Feasibility Study Report for the East Residue Storage Facility #6

Tronox Namakwa Sand EOFS Project

epoch resources (pty) ltd

mine residue and environmental engineering consultants

PROJECT NUMBER 126-005 REPORT NO.1 EIA Rev 1 June 2021

EXECUTIVE SUMMARY

Introduction

Tronox Namakwa Sands (Tronox) has requested Epoch Resources (Pty) LRD (Epoch) to conduct a Feasibility Study (FS) of the East Residue Storage Facility #6 (RSF) for the Tronox East Orange Feldspathic Sands Project (Tronox EOFS Project). Tronox is an open pit mining operation, processing Heavy Mineral Sands producing Zircon, Rutile, Iron and Pigment products. Mining activities are undertaken on two sites, namely the East and West mines. The current mining activities involves the mining of the shallow Red Aeolian Sands (RAS), however, Tronox wishes to mine and process the deeper Orange Feldspathic Sands (OFS) which will produce two by-products; a coarse sandy residue referred to as "sand tailings" and a fine silty residue referred to as "residue". This study relates to activities undertaken only on the East Mine relating to the OFS mining operations, with the RSF containing the residue stream for the 20 years Life of Mine (LoM).

The RSF is to be a full containment facility with embankment walls constructed using either the EOFS or the RAS coarse sand tailings material.

Scope of Work

The scope of work for the FS of the RSF was as follows:

- Stage capacity characteristic curves (area-volume-height curves) for the RSF;
- A geotechnical investigation of the preferred site and laboratory testing of samples to characterise the insitu soils properties;
- Geotechnical laboratory tests on the residue products to define their geotechnical properties;
- Seepage analyses for the RSF;
- Slope stability analyses of the RSF;
- A monthly water balance of the RSF to determine typical return water volumes;
- The design of the RSF and the associated infrastructure (decant system, pool access wall, dlanket darins and storm water diversion).
- Site layout and typical drawings of the RSF;
- Estimation of the capital costs to an accuracy of +20%-15% percent and operating costs associated with the RSF to an accuracy of +20%-15% percent;
- Estimation of closure, rehabilitation and aftercare costs to an accuracy of 30%; and
- Estimation of the costs over the life of the facility.

Design Criteria

The life of mine production of the fine residue will amount to 38.9 Mt (64.83 Mm^3) over 20 years. The particle Specific Gravity (SG) of the residue was determined to be 2.63, by Specialized Testing Laboratory (Pty) LTD. The coarse sand tailing will be produced at an average rate of 7.09 Mt/annum with an SG determined as 2.66.

The design criteria are summarised in Table 1.

TABLE 1: DESIGN CRITERIA

Item	Criteria	Value	Source
1	Ore type	Heavy mineral sands	Tronox
2	Design Life of Facility	20 years	Tronox
5	Average Residue Deposition Rate:	1.945 Mtpa	Tronox
6	Total Residue	38 900 000 tonnes	Tronox
7	Particle Specific Gravity	Residue -2.63 Sand tailings -2.66	ST Lab
8	Average Dry Density	Residue -0.6 t/m3 Sand tailings – 1.7 t/m^3	ST Lab/Epoch
9	Average Particle Size Distribution	Residue -75% passing 15 µm Sand tailings – 75% passing 0.3mm	Patterson & Cooke ST Lab/Epoch
10	% solids to water (by mass)	Residue – 22% Sand tailings – 80%	Fluor/Tronox
11	Delivery Method	Residue - Hydraulically Pumped Sand Tailings - Trucked	Tronox
12	Geochemistry of residue	Inert, non-acid generating	SRK
13	Geochemistry of EOFS tailings	Inert, non-acid generating	SRK
14	Geochemistry of RAS tailings	Inert, non-acid generating	SRK
15	S-Pan to Lake Evaporation factor	0.75	Epoch

Site Selection

A site selection study was undertaken in 2019. The required capacity for the study was 26.8 million tonnes, however the ability for expansion was a key requirement of the study, thus making the study applicable to the new tonnages The study investigated 4 sites for the placement of the RSF are depicted in Figure 1..The preferred site for the RSF was determined to be the “Depression” site situated north-east of the plant.

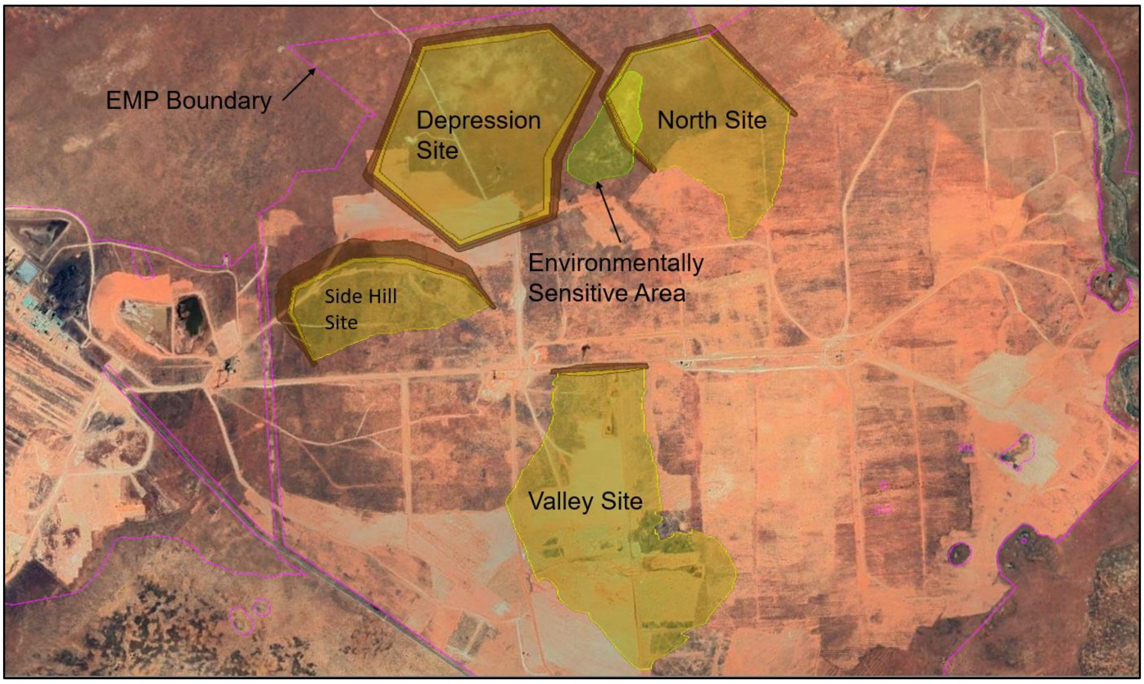

FIGURE 1: SITES IDENTIFIED FOR THE RSF

Waste Classification

In June 2020, SRK Consulting undertook the geochemical characterisation of the tailings and residue. The coarse tailings material is non-acid generating, inert and classified as a Type 4 waste. The fine residue material is non-acid generating, inert and classified as a Type 3 waste due to elevated leachate concentrations (LCT) of Cl, TDS and B (primarily residual sea water from the separation process). In the absence of a Risk Based approach, the tailings would require disposal on a Class D liner system and the residue on a Class C liner system.

Given that the sea water is used in the process plant, the elevated LCT values for TDS and Cl in the fines are not unexpected. The natural background water quality in the area has a mean EC of 1000 mS/m indicating poor water quality, and hence the leachate from the fines is not found to have a significant impact on the receiving environment.

The Geochemical Abundance Index (GAI) which compared the global median soil values for the tailings, fines and background soil, indicated that chromium, boron and zinc are slightly increased in the residue but not considered significant. Natural soils are not enriched relative to global soil mean for total concentrations only, leachate concentrations of the background soil are 4 times lower than the tailings with regards to Cl and TDS and significantly lower than the leachate concentrations of the fines.

Geotechnical Investigation

A geotechnical investigation of the proposed site was undertaken by Inroads. This included excavating and profiling of test pits and core drills, sampling of soils and laboratory test work of the samples.

The RAS material has been predominantly mined out over the majority of RSF footprint area, with these areas having been backfilled with RAS coarse tailings. The remaining RAS material in the RSF footprint area is expected to be mined prior to the construction of the RSF.

The subsoil conditions within the RSF site are characterised by dune sand, in the unmined area, and sand tailings fill in the rehabilitated area, underlain by sand of aeolian origin at an average depth of 2,0 m ranging from 0,9 to 3,3 m below the present ground surface. The aeolian soils comprises mainly medium dense to dense and in places loose silty sand with scattered friable weakly cemented pockets. The aeolian soils are underlain by either very soft rock dorbank or completely weathered granite gneiss.

No groundwater was encountered within any of the test pits or core drills excavated on site.

Site Development and Stage Capacity Curves

The RSF was designed to accept residue at an average rate of 162 083 tonnes per month (tpm) from the Process Plant with a maximum capacity of 38 9 Mt. The placed dry density for tailing used in the curves is 0.6 t/m^3 resulting in a total storage capacity of 64.83 Mm^3 over the 20 year LoM.

The containment walls are to be constructed with either RAS or EOFS coarse sand tailings. The total volume of material required in these walls is 9.44Mm^3 with the volume of material required per wall summarised below in Table 2. The natural topography of the site allows for some residue storage capacity within the depression below the containment walls. The corresponding time taken for the residue to reach 1 m below the upstream toe of each wall (allowing for 1m freeboard), from the time of commissioning the RSF, is also depicted in the table, indicting by when the construction of each wall must be completed.

TABLE 2: CONTAINMENT WALL VOLUME REQUIREMENTS AND CONSTRUCTION TIMELINE

Wall	Volume (m^3)	Time from commissioning of RSF for residue to reach toe is wall (months)
North	331 749	137.3
East	2 952 432	6.8
South-East	1 145 757	55.2
South	1 580 342	39.1
South-West	1 420 342	55.2
North-West	2 013 203	39.1

In a conventional self-raising residue dam, the rate of rise of the dam must be at such a rate as to allow for the residue to drain and consolidate to be able to harvest residue material in order to raise the “containment walls”. As the RSF is a full containment facility the stability of the RSF is not dependent on the Rate of Rise. The Rate of Rise of the residue is at 6 m/year when the facility breaks ground steadily decreasing to 1.1 m/year by the end of LoM.

Seepage and Stability Assessment

The stability of the RSF was assessed under various seepage conditions. The results show that the RSF is stable, with a factor of safety well above the NEMWA Act No.58 minimum requirement of 1.5 for both the operational and post closure phases of the facility under static conditions and above 1.4 for pseudo-static conditions.

Water Balance

A water balance study has been undertaken for the Tronox RSF to assess the expected range of daily returns to the plant as well as the volume of excess water to be stored on the facility. As the RSF is a full containment facility and capable of storing water, no return water facility has been provided for as supernatant water will be returned directly to the plant. All excess water arising from storm events, will be stored on the RSF and gradually returned to the plant.

The expected daily returns are summarised in Table 3 below.

TABLE 3: EXPECTED DAILY RETURN VOLUMES FOR AN AVERAGE YEARLY RAINFALL

Descriptor	Unit	Values
Wet Season Average Daily Return (May to Aug)	m^3	10,867.6
	%	64.2
Dry Season Average Daily Return (Sep to Nov)	m^3	10,135.4
	%	59.0
Average Daily Return per Yearly	m^3	10,440.5
	%	61.2
Minimum Daily Return	m^3	2,640.9
	%	53.2
Maximum Daily Return	m^3	21,732.6
	%	100.0
Minimum Monthly Return	m^3	84,271.9
	%	54.8
Maximum Monthly Return	m^3	438,276.1
	%	66.9

Operational Methodology

The depositional technique selected for this project will be a full containment, hydraulically deposited facility. The containment wall will be constructed using coarse sand tailings material from the plant and the fine residue will be deposited behind the wall. This design is a common construction technique used in residue storage facilities.

The residue will be discharged from the top of the dam crest creating a beach with the resulting supernatant pool developing as far away from the wall as possible. Natural segregation of the material occurs where the coarse material settles closest to the deposition ponts and the fines furthest away.

For the selected depositional methodology, residue is deposited into the RSF basin via an open-end pipeline located on the inner crest of the perimeter wall as shown in FIGURE 12-1. During commissioning, deposition of the residue behind the containment wall is directed to the base of the inner toe of the containment wall by flexible hoses. Deposition during this stage is to be carefully controlled, monitored, and intensely managed to ensure that the walls are not eroded by the residue stream.

Key Design Features

The layout of the RSF is shown in Figure 2 and the key design features of the facility are as follows:

- An engineered, tailings containment wall constructed with coarse sand tailings;
- Open ended deposition of fines into the basin;
- A floating pump decant system with access via a pool wall;
- Blanket drain seepage collection system inside the containment wall (to reduce the phreatic level within the wall);
- Toe paddocks at the downstream toe of the RD;
- Storm water diversion bunds.

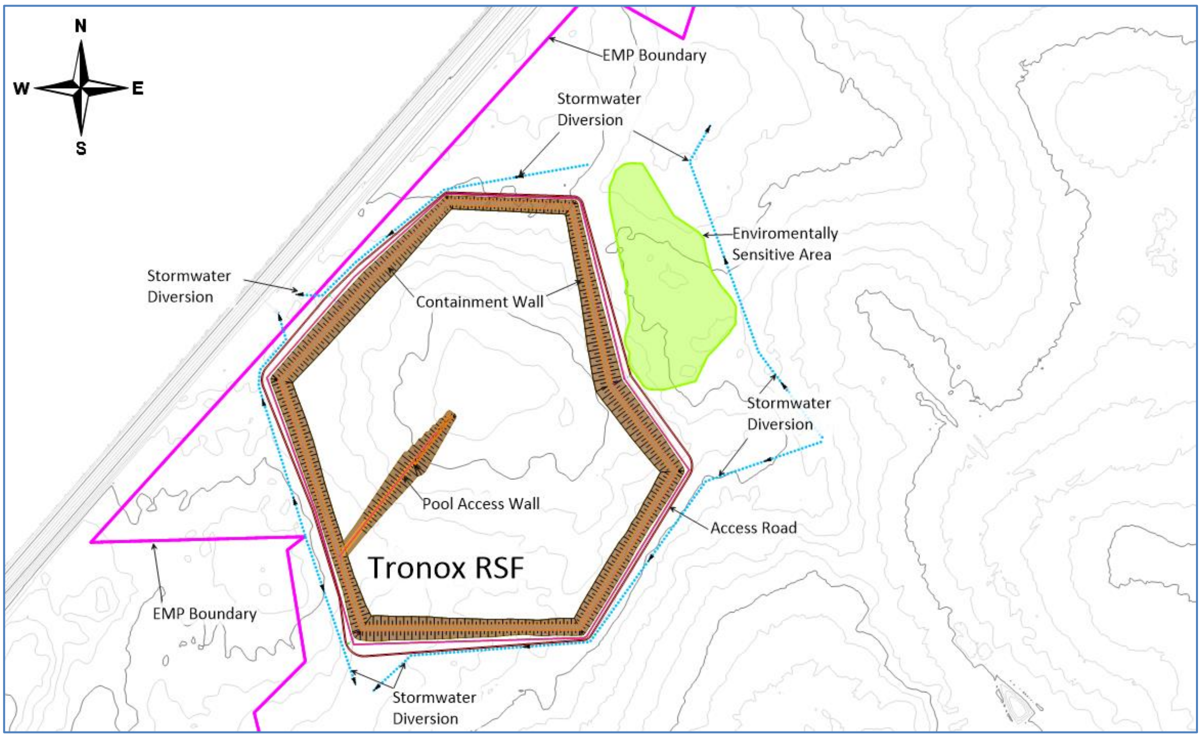

FIGURE 2: RSF LAYOUT

Containment Barrier System

The RSF is a potential groundwater contaminant source of the EOFS Project. SRK undertook a geohydrological study to determine the impact the RSF would have on groundwater as detailed in their report "*East OFS Project Residue Disposal Plan, Groundwater Specialist Study*", Dec 2020. To assess the impact the RSF would have on the groundwater, three scenarios were considered with regards to the RSF base layer:

The Groundwater study undertaken modelled the contamination plume emanating from the RSF for three base preparation scenarios. The model comprised of various layers depicting the insitu soil profiles, overlain be a 300m layer. The permeability (K) of this layer was varied to simulate the different base preparation scenarios as follows:

- No base preparation with K of $1x10^{-8}$m/s (equivalent to the fines) – Scenario 1;
- A "moderate" installed liner with K of $2.6x10^{-9}$ m/sec – Scenario 2;
- An "excellent" installed liner with K of $7.4x10^{-11}$ m/sec - Scenario 3;.

The modelled results show that there is negligible difference in plume extent between the three scenarios. Concentrations differences between the scenarios are also minor and confined to the location of the RSF footprint area. A summary of the model results at the end of operations is depicted in Table 4.

TABLE 4: AQUIFER CONCENTRATION VS PLUME EXTENT

Aquifer	Conc. Max (% of source)			Max distance (m) beyond footprint of facility (where conc. >5%)
	Sc1	Sc2	Sc3	
Primary	100	93	87	200
Secondary	92	86	80	350

Following this risk-based approach the inclusion of a Class C liner, as proposed by the Waste Classification report (and in line with the Regulations regarding the planning and management of residue stockpiles and deposits, 2015 (GNR 632)), was found to have minimal effect in reducing the impact on the receiving environment.

The RSF site is underlain by aeolian soils comprises mainly medium dense to dense and in places loose silty sand with scattered friable weakly cemented pockets The geotechnical investigation of the insitu soils indicated that the undisturbed aeolian soils have a permeability of 10^{-7} m/sec but that remoulded samples of these soils (to 98% proctor) have a higher permeability of between 10^{-5} to 10^{-6} m/sec. Disturbing these soils by ripping and recompacting will result in increase in permeability.

Based on the above risk-based approach and the existing poor water quality, the inclusion of any type of liner system would not yield significant environmental benefit. It is thus proposed that no liner/ base preparation be included in the design and construction of the EOFS RSF6.

Closure Plan

The rehabilitation, closure and aftercare plan are based on the assumption that the objective of the process is to rehabilitate, as far as possible, the area disturbed during the establishment and operation phases of the project. The anticipated closure plan is summarised below:

- Flattening the downstream side slopes of the RD to 1V:5H by reducing the wall crest width to 15 m and dozing the existing material down to the required slope.
- Capping of the top surface area of the RD with a layer of coarse tailings
- Construction of evaporation dam.
- The upgrading of the overflow spillway;
- The placement of a mixture of soils and selected waste materials to the outer slopes of the walls and cladded top surface of the RD in preparation for the establishment of vegetation;

- The planting/seeding of vegetation to the outer slopes of impoundment wall and top of the RD to assist in the prevention of erosion;

Zone of Influence

The zone of influence, as shown in Figure 3, may be described as the extent of the area around the RSF that may be affected with time, taking into consideration the possible impacts that may arise from the RSF e.g. flow slide, sterilisation of arable land etc.

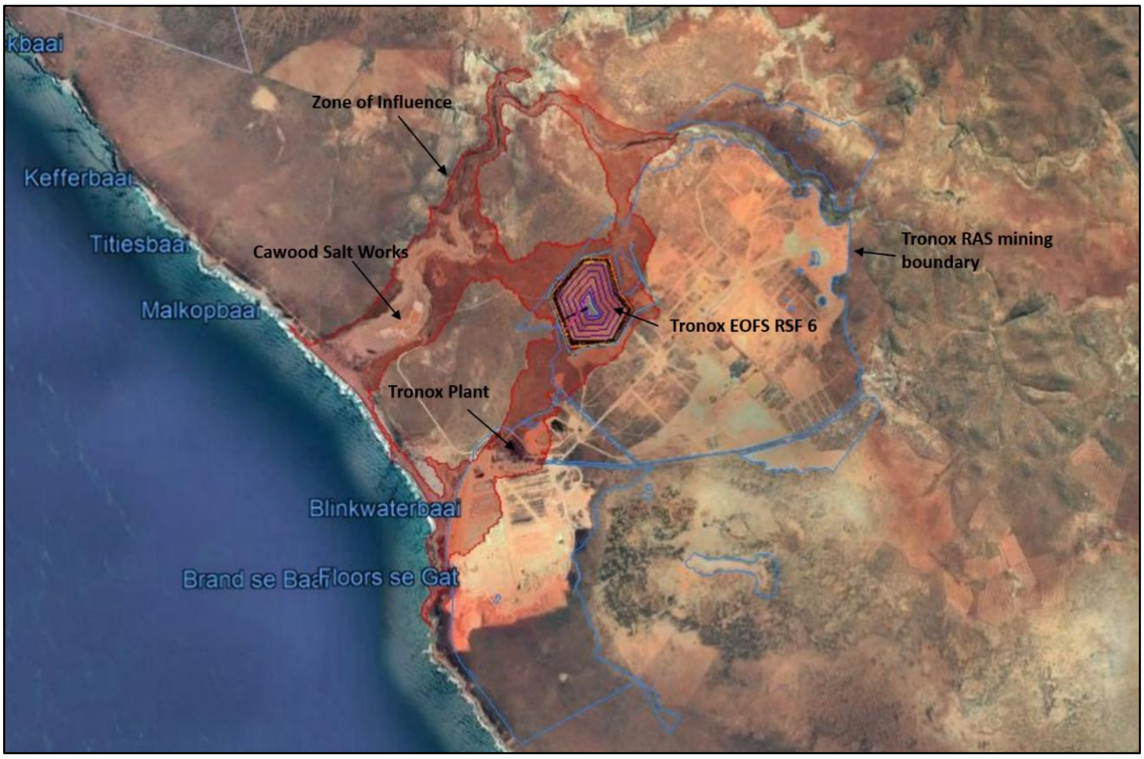

FIGURE 3: ZONE OF INFLUENCE FOR THE RSF

Based on the safety classification criteria detailed in the Code of Practice for Mine Tailings (SANS 0286:1998), the RSF has been classified as a High hazard dam as two of the criteria fall under the high hazard rating.

