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AMENDMENT TO THE EXISTING TAILINGS STORAGE FACILITY OPERATION AT ROSH PINAH ZINC CORPERATION'S MINE

-

SOUTHEAST EXTENSION

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ACRONYMS, ABBREVIATIONS AND GLOSSARY

Acronyms / Abbreviations	Definition
El.	elevation
HDPE	High-density polyethylene
IDF	Inflow designed flood
Dmt	Dry metric tonnes
m/yr	Meter per year
m^3/h	Cubic meters per hour
Mm^3	Million cubic meters
mbs	m below surface
MDL	minimum detection limit
Mt	million tonnes
Non-PAG	Non-Potential Acid Generation
PMP	Probable Maximum Precipitation
RWD	Return Water Dam
tpd	tonnes per day
TSF	Tailings Storage Facility
VWPs	Vibrating wire piezometers

GLOSSARY OF TERMS USED AT TAILINGS STORAGE FACILITY

	Definition
beach length	The distance from embankment crest to decant pool.
crest width	The horizontal distance from one side of the embankment to the other side of the embankment
daywall	The use of tailings hydraulically placed in a hand compacted wall zone during day light time to form an embankment
decant pool	A settling basin, settling pond or **decant** pond on top of the tailings dam.
embankment	A wall on top of the TSF to contain the tailings.
freeboard	The distance between the waterline and embankment crest.
penstock	An intake structure that controls water flow into an enclosed pipe that delivers water to the water retention dam.
supernatant	The water/liquid overlying material deposited by settling, precipitation, or centrifugation.
TSF basin	The area behind the embankments to store tailings and water
Return Water Dam	Holding structure for the return water from the TSF to be pumped back to the plant area
Decant intake	Intake tower/structure of the penstock

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SOUTHEAST EXTENSION

1 INTRODUCTION

Rosh Pinah Zinc Corporation (Pty) Ltd (RPZC) appointed A. Speiser Environmental Consultants (ASEC) to conduct the amendment to the existing Environmental Clearance Certificate No. 0082 (ECC0082). The amendment solely focuses on the Tailings Storage Facility operation. The current tailings disposal facility was described and assessed in the "Environmental overview and environmental management system at Rosh Pinah Mine" (ASEC, November 2008).

The mining licence No. 39 (ML 39) is held by PE Minerals. PE Minerals and RPZC have an Operational Agreement in which PE Minerals transferred all mining interest to RPZC. The Operational Agreement has been approved in writing by MME in 1999.

The Rosh Pinah mine is situated in the Karas Region, 165 km south of Aus, which is 125km east of Lüderitz. At present RPZC (owned by Trevali) produces 100,000 dmt of zinc concentrate and 10,000 dmt of lead concentrate per annum.

2 MOTIVATION/REASON OF THE AMENDMENT

In 2019 RPZC started a project to investigate the increase of ore throughput in the plant. The current mill feed is 2,000 tonnes per day (tpd), which should be increased after the plant has been upgraded (this will be a separate amendment once all technical data are available) to 3,600 tpd mill feed. RPZC appointed Knight Piésold Consulting (Pty) Ltd (KP) to conduct a pre-feasibility study of the tailings and water management design for the Southeast Extension, as the existing Tailings Storage Facility (TSF) is approaching its ultimate storage capacity.

The existing TSF will reach its ultimate storage capacity in August 2022 (Knight Piésold Consulting (Pty) Ltd, Memorandum, 26 January 2021, Remaining Tailings Storage Capacity at the Existing TSF). KP completed pre-feasibility level tailings and water management designs for the proposed Southeast Extension in 2019. The Southeast Extension will be located adjacent to the existing TSF. In 2020, RPZC appointed KP to provide detailed designs for the storage of an additional 3.96 million tonnes (Mt) of fine grind tailings at the proposed Southeast Extension from 2022 through 2031.

3 BIO-PHYSICAL ENVIRONMENTAL ASPECTS PERTINENT TO THE TAILINGS DISPOSAL FACILITY EXTENSION

3.1 Climate

RPZC mine is situated in a predominately winter-rainfall region. The winds of the south Atlantic anticyclone system and cold Benguela current are the main elements influencing the area's climate.

The climate of the wider Rosh Pinah area is arid with low unpredictable rainfall, mainly occurring between April and August. Summers are hot and winters are mild. A large diurnal temperature range is exhibited in the winter months resulting in early morning mist and heavy dew.

3.2.1 Rainfall

The ML 39 has received an average of 79 mm of rain per year over the last 10 years, where data were recorded. The highest average rainfall events during these years usually occur in January and between May and August. However, as Rosh Pinah falls within the southern part of the winter-summer rainfall area, rain events can be expected throughout the year. The highest rainfall event – 100 mm was recorded in January 2011. The rainfall data shows that run-off events are uncommon. The ephemeral channel west of Rosh Pinah flowed in January 2011 for the first time since 2000. **Table 1** provides rainfall data recorded at the rain gauge at RPZC mine.

Table 1: Rainfall from 2008 - 2020/mm/Year - Roah Pinah (source: RPZC weather station).

	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	14								2.5	2	9.5		
2009	59.6		12	7.5		2	7	5.5	6.5	5.6	0.5	13	
2010	13.7		3.6	1.5			2.5	4.5		1.6			
2011	100	2.5		12.8		48.5	1	3	28.2			4	
2012	34.1			11.5			2.5	9	7.5	3.6			
2013	69.5				27		3		29.5	9			1
2014	29.3	6		8		3	6	5.5				0.8	
2015	11				6		5						
2016	No data were recorded												
2017													
2018													
2019	10	0	3	0	0	7	0	0	0	0	0	0	0
2020	54	4	0	0	0	20	8	22	0	0	0	0	0
Total	395.2	12.5	18.6	41.3	33	80.5	35	49.5	74.2	21.8	10	17.8	1

3.2.2 Evaporation

The potential annual evaporation in the Rosh Pinah area is approximately 3,000 mm. The maximum is during the summer months and progressively declines during the autumn, winter and spring. The evaporation decreases slightly – to approximately 2,600 mm – towards the coast due to the presence of fog (Pallet, 1995). Comparing the average annual precipitation figures – between 54 and 64 mm – with the potential annual evaporation it becomes clear that overall, there is a net loss of water within the Rosh Pinah area.

3.2.3 Temperature

Airshed Planning Professionals interpreted the available data measured at the weather station at RPZC mine. Data were provided from 2011 to January 2021.

Diurnal and average monthly temperature trends are presented in **Figure 1**. Maximum, minimum and mean temperatures for the study area are given in **Table 2**, as 41°C, 3.8°C and 19°C respectively, based on Rose Pinah weather data for the period Sep 2011 – Aug 2019; Jan 2020 – Jan 2021. Average daily maximum temperatures range from 41°C in January to 30°C in June, with daily minima ranging from 13.6°C in March to 3.8°C in July. For the month of May, no data was recorded for the entire dataset. Ambient air temperature decreases to reach a minimum at around 03:00 i.e., just before sunrise.

Table 2: Hourly minimum, maximum and average hourly temperatures based on Rosh Pinah meteorological data (Sep 2011– Aug 2019; Jan 2020 – Jan 2021).

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Minimum	13.2	12.6	13.6	11.3	0	7.5	3.8	6	8.9	9.1	10.5	12.9
Maximum	41	40	40.9	35.5	0	30	30.4	36.6	35.3	30	39.8	37.7
Average	19.7	5.2	19.4	19.6	0	18.8	18.2	18.2	17.7	19.4	19.4	19.66

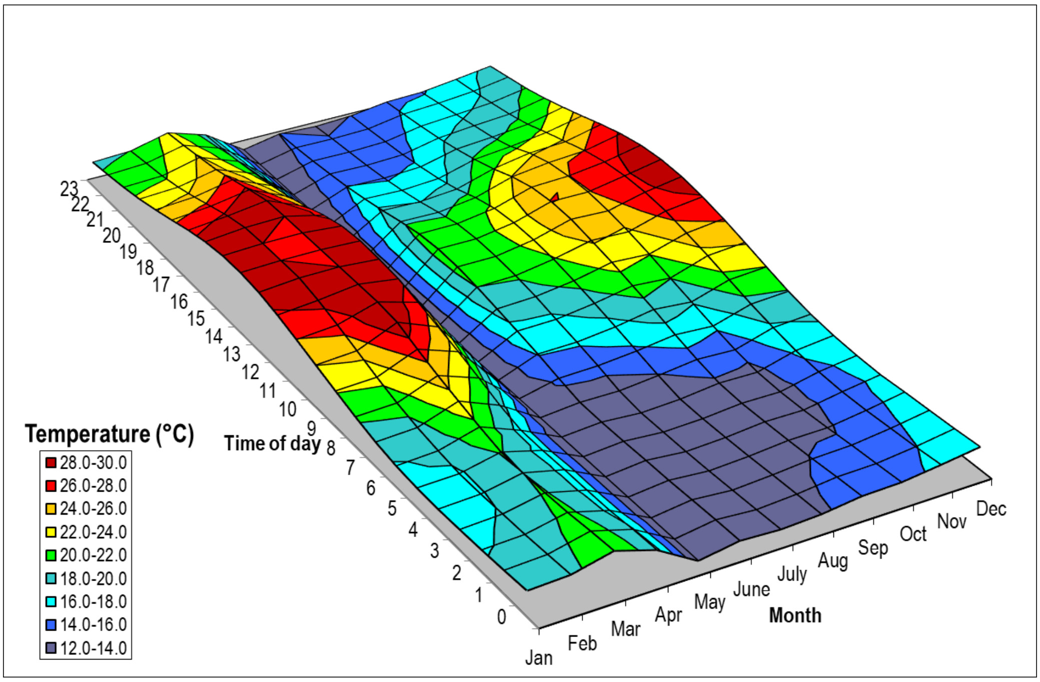


Figure 1: Daily average temperatures based on Rosh Pinah meteorological data (Sep 2011 – Aug 2019; Jan 2020 – Jan 2021).

3.2.4 Fog

Namdeb has recorded an average of 100 days of fog per annum at Oranjemund. Along the coastal areas of the Sperrgebiet, fog occurs most often in February and March. Often the fog also moves many kilometres inland along the Orange River and calculations conducted for the Rosh Pinah Landfill Study (WSP Walmsley, 2001) suggested that fog occurs about five or more times per month during February and March at Rosh Pinah.

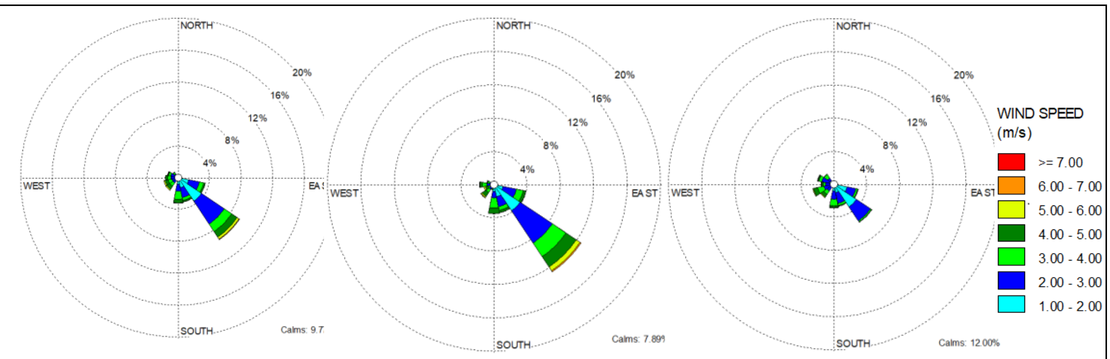
3.2.5 Surface Wind Fields

Wind roses comprise 16 spokes, which represent the directions from which winds blew during the period. The colours used in the wind roses below, reflect the different categories of wind speeds; the red area, for example, representing winds between higher than 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred refers to periods during which the wind speed was below 1 m/s.

