

SCOPING REPORT (INCLUDING IMPACTS ASSESSMENT) FOR THE PROPOSED CHANGES TO THE HUSAB MINE AND LINEAR INFRASTRUCTURE:

Husab Mine

Prepared for: Swakop Uranium



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EXECUTIVE SUMMARY

1. GENERAL INTRODUCTION AND PROJECT MOTIVATION

Swakop Uranium owns and operates the Husab Mine and processing plant on Mining License No 171. The mine is located in the northern part of the Namib Naukluft National Park (NNNP), 52 km east of the coastal town on Swakopmund and south of the Rössing Uranium mine. Mining started in March 2014 and the processing plant was commissioned in December 2016.

An environmental impact assessment (EIA) process was undertaken in 2010 for the Husab Mine and plant and it related onsite infrastructure. This was followed by a second EIA in 2011 for the linear infrastructure required for the mine; both temporary and permanent access roads, power lines and water pipelines. Both EIAs were approved by the MEFT in 2011. Process optimisation using a finer grind resulted in an EIA Amendment being undertaken in 2013 for a dedicated tailings storage facility and a stand-alone waste rock dump as opposed to the original co-disposal facility. This amendment was also approved.

Further exploration drilling conducted at the Husab Mine led to an increase in the defined mineral resource which consequently increased the total life of mine (LOM) from 20 years to ± 22 years. However, in order to mine the increased resource, additional waste rock is mined concurrently, and thus a change to the size of the waste rock dump footprint was required to accommodate the additional waste. An EIA Amendment was undertaken in 2018 for the proposed waste rock dump expansion, as well as an incinerator and telecommunication poles. An EMP commitment related to the environmental clearance certificate (ECC) that was received for this amendment, is the requirement for an approved engineered design of a diversion channel around the extended footprint, to allow unimpeded stream flow along the Husab channel and into the Welwitschia Field which lies south of the mine site (Figure 1).

The Husab plant has been designed to treat ore of a particular grade. Low-grade ore is being stockpiled pending treatment at the end of the LOM through the existing tank leach process.

Swakop Uranium undertook a pre-feasibility study in 2017 to investigate the possibility of subtracting uranium via a heap leach process from this low-grade run-of-mine that is currently being stockpiled. The subsequent feasibility study of 2021 has concluded that heap leaching may offer an attractive option to increase uranium production at the Husab Mine, as it would allow for expanded leaching capacity, without the need for additional milling capacity, or the costs associated with tank leaching, and could generate additional revenue.

2. EIA AMENDMENT

The purpose of this EIA Amendment is to apply for authorisation for Swakop Uranium to undertake the construction and operation of a heap leach circuit, which includes a new crushing and screening circuit, the heap leach pad, conveyors, and the deposition of the waste generated by the process on a standalone heap leach waste facility (HLWF) (Figure 1). The proposed development will be preceded by a pilot heap leach trial.

In addition, Swakop Uranium also wishes to retain the construction water pipeline laid down in 2012 for the temporary supply of water that was used during construction of the Husab Mine, and before the permanent water pipeline was commissioned.

Prior to the commencement of these proposed activities, an EIA Amendment application must be submitted to the MEFT for a decision in terms of the Environmental Management Act, 7 of 2007. The amendment process includes a screening phase, a scoping phase (including an assessment of impacts), and the updating of the current Husab Mine environmental management plan.

SLR Environmental Consulting (Namibia) (Pty) Ltd (SLR) has been appointed by Swakop Uranium as the independent Environmental Assessment Practitioner to undertake the EIA process.

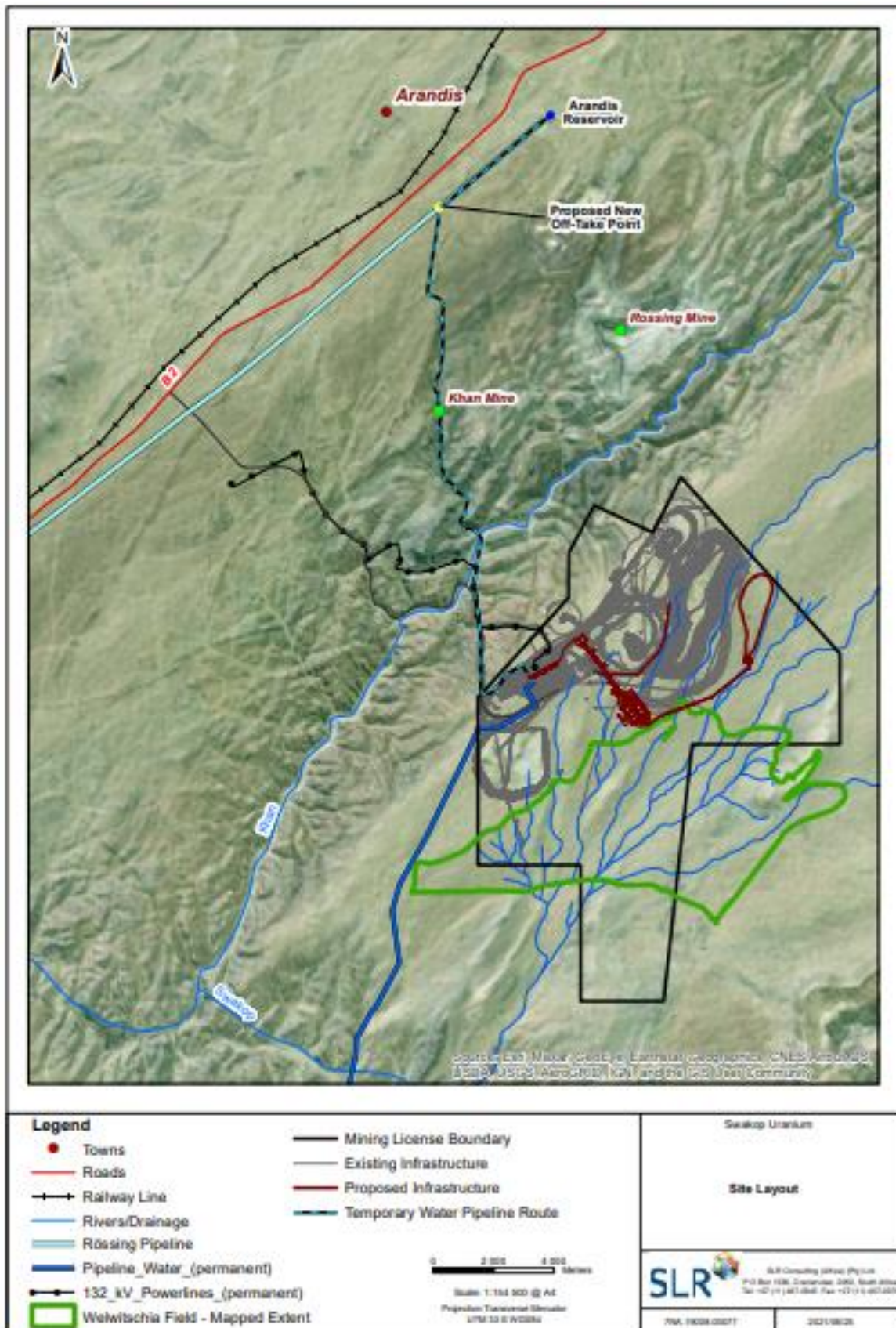


Figure 1. Husab Mine site locality map with approved infrastructure in grey. The proposed heap leach is shown in dark red, and the construction water pipeline in stippled blue & black.

3. RETENTION OF THE TEMPORARY CONSTRUCTION WATER SUPPLY PIPELINE

3.1 PIPELINE MOTIVATION

Processing of the low-grade ore on the proposed heap leach facility requires an additional 1,9 Mm³ water per annum in addition to the 8 Mm³ currently being used by the Husab Mine which is supplied via the permanent water pipeline running northward from the C28. Although the permanent water pipeline capacity is sufficient for the heap leach process, it is near capacity. Swakop Uranium therefore wishes to retain the temporary construction water supply pipeline as a contingency supply for the 20-year LOM of the proposed heap leach facility.

3.2 PIPELINE DESCRIPTION

The pipeline starts at NamWater's Central Namib reservoir (known as the Rössing reservoir) and runs southwards through the Khan Mine valley, across the Khan River and then parallel to the tarred access road leading up to the Husab Mine (Figure 1). The 25 cm diameter HPDE and steel piping lies adjacent to the gravel road in the Khan Mine valley and is buried where secondary tracks join the main roads. The pipeline has been buried next to a rock gabion in the Khan River's bed to protect it from floods.

The route has numerous bends, and the pipeline structure has been strengthened by hammering metal rods into the ground to stabilize the pipes. The temporary water pipeline infrastructure, sourced from Trekoppie's old temporary water supply, was installed in 2013 and used until 2016. The pipeline was to have been removed following the commissioning of the permanent water supply line, as per the conditions in the Husab Mine EMP

Permission to lay the pipeline over various EPLs held along the route was obtained from Rössing Uranium Limited and the former holders of the Khan Mine, Ohlthaver and List. There are now several small Mining Licenses held by Khan Mine (Pty) Ltd along a section of the pipeline route. Khan Mine may start reprocessing the tailings that remain in the vicinity of the old mine.

4. HEAP LEACH PROCESS

4.1 HEAP LEACH MOTIVATION

Low-grade material mining estimates, for Zone 1 and Zone 2 pits, indicates that approximately 180 Mt low-grade material between 100 and 400 ppm U₃O₈ is available for heap leaching. The HLF capacity was fixed at 7.5 Mtpa.

The DFS study indicated that the HLF could potentially reduce current and LOM processing costs, and that the proposed HLF facility design will be able to produce approximately 52 million pounds (23 260 Mt) of U₃O₈ over a twenty-year life of mine (LOM) at an average recovery of 77% from the HLF, operating at 7.5 Mtpa.

Heap leach process description

The feasibility study HLF design is based on a dynamic heap leach circuit, with a dedicated residue waste storage facility, and associated civil, electrical, and surface water management infrastructure. The heap leach facility has been designed to contain all liquid effluent to mitigate potential environmental risks. A summary of the process is provided below.

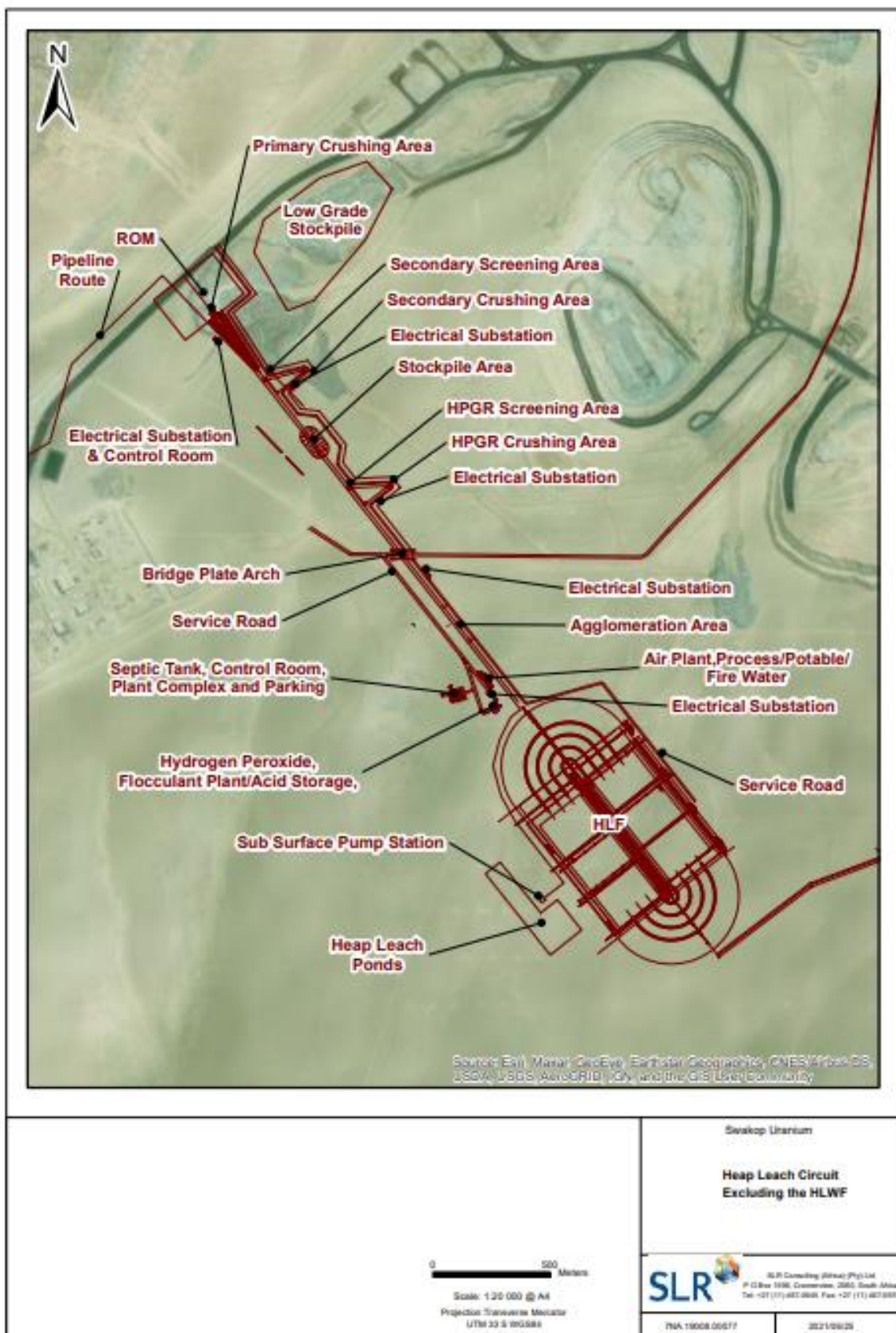


Figure 2. The heap leach circuit: heap leach waste facility not shown.

4.1.1 Heap leach pad

The heap leach operation is based on the use of a dedicated pad for the life-of-mine. The pad will be operated in a racetrack configuration with cells arranged in an on/off fashion. The 1 300 by 600 m racetrack heap leach facility (HLF) comprises of a central spine with a tipper and reclamation arm rotating around the central spine. The HLF consists of six Class C lined cells for the stacking, leaching, drain down, rinse, and reclamation operations, as well as a dormant cell to allow flexibility in the operation. Lined storm water and solution collection ponds are located adjacent to the HLF.

As the stacking of a cell with the <8 mm agglomerated low-grade ore is completed and the section has been made ready for irrigation (by laying piping for drippers and sprinklers), the leaching and washing cycles are initiated. The sulphuric acid storage will accommodate 1 080 tonnes of acid per HL cycle, with the sulphuric acid delivered with 30-tonne tankers over a three-day period during each cycle.

Solution is only applied to one cell at a time from each of the solution ponds. Leach solution will be collected by a series of solution collection pipes within the drainage layer. The pregnant leach solution (PLS) is collected in the PLS pond and will be pumped to the existing tank leach facility (TLF) PLS pond at the main processing plant. Barren solution from the TLF barren liquor pond is piped to the HLF barren pond as make-up solution. Wash water is used to rinse the cell at the end of the cycle, recovering reagents and uranium-bearing leach liquor.

Once the leaching cycle is completed the washed and drained residue is reclaimed mechanically and placed onto a conveyor that transports it to the heap leach waste disposal facility.

The heap leach pad operational cycle, from stacking, through leaching and reclamation will take 100 days resulting in ~6 cycles per year. Each cycle will include 17 days for stacking, 3 days for curing; surface piping and pipe laying, the leaching process will take 45 days whereafter 2 days for washing, 8 days for draining, 3 days for piping and network removal, and 17 days for reclamation.

4.1.2 Heap leach waste facility (HLWF)

The post leach residue will be collected with a bucket wheel reclaimer onto a conveyor system that transports it to a dedicated waste storage facility where it is deposited by means of a grass-hopper stacker. The HLWF will be 70 m high, with benches every 15 m accommodating 375 000 tpa of leach residue. The HLWF footprint be approximately 170 ha.

The chemical composition of the waste material will pose a low health risk. The solids will have low leachability and comprise of silica (34-35%), aluminium (5.8-6.2%), iron total (2.2%), sodium (1.6-1.7%), and potassium (4.1-5.4%). These chemical elements, including in its current form (solids, low leachability), are not considered a human health risk.

An engineered environmental barrier is to be constructed in phases to match the dump progression and is designed according to the waste classification of the South African National Norms and Standards for Disposal of Waste to Landfill (GN R. 636 of 2013). The heap leached waste was geochemically characterised and is classified as Type 3 waste which requires, as a minimum, at least a Class C barrier system.

The Class C barrier system will comprise a 300 mm base layer constructed out of clayey material. This base layer will be overlain with 1.5 mm HDPE geomembrane and the geomembrane will be covered with a 100 mm thick silty sand or protection geotextile.

The HLWF is the only structure that remains at the end of the heap leach LOM. It must therefore be designed for closure, with a covering of inert waste engineered to reduce water ingress, and with slopes that are resistant to water and wind erosion.

4.1.3 Storm water management

The dirty water system will consist of canals located around the outside of the HLF and HLWF footprint and associated storm water control dams (SWD). The canals will intercept the dirty water run-off from the HLWF and HLF and will discharge in the new SWD located down-dip of the facilities. The canals will also accommodate seepage from the seepage management system. The SWD will be lined with an HDPE geomembrane which will be regularly inspected and cleaned as necessary. Dirty water will be pumped from the pollution control dams back to the main processing plant. Clean water will be diverted around the facility and back into existing drainage channels.

All pipelines carrying the PLS, barren solution, return storm water etc will be placed in a lined/impermeable trench between the HLF and existing process plant. Pipelines to and from the HLWF and HLF will be placed on the conveyor structure where it crosses the Husab channel.

4.1.4 Pilot heap leach

Mini heap leach test work has been recommended prior to the full-scale process, in order to de-risk the current parameters for the heap leach design. The pilot heap leach facility involves construction of a scaled-down version of the plant, with the same process description, located within the footprint of the proposed heap leach facility. It is estimated that this pilot facility (including support facilities) will be scaled to between 5-15% of the main plant, but limited to 2 cells only, to investigate two different sets of conditions.

5. EIA AMENDMENT PROCESS

The impact assessment process followed for this EIA Amendment has been done in line with the requirements of the Environmental Management Act, 7 of 2007 and the Environmental Impact Assessment Regulations GN, 4878 of 2012. The overall objectives of the assessment process are to:

- provide an independent assessment of the potential environmental impacts associated with the proposed changes to the existing approved EIA and EMP;
- undertake public consultation;
- develop additional/revised management and mitigation measures for identified additional/different potential impacts where necessary; and
- present an objective view to the authorities for final decision making with respect to approval (or not) of the proposed changes, and the conditions to be applied thereto.

5.1 SPECIALIST STUDIES

The environmental and socio-economic baseline for the Husab Mine and its associated Linear Infrastructure has been assessed several times over the past 10 years, with each successive EIA amendment. In addition, environmental monitoring programmes at Husab, and research by students, Gobabeb and other universities has added to the understanding of the ecological processes that operate in the Husab Mining Licence area.

The proposed heap leach process has a relatively large footprint, estimated at over 216 ha, and will be operating for a 20-year period. The commodity being mined and processed, uranium, has potential health and pollution risks associated with it. To this end, seven specialist studies were undertaken to provide input to the impact assessment process: air quality, radiation, biodiversity, surface water, ground water, archaeology and visual assessments have been done.

5.2 SITE LAYOUT ALTERNATIVES

A large component of the scoping study has been the site selection process for the proposed heap leach facility. Given that the Husab Mine is located in an area of significant biodiversity and habitat, and adjacent to the large and renowned Welwitschia field fed by ephemeral streams that flow south-westwards across the site, the amount of less sensitive real estate available for the placement of the two large structures, the HLF and HLWF is severely constrained. In addition, potential ore reserves are located in the stratigraphic sequence south-west of Pit Zone 2. At least eleven site layout options have been considered. Two layouts, Option G and Option H, were eventually chosen for the specialists studies, and these were evaluated.

The biodiversity specialist report produced a revised site sensitivities plan that showed that infrastructure of either option was partially located in the No-Go area at the edge of the Welwitschia field, and partially in the Husab channel. As a result, the Husab project team, environmental department, SLR, and the air quality and biodiversity specialists reassessed the site layout options and agreed upon Option K.

Site layout Option K (Figure 3) was then reviewed by the air quality, biodiversity and radiation specialist. The ground water and surface water management studies were remodelled. All the updated specialist reports are provided in the Appendices. Option K is the preferred option and is the layout that is proposed for this development.