Risk Identification

The risk issues associated with construction are summarised as follows:

- The preferred site lies adjacent to an environmentally sensitive area. Care must be taken to not impact this area during the construction of the RSF;
- The liner requirements for the basin of the RD have not been finalised. Approval must be obtained from authorities for the exclusion of any base preparations/liner system. Should the lining of the basin of the RSF be required this would result in a significant increase in capital costs as well as lengthened construction time, jeopardising the financial viability of the project and the commissioning start date of the plant;

- Large earthmoving vehicles will be on site during construction and staff must be made aware of the dangers involved with working near these large machines. Health and Safety procedures must be adhered to.
- Diversions of clear storm water runoff must be in place prior to the construction of the preparatory works to avoid runoff damaging the works;
- The dust generated by the works to be monitored and if required dust suppression measures must be implemented.

The risk issues associated with operation and mitigated in the design are summarised as follows:

- The RSF failing and causing a flow slide is a key risk. This must be managed through an intense QA / QC system, construction management/supervision during the construction of the facility and competent operational management so as to reduce the risk of failure. More specific issues and mitigation measures are identified including:
    - Piezometer be installed in the RD wall to monitor the phreatic surface within the wall;
    - The entire perimeter of the RD must be inspected on a daily basis to ensure any defects are noted as early as possible. Such as: sloughing, slips, ratholing, seepage, etc.;
- The RD it expected to have water on the dam, as well as very soft residue, such that if a person falls in they could drown. Emergency measures must be provided for such cases (e.g. safety ropes, lifesavers, etc.). Residue personnel should be aware of the dangers of falling in the RD, however the local population would not be. It is suggested that sufficient signage, warning people of the dangers, be provided. It is also recommended that the dangers of the RD is clearly explained to people living near the mine;
- The water levels on the RD must be monitored to ensure that sufficient water is pumped off the RD and not allowed to exceed 50 000 m^3 during normal operating conditions. Similarly the minimum pool operating level must be maintained so as to not run the risk of beaching the decant turret.

Key risks to closure are:

- Time taken to clad the top surface area is dependent on the rate of consolidation of the residue. This may result in a lengthy closure period;
- It will be difficult to predict the long term effectiveness of the re -vegetation of side slopes and crest or the RSF; and
- There is a risk for potential for post-closure water treatment.

Conclusions

The following conclusions were deduced from the studies documented in this report:

- Following a site selection proceed, an appropriate site was identified for the location of the RSF capable of storing the LoM fine residue;
- The RSF has been designed to store a total of 38.9 million dry tonnes (64.83 Mm^3) of residue over a period of 20 years and comprises:

   - A RD, with a footprint area of 350 Ha and a maximum height of 27 m from the lowest contour;
   - Associated Infrastructure (decanting system, pool access wall, blanket drains, storm water diversion, catchment paddocks etc);
- The RSF is to be a full containment facility with walls constructed from the coarse sand tailings and the fine residue hydraulically placed in the facility;
- The containment walls require 9.44 m^3 of coarse sand tailings
- From the seepage and slope stability analysis for the RD, it was found that based on the parameters determined from the test work and the geometry of the RD, the facility should be stable, with a factor of safety above 1.5 under static conditions and above 1.4 for pseudo-static;
- The water balance model indicated that on average 10 440 m^3 may be returned to the process plant circuit per day;

Recommendations

The following recommendations are provided for the Detailed Design Phase of the project:

- Confirm design criteria;
- Confirm with the authorities the liner requirements for the basin of the RSF;
- Confirmation of survey data accuracy. It is recommended to undertake survey points of the site to confirm elevation.
- Confirm the permeability and degree of fissuring in the bedrock and re-asses the need for the blanket drain;
- Confirm the construction methodology for the containment walls and the construction timelines thereof;
- Investigate the opportunity of eliminating double handling of the coarse sand tailings material by constructing the containment walls to the required 1V:5H for closure during the construction phase.

Preliminary Feasibility Study Report for the East Residue Storage Facility #6

Tronox Namakwa Sand EOFS Project

Prepared For

Tronox Mineral Sands (Pty) LRD

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Project No. 126-005 June 2021

Report No. 1 EIA Rev 1

FEASIBILITY STUDY REPORT FOR THE EAST RESIDUE STORAGE FACILITY #6

TRONOX NAMAKWA SAND EOFS PROJECT

1. INTRODUCTION

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The RSF is to be a full containment facility with embankment walls constructed using either the EOFS or the RAS coarse sand tailings material.

A site selection study was undertaken in 2019 as part of a Pre-Feasibility Study (PFS), and documented in Epoch’s report: “*Pre-feasibility study report for the EOFS Residue Storage Facility*”. The preferred site for the RSF was determined to be the “Depression” site situated north-east of the plant.

This document describes the design of the Residue Storage Facility for the project. The design process included:

- Confirmation of the design criteria for the facility;
- A review of the available information of the project site;
- The development of a site layout of the proposed residue storage facility;
- Characterisation of the residue based on information supplied as well as geotechnical test work;
- A geotechnical study to characterise the insitu soils beneath the RSF;
- Feasibility design of the works required for the development, operation and closure of the facility;
- The compilation of a set of layout and typical detail drawings of the facility;
- The compilation of a life of mine estimate of costs associated with the development, operation and closure of the facility; and

- The collation of the work carried out into this Feasibility Design Report.

2. UNITS AND TECHNICAL ABBREVIATIONS

Table 2-1 lists the units and abbreviations referenced in this document.

TABLE 2-1: UNITS AND ABBREVIATIONS

Unit	Description
Mt	Million Tonnes
m	Metres
ktpm	Thousand Tonnes Per Month
tpa	Tonnes Per Annum
µm	Micro Metres
mm	Millimetres
m^3	Cubic Metres
t/m^3	Tonnes per Cubic Metre
m^2	Square Metre
m.a.m.s.l	Metres above mean sea level

Abbreviation	Description
FS	Feasibility Study
FoS	Factor of Safety
FSL	Full Supply Level
HDPE	High Density Polyethylene
LoM	Life of Mine
MAP	Mean Annual Precipitation
OFS	Orange Feldspathic Sands
PMA	Peak Maximum Acceleration
PSD	Particle Size Distribution
PI	Plasticity Index
RAS	Red Aeolian Sands
SG	(Particle) Specific Gravity
SPT	Standard Penetration Tests
RD	Residue Dam
RSF	Residue Storage Facility
TP	Test Pit

3. PROJECT SETTING

The Tronox EOFS Project is located in the Matzikama Municipal District of the Western Cape Province of South Africa, as shown Figure3-1, approximately 71 km north-west of the town of Vredendal and 385 km north of Cape Town. The mine consists of two mining areas namely the East and West Mine with a Satellite image of the Mine depicted in Figure 3-2.

FIGURE3-1: **PROJECT LOCATION**

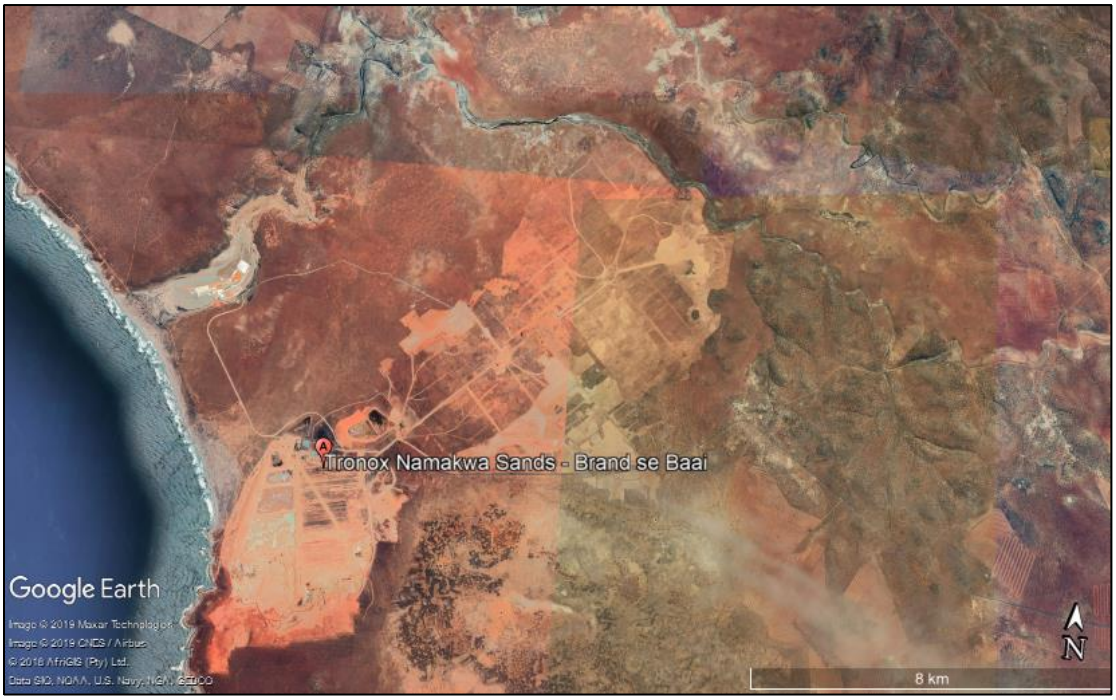


FIGURE 3-2: **TRONOX NAMAKWA SANDS MINE**

4. FRAMEWORK FOR THE DESIGN OF THE RESIDUE STORAGE FACILITY

4.1. TERMS OF REFERENCE

The terms of reference that Epoch were responsible for comprised:

- The design of the RSF comprising:
  - A full containment Residue Dam (RD) that accommodates 38.9 million dry tonnes of residue over a 20 year Life of Mine (LoM); and

  - The associated infrastructure for the RD (i.e. perimeter slurry deposition pipeline, pool access wall, storm water diversion, etc.);

- Estimation of the capital costs to an accuracy of +20% -15% percent, operating costs associated with the facility to an accuracy of +20% -15% percent and closure costs to an accuracy of ±30 percent; and
- Estimation of the costs over the life of the facility.

4.2. Battery Limits

The battery limits for the FS are as follows:

- The perimeter fence around the RSF;
- Downstream of the point where the slurry delivery pipeline intersects the RD wall;
- Upstream of the suction end of the of the floating pump dewatering system;

Epoch's terms of reference included:

- Geotechnical site investigation and laboratory test work of the in-situ soils of the RSF site; and
- Geotechnical laboratory test work of the coarse sand tailings and residue material.

The following are excluded from Epoch's terms of reference:

- Ground survey work;
- Site Selection process as this was undertaken in the PFS phase;
- Liaising or obtaining permission from various government authorities e.g. licences, permits, relocation of major services etc.;
- Hydrological, Geohydrological, Geochemical, Mineralogical and other environmental investigations or studies required for the EIA or for engineering design purposes. Some of the results from these studies are however required for the design of the RSF and are were conducted by others;
- Determination of flood lines along water courses;
- Stream diversions;
- Water supply studies;
- Participation and consultation with Interested and Affected Parties (I & APs);
- Equipping of the outlet manholes including pumps, motors electrics, instrumentation etc.;
- The design and costing of:
  - The RSF dewatering turret;
  - Pumps, motors, electrical components and instrumentation;
  - The slurry delivery pipeline from the process plant to the RSF; and
  - The return water pipelines from the dewatering turret to the process plant.

4.3. DESIGN CRITERIA

The life of mine production of the fine residue will amount to 38 900 000 tonnes over 20 years. The particle Specific Gravity (SG) of the residue was determined to be 2.63, by Specialized Testing Laboratory (Pty) LTD. The coarse sand tailing will be produced at an average rate of 7.09 Mt/annum with an SG determined as 2.66.

The design criteria are summarised in Table 4-1.

TABLE 4-1: DESIGN CRITERIA

Item	Criteria	Value	Source
1	Ore type	Heavy mineral sands	Tronox
2	Design Life of Facility	20 years	Tronox
5	Average Residue Deposition Rate:	1.945 Mtpa	Tronox
6	Total Residue	38 900 000 tonnes	Tronox
7	Particle Specific Gravity	Residue -2.63 Sand tailings -2.66	ST Lab
8	Average Dry Density	Residue -0.6 t/m3 Sand tailings – 1.7 t/m^3	ST Lab/Epoch
9	Average Particle Size Distribution	Residue -75% passing 15 µm Sand tailings – 75% passing 0.3mm	Patterson & Cooke ST Lab/Epoch
10	% solids to water (by mass)	Residue – 22% Sand tailings – 80%	Fluor/Tronox
11	Delivery Method	Residue - Hydraulically Pumped Sand Tailings - Trucked	Tronox
12	Geochemistry of residue	Inert, non-acid generating	SRK
13	Geochemistry of EOFS tailings	Inert, non-acid generating	SRK
14	Geochemistry of RAS tailings	Inert, non-acid generating	SRK
15	S-Pan to Lake Evaporation factor	0.75	Epoch

4.4. AVAILABLE INFORMATION

The following information was made available for the design of the RSF:

- A 1m interval digital terrain model of the project area;
- An aerial image of the area;
- Residue production rate over the life of the project;
- Residue characteristics based on test work conducted in the FS study.

4.5. APPLICABLE LEGISLATION

The South African legislative requirements for the design of mine Residue Storage Facilities are listed below:

- National Environmental Management: Waste Act (Act 59 of 2008).
- Environmental Conservation Act (Act 73 of 1989).

- National Water Act (Act 36 of 1998).
- National Environmental Management Act (Act 107 of 1998).

A summary list of the requirements for the design of an RSF as stipulated in the National Environmental Management Act is contained in Appendix A of this report. The reports/ studies in which the requirements have been address are cross-referenced with the requirements in this list.

4.6. Climatic Data

The Tronox EOFS project is located within the F60E Quaternary catchment of South Africa.

The catchment exhibits a winter rainfall pattern with most of the rainfall occurring in the months from April to September. Rainfall data collected by Tronox on the West Mine from 1994 to 2015 was used to establish the average monthly rainfall for the area.

The average S-Pan evaporation determined from the Water Resources of South Africa 2005 study (WR2005 BJ Middleton and AK Bailey) is 1 586.73 mm per annum. A coefficient of 0.75 was assumed to yield Lake Evaporation from the S-Pan depths, and equates to 1 190.05 mm. No correction has been made for a reduction in evaporation due to the salinity in the process water.

The average monthly rainfall, S-Pan and Lake evaporation are listed in Table 4-2 as well as the variance between the two, indicating that annual evaporation exceeds the annual rainfall depth by over 1000 mm (1.0 m).

Table 4-2: Average Monthly Rainfall And Lake Evaporation Values For Tronox

Month	Average Rainfall (mm)	Average S-Pan Evaporation (mm)	Average Lake Evaporation (mm)	Variance (Rainfall - Lake Evaporation) (mm)
January	4.85	218.02	163.52	-158.67
February	7.96	172.48	129.36	-121.40
March	7.97	147.09	110.32	-102.35
April	11.87	103.14	77.36	-65.49
May	24.19	75.85	56.89	-32.70
June	30.02	58.07	43.55	-13.53
July	32.19	62.52	46.89	-14.70
August	27.78	82.83	62.12	-34.34
September	11.93	111.23	83.42	-71.49
October	8.67	152.80	114.60	-105.93
November	8.55	185.96	139.47	-130.92
December	9.18	219.75	162.56	-123.38
Annual	**185.16**	**1586.73**	**1190.06**	**-1004.90**

The storm event depths as listed for the Doringbaai Weather Station (Station 0106408W) were used in this study. This station is the one situated closest to the project area, some 65km south of Tronox, along the western coastline with a similar elevation (88 m.a.m.s.l) and 48 years of rainfall records.

In a study undertaken in 2017 by SRK on the West mine, SRK estimated the storm event depths for the West Mine using the Pearson Type III distribution based on the mine's 23 years of rainfall data. This study is documented in SRK Report "*Namakwa Sands West Mine Slimes Dam 6 Report – Rev 2*" of 2017. The 24hr design flood depths for the Doringbaai Weather station and the SRK study are depicted in Table 4-3.

In order to accurately predict storm event depth, data is typically collected for over a 30 year period. The mine only has 23 years of records, as such the Doringbaai storm event depths were used in calculating the required storage capacity. It should however be noted that the SRK study results correlated well with the Doringbaai data for the greater return period events, i.e. 50 and 100 year events, which are considered in this design.

TABLE 4-3: DESIGN STORM RAINFALL DEPTHS FOR TRONOX

Station	Rainfall Depth (mm) for each Recurrence Interval						
	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years
Doringbaai	30	41	49	58	69	78	87
SRK	8	15	28	41	60	76	92

5. SCOPE OF WORK

The scope of work for the FS of the RSF was as follows:

- Stage capacity characteristic curves (area-volume-height curves) for the RSF;
- A geotechnical investigation of the preferred site and laboratory testing of samples to characterise the insitu soils properties;
- Geotechnical laboratory tests on the residue products to define their geotechnical properties;
- Seepage analyses for the RSF;
- Slope stability analyses of the RSF;
- A monthly water balance of the RSF to determine typical return water volumes;
- The design of the RSF and the associated infrastructure (i.e.pool access wall, storm water diversion, etc.).
- Site layout and typical drawings of the RSF;
- Estimation of the capital costs to an accuracy of +20%-15% percent and operating costs associated with the RSF to an accuracy of +20%-15% percent;
- Estimation of closure, rehabilitation and aftercare costs to an accuracy of 30%; and
- Estimation of the costs over the life of the facility.

6. SITE SELECTION STUDY

A site selection study was undertaken in 2019 as part of a Pre-Feasibility Study (PFS), as documented in Epoch's report: "*Pre-feasibility study report for the EOFS Residue Storage Facility*", contained in Appendix B of this report.

The required capacity for the study was 26.8 million tonnes, however the ability for expansion was a key requirement of the study, thus making the study applicable to the new tonnages. The study investigated 4 sites for the placement of the RSF as depicted in Figure 6-1.The preferred site for the RSF was determined to be the "Depression" site situated north-east of the plant. The Depression site ranked first on the weighted site selection rankings as a result of its ratings for safety and public health and proximity to the plant. The Depression site also yielded the lowest LoM costs based on the high-level cost comparison of the sites considered and also provided the ability for future expansion.

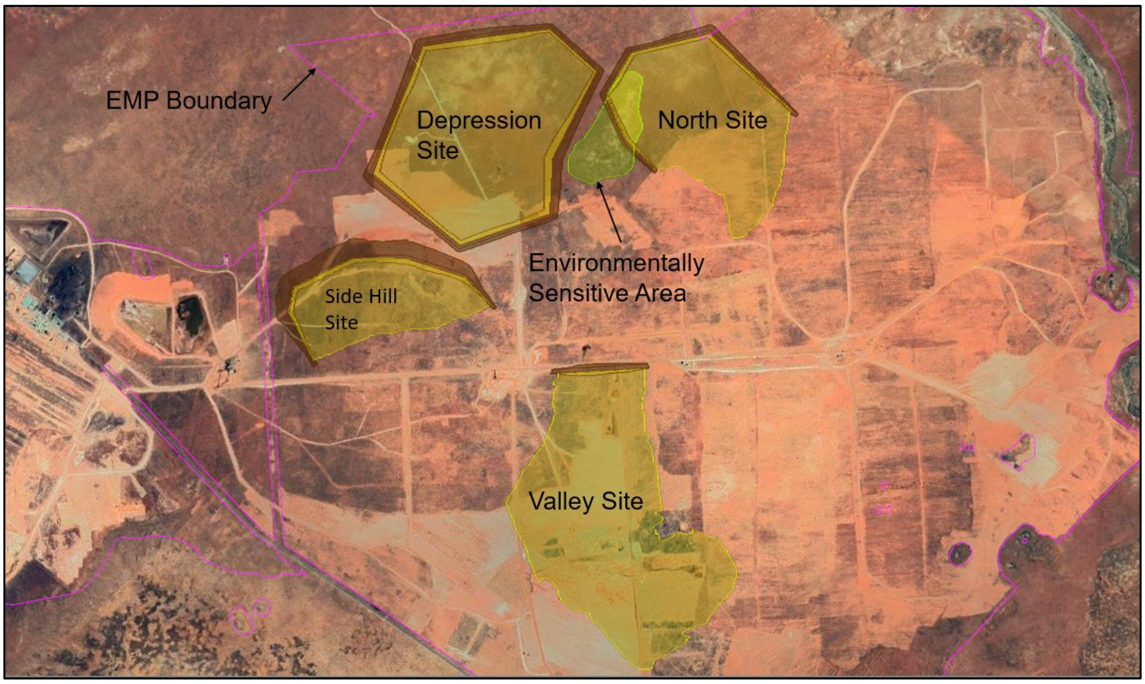


FIGURE 6-1: SITES IDENTIFIED FOR THE RSF

7. CHARACTERIZATION OF THE RESIDUE

7.1. PHYSICAL CHARACTERISATION OF THE FINE RESIDUE

The physical characteristics of the residue product is described in terms of its particle specific gravity (PSG) and particle size distribution (PSD). These characteristics are significant in that they will influence the in-situ dry density of the placed residue as well as the behaviour of the material during deposition. Four samples of fine residue were received for testing. The samples were created from the ore body from various areas across the mine site, which if blended would form a representative sample of the residue.