Period, day-time and night-time wind roses for the study area, based on Rosh Pinah meteorological data for the period: Jan 2020 – Jan 2021 are depicted in **Figure 2**. This year was selected since it has the highest data availability (40%). Yearly wind roses are provided in **Figure 4** and represent where data for a full calendar year was available. The seasonal variability is based on the period Jan 2020 – Jan 2021 and is shown in **Figure 3**.

Weather data from the Rosh Pinah weather station had very low data availability with 54% of the dataset recorded as zero, and according to the US EPA the data availability should at least be 90%. This explains the missing data from the northerly sector of the wind roses shown in Figure 1 and 2. Possible reason for this missing data could be due to malfunctional weather station or possible obstacles blocking the northern sector of the weather station.

- During the Jan 2020 – Jan 2021 period, the wind field was dominated by frequent winds from southeast, east-southeast, south-southeast and south, with less frequent winds from the west. During the day wind is predominantly from the southeast, followed by south-easterly winds with strong wind speeds and little calms conditions recorded at 8% (Error! Reference source not found.). During the night, wind from the southeast d ecreases with more frequent winds from the west-northwest and west-southwest. Day- and night-time average wind speeds are 2.18 m/s and 1.58 m/s, respectively with an average wind speed of 1.91 m/s and a maximum of 6.5 m/s. Winds are strongest during the day with more frequent calm conditions during the night.



(a) Period Jan 2020-Jan2021 (b) Day-time Jan 2020-Jan 2021 (c) Night-time Jan 2020-Jan 2021

Figure 2: Period, day- and night-time wind roses based on the Rosh Pinah meteorological data (Jan 2020 – Jan 2021).

- Seasonal wind roses for the period of Jan 2020 – Jan 2021 are provided in **Figure 3**. There is only data for the months of January to March, and October to December. Thus, the only two seasons which is adequately represented are Summer and Spring, with autumn only represented by the month of March and no data for the winter months. The prevailing south-easterly winds are reflected in the summer and spring data, with more frequent winds from the seasonal dataset reflects a similar trend between summer and spring month roses. During summer months winds were dominantly from east-southeast, southeast and south. During autumn months the data availability was very low hence the wind rose show a lot of missing data. The spring months showed a larger variation in wind direction with similar winds as the summer months.

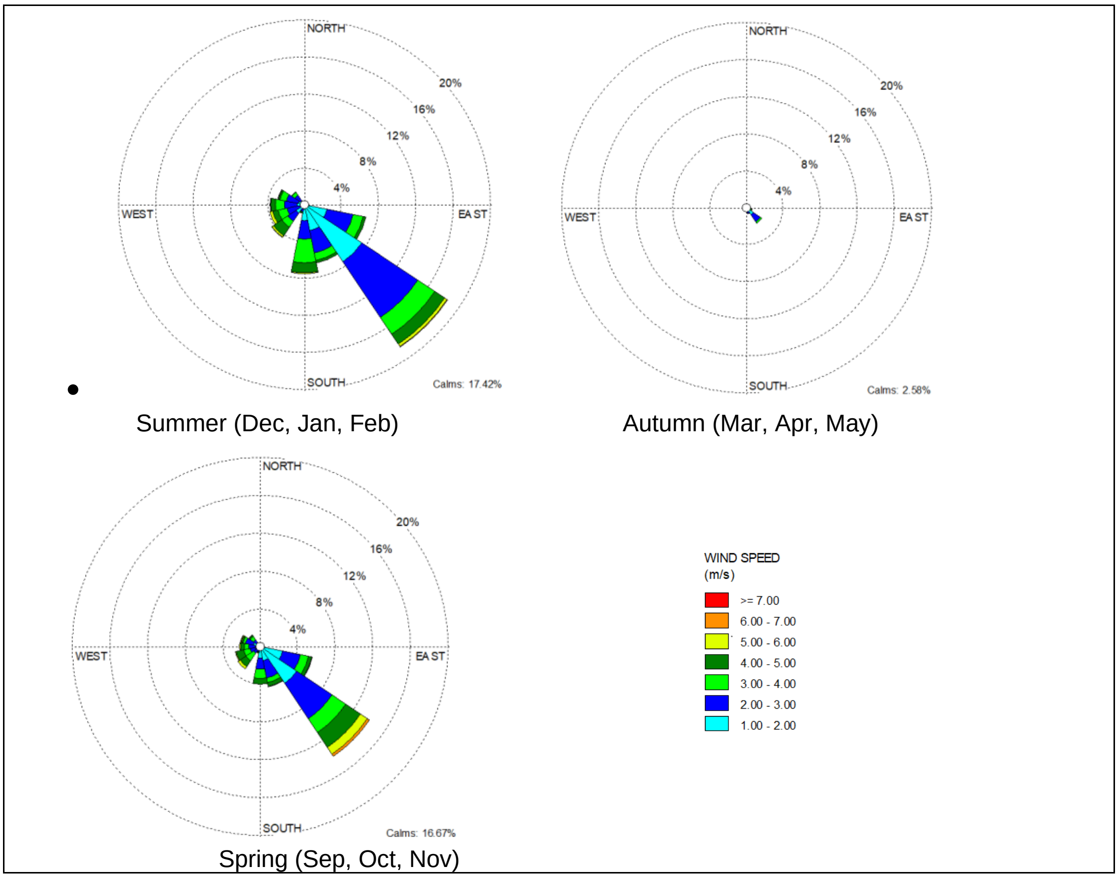


Figure 3: Seasonal wind roses based on the Rosh Pinah meteorological data (Jan 2020 – Jan 2021).

- Over the individual years (2011; 2013; 2014; 2016; 2017 and 2020) the prevailing wind field is from the southeast with some years reflecting easterly, southerly and westerly winds (**Figure 4**). The reason for not all the years to reflect other wind directions are likely due to the little data availability for the years. The most credible years are 2017 and 2020 (even though the data availability for these two years are also very low at 34% and 40%, respectively).

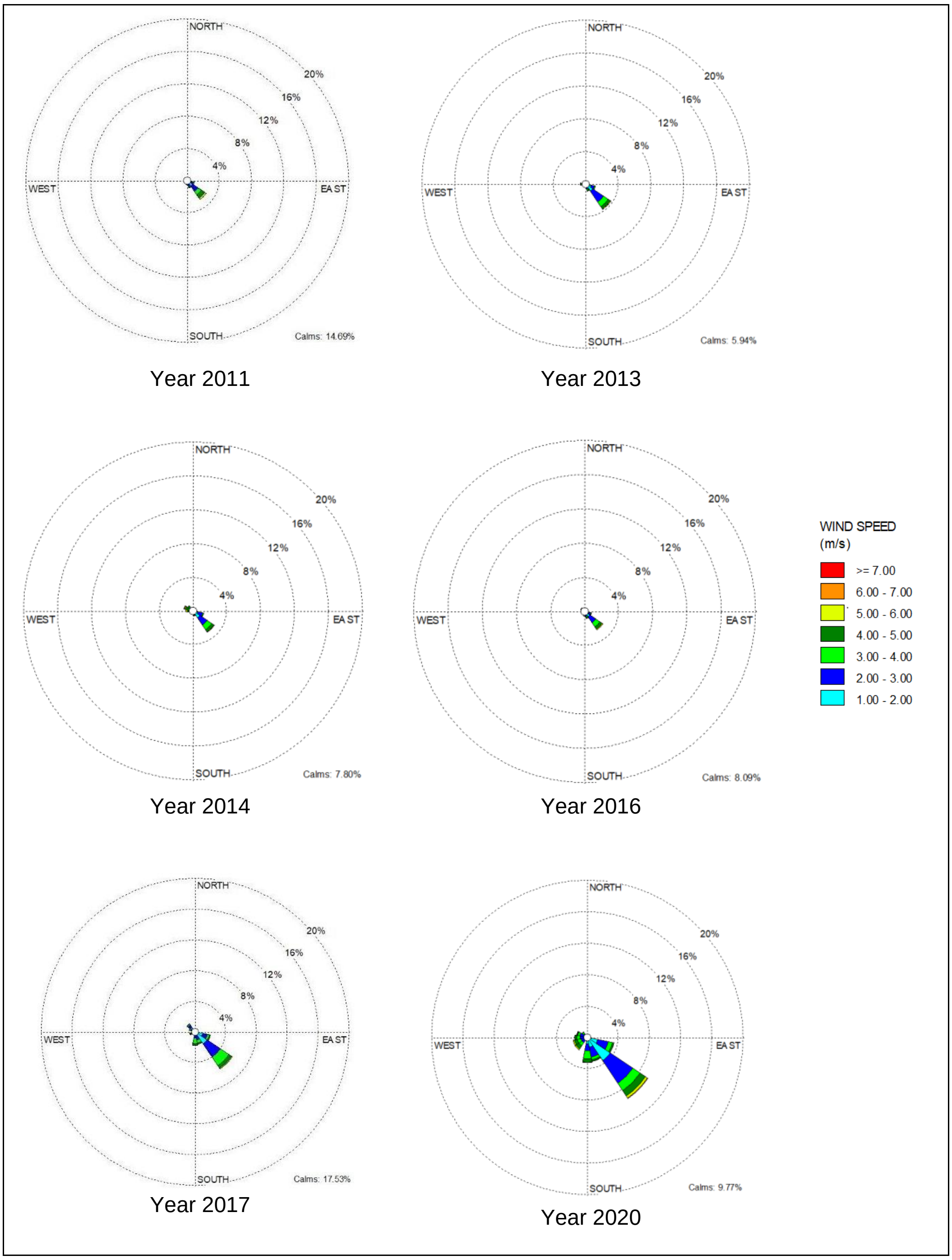


Figure 4: Yearly wind roses based on the Rose Pinah meteorological data (2011; 2013; 2014; 2016; 2017; 2020).

According to the Beaufort wind force scale (https://www.metoffice.gov.uk/guide/weather/marine/beaufort-scale), wind speeds between 6-8 m/s equate to a moderate breeze, with wind speeds between 14-17 m/s near gale force winds. Based on the available data for the period Sep 2011 to Jan 2021, wind speeds fell mostly in the 2-4 m/s category with winds exceeding 3 m/s only for 2.9% (**Figure 5**). Winds exceeding 5 m/s occurred for 0.3% of the time, with a maximum wind speed of 10.05 m/s (which was recorded in 2013). The average wind speed over the period was 1.48 m/s. Calm conditions (wind speeds <1 m/s) occurred for 7.12 % of the time.

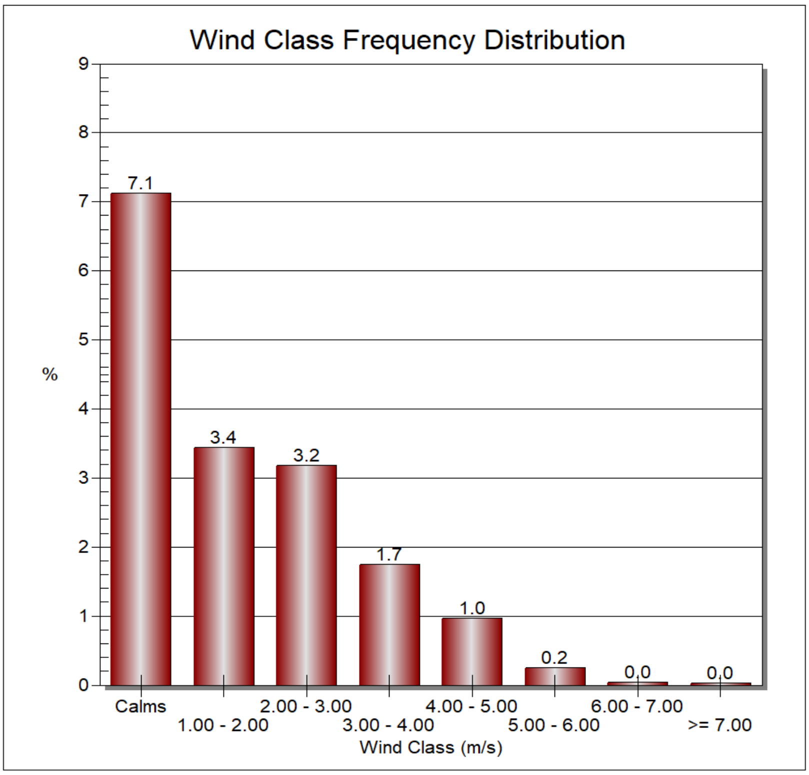


Figure 5: Wind speed categories based on the Rosh Pinah meteorological data (Sep 2011 – Jan 2021).