5.3 PUBLIC AND STAKEHOLDER CONSULTATION

The Husab Mine EIA Amendment for the proposed heap leach process and retention of the construction water supply pipeline was advertised in local newspapers and an invitation was sent to Swakop Uranium's interested and affected parties database asking for any issues or comments. Focus group meetings were also held with key stakeholders. Issues and comments have been captured and addressed in the report and Appendices D & E.

The principal concerns that were raised are around security of water supply in the region, the off-take agreements with Rössing and NamWater for the continues use of the pipeline, the potential impact of the HLF and HLWF on soils, ground water and surface water, and cumulative impacts of dust and radiation in the area.

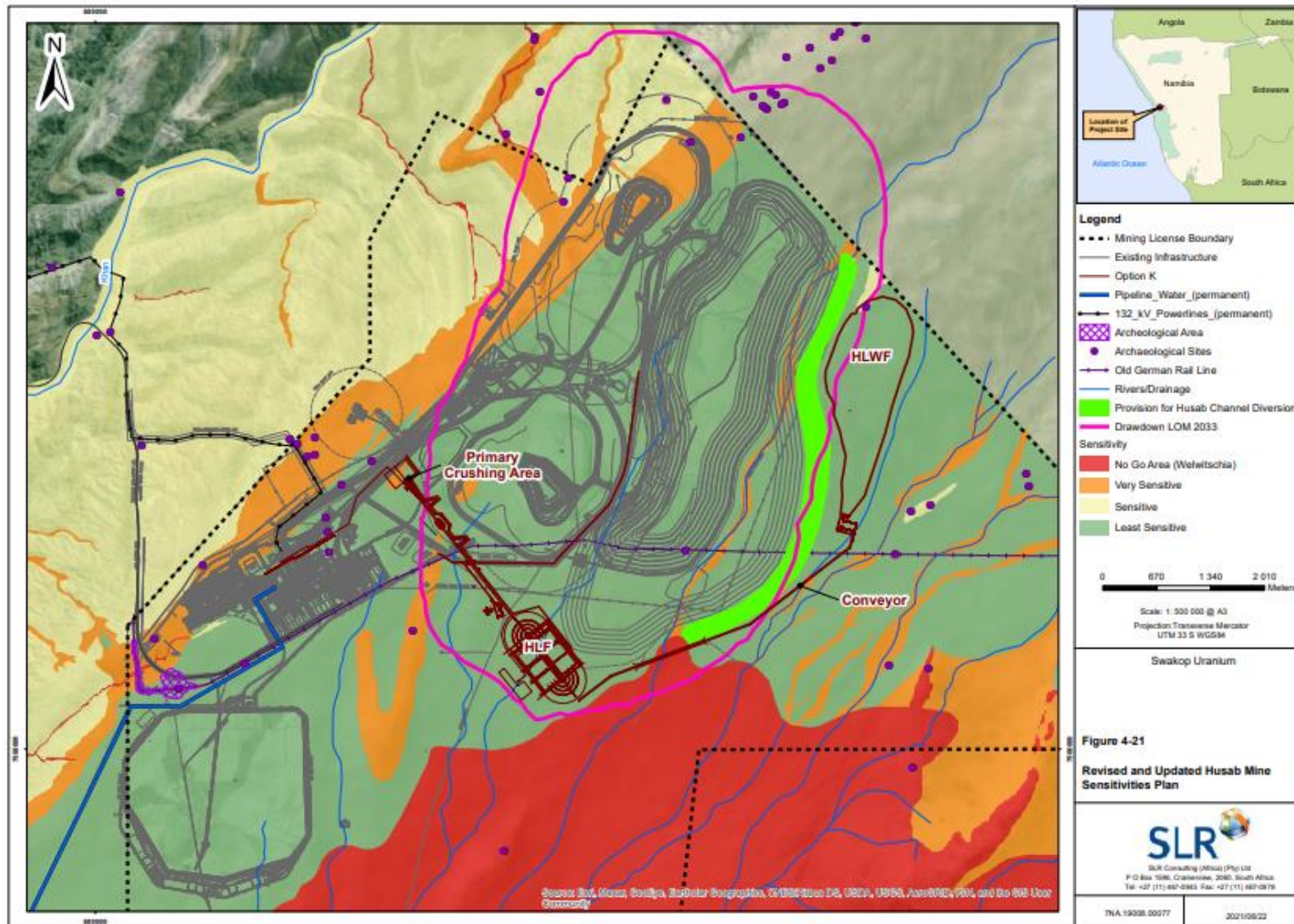


Figure 3. Updated site sensitivities plan with the LOM drawdown cone, main drainage channels and archaeological sites with layout Option K.

6. IMPACT ASSESSMENT FINDINGS

6.1 IMPACTS RELATED TO RETENTION OF THE CONSTRUCTION TEMPORARY WATER PIPELINE

6.1.1 Impacts

The pipeline was constructed in 2012 and has been lying adjacent to the Khan Mine valley road and the Husab Mine access road since then. The potential impacts associated with refurbishment, use and maintenance of the pipeline are related to: -

- Biodiversity:
 - Potential disturbance of animals when working, or through accidents caused by vehicles.
 - Loss or damage to protected trees.
- Visual impacts and tourism
 - The Khan Mine valley and historic mine buildings have tourism potential that should be preserved.
 - The pipeline is clearly visible and thus affects the sense of place.
- Archaeological resources/heritage
 - Impact on, or erosion of, the many heritage sites associated with historic Khan mine, including graveyards.
- Surface rights and use of the Khan Mine valley road
 - Swakop Uranium does not have legal jurisdiction over the Kahn Mine valley area but road user safety can potentially be affected by high pressure pipe burst, or accidental impact with pipeline or supporting structures.

6.1.2 Mitigation

The issues are manageable through the existing Swakop Uranium EMP, and the standard operating procedures, which may need slight modification to include issues related the above. The current EMP has been updated and is attached as Appendix M.

Swakop Uranium must engage with the EPL and ML holders to negotiate retention of the pipeline and use of the Rössing water supply.

6.2 IMPACTS RELATED TO THE PROPOSED HEAP LEACH PROCESS AND RELATED INFRASTRUCTURE

The impact assessment for the heap leach process and infrastructure has included input from previous investigations on site, comment from key stakeholders, as well as specialist assessments of key aspects that may be vulnerable to impact. From these inputs, it has been determined that the critical decision-making criteria on whether this project will be authorised is related to the conservation of local biodiversity, to the prevention of pollution of ground and surface water, and to the containment of impacts related to the generation of inhalable dust fractions and exposure to radiation.

The specialist investigations have indicated medium and low impacts with mitigation. These mitigation measures have been included in the Amended EMP (Appendix M). The following overarching conditions are applicable to the impact assessment for the proposed heap leach circuit and related infrastructure: -

- The heap leach circuit and its infrastructure have a large footprint that affects a significant area of the Mining License (~216 ha). The layout, Option K, is the best fit that reduces most of the direct impacts on sensitive biodiversity in the area.

- All the specialist assessments have assumed that the Husab channel will be diverted around the extended footprint of the waste rock dump and that the impact of this is already accounted for, except that it contributes to the cumulative impact on the Welwitschia field.
- The soils, radiation, visual and biodiversity assessments all require that the mitigation measures provided by the air quality assessment are fully implemented. Dust must be contained.
- The soils, ground and surface water, radiation and biodiversity impact assessments also depend on the implementation of an effective and managed storm water management system. The HLWF must be designed for closure.
- The soils, ground water, surface water, radiation and biodiversity impact assessments all depend on the correct design and implementation of the Class C liner for the HLF and HLWF. Without the liner the impacts to surface and ground water, and to any downstream receptors, would be significantly higher.
- The radiological assessment concludes that, in view of the principle of optimisation as applies to radiological practices in Namibia, recommends that **only mitigated heap leaching options are considered for implementation**, provided that environmental impacts are minimised by way of applying best practice mitigation measures as applied in modern open pit mining and processing environments in hyper-arid climates as is the case in the western Namib desert.

6.2.1 Impacts and mitigation

The construction, decommissioning and closure activities associated with the proposed heap leach facilities are similar in nature to that assessed and approved in the original Husab Mine EIAs. General construction activities have not been reassessed, except where the potential impacts associated with construction of the heap leach facility are significant. Changes in environmental aspects and impacts related to the operation of heap leach facility, and closure of the HLWF are discussed further.

Loss of soils resource through physical disturbance and loss of soil ecological functioning from pollution

The footprint of the proposed heap leach circuit and its infrastructure will impact at least 216 ha of mostly undisturbed soils. Soils are a significant component of most ecosystems and is the medium in which vegetation grows, and a range of vertebrates and invertebrates exist.

Soil is also important for the rehabilitation processes needed at the closure at the end of LOM.

During the construction and operation of the heap leach waste facility there are several activities that have the potential to disturb soils through removal, compaction and/or erosion or through loss of soil functionality through pollution by hazardous liquids and contaminated dust. Physical soil disturbance can result in a loss of soil functionality through loss by erosion, or compaction which compromises rooting ability, water infiltration and soil aeration. Pollution of soils can create a toxic environment for vegetation, vertebrates and invertebrates that rely on the soil.

Various soil horizons (e.g. calcrete) and surface crusts have been identified by the soils, groundwater and biodiversity specialists. These features are probably important aspects of ecosystem functionality in the protection of soils from erosion and/or the retention of moisture in parts of the soil horizon. Soils can be conserved and reused but it is not yet clear whether the calcrete and crust layers can be effectively re-established with the same or similar material.

The impact assessment rating for the loss of soil resource through disturbance and pollution are:-

- Loss of soils resource through physical disturbance in the unmitigated scenario is assessed as a HIGH significance.

- Loss of soil ecological functioning from pollution in the unmitigated scenario is also assessed as a HIGH significance.

Mitigation of potential impacts on soils is achieved by limiting the physical disturbance to the smallest area possible with No-Go areas clearly delineated. All topsoil must be stripped, including under the HLWF, according to the Husab land clearance procedures and stockpiled for use in rehabilitation.

Pollution prevention can be achieved by existing standard operating procedures and full implementation of the dust suppression recommendations from the air quality study.

If these recommended mitigation measures are implemented and maintained, then the impact assessment ratings improve: -

- Loss of soils resource through physical disturbance in the mitigated scenario is assessed as a MEDIUM significance.
- Loss of soil ecological functioning from pollution in the unmitigated scenario is assessed as a LOW significance.

Two other concerns raised by the specialists are a) the possibility of acidic dust from the heap leach process contaminating surface soils, and/or causing damage to plant leaves, and b) the formation of a thin layer of fine dust, wetted by fog, that creates an impermeable barrier to rainfall infiltrating the soil. There is a paucity of information on these possible impacts, and detailed studies are thus recommended during the pilot plant trials. Pilot studies must also be undertaken during the operation phase to determine the best method of re-creating the subsurface impermeable layers and crust layers to restore their role as ecological drivers.

Deep and shallow groundwater contamination

The Husab Mine ground water model has been developing progressively over the past 10 years based on past drilling and test pumping activities, results of routine groundwater monitoring as well as information provided through hydrogeological, geological, and geophysical investigation within the study area. In 2016 SLR developed a numerical Groundwater Flow Model to evaluate potential impacts of the Husab Mine on the regional groundwater environment, and to estimate groundwater inflow rates into the open pit excavations, and potential contaminant transport emanating from the TSF. This model was updated for this assessment to create the groundwater transport models required to evaluate the environmental impact of the HLF and HLWF of the Option K layout.

The simulation was modelled for the worst-case scenario, which has the Class C liner in place, but assumes high rainfall ingress (creating a greater ratio of rock to water), coupled with acid rock drainage and little neutralisation potential in the waste. The model results indicate that during LOM any seepage will be stored in the sediments underlying the facility and will not migrate horizontally to any significant extent (Figure 4). Additionally, vertical migration of contaminated seepage will only reach approximately 60 m below the HLF and 80 m below the HLWF.

- The worst-case scenario for deep ground water contamination was rated as a MEDIUM significance.
- The worst-case scenario for shallow water contamination was rated as a HIGH significance.

As the HLF will be constructed with a Class C liner as a main mitigation measure, rainfall in the area is sporadic and scattered, the evaporation rate is high, the waste is “dry”, the potential to generate the worst-case level of seepage into groundwater is likely to be very low resulting in no significant migration of potential seepage from the HLF or HLWF.

- In the mitigated scenario, both deep groundwater and shallow groundwater contamination was rated as having a LOW significance.

Mitigation against any possible groundwater impacts from the HLF and HLWF is that the Class C liner is installed and that it is maintained, there must be sufficient footwall capacity in the facilities to retain the 1:50 year rainfall event. The stormwater management system, that caters for slightly more than the 1:50 event, must also be installed and maintained. At the end of LOM the HLWF must be closed with an engineered cover design limit rainwater ingress and prevent erosion of the slopes by wind and water.

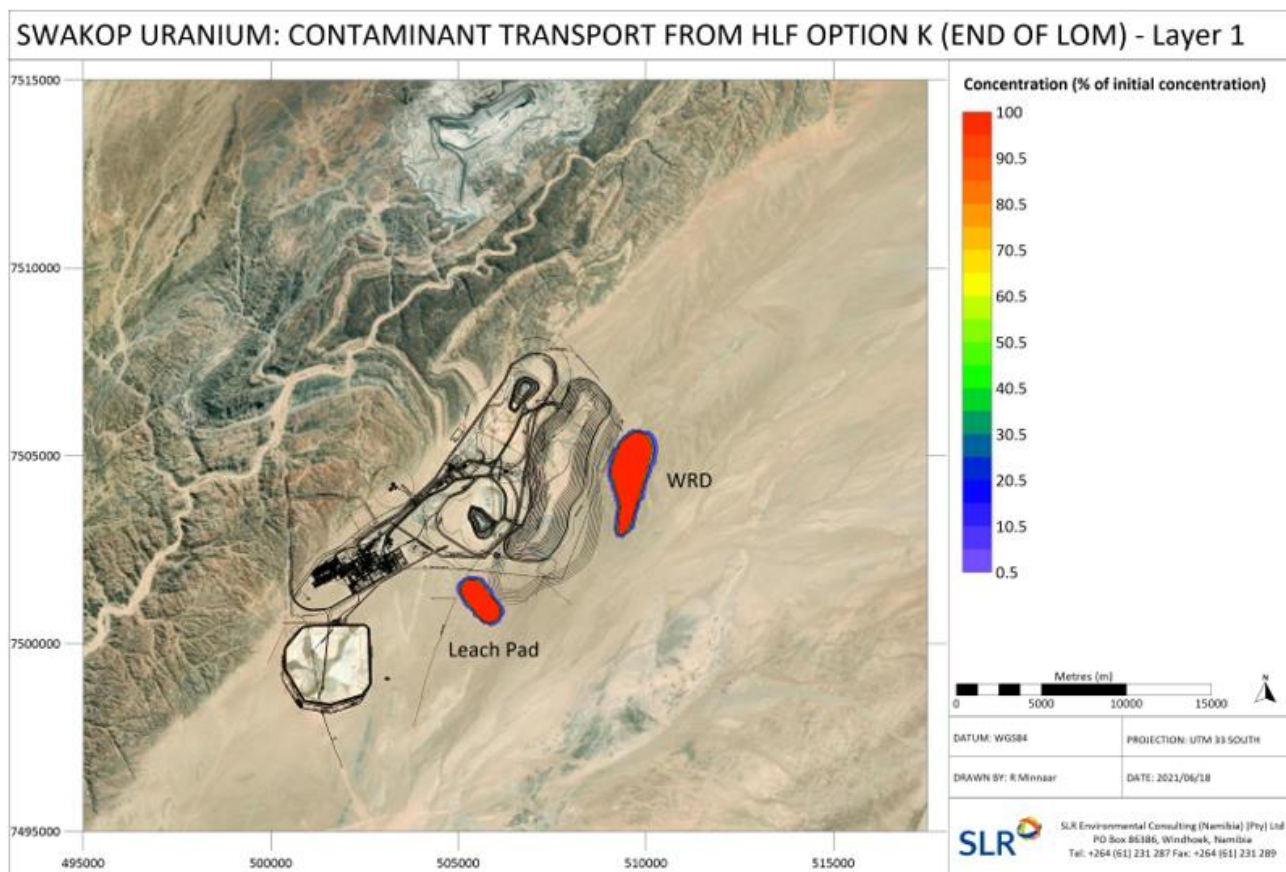


Figure 4. Contaminant transport from the HLP and HLWF at end of LOM in Layer 1

Baseline surface water quality affected by sediment and silt and dirty water runoff

The surface water assessment determined that clean and dirty water runoff from disturbed soil surfaces during construction and operation could enter the drainage channels and potentially affect the quality of water by increasing the increased sediment load. The potential for dirty water runoff off from contaminated or polluted surfaces or the HLF and HLWF also poses a risk to the quality of water in the local drainage channels. Polluted water may impact on the ecological functioning of the Welwitschias and other plants downstream.

- Both these impacts were rated with a HIGH significance in the unmitigated scenarios.
- With mitigation, by the design, construction, and operation of a storm water management system, the significance of the impacts can be reduced to a LOW significance.

The design specifications for the HLWF must keep all infrastructure edges at least 100 m, away from the closest edge of recognisable drainage channels, as well as from the bypass channel.

Reduced catchment runoff (interference to water supply to the Welwitschias)

There are 3 large and 2 smaller catchments that feed the drainage channels that cross the Husab mining license area feed the Husab channel that is a tributary of the Swakop River. Studies on the relative health and size of the Welwitschias in the area shows a strong correlation between the healthiest and biggest plants and their position relative to these channels. Several studies on the source of water for these plants have been undertaken over the past years, and it has been determined that fog cannot be the only contributor to plant health. The viability of the population of Welwitschia plants to the south of the mine critically depends on uninterrupted surface flows in the numerous catchments that feed into the main drainage of the plain south of the mine (Wassenaar, 2018). The construction and placement of any infrastructure in the catchments, or in these channels would represent a potential loss of water supply to the Welwitschia.

The placement of the HLWF between the proposed Husab channel diversion and the major channel to the east of it has mitigated any potential interruption to the flow of water from the catchment to the Welwitschia Field.

- The unmitigated impact was rated having a LOW significance.

The storm water management system proposed for the HLF and HLWF captures water runoff from these two areas thus reducing the volume of water that would normally flow through the channels. The volumes are not considered significant.

- The mitigated impact is also rated having a LOW significance.

Destruction of or damage to Welwitschia plants

The extensive heap leach site selection process has resulted in a site layout that has the least footprint impact on protected or important vegetation and habitat, i.e. the marble ridge and the drainage channels and Welwitschia Field, the No-Go area, were avoided (Figure ss).

However, the conveyor that transports the waste to the HLWF must cross the important Husab channel (or its diversion), in order to reach the HLWF. Individual plants may be damaged or destroyed during the construction of the conveyor belt, its support structures and any service roads along the infrastructure. The loss of any single plant represents a loss of reproductive potential and therefore an increased risk to the population. However, the total number of plants at risk is a very small percentage of the total population.

- The significance of this impact is rated as MEDIUM.

Mitigation measures already included in conveyor design is a bridge-like structure that crosses this important area. No support structures should be built inside the channel itself. There should be no structure erected closer than 30 m from any individual Welwitschia plant. Service roads should also not be closer than 30m from the individual plants.

- With these mitigation measures implemented, the potential impact on Welwitschia plants is reduced to a LOW significance.

Dust deposition on vegetation (and soil)

The heap leach process has the potential to contribute significant amounts of dust to the Husab Mine environment through the crushing and screening circuit, conveying, tipping, reclaiming and stacking. The air quality study indicates that the heap leach process contributes some 10% to existing total particulate emissions, increases PM10 emissions by 4% and PM2.5 increases by 2% in the unmitigated scenario.

The potential impacts of dust are mostly viewed from the perspective of its effects on human health (aka the inhalable fraction and Radiation), but it has also been shown to affect plants' physiological processes – and thus presumably also their 'health' – through a number of pathways. These pathways include reduced photosynthetic ability by clogging of stomata, or deposition of fine dust on leaf surfaces. Naturally occurring desert dust is

rounded due to constant abrasion, whereas dust created by blasting and crushing is more angular, and the sharper/rough edges can cause physical damage to the plant leaves, although abrasion of the Welwitschia leaves following significant east winds has also been observed.

An additional pathway for an impact to occur to plants is the caking of the surface of the soil by fine particles that forms a physical crust when receiving low moisture additions (such as would happen in a fog or light rainfall event) and the potential for reduced water ingress into the ground.

The heap leach facilities are not enclosed in any structure. Sulphuric acid is applied to the crushed ore at the HLF and, although heap is washed at the end of the cycle, the pH of the waste transported by conveyor to the HLWF, will be between 4.5 and 5.2. which, according to the feasibility study, is enough to be considered a skin corrosive and eye irritant. Any dust emanating from the HLF, conveyor and HLWF with a pH lower than neutral is likely to have corrosive effects on plant tissues, which will be multiplied over time and with fog precipitation, thus exacerbating any existing damage because of natural dust scour.

