaceae	Sufficient
Gardenia megasperma	Shrub	Rubiaceae	Sufficient
Grevillea mimosoides	Shrub	Rubiaceae	Collect Sep - Nov
Jacksonia dilatata	Shrub	Fabaceae	Collect Jul - Nov
Livistona humilis	Palm	Arecaceae	Collect Jul – Dec
Melaleuca viridiflora	Tree	Myrtaceae	Sufficient
Planchonella arnhemica	Shrub	Sapotaceae	Collect Jul – Aug
Planchonia careya	Shrub	Lecythidaceae	Collect Jul – Dec
Stenocarpus acacioides	Tree	Proteaceae	Collect Nov – Dec
Syzygium eucalyptoides ssp. bleeseri	Shrub	Myrtaceae	Collect Nov – Dec
Terminalia ferdinandiana	Shrub	Combretaceae	Sufficient
Terminalia pterocarya	Shrub	Combretaceae	Sufficient
Understorey			
Acacia gonocarpa	Shrub	Fabaceae	Sufficient
Alloteropsis semialata	Grass	Poaceae	Sufficient
Ampelocissus acetosa	Vine	Vitaceae	Sufficient
Aristida holathera	Grass	Poaceae	Collect Jul – Nov

Species	Lifeform	Family	Seed Quantity Status
Cartonema spicatum	Herb	Commelinaceae	Sufficient
Eriachne obtusa	Grass	Poaceae	Sufficient
Galactia tenuiflora	Vine	Fabaceae	Sufficient
Haemodorum coccineum	Herb	Haemodoraceae	Sufficient
Heteropogon triticeus	Grass	Poaceae	Sufficient
Indigofera saxicola	Shrub	Fabaceae	Sufficient
Larsenaikia suffruticosa	Subshrub	Rubiaceae	Collect Jun – Dec
Petalostigma quadriloculare	Shrub	Picrodendraceae	Sufficient
Tacca leontopetaloides	Herb	Taccaceae	Sufficient
Uraria lagopodioides	Vine	Fabaceae	Sufficient

Four tubestock treatments are to be trialled during three different planting times; these are described in Table 9-8, Table 9-9 and Table 9-10.

Table 9-8: Tubestock treatment factors and rationale

Factors to be investigated	Rationale
Pot types	Although plastic nursery tubes are the commercial standard for revegetation, past experience at Ranger Mine suggests biodegradable pots may be a preferable option as they eliminate the need to de-pot. The preliminary results from Stage 13.1 suggest that tubestock grown in nursery tubes generally have greater survival than tubestock grown and planted in biopots. However, these results may be because the plants in biopots were disproportionally impacted by the nursery irrigation failure incident (due to their slotted sides) and/or the delayed planting and additional bench time (due to their smaller volume). Further trials are needed to determine whether biopots or nursery tubes are optimal for plant establishment.
Plant Size/Age	Planting smaller tubestock may result in a higher root-shoot ratio, decreasing the initial water demand of the seedling. Planting smaller sized tubestock appeared to improve *Xanthostemon paradoxus* survival on the TLF. Nursery observations of the Stage 13.1 tubestock, and experience from previous revegetation trials that were also unexpectedly delayed, indicate that prolonged bench time can significantly impact plant health and presumably field performance. Although 'maximum holding times' are relatively clear, 'minimum holding times' were tubestock field performance is still optimal are relatively unknown.

Factors to be investigated	Rationale
Unseasonal planting	Tubestock planting traditionally takes place during the wet season. However when revegetation operations peak in 2024/2025, tubestock will need to be grown and planted all year round. It is believed that rates of (some) seed germination and tubestock growth may be reduced during the cooler dry season. Understanding this will be important to setting the correct propagation plan for areas requiring dry season planting in future. In contrast, there is a concern that the harsh conditions during the 'build up' period (very high temperatures and humidity) may stress plants in the nursery, and/or when newly planted out, resulting in unacceptably high rates of mortality. Depending on the findings of this trial, there may be options to modify the nursery and/or planting out methods, or look to reschedule works during particularly harsh periods. This treatment is included in the Stage 13.1 trial, however planting is not scheduled until October 2020.

Table 9-9: Tubestock Treatments

Treatments	Pot Type		Plant size	
	Plastic	*Bio*	*Smaller*	*Standard*
Control (C)	X			X
Smaller (S)	X		X	
Biopot (B)		X		X
Biopot + Smaller (B+S)		X	X	

Table 9-10: Tubestock Trial Planting Details

Planting Time	Revegetation Trials		
	Hectares (approx.)	Total Stems (approx.)	Total Species
March	~ 6.6	6,570	41
Dry	~ 3.4	3,420	19
Build-up	~ 3.4	3,420	19

All of the overstorey and midstorey species will be trialled with the four tubestock treatments (Table 9-9), excluding *Livistona humilis,* which will only be trialled with different pots (treatments C and B) due to its long propagation requirements (Table 9-8). The majority of the understorey species will only be grown in biopots with different sizes/ages (treatments B and B+S), except for species which will be the focus of a PhD (future work by Megan Parry).

All of the trial species will be planted in March and half of the species will be included in the dry and build-up trials (Table 9-11 and Table 9-12). The species chosen for the unseasonal planting trials generally occur at high densities, are a range of families and lifeforms, and a combination of deciduous, evergreen and/or fresh-seeded species.

Table 9-11: Experimental Design (subject to change depending on seed collection/availability and statistical method chosen)

Species	Treatments	Replicates	Planting Seasons	Total Stems
Acacia lamprocarpa	4	45	3	540
Acacia mimula	4	45	3	540
Brachychiton megaphyllus	4	45	3	540
Buchanania obovata	4	45	3	540
Calytrix exstipulata	4	45	1	180
Corymbia bleeseri	4	45	3	540
Corymbia chartacea	4	45	1	180
Corymbia disjuncta	4	45	1	180
Corymbia dunlopiana	4	45	1	180
Corymbia foelscheana	4	45	1	180
Corymbia polysciada	4	45	1	180
Corymbia porrecta	4	45	3	540
Erythrophleum chlorostachys	4	45	3	540
Eucalyptus miniata	4	45	3	540
Eucalyptus tectifica	4	45	1	180
Eucalyptus tetrodonta	4	45	3	540
Gardenia megasperma	4	45	1	180
Grevillea mimosoides	4	45	1	180
Jacksonia dilatata	4	45	1	180
Livistona humilis	2	45	1	90
Melaleuca viridiflora	4	45	1	180
Planchonella arnhemica	4	45	1	180
Planchonia careya	4	45	3	540
Stenocarpus acacioides	4	45	1	180
Syzygium eucalyptoides subsp. bleeseri	4	45	3	540
Terminalia ferdinandiana	4	45	3	540
Terminalia pterocarya	4	45	3	540
Acacia gonocarpa	4	45	3	540

Species	Treatments	Replicates	Planting Seasons	Total Stems
Alloteropsis semialata	4	45	3	540
Ampelocissus acetosa	2	45	1	90
Aristida holathera	2	45	1	90
Cartonema spicatum	2	45	1	90
Eriachne obtusa	4	45	1	90
Galactia tenuiflora	4	45	3	540
Larsenaikia suffruticosa	2	45	3	540
Grevillea goodii	2	45	1	90
Haemodorum coccineum	2	45	1	90
Heteropogon triticeus	4	45	3	540
Petalostigma quadriloculare	2	45	3	540
Tacca leontopetaloides	2	45	1	90
Uraria lagopodioides	4	45	1	90
TOTAL STEMS				13,410

Table 9-12: Example propagation, planting and irrigation schedule for 2020 – 2021

Season	Size	Size	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Wet	Normal	Normal	Nursery propagation					Planting event	Irrigation period												
		Small																			
	Small	Normal																			
		Small																			
Dry	Normal	Normal										Planting event	Irrigation period								
		Small																			
	Small	Normal																			
		Small																			
Build-up	Normal	Normal													Planting event	Irrigation period					
		Small																			
	Small	Normal																			
		Small																			

The first planting will commence in March 2021, and the third planting event is scheduled for the start of October 2021 (Table 9-12). The tubestock with the smaller/younger treatments (S and B+S) will be propagated approximately four weeks after the treatments with standard growing periods (C and B). The dry and build-up trials may require slightly longer propagation times (to be informed by the Stage 13.1 ‘unseasonal’ trials that are currently underway).

The seedlings will be tagged to ensure individual species, treatment and replicate number are identifiable. Survival and health, growth, flowering, fruiting, and recruitment will be monitored throughout the trial.

Direct seeding trials

The ERA revegetation strategy primarily involves the use of tubestock. Due to the restricted provenance zones for seed collection it is not possible for ERA to gather the volume of seed that would be required for traditional broadcast seeding of all species. However, newly discovered ‘finer’ waste rock material (such as that present at Pit 1) may provide an opportunity for improved establishment of some species from seed. Furthermore, there is still opportunity to direct seed species that have readily available and reliable volumes of seed, such as grasses.

The revegetation strategy for introducing midstorey and understorey species from seed would be different based on their life cycles/traits. Understorey species mature quickly and generally begin self-recruiting within one to two years. In theory, understorey species could be introduced in patches, which would then spread outward into the remaining revegetated area over time. This would minimise the risks of introducing understorey at the initial stages of revegetation (eg. increased competition and likelihood of fire as discussed in Appendix 9.4), and would reduce the amount of seed needed for the successful introduction of these species. Conversely, midstorey species are relatively slow to mature and would take decades to colonise through the revegetated area naturally, therefore these species need to be broadcast throughout the revegetated landform rather than in patches.

The overall objective of the direct seeding trails is to determine which species can successfully establish from seed on the final landform during the initial stages of revegetation. In addition, for some species:

- Does time of sowing impact plant establishment from seed?
- Does surface treatment impact establishment from seed?
- Does irrigation impact establishment from seed?

Midstorey and understorey species have been selected for the direct seeding trials (Table 9-13). Because the revegetation strategies/methods are different for midstorey and understorey species, each strata had different considerations when selecting trial species.

Midstorey species were selected for direct seeding trials based on the following key considerations:

- Availability of seed in sufficient quantities, and are easy to collect and process.

- Potential suitability of species for direct seeding: eg. they were amongst the better performing species in previous trials on Ranger Mine waste rock, they typically grow in harsh conditions somewhat similar to those found on the initial final landform etc.
- Species which occur at high densities in the surrounding bushland, therefore would provide significant savings if able to direct seed.

The understorey species were selected based on:

- Common species in the woodlands surrounding Ranger mine, based on ERA and ERISS reference surveys.
- Species which have colonised revegetated areas over time such as many annual species on the trial landform, and therefore may not require active re-introduction.
- Species not suitable for initial introduction because they are too competitive or pose a fire risk (eg. Sorghum intrans).

Most of the species will only be sown during the wet season with no additional treatments (Table 9-13). Four to six understorey species will have more treatments as they will be the focus of future studies. These treatments include:

- Different sowing times (wet, dry and build-up)
- Irrigated and non-irrigated, wet season only (still pending)
- With and without surface mulch. A thin layer of litter mulch has previously been found to improve seed germination and seedling survival in the harsh dry conditions of hard-rock mines in northern Australia (Parry 2018, Saragih 2017, Spain & Reddell 1995). However, litter may have a negligible effect on seed germination and establishment in plots that are receiving regular irrigation. The addition of litter also has the potential to add biological elements to the barren waste rock, including seeds, microbes, fungi etc. Ethical aspects of litter collection methods, volumes and sources need to be considered for this treatment.

Table 9-13: Direct seeding species and experimental design

Species	**Strata** **Understorey - US** **Midstorey - MS**	**Treatments**	**Replicates**	**Sowing Times**	**Total Plots**
Acacia gonocarpa	US	2	8	4	64
Alloteropsis semialata	US	2	8	4	64
Ampelocissus acetosa	US	1	8	1	8
Aristida holathera	US	1	8	1	8

Species	Strata Understorey - US Midstorey - MS	Treatments	Replicates	Sowing Times	Total Plots
Brackychiton megaphyllus	MS	1	8	1	8
Calytrix exstipulata	MS	1	8	1	8
Cartonema spicatum	US	1	8	1	8
Eriachne obtusa	US	2	8	4	64
Galactia tenuiflora	US	2	8	4	64
Grevillea goodii	US	1	8	1	8
Haemodorum coccineum	US	1	8	1	8
Heteropogon triticeus	US	2	8	4	64
Larsenaikia suffruticosa	US	1	8	1	8
Livistona humilis	MS	1	8	1	8
Petalostigma quadriloculare	US	1	8	1	8
Tacca leontopetaloides	US	1	8	1	8
Terminalia ferdinandiana	MS	1	8	1	8
Uraria lagopodioides	US	2	8	4	64
Total					488

All seeds will be viability tested to determine appropriate sowing rates. Plots/patches will be 2 m x 2 m (pers comm. Kingsley Dixon) and located in between trial tubestock, therefore will be irrigated at the same frequency and duration as the trial tubestock.

Seeds will be sown by hand, with one species sown per plot. Small and/or fluffy seeded species will be sown mixed with a portion of substrate to help evenly distribute seeds in the plot. Species such as *L. humilis* and *T. ferdinandiana* are large and heavy enough to easily broadcast evenly into plots without bulking agents.

A small amount of slow-release fertiliser will be applied to each plot, once immediately after sowing and potentially the first year after sowing.

9.3.1.4 Contingency planning

There is an ongoing monitoring program (Section 10) that will consider the consolidation, erosion rates and revegetation success. Remedial action will be determined and implemented, where required, with appropriate consultation with the Minesite Technical Committee (MTC) stakeholders.

Table 9-14: Schedule for Pit 1 closure rehabilitation

DOMAIN	ACTIVITY	TASK	STATUS	20	21	22	23	24	25	26>
Pit 1	Wicks	Installation of prefabricated vertical drains (wicks) within previously transferred tailings	Complete							
	Geofabric etc.	Installation of geotextile and preload activities	Complete							
	Backfill	Pit 1 bulk backfill	Complete							
	Landform	Surface contoured to final landform shape	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation activity commences on the perimeter of the pit	Scheduled							
	Monitoring	As per Pit 1 progressive monitoring framework and associated monitoring plans	Ongoing							
	Maintenance	Weed control, remedial works etc.	Scheduled							

9.3.2 Pit 3

Figure 9-5: Pit 3 (May 2019)

9.3.2.1 Completed rehabilitation

Open-cut mining in Pit 3 commenced in July 1997 and ended in November 2012 with a base (floor) elevation of -265 mRL. A timeline of the key mining, backfill and remediation activities that have taken place in Pit 3, from 1995 to present, is provided in Table 9-15.

Table 9-15: Completed Pit 3 rehabilitation

Year	Pit 3 activity
1995	ERA applied to the MTC to mine Ranger Pit 3, and was approved to do so in May 1996
1997	The excavation/mining of Ranger Pit 3 commenced in July 1997.
2008	Preliminary earthworks for the Shell 50 expansion/cutback commenced in the second half of 2008.
2012	Mining in Pit 3 ceased on 27 November 2012 and works to prepare the pit for closure commenced in December 2012.
2014	Completion of underfill. Construction of engineered underdrain for brine injection. Submission of assessment of potential environmental impacts from the interim final tailings level in Pit 3 (ERA 2014) to MTC in August.
2015	In February, disposal of approximately 15 Mt of mill tailings commenced, with tailings deposited from the east side of the pit. The transfer of mill tailings will continue until mill production ceases on/before January 2021. Pit 3 became a process water catchment. The brine injection system was commissioned in Q4.
2016	In January, transfer of approximately 27 Mt of dredged tailings from the Tailings Storage Facility (TSF) commenced. The brine injection system commenced full-scale operation in Q1.

Year	Pit 3 activity
2017	In March, ERA notified the MTC of a potential need to change the tailings deposition method in Pit 3 and the intention to undertake an assessment of the feasibility of changing to subaqueous discharge.
2018	ERA notified the MTC of the intention to trial subaqueous deposition of dredged TSF tailings in Pit 3. This trial commenced in 2018.
2018	ERA submitted an application seeking approval to modify the method of TSF tailings deposition from subaerial to subaqueous. Mill tailings continued to be deposited sub-aerially along the Eastern wall of Pit 3. Approval was granted in 2019.
2018	Sub-aqueous tailings deposition from TSF dredging commenced.
2019 – current	Installed and commissioned a second dredge. Sub-aqueous deposition of dredged tailings continues.

Underfill and brine injection

Prior to tailings being deposited into the mined out Pit 3, works were completed to prepare the pit to receive tailings and brine and to ensure backfill and closure of the pit can be achieved by January 2026. The overall backfill design for Pit 3 is provided in Figure 9-8. The underfill, comprised of waste rock, was constructed at the base of the mined out Pit 3 to raise the floor from -265 mRL to -100 mRL[2] (including the drainage layer) providing a broad, level surface area for tailings deposition. The intent of this underfill was, in part, to generate a low rate of tailings rise and to optimise consolidation rates allowing for minimal backfill consolidation over time. Early and rapid consolidation will provide for a stable rockfill cap design and improve the success of the revegetation and rehabilitation programs.

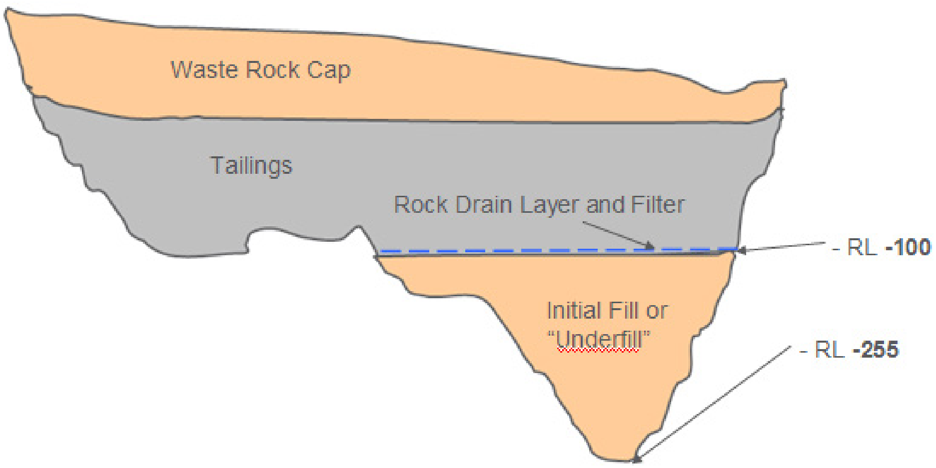
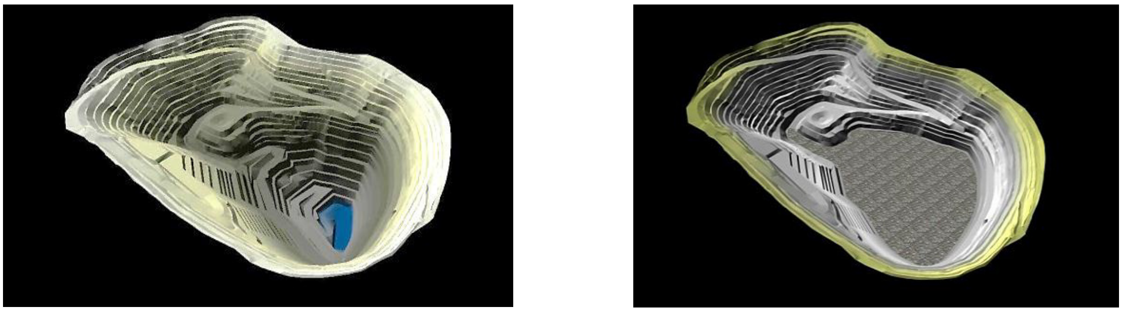


Figure 9-8: Pit 3 backfill conceptual design

[2] The final as built depth of Pit 3 was -265mRL and the underfill was constructed to -102mRL



(a) Empty pit shell: December 2012 (b) Pit base at end of underfill construction

Figure 9-9: Pit 3 before and after underfill construction

The underfill material was sourced from the nearby Low 2s stockpiles as this material was unable to be processed economically and as such is classed as waste. The underfill was deposited via a tall dump from -100 mRL in a fan pattern radiating outwards from a fixed point to maximise segregation of material. This ensured the larger size fraction filled the bottom and the fines content increased as the underfill approached its maximum elevation of -100 mRL (Figure 9-10).

In addition to providing a broad, level surface for tailings deposition, promoting a low rate of rise and improved consolidation rates, the underfill also serves as a repository for the brine produced by the brine concentrator. The brine concentrator produces a concentrated brine stream that requires management and final disposal as a hazardous waste, details of the process water treatment and the brine concentrator are provided in Section 9.4.3.

Figure 9-10: Pit 3 underfill during construction in 2014.

The volume of brine produced by the brine concentrator is currently forecast, using the site water balance model, to be 1.8 GL. The void volume available in the Pit 3 underfill has been estimated to be 2.48 GL (Coghill 2016). This void volume was determined from test work undertaken on the specific waste rock used in the underfill and the final survey volumes.

Following the completion of the underfill in August 2014, an engineered underdrain was constructed. The underdrain consists of a nominal 2 m thick waste rock layer to remove water, both expressed downwards by the overlying tailings during the consolidation process, and entrained pond water displaced upwards from within the underfill by the brine injection process. The drainage layer was graded slightly to the west to direct the collected water streams to an extraction sump. An underdrain bore was installed in order to extract water from this sump. This underdrain bore consists of a horizontal section that connects the sump and intersects a vertical bore installed on the south western wall of Pit 3. An underdrain pumping system was installed that consists of a submersible pump and associated power and piping infrastructure. In late 2016, the bore was shut down due to ingress of ground water. ERA has undertaken remediation work to repair the bore and is now in the process of recommissioning the underdrain pumping system.

Five brine injection bores have been installed into the underfill. Each bore has a dedicated pipeline connected to a valved manifold. A brine pumping system has been installed at the brine concentrator to manage the cooling of hot concentrated brine to below boiling point to:

- maintain a safe working environment
- reduce materials costs
- minimise salt precipitation.

The hot concentrated brine is cooled using indirect heat exchangers with process water as the cooling medium, and pumped to a storage (surge) tank. The brine is drawn from the surge tank and pumped to the brine injection system, refer Figure 9-11.

Due to the inherent scaling issues associated with concentrated brine, all lines and equipment within the brine injection area are regularly flushed with process water. In addition to this, a 'pigging' system has been installed to remove any residual scale.

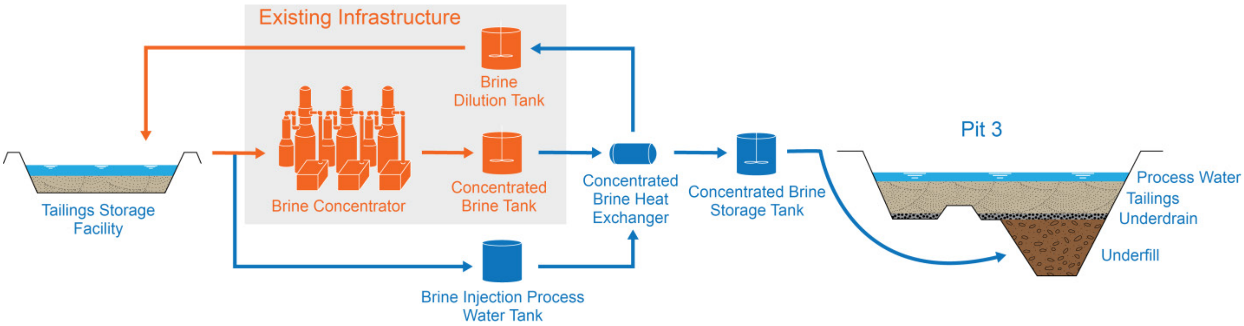


Figure 9-11: Flow Diagram of Brine Injection

A schematic cross-section of Pit 3, before tailings deposition commenced in 2015, is presented in Figure 9-12.

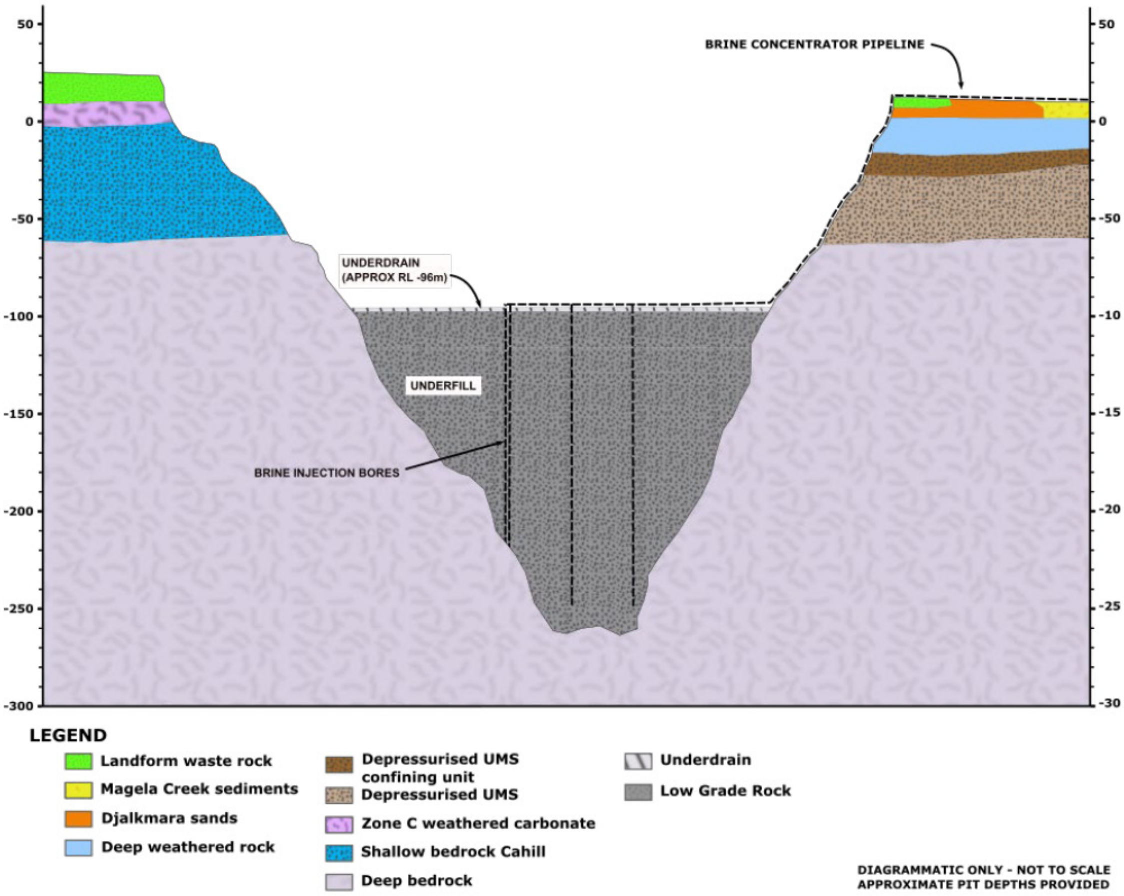


Figure 9-12: Schematic cross-section of Pit 3 before tailings deposition commenced

Tailings deposition

The direct deposition of processing plant (mill) tailings into Pit 3 commenced in 2015. The deposition of reclaimed tailings from TSF dredging operations into Pit 3 commenced in early 2016. Tailings deposition into Pit 3 is currently undertaken to meet Environmental Requirement 11.2, to ensure all tailings are placed in the mined out pits by the end of operations. The techniques employed to deposit tailings in Pit 3 must also meet the following objectives:

- tailings must be distributed in the pit so as to reduce the tailings differential to present a more uniform tailings surface with an ultimate slope from east to west.
- location and size of the supernatant pond must be controlled, including the maintenance of an adequate freeboard to prevent the risk of overtopping, particularly when the facility is nearing its full capacity.
- tailings must be deposited in such a manner as to reduce tailings segregation.
- tailings must be deposited cyclically to facilitate their consolidation and achieve the required dry density.

Mill tailings are pumped as a neutralised slurry of approximately 50% solids by weight directly into Pit 3 via an overland high-density polyethylene (HDPE) pipeline.

Tailings were initially recovered from the TSF using a single diesel-powered cutter suction dredge. In 2019, ERA installed and commissioned a second dredge to increase the dredging capacity to meet the target date of January 2021 for the completion of tailings transfer. The slurry produced by the dredges varies between 18 and 28% by weight solids, depending on the type of tailings solid material (i.e. fine or coarse) and on the action of the dredge cutting head as it sweeps from side to side. Dredged tailings are transferred from the dredges via floating HDPE pipelines connected to an overland HDPE pipeline at the edge of the TSF for delivery to Pit 3. Residual tailings that cannot be dredged from the TSF will be transferred by truck to Pit 3 (Section 9.3.3).Plans for the deposition method into Pit 3 will be included within the Pit 3 closure application and the 2021 MCP.

Both mill and dredged tailings slurry were originally deposited into Pit 3 using a subaerial deposition method. This involved depositing tailings slurry via a number of spigots on the pit crest to form a sloping beach across the pit floor (Figure 9-13). Subaerial deposition of tailings was the preferred approach until an observation of coarse and fine tailings segregation led to a review of the subaerial deposition technique. It was observed that coarse tailings had formed an elevated beach in the eastern end of the pit whereas relatively finer tailings had migrated towards the western end of the pit and settled below the water surface.

Figure 9-13: Pit 3 showing the original location of mill and dredge tailings deposition points

The segregation was a result of the concentration of low discharge solids necessary for the TSF dredging and the ongoing fluctuation of process water volumes in Pit 3, a consequence of dredging operations. The combination of these processes created a differential in tailings elevation from east to west of about 10 m. This is demonstrated in the surface contours created from tailings surface surveys in April 2019 (Figure 9-14). The segregation of tailings and subsequent differential in tailings elevation indicated that the maximum approved tailings elevation of the time, -20 mRL, may be exceeded. The uneven tailings surface that would remain at the end of deposition and the associated segregated fine tailings and extended period of consolidation, presented a critical risk to the successful closure of Ranger Mine by 8 January 2026.

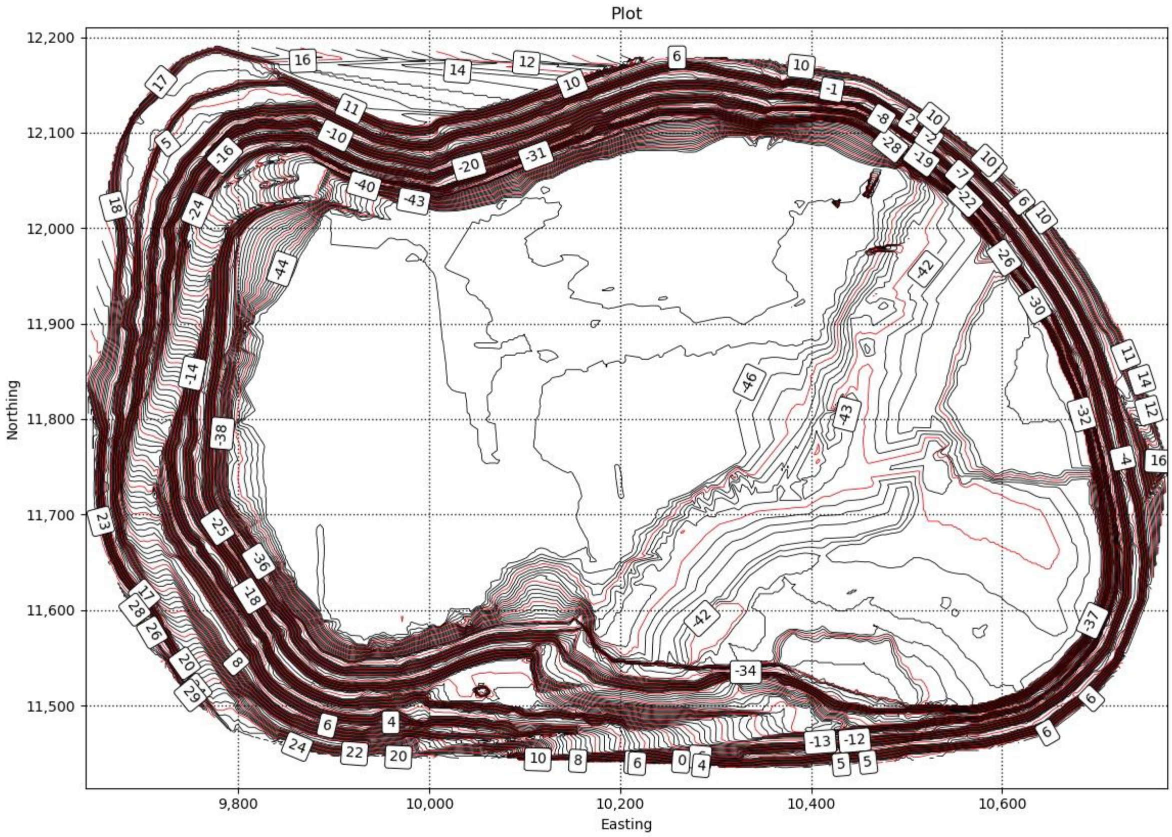


Figure 9-14: Tailings surface in April 2019 (Source: Fitton 2019)

Subaqueous tailings deposition was identified as a way to mitigate the risk of the deposition of segregated coarse tailings to a height that would exceed -20 mRL.

The benefits of subaqueous deposition in a fluctuating water level situation include:

- elimination of a coarse tailings beach deposited higher in the pit
- elimination of a steep uneven tailings surface

- promotion of the homogenous deposition of tailings by systematically moving the deposition point

On 15 and 16 January 2018, ERA hosted a stakeholder workshop to discuss current and proposed Pit 3 tailings deposition. Stakeholders agreed that the information presented by ERA at the workshop demonstrated that the "*[subaqueous] tailings deposition is unlikely to increase the risk of long-term environmental impact to ground and surface water from solute egress*." ERA was subsequently approved to deposit tailings subaqueously in the short-term pending the completion of tailings characterisation studies (Section 5.4.1), groundwater modelling (Section 5.4.3), a subaqueous deposition trial and the submission of a formal application to change tailings deposition method. The outcomes of these studies concluded that a change in tailings deposition method (and consequent maximum tailings level at the end of tailings deposition) would not result in any long-term environmental impacts to the surrounding Kakadu NP, nor any material impacts on the Pit 3 closure schedule.

In April 2019, ERA submitted an MTC application to seek approval to modify the dredged tailings deposition method from subaerial to subaqueous, and to increase the final maximum tailings level from -20 mRL to -15 mRL at the end of deposition. Approval was received in August 2019 to increase maximum tailings level to -15 mRL, applying specifically to the discharges from the fixed mill deposition spigots situated along the south and eastern pit perimeter. A tailings deposition level of -20 mRL was instated as the final average level of deposited tailings. This approved final deposition level was further increased in August 2020 to maximum height of -10mRL across the pit. This increase acknowledges the limitations on ERA that all remaining tailings must be deposited in Pit 3 and recognises that the risk to the offsite environmental during deposition is low provided process water levels in Pit 3 remain below 3.5 mRL.

The modified deposition system allows for the tailings dredged from the two operational TSF dredges to be deposited subaqueously into Pit 3. The existing subaerial discharge points will be maintained as a backup option to be employed during diffuser maintenance periods, planned pontoon movement operations, and monthly bathymetric surveys. Based on the periods of diffuser down time during the subaqueous trial and forecasts in deposition planning, the subaerial deposition system was predicted to be reinstated for the deposition of dredged tailings for approximately 5% of the remaining deposition schedule.

The current configuration of subaqueous deposition of dredged tailings is illustrated in Figure 9-15, whilst the location of the subaerial deposition points is provided in Figure 9-16, noting that the proposed points have since been implemented and the water level in Pit 3 as of the end of June 2020 was -22 mRL.

Figure 9-15: Subaqueous deposition of dredge tailings via floating pipelines and diffusers

Figure 9-16: Subaerial deposition of mill tailings from multiple spigot points

The key elements of the subaqueous deposition system are:

- Tailings is pumped via separate HDPE pipelines to Pit 3 (each pipeline sized to match flow from the dredge being served).
- Floating sections of pipeline allows for discharge over all parts of Pit 3.
- Each pipeline is fitted with a novel diffuser to reduce the velocity of slurry at the discharge point and reduce coarse and fine tailings segregation (Figure 9-17).
- Each diffuser is designed for the slurry flow from each dredge. The second diffuser is larger to accommodate the higher tailings transfer rate from the second dredge, but the configuration is essentially the same for both diffusers.
- Both diffusers are supported by a single pontoon.
- Diffusers are systematically moved across Pit 3 (using diesel-powered winches) following a deposition plan to ensure an even deposition across the pit. The location of the diffuser heads is shown in Figure 9-18.

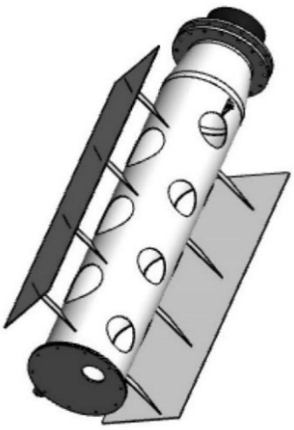


Figure 9-17: Novel subaqueous diffuser design

ERA engaged Fitton Tailings Consultants to develop a Pit 3 tailings deposition plan following a Fugro survey completed in Pit 3 on 17 March 2019. This survey allowed an assessment of the subaqueous deposition that had been completed up to that point and hence the development of an appropriate plan, in June 2019. The proposed plan, called “Pit 3 interim tailings deposition plan” comprised mill tailings discharge from spigots at the east and dredged tailings discharge from diffusers on the west. This interim deposition plan has now been finalised and is described in Section 9.3.2.2.

9.3.2.2 Current rehabilitation

Subaerial mill tailings deposition into Pit 3 is planned to end with the cessation of milling January 2021. Dredge tailings deposition is also currently scheduled to be completed in January 2021.

Mill tailings deposition

Subaerial deposition of mill tailings will continue until the end of milling operations. As described in Section 9.3.2.1, tailings are discharged from spigots on the east wall of Pit 3 to better distribute the tailings (Figure 9-16 and Figure 9-19). Discharge is through a single spigot at any one time.

Subaerial deposition of mill tailings will help maintain the westerly drainage of the tailings surface, but without excessively elevating the tailings beach as mill tailings constitute only a third of the total quantity of tailings to be disposed in Pit 3.

Subaqueous deposition

The subaqueous deposition of dredged tailings continues according to plan:

- both dredges discharge from the same location (approximately 148,000 tonnes per week)
- dredged tailings sink to the fine/coarse tailings interface and build up flat cones
- fine tailings are displaced upwards and form a near horizontal surface

Deposition plan

The basis of the deposition plan is to fill in the deep void at the western end of the pit. The "interim tailings deposition plan" could not be fully implemented due to the need to improve water recovery from Pit 3 to TSF to maintain dredge production. The dredged tailings deposition was, reverted to the subaerial method using spigots on the southern end of the pit from October 2019 to January 2020. The interim plan was then reviewed using the data obtained from the cone penetration test and geophysical survey completed in November and December 2019 respectively, along with monthly bathymetric surveys (Section 5.4.1.6). Subsequently, the interim deposition plan was revised in March 2020 and implemented in April 2020.

The mill tailings deposition method described within the interim deposition plan was considered appropriate and remains the same for the revised plan. The aim of the subaerial deposition is to achieve uniformity of the maximum level of the tailings at each spigot location, as much as possible. To achieve this tailings material is discharged from each spigot, in turn, for a duration of at least one week or until the maximum tailings elevation equals the level of the maximum elevation at the previous discharge location. The dredged tailings will be discharged initially from diffuser location 1 for three months and location 2 for two months (Figure 9-18). The deposition plan will be reviewed at the end of this period (October 2020).

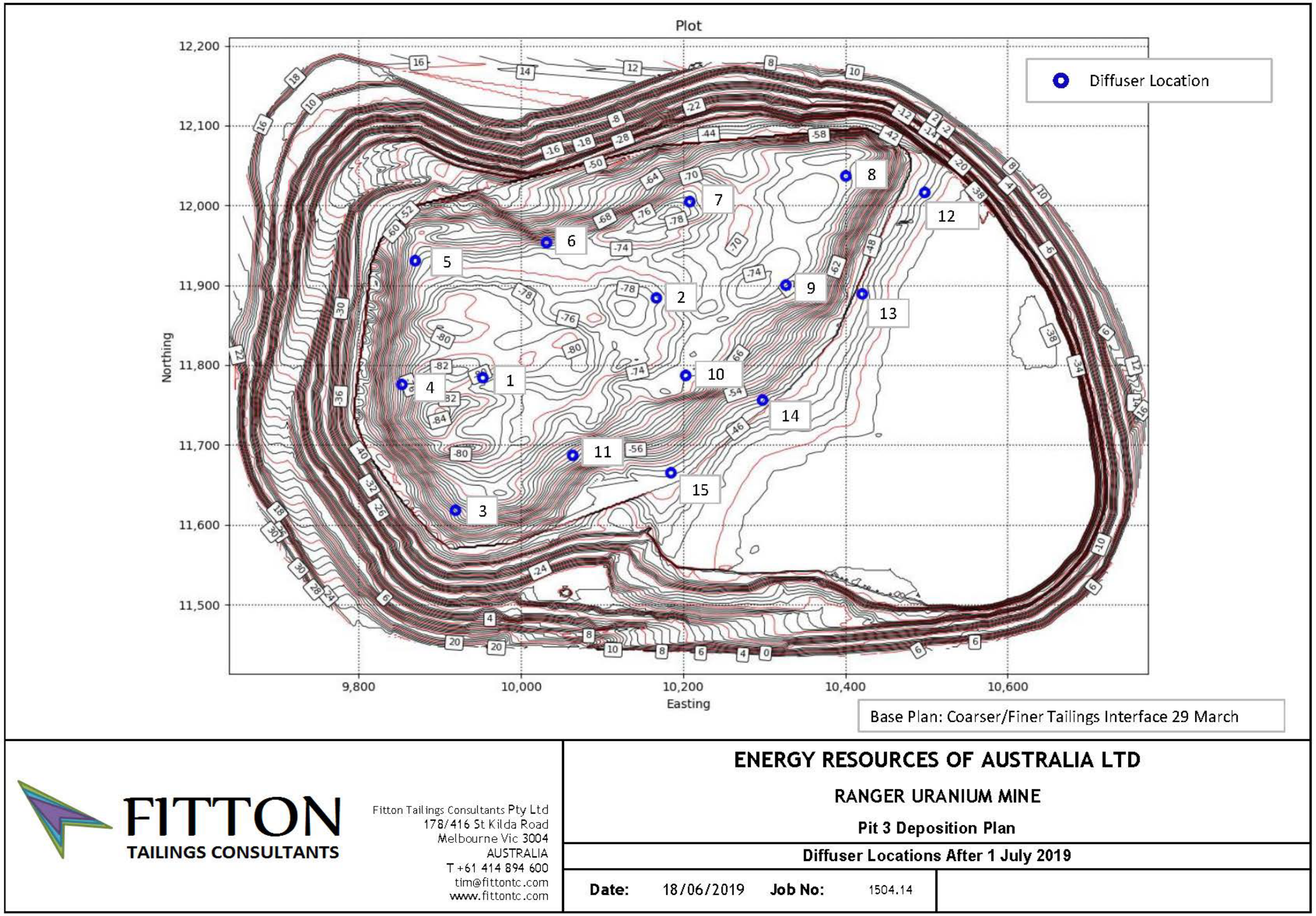


Figure 9-18: Pit 3 dredge tailings deposition plan

Figure 9-19: Southeast wall of Pit 3 – subaerial discharge point for mill tailings (Nov 2019)

9.3.2.3 Planned rehabilitation

The Pit 3 closure (wicking, capping, waste disposal and bulk backfill) will be subject to a standalone application to the MTC. This application will detail all the components of the closure of Pit 3, with associated supporting studies, and is scheduled to be submitted in Q4 2020. The final 6 m of the landform will be considered under a separate 'Final Landform' application, due for submission in Q2 2022.

After tailings deposition into Pit 3 has been completed (including mill, dredge and any residual tailings transfer), a series of activities will be carried out to facilitate the consolidation of deposited tailings. These activities will be undertaken in the following sequence:

- installation of wick drains within the tailings to promote consolidation
- installation of geofabric over the surface of the tailings to improve the bearing capacity
- placement of approximately 2 m layer of waste rock over the geotextile as a preloading material (initial capping)
- dewatering of the pit and installation of a decant system comprising a decant sump and extraction pipelines for continuous removal of expressed water from the wick drains
- construction of approximately 5 m layer of waste rock capping over the preloading layer

- placement of backfill material over the waste rock capping to a final stage ready for revegetation

Prior to the commencement of Pit 3 capping, geotechnical investigations will be required to determine the strength of the tailings and assess the geotechnical risk posed to construction. The geotechnical investigation will be conducted from September to November 2020, and will be comprised of cone penetration test with pore pressure measurement, vane shear test, recovery of tailings samples and laboratory testing. The strength of the tailings will inform the selection of geosynthetic material as the material must provide adequate bearing capacity. Tailings strength will also determine the size and weight of the construction equipment to be used in the placement of the secondary capping layer and bulk fill. The thickness of each capping layer is consequently influenced by equipment size.

Current scheduled milestones are provided in Table 9-16. Inherent in the sequence of Pit 3 closure activities is the continual water management to manage process water and, where possible, manage ‘clean’ surface runoff water separately (Section 9.3.7).

Table 9-16: Progressive tasks for closure of Pit 3

Key Milestone.	**Date**
Completion of all mill and dredged tailings deposition activities.	January 2021
Completion of the transfer activities from the TSF floor and wall cleaning.	August 2021
Injection of brines from the brine concentrator into Pit 3 underfill (ongoing until 2025).	Present to 2025
Installation of additional brine injection wells into Pit 3 underfill, if required.	As required
Installation of prefabricated vertical drains (wicks) within tailings.	September 2021 – January 2022
Commencement of the decommissioning and demolition of the processing plant infrastructure and stockpile for later disposal, potentially in Pit 3.	January 2021
Installation of geofabric and initial preload over pit.	February 2022
Commencement of bulk backfilling of Pit 3 and placement of waste material including site infrastructure.	October 2022
Backfilling of Pit 3 completed, surface contoured to Final Landform shape, and revegetation commences.	May 2025

Table 9-17: Schedule of closure for Pit 3

DOMAIN	ACTIVITY	TASK	STATUS	20	21	22	23	24	25	>26
Pit 3	Backfill	Initial backfill of Pit 3 with waste rock for underfill	Complete							
	Drainage	Underfill drainage layer & installation of extraction pumping system	Complete							
	Piping	Piping etc installation: from process plant to pit for delivery of tailings	Complete							
	Tailings	Tailings from process plant and from TSF delivered to Pit 3	Ongoing							
	Wicks	Installation of prefabricated vertical drains (wicks) within previously transferred tailings	Scheduled							
	Geotextile	Installation of geotextile	Scheduled							
	Backfill	Initial capping	Scheduled							
		Secondary capping	Scheduled							
		Final landform layer	Scheduled							
	Demolition	Potential placement of deconstructed mill and other infrastructure	Scheduled							
	Demolition	Decommission tailings transfer infrastructure	Scheduled							
	Landform	Surface contoured to Final Landform shape	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation	Scheduled							
	Monitoring	Closure & post-closure	Scheduled							

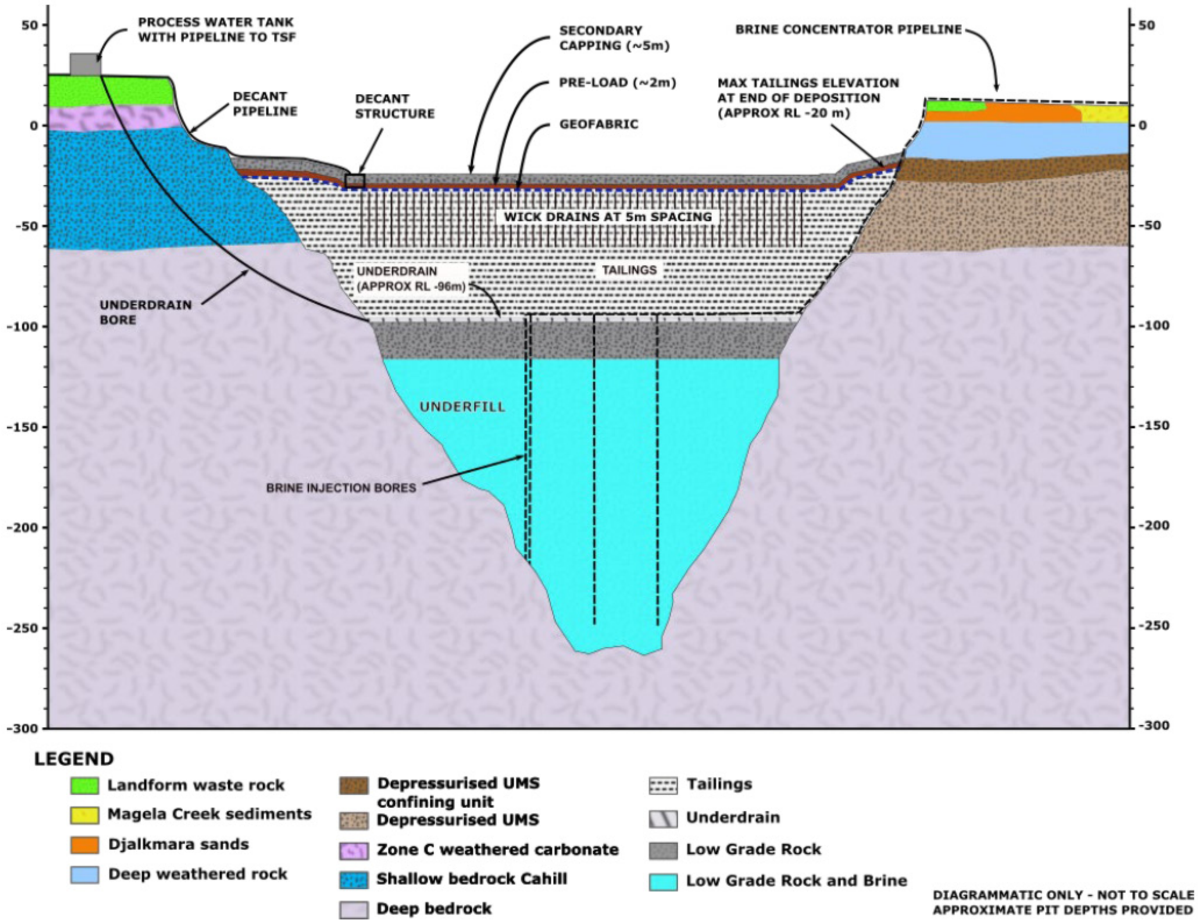


Figure 9-20: Cross-section of Pit 3 after tailings deposition

[Note: wick spacing may be altered and maximum tailings levels has been recently approved to be -10 mRL (DPIR, 2020)]

Underdrain bore and Brine injection

Brines were injected into the underfill during 2016; however, operational issues with the Pit 3 underdrain bore have required that brines be diverted back to process water. It is expected that brine injection will resume again in 2020. Once operational, the brine injection system is expected to be available for 80 percent of the time, with brines diverted back to process water when the system is offline.

The recirculation of brines to process water causes the process water salt content (measured through total dissolved solids) to increase. The brine concentrator is specifically designed to treat high salt content water. However, at total dissolved solids concentration over 120 g/L, the distillate production capacity of the brine concentrator is impacted. ERA regularly monitors for total dissolved solids concentration in process water and also forecasts future concentrations through its operational water balance modelling software. The most recent forecast (February 2020) uses the actual concentration in process water and assumes brine injection is operational for 80 percent of the time. This shows that the median forecast for total dissolved solids concentration in process water over time will remain below 120 g/L (Figure 9-21).

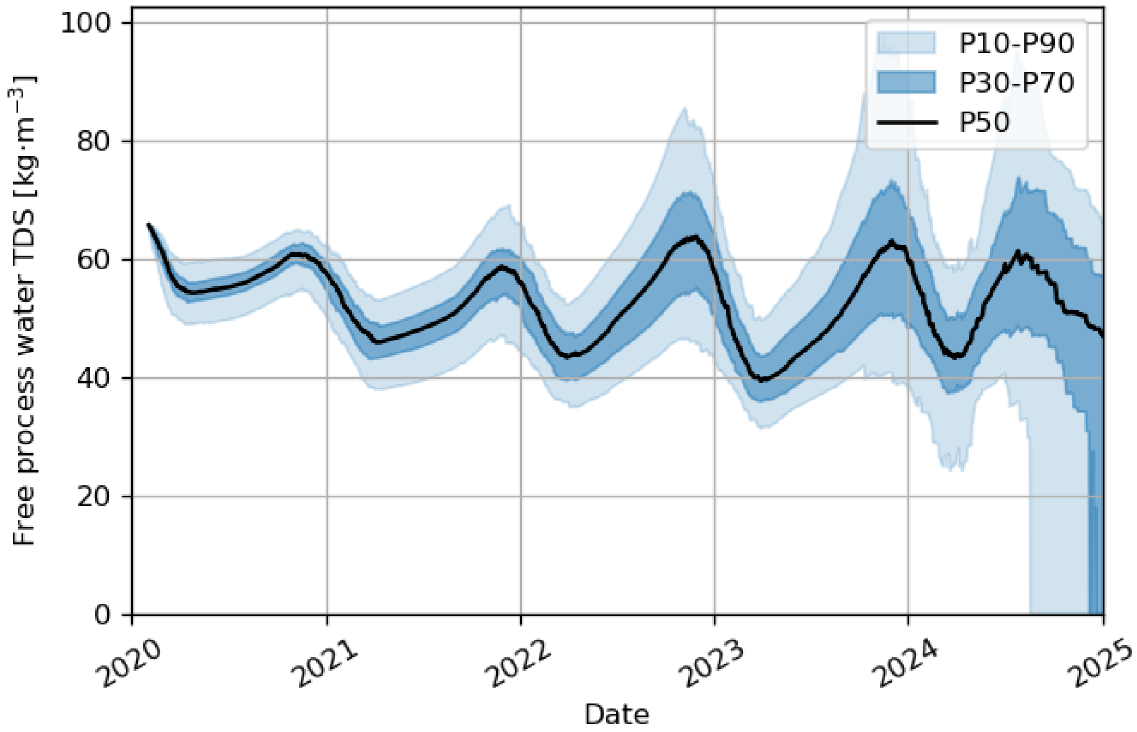


Figure 9-21: Site water model forecast of total dissolved solids concentration in process water

Tailings deposition

Deposition of dredged and mill tailings into Pit 3 is planned to continue until January 2021.

A tailings beach scan was completed in May 2020 and indicated that the beach height was at -24 mRL (Figure 9-22). Current modelling indicates that the final beach level will be -15 mRL, as predicted in 2019. The final beach level is highly dependent on the process water level in the pit which, in turn, is influenced by factors such as dredging performance and rainfall. Therefore, the final deposited tailings level cannot be predicted with a high level of confidence. ERA has approval to deposit tailings to a maximum height of -10 mRL.