The following tests were conducted on all four samples:

- Foundation Indicator/Atterberg Limit tests;
- Relative density of the residue (Specific Gravity);
- Laser Diffraction mass grading;

The results of these test are summarised below:

- The average particle specific gravity of the residue samples tested was 2.63;
- The PSDs of the samples are shown in Figure 7-1. The figure shows that the 75% passes 15 µm;

- Two samples tested have a medium Plasticity Index (PI) of 9, classifying these samples as CH according to the Unified Soil Classification System;
- The other two residue samples tested with a high plasticity index of 27 and 36, classifying these samples as MH/OH according to the Unified Soil Classification System.

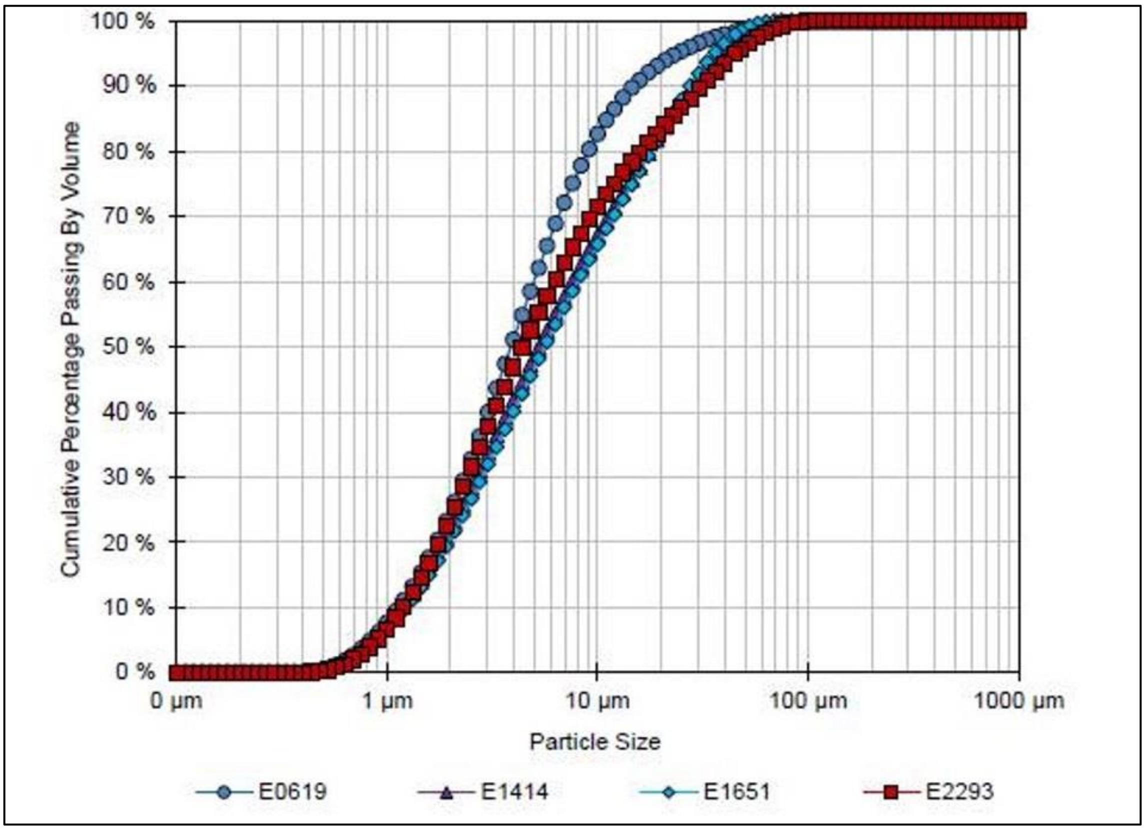


FIGURE 7-1: **PARTICLE SIZE DISTRIBUTION OF THE FINE RESIDUE SAMPLES TESTED**

The plasticity index is the size of the range of water content in which the soil exhibits plastic properties. Given the difference in plasticity indexes in the tested samples, there is a potential for significant variability in the setting properties of the material, ultimately impacting the placed dry density of the residue and subsequently impacting capacity requirements.

The following additional tests were conducted on two samples of the residue, namely E1414 -45micron with a PI of 9 and E0619 -45 micron with a PI of 36:

- Settling and evaporation tests;
- Triaxial consolidated undrained;
- Volumetric consolidation in triaxial cell; and
- Permeability - flexible wall.

7.1.1. ESTIMATED PLACED RESIDUE DRY DENSITY

The estimated placed dry density of the residue was determined using the particle Specific Gravity (*SG*) and laboratory test results of the residue. Three tests were carried out on the two residue samples with the results listed below. Each test simulates the different conditions associated with the deposition of residue from the perimeter of the RD in order to ascertain the residue placed dry density under each condition.

- The undrained settling test simulates conditions below the pool at the centre of the RD. A dry density of 0.558t/m^3 was achieved for the E1414 (-45μm) residue sample and 0.271 t/m^3 for the E0619 (-45μm) sample;
- The bottom-drained test simulates beach conditions where water drains through the bottom of a layer. A dry density of 0.905 t/m^3 and 0.487 t/m^3 was achieved for E1414 (-45μm) and E0619 (-45μm) respectively.
- The evaporation test simulates the outer beach conditions with evaporation. A dry density of 1.054 was achieved at a moisture content of 10.6% for the E1414 (-45μm) and 1.075 t/m^3 at a moisture content of 41.6% for the E0619 sample.

The overall weighted dry density of the residue is expected to be in the region of 0.6 and 0.7 t/m^3. Given that the volume of residue being produced from the various regions of the mine is unknown and each sample tested is not a representative of the final residue product reporting to the RSF, as well as the average dry density based on historic mass balances of existing RSFs at Tronox equals 0.61t/m^3, the FS design of the EOFS RSF6 will be based on a placed dry density of 0.6t/m^3.

The laboratory test results can be found in Appendix C.

7.2. Physical Characterisation of the Coarse Sand tailings

Four samples of EOFS coarse sand tailings and one sample of the RAS sand tailings were received for testing.

The following tests were conducted on all five samples:

- Foundation Indicator/Atterberg Limit tests;
- Relative density of the tailings (Specific Gravity);
- Sieve analysis mass grading;

The results of these test are summarised below:

- The average particle specific gravity of the EOFS tailings samples tested was 2.66;
- The particle specific gravity of the RAS tailings tested was 2.16;
- The PSDs of the samples are shown in Figure 7-2. The figure shows that the 20% passes 200 μm;

The following additional tests were conducted on the RAS samples and the E0619 (+45μm) EOFS coarse tailings sample:

- Shear box tests;
- Permeability – falling head.

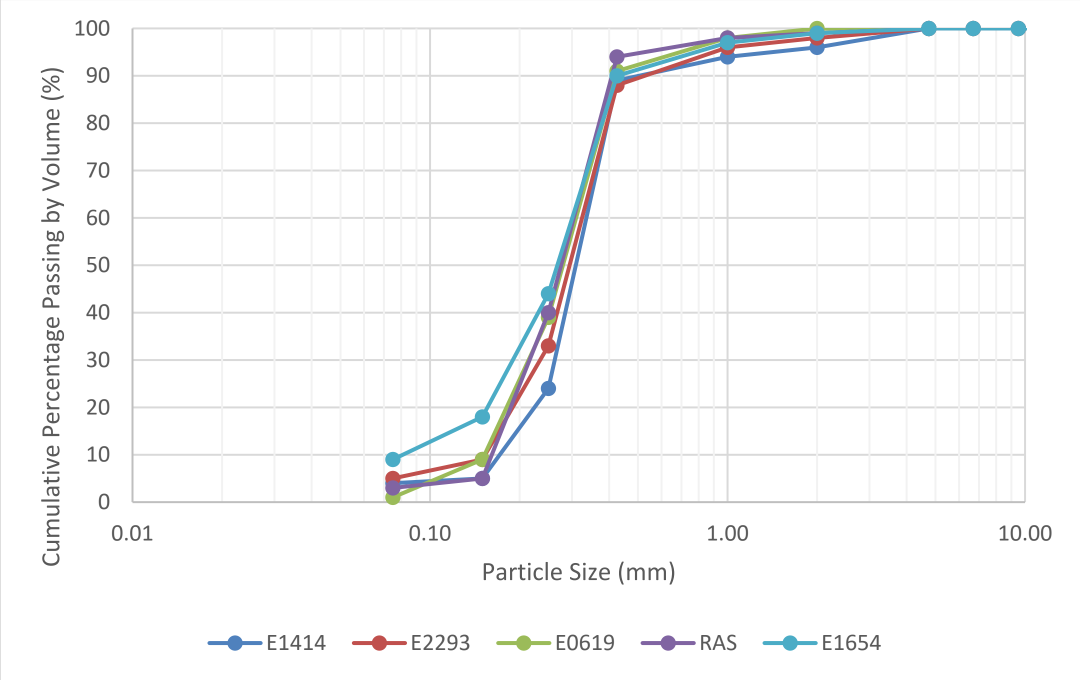


FIGURE 7-2: PARTICLE SIZE DISTRIBUTION OF THE COARSE TAILINGS SAMPLES TESTED

The laboratory test results for the coarse sand tailings can be found in Appendix C.

7.3. GEOCHEMICAL/ WASTE CLASSIFICATION CHARACTERISATION

In June 2020, SRK Consulting undertook the geochemical characterisation of the tailings and residue. The coarse tailings material is non-acid generating, inert and classified as a Type 4 waste. The fine residue material is non-acid generating, inert and classified as a Type 3 waste due to elevated leachate concentrations (LCT) of Cl, TDS and B (primarily residual sea water from the separation process). In the absence of a Risk Based approach, the tailings would require disposal on a Class D liner system and the residue on a Class C liner system.

Given that the sea water is used in the process plant, the elevated LCT values for TDS and Cl in the fines are not unexpected. The natural background water quality in the area has a mean EC of 1000 mS/m indicating poor water quality, and hence the leachate from the fines is not found to have a significant impact on the receiving environment.

The Geochemical Abundance Index (GAI) which compared the global median soil values for the tailings, fines and background soil, indicated that chromium, boron and zinc are slightly increased in the residue but not considered significant. Natural soils are not enriched relative to global soil mean for total concentrations only, leachate concentrations of the background soil are 4 times lower than the tailings with regards to Cl and TDS and significantly lower than the leachate concentrations of the fines.

The TCT and LCT concentrations for the two waste streams as well as the insitu background soils are listed in Figure 7-3 below as analysed by SRK.

Lab number	FINES		TAILINGS		BGK Soil		LCT0 mg/l	LCT1 mg/l	TCT0 mg/kg	TCT1 mg/kg
	TC	LC	TC	LC	TC	LC				
Antimony, Sb	2.00	<0.002	<1.00	<0.002	<1.00	<0.002	0.02	1.0	10	75
Arsenic, As	6.1	<0.003	0.60	0.004	1.70	0.004	0.01	0.5	5.8	500.0
Barium, Ba	167.0	0.090	10.00	0.013	37.00	0.027	0.7	35	63	6 250
Cadmium, Cd	<0.10	<0.001	<0.10	<0.001	<0.10	<0.001	0.003	0.15	7.5	260
Chromium (total)	362.40	0.004	89.10	0.002	170.30	0.004	0.05	2.5	46 000	800 000
Chromium (VI)	<0.30	<0.006	<0.30	<0.006	<0.30	<0.006	0.05	2.5	6.50	500
Cobalt, Co	15.60	<0.002	1.40	<0.002	6.80	<0.002	0.50	25	50	5 000
Copper, Cu	12.00	<0.007	6.00	0.020	3.00	<0.007	2.0	100	16.0	19 500
Lead, Pb	85.0	<0.005	6.00	<0.005	<5.00	<0.005	0.01	0.5	20	1 900
Manganese, Mn	991.00	0.231	57.00	0.038	290.00	0.025	0.50	25.0	1 000	25 000
Mercury, Hg	<0.10	<0.001	<0.10	<0.001	<0.10	<0.001	0.01	0.30	0.93	160
Molybdenum, Mo	0.30	<0.002	0.30	<0.002	<0.10	<0.002	0.07	3.5	40	1 000
Nickel, Ni	47.90	0.009	3.90	<0.002	16.00	<0.002	0.07	3.5	91	10 600
Selenium, Se	<1.00	<0.003	<1.00	<0.003	<1.00	<0.003	0.01	0.5	10	50
Vanadium, V	202.0	0.003	16.00	0.002	67.00	0.003	0.2	10	150	2 680
Boron	69.68	0.8	3.80	0.064	18.30	0.125	0.5	25	150	15 000
Zinc, Zn	305.0	0.988	18.00	0.158	21.00	0.009	5.0	250	240	160 000
TDS		1 374.0		437.00		168.000	1 000	12 500	-	-
Sulfate, SO_4		228.30		36.30		20.600	250	12 500	-	-
Chloride,Cl		1 683.1		206.50		52.400	300	15 000	-	-
Nitrate as N		0.17		<0.05		0.080	11	550	-	-
Fluoride,F	4.60	<0.30	0.60	<0.30	1.30	<0.300	1.50	75	100	10 000
Cyanide,CN	<0.50	<0.01	<0.50	<0.01	<0.50	<0.010	0.07	3.5	14	10 500

FIGURE 7-3: SUMMARY OF TOTAL AND LEACH CONCENTRATIONS FOR THE WASTE IN mg/kg

8. GEOTECHNICAL INVESTIGATION

A geotechnical investigation of the proposed site was undertaken by Inroads, and the results of the near-surface investigation were published in their report: “*Report on Geotechnical Investigation for the proposed Residue Storage Facility, Stormwater Dam & Overburden Facility fo rthe Tronox Namakwa Sands EOFS Project in Brand-se Baai, Wester Cape” February 2021.* This report is contained in Appendix D.

The focus of the investigation was to determine the geotechnical parameters and depths of the in-situ soil horizons in the vicinity of the RSF for seepage and stability analyses, as well as to identify any problem soils which could affect stability or soil permeability.

8.1. SOIL PROFILE

Inroads undertook to investigate and provide typical soil profiles of 82 Test Pits (TPs) and 6 rotary core drills, drilled to 20m within the area of the RSF, as depicted in Figure 8-1. During the geotechnical investigation, soil profiling was undertaken to determine the individual layers, or horizons, of the underlying soils and are summarised in Table 8-1 below.

The RAS material has been predominantly mined out over the majority of RSF footprint area, with these areas having been backfilled with RAS coarse sand tailings. The remaining RAS material in the RSF footprint area is expected to mined prior to the construction of the RSF.

The subsoil conditions within the RSF site are characterised by dune sand, in the unmined area, and sand tailings fill in the rehabilitated backfilled area that was previously mined along the southern boundary of the RSF. These soils are almost identical and of very loose consistency.

In most of the largely unmined area very loose dune sand overlies silty sand of aeolian origin at an average depth of 2,0 m ranging from 0,9 to 3,3 m below the present ground surface. The aeolian comprises mainly medium dense to dense and in places loose silty sand with scattered friable weakly cemented pockets.

The aeolian sand extends to the bottom of most of the holes at depths of about 3,0 m and, in places, the TLB partially refused on very dense aeolian sand and very occasional very soft rock hardpan dorbank. Boreholes NRSF01, NRSF06 to NRSF08 drilled within the unmined area show the aeolian horizon to extend to depths mostly in excess of 20,0 m. The Standard Penetration Tests (*SPT*) carried out on the subsoils to depths of up to between about 2,0 to 3,5 m yielded N values of 20 to 32, which suggests that their consistency is medium dense. Below these depths, the SPT N value recorded mainly above 50 or refused, indicating that the soils are very dense and comprise cemented sand and very soft rock in places.

Borehole NRSF06, at a depth of 17,7 to 20,1 m, encountered a soil horizon resembling the residual schist comprising a clayey silt with very stiff to very soft rock. In the rehabilitated area, very loose fill covers the site to a depth of between 1,1 to 3,2 m where it generally extends to the bottom of the pits or is underlain by loose aeolian and very occasionally moderately cemented very dense sand and very soft rock gneiss.

Boreholes NRSF02 and NRSF05 drilled along the southern wall of the RSF and within the rehabilitated area, show the fill, together with the underlying aeolian sand, to extend to depths of between 4,5 and 12 m where they are underlain by either very soft rock dorbank or completely weathered granite gneiss.

The SPT carried out in soils within the rehabilitated area to depths of up to 3,5m yielded N values of 9 to 17 which suggests that their consistency is loose to medium dense. At a depth of about 4,5 m, the SPT in borehole NRSF02 refused, signifying the presence of very dense or very stiff to very soft rock horizons below this depth and extending to 20,0 m. These comprise very soft to soft rock dorbank overlying very stiff to very soft rock completely to highly weathered limestone at about 10,0 m.

In borehole NRSF05, the aeolian becomes dense and very dense below depths of 7,5 m and 9,0 m with N values of 39 and 69 to 75 respectively. Below a depth of 12,0 m and extending to the bottom of the hole at 20,0 m, completely weathered granite gneiss occurs. It comprises very dense to very soft rock and relict jointed silty sand with clayey sandy silt below 16,5 m.

TABLE 8-1: SUMMARY OF SOIL HORIZON PROFILES

Material	Typical Depths (m-m) (where prominent)	In-situ Moisture Condition	Colour	Consistency	Soil Classification
Aeolian/Dune	0-2.0	Moist	Light brown	Very loose	Silty SAND
Aeolian	1.0 – 3.3 (TLB Refusal)	Moist	Yellow Brown/ Reddish Brown	Loose/ medium dense to dense	SILTY SAND
Weekly cemented Aeolian	1.6 - 20	Slightly moist to moist	Reddish brown	Dense	SILTY SAND
Fill	0 - 3.2	Moist to very moist	Light brown	Very loose	SAND
Residual Gneiss	0.2-refusal	Moist	Speckled grey and orange	Very dense	SILTY Coarse SAND

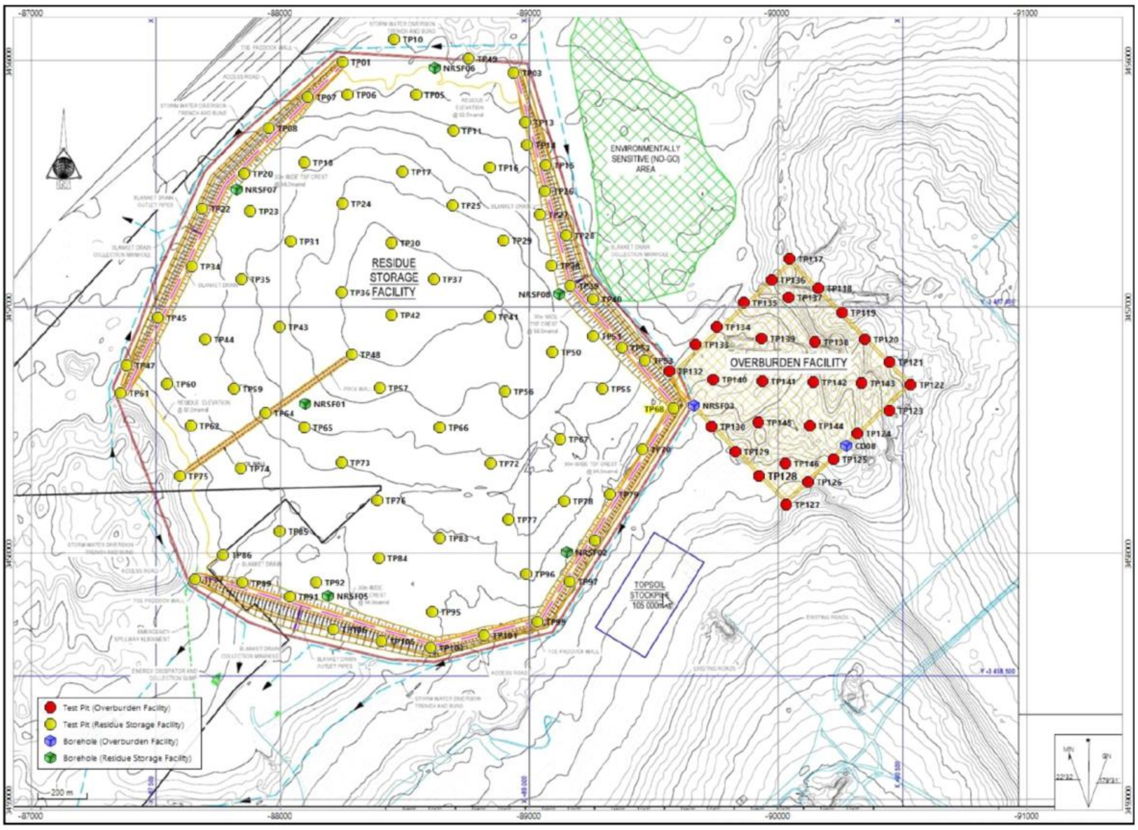


FIGURE 8-1: RSF TEST PIT AND CORE DRILL LOCATIONS

8.2. GROUNDWATER

No groundwater was encountered within any of the test pits excavated on site. The primary aquifer is located approximately 60m below surface and as such not intercepted in this investigation.