The potential impacts of dust emanating from the heap leach process have the potential to significantly impact vegetation, especially the Welwitschias, and soil surface chemistry and/or infiltration rates. Little research is available to corroborate the concerns.

- These impacts in the unmitigated scenario have been rated as having a HIGH significance.

The mitigation measures rely strongly on the implementation of all the dust reduction mitigations proposed by the Air Quality specialist. With these mitigations in place, the modelled potential reduction in the contribution of the heap leach facility to the overall emission at Husab are reduced from unmitigated 10 % to mitigated 5% for total particulates, PM10 contribution reduces from 4% to 3%, and PM2.5 drops from 3% to 1% in the mitigated scenario.

Other proposed mitigation measures require the leached material to remain moist (at least 2% recommended in feasibility study) as it is loaded onto the conveyor belt for transport to the HLWF and, ideally, the heap should be washed, and the pH of the waste increased to pH 6 or 7.

- With the prescribed air quality mitigation measures in place the potential impact of dust on vegetation and soils was reduced to a MEDIUM significance.

The construction of a pilot heap leach plant presents an opportunity to better understand the issues related to acidic dust, its angularity, and possible abrasion effects on plant leaves (Welwitschia and other species).

Agglomeration is a step in the heap leach process which in addition to improving penetration of acid into the interstitial matrix of the ore by pugging, it also allows for the collection and binding of fines on the ore surface to improve the physical competence and regularize the shape of the ore being stacked onto the heap. This improves the structural characteristics of the heap and facilitates adequate percolation of irrigation solution during leaching. The latent result of this process on the heap leach waste should be investigated to determine the physical attributes of the waste to be transported and stacked.

Also, dust buckets should be placed in several locations around the main dust sources to monitor both dust loads and pH of dust simultaneously monitoring the health of plants near the dust buckets using different indicators, so that effects can be correlated with dust levels and pH. Should there be any indication of damage to the relative health of plants, then further mitigation measures to further reduce dust emission, such as a screens and increased moisture, should be determined.

Destruction of the gravel plain vegetation patches and the ecological engineering effect of gerbils

Destruction of the gravel plain vegetation patches and the ecological engineering effect of gerbils that excavate their burrows here, have consequent knock-on effects on plant productivity and large herbivore presence. A Master's level study conducted on the role of gerbils as ecological engineers has conclusively shown that these small mammals are critical for the maintenance of vegetation productivity on the gravel plains. The enhanced productivity of the naturally occurring vegetation patches is quite likely the reason why zebras are resident in this hyper-arid zone. A study conducted for Swakop Uranium's biodiversity monitoring programme has shown that the zebras do indeed utilise the area in question. The destruction of these vegetation patches and the removal of the gerbils will thus lead to an unknown reduction in the number of zebras that can be supported in this area, as well as to a reduction in the time that they can spend here.

According to the biodiversity expert these impacts are not likely to lead to the extinction of any species, but construction activities will displace, and maybe harm, individual small fauna.

- The unmitigated impact has been rated as having a LOW significance.

Unless the heap leach facilities are not constructed, these impacts remain. Mitigation is therefore restricted to ensuring that all efforts are made to prevent physical harm to fauna in the footprint of the heap leach circuit infrastructure during vegetation and topsoil removal prior to earthworks.

- The mitigated impact significance remains a LOW significance.

Cumulative HL and mine PM2.5 GLCs PM10 GLCs Dustfall rates

The air quality impact assessment quantitatively assessed the base case scenario layout for the proposed heap leach circuit (HLF and HLWF adjacent to and south-east of the extended waste rock dump) for both stand alone, and cumulatively with the existing mine and plant. Option K was qualitatively assessed based on the results of the base case. The main pollutant of concern from the heap leach process circuit is particulate matter that primarily results from the crushing and screening operations, followed by materials handling.

Wind erosion is an intermittent source of the emissions likely to occur for only 15% of the time (when the wind exceeds 5.4 m/s), and only when the HL material is dry (during stacking and reclaiming). It could, however, result in significant short-term impacts when incidences of high wind speeds occur. (This relates particularly to the concern about the effect of potentially acidic dust on vegetation).

During the leaching process at the HLF, very low concentrations of sulphuric acid mist are expected due to very low saturation concentrations in the air and the likelihood that the spray droplets would deposit close to the application, unless it is very fine and there is a strong wind present.

Over an annual average, the heap leach project contributes between 1% and 6% to the cumulative PM2.5 ground level concentrations (GLC) at the air quality sensitive receptors (AQRS), and between 0% and 12% to the dustfall rates (Figure 5). It must be noted that these cumulative PM2.5 concentrations and dustfall rates are very low and well below the air quality objectives (AQO).

Simulated PM10 GLCs, on the other hand, resulted in high short-term impacts on-site and contributing up to 41% of the 24-hour AQO concentration ($75 \mu\text{g}/\text{m}^3$) at the nearest AQSRs when unmitigated (Figure 6). With mitigation in place, the impacts reduce, covering smaller areas around the crushers and screens, materials transfer points, HL pad and waste storage facility.

Cumulatively, the total heap leach project contributes between 6% and 28% to the PM10 GLCs at the AQSRs. With mitigation in place at all the sources, the cumulative PM10 annual average GLCs are well below the AQO, and even the short-term GLCs (24-hour average) are likely to remain within the set limit.

For the simulated average daily dustfall modelled for the base case and assessed cumulatively (both mine and the proposed heap leach), the impacts remain within the Husab fence line for both unmitigated and mitigated scenarios, except for the south-westerly low dustfall plume from the TSF.

- The significance of the impact assessment ratings for the **cumulative heap leach and existing mine and processing plant** before mitigation are: -

PM2.5 GLCs – MEDIUM PM10 GLCs – MEDIUM Dustfall rates - LOW

The Air Quality report provides specific measures for the mitigation of the dust emissions from the heap leach facility. These mitigation measures are of great importance to the other specialist studies, especially soils, biodiversity and radiation, as they underpin the mitigations required for each discipline.

The following factors were used to model the mitigated impacts associated with particulate matter. They must be implemented. If not implemented as recommended, it presents a fatal flaw from the radiation perspective.

Table 1. Assumed mitigation measures and associated control efficiencies.

Source	Mitigation	Control Efficiency (%)
Materials Handling	Dust suppression at Primary and Secondary Crushers using a chute	75% for telescopic chute with water sprays
	Dust suppression through water sprays at HPGR and agglomeration area	50% for water sprays
	no information on stacking and leaching - assumed no mitigation	0%
Crushing & Screening	hooding with fabric filters	83%
Conveyor	roof and one side covered	50%
Service Road	Watering (minimum application rate of 2 litres/m ² /hour)	50%
Wind Erosion	No mitigation assumed	0%

The assessment expects all conveyors to be roofed and have at least one side, and it is recommended that the conveyor from the HLF to the HLWF has 2 sides to reduce possible dispersion of acidic dust in the Welwitschia field. Good engineering practices must be adopted during design of the heap leach process and related infrastructure must be to ensure minimal emissions to air during construction, operations and at closure, particularly the HLWF.

Emission factors were used to estimate all fugitive and processing emissions resulting from the proposed HL process. These emission factors generally assume standard operating conditions. Design figures were used in the emissions quantification.

With the recommended mitigation measures being implemented and maintained, the dispersion field of the particulate emissions reduces significantly, Figures 5 and 6.

- The significance of the cumulative (heap leach and Husab Mine) impact assessment ratings with mitigation however, remain the same.

PM2.5 GLCs – MEDIUM PM10 GLCs – MEDIUM Dustfall rates - LOW

The heap leach pilot provides an ideal opportunity to monitor the impacts from the operations by installing dustfall units downwind of the HLF, the HLWF, the crushers, and conveyors, and to conduct acid mist sampling during the leaching process.

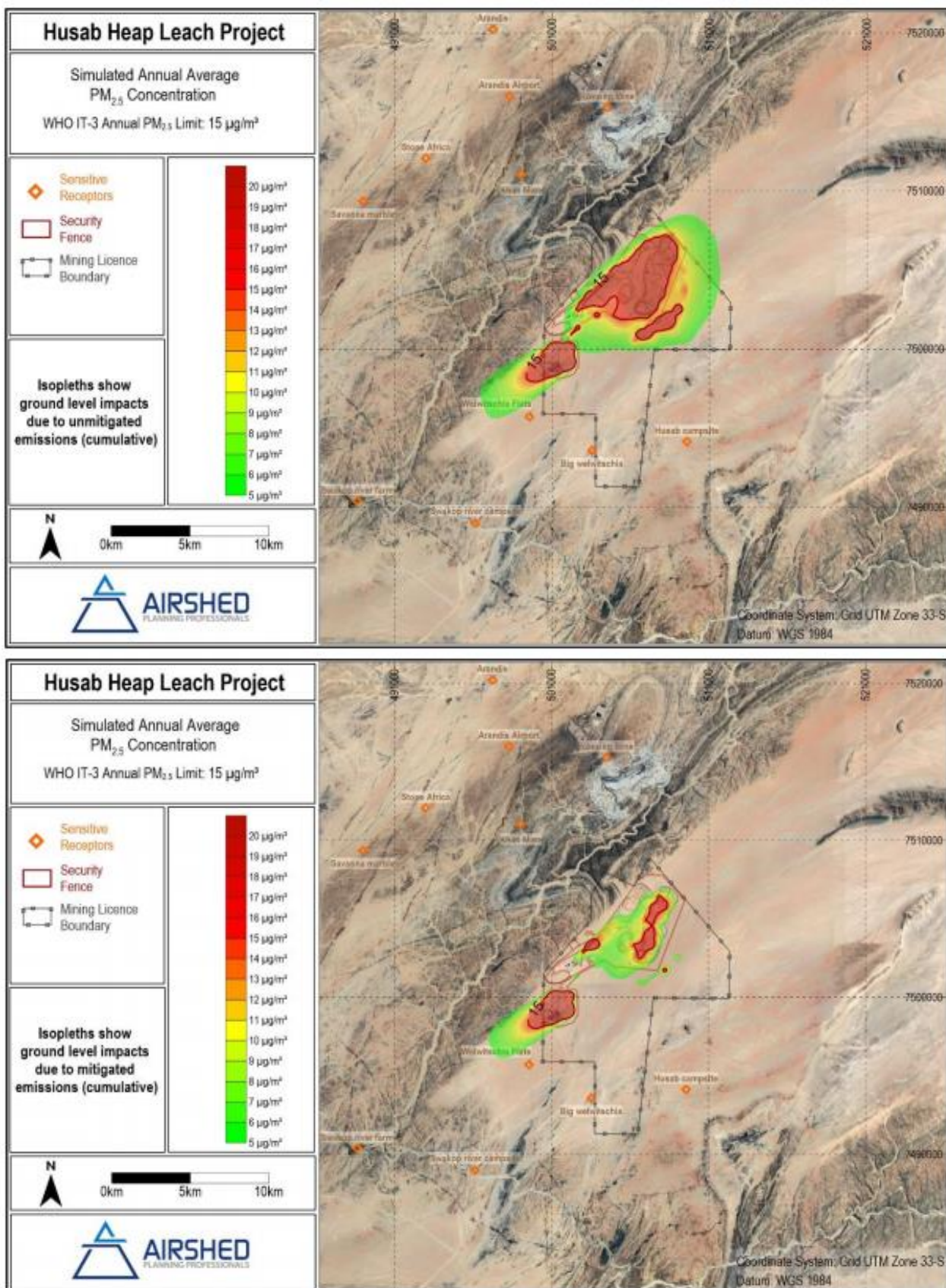


Figure 5. Simulated annual average $PM_{2.5}$ ground level concentrations in the unmitigated (top) and mitigated scenarios (bottom).

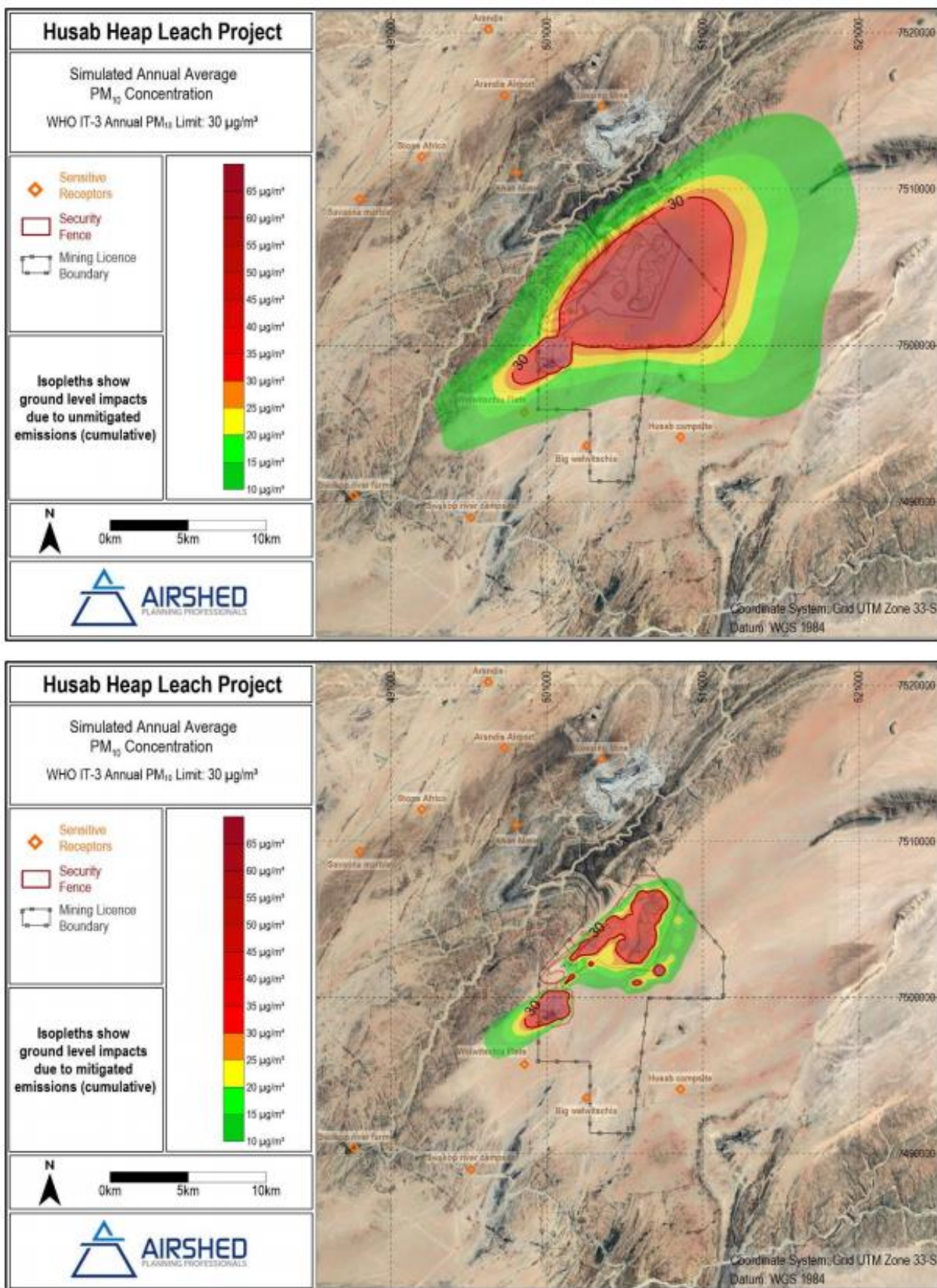


Figure 6: Simulated annual average PM10 ground level concentrations in the unmitigated (top) and mitigated scenarios (bottom).

Radiological impacts

Potential radiological impacts are location-dependant and are the result of specific operational practices which lead to the release of radionuclides into the environment. Relevant heap leach operational practices include, amongst others, the crushing and screening circuit, the conveying of crushed ore, agglomeration, stacking of the HLF and the subsequent removal and conveyance of the waste for disposal by grass-hopper stacker on the HLWF. Atmospheric and aquatic exposure pathways are impacted by the generation of radiologically relevant dust through these processes.

The aquatic pathways, and soils, may be impacted by the production of pregnant leach liquor, which is radiologically relevant, through its storage, transportation (pumping), potential seepage from HLF and HLWF, and overflow due to poor storm water management.

Handling of pregnant liquid may lead to direct external exposure to gamma radiation. The production of concentrated uranium from the PLS produced by heap leaching is potentially associated with a multitude of new and incremental (cumulative effect) radiologically relevant impacts. Operation of the heap leach process increases the overall production of uranium concentrate at the Husab Mine, which necessitates additional handling and processing of uranium concentrate which potentially implies additional relevant impacts on direct external exposures to gamma radiation, as well as the atmospheric and aquatic pathways.

Two other areas of radiological concern for the atmospheric pathway and aquatic pathways are the potential for dried out mineral waste on the HLWF to be distributed around the desert by wind, unless it is covered by an inert substance, such as for example a layer of uncontaminated soil, waste rock, clay or liner.

Also related the HLWF is the potential for runoff/spillage/seepage from the mineral waste disposal facility that may potentially lead to environmental releases in the form of radioactive contaminants seeping into the soil as is of relevance to the atmospheric and aquatic pathways, both during operations and post closure.

The radiation report utilised the air quality model produced by Airshed for the Husab heap leach project. Of importance to the radiological study is the dispersion of PM_{2.5} as inhalable and respirable dust. In addition, the ground water model produce by SLR for this report was also used to assess potential aquatic dispersion of radio nuclides in ground water.

The qualitative assessment based on the models indicate that direct external exposure pathway is not considered relevant for any of identified public receptors (receptors are the same for air quality, visual and radiation), as these receptor locations are physically separated from the actual mining site, and therefore not exposed to any of the various on-site sources of direct external gamma radiation.

Monitoring of boreholes at the select receptor sites do show evidence of radionuclides in the borehole water, but this is not attributable to the Husab Mine, as most borehole water in the Swakop River and the Khan River are characterised by considerable radionuclide concentrations, which are the result of in-river transfers that have been taking place for millennia (Von Oertzen, 2021).

An increase of the Husab Mine's total production capacity implies that the risk of adverse environmental impacts increases. The HLF contributes some 10% (unmitigated), 5% (mitigated) to existing total particulate emissions from the Husab Mine [Airshed, 2021]. Similarly, the HLF adds to the PM₁₀ emissions contribution by 4% (unmitigated) or 3% (mitigated). PM_{2.5} increases by 2% in the unmitigated scenario and drops to 1% all mitigation measures are applied.

The principal radiological impacts of the proposed heap leaching operations are the: -

- Generation of additional radiologically relevant dust as well as radon which may have adverse impacts on sensitive air quality receptors in the area;
- Potential contamination, seepage and other unintended emissions of radiologically relevant minerals and gases into the environment;
- Generation and disposal of additional radiologically relevant mineral waste.

Of concern is the long-term management, or possible failure of the HLWF following closure, with adverse radiological impacts that could potentially occur decades after the closure of a facility.

Unmitigated impact ratings are:

- Probability summation - atmospheric dust, atmospheric radon, aquatic & direct external pathways - HIGH significance.
- Consequence summation - atmospheric dust, atmospheric radon, aquatic & direct external pathways – MEDIUM significance; and
- Significance summation - atmospheric dust, atmospheric radon, aquatic & direct external pathways – MEDIUM significance.

Mitigation measures for radiation are all premised on the full implementation, and continual maintenance, of all the recommended air quality, ground water and stormwater management mitigations. In addition to this, the process to dispose of the mineral waste from heap leaching must satisfy the Namibian regulatory requirements for the disposal of radioactive waste, as per the Atomic Energy and Radiation Protection Act No. 5 of 2005 and Regulations. The operations of the HLF are to be included in the Husab Mine's Radiation Management Plan, which must be submitted to the Namibian National Radiation Protection Authority **for approval prior** to the commencement of HL operations.

With mitigation measures in place the impacts are considered to be: -

- Probability summation - atmospheric dust, atmospheric radon, aquatic & direct external pathways – MEDIUM significance;
- Consequence summation - atmospheric dust, atmospheric radon, aquatic & direct external pathways – LOW significance; and
- Significance summation - atmospheric dust, atmospheric radon, aquatic & direct external pathways – MEDIUM significance.

Husab Mine's Radiation Management Plan is to be updated and monitoring programmes expanded to strengthen the monitoring protocols on site.

The radiation study recommends that **only mitigated heap leaching options are considered for implementation**, provided that environmental impacts are minimised by way of applying best practice mitigation measures as applied in modern open pit mining and processing environments in hyper-arid climates as is the case in the western Namib desert.