Minor quantities of tailings will remain in the TSF following the completion of bulk dredging. The remnant tailings will be cleaned from the walls and floor of the TSF for transfer to Pit 3. The cleaning process is described below in Section 9.3.3. The final volume of this material cannot be known until the completion of dredging, as it is dependent upon the ability of the dredges to access the material and the volume of 'spill' during the dredging process. However, it is of a relatively minor volume compared to the main body of tailings in Pit 3.

It is currently planned to transfer the majority of these remnant tailings as a pumped liquid slurry, using the existing tailings deposition method. Some material may also need to be transferred to Pit 3 using heavy mobile equipment. Tailings and contaminated material will be transferred from the heavy mobile equipment to Pit 3 from one or more tip heads in Pit 3 prior to the placement of the geotextile layer. The final tipping location will be determined in early 2021. The management of contamination and dust from the transfer of this material will be according to the approved ERA Radiation Management Plan. The specific hazards identified and controls to be implemented during this phase of the project are detailed in Table 9-18.

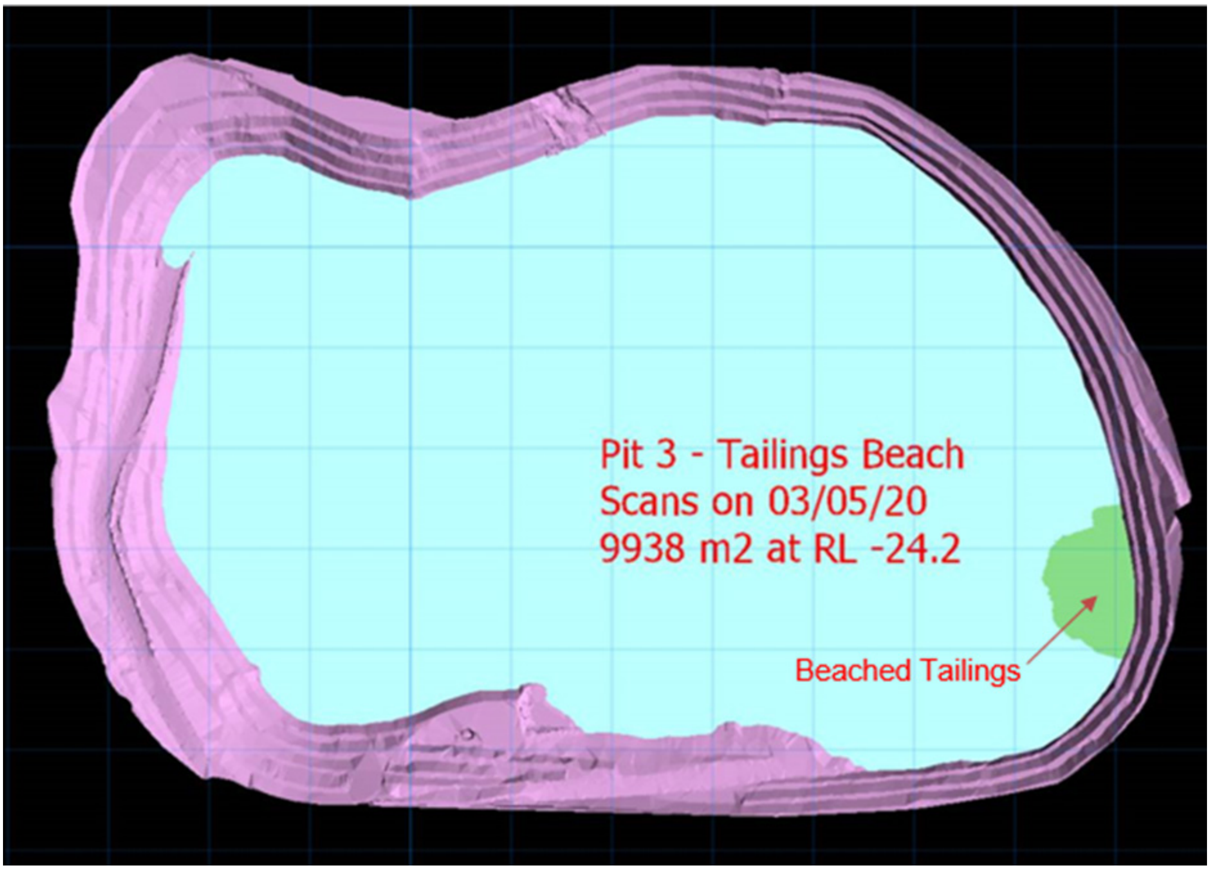


Figure 9-22: Pit 3 tailings beach scan in May 2020

Table 9-18: Risks and controls identified for transport and re-deposition of contaminated material from the TSF to Pit 3

Hazard	Impacts	Controls
Spillage during transport	Contamination of haul road	Transport of the less competent tailings and tailings contaminated material will utilise a range of controls that will minimise risk of material to spill from the equipment used. At this time the type, size and configuration of this equipment has not been finalised. Partial filling of heavy mobile equipment to minimise the risk of spillage. Grading / cleaning of road of any spilt material at end of transfer activities. Collected material will be deposited in Pit 3. Limit speed of trucks to minimise potential for spillage.
Spread of contamination	Contaminated equipment Movement of contaminated material into supervised area and/or off site	All equipment used to be radiation cleared before leaving site Transport route is designated a controlled area Visual inspection of the road for spillage by supervisor and equipment available for immediate clean up where necessary. Wash down facilities available by water truck if heavy mobile equipment is observed to have visible contamination that may fall from the equipment during transport operations Excavators and loaders to clean up any spillage after each load to prevent contamination of next truck wheels.
Dust emissions during loading, transport and dumping	Inhalation by project workers	Water cart to keep material damp during excavation and prior to transport. Project workers in air conditioned cabins. Water cart to keep material dust on roads to a minimum

Wick drains

Wick drains, or prefabricated vertical drains (PVD), will be required to increase the rate of tailings consolidation and reduce the time for the closure landform to reach its final profile. Wick drains have been installed and used successfully to consolidate the tailings deposited in Pit 1 (Section 9.3.1.1.1). By increasing the rate of consolidation, wick drains also increase the rate of tailings strength with time. In addition to strength gains, this will increase the rate of removal of consolidation flux (water trapped within the tailings) as process water. The drains consist of a geotextile filter - wrapped plastic strip with extruded channels that allow water to drain upwards from the tailings as it consolidates. The geotextile filter prevents soil particles from entering the channels and clogging the drain.

Wick installation will be undertaken from either a tracked amphibious vehicle or a barge, depending on the preferred option of the contractor selected. Wick drains will be installed at 2-3 m spacing in the western portion of the pit to an approximate depth of 38 m.

By the completion of dredged tailings transfer, process water levels will be managed in Pit 3 to facilitate subaqueous wicking, subaqueous geofabric placement and subaqueous initial capping. During this time, the remaining tailings from the TSF floor will be transferred to Pit 3. Process water will be returned to the TSF when the TSF wall and floor cleaning is complete, utilising the return water system that currently services the TSF dredges.

Geotextile

The most conventional approach to improve the bearing capacity and constructability of a capping layer on very soft tailings is to provide a geosynthetic layer between the two materials. Key performance requirements include:

- separation – preventing loss of cover material into the tailings layer and preventing tailings from extruding into the cover layer (the "opening size" of the geotextile needs to be sufficiently small to retain the fine particles)
- drainage – allow consolidation bleed liquor to express from the tailings into the permeable capping system (the permeability of the geotextile needs to be sufficiently high to meet the required flow rate), and
- reinforcement – provide tensile strength to the underside of the capping layer to improve the bearing capacity and stability and/or reduce capping layer thicknesses.

The geosynthetic material needs to provide the required tensile strength at relatively low strain, which typically precludes the use of a non-woven geotextile.

Either a woven geotextile or a geocomposite (geogrid in combination with a separation geofabric, often thermally bonded together) could meet all three of these requirements, dependent upon the specific criteria. Reduction factors are included in the material selection process to account for issues such as clogging, long-term creep, environmental and installation damage. The specific product to be utilised is still to be determined.

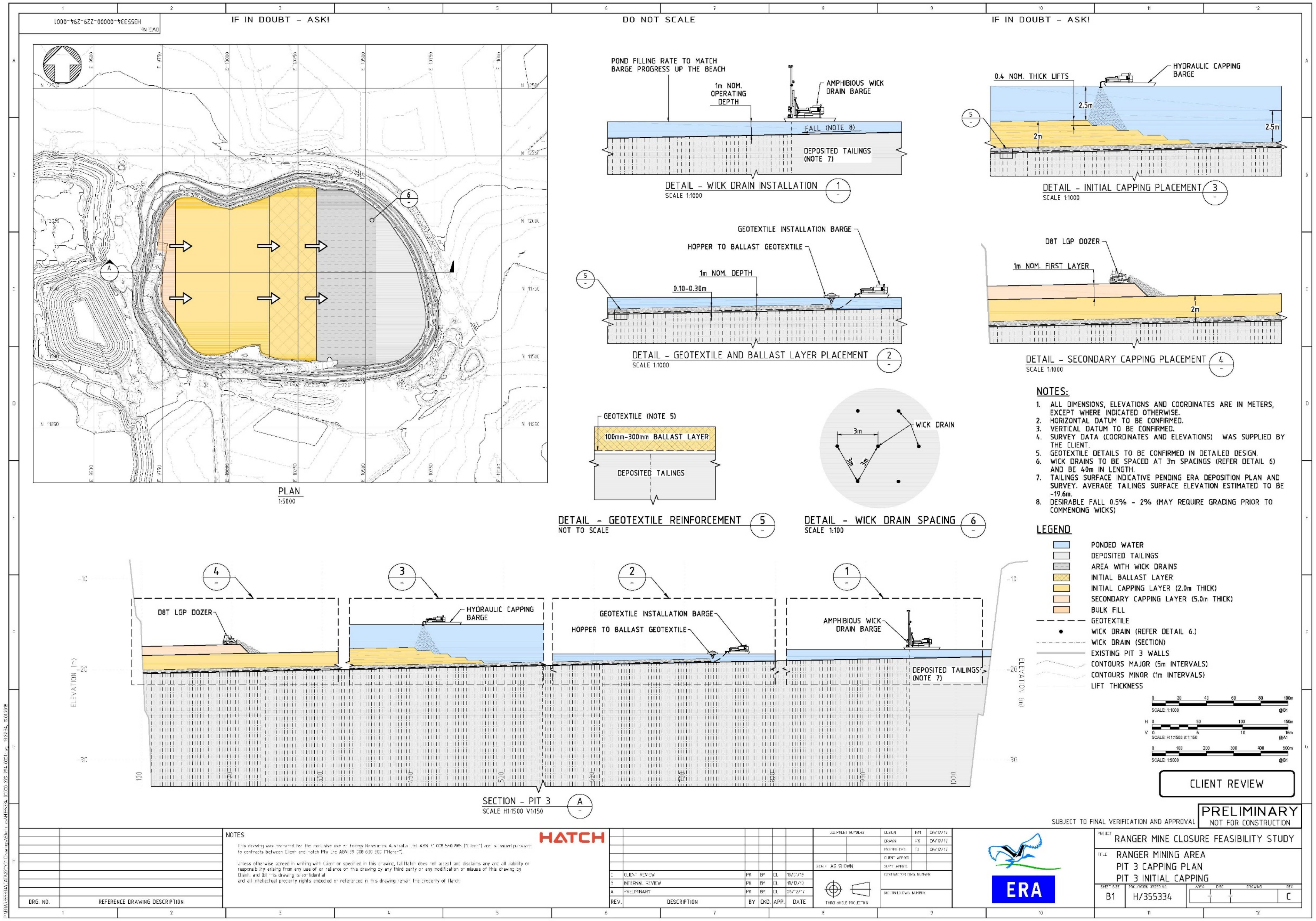


Figure 9-23: Indicative Pit 3 wicking, geofabric and initial capping plan.

Access to the pit will be from the western and, potentially, the southern ramp. Key challenges for the installation of geotextiles over the tailings include:

- sinking the geosynthetic material into the correct position
- minimising slack during deployment

Whilst subaqueous capping is a relatively uncommon approach, the unique conditions for Pit 3 provide significant drivers for its adoption. The constraints are:

- timing to complete closure implementation
- subaqueous deposition
- the rapid rate of rise of tailings

Various methods of placing the geosynthetic material were reviewed during the Feasibility Study. The baseline approach taken forward includes for the rolls of geosynthetic to be joined on the shore to the maximum size panels that could be efficiently and safely handled by the installation crew. The approach includes the installation of weights (prefabricated sleeves using heavy chain of reinforcing steel bars or similar to promote sinking) into the fabric which will subsequently be loaded, typically from a crane on the base level of the ramp, into the barge and deployed/placed by barge. It is planned to join the fabric by stitching rolls to achieve a nominal width of approximately 20 m and the trials planned will confirm the ability to join the overlapping layers. The plan provides for a wire rope or similar to support one edge of the fabric to allow joining the subsequent layers. That ballasting will need to be sufficient to flatten the wicks and to provide a level of anchoring for the geosynthetic material. Geosynthetic material will be laid over the wick drains but will not inhibit their performance.

During the placement of the geosynthetic material, the water level in Pit 3 will be maintained at a nominal depth. Trials will be conducted prior to finalising the design, these will focus on methods to control the direction of the barge, anchoring methods, stitching versus overlap and safety. These trials are expected to occur during 2020.

Initial capping

Following placement of the geotextile, the initial capping layer (waste rock) will be placed subaqueously up to an initial thickness of 2m.

The objectives of the initial capping layer are to:

- provide a drainage layer to allow the dissipation of excess pore pressures generated in the consolidating tailings
- act to dissipate the bearing pressure of the construction equipment acting on the surface during construction of the secondary capping layer. Thus allowing for safe access of heavy equipment

The initial capping material will continue to be placed until the second objective is achieved, to enable the secondary capping works to be completed. Depending upon tailings strength, the thickness may be up to or more than 5m.

The initial capping material will be sourced from the existing stockpiled waste rock. The subaqueous placement of the initial capping will be achieved by either hydraulically pumping to a barge or conveyer. This waste rock material will be specifically graded with screening and/or crushing to generate the correct sized for the placement method chosen. The initial capping layer is to be placed in a number of passes to minimise disturbance to the underlying geotextile and tailings.

During this phase of the work, process water will need to be transferred between the TSF and Pit 3 to control the water level above the geotextile/rock as the initial capping layer is constructed. A 'sump' arrangement will be required, typically in the western side of the pit, to allow for this continual water management.

Following the completion of the initial capping, Pit 3 will be dewatered to allow the surface to dry sufficiently for access to heavy equipment for secondary capping.

Secondary capping

The backfill requirements for the Pit 3 secondary capping and bulk fill are included in Table 9-19. Full details of the bulk material movement plan for Ranger closure are provided in the activities section 9.4.5 as it relates to multiple domains.

Table 9-19: Backfill specifications for Pit 3

Backfill layer	**Layer thickness (m)**	**Lift height (m)**	**Maximum slope (%)**	**Minimum bench offset (m)**
Secondary capping	5	1	10	10
Bulk fill – 1st layer	5	5	Nil	Nil
Bulk fill – successive layers	10	10	Nil	Nil

The placement of the secondary capping layer in Pit 3 will commence once there is sufficient strength in the tailings surface to allow access for heavy equipment. The secondary capping layer includes all works required to place and compact about 5 m of material onto the initial capping layer. The secondary capping is anticipated to be placed in 1 m lifts with mid-sized construction equipment such as a D8T dozer initially pushing from pit edge and ultimately using CAT D740 dump truck and a dozer combination (Figure 9-24). To minimise the risk of slumping at the face of the advancing cover, fill materials will need to be dumped away from the free face and pushed into place with dozers.

The maximum slope and bench offset for the secondary capping layer (Table 9-19) is in place for geotechnical stability. The first lift/layer does not need to be completed prior to commencing following lifts. There can be several work fronts open, each with a number of lifts in progress (Figure 9-24). If the secondary capping layer is completed using 1 m lifts, the minimum bench offset is 10 m for successive lifts. This method also specifies the equipment shall not exceed the equivalent bearing pressure of a CAT740 dump truck or D8T dozer for secondary capping works.

Once the full secondary cap thickness has been placed, mine fleet vehicles can be used to place the bulk fill materials. The proposed construction method is indicated below in Figure 9-24.

Water management during wet season works will involve the installation of sumps and pumps, as per previous operational water management. Currently it is planned to install this infrastructure in the western side of the pit with secondary capping commencing at the southern ramp. Once the capping layer at the western ramp has developed some competency, the secondary capping can continue over two work fronts.

Due to the limited competence of the deposited tailings, the construction of the secondary capping layers will be carefully controlled. Where very soft subgrade zones are encountered during placement, the area will be stabilised by using long reach excavators or mobile conveyors to reach the area.

Decant installation

Decant towers are required to remove the expressed tailings pore water (process water) as the tailings consolidate during placement of capping material. This water is termed Pit Tailings Flux.

Two decant wells located in the lower slope end of Pit 3 will be constructed with the base sitting in the initial capping layer to allow for removal of process water expressed from the wick drains as part of the consolidation process. Tailings consolidation will steadily drive contained process water towards the wick drains installed in the tailings and up into the waste rock, this will flow to the decant towers where it will be extracted. Pumps and pipes will be installed in the decent wells to extract and transfer flux to the TSF and subsequently to RP6.

Decant towers will be required to be operational until such time as the consolidation has reached a point where the remaining expressed process water, or pit tailings flux, will not case detrimental environmental impact (Environmental Requirement 11.3 (ii)). Based on the experience in Pit 1, ERA is currently assuming this will be 95% consolidation. Modelling for consolidation, groundwater solute transport and surface water quality are all currently underway as part of this assessment with results to be provided in the Pit 3 capping application and the 2021 MCP. Further details on these studies are provided in Section 5.4.1.6. This level of consolidation is expected 6 months after completion of backfilling activities. Decanting of Pit 3 is expected to commence during secondary capping installation in 2022 and continue until end May 2025.

A schematic of the proposed decant towers design has been provided in Figure 9-24.

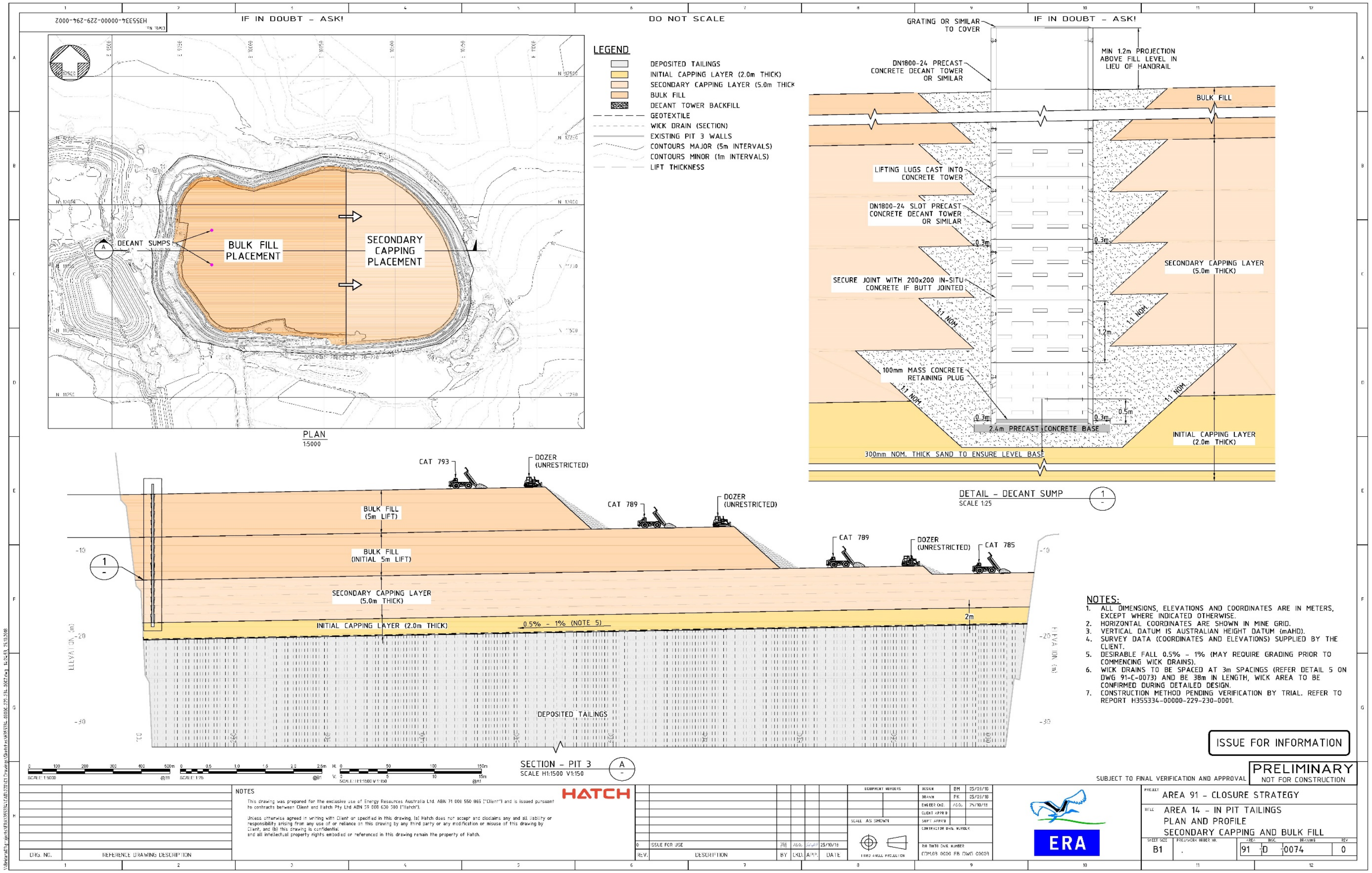


Figure 9-24: Pit 3 Secondary capping, decant wells and bulk fill plan

Bulk backfill

Following the placement of the secondary capping layer and the decant wells installation, the backfilling operation for Pit 3 can commence. The total waste rock fill to be placed into Pit 3 is approximately 67 M tonnes. The bulk backfill requirements for the Pit 3 are included in Table 9-20 with full details of the bulk material movement plan for Ranger closure provided in the Section 9.4.4 as it relates to multiple domains. Pit 3 can be accessed via two ramps; one on the western side and one on the proposed upgraded southern side. The western ramp is currently accessible by a CAT 785 dump truck. The southern ramp will be upgraded to allow access for at least this size of equipment; however, ramps may need to be widened if larger mine trucks are required. Vehicle movement and traffic control will form a critical part of the works.

Solute transport source term modelling has identified a better environmental outcome will be achieved if all mineralised material is placed below the vadose zone, refer Section 5.4.3.3. This surface has been determined as between 8 to 14 mRL across the Pit 3 surface and is termed the 2s cap. Approximately 50 M tonnes of material must be placed below the surface of the 2s cap. It is noted that an allowance may be required for keeping a void open in Pit 3 below the 2s cap to allow for late placement of demolition and/or contaminated material. This decision is subject to the completion of the finalisation of the detailed demolition execution plan and schedule. Once completed details of any void will be included in the MCP.

The backfilling of Pit 3 must also potentially accommodate the dumping of demolished process plant, administration offices, workshops/warehouses, and other materials and mobile equipment during operations. The demolition materials will be transferred to Pit 3 via the southern ramp.

Table 9-20: Bulk material movements to Pit 3

Stage	Material movement (m^3)	Haul distance (m)
Stage 9	3,188,633	1,000
ROM/crusher stockpile	996,641	2,000
Stage 6	3,015,822	2,100
Stage 8	3,162,177	2,050
Stage 10	37,932	1,800
Stage 11	6,254,874	2,100
Stage 14	2,909,829	1,500
Stage 15	4,242,621	1,500
Stage 12	913,582	2,700
Stage 16	44,481	1,500
Stage 16 (non-mineralised)	7,082,833	1,500
TOTAL	*31,849,425*	

Final landform

The last phase of Pit 3 backfill consists of 20 M tonnes of non-mineralised material to the final landform surface. Details of the methods to be used to confirm material in the final landform are non-mineralised are provided with the bulk material movement plan in Section 9.4.4.

The final landform revegetation layer will be 6m thick. Details on the materials and methods of construction of the revegetation layer are provided in Section 9.4.5.

Following construction of the revegetation layer, the final surface will be contoured to form the approved final landform surface, this is currently final landform version 6.2 (FLv6.2), refer Sections 9.4.5 and 5.5.1.1. The surface will be ripped and the other erosion and sediment control structure installed, details of these have been provided in Section 9.4.5.

Revegetation

Revegetation will commence upon completion of the final landform surface. Revegetation works include:

- pre-emergent herbicide spray
- installation of irrigation
- initial planting
- infill planting

Details of these activities along with contingency plans are provided in the overall revegetation implementation plan provided in Section 9.4.6.

9.3.2.4 Contingency planning

Brine injection

During the construction of the Pit 3 underfill five brine injection bores well were installed to allow for injection of waste brine from the brine concentrator to be disposed of in the waste rock void spaces. During the operation of the brine injection system it is expected that wells will become scaled over time and eventually become unusable. The exact timing of this is dependent upon a number of factors so cannot be determined; therefore, ERA has allowed for the installation of additional directionally drilled wells to be installed from the edge of Pit 3 into the underfill. To provide confidence in this option, ERA completed a pilot directionally drilled hole 2012. Currently ERA have included the installation of three additional wells into the closure plan schedule.

In addition to the provision for additional wells, ERA is currently investigating injection of brine at a higher pressure and various system maintenance options such as chemical or other flushing. These are in the early phases of development; if they should form a contingency option or part of the plan then they will be included the MCP.

Should injecting brine into the Pit 3 underfill cease to be a viable option and/or the allowed void space is insufficient for the brine volume, then additional contingencies are required. Currently ERA are progressing with the development of contingency options for two scenarios:

- The brine injection system fails to operate early in the closure project
- The brine injection system fails and/or void spaces are exhausted late in the closure project.

ERA is currently engaging with contractors to complete a broad investigation of alternatives across the industry for current best practice. This work will build on the previous options analysis completed in 2012. Options selected will be subjected to a best practical technology assessment with any viable contingencies included in the 2021 MCP.

Tailings deposition

At this stage of the life of Pit 3, it is not possible to plan and commission an alternative deposition strategy as a contingency. ERA, however, does have a number of potential contingencies available should modelling and/or monitoring indicate that the tailings level in Pit 3 will rise above -10 mRL. These include:

- apply for an increase in the final tailings level (supported by sufficient information to demonstrate there will be no detrimental environmental impact)
- apply for an interim increase in tailings deposition level with a requirement to move tailings to below -10 mRL prior to the commencement of backfilling
- increase the volume of water in the TSF and therefore reduce the rate of rise of the mill deposited beached tailings (this would not be implemented until a favourable assessment on impact of dredging performance was achieved)
- installation of a mill subaqueous deposition system (only relevant if implemented before the ceasing of milling on 8 January 2021), and
- cease milling and therefore cease subaerially deposition of tailings into Pit 3.

Wicking, geofabric and Initial capping

The wicking, geofabric placement and initial capping activities and standard construction activities that do not have outcomes related to environmental risk. The risks associated with these activities are all project related around cost and schedule. Standard project management practices will be used to manage these elements. The influence these elements have on the consolidation are discussed in the subsequent section.

Secondary capping and Bulk backfill

The secondary capping and bulk backfill activities are standard mining activities of which ERA has over 40 years experience, including the bulk backfill of Pit 1. Standard mine planning and survey techniques will be used to manage the bulk fleet and material movement. These techniques are flexible enough to all for daily modification based on monitoring and observations. No specific contingency plans are required.

Tailings consolidation

The volume and rate of water expressed during consolidation of tailings is dependent upon the properties of the tailings and the mass of rock placed for the capping layer. Both of these are well understood by ERA, refer to Section 5.4.2 for the tailings properties data. The consolidation model will inform the safe design of the capping layer and provide an estimation of the timing for expressed water. The 2019[3] consolidation model predicts that the 95% consolidation target will be achieved by June 2025, leaving ERA sufficient time to deconstruct the water treatment infrastructure by January 2026. ERA has a number of contingency options should either the consolidation target of 95% be shown, through solute transport modelling, to be insufficient to protect the environment or the consolidation model update determines that the consolidation will take longer. These options are all related to the timing of achievement of the closure project and will not impact on the environmental outcome.

ERA has identified two contingency options to reduce the timing for consolidation:

- modification to the wick design to speed up the removal of water, including spacing, length and area wicked
- bringing forward the Pit 3 capping works to have the wicks installed earlier and the capping material placed earlier

For the case where no design options remain to increase the speed of consolidation or where it is identified during execution that consolidation is taking longer than expected, the contingency would be to operate the decant structures and treat the expressed water until the consolidation target was achieved. In this case, an application would be submitted to the MTC requesting that water treatment infrastructure be allowed to remain on site for a period to allow for completion of this treatment. Refer to Section 9.4.3.6.

Final Landform and Revegetation

Contingency plans for the final landform construction, sediment and erosion control installation and revegetation have been provided in Sections 9.4.6.

[3] An update to the consolidation model is currently in progress and will be included in the 2021 MCP

9.3.3 Tailings Storage Facility

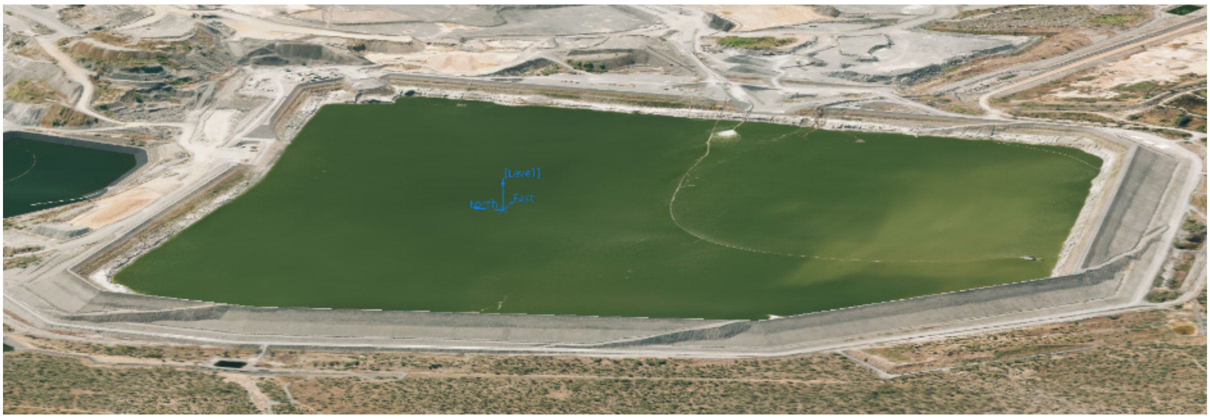


Figure 9-25: TSF (May 2019)

The Ranger Mine has three tailings storage facilities, Pit 1, Pit 3 and the Tailings Dam (referred to as the TSF). This section discusses the closure of the TSF only.

After completion of tailings reclamation and transfer, the TSF will be cleaned of all remnant tailings, infrastructure and foreign objects prior to use as a process water storage. On completion of process water storage, the TSF will be deconstructed.

9.3.3.1 Completed rehabilitation

Deposition of mill tailings into the TSF ceased in 2016 following the conversion of Pit 3 into a tailings storage facility. Progressive rehabilitation then commenced with the dredging of all tailings from the TSF to Pit 3. A summary of completed rehabilitation works in the TSF is provided in Table 9-21.

Table 9-21: Completed TSF rehabilitation

Year	TSF closure activity
1996	Tailings deposition from the TSF into Pit 1 commenced in August
2008	Tailings deposition into Pit 1 ceased
2015	The tailings dredge 'Jabiru' was launched and commissioned in the TSF
2016	In January, transfer of approximately 27 Mt of dredged tailings from the TSF to Pit 3 commenced
2019	Cleaning remnant tailings from the walls of the TSF commenced
2019	The second tailings dredge 'Brolga I' was fully commissioned in Q3
2019	Tailings transfer upgraded to new flow rates to meet the requirements of the two dredges

9.3.3.2 Current rehabilitation

Current rehabilitation works in the TSF include:

- dredging of tailings from the TSF and transfer to Pit 3, scheduled for completion in January 2021
- cleaning of remnant tailings from the walls and floor and transfer to Pit 3
- deconstruction of small sections of the wall to facilitate dredging, wall and floor cleaning

Details of these activities are provided in the following sections.

Tailings reclamation

The tailings reclamation system recovers tailings material from the TSF via use of two dredges, "Jabiru" and the "Brolga I" and their supporting maintenance crafts "Mudskipper" and "Ginga" respectively.

The Jabiru (Figure 9-26) is a stainless steel dredge, weighing approximately 170 t. The Jabiru uses a five-wire three-anchor system to manoeuvre whilst dredging.

Figure 9-26: The Jabiru dredge

The Brolga I (Figure 9-27) is a Damen CSD500S cutter suction dredge, using two spuds and two side wire anchors.

Figure 9-27: The Brolga 1 dredge

Maintenance craft (or workboats) set the anchors and assist dredge moves under tow. They also mobilise crew and equipment and support in servicing the vessels.

The Mudskipper (Figure 9-28) is a 13 m maintenance craft that services the Jabiru. The Ginga services the Brolga I.

Figure 9-28: The Mudskipper

A dredge plan has been developed by ERA and is currently based on HYPACK DredgePack dredging software. This provides for controlled dredging practices with accurate positioning and monitoring of progress per shift. Current run lines allow for a 40 m swing cut currently used by the Jabiru and 50 m wide run lines for the Brolga I.

The TSF rock walls are protected from contact with the dredge cutter head by the inclusion of a 0.5 m standoff zone. This standoff is programmed into the dredge computer.

Each dredge will operate in its own working area in order not to impede each other's operation. The south side will be dredged by the Jabiru. The remainder will be dredged by the Brolga I. The result is a 60 /40 volume split between the Brolga I and Jabiru. The north side of the TSF has been allocated to the Brolga I because the TSF the floor is considerably deeper there. This provides more scope for the water level to drop consistently over the course of the project. The maximum dredging depths for the Jabiru and Brolga are 10 m and 14 m, respectively. When a run line is completed, the dredge will shift in a clockwise direction to the adjacent run line. To manage free process water inventory the dredges will use an alternate run line method, dredging every second run. The resulting 'fingers' of tailings are evident in Figure 9-29. This means that if the TSF water level needs to be lowered the remaining 'fingers' can be dredged from the channels already dredged. When the dredges are on a floor dredging horizon they may use different cutter and swing speeds to minimise the quantity of tailings left behind (remnant tailings).

Whilst a cut layer is dredged, the water level within the TSF must remain at +/-0.5 m the optimal level. On completion of each cut layer, the TSF water level must be reduced to the next optimal water level as quickly as possible within the rate of change limits; nominally 0.5 m per week, or 2.0 m per 4 weeks.

Tailings transfer

The dredged tailings are transferred to Pit 3 via a dedicated single overland pipeline for each dredge. The pipelines are connected directly to the discharge of the floating pipeline from the dredge on the eastern notch. Tailings are discharged into Pit 3 via either subaqueous or subaerial deposition (during subaqueous maintenance periods). Further detail on the deposition of dredged tailings into Pit 3 is discussed in Section 9.3.2.

Process water return Pit 3 to TSF

Upon deposition in Pit 3, the TSF and mill tailings will consolidate. Process water mixed with the tailings is continuously expressed as the tailings consolidate. The process water that flows upwards (decant) and rainwater are recovered at the Pit 3 surface and returned to the TSF. This is shown in the block diagram in Figure 9-30.

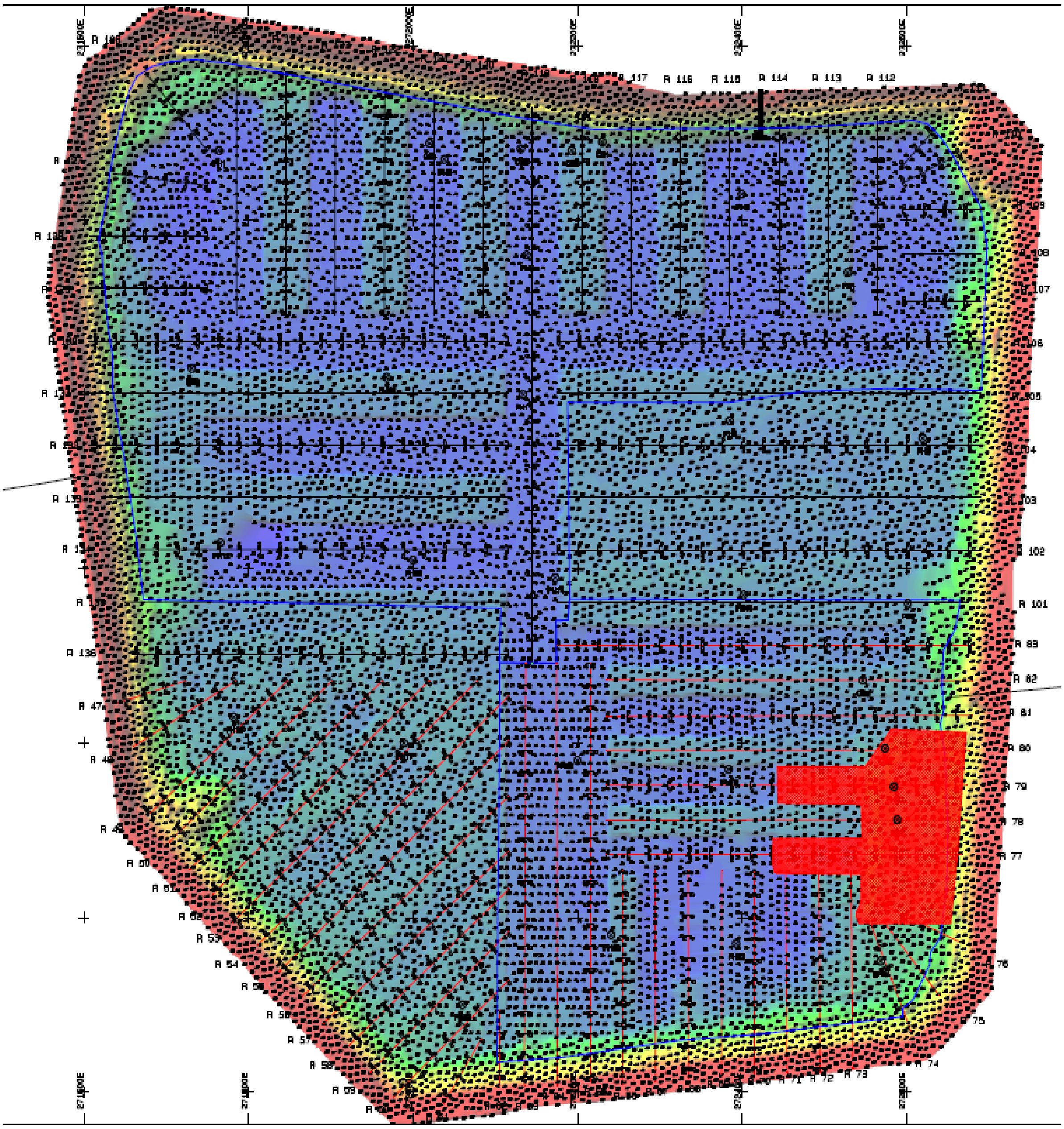


Figure 9-29: Dredge run lines evident as alternating shades of blue in this survey of the TSF

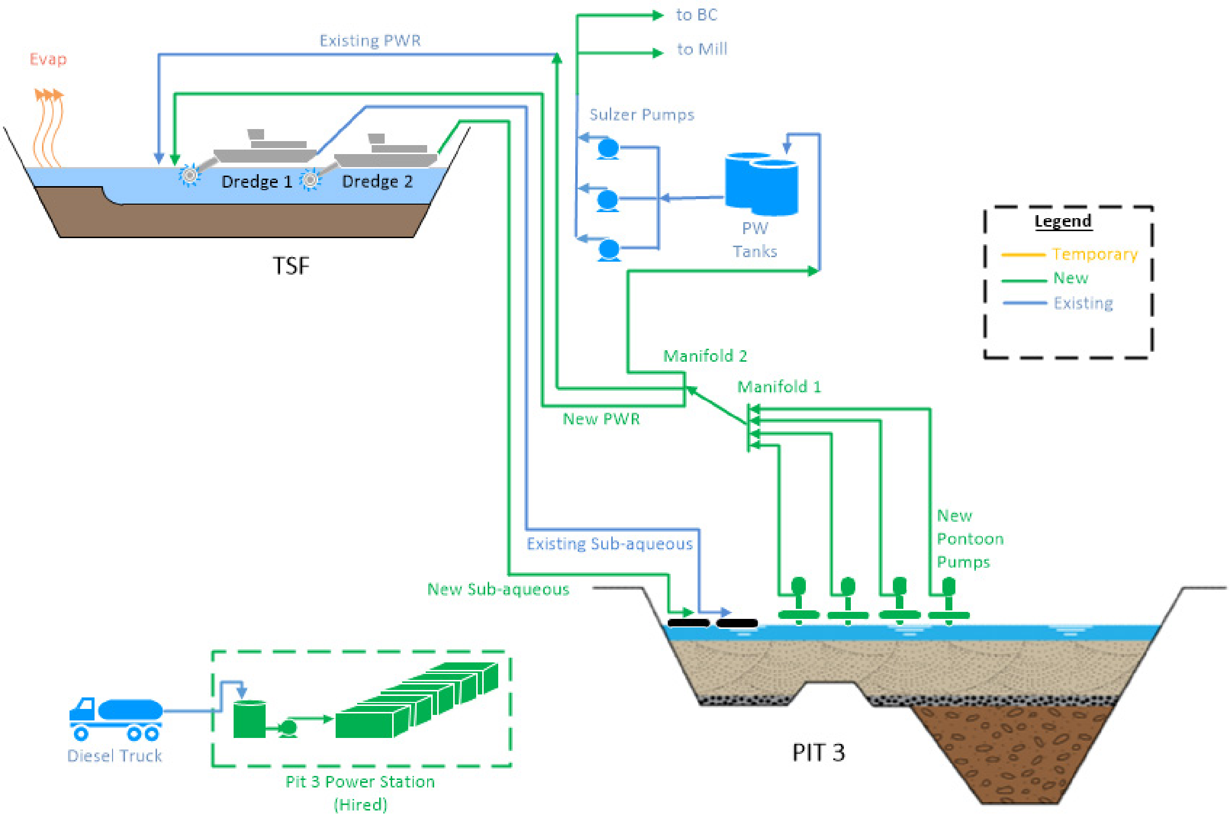


Figure 9-30: Process water return from Pit 3 to the TSF

TSF wall cleaning

Condition 11.2 of the Environmental Requirements of the Commonwealth of Australia for the Operation of Ranger Uranium Mine (the ERs), requires that all tailings must be placed in the mined out pits. In order to comply with this condition ERA have implemented a wall and floor cleaning program. Whilst the cleaning program progresses, ERA continue to collaborate with stakeholders to determine the final criteria to confirm compliance with condition 11.2.

The tailings must also be cleaned from the walls to eliminate the risk of moisture build-up between the remnant tailings on the wall and the clay layer within the wall. Such moisture build-up could result in erosion of the clay core with the potential to impact the integrity of the TSF walls.

The wall cleaning program developed by ERA employs excavators to scrape remnant tailings from the internal TSF walls, progressively transferring the tailings down the walls and into the dredge pool. ERA have purchased an amphibious excavator that will enable wall access from within the dredge pool, where conventional excavators cannot be used.

The excavators have optional screening tilt buckets to allow screen rock armour during scraping, ensuring that only tailings material is then transferred into the dredge pool. A sorter/stacker is also used to sort out any larger rocks and transfer only the tailings into the dredge pool.

Images of the remnant tailings on the walls, clean walls, excavators and stacker are provided in Figure 9-31 through Figure 9-33.

Any final tailings material on the walls is washed down the wall during the wet season. In order to better facilitate this ERA will trial a hydraulic monitor (hydraulic mining equipment) to 'wash' the tailings from walls using high pressure water. If successful, this method will be employed for both wall and floor cleaning.

As of June 2020, the wall cleaning program was 45 percent complete.

Figure 9-31: Typical remnant tailings on TSF wall after dredging

Figure 9-32: Land based excavator cleaning tailings off North wall of TSF

Figure 9-33: Sorter/stacker removing rocks before placing tailings into dredge pool.

TSF floor cleaning

The dredges will remove most tailings material from the floor of the TSF. However, due to the presence of buried waste material, large displaced rock armour, and ‘spill’ from the dredges, some remnant tailings will remain on the TSF floor following the completion of the dredging program.

ERA has commenced floor cleaning trials with the Jabiru dredge, these will be ongoing during 2020 to inform the final TSF floor cleaning plan. Details of the current program are provided below.

TSF North east ramp

The ramp in the north-eastern corner of the TSF (Figure 9-34) is founded on tailings and will therefore need to be removed and the underlying tailings subsequently recovered.

Figure 9-34: Aerial image of the North-Eastern ramp

Dredging of the tailings in the vicinity of the ramp has the potential to undermine the ramp. Presumably, as the water level is lowered, the tailings underlying the ramp will drain down, but at a lower rate than the pond level, creating an elevated phreatic head under the ramp. This mechanism typically reduces slope stability.

As the ramp has been constructed from dump rock it may not be suitable for dredging. Undermining of the ramp (to allow it to fall into the pond for reclamation by the dredge) is unlikely to be viable without extensive damage to the riprap and potentially the low-permeability clay core of the TSF wall.

ERA has now commenced the deconstruction of this ramp and cleaning of any tailings material using the wall cleaning techniques described above.

Foreign material removal

A 2012 magnetometer survey (Fugro 2012) reported “a very strong anomaly on the south-eastern side of the TSF, believed to be the sunken remains of the old survey barge / pontoon”. Data acquired through the 2019 magnetometer surveys (Surrich Hydrographics 2019) with a towed magnetometer compared to the 2012 is shown in Figure 9-35. The primary objective of the survey was to locate any potential buried iron objects which could impact proposed dredging operations.

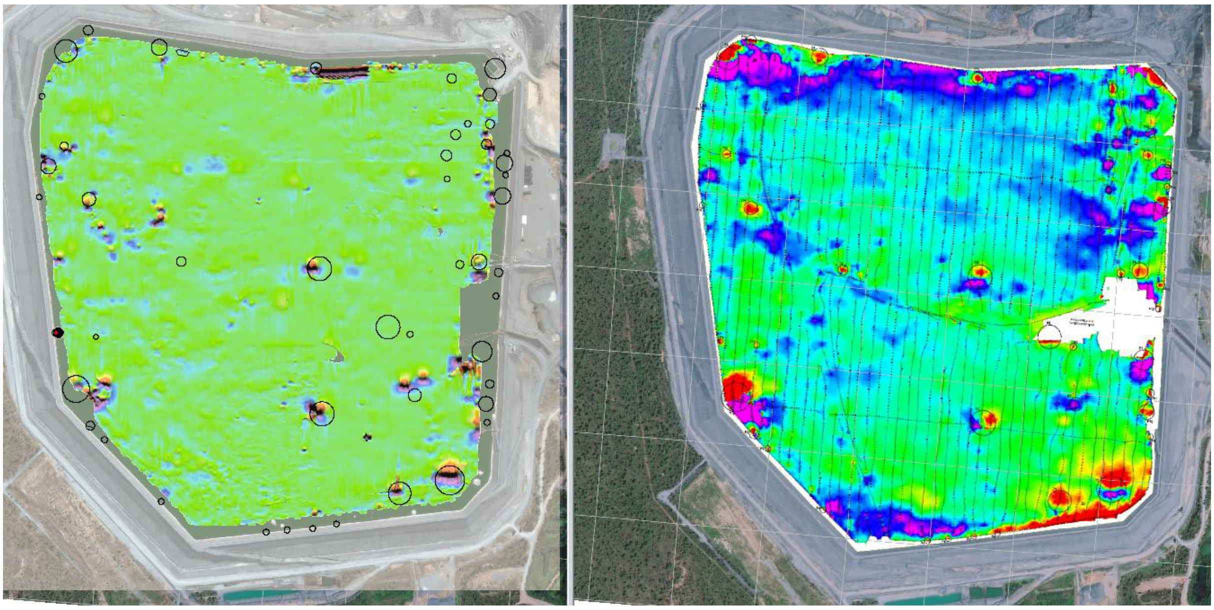


Figure 9-35: April 2019 Magnetic Anomaly Map (left frame) comparison with the 2012 Magnetic Anomaly Map (right frame)

As expected, objects were identified close to the TSF embankment, whilst the central area was relatively free of anomalies. The magnetometer detected a very strong anomaly on the south-eastern side of the TSF, again, believed to be the sunken remains of the old survey barge/pontoon. No other features of similar magnitude were found. Many anomalies, either localised or diffuse, are likely to be caused by magnetic material in the tailings, accentuated by variations in the water depth that changes the range between source and detector. Small, localised anomalies, particularly around the TSF perimeter, probably represent iron debris.

The Dredging Stability Assessment report (Coffey 2015) states that debris close to the actual embankment includes:

- recycle pump barge and power pole(s) – West Wall of the TSF
- steel cables
- ropes
- fuel drums

- dumped oversize rockfill, and
- plastic sheeting

Throughout the dredging operations, foreign material has been encountered as expected. To facilitate dredging this material is either removed from the TSF, cleaned and stored or placed temporarily on the walls as it is encountered. All waste material found in the TSF will either be buried in-situ, transferred to Pit 3 or transferred to RP2 for final burial.

TSF wall notches

The progressive reduction in water level associated with the dredging operations necessitated the creation of notches within the TSF walls to facilitate safe access to floating infrastructure and to improve return water pumping efficiency. To date, three notches have been successfully constructed; the East wall notch, to improve the pump efficiency for process water and tailings pipelines, and stages one and two of the North wall notch, to allow safe access to floating infrastructure in the TSF.

Two shallow notches will also be constructed in the second half of 2020 in the western wall and south eastern corner of the TSF to allow access into the TSF for wall and floor cleaning activities.

Prior to the construction of each notch the dam engineer from Coffey Services Australia provides ERA with engineering designs and completes the required stability assessment. The design and assessment is also reviewed by an independent specialist to meet the requirements of the Rio Tinto Group Standard D5 – Management of tailings and water storage. Regulatory approval is also sought prior to the execution of notch works where such notches will result in a change to the certified clay core crest height and associated decrease to the maximum operating level (MOL) of the TSF.

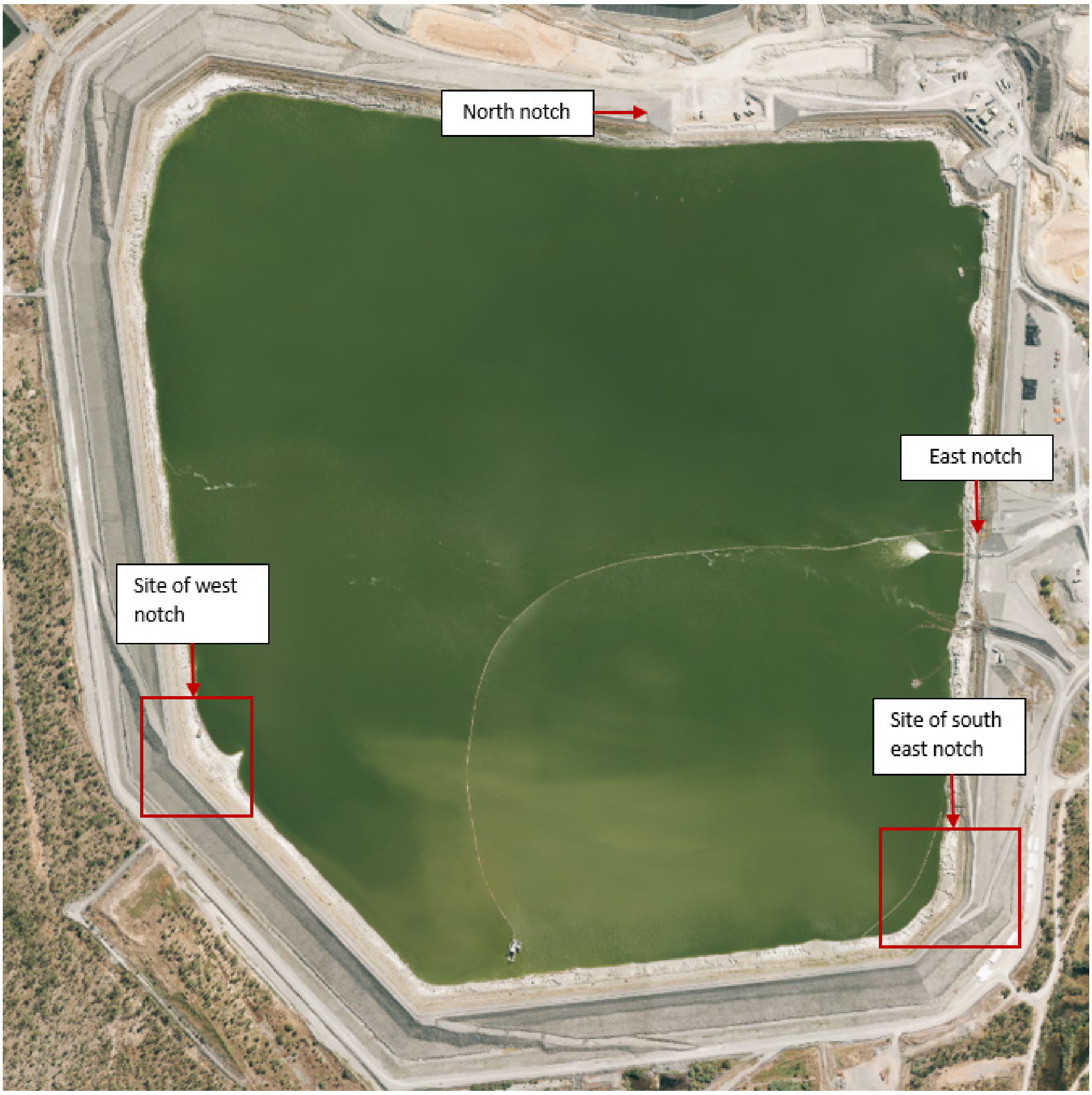


Figure 9-36: Location of notches within the TSF walls

9.3.3.3 Planned rehabilitation

Current scheduled milestones for the closure of the TSF are provided in Table 9-22 andTable 9-23.