3.2 Groundwater

Background information regarding groundwater was obtained from the in-house report "Groundwater investigations at Rosh Pinah mine" (G. Steenekamp, Kumba Resources, 2003) and "Groundwater study and risk assessment as part of the western ore filed 3 feasibility study for Rosh Pinah Zinc Corporation" (Groundwater Complete, 2015).

3.2.1 Background of historical groundwater work at Rosh Pinah Mine

Groundwater management at Rosh Pinah was a very low-key issue until the late 1990's when deeper ore bodies were exploited and seepage rates started to increase. Specific structures such as the 'Squad Valley Fault' had especially high inflow rates when intersected by exploration boreholes or development tunnels. Such intersections significantly increased awareness of the importance of groundwater management and actions were implemented to gain a better understanding of the groundwater regime and thus the associated risks.

Table 3 provides an overview of the milestones/events taken at RPZC for groundwater monitoring and management.

Table 3: Key milestones/events in terms of groundwater monitoring and management at RPZC.

Time	Event	Actions / Recommendations
1997	High volumes and pressure groundwater influx through boreholes in WOF	• Start measuring water levels in boreholes around the mine; • Stop discharging water right outside declines; • Consider isotope tests to determine origin.
1997	Drill 7 monitoring boreholes at Tailings Storage Facility	• Start measuring groundwater levels every two weeks; • Measure water quality quarterly.
1998	Expansion of water quality monitoring program	• Measured effluent streams like EOF, WOF, Plant, Tailings discharge plus additional boreholes; • Measure water levels in open exploration boreholes; • Recommend measuring of groundwater inflows to mining areas.
1999	Construct first phase numerical groundwater model	• Simulate inflows and predict; • Recommend provision for additional pump capacity; • Measure water pressures in selected boreholes; • Consider drilling of boreholes around the mine for dewatering and water level monitoring; • Monitor inflows to and outflows accurately for calibration of model.
2000-2001	Rosh Pinah water project	• Minimize GW risks, optimize reuse, reduce consumption; • Included water balance compilation; • Plant water quality tolerance assessed.
2002	Follow-up numerical model	• Models updated but value limited due to gaps in flow and pressure records in space and time.
2002-2003	Drilling of additional impact monitoring boreholes	• Accurate impact quantification prompted drilling of additional monitoring boreholes; • Boreholes drilled in December 2002 at tailings, sewage ponds, rock dumps etc.; • Monthly water level and quarterly quality monitoring commenced.
2005	SAMREC code	• The SAMREC code was implemented at Rosh Pinah. This included a groundwater monitoring and risk management plan for ongoing application.

At present SLR Namibia was appointed to conduct the 'Groundwater Study for Rosh Pinah Zinc Corporation'

3.2.2 Summary of the "Groundwater investigations at Rosh Pinah mine" (G. Steenekamp, Kumba Resources, 2003)

The groundwater flow through an aquifer exists because of differences in water level or piezometric head. Generally, recharge to the aquifer is distributed fairly evenly over the land surface. Therefore, the groundwater level or piezometric head usually follows the trend of the surface topography and tends to mimic the direction of surface water run-off. On a smaller scale, inhomogeneities in the aquifer structure, like fracture zones, groundwater flow barriers and artificial discharge or recharge points, will disturb the general flow pattern, but the regional trend usually prevails. Since regional surface drainage in the Rosh Pinah area is towards the south-east, the same could be expected for groundwater. In the Rosh Pinah mining area, static groundwater (or piezometric) levels vary from 36 - 68 m below surface (mbs). However, the shallower water levels occur closer to the mountain in the topographically higher lying areas and water levels exceeding 50 mbs are measured in the plain or in the valley near the Tailings Storage Facility. This phenomenon is explained by the difference in aquifer types, which can be divided into:

- a predominantly primary porous, medium type aquifer in the alluvial plains; and
- a secondary fractured-rock type aquifer with higher piezometric heads in the mountain and outcrop areas.

Figure 6 presents a map with the groundwater levels contoured from positions where data exists. The figure shows that although local variations and anomalies do occur, the general trend for water (or piezometric) levels is the same as the surface topography, namely in a southerly and south-easterly direction, with relatively high gradients close to the mountains and flatter gradients in the alluvial plains.

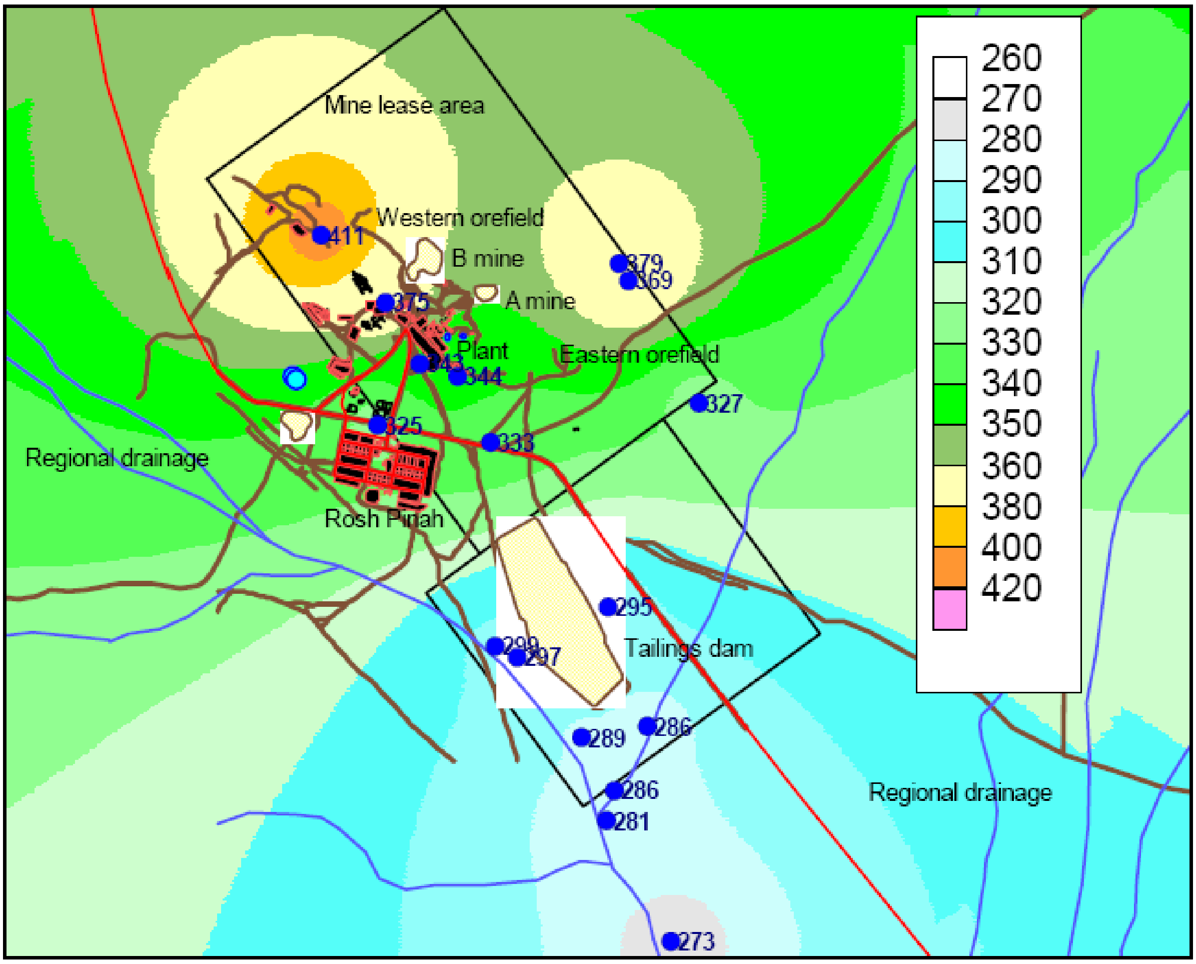


Figure 6: Groundwater level contours constructed from measured groundwater levels.

At Rosh Pinah the static water levels and piezometric heads show that two different aquifer types, namely the largely unconfined primary type aquifer and the confined fractured-rock type, exist. The mine dewatering has not affected any of the boreholes because the natural relationship of water level elevation and surface topography is a straight line for each aquifer type, and anomalous low groundwater elevations do not occur.

For Rosh Pinah only the available groundwater levels were used. The general groundwater elevation trend is evident from **Figure 6** and the flow direction will be perpendicular to the contour lines, namely in a south-easterly direction on a regional scale.

3.2.2.1 Yields

Blow yields in the monitoring boreholes varied between 1 and 20 m^3/h. The highest yields occurred in the alluvial plain to the west and south of the Tailings Storage Facility, where a thick and mostly unconsolidated gravel and boulder layer occurs.

The overall success in water strikes in the fractured rock aquifer is probably attributable to the high degree of structural deformation, such as the intense folding, shearing and thrusting of the geological terrain at Rosh Pinah.

3.2.2.2 Groundwater Quality

Groundwater quality is influenced by the following factors:

- **Annual recharge** to the groundwater system

The ambient groundwater levels are relatively deep, especially in the alluvial plains where water levels are often in excess of 50 mbs. Mean annual rainfall is around 70 mm, and even if the effective recharge were as high as 5 - 10 %, the recharge would still be less than 7 mm per annum. In these conditions an old, fairly saline type groundwater is to be expected.

- **Type of bedrock** where ion exchange may impact on the hydrogeochemistry

The bedrock in the area consists of different metamorphic rock types, including carbonaceous rocks, argillites, schists, and volcanic tuffs. The impact on the hydrogeochemistry of the aquifer host rock is not expected to be significant. In the mining area itself, with the sulphide ore bodies occurring, leaching and oxidation could play a role, but not a very significant one because of the low effective recharge. In the alluvial valleys, the rock types are generally chemically inert and dissolution is not expected to have a major impact on the water quality.

- **Flow dynamics** within the aquifer(s), determining the water age etc.

Aquifer flow dynamics at Rosh Pinah will have a positive effect on the groundwater quality because the transmissivities in the aquifers are relatively high and flow can take place fairly evenly through the aquifers. The high incidence of measurable blow yields confirms that zones of high transmissivity are widespread in the mining area and that the flow system is an active and dynamic one. The low recharge is thus the main cause of poor ambient groundwater quality.

Source(s) of pollution with their associated leachates or contaminant streams:

- Tailings Storage Facility system;
- hydrocarbon sources (oils, greases, fuels and organic solvents) usually concentrated in and around workshop areas, service stations and fuel depots, but also occurring because of spillages, leaks and breakdowns in the active mining areas;
- remnants of nitrate-based explosives in mining areas as well as in the processing plant and discard dumps; and
- acid mine drainage type contamination from discard dumps, stockpiles and the processing plant area where base metals or coal are mined and processed.