Archaeological impacts

Several archaeological studies have been conducted for the Husab Mine and its associated Linear Infrastructure, with the first study being undertaken in 2009 during the exploration phase. The area has thus been well studied and heritage sites of significance have been surveyed and documented, for example, the Welwitsch siding and Khan Mine valley. The Welwitsch siding and remnant of the rail embankment on the west of the site have been protected from disturbance by physical barriers.

Figure 6 shows the known archaeological sites at the Husab Mine. Only one site (QRS105/86), the site of an old seed digging with a manuport located on a schist outcrop at the far north of the HLWF is likely to be impacted. The archaeology specialist has confirmed that it is of no significance, given the large number of seed diggings in the area. The heap leach conveyor infrastructure will cross the old narrow gauge rail line embankment in two places. This too has been mapped and documented.

- The archaeological assessment LOW to MODERATE significance.

The northern boundary of the HLWF can be shifted to avoid the ecologically sensitive schist outcrop and archaeological site. The rail embankment should not be destroyed during construction. The conveyor can pass over it.

The Husab Mine has adopted the Chance Finds Procedure recommended by the archaeologist and it is an operational procedure used when buried archaeological remains are discovered, which are not visible to surface survey, so that they may be handled in accordance with the provisions of Part V Section 46 of the National Heritage Act (27 of 2004).

Visual impacts

The visual impact of the proposed heap leach project will occur because of the visibility of the HLF and the HLWF with its associated stacker system. The rest of the infrastructure associated with the project will mostly be on ground level or will not exceed 3 m and will have a minimal visual impact. This will, however, contribute to the cumulative impact of the overall project. The crushing and screening will take place between the existing process plant and the mined area and will therefore be absorbed into the current activities but will contribute to the cumulative impacts.

The visual impact will mostly be associated with the construction and operational phase of the project. The mine is already visible from the B2 road, the D1914/Welwitschia Drive, and the Moon Landscape Road/lookout points both during the day and night. The heap leach circuit will add to the complexity, and the HLWF will remain visible in perpetuity.

- The visual assessment assessed impacts as being of medium significance for both the mitigated and unmitigated scenarios.

Other than the recommended dust suppression measures and careful placement of security lighting, there is little that can be done to ameliorate the impacts on distant views.

7. CONCLUSION

The proposed heap leach processing facility provides an opportunity for Swakop Uranium to realise the value of uranium in the low-grade run of mine ore that is currently being stockpiled. The site selection process has determined the most suitable position for the major infrastructure, the heap leach pad, and the heap leach waste facility. Potential impacts on the Welwitschia field have been reduced as far as it possible. Radiation health risks, and potential impacts on ground and surface water, soils and biodiversity are mitigated through the implementation of the measures provided in the air quality assessment, the design of liners for the HLF and HLWF, and the proposed storm water management plans.

The impacts related to retention of the construction temporary water pipeline are not significant and can be managed through existing Husab Mine procedures.

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ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
AQSR	Air Quality Sensitive Receptors
BIA	Background Impact Assessment
BID	Background Information Document
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
DEA	Directorate of Environmental Affairs
DEM	Digital Elevation Model
EAP	Environmental Assessment Practitioner
EAPAN	Environmental Assessment Professionals Association of Namibia
ECC	Environmental Clearance Certificate
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPL	Exclusive Prospecting License
GLCs	Ground Level Concentrations
ha	Hectares
HCs	Hydrocarbons
Hg	Mercury
HLF	Heap Leach Facility
HLWF	Heap Leach Waste Facility
IAP	Interested and Affected Party
LOM	Life of Mine
MAWLR	Ministry of Agriculture, Water and Land Reform
MEFT	Ministry of Environment, Forestry and Tourism
MHSS	Ministry of Health and Social Services
ML	Mining Licence
MME	Ministry of Mines and Energy
NBR	Natural Background Radiation
NNNP	Namib Naukluft National Park
NO ₂	Nitrogen Oxide

Acronym / Abbreviation	Definition
NO _x	Oxides of Nitrogens
NP	Neutralisation Potential
NWQS	Namibian National Water Quality Standards
PAG	Potentially Acid Generating
PCS	Pollution Control System
PM	Particulate Matter
PPP	Public Participation Process
RMP	Radiation Management Plan
SEM	Sub-economic Material
SLR	SLR Environmental Consulting (Namibia) (Pty) Ltd
SO ₂	Sulphur Dioxide
SU	Swakop Uranium (Pty) Ltd
TSF	Tailings Storage Facility
TSP	Total Suspended Particles
TWI	Topographic Wetness Index
VOC	Volatile Organic Compounds
WRB	World Reference Bank
WRD	Waste Rock Dump

SCOPING REPORT (INCLUDING IMPACTS ASSESSMENT) FOR THE PROPOSED CHANGES TO THE HUSAB MINE AND LINEAR INFRASTRUCTURE: PROPOSED HEAP LEACH PROCESS AND ASSOCIATED ACTIVITIES AND RETENTION OF CONSTRUCTION WATER PIPELINE

1. INTRODUCTION

1.1 PURPOSE OF THE REPORT AND OPPORTUNITY TO COMMENT

This Scoping Report (including an impact assessment) has been compiled and distributed for review and comment as part of Swakop Uranium's application for an amendment to its environmental clearance certificate to include a proposed heap leach circuit and the retention of the temporary construction water pipeline. The EIA Amendment Process is being done in accordance with the Environmental Management Act, 7 of 2007 and its Regulations of 2012.

This report summarises the EIA process followed and provides an overview of the proposed amendments and the affected environment. It includes the findings of the specialist studies, an assessment and re-assessment of the environmental impacts that the proposed amendments are likely to have and sets out SLR's recommendations. The proposed management and mitigation measures relating to the proposed amendments are documented in an amended environmental management plan (EMP), see Appendix M.

Registered interested and affected parties (IAPs) are now provided with the opportunity to comment on this Scoping Report (including impacts assessment). Once the comment period closes, the Scoping Report will be updated to a final report with due consideration of the comments received. The report will then be submitted to the Ministry of Environment, Forestry and Tourism (MEFT) for review.

The Scoping Report provides information to assist the State to make decisions related to the protection of the environment in terms of the Environmental Management Act and any other law.

1.2 INTRODUCTION TO THE PROPOSED PROJECT

Swakop Uranium holds the mining licence (ML) 171 and Environmental Clearance Certificates (ECCs) for the Husab Uranium Mine (and associated activities / infrastructure) and for its associated linear infrastructure. The two open pits and associated processing plant are situated in the northern most part of the Namib Naukluft National Park, approximately 50 km inland from Swakopmund (Figure 1-1) in an area of important biodiversity, habitat, archaeology, and tourism. Mining started in March 2014 and the commissioning of the processing plant commenced in December 2016.

Swakop Uranium undertook a pre-feasibility study in 2017 to investigate the possibility of subtracting uranium via a heap leach process from the low-grade run-of-mine that is currently being stockpiled. The pre-feasibility study conducted by SGS concluded that heap leaching may offer an attractive option to increase uranium production at the Husab Mine, as it would allow for expanded leaching capacity, without the need for additional milling capacity, or the costs associated with tank leaching, and could generate additional revenue.

A full feasibility study, also conducted by SGS in 2020, refined the heap leach process further, and Swakop Uranium now wishes to develop the proposed heap leach circuit, which will be preceded by a pilot heap leach trial. This proposed heap leach circuit is the focus this scoping report and impact assessment.



Figure 1-1: Locality Map

Swakop Uranium also wishes to permanently retain the construction water pipeline laid down in 2012 for the temporary supply of water that was used during construction of the Husab Mine, and before the permanent water pipeline was commissioned.

Prior to the commencement of these proposed amendments, an EIA Amendment application must be submitted to the MEFT for a decision in terms of the Environmental Management Act, 7 of 2007. The amendment process included a screening phase, a scoping phase (including an assessment of impacts), and the updating of the current Husab Mine environmental management plan.

SLR Environmental Consulting (Namibia) (Pty) Ltd (SLR) has been appointed by Swakop Uranium as the independent Environmental Assessment Practitioner to undertake the EIA process.

1.3 MOTIVATION (NEED AND DESIRABILITY)

1.3.1 Motivation for retention of the construction water pipeline

Processing of the low-grade ore on the heap leach facility requires an additional 1,9Mm³ water per annum in addition to the 8Mm³ currently being used by the Husab Mine which is supplied via the permanent water pipeline running northward from the C28.

Prior to construction of the Husab mine and plant, a 25 cm diameter HDPE and steel pipeline was installed, mostly on surface, from the Rössing reservoir, through the historic Khan Mine site, across the Khan River, then parallel to the access road up to the Husab Mine. Although this pipeline was to have been removed post construction, Swakop Uranium now wishes to make it permanent, as an emergency standby water supply for the heap leach process.

1.3.2 Motivation for the heap leach process

Swakop Uranium continually assesses and optimises its operation to ensure a sustainable business model for all stakeholders. To this end, the processing via heap leach facility (HLF) of the low-grade ROM ore has been under investigation for several years. The low-grade ore is currently being stockpiled in the long term, for processing at the end of the Pit Zones 1 and 2 LOM through the existing tank leach plant.

The 2017 pre-feasibility study and the 2020 definitive feasibility study done by SGS indicated that a heap leach circuit could potentially reduce Swakop Uranium's current and LOM processing costs by processing 7.5 Mtpa of the low-grade ore material (100 and 400 ppm U₃O₈) over a twenty-year life of mine, thereby producing, at an average recovery of 85%, to produce approximately 52 million pounds (23 260 Mt) of U₃O₈. Concurrent processing of the low-grade ore through the HLF would reduce the LOM by about 4 years.

Various heap leach facility circuit layouts have been proposed that are discussed in the alternatives section of the report (Section 5.4). Following an intensive consultation process between environmental specialists, SLR and Swakop Uranium, a final layout for the heap leach facility (Option K) has been agreed upon and will be described in Section 5.4.5 and assessed in Section 6.5.

1.4 EIA AMENDMENT SCOPE OF WORK

SLR was appointed by Swakop Uranium to undertake a scoping study with an impact assessment, including cumulative impacts, for the site layout, construction, operation and closure of the proposed heap leach facility and circuit, and to assess impacts related to the retention of the construction water pipeline.

The study does not include anything ancillary to the heap leach process and circuit, such as additional sulphuric acid production or expansion of the existing plant process. Separate EIA assessments will need to be undertaken to licence these activities.

1.5 EIA AMENDMENT PROCESS

EIAs and Amendment Applications are regulated by the Ministry of Environment, Forestry and Tourism (MEFT) in terms of the Environmental Management Act, 7 of 2007. This Act was gazetted on 27 December 2007 (Government Gazette No. 3966). The Environmental Impact Assessment Regulations: Environmental Management Act, 2007 (Government Gazette No. 4878) were promulgated on 6 February 2012. An environmental clearance (amendment) is required based on an amendment application, prior to the commencement of the proposed changes and additions.

The overall objectives of the assessment process are to:

- provide an independent assessment of the potential environmental impacts associated with the proposed changes to the existing approved EIA and EMP;
- undertake public consultation; and
- develop additional/revised management and mitigation measures for identified additional/different potential impacts where necessary, and
- present an objective view to the authorities for final decision making with respect to approval (or not) of the proposed changes, and the conditions to applied thereto.

1.5.1 EIAs previously approved for Husab Mine and associated Linear Infrastructure.

The MEFT: Department of Environmental Affairs (DEA) has issued the following Environmental Clearance Certificates (ECCs) to Swakop Uranium after review and acceptance of the relevant EIAs. Table 1-1 below is a summary of the authorisations and amendments undertaken for the Husab Mine and its associated Linear Infrastructure. ECCs are valid for a period of 3 years, after which they must be renewed. Additional detail about each EIA Amendment that is relevant to this Scoping Report is provided in the sections that follow.

A combined environmental management plan (EMP) for both the Husab Mine EIA and Linear Infrastructure EIA was compiled in 2012 and has subsequently been updated or modified with each EIA amendment. The current EMP was approved in 2019.

1.5.2 Original Husab Mine and processing plant EIA (2010)

In 2009/2010 Swakop Uranium undertook an Environmental Impact Assessment (EIA) process for the Husab Mine and plant site infrastructure, including 2 open Pits, Zone 1 and Zone 2, a combined waste rock dump (WRD) and tailings storage facility (TSF), named a 'co-disposal facility', with a footprint of $\pm 1\ 200$ hectares (ha). The LOM was calculated to be 14,5 years with low grade ore being stockpiled for processing for an additional 2 years at the end of mining.

This EIA was approved by the MEFT in January 2011.

Table 1-1 Summary of EIAs and Amendments and environmental clearance certificates issued.

Issue date	Environmental clearance certificates issued	Renewed
Jan 2011	Husab Mine EIA	Renewed 2011 & 2013
Jun 2011	Linear Infrastructure EIA	Renewed 2011 & 2013
Submitted Dec 2012	Linear Infrastructure EIA Amendment: Upgrade of track through Khan Mine valley and across Khan River to transport personnel.	
April 2013	Linear Infrastructure EIA Amendment. EMP for temporary use of Khan Mine Road for transport of bridge and powerline construction materials.	
Sep 2013	Husab Mine EIA Amendment: Tailings facility	Renewed Sept 2016
Mar 2014	Linear Infrastructure EIA Amendment: Permanent Water Supply Pipeline and 132Kv power line routes.	Renewed Sept 2016
Mar 2014	Husab Mine EIA Amendment: Emulsion Manufacturing plant	Renewed Sept 2017 & Aug 2020
Jul 2014	Husab Mine EIA Amendment: Increased Height of the Base Transmitter Mast from 30 m to 60 m.	Renewed Sept 2017 & Aug 2020
Sep 2016	Linear Infrastructure EIA Amendment: 33 kV powerline for permanent water pipeline.	Renewed April 2019
Feb 2017	Second Telecommunication Tower at Husab.	Renewed March 2020
April 2018	Husab Mine EIA Amendment: Additional raw water pond	
April 2019	Linear Infrastructure EIA Amendment: Additional mobile communication antenna poles.	
Sep 2019	Husab Mine EIA Amendment: Increased waste rock dump footprint (which requires the Husab channel diversion), an on-site waste incinerator and communication antenna.	
Sep 2019	12 MW Solar PV Power Plant.	

1.5.3 Linear infrastructure EIA process (2011)

A second EIA process was conducted in 2010/2011 for all the linear infrastructure associated with the Husab Mine and included the permanent access road, temporary and permanent water supply pipelines, temporary and permanent power lines, among others.

This Linear EIA was approved by the MET in July 2011.

1.5.4 EIA Amendment for tailings and waste disposal (2013)

Subsequent to the above approvals, an improved process was developed for the recovery of Uranium from the ore which resulted in the production of finer tailings that could no longer be co-disposed with the waste rock. Instead, the tailings had to be pumped for disposal onto a separate, standalone tailings storage facility (TSF).

An EIA Amendment process with an alternatives site selection study was therefore conducted and approved by the MEFT in 2013 for the stand alone TSF and a separate WRD, with a higher profile, and smaller footprint of ±659 ha. The open pit life was changed to approximately 20 years with the plant processing the stockpiled low-grade ore for an extra two years.

1.5.5 EIA Amendment for waste rock dump design change, on-site waste Incinerator and mobile communication antenna poles (2017/8)

Mining started at the Husab Mine in 2014, and the process plant was commissioned in 2016. Further technical assessments and optimization by Swakop Uranium, including a review of operating costs, led to the requirement for another design change to the WRD design. The redesigned structure requires a lower WRD height, from 210 m to 150 m, but with a significantly larger footprint that covers at least 5 km of the Husab Channel that feeds the Welwitschia population downstream (Figure 1-2).

A new EIA Amendment application process was undertaken during 2017/2018 to assess the potential (cumulative) impacts associated with the WRD design change. In addition, the same EIA amendment process included the assessment of the construction and operation of an on-site incinerator for the purposes of improved waste management, and the erection of mobile communication antenna along the access road to improve safety.

MEFT approved the EIA Amendment application in Sept 2019 and issued an ECC containing several conditions, particularly pertaining to the proposed diversion of the Husab channel. This channel is one of the main feeders of the Welwitschia Field. One the conditions was the engineered design of a channel to divert water from the Husab Channel, bypassing the extended WRD to discharge stream flow back into the original channel downstream.

It is important to note these ECC conditions have not yet been implemented by SU. The waste rock dump has only recently been extended southwards but has not yet extended eastwards across the Husab Channel. Detailed engineering design of the diversion channel has yet to be completed.

Both these points are important to the heap leach circuit layout that is the subject of this Scoping report.

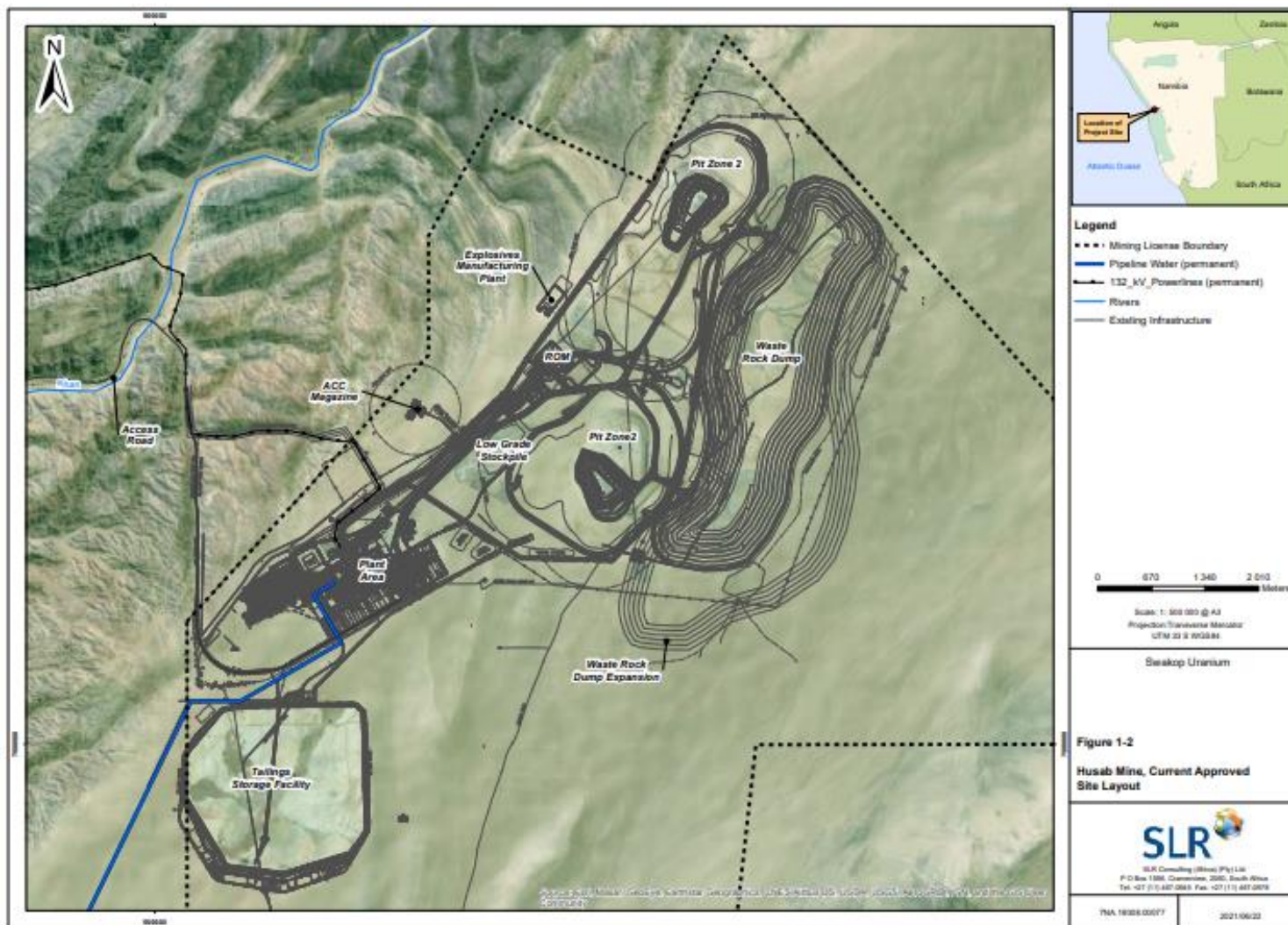


Figure 1-2: The Husab Mine and processing plant – current approved infrastructure layout

1.5.6 EIA Amendment for heap leaching facility and associated infrastructure – this report (2021)

Heap leach

Current operations at Husab Mine include, amongst others, surface mining of uranium bearing ore, ore processing plant, a sulphuric acid treatment plant to produce the sulphuric acid used in the ore treatment process, a TSF, two pit zones (Zone 1 and 2) and a WRD. During processing, ROM ore temporarily stockpile, then crushed, screened and leached in the existing process plant tank leach facility (TLF). The main plant is designed to process 15 million tonnes of ore per annum (Mtpa) at an average grade of 512 gram per ton of triuranium octoxide (U_3O_8), and approximately 7 000 tons per annum of uranium oxide at a recovery rate of 91.7%.

