Site Selection Report - Tronox East Orange Feldspathic Sands Residue Storage Facility

epoch resources (pty) ltd

mine residue and environmental engineering consultants

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Prepared For

Tronox (Pty) Ltd - Namakwa Sands

PROJECT NUMBER 126-003

Final

May 2019

DOCUMENT INFORMATION

Confidentiality	Confidential
Title	Site Selection Report - Tronox East Orange Feldspathic Sands Residue Storage Facility
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Client	Tronox (Pty) Ltd - Namakwa Sands
Electronic File Name	20190522 Tronox site selection_Rev 1
Date last printed	2019/10/01 13:29:00
Date last saved	2019/10/01 13:29:00
Comments	
Keywords	
Project Number	126-003
Report Number	1
Status	Final
Issue Date	May 2019

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Project No. 126-003 May 2019

Status: Final

SITE SELECTION REPORT - TRONOX EAST ORANGE FELDSPATHIC SANDS RESIDUE STORAGE FACILITY

1. INTRODUCTION

Epoch Resources (Pty) Ltd (*Epoch*) have been requested by Fluor (Pty) Ltd (*Fluor*) on behalf of Tronox (Pty) Ltd (*Tronox*) to undertake a Pre-Feasibility Study (*PFS*) for the East Orange Feldspathic Sands (*EOFS*) Residue Storage Facility (*RSF*) situated at Tronox's Namakwa Sands Northern Operation. In this report a site selection study is undertaken as part of the PFS. The study aims to deliver a position for the RSF which is most suitable based on the following considerations:

- Required storage capacity;
- Topography;
- Other mine infrastructure;
- Distance from the mine infrastructure (Process Plant, Open pits etc);
- Surrounding ore bodies;
- Geological anomalies;
- Environmental and social; and
- A risk-based analysis.

A total of four sites were identified. From these four sites, five options/combinations were investigated and classified according to predetermined design criteria and the risks/hazards associated with each option. As part of the study, a high-level cost estimate of each option was undertaken. Through this process it was possible to draw conclusions and recommendations for the most feasible site(s) for the construction of the RSF.

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2. SCOPE OF WORK

A trade off based on a risk assessment was undertaken to ascertain the most suitable site. The assessment was conducted with the following Risk Categories for each site:

- Safety;
- Public health;
- Environmental;
- Mining proximity;
- Financial issues;
- Other issues which include: visual impact, complexity of construction, geological anomalies; and
- Potential for expansion.

The site selection process undertaken in this report as part of the PFS, is of a conceptual nature. The objective of this report was to identify the most suitable RSF site(s). Once the preferred site(s) is finalised, a more detailed assessment with regard to environmental, social and financial impacts needs to be undertaken.

3. DESIGN CRITERIA AND ASSUMPTIONS

3.1. DESIGN CRITERIA

The design criteria of the Fine Residue used in the trade-off of the Residue Storage Facility are shown in Table 3-1.

TABLE 3-1: DESIGN CRITERIA OF THE FINE RESIDUE

DESCRIPTION	VALUE	UNIT
Particle Specific Gravity	2.79	-
Particle Size Distribution	75% passing the 10 µm	-
Placement Dry Density	0.6	t/m^3
Tailings Production Rate	1 240 000	tpa
Life of Mine	20	years
Total Tonnes of fine residue	29	Million tonnes

3.2. ASSUMPTIONS

The following assumptions were used in the study:

- The type of storage facility was assumed to be a full containment facility, due to the expected fineness of the residue and the low solids content of the slurry;

- The embankment wall will be constructed from the coarse residue reporting from the plant. The coarse residue will be trucked to the RSF and constructed using a spreaders and dozers;
- It has been assumed that the facility will not be lined;
- No water dams were included, as it was assumed that water would be stored on the RSF and pumped to the plant via a floating pump/barge on the RSF.

4. TRONOX RESIDUE STORAGE FACILITY SITE SELECTION

Residue Storage Facilities are generally large structures that can pose a significant hazard to health, safety and the environment, depending on their location, site-specific characteristics, method of construction, operation, and level of management and operational control. In addition, the RSF construction, operation and closure can be costly and impact dramatically on the financial viability of any mining operation. It is therefore considered essential that the planning of any mine requires a rigorous RSF site selection exercise in which the trade-offs of reliability and affordability can be assessed for alternative sites and methods of construction.

Several approaches can be adopted for RSF site selection, these range from informal “gut feel” approaches, to formal quantified assessments in which considerable effort and calculations are undertaken.