3.2.2.3 Groundwater Use

Groundwater around the Rosh Pinah mining area is used for domestic purposes and livestock water supply.

Until 2001 the mine itself had used no groundwater. Since the end of 2001 groundwater influx into the underground mine – instead of being pumped out directly – has been used for drilling, dust suppression and other industrial purposes in the underground workings. The utilisation of groundwater in this way has two positive purposes:

- Water is saved and prevented from being contaminated because clean water does not have to be pumped underground where it is contaminated in the mining process.
- Risks of mine flooding are reduced because groundwater is allowed to flow freely into the mine from where it is used and then pumped out.

The groundwater flowing into the mine is very saline and has to be treated with anti-corrosion agents (PO_4 derivates) to prevent excessive corrosion on mine equipment and reticulation infrastructure.

3.3 Soils

Due to the arid and semi-arid climatic conditions mechanical weathering predominates. This results in residual soils above the rock which are usually thin. Transported soils are predominantly aeolian sands during strong wind events or coarse colluvial talus from the surrounding mountain ranges. The soils are mainly developed on the gravel plains and in depressions/valleys, which provide some geomorphological stability (Pallett, 1995).

Desert soils are often stabilised by an organic or inorganic layer, which protects the underlying soils from erosion in areas devoid of macro-vegetation (Daneel, 1992). Soil algae and/or the inorganic surface gravel layer, usually a small pebble layer or desert pavement, protects the underlying soil from erosion. Disturbance to this fragile protective layer will result in erosion, by wind, of the soil fines, which are important for moisture retention and nutrient adherence. Recovery from structural damage by disruption to surface micro-topography and compaction may take as long as soil formation – several thousand years (Daneel, 1992).

The soils in the Rosh Pinah area are predominately surface alluvial sediments that support mainly sparse grassland and have a low agricultural value (Rosh Pinah Landfill Study, Walmsley, 2001). Typically, the soils have a pH of ±9, high salinity and sodicity and low clay and organic-matter content (RPZC, 1999). The soils have no agricultural potential.

Although thin, the soil layer must be protected, for it is presumed to contain the valuable seedbed for the Succulent Karoo and Nama Karoo Biomes, especially since soil formation takes such a long time. Some of the plant species that are found within the Rosh Pinah Mining Licence are endemic to the area. Disturbance of the organic and inorganic protective layers can lead to increased wind and water erosion; reduced infiltration rates; reduced soil moisture content; and the inhibition of plant germination.

4 GROUNDWATER AND DUST MONITORING AROUND THE EXISTING TSF

4.1 Groundwater Monitoring at the Existing TSF

RPZC Mine has a total of 15 monitoring water boreholes within and around the mine facilities. Nine monitoring boreholes are situated around the existing TSF (see **Figure 7**). Since 1997 the monitoring system is in place, and all monitoring boreholes are sampled quarterly and analysed by NamWater in Windhoek. Samples are analysed for zinc (Zn), lead (Pb), copper (Cu), arsenic (AS), cadmium (Cd) and cyanide (CN). The groundwater quality is reported in comparison with the 'Requirements for the purification of wastewater effluent' – General Standards, Water Act of 1956 (Act 54 of 1956). Water levels are very constant in the region, staying within 40 to 60m below surface for all measured boreholes. Boreholes depth readings are taken every 2 weeks.

Table 4 shows the results from 2019 and 2020, while **table 5** provides the maximum concentration in milligrams per liter 'Requirements for the purification of wastewater effluent' (Act 54 of 1956)).

Table 4: Monitoring boreholes in which one of the elements analysed exceeded the maximum concentration (2019 and 2020).

	2019				2020			
Elements	**1st quarter**	**2nd quarter**	**3rd quarter**	**4th quarter**	**1st quarter**	**2nd quarter**	**3rd quarter**	**4th quarter**
Zn	none	none	no data available	none	no data available due to Covid19 pandemic	none	none	none
Pb	none	WBH12		WBH12, water return dam		none	none	WBH 13, water return dam
Cu	none	RPZ4		none		none	none	none
AS	none	none		none		none	none	none
Cd	none	plant outflow, tailings returned		none		none	none	none
CN	plant flow out, tailings return	plant outflow		none		none	none	none

Table 5: maximum concentration in milligrams per liter 'Requirements for the purification of wastewater effluent' (Act 54 of 1956)).

Element	Permitted max. concentration in milligrams per liter
Zn	5.0
Pb	0.1
Cu	1.0
AS*	0.5
Cd	0.1
CN	0.5

*(0.01mg/l in drinking water – WHO)

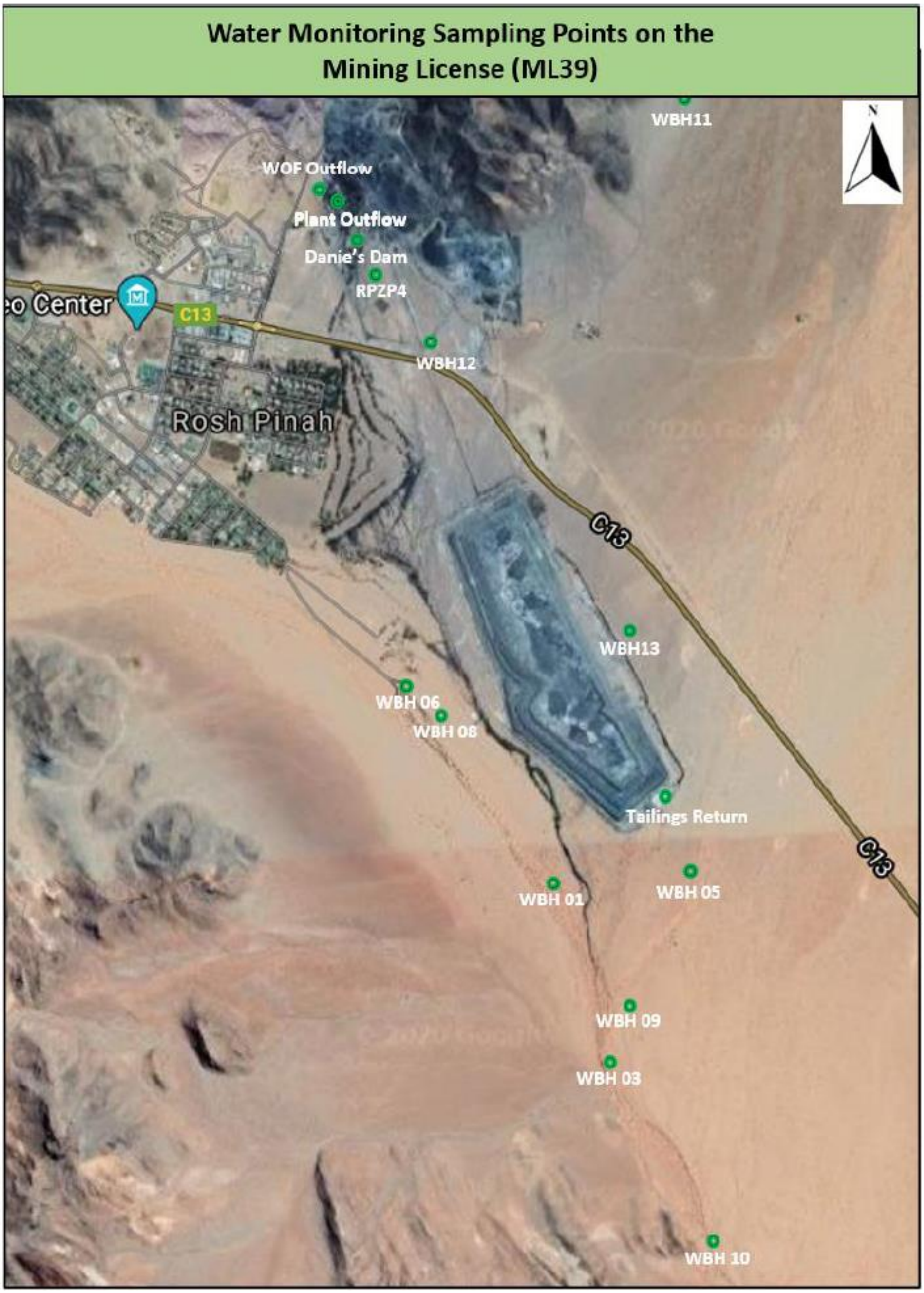


Figure 7: Monitoring boreholes around the existing TSF.

4.2 Dust Monitoring

After Fraser Alexander took over the tailing disposal facility operation, a dust monitoring programme was initiated in August 2006. A total of 12 dust collection buckets have been erected within the mine premises and Rosh Pinah village (see **Figure 8**).

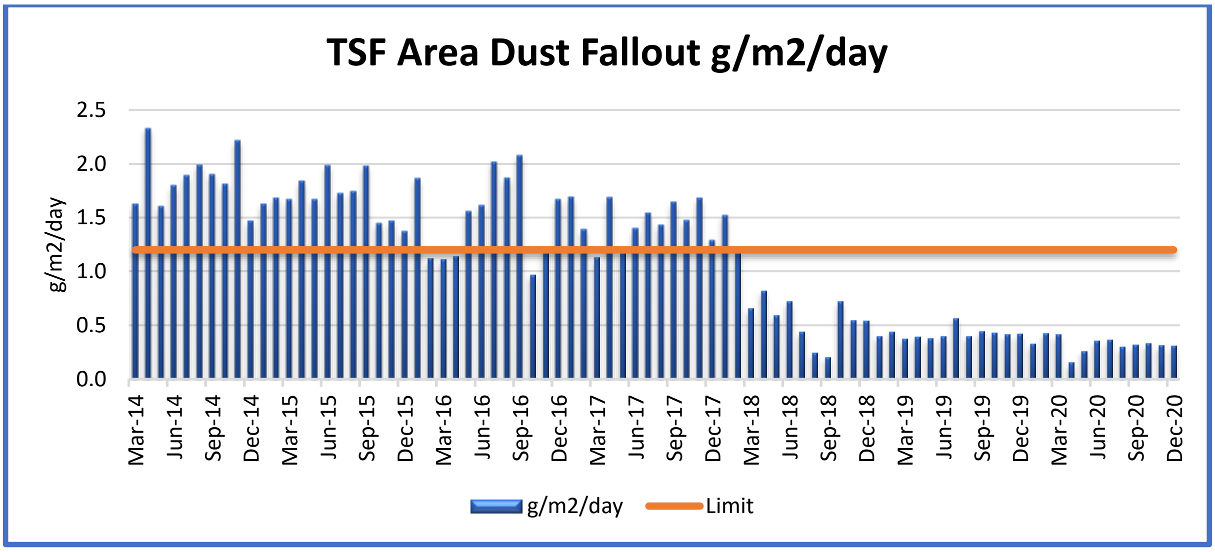
Figure 8: Dust monitoring sample point locations. (source: Fraser Alexander).

According to SABS standards the following classification regarding concentration levels for dust are applicable:

0 – 600 mg/m^2/day:	RESIDENTIAL LEVEL - Permissible for residential & light commercial areas
600 – 1 200 mg/m^2/day:	INDUSTRIAL LEVEL - Permissible for heavy industrial areas
1 200 – 2 400 mg/m^2/day:	ACTION LEVEL - Investigation required immediately
Above 2 400 mg/m^2/day:	ALERT LEVEL - Action required immediately

Figure 4 provides the results of the dust monitoring programme.