8.3. MATERIAL STRENGTH PARAMETERS AND HYDRAULIC CONDUCTIVITY

Representative disturbed and undisturbed soil samples were collected during the site investigation. Particle size distributions and Atterberg limit determinations were carried out in order to determine the Unified System Classification of Soils (*USCS*) of the soils. Slow drained shear box and flexible wall triaxial cell permeability tests were carried out on undisturbed and remoulded samples of the soils. Collapse potential and consolidation test were carried out on undisturbed samples of the Aeolian soils. The tests were undertaken to determine the geotechnical parameters required for the design of the RSF.

The hydraulic conductivity values were then utilized in the seepage analyses of the RSF. The strength parameters were used in the analysis of the slope stabilities in conjunction with the results of the seepage analyses. Table 8-2 presents the geotechnical parameters of the insitu soils.

TABLE 8-2: GEOTECHNICAL PARAMETERS OF MATERIALS CLASSIFIED IN TEST PITS

Material	Typical Depths (m)	Unified Classification	Average Bulk Density (kN/m^3)	Friction Angle (degrees)	Cohesive Strength (kPa)	Hydraulic Conductivity (m/s)
Fill & Dune (uncompacted)	0 – 2	SP	14	28	0	10^{-4}
Fill & Dune* (compacted)	0 – 2	SP	16	35	0	10^{-5}
Aeolian (uncompacted)	2 – 3.5	SP / SP-SM	16	32	0	10^{-6}
Aeolian* (compacted)	2 – 3.5	SP / SP-SM	18	37	0	10^{-5}
Weakly cemented aeolian, residual, weak dorbank (Very dense to very soft rock)	15	SP / SP-SM	19	40	0	10^{-7}

*Notes: * Disturbed samples remoulded to 98% Modified AASHTO density.*

The walls of the RSF will be built from sand tailings trucked from the PCP East Plant and no conventional compaction will be undertaken during construction of the wall. Compaction will only take place under traffic loading during construction, and under the self-weight of the sand as the wall height increases. Under such conditions where the consistency of the soil may improve slightly a friction angle of 30 degrees and dry density of 1600 kg/m^3 is considered appropriate to be used as the design parameters for the wall fill material.

Inroads recommended that before constructing the wall, the in-situ material beneath the RSF wall be compacted using an impact roller able to compact to depths of up to 2-3 m. This will however not be required as the Dune sands (which comprise the top 2 to 3m of insitu soils) throughout the RSF footprint area will be mined (and hence removed) prior to the construction of the RSF. Any fill material under the RSF walls will also be removed prior to the construction of the walls, so as to allow for the excavation of the box cut into aeolian material and the installation of the blanket drains.

8.4. GEOTECHNICAL TESTING OF TAILINGS SAMPLES

Geotechnical testing was conducted on sample E0619 (+45µm) of the sand tailings products. The summary average results of these tests are listed below:

- Friction Angle – 30°;
- Cohesion – 2 kPa;
- Unit weight – 16.6 kN/m^3; and
- Hydraulic conductivity – 2 x 10^{-5} m.s^{-1}.

8.5. GEOTECHNICAL TESTING OF RESIDUE SAMPLES

Geotechnical testing was undertaken on two different samples of the residue product namely E1414 (-45µm) and E0619 (-45µm). The summary result of these tests are listed below:

- Friction Angle – 33°;
- Cohesion – 0 kPa;
- Unit weight – 15 kN/m^3; and
- Hydraulic conductivity – 4 x 10^{-8} m.s^{-1}

9. SITE DEVELOPMENT PLAN AND STAGE CAPACITY CALCULATIONS

The stage capacity curve for the RSF, reflecting the relationship between residue elevation, rate of rise, storage volume, footprint area, cumulative tonnage, elevation, and time is included in Appendix E.

The stage capacity relationship of the RSF was calculated using the survey information supplied by the mine and the residue production rate of the Process Plant. The RSF was designed to accept residue at an average rate of 162 083 tonnes per month (tpm) from the Process Plant with a maximum capacity of 38 9 Mt. The placed dry density for tailing used in the curves is 0.6 t/m^3 resulting in a total storage capacity of 64.83 Mm^3 over the 20 year LoM.

The containment walls are to be constructed with either RAS or EOFS coarse sand tailings. The total volume of material required in these walls is 9.44Mm^3 with the volume of material required per wall summarised below in Table 9-1. The natural topography of the site allows for some residue storage capacity within the depression below the containment walls. The corresponding time taken for the residue to reach 1 m below the upstream toe of each wall (allowing for 1m freeboard), from the time of commissioning the RSF, is also depicted in the table, indicting by when the construction of each wall must be completed.

TABLE 9-1: CONTAINMENT WALLS VOLUME REQUIREMENTS AND CONSTRUCTION TIMELINES

Wall	Volume (m^3)	Time from commissioning of RSF for residue to reach toe is wall (months)
North	331 749	137.3
East	2 952 432	6.8
South-East	1 145 757	55.2
South	1 580 342	39.1
South-West	1 420 342	55.2
North-West	2 013 203	39.1

In a conventional self-raising residue dam, the rate of rise of the dam must be at such a rate as to allow for the residue to drain and consolidate to be able to harvest residue material in order to raise the “containment walls”. As the RSF is a full containment facility the stability of the RSF is not dependent on the Rate of Rise. The Rate of Rise of the residue is at 6 m/year when the facility breaks ground steadily decreasing to 1.1 m/year by the end of LoM.

10. SEEPAGE ANALYSES

Seepage analyses were undertaken to model the development of a phreatic surface within the RSF under varying operating conditions as detailed in the report contained in Appendix F. An increase in pore-water pressure brought on by the onset of seepage can result in the reduction in the stability of an earth structure’s slope and potentially has other adverse secondary effects such as:

- Piping (erosive loss of material);
- Loss of effective strength of the material;
- Increase in the liquefaction potential of soils; and
- Increase in the collapse potential of sensitive soils.

It is therefore imperative not only for the designer to take cognisance of the above but also the construction of the facility to be as per design and for the operator of the RSF to ensure that best-operating practices are adhered to at all times.

10.1. METHODOLOGY

Seepage analyses of the RSF were carried out using the finite element program Seep/W to assess the location of the phreatic surface that would develop under various conditions during the operational and closure phases, such as:

- Normal operating conditions including:
  - Functional drains; and
  - Normal operating pool
- Abnormal operating conditions including:
  - Failed drains; and
  - The pool will be located 100 m from the upstream face of the containment wall.

10.1.1. INPUT PARAMETERS TO SEEPAGE MODEL

The soil USCS classifications and hydraulic conductivities used are listed in Table 10-1.

TABLE 10-1: LIST OF HYDRAULIC PARAMETERS

Material	Anisotropy Ky'/Kx' Ratio	Saturated Hydraulic Conductivity ($m.s^{-1}$)	Saturated/Unsaturated Condition
Residue	0.5	4.03×10^{-8}	Saturated only
Embankment (Tailings)	1	1.00×10^{-5}	Saturated/Unsaturated
Drains	1	1.00×10^{-3}	Saturated only
Aeolian (Silt)	1	1.00×10^{-6}	Saturated/Unsaturated
Aeolian (Slightly Cemented)	1	1.00×10^{-7}	Saturated/Unsaturated

The insitu soils are underlain by fractured bedrock. As the water tightness and preferential flow paths of the bedrock are unknown, for the purpose of the seepage analysis the bedrock was modelled as being an impermeable layer. The natural topography of the site is that of a depression (bowl), with the insitu soil layers and bedrock following the shape of the depression. By modelling the bedrock as impermeable, seepage into the underlying soils is allowed to accumulate above the bedrock and dissipating horizontally. The model was set up in this manner to provide a worse-case scenario for the stability models.

The bedrock is however fissured, with the mounding of seepage expected only in localised pockets under the RSF and as such the model should be reassessed during the detailed design phase of the project once the permeability of the bedrock is confirmed.

10.1.2. Configuration of Seepage Models

Once all the required input parameters have been allocated as necessary, it is possible to compute the steady-state condition by determining the location of the water table (phreatic surface, or zero pore water pressure) under the given criteria and conditions. The Critical Section of the RD used for the Seepage and Stability analyses are illustrated in Figure 10-1. The typical model setup for the RD along the Critical Section is illustrated in Figure 10-2 to Figure 10-4. The RSF was assessed with a centre banket drain, upstream toe blanket drain and no drain, respectively, with the operating pool positioned in the centre of the facility and with an upset condition of the pool positioned 100 m from the edge of the upstream face of the containment wall.

The construction of the containment walls will be a two-phase process. During the initial phase, the walls will be constructed with 1V:2.5H side slopes for both the upstream and downstream slopes and a 30 m crest to allow adequate space for construction vehicles to end tip and spread the coarse material. During the second phase, the slope of the embankments downstream face will be flattened to a 1V:5H slope by reshaping the existing material. Subsequently, the crest width will be reduced to 15 meters.

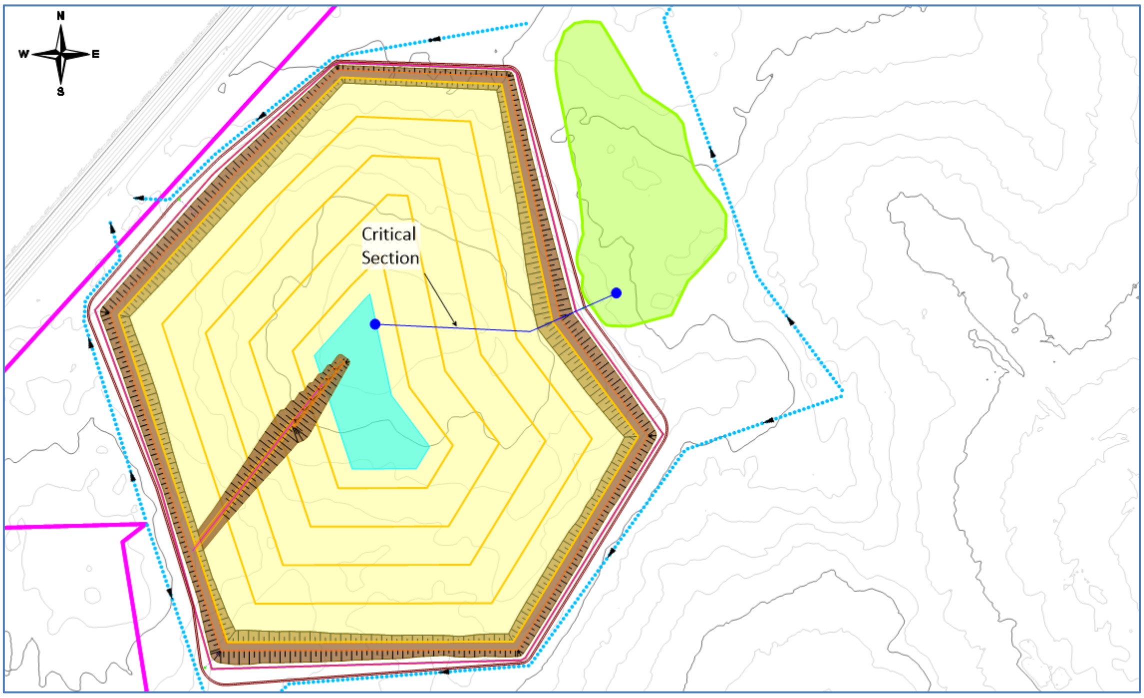


Figure 10-1: Critical sections across the RSF

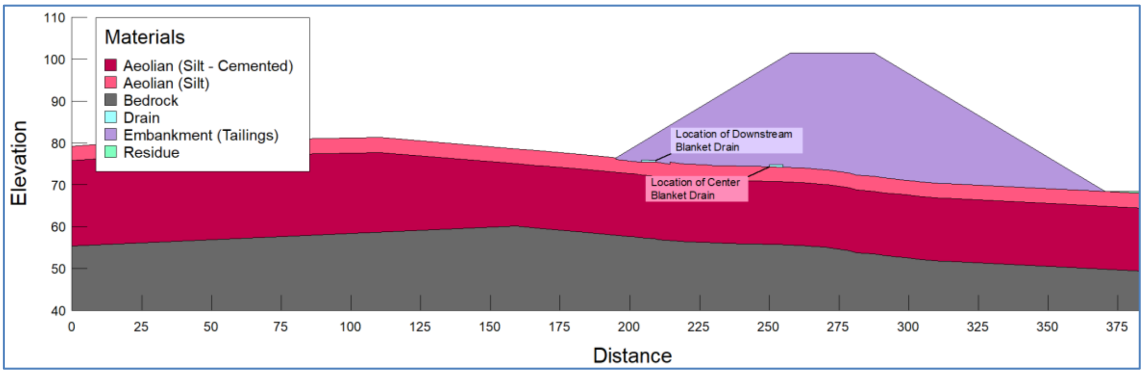


FIGURE 10-2: OPERATIONAL PHASE – INITIAL

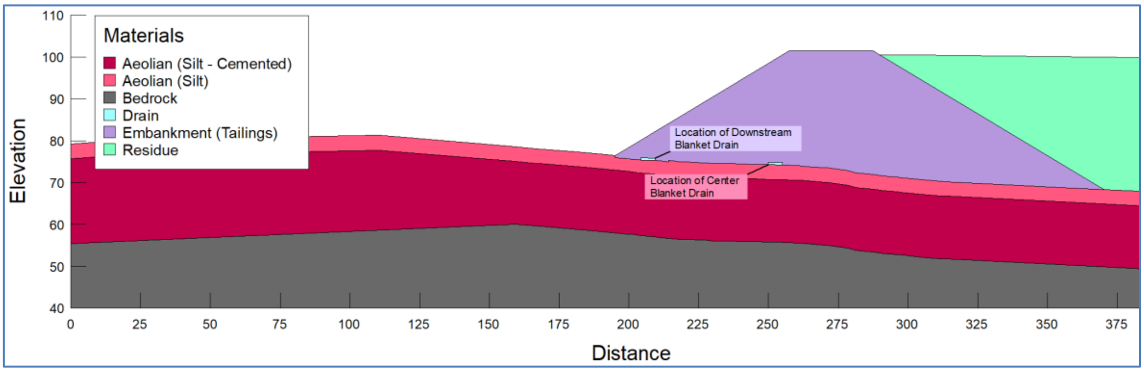


FIGURE 10-3: OPERATIONAL PHASE – RESIDUE AT MAXIMUM CAPACITY

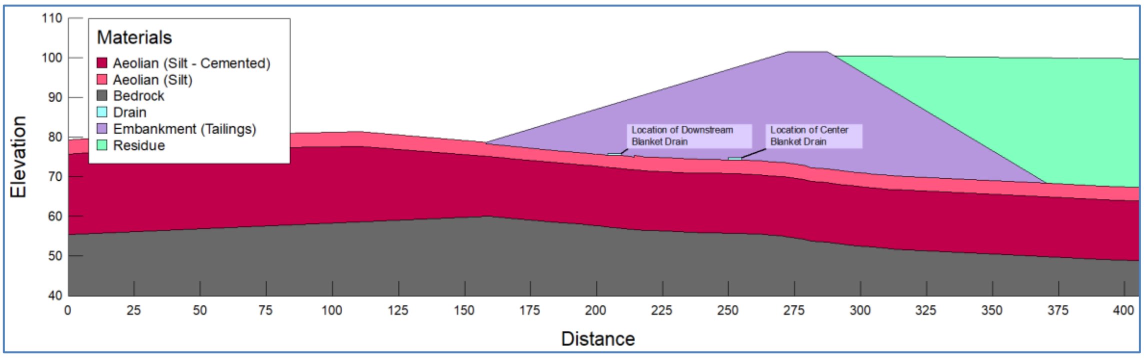


FIGURE 10-4: CLOSURE PHASE

10.2. RESULTS OF ANALYSES

A series of seepage analyses were conducted under varying operating conditions to determine the generation of pore water pressures within the RSF. The seepage assessments were also carried out to determine the effect of drainage infrastructure in reducing the generation of pore water pressures that may have adverse effects on the safety and stability of the RSF.

Each scenario was modelled with the pool in the centre of the facility and an upset condition with the pool located 100 m from the upstream face of the containment wall. A water balance conducted by Epoch titled "*Water Balance Study for the Tronox EOFS Residue Storage Facility*", revealed that the pool volume would not exceed 43 328 m^3 at any given point, during the operational life of the facility. The volume of water expected to report to the RSF during the 1 in 200-year return period storm event (including the operational pool) is 300 000 m^3 and discharged off the facility over a period of 30 days. The seepage models assume a pool volume of 300 000 m^3 which is considered a conservative approach as the analysis are run under steady state conditions.

10.2.1. Seepage Analysis Result of Initial Operational Phase

The model presented in a Figure 10-5 illustrates a typical cross-section along the Critical Section during the initial portion of deposition when the residue material starts encroaching on the upstream toe of the facility. This scenario is seen as the worst-case as the deposited material could lead to the saturation of the upstream toe should a significant storm event occur. Further analysis showed that increasing the residue level resulted in an increased FoS.

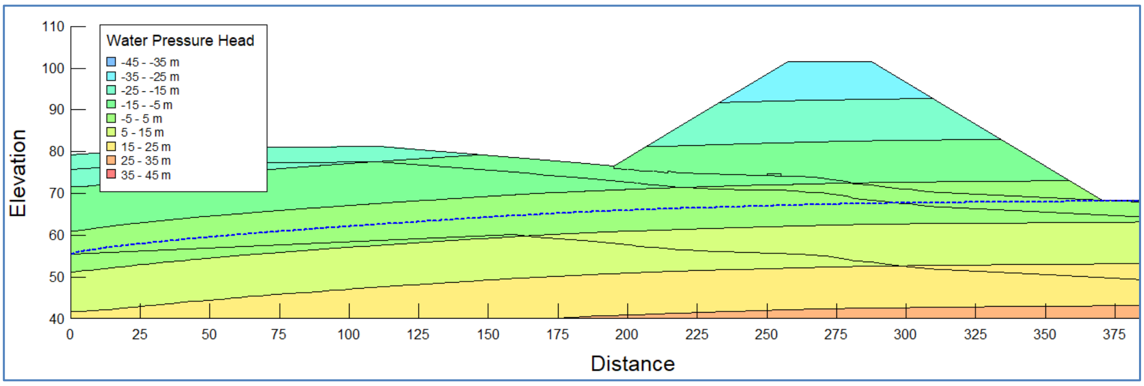


Figure 10-5: Initial Operational Phase, seepage assessment of the RD with an active centre blanket drain

The embankment illustrated in Figure 10-5 consists of upstream and downstream slopes equal to 1V:2.5H and a 5 m wide centre blanket drain. No further models were included for this scenario as it is shown that the phreatic surface remains below the blanket drain thus indicating that excluding the drains from the analysis would have no significant impact on the phreatic surface within the embankment.

10.2.2. Seepage Analysis Results of Operational Phase at Capacity

Figure 10-6 to Figure 10-8 illustrates the effect a blanket drain would have on the phreatic surface within the embankment. It is shown that, due to the topography, a centre blanket drain is the most effective means by which to decrease the phreatic surface (Figure 10-6). However, similarly due to the topography, manholes in excess of 6m depth will need to be excavated in order to reach the blanket drain outlets. Therefore, it is believed that a downstream blanket drain is the most feasible means by which to prevent saturation of the downstream toe.