Important issues regarding any site selection process are as follows:

- The need to have a formal approach;
- Maintaining as far as possible objectivity (although any qualified selection process involves some degree of subjectivity);
- The need to consider all the impacts; and
- To provide an approach that’s is defensible and open to review.

RSF sites suggested by Tronox and Epoch were selected based on:

- Suitable topography for the RSF;
- Distance from the process plant;
- The nature and sensitivity of the surrounding environment, i.e. the receiving environment
- The sites being located within the Mine Lease Area. Tronox has indicated that if a site’s footprint slightly extends past the mine lease area this would not pose an issue;
- Avoiding the following:
  - Planned mine infrastructure;
  - Existing mine infrastructure;

- Surrounding ore bodies; and
- Environmentally sensitive area.

The four potential sites identified for the storage of the fine residue are as follows and shown in the Figure 4-1 below:

- Depression site
- Valley site
- Northern site
- Side Hill site

4.1. DEPRESSION SITE

The depression site is situated North of the process plant. The natural topography of the site allows for a large majority of the tailings tonnages to be contained by the natural depression with the remainder accommodated by constructing walls around the perimeter of the depression. Key features of the site include:

- No infrastructure, communities and/or agricultural activities are located downstream of the facility;
- Walls may not be required at start-up due to the natural depression at the site;
- The site is in close proximity to an environmentally sensitive area situated on the North Eastern side;

4.2. VALLEY SITE

The valley site is situated in a North Easterly direction from the process plant. A small natural valley situated on the northern side of the site allows for the construction of a wall across the valley. Key features of the site include:

- The site is situated upstream of the dual carriage conveyor;
- The site is situated over an ore body. Concurrent mining and deposition of residue is required. Careful planning is required to ensure production is not hindered;
- No communities and/or agricultural activities are located downstream of the facility; and
- The southern extents of the site are situated approximately 1km from a provincial road.

4.3. NORTH SITE

The North site is situated in a North-Easterly direction from the process plant. The site cannot feasibly contain all the residue over the LoM therefore, an additional site would need to be commissioned for the remainder of the residue. Key features of the North site include:

- An environmentally sensitive area is situated on the South Westerly extent of the RSF; and
- The North site is the furthest distance from the process plant.

4.4. SIDE HILL

The Side Hill site is situated North East of the plant. The wall would be built on the downstream side of the slope, containing residue between the wall and side of the slope. The site cannot feasibly contain all the residue over the LoM therefore, an additional site would need to be commissioned for the remainder of the residue. Key features of the site include:

- Steep topography; and
- Close proximity to the plant.

