Appendix 2 EIS Supplement Response – Tailings and Residue Storage Aspects (ATC Williams, August 2017)

REPORT

ARAFURA RESOURCES LIMITED

NOLANS PROJECT

EIS Supplement Response - Tailings & Residue Storage Aspects

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1 INTRODUCTION

Arafura Resources Limited (Arafura) proposes to develop the Nolans Rare Earth Project (the project) in central Australia and is currently finalising the Environment Impact Statement (EIS) for the project in accordance with Northern Territory (NT) regulatory requirements.

Arafura has commissioned ATC Williams Pty Ltd (ATCW) to provide additional information regarding the project's tailings and residue management aspects in response to information requests relating to additional EIS supplementary documentation submitted.

1.1 Project Description

The Nolans Project is located some 135 km to the north west of Alice SpringsError! Reference source ot found.. Infrastructure in the local vicinity includes the Stuart Highway 10 km to the east, and a natural gas pipeline located some 5 km to the south-east. At the closest point, this pipeline is located up-gradient of the site location.

The project is sited over the Nolans Bore Rare Earths Resource and has an estimated life of mine of 43 years. Information presented as part of the EIS provides a description and shows the general layout and configuration of the project, which features:

- northern mine site area (comprising an open-cut pit, waste rock dumps, and concentrator)
- southern processing plant (producing a rare earth intermediate product).

Additional infrastructure includes:

- a slurry pipeline connecting the concentrator to the processing plant
- access and haul roads
- accommodation village
- water and sewage treatment plants
- gas-fired power station
- overhead power lines and gas supply line
- fuel and materials storage facilities.

Site dams and drainage features supporting mining and processing operations will include sediment basins, evaporation ponds, residue storage facilities (RSF) and a tailings storage facility (TSF).

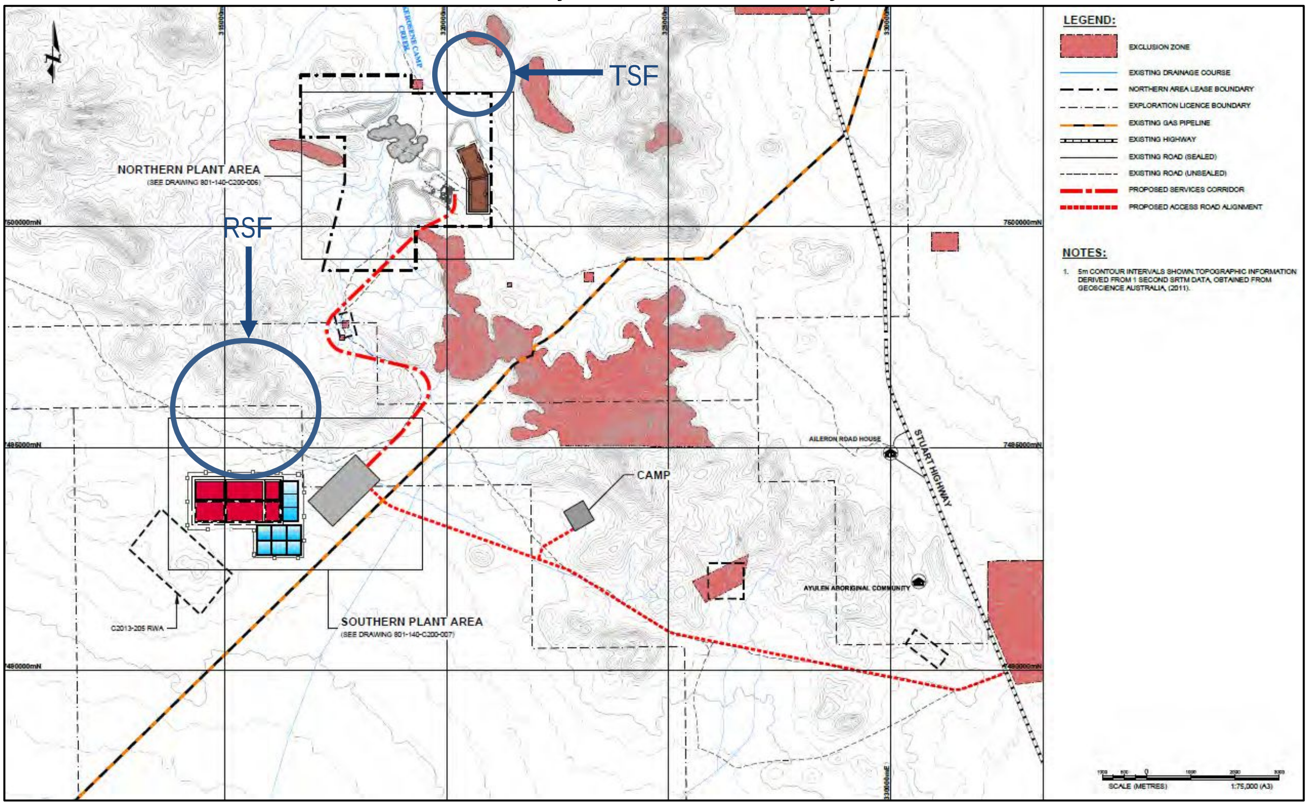
1.2 Tailings & Residue Management

Two separate facilities are proposed to manage tailings from the mine site concentrator and residues from the processing plant, as follows:

- Flotation TSF adjacent to the concentrator at the mine site.
- RSF complex comprising separate cells for residues from water leach, neutralisation and phosphate processes, plus evaporation ponds.

The general site arrangement submitted as part of the EIS that shows the initial proposed location and layout of the TSF and RSF (Knight Piesold Consulting, 2014) is reproduced as Figure 1.

Plate 1
Nolans Project General Site Layout



Details of the proposed design, construction, operational and closure considerations for these facilities form the basis of this report, and are provided in Sections 2 to 5 as follows.

1.3 Report Purpose

The draft EIS for the project was compiled on behalf of Arafura by GHD and submitted to the NT Environment Protection Authority (EPA) in May 2016 [1]. Following the statutory period of public consultation and regulatory review, a number of comments and requests for information (RFIs) were provided to Arafura for consideration.

As a response to these RFIs, Arafura compiled and submitted a Supplement to the Draft EIS to the EPA in February 2017. Assessment of the additional information presented in the supplement resulted in a second set of comments and RFIs, provided to Arafura in March 2017.

Arafura are now compiling further information in response to these additional RFIs. As part of this work, Arafura has engaged ATCW to provide additional clarification and planning considerations concerning the proposed design, operational and closure aspects associated with the proposed tailings and residue management system.

The scope of work associated with the clarification of the conceptual TSF and RSFs design is based on consideration of a 10-year design and operational strategy for the facilities as follows:

- TSF and RSF conceptual design discussion including details on the slurry line bunding (refer Section 2).

- Estimation of solids run out distances from the TSF and RSF due to a dam break scenario (see Sections 2.2.5 and 2.3.4).
- TSF and RSFs inspection frequency, and other related details (see Section 4.6).
- TSF and RSF monitoring requirements to detect and collect seepage (see Sections 4.5 and 4.6).
- TFS and RSF operation management plans, and generic discussion on the management of these facilities in-line with good industry practice (see Section 4).
- TSF and RSF closure considerations (see Section 5).

Although the key purpose of this report is to conceptualise a 10-year design period for the facilities, consideration is also given to the remainder of the life-of-mine (LOM) requirements in order to ensure effective and practicable operation of these facilities into the future.

2 DESIGN ASPECTS

2.1 Design Standards & Guidelines

Dam safety legislation and guidelines within the Northern Territory have not been codified. As such, dam safety in the Northern Territory is currently self-regulated by dam owners.

The criteria adopted for conceptual design and operation of the TSF and RSFs are summarised in Sections 2.2.1 and Section 2.3.1. These criteria are based on the available information in relation to the characteristics of the tailings and residue materials that will be managed within these facilities, as well as the following key references and industry guidelines:

- ANCOLD (Australian National Committee on Large Dams), 2012. *Guidelines on Tailings Dams, Planning, Design, Construction, Operation and Closure* [2].
- Geoscience Australia, 2011. *1 second SRTM Derived Products User Guide (Version 1.0.4).* October 2011 [3].

Related references include ANCOLD publications addressing design guidelines for earthquakes [4],consequence categories, risk assessment [5] and flood capacity [6] as well as International Committee of Large Dams (ICOLD) Bulletins 74, 77, 97 and 98 [7][8][9][10].

The primary objectives for the design of a TSF or RSF as outlined in the ANCOLD guidelines is as follows:

- safe and stable containment of tailings and contaminants
- safe management of decant and rainfall runoff
- management of seepage
- ability to achieve long-term effective closure, leaving no unacceptable environmental legacy
- meeting of these objectives in a cost-effective manner.

2.2 Tailings Storage Facility Design

2.2.1 Design Parameters

The principle design parameters based upon information provided by Arafura or included in the initial EIS submission are summarised in Table 1.

Table 1
Assumed TSF Design Parameters

Parameter	Value
Solids concentration	38.6%
Average design density of deposited tailings	1.4 t/m^3
Production rate	525,000 tpa
Tailings deposition rate	375,000 m^3
Initial design storage capacity (10 years)	3,750,000 m^3
Configuration	2 cell
Footprint	
Cell 1	80 ha
Cell 2	115 ha

Prior to commencement of TSF deposition, a suite of tests should be conducted to determine the tailings characteristics. These tests may consist of the following:

- Soil Particle Density (Specific Gravity)
- Atterberg Limits
- Particle size distribution, Sieve & Hydrometer
- Initial Settled Density
- Segregation Threshold
- Shrinkage Limit Density
- Rheology
- Permeability
- Consolidation

For the purposes of this conceptual design discussion, the operational objective of the initial cell is to contain 10 years of thickened tailings with no raises required.

2.2.2 Embankment Material

Embankment construction materials for the TSF would comprise low permeable material used to form upstream containment zones, and rock fill used to form buttress zones. Target properties of these materials are as follows:

(i) Low Permeable Material - generally greater than 30% fines and a PI of 8 or more. This material would also be engineerable to reduce potential “internal” erosion/piping. Additionally, the material would have an achievable compacted permeability of less than 5 x 10^{-9} m/s.

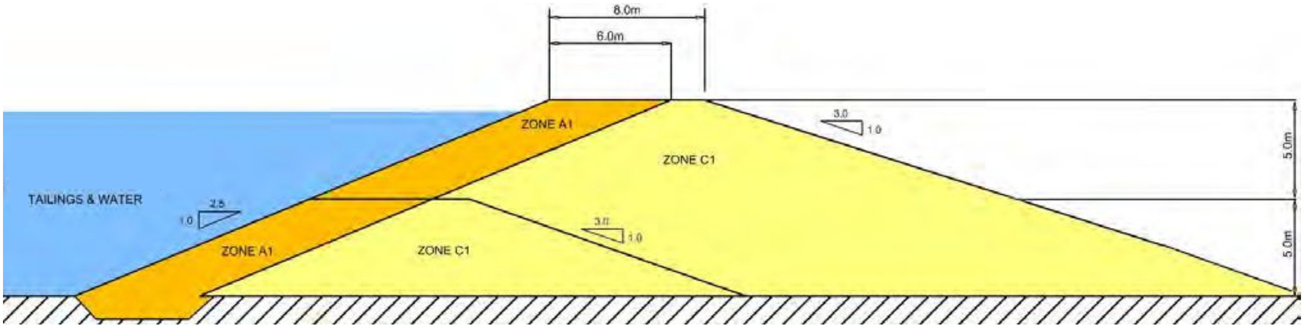
The key to the above suite of properties is to create a fill layer that possesses high strength, compacts well, is stable (i.e. not subject to significant vertical settlement under load or volume instability due to variation in moisture content) and importantly, provides an appropriately low level of permeability.

(ii) Rock Fill- high load bearing capacity, stable and durable (with respect to potential settlement, volume instability, erosion potential and weathering), geochemically stable (i.e. non-acid producing).

The purpose of Rock Fill within an embankment would be to enhance structural stability as well as to provide erosion protection to external portions of the embankment.

A typical cross-section showing the configuration of these zones is provided in Plate 2.

Plate 2
TSF Embankment Zones



The embankments have been zoned as described above to make best use of the available construction materials on site. As noted in the EIS, Arafura intends using material from the pit pre-strip as construction material. The embankments will be zoned such that the width of Zone A material is maintained to minimise seepage from the TSF, whereas Zone C provides the required embankment stability.

The base of the storage area would also be lined with Zone A material (not shown in Plate 1) in order to create a low permeable foundation. It has been inferred that competent bedrock is rather shallow.

2.2.3 Embankment Raises

Table 2 provides a schedule of the anticipated downstream embankment raising over the life of the mine as well as the tailings storage capacity/ore processing tonnage, earthwork fill requirements and the storage life for each raise, which are based on the design assumptions detailed in Section 2.2.1.

Table 2
Downstream Raise Embankment Requirements

Year	Cell	Max. Perimeter Embankment Raise (m)	Crest Elevation (RL mAHD)	Tailings Storage Capacity Volume (m^3)	Ore tonnage (t)	Embankment Earthwork Fill (m^3)	Cell Storage Life (years)
0-10	1	13	678	3,850,000	5,250,000	860,000	10
10-20	1	6.5	684.5	3,715,000	5,250,000	1,371,000	10
20-30	2	14.5	679.5	3,790,000	5,250,000	335,000	10
30-43	2	5	684.5	4,890,000	6,825,000	990,000	13
TOTAL				16,245,000	22,575,000	3,556,000	43

2.2.4 Spillway Design

Consistent with ANCOLD requirements and industry best practice, a spillway will be provided for the prevention of overtopping the embankment crest during extreme or unexpected events. A dam failure consequence category assessment will be performed for the TSF.