The original mine plan determined that low grade ore was to be processed when mining of Pit Zones 1 and 2 was completed at the end of the LOM. The processing plant would run for an additional 2 years using the stockpiled low-grade ore before being decommissioned.

Swakop Uranium undertook a pre-feasibility study in 2017, followed by a definitive feasibility study in 2021 on the option of processing low-grade ore concurrent with the main mining and existing process plant extraction processes. The low-grade ore will be crushed and milled to a size suitable for the acid digestion and liberation of the uranium containing minerals by a process called heap leaching. Pregnant liquor from the heap leaching process will be fed back into the main processing plant circuit for final extraction of the uranium. Processing the low-grade ore concurrent with TLF will reduce the LOM by about 4 years, ending in 2036.

Contingency water supply

There is an additional water requirement for the heap leaching process. The mine is currently supplied with desalinated water by NamWater via a pipeline that runs northward from the C28 Road to site. It is anticipated that sufficient water will be available from this supply, and that the pipeline capacity is adequate for the increased water demand. However, a contingency supply of water, via the pipeline that was used during construction, is required.

The construction water pipeline starts at the Rössing reservoir near the B2 and then runs southwards through the old Khan Mine site, across the Khan River and then parallels the permanent access road to the Husab Mine. The EIA process undertaken for the linear infrastructure in 2013 envisaged that this temporary pipeline would be removed after construction. This expectation is currently a commitment in the EMP. However, the pipeline has not yet been removed, and Swakop Uranium now wishes to retain it as an emergency water supply.

This EIA Amendment scoping study describes the site selection, construction, and operation of the proposed HLF and associated infrastructure and activities, in addition to the proposed retention of the construction water pipeline.

2. SCOPING AND EIA METHODOLOGY FOR THE HEAP LEACH PROCESS

2.1 EIA SCOPING PROCESS OVERVIEW

Prior to the commencement of the proposed changes described in this document, an Amendment Application (form 2) was submitted to the MEFT: DEA to advise that an EIA process was to be conducted in terms of the Environmental Management Act, 7 of 2007. This process includes: a screening phase and a scoping phase, which includes an impact assessment and an amended Husab Mine and associated Linear Infrastructure Environmental Management Plan (EMP).

This report is the Scoping Report, the main purpose of which is to provide information relating to the proposed Heap Leach Process and Circuit and the retention of the construction water pipeline.

Information gathered from the earlier EIAs that have been conducted for the Husab mine and associated liner infrastructure (refer to Section 1.5) was further augmented by environmental monitoring results and additional specialist studies, together with input from comments gathered through the stakeholder consultation process. The potential cumulative impacts of the activities associated with the proposed amendments could therefore be assessed / re-assessed.

The information provided in this Scoping Report (including impacts assessment) and amended EMP should provide sufficient material for MEFT:DEA to make an informed decision regarding the proposed changes, and whether environmental clearance certificates for the amendments can be issued or not.

The EIA process and corresponding activities which have been undertaken for this project are outlined in Table 2-1 below. The process that was followed was in accordance with the requirements outlined in the EIA Regulations of 2012.

Table 2-1: EIA Process Followed

Objectives	Corresponding activities
Project initiation and Screening phase (February – March 2021)	
<ul style="list-style-type: none"> Identify environmental aspects and potential impacts of the proposed changes Notify the decision-making authority of the proposed project Initiate the EIA Scoping process. 	<ul style="list-style-type: none"> Notify the MEFT: DEA of the proposed amendment and EIA process (Amendment Applications were submitted to MEFT for the proposed changes to the Husab Mine and associated Linear Infrastructure). Project initiation meetings and site visits with the Swakop Uranium technical team to discuss the proposed changes. Early identification of environmental aspects and potential impacts that might change because of the proposed amendments and determine additional legal requirements. Decision on EIA process to be followed and specialists to be used in the process. Identify key stakeholders (update existing Husab Mine interested and affected party (IAP) database).
Scoping (including assessment) phase (February – July 2021)	
<ul style="list-style-type: none"> Involve IAPs in the scoping process through information sharing. Identify further potential environmental issues associated with the proposed amendments. Determine the terms of reference for additional assessment work. Consider alternatives. Identify any fatal flaws. 	<ul style="list-style-type: none"> Notify government authorities and IAPs of the proposed amendment and EIA process (telephone calls, e-mails, newspaper advertisements and site notices). Interested and affected party (IAP) registration and initial comments. Scoping public meeting and key stakeholder (focus group) meetings and Include IAP issues and concerns in the studies and assessments. Conduct specialist studies. Compilation of Scoping Report (including impact assessment) and updated EMP.

<ul style="list-style-type: none"> • Provide further details associated with the potentially affected environment. • Assessment of potential environmental impacts associated with the proposed changes. • Additional/amended management and mitigation measures. • Receive feedback on application 	<ul style="list-style-type: none"> • Distribute Scoping Report and revised EMP to relevant authorities and IAPs for review (June/July 2021). • Forward finalised Scoping Report with combined and updated EMP and IAPs comments to MET for decision making.
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Figure 2-1: Flow Diagram for the EA Amendment Process

2.2 EIA TEAM

SLR Consulting (Namibia) (Pty) Ltd is an independent Namibian registered firm of consultants who was appointed to undertake the environmental impact assessment processes. Two members of the SLR team are registered with EAPAN. The specialists appointed to undertake the various studies have been involved in many of the earlier assessments for the Husab Mine and Linear Infrastructure and/or the various environmental monitoring programmes at the mine and are thus familiar with the environment in which the proposed HLF is to be constructed (Table 2-2).

Table 2-2: The Environmental Project Team

Team	Name	Designation	Tasks and roles	Company
Swakop Uranium project team	Jordan Dengeinge	Head of Planning and Projects	Responsible for technical input and implementation of the EMP commitments	Swakop Uranium
	Leonard Eiman	Senior Metallurgist Projects		
	Ilka Schroer	Biodiversity	Environmental input	
EIA Project management	Sharon Meyer	Project Manager	Report compilation, management of the process, team members and other stakeholders	SLR
	Michele Kilbourn Louw	Environmental practitioner (EAPAN)		
	Edwynn Louw	Project Assistance	Project administration, compilation of reports	
	Ed Perry	Reviewer	Report review	
	Werner Petrick	Environmental practitioner (EAPAN)	Screening Study Public Participation Process	
Specialist investigations	Arnold Bittner	Ground and surface water specialists	Groundwater and surface water assessment	SLR
	Winnie Kambinda			
	Kevin Bursey	Surface water specialist	Surface water assessment	
	Hanlie Liebenberg Enslin	Air quality specialist	Air quality specialist assessment	Airshed Planning Professionals
	Detlof von Oertzen	Radiation specialist	Radiation impact assessment	VO Consulting
	Theo Wassenaar	Biodiversity specialist	Biodiversity specialist study	African Wilderness Restoration
	John Kinahan	Heritage specialist	Heritage assessment	Quaternary Research Services
	Yonanda Martin	Environmental Assessment Practitioner (SA)	Visual assessment	Green Tree Environmental Consulting

2.3 INFORMATION COLLECTION

An (internal) environmental screening study was carried out by SLR in 2020 to provide input into Swakop Uranium's heap leach feasibility study. The screening study provided a "high level" description of environmental aspects and potential impacts associated with the proposed development of the HLF and associated infrastructure and activities and provided initial input in terms of project alternatives, including location options.

The EIA Amendment process used the screening report findings as a basis for the desktop and site investigation that took place during the first part of 2021. The following tasks were carried out to obtain additional information for this assessment:

- Review of the approved Husab Mine EIA Reports and Environmental Management Plan (EMP) and project related investigations;
- Site visits to assess the options for infrastructure layout relative to sensitive environmental areas;
- Consultation with Project Technical Team (Swakop Uranium);
- Consultation with relevant regulating authorities;
- Focus group meetings with key stakeholders to obtain comment on, and input to, the project options; and
- Specialist studies were carried out to investigate any potentially significant impacts to inform impact assessment rating as well as recommend mitigation measures to be included within the Amended EMP:
 - Air Quality (Appendix F).
 - Biodiversity (Appendix G).
 - Groundwater (Appendix H).
 - Radiology (Appendix I).
 - Surface Water (Appendix J).
 - Visual (Appendix K), and
 - Heritage (Appendix L).

2.4 SCOPING REPORT

The main purpose of this Scoping Report is to present the potential environmental baseline in which the proposed heap leach facility is to be constructed and to document the potential impacts related to the construction, operation and closure of the proposed heap leach facility and circuit. The Scoping Report will also provide additional assessment and/or mitigation measures, where required, for incorporation into the Husab Mine EMP.

Table 2-3 outlines the Scoping Report requirements as set out in Section 8 of the Environmental Impact Assessment Regulations that were promulgated in February 2012 in terms of the Environmental Management Act, 7 of 2007.

Table 2-3: Scoping Report Requirements stipulated in the EIA regulations.

Requirements for a Scoping Report in terms of the February 2012 regulations	Reference in report
(a) the curriculum vitae of the EAPs who prepared the report;	Table 2-2 and Appendix A
(b) a description of the proposed activity;	Section 5.1 and 5.3
(c) a description of the site on which the activity is to be undertaken and the location of the activity on the site;	Sections 4 & 0
(d) a description of the environment that may be affected by the proposed activity and the manner in which the geographical, physical, biological, social, economic and cultural aspects of the environment may be affected by the proposed listed activity;	Sections 4 and 6
(e) an identification of laws and guidelines that have been considered in the preparation of the Scoping Report;	Section 3
(f) details of the public consultation process conducted in terms of regulation 7(1) in connection with the application, including - <ul style="list-style-type: none"> (i) the steps that were taken to notify potentially interested and affected parties of the proposed application; (ii) proof that notice boards, advertisements and notices notifying potentially interested and affected parties of the proposed application have been displayed, placed or given; (iii) a list of all persons, organisations and organs of state that were registered in terms of regulation 22 as interested and affected parties in relation to the application; and (iv) a summary of the issues raised by interested and affected parties, the date of receipt of and the response of the EAP to those issues; 	Sections 2.3 to 2.5
(g) a description of the need and desirability of the proposed listed activity and any identified alternatives to the proposed activity that are feasible and reasonable, including the advantages and disadvantages that the proposed activity or alternatives have on the environment and on the community that may be affected by the activity;	Sections 1.3 and 5
(h) a description and assessment of the significance of any significant effects, including cumulative effects, that may occur as a result of the undertaking of the activity or identified alternatives or as a result of any construction, erection or decommissioning associated with the undertaking of the proposed listed activity;	Sections 6
(i) terms of reference for the detailed assessment; and	Section 1.4
(j) a management plan, which includes - <ul style="list-style-type: none"> (i) information on any proposed management, mitigation, protection or remedial measures to be undertaken to address the effects on the environment that have been identified including objectives in respect of the rehabilitation of the environment and closure; (ii) as far as is reasonably practicable, measures to rehabilitate the environment affected by the undertaking of the activity or specified activity to its natural or predetermined state or to a land use which conforms to the generally accepted principle of sustainable development; and 	Appendix M

Requirements for a Scoping Report in terms of the February 2012 regulations	Reference in report
(iii) a description of the manner in which the applicant intends to modify, remedy, control or stop any action, activity or process which causes pollution or environmental degradation remedy the cause of pollution or degradation and migration of pollutants.	

2.5 PUBLIC PARTICIPATION PROCESS

The public participation process for the proposed amendments is conducted to ensure that all persons and/or organisations that may be affected by, or interested in, the proposed changes, were informed of the project and could register their views and concerns. By consulting with relevant authorities and IAPs, the range of environmental issues to be considered in the EIA amendment has been given specific context and focus.

Public participation was undertaken with objectives of:

- Informing interested and affected parties and key stakeholders of the proposed project;
- Obtaining comment and input from stakeholders; and
- Addressing comments and concerns raised through the process.

2.5.1 Swakop Uranium’s IAPs

The Interested and Affected Parties (IAPs) that have been identified or who have registered for this project are provided in Appendix C. The Swakop Uranium Stakeholder Database that has been used for previous processes formed the basis for the current project database. Communication with registered stakeholders will continue throughout the process.

2.5.2 Steps in the consultation process

2.5.3 The announcement of the project was made via Background Information Documents (BIDs) sent to all stakeholders on the database, site notices, and an advert published in the Republikein newspaper on 12th April 2021 and 19th April 2021. IAPS were provided 20 working days to register from 12th April to 7th May 2021. Proof of adverts, site notices and BID are available in Appendix B. Summary of issues raised

The issues raised by the various stakeholders are summarised in Table 2-5 and the full list can be found in the Comments and Response Report (CRR) Appendix E. Additional issues raised during the Scoping Report public review period will also be included in the CRR prior to submission to the MEFT.

See Appendix D for the Focus Group Meeting Minutes. No further comments have been received at this time.

Table 2-4 summaries the consultation process undertaken.

2.5.4 Summary of issues raised

The issues raised by the various stakeholders are summarised in Table 2-5 and the full list can be found in the Comments and Response Report (CRR) Appendix E. Additional issues raised during the Scoping Report public review period will also be included in the CRR prior to submission to the MEFT.

See Appendix D for the Focus Group Meeting Minutes. No further comments have been received at this time.

Table 2-4: Consultation Process with I&APs and Authorities

TASK	DESCRIPTION	DATE
Notification - regulatory authorities and IAPs		
Notification to MEFT	SLR submitted the Application for Amendment Forms to MEFT. A copy of the Background Information Document (BID) was also sent to MEFT.	April 2021
IAP identification	The Swakop Uranium stakeholder database was updated a copy of the which is attached in Appendix C. All parties who registered or showed an interest in this amendment process, together with relevant Local, Regional and Governmental Ministries are included in Appendix C.	March 2021 and throughout the process
Distribution of background information document (BID)	BIDs were distributed via email to all authorities and IAPs on Swakop Uranium’s stakeholder database and were available at the scoping meetings. The purpose of the BID was to inform IAPs and authorities about the proposed project, the EIA amendment process, possible environmental impacts and means of providing input into the EIA process. Attached to the BID was a registration and response form, which provided IAPs with an opportunity to submit their names, contact details and comments on the project. A copy if the BID is attached in Appendix B.	20 working day registration period 12 April to 7 May 2021
Site notices	A site notice was placed at the Husab Mine Access control point. Refer to a copy of the site notice in Appendix B.	April 2021
Newspaper Advertisements	Block advertisements were placed as follows: Republikein newspaper 12 th and 19 th April 2021 Refer to Appendix B.	April 2021
Public meeting and Focus Group meetings and submission of comments		
Focus group meetings	Focus group meetings were held with key stakeholders and affected parties. The same project information was presented/shared at all meetings. A copy of the presentation is attached as Appendix B. Minutes of Focus Group Meetings are available in Appendix D.	
	• Earth Life Namibia	29 April 2021
	• Arandis Town Council	29 April 2021
	• Coastal Tourism Association of Namibia (CTAN)	29 April 2021
	• Namibian Uranium Institute - Sustainable Development Committee	6 May 2021
• Orano SA	20 May 2021	

TASK	DESCRIPTION	DATE
	<ul style="list-style-type: none"> NamWater 	20 May 2021
	<ul style="list-style-type: none"> Swakop Municipality 	20 May 2021
	<ul style="list-style-type: none"> H Nekwaya - Khan Mine (Pty) Ltd 	15 June 2021
Comments and Responses	Minutes of the meetings and all comments received during the process, by email are attached in Appendix D. A Summary Issues and Response Report is attached in Appendix E.	
Review of draft Scoping Report		
IAPs and authorities (excluding MET) review of Scoping Report and updated EMP	<p>The Scoping Report Executive Summary will be sent via email to all parties who registered or showed an interest in this amendment process, as well as relevant Local, Regional and Governmental Ministries. Electronic copies of the full report (including appendices) will be made available on request to SLR (on a CD).</p> <p>Copies of the full report are available for download from the SLR website (go to: http://www.slrconsulting.co.za) and hard copies will be available at the Windhoek National Library and the Swakopmund Public Library. An electronic copy of the EIA Report can be provided on request to SLR.</p> <p>Authorities and IAPs have 4 weeks to review the Scoping Report and submit comments in writing to SLR. The closing date for comments is 23rd July 2012.</p>	June/July 2021
MET review of Scoping Report and EMP	A copy of the final Scoping Report, including authority and IAP review comments, will be delivered to MET on completion of the public review process.	August 2021

Table 2-5: Summary of issues raised

Key Issues Raised	Short response or report section
Questions were raised about the additional amount of water required for the heap leach process.	1,9 Mm ³ per annum.
The security of water supply for the region, with all the different mines and towns requiring water was raised as a concern.	Sufficient capacity exists at the desalination plant.
What potential ground water impacts are expected, and how will the ground water be protected.	Ground water study (Sections 4.3 and 6.42)
What about other resources required for project such as water, power, reagents, sulphuric acid.	Increase the acid plant capacity and/or transport to site by road like the reagents.
How will the heap leach process impact on the availability of surface water?	Surface water and biodiversity study (Sections 4.4, 4.6 and 6.4.4).
The proposed expansion of the waste rock dump and the Husab channel diversion were raised. Construction sequence of events.	Heap leach pilot plant before full HLF. Husab Channel diversion design and construction dates unknown. WRD expansion will only occur after channel diversion.
Cumulative impacts of the heap leach process on dust and air quality in the area.	Air quality study (Section 4.7 and 6.4.5).
Transport of additional reagents implies additional traffic on the already heavily utilised roads.	Concerns and response report (Appendix E).
Concerns about the disposal of the heap leach waste and increased risks of radiation, wind erosion, dust, pollution of soil and groundwater.	Process description and pollution protection mitigation measures designed (Section 5.2), site layout, closure requirements (Section 8 and EMP).
Radiation exposure risks for personnel.	Refer to SU existing radiation management plan and procedures.
Retention of construction water pipeline concerns include the age of the pipes, missing sections, and off-take from Rössing supply.	Section 5.1 and 6.3 and Appendix E

3. LEGAL FRAMEWORK

3.1 SUMMARY OF ACTS & POLICIES, LEGAL REQUIREMENTS AND STANDARDS

Please refer to Table 3-2 for a comprehensive list of relevant and applicable Namibian legislation and policies.

3.1.1 Environmental Management Act – Listed Activities

In terms of the Environmental Management Act and its Regulations, the proposed Heap Leach project at the Husab Mine triggers the listed activities provided below.

Table 3-1: Listed Activities Relevant to the Proposed Heap Leach Project

LISTED ACTIVITIES	DESCRIPTION	RELEVANCE TO THE PROJECT
Energy Generation, Transmission and Storage activities	The construction of facilities for: - (b) The transmission and supply of electricity.	Power lines from existing substation to the HLF and HLWF
Waste Management, Treatment, Handling and Disposal Activities	2.1 The construction of facilities for waste sites, treatment and disposal of waste.	Disposal of mineralised waste at the heap leach waste facility
Mining and Quarrying Activities	3.1 The construction of facilities for any process or activities which requires a license, right or other form of authorization, and the renewal of a license, right or other form of authorization, in terms of the Minerals (Prospecting and Mining Act), 1992.	The heap leach processing circuit
Forestry Activities	4. The clearance of forest areas, deforestation, afforestation, timber harvesting or any other related activity that requires authorization in term of the Forest Act, 2001 (Act No. 12 of 2001) or any other law.	Clearing of more than 200 ha of undisturbed land for construction of the HLF and HLWFL and associated infrastructure. Protected species that are to be removed will require a permit.
Water resource developments	8.8 Construction and other activities in water courses within flood lines. 8.9 Construction and other activities within a catchment area	HLWF will be constructed between two water courses, and the conveyor and pipelines to the facility will cross the Husab channel.

3.1.2 Radiation

The radiation assessment (Section 6.4.7 of this report and Appendix J) is guided by the requirements of Namibia's Atomic Energy and Radiation Protection Act, Act No. 5 of 2005 (Act, 2005), and the relevant regulations under the Act, i.e. the Radiation Protection and Waste Disposal Regulations, No. 221 of 2011 [Regulations, 2011].

Namibia's legal framework that applies to radiation-relevant aspects is substantially based on the following international guidance documents: a) The recommendations contained in the Basic Safety Standards of the International Atomic Energy Agency (IAEA) (IAEA, 1996), (IAEA, 2004) and (IAEA, 2014); and b) those by the International Commission on Radiological Protection (ICRP) (refer to (ICRP, 1993), (ICRP, 1995) and (ICRP, 2007)).