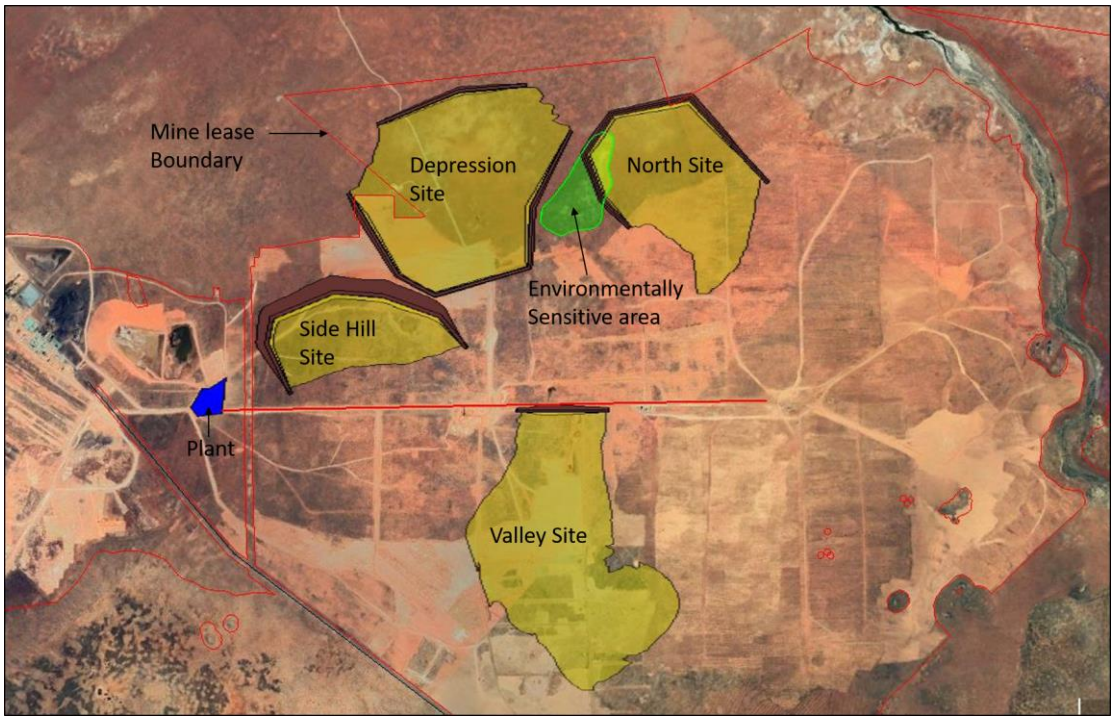

FIGURE 4-1: RSF SITE LOCALITY

5. RESIDUE STORAGE FACILITY OPTIONS

Of the four sites identified, only the Depression and Valley sites have enough capacity to store the full residue over the proposed LoM.

Five options, each capable of storing the full LoM Residue, were thus identified for investigation in this study:

- The Depression site only;
- The Valley Site only;
- A combination of Depression and Valley sites;
- A combination of the Depression and North sites;
- A combination of the Depression and Side Hill sites.

A summary of the five options can be seen in Table 5-1.

TABLE 5-1: OPTIONS STORAGE CAPABILITIES

	Depression	Valley	Depression & Valley	Depression & North	Depression & Side Hill
Wall Volume	3 000 000	1 000 000	1 195 000 + 650 000	1 195 000 + 2 857 000	1 195 000 + 6 862 000
Footprint area	3 500 000	4 000 000	2 400 000 + 3 100 000	2 400 000 + 2 000 000	2 400 000 + 1 500 000
Piping Distance to Plant	4.3	3.1		7.0 (North)	0.8 (Side Hill)
Comments	Walls are not required at start-up due to the natural depression at the site. A single site may be easier to acquire permission from the authorities. Permission to extend rights of a portion of the site will be required.	Concurrent mining and deposition of residue is required. Careful planning is required to ensure production is not hindered. Safety will be an issue. A single site may be easier to acquire permission from the authorities. This site is visible from the main road.	Two sites may not be preferable to the authorities as two areas would be considered disturbed. The Depression site would be built first while the valley site is mined.	Two sites may not be preferable to the authorities as two areas would be considered disturbed. The north site will require permission to use the environmentally sensitive area.	Two sites may not be preferable to the authorities as two areas would be considered disturbed.

The use of two sites may have the following impacts on the mine:

- Permitting and licensing for two facilities may be more difficult to obtain as opposed to one facility;
- Closure can occur independently at one facility while operations continue at the other;
- With wind speeds between 28 – 40 km/hr the probability of dust fall out from the facilities will be high. This may be more challenging to manage between two facilities.

5.1. SUMMARY OF RSF SITES

TABLE 5-2: SUMMARY OF RSF SITE OPTIONS

	UNITS	DEPRESSION	VALLEY	DEPRESSION + VALLEY	DEPRESSION + NORTH	DEPRESSION + SIDE HILL
Method of Construction	-	Fine residue pumped and coarse residue conveyed				
Footprint Area	ha	350	400	550 (Combined)	440 (Combined)	390 (Combined)
Containment Wall Height	m	23	21	10 & 12	10 & 25	15 & 25
Future Expansion	-	Yes	No	Yes at Depression	Yes	Yes
Distance from Plant	km	4.3	3.1	4.3 & 3.1	4.3 & 7.0	4.3 & 1.0

6. RISK BASED METHOD – SITE SELECTION ROCESS

In order to understand the risk-based approach to site selection it is necessary to provide some background information and to supply some definitions.

6.1. DEFINITIONS

Hazard - A hazard is the potential of a structure/equipment/plant etc. to cause harm and/or damage in the event of a failure or shortfall in performance. In the case of a RSF the hazards include the potential of the RSF to cause death (safety), illness (health), and damage to the environment (environment). The hazard could manifest itself or become a reality through a number of mechanisms e.g. in the case of the catastrophic failure of a RSF, the events which could occur resulting in the failure are typically side slope failure, overtopping failure, penstock pipe failure. The probability of the hazard becoming reality is therefore an assessment of the likelihood of the facility failing as a result of one or more of these events occurring leading to a flow slide.

Consequence - A consequence is the end result, or outcome, arising given that a hazard has become reality i.e. it actually happens. For example, should a RSF fail catastrophically, and should people be living or working within the downstream failure zone, the consequence could be death or injury to a certain number of people. The level or severity of the consequence is related to the extent, position and number of people within the failure zone.