The assessment of a consequence category under the ANCOLD Consequence Guidelines requires an assessment based upon the severity of the following damage types:

- infrastructure (dam, houses, commerce, farms, community)
- business importance
- public health
- social dislocation
- impact area
- impact duration
- impact on natural environment.

Based upon the above damage types, the severity level could fall into the following impact categories: minor, medium, major, or catastrophic. Considering both People at Risk (PAR) and severity of damages classification, the recommended consequence category can be determined, as defined in Table 3 (reproduced from 2012 ANCOLD Guidelines).

Table 3
Recommended Consequence Category

PAR	Severity of Damage and Loss			
	Minor	Medium	Major	Catastrophic
<1	Very Low	Low	Significant	High C
>1 to 10	Significant (Note 2)	Significant (Note 2)	High C	High B
>10 to 100	High C	High C	High B	High A
>100 to 1,000	(Note 1)	High B	High A	Extreme
>1,000		(Note 1)	Extreme	Extreme

Note 1: With a PAR in excess of 100, it is unlikely Damage will be minor. Similarly with a PAR in excess of 1,000 it is unlikely Damage will be classified as Medium.
Note 2: Change to "HIGH C" where there is the potential of one or more lives being lost. The potential for loss of life is determined by the characteristics of the flood area, particularly the depth and velocity of flow.

Based upon the outcome of this assessment, the spillway will be sized according to its designated consequence category as outlined in the ANCOLD guidelines. The recommended minimum design floods for spillway design per ANCOLD guidelines is reproduced in Table 4.

Table 4
Recommended Min. Design Floods for Spillway Design and Wave-freeboard Allowance

Dam Failure Consequence Category	Design Flood AEP (Note 1)	Wave Freeboard Allowance
Low	1:100	Wave run-up for 1:10 AEP wind
Significant	1:1000	Wave run-up for 1:10 AEP wind
High	1:100,000	Wave run-up for 1:10 AEP wind
	PMF	None
Extreme	PMF	To be determined by risk assessment

2.2.5 Dam Break Runout Estimate

ATCW undertook a Failure Impact Assessment (FIA) of the TSF in March 2016, in order to establish the potential risk to downstream residents from hypothetical dam-break scenarios. Two failure scenarios were assessed:

- Sunny Day Failure (SDF) event, of which failure is sudden and unexpected, with little to no warning time provided to downstream occupants.
- Flood Failure (FF) event, of which failure occurs during a rare or extreme rainfall event.

Based on the modelling results (determined Population at Risk and Potential Lives Lost) a Consequence Category, as per the 2012 ANCOLD Guidelines, of "Low" for the TSF was determined. Results from the SDF scenario indicated that flooding impacts (in terms of water depths greater than 0.3 m) could be experienced some 27 km downstream of the TSF (refer to Plate 3). While an assessment of the tailings solids runout distance limit was not required as part of the FIA, it is noted that the extent of any potential environmental impacts associated with a TSF dam break would be determined by the limits of tailings water flow as shown on Plate 3.

Accordingly, a dam-break runout estimate of 27 km is adopted for the TSF.

Plate 3
Sunny Day Failure Inundation Depth

LEGEND

TUFLOW MODEL DOMAIN

DEPTH

0.0 - 0.3 m
0.3 - 0.5 m
0.5 - 1.0 m
1.0 - 1.5 m
1.5 - 3.0 m
3.0 - 5.0 m

As the dam-break event in a FF scenario coincides with a high rainfall event, flood impacts and flow distances associated with the failure are exacerbated by the natural flooding that is also occurring within the catchment. As such it is not possible to define a geographical limit to which any impacts from the dam failure would be experienced; however, it is noted that tailings material would blend with the downstream flood waters and become substantially diluted, thus reducing associated downstream impacts.

2.3 Residue Storage Facility Design

2.3.1 Design Parameters

The principle design parameters based upon information provided by Arafura or included in the initial EIS submission are summarised in Table 5.

Table 5
Assumed RSF Design Parameters

Parameter	Value
Average design density of deposited residue	1.2 t/m^3*
Production rate	900,000 tpa
Residue deposition rate	750,000 m^3
Initial design storage capacity (10 years)	7,500,000 m^3
Footprint	325 ha**

* Inferred based on qualitative characteristics of residue (filter cake residue, high gypsum content, etc.)
**Based upon information taken from EIS (GHD, 2016) [1]

Prior to commencement of RSF deposition, a suite of tests should be conducted to determine the tailings and residue characteristics. These tests may consist of the following:

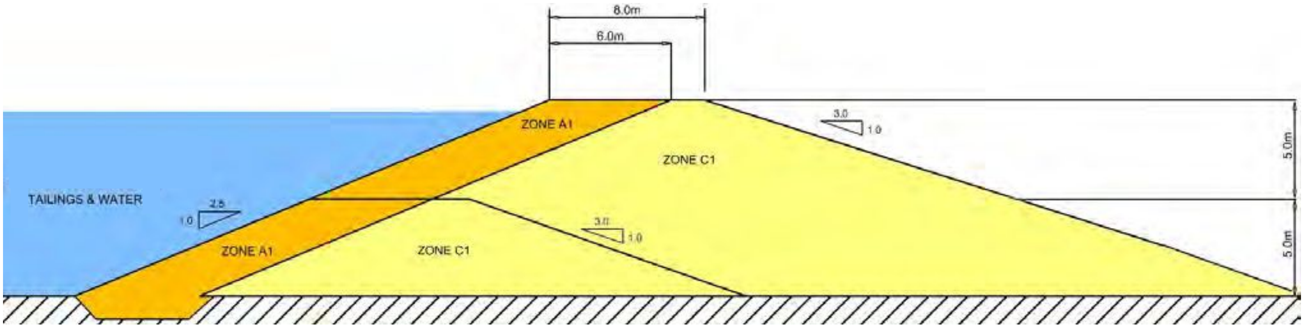
- Soil Particle Density (Specific Gravity)
- Atterberg Limits
- Particle size distribution, Sieve & Hydrometer
- Initial Settled Density
- Segregation Threshold
- Shrinkage Limit Density
- Rheology
- Permeability
- Consolidation

For the purposes of this conceptual design discussion, the operational objective of the initial cells is to contain 10 years of residues with no raises required.

2.3.2 Embankment Material

Consistent with the material definitions and embankment design presented in Section 2.2.2 for the TSF, embankment construction materials for the RSF structures would comprise low permeable material used to form upstream containment zones and within the storage area, and rock fill used to form buttress zones (refer Plate 4).

Plate 4
RSF Embankment Zones



Additionally, a geomembrane liner will be placed on top of the low permeable material as an extra measure to minimise seepage into the foundation and surrounding areas.

2.3.3 Spillway Design

The spillway design will have a similar approach as the TSF, as defined in Section 2.2.4.

2.3.4 Dam Break Runout Estimate

An estimate of the runout distance from the RSF in the event of a dam failure has been made based on the volume of residue contained within the RSF after 10 years of operation, the estimated outflow volume, and the local topography downstream of the RSF location.

Properties and characteristics of the residues resulting from the processing operations are currently under determination by Arafura. Accordingly, a simplified methodology was developed and employed for this estimate, described as follows.

RSF volume (based on assumptions used for the estimate) are as follows*:*

- Residue throughput rate of 900,000 tpa over 10 years.
- Estimated residue and (residual) tailings density of 1.2 t/m³.
- Ten year period, total tailings volume of contained residue is 7,500,000 m^3 or 7,500 ML.

Residue outflow volume:

It was assumed that in the event of dam failure, a portion of the stored residues would be discharged from the embankment breach (outflow volume), with the remainder being retained within the RSF. The outflow volume is calculated using the method described by M. Rico et al (2007) [11] which provides the following regression formula based on analysis of data available from historical tailings dam failures:

$$V_F = 0.354 V_T^{1.01}$$

Where:

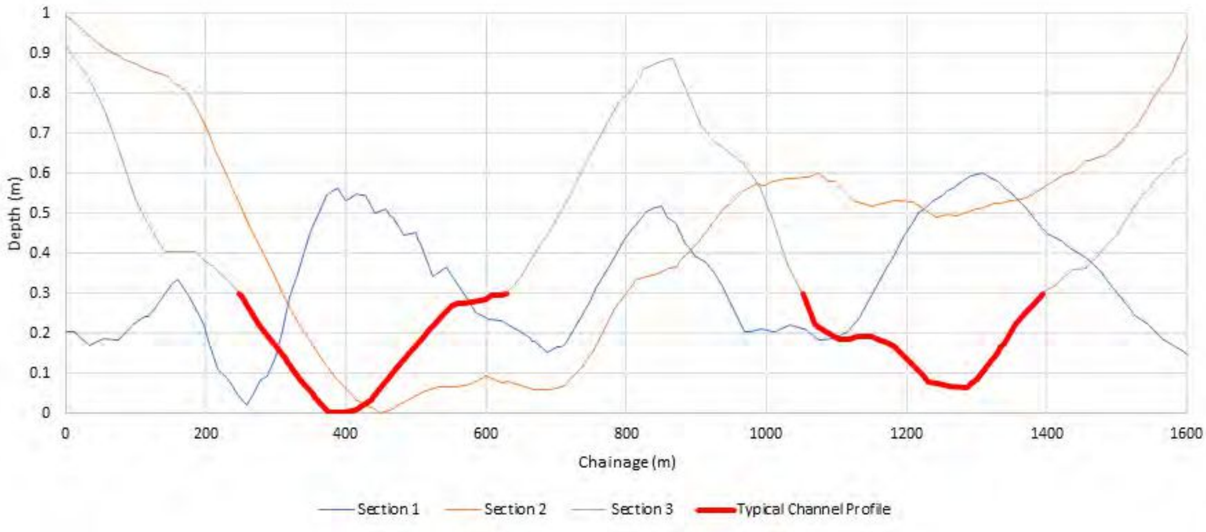
V_F = outflow volume (m^3)
V_T = stored volume (m^3)

Applying the regression formula above, the residue outflow volume is 3,110.4 ML.

Runout distance:

The drainage lines downstream of the RSF consist of low gradient, poorly defined ephemeral creeks. In order to assess the runout distance of the outflow volume, three cross-sections of the channel downstream of the RSF were analysed in order to determine a typical cross-section to apply. Plate 5 shows these cross-sections, of which the low gradient and high variability of the drainage channels are presented in an enhanced vertical scale.

Plate 5
RSF Downstream Flow Path Cross Sections



Cross-section 3 was adopted as a typical cross-section given the clear definition of two channels deemed representative of the nature of drainages within the project area. The red lines represent the typical channel profile, which shows a flow depth of 300 mm over a channel width of some 350 metres.

Flow of residue within these channels was assumed to fill all areas above the minimum channel invert to a defined residue tailings depth (representing the final depth of settled flow from the dam-break event) in order to determine the runout distance based on the average cross-sectional area.

The estimated runout distances based on the above methodology are presented in Table 6.

Table 6
RSF Dam Break Runout Distance

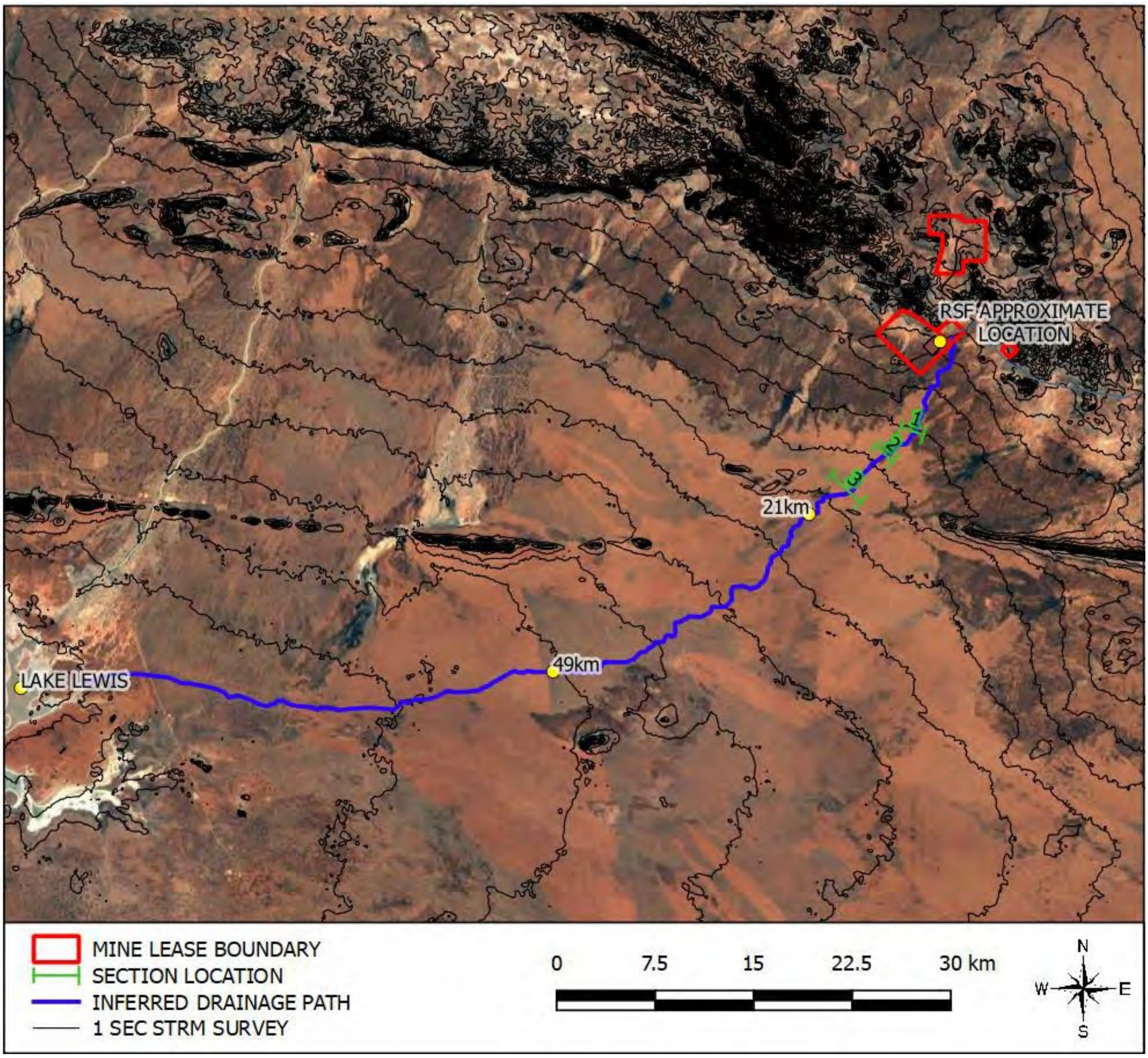
Final Residue Depth	Downstream Runout Distance
100 mm	49 km
200 mm	21 km