Table 9-22: Milestone tasks for closure of the TSF

Task	Scheduled
Dredging increased to full operational capacity, completion scheduled for January 2021.	January 2021
Decommissioning of the dredges and tailings transfer infrastructure. Removal of remnant tailings/contaminated material from the TSF floor and walls.	August 2021
TSF cleaned, process water returned from Pit 3 to TSF.	September 2021

Task	Scheduled
Process water storage in the TSF ends, and deconstruction commences.	August 2024
Removal of TSF walls complete. Final landform contouring complete and commence revegetation.	1 October 2024

Table 9-23: Closure schedule for the TSF

ACTVITY	TASK	STATUS	20	21	22	23	24	25	>26
Infrastructure	Construction of dredge to deliver tailings from TSF to Pit 3	Complete							
Piping	Installation of tailings transfer piping and infrastructure	Complete							
Demolition	Decommission dredge and tailings transfer infrastructure	Scheduled							
Tailings	Removal of remnant tailings and contaminated material from TSF	Ongoing							
Process water	Conversion to water storage dam	Scheduled							
Decommission	Decommission TSF	Scheduled							
Remediation	TSF floor remediation – if required	Scheduled							
Waste	Grade 1 (1s) waste coverage	Scheduled							
Landform	Surface contoured to final landform shape	Scheduled							
Erosion	Installation of erosion control features	Scheduled							
Revegetation	Revegetation	Scheduled							

TSF floor cleaning

The floor of the TSF slopes from south to north. The floor will therefore be exposed in the southern section of the TSF prior to the completion of dredging. This is currently expected in September 2020 (Figure 9-37). Heavy mobile equipment such as dozers, excavators (land based and amphibious) and trucks will be able to access the southern section of the floor. The type of heavy mobile equipment employed will depend on the capacity of the TSF floor following drainage.

A broad outline of the proposed methodology to clean the TSF floor is as follows:

- a cleaning sweep to maximise the volume of tailings removed by the dredges has commenced
- the amphibious excavator, hydraulic monitor, and other equipment as necessary, will continue from the wall cleaning onto the floor, clearing a work area for dozers and stockpiling any foreign material (riprap, foreign objects etc.)
- heavy mobile equipment will be used to push tailings toward the dredge pool, where it will be recovered and pumped to Pit 3
- water monitors (hydraulic mining equipment) will be used to wash the tailings towards the dredge pool and 'clean the floor'

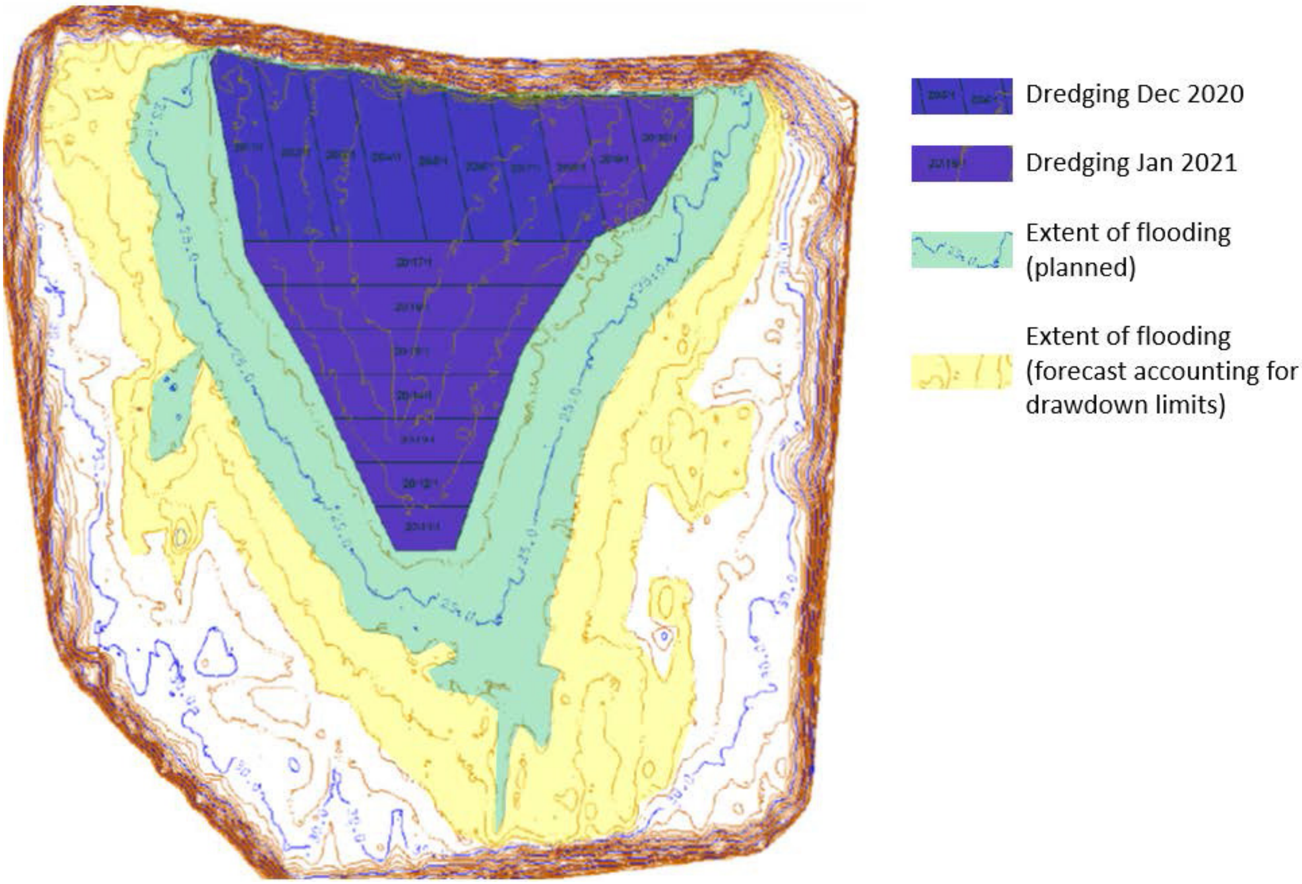


Figure 9-37: Mapping of water levels from the dredge plan

9.3.3.3.3 TSF subfloor material management

The management of contaminated sites is a critical step for rehabilitating Ranger mine and meeting closure criteria. The TSF subfloor was identified as an area requiring further investigation to assess the levels of contamination and solute egress risk based on a final disposal location. In June 2020, ERA submitted an application to the MTC to remove the option of transferring TSF subfloor material to Pit 3 as part of the closure strategy. An assessment was undertaken to identify a management option that would achieve the best environmental outcome in terms of minimising contaminant loading to the environment. The outcomes of supporting studies and a BPT assessment indicated that the most viable management option was to leave the subfloor material *in situ* as opposed to disposing the material within Pit 3. This outcome was important for informing the list of source terms for the closure of Pit 3 and to commence TSF deconstruction planning with consideration of future remediation options.

The outcomes of solute egress modelling undertaken by INTERA indicated that all options involving the transfer the TSF subfloor material to Pit 3 would increase the direct Magnesium (Mg) peak loadings to Magela Creek by a significant margin in contrast to leaving the material *in situ*. In addition, the physical removal of the TSF subfloor, and backfilling with waste rock, would further alter the hydraulic characteristics within the TSF footprint, causing changes to the surrounding drainage dynamics and increasing the peak Mg loading to drainage areas within the Ranger Project Area (RPA). It was also found that Mg loadings to the Coonjimba catchment (the nearest sensitive receptor to the TSF) will not differ significantly if either the TSF subfloor material is retained *in situ* or removed, when taking into consideration the contribution from the broader TSF groundwater plume. The modelling work is discussed detail with Section 5.5.2.5.

The TSF subfloor risk assessment concluded that the risks associated with leaving the TSF subfloor material *in situ* can be adequately managed. Any potential consequences resulting from this management option are likely to be confined to TSF footprint and surrounding drainage areas and represent consequences that are as low as reasonably achievable (ALARA) within the boundary of the RPA. In implementing this management option, ERA recognised the opportunity to undertake *in situ* remediation to further minimise levels of contamination. This would be investigated through further assessment.

Regulatory approval to leave the TSF subfloor *in situ* was received in August 2020. The TSF deconstruction application will include a BPT assessment of potential remediation options and an updated risk assessment to demonstrate how risk ratings can be improved.

Figure 9-38: Sampling of the TSF wall at North Notch 2 as part of the TSF wall and floor contamination sampling campaign

Dredge disposal

Due to the size and weight of the two dredges and associated workboats, this infrastructure will be dismantled prior to disposal. Options for disposal of the vessels include the following:

- burial in the TSF
- removal and burial in Pit 3 or RP2
- removal and decontamination for future sale

An environmental assessment, completed in 2018, determined the depth for burial of non-mineral waste as 6 m below final landform (Section 9.4.2). ERA has identified a suitable location in the south-east corner of the TSF; where the surface area and cover depths in relation to the final landform and minimum burial requirements allow for burial without need for further excavation. This option allows for the burial of the dredging equipment and any other miscellaneous waste material remaining in the TSF at the time of deconstruction.

The demolition contractor will dismantle and demolish vessels into suitably sized pieces to be spread within the available burial area. Vessels will be covered with waste rock during TSF deconstruction. The TSF burial option is currently being progressed, however sale of the vessels is still under consideration.

Process water storage

At the completion of the Pit 3 initial capping works, water in Pit 3 will be pumped back to the TSF for storage pending treatment. Once the process water volume in the TSF falls below 1 GL, the process water will be transferred out of the TSF into RP6. This allows the deconstruction of the TSF to occur, before the completion of process water treatment. Further details of process water storage have been provided in Section 9.4.3.1.

When the TSF is empty of process water, deconstruction will commence. During the deconstruction work the TSF will be converted to a pond water catchment. Any water captured in the TSF area after this time will be collected and transferred to Retention Pond 2 (RP2).

Upon completion of the final landform in this area, the TSF catchment will be converted to a release water catchment.

TSF deconstruction

TSF deconstruction will involve reducing the walls to final landform level. Wall material will be used to fill in the TSF basin. The majority of the material used in the construction of the TSF walls will fit into the TSF basin to achieve the final landform. A small volume of the wall material will need to be transported to a nearby stockpile area. The material in the wall will be mined using standard material movement practices with dozers, trucks and excavators. The TSF deconstruction material quantities are shown in Table 9-24 with sequencing shown in Figure 9-39.

Table 9-24: TSF deconstruction material quantities

TSF Segment	Material Movement	Brief Description
TSF EAST	Excavation and distribution to final landform levels: 835,121 m^3 Final landform surface area: 24.99 ha	Deconstruction of the eastern TSF walls. Utilise material to shape final landform surface in the eastern area. Excess material taken to other site fill areas.
TSF WEST	Excavation and distribution to final landform levels: 2,440,743 m^3 Final landform surface area: 43.07 ha	Deconstruction of the western TSF walls. Utilise material to shape final landform surface in the western area. Excess material taken to other site fill areas.
TSF SOUTH	Excavation and distribution to final landform levels: 2,881,980 m^3 Final landform surface area: 98.15 ha	Deconstruction of the southern TSF walls. Utilise material to shape final landform surface in the southern area. Excess material taken to other site fill areas.

TSF Segment	Material Movement	Brief Description
TSF NORTH	Excavation and distribution to final landform levels: 1,463,850 m^3 Excavation and distribution to Pit 3: 1,086,537 m^3 Final landform surface area: 31.19 ha	Deconstruction of the northern TSF walls. Utilise material to shape final landform surface in the northern area. Excess material taken to site fill areas.

TSF plume

Gradual seepage from the TSF, since the time of its construction, has resulted in the formation of a groundwater contamination plume. The extent and behaviours of the plume have been investigated repeatedly over the years (Weaver 2010). Test work and studies were completed during 2019 to further define the plume and model the groundwater transport (Section 5.5.2.5). A BPT assessment of potential remediation options for this plume is planned to be completed in conjunction with the other TSF contaminated material, as discussed above. These assessments and any remediation plans required will be included in the TSF deconstruction application and subsequent updates of this MCP.

Landform and erosion control

The final surface of the TSF will be shaped to form the final landform, refer Section 9.4.5 for details. The TSF topography forms a drainage flow path running south to north along the historic Coonjimba Creek.

Sediment and erosion control features for the TSF domain have been described in Section 9.4.5.3.

Revegetation

ERA is currently assessing the potential impacts on vegetation from any contaminated materials buried under the final landform. The outcomes of this work and any risk mitigation measures required will be included in the TSF deconstruction application, to be submitted for approval in 2023 and included in the subsequent update of the MCP

9.3.3.4 Contingency planning

TSF deconstruction methods are currently being finalised by ERA in preparation for the TSF deconstruction application. This involves a best practical technology assessment of the options. The options not selected for progression, that have not been show stopped for environmental or cultural reasons, will then form the basis of ERA's contingency planning.

The 2023 MCP will provide details of both the TSF deconstruction and the associated contingency planning.

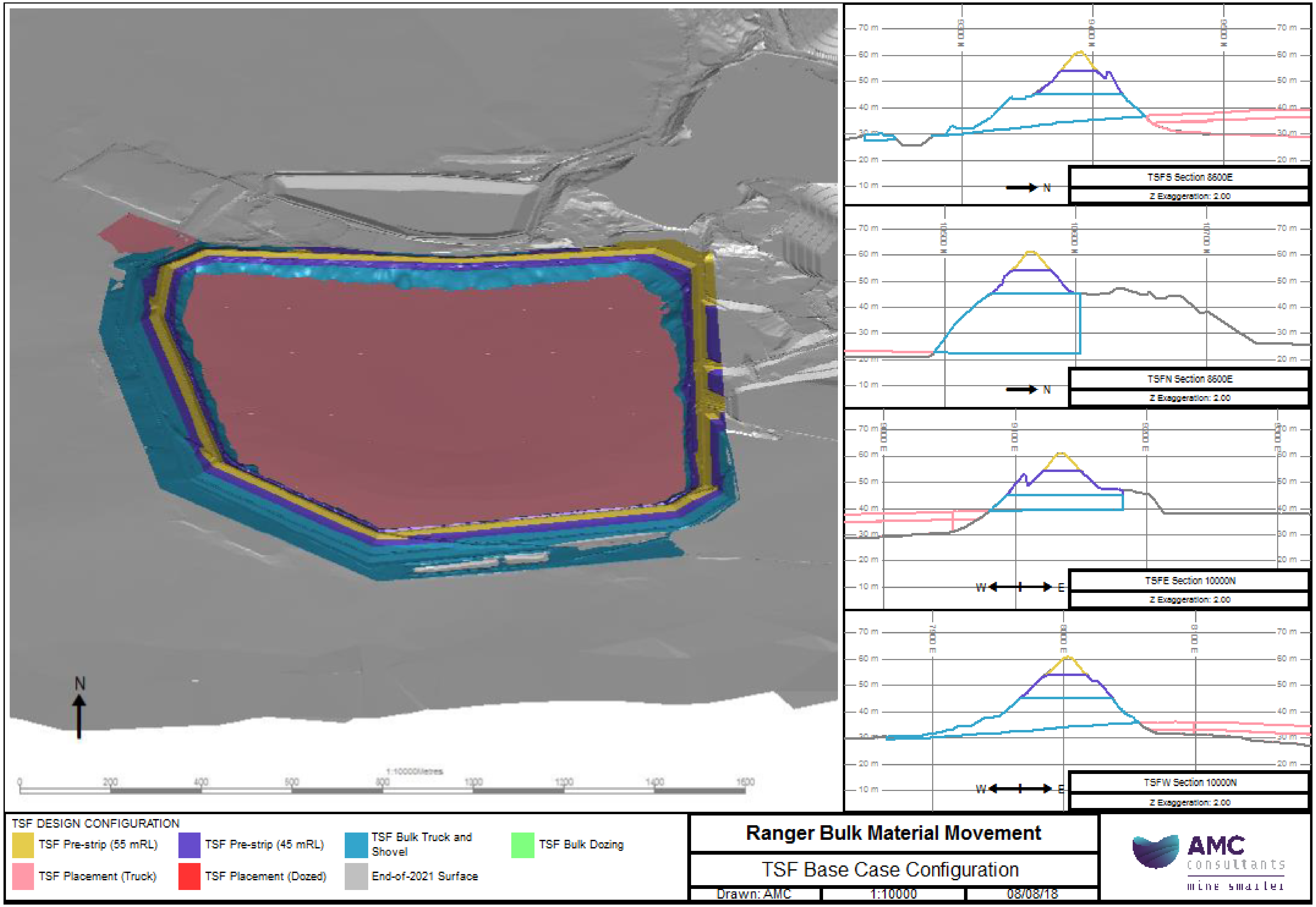


Figure 9-39: TSF wall deconstruction sequence

9.3.4 Land Application Areas

Figure 9-40: Djalkmarra and Djalkmarra Extension Land Application Areas (May 2019)

Land application areas (LAAs) will be required throughout closure to allow for the ongoing disposal of release water, generated through rainfall runoff and water treatment. As catchment areas transition to direct release (Section 9.3.7) and water treatment requirements reduce, these areas will gradually become available for decommissioning.

Decommissioning of these areas will involve:

- removal of any infrastructure (i.e. pipes, irrigation sprayheads). Figure 9-41 and Figure 9-42 provides some examples of infrastructure at each LAA
- completion of any remediation works, as determined from contaminated sites and best practical technology assessments
- scarifying of any tracks, as required
- completion of any infill revegetation, as required

Figure 9-41: Infrastructure for removal at Corridor Creek LAA (Oct 2019)

Figure 9-42: Infrastructure for removal at Corridor Creek LAA

A preliminary assessment of the total percentage of each LAA requiring rehabilitation has been made (Addison, 2011). The size of these areas is dependent on the quantity and quality of the native vegetation and the density of weeds, present after years of irrigation (Table 9-25).

Table 9-25: Area of the LAAs

#	LAA		AREA (ha)
A	Corridor Creek LAA	Total area:	131
		Planned rehabilitation (10%):	13.1
B	Magela A LAA	Total area:	33
		Planned rehabilitation (100%):	33
B	Magela B LAA	Total area:	20
		Planned rehabilitation (70%):	14
C, D	Djalkmarra East (DLAA) & Djalkmarra West (DLAA ext) LAA	Total area:	38
		Planned rehabilitation (50%):	19
E	Retention Pond 1 LAA	Total area:	46
		Planned rehabilitation (80%):	36.8
F	Retention Pond 1 LAA ext.	Total area:	8
		Planned rehabilitation (10%):	0.8
G	Jabiru East LAA	Total area:	52
		Planned rehabilitation (80%):	41.6
LAA – TOTAL HA			328
TO BE REHABILITATED – TOTAL HA			158

9.3.4.1 Completed rehabilitation

There has been no progressive rehabilitation undertaken of the LAA sites to date.

9.3.4.2 Current rehabilitation

Assessments are currently underway to determine the level of contamination in the LAAs (Section 5.5.2.4). These assessments will form the basis of a best practical technology assessment to determine what consequences will be considered as low as reasonably achievable for LAA remediation, thereby informing appropriate remediation plans for each. Further detail on the ALARA process is provided in Appendix 8.1. The rehabilitation percentages detailed in Table 9-26 will be reviewed for each LAA following the assessement.

9.3.4.3 Planned rehabilitation

Table 9-26: Closure schedule for LAA rehabilitation

DOMAIN	ACTIVITY	TASK	STAGE	20	21	22	23	24	25	26>
LAAs	Assess	Assessment of contamination in soils	Ongoing							
	Demolish	Staged removal of infrastructure	Scheduled							
	Remediate	Remediation, if required	Scheduled							
	Revegetation	In fill revegetation, if required	Scheduled							

As described above and shown in Table 9-25, it has been determined that only 158 ha within the total area of LAAs will require active revegetation (i.e. planting in addition to self-regeneration). As detailed above, a best practical technology assessment will be undertaken to assess the level of remediation required at each LAA. Following this determination, revegetation will be undertaken following the Ranger Mine Revegetation Strategy (Appendix 5.1) and the general approach which is described under the Section 9.4.6. Detailed remediation plans, as required, and revegetation plans for the LAAs will be provided in future updates of this MCP.

9.3.4.4 Contingency planning

No contingency planning is required for the LAAs:

- Land application areas will not be rehabilitated until the areas are no longer required for water disposal.
- Historical soil sampling has been undertaken across all the LAAs. The analysis of these soil assessments will be used to undertake a BPT assessment to determine, if required, the best strategy for remediation of the LAAs.
- Monitoring will determine whether the selected revegetation strategy has been successful and if any further additional works are required.

9.3.5 Process plant, water treatment plants & other infrastructure

Figure 9-43: Process plant, mill and water treatment plants (May 2019)

This domain as shown in Figure 9-43, includes all infrastructure from the processing plant, administration block, heavy vehicle area, gatehouse and water treatment plants. Other miscellaneous infrastructure around site is also discussed in this section in regards to demolition.

A discussion on the activity of water treatment is provided in Section 9.4.3, whilst this section describes the removal of the water treatment infrastructure.

The following infrastructure has been excluded from the Ranger Mine closure demolition scope as discussions are currently underway on the transfer of the facilities to the Northern Territory or Commonwealth government:

- offices of the Environmental Research Institute of the Supervising Scientist (ERISS)
- external services (Telstra).

9.3.5.1 Completed rehabilitation

As milling will continue until the end of 2020, there has been no progressive rehabilitation completed within this domain.

9.3.5.2 Current rehabilitation

Work has commenced on decommissioning and decontamination for any infrastructure within the processing plant that is no longer in use. This includes:

- laterite plant

- ore sorter
- leach pachuca tanks

The main goals of the decommissioning and decontamination implementation strategy are:

- conversion of the Ranger Project Area (RPA) from its current operational state to a decommissioned state
- controlled shutdown of all assets within a demolition area
- decontamination of all infrastructure to the extent required to ensure safe and efficient demolition and disposal
- de-energisation and isolation of each demolition area, scheduled in conjunction with the continuity of services works
- interim management of the demolition area until handover to the demolition contractor
- walk-down, punch-listing (checklist) and handover to the demolition contractor

Works to ensure the continuity of services have also commenced. This involves moving service corridors, such as power and water lines, outside of the future zone of demolition. This process is required to be completed before the commencement of demolition (Q1 2023).

9.4.1.1 Decommissioning

The overall shutdown of the plant has three steps, which are linked to the progression of decontamination works:

1. initial emptying and flushing of the energised plant, performed as per current ERA procedures for a major maintenance shutdown
2. shutdown, de-energisation and isolation of assets as required, to enable safe completion of decontamination (e.g. to enable confined space entry for intrusive cleaning or inspection works)
3. shutdown, de-energisation and isolation of all remaining assets to enable safe completion of demolition (e.g. de-energisation and isolation of the lighting, small power, services and utilities systems which has to remain active during decontamination)

Decommissioning will be phased to align with demolition. The main stages of the decommissioning works are represented in Figure 9-44. Prior to demolition of some components of the processing plant, ERA will obtain a ‘Permit to Decommission Facility’ from the Australian Safeguards and Non-Proliferation Office (ASNO). The application for a permit will outline timeframes and estimated start and completion dates for the decommissioning of infrastructure associated with the leaching and solvent extraction circuits and areas of calcination, drying and product packing. The permit application will be submitted following the cessation of uranium oxide production. Decommission works can only proceed following the receipt of, and in accordance with the permit.

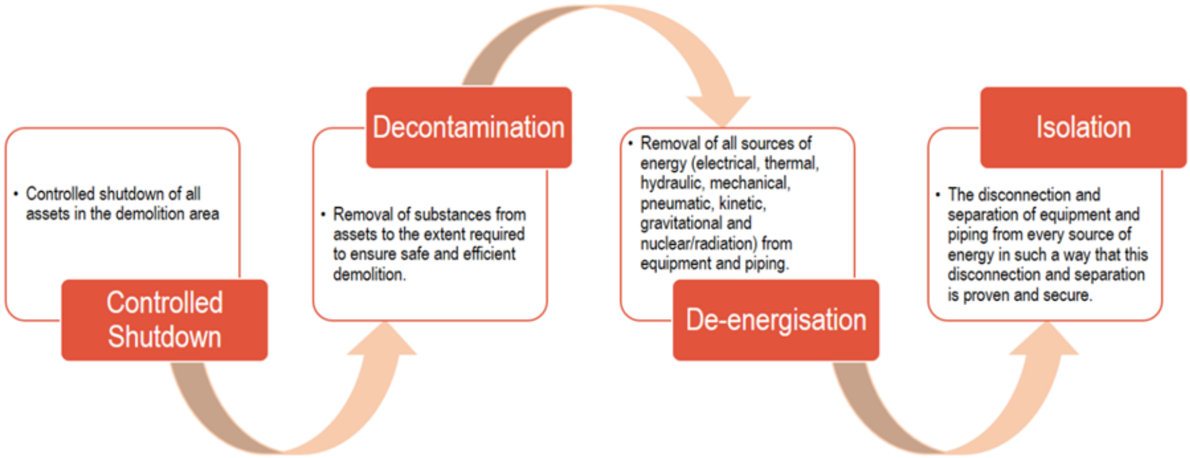


Figure 9-44: Decommissioning stages

The decommissioning phase involves the decontamination of assets in the demolition area. This work is required to ensure safe and efficient demolition and disposal. It will include the following activities:

- decontamination of piping and in-line items
- decontamination of equipment
- preparation of equipment to be disposed whole and intact. This is applicable to equipment containing loose internals that are contaminated with radioactive material.
- documentation of equipment that cannot be decontaminated as an identified residual hazard. The type of hazardous material, along with the reasons why it could not be decontaminated, will be documented appropriately.
- demonstrating completion of decontamination activities by spray painting the asset on site and highlighting, initialling and dating the asset on the decommissioning drawings
- emptying of all stockpiles
- hosing, flushing and emptying of bunds and sump tanks
- draining of oil from transformers, gearboxes, hydraulic systems and lubrication systems and steam cleaning of large oil reservoirs
- opening of all manual valves, drains, vents to demonstrate a vented and free-draining state
- removal of all hazardous materials as per ERA standard
- completion of radiation surveys on the exterior of assets and in the general demolition area, as per ERA standards and operating procedures

- completion of gas clearance surveys, where required

All de-energisation and isolation activities of the demolition area will be divided into electrical and control, piping, structural and miscellaneous and all activities will be completed according to ERA standards.

A decommissioning sequence has been determined for the areas of the plant based on the interaction of the plant decommissioning with other activities in the overall closure project. The criteria that determines, at a high-level, the sequence in which the area can be decommissioned, are as follows. Each plant area is colour coded according to the sequencing in the decommissioning (Figure 9-45):

- Infrastructure not in use (highlighted in yellow): Decommissioning of these assets can commence at any time.
- Infrastructure not required post-mill operation (highlighted in green): Decommissioning of these assets can commence after the mill stops operation. Some areas will require a Permit to Decommission Facility from the Australian Safeguards and Non-Proliferation Office prior to the start of decommissioning.
- Infrastructure required for continuity of services (highlighted in blue): Decommissioning of these assets can only proceed after the continuity of services scope of work has been completed.
- Laydown areas (highlighted in light pink): These areas are currently in use but require minimal decommissioning work prior to handover to the demolition contractor. Decommissioning is to proceed as the areas become available with ramp-down of operations.
- Infrastructure required for water treatment (highlighted in red): Decommissioning of these assets can only proceed after treatment of process water is completed.

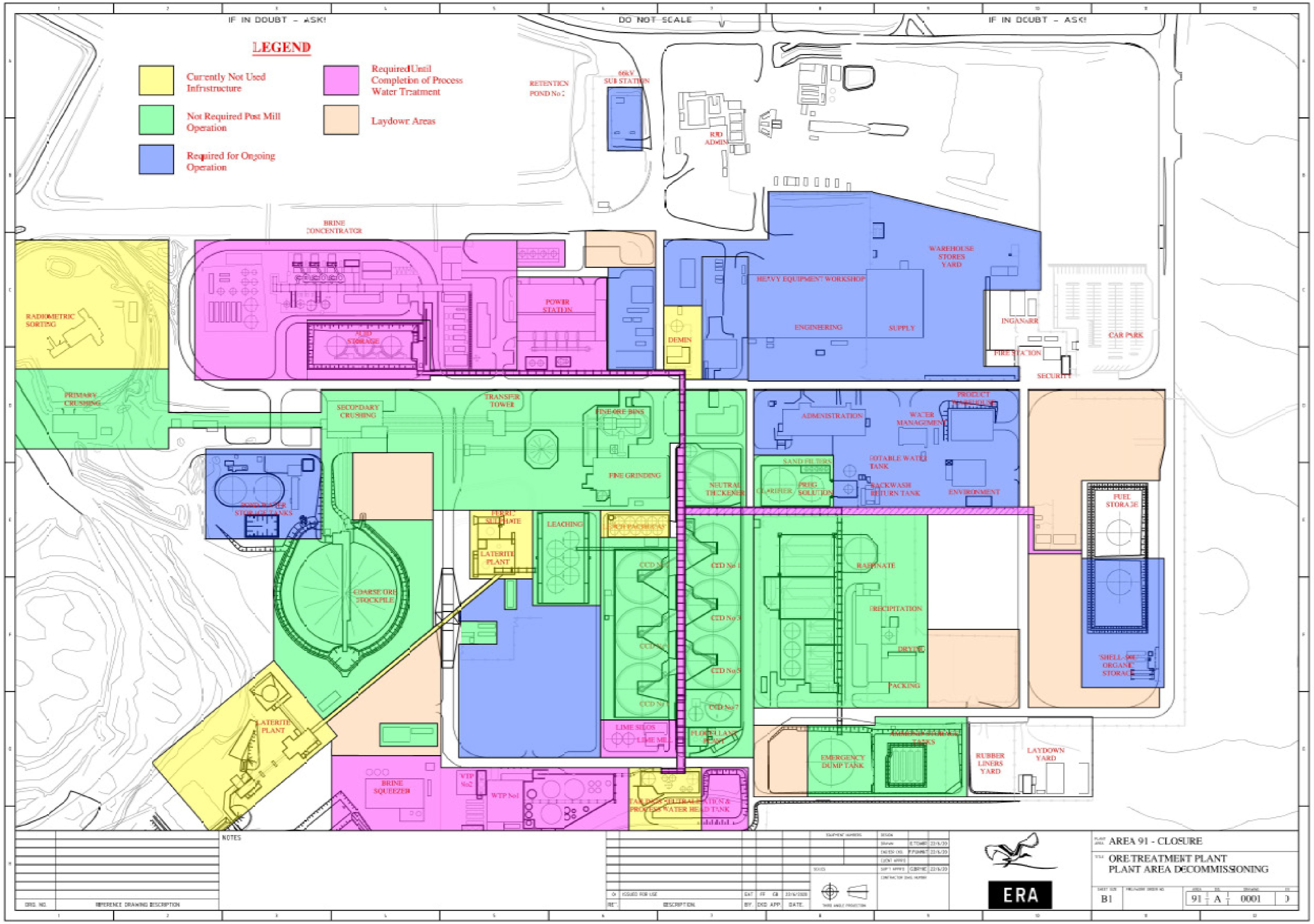


Figure 9-45: Plant decommissioning sequence

The interim management of the demolition area (prior to handover to the demolition contractor) will involve the following activities:

- Management of rainwater in the process area bunds once the existing system of sump pumps are shutdown. This shall include the following activities:
  - sampling and testing of rainwater in 'decontaminated' sumps to confirm that it is still sufficiently contaminated that it cannot be released
  - design and installation of a system of portable diesel pumps and lay flat hosing to pump contaminated rainwater to the retention ponds
  - documentation of the system to enable handover of management to the demolition contractor
- Demarcation of the demolition area boundary with tape or spray paint
- Installation of a temporary generator to connect to the light and power board to provide power for lighting in de-energised buildings during inspection activities. This generator is to be removed after inspection activities are completed.
- Completion of the decommissioning work pack and handover check sheet (by the responsible party as the work is completed), including:
  - initialled and dated sign-off of all work by the responsible party
  - identification of any residual hazards on registers and drawings, and
  - results of radiation survey, gas clearance surveys and underground services surveys appended to the work pack.
- Walk-down of the demolition area (without the demolition contractor) to confirm completion of all activities in the decommissioning work pack and punch-listing (checklist) incomplete items. Sign-off of the completion of activities is to be performed by the following accountable parties:
  - Area Superintendent – to confirm that all shutdown and decontamination work is complete
  - Radiation Safety Officer – to confirm all radiation surveys have been completed correctly and radiation levels are acceptable
  - Safety Officer – to confirm that all gas clearances have been completed correctly and explosion risks have been removed, and
  - Closure Project Engineering – to confirm that all continuity of services and de-energisation and isolation work is complete.

- Gas clearance and radiation surveys will be re-performed immediately prior to handover to demolition, to confirm areas are still safe after any extended period between decommissioning and demolition.
- Second walk-down and punch-listing (check list) will be undertaken with the demolition contractor (to be conducted with demolition contractor prior to mobilisation of demolition equipment and crew to site and with sufficient schedule float for rectification works). As a minimum, the following checks are expected to be requested by the demolition contractor:
  - verification that all energised piping systems (i.e. services) that have lines passing into the demolition area have been air-gapped
  - verification that all de-energised piping systems that have lines passing into the demolition area and have all block valves, drain valves and vent valves open
  - verification that all underground pipes passing into the demolition area have been air-gapped, where they pass above ground outside of the demolition area
  - verification that all cables passing into the demolition area via cable trays/ladders have been air-gapped
  - verification that all underground cables have been air-gapped, where they pass above ground outside of the demolition area
  - review of any items of note as marked up on check sheets (e.g. residual hazardous materials, underground pipes with fluid in them)
  - review of all gas free clearances and sampling points

9.4.1.3 Continuity of services

Some services are required to be kept online or re-routed to allow continued operation of some aspects of the mine beyond cessation of operations.

Key aspects of the continuity of services plan:

- Essential services are assumed to remain operational, as per the current operating system, until commencement of Phase 1 demolition (Table 9-30).
- Services within the Phase 1 demolition zone which are required after demolition are subject to continuity of services.
- Central “hub” for infrastructure post-plant decommissioning will be in the decommissioned Ranger 3 Deeps area
- Equipment will be reused where possible

- purchase of new equipment will be minimised, and
- pipe and cable routes will avoid the Phase 1 demolition zone, where possible.

Continuity of services requires 221 piping tie-ins for various services. These services are split into ten separate packages of work in the following services:

- acids and reagents
- portable water
- plant air
- diesel
- fire water
- miscellaneous
- pond water
- instrument air
- process water
- sewage.

9.3.5.3 Planned rehabilitation

Current schedule milestones for demolition are provide in Table 9-27.

Table 9-27: Schedule key milestones for completion of demolition

Key milestone	Date
Decommissioning	Q1-Q3 2021
Commence Phase 1 demolition	Q1-Q3 2023
TSF ready for deconstruction (RP6 ready for process water storage)	Q2 2024
Complete decant pumping from Pit 3 to TSF	Q1 2024
Complete process water treatment	Q1 2025
Commence Phase 2 demolition	Q2 2025
Undertake remediation of any identified contaminated sites	Q3 2025
Final landform earthworks	Q3 2025
Revegetation	Q4 2025
Handover / end of RPA lease	08 January 2026

The schedule for closure activities in this domain is provided in Table 9-28.

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Table 9-28: Schedule of closure activities for the processing plant, administration buildings and water treatment structures.

DOMAIN	ACTIVITY	TASK	STATUS	20	21	22	23	24	25	26>
Processing plant, admin buildings and water treatment infrastructure	Services	Continuity of services	Ongoing							
	Decommissioning	Decommission of processing plant and place in care and maintenance.	Scheduled							
	Demolition	Phase 1 demolition of plant and place in stockpile for placement in Pit 3 / RP2. Removal of footing to 1.5 m depth	Scheduled							
	Remediation	Remediate if required	Scheduled							
	Demolition	Phase 2 demolition: Removal of water treatment infrastructure, including pipelines and services	Scheduled							
	Demolition	Administration infrastructure	Scheduled							
	Remediation	Remediate if required	Scheduled							
	Landform	Surface contoured to final landform shape	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation	Scheduled							

Demolition and disposal

All plant, equipment, buildings and other structures will be removed unless approval of the Traditional Owners and Commonwealth Minister is provided for infrastructure to remain on the RPA.

Demolition is defined as the tearing down of buildings and other structures (including the underground works) within the boundaries of the RPA. It includes:

- fixed or demountable process plant, buildings, mechanical or electrical infrastructure
- tanks, both above and below ground
- all pavements (bitumen and/or concrete) and associated infrastructure such as kerbs, gutters and gully pits
- concrete slab and foundations to a depth of 1.5 m below ground level
- all piping to a depth of 1.5 m below ground
- all cabling to a depth of 1.5 m below ground
- bitumen surfaces from roads
- asbestos
- loose solid materials across the sites
- processing of demolished materials to 1 m x 1 m lengths to ensure maximum density can be achieved at the disposal location
- removal and final disposal of the materials and hazardous waste

Demolition differs to deconstruction. Deconstruction involves dismantling structures to preserve valuable elements for reuse. Deconstruction will occur where it is unsafe and/or there is a danger of damaging other assets that are required for the continuity of services. The use of deconstruction methodologies will be minimised as this takes more time and is thus considerably more expensive.

Demolished items must be buried on site at 6 m level deep below final landform, refer Section 9.4.2. Due to this ERA requirement, infrastructure will be disposed of in Pit 3, RP2 or other purpose excavated locations on site. The environmental impact from burial in these locations has been assessed as part of ERA solute transport model. Some hazardous wastes will be returned to suppliers following strict removal guidelines and requirements.

Demolition of infrastructure within a certain area is deemed to be complete when the area is available for rehabilitation activities (bulk material movement and final landform works) and, subsequently, revegetation activities.

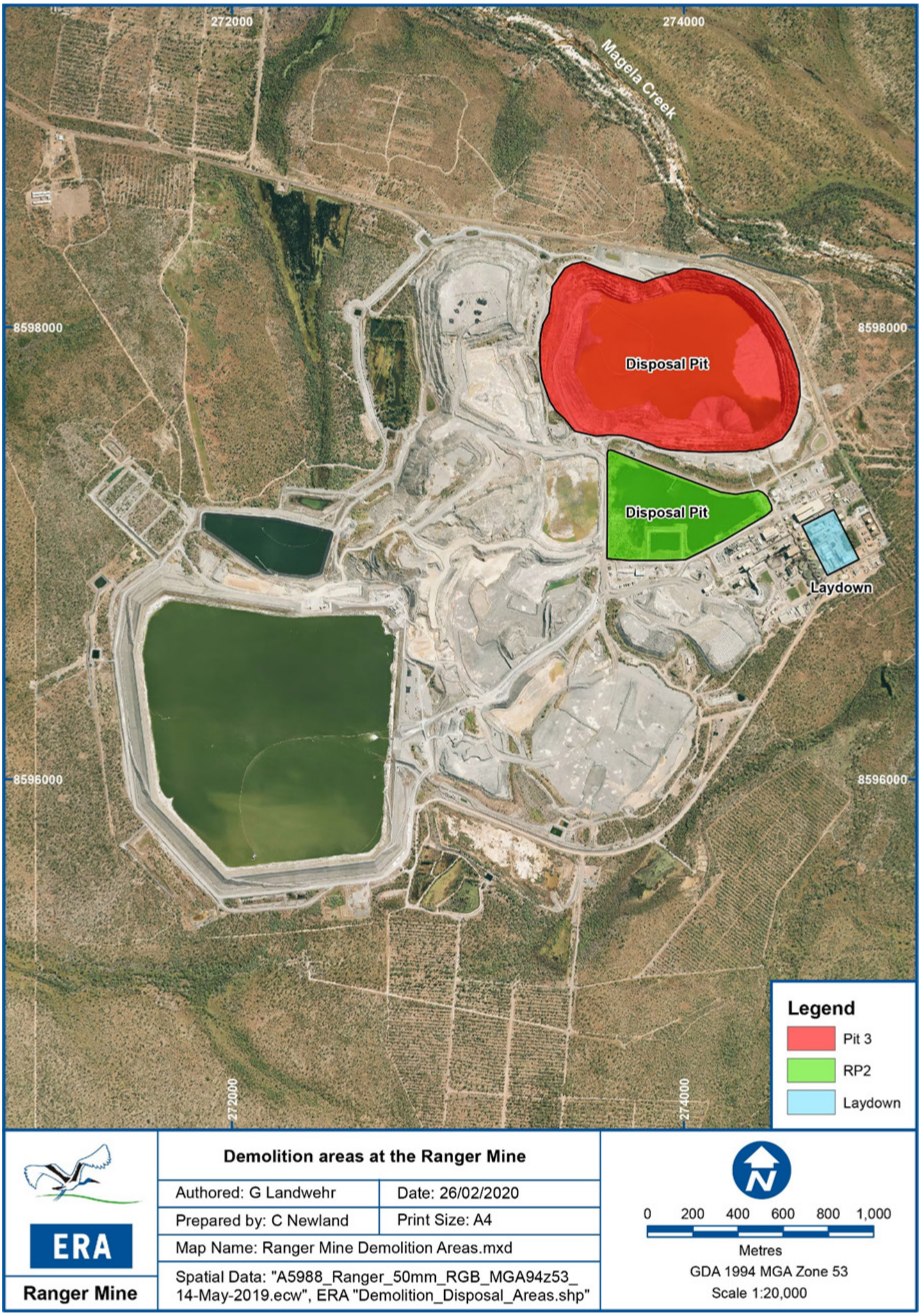

Figure 9-46: Areas for disposal of demolition material

Table 9-29: Demolition phases

Phase	Approximate duration	Associated infrastructure
1	January 2023 to December 2023	Mill, processing plant and tailings transfer infrastructure
2	April 2025 to September 2025	Process water treatment / transfer, mine and closure activities infrastructure
3	October 2027 to December 2027	Post-closure management infrastructure

The following demolition methods will be used to demolish the facilities on the RPA:

- manual demolition
- mechanical demolition
- cut and pull
- induced collapse
- explosive demolition

Wherever possible, large-scale demolition activities will be performed using machinery as it is the quickest, safest and cheapest method. Where explosive demolition is used, the demolition contractor will provide a detailed explosives plan prior to mobilisation.

The key infrastructure and services for Phase 1 works, including demolition and transportation of the waste (including hazardous materials) to Pit 3 are listed in Table 9-30. The key infrastructure and services for Phase 2 works are listed in Table 9-31: Phase 2 demolition areas.

Asbestos was identified in the processing plant, power station and associated administration buildings through an initial audit of the Ranger Mine by Environmental Health Services in February 2003, and a subsequent audit by SLR Consulting in 2016. The quantities of asbestos across the site are relatively small and are located in clearly defined areas. Asbestos shall be removed by an appropriately qualified contractor and buried in Pit 3.

Detailed material take-offs (a list of materials with quantities and types) have been completed to provide a more accurate estimate for major process buildings. These include the fine crushing building, grinding building, solvent extraction plant, calciner and product packing, engineering supply workshop and power station. Quantities were approximated based on similar metrics for remaining areas.

Table 9-30: Phase 1 demolition areas

Area	Infrastructure/service demolished
Radiometric sorting	All infrastructure and services
Primary crushing	All infrastructure and services
Fine crushing	All infrastructure and services
Demin plant	All infrastructure and services
Engineering and supply	All infrastructure and services
Grinding	All infrastructure and services
Leaching, counter-current decantation (CCD) and clarification	All infrastructure and services
Neutralisation	All infrastructure and services
Solvent extraction	All infrastructure and services
Laterite treatment plant	All infrastructure and services
Product warehouse	All infrastructure and services
Precipitation, drying and packing	All infrastructure and services
Ammonia handling	All infrastructure and services
Sewage treatment	All infrastructure and services
Pond water	Pond water tanks demolished, pond and fire water system and pumps relocated to R3D
Acid storage	Acid storage tanks A and B, and distribution pumps
Bulk fuel storage	Bulk fuel storage tank B and shellsol tanks
Administration	All – laboratory and laundry relocated to R3D
Plant services	All – One compressor relocated to Water Treatment Plant 1 (WTP1)

Phase 1 demolished materials will be disposed of in Pit 3 whilst it is open and accessible, concurrently with bulk material movement works. Demolished items will be processed at the designated laydown area (Figure 9-46) and transferred to Pit 3.

The following items have been identified as materials that should not be processed but placed in Pit 3 whole due to the expected level of contamination post decommissioning:

- calciner
- sand filter in SX building
- asbestos drums

The key assumptions for Phase 1 are:

- all Phase 1 demolition material to be disposed of in Pit 3

- all Phase 1 demolition hazardous materials (except for contaminated hydrocarbons and items returnable to vendor, such as density gauges, acid and ammonia) to be disposed of in Pit 3
- disposal activities in Pit 3 will be concurrent with bulk backfill activities
- disposed items in Pit 3 to be buried 6 m below final landform (Section 9.4.2)

Phase 2 demolished materials will be disposed of in RP2 concurrently with rehabilitation works. Key assumptions for the Phase 2 demolition are:

- phase 2 materials can be disposed of in RP2 if pond water storage requirements permit
- ERA mobile fleet, consisting of 18 heavy vehicles (21,000 m^3), and light vehicles will be disposed of in RP2. Forklifts and service trucks will be taken offsite
- items disposed in RP2 are to be buried 6m below final landform

Table 9-31: Phase 2 demolition areas

Area	Infrastructure/service demolished
Bulk fuel storage	All remaining infrastructure and services
R3D	All remaining infrastructure and services
Brine concentrator	All remaining infrastructure and services
Mine centre	All remaining infrastructure and services
Water treatment plant 3 (WTP3)	All remaining infrastructure and services
Power station	All infrastructure and services
Security, gatehouse and emergency services	All remaining infrastructure and services
Acid storage	All remaining infrastructure and services
Orica yard	All remaining infrastructure and services
Tailings Storage Facility (TSF)	All remaining infrastructure and services
Retention ponds	All remaining infrastructure and services
WTP1 and WTP2	All remaining infrastructure and services
Brockman bore field	Remain post-closure for potable water supply

9.3.5.4 Contingency planning

If the demolition of specific infrastructure planned to be deposited into Pit 3 is delayed, then RP2 has the capacity to take extra material than currently planned.

9.3.6 Stockpiles

Figure 9-47: Stockpile area (May 2019)

Bulk material movement from the stockpiles is covered in the activities Section 9.4.4.

9.3.6.1 Completed rehabilitation

A 3.6 ha section of the stockpile Stage 13.1 (Areas A-C), became available for revegetation at the beginning of 2020 (Figure 9-48). ERA used this area to conduct opportunistic, small-scale precursor revegetation trials to inform future large-scale Pit 1 activities.

Stage 13.1 (Areas A-C) is the remainder of a waste rock stockpile that was cut down to the designed final landform surface level and used to backfill Pit 1, leaving an average 3.1 m thickness of waste rock overlying natural ground. On inspection, the surface material was identified as relatively fine compared to previous revegetation experience such as on the trial landform. The area was ripped at 3 m intervals to a depth of 50 cm to provide surface roughness and alleviate any compaction.

Area A (0.6 ha) did not require additional surface works and 1,207 tubestock of 22 species were planted out on the 16th and 17th of April 2020. All of the planted tubestock are part of trials under investigation by the ERA. These trials are further described in 9.3.1.3.

Figure 9-48: Native seedlings planted on Stage 13.1 (8 July 2020)

9.3.6.2 Current rehabilitation

Refer to bulk material movement section (Section 9.4.4).

9.3.6.3 Planned rehabilitation

Mining of stockpiles for the backfilling of Pit 3 and creation of the final landform is scheduled to commence in October 2022. Mining material from stockpiles and the TSF is scheduled for completion in September 2025.

The bulk material movement (BMM) plan provides for excavation of areas above the final landform (in the stockpiles and TSF) when there is nearly 100 percent acceptable material for the final landform. However, mineralised material will be mined below the final landform height in many areas of the stockpiles and will be placed into Pit 3. Therefore, a proportion of material in the stockpiles will remain in place as it is not mineralised and is already below level of the final landform.

Figure 9-49: Mining Stage 10 of the stockpile area (waste is transferred to backfill Pit 1)

Table 9-32: Schedule for closure activities for the stockpile area

DOMAIN	ACTIVITY	TASK	STATUS	20	21	22	23	24	25	26 >
Stockpiles	Waste	Bulk backfill	Scheduled							
	Landform	Surface contoured to final landform shape	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation	Scheduled							

Landform & erosion controls

Earthworks for final landform construction, including erosion control structures, will be implemented after the bulk material movement from the stockpiles is complete (Section 9.4.5).

Revegetation

The two remaining sections of Stage 13.1 will be revegetated in October 2020 (Area B) and early 2021 (Area C, pending Pit 1 logistics). Area B (~1 ha) is planned to be planted out in October 2020 and will be part of a 'dry season/build up' planting trial. Area C (~3 ha) will be revegetated in early 2021 with 'general planting' which consists of overstorey and midstorey species typical of local Eucalypt-dominated woodland ecosystems, planted at 1000 stems/ha.

Revegetation of other stockpile areas will be undertaken following the Ranger Mine revegetation strategy (Appendix 5.1). A detailed revegetation plan for the stockpiles will be provided in future updates of this MCP.

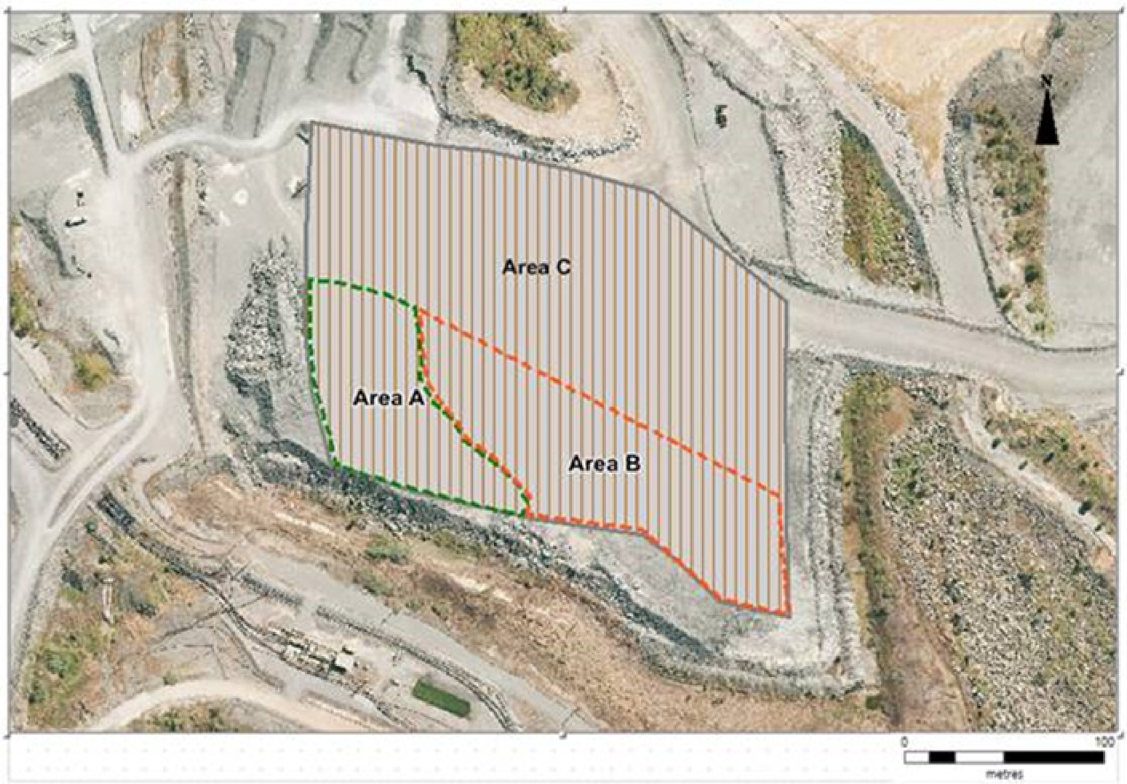

Figure 9-50: Planting areas A, B and C of Stage 13.1

9.3.6.4 Contingency planning

There are no contingencies specific to the stockpile domain as:

- All mineralised material will be moved to Pit 3 through bulk material movement scheduling
- Contingencies for unsuccessful revegetation or erosion control are covered in Section 9.4.5.7.

9.3.7 Water management areas

Figure 9-51: Retention Pond 1 (RP1) and RP1 Wetland Filter (May 2019)

Figure 9-52: Retention Pond 2 (May 2019)

The effective management of water at the Ranger Mine is critical for successful operations and closure and to ensure the surrounding Kakadu NP remains protected. There is an ongoing need to actively manage water throughout the closure phase. By January 2026, however, all water management areas will need to have been rehabilitated. These water management areas include:

- pond water storage (RP2 and RP6)

- release water storage (RP1, GCMBL and Sleepy Cod)
- wetland filters (Corridor Creek wetland filter and RP1 wetland filter)
- various water management sumps
- onsite billabongs that have received release discharge water

This section provides a summary of how the various water management catchments will be managed and an outline of the overall plan for closure of these water management areas. Land application areas are also water management areas, but are discussed under a separate domain (Section 9.3.4). Further details of each water management area, the different classes of water at Ranger Mine, and their use during operations is provided in Section 9.4.3.

Figure 9-53: Corridor Creek Wetland Filter (November 2019)

9.3.7.1 Completed rehabilitation

No progressive rehabilitation has been possible to date as all water management areas are in use.

9.3.7.2 Current rehabilitation

There is no current rehabilitation underway as there are no areas available.

9.3.7.3 Planned rehabilitation

The exact timing and methods for the rehabilitation of the various water management areas will depend upon a number of factors, primarily rainfall and continued need. Currently, within the closure schedule, each is assumed to undergo rehabilitation as late as possible. This is expected to commence in 2023 and been staged through to the end of closure, depending upon the level of rehabilitation required.

Table 9-33: Schedule for water management area closure activities

DOMAIN	ACTIVITY	TASK	STATUS	20	21	22	23	24	25	26 >
Water management areas	Decommission	Remove lining of RP6, and infrastructure of RP 2, 3 & 6	Scheduled							
	Landform	Surface contoured to final landform shape (RP 2, 3 & 6)	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation	Scheduled							

Catchment management

This section describes the major activities associated with the conversion of catchments throughout closure from pond or process water to release water. The Ranger Water Management Plan describes the detailed aspects of water and catchment management on the RPA.

Each catchment may comprise several elements, such as retention ponds, sumps, collection basins and groundwater interception ponds. The staged formation of the final site landform results in water catchments being converted to release water catchments over time. Once the final landform of an area is completed, it becomes a release catchment. Any rainfall captured on final landform areas will be directed to release, in accordance with the Ranger Water Management Plan.

Due to the slope of the final landform, surface runoff water from some of the catchments will need to be actively diverted, or collected and pumped, to prevent it from reporting to pond or process water catchments. This is currently managed by operations through the Ranger Water Management Plan, and this will continue throughout closure.