6.2. TYPES OF HAZARDS

The types of hazards generated by a RSF are as follows:

- Catastrophic failure resulting in a flow slide from the RSF;
- Release of contaminated surface water/effluent from the top of the RSF basin as a result of direct spillage;
- Release of contaminated seepage water from the base of the facility into the groundwater and/or manifesting itself as a downstream surface seep;
- Release of contaminated residue (silt/tailings) from the RSF as a result of erosion due to rain runoff, spillage etc.;
- Release of contaminated residue (dust) from the RSF as a result of surface drying and strong winds;
- Positioning of the RSF resulting in the loss of housing, agriculture, relocation and compensation to varying degrees;
- Positioning of the RSF resulting in visual intrusion; and
- The release of possible toxic/irritating gases emitted from the RSF has been ignored as this is considered to be of insignificant importance.

6.3. TYPES OF CONSEQUENCES

The various types of consequences associated with the types of hazards mentioned above that relate to the Tronox Project mine lease footprint and its surrounding area are as follows:

- Loss of life to people in the area surrounding the RSF sites;
- Loss of property (houses, dwellings, infrastructure);
- Illness and sickness to people in the vicinity of the RSF sites;
- Environmental damage which includes damage to cultivated areas, natural flora and fauna and destruction of aquatic systems;
- Community concern giving rise to delays/objections to, or cessation of, the project arising from the relocation of people, houses, loss of cultivated land and compensation costs;
- Visual intrusion;
- Mining operations are affected; and
- Financial impacts.

6.4. RISK - A COMBINATION OF THE HAZARDS AND CONSEQUENCES

Risk is defined as the probability of an event occurring (or a hazard becoming reality) and its consequences. Put more simplistically, risk is the probability that a hazard generates a consequence. For example the risk of people being fatally injured as a result of a RSF failure is the probability that the RSF fails catastrophically combined with the presence of people being located within the zone of failure. As an extreme example, if no people are present then the probability of a person being fatally injured is remotely small, even if the RSF does fail.

The hazards listed above are combined with the one, or possibly more, of the listed consequences to give a number of risk related aspects e.g. the probability of the RSF failing causing environmental damage, or loss of property, or loss of life. The "risk aspects" are categorised according to public safety, public health, environmental, financial and other issues (which includes social, political and mining related issues).

6.5. TRANSLATION OF HAZARDS AND CONSEQUENCES TO A RISK RATING

The translation of the various hazards and their associated consequences to a "risk rating" is undertaken in the following manner:

- The probability, or likelihood, of the hazard becoming reality is assessed based on:
  - The site specifics (facility location, climate, topography, ground conditions, hydrogeology etc.), type of facility development, method of construction and operation, level of management etc.; and
  - The designers experience (subjective input).

The qualified statement of the probability of a hazard becoming reality (e.g. very high, high, medium, low, very low; or highly likely, likely, moderate, unlikely, rare) is transformed to a value between 1 and 5 using the probability descriptor versus rating number shown in Table 6-1. For example, if the catastrophic failure of a RSF is considered to be "possible" (or "moderate", or "medium") a value of 3 is applied. It must be noted that the lowest value of 1 indicates a very high or highly likely event, while the highest value of 5 denotes a very low probability or rare chance of something happening.

TABLE 6-1: EXAMPLES OF PROBABILITY DESCRIPTORS

RATING	EXAMPLES OF PROBABILITY DESCRIPTORS			
1	Very High	Very Probable	Highly Likely	"It Happens Often"
2	High	Probable	Likely	"It Has Happened"
3	Medium	Possible	Moderate	"I've Heard of It Happening Elsewhere"
4	Low	Unlikely	Unlikely	"Never Heard of It"
5	Very Low	Very Unlikely	Rare	"Practically Impossible"

The consequence of an occurrence is assessed based on:

- The severity of the consequence from a knowledge of the area, and the location and extent of associated activities undertaken in the area; and

- The experience of the designer (subjective input).

The qualified statement of the degree of severity of a consequence is translated into a value between 1 and 5 depending on the aspect under consideration using the consequence descriptors shown in Table 6-2. It must be noted that low consequence rating numbers are indicative of severe/very high levels of consequence/concern, while higher consequence rating numbers relate to low or insignificant levels of consequence/concern.