Plate 6 shows the two estimated runout distances as yellow dots. It is highlighted that the estimated runout distances are considered conservative given that:

a) the RSF was considered to fail as a single cell - the multiple cell design would reduce the runout volume and also allow for operational management of the low-density material; and,

b) no losses of entrained water or solids within the drainage channel were included in the estimate - various effects such as subsurface infiltration, pooling within localised surface depressions, retention due to the presence of vegetation and surface features, such as boulders and logs, would be expected to reduce the volume of downstream residue flow and accordingly the runout distances.

Plate 6
RSF Dam Break Runout Estimate

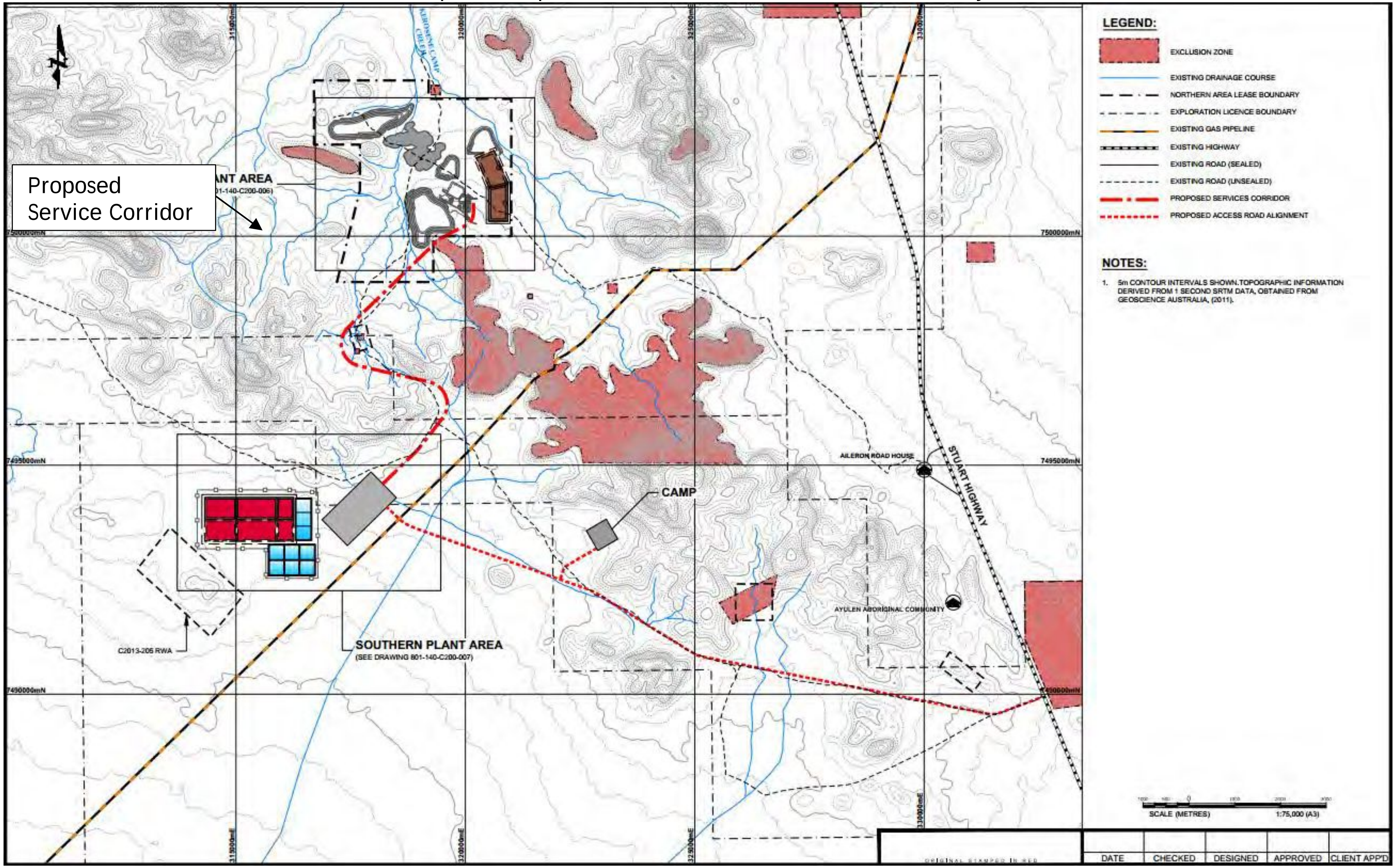


2.4 Bunded Slurry Line

It is proposed that concentrate will be pumped through an HDPE slurry pipeline from the concentrator (located at the mine site) to the processing plant (refer Plate 6). The bunded corridor location will be determined as part of the detailed design.

This pipeline would run above ground within a compacted earth bunded corridor, with event ponds located at low points along the alignment. These event ponds will be designed to hold a calculated volume using a designated flow rate and anticipated time required to stop pumping after becoming aware that there is a ruptured pipe. It is assumed that the longest time between the rupture occurring and personnel aware that is has happened is 12 hours. Flow rate monitors can be placed at the beginning and end of the pipe line with alarms at the process plant should differences be noted. Event pond sizing will be completed as part of the detailed design, although the storage capacities of ponds are conservatively estimated to be some 0.5 ML for every 250 m of pipeline.

Plate 7
Conceptual Proposed Services Corridor for Bunded Slurry Line



Source: Knight Piesold Pty Ltd (2014)

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3 CONSTRUCTION ASPECTS

3.1 Geotechnical Site Assessment

The purpose of geotechnical investigation works associated with the TSF and RSF structures design is to develop an appropriate embankment configuration and seepage management works based on an assessment of embankment foundation and storage area geotechnical and hydrogeological conditions. In addition, available construction materials would also be identified within the storage area.

Works to be undertaken would comprise a test-pitting program and in-situ permeability testing, with summary details of the proposed program as follows:

A test pit program with material sampling for laboratory testing would be undertaken within the proposed embankment footprint and storage to assess/identify:

- Foundation conditions for the TSF embankment and floor
- Sources of clay borrow materials for the embankment and lining (if required).

The test pits will be logged by an appropriately qualified and experienced geotechnical engineer, and representative disturbed samples will be collected for laboratory testing.

For the investigation, it is assumed a minimum of one test pit every 100 m along the proposed embankment alignment. More test pits may be required within the proposed storage area and/or proposed borrow areas.

Laboratory testing program to address the above requirements has been assumed as follows:

- Moisture content
- Atterberg Limits
- Emerson Class
- Particle size distributions
- Maximum Dry Density (Std)
- Triaxial (CU)
- Permeability

3.2 Construction Materials

Embankment construction materials will be sourced locally (i.e. within close proximity to the TSF and RSF structures), with the open cut mining operation providing the construction fill source for rock fill materials. Other areas within the mine site will be used as borrow areas for the low permeable material. Should the required material not be available on site, borrow areas near the mine site will be utilised. Target properties of these materials proposed for the construction of the embankment are outlined below:

(i) Low permeable material (for use as containment zone)
  a) Clay dominant material (clay/silt fraction greater than 20% and Liquid Limits ranging from 25% to 60%).
  b) Undrained shear strength in excess of 50 kPa after compaction.
  c) Achievable compacted permeability of less than 10^{-8} m/s.
  d) Engineerable to reduce potential “internal” erosion/piping.

The key to the above suite of properties is to create a fill layer that possesses high strength, compacts well, is stable (i.e. not subject to significant vertical settlement under load or volume instability due to variation in moisture content) and importantly, provides an appropriately low level of permeability.

(ii) Rock Fill (for use as embankment fill)

The purpose of rock fill within an embankment would be to enhance structural stability as well as to provide erosion protection to external portions of the embankment. General requirements for rock fill would be as follows:

- High load bearing capacity.
- Stable and durable (with respect to potential settlement, volume instability, erosion potential and weathering).
- High permeability relative to adjacent embankment or subgrade zones.
- Geochemically stable (i.e. non-acid producing).

Waste rock at the site will be typically comprised of gneiss, pegmatite and schists. This material is acceptable for use as Rock Fill in accordance with the requirements above.

3.3 Construction Costs

The following assumptions were made concerning the cost estimating:

- 30% of the material is comprised of low permeable fill while the other 70% is comprised of rock fill material.
- This cost only pertains to earthwork construction material pricing.
- This cost estimate is only accurate to +/- 30%.
- Year 10 and Year 20 account for lining of the storage area.

Table 7 contains estimated quantities and costs for each raise. A layout and cross section of the raises is shown on Figures 1 and 2.

Table 7
Earthworks Cost Estimate

Year	Cell	Embankment Construction	Rate ($/m^3)	Quantity (m^3)	Amount
0 - 10	1	Low Permeable Fill	5	428,000	$2,140,000
		Rock Fill	3	602,000	$1,806,000
				Subtotal	$3,946,000
10 - 20	1	Low Permeable Fill	5	411,300	$2,056,500
		Rock Fill	3	959,700	$2,879,100
				Subtotal	$4,935,600
20 - 30	2	Low Permeable Fill	5	409,000	$2,045,000
		Rock Fill	3	234,500	$703,500
				Subtotal	$2,748,500
30 - 43	2	Low Permeable Fill	5	297,000	$1,485,000
		Rock Fill	3	693,000	$2,079,000
				Subtotal	$3,564,000
				TOTAL	$15,194,100

4 OPERATION ASPECTS

4.1 Operations and Management Plan

Operations and Management Plans (O&MP) are developed once the final detailed design has progressed adequately to inform the tailings placement procedure. The principal purpose of an O&MP is to provide documented operation procedure to assist in the safe and efficient storage of tailings in the TSF and RSF. The O&MP will set out how the TSF and RSF structures can be operated in a way that is in line with the assumptions and principles adopted by the designer of both structures.

O&MPs will be reviewed and updated regularly or when an operational change is required due to design changes.

A preliminary draft of the O&MP for the TSF is provided as Appendix A as an indication of the typical format and content of a final O&MP.

4.2 Operating Objectives

Operation of the TSF and RSF includes a number of specific actions, including pumping and piping, spigot management, monitoring, inspections, and audits. The objectives of these actions are to assist in the safe and economic operation of the TSF and RSF structures and to set out the way in which these should be operated in order that the design and regulatory requirements with respect to geotechnical safety are met. The operating objectives therefore include operating both structures in a manner which will achieve the desired outcomes set out in Table 8.

Table 8
TSF and RSF Operating Objectives

Operating Objective	Rationale
Control tailings discharge to prevent erosion of internal embankment slopes.	Erosion will compromise the integrity of the embankments and low permeable liner.
Control tailings discharge to prevent pooling of water anywhere near the deposition areas.	Pooling must be kept away from the embankments.
Deposit tailings in such a way as to create a relatively uniform beach accordance with the design, maintain pool control.	Embankments were designed to contain tailings, and some were designed to contain tailings and water.
Rotate deposition locations as per the design.	Assists in beach development and reduces seepage potential.
Maximise recovery of clean water by controlling the pond depth, location and discharge rate.	Clean water with minimal suspended solids reduces wear on pumps and pipes, and minimises deposition of solids in the RWP.
Control water level and deposited tailings levels to maintain required freeboard.	Maintaining adequate freeboard reduces the likelihood of tailings or water release to the environment during operation or in an extreme rainfall event, and is a requirement of the statutory guidelines.
Maintain access to the TSF and RSF all year round.	Access is required for maintenance, inspection and in case of emergency.
Control rainfall run-off.	Rainfall run-off, if not properly controlled, can erode the TSF and RSF structures compromising integrity.
Complete daily monitoring identifying potential failure signs and implement remedial or preventative action as required.	Conditions change, daily monitoring can assist in seeing how those changes impact on the integrity of the TSF and RSF structures.
Rapidly identify and limit any spills and leaks from the pipelines by regular inspections of pipes, pumps and valves.	To minimise the environmental impact.
Maintain the TSF and RSF workplace in a tidy and safe working order.	To reduce workplace risk.
Monitor and maintain seepage collection drains	Inspect for erosion or silting which can affect flow conditions
Operate TSF and RSFs as dry as possible	Check piezometers and monitoring bores to ensure that conditions changing have not caused elevated ground water or phreatic levels.