Pond water storage

Pond water collected on the RPA is transferred to RP2 (the main pond water storage) or RP6. Water inventory within the ponds is maintained to a minimum level to ensure the supply of pond water to the mill. The total inventory of pond water is balanced between RP2 and RP6 to prevent the overflow of RP2 into Pit 3.

When operations cease, the required minimum inventory of pond water is substantially reduced. The primary use for pond water at this stage will become dust suppression. The total inventory of RP6 will be transferred to RP2, most likely in the dry season. This allows the conversion of RP6 to a process water storage (see details below). RP2 will then become the only pond water inventory on the RPA. RP2 will remain an open pond water store and catchment until the collection and treatment of pond water is completed.

Retention Pond 6

To allow earlier deconstruction of the TSF, process water in the TSF will be transferred out of the TSF into RP6. This is initiated once the process water volume in the TSF falls below a threshold level. The total process water storage volume of RP6 is approximately 800 ML. This plan assumes that the transfer of water from TSF to RP6 will take a maximum of one month, after which, RP6 is the only process water store on the RPA.

When water transfer starts, all infrastructure associated with process water must be relocated from the TSF to RP6. This includes infrastructure associated with:

- WTP brine discharge
- Brine Squeezer brine discharge
- Brine Squeezer process water feed
- BC concentrated brine discharge
- BC process water feed
- HDS plant process water.

Whilst RP6 has historically been used for storage of pond water, it was originally designed with the ability to store process water, being fitted with a lining system and both an underdrain system (to mitigate uplift) and a leak detection/recovery system. The RP6 conversion plan outlines the conversion of RP6 to a process water store. RP6 will remain a process water store and catchment until the treatment of free surface process water is completed.

Once the free process water inventory reaches zero then the demolition of RP6 will commence. This will involve the removal of the liner and the subsequent burial in RP2, followed by the recontouring of the site to form the final landform

Retention Pond 2

RP2 is an identified site for the disposal of waste generated during Phase 2 demolition. Once all the pond water has been treated on site, RP2 will be prepared to receive waste material from Phase 2 of demolition. Details of the volume available for storage in RP2 and the types of material to be disposed have been detailed in Section 9.4.2. Following the completion of waste disposal, the pond will be backfilled to final landform with waste rock. An environmental assessment, completed in 2018, determined the minimum depth for burial of non-mineral waste beneath the final waste rock landform as 6 m. ERA is currently designing waste disposal sites to have a minimum thickness of waste rock material cover of 8 m.

Release water storage

Release waters are stored within RP1 and GCMBL. As detailed in the land application areas section (Section 9.3.4), these ponds will be required until almost to the end of closure. Once no longer required, these areas will have any infrastructure removed, be re-contoured and revegetated. Refer to Section 9.4.1 for details of further assessments to determine if any additional remediation works are required.

Wetland filters

ERA has installed wetland filters at Ranger Mine to passively treat water prior to release. Historically, raw pond water was sent to these wetland filters. More recently, however, the filters provide final polishing receiving water of better quality and the BC distillate.

Wetland filters will be required throughout the majority of closure for ongoing water management. Once no longer required, the areas will be rehabilitated by the removal of any infrastructure, and by recontouring and revegetated. The use of these areas for passive water treatment over the years may have resulted in some level of contamination. These areas will be assessed to determine the extent of any contamination and a best practical technology assessment undertaken to determine if any additional remediation work is required.

Water management sumps

The Ranger Water Management Plan requires many sumps and pumps to manage the flow and separation of classes of water throughout the wet season. This will continue during closure.

As the construction of the final landform is progressed and catchments are converted to direct release, sumps will no longer be required. These sumps will be rehabilitated by the removal of any infrastructure, and by recontouring and revegetation.

Onsite billabongs

There are two billabongs on site that have received release quality water throughout operations. These billabongs, Georgetown and Coonjimba, will continue to receive direct release water from the final landform during and after closure.

Studies are currently underway to assess the rehabilitation strategy for these billabongs (Appendix 5.1). This information will be provided in future versions of this MCP.

Revegetation

Revegetation will be undertaken in accordance with the Ranger Mine revegetation strategy (Appendix 5.1). A detailed revegetation plan for the water management areas will be provided in future updates of this MCP.

9.3.7.4 Contingency planning

As the final rehabilitation plan for many water management areas is not complete, contingency plans have not yet been developed. Those areas that are simply being removed do not require a contingency plan.

If RP2 is later determined to be unsuitable as a waste disposal site, an alternative landfill will be constructed on site following an appropriate approval process.

Studies assessing the current level of contamination of various water management areas are currently underway and have been detailed in Section 5.5.2. Once complete, these studies will be used to determine if remediation of any area is required and inform the final closure strategy for each. This closure strategy will be provided in future updates of this MCP.

9.3.8 Linear infrastructure

Figure 9-54: Multiple tracks east of Pit 3 (May 2019)

Linear infrastructure around the site includes the various road, tracks, fences and other minor miscellaneous infrastructure and/or corridors that have been installed during operations. Areas included within this domain are indicated in Figure 9-54. These areas are outside of the final landform footprint. Rehabilitation will include removal of infrastructure and scarifying the natural soil, as required. This has been a successful rehabilitation protocol for areas disturbed during exploration on the RPA and requires neither direct seeding nor planting to achieve acceptable outcomes.

The planned rehabilitation of the ERA groundwater bore network is divided into three stages. Stage 1 is near completion, and involved the collation of all the information on the ERA groundwater monitoring network. ERA are finalising the last aspect of Stage 1 through the implementation of AcQuire, a geoscientific data management software package which will be used to track the progressive rehabilitation of groundwater bores located across the RPA. Stage 2 will involve the ground-truthing of all collated data and tracking in AcQuire, and is likely to commence later in 2020. Stage 3 involves the active decommissioning of redundant infrastructure and is likely to commence late 2021.

The timing for the rehabilitation of linear infrastructure will be based on the utilisation requirements for operations and/or closure. Some linear infrastructure, for example the boundary fence and various access roads, may be required following 2026 as part of the ongoing monitoring, maintenance and security of the site. Discussions with Traditional Owners are underway to determine preferred pathways for cultural use in the future.

9.3.8.1 Completed rehabilitation

There has been minimal opportunity for progressive rehabilitation of the linear infrastructure. Two redundant tracks have been rehabilitated, totally an area of 3.65ha.

There have also been six drill pads rehabilitated, representing 0.8ha of previous disturbance.

9.3.8.2 Current rehabilitation

No current rehabilitation underway.

9.3.8.3 Planned rehabilitation

Table 9-34: Schedule for linear infrastructure closure activities

DOMAIN	ACTIVITY	TASK	STATUS	20	21	22	23	24	25	26 >
Linear infrastructure	Demolition	Remove any infrastructure in corridors (roads, tracks, service corridors, exploration lines, groundwater bores)	Scheduled							
	Landform	Recontour and/or rip if required. Block access to tracks	Scheduled							
	Infrastructure	Install fencing and/or signs if agreed to by TOs	Scheduled							

9.3.8.4 Contingency planning

There are no contingencies required for this domain. However, permission to leave infrastructure such as fencing and signage in place after January 2026 will be obtained before that time.

9.3.9 R3 Deeps decline

Figure 9-55: R3 Deeps portal and offices (May 2019)

The Ranger 3 Deeps (R3D) exploration decline (the decline) was constructed between May 2012 and December 2014, to allow for exploration and delineation of the Deeps resource associated with the proposed R3D underground mine, east of the Ranger Mine Pit 3 (Figure 9-55). The decline was extended, and the ventilation shaft was constructed between October 2013 and October 2014. Exploration diamond drilling began in May 2013. Preliminary drilling results were announced in August, and the third drill rig was mobilised in November 2013. Drilling ceased in September 2014.

The proposed R3D underground mine project was not progressed and the decline has been in care and maintenance (C&M) since June 2015.

Closure planning has considered the major R3D infrastructure including the:

- decline (which is 2,710 m long, 5.5 m wide by 6.0 m high, and descends at a gradient of 1 in 6 to approximately -430 mRL),
- ventilation shaft (approximately 3 m wide, extending to 280 m below the ground)
- portal (a steel lined "tunnel" which extends 185 m from the ground surface, through the weathered rock zone to approximately -8 AHD[4]) (Figure 9-57).

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4 AHD: Australian Height Datum.

Major infrastructure including pumps, fans, compressors, generators and refuge chambers will also be decommissioned and removed, where necessary.

ERA submitted an application to commence rehabilitation and closure of R3D in September 2018 and received approval from both the Commonwealth and Northern Territory Ministers in April 2019. An updated decommissioning plan is planned to be submitted to stakeholders in August 2020 to provide updates to address stakeholder comments received in November 2018, the dewatering/pumping and water sampling regime, and actions completed to early 2020. These updates are included in the sections below.

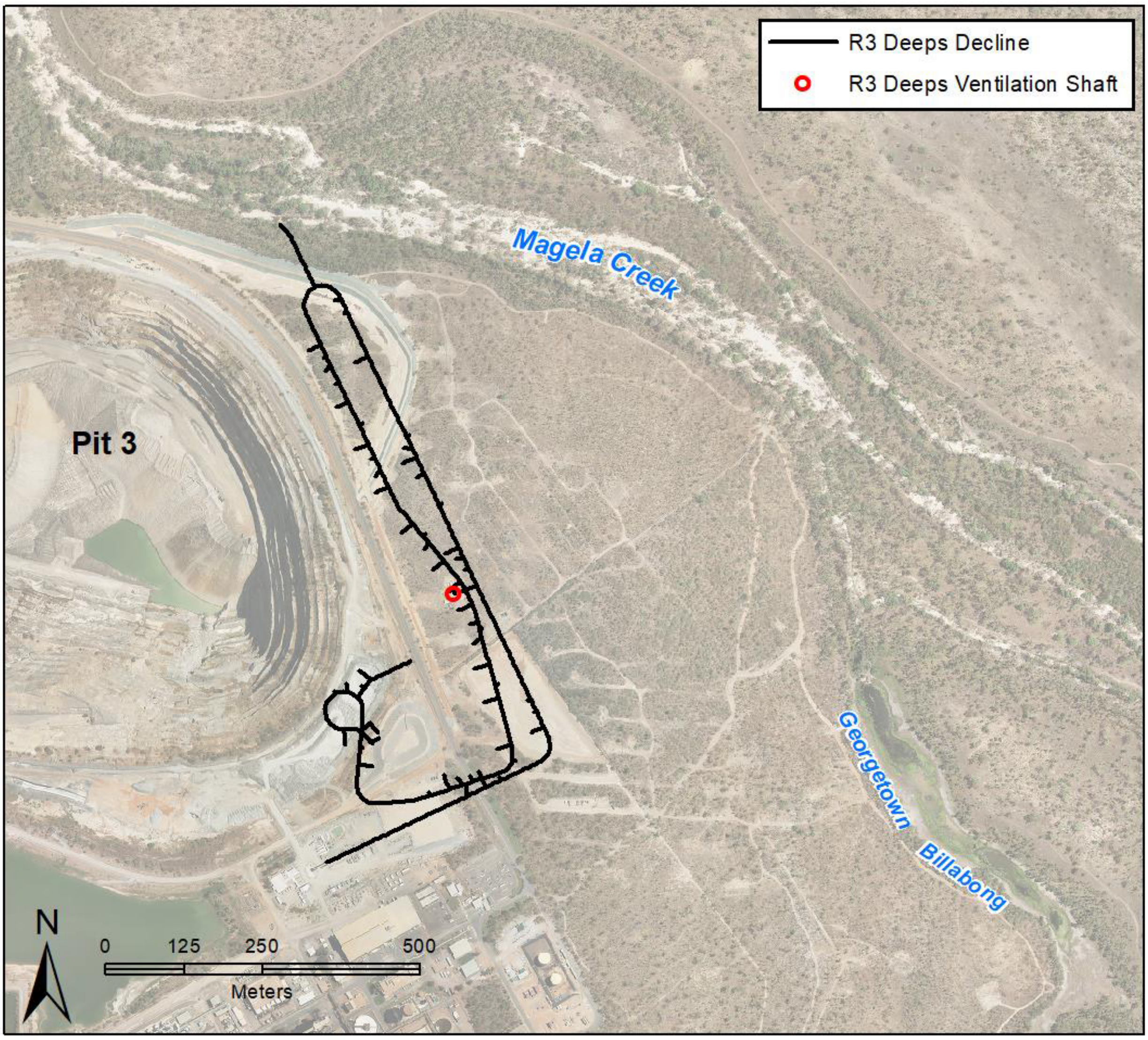

Figure 9-56: Plan view of the decline

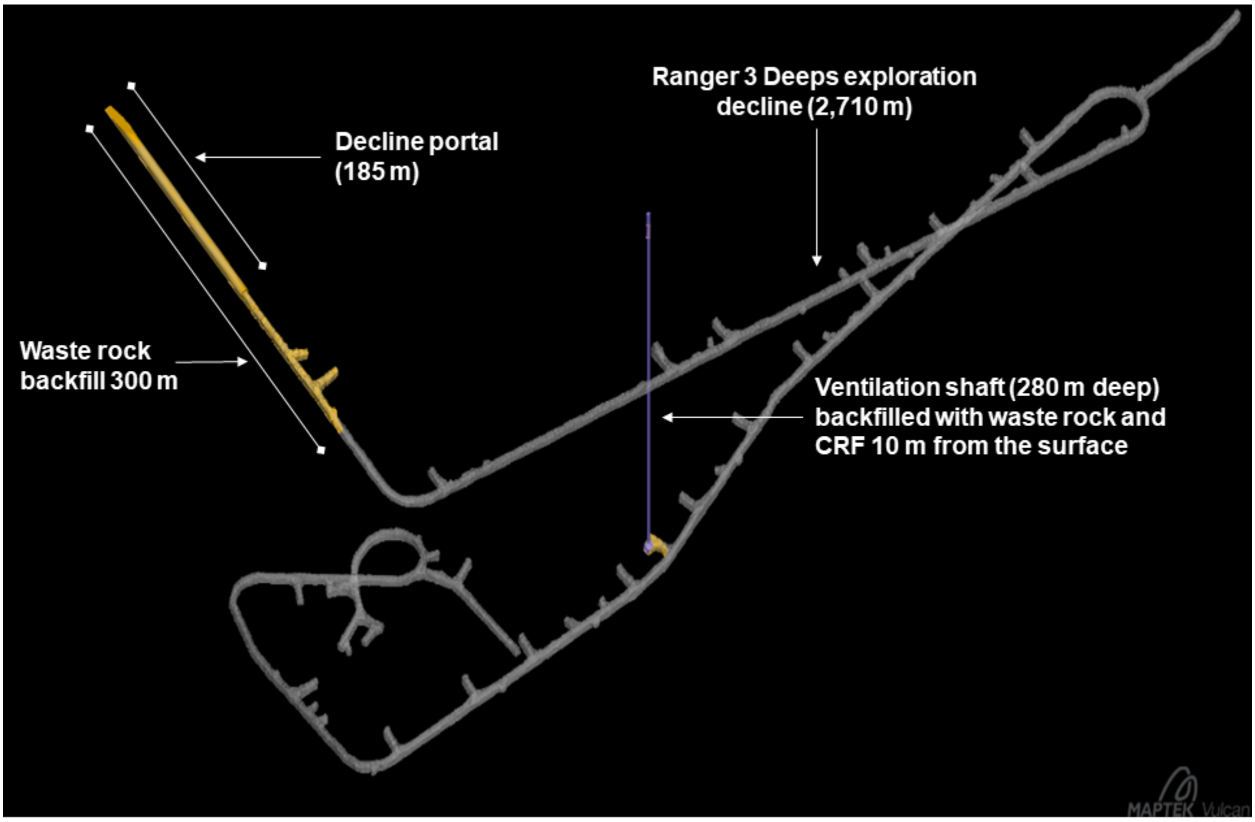

Figure 9-57: Oblique view of R3D decline and main closure elements

9.3.9.1 Completed rehabilitation

While the decline remains subject to a reduced care and maintenance (C&M) program, certain works commenced immediately after approval of the closure plan in April 2019. During early 2019, many of the demountable accommodation units at Ranger 3 Deeps were sold and transported off site.

The 2019 works program incorporated the removal of infrastructure, including pumping and electrical equipment, within the vicinity of the base of the ventilation shaft and subsequent backfilling of the vent shaft access. These works were completed between mid-April 2019 and end of June 2019 and included:

- installation of water level monitoring equipment in the vicinity of the base of ventilation shaft and monitor water level
- removal of existing pumps to allow the decline to flood
- backfilling of the -263 mRL ventilation shaft access with 700 m^3 of fresh rock
- removal of refuge chambers
- installation of a temporary 500kVA, 1000 volt power system on the surface to power the existing ventilation fans

- removal of the underground 11kVA substation
- removal and demobilisation of the two twin 90 kW fans
- installation of a 25 kW submersible pump in the ventilation shaft to maintain the water level below -25 mRL
- cleaning and radiation clearance of the removed infrastructure
- blocking of access to the decline through the portal
- demobilisation

The ventilation shaft access at -263 mRL was backfilled with waste rock to form a plug to mitigate the possibility of the backfill material flowing out into the decline. The decline was then allowed to naturally flood to -25 mRL.

9.3.9.2 Current rehabilitation

Reduced care and maintenance activities are required until the completion of all rehabilitation works. These activities include:

- keeping the decline dewatered to -25 mRL via the submersible pump in the ventilation shaft
- monitoring the submersible pump on a weekly basis
- prevention of access to the decline unless under special permit
- monitoring of the water level rise in decline by the decline monitor installed near the base of the shaft at -263 mRL, and from existing surface monitoring bores.

The C & M program is ongoing and the Final Closure & Backfill Program will take place after the cessation of processing – this is currently anticipated to occur as part of the demolition of the mine site infrastructure. A full geotechnical inspection will take place at this time before access for final backfilling.

9.3.9.3 Planned rehabilitation

The reduced C&M activities until 2021 will maintain the water level in the decline at -25 mRL. Final closure activities after January 2021 will consist of the closure of the top portion of the ventilation shaft and waste rock backfill of 350 m of the decline from ground level. This includes 185 m of the decline portal (Figure 9-57). The original 300 m backfill commitment was extended to 350 m after a meeting with the SSB on 9 November 2018 to mitigate against any risk of decline collapse propagating through the weathered zone to the surface. The remainder of the ventilation shaft will be filled with sized waste rock with a 10 m section of CRF placed 10 m from the surface. The steel portal will be cut down and removed to ground level and the surface concrete pads and concrete collar in the vicinity of the ventilation shaft will be removed.

Only a few buildings remain to be removed from site, and this will occur once a suitable buyer can be identified. The timing for completion of the revegetation will be dependent upon this. The workshop area is planned for demolition when Pit 3 is available to receive waste materials.

Ventilation shaft closure

To progress permanent closure in 2021, the ventilation shaft will be filled with crushed rock (crushing to occur in the existing plant) up to the weathered zone. The last 20 m of the ventilation shaft is first filled with 10 m of cemented rock fill (CRF) and then 10 m of crushed rock to surface (Figure 9-58). The surface concrete pads and concrete collar will be removed. The volume of material for the waste rock plug is approximately 705 m^3, the volume of crushed rock in the ventilation shaft is approximately 2,025 m^3, and the volume of CRF is approximately 125 m^3.

Portal closure

The steel multi-plate tunnel will be dismantled/cut down to final ground level. The void will be backfilled and covered with waste rock. Figure 9-59 depicts the dismantling/cutting gradient required to reduce the portal to land surface. One metre of waste cover is required over the tunnel (at a gradient of 1 in 20; less than 2,500 m^3 of waste rock is required).

Decline closure

The weathered zone (approximately 350 m) of the decline will be backfilled with waste rock up to ground level. The four standpipe holes will be left with stainless steel valves closed and the holes will not be grouted (INTERA 2018). The volume of waste rock required to backfill the weathered zone is approximately 14,500 cubic metres.

Geotechnical considerations

The geological conditions (strength and weathering of schist) varied along the depth of the portal and decline. During the construction there was always a company geotechnical engineer onsite. Every development cut was mapped by a geotechnical engineer or geotechnically trained geologist, and the required ground support for that cut was determined. Considerations for closure of the decline and portal relating to these conditions are described in Table 9-35.

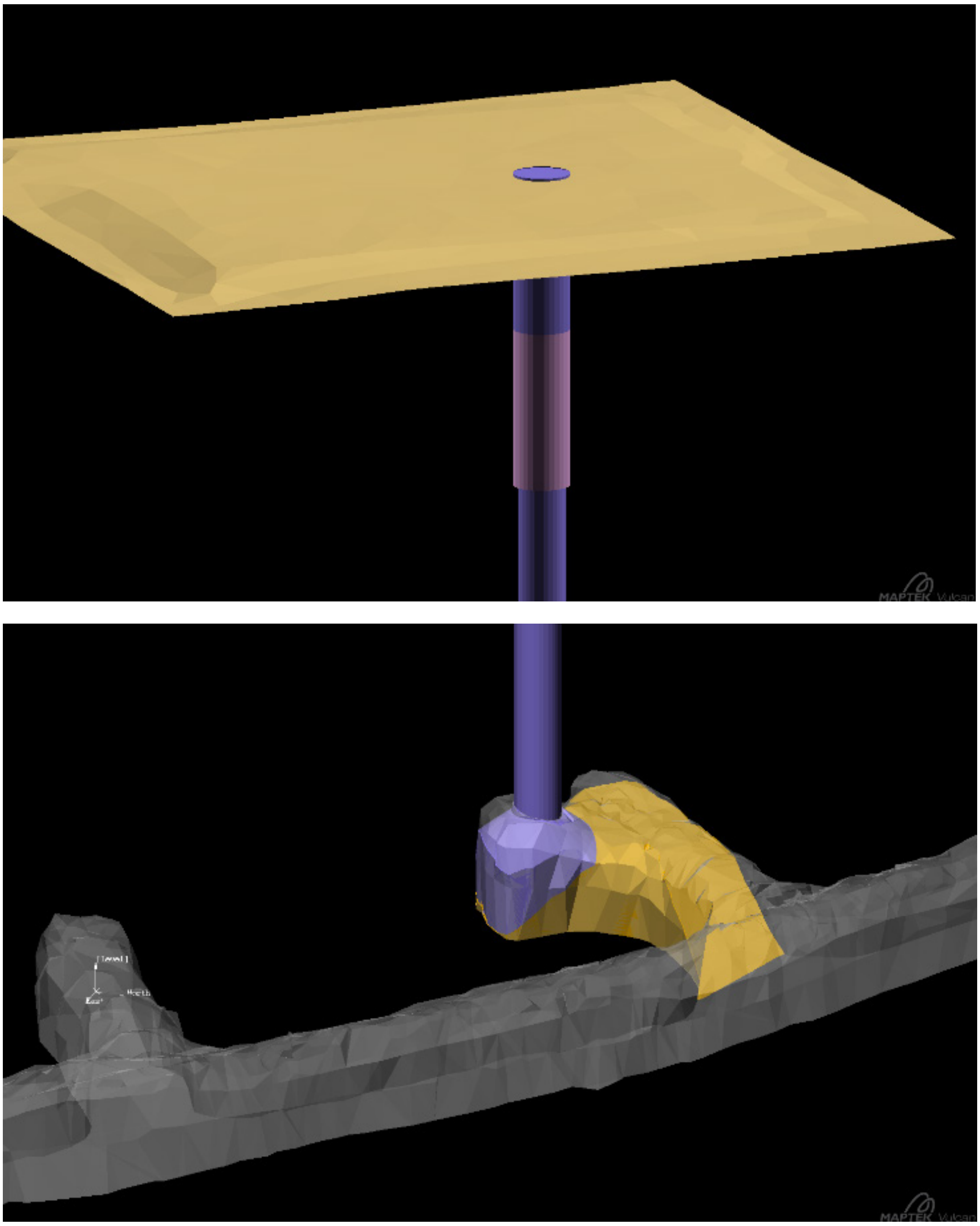

Figure 9-58: Backfilled shaft with waste rock plug (orange), crushed waste rock (purple); cemented rock fill layer (pink) with a crushed rock "cover" for the last 20 m of the weathered zone; and, concrete collar removed

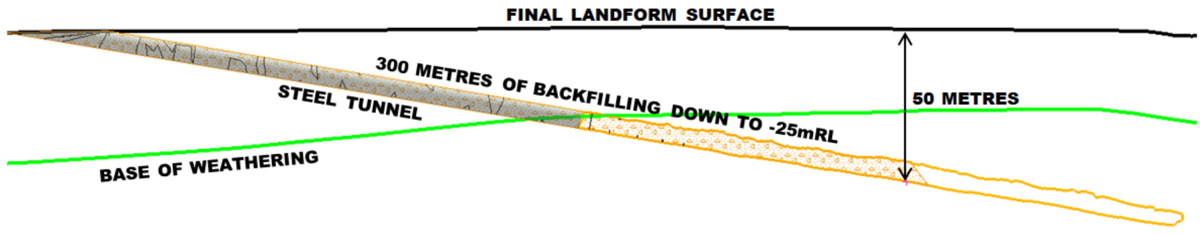

Figure 9-59: Schematic of backfilling detail to below weathered zone

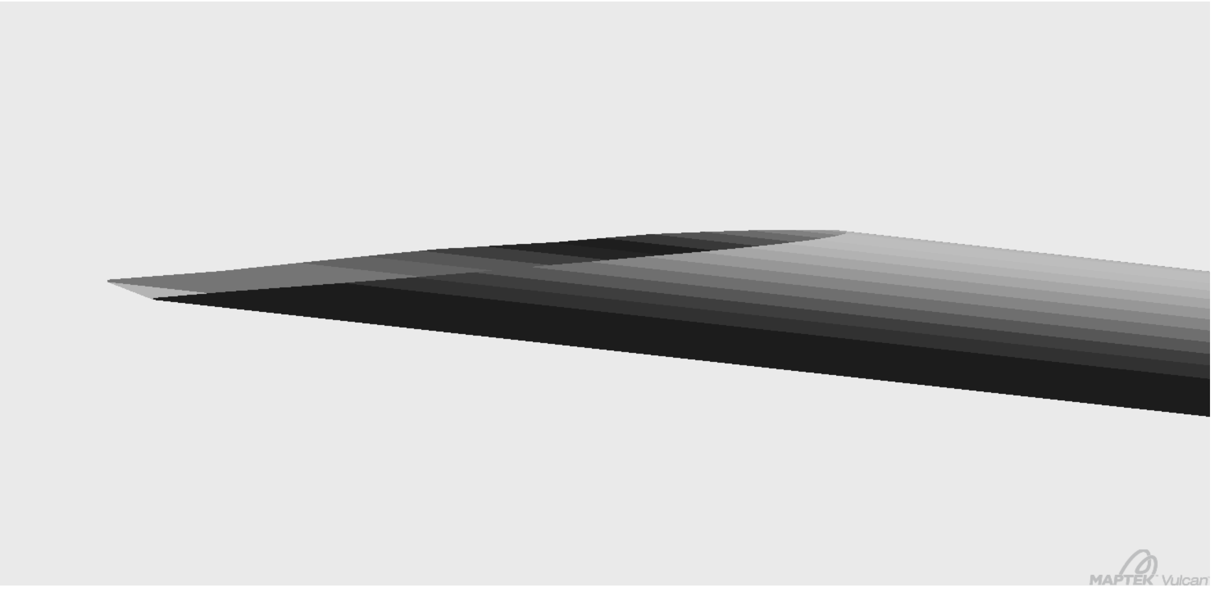

Figure 9-60: Dismantling and cutting gradient of the steel portal to ground level

Table 9-35: Geological conditions, decline reinforcement methodology

Depth (m)	Substrate	Methodology
0 - 185	Low strength, weathered schist	Cut and cover tunnel (see below).
185 - 213	Low strength, highly weathered to moderately weathered schist	Category 5 support and consisted of lattice girders, spiling bars and 290 mm thick fibrecrete.
213 - 290	Low, then medium strength; moderately weathered to fresh	Category 3 support. This support comprises 2.4 m galvanised fully encapsulated chemset bolts and 100 mm thick fibrecrete.
290 - 675	Medium strength fresh schist	Category 2 support. This support comprises 2.4 m galvanised fully encapsulated chemset bolts and 50 mm thick fibrecrete.

Due to the poor ground conditions in the vicinity of the portal, the first 185 m of the decline down to a depth of 35 m was developed as a cut and cover tunnel. A 35 m deep boxcut was excavated; then a steel arched tunnel was constructed from the bottom of the boxcut back to ground level (Figure 9-61). The boxcut was progressively backfilled with sized waste rock and boxcut material. When the boxcut was excavated groundwater was intersected 6 m below surface at 17 mRL.

Figure 9-61: Boxcut and portal, completed in December 2012

The schist is foliated and jointed, giving rise to a blocky structure. Figure 9-62 shows the anticipated wedge geometry of potential failure blocks in the first leg of the decline. These blocks were supported by the ground support that was installed at the time of development (pattern bolted with 2.4 m long, galvanised rock bolts at 1.5 m centres, plus 50 mm thickness of plastic fibre reinforced, pneumatically sprayed concrete). This decline ground support has a design life of a minimum of 20 years, so the chance of a significant failure before backfilling is undertaken is extremely low.

Long term, any unfilled sections of decline may start to fail. Blocks could fall out from the back (roof) and side walls. The failed material falls apart taking up 30 to 40% more volume than the *in situ* rock (simply because the broken pieces do not fit together as well and take up more room). Eventually the failure cannot continue because the void is completely filled with caved material. Any potential failure blocks are supported by the fallen material. This mechanism is documented in Brady and Brown (2014). If failure material is not removed the maximum height a progressive failure will propagate is determined by the bulking factor of the fall material and the volume of void available to be filled.

To determine the maximum height a progressive failure of the decline could propagate, a structurally controlled failure of the decline was simulated (Murphy 2018). A grid of failure surfaces was generated using structural mapping data for the first leg of the decline. A maximum possible failure was propagated in 10 logical steps. A bulking factor of 30% was applied to the fall (cave) material. After 10 failures, the available void was effectively zero and the failure could not propagate any further. Figure 9-63 shows the failure grid that was applied (decline profile grey, ultimate failure profile shown in black), and the 10 failure surfaces and the 10 cave material surfaces.

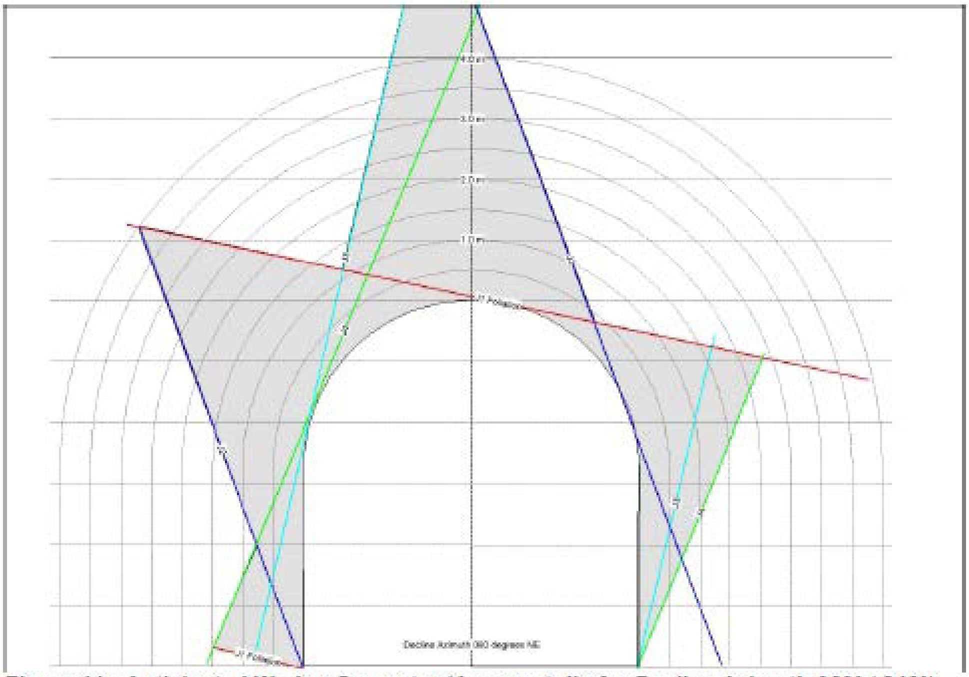

Figure 11: Anticipated Wedge Geometry (Apparent dip for Decline Azimuth 060° / 240°)

Figure 9-62: Potential structurally controlled wedge failures (ERA GCMP 2017)

The bulking factor of 30% is conservative. The weathered schist at the Ranger Mine has an *in situ* specific gravity of 2.6 t/m^3 and the bulk density of weathered material on the stockpile is 1.7 t/m^3. The bulking factor is about 40% and so the failure height would be reduced by around 5 m compared to the 30% case.

The ventilation shaft was developed in low strength to medium strength hanging wall schist. On completion, the shaft walls were sprayed with a layer of shotcrete. The top 21 m has a steel liner. The shaft goes through some fairly weak zones and is it reasonable to expect that over an extended period of time that if left unfilled the weak areas would eventually fail. The shaft is vertical so the volume of void available for fall material is the volume of the shaft and the rill area at the shaft base. The only way to guarantee the long-term stability of the shaft is to completely backfill it and the rill area at the base of the shaft.

Hydrological conditions

INTERA conducted an assessment of the expected hydrological conditions at the decline once dewatering pumps are turned off, and the decline and ventilation shaft flooded. INTERA also assessed the requirements for grouting of the four standpipe holes and construction of bulkheads (INTERA 2018).

9.3.9.4 Contingency planning

The closure of the Ranger 3 Deeps decline is well advanced and so no contingency plans are required.

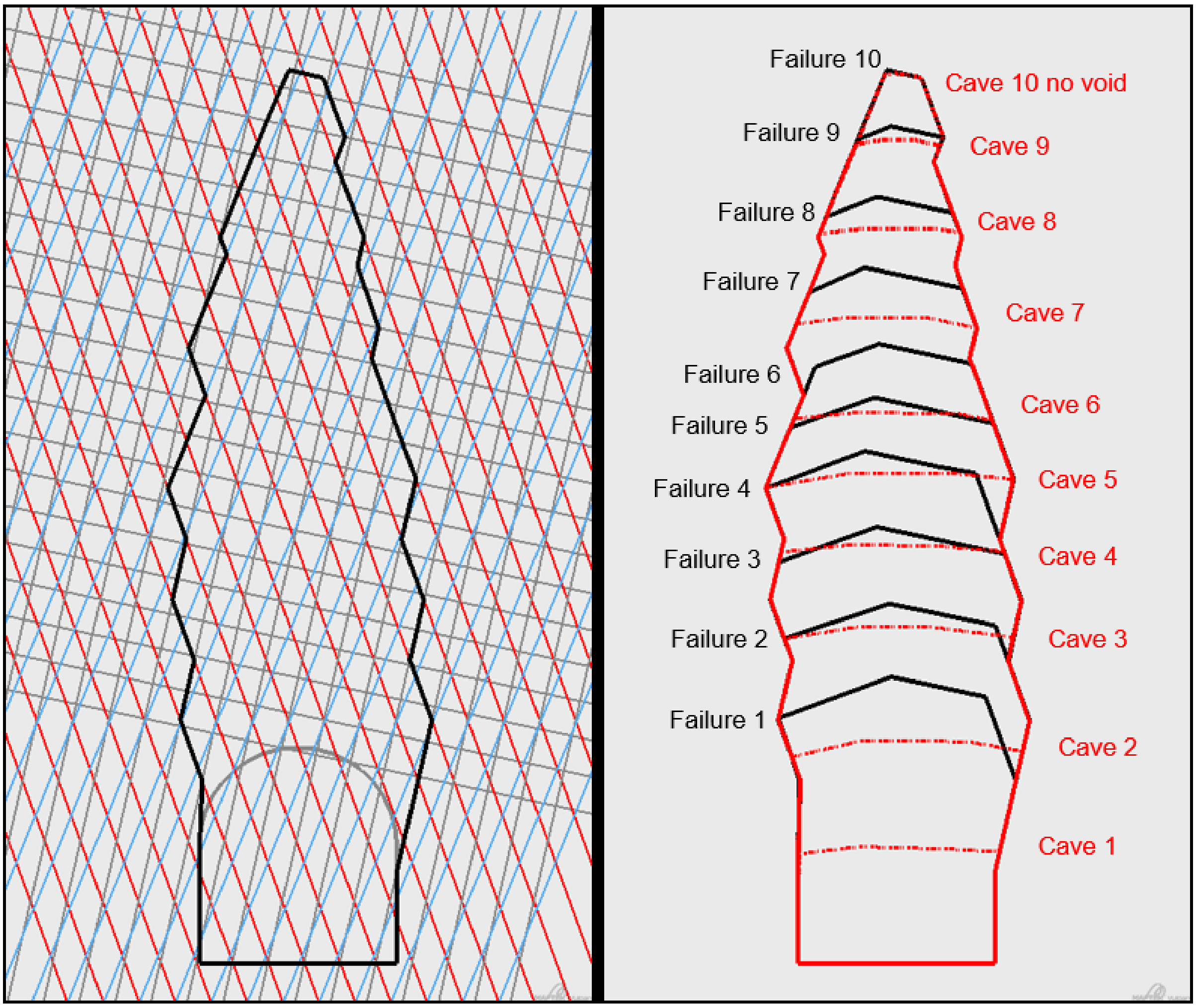

Figure 9-63: Cross-sections of decline and possible ultimate progressive failure. The left picture shows the rock structure for the first decline leg and the right picture shows the progression of failures and caved material height

9.3.10 Miscellaneous

9.3.10.1 Gagadju Yard

Figure 9-64: Gagadju Yard (May 2019)

Completed rehabilitation

There has been no rehabilitation of this site.

Current rehabilitation

There is no current rehabilitation activity at the site.

Planned rehabilitation

Infrastructure will be demolished and placed into Pit 3. Site works and revegetation will be completed as soon as practicable after the infrastructure is removed.

Contingency planning

No contingency planning is required for the rehabilitation of Gagadju Yard , other than remedial revegetation works if required.

9.3.10.2 Ranger Mine Village

Figure 9-65: Range Mine Village (May 2019)

Completed rehabilitation

The contactor camp, and nearby old workshop area, had all infrastructure and concrete removed. The accommodation and other demountable units were sold, where possible.

A 1.4 ha site was revegetated on the 24th and 25th of February 2020 (Figure 9-67). The natural soil surface was prepared with 20 cm deep rip lines at 1 m spacing using a grader. Approximately 2,000 stems of 44 different species were planted, with a combination of overstorey, midstorey and understorey species. Several kilograms of additional understorey seed from 10 species was also sown in between tubestock. The revegetation was performed during a rainy period and no irrigation has been used in the area.

Figure 9-66: Ranger Mine Village area prior to planting (January 2020)

Figure 9-67: Rehabilitation site at Ranger Mine Village (June 2020)

Current rehabilitation

There are no current ongoing rehabilitation activities at the site.

Planned rehabilitation

The remaining infrastructure disturbance at the site will be rehabilitated in a similar manner when services are disconnected.

Contingency planning

No contingency planning is required for this area. The workshop area may have some minor contaminated soils from old oil spills or similar. If this material is encountered during closure it will be removed and stored for eventual burial in Pit 3.

9.3.10.3 Nursery / coreyard

Figure 9-68: Nursery and old core yard at Jabiru East (May 2019)

During 2018 and early 2019, ERA converted the old exploration area in Jabiru East into a nursery to support closure operations. This work included the removal of exploration infrastructure and general clean-up of the area. In addition, benches to facilitate the propagation of seedlings have been installed along with associated irrigation system and security.

The nursery will be required to support the revegetation through the Ranger Mine rehabilitation works and, subject to confirmation of continuing access to the RPA by ERA, could also be used into the post-2026 monitoring and maintenance phase. A base for the completion of monitoring and maintenance of the site will be required post-2026, and the nursery and associated office area would be suitable for this purpose

Completed rehabilitation

Fencing and security has been installed at the site which would facilitate utilisation following closure.

Current rehabilitation

No rehabilitation is currently underway as the site is actively functioning as a nursery and seed store.

Planned rehabilitation

In addition to the nursery, core is currently stored from the exploration of the Ranger 3 Deeps deposit, MLN1 and other exploration around the RPA. ERA has legal obligations to keep certain core and this core material will be transported to Darwin for secure storage prior to 2026. All remaining core will be disposed to Pit 3 during the backfill operations.

Contingency planning

Appropriate approvals will be required prior to closer to enable the nursery asset to remain on the RPA. No further contingency planning is required.

9.3.11 Magela Levee

Figure 9-69: Magela levee (May 2019)

Completed rehabilitation

No rehabilitation has been completed as the levee is still utilised for water diversion.

Current rehabilitation

No rehabilitation is underway as the levee is still utilised for water diversion.

Planned rehabilitation

The levee will be able to be removed and rehabilitated as part of the Pit 3 final landform earthworks and revegetation. Levee material will be returned to the original borrow pit (Section 9.3.11.1) with any excess material either placed in Pit 3 or used for any site works requiring lateritic material.

Contingency planning

No contingency planning is required for the levee as it will not be removed until it is no longer required.

9.3.11.1 Borrow pits

Figure 9-70: Borrow pit for TSF lift

Figure 9-71: Borrow pit for Magela Creek Levee (May 2019)

Completed rehabilitation

No borrow pits have been rehabilitated.

Current rehabilitation

There is no current rehabilitation underway

Planned rehabilitation

There are currently two borrow pits located on the RPA:

- borrow pit for the construction of a TSF lift located at the proposed site for Retention Pond 5 that was not constructed (Figure 9-70)
- borrow pit for the construction of the Magela Creek levee (Figure 9-71).

The site of the old RP5 will be recontoured as part of the final landform for the corridor creek catchment.

The levee borrow pit will have levee material returned, recontoured to the natural contours and revegetated.

Contingency planning

If these borrow pits are required over the closure period, rehabilitation will be delayed until no longer required.

9.3.11.2 Landfill sites and bioremediation pad

Figure 9-72: Temporary waste storage facility on the western edge of Pit 3 (May 2019)

All wastes generated at Ranger are managed on site. This has been primarily through the use of landfills or disposal in mined-out pits. In addition to this ERA have managed any hydrocarbon contaminated soils though the use of bioremediation pads, located to the north west of Pit 1.

The following landfill sites are located at Ranger:

- historic industrial waste landfills to the south of the TSF;
- domestic waste landfills to the north of Pit 1; and
- temporary industrial waste landfill to the west of Pit 3.

Completed rehabilitation

Contaminated sites sampling of the historic landfills and the bioremediation pads were completed during 2019. Details of this are provided in Section 5.5.2.5. This information has been used to define a source term for inclusion into the whole of site groundwater solute transport model (Section 5.5.2.5). The results of this model are expected in late 2020 and will be used to assess remediation options via a best practical technology assessment.

Several of the old domestic landfills to the north of Pit 1 were covered with waste rock during 2020 as part of the final backfill of the pit.

Current rehabilitation

There is currently no rehabilitation of landfills underway.

Planned rehabilitation

The temporary landfill to the west of Pit 3 will have the waste removed and for placement in Pit 3 with the other demolition waste.

Domestic landfills, once they are no longer required, will be covered by the final landform waste rock material.

The plan for rehabilitation of the historic industrial landforms to the south of the TSF, and the bioremediation pads will be finalised once the best technology assessments are completed and detailed included in updates to this MCP.

9.3.9.6.4 Contingency planning

No contingency planning is required for this site.

9.3.11.3 Explosives magazine area

Figure 9-73: Old magazine site (May 2019)

Completed rehabilitation

All explosives have been removed from the magazine and it has been de-registered.

Current rehabilitation

No current rehabilitation underway.

Planned rehabilitation

Demolition requirements at the old explosives magazine involve the removal of the magazine, concrete slab and associated footings. The surrounding fence will also be removed. The area will then be contoured and revegetated.

Contingency planning

No contingency plan is required for this site.

9.3.11.4 Trial landform

Figure 9-74: Trial landform (May 2019)

Completed rehabilitation

A 6 ha landform and revegetation trial was established in 2009-2010. Revegtation and faunal recolonisation trials continue to be undertaken on this landform as described in Section 5.5.4.

Current rehabilitation

Ongoing trials are underway on the 6 ha site to further establish understorey and improving the overall biodiversity and weed management.

Planned rehabilitation

The trial landform will be integrated into the final landform, requiring the removal of infrastructure and reshaping of edges.

Contingency planning

Appropriate weed and fire management will be implemented as necessary.

9.3.12 Airport

Figure 9-75: Jabiru airport (May 2019)

The airport at Jabiru East and other infrastructure, such as the Environmental Institute for the Supervising Scientist (ERISS) and the Telstra building, are considered to be of high value to the community and, as such, are currently assumed to remain following closure of the Ranger Mine. Under the current arrangements, the Commonwealth is required to rehabilitate and restore the area occupied by ERISS before vacating, including the removal of the buildings.

Under the current legislative framework, ERA is obliged to rehabilitate the airport precinct. ERA is currently operating the airport largely for the benefit of third parties, including the Commonwealth and NT Governments, and from 2021, ERA does not intend to use the airport for its operations. ERA is working with the Department of Industry, Science, Energy and Resources (DISER), the Northern Land Council (NLC) and the Gundjeihmi Aboriginal Corporation (GAC) to develop a plan that allows for the airport facility and associated infrastructure to continue to be in operation throughout the rehabilitation period. However, in the absence of an agreed plan, ERA will begin a process to close the airport some time in 2021, with rehabilitation likely to commence in 2024.

9.3.12.1 Completed rehabilitation

No rehabilitation has been completed to date.

9.3.12.2 Current rehabilitation

No rehabilitation is currently occurring on the site as it is still operating as an active airport.

9.3.12.3 Planned rehabilitation

Planning for removal of the airport is in the initial stages. A desktop assessment of contaminated sites will be completed in the coming year. This will determine if further sampling is required prior to completion of a best practical technology assessment of remediation options.

The airport tourist centre contains asbestos. Demolition will include provision for the removal of this asbestos for burial in Pit 3.

Demolition of the airport will include the following elements:

- removal of all infrastructure, either off site or burial in Pit 3 or RP2
- removal of the bitumen airport strip
- removal of security fencing
- remediation of contaminated sites, as required
- ripping of hard stand areas
- revegetation

The access road to the airport will remain to allow access to the ERISS and Telstra buildings.

9.3.12.4 Contingency planning

Any agreed plan for the continued operation of the airport by an operator other than ERA will include provisions confirming responsibility for the rehabilitation of the airport facility and associated infrastructure, including contaminated site management and remediation.

9.4 Closure activities

Closure activities are those that occur across multiple domains and, although referred to within domains, are discussed in detail within this section.

9.4.1 Contaminated sites

This section describes any generic information on the closure activities related to contaminated sites that is not presented within a specific domain. Section 5.5.2.5 presents details regarding contaminated sites studies. The following section relates to closure activities required as a result of those studies. Closure activities relating to LAAs, and potential contamination, are discussed in Section 9.3.4

The *Contaminated Land Risk Register* (ERA 2018) has been developed and is maintained by the site environment team at the Ranger Mine, in accordance with the operational *Hazardous material and contamination control plan* (Appendix 9.5). The *Contaminated Land Risk Register* identifies all sites where activities have occurred that have the potential to contaminate land.

A significant number of targeted contaminated land assessments have been undertaken previously on the RPA at known contaminated sites between 2006 and 2016. Whilst the focus of previous assessments was predominantly identifying groundwater contamination, soil and sediment profiles have also been assessed at known contaminated sites to define the lateral extent of contamination in the soils and sediments at the RPA.

As part of the feasibility study undertaken in 2018, a review of the *Contaminated Land Risk Register* was undertaken to provide a register (at that point in time) suitable for closure planning purposes. The review involved ensuring all areas of potential contamination were captured as well as aligning historical investigations undertaken to date, thereby developing a current site contamination knowledge base. Sites were also classified according to risk (costs of remediation). Any new potentially contaminated land as a result of operational activities occurring after this review will be added to the *Contaminated Land Risk Register* by the site environment team and will be incorporated into closure investigations if required.

Following this review, a *Plume and contaminated site management plan* was developed during the feasibility study. The plan describes future work (site assessments and BPT assessments), post remediation validation assessments and post-closure monitoring. This plan was further reviewed for appropriateness in April 2019 to confirm whether broad remediation statements made during the feasibility study were supported by outcomes of previous studies and outcomes of the feasibility study. A gap analysis was also completed. Areas identified during the gap analysis as having insufficient data to adequately determine a remediation treatment option were identified for further investigation including depth and COPC data.

In December 2019 and January 2020, a contaminated sites drilling program was completed. Targeted areas defined by the gap analysis were sampled as part of this campaign in April 2019. The areas identified as requiring further work included the:

- historical landfill
- emergency dump tank
- leaching counter current decanters
- former sulfur stockpile
- power station
- shellsol underground and aboveground tanks
- bioremediation pad
- TSF walls

Results from this drilling program, in addition to the knowledge base captured in historical investigations, the feasibility study and gap analysis, will be used to inform BPT assessments to determine what impacts will be considered as low as reasonable achievable for each contaminated site. A summary of this contaminated sites drilling program is summarised in Section 5.5.2.5.

An objective for closure is that, where needed, soils will be remediated to a level where their environmental impact is as low as reasonably achievable. The preferred option identified during the BPT assessment will be progressed whilst the other options then form the contingency plan, prioritised by rank. Outcomes of contaminated sites assessments will be included in future versions of the MCP.

Table 9-36 summarises the contaminated sites, grouped into major site areas, based on location, contamination risk and proposed remediation strategies. This table will be updated as BPT assessments and appropriate remediation, if required, are completed and will be detailed in future MCPs.

Table 9-36: Proposed management of contaminated land

Area	Sites included	Proposed Treatment	Further Work
Ranger Mine area			
Processing Plant	Processing plant area including all sites identified in processing plant area in Figure 5-89.	Remove surface infrastructure, a selective scrape of surface soil to be undertaken as determined by BPT assessments and place in Pit 3. Area to be backfilled with waste rock.	Ongoing groundwater monitoring. Assessment of soil contaminant/s mobility and risk to key receptors. Refine groundwater source terms. BPT assessments undertaken to determine appropriate remediation approach, if required.
Tailings Storage Facility (TSF)	TSF and sumps	Remove all tailings, thereby reducing head pressure of groundwater plume under the TSF. Contaminated natural ground below the TSF to remain in-situ post closure.	Further work required to determine if groundwater remediation is required to protect environmental receptors post closure. Ongoing monitoring to support further assessments including source term development for post closure groundwater modelling and remediation options assessment. Remediation options to be assessed through BPT and the TSF deconstruction application.
Pit 3	Pit 3	All tailings and surface mill infrastructure, including hazardous materials and contaminated soil to be disposed of in pit, on top of a geotextile layer, and covered with waste rock.	Disposal of hazardous waste in pit to be approved through Pit 3 application approval. Waste remaining post-closure of the pit will be disposed of in RP2. A register is to be kept detailing material disposal of in Pit 3 and RP2. Standalone backfill plan required.
Stockpile area	Stockpile areas, mine maintenance workshop, mine washdown bay, historical landfill and dredge diesel unloading, storage, and pumping.	Workshop areas (including washdown bay, diesel unloading, storage and pumping) will be treated similar to the processing plant area. Area to be covered in waste rock. Remainder of stockpile area requires no additional remediation.	Further sampling and BPT assessments required to determine an appropriate ALARA remediation approach.

Area	Sites included	Proposed Treatment	Further Work
Wetlands			
Ponds	SED2B, RP1WLF, RP1, RP2, RP3, RP1WLF-Sumps, RP6, Corridor Creek wetland filter network (six cells), Georgetown Billabong, Coonjimba Billabong	Currently assumed sites do not require scraping or waste rock cover. Surface infrastructure to be removed and sites to be left as is.	Further investigations required to confirm areas do not need to be scraped and covered with waste rock. Sampling required to confirm whether remediation is required for billabongs and RP1WLF. BPT assessments to be undertaken.
LAAs and Irrigation Areas	Magela A, Magela B, Djalkmarra East & West, Jabiru East, RP1 & RP1 Ext, Corridor Creek	Removal of all infrastructure (spray heads, pipework etc), remediation to be undertaken as determined by BPT assessments, revegetation as detailed in Section 9.3.4 with local native species.	Undertake BPT assessments to confirm appropriate remediation approach for each LAA, if required.
Other Infrastructure			
Infrastructure in Jabiru East	Underground storage tanks, exploration wash bay, septic tanks at Ranger Mine village, Gagadju workshops	Remove surface infrastructure and scrape of surface soil as required. Soil to be disposed of in pit.	Exploration wash bay will remain for duration of revegetation activities and to be removed following closure (ie post-2026).
Pit 1	Current domestic landfill, bioremediation pad, historic/decommissioned and buried industrial landfills, Tailings Dam pipe corridor.	Remove surface infrastructure, leave sites *in situ* as under final landform. Surface scrape Tailings Dam pipe corridor and place in Pit 3.	BPT assessments to be undertaken as required.

9.4.2 Waste and hazardous material management

This section contains the management of waste and hazardous material that is applicable across numerous domains. Further details are provided within the Hazardous Material and Contamination Control Plan (Appendix 9.5)

ERA has identified that the following hazardous wastes will be onsite at cessation of ore processing activities (8 Jan 2021):

- tailings
- BC brine and sludge from the HDS plant
- mineralised waste rock (2s rock or higher)
- non-mineralised waste rock (1s rock)
- materials to be demolished (steel, concrete, asphalt)
- listed wastes - non-radiation contaminated hydrocarbon, asbestos, rubber, tyres and other hazardous wastes
- general waste (non-hazardous[5]) – domestic, HDPE pipe, concrete, fencing
- heavy mining equipment and other vehicles
- special items:
    - radiation contaminated hydrocarbons
    - calciner
    - geological core samples

The total volumes of each waste have been provided in Table 9-37.