TABLE 6-2: EXAMPLES OF CONSEQUENCE DESCRIPTORS

RATING	EXAMPLES OF CONSEQUENCE DESCRIPTORS					
	Mortality	**Health**	**Environment**	**Cost**	**Production**	**Community Concern**
1	Many	Lethal	Very Extensive	Very High	Several Months	Very Severe
2	A Few	Toxic	Extensive	High	Several Weeks	Severe
3	One	Temporary Illness	Localised	Moderate	A Week	Moderately Severe
4	Severe Injury	Irritation	Low	Low	A Few Days	Low
5	Injury	Mild Irritation	Insignificant	Insignificant	One Day	Insignificant

Each area of risk (or risk aspect) now has a probability hazard value and a consequence value. One method of combining probability and consequence is through a “risk ranking” (or “risk rating”) as shown Table 6-3 that has been adapted from ALARA (1997).

TABLE 6-3: RISK RATING/RANKING NUMBERS BASED ON PROBABILITY AND CONSEQUENCE

			Probability Rating				
			Very High				Very Low
			1	2	3	4	5
Consequence Rating	Very High	1	1	2	4	7	11
		2	3	5	8	12	16
		3	6	9	13	17	20
		4	10	14	18	21	23
	Very Low	5	15	19	22	24	25

As an example, if the probability of a hazard occurring is 2 (high) and the consequence arising from the hazard is 4 (low), then the risk rating is 14.

6.6. SITE RANKING

Once all the risk rating values are applied to the various risk aspects the following analyses can be undertaken:

- Individual risk ratings of 6 or less are considered to be serious and require some form of action to reduce the risk level (i.e. increase the risk rating value). These actions could typically include applying additional engineering measures (e.g. plastic lining or flattening side slopes, enlarged compacted starter wall), changing the method of disposal (e.g. from sub-aerial to sub aqueous, upstream construction using tailings to downstream construction using compacted earth), relocating people to another area etc. If risk ratings cannot be increased above 6 by design upgrades or application of mitigating factors, consideration must be given to dismissing the site due to a fatal flaw;
- The sites can be ranked on each of the specific risk aspects e.g. under the environmental category the release of contaminated surface water resulting in environmental damage;
- The sites can be compared on each of the individual risk categories of public safety, public health, environmental, financial and other (social, political, mining etc.) i.e. the risk ratings in each of the categories can be added up to provide an indicator of how the sites are ranked purely on that individual category. For example, the comparison of the health category can indicate which sites show less overall risk as far as public health is concerned; and

- The risk ratings for all of the aspects can be added up. This is an “un-weighted” number which considers all risk aspects to have the same degree severity/impact. The sites can be rated on this un-weighted summed number. Higher numbers being more favourable site(s) and the lowest numbers being the less favoured site(s).
- Weighting factors can then be applied to each risk category and sub-category. The purpose of the weighting factor is to place more emphasis, or importance, on certain parameters of the site selection to provide a more objective ranking of the selected sites. These weighted factors can them be summed up for each site and the sites ranked . Higher numbers being more favourable site(s) and the lowest numbers being the less favoured site(s).

7. RISK ANALYSIS OF RESIDUE STORAGE FACILITIES

Five options were included in the risk analysis. For the analysis, the RSFs were considered at full capacity.

7.1. RISK CATEGORIES

The risks categories and sub-categories investigated are shown in Table 7-1. The risks encompass the possible effects the RSF can have on safety, public health, the environment, financial implications, further expansion and other issues. There may be other issues not investigated in this report, however these risks are sufficient to illustrate which RSF will be the safest option and most economical.

7.2. RISK RATING FOR EACH SITE

The various risk categories and sub-catagories considered are shown in Table 7-1 below. For all sites the hazards and consequences under each risk category were assigned a risk rating score based on Table 6-3. The final scores for each site were computed by adding all the combined scores, for the different risk categories providing an un-weighted risk rating for the sites. A summary of the Un-Weighted risk ratings for each site is shown in Table 7-2.