With the appointment of the Environmental Specialist in Sept 2019, the directional dust monitoring was taken over from the Occupational Hygienist which have managed the multiple directional buckets from 2018. The results are analysed at the mine. **Figure 9** shows the results of the dustfall out measured around the tailings disposal facility and within Rosh Pinah town. None of the analyzed dust fallout around the existing TSF has exceeded the proposed daily dustfall out of 1.20 g/m^2/day for industrial level since March 2018. Since September 2016 the residential level of daily dustfall out of 0.6 g/m^2/day was not exceeded. This proves that the mitigation measures introduced in 2014 are working (see Chapter 4.2.1).



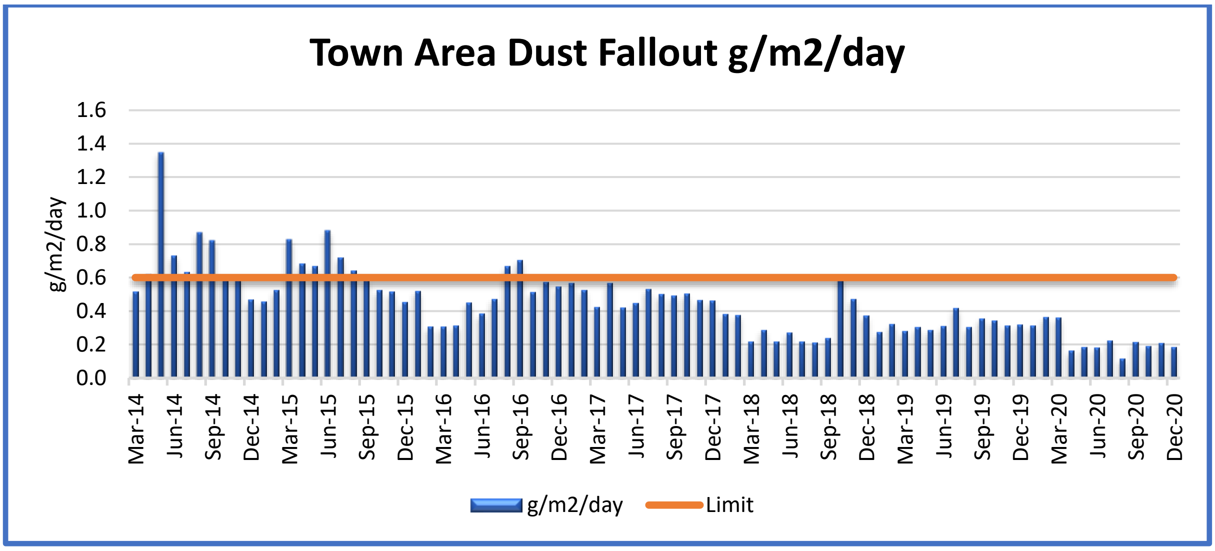


Figure 9: Results of the dustfall out monitoring programme (March 2014 – December 2020). (source: Environmental Specialist, RPZC).

4.2.1 Tailings Storage Facility Dust Mitigation Measures

Since 2014 budget was allocated to minimize the dust generated from the existing TSF. The measures introduced are:

1. **Rock Cladding:**
   - Rock Cladding was started in 2014 of which a Capex Budget was made in the amount of +/- N$ 500,000 per annum. An assessment was done to optimally focus on areas that would yield the best results in reduction of dust. As the area covered by the rock cladding increases there is a reduction of dust levels recorded year on year.

2. **Road Dust Control (RDC):**
   - In the same year (2014) an additional budget of N$ 1million was budgeted for further dust reduction strategies. The administration of a product called Road

Dust Control (RDC) surfactant was done. This product was most utilized to the upper berms where it was not possible to execute rock cladding.

- At the time, some beach areas were not in operation thus the RDC was applied to those areas as it is water soluble it was easy to do the spray application.
- Once the different TSF's beach sections became smaller the contractor Frazer Alexander were able to cover the entire beach area within a month addressing dust generation by constant rewetting.
- RPZC converted to spraying the more permanent TDS on the upper berms.

5 EXISTING TAILINGS OPERATION

The existing TSF is situated approximately 1.5 km to the south of the plant area and 500 m south-east of Rosh Pinah village. The location of the TSF was identified in 1969 when mining operations started. The TSF is founded on the alluvial sediments of the valley drainage system. The Tailings Storage Facility has no liner system to prevent seepage into groundwater. Monitoring wells have been drilled around the impoundment and monitor possible seepage into the groundwater (see **Chapter 4.1**). The dust monitoring is described in **Chapter 4.2**. The hydrological model of the mine area is discussed in **Chapter 3.2**.

Initially, tailings were pumped to the area and the pipes manually moved to control the growth of the Tailings Storage Facility. During the past decades the Tailings Storage Facility rose significantly to approximately 15 m. A tailings pipe failure in 1995 led to the establishment of retention paddocks to manage the growth better and therefore the stability of the Tailings Storage Facility. The paddocks help to minimise the dust generated from the top of the Tailings Storage Facility as well because they are kept moist.

The slimes from the lead and zinc thickener ponds are pumped via a 1.5 km-long and 200 mm-thick HDP pipe to the TSF.

In 2005 Rosh Pinah Zinc Corporation appointed Fraser Alexander to manage the current tailings disposal facility operation. Information describing the current TSF operation is taken from KP memorandum "Remaining Tailings Storage Capacity at the existing TSF" (October 2020).

Figure 10 shows the existing TSF and the proposed Southeast Extension.

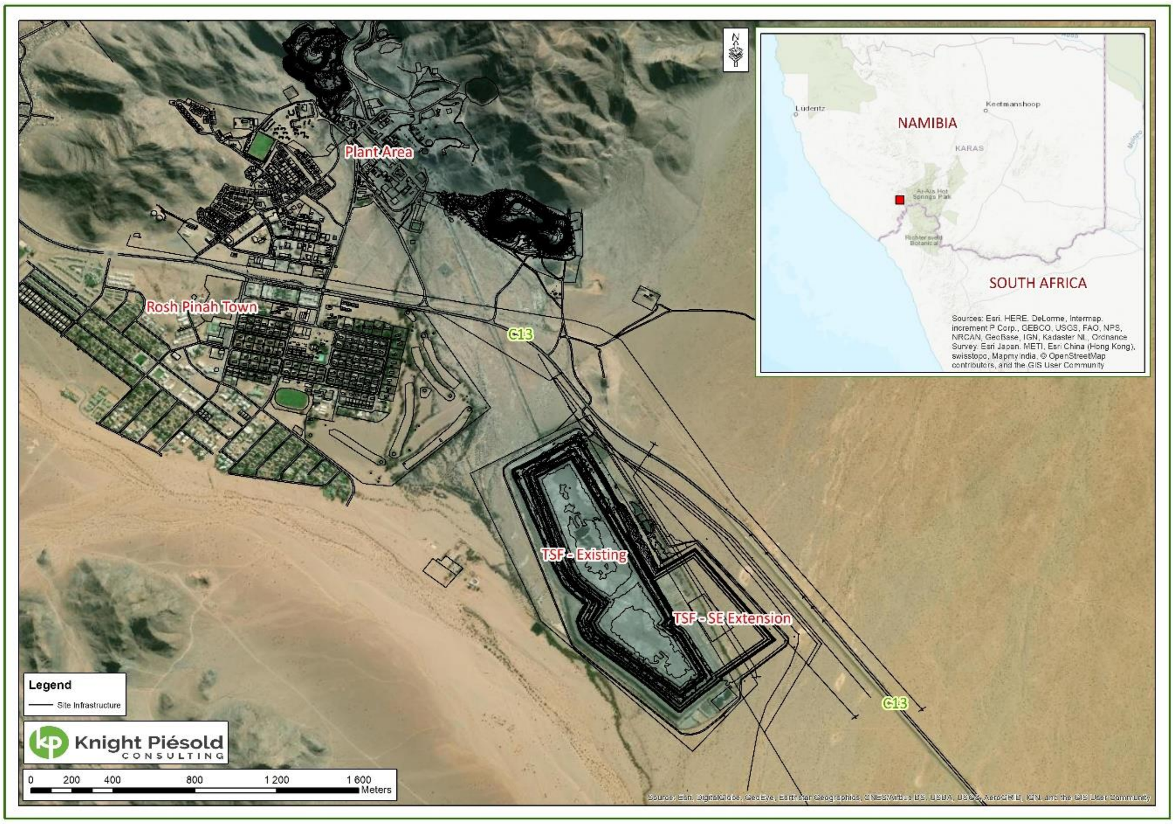


Figure 10: Existing TSF and proposed Southeast Extension.

5.1 Embankment construction

The existing TSF is raised along all four sides of the facility using the Daywall upstream construction method with hand-compacted tailings. The Daywall upstream construction method typically includes the following measures (Fraser Alexander, 2019):

1. Establishment of a step-in from the previous embankment raise to maintain the overall slope angle

2. Construction of an underdrainage system excavated into the previous embankment stage to maintain a low phreatic surface in the next embankment as it is developed

3. Construction of 250 mm to 500 mm high embankments along the perimeter of the TSF to create paddocks that are typically 48 m long by 14 m wide. The embankments are constructed by hand using tailings excavated from the tailings beach and consolidation is achieved by the weight and drainage of the tailings.

4. Filling of the paddocks with slurry tailings. Supernatant and finer tailings are decanted into the main basin and the deposited tailings are given time to dry and consolidate

5. Repetition of Steps 3 and 4 with progressively smaller embankment widths while maintaining 1V:3H upstream and downstream embankment slopes and until the embankment is approximately 6 m wide.

6. Widening of each paddock in the upstream direction and raising to establish a platform, then additional raising of the entire embankment to establish the final embankment crest elevation

As of the end of July 2020, the existing TSF was constructed to approximate embankment crest El. 388 m and was approximately 43 m high in the southwestern corner of the facility. The current overall slope of the outer embankments complies with the 1V:3H overall slope specified in the design criteria by Fraser Alexander (2006 FA Continuation Report, section 6.1) and seconded by KCB in 2019 (2019 KCB Dam Safety Assurance Report). **Figure 11** shows the current TSF layout and compartments.

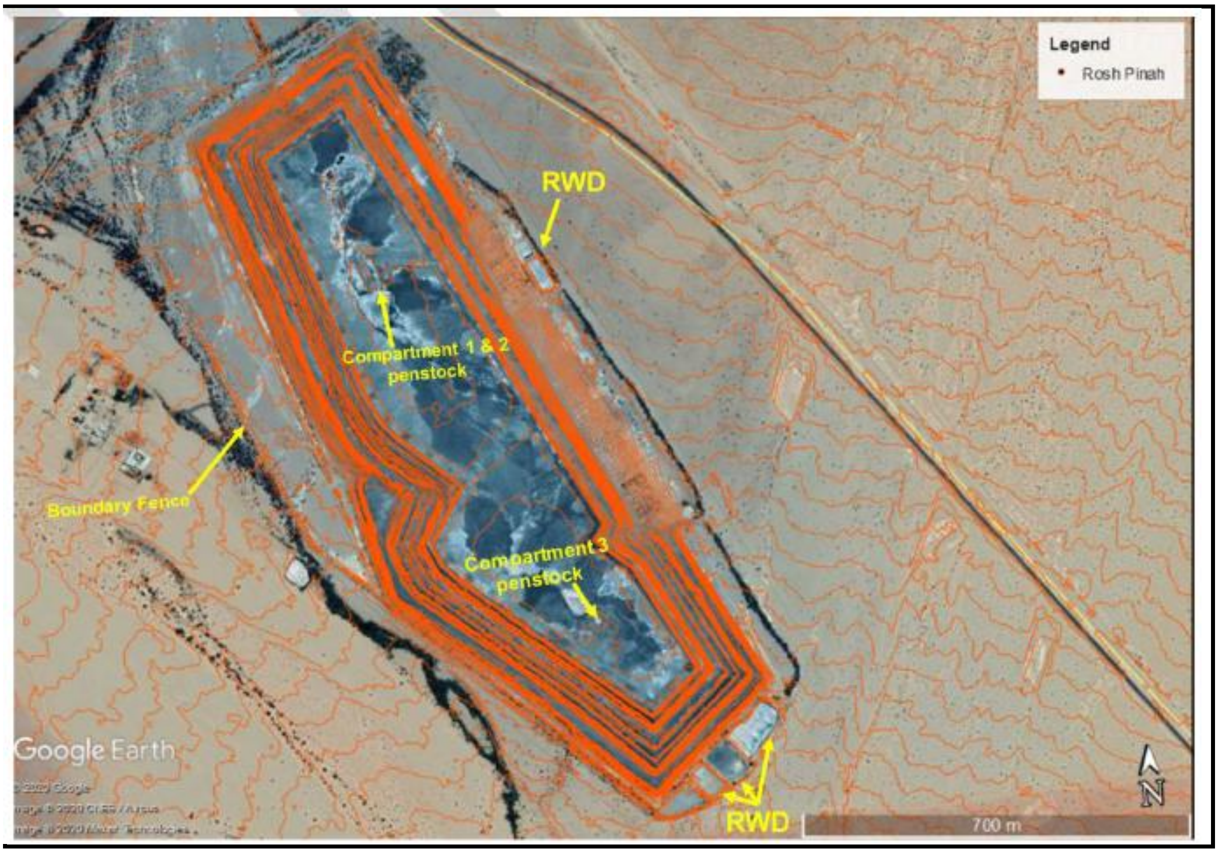


Figure 11: Arrangement of the existing TSF.