4.3 Tailings Deposition Methodology

Tailings discharge points will be identified based on the detail design and final adopted storage geometry, of which discharge must take place from these deposition points as per the proposed sequencing designed for optimal storage efficiency. Flow through the spigots must be monitored and control valves used to control the build-up of tailings as directed in the operating manual. Decant recovery will be a platoon mounted pump or decant structure and via seepage collection.

The embankment crests should be sloped toward the inside of the TSF and RSF structures at a minimum 2% cross fall. Peripheral discharge will form an inward sloping beach profile, which will assist in draining water away from the embankments.

4.4 Water Management

4.4.1 Decant Pond on the TSF/RSF

The ponded water may be decanted via a pontoon mounted pump or decant structure.

The deposition methodology (see Section 4.3) is aimed to maintain control of the location of the decant pool around the decant structures. The decant pool depth is to be maintained at around 1 m above tailings level to promote the settling of solids from the slurry water.

4.4.2 Freeboard

The height between the lowest point of the embankment crest (i.e. the spillway) and the operating pond level, should not be permitted to be less than the required freeboard as determined during the design phase based upon ANCOLD Guidelines.

4.5 Seepage Management

Appropriate practices to manage the rate or quality of seepage water that may be released from the system are to be adopted, with some methods documented in the list below. These practices will be implemented to comply with environmental requirements, specifically to achieve the downstream and downgradient water quality requirements. Provisions to be made to manage seepage migration effects will include:

(i) The embankments will have cut off keyways (comprising of compacted clayey low permeability material) to restrict potential seepage under the perimeter embankments.
(ii) Maintaining an appropriate tailings deposition regime (in terms of cycling periods) to maximise consolidation of the tailings and water recovery.
(iii) Whilst maximising water recovery, as outlined above, the volumes of free water occurring within the decant pond is limited. This outcome requires an effective balance between deposition scheduling and decant water recovery rate.
(iv) Operating and maintaining the seepage interception and recovery systems, which for the TSF will likely comprise a seepage collection drain. The RSFs design incorporates an HDPE/low permeability soil liner.
(v) Undertaking groundwater monitoring to assess the TSF and RSF performance.

4.6 Monitoring and Surveillance

Nested groundwater monitoring bores will be installed at the TSF and RSF sites for monitoring water quality. Any bores which have already been installed should be regularly monitored for collection of background data.

In general, monitoring bores should be located along the toe of the embankments of the TSF and RSFs approximately 500 m downstream. As the bedrock is fairly shallow and groundwater has been encountered at depth (approximately 15 m below ground surface at the mine site), the amount of monitoring bores near each structure will be minimal. These locations will be determined as part of the detailed design and in conjunction with the Arafura’s environmental consultant.

Monitoring and sampling of the bore network is proposed to be undertaken to meet environmental requirements as per the NT EPA guidelines.

In addition to the monitoring bores, standpipe piezometers are proposed to be installed in the TSF and RSFs embankments. Piezometers assist to monitor the potential development of a phreatic surface within the embankments. Standpipes are sometimes difficult to protect during raising and operations, so vibrating wire or electronic piezometers may be a good alternative. Piezometers should be installed in a line of three from the crest to the toe of the TSF and RSF embankments at different locations along the embankment.

Monitoring of the development of the tailings beaches takes place during inspections and design reviews to enable assessment of achieved storage capacity and construction timing.

The following monitoring would take place, particularly during daily inspections:

- Serviceability of pipelines (tailings delivery and return water lines)
- General integrity of all embankments (e.g. observable deformation or settlement etc.)
- Indication of any seeps or expression of water downstream of any embankment
- Location and current status of tailings deposition in the TSF
- Location and size of the TSF decant pond
- Operability of return water systems (the TSF decant and the Seepage Recovery System)
- Serviceability of bunding and emergency spillway
- Any other aspect that may impact on embankment integrity.

It is recommended that an annual inspection is carried out on these facilities, and that routine safety inspections be carried out in accordance the operations manual. It is recommended that the discharge, decant, spillways, embankments and return water facilities are inspected daily and more frequent during extreme rainfall events.

5 CLOSURE/REHABILITATION ASPECTS

The typical objectives to be adopted for rehabilitation of the TSF and RSF structures would be to create a landform that is:

(i) safe, stable and sustainable
(ii) compatible with the surrounding landform
(iii) of minimum long term environmental impact (i.e. non-polluting).

Based on these objectives, a concept for the TSF and RSF structures rehabilitation is detailed below.

5.1 Closure Water Management

Maintain the rainfall runoff capacity to comply with regulatory requirements within the existing TSF area, until such a time that it is demonstrated that the runoff is of suitable quality to allow discharge from the site. Following demonstrated compliance with release criteria, the final ponded area would be breached/filled to facilitate drainage of the area.

5.2 Landform Development

It is envisaged that the final TSF landform would comprise long-term stable external batters with an upper surface formed such that ponding is substantially avoided. This would therefore necessitate a final campaign of tailings deposition within the TSF to infill any significant depression.

5.3 Tailings Surface Capping

5.3.1 Background

A tailings surface cap would serve the following purposes:

(i) facilitate ongoing surface water drainage and prevent ponding
(ii) stabilise the surface to mitigate against potential ongoing erosion
(iii) reduce potential rainfall infiltration into the tailings as recharge to seepage
(iv) minimise radiation escaping to the environment.

A "Bulk Cover" type cap is proposed with the capping system comprising the following features:

Surface Features	- Maximum slopes of 1 in 100 - Surface to be generally freely drained - Maximum overland flow length for surface topsoils to be 150 m to 200 m (at maximum slopes of 1 in 100) - Flow lengths greater than 200 m to be channelized within broad shallow rock armoured channels
Capping System	- Preferred capping system to comprise a "bulk" cap which would utilises available mine waste and stockpiled topsoils.

5.3.2 Conceptual Capping Arrangement

This configuration assumes that the tailings would remain geochemically benign. Based on the above assessment, the conceptual cap would comprise the following components.

- Tailings Surface Stabilisation Layer

  To provide a geotechnically competent surface over the surface of the tailings, a stabilisation layer may be necessary. The purpose of the stabilisation layer would be to provide a competent subgrade or bridging layer, which would limit the effective surcharge onto the tailings surface and thereby limit potential settlements. The area most likely to require stabilisation would be the decant pond surface, due to the likely extent of saturated slimes materials.

  The stabilisation layer would typically comprise rock mattress (the rock comprising competent and durable material).

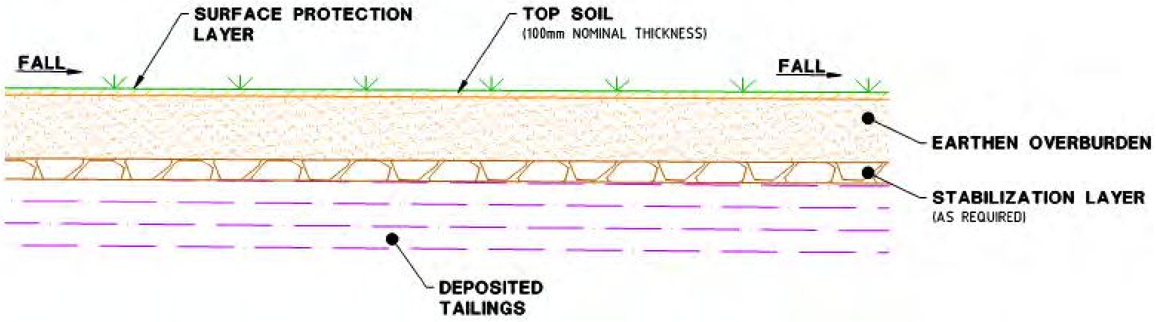
- Surface Cover Layer

  To protect the tailings surface stabilisation layer from erosion and exposure deterioration (through wetting and drying), a surface cover layer would be required. This layer would also be utilised as a rooting zone for vegetation depending on the proposed end land use. This layer would be formed typically using select earthen material from run-of-mine weathered overburden. Geochemically, the earthen material should be non-acid or saline drainage producing. From a geotechnical perspective, the material should be non-erosive/dispersive.

  The thickness of this layer would be selected to not only maintain drainage, but also to compensate for settlement within the underlying tailings. A hummocky final land surface may also have some benefit with respect to maintaining moisture within the surface layers to support vegetation growth and to reduce erosion potential. The final surface landform would be subject to further, on-going assessment through the final stages of the facility.

A conceptual detail of the proposed TSF capping arrangement is provided in Plate 8.

Plate 8
Conceptual TSF Capping Arrangement



A more detailed assessment of a suitable capping configuration would need to be completed, subject to more data being available with respect to the physical and geochemical characteristics of the tailings. In particular, geochemical compatibility between the tailings and capping materials must be confirmed to ensure the integrity of the capping horizon is not compromised. Due to the nature of the tailings and residue, the cover system will comprise of minimum of 0.5m cover material to provide shielding of the radiation.

5.4 Closure Progression

Closure/rehabilitation of the TSF and RSF structures can be done progressively during the LOM. As a cell of the TSF reaches maximum storage capacity, this cell can start closure/rehabilitation works.

Progressively closing and rehabilitating the TSF and RSF cells may help the site water balance and with the levy requirement.

Additionally, the closure design plan can be refined for the next cell based upon the performance of the rehabilitated cell. This approach can demonstrate to the regulator that the closure methodology is reasonable and sustainable.

5.5 Post Closure Site Investigation

To aid in detailed closure design, a geotechnical investigation and laboratory testing should be conducted on the tailings. The geotechnical investigation would comprise Cone Penetrometer testing (CPT). The CPT results can be used to predict shear strength values of the tailings at depth. This information would be used for both the closure design and constructability requirements.

Additionally, geochemistry and soil laboratory testing should be performed on the tailings and residue.

REFERENCES

[1] GHD, 2016. *Nolans Project, Environmental Impact Statement.* Prepared for Arafura Resources Limited.

[2] ANCOLD (Australian National Committee on Large Dams), 2012. *Guidelines on Tailings Dams Planning Design, Construction, Operation and Closure*.

[3] Geoscience Australia, 2011. *1 second SRTM Derived Products User Guide (Version 1.0.4).* October 2011.

[4] ANCOLD, 1998. *Guidelines for Design of Dams for Earthquake*.

[5] ANCOLD, 2003. *Guidelines on Risk Assessment*.

[6] ANCOLD, 2000. *Guidelines on Selection of Acceptable Flood Capacity of Dams*. March 2000

[7] ICOLD (International Commission on Large Dams), 1989. Bulletin 74, *Tailings Dam Safety.*

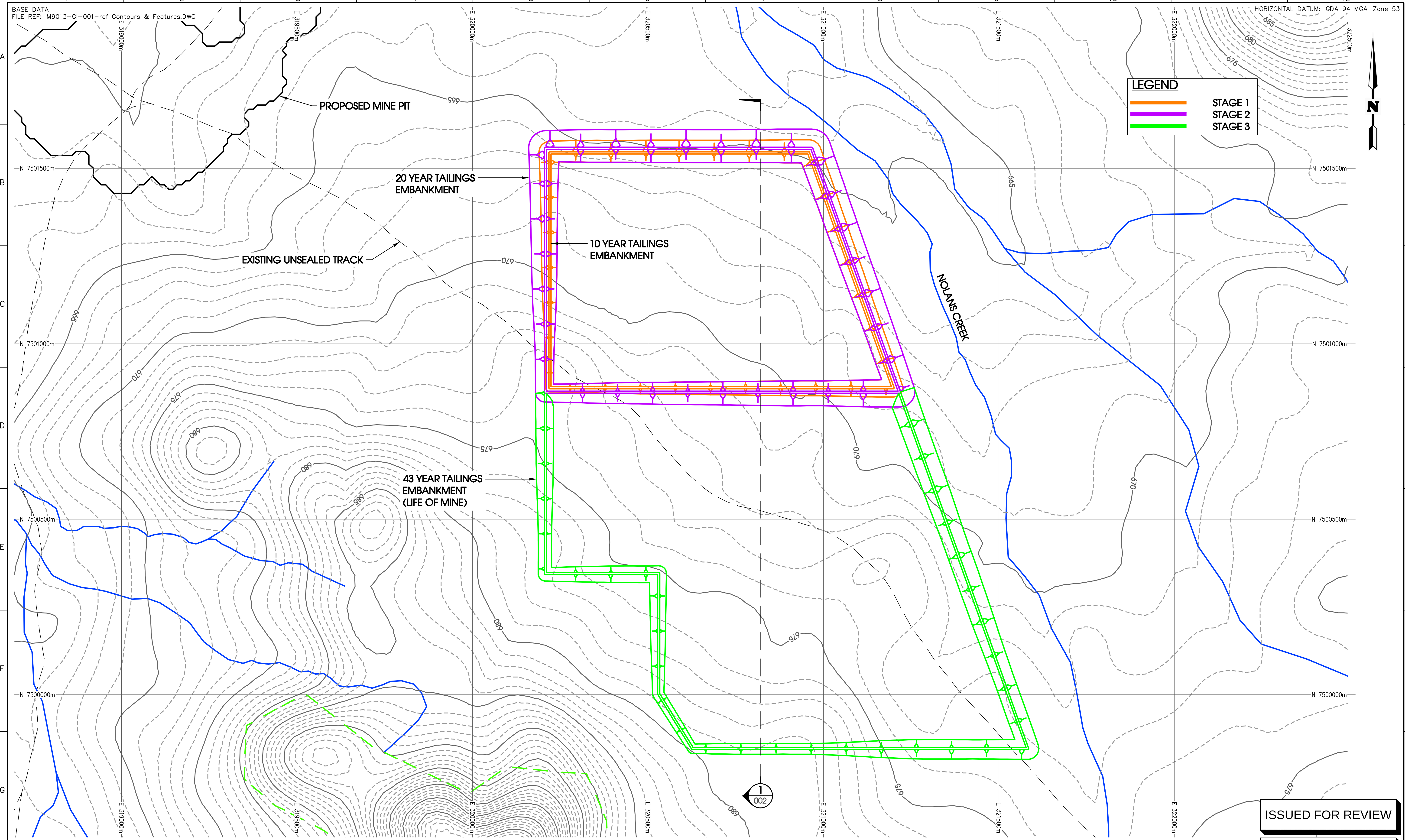
[8] ICOLD, 1990. Bulletin 77, *Dispersive Soils in Embankment Dams*.