TABLE 7-1: RISKS CATEGORIES AND SUB-CATEGORIES CONSIDERED

Safety
RSF failure leading to loss of life
RSF failure leading to loss of property and infrastructure
Public Health
Release of contaminated surface water leading to illness
Release of contaminated seepage water leading to illness and/or contamination of water resources
Release of contaminated dust
Environmental
RSF failure results in a flow slide and environmental damage
Release of contaminated surface water leading to environmental damage
Release of contaminated seepage water leading to environmental damage
Release of contaminated silt (Tailings) by erosion leading to environmental damage
Release of tailings or slurry water from delivery pipeline and effluent from return water pipeline resulting in environmental damage
Positioning of RSF results in damage/loss of pristine/rare plant and animal species
Mining Proximity
Implications of proximity to open pits
Implications of constructing RSF in area that will result in sterilisation of ore
Financial Issues
Location of RSF relative to the plant and the cost thereof. i.e. pumping head, slimes pipeline length, infrastructure etc.
Footprint size of the RSF and its cost implications to RSF in terms of drains, solution trenches, storm diversion, access roads etc.
Cost implications of coarse residue impoundment walls / Excavations
Other Issues (Social, Political, etc.)
Degree of visual impact of RSF in relation to its surrounding environment/public
Complexity
Possibility of geological faults within the RSF footprint
Possibility of lining the RSF
Future Expansion
Possible future expansion and the effect on cost and the environment

TABLE 7-2: SITE SELECTION COMPARISON BASED ON UN- WEIGHTED RISK RATING

Weighted Risk Rating (Risk Rating Un-Weighed)					
Category	**Depression**	**Valley**	**Depression + Valley**	**Depression + North**	**Depression + Side Hill**
Safety	641	592	592	641	592
Public Health	283	185	173	283	201
Environment	229	245	236	133	148
Mining Proximity	245	60	60	245	245
Financial Issues	84	92	92	43	38
Other Issues	292	301	309	282	273
Further Capacity	63	42	54	63	63
TOTAL	**1837**	**1517**	**1516**	**1690**	**1560**
	1	**4**	**5**	**2**	**3**

Weighting factors were then applied to each risk category and sub-category. Weighting factors applied to the subcategories can be seen in the Appendix in the "Weighted Tailings Site Selection Comparison" table. The purpose of the weighting factor is to place more emphasis, or importance, on certain parameters of the site selection to provide a more objective ranking of the selected sites. The weighting factor for each category is based on literature, engineering judgement, and client preference. Table 7-3 summarizes the weighted risk ratings in accordance with the proposed plant location. The risk assessment tables for each site is provided in the Appendix.

TABLE 7-3: SITE SELECTION COMPARISON BASED ON A WEIGHTED RISK RATING

		Weighted Risk Rating (Risk Rating x Weighting Factor)				
Category	**Weighting Factor**	**Depression**	**Valley**	**Depression + Valley**	**Depression + North**	**Depression + Side Hill**
Safety	37	39	32	32	39	32
Public Health	14	61	47	44	61	48
Environment	14	102	106	96	81	84
Mining Proximity	10	49	12	12	49	49
Financial Issues	12	22	23	22	10	10
Other Issues	10	73	64	68	67	64
Further Capacity	3	21	14	18	21	21
TOTAL	**100**	**366**	**298**	**292**	**328**	**308**
	Ranking	**1**	**4**	**5**	**2**	**3**

Each RSF site has its own advantages and disadvantages. The purpose of this report is to identify and list them as objectively as possible and rank them accordingly. The following is a summary of the main characteristics of each site:

- The **Depression** site only, 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 **Valley** site only, ranked fourth due to scoring poorly in its rating for proximity to mining activities, as concurrent mining and deposition on the site would be required resulting in higher risk of sterilisation of resources and risk to mining staff. The site is also situated upstream of a dual conveyor.
- The combination of the **Depression and Valley** sites, ranked last in the weighted site selection rankings, due to its safety and environmental rating as a result of its close proximity to mining activities and for public health. The Valley site is limited in terms of further expansion due to the surrounding ore body.
- The combination of the **Depression and North** sites ranked second, however, the North site is partially situated over an environmentally sensitive area that would require environmental authorisation. The North site is situated the furthest from the process plant.
- The combination of the **Depression and Side Hill** sites scored third on the ranking due its low score in the safety and financial categories. The side hill site has safety and public health concerns as it is situated less than 1 km from the process plant. The site will be one of the more expensive options to construct as a result of the steep topography present.

8. HIGH LEVEL COST ESTIMATE

A high-level cost estimate has been undertaken to determine the comparative cost of the RSF options. The main objective for this was to determine if there was a significant increase in cost if two sites were selected rather than a single site. Table 8-1 shows the costs for each option analysed.

The Depression site on its own was determined to be the lowest cost option in Capital Costs (CapEx), Operational Costs (OpEx) and Closure Costs. In terms of initial start-up costs the selection of an option with two smaller footprint areas would result in a lower upfront cost, however it may be possible to phase the single site option which should be considered in the PFS.