5.2 Tailings and Water Management

The existing TSF basin is divided into two compartments to manage tailings and water more efficiently. The TSF initially comprised three compartments, namely: DAM1, DAM2 and DAM3, but is currently split into two compartments, Compartment 1 and Compartment 3 (see **Figure 11**). Tailings are deposited from the upstream face of the TSF embankments and a portion of the tailings is used for Daywall construction. Supernatant decanted from the tailings is routed to a penstock in the centre of each compartment. The penstocks then convey the collected supernatant to the Return Water Dams, where it is transferred to the zinc circuit in the plant for re-use in the milling process.

The northern and southern beach lengths (distance from embankment crest to decant pool) were approximately 75 m and 60 m from the embankment crest in July 2020, respectively. The tailings surface elevation at that time ranged from El. 386.5 m to El. 387.5 m.

5.3 Capacity Assessment of the Existing TSF

The available tailings storage capacity at the existing TSF has been studied frequently, especially over the last four years. The results from previous capacity assessments, along with the current estimate of tailings storage capacity, are summarized below.

Knight Piesold completed a three-dimensional (3D) modelling using Muk3D and the July 2020 Photosat survey to estimate the remaining tailings storage capacity. Two scenarios were modelled bringing the final height of the TSF to an embankment crest of El. 393m and El. 395m respectively. The capacity estimates were based on a start date of July 2020, which matched the current tailings production estimates (RPZC, 2020). The July 2020 survey shows that the embankment crest was at El. 388.2 m at the time of the survey.

The first scenario would approximately have 0.89Mm^3 available storage capacity and would provide enough tailings storage capacity until August 2022. Scenario two would approximately have 1.3Mm^3 available tailings storage capacity and would last until August 2023.

Due to stability aspects the TSF cannot be built higher. The Southeast Extension will receive additional tailings once the ultimate storage capacity at the existing TSF is reached. The commissioning date for the Southeast Extension has been set to April 1, 2022 based on recent discussions with RPZC and Knight Piésold and operations at the existing TSF will cease on that date.

6 TSF EXTENSION OPTIONS CONSIDERED

KP considered the following options for TSF extension during the pre-feasibility study based on the information provided in the RPZC (2019):

- **Option 1:** Raising of the existing TSF
- **Option 2:** Buttress* around the entire perimeter of the TSF
- **Option 2A:** Buttress along the western side of the existing TSF
- **Option 2B:** Buttress along the western and eastern sides of the existing TSF
- **Option 3B:** Extend the TSF to the southeast
- **Option 4A:** New TSF to the east of the TSF, on the eastern side of Highway C13
- **Option 4B:** New TSF at the northwest corner of the existing TSF
- **Option 4C:** New TSF to the west of the existing TSF and to the west of the existing drainage

* A buttress is a berm constructed at the bottom of a TSF either from a cyclone operation or from mechanically raised tailings. It does require downstream water management structures.

Options 1, 2, and 4B were deemed to have a fatal flaw (or flaws) in relation to geotechnical concerns and geometry of the expansion plan and were not further included in the alternative assessment.

6.1 Description of viable options

Figure 12 shows Options 2A, 2B, 3B, 4A, and 4C, which were further investigated.

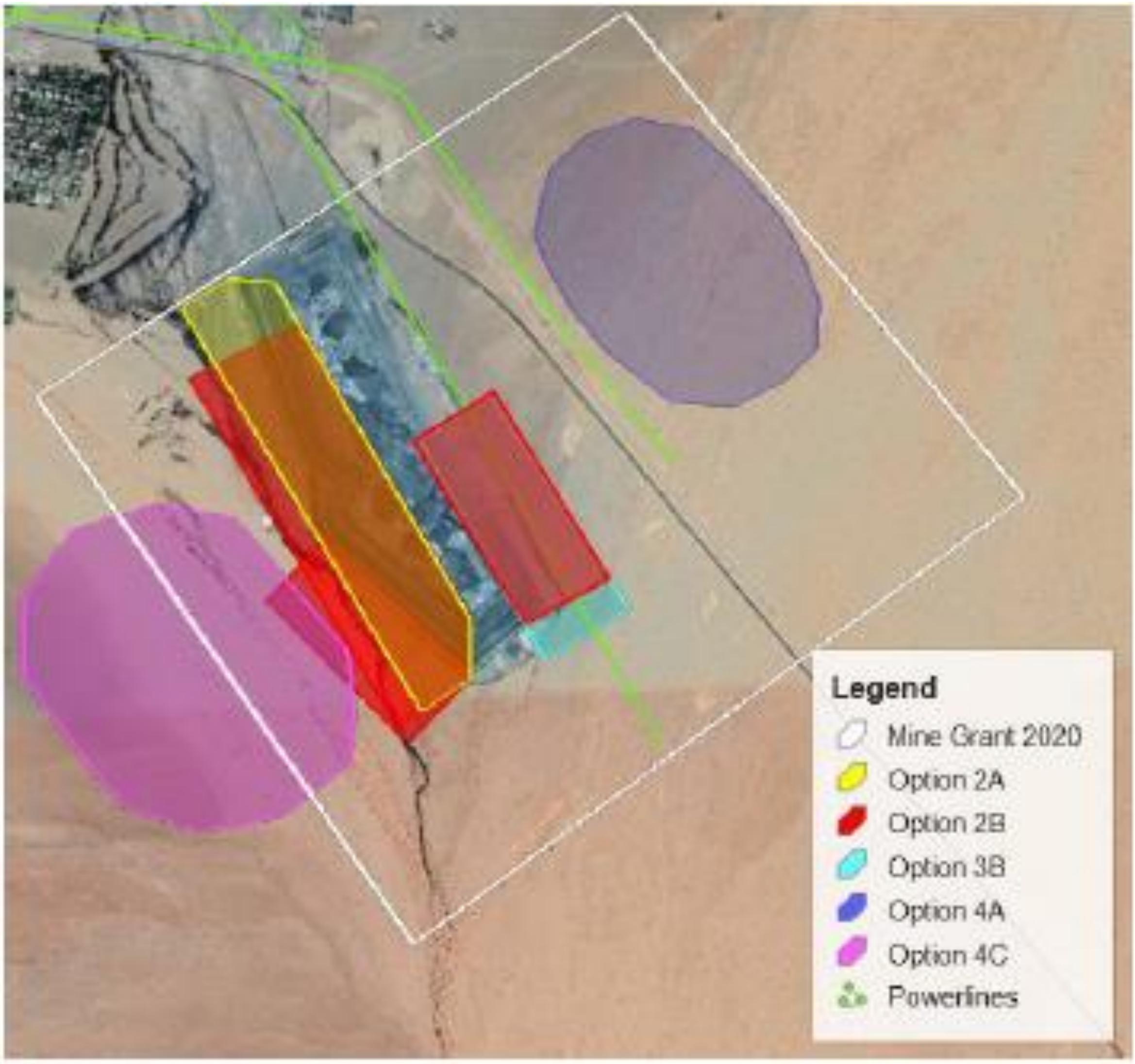


Figure 12: High-level option assessment for TSF expansion (Knight Piesold, November 2019).

The assessment included the following main components:

- Access and external infrastructure, such as the re-location of powerlines
- Solution and runoff collection trench construction. It is assumed that each of these trenches will be lined with concrete infilled geocell.
- Starter wall construction for each option. It is assumed for this assessment that the starter wall will be constructed with borrowed material.
- Daywall construction with tailings to raise the perimeter embankments
- Diversion measures to divert runoff from the IDF
- Installation of geosynthetic lining and underdrainage systems
- Return water system upgrades, including decant tower and penstock construction
- Return Water Dam construction and extension of the Return Water Pipeline

6.1.1 Option 2A – West Buttress (yellow in Figure 12)

This option involves ongoing tailings deposition at the existing TSF, followed by the construction of a buttress along the west side of the existing TSF. For this assessment, the existing TSF stores 1.3 Mm3 of tailings and the buttress stores 3.0 Mm^3 of tailings. The tailings deposition period at the existing TSF and resultant start date at the proposed buttress varies according to the feed scenario.

Under this option, the existing TSF would be raised to embankment crest El. 390 m. The buttress height ranges from 12 to 23 m (buttress crest El. 354 to 369 m) to maintain the rate of rise target of 3 m/year under each feed scenario.

6.1.2 Option 2B – Buttress (re in Figure 12)

This option involves ongoing tailings deposition at the existing TSF, followed by the construction of buttresses along the west and southeast sides of the existing TSF. For this assessment, the existing TSF stores 1.3 Mm^3 of tailings and the buttresses store the remaining 3.0 Mm^3 of tailings. The tailings deposition period at the existing TSF and resultant start date at the proposed buttresses vary according to the feed scenario.

Under this option, the existing TSF would be raised to embankment crest El. 390 m. The west buttress height ranges from 3 to 15 m (buttress crest El. 345 to 357 m) and the southeast buttress height ranges from 8 to 10 m (buttress crest El. 360 to 362 m) to maintain the rate of rise target of 3 m/year under each feed scenario.

6.1.3 Option 3B - Southeast extension (light blue in Figure 12)

This option involves ongoing tailings deposition at the existing TSF, followed by extending the TSF to the southeast. For this assessment, tailings deposition begins at the southeast extension in mid-2020. The tailings deposition volumes at the existing TSF and extension vary according to the feed scenario.

Under this option, the existing TSF would be raised to approximate embankment crest El. 386 to 387 m based on six months of tailings deposition to mid-2020. The extension height ranges from 15 to 32 m (extension crest El. 367 to 382 m) to maintain the rate of rise target of 3 m/year under each feed scenario.

6.1.4 Option 4A – East TSF (dark blue in Figure 12)

This option involves ongoing tailings deposition at the existing TSF, followed by the construction of a new TSF to the east of the existing TSF on the east side of Highway C13. For this assessment, tailings deposition begins at the East TSF in mid-2021. The tailings deposition volumes at the existing TSF and East TSF vary according to the feed scenario.

Under this option, the existing TSF would be raised to an elevation that ranges from embankment crest El. 387 to 389 m based on tailings deposition to mid-2021. The East TSF height ranges from 12 to 13 m (crest El. 378 to 379 m) to maintain the rate of rise target of 3 m/year under each feed scenario.