Table 9-37: Waste materials for management and/or disposal at closure

Waste Material	Amount
Tailings	
Pit 1 tailings	25.2 Mt
Pit 3 tailings (June 2019)	36.7 Mt
TSF tailings (June 2019)	4.9 Mt
Estimated tailings produced in mill Jun 19 – Dec 20	1.27 Mt

[5] Current testing of samples indicates no significant radiation or contamination

Waste Material	Amount
Mineralised waste rock (2s and above)	
Pit 3 underfill (mixed rock of various grades)	32.5 Mt
Pit 3 forecast backfill	28.1 Mt
Pit 1 mineralised waste rock (below water table)	3.8 Mt
Pit 3 mineralised waste rock	6.9 Mt
Beneath RP6	0.7 Mt
1s waste rock	
Pit 1 (below water table)	1.7 Mt
Pit 1 (above water table)	7.1 Mt
Pit 3 (below water table/above tails)	20.3 Mt
Pit 3 (above water table)	12.6 Mt
Stockpile areas	14.1 Mt
Tailings Dam (backfill from walls)	13.0 Mt
Site area fills to final landform	9.6 Mt
Brine	
BC Brine to Pit 3 underfill total	1.8 GL
Demolished material	
Demolished structural steel, concrete, asphalt	60,000 m^3 (150 kt)
Non-structural steel	11,000 t
Concrete up to 1.5m below ground	115,000 t
Asphalt	16,000 t (84,000 m^2)
Phase 1 demolition to Pit 3 2023	40 – 50,000 m^3
Phase 2 demolition to RP2 H2 2025	10 – 20,000 m^3
Phase 3 demolition off site following closure	<1,000 m^3
Listed wastes	
Non-radiation contaminated hydrocarbons to offsite disposal	1,500 t
Asbestos to Pit 3	35 t
Rubber and other hazardous wastes	8,000 t
General waste	
General (non-hazardous) wastes	
General rubbish	3,500 t
HDPE	170 t
Fencing	75 t
Heavy Mining Equipment (18 heavy vehicles to RP2)	21,000 m^3
Special Items	

Waste Material	Amount
Radiation density gauges to be disposed in suitable location off site	20 – 30 units
Calciner to Pit 3	1 unit
Geological ore samples (mixed uranium content) to Pit 3	1,400 t
Radiation contaminated hydrocarbons to offsite disposal (blackjack, grease and oily rags)	120 t

An environmental assessment, completed in 2018, determined the minimum depth for burial of non-mineral waste beneath the final waste rock landform as 6 m. The following aspects were assessed:

- plant (vegetation) available water and vegetation requirements
- Northern Territory asbestos disposal requirements
- predicted denudation over 10 000 years
- diffusion length for 222Radon
- Northern Territory general landfill requirements
- Ranger Conceptual Model (plant plumes)

The outcome of the assessment determined that revegetation was the most restrictive aspect for minimum depth of waste rock. This is associated with plant available water and rooting depth in waste rock.

9.4.3 Water treatment

This section describes the reduction of the water inventory, and separation of pond and process water. The closure of the physical areas, such as RP2 or the water treatment plants, are described previously under each specific domain. The overall management of water on site is detailed within the Ranger Water Management Plan.

The main water inventories relevant to closure are those associated with pond water and process water. Pond water is derived from rainfall that falls on the active minesite catchments and results in runoff that is of a quality that requires active management. Process water is the most impacted water class on site and is derived predominantly from water that has passed through or encountered the uranium extraction circuit, and from rainfall onto designated process water catchments.

To enable the successful closure of the Ranger Mine, both the pond and process water inventory on site must reduce to a zero balance early enough to allow for deconstruction of the water storage facilities prior to the closure of the RPA in January 2026.

ERA has completed water modelling using operation simulation modelling (OPSIM) which is validated annually by an external party. The Water Model defines the management of water until closure of the RPA. Assumptions in the model, as described below, form targets that must be achieved to meet the closure schedule.

Pond water treatment will continue with the existing water treatment plants discharging permeate to available wetland filters and LAAs until 2025. The ultimate reject from pond water treatment, after further treatment using the Brine Squeezer, is discharged to the process water inventory.

The flow diagram provided in Figure 9-76 shows the flows on site relevant to process water treatment. Process water treatment for the current model is undertaken through a number of operational processes and infrastructure; namely, the BC, High Density Sludge Plant (HDS) and the Brine Squeezer, details of each treatment method are provided in the subsequent sections. The most recent water model completed in February 2020 predicted a zero process water inventory before 2026 (refer Section 2.2.9.7). This water model assumes the following for future active process water treatment:

- The BC continues to be the principal route for process water treatment. Distillate production capacity in 2020 is 2.10 GL/a, rising to 2.53 GL/a in 2021 following the BC3 fan upgrade. BC treatment concludes in mid-2025 once all process water sources have ceased. As described in Section 9.3.2.3, the concentrated brine produced by the BC is permanently disposed of by injection into the Pit 3 underfill, although there may be periods where the brine is recycled to the bulk process inventory.

- The HDS plant operates with a feed capacity of 2 ML/d, generating product water of a quality suitable for final treatment by the existing pond water treatment plants. This HDS plant operates through to the end of 2022.

- The Brine Squeezer treats low salt process water resulting in 1.2 ML/d of release water. This reverse osmosis based treatment operates through to mid-2025.

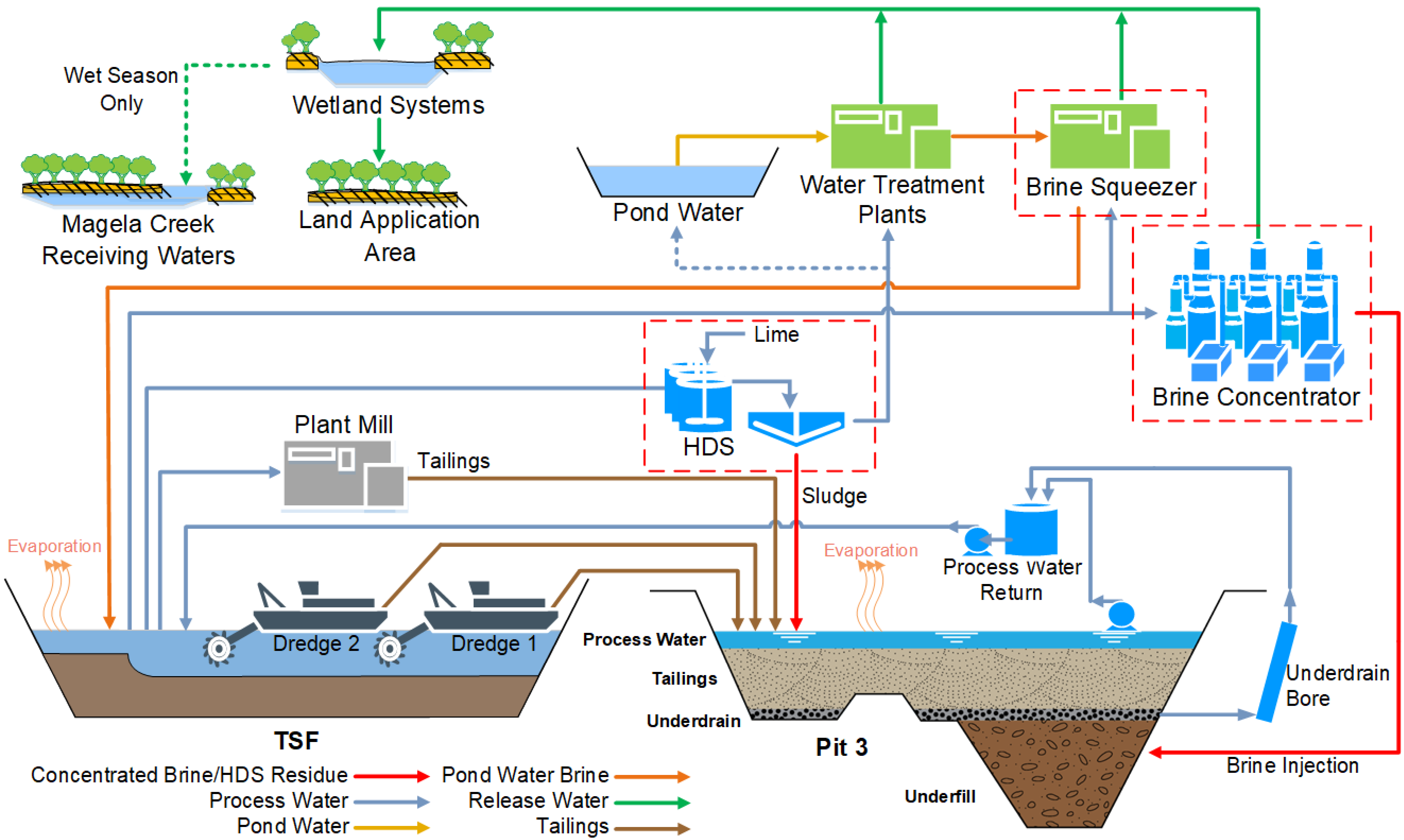

Figure 9-76: Process water flow diagram for the current water model

Note that under the current version of the site water model (February 2020), the assumed closure activity timeline may differ from what has been progressed with site operations. The process water inventory is actively tracked in situ, whilst the water balance model is updated regularly to provided references for future water treatment planning. The next version update is expected in August 2020. Additional water treatment facilities may need to be installed if the expected water treatment and inventory targets are not met, see contingency details in Section 9.4.3.6.

9.4.3.1 Brine Concentrator

The Brine Concentrator (BC) is a process water treatment plant, constructed in 2012 and commissioned in 2013. The BC consists of three trains: BC1, BC2 and BC3. Each train comprises of a falling film evaporator and a vapour recompression fan. The three trains are arranged so that BC1 and BC2 are fed in parallel, with their combined concentrate, along with additional process water, fed to BC3.

Process water is delivered via overland pipeline to the BC. The plant produces a clean distillate product that is discharged to available release storages, and a concentrated brine, which is either injected into an underfill layer of waste rock deep inside Pit 3 or diluted with process water and returned to the process water inventory. Injection of concentrated brine into the Pit 3 underfill is the primary method to dispose of salt from the process water inventory; details of the Pit 3 underfill and brine injection system have been provided in Section 9.3.2.1.

The BC draws its feed as follows:

- Prior to the end of tailings deposition: from the bulk process water inventory stored in either Pit 3 or the TSF.
- After the end of tailings deposition and prior to September 2021, when cleaning of the TSF is complete: from bulk process water stored above the tailings in Pit 3.
- After cleaning of the TSF and prior to August 2024, when process water is transferred to RP6: from bulk process water inventory stored in the TSF.
- After the transfer of process water from the TSF to RP6, until the free process inventory is zero: from bulk process water inventory stored in RP6.
- After the free surface process water inventory is zero, until the end of tailings consolidation expression (July 2025): tailings consolidation expression directly from the decant wells in Pit 3
- Water treatment plant brine directly from the Brine Squeezer
- Underdrain water directly from the underdrain bore

BC capacity is specified via the flow of product distillate. The BC initially had a distillate production capacity of 5.0 ML/d and has been slowly increasing through operational excellence programs. At data input cut-off for the MCP of end June 2020, the average BC distillate production was 5.4 ML/day.

The water management strategy requires the capacity of the BC to be increased to 6.92 ML/d. The increase in capacity is based on upgrading BC3 by installing a 2.1 MW vapour recompression fan, identical to the current fans of BC1 and BC2. Currently, BC3 is fitted with a 1.2 MW fan. The new fan is to be installed adjacent to the existing fan and tied into the existing vapour ductwork. The block flow diagram for the BC3 fan upgrade is provide in Figure 9-77: Block flow diagram for BC3 fan upgradeThe upgrade to BC3 increases recovered water production, which subsequently increases flows throughout most of the existing plant. Several existing items of equipment must be upgraded for these increased flows, including:

- most of the continuously operating pumps
- specific major process pipelines
- the steam system
- the electrical substation
- the power station and diesel generators

The BC fan upgrade has commenced with operation expected to begin in February 2021.

Once the free process water inventory has been drawn down to zero, the supply of process water to the BC is expected to be less than the treatment capacity of the BC. All sources of process water are expected to conclude by July 2025, and operation of the BC will then cease.

9.4.3.2 HDS Plant

The HDS plant was built in 2005 and overhauled in 2009. Plant operations ceased due to operability issues and with the installation of the BC. Subsequently, parts from the plant were re-purposed elsewhere on site.

The plant has recently been restored to its 2009 condition and ERA has obtained approval to operate the recommissioned plant with discharge of the product water to the pond water inventory. Provisional approval has also been obtained to direct the product water on to the pond water treatment plant 1 (WTP1) to complete additional test work on the product water quality. It is expected that the confirmation of this water quality will occur in the second half of 2020, with the permeate then being approved for release.

Subject to ongoing studies and the subsequent approval of a long term sludge disposal option it is planned to operate at approximately 2 ML/day of process water feed until such time as either it is no longer required to achieve inventory reduction or plant demolition is required to maintain the overall rehabilitation schedule.

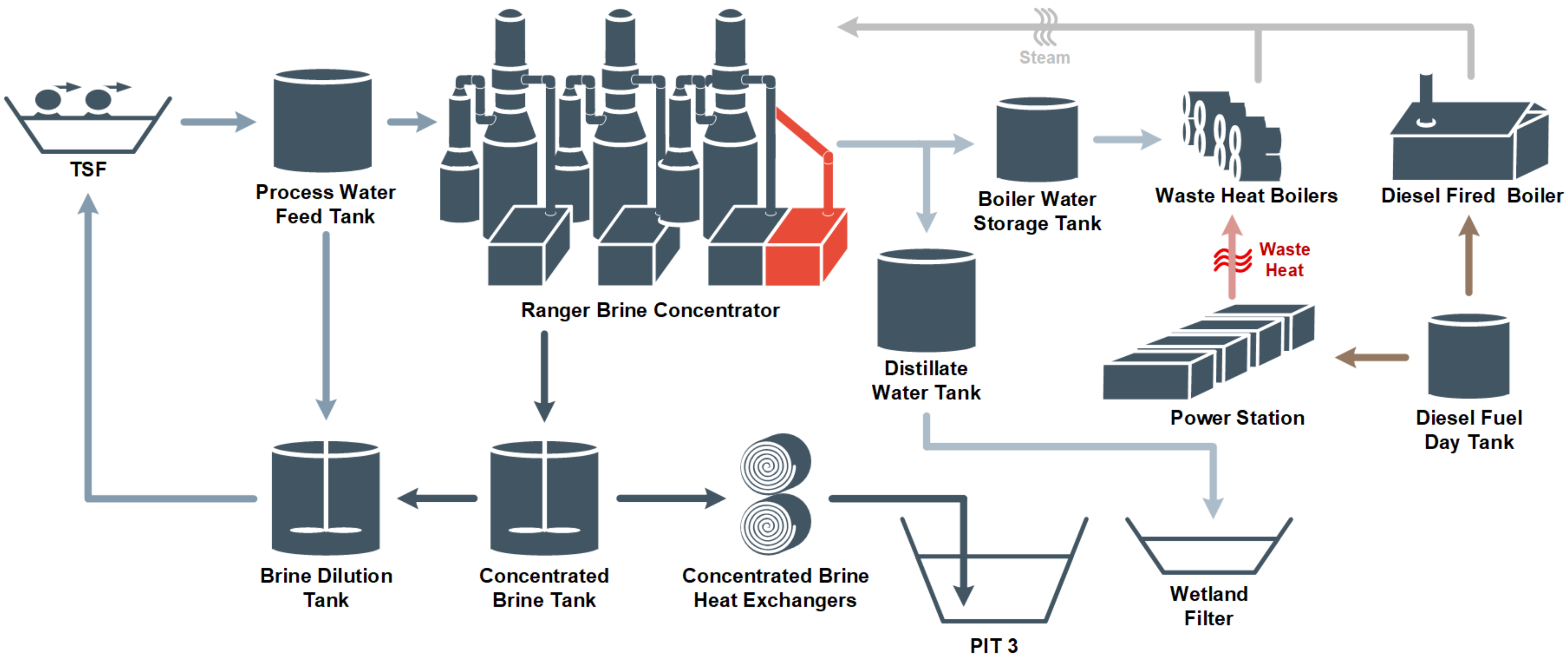

Figure 9-77: Block flow diagram for BC3 fan upgrade

The HDS plant treats process water, through to a water quality similar to pond water, through two processing stages (Figure 9-77Figure 9-78). In the first stage (primary softening), acidic process water is mixed with alkaline milk of lime, resulting in the precipitation of gypsum and the precipitation of most of the metals originally in the process water as metal hydroxides. The precipitates are separated from the solution in a thickener as a sludge, some proportion of which is recycled to act as a seed for precipitate growth, the remainder is sent for disposal. The separated solution, known as primary softened water, is saturated in calcium from the milk of lime and is sent onward for secondary softening.

In the second stage (secondary softening), a solution of soda ash (Na_2CO_3) is dosed into the primary softened water, precipitating most of the contained calcium as calcium carbonate ($CaCO_3$). Again, the precipitate is separated from the solution as a sludge, some proportion is recycled as a seed for precipitate growth and the remainder is sent for disposal. The alkalinity of the separated secondary softened water is neutralised by addition of a small quantity of sulfuric acid solution and discharged from the plant.

The combination of the sludge from primary and secondary softening is discharged from the HDS plant into the processing plant neutralisation tank and then pumped to Pit 3 via existing mill tailings pipeline. Within Pit 3, the sludge will be co-disposed with mill and dredge tailings, until the cessation of mill operations. After this, the sludge must be disposed of in an alternative manner. The options for disposal after cessation of mill operations are the subject of a BPT assessment and will be subject to a separate application to the MTC. Treated water is discharged from the HDS plant to either the pond water inventory (via RP2) or directly to water treatment plant (WTP) 1 depending on water treatment plant requirements and the condition of the pond water inventory. HDS product discharged to the pond water inventory may be then treated by any of the pond water treatment plants.

HDS product water contains ammonium that is originally present in the feed process water to the plant – this ammonium is not removed by the primary and secondary softening stages of HDS treatment. HDS product also contains some sodium that arises from the soda ash dosing in secondary softening. Treatment of HDS product water through the pond water treatment plants removes the vast majority of the ammonium and sodium present in the HDS product. If further ammonia removal is required, options are available such as passage through wetland filters, additional holding time in RP2, or partial recycling through additional polishing stages within the pond water treatment plants.

When treating high salt process water drawn from the bulk process water inventory, the capacity of the HDS plant is limited by the rate at which solids can be settled and separated from solution in the primary thickener. The generation of solids within the primary softening part of the HDS process is directly proportional to the TDS concentration of the feed. The strategy to achieve the treatment rate required of the HDS plant, of 2 ML/d of process water feed, is then to limit the solids generation in the process by operating the HDS plant on low TDS process water.

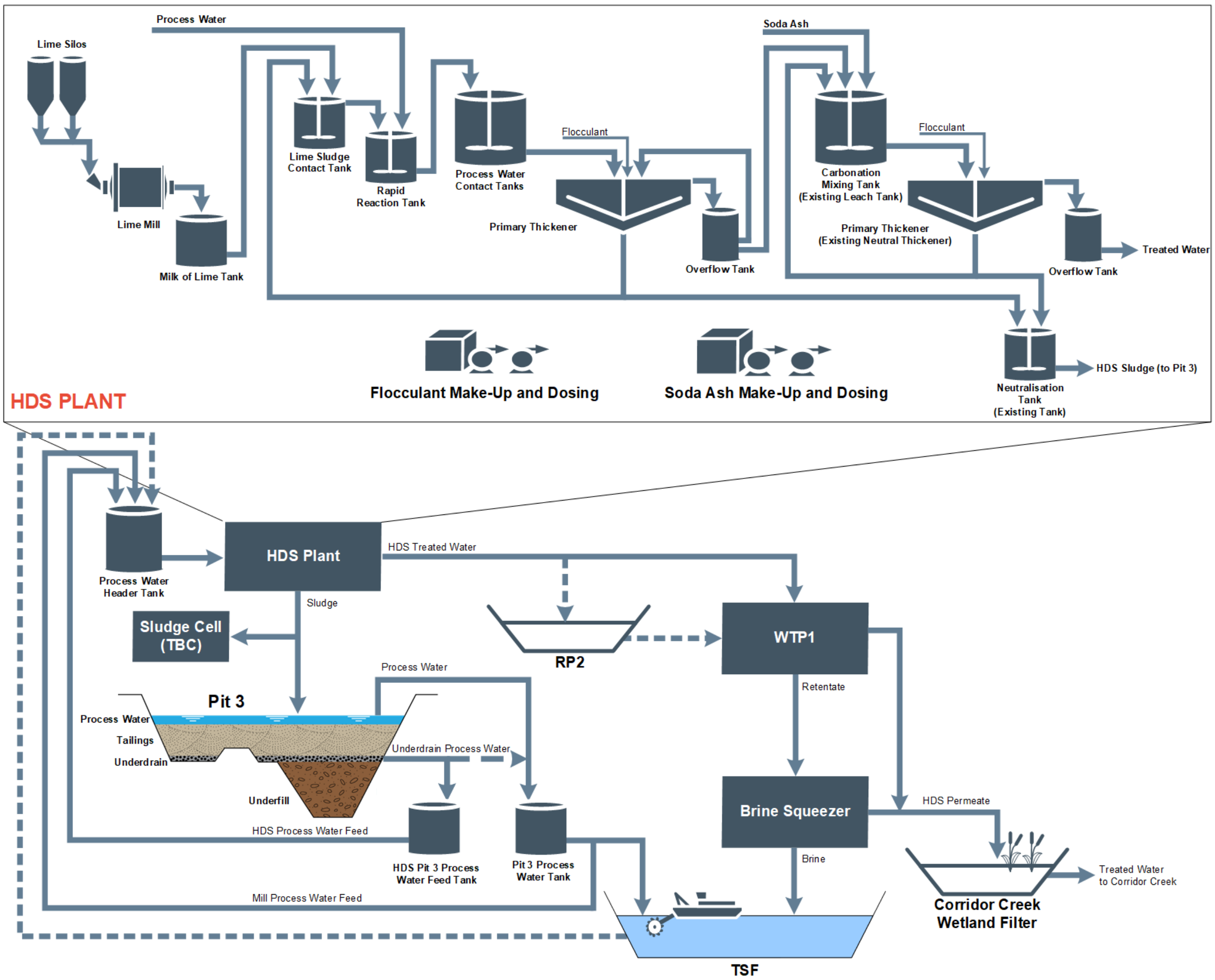

Figure 9-78: HDS Plant Block Flow Diagram

Initially the HDS plant will be fed with Pit 1 decant water, which has a lower salt content than the bulk process water inventory. That source is expected to be depleted in the second half of 2020, at which time the Pit 3 underdrain bore is expected to operational and will provide the lower salt water. When process water flow from Pit 1 or the Pit 3 underdrain bore is not sufficient to match plant capacity, the feed to the HDS plant will be supplemented with process water drawn from the bulk inventory in the TSF and Pit 3.

9.4.3.3 Brine Squeezer

The Brine Squeezer is a reverse osmosis style water treatment plant that further extracts clean water from the reject of pond water treatment (Section 9.4.3.4). Prior to the installation of the Brine Squeezer, a significant proportion of the reject from pond water treatment was directed to the process water circuit. The implementation of the Brine Squeezer effectively intercepts and minimises the volume of this process water source.

The Brine Squeezer was constructed during 2018 and the first half of 2019, has been process commissioned and is awaiting the conclusion of performance testing when sufficient quantities of pond water, and thus pond water brine, are available in the 2020/21 wet season.

An application to discharge permeate from the Brine Squeezer was approved by the MTC in the first half of 2019. Permeate from the Brine Squeezer is discharged through the existing pond water treatment permeate system and is subject to the same release conditions and controls. Reject from the Brine Squeezer is sent to the process water circuit.

The process water treatment strategy requires 1.2 ML/d of release water to be generated from the Brine Squeezer (or a similar alternative treatment process) as a consequence of treating process water. This rate of release water generation is approximately the spare capacity of the Brine Squeezer after treating pond water treatment reject.

ERA commenced a continuous piloting and subsequently a full plant trial in the second half of 2020 to establish the capacity of the Brine Squeezer technology to treat a range of process water sources (of varied salt concentration and chemical composition). This trial will consider low salt sources of process water, such as that drawn from the Pit 1 decant or Pit 3 underdrain bore and also process water that has been subject to some degree of pre-treatment through the HDS plant, to remove metals that are problematic for reverse osmosis based treatment processes.

9.4.3.4 Pond water treatment

The three water treatment plants are the primary method of managing pond water on the RPA. Each is a micro-filtration reverse osmosis plant. The water treatment plants treat pond water from RP2 and RP6, and produce a clean water stream (permeate) and a reject stream (pond water treatment brine). Permeate from the pond water treatment plants is directed to the release water catchments of either Corridor Creek or RP1. Currently, reject is typically discharged to the TSF, though it may be recycled back into the pond water inventory if pond water quality permits. With the availability of the Brine Squeezer, reject from WTP1 and WTP2 may be diverted to the Brine Squeezer, whilst reject from WTP3 will continue to be handled as before.

The water treatment plants are operated on an as-required basis to manage the accumulation of pond water from rainfall in the wet season, and a relatively small quantity of HDS product. Based on a median rainfall scenario, the total pond water treatment capacity delivers 1,400 kL/a of permeate to release. Treatment capacity across the three plants is approximately 14,100 kL/d, allowing for the discharge of most permeate to Magela Creek during the wet season with the remainder disposed of by irrigation to land during the dry season.

Operation of the pond water treatment plants is triggered based on total pond water inventory. Trigger volumes will be set consistent with the water management plan and water treatment strategy. The pond water treatment plants will continue to treat water until the entirety of the final landform catchment is converted to release.

9.4.3.5 Schedule of progressive plans

The sequence for process water storage during the closure phase, with approximate dates, is provided in Table 9-38

Table 9-38: Sequence for process water storage

TIMING	TASK
January 2021	After tailings deposition has finished (post tailings transfer from the TSF to Pit 3 and mill operations), all process water will be transferred to Pit 3 to allow cleaning of remnant tailings solids from the TSF.
September 2021	Following the cleaning of the TSF, free process water will be split between the TSF and Pit 3. The volume in Pit 3 will vary to suit the requirements for the installation of wicks in the Pit 3 tailings and the operation of the barge for hydraulic placement of the initial Pit 3 cap. The balance of free process water will be stored in the TSF.
October 2022	On completion of hydraulic placement of the initial Pit 3 cap, all free process water in Pit 3 will be transferred to the TSF, to allow for bulk material movement to backfill Pit 3.
August 2024	Once the free process water inventory has sufficiently reduced, free process water will be transferred from the TSF to RP6.
July 2025	The free process water inventory will have been drawn down to zero.

Figure 9-79: WTP 1 – reverse osmosis membranes

9.4.3.6 Contingency plans

The final volume of process water that will require treatment prior to the end of closure is directly dependent upon rainfall. The current closure strategy is based on a median forecast (or a 50th percentile – i.e. P50 case) of outcomes given historical variation in rainfall.

In the case where current process water treatment rates are not achieved, or higher than average rainfall is experienced earlier in closure, then the contingency plans for water treatment, in turn, are potentially to:

- extend the operation of the HDS plant post-2022
- purchase a second Brine Squeezer and/or
- construct and operate additional evaporative plant

There is potential for rainfall scenarios to exceed the capacity of the above contingencies, particularly a significant rainfall occurring late in the closure phase. Should this occur, the identified contingency would see water treatment extend following closure. It should be noted that whilst the cumulative volume of water to be treated will depend on many factors, predominantly rainfall, the inventory of contained salt is much less variable and thus there is a high degree of confidence in the capacity of the Pit 3 underfill void space for brine disposal, see Section 9.3.2.1.

Extend HDS plant operation

HDS plant operation is constrained to the end of 2022 due to the availability of Pit 3 as a sludge disposal repository. HDS plant operation can be extended by one year to the end of 2023 if an alternative sludge disposal repository can be identified, without impacting other closure schedule activities. Such an extension in operations could add over 1 GL of additional capacity for process water treatment.

Operation of the HDS plant post-2023 would impact mill demolition requirements, due to the HDS plant requirement for use of mill infrastructure such as the lime silos and lime mill.

Studies on options for HDS sludge disposal post-2021 are underway. It is possible that a suitable sludge disposal option will not be identified, in which case the extension of HDS plant operation will not available as a contingency.

Additional evaporator

The additional evaporator is a small scale standalone evaporative plant. The plant will operate similarly to the existing BC, with a distillate production of 1.8 ML/d. The plant can be located so as to not interfere with other decommissioning and closure activities.

This contingency strategy is not constrained by the closure demolition schedule, can be implemented at any time and can operate as long as necessary. This option will require engineering development, and an implementation plan. The plan must include the trigger for proceeding so as to optimise evaporator impact on process water treatment in the closure phase.

Post-closure water treatment

Should a number of higher than predicted wet seasons occur, in particular late in the closure project, additional water treatment capacity may be required in order to meet the final closure date in January 2026.

In the case of a very large late wet season, ERA may not be able to treat all the process water prior to the final closure date. In this case an application would be submitted to the MTC requesting that water treatment infrastructure, including ponds, be allowed to remain on site for a period to allow for completion of this treatment. This would be requested under the current Clause 2.3 of the Environmental Requirements (ERs).

> *Where all the major stakeholders agree, a facility connected with Ranger may remain in the Ranger Project Area following the termination of the Authority, provided that adequate provision is made for eventual rehabilitation of the affected area consistent with principles for rehabilitation set out in subclauses 2.1, 2.2 and 3.1.*

9.4.4 Bulk material movement

The bulk material movement (BMM) plan was updated in the Feasibility Study. It included the movement of all waste rock to final destination and the construction of the final landform. Specific details of the closure plan for Pit 1, Pit 3, TSF deconstruction and the final landform are presented within the specific domains in the implementation section above. This section provides the overall material movement plan.

The BMM activities will be executed after tailings has been transferred from the TSF to Pit 3 and after Pit 3 is prepared for capping activities. The BMM mining equipment is not able to start backfilling Pit 3 until a geotechnically stable capping layer is installed. The BMM interfaces with the tailings capping methodology described in Section 9.3.2.3.

The BMM works cover the specific disturbed footprint area of 795 ha. A dynamic mine model, including haulage simulations, has been created to assist in producing the closure strategy. This model determined a complex sequence of material movements to ensure all mineralised material ended up in the correct section of Pit 3 and that the Pit 3 backfill is not ramp constrained.

Mining of stockpiles for Pit 3 filling and final landforms is scheduled to commence in October 2022. Mining material from stockpiles and the TSF is planned to be completed in September 2025. The final landform construction will be an ongoing process commencing March 2023 to enable areas to be released progressively for revegetation. This will enable revegetation works to be completed by the completion of closure milestone (8 January 2026). Using predominantly excavators and trucks, a total of approximately 96 Mt of material will be moved.

The BMM plan excavates areas above the final landform (stockpiles and TSF) when there is nearly 100 percent acceptable material for the final landform. However, mineralised material will be mined below the final landform in many of the stockpiles to be placed into Pit 3. A minor amount of mineralised material in the RP6 area will be excavated very late in the closure project and will be buried in the low part of RP2 because Pit 3 backfilling will have reached the point where no more mineralised material can be placed into Pit 3.

The plan for excavation and placement areas are shown in Figure 9-81 and Figure 9-82 respectively.

Manual and dynamic mine modelling was performed as an iterative process where output was reviewed, and assumptions and constraints modified as required. Material was only scheduled to be mined, where necessary, as a proportion of material in stockpiles remains in place due to not having mineralised material and being already below final landforms level. The location and alignment of haul roads was optimised and determined by the dynamic mine model.

The bulk material movements achieved monthly in the closure mine plan are shown in Figure 9-80.

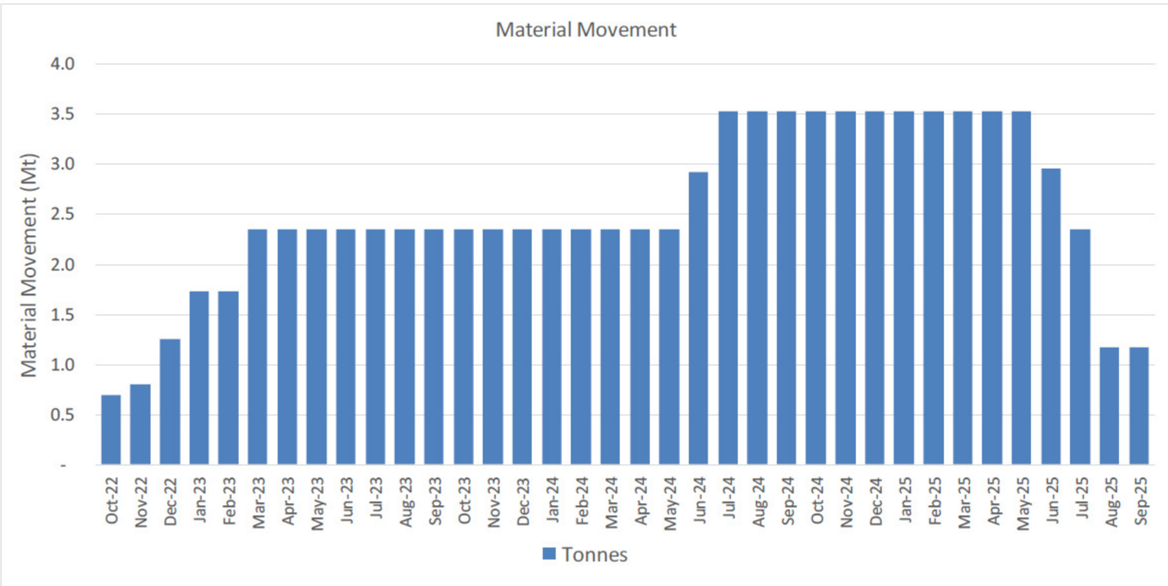

Figure 9-80: Bulk material movement scheduled monthly rates

The ramp-up in October 2022 to February 2023 reflects slower placement rates for Pit 3 secondary capping placement. The increase from June 2024 reflects additional work-fronts established at the TSF. There is a ramp-down in production from June 2025. The production plan was optimised for minimising peak mining equipment and for achieving the required rate of handover of final landforms to the revegetation contractor.

Further details are provided in Section 9.4.5**,** which together provide a summary of the BMM and final landform timing.

The materials placement production is shown in Figure 9-83. The designation surface is areas other than Pit 3, TSF or the stockpile areas. An increase in productivity is required from June 2024 to accommodate TSF works and achieve required progress for final landform handover.

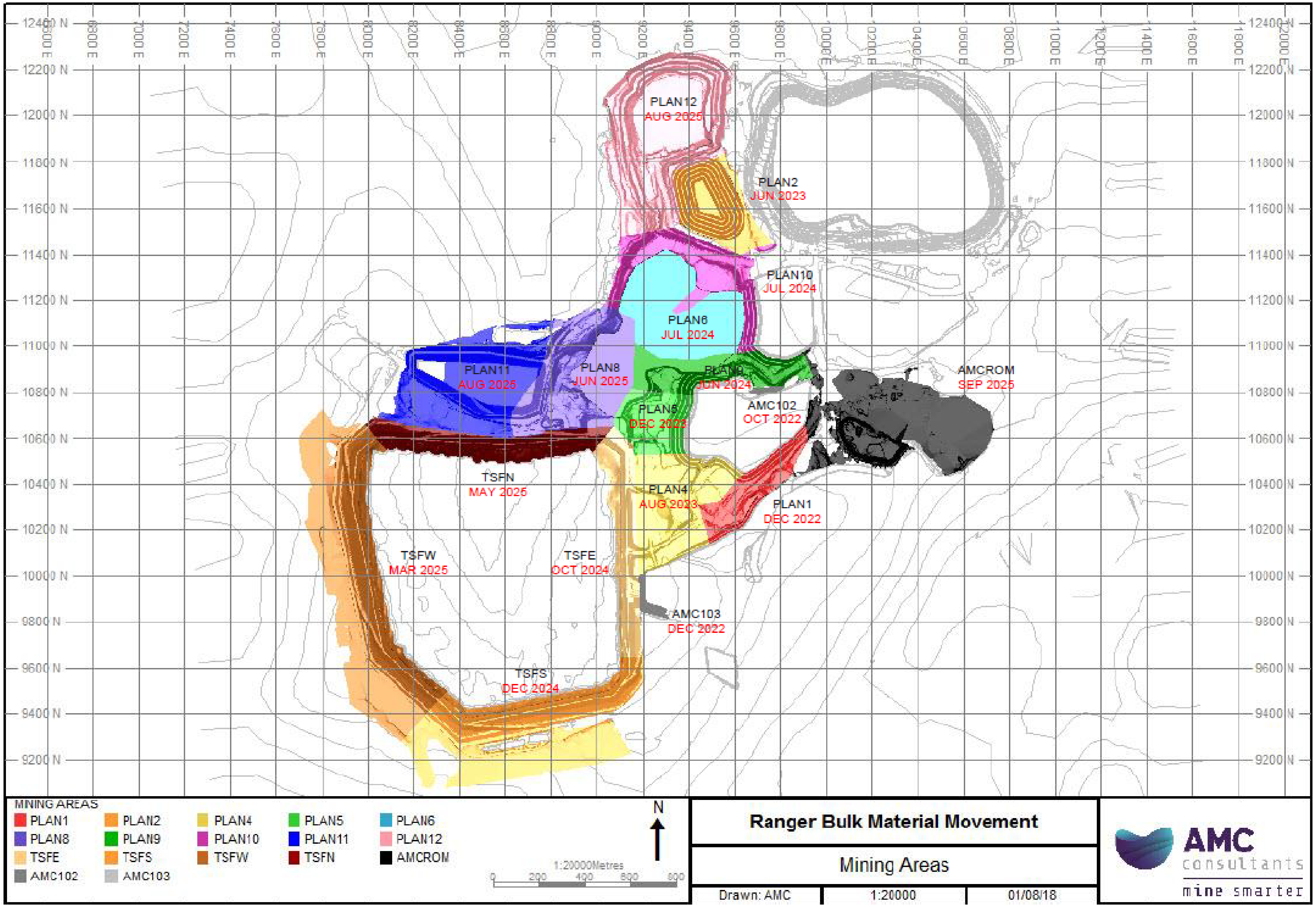

Figure 9-81: Material movement excavation areas

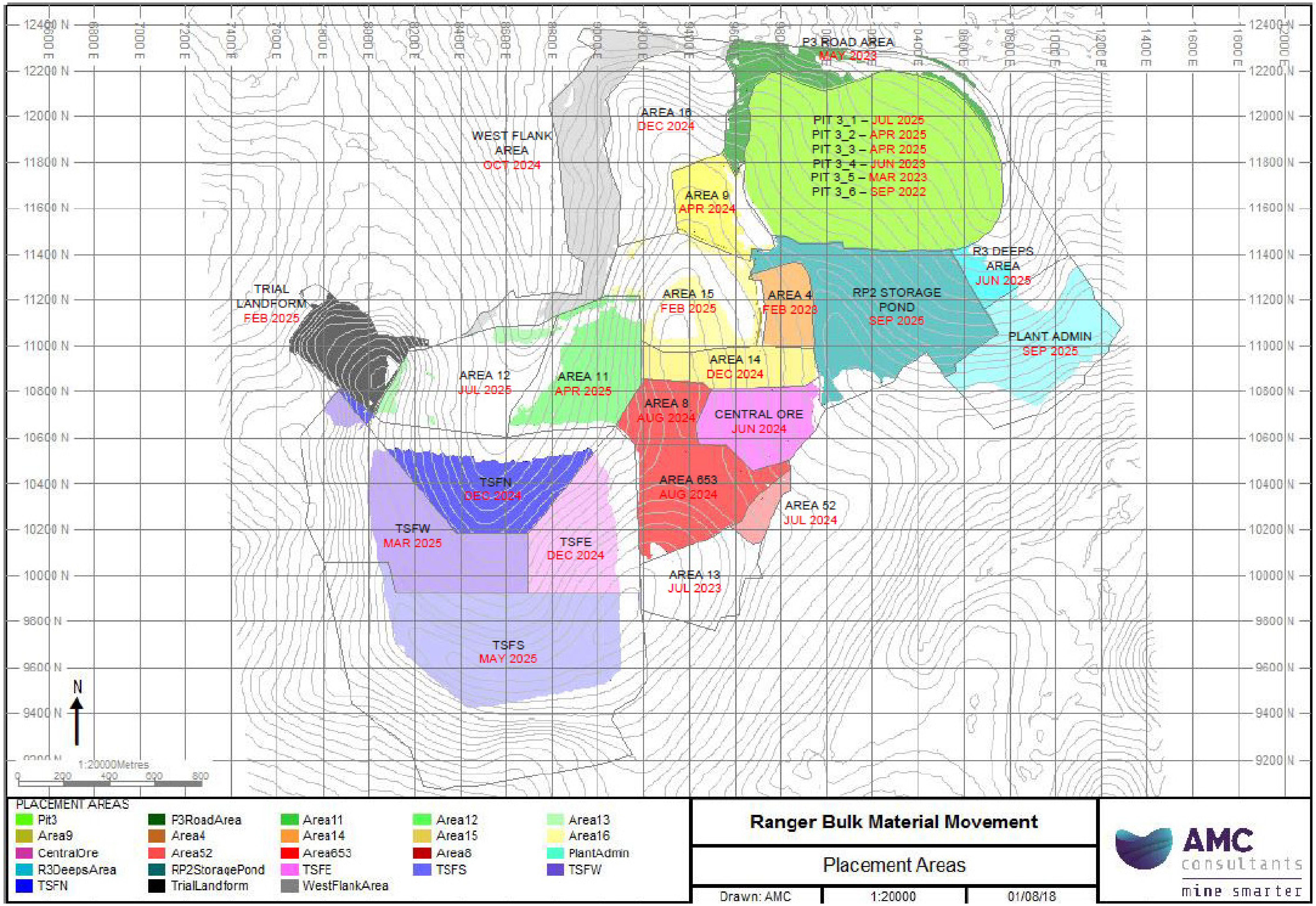

Figure 9-82: Material movement placement areas

Table 9-39: Bulk material movements

Excavation Area	Material movement quantity (t)	Pit 3	Other / Final Landform	TSF	RP2
Plan 1	1,368,486	1,210,465	158,022	0	0
Plan 2	6,305,221	4,676,466	1,628,755	0	0
Plan 4	7,905,547	5,867,893	2,037,653	0	0
Plan 5	7,172,219	6,378,274	793,945	0	0
Plan 6	12,683,261	12,036,622	646,639	0	0
Plan 8	8,617,015	7,556,059	1,060,956	0	0
Plan 9	6,296,065	4,196,980	2,099,085	0	0
Plan 10	2,591,330	2,280,646	310,684	0	0
Plan 11	3,295,667	0	81,040	0	3,214,627
Plan 12	15,525,962	13,443,634	1,130,661	0	951,667
TSFE	2,429,966	0	954,429	1,475,537	0
TSFS	3,484,063	0	1,175,859	2,308,203	0
TSFW	4,958,672	0	244,688	4,713,984	0
TSFN	5,488,161	0	1,230,670	4,257,491	0
AMCROM	2,344,560	0	533,461	0	1,811,099
AMC102	0	0	0	0	0
AMC103	339,715	43,147	296,568	0	0
TOTAL	**90,805,909**	**57,690,186**	**14,383,114**	**12,755,215**	**5,977,394**

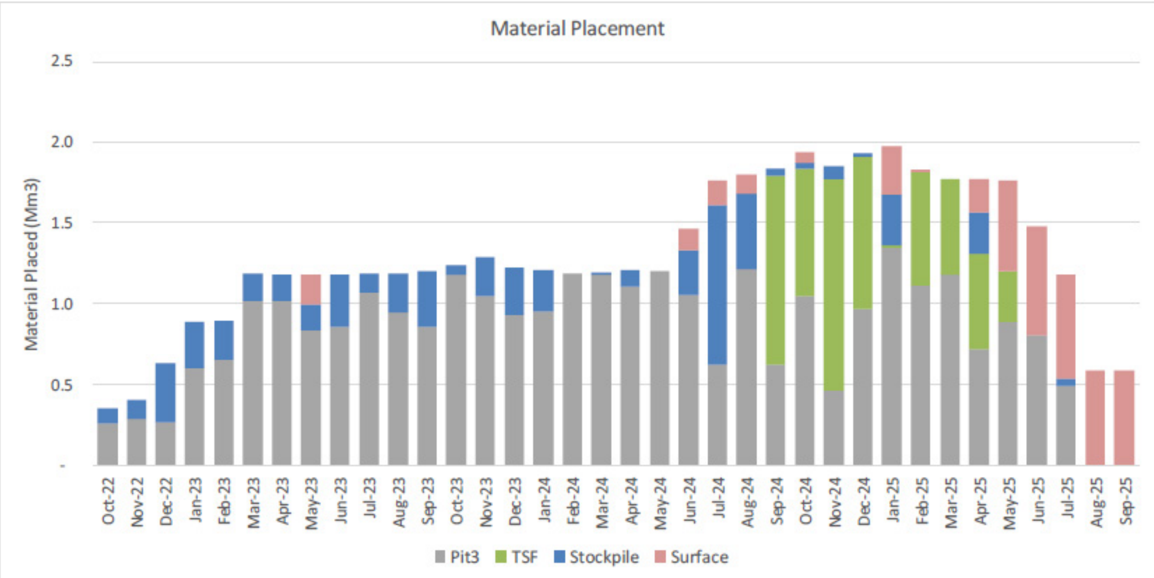

Figure 9-83: Bulk material placement rates

The location, quantity and grade of material in each stockpile is provided in the block model. The current mine plan influences the closure mine plan for location and quantity of stockpiled material forecast to be in place at the start of closure works (after December 2020). Current mining activities are taking place in the southern end of the stockpile area, with material being transferred to the Run-of-Mine (ROM) area to be fed to the mill for processing.

The feasibility study investigated individual stockpiles, the material make-up (presence of 2s and high 1s material) and the volumes within each mining excavation area for each of the material groups. The ability to bury mineralised material in Pit 3 below the 2s material cap (defined by forecasted permanent water table) generally requires material in the southern stockpiles to be prioritised for initial bulk movements. The non-mineralised material in the central and northern stockpiles, will be moved later to form final landforms.

Stockpiles have variable content of uranium oxide (U_30_8) present. The uranium oxide ranges present within the stockpiles are detailed in Section 2. Grade class 1s material is categorised as non-mineralised rock, whereas grade class 2 materials are categorised as mineralised material.

In 2008 an extensive drilling program was conducted to allow a stockpile block model to be developed, and tonnages and grades to be further evaluated. This block model has been maintained via GPS locations of sources and destinations of materials since that time. The block model was used as the base information for the closure mine plan. The material grades distribution across the main stockpile areas are shown in Figure 9-84. The majority of mineralised material is in the southern stockpile areas. Mineralised material stockpiled for processing will be processed prior to commencement of closure. The majority of non-mineralised material is in the central and northern stockpiles as well as within the TSF walls. Non-mineralised material is present in the southern stockpiles as well, as confirmed in the block model.

All mineralised material will be placed below final landform surfaces. Non mineralised rock is scheduled to be used for the final landform. Due to overall cut and fill being balanced, mining of 2s material is prioritised so that it can be placed below this non mineralised rock.

During active mining operations, extracted material was transported by truck to pass beneath a radiometric discriminator, which uses scintillometer heads to measure the gamma particle emissions of each load and categorise the material. Material was allocated to tipping locations based on grade classification. A discrimination plan has been developed for stockpiles to ensure the correct final emplacement of material. The discrimination plan is reflected in Section 9.4.5.1. More discrimination is planned on the southern stockpiles than the northern stockpiles, due to more mineralised material being present. The discrimination plan has a reduced level of discrimination compared to that which occurs for milling, as it is unnecessary to determine whether material should be milled or re-stockpiled.

All the material used in the construction of the TSF walls was confirmed as un-mineralised during construction; therefore, can be used for final landform shaping and does not require to be buried in RP2 or below the Pit 3 2s material cap.

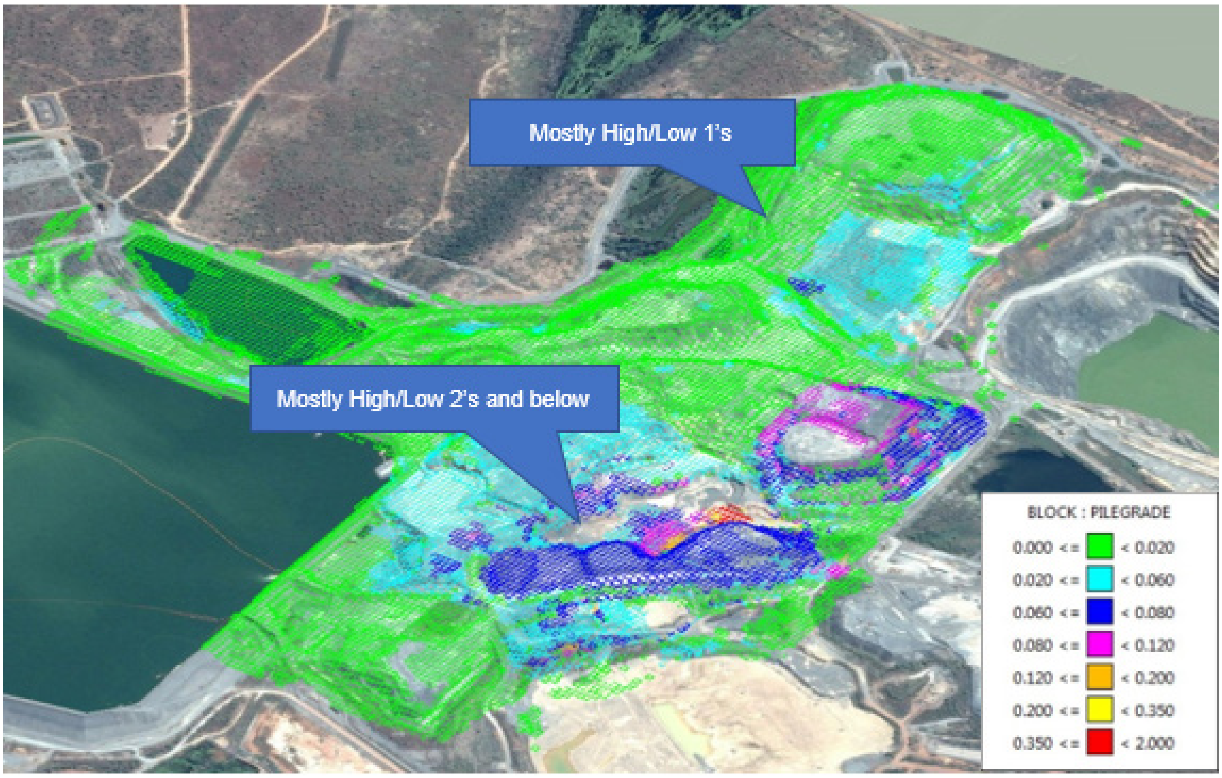

Figure 9-84: Stockpile material grades variance

9.4.5 Final landform / Surface preparation

The final landform is an area, and could be defined as a domain rather than a closure activity. However, it has been included within the activities section, and each of the rehabilitation steps (such as erosion control) will apply to the separate domains. The area of the final landform will be 795 ha. A figure of the boundary of the final landform is provided below (Figure 9-85)

During the closure feasibility study, the final landform topography was updated (to create Digital Elevation Model (DEM) Version FLV6.2) and included progression of the following aspects from the prefeasibility study design:

- material balance for closure works (total material available)
- flood modelling for erosion
- location of drain flow paths to prevent channels forming over pits
- overall landform slope gradient to minimise sediment transport
- slope contour ripping to minimise sediment transportation and improve water ingress
- in-stream environmental rock bars to slow sediment transportation
- in-stream sediment control structures to prevent (as far as practical) the loss of sediment from the disturbed area, and

- learnings from land evolution modelling conducted by the SSB.

The final landform design continues to mirror the original topography as much as possible. Figure 9-86 and shows the proposed final landform topography.

Figure 9-85: Final landform boundary

Figure 9-86: Final landform topography contours on current aerial photo

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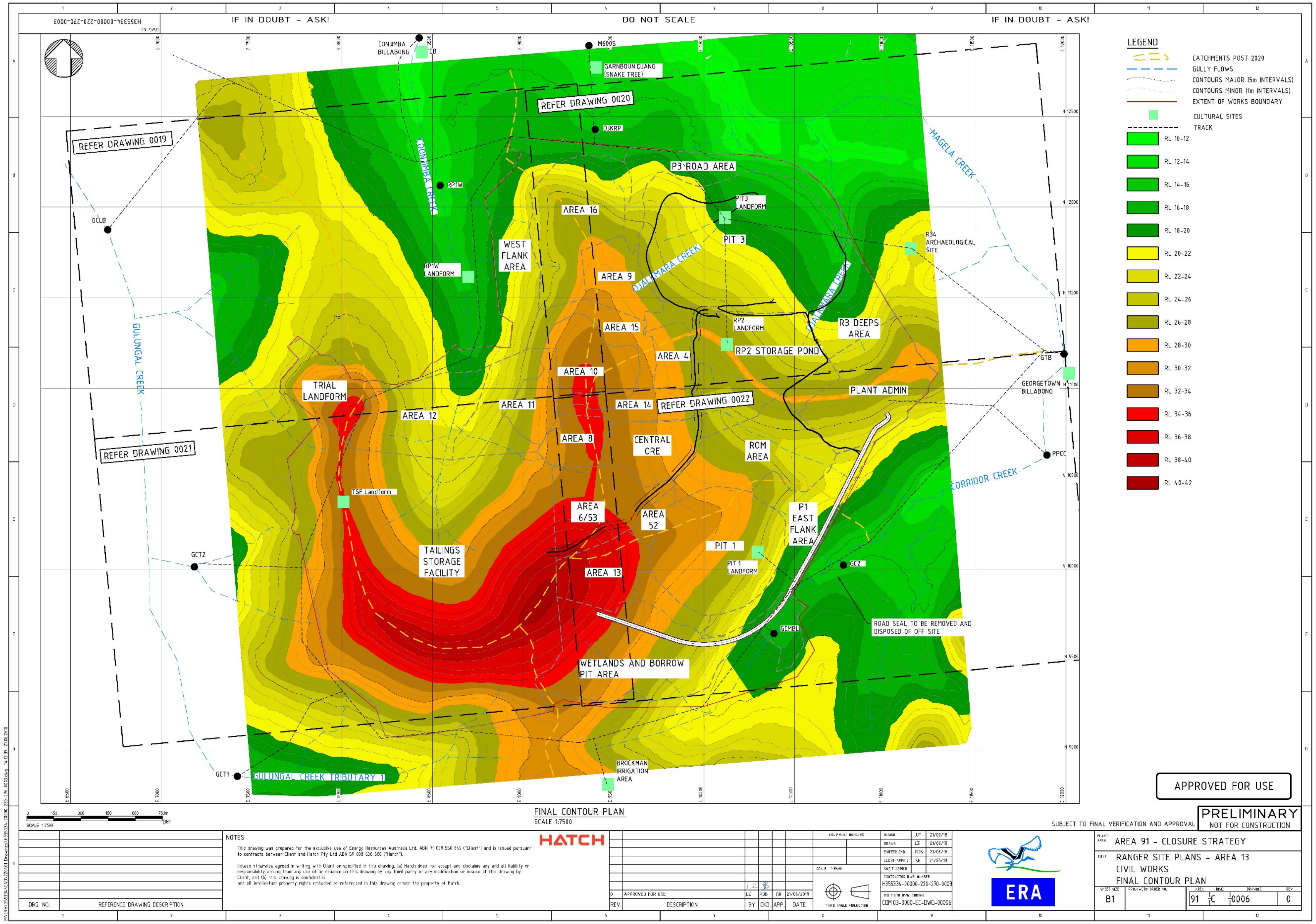


Figure 9-87: Final landform contours

9.4.5.1 Source of waste rock for surface layer

The surface layer of the final landform will be constructed as 1s waste rock (non-mineralised) to ensure that radiation doses are as low as reasonably achievable.