TABLE 8-1: LOM OPTIONS COST COMPARISON

				One Site (Option 1)		One Site (Option 2)		Two Sites (Option 3)				Total	Two Sites (Option 4)				Total	Two Sites (Option 5)				Total
				20 Years LoM Depression		20 Years LoM Valley		10 Years LoM Valley		10 Years LoM Depression			10 Years LoM North		10 Years LoM Depression			5 Years LoM Side Hill		15Years LoM Depression		
		Unit	Rate (Rands)	Qty	Cost (SA Rand)	Qty	Cost (SA Rand)	Qty	Cost (SA Rand)	Qty	Cost (SA Rand)		Qty	Cost (SA Rand)	Qty	Cost (SA Rand)		Qty	Cost (SA Rand)	Qty	Cost (SA Rand)	
CAPEX	**Indirect Costs**																					
	Mob/De-mob, Engineering and Contingency	LS	4,104,896	1	11,126,819	1	8,502,495	1	3,007,114	1	6,046,050	9,053,164	1	11,767,350	1	6,046,050	17,813,400	1	19,417,500	1	10,221,354	29,638,854
	Earthworks																					
	Clear and Grub	Ha	20,000	15	307,160	27	534,000	13	256,912	22	440,000	696,912	30	600,000	22	440,000	1,040,000	58	1,164,000	12	240,000	1,404,000
	Top-soil strip	m3	18.5	15,000	277,500	26,700	493,950	25,700	475,450	44,000	814,000	1,289,450	60,000	1,110,000	44,000	814,000	1,924,000	58,000	1,073,000	11,250	208,125	1,281,125
	Base Prep (Rip and Re-compact)	m2	11.1	153,580	1,704,738	267,000	2,963,700	128,500	1,426,350	220,000	2,442,000	3,868,350	300,000	3,330,000	220,000	2,442,000	5,772,000	580,000	6,438,000	115,185	1,278,554	7,716,554
	Embankment Fill (Tailings Sand)	m3	8.5	3,000,000	25,500,000	1,700,000	14,450,000	650,000	5,525,000	1,195,000	10,157,500	15,682,500	2,857,000	24,284,500	1,195,000	10,157,500	34,442,000	5,500,000	46,750,000	2,985,000	25,372,500	72,122,500
	Wall drain + Solution Trench	m	3,000	3,100	9,300,000	3,300	9,900,000	780	2,340,000	2,100	6,300,000	8,640,000	3,300	9,900,000	2,100	6,300,000	16,200,000	3,100	9,300,000	2,324	6,972,000	16,272,000
	Return water																					
	Supernatant return pipe	m	901	5,000	4,505,000	6,000	5,406,000	6,000	5,406,000	5,000	4,505,000	9,911,000	7,300	6,577,300	5,000	4,505,000	11,082,300	800	720,800	3,745	3,374,245	4,095,045
	Floating walkway and floating barge system for wall mounted pumps	Sum	1,221,238	1	1,221,238	1	1,221,238	1	1,221,238	1	1,221,238	2,442,476	1	1,221,238	1	1,221,238	2,442,476	1	1,221,238	1	1,221,238	2,442,476
	Slimes Distribution Piping																					
	400mm Ring Main Pipe	m	1,722	7,500	12,915,000	10,000	17,220,000	4,700	8,093,400	3,000	5,166,000	13,259,400	3,050	5,252,100	4,700	8,093,400	13,345,500	4,900	8,437,800	5,620	9,677,640	18,115,440
	400mm T-pieces	ea	10,353	151	1,563,303	201	2,080,953	95	983,535	61	631,533	1,615,068	62	641,886	95	983,535	1,625,421	99	1,024,947	112	1,159,536	2,184,483
	400mm valves	ea	51,608	151	7,792,808	201	10,373,208	95	4,902,760	61	3,148,088	8,050,848	62	3,199,696	95	4,902,760	8,102,456	99	5,109,192	112	5,780,096	10,889,288
	Downpipes	m	1,500	2,265	3,397,500	3,015	4,522,500	1,425	2,137,500	3,050	4,575,000	6,712,500	930	1,395,000	1,425	2,137,500	3,532,500	1485	2,227,500	1,650	2,475,000	4,702,500
	Return Water Pump System																					
	25MG 250KW Barge Pump	ea	821,216	1	821,216	1	821,216	1	821,216		0	821,216	1	821,216		0	821,216	0	821,216	1	821,216	821,216
	25MG 250KW Skid Pump	ea	717,216	1	717,216	1	717,216	1	717,216		0	717,216	1	717,216		0	717,216	0	717,216	1	717,216	717,216
	Total CAPEX				**81,149,498**		**79,206,476**		**37,313,691**		**45,446,409**	**82,760,100**		**70,817,502**		**48,042,983**	**118,860,485**		**104,422,409**		**69,518,719**	**173,941,128**
OPEX	**Pipe and Valve Replacements**	m	698	0	2,841,300	0	3788400	0	1,780,548	0	1,136,520	**2,917,068**	0	1,155,462	0	1,780,548	**2,936,010**	0	1,856,316	0	2,129,081	**3,985,397**
REHAB	**Cut to Fill Side Slopes**	m3	2.7	221,534	598,142	161,000	434,700	100,000	270,000	159,285	430,070	**700,070**	427,244	1,153,559	159,285	430,070	**1,583,628**	1,500,000	4,050,000	167,000	450,900	**4,500,900**
CLOSURE	**Load, Haul and place capping layer**	m3	14.2	3,500,000	49,700,000	4,500,000	63,900,000	3,500,000	49,700,000	2,000,000	28,400,000	**78,100,000**	2,200,000	31,240,000	2,000,000	28,400,000	**59,640,000**	1,200,000	17,040,000	2,950,000	41,890,000	**58,930,000**
LoM	**Sub-Total:**	R		**134,288,940**		**147,329,576**		**89,064,239**		**75,412,999**		**164,477,237**	**104,366,523**		**78,653,601**		**183,020,123**	**127,368,725**		**113,988,700**		**241,357,425**
Cost	**Total:**	R		**134,288,940**		**147,329,576**		**164,477,237**					**183,020,123**					**241,357,425**				