6.1.5 Option 4C – West TSF (pink in Figure 12)

This option involves ongoing tailings deposition at the existing TSF, followed by the construction of a new TSF to the west of the existing TSF within the catchment of a large valley to the northwest of the project site. For this assessment, tailings deposition begins at the West TSF in mid-2021. The tailings deposition volumes at the existing TSF and West TSF vary according to the feed scenario.

Under this option, the existing TSF would be raised to an elevation that ranges from embankment crest El. 387 to 389 m. The West TSF height ranges from 11 to 14 m (crest El. 352 to 355 m) to maintain the rate of rise target of 3 m/year under each feed scenario.

6.2 Assessment of viable options

The following Pros and Cons for each option were assessed based on the following to enable a clear and transparent comparison between the options:

- **Development Costs:** Options with lower development costs are preferred to save on future capital and operational expenditures.
- **Expansion Potential:** Options with greater expansion potential are preferred in case additional mineral resources are found at Rosh Pinah in the future.
- **Dust Generation Potential:** It is understood that the principal wind direction is from the southeast; from the existing TSF and towards the townsite. Options with low dust generation potential are preferred.
- **Permitting Requirements:** Options with lower permitting requirements are preferred, as operations can terminate at the existing TSF sooner.

Table 6: summarizes the Pros and Cons for each option

Option	Pros	Cons
Option 2A	• Relatively low development costs (second lowest among the five options) • Low permitting requirements and schedule advancement (tied for first among the five options), as the buttress can be treated as an extension to the existing TSF and the buttress is within the Mine Grant 2020 Boundary. This would allow the cessation of operations to occur sooner at the existing TSF.	• High potential for dust generation (fourth among the five options) due to the relatively high embankment height and exposure to the principal wind direction from the southeast • Very poor expansion potential (fifth among the five options), as additional expansion to the west would require additional diversion requirements to protect the TSF from runoff during the IDF. Additional dust would also likely be blown into the townsite.
Option 2B	• Moderate expansion potential (third among the five options), as the TSF could be expanded to the Southeast • Low permitting requirements and schedule advancement (tied for first among the five options), as the buttress can be treated as an extension to the existing TSF and the buttress is within the Mine Grant 2020 Boundary. This would allow the cessation of operations to occur sooner at the existing TSF.	• Relatively high development costs (third among the five options) • Medium potential for dust generation (third among the five options) due to the relatively high embankment height and exposure to the principal wind direction from the southeast
Option 3B	• Lowest development costs • Low potential for dust generation (second among the five options), as the extension is partially protected by the existing TSF. • Low permitting requirements (tied for first among the five options) and	• Poor expansion potential (fourth among the five options), as limited expansion is possible to the south, within the existing Mine Grant 2020 Boundary. This potential is judged to be less favourable than Option 2B, as Option 2B has less tailings volume in this area.

Option	Pros	Cons
	schedule advancement, as the buttress can be treated as an extension to the existing TSF and the buttress is within the Mine Grant 2020 Boundary. This would allow the cessation of operations to occur sooner at the existing TSF.	
Option 4A	• Very low potential for dust generation (first among the five options) due to the relatively low embankment height. Any dust from the facility would blow into the mountains and away from the townsite. • Excellent expansion potential (first among the five options). The TSF can be raised or extended easily.	• Relatively High development costs (second highest among the five options) • High additional permitting requirements (tied for last among the five options) and schedule delays, as the East TSF would be considered as a new tailings storage structure. This would extend operations at the existing TSF.
Option 4C	• Good expansion potential (second among the five options). The West TSF can be raised or extended, but the diversion requirements would increase more significantly than Option 4A.	• Highest development costs • Extreme dust generation potential (fifth among the five options), due to being directly upwind from the townsite. • High additional permitting requirements (tied for last among the five options), as the West TSF would be considered as a new tailings storage structure. This would extend operations at the existing TSF.

6.3 Discussion and conclusion

The following main conclusions can be made from the options assessment:

- Option 3B has the lowest development costs and has the most Pros and the least Cons
- Options 2A, 2B and 4A have two Pros and two Cons
- Option 4C has the least Pros and the most Cons

Based on the above, Option 3B is the preferred tailings and water management option for the pre-feasibility study. **Chapter 6** describes Option 3B in detail after further studies had been undertaken by KP.

7 SOUTHEAST EXTENSION

The Southeast Extension will receive tailings at the start of Q3, 2022. The Southeast Extension will reach its ultimate storage capacity target at the end of 2031. **Figure 13** shows the location of the Southeast Extension in relation to the existing TSF.

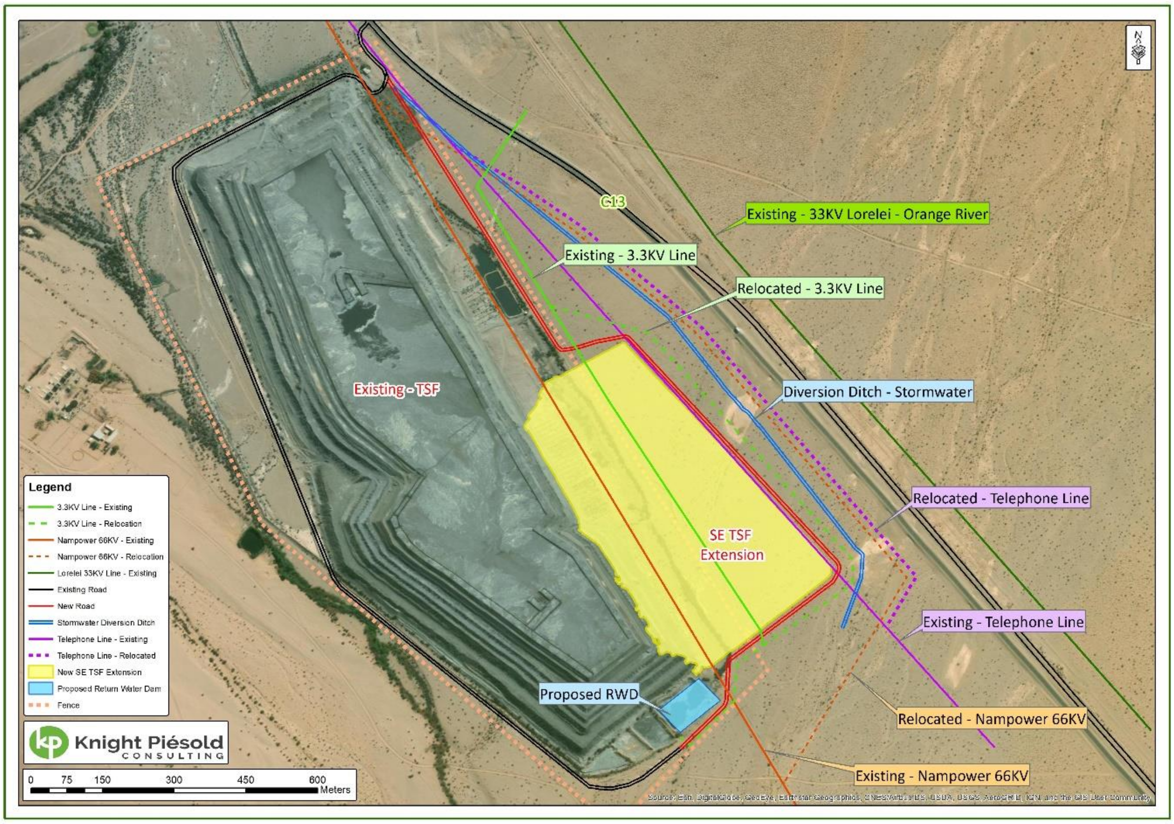


Figure 13: The blue line shows the southeast extension of the existing TSF.

Information provided below are taken from "Pre-Feasibility Study for Tailings Storage Facility Expansion – Design Summary Report" (Knight Piesold, June 2020).

7.1 Construction of the Southeast Extension

Alluvial, aeolian and littoral materials are typically present within the Southeast Extension foundation. The embankment foundations and basin will be cleared, grubbed and stripped of surface soils and unsuitable materials to expose a medium dense sand and gravel soil layer.

The Stage 1 (starter wall) embankment will be constructed with sand and gravel fill excavated from the basin shaping work completed inside the tailings basin. The embankments will be constructed immediately to the east of the existing TSF to form a three-sided impoundment (see **Figure 13**, yellow area), with the west wall of the Southeast Extension consisting of the existing TSF Daywall. The Stage 1 embankment will be approximately 12m in height with the embankment crest constructed to El. 361 m. The upstream slope will be 2.5H:1V, the downstream slope will be 3H:1V and the crest width will be 8m.

The Stage 1 tailings dry density is 1.45 t/m^3. The final tailings dry density is 1.65 t/m^3. The lower density estimate was used to size the Stage 1 embankments only. The overall Southeast Extension size was based on the higher dry density value, as it is assumed that the Stage 1 tailings will consolidate over time and reach the higher density value at the end of Stage 2 (building up the Southeast Extension) operations.

A Basin Underdrain is included in the design to enhance consolidation of the tailings mass and collect a portion of the seepage through the tailings mass. The Basin Underdrain will include perforated HDPE collection pipes and HDPE conveyance pipes. The Basin Underdrain will be installed in the basin foundation. The Basin Underdrain collection pipework will be connected to the Basin Underdrain outlet pipe that will drain by gravity to the Return Water Dam south of the existing TSF, where the collected water will be recycled back to the plant. The Return Water Dam will be lined with geosynthetic lining system (see **chapter 7.5**).

Vibrating wire piezometers (VWPs) will be installed in the tailings mass and in the Southeast Extension embankments to confirm that it is performing as designed. VWPs were selected as the preferred type of piezometer based on ease of installation, minimal maintenance requirements, and the ability to obtain readings via datalogger, which will provide a more accurate estimate of the phreatic surface over time. The VWPs will provide an early warning if the phreatic surface in the embankments exceeds allowable levels. Surface Movement Monuments will also be installed on the interim and final embankment crests to monitor for potential movement of the embankments.

The total Southeast Extension footprint will be 19.7 ha and the facility will be constructed to El. 372.2 m (23.5 m in total height). The Stage 1 rate of rise is approximately 5 m/yr at the start of operations, then reduces to 2.2 m/yr at the end of Stage 1 operations. The rate of rise for Stages 2 and 3 ranges from 1.0 to 1.5 m/yr.

7.2 Tailings Management

Tailings will be conveyed to the southeast extension as a conventional slurry and deposited from the upstream face of the southeast extension embankments. A portion of the tailings will be used for Daywall construction during the operation of Stages 2 and 3. This deposition and construction strategy will develop a low permeability tailings deposit adjacent to the sand and gravel embankments and Daywalls.

The supernatant pond will be maintained in the center of the basin, well away from the perimeter embankments, and two penstocks will operate in the center of the Southeast Extension basin. Tailings will be deposited from set locations around the perimeter of the basin to promote even filling, construct the Daywalls as the Southeast Extension is raised, and manage the location of the supernatant pond. The deposition plan will include for rotational discharge of tailings from several discharge locations to develop an exposed tailings beach. The development of the tailings beach will allow for sub-aerial (above water surface) tailings deposition to achieve the following objectives:

- Optimize the basin filling by depositing tailings in relatively thin layers around the perimeter of the facility above the supernatant pond surface
- Maintain the supernatant pond location well away from the embankments, while maintaining adequate depth adjacent to the penstock
- Maximize the settled density and strength of the tailings by promoting drainage of process water and air drying of the tailings

The tailings slurry will be conveyed to the TSF from the plant site via HDPE pipeline. The pipeline will extend to the farthest discharge point along the embankment crests during operations with discharge spigots at approximately 25 m spacing along the embankment crest.