[9] ICOLD, 1994. Bulletin 97, *Tailings Dams - Design of Drainage.*

[10] ICOLD, 1995. Bulletin 98, *Tailings Dams and Seismicity.*

[11] Rico M., Benito G., and Diez-Herrero A., 2007. *Floods from Tailings Dam Failures.* Journal of Hazard Management.

FIGURES



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NOLANS PROJECT

TAILINGS STORAGE FACILITY
10 YEAR, 20 YEAR AND 43 YEAR LAYOUT

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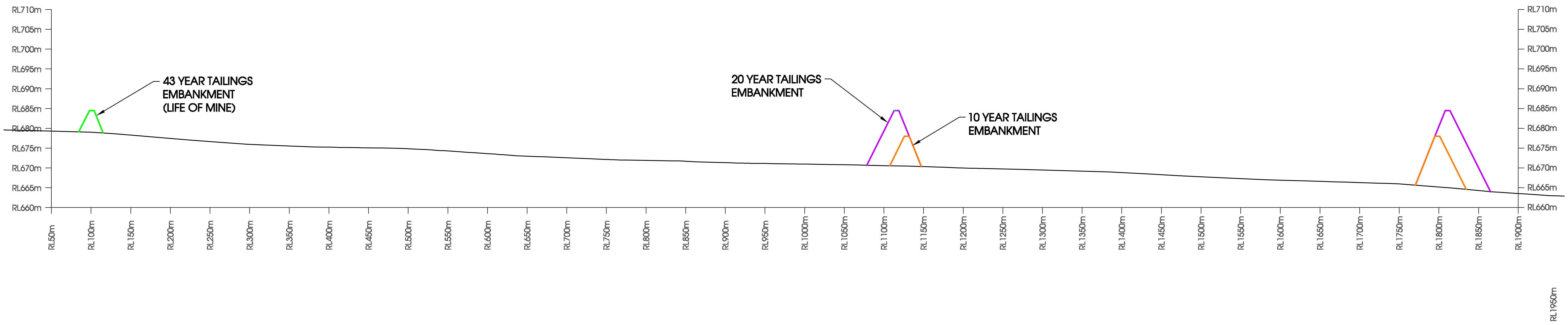

SECTION (1 / 001) **TAILINGS STORAGE FACILITY**

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TAILINGS STORAGE FACILITY
10 YEAR, 20 YEAR AND 43 YEAR SECTION

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APPENDICES

APPENDIX A

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REPORT

ARAFURA RESOURCES LIMITED

Nolans Project

TSF

Operations & Management Plan

Document History and Status

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				Author	Reviewer
	Preliminary Draft	B. Fowler	22/8/17		

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PREAMBLE

Introduction

This Operations and Management Plan (OMP) has been prepared as the basis for operation and ongoing management and monitoring of the Tailings Storage Facility (TSF), a structure at Nolans Mine Site.

This OMP has been developed with reference to the following design and construction documentation:

- Design Documentation
- Construction Documentation

Purpose of Document

This document describes the obligations of the operator with respect to acceptable standards for operation of the TSF, as a means of maintaining the long term integrity of the facility. In addition, the OMP is intended to assist with training of staff in matters related to management of the TSF (including incident response) and maintenance of appropriate operating records.

Specifically, the purpose of the OMP is as follows:

- To provide relevant background to the TSF, relating to specific regulatory requirements and performance expectations.
- To identify the principal components of the TSF and describe the contribution of these components to the effective operation of the structure.
- To describe general guidelines for the operation of the TSF, including tailings deposition and associated water management/recovery practices, with the scope of these guidelines being to facilitate effective and efficient storage utilisation and to achieve a competent tailings beach surface to assist future embankment lifting and rehabilitation.
- To outline minimum inspection and monitoring requirements for the TSF.
- Important note: The scope of this document does not extend beyond the TSF to other site water /tailings management elements (e.g. turkey nests, diversions and drainage elements).

Reviews and Updates

The OMP is a working document, with operating, management and monitoring practices, as outlined, subject to periodic review and update to reflect modifications to the conditions on which the document is based. The timing for such updates includes, but is not necessarily limited, to the following for the TSF:

(i) Alteration (either increase or decrease) of the capacity of the TSF by changing footprint or storage height or alteration of the Consequence Category.
(ii) A significant incident with respect to the operation and/or performance of the TSF is experienced.
(iii) A significant change to the environmental requirements for the Mine Site, or conditions contained therein, is made, which would materially impact on the operating and management conditions of the facility.

Notwithstanding these conditions, review and updating of the OMP should be completed every three years, as a minimum, should the life of the Regulated Structure extend beyond this timeframe.

<u>Document Structure</u>

The OMP is structured as follows:

Section 1	General Background.
Section 2	Environmental Authority Requirements.
Section 3	Describes the layout and development of the TSF.
Section 4	Outlines the operating principles and objectives related to the TSF with respect to regulatory constraints/approvals conditions, as well as overviewing key design criteria applying to the facility.
Section 5	Presents operating procedures for the TSF
Section 6	Outlines inspection and monitoring requirements to be implemented in conjunction with operation of the TSF.
Section 7	Provides Emergency Response Plans for the TSF.
Section 8	Outlines documentation requirements related to the TSF operation and auditing.

A figure is also included to show the layout of the TSF.

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2 ENVIRONMENTAL AUTHORITY REQUIREMENTS

2.1 TSF Containment and Freeboard Requirements

Table 1 Containment and Freeboard Requirements for TSF

Name of Structure	Consequence Category	Spillway Capacity Critical Design Storm
TSF		

3 TSF DESCRIPTION

3.1 Design History

3.2 Design Configuration

The current configuration of the TSF is as follows:

- Construction Type — Engineered Embankment
- Construction Materials — Clay Fill, Rock Fill, Select Rock Fill
- Embankment Crest Elevation
- Embankment Crest Width
- Upstream Embankment Slope
- Downstream Embankment Slope

- Perimeter Embankment Length
- Total Storage Capacity
- Emergency Spillway Invert Elevation (top of Rock Armouring)
- Emergency Spillway Containment Level (Full Supply Level, i.e. base of Rock Armouring)
- Emergency Spillway Width
- Emergency Spillway Depth
- Emergency Spillway Catchment Area (assuming clean water diversion is ineffective, used for emergency spillway design)

3.3 Associated TSF Features

Other infrastructure elements directly associated with the TSF comprises:

3.3.1 TSF Water Management System

Water occurring within the TSF is derived from the following sources:

- Direct rainfall within the TSF catchment area.
- Process water inputs to the TSF, via water liberated from deposited tailings.

The recovery of water from the TSF is to occur from a decant pond. The intent is that tailings is to be deposited within the TSF such that the decant pond is relocated to a central position within the TSF (i.e. not against the perimeter embankments). The decant pond is to be operated such that the water depth, footprint area and volume within the decant pond is kept at a minimum level. A recovery pump is to be used to remove water from the TSF for storage / use elsewhere on site.

3.3.2 TSF Seepage Collection System

A subsurface seepage collection system is [ ]

4 BASIS FOR SYSTEM DEVELOPMENT AND OPERATION

4.1 Operational Principals and Objectives

The philosophy or commitment of Arafura in relation to the operation of the TSF is as stated below:

- The system will achieve appropriate environmental performance standards, given the setting and design constraints of the facility. Specifically, these standards relate to protection of receiving environments, with emphasis on maintaining environmental values of surface water, groundwater and air quality.
- A system of operating, monitoring and reporting in relation to tailings deposition and associated activities will be maintained to ensure that all statutory requirements are met.

Specific objectives of the TSF operation, reflecting the above philosophies/commitments, are as follows:

- The TSF will provide effective containment for all tailings solids and liquor, in accordance with conditions of the relevant approvals/authorities. Storage enhancement, by lifting or whatever means are appropriate, and operational practices will be implemented during the life of the facility to ensure that such containment is maintained.
- The operation of the facility will be focussed on limiting the quantities of seepage from the impoundment, which is linked to maximising storage efficiencies and achieving a competent tailings beach.
- The operation of the facility will be focussed on limiting the overall quantity of water "stored" in the TSF to a minimal operational level.
- Rehabilitation of the facility will be carried out in compliance with approvals requirements, with emphasis on developing a geotechnically competent and sustainable landform to support appropriate end land use(s).

To achieve, or significantly contribute to the above objectives, the subaerial deposition of tailings has been adopted as a minimum operating standard. Subaerial deposition involves discharge of tailings via a series of moveable discharge locations. Typically this involves spigot lines off a main delivery pipeline laid around the embankments. At each discharge location, the tailings slurry produces near-laminar flow over a gently sloping tailings beach to enable segregation and deposition of tailings solids. Subsequent evaporation from the exposed beach surface dries and consolidates the tailings as a means of increasing in-situ deposited densities and beach strengths. Water liberated from the tailings through the deposition phase accumulates within a water pond (i.e. the decant pond) at the toe of the beach. From this pond, water can be decanted and is available for reuse. The benefits of such a deposition method are as follows:

- Maximises tailings densities, therefore the operational efficiency of the storage.
- Maximises the geotechnical strength/integrity of the tailings beach to enable future embankment lifting over the beach surface as an option should it be required.
- Allows the recovery of tailings water to be maximised for recycling purposes, and results in minimal storage of decant pond water within the TSF, which is important for TSF integrity.

4.2 Minimum Design and Operating Standards

4.2.1 Key Design References

In addition to the EA, other design benchmarks for Regulated Structures (including the TSF) are as follows:

- ANCOLD (2012): *Guidelines on the Consequence Categories for Dams*
- ANCOLD (2012): *Guidelines on Tailings Dams - Planning, Design, Construction, Operation and Closure*
- ANCOLD (2000): *Guidelines on Selection of Acceptable Flood Capacity for Dams*
- ANCOLD (1998): *Guidelines on Design of Dams for Earthquake*

Other related references include ANCOLD and ICOLD publications addressing design guidelines for risk assessment and earthquake design.

4.2.2 Consequence Category

Dams and related land-based containment structures associated with environmentally relevant activities (ERA's) and referred to as regulated structures are subject to an assessment of consequence category, based on the 2012 ANCOLD guidelines.

4.2.3 Design Basis

Based on the key references as outlined in Section 4.2.1, the principal aspects of design for the TSF, as a regulated structure, are as follows:

(i) construction materials
(ii) structural stability
(iii) seepage
(iv) hydraulic performance.

4.2.4 Construction Materials

Target properties of the materials used in the TSF construction, based on past experience and performance assessment are as follows:

(i) Clay Fill (for use as low permeability zone)

- Clay dominant material (clay/silt fraction greater than 30% and Liquid Limits greater than 30% and Plasticity Index greater than >20%).
- Achievable compacted permeability of less than $1x10^{-8}$ m/s.
- Able to be engineered to limit potential for 'piping' (subsurface erosion).

The key to the above suite of properties is to create a fill layer that possesses high strength, compacts well, is stable (i.e. not subject to significant vertical settlement under load or volume instability due to variation in moisture content) and importantly, provides an appropriately low level of permeability.

(ii) Rock Fill (for use as embankment fill)

The purpose of Rock Fill within the embankment is to provide stability and erosion protection to external portions of the embankment, where required. General requirements for Rock Fill are as follows:

- High compacted strength.
- Stable and durable (with respect to potential settlement, volume instability, erosion potential and weathering).
- High permeability relative to adjacent embankment or subgrade zones.
- Suitable grading to reduce migration of fines from adjacent zones.
- Geochemically stable (i.e. non-acid producing).