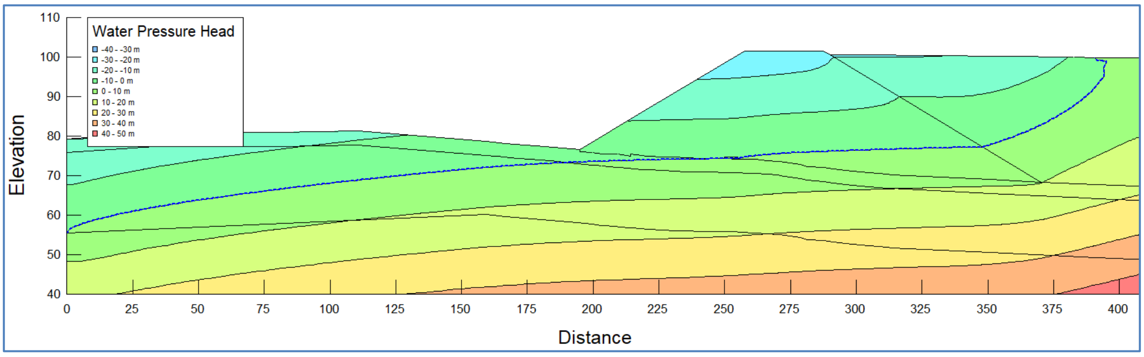


FIGURE 10-6: **OPERATIONAL PHASE AT CAPACITY, SEEPAGE ASSESSMENT OF THE RD WITH AN ACTIVE CENTRE BLANKET DRAIN**

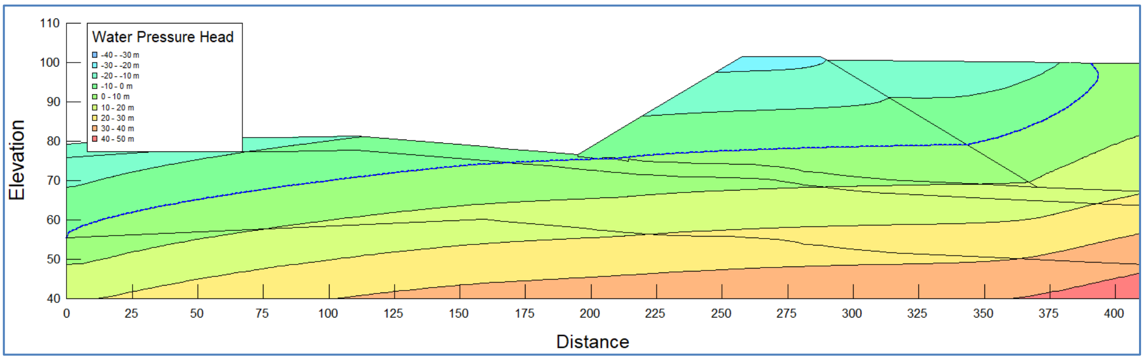


FIGURE 10-7: **OPERATIONAL PHASE AT CAPACITY, SEEPAGE ASSESSMENT OF THE RD WITH AN ACTIVE DOWNSTREAM BLANKET DRAIN**

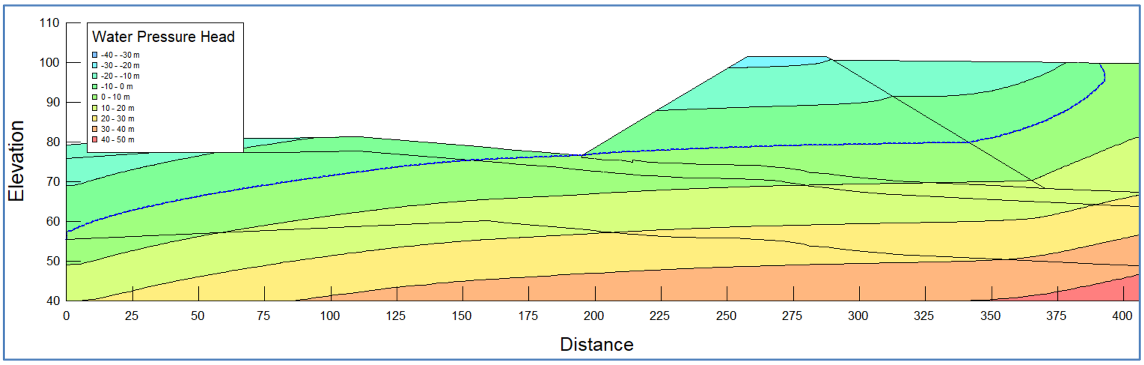


FIGURE 10-8: **OPERATIONAL PHASE AT CAPACITY, SEEPAGE ASSESSMENT OF THE RD WITH NO ACTIVE DRAINS**

10.2.3. SEEPAGE ANALYSIS RESULTS AT CLOSURE PHASE AT CAPACITY

The closure phase of the facility is depicted in Figure 10-9 to Figure 10-11. It is shown that, as during the operational phase, the downstream blanket drain is an effective means by which the phreatic surface can be decreased within the embankment. The inclined slope of the topography on which the embankment is to be built further improves the separation between the phreatic surface and downstream toe as downstream slopes are reshaped from a 1V:2.5H slope to a 1V:5H. This will decrease the likelihood that the downstream toe will become saturated, preventing piping as well as a decrease in the effective strength of the material as it becomes saturated.

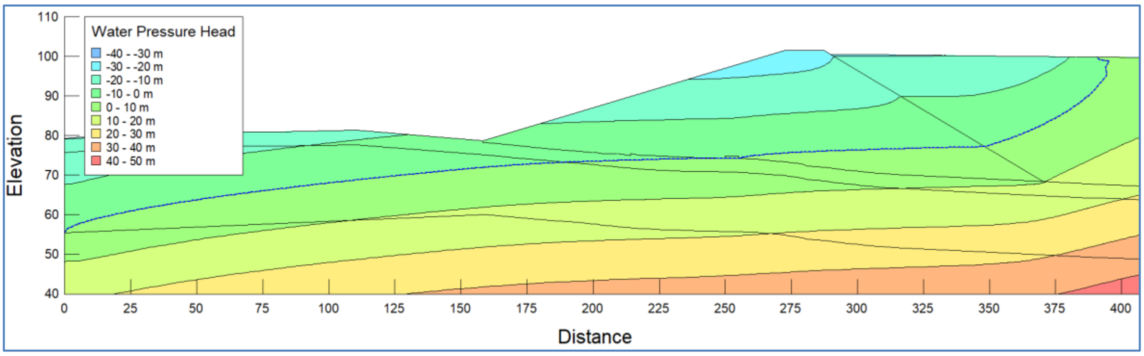


FIGURE 10-9: **CLOSURE PHASE AT CAPACITY, SEEPAGE ASSESSMENT OF THE RD WITH AN ACTIVE CENTRE BLANKET DRAIN**

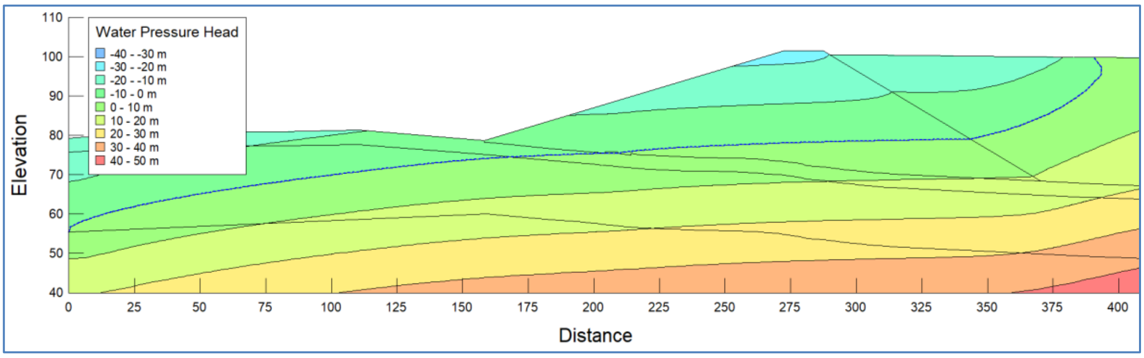


FIGURE 10-10: **CLOSURE PHASE AT CAPACITY, SEEPAGE ASSESSMENT OF THE RD WITH AN ACTIVE DOWNSTREAM BLANKET DRAIN**

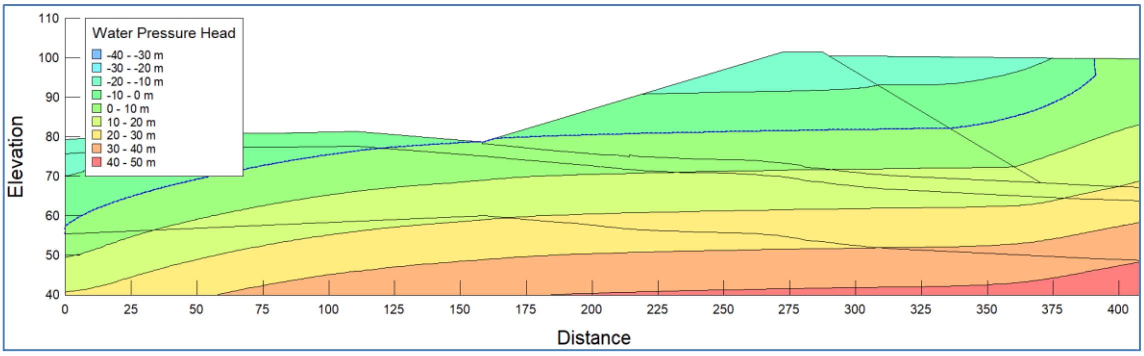


FIGURE 10-11: **CLOSURE PHASE AT CAPACITY, SEEPAGE ASSESSMENT OF THE RD WITH NO ACTIVE DRAINS**

10.3. DISCUSSION OF RESULTS

The high permeability of the embankment material, compared to that of the residue material, results in the phreatic surface decreasing rapidly within the containment wall, it should be noted that the topography and underlying soil profile does not allow water to daylight a distance downstream of the facility. Instead, water seeps from the toe of the facility if no drains are included. Although this does not result in a build-up of pore water pressure through the wall, seepage through the downstream toe of the embankment increases the potential for erosion of the embankment and for piping through the wall to occur. Under these conditions it is recommended that a blanket drain be included in the wall.

It is recommended that the state of the underlying bedrock be further investigated, and the seepage models reassessed in the detailed design phase of the project. Should the permeability of the bedrock be such that the phreatic surface does not build up beneath the footprint of the RSF, the need for the blanket drains may be negated.

Piezometers will be installed in the RSF walls to monitor the phreatic surface within the walls. These are to be installed prior to the commissioning of the facility.

11. SLOPE STABILITY ANALYSIS

A slope stability analysis was completed to assess the safety of the slopes of the RD under varying conditions. The following sections describe the process by which the analysis was completed.

11.1. METHODOLOGY

To analyse the stability of a slope requires that the Factor of Safety against the failure of the slope be determined as well as the associated Probabilities of Failure and the Reliability Index of the analysis. The level of uncertainty associated with the long-term stability of a slope is a function of the level of uncertainty associated with:

- The shear strength parameters of the materials comprising the slope and its foundation as expressed in terms of their friction angle and cohesion; and
- The location of the phreatic surface within the slope.

11.1.1. Factor of Safety

The Factor of Safety *(FoS)* against the failure of a slope is a ratio between opposing forces: the forces causing failure (gravity forces of the material weight) and the forces preventing failure (shear strength of the containment wall material).

South African legislation as documented in the NEMWA Act No. 59 of 2008 and Regulation 632 (24 July 2015) Chapter 2, 7 (4)(d), says:

"Other design considerations, as appropriate to the particular type of residue stockpile and residue deposit that must be incorporated include:

(d) keeping the pool away at least 50 meters from the walls and a factor of safety not less than 1,5; where there are valid technical reasons for deviating from this, adequate motivation must be provided, and the design must be reviewed by a competent person".

Therefore, the RD has been designed in order to achieve this factor of safety of 1.5 during the operational and closure phase.

11.1.2. Probabilistic Analysis

To allow for variability in the input parameters, a probabilistic analysis is conducted. The software is provided with the probabilistic distribution of the design parameters which includes:

- Type of distribution i.e. Normal distribution, Log-normal distribution etc.;
- The mean; and
- The standard deviation.

A finite number of Monte Carlo trials are conducted which selects, at random, combinations of new parameters within the defined probabilistic distribution. These randomly selected parameters are applied to the critical slip surface which is determined by the deterministic analysis. The FoS from each of the Monte Carlo simulations is recorded as it converges to an overall solution from which a *Reliability Index (RI)* and *Probability of Failure (PoF)* is determined.

The PoF is defined as the number of Monte Carlo trials that resulted in a FoS less than one represented as a percentage of the total number of trials conducted. For long term slopes, a PoF less than 0.0007% (<1:143 000) is widely accepted. Recommended PoFs for short- and medium-term slopes should not exceed 0.07% (1:1 430) and 0,007% (1:14 300) respectively (Cole, 1993).

The RI is defined as the number of standard deviations separating the defined failure FoS of 1.0 from mean FoS that the Monte Carlo simulation converged towards. A Reliability Index of 4.83 correlates to the minimum acceptable PoF, thus values greater than (>) 4.83 is considered acceptable for a long term, or permanent slope.

11.1.3. Seismicity

The horizontal force imposed on the structure when undertaking a pseudo-static analysis is derived from the Peak Ground Acceleration (PGA) parameter. PGA values are based on prior earthquakes and fault studies and are measured as factors of the earth's gravitational acceleration (i.e. 1g is equivalent to 9.81 $m.s^{-2}$).

The minimum allowable Factor of Safety for side slopes, according to NEMWA, is 1.5. Deviations from the prescribed minimum FoS must be substantiated by the designer.

The Peak Ground Acceleration (PGA) for Namakwa will be about 0.04g, based on a 10% probability of exceedance in 50 years from the Global Seismic Hazard Assessment Program (GSHAP) study (Figure 3-1) and between 0.02g and 0.03g (10% probability of exceedance in 50 years) based on the PGA map produced by the Council of Geoscience for South Africa, as depicted in Figure 11-1 below.

A value of 0.03g was used in the stability assessments for the RSF.

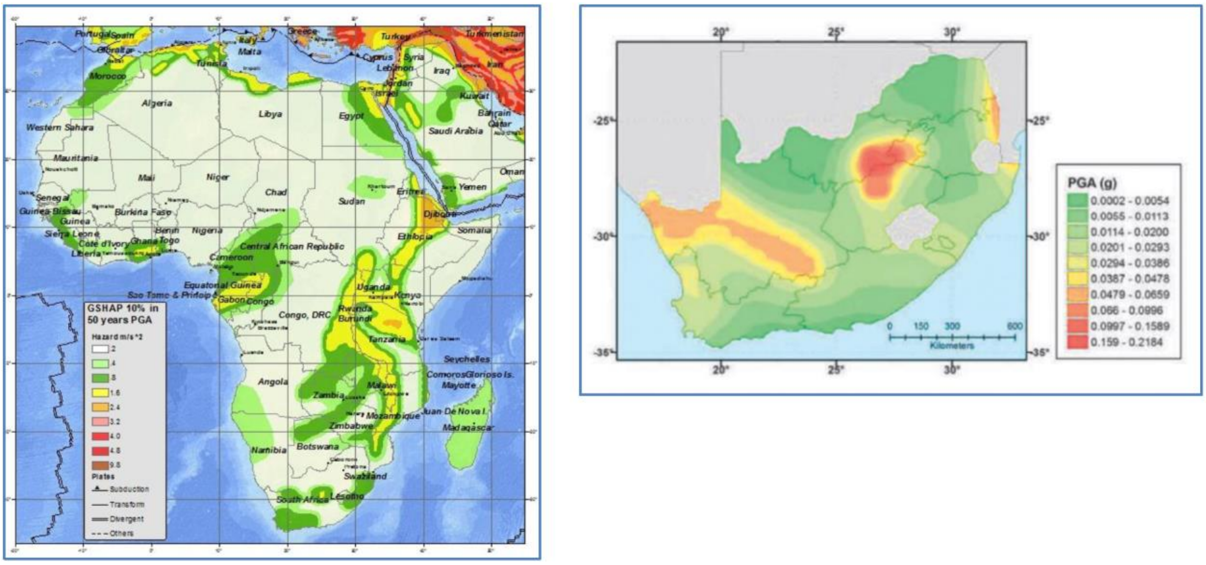


Figure 11-1: Peak Ground Acceleration (GHSAP (left) and Council of Geoscience (right).

11.2. Input Parameters to the Slope Stability Models

The slope stability model was defined in terms of the physical configuration of the structure and its foundations as well as the geotechnical properties of the tailings material, and the foundation material. Two types of slope stability analyses are conducted:

- Static analyses which determine the FoS without the addition of PGA (i.e. without an earthquake event); and
- Pseudo-static analysis which incorporates the PGA into the assessment to determine FoS during a seismic event.

11.2.1. Configuration of the Stability Models

The configuration of the slope stability model and its foundations is comprised of the following:

- The same geometry that was used in the associated seepage analysis;
- The phreatic surface determined by the associated seepage analysis;
- In-situ soils modelled with engineering properties obtained from laboratory testing;

- Pseudo-static analysis performed with a PGA of 0.03 g for the RSF;
- It is envisaged that the RD will be constructed in 2 phases as is illustrated in Figure 11-2 and Figure 11-3.

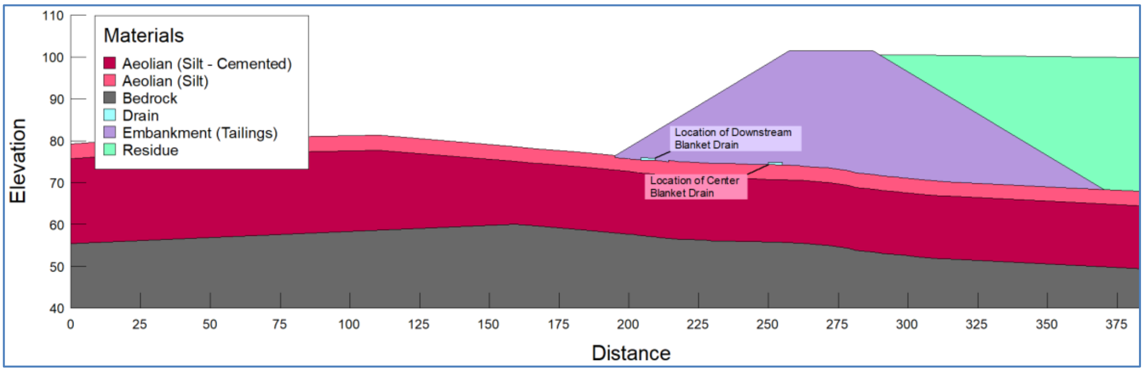


FIGURE 11-2: OPERATIONAL PHASE AT CAPACITY

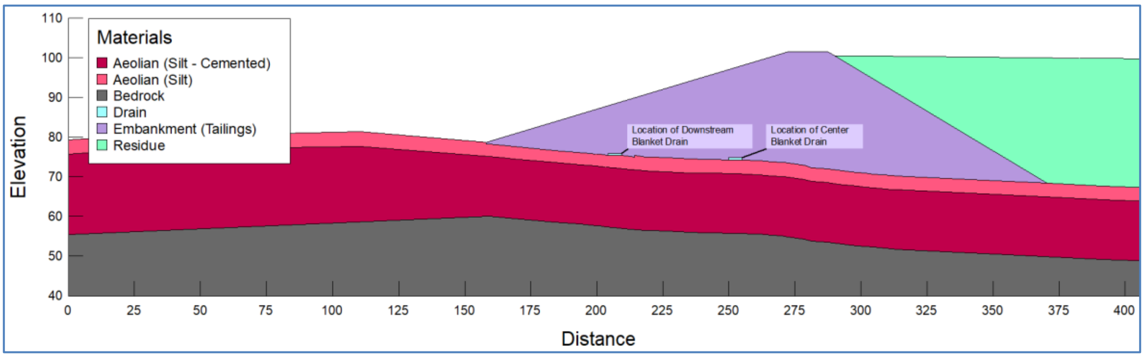


FIGURE 11-3: CLOSURE PHASE AT CAPACITY

The geometry used to analyse the operational and closure phase of the RD cross-section along the Critical section is listed in Table 11-1.

TABLE 11-1: SUMMARY OF RSF GEOMETRY FOR STABILITY ASSESSMENT

Feature	Operational Phase	Closure Phase
Crest Elevation (m.a.m.s.l.)	101.5	101.5
Minimum Toe Elevation (m.a.m.s.l.)	74.26	74.41
Maximum Wall Height (m)	27.24	27.09
Crest Width (m)	30	15
Upstream Slope	1V:2.5H	1V:2.5H
Downstream Slope	1V:2.5H	1V:5H

11.2.2. MATERIAL PROPERTIES

The input geotechnical parameters used in the slope stability analysis of the RD are summarised in Table 11-2. It was assumed that RAS or EOFS tailings would be used to construct the containment wall of the facility. It was also assumed that the layer of dune sand that covers the area will be removed and sent to the mines processing plant. The remaining predominant soil profile consists of silty Aeolian sand that becomes weakly cemented with depth. It was assumed that a 3.5 m deep layer of Aeolian material overlays a 15 m deep layer of weakly cemented material before encountering bedrock in the form of very soft rock dorbank.

TABLE 11-2: GEOTECHNICAL PARAMETERS USED FOR SLOPE STABILITY ANALYSIS

Region	Unit Weight (kN/m^3)	Friction Angle (degrees)	Cohesion (kPa)
Residue	15.0	33	0
Embankment (Sand tailings)	16.0	30	2
Aeolian (Silt)	16.0	32	0
Aeolian (weakly cemented)	19.0	40	0

11.3. RSF STABILITY RESULTS

A detailed list of the results obtained from the slope stability assessment of the RD are published in Epoch's Stability report contained in Appendix F, along with the critical slip surface generated for each model.

The results of the slope stability assessment have been separated into three sections. The first section considers results from the analysis of the upstream face of the embankment with the residue encroaching on the toe of the wall to determine the stability of the upstream face prior to it being "buttressed" by the residue. The second section investigates the stability of the downstream face of the operation phase of the embankment once the maximum deposition capacity of the RD has been reached. The last section discusses the FoS against a failure of the downstream slope of the containment wall of the closure phase.

11.4. Discussion of Results

The results of the slope stability assessment indicate that the facility is stable under static loads for the short, medium and long-term slopes under all scenarios considered. A blanket drain is required to achieve FoS above the minimum required value of 1.5 for the downstream slope of the operational phase in the event of pseudo-static conditions. Additionally, it is advised to include the drain as a means to prevent water seeping through the downstream toe of the embankment.