9. CONCLUSIONS

It can be concluded that:

- The Depression Site ranked best and yielded the lowest LoM costs. As such it should be assessed further as the preferred site;
- Although the other options resulted in lower rankings they may be considered as 'back-up' options if a fatal flaw is discovered at the Depression site; and
- When considering the single or phased options it is evident that a single site will have a lower LoM cost. However, the level of accuracy for the cost trade-off does not warrant basing the decision of which site to choose on the cost trade-off alone.

10. RECOMENDATIONS

It is recommended that:

- The Depression site be considered for further study. The North and Valley sites are considered possible options and subsequent phases of the project should confirm the preferred site; and
- Detailed EIA study be completed to determine the environmental impacts of the Depression RSF.

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Appendix A: Risk Matrices

SUMMARY OF UNWEIGHTED RISK MATRIX						
Category	**Description**	**Depression**	**Valley**	**Depression + Valley**	**Depression + North**	**Depression + Side Hill**
SAFETY						
	Total risk rating for Safety	39	32	32	39	32
PUBLIC HEALTH						
	Total risk rating for Public Health	61	47	44	61	48
ENVIRONMENTAL						
	Total risk rating for Environmental	102	106	96	81	84
MINING PROXIMITY						
	Total risk rating for Mining Proximity	49	12	12	49	49
FINANCIAL ISSUES						
	Total rating for Financial Issues	22	23	22	10	10
OTHER ISSUES (SOCIAL, POLITICAL, etc)						
	Total Risk rating for Other issues	72	*64*	*68*	*67*	*64*
FURTHER EXPANSION						
	Total Risk rating for Further Expansion	21	*14*	18	21	21
	Overall Risk rating (Sum of Risk rating numbers)	366	298	292	328	308
	Un-weighted ranking of sites	1	4	5	2	3

SUMMARY OF WEIGHTED RISK MATRIX							
Category	Description	Weighting Factors	Depression	Valley	Depression + Valley	Depression + North	Depression + Side Hill
SAFETY							
	Total risk rating for Safety	*37*	641	592	592	641	592
PUBLIC HEALTH							
	Total risk rating for Public Health	*14*	283	185	173	283	201
ENVIRONMENTAL							
	Total risk rating for Environmental	*14*	229	245	236	133	148
MINING PROXIMITY							
	Total risk rating for Mining Proximity	10	245	60	60	245	245
FINANCIAL ISSUES							
	Total risk rating for Financial Issues	*12*	84	92	92	43	38
OTHER ISSUES (SOCIAL, POLITICAL, etc)							
	Total Risk rating for Other issues	*10*	292	301	309	282	273
FURTHER EXPANSION							
	Total Risk rating for Further Expansion	*3*	63	42	54	63	63
	Overall Risk rating (Sum of Risk rating numbers)		1837	1517	1516	1690	1560
	Weighted ranking of sites	100	1	4	5	2	3