(iv) Rock Armour (for use as emergency spillway surface erosion protection)

The purpose of Rock Armour within the TSF is to provide surface erosion protection for the spillway channel. Rock Armour is to meet the same specification requirements as Rock Fill, except that particle sizing is to be as follows:

4.2.5 Structural Stability

On the basis of limit equilibrium conditions, the following typical minimum factors of safety for embankment stability would apply:

Condition	Minimum Factor of Safety
Long Term/Steady State Seepage (at maximum storage level)	1.5
Seismic Conditions* • Pseudo static (OBE) • Maximum Design Earthquake (MDE)	 1.2 1.0
Post-Seismic (liquefied shear strength adopted, if applicable)	1.0

* OBE: Operating Base Earthquake, producing a level of ground motion which will cause only minor and repairable damage to the structure. For the TSF, the 1 in 1,000 year AEP event has been adopted for the OBE.
MDE: Maximum Design Earthquake (MDE), with the design requirement being that the dam may be badly damaged but the facility should maintain its integrity and cannot allow the release of impounded water. For the TSF, the 1 in 10,000 year AEP event has been adopted for the MDE.

4.2.6 Seepage Management

For the purpose of embankment design and stability, the following criteria are inferred with respect to seepage management:

(i) Excessive surface expression of seepage discharge downstream from the embankment should not occur.
(ii) A significant impact on the environmental status of receiving waters should not result.
(iii) The potential beneficial uses of surface and groundwater down gradient from the site should not be compromised.

Under worst case conditions assuming limited seepage mitigation measures are implemented and/or proposed seepage systems are not operated over the long term, seepage from the storage during the operation of the TSF LoM stages and into the post closure phase would occur by development of a seepage plume, initially migrating slowly downwards into the foundation sequences. A local groundwater mound would form beneath the storage, either directly connected with the underlying groundwater system, or perched above a horizon of lower permeability. This mound will eventually move hydraulically down gradient, likely towards the south to south west. The time taken for such seepage to migrate would depend on the hydraulic capacity of the seepage pathways that exist, either through the basement or beneath the cut-off key.

Based on the above conceptual conditions, it is likely that the fate of seepage from the storage would report to the seepage collection system or manifest itself downstream of the TSF. Evidence of seepage would likely be observed as follows:

- Expression of seepage at ground surface directly downstream from the embankment.
- Depending on the continuity of surface soils, some seepage springs may appear in depressions/hollows or intersecting drainages further downstream.

A series of nominal seepage control measures were incorporated into the embankment configuration, including:

i) General sub-excavation within the embankment footprint to remove topsoil and any weak or loose soils.
ii) A foundation cut-off trench along the embankment footprint, excavated to a nominal depth of 1.0 m.
iii) The primary mechanism for containment of water was a low permeability earthfill core within the embankment.

iv) A seepage collection system comprised of a seepage interception trench, a seepage collection drain and a seepage collection. The seepage water in the manhole is pumped back to the storage.

In addition to the proposed seepage control measures, monitoring and if necessary, subsequent implementation of additional seepage controls is a fundamental component of the ongoing TSF development. Groundwater monitoring within the environmental monitoring bores should be maintained, particularly downgradient from the TSF. An observational approach should be implemented and remedial measures taken, if required.

4.2.7 Hydraulic Performance

Key hydraulic performance aspects relevant to development and operation of LoM TSF is based on the spillway.

It is noted that the hydraulic performance requirement is outlined are operational criteria. In the context of this broad level of engineering for LoM TSF, these requirements are not controlling aspects, although would reflect in approval conditions for the development.

An emergency spillway for the TSF is a mandatory requirement, with the design of the spillway based on a PMF critical duration event, as outlined in Section 2.1.

Emergency spillway details for the TSF are presented in Section 3.2 and shown in Appendix A, Figure 101.

5 TSF OPERATING PROCEDURES

5.1 Objectives

The operational objectives for the tailings storage facility are as follows:

- The tailings disposal system will provide effective containment for all tailings solids and liquid, in accordance with EA conditions. Storage enhancement, by lifting or whatever means are appropriate, and operational practices will be implemented during the life of the facility to ensure that such containment is maintained as the final land form if developed.
- The operation of the tailings dam will be focussed on reducing the quantities of seepage from the storage, whilst achieving acceptable storage efficiencies and a safe, stable and sustainable tailings surface.
- Rehabilitation of the facility will be carried out in compliance with statutory requirements, with emphasis on developing a competent and sustainable landform to support an appropriate Post Mine Land Use(s).

To achieve, or significantly contribute to the above objectives, the subaerial deposition of tailings material is proposed. Subaerial deposition involves discharge of tailings from multiple locations on the storage perimeter. At each discharge location, the tailings slurry produces near laminar flow over the gently sloping tailings beach to enable segregation and deposition of tailings solids. Subsequent evaporation from the exposed beach surface consolidates the tailings as a means of increasing in-situ deposited densities and beach strengths. Water which is liberated from the tailings matrix through the deposition phase accumulates within a water pond (i.e. the decant pond) at the toe of the beach inside the holding facility. From this pond, water can then be decanted and is available for recovery as reclaimed tailings water which is to be pumped back to the [ ].

The duration of deposition of tailings from a single deposition site and the associated rate of cycling around the storage between release points will be subject to a number of key issues as follows:

- Achievable tailings densities, such that the overall efficiency of the storage is maximised.
- Achievable strength and integrity of the tailings beach to enable future embankment lifting over the beach area.
- Rate of tailings water bleed from the beach surface, such that recovery efficiencies can be maximised and the availability of tailings water reporting as seepage can be minimised.
- Rate at which oxidation of products from drying tailings beaches may be mobilised, implying a minimum moisture condition within the beach that is to be maintained.

To assist in managing the TSF, it is intended that a daily record (inspection log book) be maintained which includes maintaining daily records of tailings pumped to storage, volumes of decant water pumped and out of the storage, and any works undertaken.

5.2 Operating Procedures

Six (6) key operating aspects are relevant to the TSF. These aspects are as follows:

- deposition of tailings
- operation of decant system (return water management)
- operation of seepage management
- rectification of faults/leakage in pipelines
- environmental reporting
- maintenance of system infrastructure.

These aspects contribute to protection of environmental values surrounding the Project site, including:

- surface water
- groundwater
- air quality.

5.2.1 Deposition of Tailings

5.2.1.1 *System Description*

The tailings pipeline will be laid along the upstream crest edge. Deposition will be undertaken by spigotted discharge methods, once commissioning has been completed and will be operational for the life of the storage. Spigot locations will be at x m nominal centres along the pipeline within the zone of deposition. Each spigot is directed into the storage area and is individually controlled by manually operated spigot values.

5.2.1.2 *Operating Guidelines for Tailings Deposition*

The philosophy for tailings management within the TSF is the sub-aerial deposition of tailings, with key objectives of deposition as follows:

- To develop and maintain a constant rate of deposited tailings surface rise, with tailings applied in consistent cycles around the storage, thus maximising tailings beach exposure and maximising the opportunity for consolidation and air-drying of the tailings matrix,
- To control the decant pond condition and location.
- To ensure that the addition of new material for tailings deposition does not cover "fresh" tailings, with the period between deposition periods to be sufficient to achieve the degree of desiccation required to maximise the tailings beach dry density.

A guideline for tailings deposition is provided as follows:

- Prior to commencement of the deposition of tailings via the delivery pipeline, a sufficient number of spigots within the operating section of pipeline are to be opened, with spigots (or banks of spigots) systematically closed in the same direction to the direction of pipe flow. The minimum number of spigots to remain open will be such that excessive pressure within the delivery line is prevented.
- Deposition will occur nominally from between 2 to 4 consecutive spigots at any one time in a rotating cycle.
- Rotating cycle time through all the spigot points shall typically be 2 to 4 weeks.
- This approach would form a low point in the tailings beach around the centre of the storage, which can be accessed via a pontoon mounted pump from the north eastern perimeter.
- Spigot closures will depend on total tailings thickness deposited at spigot locations. Nominally, a depth of between 300 mm and 500 mm of tailings is to be deposited from a set of operating spigots at one time. As the beach develops to the required level for that cycle, spigots are to be closed, which will move the point of deposition further up the line. After flow commences at the corresponding upstream spigots, further spigots may be closed, with this process continuing until all spigots not required are closed.
- On the completion of pumping through any one of the delivery pipelines, that section of line shall be immediately flushed by directing decant water to the tailings pumps, with flushing to continue until the discharge runs clean. This assists in the prevention of settlement of tailings solids within the pipeline, minimising the potential of a blockage.
- Discharge of tailings from any spigot will occur perpendicularly and away from the embankment. Discharge parallel to or towards the embankment on which the spigot is located is not permissible.
- Visual inspection of the tailings deposition condition is to be undertaken once daily as a minimum. Subaerial deposition conditions would need to be maintained.
- Visual assessment (daily) of the decant pond location shall also be made as part of the deposition process, with discharge onto discrete areas of beach undertaken to control this pond area. The intent is that tailings is to be deposited within the TSF such that the decant pond is relocated to a central position within the TSF (i.e. not against the perimeter embankments). The decant pond is to be operated such that the water depth, footprint area and volume within the decant pond is kept at a minimum level, maintaining a distance from any external embankment to the pond edge of no closer than 100 m.
- Solids concentration for the deposited tailings stream should be kept at a level that would promote segregation of tailings solids (encouraging the coarse tailings fraction to deposit nearer to the embankment, with finer solids migrating to the centre of the storage), whilst reducing the quantity of decant water to be recovered.
- The maximum tailings deposition (and decant pond water) profile within the TSF shall be managed by regular survey of the TSF storage area to meet ongoing spillway capacity requirements. The control of deposition periods/cycles, and further, the requirement for deposition over discrete sections of tailings beach will be assessed by periodic survey of the beach adjacent to individual spigot locations. This survey shall be used essentially to

maintain a consistent beaching configuration, achieving the desired beaching thickness. Further, and notwithstanding the above, at any discharge location, the tailings beach shall not be formed any higher than 0.5 m below the Emergency Spillway Containment Level

5.2.2 Operation of Decant System (Return Water Management)

5.2.2.1 *System Description*

Decant water will be recovered from the tailings storage facility via [ ].

Water will be reclaimed and pumped back to the [ ]. The return water pipeline is located within the tailings pipeline corridor.

5.2.2.2 *Operating Guideline for Decant Water Recovery*

The operating objectives for the decant system within the TSF are:

- To minimise the volume of standing water contained within the storage (thus contributing to maintenance of freeboard levels, and facilitating exposure of the deposited tailings beach to consolidation and air-drying, particularly as the capacity of the storage is approached).

Key aspects of the TSF decant operation are as follows:

- The location of the internal decant pond around the defined decant area is maintained by effective tailings deposition (refer Section 5.2.1). This practice involves opening spigot sets on appropriate sides of the tailings storage area, ensuring that sets are not operated for too long a period, with the key objective to keep the pond centred around the decant location.
- The overall size of the decant pond is maintained by operation of the decant pump system, with the key objective being to maintain a distance from any external embankment to the pond edge of no closer than 100 m. The decanting process is controlled by varying the periods and rate of pumping to maintain an adequate decant pond water depth, corresponding to a suitable pond size.
- The decanting of liquor from the TSF shall occur as a "general priority". As such, the volume of water contained within the storage shall be kept to a practical minimum, and below the operating freeboard level and MRL.
- Prior to operating the decant pumping system, following any period of non-operation, an inspection of the system shall be carried out to confirm operability and to clear any debris from intakes, as required.
- General surveillance of the clarity of decant water is to be maintained, with pumping rates reduced when the clarity is poor, or increased when the clarity is good, whilst minimising the total pond area (as required).

To achieve the above conditions, safe all year round access for operational staff to the pumping system is to be maintained. Such access relates to the integrity of the causeways/roadways leading to the pump location.

5.2.2.3 Performance Requirements for Decant Pump System

The following basic performance requirements exist for the decant pump system, based on operating requirements as described above:

- The minimum pumping duty will be the equivalent to the rate of liquor liberated from settling of tailings material on deposition into the TSF. This rate is controlled by the tailings production rate, solids concentration for the tailings stream, and solids settling characteristics.
- The nominal maximum pumping duty will be equivalent to that rate of water accumulated within the TSF through a combination of full-production tailings deposition and direct rainfall inputs under critical wet season conditions balanced against maintaining containment requirements. This rate will vary season to season depending on available storage, season variability and projected production characteristics. This rate will be updated by the annual water balance modelling likely to be undertaken as part of the annual dam safety inspection and completed prior to the onset of each wet season period. Subject to Arafura's preferred approach, the options for equipping the system to accommodate the maximum pumping duty are to provide a dedicated permanent/standby pumping capacity, or to mobilise temporary pump(s) for the period of each wet season. The permanent/standby system is the preferred approach.

5.2.3 Operation of Seepage Management

5.2.3.1 *System Description*

Detailed descriptions of the seepage management systems are provided below:

A seepage collection drain

5.2.3.2 *Operating Guideline for the Seepage Recovery System*

The key operating objective for the Seepage Recovery System is to reduce the potential for release of seepage water from the TSF area to the environment.

The key aspect of the Seepage Recovery System operation is the maintenance of an effective pumping system, with the capacity to accommodate the expected peak seepage in flows and the ultimate hydraulic head. Seepage water is to be returned to the decant pond as reclaimable water for processing activities. The availability of this pumping system needs to be maximised to ensure that pumping capacity can match seepage recovery rates.