Similarly, to the downstream face, the upstream face of the embankment yielded FoS greater than 1.5 for static conditions. However, all pseudo-static loading conditions resulted in FoS below 1.5 with a minimum of 1.427. It is argued that the upstream slope will be buttressed with residue as residue deposition takes place, and the resultant slip surface does not compromise the majority of the wall. As such FoS greater than 1.4 are considered acceptable for the upstream short term slope under pseudo-static conditions.

It is recommended that the stability models be reassessed in the detailed design phase of the project should the seepage models change once the bedrock permeability has been confirmed.

12. RESIDUE OPERATIONAL METHODOLOGY

The depositional technique selected for this project will be a full containment, hydraulically deposited facility. The containment wall will be constructed using sand tailings material trucked from the plant, and the fine residue will be hydraulically deposited behind the wall. This design is a common construction technique used in residue storage facilities.

The residue will be discharged from the top of the dam crest creating a beach with the resulting supernatant pool developing as far away from the wall as possible. Natural segregation of the material occurs where the coarse material settles closest to the deposition points and the fines furthest away.

As the residue is expected to be ultra-fine, more water is expected to be locked up between the residue particles, resulting in lower densities and strength. Another consequence of ultra-fine residue is very flat beaches are expected to form, which could make pool control difficult and will require careful management by the operator.

For the selected depositional methodology, residue is deposited into the RSF basin via an open-ended pipeline located on the inner crest of the perimeter wall as shown in Figure 12-1. During commissioning, deposition of the residue behind the containment wall is directed to the base of the inner toe of the containment wall by flexible hoses. Deposition during this stage is to be carefully controlled, monitored to ensure that the walls are not eroded by the residue stream.

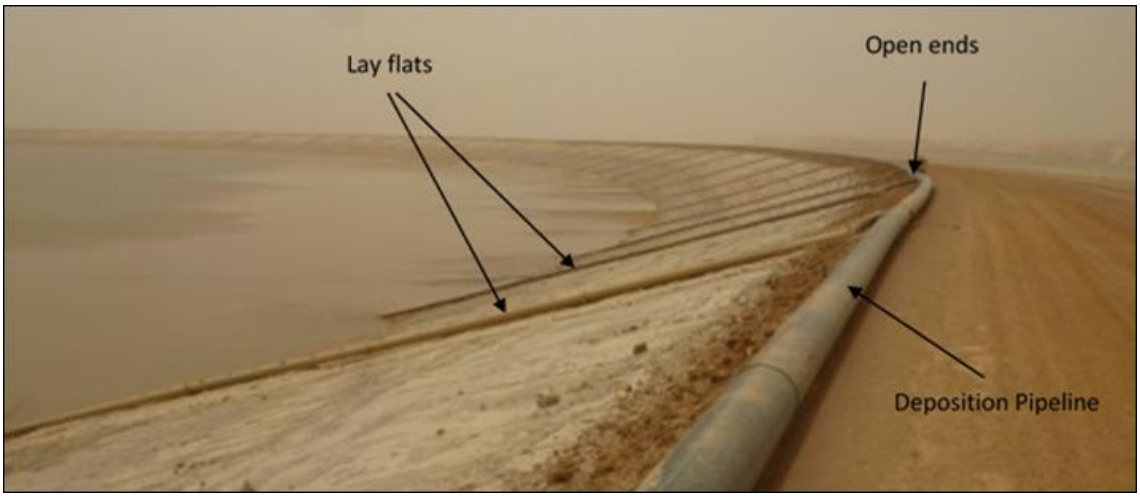


FIGURE 12-1: RESIDUE DEPOSITION FROM MULTIPLE OPEN ENDS

13. WATER BALANCE

Water from the supernatant pool will be returned directly to the plant. As the RSF is a full containment facility and capable of storing storm events, no return water facility has been provided for in the design of the RSF. All excess water arising from storm events, will need to be stored on the RSF and returned to the plant as part of the process make up water requirements. This is discussed further in Section 13.4 below.

A water balance study has been undertaken for the Tronox RSF in order to assess the expected range of daily returns to the plant as well as the volume of excess water to be stored on the facility. This section summaries the findings of the study. The full report can be found in Appendix G.

A deterministic approach was followed during the assessment of the inflow and outflow relationship associated with the proposed RSF. The model makes use of daily rainfall values from the Nuwerus weather, situated 43 km east of the Tronox RSF location, as well as the natural topography associated with the site and deposition data determined from stage capacity calculations. An illustration of the RSF and its associated infrastructure, estimated beach slopes and catchment area can be seen in Figure 13-1.

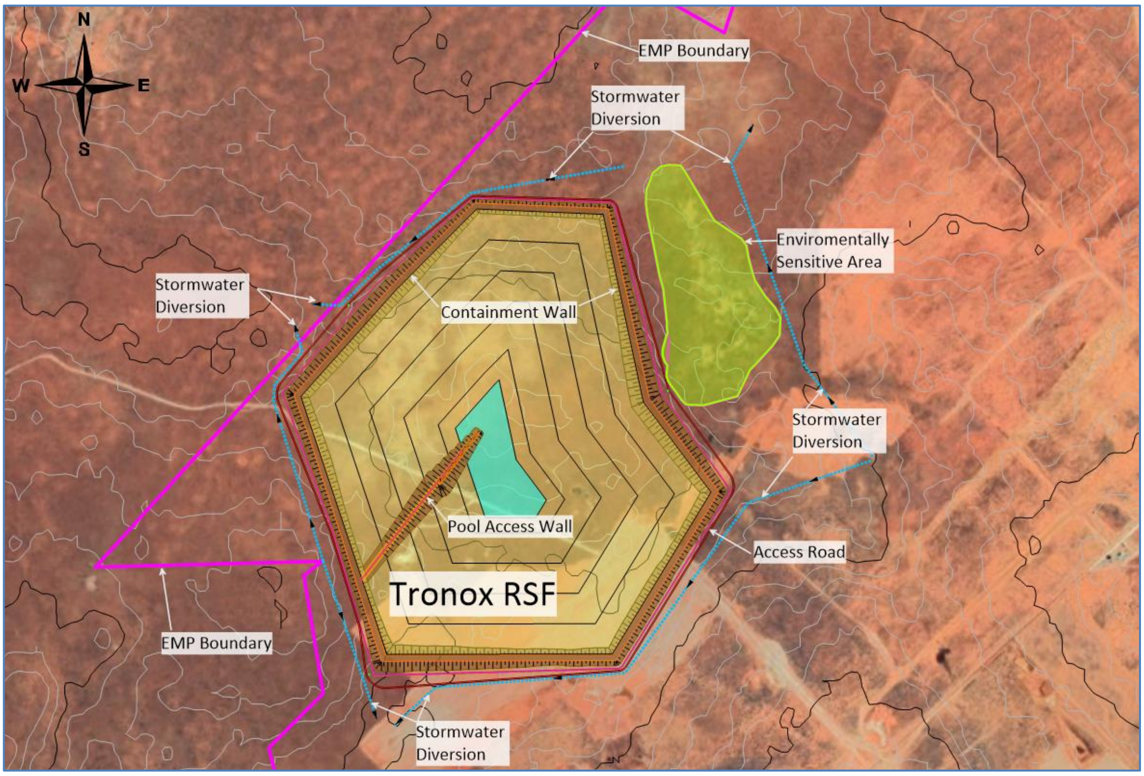


FIGURE 13-1: TRONOX RSF AT FULL CAPACITY

The water balance model assesses the volume of water that will be reporting to the RSF pool. The model quantifies the inflows and outflows of water that would affect the volumetric fluctuation of the pool.

Inflows into the RSF include:

- Rainfall run-off from the catchment area of 311 Ha, consisting of the dry beach, deposition beach, and pool surface area, and;
- Residue delivery water.

Outflows from the RSF include:

- Evaporation;
- Return water (via pumps);
- Interstitial lock-up between residue particles; and
- Seepage.

The various inflows are calculated for each day based on the pool size, deposition tonnage and related deposition area as well as the remaining catchment area of the dry beach. The daily outflows are subtracted from the daily inflows and the remainder is added to the pool volume of the previous day to determine the current day's pool volume and area.

13.1. PLANT RETURNS

A summary of the expected daily plant returns is listed in Table 13-1. The average daily volume of water sent from the plant to the RSF is 17 521 m^3. The results show that an average annual return of 58.9 % of the residue water reporting to the RSF can be expected during an average rainfall year. During periods of high rainfall, it is possible to return 100 % of the residue water reporting to the RSF. The simulation also indicated that a pump with a decanting capacity of 860 m^3/hr would be active for an average of 11.03 hours per day. Periods of peak activity (24 hr active pumping hours) followed days of substantial rainfall due to the increase in available return water.

TABLE 13-1: EXPECTED DAILY RETURN VOLUMES FOR AN AVERAGE YEARLY RAINFALL

Descriptor	Unit	Values
Wet Season Average Daily Return (May to Aug)	m^3	10,867.6
	%	64.2
Dry Season Average Daily Return (Sep to Nov)	m^3	10,135.4
	%	59.0
Average Daily Return per Yearly	m^3	10,440.5
	%	61.2
Minimum Daily Return	m^3	2,640.9
	%	53.2
Maximum Daily Return	m^3	21,732.6
	%	100.0
Minimum Monthly Return	m^3	84,271.9
	%	54.8
Maximum Monthly Return	m^3	438,276.1
	%	66.9

13.2. FREEBOARD

The total freeboard of a dam is defined as the vertical distance between the normal Full Supply Level (*FSL*) and the nominal Non-Overspill Crest (*NOC*) of the dam. Freeboard is divided into two components namely the flood surcharge rise above the FSL, the primary component, and a secondary component allowing for wind, wave and surge effects (SANCOLD, 2011). In the case of a RSF, the beach freeboard developed by the deposition of the residue provides additional storage of water within the basin. The different freeboard components are illustrated in Figure 13-2.

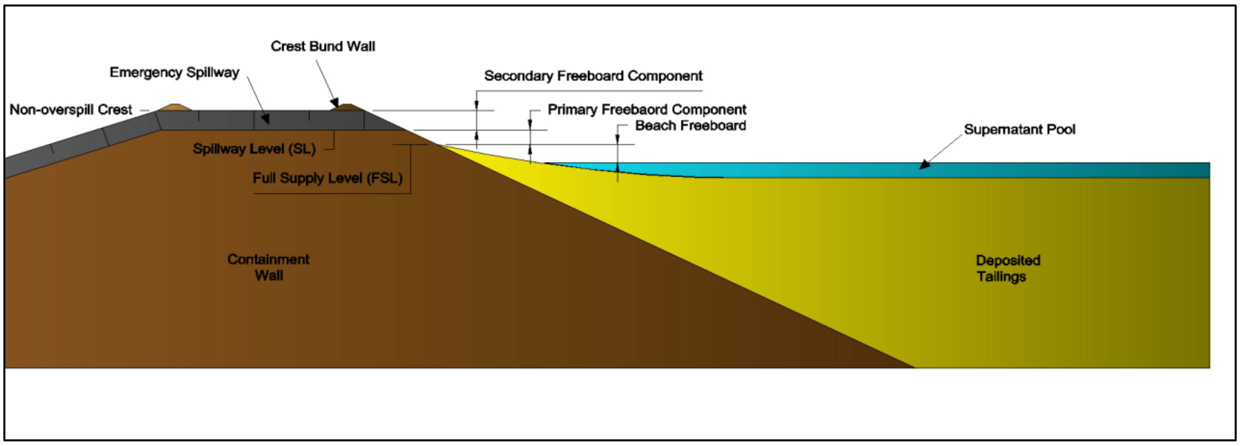


FIGURE 13-2: TYPICAL PROVISION OF FREEBOARD ON A FULL CONTAINMENT RSF

Based on South African regulation GN704 of the National Water Act, the minimum freeboard requirement for the Tronox RSF is 0.8 m, over and above the storage of the 1 in 50-year design flood (primary freeboard).

The walls of the facility will be constructed within the first years of operations to final elevation resulting in a substantial freeboard that slowly decreases as residue is deposited within the basin of the RSF. Geometric modelling of the RSF indicates that the minimum available freeboard between the surface of the maximum operating pool and the no overflow crest of the facility is estimated to be 2.61 m, with a beach freeboard of 1.67m and a primary freeboard of 1m. Thus, adequate freeboard is available to accommodate the 1:50 year storm event as well as its accompanying wave action.

13.3. Supernatant Pool Management

The large catchment area of the RSF combined with instances of high rainfall result in an increase in the supernatant pool volume during the wet season.

The dry season of the project typically experiences a notable net negative inflow of run-off water as evaporation exceed the volume of recharge received by rainfall. It would be expected that an overall decrease in the supernatant pool volume will occur in the dry seasons. The risk of beaching the decanting system is increased if the supernatant pool volume decreases too rapidly. It is thus essential to manage the returns from the RSF such that the minimum permissible storage volume is maintained to prevent the damage or loss of the decant equipment. It is assumed that a minimum dead storage volume of 20 000 m^3 (to allow for a minimum pool depth of 400mm) must be maintained on the Tronox RSF to mitigate the risk of damage or loss of the decanting infrastructure.

A gradual drawdown approach is proposed that balances the water returns from the RSF such that the minimum dead storage is not depleted by the end of the dry season.

13.4. Storm Water Management

Section 123(1) of the National Water Act, 1998 (Act No. 36 of 1998) defines a “dam with a safety risk” as a dam storing more than 50 000 m^3 and a wall of vertical height more than 5 m. Based on the daily water balance, the RSF supernatant pool volume pool would not exceed 43 328 m^3 at any given point under normal operating conditions, thus not exceeding the 50 000 m^3 requirement.

During storm events, the volume of water reporting to the RSF will increase and need to be decanted as Process Plant make-up water over a short period of time. The average daily plant outputs and returns where considered in order to estimate the time over which storm water can be bled off the RSF back to the Process Plant.

Average daily Process Plant outflows equals 25 947m^3 comprising of:

- Thickener underflow water (to RSF) (17 521 m^3);
- Concentrate water (3 314 m^3); and
- Sand Tailings water (5 112m^3).

Average daily Process Plant returns equate to 17 150 m^3 comprising of:

- RSF return water (10 434 m^3);
- Sand tailings return water (3 578 m^3); and
- ROM water (3137 m^3).

This leaves an average daily deficit of 8 797 m^3/day .

Storm water stored on the RSF (when available) can be used to make up this deficit. The average time taken to decant the storm water from the RSF for a given 24hr storm event is depicted in Table 13-2.

TABLE 13-2: TIME TAKEN TO DECANT A STORM EVENT

Storm Return Period (years)	Storm Event (mm)	Volume of storage (m^3)	Time taken to bleed of storm event (days)
2	30	93 195	10.6
5	41	127 367	14.5
10	49	152 219	17.3
20	58	180 177	20.5
50	69	214 349	24.4
100	78	242 307	27.5
200	87	270 299	30.7

With the RSF being a full containment facility, it is capable of storing any of the above storm events for the listed period of time, without compromising the stability of the RSF as detailed in Section 10.2 and 11.4 above. Furthermore, given that the RSF will be returned to normal operating conditions within a short period of time, the facility is not considered a dam with a risk classification and as such no Storm Water Dam was included in the design of the RSF.

14. RESIDUE STORAGE FACILITY DESIGN

The RSF comprises:

- A Residue Dam; and
- Associated infrastructure (i.e. slurry deposition pipeline, pool access wall, decant system, storm water diversion, access road)

14.1. RESIDUE DAM DESIGN

The location and footprint area of the RD was influenced by the following factors:

- The average in-situ placed density of the residue;
- The required capacity for the residue;
- The topography (rivers, ground slopes);
- Climatic conditions;
- The receiving environment in the area of the facility;
- Acceptance of level of risk by Mine owner for long term environmental liability;
- Type of facility required (self-raising versus full containment); and
- The overall outer slopes of the facility.

The overall operational layout of the RSF is shown in Figure 14-1. Table 14-1 summarises the key layout parameters of the RD.

TABLE 14-1: KEY PARAMETERS ASSOCIATED WITH THE TRONOX RD

Item	RD Parameter Description	
1	Total Footprint Area of RD	350 Ha
2	RD Wall Elevation	101.5 mamsl
3	Final Residue Elevation	101.5 mamsl
4	Maximum Height of RD wall	27 m
5	Wall Length	6 617 m
6	Upstream Side Slopes	1V:2.5H
7	Downstream Operational Side Slopes	1V:2.5H
8	Downstream Closure Side Slopes	1V:5H
9	Time Period for Residue to reach Design Capacity	20 years

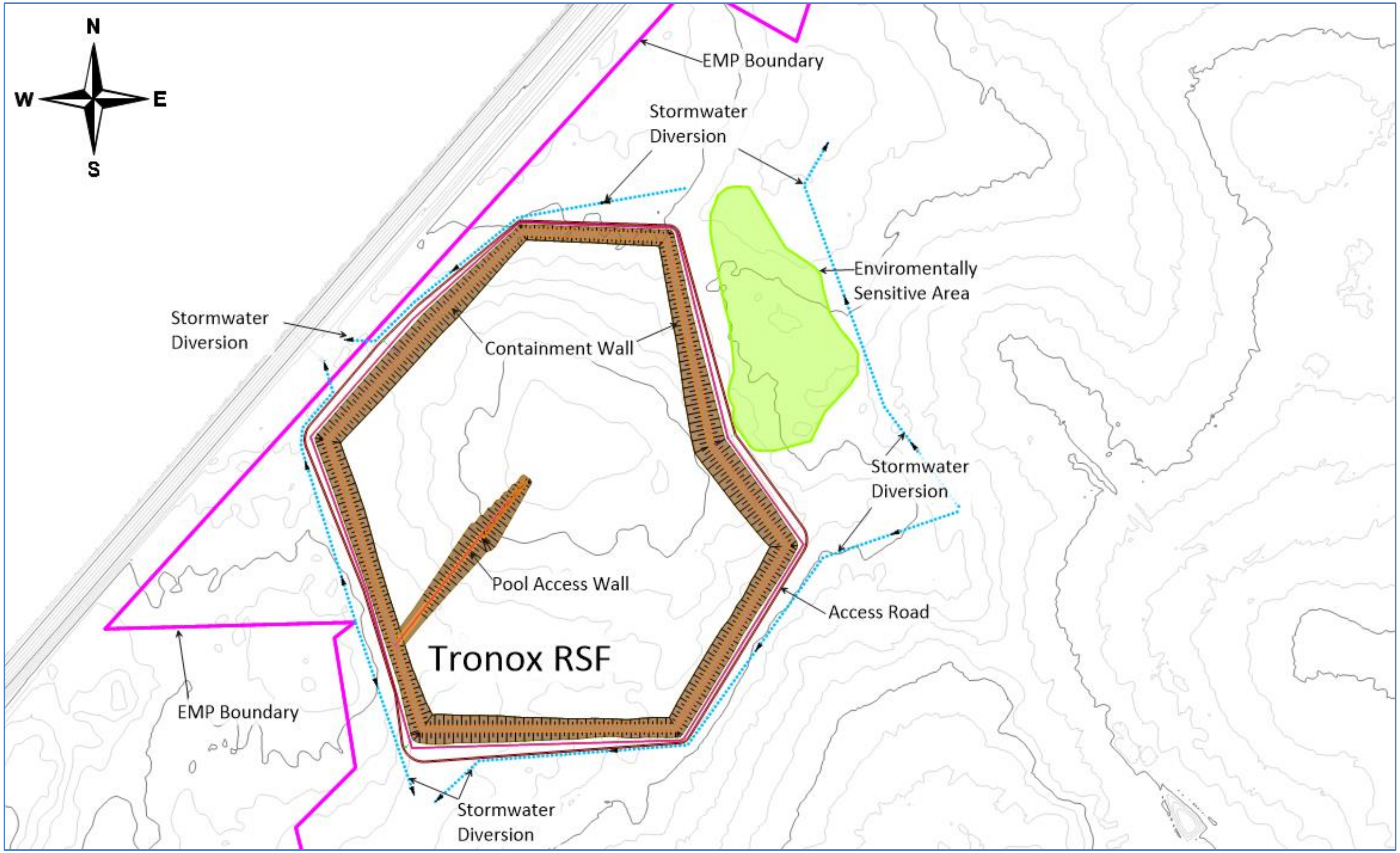


FIGURE 14-1: RSF LAYOUT

14.1.1. Containment Wall Design

Containment wall:

The mine will endeavour to construct the containment walls to final elevation (101.5 m.a.m.s.l) prior to the commissioning of the facility and failing this, the walls will be completed prior to the residue breaking ground in the basin. The wall will be constructed over two phases, the operational and closure phase. The operational wall will be 27 m high (101.5 mamsl) from the lowest downstream point. It will have a crest width of 30 m, with upstream and downstream slopes of 1V:2.5H. A 0.5 m high safety bund will be provided on either side of the crest of the wall.

The wall will be constructed using coarse sand tailings material sourced from the plant. The material will be trucked to the RD and tipped. No formal compaction of the material is to be undertaken. Once in position the material will be dozed to create the required side slopes.

The volume of the operational phase wall is 9 443 703 $m^{3.}$ The closure phase of the facility will require the downstream slope of the RD to be flattened to 1V:5H by reducing the crest width to 15m and introducing some additional 692 574 m^3 of sand tailings into the wall. The volume of the wall at the closure phase will be 10 136 277 m^3.