The results of an extensive drilling program in 2008 allowed a block model of the stockpiles to be developed and identified non-mineralised 1s material in several locations in the stockpiles (Section 9.4.4). The block model has been used to identify potential sources of 1s waste rock for construction of the final landform. Commonly used mine planning systems (Vulcan and XPAC) have been used to schedule the material required for construction of the surface layer. The source and destination of waste rock material for final landform construction will be driven by waste rock type and timing of landform construction.

The use of grade 1 material (<0.02 percent U_3O_8) for the Pit 1 final layer will be confirmed using both the stockpile grade block model and truck load gamma analysis via a discriminator (ERA & ELA 2018). Discrimination of every load will occur in specified locations such as the ore stages. Discrimination of every 50 loads will occur in large areas of 1s material where it can be unequivocally demonstrated in the stockpile model that these stages are non-mineralised material. Additional controls include strictly enforced communications and the implementation of the special areas bounded by no-go stakes. Checks of the Tritronics database and reconciliation against the predicted model grades, will also be completed. Any major portions of above grade fill materials detected will be excavated and redirected to the correct location.

ERA will include in its routine operational records, information on the general source and destination locations of surface layer material. Other routine operation activities to be undertaken during construction of the final landform include surveying and mapping of the excavation and fill surfaces.

9.4.5.2 Surface layer construction

To achieve the revegetation objectives, design and construction of the surface layer requires consideration of plant available water, depth and heterogeneity of the waste rock surface layer, material chemical characteristics, and surface treatments to optimise nutrient cycling.

There is a range of vegetation community types in areas outside the mine footprint that represent the spectrum of environments likely to be found across the rehabilitated Ranger Mine final landform and RPA. By understanding the environmental features that are associated with the normal range of native vegetation community types, the conditions required to support these communities and/or the community types that best suit particular environmental conditions of the Ranger Mine final landform can be identified (Humphrey *et al*. 2009). This information informs the final landform design and construction techniques, including the maximisation of the potential plant available water (PAW) stored in the final landform cover (Section 5.5.4).

The design and construction methodology for the final landform has been based on the studies outlined in Section 5. The methodology is based on outcomes of additional WAVES modelling and sensitivity analysis on PSD (particle size distribution) and surface layer thickness, as well as review of literature on the effects of dumping and construction methods on particle size distribution, consolidation of placed materials, and macropores and preferential flow.

The final landform surface layer over mined out pits needs to be between 4 m and 6 m thick (depending on location) in order to provide sufficient PAW to sustain vegetation. As a conservative approach, a layer of at least 6 m will be provided wherever possible. The surface layer will be constructed in at least two lifts, similar to the TLF (Trial Landform). Constructing the layer in two lifts will result in a consolidated layer between lifts, as observed in the TLF, which will be beneficial in cutting off preferential flow paths, thus improving steady water percolation and improving water-holding capacity.

The first layer will be constructed using end-tipping methods. This method results in heavy equipment traffic over the layer and the development of a consolidated layer. The second (and final) layer will be constructed using paddock dumping methods and dozed using GPS-guided dozers to create the final landform.

The physical characteristics of the source material will be assessed visually by the mining team during construction of the final landform cover. Methods for characterisation of waste rock for final landform construction will be refined during construction of the Pit 1 final landform cover and will be able to be applied to other areas of the final landform. Adaptive management for sourcing waste rock for construction will also be refined during construction of the Pit 1 final landform, and may include field assessment of physical characteristics, selective mining of stockpiles and selective placement of different waste rock types depending on the targeted location within the final landform cover.

The final landform will be constructed to achieve the final landform model, which was updated in 2018 during the Ranger Closure Feasibility Study (Digital Elevation Model (DEM) Version FLV6.2). Frequent surveying and GPS guidance will enable the design topography to be followed with a high degree of accuracy. Non-compliances will be discovered by survey during backfilling and can be rectified as operations continue or consolidation requires in-filling after construction. Tolerances on the final construction compared to design are driven by the size of equipment and rock material being handled, these are likely to be in the order of +/- 0.5 m at drainage boundaries and +/- 1 m elsewhere.

9.4.5.3 Erosion and sediment controls

In 2017 Water Solutions Pty Ltd undertook the *ERA Ranger Mine Final Landform Preliminary Flood Modelling and Hydraulic Design* associated with flooding and sediment and erosion control for the proposed Ranger Mine final landform profile. This was further developed as part of the Ranger Closure Feasibility study with drainage channel and sediment basin designs and locations finalised (Appendix 9.3 and Figure 9-93). The key changes to the final landform design surface are summarised below:

- Flow paths are now diverted further from the Pit 1 region, which had previously raised concerns.

- Channels previously reporting to Djalkmarra Creek (flowing over Pit 3) in pre-mining conditions have been diverted to Corridor Creek (flows south of Pit 1) for the final landform. This reduces erosion possibilities over Pit 3.
- Modelling conducted with the inclusion of the sediment control structures demonstrated a reduction in velocities upstream.
- The comparison between ten per cent and one per cent annual exceedance probability (AEP) events to the (probable maximum precipitation) PMP highlight the low velocities expected through the main channels. The stream velocity rarely exceeds the recommended limit of 1.5 m/s for events up to the one per cent AEP event. Velocities would only approach the 2 m/s to 2.5 m/s in the unlikely circumstance where the PMP was to occur.

The changes to the final landform design surface were incorporated into the final landform surface DEM Version FLV6.2. This included the diversion of all major drainages away from the pits and areas identified in the modelling predictions on the landform version FLV5_02 (Supervising Scientist 2016).

The management of water and sediment are key issues during the construction phase of the final landform. ERA plans to construct temporary drainage structures and sumps with appropriate pumping infrastructure. These will be installed as required with details provided in the Ranger Water Management Plan. Temporary structures will remain in place until the installation of the permanent erosion control measures detailed within this section.

Surface treatment

A variety of surface treatments have been identified by ERA to limit erosion and sediment discharge on the general surface of the landform. If erosion can be limited then the amount of sediment that travels downstream can be significantly reduced. Several of these treatments are being trialled on Pit 1 to help inform the final measures. The treatments applied to the various areas of the final landform will depend upon a number of factors, including slope and location.

The two main surface treatments are revegetation and ripping. Revegetation is a critical action in reducing erosion from the site as the roots act to bind the soil together, the canopy helps intercept direct rainfall on the soil surface, and the leaf matter and woody debris falling from vegetation will, in the longer term, help to protect the surface (Section 9.4.6).

The current areas of the final landform identified as requiring ripping are shown in Figure 9-88. These were the locations of higher flow identified in the flood modelling completed during the Ranger Closure Feasibility Study. A ripping spacing of 3-4 m was chosen to allow the safe operation of a small excavator and all-terrain vehicles during planting. Previous examples of waste rock ripping are shown in Figure 9-89 and Figure 9-90.

Some shallow ripping of the landform surface is required to allow water to infiltrate and to capture other resources locally for plants use and soil development, such as fine sediments, seeds, litter/organic matter and nutrients. However, advice received through stakeholder consultation with the Northern Land Council and the Gundjeihmi Aboriginal Corporation have indicated that ripping of the landform may impact traversibiilty, so it should be minimised wherever possible. To address these stakeholder concerns ERA is conducting a ripping trial on the Pit 1 landform (Section 9.3.1.3). The outcomes of this will inform the final landform ripping plan and will be included in subsequent MCP updates.

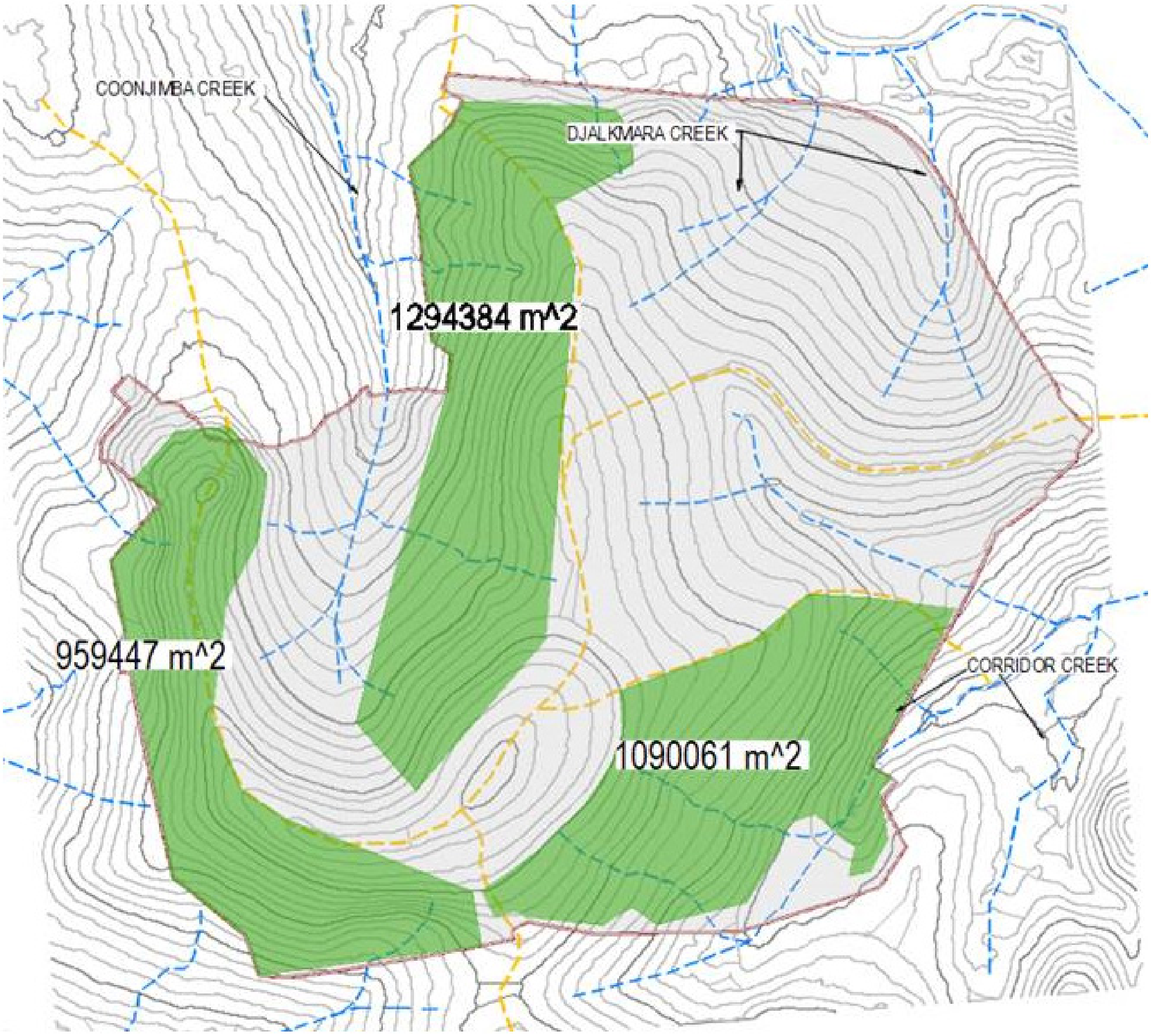


Figure 9-88: Footprint of final landform requiring contour ripping

Figure 9-89: Contour ripping on trial landform trial of 2m interval (2010)

Figure 9-90: Contour ripping on Stage 13, with 3 m intervals (March 2020

Environmental rock bars

Where the streambeds exceed the maximum desired slope of two per cent or where flood modelling has indicated that stream velocity exceeds 1.5 m/s, environmental rock bars will be installed to mitigate streambed erosion. The alignment of environmental rock bars was made to ensure both edges are tied into the crest height level to ensure proper functionality.

The following catchments will have environmental rock bars:

- Coonjimba Creek (CJ) (four rock bars)
- Djalkmarra Creek (DJ) (three rock bars)
- Corridor Creek (CR) (two rock bars)

Environmental rock bars will be placed upstream of the main sediment control structure, as these are considered the major flow paths and are near key areas such as Pit 1, Pit 3 and the TSF. Figure 9-93 shows the location of each along with the storage data. Figure 9-91 shows the typical section for the environmental rock bars. Table 9-40 provides design details for typical rock bars.

Table 9-40: Environmental rock bar design features

Environmental rock bar design features	
Height at centre	0.8 m
Crest width	0.8 m
Rip rap sizing	d_{50}=400 mm
Downstream slope	1V :4H
Upstream slope	1V :2H
Key trench depth	300 mm
Geotextile	A44 BIDIM or equivalent

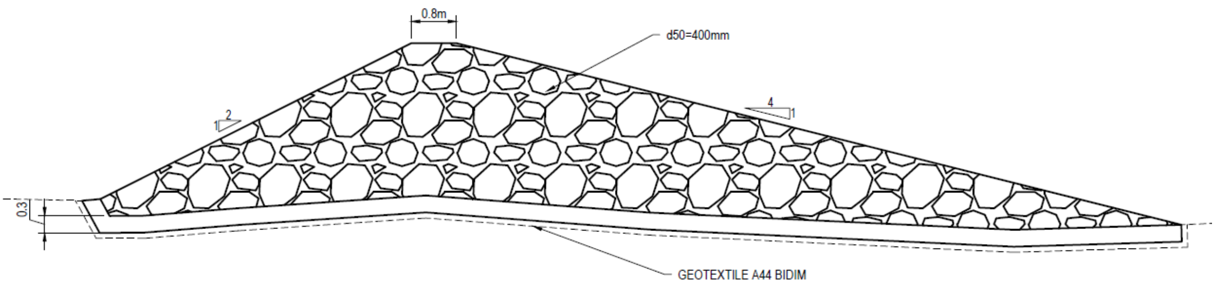


Figure 9-91: Environmental rock bars – section view

The general drawings of the environmental rock bars planned for installation on the final landform and provided in Appendix 9.2.

Sediment control structures

There are 18 boundary sediment control structures to be installed in streambeds to prevent sediment from leaving the current disturbed areas. Figure 9-93 shows the location of each along with the sizing and storage volume. The control structure consists of a leaky wall with a fine filter on the upstream side of the embankment. The structures are similar but larger than the environmental rock bars and include additional features. The design features and positioning of the structures are summarised in Table 9-41 shown on Figure 9-92. The designs in these figures are typical for these structures.

Table 9-41: Sediment control structure design features

Sediment Control Structure Design Features	
Height at centre	1.2 m
Crest width	1.2 m
Rip Rap sizing	d_{50}=400 mm
Downstream slope	1V :4H
Upstream slope	1V :2H
Key trench depth	300 mm
Upstream rock pad	Length=5 m, d_{50}=200 mm, thickness=400 mm
Downstream rock pad	Length=2.4 m, d_{50}=200 mm, thickness=400 mm
Filter layer	300 mm thick, 15-25 mm aggregate
Geotextile	A44 BIDIM or equivalent

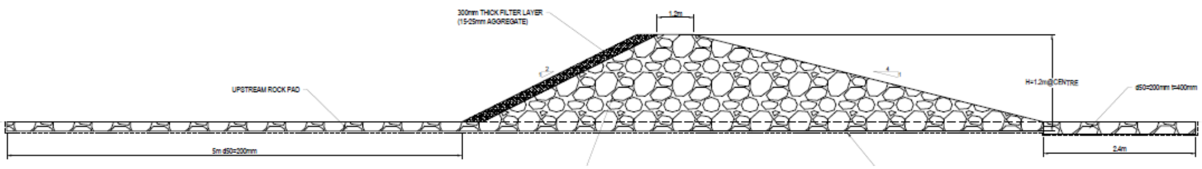


Figure 9-92: Boundary sediment control structure – section view

The height of the structures will vary based on the width / depth of drain.

The locations and design of erosion and sediment control features on the final landform and provided in Appendix 9.2.

IF IN DOUBT – ASK! DO NOT SCALE IF IN DOUBT – ASK!

TABLE 1 – SEDIMENT BASINS

ID	DESCRIPTION	STORAGE AREA* (m^2)	STORAGE VOLUME* (m^3)	(W) WEIR SPILLWAY WIDTH (m)	(C) CREST LENGTH (m)
1	SB01	21189	15557	20	174
2	SB02	28203	16921	20	131
3	SB03	2707	1561	20	155
4	SB04	2637	1347	15	136
5	SB05	3601	1974	20	149
6	SB06	1358	657	11	96
7	SB07	845	408	10	78
8	SB08	20055	8230	30	169
9	SB09	15360	8024	60	250
10	SB10	2190	1114	15	123
11	SB11	3714	2097	20	168
12	SB12	3553	2167	25	154
13	SB13	4577	2476	35	177
14	SB14	8250	4182	35	204
15	SB15	3481	1798	15	148
16	SB16	3778	2120	35	165
17	SB17	4026	2205	15	149
18	SB18	1596	845	15	102

*ALL BOUNDARY SEDIMENT BASINS ARE 1.2M HIGH AT CENTRE. BASIN AREA AND STORAGE VALUES ARE THEORETICAL AS STRUCTURES DESIGNED AS LEAKY ROCK WALL (PERMEABLE).

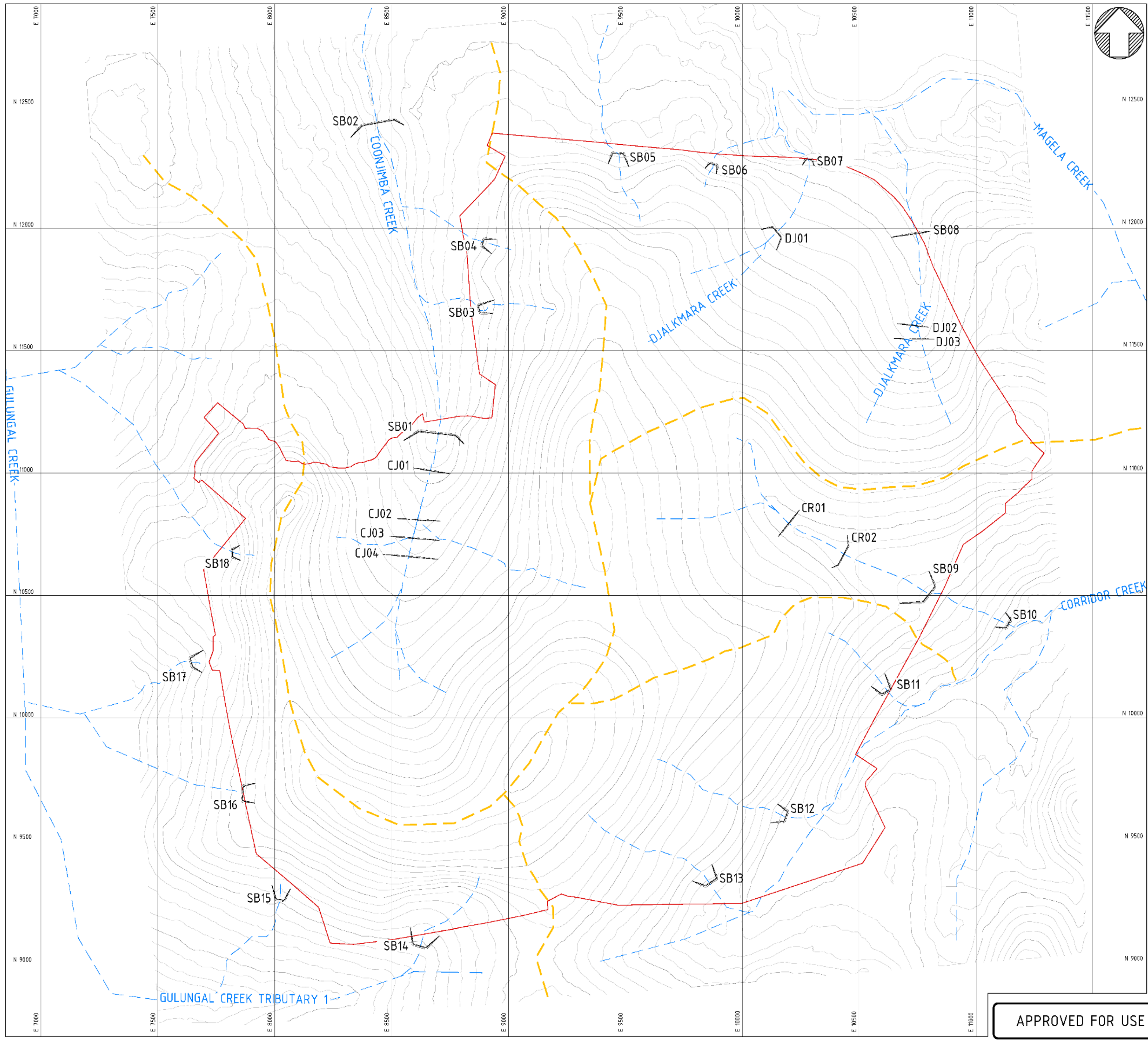
TABLE 2 – ENVIRONMENTAL ROCK BARS

ID	DESCRIPTION	STORAGE AREA* (m^2)	STORAGE VOLUME* (m^3)	(W) WEIR SPILLWAY WIDTH (m)	(C) CREST LENGTH (m)
1	CR01	5292	2381	4075	143
2	CR02	25742	10157	20	163
3	CJ01	5128	1511	20	158
4	CJ02	9042	2810	20	183
5	CJ03	10479	3324	20	215
6	CJ04	12294	3811	20	237
7	DJ01	4083	1452	40	160
8	DJ02	4862	1399	20	136
9	DJ03	5698	1583	50	173

*ALL ENVIRONMENTAL BARS ARE 0.8M HIGH AT CENTRE. BASIN AREA AND STORAGE VALUES ARE THEORETICAL AS STRUCTURES DESIGNED AS LEAKY ROCK WALL (PERMEABLE).

LEGEND

- CATCHMENTS POST 2020
- GULLY FLOWS
- CONTOURS MAJOR (5m INTERVALS)
- CONTOURS MINOR (1m INTERVALS)
- EXTENT OF WORKS BOUNDARY
- SEDIMENT BASINS (SB)
- ENVIRONMENTAL ROCK BARS



CATCHMENT PLAN – FINAL LANDFORM
SCALE 1:7500

SUBJECT TO FINAL VERIFICATION AND APPROVAL

PRELIMINARY
NOT FOR CONSTRUCTION

HATCH

AREA 91 – CLOSURE STRATEGY

GENERAL – AREA 00
CATCHMENT PLAN
FINAL LANDFORM

Figure 9-93: Catchment plan for final landform with sediment basins and environmental rock bars

9.4.5.4 Surface rock structures

Excess large rocks on the landform surface may pose increased safety risks for revegetation execution activities (personnel and equipment) and later access by Traditional Owners traversing the land. However, these rocks may be in high demand for construction of water management features and provide an opportunity to improve early revegetation ecological variability and habitat quality through increased surface heterogeneity.

Many large rocks (e.g. between approximately 500-1500 mm diameter) exposed on the landform surface following construction shall be relocated for use in constructing water management features, such as rock lined drains or sediment traps.

There should be few rocks larger than this, but in areas where very large rocks occur, there is an opportunity to pile them together to form structures that will provide important habitat refugia to encourage early colonisation by fauna and specialist plant species. For example, some reptiles have been found to more-rapidly recolonise degraded landscapes where rock pile habitat is provided (e.g. Croak *et al.* 2013; Goldingay and Newell 2017; McDougall *et al.* 2016).

These structures are under consideration for trialling at Pit 1.

9.4.5.5 Access track installation

Revegetation Execution tracks

Revegetation execution tracks provide access for equipment and teams undertaking:

- irrigation installation and removal
- tubestock planting
- irrigation operations and maintenance.

These tracks will be located across the area requiring revegetation to provide access to the trucks, excavator and vehicles required for revegetation execution activities. As revegetation execution concludes, some of these tracks can be removed (e.g. prepared and revegetated in the following wet season) to reduce the remaining track network to those required for ongoing monitoring and maintenance.

Monitoring and Maintenance tracks

Monitoring and maintenance tracks provide access for teams undertaking:

- water, vegetation and weed monitoring
- weed control activities
- minor revegetation maintenance works, e.g. infill planting, secondary introductions
- site perimeter access for fire and weed control

These tracks need to be suitable for 4WD access and at a general frequency of at least every 100-200 m (loose grid formation) across the landform (this is based on the reach of a hose from a standard slip-on herbicide spray unit). The tracks will be required to remain for at least 2 years following planting, and can be removed (rehabilitated / revegetated) as the vegetation develops and weed risks reduce (e.g. across a 5-10 year period).

Long-term access tracks

Long term access tracks provide access for:

- long term monitoring and maintenance of the developing, rehabilitated site (water, vegetation, weeds)
- stakeholders to inspect the landform, undertake cultural criteria assessments
- Traditional Owners to access the area, spend time on country etc. (Section 8)

9.4.5.6 Schedule of progressive tasks

The final landform construction of Pit 1 has commenced and is scheduled for completion in August 2020. The remainder of the final landform construction will not commence until March 2023 and will be ongoing to enable areas to be released progressively for revegetation (Figure 9-100). This will enable revegetation works to be completed by the closure milestone (8 January 2026).

9.4.5.7 Contingency planning

Following construction of the final landform the post closure monitoring and maintenance phase will commence. Adaptive management processes will be used to manage erosion and ensure long term revegetation success.

9.4.6 Revegetation implementation

Revegetation planning and implementation will be guided by the ERA revegetation strategy that has been developed based on the learnings from over 30 years of revegetation trials and research and an understanding of the natural surrounding ecosystems.

Initial revegetation activities commence after site preparation is complete for an entire revegetation area. However, revegetation planning and preparation begins several years earlier; for example, with seed collection and tubestock production. The initial revegetation process broadly includes:

- planting design (planting density and distribution according to domain).
- seed collection and plant production.
- revegetation activities such as:

- site preparation (herbicide application, irrigation installation, planting site cultivation)
- tubestock planting (hole digging, fertiliser application, planting, watering in and/or irrigation)

Post-planting monitoring and maintenance activities including ongoing irrigation management, vegetation monitoring, infill and understorey planting, weed, fire and feral animal management are covered in Section10.

Site revegetation plans will be prepared for each area to be revegetated. These plans will detail all revegetation activities, how these activities will be implemented and the schedule of implementation over a five-year period. Included will also be maps, field layout plans, monitoring and reporting requirements for each area. The plans will also include any on-ground activities required with respect to the identification of planting boundaries, planting configuration and location of species, monitoring plots and service tracks. This approach will ensure that lessons learnt from previous revegetation trials are incorporated in the future revegetation activities.

There is approximately 1062 ha of land to rehabilitate and revegetate for the successful closure of the Ranger Mine, including 795 ha of waste rock covered area. Unless specified in the respective domain descriptions in Section 9.3 above, all areas shall receive the following standard revegetation treatment.

9.4.6.1 Revegetation domains and species selection

As described in detail in the Section 5, revegetation domains will be developed to reflect any physical and/or chemical constraints that may impact the type of revegetated ecosystem that is able to be re-established. These ‘revegetation domains’ will each have a suitable ‘agreed conceptual reference ecosystem’ identified, which will form the basis of the species list and target densities for revegetation planning and implementation (Table 9-42). Whilst the conceptual reference ecosystems are yet to be finalised, the intention is to revegetate the majority of the landform post mining with open eucalypt-dominated woodlands that have similarities to the native vegetation typical of the surrounding areas near Ranger and within Kakadu NP. In the meantime, a list of agreed tree and shrub species has been developed based on reference site monitoring, revegetation trials, and cultural consultation with Traditional Owners and forms the basis of current revegetation planning (Table 9-43).

Table 9-42: Information available for the major physical and/or chemical constraints.

Potential Constraint	Planning Information Source
Material type and relationships to plant water availability, rooting depth and so on	- The final landform design (currently v6.2) indicates where waste rock will generally be located and the depth of waste rock over natural soils. - Stockpile inspections, observations during construction and upon final handover inspection shall identify localised areas of particularly low or high fines. - LAAs and other areas of disturbance have been mapped as separate closure domains
Surface hydrology and subsurface hydrogeology, including seasonal variations.	- The post closure Ranger groundwater modelling (INTERA 2019) will indicate locations where groundwater exfiltration is likely to occur identifying where increased seasonal water logging may be expected -
Substrate chemical status, including nutrients and contaminants of potential concern.	- Contaminated land assessments - Groundwater quality monitoring and modelling

Over 60 species are currently being considered for initially establishment as tubestock, with a nominal planting density of 1,000 stems per hectare to allow for attrition during plant establishment and subsequent ecosystem development. The vegetation establishment strategy, including more detail on target species, is described in the Section 5.5.4.

Other than species lists and plantings densities specific to the different revegetation domains, the revegetation execution shall follow a standard series of general steps as outlined below.

Table 9-43: Agreed tree and shrub list for Ranger revegetation

TREES	
Acacia aulacocarpa	*Grevillea decurrens*
Allosyncarpia ternata	*Grevillea pteridifolia*
Alphitonia excelsa	*Hakea arborescens*
Asteromyrtus symphyocarpa	*Lophostemon lactifluus*
Brachychiton diversifolius	*Melaleuca argentea*
Brachychiton megaphyllus	*Melaleuca cajuputi*
Buchanania obovata	*Melaleuca dealbata*
Corymbia bleeseri	*Melaleuca leucadendra*
Corymbia chartacea	*Melaleuca nervosa*
Corymbia confertiflora	*Melaleuca viridiflora*
Corymbia dichromophloia	*Owenia vernicosa*

TREES	
Corymbia dunlopiana	*Pandanus spiralis*
Corymbia foelscheana	*Planchonia careya*
Corymbia latifolia	*Stenocarpus acacioides*
Corymbia polysciada	*Sterculia quadrifida*
Corymbia porrecta	*Syzygium eucalyptoides* subsp. *bleeseri*
Elaeocarpus arnhemicus	*Syzygium eucalyptoides* subsp. *eucalyptoides*
Erythrophleum chlorostachys	*Syzygium suborbiculare*
Eucalyptus miniata	*Terminalia carpentariae*
Eucalyptus phoenicea	*Terminalia ferdinandiana*
Eucalyptus tectifica	*Terminalia pterocarya*
Eucalyptus tetrodonta	*Vitex glabrata*
Eucalyptus tintinnans	*Xanthostemon eucalyptoides*
Gardenia megasperma	*Xanthostemon paradoxus*
SHRUB / SMALL TREES	
Acacia difficilis	*Coelospermum reticulatum*
Acacia dimidiata	*Ficus racemosa*
Acacia hemignosta	*Gardenia fucata*
Acacia latescens	*Grevillea dryandri*
Acacia mimula	*Jacksonia dilatata*
Banksia dentata	*Persoonia falcata*
Calytrix achaeta	*Petalostigma pubescens*
Calytrix exstipulata	*Verticordia cunninghamii*
Clerodendrum floribundum	*Wrightia saligna*
Cochlospermum fraseri	
SHRUBS	**PALMS**
Grevillea goodii	*Livistona humilis*
Petalostigma quadriloculare	*Livistona inermis*

9.4.6.2 Seed collection and tubestock propagation

ERA has been working extensively with Kakadu Native Plants Pty Ltd (KNPS), a locally owned and run indigenous supplier, to collect seed and provide seedlings for progressive revegetation that has occurred both at Ranger Mine and Jabiluka over the past 15 years. This supplier has extensive expertise in local plants including seed biology, propagation, revegetation and weed and fire management.

Seed Collection

ERA and KNPS have developed a collaborative process of planning and implementing the seed collection program that is visually presented in the flowchart provided as Figure 9-94. Area-specific revegetation plans, including required species stems per hectare, inform the tubestock and seed collection plans are derived, including inputs of knowledge (e.g. previous nursery performance & phenological traits of targets species within the target provenance zone) and data (e.g. seed lot testing results). With consideration of the rehabilitation schedule and the storage specifics of the different species, ERA issues a monthly 'order' to KNPS to proceed with seed collection. This monthly frequency enables routine update and review of the status of the stock on hand against plan, and modification of the collection plan to respond to any low collections and also to take advantage of any opportunities (such as a group of plants flowering / seeding earlier than usual due to localised seasonal variations).

KNPS undertake ongoing field reconnaissance (including during other 'on country' activities such as weed and fire management) to continuously build on their knowledge of what looks likely to flower and fruit and when. Following collection of seed, KNPS air dry the seed and process it until it is 'clean' of chaff and other material. ERA is accountable for final storage of the delivered seed and maintains the seed management database with all relevant information for each seed lot.

Seed may lose viability over time, and sub-optimal preparation or storage conditions risk accelerating this. Some species have seeds that will keep for many years (such as many Eucalypts) while some cannot be stored for long at all and should be used in the same year that it is picked (such as many native grasses). Seed collection strategies must take these storage timeframes into account to ensure that seed of the best possible quality is available when needed. Seed longevity in storage is highly dependent on seed moisture content and storage temperature. Seed picked for rehabilitation at Ranger is dried, packaged and stored in two secured, climate-controlled storage rooms to preserve seed quality and longevity.

The closure revegetation program is highly influenced by the timing of the rehabilitation schedule, especially the bulk material movement completion and handover process and the January 2026 completion deadline. Whilst some tubestock (and therefore seed) is required early for 2020/21 wet season planting of Pit 1 areas, the majority of planting will occur in the 2024-2025 (inclusive) period.

The majority of seed has a long enough longevity to be collected early and stored to be on hand when required. Collection of these species has already commenced and is progressing well. The plan is that these species should be fully stocked before the peak tubestock propagation and planting period commences.

Some seed, however, can only be used 'fresh' and these collections must be timed to optimise seed availability and time from planting. Whilst pro-active collection strategies and storage improvements aim to extend seed longevity, there remains a risk that 'fresh' seed availability is impacted by uncontrollable factors such as repeated 'failed' wet seasons, high levels of herbivorous predation (e.g. cockatoos), or high fire frequencies or intensities within the provenance collection zone, all of which can reduce the seed of many species. For these species, ongoing reconnaisance will ensure that collections tactics are primed for the instance when they are available and required, to make sure that targets can be achieved and quality is maintained. In addition to this, these species (especially those of particular ecological or cultural importance) are candidates for alternative propagation or revegetation introduction strategies, such as:

- careful use of limited seed to establish ‘source’ populations in the revegetation to provide for ongoing self-colonisation of the ecosystem as it develops
- propagation of tubestock from vegetative material (rather than seeds)
- introductions as part of the secondary introduction program, whenever seed becomes available, and/or conditions are more favourable such that plants from any seed obtained will be more likely to survive and establish

These, and other methods, are being investigated by ERA and KNPS as part of the continued refinement of the revegetation program.

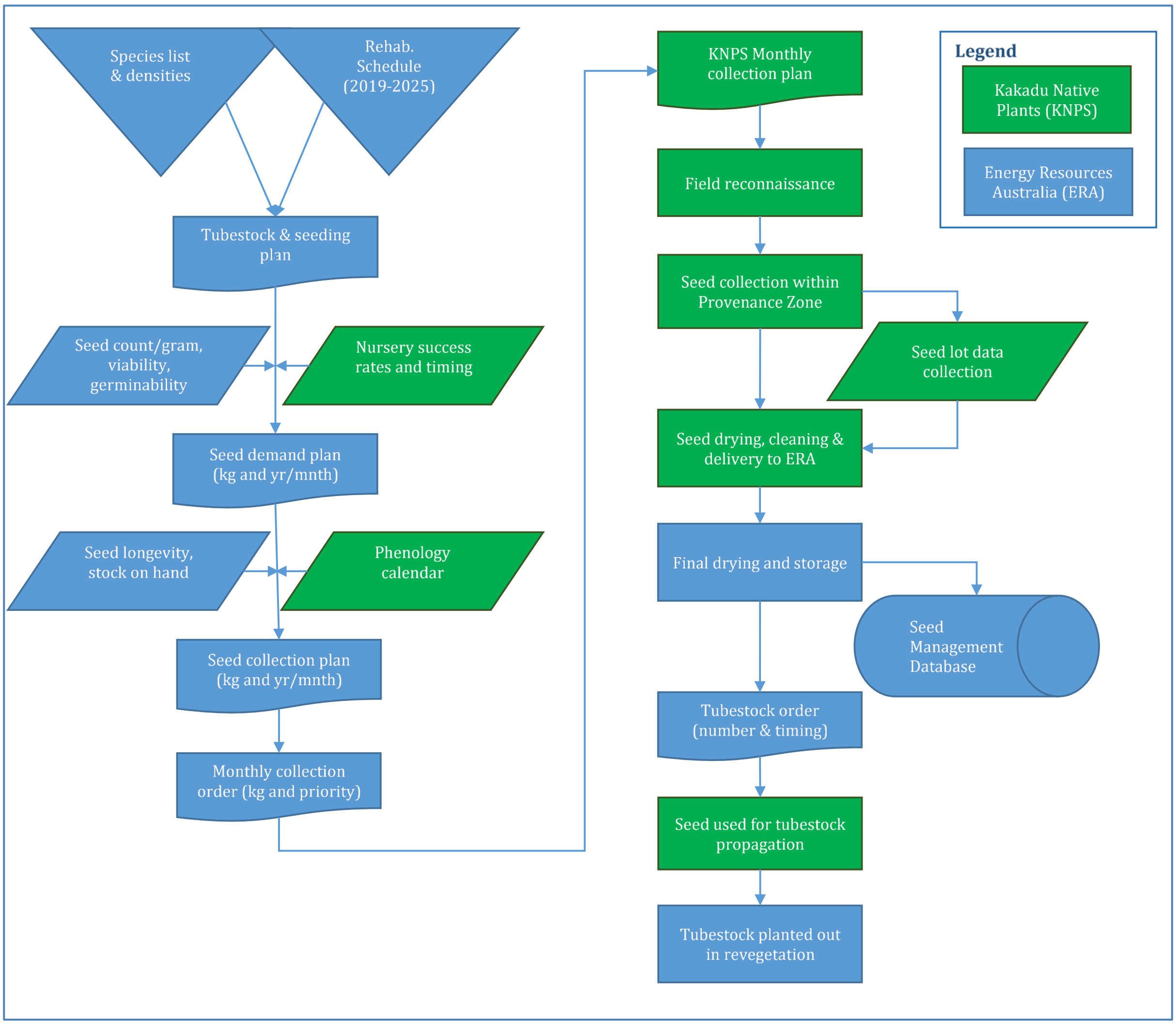


Figure 9-94: Flow chart of seed collection program

Tubestock propagation

Tubestock is propagated in the recently commissioned ERA Nursery near the current exploration yard, north of Jabiru East LAA. Current annual capacity is 250,000 seedlings which is more than sufficient for the 2020-2024 revegetation requirements. For the 2025 peak demand it may be necessary to temporarily expand the facility and/or engage additional, approved suppliers and options for this are being explored (Section 9.4.6.8).

Tubestock is propagated to meet an agreed specification to ensure that seedlings have the best chance of survival after planting out. The ERA tubestock specification is based on best practice (NGIA 2018; Standards Australia 2018), field trials, observations and local knowledge and includes criteria relating to plant form, health, size, and rooting characteristics.

Propagation of tubestock for any given area of revegetation commences approximately 4-6 months before the target planting out date, depending on the expected growth rate of the species and the growing season (e.g. some species may germinate or grow slower in the cooler dry season months). The seed collection program is also based on this timeline so that sufficient seed of target species is available for propagation each time. If any particular species is not available exactly on time for propagation (e.g. due to seasonal impacts to seed collection), they can always be introduced later on during the infill planting program. It is highly unlikely that these will ever be the key overstorey, framework Eucalypt species as these generally have long seed storage times and collection can start early and cover a number of years.

9.4.6.3 Irrigation installation and operation

On the waste rock final landform, newly planted seedlings will be irrigated to ensure good plant survival rates across all species during the dry season, and during wet seasons which can have erratic rainfall. Irrigation will be applied for approximately 6 months with a reduced rate of irrigation for the last 3 months to encourage trees to develop deep root systems, important for accessing water during the dry season and withstanding strong prevailing winds.

Based on experience on the trial landform (Daws and Poole 2010; Lu et al 2019), plants will be irrigated for the first three months to receive an average of 2mm/day, adjusted dependent upon temperatures, evaporation, infiltration and rainfall. For the 3 to 6 month period, this will be reduced so that the soil profile is saturated but allowed to dry before further irrigation.

The proposed irrigation design will utilise above ground, rotational sprinklers connected by polypipe networks to generator-powered pumps at the two water sources (RP1 and GCMBL), and if required, additional bore field sources. Wherever possible, irrigation equipment will be relocated and reused following each 6 month irrigation period. Irrigation infrastructure will be installed after final land forming is complete and prior to planting by teams of workers laying out the pipe network and installing required connections.

Monitoring and maintenance of the irrigation system during operation is critical. In the 2010 trials, an irrigation lateral was found to have been chewed by dingoes/feral dogs and required repair (Daws & Poole 2010). Other issues that may arise include mechanical damage to piping, sediment clogging up filters and smaller-aperture fittings, pump failures and more. Any damage or malfunctioning of the irrigation equipment must be recognised within 48 hours of occurring to ensure there is no impact upon vegetation. The use of pressure-based alarms and a log recording the operation of each panel will ensure that any incidents are recognised and rectified. A stock of critical spares will be maintained so that most maintenance activities can be undertaken without delay.

9.4.6.4 Preventative weed control

Substrates used in the construction of the final landform shall be carefully managed during construction to prevent site contamination with weeds or their seeds. Furthermore, a weed control buffer zone (approximately 200 m wide) around the revegetation sites will be established to assist in preventing weed incursion into revegetation areas and, where required, these areas will be treated with a pre-emergent, residual herbicide prior to planting. The requirement for the pre-emergent herbicide shall be based on a risk assessment considering, among other things, risks relating to; proximity to weeds in adjacent areas, risk of substrate contamination; and substrate type (noting that areas of high fines may be more disposed to weed invasion than rocky areas).

9.4.6.5 Mechanical planting site cultivation

Initial planting of tubestock will be at a density of between 800-1200 stems per hectare (averaging approximately 1000 st/ha) which requires spacing of between 2.5 - 3.5 m. To achieve a ‘natural’ planting effect (e.g. Figure 9-95), planting sites shall be positioned non-uniformly across the prepared surface, along and between (but not in) the rip lines where they occur. Planting sites shall be cultivated by an excavator auger attachment (Figure 9-96) or similar mechanical device. This will ensure there are no large rocks directly in the planting location and loosen the substrate in preparation for manual planting that follows soon (Figure 9-97).

Figure 9-95: View of a 'natural' tree planting distribution and also the flat ground space among trees at Jabiluka revegetation site, Feb 2016. (Note that the surface at Ranger Project Area will be rougher due to waste rock substrate).

Figure 9-96: Example of a specially modified auger cultivator attached to a small excavator, here seen being trialled in waste rock on the Trial Landform in March 2020.

Figure 9-97: A mechanically cultivated planting site.

9.4.6.6 Tubestock planting

Once the preceding steps are completed, the required tubestock in the nursery shall be prepared for planting out. Tubestock of the different species shall be arranged into each tray to reflect the planned species distribution in the field and any plants targeted for ongoing monitoring will be tagged. If required, the revegetation area should be irrigated prior to planting to moisten the substrate and reduce plant stress.

The ERA Standard Operating Procedure (SOP) for Planting Tubestock shall be followed, which includes the requirement for a job hazard analysis prior to starting to identify hazards for the particular revegetation area/project. Following the SOP will ensure the planting task is completed safely, efficiently, and with the quality required to deliver high plant survival rates and rapid early growth. The SOP covers the following key steps:

- Planting locations should already be in place, being the mechanically cultivated site holes.
- Where sites have not been cultivated (or the cultivated hole has collapsed), check the revegetation plan for location and use a forestry shovel (or similar) to prepare a planting hole approximately 400 mm deep and 150 mm wide (Figure 9-98 Step 1).
- Add one slow release fertiliser tablet (e.g. Agriform® or Typhoon®) and, if planting without irrigation (e.g. at the LAAs), a small handful of pre-soaked Earthcare® or Aquasorb 3005 KL® water crystals to the base of each planting hole. Cover the tablet with a small amount of soil to avoid root burn (Figure 9-98, Step 2).
- Place tubestock into the planting hole. Plants in biodegradable pots can be placed directly into the hole (reducing transplant shock), and plants in plastic pots shall be removed from the pot and carefully placed into the hole, and then backfilled with loose material. The surface of the potting mix should be just below the final surface leaving a slight depression which will assist with collecting water for the plant. The rims of biodegradable pots should be buried below the surface to improve thermal insulation of the root ball and prevent moisture wicking. Taking care not to damage the root system, the soil should be pressed firmly into place to ensure there are no air pockets (Figure 9-98, Step 3).
- Newly planted tubestock shall be watered in, either by the irrigation system, low pressure hoses or watering cans.
- For individual plants requiring monitoring, a stake or tag shall be placed into the ground at least 10 cm from the base.

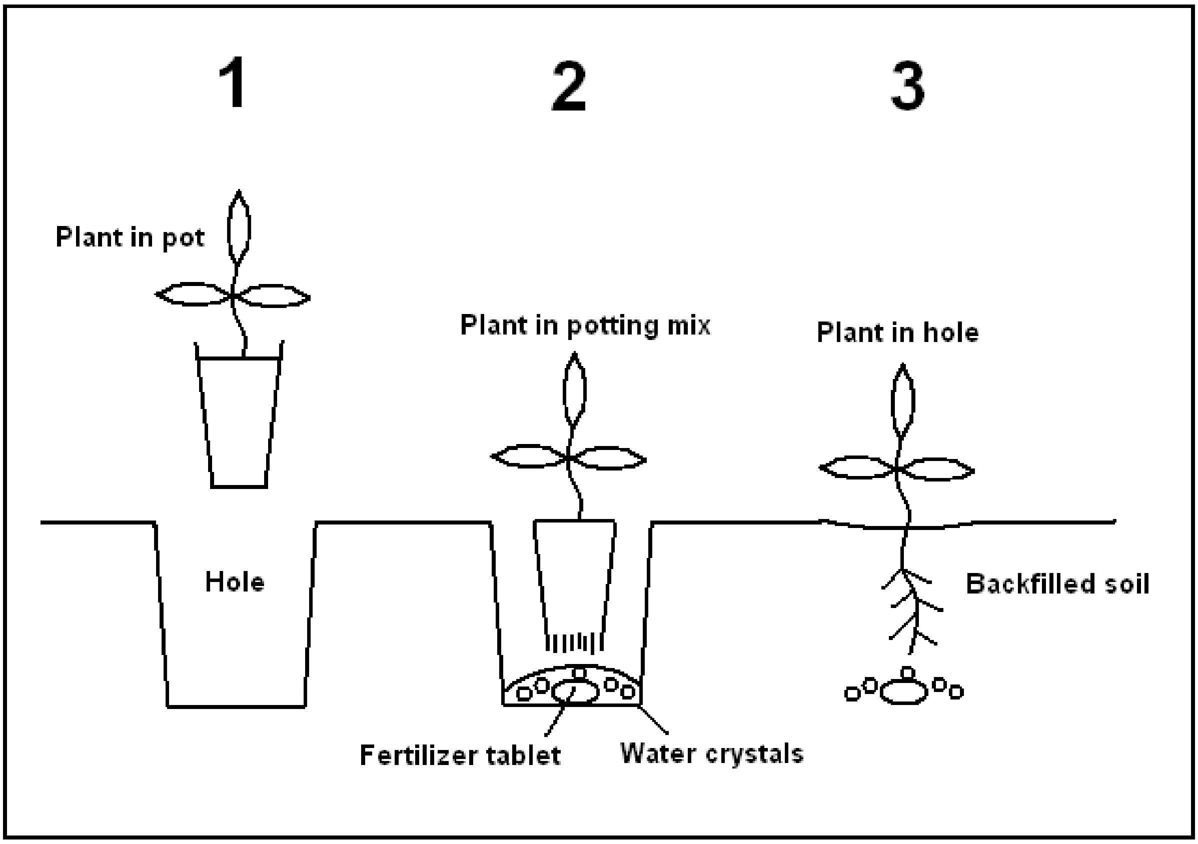


Figure 9-98: Tubestock planting out steps

9.4.6.7 Schedule of progressive tasks

A key consideration of the closure strategy was to provide progressive handover of final landforms to facilitate achievable revegetation production rates for contractors. A rate of 1.5 hectares per day revegetation day was set as a target.

The progressive release of final landforms output from the feasibility study that achieves this rate is shown in Figure 9-100.

Figure 9-99: Example of a completed, revegetated area (Stage 13.1).

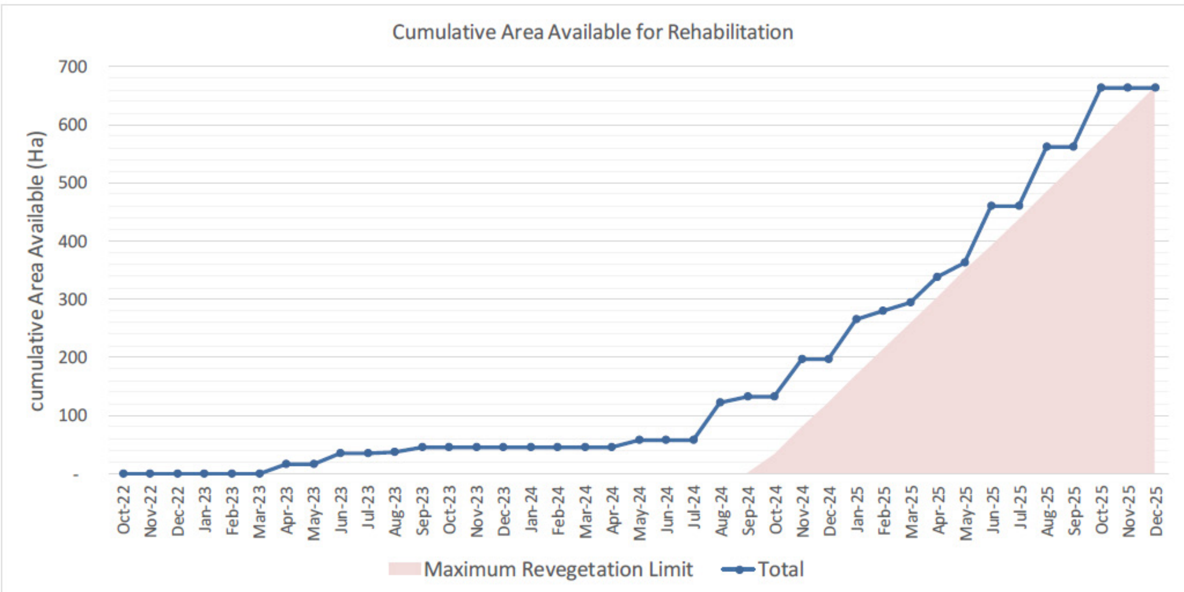


Figure 9-100: Cumulative handover of completed final landforms

9.4.6.8 Contingency plans

Tubestock production

The Ranger Mine nursery has been commissioned with a current annual capacity of 250,000 plants. ERA has identified two suitable contingency options to mitigate potential issues associated with tubestock production:

- A temporary expansion of the on-site Nursery facility could support the anticipated peak demand during 2025
- ERA will establish an arrangement with a suitably qualified service provider to grow tubestock from seeds provided by ERA, should the need arise. Under this option, the provider would be required to supply tubestock in accordance with the intended nursery and seedling specifications (e.g. soilless substrate, mycorrhiza inoculation and fertilising, seedling quality).

Seed collection

More than 150kg of clean seed and 50,000 fresh fruit of the target species is required to raise the 760,000 plus seedlings for the initial planting of the Ranger final landform. A permit to collect seed within Kakadu NP has been obtained for more than 500 kg of seed and 60,000 fresh fruit to allow for variable seed quality and also any final adjustments of the target species lists and/or densities.

It is highly unlikely that the required quantities of seed could be obtained for all species in any one collection campaign due to a number of factors, including:

- seasonal variation in seed set and availability due to environmental conditions such as rainfall, predation and/or bushfires
- logistical constraints associated with finding sufficient plants within the approved collection area with mature fruits/seeds before seeds are naturally dispersed
- timing requirements for matching tubestock propagation and planting with rehabilitation earthworks schedule

Thus, the seed collection program is a multi-year exercise with many ‘moving parts’ that requires a structured yet agile management approach.

The closure revegetation program is highly influenced by the timing of the rehabilitation schedule, especially the bulk material movement completion and handover process and the January 2026 completion deadline. Whilst some tubestock (and therefore seed) is required early for 2020/21 wet season planting of Pit 1 areas, the majority of planting will occur in the 2024-2025 (inclusive) period.

Collection of species with seed storage longevity has commenced in earnest and targets are being tracked against the plan. The plan is that these species should be fully stocked before the peak tubestock propagation and planting period commences.

Some seed, however, can only be used ‘fresh’ and these collections must be timed to optimise seed availability and time from planting. Whilst pro-active collection strategies and storage improvements aim to extend seed longevity, there remains a risk that ‘fresh’ seed availability is impacted by uncontrollable factors such as repeated ‘failed’ wet seasons, high levels of herbivorous predation (e.g. cockatoos), or high fire frequencies or intensities within the provenance collection zone, all of which can reduce the seed of many species. For these species, ongoing reconnaissance will ensure that collections tactics are primed for the instance when they are available and required, to make sure that targets can be achieved and quality is maintained. In addition to this, these species (especially those of particular ecological or cultural importance) are candidates for alternative propagation or revegetation introduction strategies, such as:

- careful use of limited seed to establish ‘source’ populations in the revegetation to provide for ongoing self-colonisation of the ecosystem as it develops
- propagation of tubestock from vegetative material (rather than seeds)
- introductions as part of the secondary introduction program, whenever seed becomes available, and/or conditions are more favourable such that plants from any seed obtained will be more likely to survive and establish

These, and other methods, are being investigated by ERA and KNPS as part of the continued refinement of the revegetation program.

9.5 Overall closure implementation schedule

The Ranger Mine closure implementation comprises a number of key tasks. Closure milestones for demolition completion and target dates are included in Table 9-44. In accordance with the Ranger Authorisation all closure activities require ministerial approval before proceeding. All identified closure projects are scheduled for submission for approval ahead of planned implementation (Section 3.4).