The above frameworks recognise that human health and the environment must be protected against the potentially adverse effects resulting from the exposure to ionising radiation, as do for example arise when handling, mining, milling, and processing of mineral ores that contain naturally occurring radioactive materials.

Table 3-2: Relevant Legislation and Policies for the Proposed Project

Year	Name	Natural Resource Use	Emissions to air	Emissions to land	Emissions to water	Noise	Visual	Land use	Biodiversity	Archaeology	Socio-economic	Safety & Health
1990	The Constitution of the Republic of Namibia of 1990	X	X	X	X	X	X	X	X	X	X	X
1997	Namibian Water Corporation Act, 12 of 1997	X									X	
1992	The Minerals (Prospecting and Mining) Act 33 of 1992	X	X	X	X				X			
2001	The Forestry Act 12 of 2001	X						X	X			
2013	Water Resources Management Act 11 of 2013	X			X						X	
2004	National Heritage Act 27 of 2004									X		X
2007	Environmental Management, Act 7 of 2007	X	X	X	X	X	X	X	X	X	X	X
2012	Regulations promulgated in terms of the Environmental Management, Act 7 of 2007	X	X	X	X	X	X	X	X	X	X	X
1975 1990 1996 2017	Nature Conservation Ordinance 4 of 1975; Nature Conservation General Amendment Act 1990; Nature Conservation Amendment Act 5; Nature Conservation Amendment Act 3	X			X			X	X			
1976	Atmospheric Pollution Prevention Ordinance 11		X									
1992	United Nations Convention on Biological Diversity	X			X				X			
1995	Namibia's Environmental Assessment Policy for Sustainable Development & Environmental Conservation	X	X	X	X	X	X	X	X	X	X	X

Year	Name	Natural Resource Use	Emissions to air	Emissions to land	Emissions to water	Noise	Visual	Land use	Biodiversity	Archaeology	Socio-economic	Safety & Health
1974	Hazardous Substance Ordinance, No. 14 of 1974			X	X							X
2005	Atomic Energy & Radiation Protection Act, No. 5 of 2005		X	X	X			X				X
2010	Strategic environmental assessment for the Central Namib uranium rush	X	X	X	X	X	X	X	X	X	X	X
2015	Public and Environmental Health Act, No. 86 of 2015	X	X	X	X	X		X			X	X
2009	Parks and Wildlife Management Bill (2009)	X							X			
2018	National Policy on Prospecting and Mining in Protected Areas							X	X			
2009	Namib Naukluft National Park management and tourism development plan							X	X			

3.2 INTERNATIONAL CONVENTIONS TO WHICH NAMIBIA IS SIGNATORY

In addition, the following International Conventions automatically form part of Namibian law may in terms of Section 144 of the Constitution:

- The Convention on Biodiversity, 1992
- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1989
- The United Nations Framework Convention on Climate Change (UNFCCC)
- United Nations Convention on the Law of the Sea, 1982
- Vienna Convention for the Protection of the Ozone Layer, 1985
- Montreal Protocol on Substances that Deplete the Ozone Layer, 1987
- Kyoto Protocol on the Framework Convention on Climate Change, 1998

3.3 STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE CENTRAL NAMIB URANIUM RUSH

The SEA was published in September 2010 and provides an overview of the potential cumulative environmental and social issues associated with the development of uranium mines in the Erongo Region. The Strategic Environment Management Plan (SEMP) provides a practical framework in terms of which existing and proposed mines can plan, collaborate, monitor, and manage issues that can impact on society, the economy and the environment.

According to the SEA, several of the potential new mines were investigating the possibility of using the 'heap leach' process whereby ore is placed onto a lined pad and acid or alkaline chemicals are sprayed onto the heap and the leachate is then collected from collection systems around the pad. The SEMP is regularly updated (the latest revision is 2018-2019). Specific principles from the SEA and SEMP that are applicable to the proposed project are provided below.

- Protection of key habitats is a core recommendation,
- The most important (i.e. 'sensitive') habitats are i) the ridges, inselbergs and valley flanks, ii) large ephemeral rivers, iii) coastal wetlands, iv) springs and ephemeral pans, v) caves, and vi) isolated sand patches.
- Maintenance of not only species but primarily ecological processes. Important processes such as surface hydrology and groundwater movement should not be compromised.
- Usage of 'infrastructure corridors', preferably along existing routes. Careful placement of infrastructure corridors to avoid important biodiversity areas, particularly 'no-go' areas, including consideration of alternatives and optimisation of service provision.
- Avoidance of impacts wherever possible, and rehabilitation/restoration after mining/development where avoidance is not possible. Restoration of biodiversity is a core strategy in the management of impacts, and, because so little is known about how to do this, much research is required. Closure and rehabilitation planning is important.
- The population of Welwitschia plants adjacent to the mine is considered to be of high biodiversity value.

4. DESCRIPTION OF THE CURRENT ENVIRONMENT

Section 1.1 and Table 1-1 provides a list of all the various Husab Mine EIA and Linear Infrastructure Amendments that have been undertaken for Swakop Uranium over the past 11 years. Many of the specialists involved with the original EIA baseline studies have been involved in each of the additional studies, and, in addition, the air quality, biodiversity and ground water specialists currently provide specialist input to the Husab Mine's environmental monitoring programmes. The original baseline data has thus been enhanced and understanding of the local environment refined.

A description of the Husab Mine environment follows. (Note, the environmental baseline specific to the retention of the construction temporary water pipeline is covered briefly in Section 5.1.2 of this report).

4.1 CLIMATE

Swakop Uranium's Husab Mine has a sophisticated Campbell Scientific meteorological weather station installed in May 2012 at Marble Ridge, just south of the plant. Two other Davies weather stations were installed in 2008 at Husab (on the watershed between the pits but now north of Pit Zone 1) and the Ida exploration camp. The Marble Ridge Campbell weather station quality data with good data availability and measures wind speed and wind direction 10 m above ground level whereas the Davies stations measure wind speed at 2 m above ground level. Information for the climate section is taken from the Air Quality specialist report (Appendix F), from data collected by the Swakop Uranium Environmental Department, and the Groundwater model report (2021).

4.1.1 Temperature

Summers are moderately hot (average maximum temperature during the hottest month is about 30°C), but the climate is tempered by cool coastal conditions brought inland by prevailing westerlies, south-westerlies and southerlies (Lindesay & Tyson 1990; Mendelsohn et al. 2002). Winters are cool (average minimum temperature in coldest month is between 10 and 12°C), but hot easterly bergwind conditions can result in unseasonal warm conditions.

The highest temperatures recorded during the three-year period between January 2017 and December 2019 was 41°C (November) with monthly averages of indicating August and September to be the cooler months, and October to March being the hottest.

Table 4-1: Monthly Temperature Summary (Marble Ridge Weather Station Data, 2017 - 2019)

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	12	11	11	8	9	8	7	6	5	8	9	10
Average	20	21	23	24	24	21	21	18	18	20	21	21
Maximum	32	39	39	38	37	35	34	36	37	39	41	33

4.1.2 Rainfall

The Husab Mine is situated within a hyper-arid region, with a long-term average rainfall of less than 50 mm rain pa (Mendelsohn et al. 2002) (Figure 4-1). Spatial and temporal variability in rainfall is high (Mendelsohn et al. 2002). Rainfall mainly occurs as convective summer storms (Lindesay & Tyson 1990), sporadic, and often falling in one area (e.g. thunderstorms) rather than widespread across the region. The Namibian rainy season occurs most often in March and April.

The rain gauge monitoring network at Husab has been recording rainfall events across the site for several years and Figure 4-2 shows how widely spaced rainfall events can be. Although some rain was recorded at other rain gauge sites across the mine for 2019, it was generally less than 5 mm for the year.

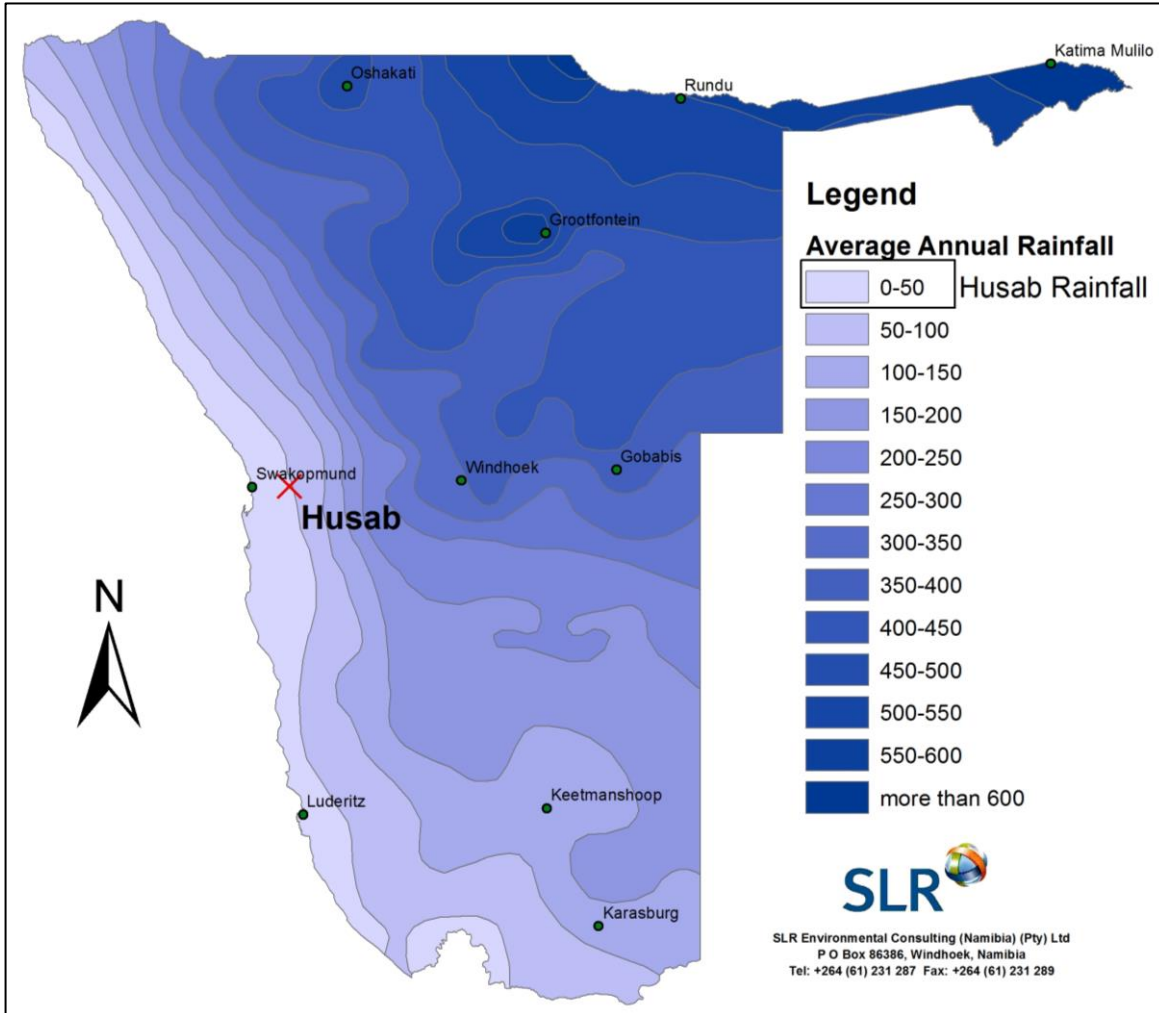


Figure 4-1: Average Annual Rainfall over Namibia. Husab Mine marked with a red X (0-50 mm/a)

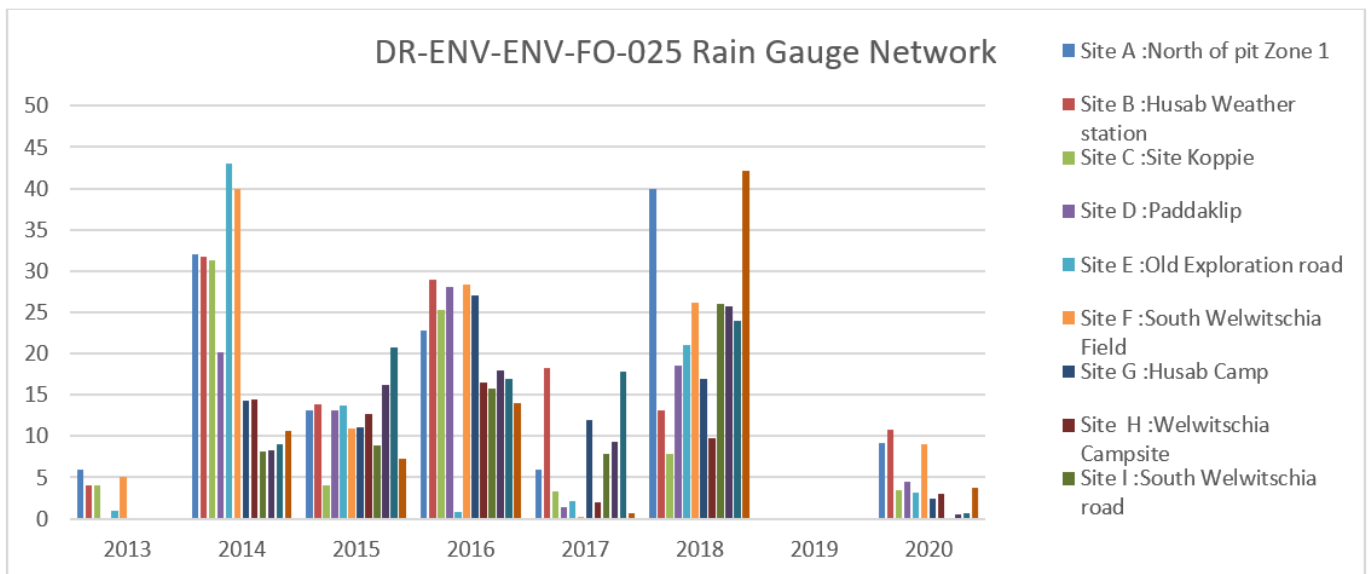


Figure 4-2: Rainfall data from the DR-ENV-FO-025 Rain Gauge Network Data

With climate change effects starting to be felt, the intensity of thunderstorms appears to be increasing. In June 2016 a high intensity storm, considered to be a 1:100-year rainfall event (Pers Comm Env Dept), caused significant water to flow along the access road north of the Khan River. Considerable damage was caused to the road reserve, and on the Husab site, several roads and plant facilities were flooded.

4.1.3 Fog

Frost is rare and cloudy conditions are common, with approximately 125 days of fog per year at Swakopmund (Mendelsohn et al. 2002). The number of fog days decreases sharply with distance from the coast (Lancaster et al. 1984). Fog probably occurs in the study area between 50 and 90 days per year and is an important source of water in the area.

4.1.4 Evaporation

The Atlas of Namibia, 2002, shows the study area to have a potential annual evaporation (ETpot) of between 1 960 mm and 2 100 mm which indicates a net loss of available moisture to the atmosphere.

4.1.5 Surface Wind Field

Wind roses showing seasonal variations in the wind field from the Marble Ridge weather station for the period 2017 – 2019 are shown in Figure 4-3 . The wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below reflect the different categories of wind speeds; the yellow area, for example, representing wind speeds between 6 and 7 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

It is important to note the frequency of wind speeds of greater than 7 m/s (orange and red on the wind rose) as these winds move dust and sand, and the direction from which the winds blow at different times of the year. This fact had was important when considering the layout options for the HLF and HLWF.

From the Marble Ridge weather data (2017 – 2019), the wind field was dominated by winds from the southwest, west and northeast with less frequent, but strong winds from the northwest and very little from the southeast. The patterns reflected in Figure 4.3 are virtually the same as wind roses produced for the period 2014-2016 (SLR, 2018).

During summer, the prevalent winds occur from the west, west-northwest, west-southwest, northwest and southwest. The prevailing wind field during autumn occurs from the southwest and northeast, with less frequent winds from the west-southwest and western wind field. During winter season, the prevailing wind field also occurs from the southwest and a much stronger northeast component. The strongest winds occur from the northeast during this season, representing the so-called “Berg- or east-wind” conditions. An increase in the west-southwest and western wind field is observed during spring, with the prevalent wind from the southwest.

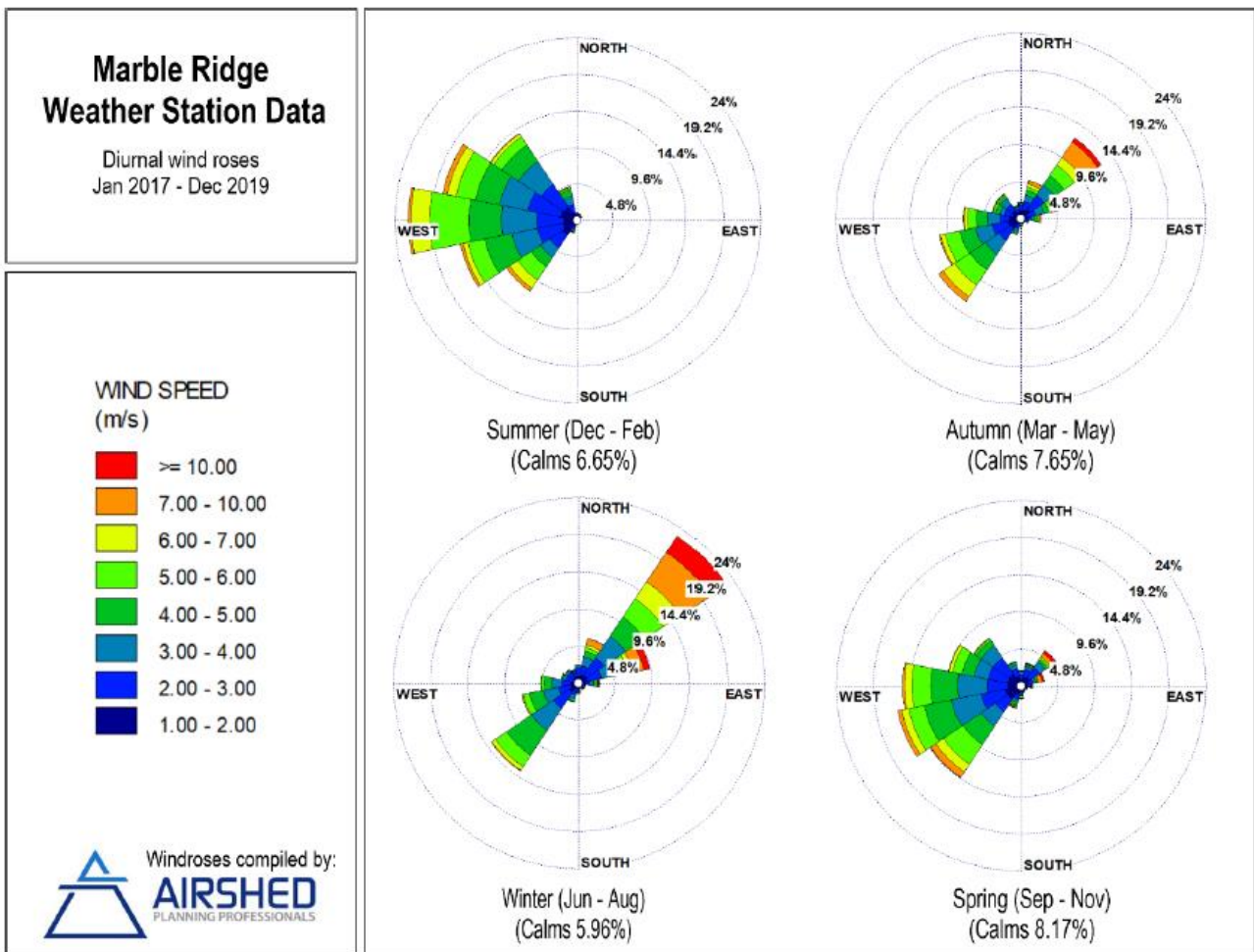


Figure 4-3: Seasonal Wind Roses (Marble Ridge Weather Station Data, 2017 - 2019) (Airshed, 2021)

4.2 TOPOGRAPHY

The Husab Mine lies on the northern side of a rough triangle bounded by two major ephemeral rivers, the Khan River to north of the site, and the Swakop River located to the south. Between these two rivers is open plain that slopes gently toward the Swakop River. The area is interspersed with limestone ridges and granite outcrops. The Swakop and Khan River valleys are deeply incised and are some 200m below the watershed (1:50 000 topographical map, 2215CA). The Husab Mountain, from which the mine's name is derived, dominates the landscape to the southeast.

Several shallow sandy water courses flow from north-east to south-west across the gravel plains and these washes supply water to the large *Welwitschia mirabilis* field that lies south of the Husab Mine site.