Containment wall foundations:

The geotechnical investigation indicated that the top 2 to 3 m of insitu material is either very loose dune sand or very loose fill material, and recommended that this material be compacted prior to the construction of the RD walls. As the dune sands are to be mined from the RSF footprint prior to the construction of the RSF (i.e., removed from the RSF footprint area), compaction of this material will not be necessary.

The loose fill material, located in the south east corner of the RSF footprint area, is to be removed from beneath the RSF walls.

Pool access wall:

The pool access wall will comprise a 10 m wide embankment running from the crest of the wall into the basin of the RD. Seven benches, each 5m high, have been incorporated at the end of the pool wall to allow for the placement of the turret decant pump. An access ramp leading to each bench will allow for the pump to be towed up to the following bench as the residue level increases in the RD, always allowing access to the pumps and turret. The wall will be constructed with a sand tailings core, cladded with a geofabric and compacted selected borrow material. The material will be compacted to at least 98% standard proctor density within 1.5% to 2% wet of optimal moisture content.

14.1.2. Contaminant Barrier System

The National Environmental Management: Waste Act (NEMWA) of 2008 GN.R.634 to R.636 provides the legislation pertinent to the waste classification of the residue stream, and the requirement for lining the RSF thereof. The regulations allow for a risk-based approach to design (i.e. design and management measures, including containment, should be commensurate with the level of risk posed to the environment).

The RSF is a potential groundwater contaminant source of the EOFS Project. SRK undertook a geohydrological study to determine the impact the RSF would have on groundwater as detailed in their report "*East OFS Project Residue Disposal Plan, Groundwater Specialist Study*", Dec 2020. The Groundwater study undertaken modelled the contamination plume emanating from the RSF for three base preparation scenarios. The model comprised of the various layers depicting the insitu soil profiles, overlain be a 300m layer. The permeability (K) of this layer was varied to simulate the different base preparation scenarios as follows:

- Scenario 1 (Sc1): "as is"/no base preparation: This scenario assumes that no base preparation is required for the RSF, thus the base layer is set to the same permeability as the residue material itself (1 x 10^{-8} m/s);
- Scenario 2 (Sc2) – engineered base preparation. This scenario assumes there is base preparation for the RSF. Although considered as an option, this scenario was not numerically modelled as the permeability for the engineered base preparation (Sc2) is higher than the residue material deposited in the RSF (as modelled in Sc1), thus it was not deemed necessary to model as the impact would be greater than that of Sc1.
- Scenario 3 - liner. This scenario assumes a Class C type liner with two different 'equivalent K' values for the 0.3 m composite base, as follows:
    - Scenario 3a (Sc3a): A "reasonable" Class C (HDPE and CCL) installation, represented by an equivalent 0.3 m thickness with permeability of 5.13 x 10^{-9} m/s; and
    - Scenario 3b (Sc3b): An "excellent" Class C (HDPE and CCL) installation, represented by an equivalent 0.3 m thickness with a permeability of 1.47 x 10^{-10} m/s.

The modelled results show that the contaminant footprint areas and concentrations are very similar for Sc1 and Sc3 (a & b): i.e. there is little difference/impact between the various RSF base preparation design options and can be summarised as follows:

- Average groundwater concentrations in 2051 in the local area directly underlying the RSF decrease by 7% and 13% for Sc3a (lined – moderate) and Sc3b (lined-excellent) respectively, in comparison to Sc1, whereas concentrations more than 200m beyond the RSF footprint are very similar across scenarios;
- The contaminant footprint areas and concentrations are very similar between Sc1 and Sc3 (a & b), thus there is little difference between the various RSF base preparation design options. The contaminant plume does not migrate further than 200 m from the facility;.
- There is little difference (<5 m) between the modelled scenarios in terms of the water level increases for the various RSF base preparation design options.

TABLE 14-2: AQUIFER CONCENTRATION VS PLUME EXTENT

Aquifer	Conc. Max (% of source)			Max distance (m) beyond footprint of facility (where conc. >5%)
	Sc1	Sc2	Sc3	
Primary	100	93	87	200
Secondary	92	86	80	350

The natural background water quality in the area has a mean EC of c.1000 mS/m indicating poor water quality.

Based on the above risk-based approach and the existing poor water quality, the inclusion of any type of liner system would not yield significant environmental benefit. It is thus proposed that no liner/ base preparation be included in the design and construction of the EOFS RSF6.

14.2. Water Management Design

Water management requires careful consideration for any RSF, due to the non-cohesive nature of residue and its propensity to flow freely when over saturated. For the Tronox RSF, water management implies the removal of supernatant water from the RD, preventing large quantities of rainwater being stored on the RD, reducing the seepage through the downstream toe and keeping clean storm water off the downstream toe of the RD.

The RSF requires the following water management systems:

- A floating pump system for removing supernatant water from the RD;
- Storm water diversion berms to prevent/reduce surface run-off reaching the toe RD;

14.2.1. Decant System

The RSF has been designed as a full containment dam, which provides certain advantages with regards to the storage of water on the RSF. The containment walls are constructed from competent material providing increased strength, thus increasing the stability of the facility, even in the event of a raised phreatic surface due to water being stored on the RSF.

A penstock dewatering system typically consist of a vertical decant tower, leading to a below ground outlet pipeline, gravity feeding the supernatant water to the return water facility at the toe of the RSF. As the natural topography of the site does not allow for the supernatant water to be gravity fed to a return water facility without excessive excavation (over 20 m deep), the use of a penstock was not considered in this study.

Supernatant water on the RD accumulates in a pool as a result of beaching and deposition control. This supernatant water, derived from the process plant and from rainfall, will be decanted from the surface of the RD for the following reasons:

- To prevent accumulation and eventually overtopping;
- To allow drying and consolidation of the residue; and
- To reduce the potential development of pore water pressures with potential stability issues.

Supernatant water from the RSF will be decanted and released by means of a floating pump system. The system is specially designed to operate in shallow water and cause minimal agitation of the settled residue. The system incorporates an external pump, which is positioned on the pool access ramp. The external pump is moved up the ramp as the residue level and supernatant pond level raises. The system has a floating inlet structure, known as the Turret (illustrated in Figure 14-2), which is placed in the supernatant pond and allows water to be extracted through the suction end without agitating or collecting the settled residue below the pond. Figure 14-3 illustrates how the turret extracts water from the pond. The manufacturer states that a single Turret can operate at flows up to 1 000 m³/hour, and is operable in ponds with depths not less than 400 mm. Based on this a minimum pool volume of 20 000m^3 must be maintained on the RD at all times.

FIGURE 14-2: TURRET SYSTEM POSITIONED IN THE SUPERNATANT WATER CONNECTED TO AN EXTERNAL PUMP

The pool access wall will be constructed to allow vehicles to drive along it in order to gain access to the pumping system. The floating pump conveys the supernatant water directly back to the plant.

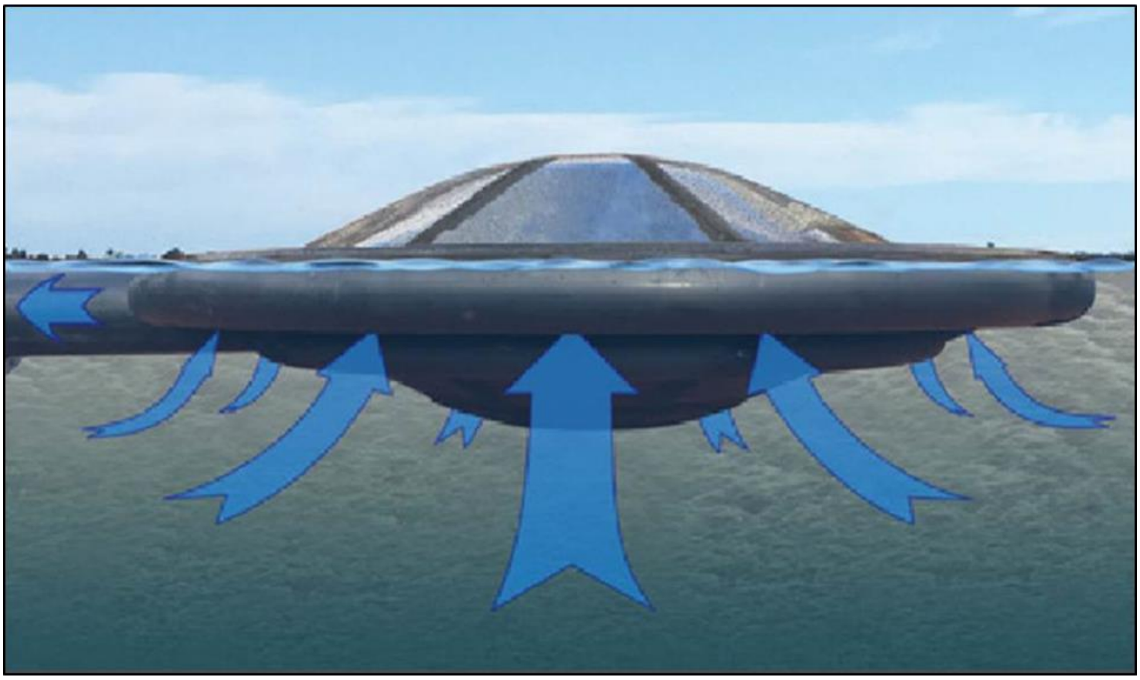


FIGURE 14-3: DESIGN FUNCTIONALITY OF THE TURRET SYSTEM

14.2.2. CLEAN STORM WATER DIVERSION

Storm water diversions are required to divert clean run-off around the RSF. Storm water diversion bunds has been provided to divert the 1 in 100-year storm event from the catchment around the RSF.

15. RSF PREPARATORY WORKS

The preparatory works associated with the RSF are discussed below. General Arrangement and typical section drawings are contained in Appendix H. The CQA plan and project construction specifications are contained in Appendix I.

15.1. CONTAINMENT WALL BOX-CUT

As discussed in Section 14.1.1, the containment wall will be founded on Aeolian soils after the removal of the loose dune and fill sands. For the preparatory works, a box cut 500 mm deep box-cut will be excavated beneath the outer 20m of the wall footprint area to allow for the construction of the blanket drains. The box cut will then be backfilled with coarse tailings material.

15.2. CONTAINMENT WALL

The containment wall will be constructed using sand tailings material which is to be trucked and tipped. It is to be constructed with upstream and downstream side slopes of 1V:2.5H. The operational phase wall will be constructed to 101.5 m.a.m.s.l with a maximum height of 27 m and a 30m crest width.

The closure phase will require the crest of the wall be reduced to 15 m and the side slopes to be flattened to 1V:5H. The wall elevation will remain at 101.5 m.a.m.s.l.

15.3. STORM WATER DIVERSION BUND

The storm water diversions will comprise of a minimum of a 1.5 m high, 1 m wide crest bund, constructed from insitu material nominally compacted. The bunds must be maintained on an ongoing basis during operations to ensure they are maintained at their minimum dimensions.

15.4. POOL ACCESS WALL

The pool access wall (10m wide) will be constructed with a sand tailings core and cladded with a geofabric and selected material compacted to 98% standard proctor density within 1.5% to 2% wet of optimal moisture content.

15.5. BLANKET DRAINS

A blanket drain will be constructed in the containment wall, located 10 m from the downstream toe of the wall. The blanket drain will be 5m width and comprise of geofabirc, slotted HDPE pipes, 6 mm stone and 19 mm stone.

15.6. Blanket Drains Outlets and Manholes

A blanket drains outlets will be constructed at the low points of the blanket drain to convey seepage water to the outlet manholes. The outlets will be 1.1m wide and comprise of geofabirc, non-slotted HDPE pipes and 19 mm stone. The manholes will comprise of 4 to 5, 1m high precast concrete chambers placed on a concrete base.

15.7. Catchment Paddocks

Catchment paddocks are to be constructed along the downstream toe of the containment walls. These will have an average height of 1m and will serve the purpose of catching and storing rainfall runoff from the side slope of the walls. During the initial stages of operation, these paddocks will also catch and contain the water seeping from the coarse sand tailings used to construct the wall, as it is understood that the tailings will be placed with a 20% moisture content. Water contained in these paddocks will be allowed to evaporate and not be pumped back to the plant.

16. CLOSURE, REHABILITATION AND AFTERCARE REQUIREMENTS

The proposed rehabilitation, closure and aftercare measures for the RSF are described below.

The rehabilitation, closure and aftercare plan are based on the assumption that the objective of the process is to rehabilitate, as far as possible, the area disturbed during the establishment and operation phases of the project.

16.1. Closure Activities at Cessation of Operations

At the cessation of operation of the RSF, the focus will be on the cover and vegetation of the top surface of the facility, the decommissioning of facilities associated with the RSF and the construction of storm water control measures if required, such as an overflow spillway. Specific activities that will be carried out will include:

- The dismantling and removal from site of all pipes and supports associated with the residue delivery and return water systems;
- Flattening the downstream side slopes of the RD to 1V:5H by reducing the wall crest width to 15 m and dozing the existing material down to the required slope. An additional 692 574 m^3 of RAS material will be required to achieve the required slopes. Given the large volume of RAS Tailings available during the construction phase of the containment walls, it is recommended that these walls be constructed to closure requirements side slopes of 1V:5H from the onset. This will negate the costs of double handling of material and will allow for the cladding and vegetating of the side slopes of the RSF during the operational life of the mine. This would also assist in reducing the dust originating from the side walls of the RSF during the operation of the facility.
- Capping of the top surface area of the RD with a layer of coarse tailings. The residue is an extremely slow settling and consolidating material with correlating low placed dry density of 0,6t/m^3, the time required for the residue to fully consolidate is expected to exceed 500 years. As such 1m layer of tailings is to be introduced onto the top surface of the RD on a progressive front basis. A layer of material will be placed on the traversable area of the RD (adjacent to the RD containment wall). Once the region adjacent

to the capped layer has consolidated sufficiently to allow it to be traversed, a capping layer will be applied to it, and the process continued until the entire crest is capped. The capping of the top surface is to be done in such a manner so as to allow for the collection of all storm water to report to a central point on the RD and allow for the water to evaporate and/or infiltrate into the facility;

- Construction of evaporation dam. With the application of the capping layer, lock-up water contained in the Residue would be released and should be pumped off the RSF surface so as to further assist with consolidation. As the Process Plant will be de-commissioned at the end of LoM of 20 years, this water cannot be returned to the plant. It is thus recommended that a facility be constructed that will provide sufficient storage of both storm water and released lock-up water to be stored and allow this water to evaporate over time. This evaporation facility would be decommissioned once the RD is fully cladded and the decant barge and return water pipelines can be removed from the RD;
- The placement of a mixture of soils and selected waste materials to the outer slopes of the walls and cladded top surface of the RD in preparation for the establishment of vegetation;
- The planting/seeding of vegetation to the outer slopes of impoundment wall and top of the RD to assist in the prevention of erosion;
- The aftercare and maintenance of the cover layers and vegetation; and
- Minor earthworks to drains, roads, silt trap, trenches, etc.

The duration of the final closure process may be affected by the length of time required for the basin of the facility to dry sufficiently to enable the placement of cover material in preparation for the vegetation establishment.

The soils placed on the outer slopes of the RSF need to be protected against erosion. This will be done by a combination of mixing with selected waste material and the establishment of vegetation to the cover. The mixing of soil with material of a gravel/rocky nature has been found to be effective in improving the erosion resistance of cover layers to sloped areas. The establishment of vegetation to the side slopes of the facility could be done by hand planting, seeding or hydro-seeding and should comprise a mixture of grass and shrubs. The vegetation used in the establishment of the vegetative cover will all be indigenous and should not require irrigation.

16.2. Aftercare and Maintenance Requirements

On completion of the final rehabilitation and closure works, an aftercare and maintenance program will be required to assist in ensuring that the closure measures are robust, have performed adequately and that no further liabilities arise. The aftercare period is normally not less than 5 years but can extend into decades depending on the physical and chemical characteristics of the facility. The aftercare and maintenance program for the Tronox RSF is expected to include:

- Periodic inspection of the cover and vegetation for signs of erosion damage and failures of the vegetation establishment process;
- Repairs and amendments to the closure works as necessary;
- Re-planting of areas of vegetation where required;

- Periodic inspection and monitoring to confirm the effectiveness of the closure works in achieving the stated closure objectives, including:
  - Collection and analysis of ground and surface water samples;
  - Measuring of phreatic surfaces within the RD and assessment of the overall structural stability of the facility; and
  - Inspections of spillway for signs of damage.

No allowance has been made for the treatment of water that will need to be discharged into the environment from the RSF after closure, as any discharge post closure is considered as clean water. This will however need to be confirmed during closure.

The maintenance requirements for the facility should decrease with time and should be confined to minor earthworks to repair erosion damage and upgrade facilities as required, as well as re-planting of areas of vegetation damaged due to erosion.

17. LIFE OF MINE COST ESTIMATE

An estimate of the Life of Mine (*LoM*) costs associated with the construction, operation and rehabilitation and closure of the RSF will be compiled based on schedules of quantities to be priced by prospective contractors. These costs are envisaged to be available in May 2021 and will be included in the final submission of this report. SRK have however included a closure cost for the RSF in their overall closure cost assessment for the EIR application.

18. RSF RISK IDENTIFICATION

Residue Storage Facilities pose a significant hazard to people and property around them as well as significant costs to the client.

The size and degree of the potential hazard depends on the location and size of the RSF, site specific characteristics, method of construction, residue material characteristics, construction materials, method of RSF development, operational control, closure planning and monitoring, and overall management.

18.1. SAFETY CLASSIFICATION

The RSF was classified according to the South African National Standards, Code of Practice for Mine Tailings (SANS 0286:1998). This classification provides the bases for the implementation of safety management practices for specified stages of the life cycle of a Tailings Dam. The code prescribes the aims, principles and minimum requirements that apply to the classification procedure. The classification in turn gives rise to minimum requirements for investigation, design, construction, operation and decommissioning.

The safety classification serves to differentiate between high, medium and low hazard on the basis of their potential to cause harm to life or property.

The zone of influence, as shown in Figure 18-1, may be described as the extent of the area around the RSF that may be affected with time, taking into consideration the possible impacts that may arise from the RSF e.g. flow slide, sterilisation of arable land etc.

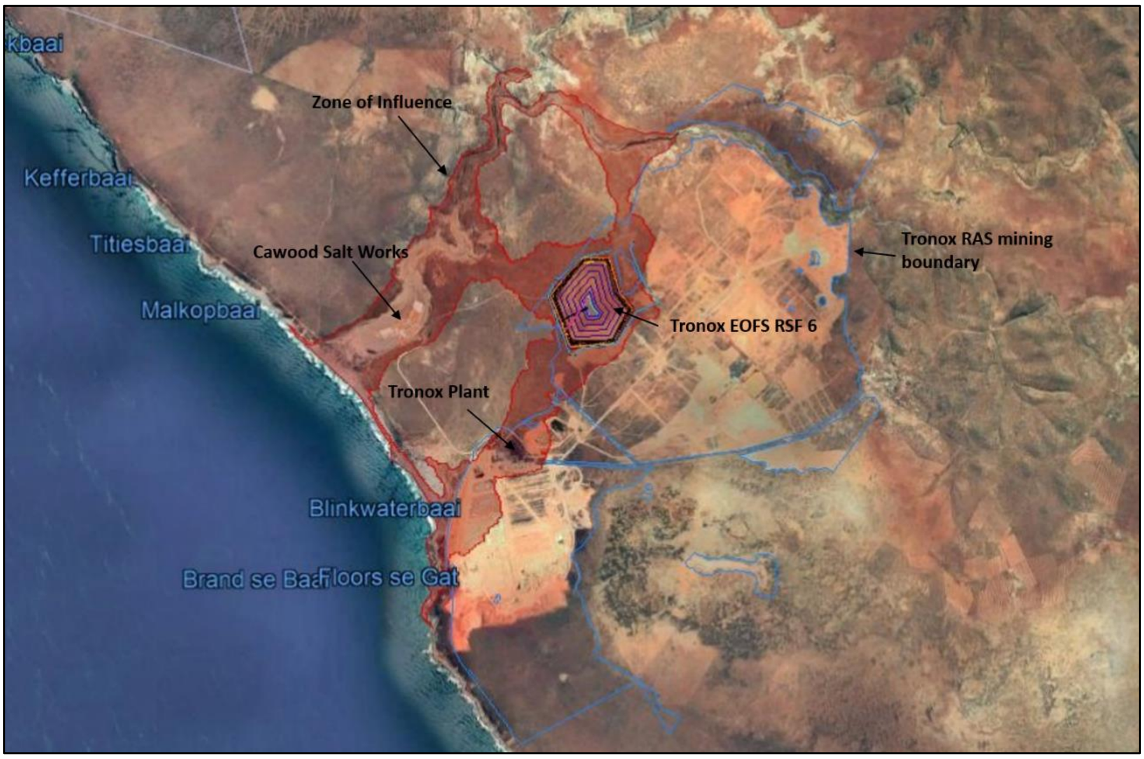


FIGURE 18-1: ZONE OF INFLUENCE FOR THE RSF

The safety classification of the RSF under each criteria is listed below in Table 18-1.