Table 9-44: Key milestones for completion of demolition

Key Milestone	Activity Reference	Date
Pit 1 Backfill (date for completion)	KM-34	31-Aug-20
BC Fan Upgrade Construction.(date for project completion)	KM-33	20-Jan-21
Dredging Complete Milestone	KM-04	31-Jan-21
TSF Floor Clean. (date for completion)	KM-31	10-Aug-21
Pit 3 Closure MTC Final Approval	KM-41	14-Sep-21
Pit 3 Wicking (date for completion)	KM-35	22-Jan-22
Pit 3 Geotextile (date for completion)	KM-08	11-Jun-22
Pit 3 Initial Cap (date for completion)	KM-36	8-Sep-22
Commence Bulk Material Movement	KM-09	27-Oct-22
Commence Phase 1 demolition	9140-88	05-Jan-23
Commence of Revegetation	KM-10	22-Apr-23
Commence TSF Deconstruction	KM-11	3-Aug-24
Process Water Inventory at Zero (Date From Water Model)	KM-13	3-Mar-25
Pond Water Inventory at Zero (Date From Water Model)	KM-15	1-May-25
Commence Phase 2 demolition	KM-14	1-May-25
Complete decant pumping from Pit 3	4244-02	25-May-25
Complete process water treatment	4231-03	31-May-25
Final Land Form Completion	KM-16	30-Sep-25
Closure Execution Schedule Planned Finish Date	KM-17	25-Nov-25
Completion of Revegetation (Initial Planting)	KM-18	25-Nov-25
End of RPA Lease	KM-32	08-Jan-26

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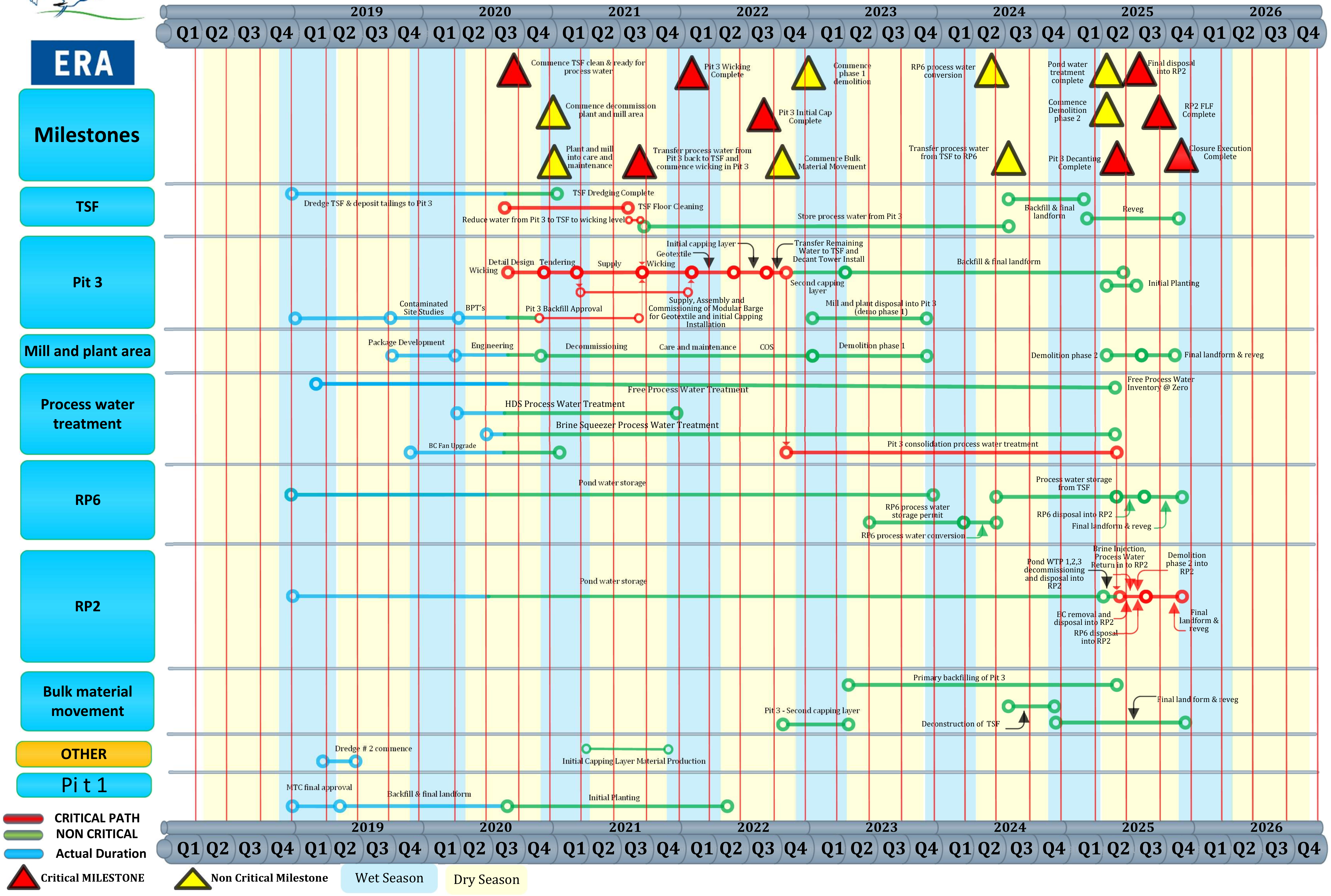
APPENDIX 9.1: SCHEDULE OF ACTIVITIES FOR CLOSURE

DOMAIN	ACTIVITY	TASK	STAGE	TIMELINE						
				2020	2021	2022	2023	2024	2025	2026
Pit 1	Wicks	Installation of prefabricated vertical drains (wicks) within previously transferred tailings	Complete							
	Geofab etc	Installation of geotextile and preload activities	Complete							
	Backfill	Pit 1 bulk backfill	Complete							
	Landform	Surface contoured to final landform shape	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation activity commences on the perimeter of the pit	Commenced							
Pit 3	Underfill	Initial backfill of Pit 3 with waste rock for underfill	Complete							
	Drainage	Underfill drainage layer & installation of extraction pumping system	Complete							
	Piping	Piping etc. from process plant to pit for delivery of tailings installation	Complete							
	Tailings	Tailings from process plant and from TSF delivered to Pit 3	Ongoing							
	Wicks	Installation of prefabricated vertical drains (wicks) within previously transferred tailings	Scheduled							
	Geofabric	Installation of geotextile	Scheduled							
	Capping	Placement of initial rock layer (initial capping) sub aqueously	Scheduled							
		Placement of secondary capping layer using smaller equipment to get sufficient geotechnical strength.	Scheduled							
	Bulk Backfill	Bulk Backfill of rock into pit.	Scheduled							
	Demolition	Placement of deconstructed mill and other infrastructure	Scheduled							
	Demolition	Decommission tailings transfer infrastructure	Scheduled							
	Landform	Surface contoured to final landform shape	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation	Scheduled							
TSF	Infrastructure	Construction of dredge to deliver tailings from TSF to Pit 3	Complete							
	Piping	Installation of tailings transfer piping and infrastructure	Complete							
	Tailings Transfer	Dredge tailings to Pit 3	Ongoing							
	Demolition	Decommission dredge and tailings transfer infrastructure	Scheduled							
	Tailings	Removal of remnant tailings and contaminated material from TSF	Ongoing							
	Process water	Conversion to water storage dam	Scheduled							
	Decommission	Decommission TSF	Scheduled							
	Remediation	TSF floor remediation – if required	Scheduled							
	Waste	Grade 1 (1s) waste coverage	Scheduled							
	Landform	Surface contoured to final landform shape	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation	Scheduled							
LAAs	Assess	Assessment of contamination in soils	Ongoing							
	Demolition	Staged removal of infrastructure	Scheduled							
	Remediate	Remediation, as required	Scheduled							
	Revegetation	In fill revegetation, if required	Scheduled							
Processing plant, admin buildings and water	Services	Continuity of services	Ongoing							
	Decommissioning (make safe)	Decommission of processing plant infrastructure	Scheduled							

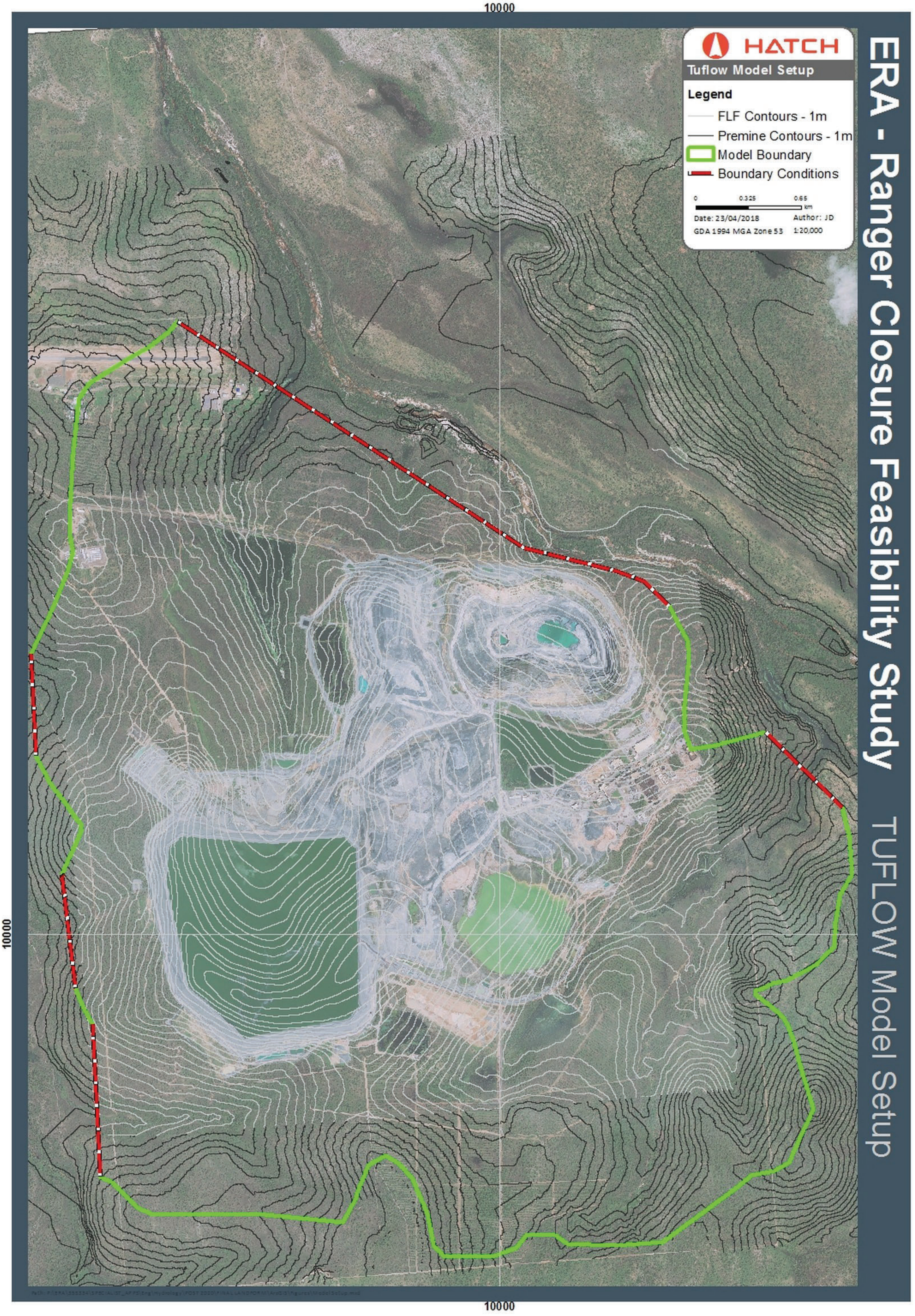
DOMAIN	ACTIVITY	TASK	STAGE	TIMELINE						
				2020	2021	2022	2023	2024	2025	2026
treatment infrastructure	Demolition	Demolition of processing plant and associated site infrastructure	Scheduled							
	Demolition	Demolition of water treatment infrastructure, including removal of pipelines and services	Scheduled							
	Landform	Surface contoured to final landform shape	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation	Scheduled							
Stockpiles	Landform	Surface contoured to final landform shape	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation	Scheduled							
Water management areas	Decommission	Remove lining of RP6, and infrastructure of RP 2, 3 & 6	Scheduled							
	Landform	Surface contoured to final landform shape (RP 2, 3 & 6)	Scheduled							
	Erosion	Installation of erosion control features	Scheduled							
	Revegetation	Revegetation	Scheduled							
Linear infrastructure	Demolition	Remove any infrastructure in corridors (roads, tracks, service corridors, exploration lines)	Scheduled							
	Landform	Recontour and/or rip if required. Block access to tracks	Scheduled							
	Infrastructure	Install fencing and/or signs if agreed to by TOs	Scheduled							
Miscellaneous – borrow pits, landfill sites, magazine etc.	Demolition	Remove any infrastructure in/adjacent to borrow pits, lay down yards, nursery, coreyard, levy, landfill sites etc.	Scheduled							
	Landform	Recontour and/or rip if required. Block access to tracks	Scheduled							

Updated 31.8.2020

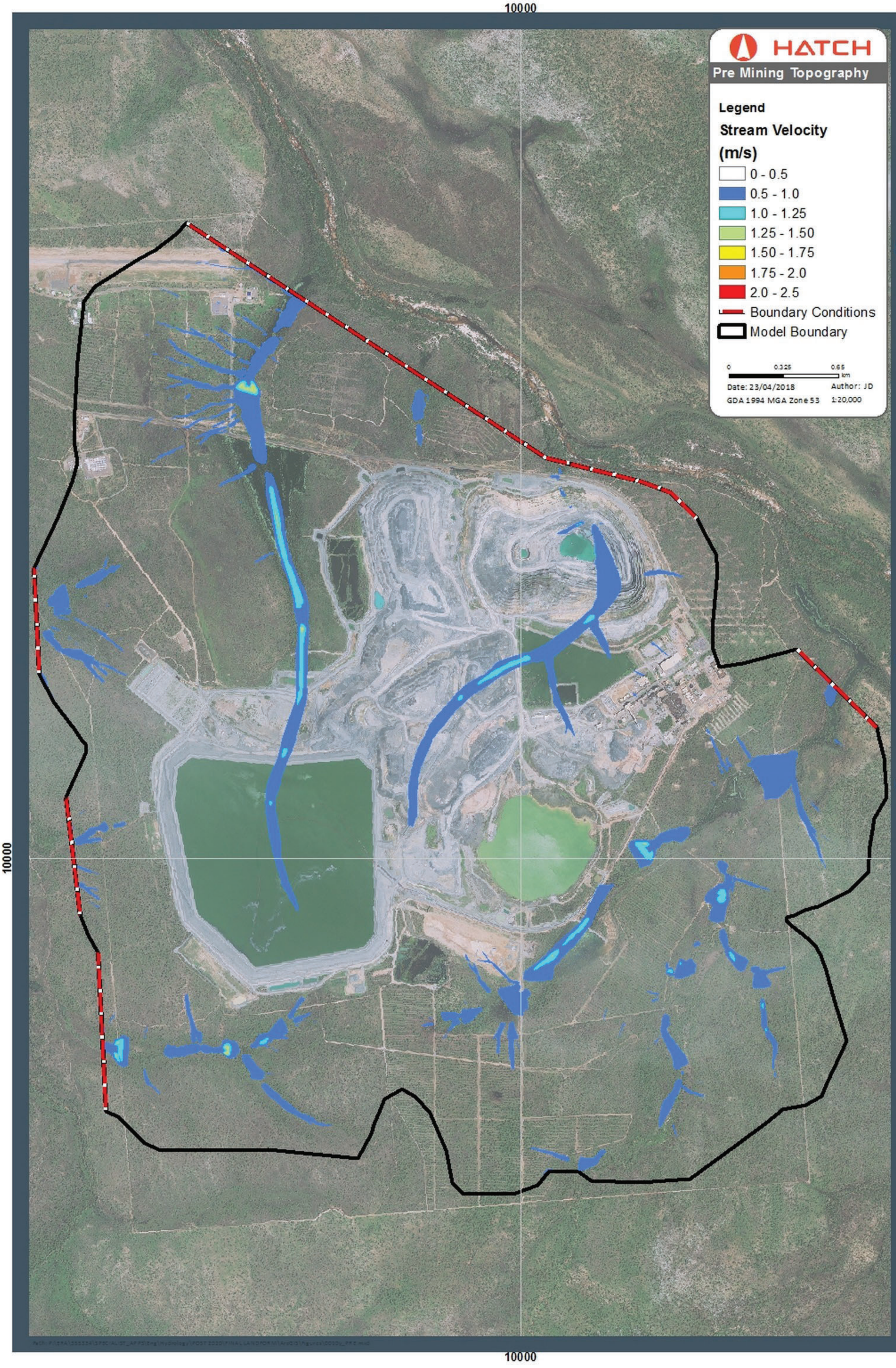
RANGER CLOSURE PROJECT LEVEL 1



APPENDIX 9.2: FLOOD MODELLING

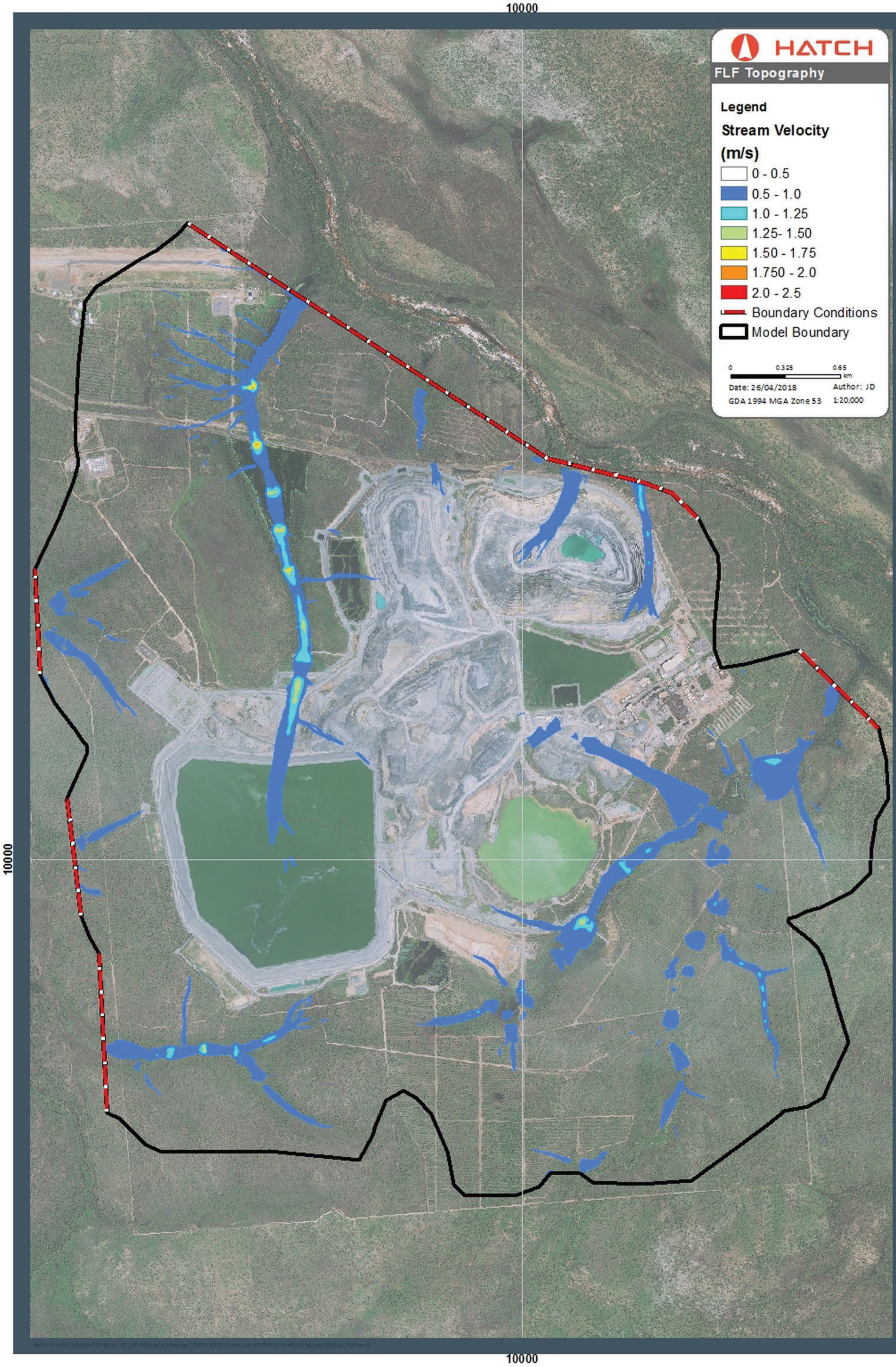


ERA - Ranger Closure Feasibility Study
TUFLOW Model Setup
HATCH
Tuflow Model Setup
Legend
FLF Contours - 1m
Premine Contours - 1m
Model Boundary
Boundary Conditions
0
0.325
0.65
km
Date: 23/04/2018
Author: JD
GDA 1994 MGA Zone 53
1:20,000
10000
10000
10000



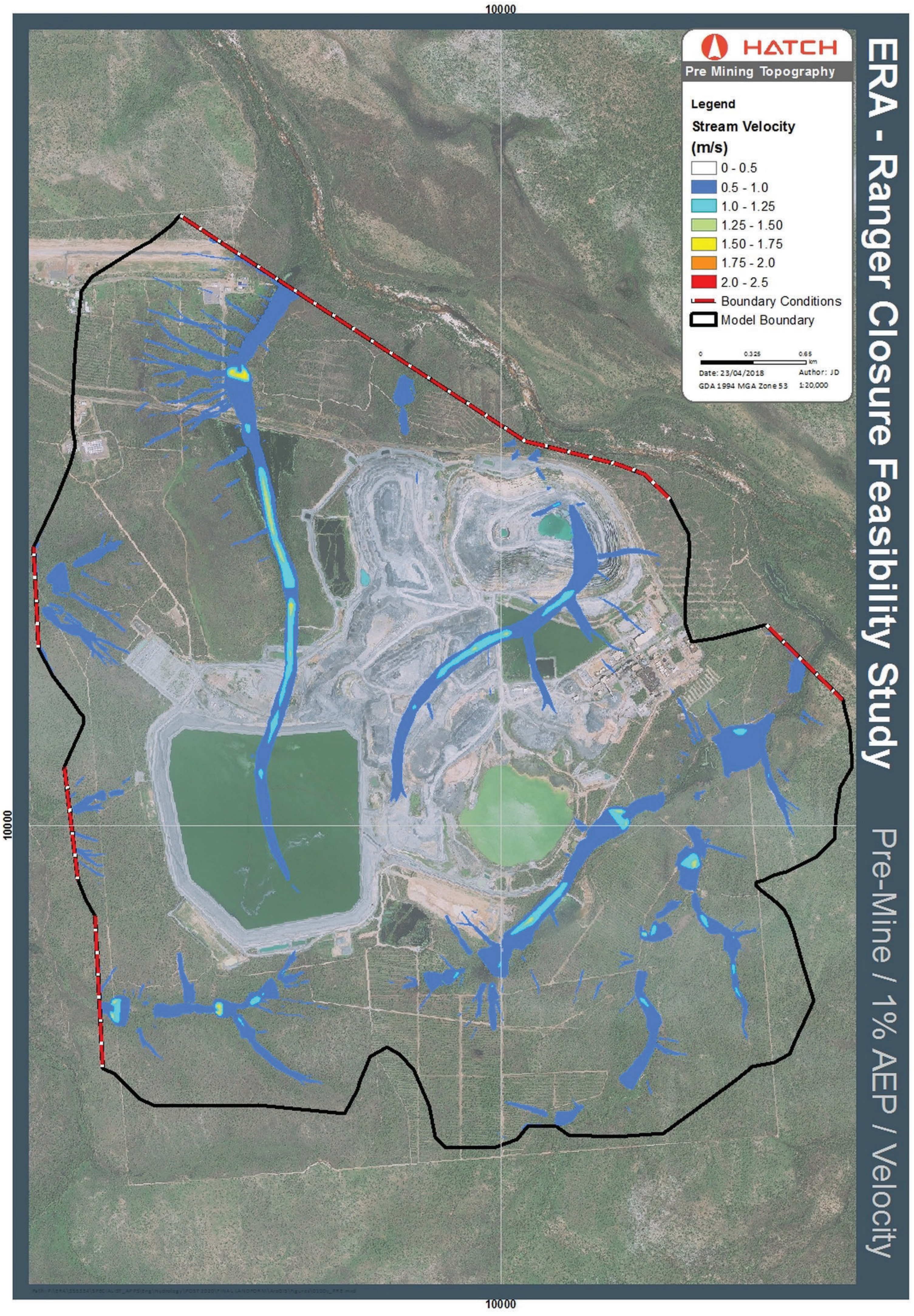
ERA - Ranger Closure Feasibility Study

Pre-Mine / 10% AEP / Velocity



ERA - Ranger Closure Feasibility Study

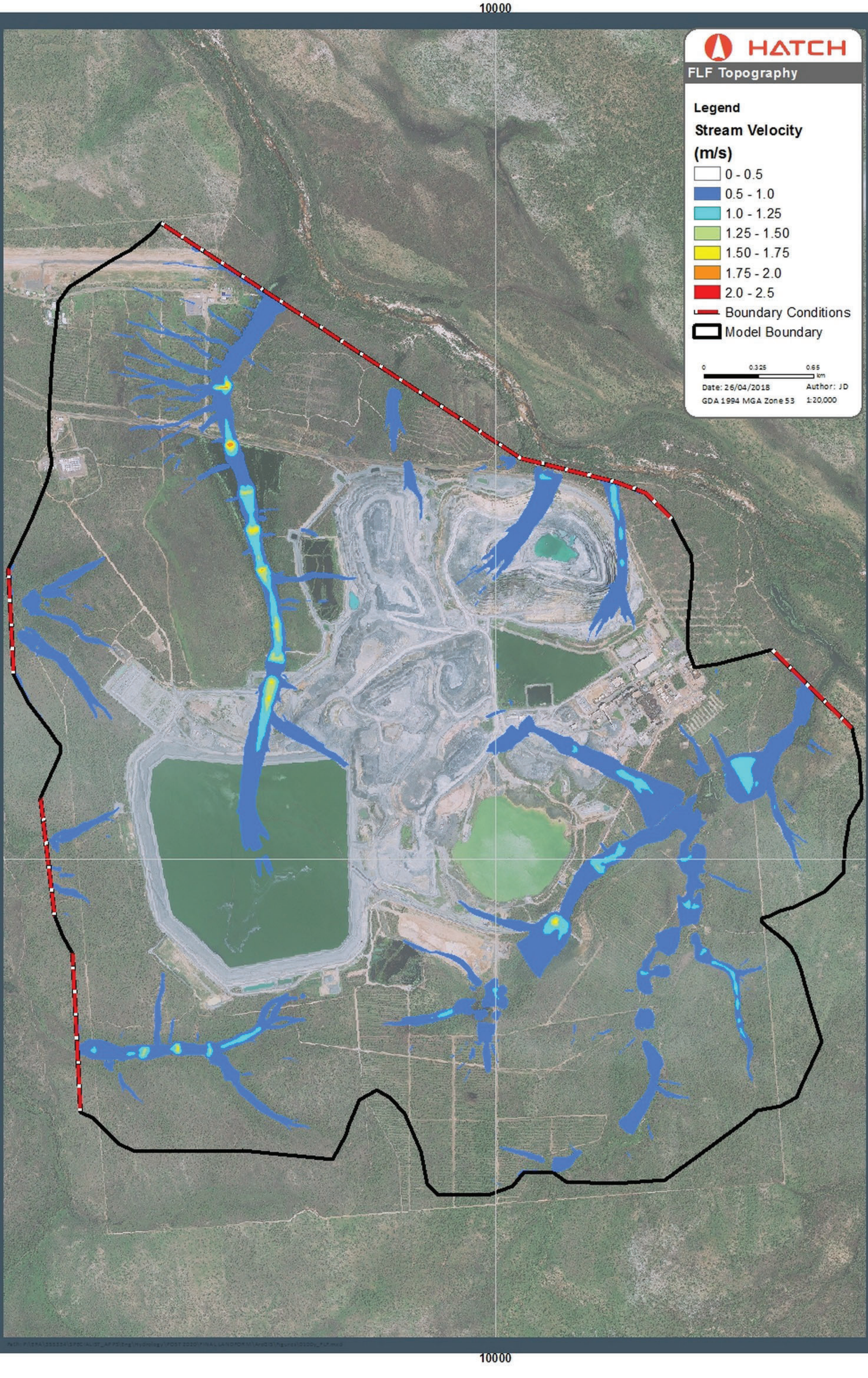
Final Landform / 10% AEP / Velocity

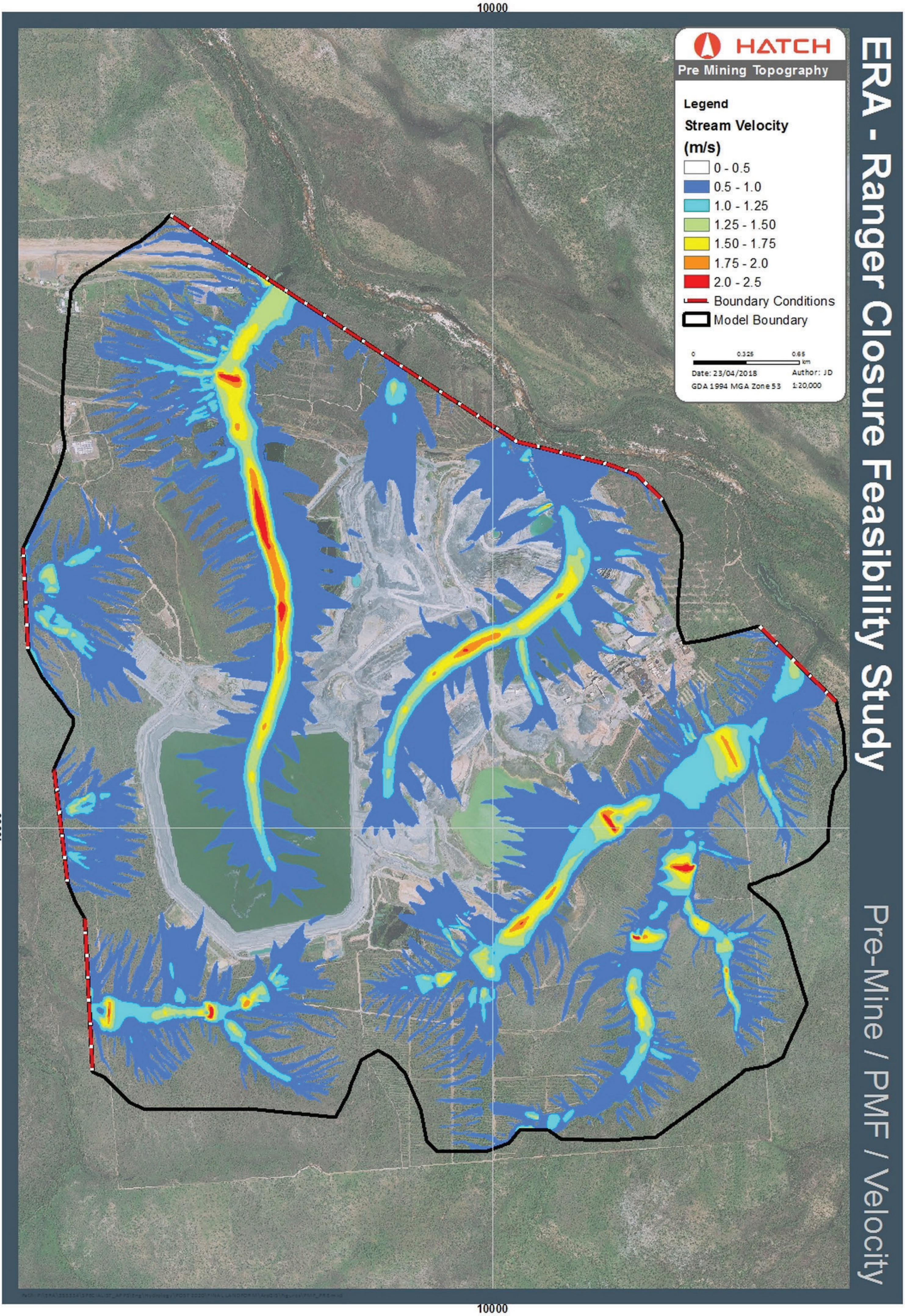


10000
HATCH
Pre Mining Topography
Legend
Stream Velocity
(m/s)
0 - 0.5
0.5 - 1.0
1.0 - 1.25
1.25 - 1.50
1.50 - 1.75
1.75 - 2.0
2.0 - 2.5
Boundary Conditions
Model Boundary
0
0.325
0.65
km
Date: 23/04/2018
Author: JD
GDA 1994 MGA Zone 53
1:20,000
10000
10000
ERA - Ranger Closure Feasibility Study
Pre-Mine / 1% AEP / Velocity

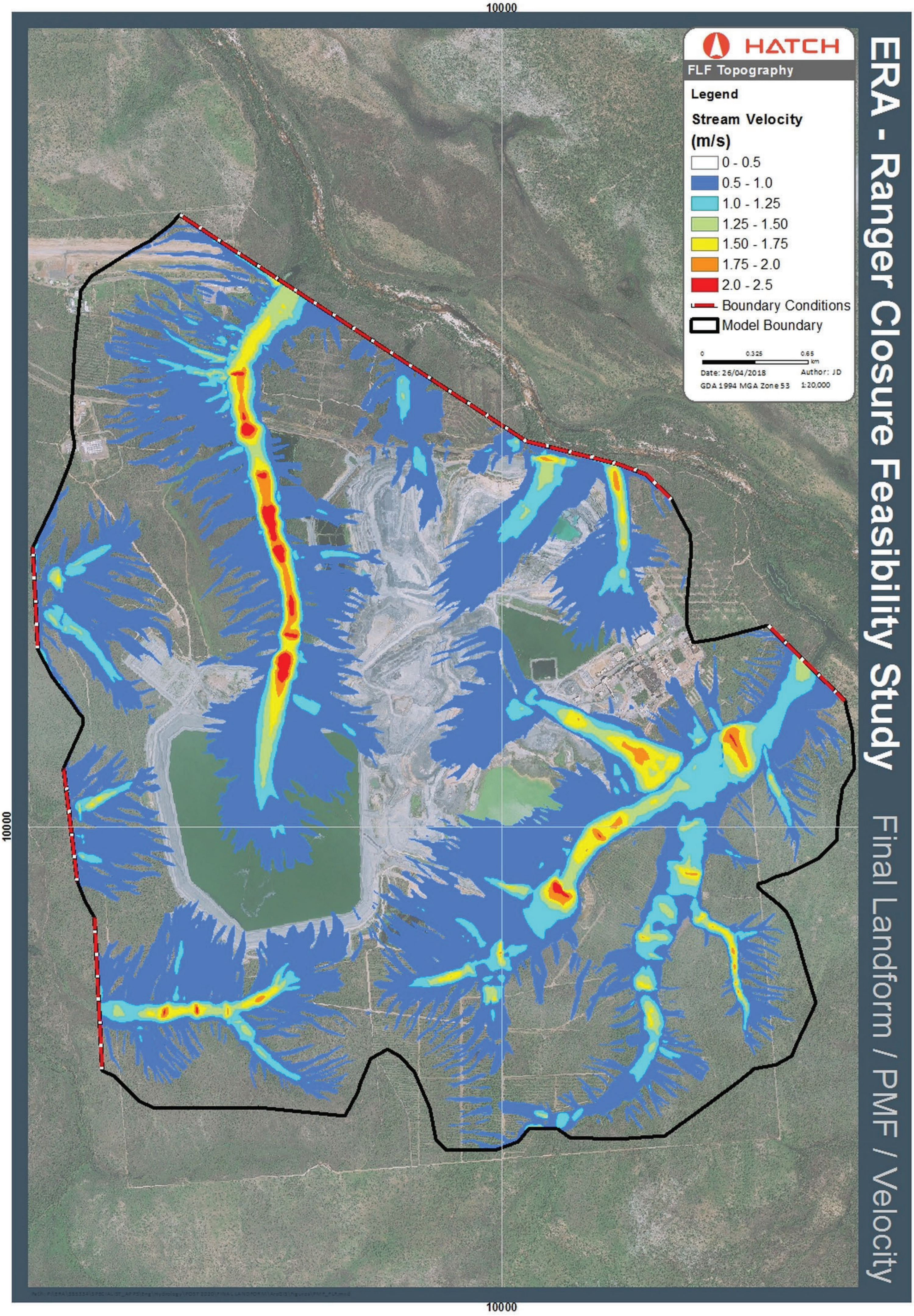
ERA - Ranger Closure Feasibility Study

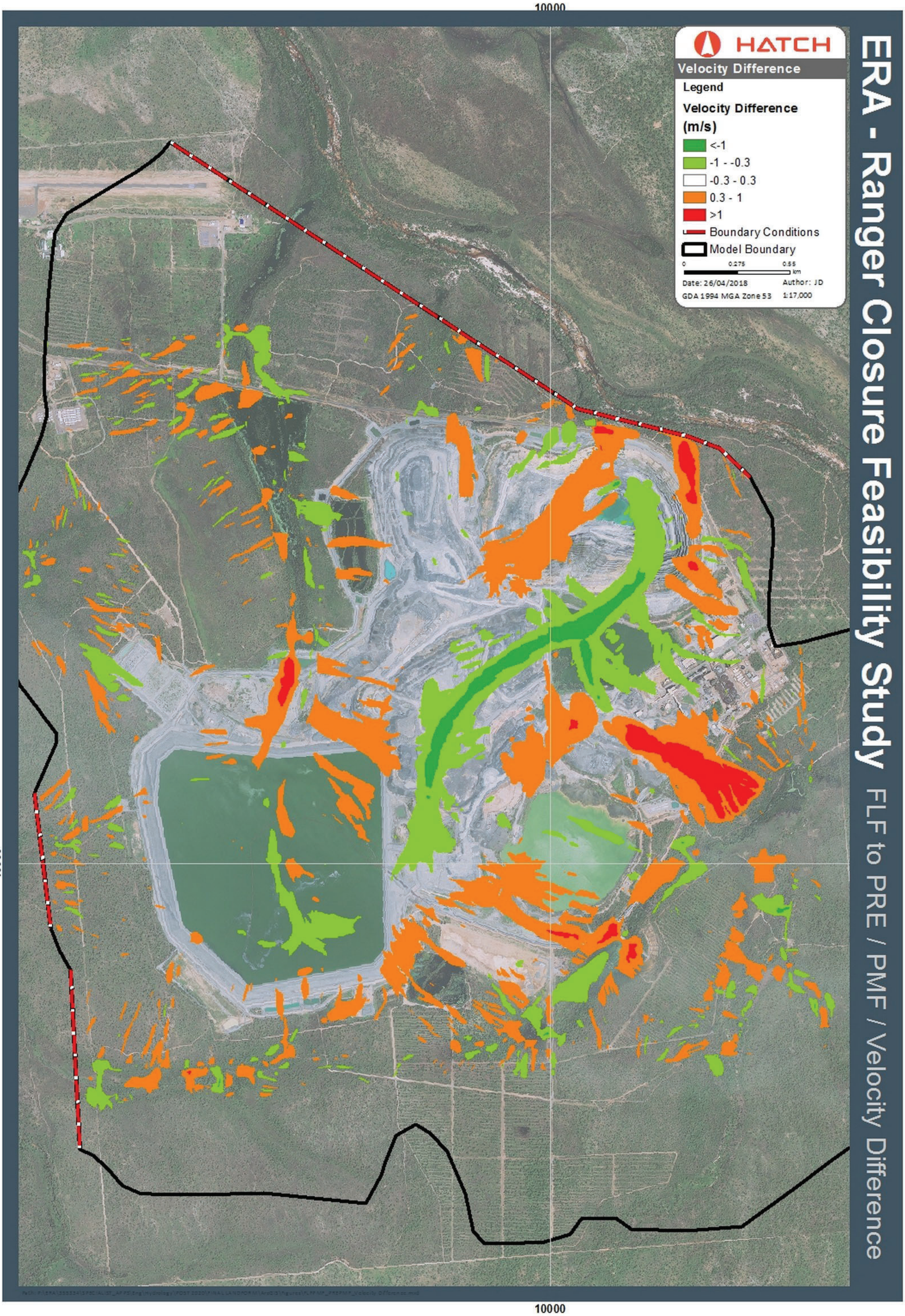
Final Landform / 1% AEP / Velocity





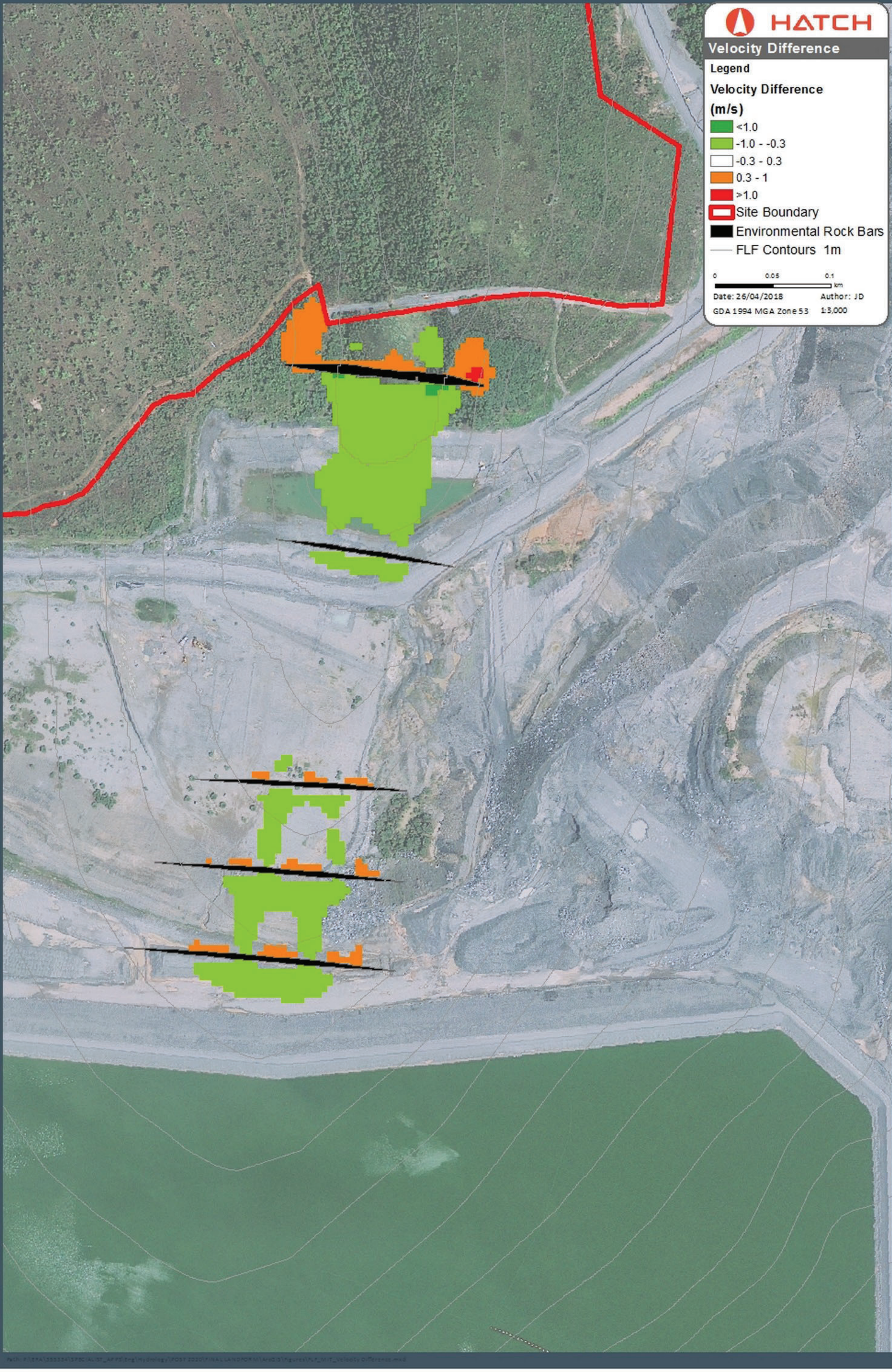
ERA - Ranger Closure Feasibility Study
Pre-Mine / PMF / Velocity
HATCH
Pre Mining Topography
Legend
Stream Velocity
(m/s)
0 - 0.5
0.5 - 1.0
1.0 - 1.25
1.25 - 1.50
1.50 - 1.75
1.75 - 2.0
2.0 - 2.5
Boundary Conditions
Model Boundary
0
0.325
0.65
km
Date: 23/04/2018
Author: JD
GDA 1994 MGA Zone 53
1:20,000
10000
10000
10000

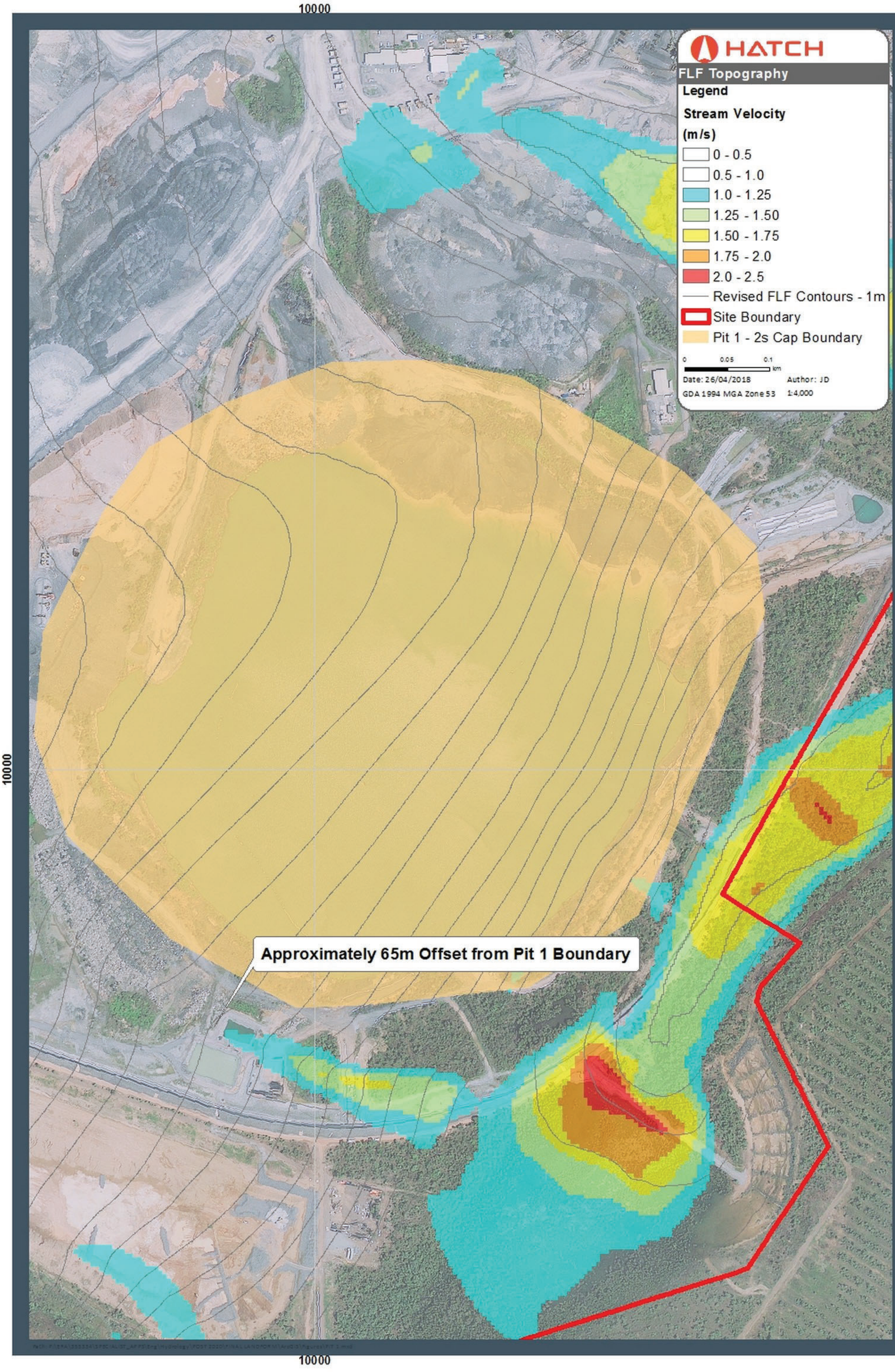

ERA - Ranger Closure Feasibility Study
Final Landform / PMF / Velocity
HATCH
FLF Topography
Legend
Stream Velocity
(m/s)
0 - 0.5
0.5 - 1.0
1.0 - 1.25
1.25 - 1.50
1.50 - 1.75
1.75 - 2.0
2.0 - 2.5
Boundary Conditions
Model Boundary
0
0.325
0.65
km
Date: 26/04/2018
Author: JD
GDA 1994 MGA Zone 53
1:20,000
10000
10000
10000



10000
10000
10000
HATCH
Velocity Difference
Legend
Velocity Difference (m/s)
<-1
-1 - -0.3
-0.3 - 0.3
0.3 - 1
>1
Boundary Conditions
Model Boundary
0
0.275
0.55
km
Date: 26/04/2018
Author: JD
GDA 1994 MGA Zone 53
1:17,000
ERA - Ranger Closure Feasibility Study
FLF to PRE / PMF / Velocity Difference

ERA - Ranger Closure Feasibility Study MIT to FLF / PMF / Velocity Difference





ERA - Ranger Closure Feasibility Study

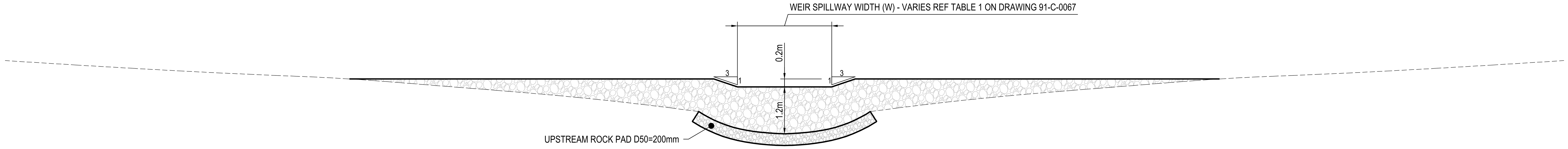
Final Landform / PMF / Velocity

APPENDIX 9.3: FINAL LANDFORM DRAWINGS

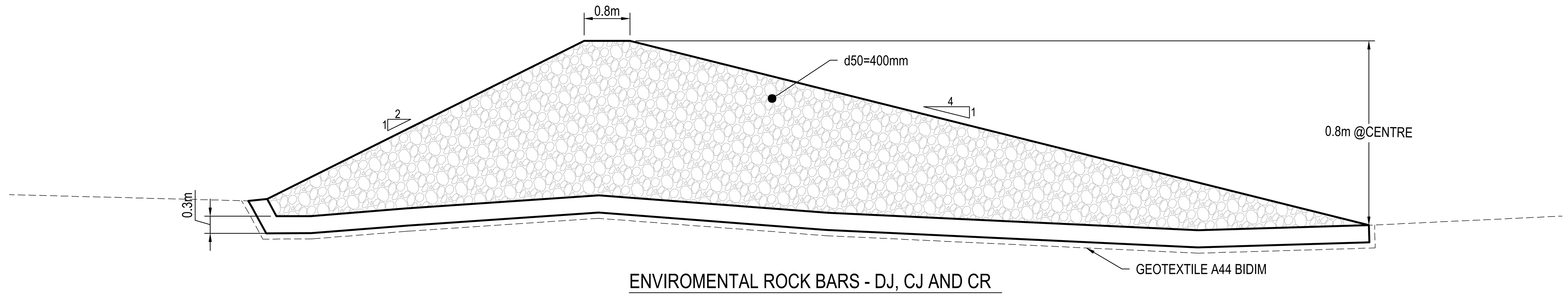
IF IN DOUBT - ASK! DO NOT SCALE IF IN DOUBT - ASK!

DWG No. H355334-00000-220-273-0034

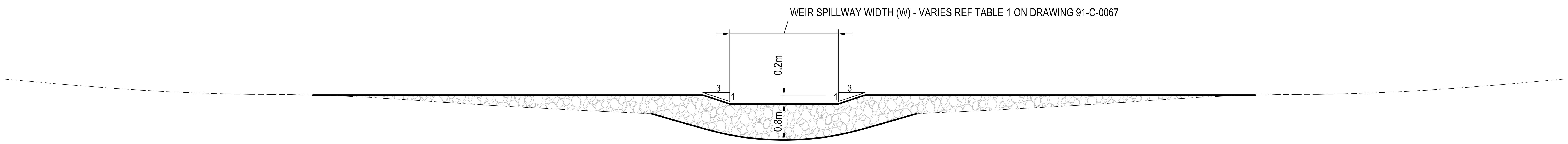
SEDIMENT BASINS
N.T.S



LONG SECTION - SEDIMENT BASINS
N.T.S



ENVIROMENTAL ROCK BARS - DJ, CJ AND CR
N.T.S



LONG SECTION - ENVIROMENTAL ROCK BARS
N.T.S

NOTES:
1. ALL WORKS REQUIRE 300mm STRIPPING AND FOUNDATION PREPARATION.
2. DESIGN SURFACES BASED ON PROVIDED SURVEY. LEVELS SHOULD BE CONFIRMED ON SITE.

APPROVED FOR USE

PRELIMINARY
NOT FOR CONSTRUCTION
SUBJECT TO FINAL VERIFICATION AND APPROVAL

NOTES

HATCH

DRG. NO.	REFERENCE DRAWING DESCRIPTION

REV.	DESCRIPTION	BY	CKD.	APP.	DATE
1	APPROVED FOR USE	PK	PDB	DB	06/02/19
0	APPROVED FOR USE	LZ	PDB	DB	21/06/18

EQUIPMENT NUMBERS

SCALE AS NOTED

THIRD ANGLE PROJECTION

DESIGN	JJT	21/06/18
DRAWN	LZ	21/06/18
ENG'EER CKD.	PDB	06/02/19
CLIENT APPR'D	SG	06/02/19
SUP'T APPR'D		

CONTRACTOR DWG. NUMBER H355334-00000-220-273-0034

RIO TINTO DWG. NUMBER CDM:03-0000-EC-DWG-00071

ERA

PLANT AREA: AREA 91 - CLOSURE STRATEGY

TITLE: ENVIROMENTAL ROCK BARS & INTREAM CHECK DAMS SECTION DETAILS

SHEET SIZE	PROJ/WORK ORDER NO.	AREA	DISC	DRAWING	REV
B1	.	91	C	0071	1

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IF IN DOUBT – ASK!   DO NOT SCALE   IF IN DOUBT – ASK!