Elevation data for the site was obtained by the soil specialist from the United States Geological Survey (USGS) (<https://earthexplorer.usgs.gov/>) in the form of the global SRTM 30m digital elevation model (DEM) and this data is provided in Figure 4-4.

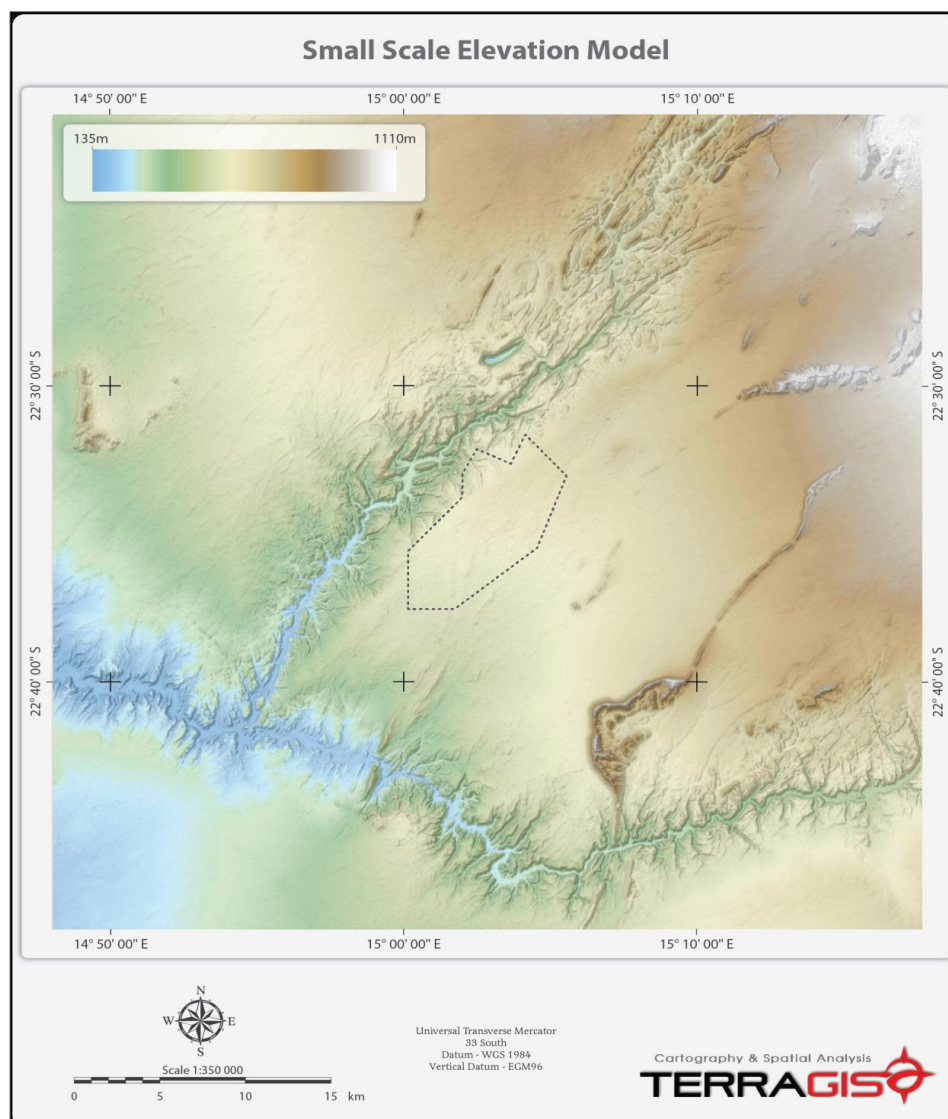


Figure 4-4: DEM Data for the General Area Surrounding the Investigation Site (White Indicates the Highest Sections and Blue the Lowest) (Terra Soil, 2018)

4.3 GROUNDWATER

The information presented in this Section has been sourced from the Groundwater Assessment Report and Ground Water Model report and includes modelling for Option K (SLR, 2021). Ground water depth and water quality has been monitored since 2010 at the Husab site and the comprehensive borehole monitoring network (Figure 4-5) has been established over the past 10 years.

The mining area is dominated by north-northeast to northeast trending regional scale anti-forms and syn-forms with gneissic and meta-sedimentary rocks of the Abbabis Formation and the Damara Super Group. Damara Super Group meta-sediments show a complex pattern of folding and faulting, and the whole sequence is extensively invaded by syn- and post-tectonic granitoids and pegmatite swarms. Cross-cutting Mesozoic dolerite dykes are also evident locally.

Namib Group sediments, which overlie the bedrock, vary in thickness across the mining area. A palaeo-basin trending northeast-southwest through the area is defined, its lithology varies from surficial, unconsolidated sands, to semi-consolidated fine-grained gravels, with clay horizons also encountered in the southern and south eastern end of the study area. The palaeo-basin does not appear to be open to the southwest since bedrock outcrops stop any path towards the Swakop River.

4.3.1 Aquifer Types

Three aquifers exist within the mining area which can potentially be impacted by the proposed project activities. These aquifers are alluvial aquifers, paleo-channel system and bedrock fractured aquifers. The following is summarised in terms of aquifer types, thickness, and groundwater levels:

- The Khan and Swakop Rivers beds contain the alluvial aquifers. Their alluvial aquifers have a general thickness between 10 and 30 meters and are characterised by high groundwater potential in terms of yield. Observed water levels in the period 2009 to 2016 range between 0 m (May-2011) and 18.6 m (Dec-2010) in the Swakop River and 11.4 m (Dec-2014) to 17.2 m (Feb-2016) in the Khan River. Water levels fluctuate depending on recharge when the rivers flow. Observed water levels in 2020 were between approximately 4 and 11 m bgl in the Swakop River and between 12 and 18 m bgl in the Khan River.
- In most areas of the site the sediments of the Tertiary Namib Group overlie the bedrock units. The sediment thickness varies from less than a metre in along the watershed and thickens south and westwards to over 140 m (the mining overburden). The lithology of the sediment cover comprises calcrete, consolidated and calcretised gravel and sand while in general being characterised by high clay content. Consequently, this 'primary aquifer' has a low permeability and does not constitute an exploitable aquifer. Water bearing sedimentary units occur in a NE-SW trending paleo-channel system, which does not appear to be continuously open to the southwest. The water level in RS6 (3km south-east of TSF), has been monitored since 2009 and shows only minor water level fluctuations which, at present, cannot be linked to a distinct rainfall event.
- The bedrock aquifers comprise pre-Damara basement rocks of the Abbabis Metamorphic Complex and meta-sedimentary units of the Nosib and Swakop Groups. Groundwater is held in fissures and fractures in otherwise impermeable strata. Given the high water levels and water quality differences between distinct geological formations and/or groups, and often within short distances, the conceptual model proceeds on the assumption that compartmentalised aquifer systems exist, implying a limited hydraulic connection between distinct hydrogeological units (predominantly perpendicular to geological strike). This fact influences the ground water model domains. Groundwater levels in the fractured aquifers are relatively deep, ranging from > 60 to 120 m bgl. Groundwater levels in rocks of the Welwitschia Syncline range between approximately 30 m bgl to 60 m bgl. These water level differences could be either linked to very low permeabilities of the marble and schist or more likely to a potential groundwater flow barrier associated with the thrust fault of the Husab West Fault Zone.

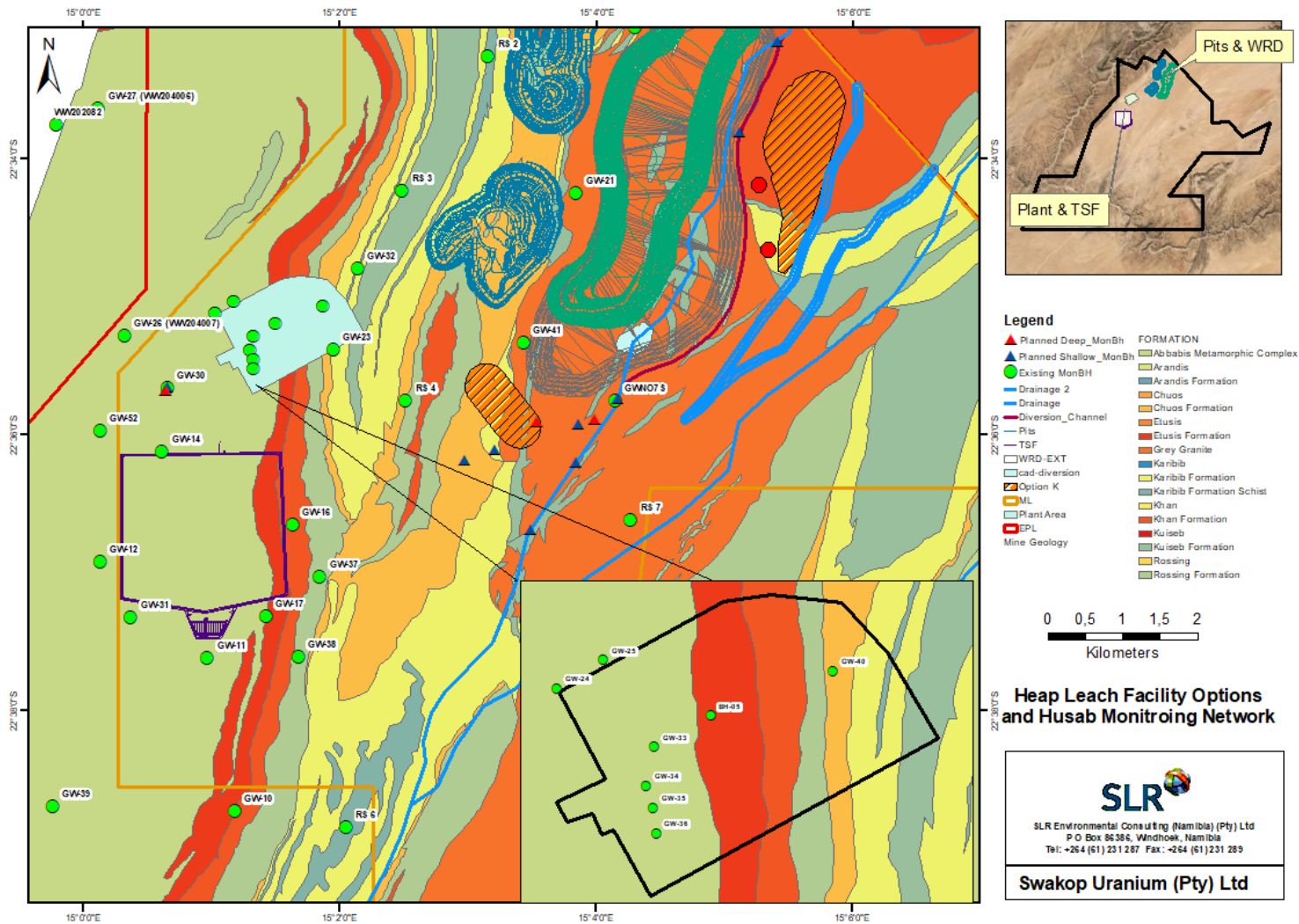


Figure 4-5: Heap Leach Option K with Subsurface Geology and Groundwater Monitoring Network. New Boreholes for HLWF are in Red.

4.3.2 Ground Water Model

SLR has identified 4 different groundwater domains: the alluvial aquifers of the Khan and Swakop Rivers, and three separate geological domains on the Husab plain. Groundwater flow is to the south and southeast over the Husab plain. A sharp drop in surface topography from the watershed down to the Khan River is likely to have groundwater flow vectors in an east-west direction. The monitoring boreholes have been subdivided into the different domains according to their hydrogeological setting and the infrastructure that may be a possible source of pollution (Table 4-2).

In 2015 a conceptual (hydrogeological) model was developed that was based on past and recent drilling, test pumping activities, results of routine groundwater monitoring, as well as information provided through hydrogeological, geological, and geophysical investigation within the study area (SLR, 2015).

SLR developed a numerical Groundwater Flow Model in 2016 to evaluate potential impacts of the Husab Mine on the regional groundwater environment and to estimate groundwater inflow rates into the open pit excavations and contaminant transport emanating from the TSF. This model has been updated with new monitoring data and was used to create the groundwater transport models to evaluate the environmental impact of the different HLF and HLWF options (SLR 2021).

Table 4-2: Hydrogeological Setting of Each Domain

Domain	Hydrogeological Unit	Infrastructure
Khan Dome	Anticline exposing gneiss of the Abbabis Metamorphic Complex locally covered with Quaternary Sediments as well as Damara Supergroup calc-silicate rock from the Khan Formation: Very low permeability	Tailings Storage Facility and western side of Processing Plant
Welwitschia / Husab	Syncline/Anticline comprising mainly Damara age schist, marble, limestone, and dolomite of the Karibib, Chuos and Rössing Formations. Low to medium permeability	Main mining areas with ore deposits (alaskite intrusions), as well as the eastern side of the Processing Plant.
Grey Granite	Damara age granite and gneiss: Very low permeability	Waste Rock Dump
Alluvial Domain	Alluvial sediment, sand, and gravel: medium to high permeability	Temporary production boreholes

4.3.3 Waste Rock and Sub-Economic Material Geochemistry

The information presented in this section has been sourced from the Groundwater and Surface Water Re-Assessment Report and Geochemistry Report (SLR, 2018a) and also applies to the proposed HLWF.

There is no water quality data available for surface water within the mining area as the channels and streams seldom flow. Samples should be collected during future storm events, to start a database which will be used to monitor possible changes in surface water quality over the life of the mine.

A geochemistry report was done by SLR in 2018 to determine if potential acid forming material is present in the regular waste rock and to assess the potential risk to water resources in (SLR, 2018a). Test programs for the acid generating potential, total elemental concentrations as well as the leachable concentrations were conducted on samples of the mineral material to be stored on the WRD and their results are summarised below:

- To determine if the WRD and the sub-economic material stockpile materials (being stored near the WRD) are potentially acid generating:
- The majority of the samples analysed were classified as non-PAG (non-potentially acid generating);
- Some of the mineral materials analysed are potentially acid generating, and include the following:
 - Schist;
 - Mixtite;
 - Gneiss;
 - Migmatite; and
 - Zone 2 – sub-economic material.
- The geological environment has a predominantly low neutralisation potential for most of the meta-sedimentary and granitic rock types in the mining area. However, the calc-silicate rock and up to 100 m thick calcareous paleochannel sediments (calcrete) underlying the WRD (and HLWF) have a higher neutralisation potential (NP) (calcrete was not tested as part of the WRD geochemistry study);
 - Based on the change of pH in the leach tests, the neutralising potential of many of the Husab lithologies can be leached over the short term, except for the calcareous sediments;
 - Acid potential appears to be associated with the presence of pyrite, except for calc-silicate, which has an excess of NP.
- To assess the potential risk to water resources:
 - The drainage emanating from the WRD and sub-economic stockpiles (and by inference the HLWF) may be acidic, **if** the acid potential of the pyrite-bearing rock exceeds the available NP and **if** the sporadic rainfall of the area is sufficient to result in water seeping through the piles;
 - The concentrations of F and Hg in pile drainage may pose a water quality risk;
 - Drainage quality depends to a significant degree on the solid to solution (rock to rainfall infiltration) ratio within the WRD and sub economic material piles (and HLWF).

Based on their findings it has been established that the WRD may present a source of ground- and surface water pollution if there is a possible pathway from the source to the receptor (in this case the biodiversity downstream, i.e. Welwitschias).

Golder (2017) undertook the geochemical characterisation and waste classification of the heap leached waste which was classified as Type 3, which, according to the South African Norms and Standards, requires at least a Class C barrier system which has been used in the conceptual design for the HLWF.

The description of the ground water model that has been developed is available in the reports in Appendix G. It is important to note that the groundwater model has been developed on the premise that the liner specifications for Type 3 waste requiring a Class C liner are adopted as per the design requirements provided by Golder Associates for the SGS feasibility study report.

4.4 SURFACE WATER

The information presented in this section has been sourced from the past surface water studies for the Husab Mine, the WRD & Incineration Scoping Report (SLR, 2018), as well as stream and catchment maps provided by the biodiversity specialist. The Surface Water Assessment for the Heap Leach Project (SLR 2021) focuses on the design of storm water management measures for the HLF and HLWF and pollution prevention measures.

An important factor to note in the surface water assessment is that the Husab channel is to be diverted because of the 2018 approval of the waste rock dump expansion (SLR, 2018) across 5 km of the channel bed. The WRD has not yet extended eastwards, and the proposed river diversion has yet to be designed. Provision for the footprint of the proposed diversion has been included for site layout Option K.

4.4.1 Regional Hydrology

The Swakop Uranium Mining Licence (ML 171) falls within an area that lies between the ephemeral Swakop and Khan Rivers. Most of the existing mine infrastructure lies within the Swakop river catchment on the south of the watershed, with the processing plant and part of Pit Zone 1 in the Khan River catchment on the north of the watershed. Figure 4-6: Stream Channels and Catchments Provided by AWR, 2021. The Rainfall Isohyets Increase Eastwards Indicating the Importance of the Total Catchment Contribution to the Welwitschia Field. shows the catchment areas for several of the drainage channels that flow across the mining licence area. Rainfall increases eastwards from the coast (Figure 4-1: Average Annual Rainfall over Namibia. Husab Mine marked with a red X (0-50 mm/a)) and thus these catchments lie in areas of higher rainfall, which on occasion will lead to channel flow across the plains.

The Khan River flows 2-4 times per annum, because of either local rainfall runoff or rainfall upstream/upper catchment areas. It is also normally short lived (1-7 days). The Swakop River south of the site last flowed strongly in 2010 and again in 2021, following above average rains in the interior and dam overflow.

4.4.2 Local Hydrology

The proposed heap leach project is located adjacent to, and across, the Husab channel catchment which is a non-perennial river which only occasionally flows during bigger rainfall events, both locally and inland to the east (Figure 4-6: Stream Channels and Catchments Provided by AWR, 2021. The Rainfall Isohyets Increase Eastwards Indicating the Importance of the Total Catchment Contribution to the Welwitschia Field.). The main catchment area is long and relatively narrow and extends approximately 50 km in a north-easterly direction. The catchment is approximately 34 500 ha or 345 km² (Metago 2010).

SLR and the SU Environmental Department have been gathering information and evidence of when the Husab channel and others have flowed in the past. Evidence from Google Earth imagery shows that big flood events occurred have between 1910 and 2010. The historic narrow gauge railway line was built across drainage channels and rivers and thus blocked the natural flows in these channels. The railway line was deserted approximately in 1910 and since then some sections of the railway embankment have been washed away. Evidence from the Husab channel shows that at least one major flood event occurred in the past 100 years.

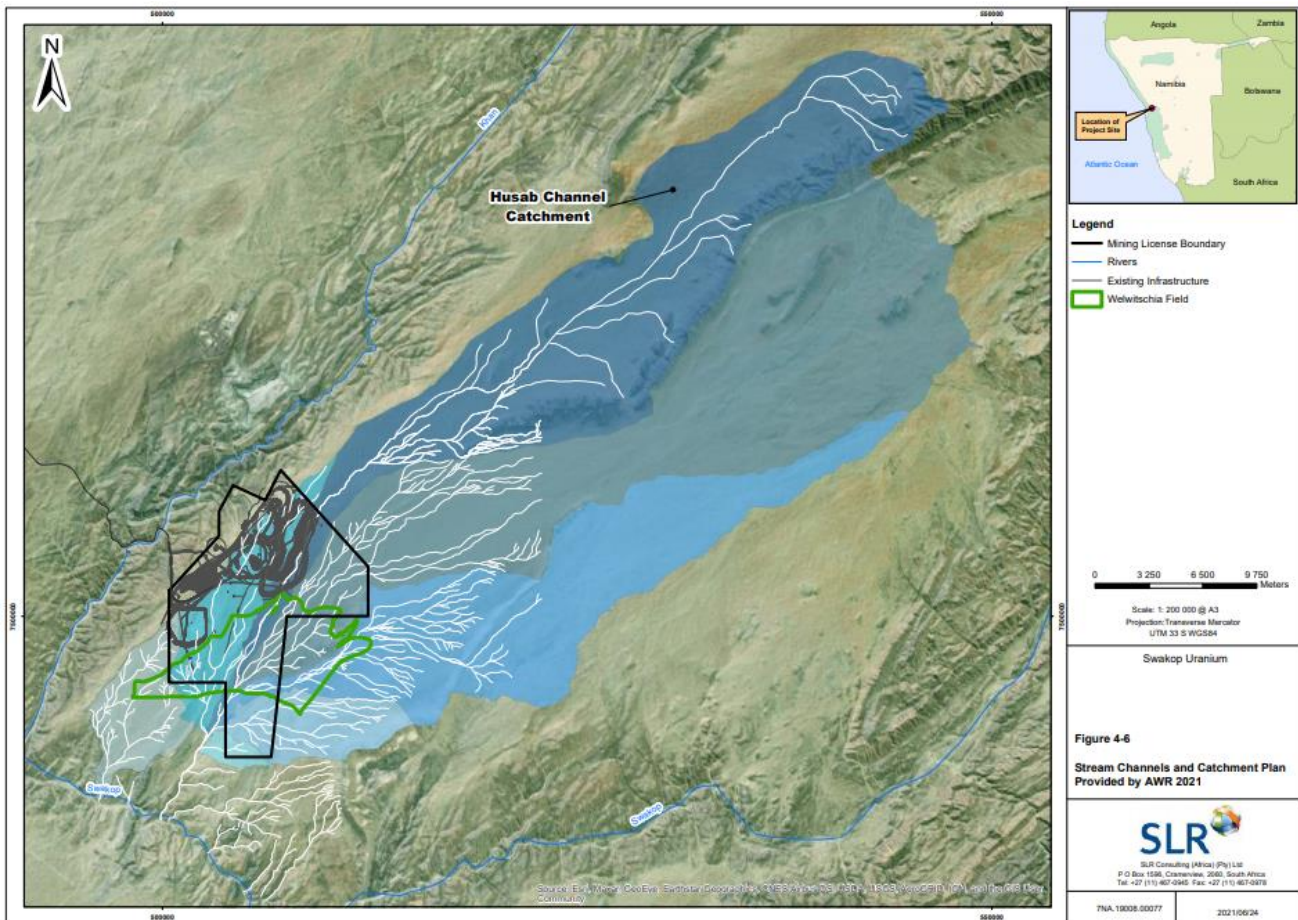


Figure 4-6: Stream Channels and Catchments Provided by AWR, 2021. The Rainfall Isohyets Increase Eastwards Indicating the Importance of the Total Catchment Contribution to the Welwitschia Field.