The pipelines will be raised and extended around the basin perimeter as required during operations.

7.3 Stormwater Management

The southeast extension TSF has been sized to provide temporary storage of the Inflow Design Flood (IDF) during operations. Based on a Dam Class of HIGH according to the Canadian Dam Association 2019 Dam Safety Guidelines, the IDF is defined as the storm that is 1/3 between the 1 in 1,000 year, 24 hour storm event and the Probable Maximum Precipitation (PMP) event. A total of 0.7 m of wet freeboard is required during operations to temporarily store the IDF, including 0.5 m for the operating pond and 0.2 m for the runoff. A dry freeboard of 0.8 m is also required, according to the GN704 guidelines, to provide overtopping protection for wave run-up (RSA, 1998). The total required freeboard above the tailings surface is 1.5 m, and this value was used to assist with the raising plan for the Southeast Extension. The two penstocks in the southeast extension TSF basin will draw the stormwater pond down following the storm and this water will be conveyed to the Return Water Dam.

7.4 Diversion System

A Stormwater Diversion Ditch will be constructed upstream of the southeast extension TSF during Stage 1 construction to divert potential runoff from storm events around the facility. The ditch was designed to divert runoff from storms up to and including the 1 in 100 year, 24-hour storm event based on current Namibian and South African Stormwater and Flood Hydrology guidelines. The ditches will be excavated into natural ground and will be trapezoidal in shape. Due to the expected high water velocity along a portion of the ditch during the design storm, concrete infilled geocell will be required to line a portion of the ditch length to prevent channel scour.

7.5 Water Reclaim System

The water reclaim system will reclaim water from the Southeast Extension to the plant site for use in the process. The system will include the following components:

- Two penstocks to convey supernatant and runoff to the Return Water Dam. The penstocks will be raised with pre-cast concrete cylinders as the tailings elevation rises.
- Barge, pump and HDPE pipeline to reclaim water from the Return Water Dam to the plant site.

The required storage volume for the Return Water Dam will be obtained by expanding a de-activated pond adjacent to the existing TSF. The Return Water Dam will be excavated into the foundation and a small berm consisting of sand and gravel fill will be constructed around the perimeter of the Return Water Dam. The Return Water Dam will be sized to store operational flows and runoff from storms up to and including the 1 in 200 year, 24 hour storm event, including stormwater from the Southeast Extension via the penstocks. A spillway will be installed at the Return Water Dam to safely pass the runoff from the PMP event to the environment.

The Return Water Dam will be lined with a geosynthetic lining system to prevent seepage from the Return Water Dam. The geosynthetic lining system will be installed on the prepared foundation and along the upstream berm face of the RWD and will consist of the following components:

- A 0.15 m thick bedding layer over the foundation materials to prevent liner puncture
- A layer of non-woven geotextile over the bedding layer to act as a cushion layer for the liner
- A layer of 60 mil HDPE geomembrane over the non-woven geotextile
- A 0.3 m thick erosion protection layer over the geomembrane to prevent liner puncture and allow for periodic cleaning of the basin

The non-woven geotextile and geomembrane will be tied in to the perimeter berm via anchor trenches.

7.6 Chemical Composition of tailings

Static testing results indicated that the tailings solids were high in sulphide and carbon (Knight Piesold, 2019). The reaction rates over time from the humidity cell testing indicate that there is a rapid depletion of sulphate, whereas the carbon species deplete slowly over time, thus providing ongoing buffering capacity and allowing the pH to remain circum-neutral. Thus, the tailings are Non-Potential Acid Generation (Non-PAG).

Total metals testing indicated that the tailings have elevated silver, bismuth, carbon, lead, and sulphur concentrations. The humidity cell testing indicated that silver and bismuth did not leach under the neutral pH conditions (both analytes remained below the minimum detection limit (MDL) throughout the 20 weeks of testing). Lead did leach above the MDL, however remained below the detection limit throughout the 20 weeks of testing. As mentioned, sulphur depletion was rapid and carbon depletion occurred steadily over time. Given the neutral nature of the leachate, metal leaching is not a significant concern.

Based on the geochemical testing results to date, the installation of a basal liner for the proposed Southeast Extension should not be required as the tailings material is Non-PAG with only minor metal leaching (ML) potential. An under-drainage system will be installed on the basin foundation to collect and re-direct supernatant and runoff from the Southeast Extension to the Return Water Dam downstream. The tailings management plan will likely be updated periodically over the mine life as results from ongoing tailings characterization programs on site become available and as the actual mine plan evolves.

7.7 Realignment of existing infrastructure

NamPower and Telecom have been consulted regarding the rerouting of a 66 KV and 3.3 KV powerlines and the telephone line.

8 ENVIRONMENTAL ASPECT IDENTIFICATION – POTENTIAL IMPACTS OF THE SOUTHEAST EXTENSION

Environmental Aspect	Potential impacts and comments
Visual	• Visual impact of the Tailings Storage Facility and Tailings Storage Facility pipeline Comment: This is negligible, as no new pipe corridors will be created. The Southeast Extension and existing TSF will be fenced in.
Emissions to water	• Surface & groundwater pollution from leakages of the tailings delivery pipeline • Effluent seepage from tailings, possible pollution plume beneath and southwards of the Southeast Extension and existing TSF
Emissions to Air	• Effect of minerals contained in tailings dust on flora and fauna • Health of people affected by inhalation of tailings dust

9 ENVIRONMENTAL ASSESSMENT OF POTENTIAL ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

9.1 Criteria

The criteria identified in Crowther (1999) have been reviewed and updated. Below each criteria is briefly described that is used to assess the degree of significance.

Legislation – is the identified impact controlled by legislation or policy and does the aspect comply

Magnitude – What is the relative severity of the impact. Severity, as opposed to size, takes account of impact magnitude, notably whether or not an impact is reversible and the likely rate of recovery.

Extent - Is it localized or may it result in a wide-ranging impact?

Frequency – How often does the activity that has been identified to have an impact on the environment occur?

Probability – What is the probability that the impact occurs?

Perception of Stakeholders – Could stakeholders be embarrassed or even become liable as a result of the impact

Table 7: Criteria Matrix

Potential / Actual Impact			
Criteria	**Rating**		
	Yes	**No**	**N/A**
Meeting of legal requirements (or meeting company policy)	Met	Not met	Not applicable
	Low	**Medium**	**High**
Magnitude	Low	Moderate	Severe
Extent	Localised impact	Wider impact but contained within surface grant area	Widespread impact affecting neighbours
Frequency	Monthly or less often	Weekly	Daily
Probability of impact occurrence	< 10% (improbable)	10% - 50% (possible)	> 50% (definite)
Perception of stakeholders	N/A	Potentially embarrassing	Potentially damaging

Allocation of Significance Rating

High Significance

Not meeting Legal requirements

Magnitude and Extent = High, **and** the probability of occurrence = High; or

Magnitude = High **and** probability of occurrence = Medium

Medium Significance

Meeting Legal requirements

Magnitude = medium to low; Extent & Frequency = low to High, **but** probability of occurrence = Medium or Low

Low Significance

Meeting Legal requirements

Magnitude, Extent, frequency = medium or low, **as well as** probability of occurrence = Low

Environmental Aspect	Visual	
Potential / Actual Impact	Visual impact of Tailings Storage Facility and pipeline	
Criteria	**Rating**	
Meeting of legal requirements	n/a	
	unmitigated	**mitigated**
Magnitude	H	M
Extent	L	L
Frequency	H	H
Probability of impact occurrence	Established	Established
Perception of stakeholders	L	L
Significance	H	M

Mitigation measures:

- **Rock Cladding:**
    - Rock Cladding was started in 2014 of which a Capex Budget was made in the amount of +/- N$ 500,000 per annum. An assessment was done to optimally focus on areas that would yield the best results in reduction of dust. As the area covered by the rock cladding increases there is an reduction of dust levels recorded year on year.

- **Road Dust Control (RDC):**
    - In the same year (2014) an additional budget of N$ 1million was budgeted for further dust reduction strategies. The administration of a product called Road Dust Control (RDC) surfactant was done. This product was most utilized to the upper berms where it was not possible to execute rock cladding.
    - At the time, some beach areas were not in operation thus the RDC was applied to those areas as it is water soluble it was easy to do the spray application.
    - Once the different dams' beach sections became smaller the contractor Frazer Alexander were able to cover the entire beach area within a month addressing dust generation by constant rewetting.
    - RPZC converted to spraying the more permanent TDS on the upper berms.

Environmental Aspect	Emissions to Air	
Potential / Actual Impact	Health of people affected by inhalation of tailings dust	
Criteria	**Rating**	
Meeting of legal requirements	Health Act	
	unmitigated	**mitigated**
Magnitude	H	M
Extent	H	H
Frequency	M	M
Probability of impact occurrence	H	M
Perception of stakeholders	H	M
Significance	H	M

Mitigation measures:

- **Rock Cladding:**
  - Rock Cladding was started in 2014 of which a Capex Budget was made in the amount of +/- N$ 500,000 per annum. An assessment was done to optimally focus on areas that would yield the best results in reduction of dust. As the area covered by the rock cladding increases there is a reduction of dust levels recorded year on year.

- **Road Dust Control (RDC):**
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  - Once the different dams' beach sections became smaller the contractor Frazer Alexander were able to cover the entire beach area within a month addressing dust generation by constant rewetting.
  - RPZC converted to spraying the more permanent TDS on the upper berms.

Environmental Aspect	Emissions to Water	
Potential Impact	Effluent seepage from tailings, possible pollution plume beneath and southwards of the Tailings Storage Facility	
Criteria	**Rating**	
Meeting of legal requirements	Environmental Management Act, 'Requirements for the purification of wastewater effluent' – General Standards, Water Act of 1956 (Act 54 of 1956)	
	unmitigated	**mitigated**
Magnitude	M	L
Extent	H	M
Frequency	L	L
Probability of impact occurrence	M	L
Perception of stakeholders	M	L
Significance	M	L

Mitigation measures:

Since 1997 the monitoring system is in place, and all monitoring boreholes are sampled quarterly and analysed by NamWater in Windhoek. Samples are analysed for zinc (Zn), lead (Pb), copper (Cu), arsenic (AS), cadmium (Cd) and cyanide (CN). Water levels are very constant in the region, staying within 40 to 60m below surface for all measured boreholes. Boreholes depth readings are taken every 2 weeks.

Except for the monitoring borehole WBH13 (see **Chapter 4.1**), all analyses are within the allowed limits. WBH13 showed slightly higher levels of Pb once in two years of monitoring, while the Water Return Dam showed twice elevated levels of Pb. The Water Return Dam is lined and water pumped back to the plant.

10 CONCLUSION AND COMMITMENTS

If all mitigation measures are carried out no adverse environmental impacts will occur from the Southeast Extension during construction and operation.

The following additional mitigation measures need to be implanted:

- An under-drainage system will be installed on the basin foundation to collect and re-direct supernatant and runoff from the Southeast Extension to the Return Water Dam downstream. The tailings management plan will likely be updated periodically over the mine life as results from ongoing tailings characterization programs on site become available and as the actual mine plan evolves.
- Monitoring borehole WBH13 will be covered by the Southeast Extension and needs to be sealed properly (concrete filled) to ensure that no tailings fluid can leak into the aquifer. It will be replaced with a new monitoring borehole to the SE of the Southeast Extension.
- The Return Water Dam will be lined with a geosynthetic lining system to prevent seepage from the Water Return Dam.
- The VWPs will provide an early warning if the phreatic surface in the embankments exceeds allowable levels. Surface Movement Monuments will also be installed on the interim and final embankment crests to monitor for potential movement of the embankments.
- Low potential for dust generation, as the extension is partially protected by the existing TSF and will not be higher than the existing TSF.

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