A guideline for the Seepage Recovery System operation, based on the above, is as follows:

- The recovery of seepage from the Seepage Recovery System shall occur as a "general priority". As such, the volume of water contained within the storage shall be kept to a practical minimum.
- Prior to operating the dedicated pumping system, following any period of non-operation, an inspection of the system shall be carried out to confirm operability and to clear any debris from intakes, as required.
- General surveillance of the operability of the pumping system is to be maintained (including pre starts and maintenance records), ensuring that operating objectives are maintained, particularly during or immediately after severe rainfall events.

To achieve the above conditions, safe year round access for operational staff to the pumping system is to be maintained. Such access relates to the integrity of the roadways leading to the Seepage Recovery System.

5.2.4 Rectification of Faults/Leakage in Pipelines

The principle pipelines associated with the TSF comprise the tailings delivery lines, the decant (return water) pipelines to the PWP and any water recovered through seepage management. A general procedure for repair of faults or small leaks within pipelines is described as follows:

- Maintain an inspection program to check for faults or leaks (refer Section 6.2).
- Where a leak is detected, this area shall be clearly flagged to assist maintenance personnel to locate the fault.
- Any potential pipe weaknesses are to be reported to your supervisor within 3 hrs of identification.
- As a temporary measure, Linatex bandages, fibreglass tape or insertion of timber plugs may be used to repair leaks. Regardless of whether temporary measures are successful or not, prompt action by the maintenance crew will be required to undertake permanent repairs of leaks or faults.
- In the event that a significant fault or leak is encountered (i.e. cannot be managed by temporary measures), the maintenance crew shall be contacted immediately. Such an event may constitute as a notifiable incident, with incident reporting to be carried out in accordance with Arafura's incident response process.

As a means of limiting the occurrence of faults or leakage or at least in the prompt identification of faults within pipeline systems around the TSF, the following management measures are of importance:

- periodic rotation of tailings delivery pipelines
- daily visual checks (refer Section 6.2.1).

5.2.5 Environmental Reporting

Any significant changes to pond levels, high pond levels, spills or leaks that are detected during regular inspections and operation will be reported to the environmental department immediately.

5.2.6 Maintenance of System Infrastructure

A maintenance program must be implemented to maintain the integrity and long term serviceability aspects of the following key infrastructure items:

- storage embankments
- emergency spillway
- decant system/return water pipeline
- storage area
- seepage management and return water systems.

Specific maintenance procedures and a maintenance schedule, developed with consideration of the monthly surveillance requirements and any issues highlighted during or as part of the Annual Dam Safety Inspection, shall be prepared and implemented by Arafura.

6 INSPECTIONS AND MONITORING

The key inspection and monitoring aspects related to the Regulated Structure is:

- Inspections to ensure the ongoing safety and serviceability.

- Monitoring of key infrastructure including embankments, emergency spillway, pumps and pipeline systems.
- Monitoring of seepage recovery systems.

These aspects are discussed below along with roles and responsibilities.

6.1 Operational Structure

Appendix B shows the operational structure for the management of the TSF at the Mine Site, covering both operational requirements and environmental compliance, day to day operation and monitoring activities. Key personnel and associated roles with respect to management of the TSF and associated systems are as follows:

- Process Manager will act as the Regulated Structures manager and is responsible for the overall management of the system.
- Process and Site Services Manager is responsible for providing operational/logistical support for the maintenance and operation of the facility including on ground support.
- Processing personnel, working under the Process Manager or Superintendent, will conduct the general daily duties/activities associated with the functioning of the TSF Regulated Dams and pipelines in respect to the operation of the Mine SIte.
- Environmental Superintendent is the nominated compliance officer for the TSF and is responsible for monitoring the functioning of the system and for environmental compliance.
- Mining Manager is responsible for providing operational/logistical support to the TSF management team through the provision of specific machinery, survey and geotechnical surveys.
- Mine Surveyor will conduct survey and technical monitoring functions.
- Off-site specialist or consultants will be utilised as required under the EA or for technical assistance and specific monitoring/audit functions.

6.2 Inspections

Visual inspections of the operating TSF are required as outlined in Table 2.

Table 2 Visual Inspection Types for the TSF Regulated Dams

Inspection Type	Frequency	Responsible Person
Daily Inspection	1 inspection per shift (minimum)	Delegate of Process Superintendent/ Process Site Services Manager
Monthly Inspection	Once per month	Process Superintendent/ Process Site Services Manager
Annual/Engineering Inspection	Once per year	Suitably qualified in dam engineering
Post Rain Event	Following >10 m rainfall event	Environment Superintendent or delegate

Inspections for the structure would focus on the key components of the system, with action required in relation to but not necessarily limited to, the following:

(i) Any significant difference to the tailings beach development characteristics.

(ii) Any significant changes within impoundment areas or to pond levels, high pond levels, or spills.
(iii) Development of any other decant ponds other than that around the decant pump.
(iv) Any excessive settlement, cracking or other deformation observed/recorded within any significant earthworks structure (i.e. perimeter embankments).
(v) Any excessive, concentrated or sediment-laden seepage from embankment surfaces or surrounds.
(vi) Scouring or visible erosion on any formed or natural surface, most notably on the batters of any embankment.
(vii) Any obstruction to the emergency spillway.
(viii) Inoperability or failure of any pumping system.
(ix) Ponding of water on embankment surfaces.
(x) Tree growth on embankment surfaces.
(xi) Loss of integrity of clean water diversion.

The scope of inspection as outlined above is described as follows:

6.2.1 Daily Inspections

The standard procedure for daily inspections should include a drive-around inspection of the entire system, incorporating the TSF (storage area, emergency spillway, MRL markers, seepage recovery systems, embankment crests and batters, downstream toe area of embankments, embankment abutments, and decant water transfer infrastructure) as a minimum requirement.

Daily inspections undertaken immediately following any rainfall event of greater than 10 mm in any one day shall include each of the above elements, with any reporting and notification implemented in a timely manner as required.

The results of any observations made during the daily inspection shall be recorded in the daily log book. The daily inspection will focus on the following:

- Serviceability of pipelines (tailings delivery and return water lines)
- General integrity of all embankments (e.g. observable deformation or settlement etc.)
- Indication of any seeps or expression of water downstream of any embankment
- Location and current status of tailings deposition in the TSF
- Location and size of the TSF decant pond
- Operability of return water systems (the TSF decant and the Seepage Recovery System)
- Serviceability of bunding and emergency spillway
- Any other aspect that may impact on embankment integrity.

The daily log book exists as a “chain-of-command” for reporting issues and variances in operation or performance. One entry per inspection is to be completed and maintained as a permanent record of the inspection, and as justification for work orders to be raised for appropriate maintenance works.

Completed log books are to be returned to the NT EPA in preparation for the annual Regulated Dam Safety Inspection.

6.2.2 Monthly Inspections

Monthly inspections of the TSF shall be carried out by the Process Superintendent or Process Site Services Manager (refer Appendix D). The monthly inspection would focus on the key areas as identified by the daily inspections, taking particular note of any previously identified issue or incident and the condition of any action undertaken. In addition to the daily inspection issues, the monthly inspections would include inspections of all the TSF embankments to confirm integrity, and in particular to assess the downstream toe area of embankments for indication of seeps/ expression of water. The results of the monthly inspections are to be compiled within a formal checklist, with work orders raised for completion of any works required.

Where required or deemed necessary, independent review or inspection of any condition considered to represent a potential dam safety or environmental hazard is to be undertaken. Such a review should be undertaken in addition to the Annual/Engineering Inspection as outlined in Section 6.2.3.

As part of these monthly inspection requirements, current tailings water levels within the TSF shall be measured as a minimum at the point of tailings deposition in the TSF and at the decant structure.

Completed event or incident documentation are to be returned to the Environment Department in preparation for the Annual Regulated Dam Safety Inspection.

6.2.3 Annual/Engineering Inspections

Annual engineering inspections shall take the form of a regulated dam safety inspection and operational audit by a suitably qualified independent third party person/s. The requirement for such a review of the TSF is in accordance with the 2012 ANCOLD. The scope of such a review is as follows:

- To identify any elements of the system that are of concern or are deficient from a dam safety perspective, with emphasis on storage embankments and hydraulic controls.
- To assess available inspection/monitoring data, against design expectations or predictions.
- Where applicable, to evaluate available storage capacities over the next 12 month period, to satisfy relevant containment requirements/conditions.

The annual inspection is to be prepared for submission to the administering authority. Included in the report will be a list of any remedial or repair works that have been identified.

Completed reports are to be delivered to the Environment Department for submission to the Administrating Authority as required under EA conditions including D26.

6.3 Monitoring

6.3.1 Embankment Integrity

A key monitoring aspect for assessment on embankment integrity of the TSF includes survey (of embankment crest displacement).

Survey shall be undertaken in relation to a series of permanent benchmarks located around the TSF. Survey monuments need to be established within the crest of all embankments, with at least one site in the centre of each embankment section. Additional settlement monitoring sites need to be established where any monitored or observed settlement of displacement occurs.

Survey monitoring shall be carried out on as a minimum of a quarterly basis. The results of survey inspection would need to be plotted, with a broad assessment of the rate of settlement to be undertaken. Any significant increase to this rate, or in the event of total settlement exceeding 50 mm over a quarter, the settlement data shall be reviewed by a suitably qualified dam engineer (unless otherwise covered by the Annual Dam Safety Inspection). All dam settlement shall be assessed regardless as part of the annual dam safety inspection/operational audit.

6.3.2 Operability of Spillway

A principle operating objective with respect to the TSF is to allow spill from the storage via the Spillway only in the event of preventing a catastrophic failure of the embankment as a last resort under extreme rainfall conditions and under expert recommendation and licencing notification procedures.

It is emphasised that the Spillway is provided for such response to extreme conditions exclusively. Notwithstanding this, there is an expectation that any uncontrolled release/spill will not be viewed favourably by the administering authority under any circumstances.

6.3.3 Water Balance Assessment

An annual water balance review in relation to the Mine site project should be completed. The purpose of this review will be to confirm compliance with containment criteria as outlined in Section Error! Reference source not found., or otherwise to identify the works required achieve compliance within the defined timeframe. Key inputs to water balance modelling will comprise:

- Survey of the TSF (as at the base date for the model) to assess the air-space capacity that has been consumed by tailings, and to define the tailings beach profile.
- Water levels occurring within the TSF as at the model base date.
- Production data for the 12 month period prior to the model base date, related to tailings production and solids concentration achieved over this period.
- Total pumping quantities from return water systems, including from the TSF decant pond, TSF leak detection standpipe, and TSF seepage collection systems.

This data will be utilised for the purpose of model calibration, as well as to establish boundary conditions for predictive modelling as a basis for a 12 month outlook.

6.4 Inspection and Monitoring Summary

A schedule for inspections and monitoring for the TSF is provided on Table 3. This schedule is based on the inspection and monitoring requirements as outlined in Sections 6.2 and 6.3.

Environmental monitoring is to be completed in line with environmental requirements to collect receiving waters samples following rainfall events which trigger flow events and sediment samples prior to and post wet season from all locations as relevant to the Site.

The Environment Superintendent is responsible for implementing all environmental monitoring and reporting programs at the site.

The Process Site Services Manager is responsible for ensuring the management and operation of equipment used during the operation of the TSF are maintained.

Table 3 Inspection and Monitoring Schedule for the TSF

Aspect	Condition	Method	Frequency	Application/ Assessment	Responsible Person
Inspections / Monitoring	Overall Condition	Visual	Once per shift	• Tailings deposition practice • Freeboard availability • Integrity of infrastructure, including embankments, emergency spillway, leak detection standpipe and pumps and pipes	Delegate of Process Site Services Manager
	Overall Condition	Visual	Monthly	• Overall condition and status of the TSF • Identification of need for action based on issues raised through daily inspections	Processing Manager or Delegate
	Seepage Recovery System	Visual	Weekly/Monthly	• Overall condition and status of Seepage Sump, containment embankments and pumping systems	Processing Manager or Delegate
	Overall Condition	Visual/Analysis	Annual	• Overall condition against industry standards and EA • Elements of concern • Qualitatively assess available data against design expectations • Assess available storage and qualitatively assess upgrade requirements	Suitably qualified geotechnical/ engineering specialist (RPEQ)
Measurement of Operational/ Performance Parameters	Tailings Surface and Decant Pond Water Level	Marker board (Mandatory Reporting and Spillway levels)	Monthly	• Assess storage level against MRL	Processing Manager, Environment Superintendent or Delegate
	Annual Performance	Aerial Survey for Tailings Beach Flow Meters for Transfer Rates	Annual	• Tailings production characteristics • Review of effectiveness of tailings deposition management practices • Water balance review (calibration and 12-month predictive outlook) • Qualitatively assess the need for future storage upgrading	Processing Manager or Delegate

7 EMERGENCY RESPONSE PLAN

7.1 Purpose

The Emergency Action Plan (EAP) for the TSF defines response procedures designed to:

- Identify emergency conditions that could endanger the integrity of either the storage or the surround environment and that would require immediate preventative or containing action.
- Prescribe procedures that should be followed by operating personnel in the event of an emergency.
- Provides timely warning to appropriate emergency management agencies for implementation of community protection measures, if deemed necessary.

7.2 Emergency Events and Actions

7.2.1 Incident (Storage Failure) Identification

Table 4 lists potential conditions that are considered most likely to initiate a failure of the TSF.