TABLE 18-1: DAM SAFETY CLASSIFICATION

Criteria	Comment	Safety Classification
Number of residences in the zone of influence	Zero, based on Google Earth images	Low Hazard
Number of workers in the zone of influence	Probably more than 100, as the plant of the mine is within the zone of influence.	High Hazard
Value of third party property in the zone of influence (replacement value in 1996 terms)	The neighbouring Cawood Salt Works Mine is in the zone of influence; therefore the costs will exceed 20 million ZAR	High Hazard
Depth to underground mine workings	No underground mining within the zone of influence.	Low Hazard

Based on the safety classification criteria detailed in the code of practice, the RSF has been classified as a High hazard dam as two of the criteria fall under the high hazard rating.

The minimum requirements associated with a high hazard dam are listed in Table 18-2.

TABLE 18-2: SUMMARY OF MINIMUM REQUIREMENTS ASSOCIATED WITH HIGH HAZARD SAFETY CLASSIFICATION

Planning Stage	Design Stage	Operation/ Commissioning Stage	Decommissioning Stage
Conceptualisation by owner with the assistance of a Professional Engineer	Geotechnical report required	Risk analysis by suitably qualified person	Professional Engineer appointed to monitor
Preliminary site selection by appropriate specialist	Residue characterisation by laboratory analyses	Suitably qualified person responsible for operation	Professional Engineer to audit annually
Geotechnical investigation by suitable qualified person	Design by Professional Engineer	Professional Engineer appointed to monitor	
	Risk analysis by suitably qualified person	Professional Engineer to audit annually	
	Construction supervision by Professional Engineer		

18.2. RISKS ASSOCIATED WITH THE RSF DURING CONSTRUCTION

The risk issues associated with construction are summarised as follows:

- The preferred site lies adjacent to an environmentally sensitive area. Care must be taken to not impact this area during the construction of the RSF;
- The liner requirements for the basin of the RD have not been finalised. Approval must be obtained from authorities for the exclusion of any base preparations/liner system. Should the lining of the basin of the RSF be required this would result in a significant increase in capital costs as well as lengthened construction time, jeopardising the financial viability of the project and the commissioning start date of the plant;
- Large earthmoving vehicles will be on site during construction and staff must be made aware of the dangers involved with working near these large machines. Health and Safety procedures must be adhered to.
- Diversions of clear storm water runoff must be in place prior to the construction of the preparatory works to avoid runoff damaging the works;
- The dust generated by the works to be monitored and if required dust suppression measures must be implemented.

18.3. RISKS ASSOCIATED WITH THE RSF DURING OPERATIONS

The risk issues associated with operation and mitigated in the design are summarised as follows:

- The RSF failing and causing a flow slide is a key risk. This must be managed through an intense QA / QC system, construction management/supervision during the construction of the facility and competent operational management so as to reduce the risk of failure. More specific issues and mitigation measures are identified including:
    - Piezometer be installed in the RD wall to monitor the phreatic surface within the wall;
    - The entire perimeter of the RD must be inspected on a daily basis to ensure any defects are noted as early as possible. Such as: sloughing, slips, ratholing, seepage, etc.;
- The RD it expected to have water on the dam, as well as very soft residue, such that if a person falls in they could drown. Emergency measures must be provided for such cases (e.g. safety ropes, lifesavers, etc.). Residue personnel should be aware of the dangers of falling in the RD, however the local population would not be. It is suggested that sufficient signage, warning people of the dangers, be provided. It is also recommended that the dangers of the RD is clearly explained to people living near the mine;
- The water levels on the RD must be monitored to ensure that sufficient water is pumped off the RD and not allowed to exceed 50 000 m^3 during normal operating conditions. Similarly the minimum pool operating level must be maintained so as to not run the risk of beaching the decant turret.

18.4. Risk Associated with the RSF During and After Closure

The risks associated with the RSF during closure and post closure are not as extreme as those during the construction and operation raise, however for closure some design work is required to design the storm water management system and to mitigate against soil erosion, as this can result in extensive damage downstream if not controlled.

Key risks to closure are:

- Time taken to clad the top surface area is dependent on the rate of consolidation of the residue. This may result in a lengthy closure period;
- It will be difficult to predict the long term effectiveness of the re -vegetation of side slopes and crest or the RSF; and
- There is a risk for potential for post-closure water treatment.

19. CONCLUSIONS

The following conclusions were deduced from the studies documented in this report:

- Following a site selection proceed, an appropriate site was identified for the location of the RSF capable of storing the LoM fine residue;
- The RSF has been designed to store a total of 38.9 million dry tonnes (64.83 Mm^3) of residue over a period of 20 years and comprises:
    - A RD, with a footprint area of 350 Ha and a maximum height of 27 m from the lowest contour;

- Associated Infrastructure (decanting system, pool access wall, blanket drains, storm water diversion, catchment paddocks etc);

- The RSF is to be a full containment facility with walls constructed from the coarse sand tailings and the fine residue hydraulically placed in the facility;
- The containment walls require 9.44 m^3 of coarse sand tailings
- From the seepage and slope stability analysis for the RD, it was found that based on the parameters determined from the test work and the geometry of the RD, the facility should be stable, with a factor of safety above 1.5 under static conditions and above 1.4 for pseudo-static;
- The water balance model indicated that on average 10 440 m^3 may be returned to the process plant circuit per day;

20. RECOMMENDATIONS

The following recommendations are provided for the Detailed Design Phase of the project:

- Confirm design criteria;
- Confirm with the authorities the liner requirements for the basin of the RSF;
- Confirmation of survey data accuracy. It is recommended to undertake survey points of the site to confirm elevation;
- Confirm the permeability and degree of fissuring in the bedrock and re-asses the need for the blanket drain;
- Confirm the construction methodology for the containment walls and the construction timelines thereof;
- Investigate the opportunity of eliminating double handling of the coarse sand tailings material by constructing the containment walls to the required 1V:5H for closure during the construction phase.

Report Author	Reviewer	Project Manager
Georgia Wills-Vagis	Guy Wiid	Andrew Savvas

epoch resources (pty) lRD

Appendix A NEMWA REQUIREMENTS SUMMARY

Summary of requirements out of National Environmental Management Waste Act, 59 of 2008 - Regulations Regarding the Planning and Management of Residue stockpiles and Residue Deposits, 2015 (GNR632 amended by GN990)			
Reg no	**Requirement**	**REPORT**	**Section in applicable REPORT**
3	**Assessment of impacts and analyses of risks relating to the management of residue deposits**		
(1)	Identify and assess environmental impacts arising from residue deposits as part of the EIA conducted in terms of NEMA.	EIA Report	6
(3)	A risk analysis based on characterisation and classification (below) to determine the appropriate mitigation measures	RSF6 BFS Design Report	14.1.2
(5)	A competent person must recommend the pollution control measures suitable for a specific residue deposit on the basis of a risk analysis as contemplated below (characterisation and classification (below))	Waste Classification RSF BFS Design Report	5.5 & 6 10, 14
4	**Characterisation of residue stockpiles and residue deposits** Characterise residue deposit to identify the potential risk to S&H and impact on environment associated with the residue when stockpiled/deposited. By a competent person Must be characterised in terms of:		
	a) physical characteristics: size distribution, permeability, void rations, consolidation, strength, specific gravity, water content (in life phases), change in above properties over time .	RSF6 BFS Design Report	4.3, 7, 10.1 & 11.2
	b) chemical characteristics toxicity, propensity to oxidise and decompose, pH & chem comp of water separated from solids, stability and reactivity (and rate thereof), acid generating and neutralising potential, concentration of volatile organic compounds.	Waste classification	5
	c) mineral content to identify any potential risk to health or safety hazard and environmental impact that may be associated with the residue when deposited.	Waste classification	5
5	**Classification of residue deposit** Risk analysis on residue deposits conducted and documented on all facilities to be established. By a competent person Classify residue deposit on the basis of:		
	a) characteristics of the residue .	RSF BFS Design Report	7
	b) location and dimensions of the deposit (height , surface area).	RSF BFS Design Report	14
	e) pollution control measured determined as a result of the risk analysis contemplated in characterisation and classification	RSF BFS Design Report	14.1.2

6	**Investigation and site selection for residue stockpiling and deposit** By a competent person		
(1)-(4)	(a) identify sufficient number of candidate sites	RSF BFS Design Report	Appendix B
	(b) qualitative evaluation and ranking of all sites	RSF BFS Design Report	
	(c) qualitative investigation of the top ranking site as in 2	RSF BFS Design Report	
	(d) Conduct a feasibility study on the highest ranking sites in terms of: i) a health and safety classification.	RSF BFS Design Report	
	ii) an environmental classification.	EIA	3.8.1.1
	iii) geotechnical investigations: - characterisation of the soil and rock profiles over footprint (and infrastructure) to define spatial extent and depth of diff soil horizons. - relevant engineering properties of foundational soil and assessment of strength and drainage characteristics.	RSF BFS Design Report	8
	iv) hydrological investigations: - potential rate of seepage and quality of seepage	RSF BFS Design Report	10.2
(5)	Conduct further investigations on the preferred site in terms of: a) land use.	EIA	All within mining areas
	b) topography and surface drainage.	EIA	3.8.1.1
	c) infrastructure and man-made features.	EIA	3.8.1.1
	d) climate.	N/A	All in similar area
	e) flora and fauna.	N/A	All in disturbed areas
	f) soils.	N/A	All in similar area
	g) ground water morphology, flow, quality and usage.	EIA	3.8.1.1
	h) surface water.	EIA	3.8.1.1
(6)	Investigation, laboratory test work, data interpretation and recommendation for the identification and selection of the most suitable site	Waste classification	5

7	**Design of the residue stockpile and residue deposit** By a Prof civil or mining engineer registered under Engineering Profession of SA Act 1990		
(2)	Consider the soil profile in the design of the residue deposit.	RSF BFS Design Report	8.1, 10, 11
(3)	Take into account all phases of the life cycle of the residue stockpile and residue deposit, from construction through to post closure, and must include the:	RSF BFS Design Report	Throughout
	a) characteristics of the residue in the design of the residue deposit.	RSF BFS Design Report	7
	b) characteristics of the site and the receiving environment in the design of the residue deposit.	RSF BFS Design Report	10, 11
	c) general layout of the residue stockpile or residue deposit, whether it is a natural valley, ring dyke, impoundment or a combination thereof and its three-dimensional geometry at appropriate intervals throughout the planned incremental growth of the residue deposit in the design .	RSF BFS Design Report	Appendix E, F and H
	d) type of deposition method used in the design of the residue deposit .	RSF BFS Design Report	12
	e) rate of rise of the stockpile or deposit in the design of the residue deposit.	RSF BFS Design Report	Appendix E
	f) design of the pollution control barrier system in the design of the residue deposit.	RSF BFS Design Report	14.1.2
(4)	Other design considerations as appropriate to the type of stockpile		
	a) control of storm water on and around the residue deposit in the design of the residue deposit.	RSF BFS Design Report	13.4, 14.2 and 15.3
	b) capping layer in the design of the residue deposit to prevent mobilisation of contaminants of concern.	RSF BFS Design Report	16
	c) provision, throughout the clean and dirty water systems making up the control measures, of a freeboard of at least 0.5 m above the expected maximum water level to prevent overtopping in the design of the residue deposit.	RSF BFS Design Report	13.2
	d) keeping the pool at least 50m from the walls and a factor of safety not less than 1.5, where there is a valid technical motivation for deviating, this must be motivated.	RSF BFS Design Report	11
	e)control of decanting of excess water under normal and storm conditions in the design of the residue deposit: -retention of polluted water (GN991); - design of aspects such as penstock, outfall pipe, under-system & return water dams; - height of phreatic surface, slope angles, method of construction of outer walls and effect on shear stability; - erosion of slopes- wind, water- and control by veg / berms / paddocks - potential pollution	RSF BFS Design Report	13.4
(5)	Include an operating manual in the design of the residue deposit, signed off by registered professional civil or mining engineer.	Operating manual to be completed at Detailed design phase	

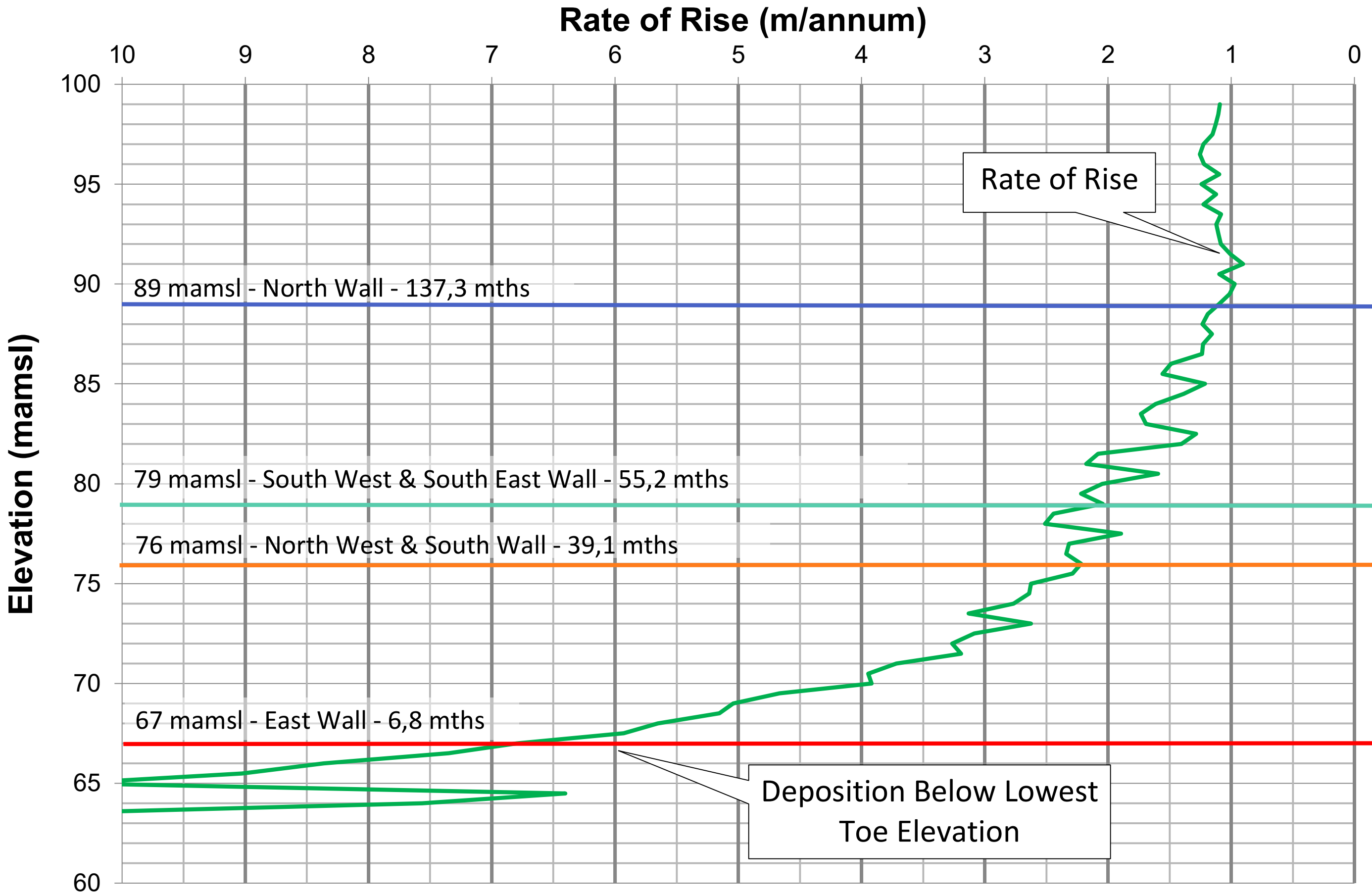
8	**Impact Management**		
	Must manage impacts in the following manner:		
	(a) Identify residue material and management practices with a potential to contaminate water	Groundwater specialist study Waste Classification RSF BFS Design Report	5, 6 5 10, 13
	(b) conduct statistical defensible and representative characterisation programme of relevant materials	Groundwater specialist study Waste Classification RSF BFS Design Report	5, 6 5 7, 10, 11 & 14
	(c) Conduct an impact prediction study to assess potential impacts on water recourses for the full life cycle of the mining operation and include: - monitoring programme - evaluate effect of mitigatory measured to demonstrate acceptable levels of impact.	Groundwater specialist study	5, 6
9	**Monitoring & reporting system**		
	Monitoring system must be "designed" and must consider:		
	- baseline conditions of air, surface and ground water quality	EMPR	Within mitigation measures: Section 5
	- objectives for air, surface and groundwater quality		
	- residue characteristics		
	- receiving environment- climate, local geology, hydrogeology, geochemical conditions		
	- migration pathways		
	- location of monitoring points and protocols		
	- reporting and frequency and procedure		

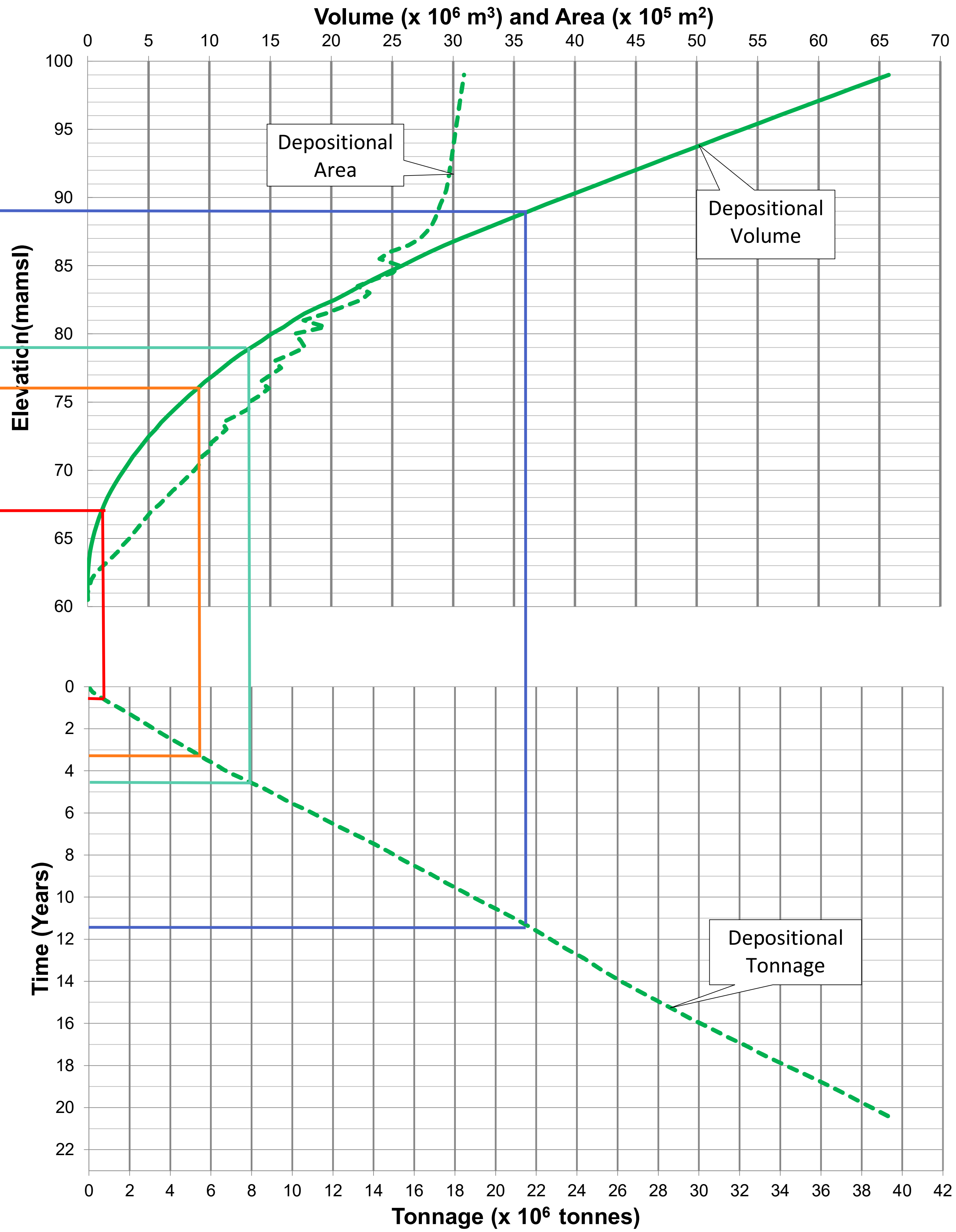
Appendix B SITE SELECTION REPORT

Appendix C LABORATORY TEST RESULTS

Appendix D GEOTECHNICAL INVESTIGATION UNDERTAKEN BY INROADS

Appendix E STAGE CAPACITY CURVES





TRONOX - 20 year LoM		
Average Deposition Rate	t/day	1 170
Capacity	tonnes	39 460 982
Lowest Upstream Toe Elevation	mamsl	68,1
Maximum Wall Elevation	mamsl	101,5

Legend			
	Elevation (mamsl)	**Wall**	**Months**
red	67	East	6,8
orange	76	North West & South	39,1
light green	79	South West & South East	55,2
blue	89	North	137,3

Appendix F SEEPAGE AND STABILITY ASSESMENT REPORT

Appendix G WATER BALANCE REPORT

Appendix H DRAWINGS

Appendix I CQA Plan and Project Specifications Document

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