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FINAL CONTOUR PLAN 1
SCALE 1:3000

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DRG. NO.	REFERENCE DRAWING DESCRIPTION

REV.	DESCRIPTION	BY	CKD.	APP.	DATE
2	APPROVED FOR USE	PK	PDB	DB	06/02/19
1	APPROVED FOR USE	PK	PDB	DB	17/12/18
0	APPROVED FOR USE	LZ	PDB	DB	21/06/18

EQUIPMENT NUMBERS

SCALE 1:3000

THIRD ANGLE PROJECTION

DESIGN	JJT	21/06/18
DRAWN	LZ	21/06/18
ENG'EER CKD.	PDB	06/02/19
CLIENT APPR'D	SG	06/02/19
SUP'T APPR'D		

CONTRACTOR DWG. NUMBER
H355334-00000-220-272-0001

RIO TINTO DWG. NUMBER
CDM.03-0000-EC-DWG-00019

PLANT AREA: AREA 91 – CLOSURE STRATEGY

TITLE: RANGER SITE PLANS – AREA 13
CIVIL WORKS
FINAL CONTOUR PLAN 1

SHEET SIZE	PROJ/WORK ORDER NO.	AREA	DISC.	DRAWING	REV
B1		91	C	0019	2

DWG No. H355334-00000-220-272-0001

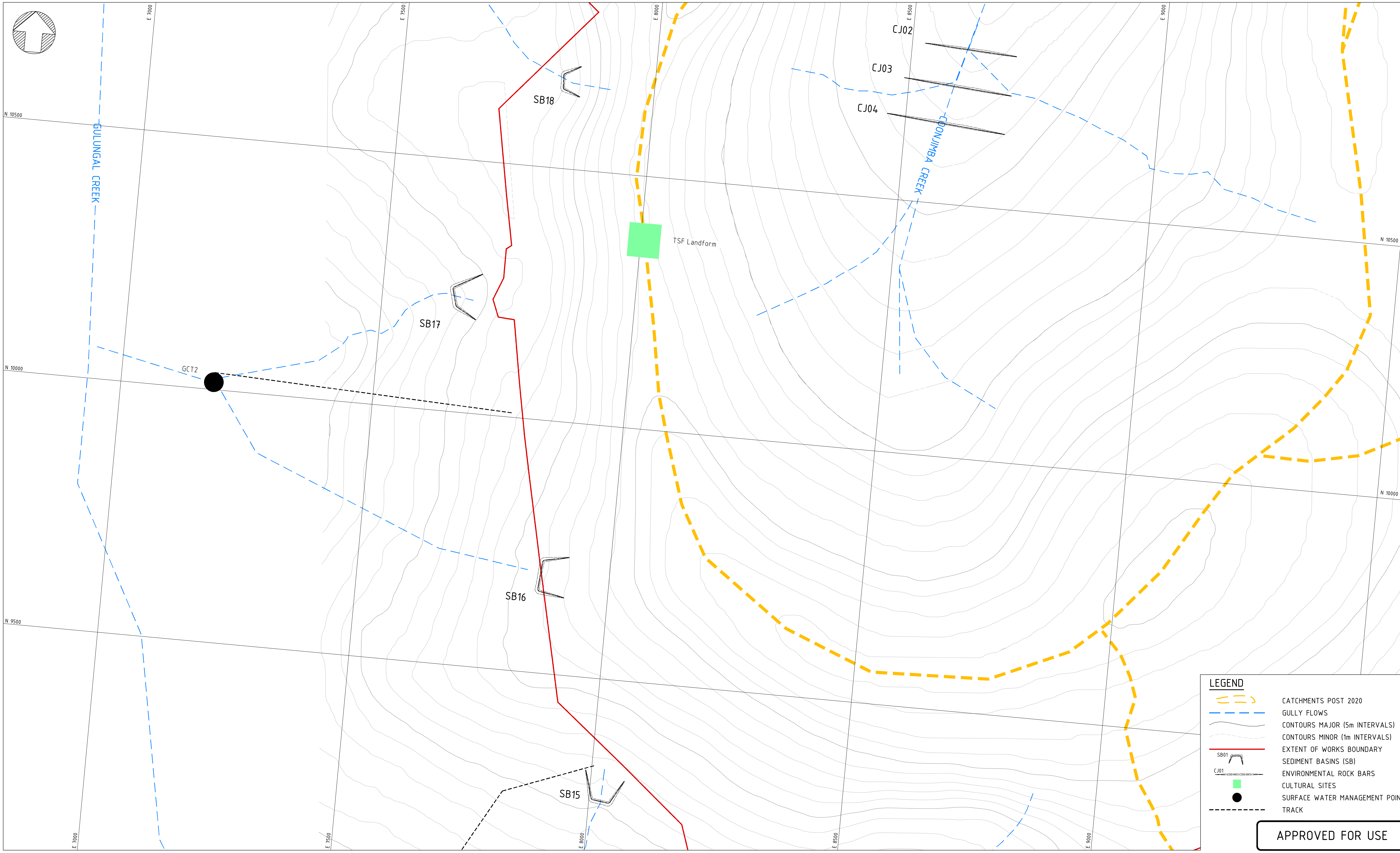
DWG No. H355334-00000-220-272-0003

IF IN DOUBT – ASK!

DO NOT SCALE

JOINS DRAWING 0019

IF IN DOUBT – ASK!



APPROVED FOR USE

FINAL CONTOUR PLAN 3

SCALE 1:3000

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PRELIMINARY

NOT FOR CONSTRUCTION

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HATCH

DRG. NO.	REFERENCE DRAWING DESCRIPTION

REV.	DESCRIPTION	BY	CKD.	APP.	DATE
2	APPROVED FOR USE	PK	PDB	DB	06/02/19
1	APPROVED FOR USE	PK	PDB	DB	17/12/18
0	APPROVED FOR USE	LZ	PDB	DB	21/06/18

EQUIPMENT NUMBERS

SCALE 1:3000

THIRD ANGLE PROJECTION

DESIGN	JJT	21/06/18
DRAWN	LZ	21/06/18
ENG'EER CKD.	PDB	06/02/19
CLIENT APPR'D	SG	06/02/19
SUP'T APPR'D		

CONTRACTOR DWG. NUMBER H355334-00000-220-272-0003

RIO TINTO DWG. NUMBER CDM.03-0000-EC-DWG-00021

ERA

PLANT AREA: AREA 91 – CLOSURE STRATEGY

TITLE: RANGER SITE PLANS – AREA 13
CIVIL WORKS
FINAL CONTOUR PLAN 3

SHEET SIZE	PROJ/WORK ORDER NO.	AREA	DISC	DRAWING	REV
B1		91	C	0021	2

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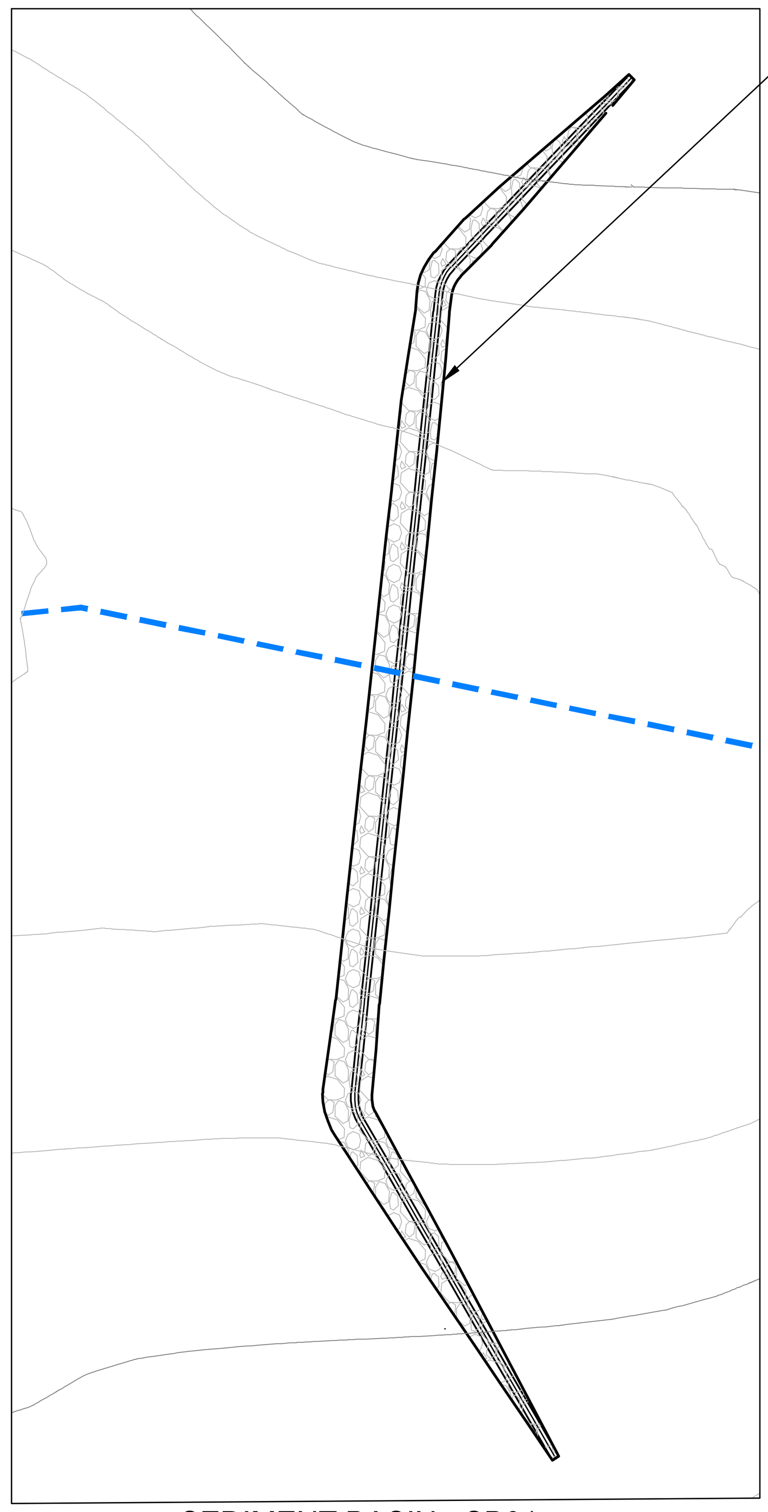
IF IN DOUBT – ASK! DO NOT SCALE IF IN DOUBT – ASK!

DWG No. H355334-00000-220-270-0005

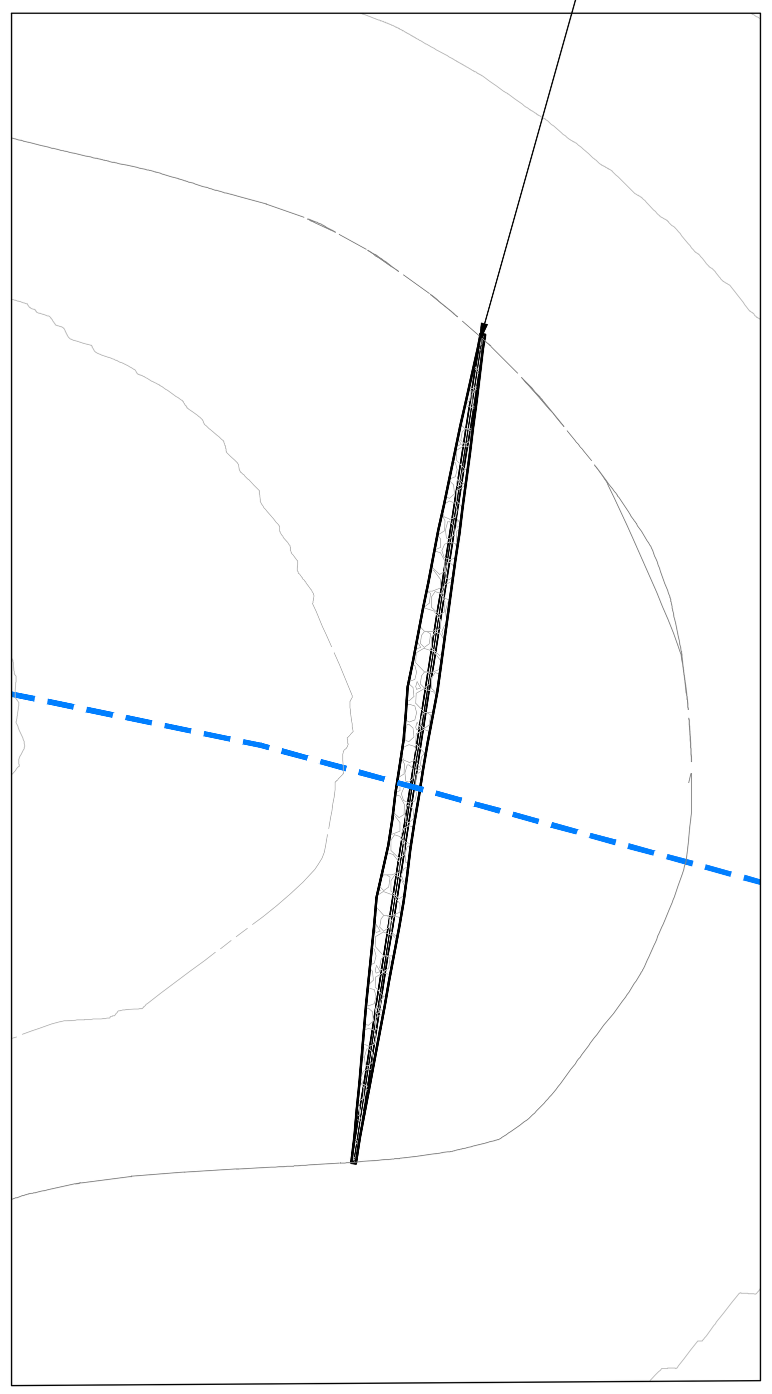
KEY PLAN - SEDIMENT CONTROL STRUCTURES
SCALE 1:5000

FOR TYPICAL SECTIONS FOR SEDIMENT BASIN AND ENVIRONMENTAL ROCK BARS REFER DRAWING 91-C-0071.

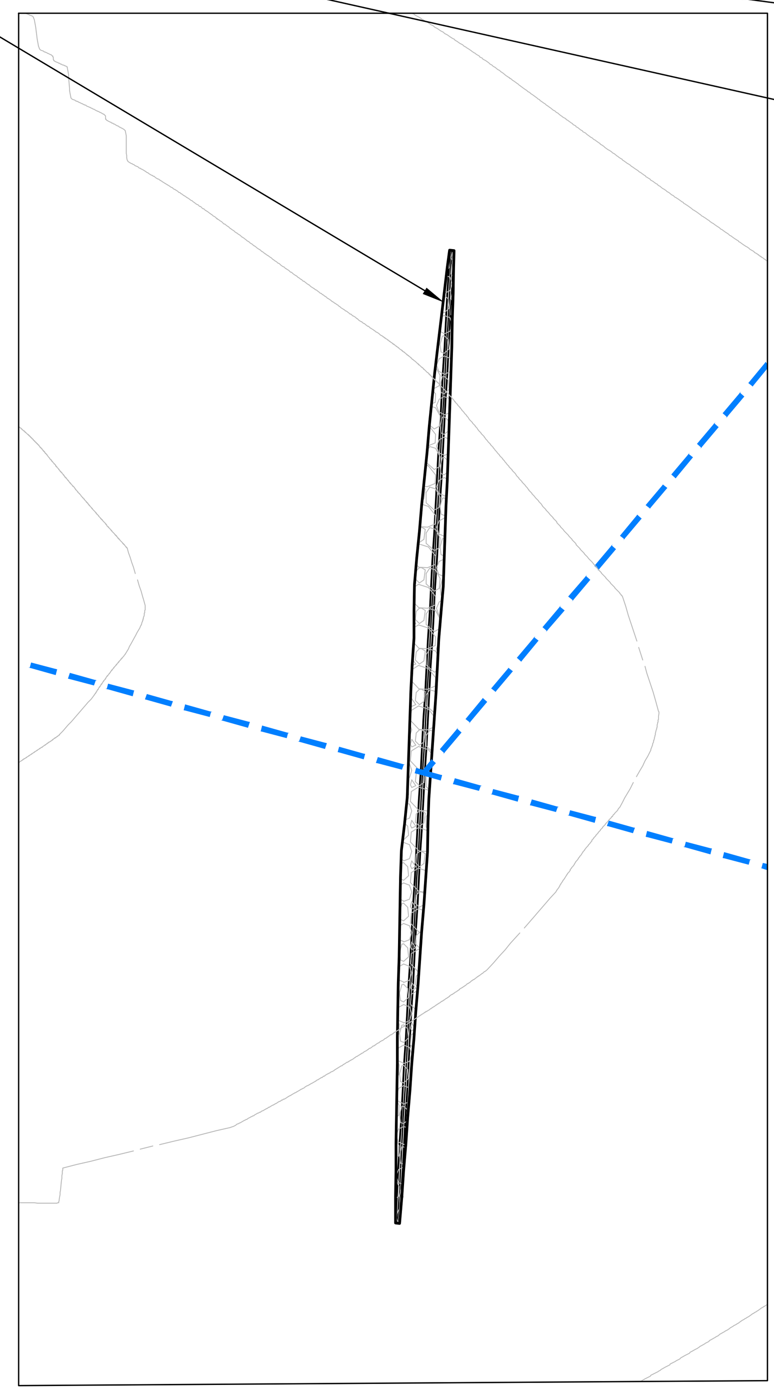
NOTES:
1. ALL WORKS REQUIRE 300mm STRIPPING AND FOUNDATION PREPARATION.
2. DESIGN SURFACES BASED ON PROVIDED SURVEY. LEVELS SHOULD BE CONFIRMED ON SITE.



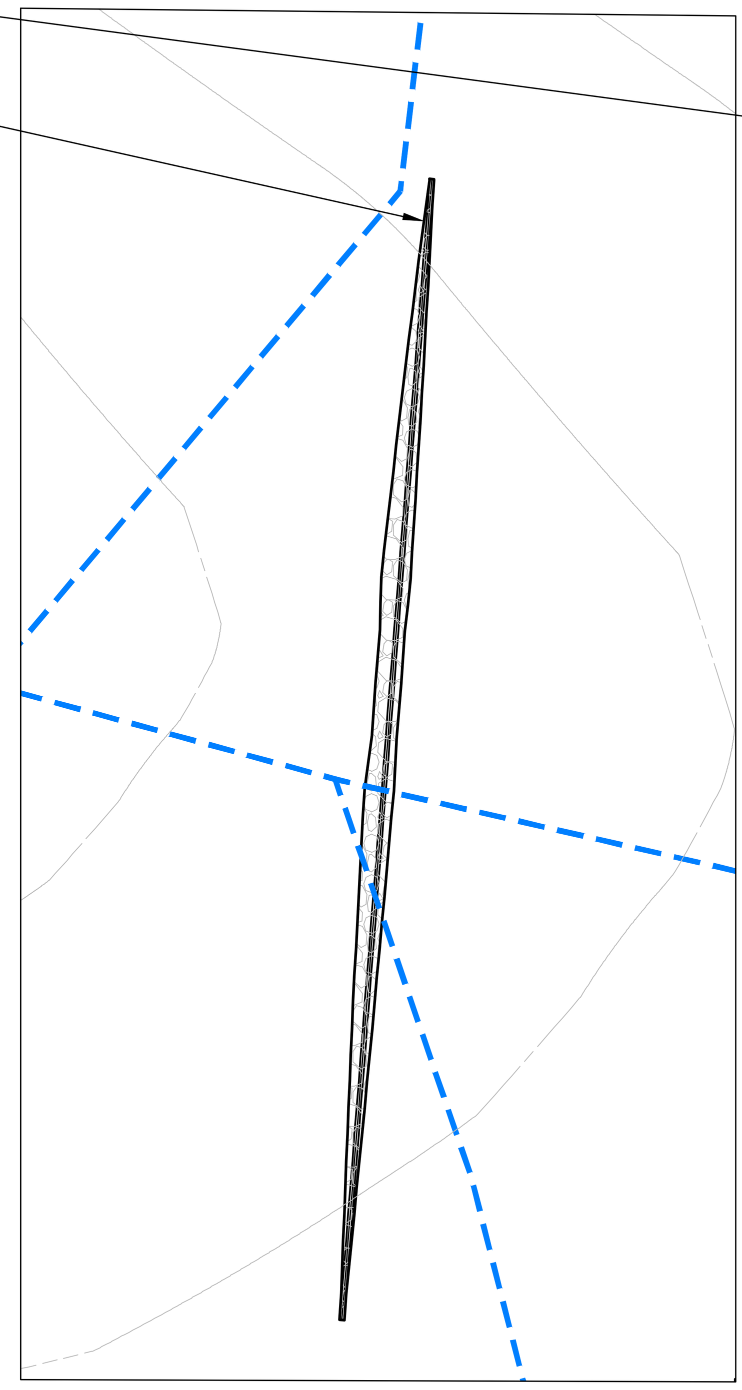
SEDIMENT BASIN - SB01
SCALE 1:1000



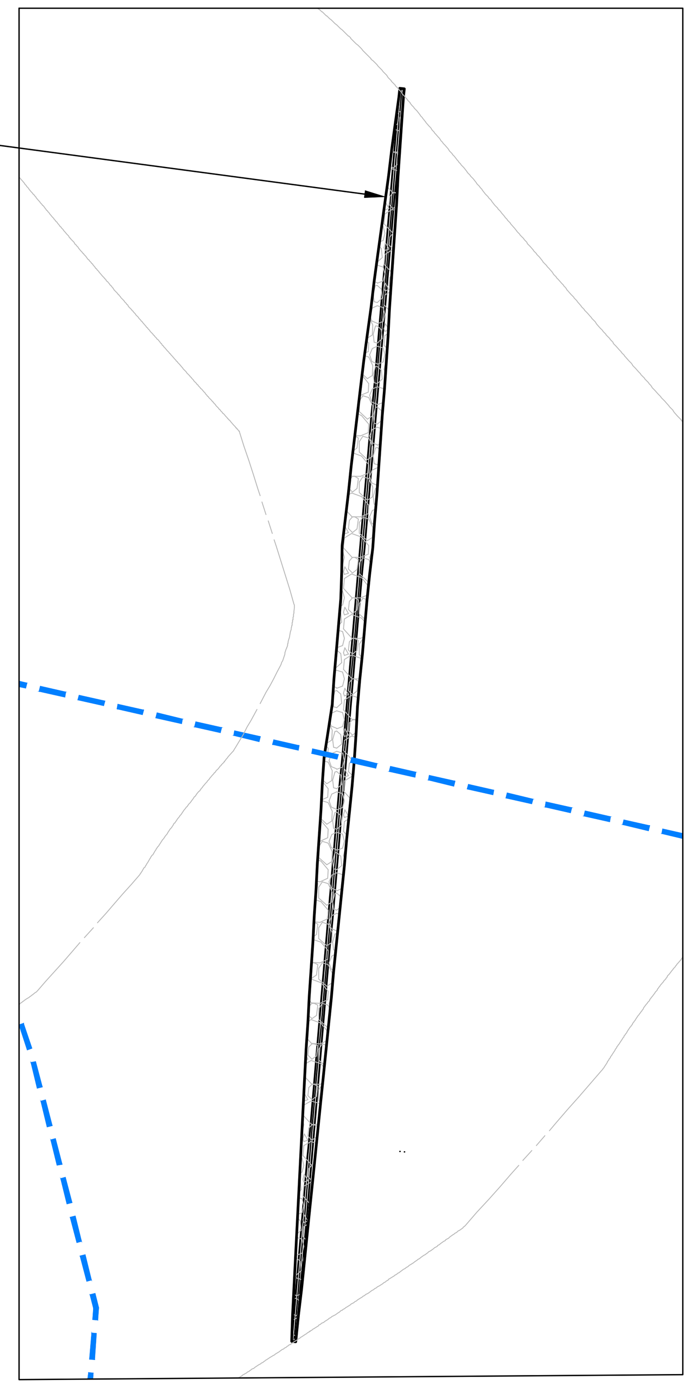
ENVIROMENTAL ROCK BAR CJ01
SCALE 1:1000



ENVIROMENTAL ROCK BAR CJ02
SCALE 1:1000



ENVIROMENTAL ROCK BAR CJ03
SCALE 1:1000



ENVIROMENTAL ROCK BAR CJ04
SCALE 1:1000

0 0.5 1.0 1.5 2.0m
SCALE: 1:20 @B1

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HATCH

REV.	DESCRIPTION	BY	CKD.	APP.	DATE
1	APPROVED FOR USE	PK	PDB	DB	06/02/19
0	APPROVED FOR USE	LZ	PDB	DB	21/06/18

EQUIPMENT NUMBERS
SCALE AS NOTED
THIRD ANGLE PROJECTION

DESIGN	JJT	21/06/18
DRAWN	LZ	21/06/18
ENG'EER CKD.	PDB	06/02/19
CLIENT APPR'D		
SUP'T APPR'D		

CONTRACTOR DWG. NUMBER H355334-00000-220-270-0005
RIO TINTO DWG. NUMBER CDM.03-0000-EC-DWG-00053

ERA

PLANT AREA: AREA 91 – CLOSURE STRATEGY
TITLE: GENERAL ARRAGEMENT
CIVIL WORK
ENVIRONMENTAL ROCK BARS

SHEET SIZE	PROJ/WORK ORDER NO.	AREA	DISC.	DRAWING	REV
B1		91	C	0053	1

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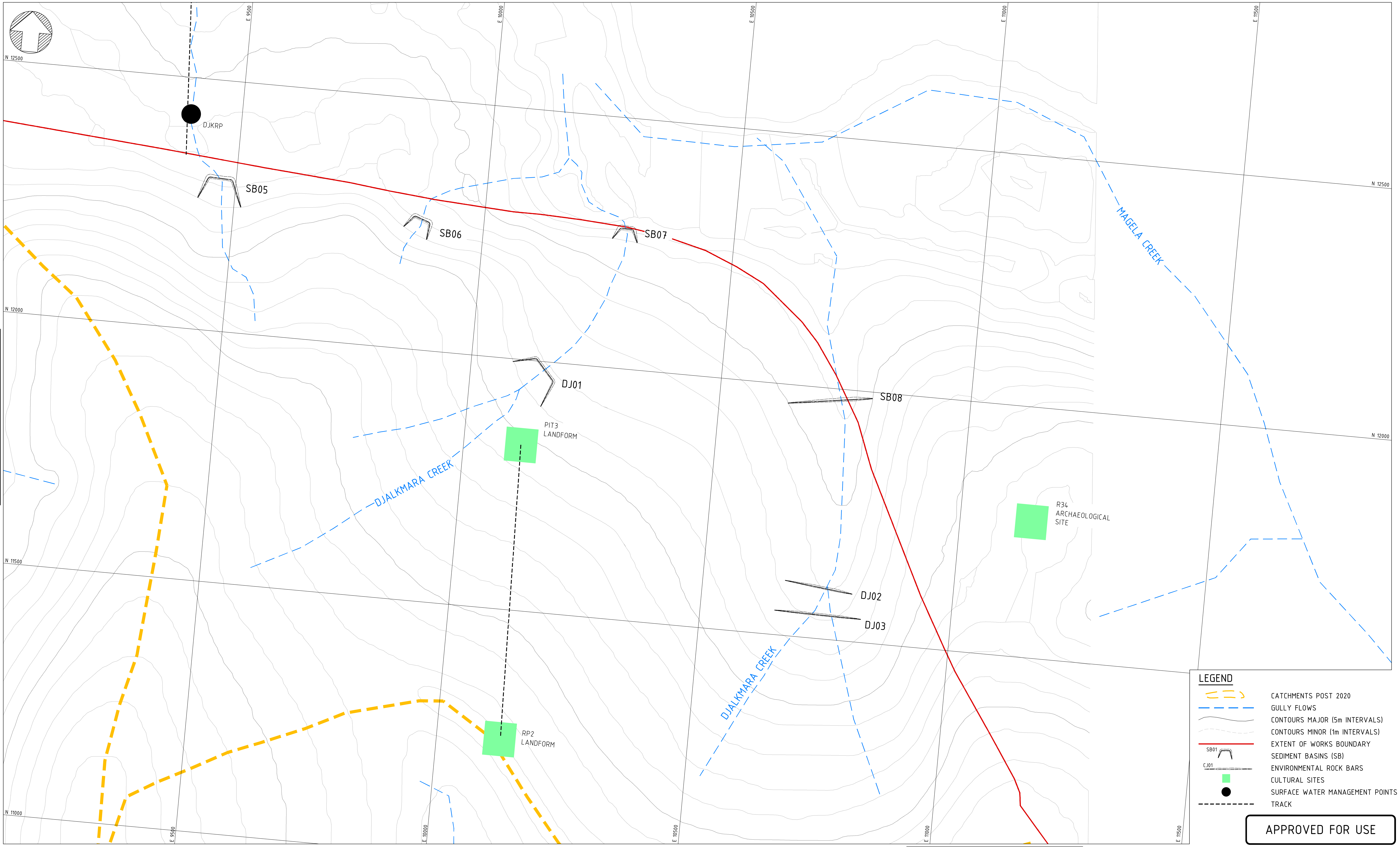
IF IN DOUBT – ASK!   DO NOT SCALE   IF IN DOUBT – ASK!

DWG No. H355334-00000-220-272-0002



JOINS DRAWING 0022

0 75 150 225 300m
SCALE: 1:3000 @B1

FINAL CONTOUR PLAN 2

SCALE 1:3000

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DRG. NO.	REFERENCE DRAWING DESCRIPTION

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HATCH

REV.	DESCRIPTION	BY	CKD.	APP.	DATE
2	APPROVED FOR USE	PK	PDB	DB	06/02/19
1	APPROVED FOR USE	PK	PDB	DB	17/12/18
0	APPROVED FOR USE	LZ	PDB	DB	21/06/18

EQUIPMENT NUMBERS

SCALE 1:3000

THIRD ANGLE PROJECTION

DESIGN	JJT	21/06/18
DRAWN	LZ	21/06/18
ENG'EER CKD.	PDB	06/02/19
CLIENT APPR'D	SG	06/02/19
SUP'T APPR'D		

CONTRACTOR DWG. NUMBER
H355334-00000-220-272-0002

RIO TINTO DWG. NUMBER
CDM.03-0000-EC-DWG-00020

ERA

PLANT AREA: AREA 91 – CLOSURE STRATEGY

TITLE: RANGER SITE PLANS – AREA 13
CIVIL WORKS
FINAL CONTOUR PLAN 2

SHEET SIZE	PROJ/WORK ORDER NO.	AREA	DISC.	DRAWING	REV
B1		91	C	0020	2

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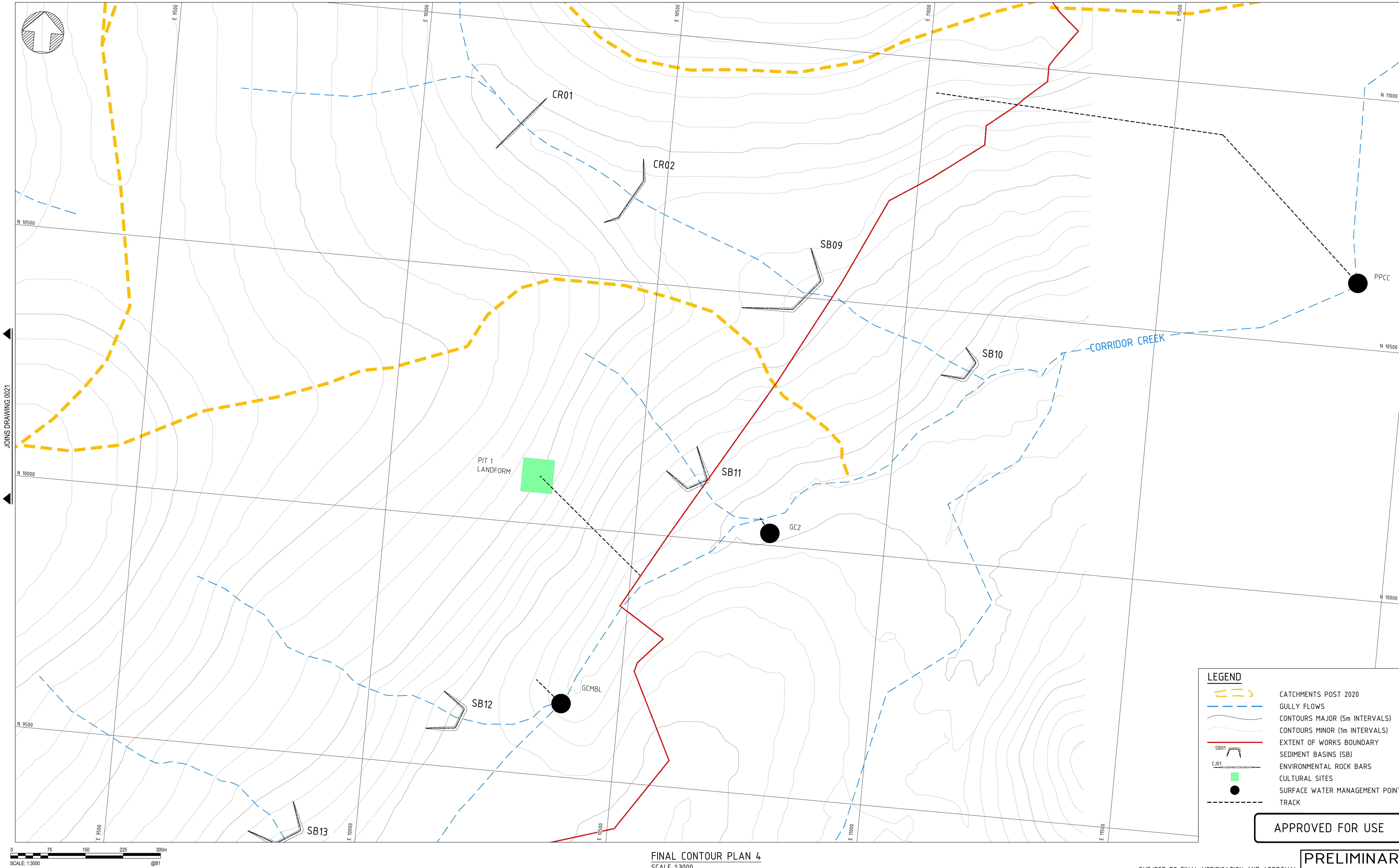
IF IN DOUBT – ASK!   DO NOT SCALE   IF IN DOUBT – ASK!

JOINS DRAWING 0020

DWG No. H355334-00000-220-272-0004



LEGEND

- CATCHMENTS POST 2020
- GULLY FLOWS
- CONTOURS MAJOR (5m INTERVALS)
- CONTOURS MINOR (1m INTERVALS)
- EXTENT OF WORKS BOUNDARY
- SEDIMENT BASINS (SB)
- ENVIRONMENTAL ROCK BARS
- CULTURAL SITES
- SURFACE WATER MANAGEMENT POINTS
- TRACK

APPROVED FOR USE

FINAL CONTOUR PLAN 4

SCALE 1:3000

SUBJECT TO FINAL VERIFICATION AND APPROVAL

PRELIMINARY
NOT FOR CONSTRUCTION

DRG. NO.	REFERENCE DRAWING DESCRIPTION

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and all intellectual property rights embodied or referenced in this drawing remain the property of Hatch.

HATCH

REV.	DESCRIPTION	BY	CKD.	APP.	DATE
2	APPROVED FOR USE	PK	PDB	DB	06/02/19
1	APPROVED FOR USE	PK	PDB	DB	17/12/18
0	APPROVED FOR USE	LZ	PDB	DB	21/06/18

EQUIPMENT NUMBERS

SCALE 1:3000

THIRD ANGLE PROJECTION

DESIGN	JJT	21/06/18
DRAWN	LZ	21/06/18
ENG'EER CKD.	PDB	06/02/19
CLIENT APPR'D	SG	06/02/19
SUP'T APPR'D		

CONTRACTOR DWG. NUMBER H355334-00000-220-272-0004

RIO TINTO DWG. NUMBER CDM.03-0000-EC-DWG-00022

ERA

PLANT AREA: AREA 91 – CLOSURE STRATEGY

TITLE: RANGER SITE PLANS – AREA 13
CIVIL WORKS
FINAL CONTOUR PLAN 4

SHEET SIZE	PROJ/WORK ORDER NO.	AREA	DISC	DRAWING	REV
B1		91	C	0022	2

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APPENDIX 9.4 HAZARDOUS MATERIAL AND CONTAMINATION CONTROL PLAN

Energy Resources of Australia Ltd

Hazardous Material and Contamination Control Plan HMP001

Approvals

	Name	Position	Signed	Date
Originator	Anthony Cullen	Advisor Environment	A.Cullen	04/04/2019
Checked	Peter Lander	Environment Superintendent	P.Lander	04/04/2019
Approved	Julie Crawford	Manager HSEC	J.Crawford	04/04/2019

Revisions

	Date	Description	By	Check	Approved
0.14.0	28/05/14	Internal Distribution	M Bush	P Lander	T Simms
1.16.0	22/06/16	Major review – incorporate revised RT Environment and Health Standards	A Lonergan/A Reid	P Lander	S Miller
0.19.1	05/02/19	Minor review	A Cullen	P Lander	J Crawford

Contents

Figures

1. Purpose

The purpose of this plan is to ensure the safe and responsible use, storage, transport, disposal and control of all hazardous materials handled by Energy Resources of Australia Ltd (ERA).

The purpose of this is also to ensure that contaminated sites are appropriately characterized and managed in accordance with the Rio Tinto Environmental Standards. A range of standard operating procedures have been developed that relate to specific aspects of hazardous materials and contamination management. This plan provides the overarching strategy for hazardous materials and contamination management on ERA managed lands.

2. Scope

This plan applies to all ERA managed lands including but not limited to Ranger Uranium Mine (Ranger). It covers the management of hazardous materials through mine life from exploration, construction and operation to closure. This document also includes the evaluation and approval through storage, transport and disposal of hazardous materials as well as prevention and remediation of contamination. Asbestos is addressed separately in ERW103 Asbestos and Non-Asbestos Fibrous Silicates Management Work Instruction and radiation hazards are addressed in RAP001 Radiation Management Plan.

3. Planning

3.1 Objectives and Targets

The objective of hazardous material and contamination control at Ranger is to eliminate, as far as practicable, high risk chemicals and hazardous substances used at ERA.

To support achievement of this objective, ERA will target reviews (e.g. periodic audits) of stockholdings and storage of high risk chemicals and hazardous substances with a view to eliminating and/or reducing high risk chemicals and hazardous substances where practicable.

3.2 Legal and Other Requirements

ERA has a COR001 Compliance Obligations Register in order to identify and record all compliance, conformance and other legal obligations imposed by environment, safety and health legislation applicable to ERA's operations. The ERS002 Compliance Standard together with ERW002 Compliance Work Instruction provide details in relation to the identification of legal requirements, the maintenance of legal information and also the means by which employees seek legal information.

Management of hazardous materials and contamination on ERA managed lands must be in compliance with the requirements of Schedule 6 Other Services, Operations and Requirements of the most up-to-date version of Ranger Authorisation

0108. Corporate legal and regulatory requirements for hazardous materials and contamination management exist in the following documents:

Rio Tinto - The Way We Work

Rio Tinto HSE Performance Standards - Environment

Rio Tinto HSE Performance Standards - Health

Rio Tinto Closure Standard

ERA Environment Policy

3.2.1 Auditing

The Hazardous Materials and Contamination Control Plan and its implementation are subject to periodic audits via Rio Tinto Business Conformance Audit and other audit internal and external processes.

In accordance with the Rio Tinto Health Performance Standard H1 – 'Chemicals and hazardous substances exposure control', written procedures for the use, storage and disposal of hazardous substances with a health, safety or environment risk classification of critical must exist and must be internally audited at least annually. Also, through the Departmental HSE representatives and the relevant RT Health Standard Team, ERA also undertakes periodic inspections of hazardous substances storage areas throughout the year. The purpose of these audits and inspections is to reconcile stock holdings and storage locations and to monitor for conformance to the Standard.

4. Hazardous Material Management

The overarching document relating to risk management at ERA is ERS003 Hazard Identification and Risk Management. ERS057 ERA Standard Hazardous Substances outlines the process for purchasing, handling, storage, use and disposal of chemical substances and other hazardous substances, and the roles and responsibilities relevant to this. The HSEQ Risk Register includes several risks relating to hazardous materials.

4.1 Approval for New Hazardous Materials

Introduction of a new hazardous substance to ERA is controlled by standard operating procedure ERW022 Introduction of a New Chemical to ERA. This procedure ensures the Safety Data Sheet (SDS) is obtained and the hazardous substance is assessed and relevant controls applied prior to introduction to a work area. Such controls may include, subject to risk, hazardous substances and/or spill response training, for example.

ERA's chemical management system ChemAlert is used to register and record details of new hazardous substances once approved for use in a work area. If ChemAlert rates a substance as amber or red, a risk assessment must be completed using the Risk Assessment module on ChemAlert. A new chemical request form (F0096) must be completed for the introduction of a new hazardous substance to a work area. The form must be accompanied by the current SDS for the product and a completed risk assessment (where applicable) for review by the Hazardous Substances Coordinator.

4.2 Hazardous Materials Inventory

ERA maintains the Hazardous Substances Register within ChemAlert. SDS's for each product stored and used on site can be sourced through ChemAlert. All employees and contractors (through ERA work supervisors) can access ChemAlert via ERAs intranet. Hardcopies of SDS's are available at point of use at Ranger and Energy House Darwin.

4.3 Handling, Storage and Transport of Hazardous Materials

Employee exposure to hazardous substances and their associated potential impacts to the environment should be eliminated or minimised through the appropriate application of the hierarchy of controls. Risks and control measures associated with the use of hazardous materials have been identified and documented in ERAs Risk Register in accordance with ERS003 HSEQ Hazard Identification and Risk Management.

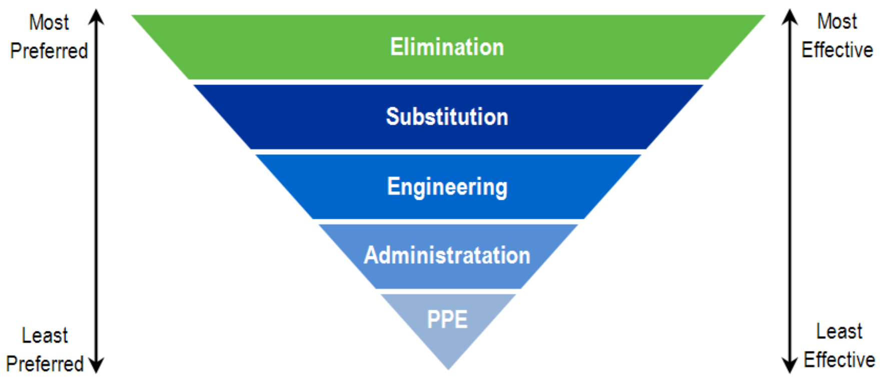

Figure 1: Hierarchy of Controls

It is the responsibility of the department and work area handling and storing a hazardous material to ensure all materials are managed and stored in accordance with the SDS for that material. The labelling, storage and segregation of hazardous materials shall be in full compliance with all relevant legislative requirements and codes of practice.

The ChemAlert system identifies where each material is stored and ERS057 Appendix A Segregation of Dangerous Goods details segregation requirements for dangerous goods. Hazardous materials shall be stored in bunded areas with secondary containment mechanisms, and bunding shall comply with the relevant Australian and Rio Tinto Standards.

4.4 Disposal of Hazardous Materials

Each department is responsible for disposing of chemicals produced by normal process activities and those which may arise from accidental leaks or spillage in their work area. ERP028 Off-Site Hazardous Substance Disposal Procedure outlines the process for disposing of a chemical substance at ERA. Most hazardous substances are disposed of off-site via a Licensed Waste Handler (i.e. a business licensed under the Waste Management and Pollution Control Act).

Hazardous substances which have been stored, used or generated in a controlled area or which fail a radiation clearance must be stored or disposed of on-site. All hazardous materials to be removed from site shall be dispatched through the warehouse. The warehouse dispatch process ensures relevant ERA and legal requirements are complied with. A Waste Transport Certificate must be completed for any transport of hazardous waste off-site. Environment Department approval is required for on-site disposal of hazardous substances (via EVF045).

4.5 Emergency Response Measures

In the event of a spill or incident involving a hazardous material, ERA standard operating procedure SFP030 Responding to Emergencies shall be followed. The procedure provides specific guidance for incidents with a serious threat to people, the environment or property. Emergency drills for HAZMAT incidents are carried out by the Emergency Response Team (ERT).

In the event of a spill or other incident requiring Emergency Response, the incident reporter must contact Emergency Services by dialling 222 from a Cisco phone. The Business Resilience and Response Plan (BRRP) has been established to coordinate the sites' response to emergency situations.

The Emergency Response Plan (Ranger) describes the tasks for specific roles in the event of a HAZMAT incident both on and offsite. Annual BRRP exercises are conducted to ensure that the BRRP continues to meet the sites' business requirements and legal obligations. After the occurrence of an emergency incident where the BRRP has been invoked, ERA debriefs the involved teams and action is taken to improve the efficiency and appropriateness of the BRRP.

4.6 Training

An overview of hazardous substance management at ERA is provided as part of the general induction (online, occupational health and environment inductions) that is required for all employees and contractors to complete. Training on managing hazardous substances at ERA is available as a web-based course for employees and contractors. ERA training co-ordinators can advise on role specific training in chemical and hazardous material management.

5. Contamination Control Management

5.1 Contaminated Site Assessment

Site investigations have been undertaken to assess soil and groundwater contamination in the Ranger processing plant area. The findings of these investigations have been used to develop a risk assessment of relevant sites following AS/NZS4360 Risk Management and National Environmental Protection Council (NEPC) guidelines. These investigations and risk assessments contribute to development of remediation strategies for closure.

The Closure Criteria Working Group (CCWG) has been established as a working group of the Ranger Mine site Technical Committee (MTC). Progress towards establishing closure criteria for Ranger mine is tracked through discussion and negotiations with stakeholders and is supported by ongoing research from both ERA and the Environmental Research Institute of the Supervising Scientist (ERISS). Research and monitoring related to the key knowledge needs associated with closure planning is reviewed by the Alligator Rivers Region Technical Committee (ARRTC). Final landforms are required to be constructed such that wastes will be securely contained to provide long-term protection of human health and the environment, as per the Ranger Authorisation.

ERA currently conditionally adopts criteria presented in the National Environmental Protection Measure (NEPM) Assessment of Site Contamination for the purpose of providing guidance on contaminated site investigation matters on a day to day basis only. The conditions on which the adopted NEPM Assessment of Site Contamination criteria is subject to include:

- The adopted criteria is interim only, secondary to and will be replaced by the Ranger mine closure criteria once approved by the MTC;
- The purpose of the adopted NEPM Assessment of Site Contamination criteria is to provide day to day guidance on matters relating to the assessment of site contamination only (for example, assessment and verification of the suitability of bio-remediated hydrocarbon impacted soil) in the absence of and until Ranger mine closure criteria are established and approved;
- The adopted NEPM Assessment of Site Contamination criteria will not be used for ERA Ranger mine site closure, closure planning, treatment and or remediation of potential or actual site contamination;
- Closure criteria approved by the MTC will be those applied to assess the adequacy of site closure, contribute to closure planning and for treatment and or remediation of potential or actual site contamination.

5.2 Contaminated Sites Register

The Contaminated Sites Register identifies all sites (including Jabiluka and Djarr Djarr) that have supported land use activity having the potential to contaminate land. The Contaminated Site Register is warehoused in GIS format and includes, but is not limited to, information on the location, land use activity, potential contaminants and risk. The register is maintained by the Environment Team.

Allowance has been made in the Ranger Mine Closure Plan for the investigation and remediation of sites identified as having potential or actual contamination. Notwithstanding this, in the event actual contamination is identified that is assessed as posing potential to harm the surrounding environment or human health, ERA shall consider containment, mitigation and/or remedial measures to manage the risk.

5.3 Remediation of Contaminated Sites

Remediation of contaminated sites may occur as progressive rehabilitation throughout the remaining life of operations at Ranger, or be addressed through the closure process. The CCWG has agreed that closure criteria will be developed under six themes:

- Landform
- Radiation
- Water and sediment
- Flora and fauna
- Soils
- Cultural

Where appropriate, closure criteria from each theme will be applied to remediation of contaminated sites as per the contaminated sites register as well as to guide closure across Ranger.

5.4 Prevention

Prevention of contamination on site is managed through (but not limited to):

- Assessment of alternative substances through the chemical approval process;
- Bunding of relevant materials to relevant standards;
- Integrity inspections for relevant under and above ground tanks and pipelines;
- Condition monitoring and housekeeping inspections to detect leaks / cracks;
- Preventative maintenance on equipment;
- Groundwater monitoring;
- Incident / spill response and clean up;
- Stock reconciliation;
- Standard operating procedures for hazardous substances and associated tasks;
- Informing all workers at ERA of their requirements with respect to managing hazardous substances, reporting spills and incident response / clean up.

5.5 Containment Systems

ERA has a suite of standard operating procedures relating to the management of hazardous substances. Hazardous material containment is addressed (but not limited to) the following documents:

- AS1940 Storage and handling of flammable and combustible liquids
- ERP003 Waste Hydrocarbon Disposal Procedure
- ERS057 ERA Standard Hazardous Substances

Secondary containment systems are also in place at locations where there is a higher risk of hydrocarbon / process spills or leaks. These locations include but are not limited to the bulk diesel tanks, sulphuric acid tanks, powerstation diesel day tanks, warehouse product and waste oil tanks, acid leach tanks, CCD's, tailings pump station, tailings and brine pipelines and the sand filters.

Containment valves must be locked in the closed position except under supervision when opened to release clean storm water. It is noted that any storm water that has accumulated in a controlled area is managed as pond or process water as appropriate.

Relevant work area owners are responsible for routine and non-routine inspections and maintenance of containment systems (including bunds) to ensure:

- Containment systems are free from product spillage;
- Storm water is identified and removed to ensure adequate containment capacity is maintained; and
- Containment systems are competent and fit for intended purpose.

5.6 Monitoring

Groundwater monitoring is conducted on site through targeted routine bore monitoring programs. As additional bores are installed on site they are incorporated into the programs. Groundwater monitoring is undertaken by the Water Management team, who are also custodians of the data obtained from the monitoring program.

5.7 Third Party Transport and Disposal

The third party transport of hazardous substances is managed through a services contract which allows ERA to competently apply controls to manage the associated risks. Transport providers and any waste receivers and/or disposers shall be appropriately licensed to transport and receive such waste.

It is noted that the interstate movement of hazardous wastes may trigger the need for additional State & Federal government approvals including but not limited to the National Environmental Protection (Movement of Controlled Waste between States and Territories) Measure.

Uranium oxide produced at Ranger is transported from site by road. The requirements for transport and incident response in the event of a spill are addressed in the UTP001 ERA UOC Transport Plan. Compliance with the requirements of the aforementioned document exceeds current statutory requirements.

6. Spill Response and Incident Reporting

6.1 Spill Response

ERA procedure MTP007 Hydrocarbon Spill Clean-Up details the guidelines and procedures for spills of different materials. Spill response kits (yellow bins labelled 'spill kit') containing the appropriate spill response equipment are available for requisition through Stores. Spill kits shall be readily available at those locations where spills have a likelihood to occur, such as at fuel bowsers, workshops and transfer points. Each work area is responsible for ensuring that their spill kit is maintained and re-stocked.

Contaminated spill kit materials shall be recovered and disposed of as per ERP003 Waste Hydrocarbon Disposal procedure.

The Ranger Environment induction outlines the requirements for every worker for spill response and clean up.

6.2 Incident Reporting

Environmental incidents are reported to regulatory authorities in accordance with Section 29 of the Mining Management Act and via the monthly Environmental Incident Report.

Health, Safety and Environment incidents are managed through the Rio Tinto Business Solution in accordance with ERS014 Non-Conformance Incident and Action Management Standard. Reporting an incident via this system requires information about spilled volume, response action and recovered volume where practicable.

Complaints are considered an incident and must be reported as above. In the event of an incident or complaint, an investigation is conducted to determine the root causes and to determine if additional controls are required.

7. Hazard Reduction

ERA shall pursue the reduction of hazardous substance use in the workplace and endeavour to substitute less hazardous substances where practicable. ERA regularly reviews the hazardous substances inventory and practical application purposes to identify redundant chemicals along with recommendations to seek alternate non-hazardous substances or less hazardous substances where practicable. Form F0096 New Chemical Request, along with work instruction ERW022, assesses the environmental risk of hazardous substances and details controls required to reduce hazards during the use, storage and transportation of the hazardous materials.

8. Accountabilities

Role / Title	Responsibility
General Managers	• Ensure adequate resources are allocated to departments to facilitate compliance with the Hazardous Materials and Contamination Control Plan (the Plan).
Department Managers	• Maintain the requirements of the Plan and all associated procedures. • Ensure employees and contractors are appropriately trained in the correct methods for handling and storage of hazardous materials. • Ensure that onsite storage facilities are inspected and maintained and inventories are kept up to date.
Manager HSE & Communities	• Ensure that ERA implements and maintains the requirements of the Plan and all associated procedures. • Ensure the Plan is regularly audited and reviewed according to Rio Tinto Standard E15.
H&S Advisor	• Maintain the HSEMS risk register, including items related to hazardous materials
Environment Team	• Provision of environmental advice relating to new hazardous substances, spills and clean up • Periodically review and maintain the Contaminated Sites Register • Assessment of requests to dispose of chemicals off site
Environment Superintendent	• Ensure the Plan and associated procedures are reviewed and maintained at periodic intervals. • Periodically review hazardous waste transporters and receivers.
Hazardous Substances Coordinator	• Ensure the Hazardous Substances Register is maintained and SDS' are available for all substances on ChemAlert. • Assessment of requests for new chemicals and hazardous substances.
ERA Company Rep	• Ensure contractors comply with the Hazardous Materials and Contamination Control Plan and all associated standard operating procedures and other associated documents.
Document Controller	• Maintain authorised system procedures, department procedures and other related documentation on the ERA drive • Ensure that the most recent issues of the documentation are available.

Role / Title	Responsibility
All ERA Employees and Contractors	• Adhere to the requirements of the Plan and all associated procedures. Specifically: o Follow approvals process for bringing new hazardous substances to site, or to a new work area o Refer to and understand Safety Data Sheets (SDS') when handling hazardous materials o Participate in induction and training programs o Wear personal protective equipment (PPE) provided, as specified o Assist in audits as required o Comply with the guidelines set out in this plan o Comply with ERA and regulatory requirements for spill response, clean up and reporting.

9. Review

The Hazardous Materials and Contamination Control Plan will be reviewed and updated no later than every three years from the date of last review. A review may occur sooner consequent to a material change in risk, legal requirements or an incident relevant to hazardous materials management.