Table 4 Potential Incidents to Initiate Failure of the TSF

Incident	Incident Indicator
Overtopping Event	Rainfall or wind event causing encroachment by erosion of any portion of embankment crest surface, or by general overtopping
Seepage	Evidence of concentrated discharge of seepage from any embankment surface, with or without presence of colour or loss of clarity due to suspended soil particles.
	Water surface disturbances such as whirlpools (vortices) in reservoir (probably associated with significant downstream leakage, soft spots or boggy areas)
Structure Failure	Defects observed in embankments or immediate surrounds (e.g. cracking, slumping, settlement, or faults in transfer system) or emergency spillway

Indicators that identify the onset of these incidents are covered in the daily inspection requirements (refer Section 6.2.1).

7.2.2 Emergency Response Procedure

Timely implementation of the ERP is a crucial element in the effectiveness of the OMP, with appropriate warning systems imperative to reduce the risk of loss of life and property damage downstream from the storage. Generic Emergency Response Procedures are presented as Figure 1 to Error! Reference source not found. which have been prepared to apply to the Mine site in a flow chart style, and provide the steps to identify and manage some, but not necessarily all, of the events that can lead to failure of key elements of either system. The fundamental requirement of the procedure is to identify and evaluate the emergency procedure, and to classify its urgency so that appropriate action can be taken.

Figure 1 Emergency Response Procedure

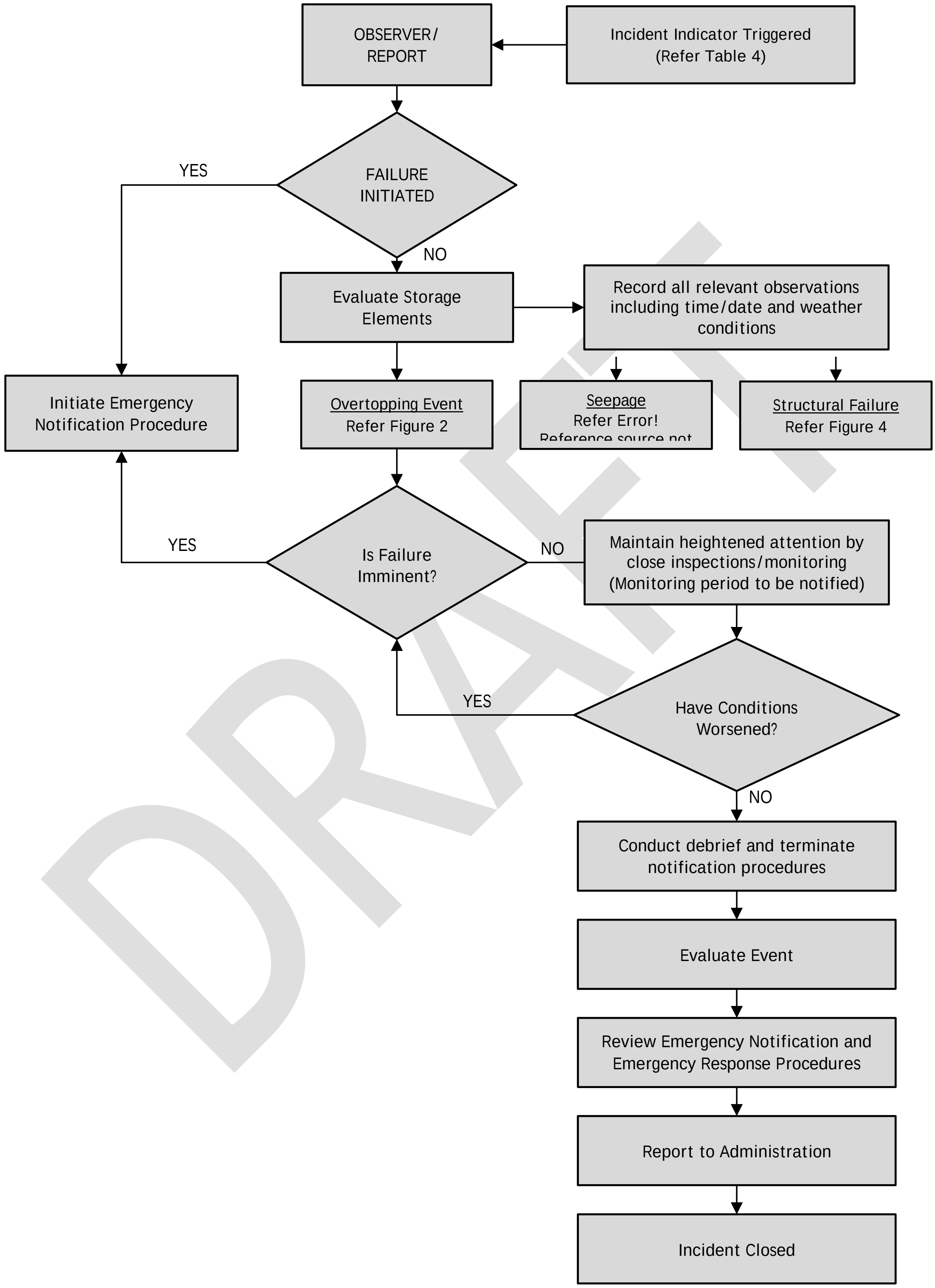


Figure 2 Emergency Response Procedure - Overtopping Event

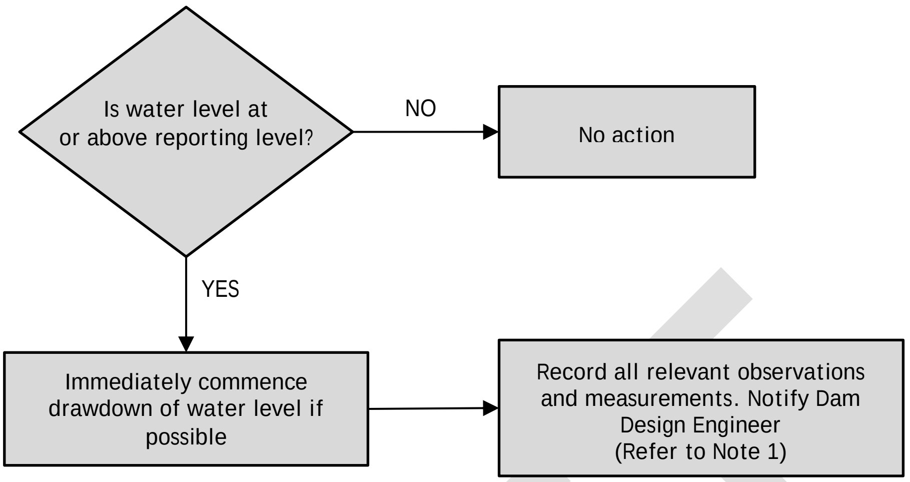


Figure 3 Emergency Response Procedure - Uncontrolled Seepage (Seepage from Embankment of Earthworks Surface)

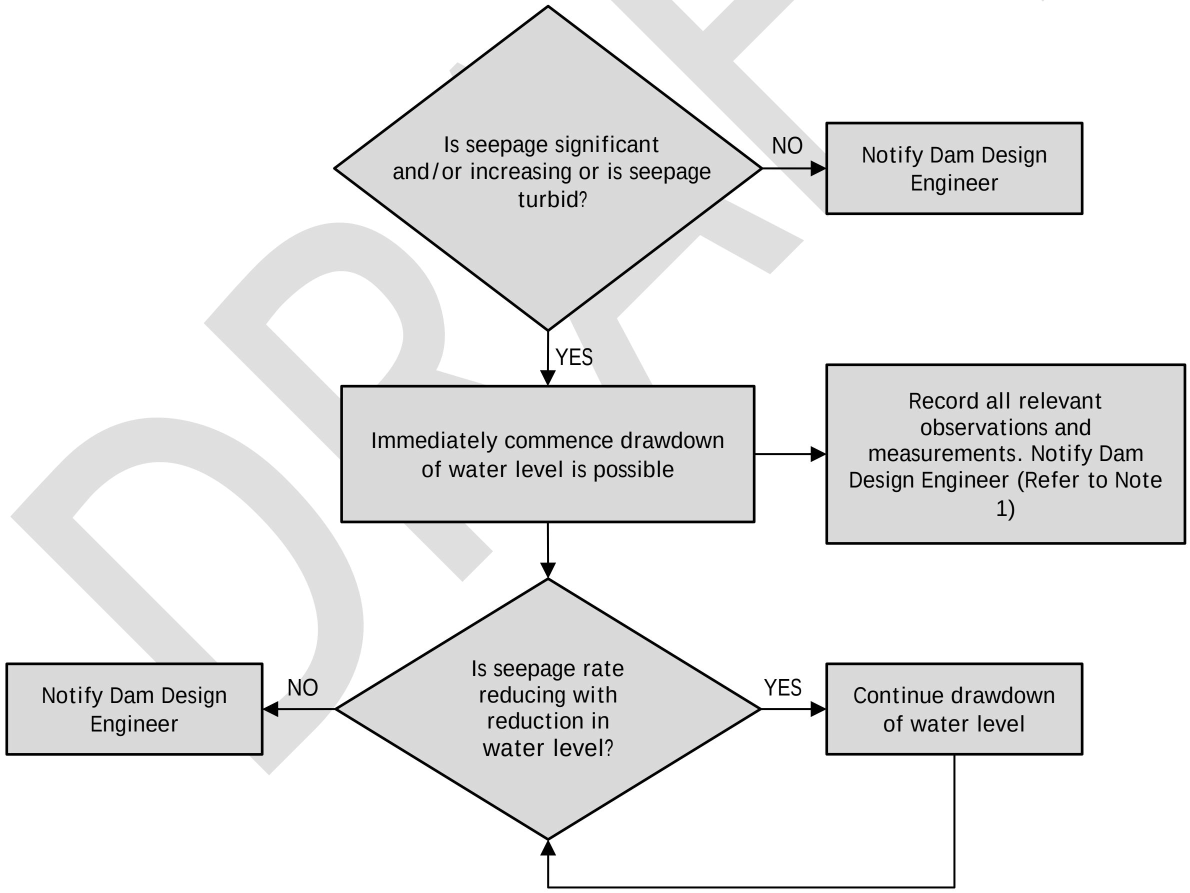
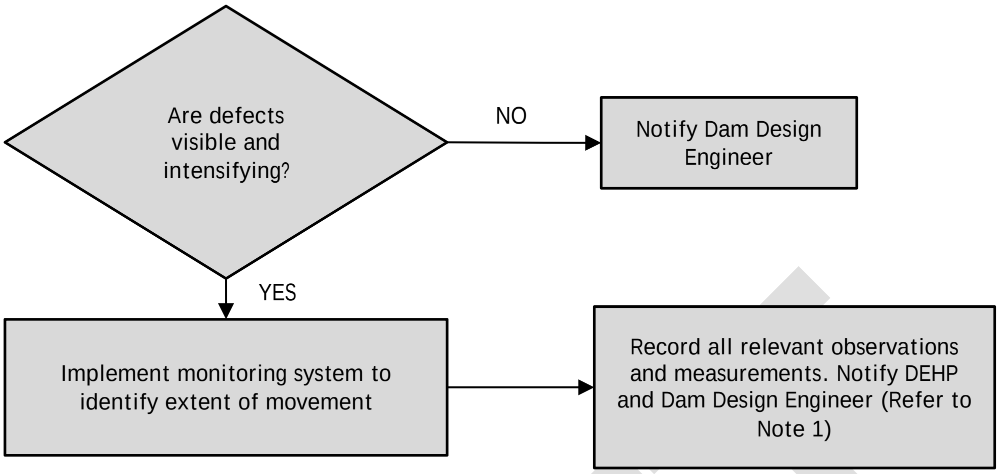


Figure 4 Emergency Response Procedure - Structural Failure



Further to the EAP, emergency action response and incident reporting will be undertaken in accordance with the relevant site standards/procedures for the site operation.

8 DOCUMENTATION

All data and information collected on site shall be compiled using the appropriate on site document control process. Information such as reference documents/reports, permits and approvals, log books, photographs, video of site conditions, inspection documents/reports, weather reports, remedial work records, response measures, etc. must be collated, recorded and retained. All of the above documents are to be made available during the annual regulated dam inspection.

Any records required by the site's EA will be kept for a minimum of seven years.

Standard forms shall be used to compile data and to report the information to appropriate personnel.

All site inspections, instrumentation data and water quality readings are to be reported to Arafura's Environmental Superintendent as the information becomes available. Any readings or unusual occurrences (e.g. design storm) should be reported immediately by Arafura.

The following documentation should be kept in the Processing Manager's office on site:

i) A copy of this Operations Management Plan.
ii) A copy of each annual safety inspection (refer Section 6.2.3).
iii) Quality control records and statistical summaries
iv) Instrument records and daily diary entries
v) Communications and activities records
vi) All incident reports
vii) Details of any emergency actions
viii) Photographic records of progress and incidents.

REFERENCES

[1] Australian National Committee on Large Dams (ANCOLD) (2012). *Guidelines on the Consequence Categories for Dams.*

[2] ANCOLD (2012). *Guidelines on Tailings Dams - Planning, Design, Construction, Operation and Closure.*

[3] ANCOLD (2000). *Guidelines on Selection of Acceptable Flood Capacity for Dams.*

[4] ANCOLD (1998). *Guidelines on Design of Dams for Earthquake*.