4.4.3 Flood Hydrology

During a site visit during 2018, SLR measured the width of railway embankment that has been washed away. The depth of the flood was difficult to estimate, but the embankment is up to 0,8 m high in places. From the measurements collected, new flood calculations were done to determine possible 1:100 floods, and to make sure that stormwater management systems do not underestimate future flood events.

The modelling package HEC-RAS was used to carry out the peak flood estimates for the Husab channel by considering the width of the railway embankment that was flushed away and reworked existing data to simulate flows equal to the extent of historic flows. The cross-section simulated flow resulted in a channel width of 60,3 m which is almost equivalent to what was measured at the disturbed railway embankment. Flows were increased incrementally to establish the best fit for possible flood events and will in future inform the Husab channel diversion design. Small short lived flow events have been witnessed at least twice in the Husab channel over the past 10 years (Pers. Comm, Env Dept).

4.4.4 Surface Water Receptors

The Husab channel is a non-perennial river and, although no people rely on flows from the river, *Welwitschia mirabilis* and other plant species are located within the river channel downstream of the planned HLF and HLWF. The *Welwitschia* plant health appears to best inside the drainage channels, which suggests that water movement along these channels is an important feeder for the *Welwitschia* field (See biodiversity Section 4.6).

4.5 SOILS AND HYDROPEDOLOGY

4.5.1 Soil

The general soil data of Namibia was extracted from the downloadable Atlas of Namibia (University of Köln, Germany) and is provided in Figure 4-7: Soil Profiles 17 and 19 dug inside and outside of the Husab channel respectively (Terra soil, 2018) for the area investigated by Terrasoil Science in October 2017. The soil classification is based on the World Reference Base (WRB) system, and it is important to note that the “Regosol” category is a rest group that remains once all other soils have been keyed out in the soil identification process. This implies that the soils are poorly developed and typically show a distinct affinity with the original geology.

Nineteen test pits were dug in the footprint of the proposed WRD expansion and across the Husab channel. The soil forms identified on the site generally belong to the Prieska, Coega, Augrabies and Dundee soil forms. However, although classified in the Taxonomic System of SA (The Soil Classification Working Group, 1991), they do not fit this system perfectly because the locality type Silica cemented old calcrete deposits do not occur in South Africa.

The approach as discussed above was used to provide adequate classification and contextualisation of the specific soil variation found on the site. In essence three distinct soil categories were identified namely:

- shallow and crusted cemented (with lime and / or silica) soils formed in the calcrete parent materials;
- thick alluvial deposits within old, eroded stream channels; and
- combinations of the above with thinner alluvial deposits overlying lime and silica cemented subsoil materials.

From the samples analysed in 2018, silt and clay content values were less than 2% for majority of the samples with a few samples of silt and clay content values above 10 %. This implies that all the samples have a coarse sandy gravel texture. In addition, the analysis results indicate alkaline pH values that are within the expected ranges for natural soils in the specific survey area context as having formed from calcrete parent materials. Most of the soil samples exhibit the profile of Ca>Na>Mg>K concentrations – as expected for a calcrete parent material in a desert environment where Ca and Na are the dominant cations.

In general, the trends that were observed can be summarised as follows:

- The dorbank and hardpan carbonate horizons exhibit very high levels of Ca and the levels tend to increase with depth, indicating a water regime driver.
- The instances where Ca levels are very high in surface horizons correspond with high sulphate levels and this is ascribed to the stability of the gypsum crusts in this environment.
- The fluvic materials exhibit much lower Ca levels than the hardpan carbonate, soft carbonate and dorbank horizons. This is indicative of 1) good drainage in the fluvic materials due to a lack of consolidation and therefore a high percolation potential and 2) the fluvic depositional nature of the materials that could have led to the removal of soluble Ca fractions through receding water.
- The Na levels are rather erratic but do indicate a trend of accumulation in subsoils. This aspect indicates a dominant downward movement of water in the soils. However, in many cases the subsoil materials exhibit a decrease in Na levels compared to some overlying deep horizon. In these cases, the Na concentration spikes indicate the maximal percolation level of water with a subsequent evaporation of water within these horizons in the profile during dry conditions. This observation confirms that the soils are not subject to leaching of salts from the profile and that the regular precipitation event is not big enough to lead to leaching losses.

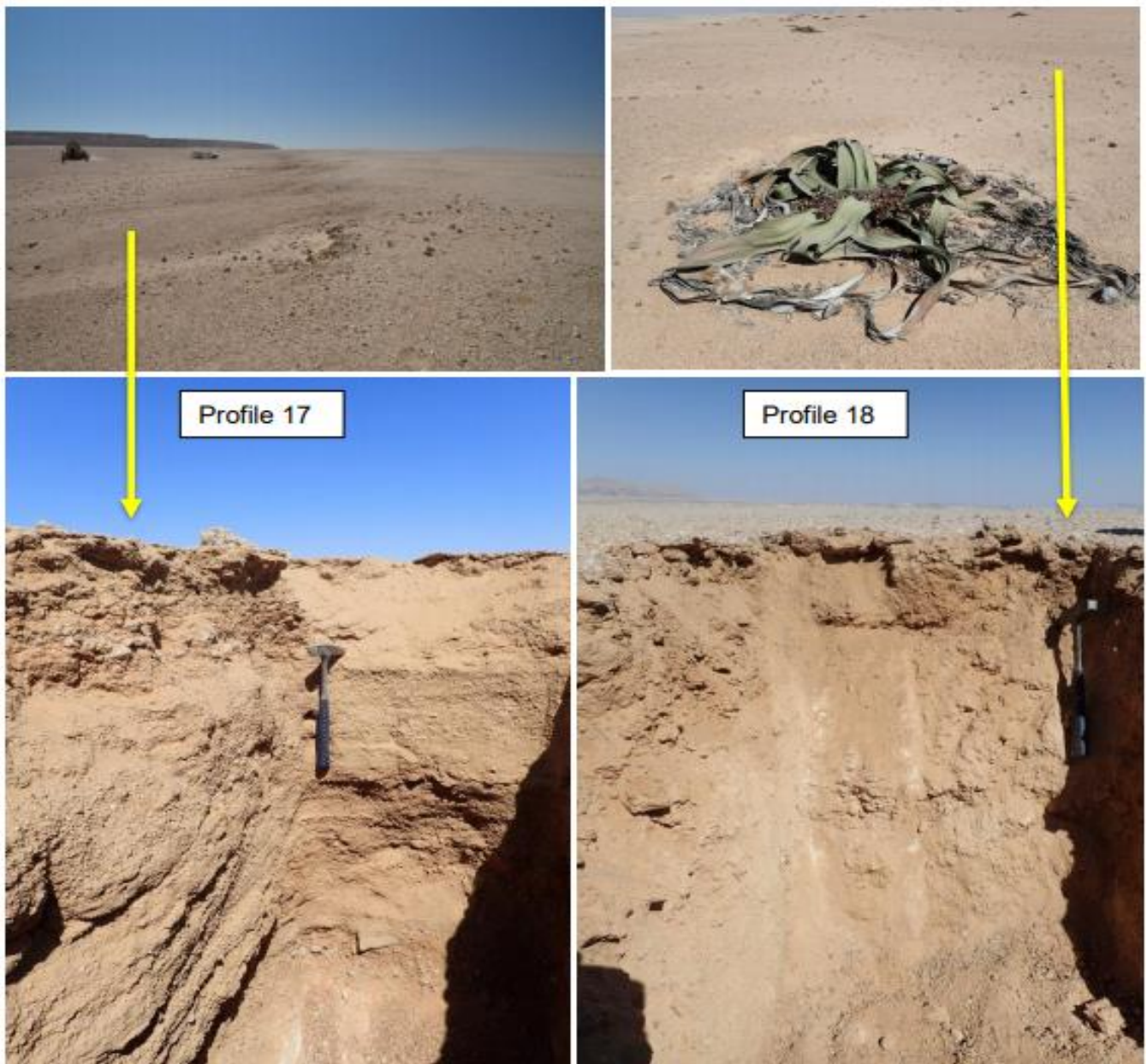


Figure 4-7: Soil Profiles 17 and 19 dug inside and outside of the Husab channel respectively (Terra soil, 2018)

4.5.2 Aerial photograph interpretation

An aerial photograph investigation undertaken in 2018 yielded that the general mining area is characterised by distinct flat surfaces that appear to be crusted and interspersed with very clear braided channel systems. The channel systems on the immediate site are relatively wide with several small secondary channels indicating preferential flow paths from the surrounding higher landscape. It is very interesting to observe the occurrence of *Welwitschia mirabilis* plants within the braided channels as well as along the zones of preferential flow (Figure 4-8). In these systems water concentration is expected in the deeper loose sandy soils that can store water.

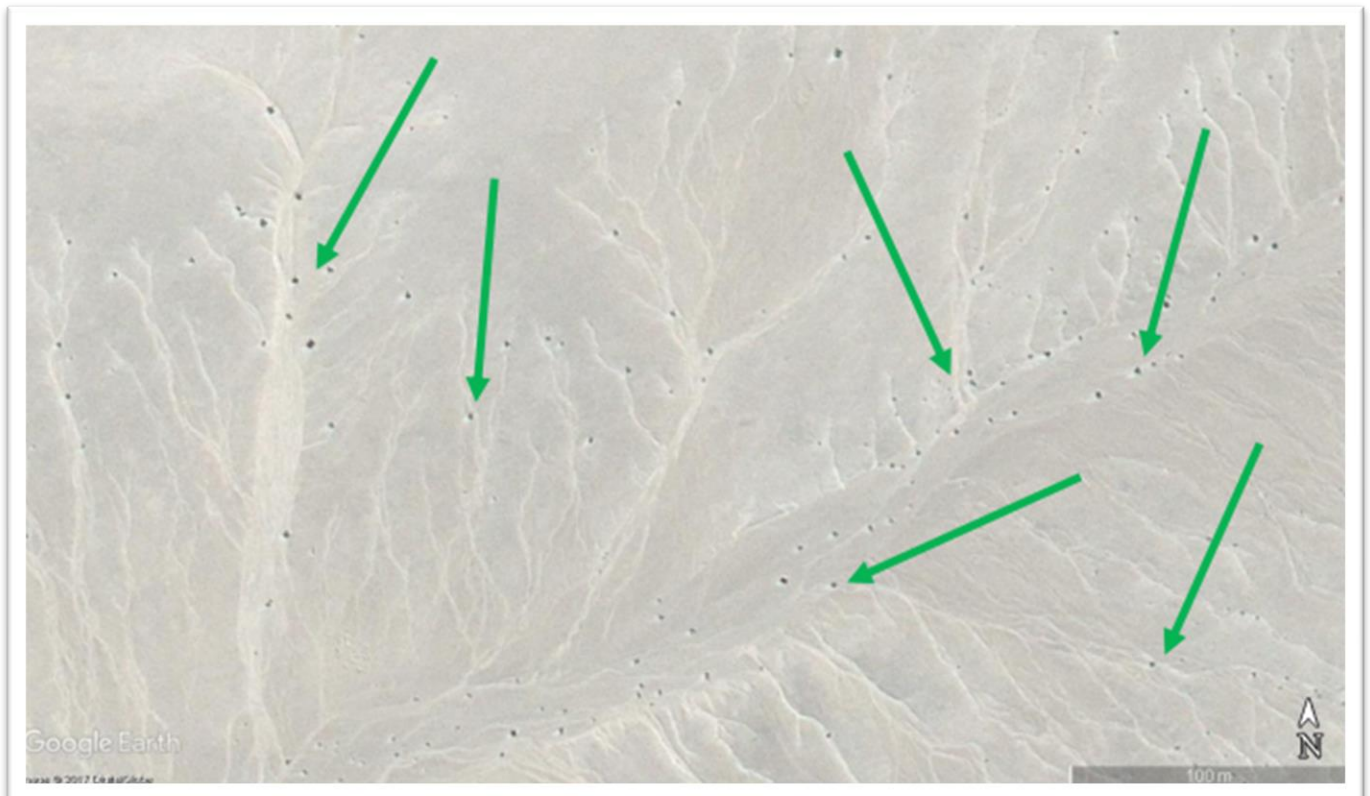


Figure 4-8: Occurrence of *Welwitschia mirabilis* Plants (Green Arrows as Examples) Along Braided Channels and Zones of Concentrated Water Flow

4.5.3 Soil and Hydrogeology Findings

This section provides a summary of the field investigation, soil profile description and the broader landscape and soil / plant interaction assessed by Terrasoil Science in 2018. The salt contents of the various soil horizons and materials tell the story of the water dynamics in this landscape. The following observations were made:

- It is evident that the *Welwitschia mirabilis* plants occur in areas where there is a distinct water “make” area upslope from a more porous and permeable material within which the plants grow. This observation is consistent for areas where the plants grow 1) within the sediment filled old, eroded channels, 2) the immediate runoff areas from crusted surfaces within small “watercourses” that experience regular water flows after precipitation events and 3) the water accumulation areas within small localised more porous materials zones (fluvic soil material, fractured rock areas and weathering calcrete areas) that are fed from water runoff from impermeable and exposed rock areas.

- The crusts observed in the soils of the site are attributed to the concentration of evaporites on the surface through evaporation of water with mobilised salts in lower soil horizons. The gypsum crusts are formed from the very long-term addition of S from marine fog and the subsequent rapid oxidation of S, formation of sulphate and precipitation as CaSO_4 due to the high Ca levels in the calcrete. Gypsum mobilisation takes place in the soils and this gypsum is precipitated along preferential flow channels and cracks in the weathering calcrete. The presence of Na in varying levels in the soil profiles confirms a rainfall induced migration to lower soil horizons where the water evaporates within the profile without complete leaching. The fact that the Na and gypsum accumulation areas do not correspond entirely indicates a variable rainfall and evaporation regime that can include inherited properties from slightly higher rainfall periods (gypsum) and more recent more arid conditions (Na).
- From the site investigation and analysis data, Terrasoil Science drew the conclusion that there are not any distinct lateral leaching and movement of water processes. Terrasoil Science therefore inferred that the plants are fed only by precipitation driven processes and not by landscape scale hydrological processes (flow paths and processes of water movement for long distances as subsurface flow mechanisms).

The landscape at the Husab Mine is characterised by shallow and hardened soil profiles on an old landscape surface. This surface also exhibits very distinct crusting that is dominated by gypsum salts with the S probably from oceanic and mist origin. These surface crusts and dense (cemented / chemically consolidated) subsoils lead to very low infiltration rates with the result that any significant rainfall leads to some runoff.

The erosion channels on this surface are filled with more recent fluvially deposited materials that exhibit infiltration rates and water storage capacity several orders of magnitude larger than the surrounding consolidated and crusted soils (Figure 4-7). This distinctly dimorphic water regime leads to the establishment of plant communities within the channels that exploit the effective “water harvesting” processes present in this landscape.

4.6 BIODIVERSITY

The original version of the biodiversity specialist report assessed the impacts associated with the heap leach layout Options G and H. It was the biodiversity specialist who provided the project team with a revised site sensitivities layout that led to the revised Option K layout. Option K is included in the revised biodiversity report (Appendix I). The information presented in this section has been sourced from the Biodiversity Impact Assessment Report (AWR, 2021) (Appendix I), and the Husab Mine WRD & Incineration Scoping (SLR, 2018).

4.6.1 Geographic, Hydrological and Biological Context

The most relevant geographic aspects for the current study relate to the location of the area in the hyper-arid part of the Namib Desert biome, in a region known for its high levels of range restricted endemism in plants, invertebrates, reptiles and mammals (Irish 1994).

The distribution of the Husab Plains *Welwitschia* population overlaps two of the vegetation units described by Juergens et al. (2013) namely unit 8 (*Arthroa leubnitziae* - *Zygophyllum stapffii* coastal plains succulent shrublands) and unit 9 (*Arthroa leubnitziae* - *Zygophyllum stapffii* - *Stipagrostis ciliata* desert plains transitional succulent shrub- and grasslands).

This distribution further emphasises the fact that the *Welwitschia* population is located in a transitional zone between the coastal areas where fog is the dominant moisture input and the inland areas where rainfall dominates. The physical orientation of the gravel plains, sloping from northeast to southwest with a relatively long catchments that originate around the inland Chuos Mountains, means that it is hydrologically linked to an area with slightly higher rainfall (Figure 4-6).

4.6.2 Flora and Habitat

The project area falls in the “Namib” biome. This biome is known for high levels of endemism in plants, reptiles, invertebrates, and mammals. Vegetation cover is sparse, mostly concentrated in washes and ravines and on rocky marble ridges, as well as on distributed patches of mostly perennial grasses on the gravel plains that form an important part of the available fodder for large grazers such as Hartmann’s Mountain zebra. These patches are probably formed by surface water flows, a well-known phenomenon in arid and hyper-arid areas, but are maintained by gerbils (AWR, 2021). Three habitats will be impacted by the proposed heap leach project footprints, these are the plains drainage channels, koppies and ridges on plains and grassy plain (AWR, 2021) (Figure 4-9).

Fog-dependent species such as *Zygophyllum stapffii* and *Stipagrostis* spp. are generally dominant, but plant communities are set apart by numerous endemic and near-endemic taxa, including *Commiphora oblanceolata*, *Euphorbia giessii*, *Ruellia diversifolia*, *Aloe asperifolia* and others. The area to the south of the mine is characterised by a population of *Welwitschia mirabilis*.

Wassenaar & Mannheimer (2010) defined **twelve habitats** across the whole study area based on their physical and ecological characteristics). The proposed project lies within areas that have been rated least sensitive (parts of the grassy plains habitat), sensitive (plains drainage channels), very sensitive (koppies and ridges on plains) and no-go (the area covered by the *Welwitschia* plants).

Inselbergs are isolated hill structures that represent distinctly different habitats from their surroundings (Burke, 2002; 2003). As a result, they often harbour species that are adapted to the microhabitat conditions there, especially soil moisture profiles. Although inselbergs are normally considered on a large scale, in the regional landscape of the central Namib with its vast gravel plains, all isolated rocky ridges could function as inselbergs.

In the study area especially, the rocky ridges are significantly more diverse, not only in plants, but also small mammals and reptiles, than the surrounding plains (Wassenaar & Mannheimer, 2010). The ridges do differ in terms of their diversity and distinctness of species composition though, principally as a result of their geology. In this regard the marble ridges and granite koppies provide more nooks and crannies for plants to grow, and cracks and fractures for water to infiltrate than the ridges formed by schist outcroppings. The marble ridges are considered as special habitats that are sensitive to disturbance, not only for each ridge separately, but as a collection of suitable habitat islands in the larger landscape.

The revised site layout Option K has been placed mostly in the grassy plains habitat, with less infrastructure in the sensitive plains drainage channels or on the very sensitive koppies and ridges on plains. The conveyor, pipelines and powerlines cross the no-go (the area covered by the *Welwitschia* plants) on the way to the heap leach waste facility (Figure 4-10) and the potential impacts of the heap leach facility on flora are discussed in Section 0.4.4.

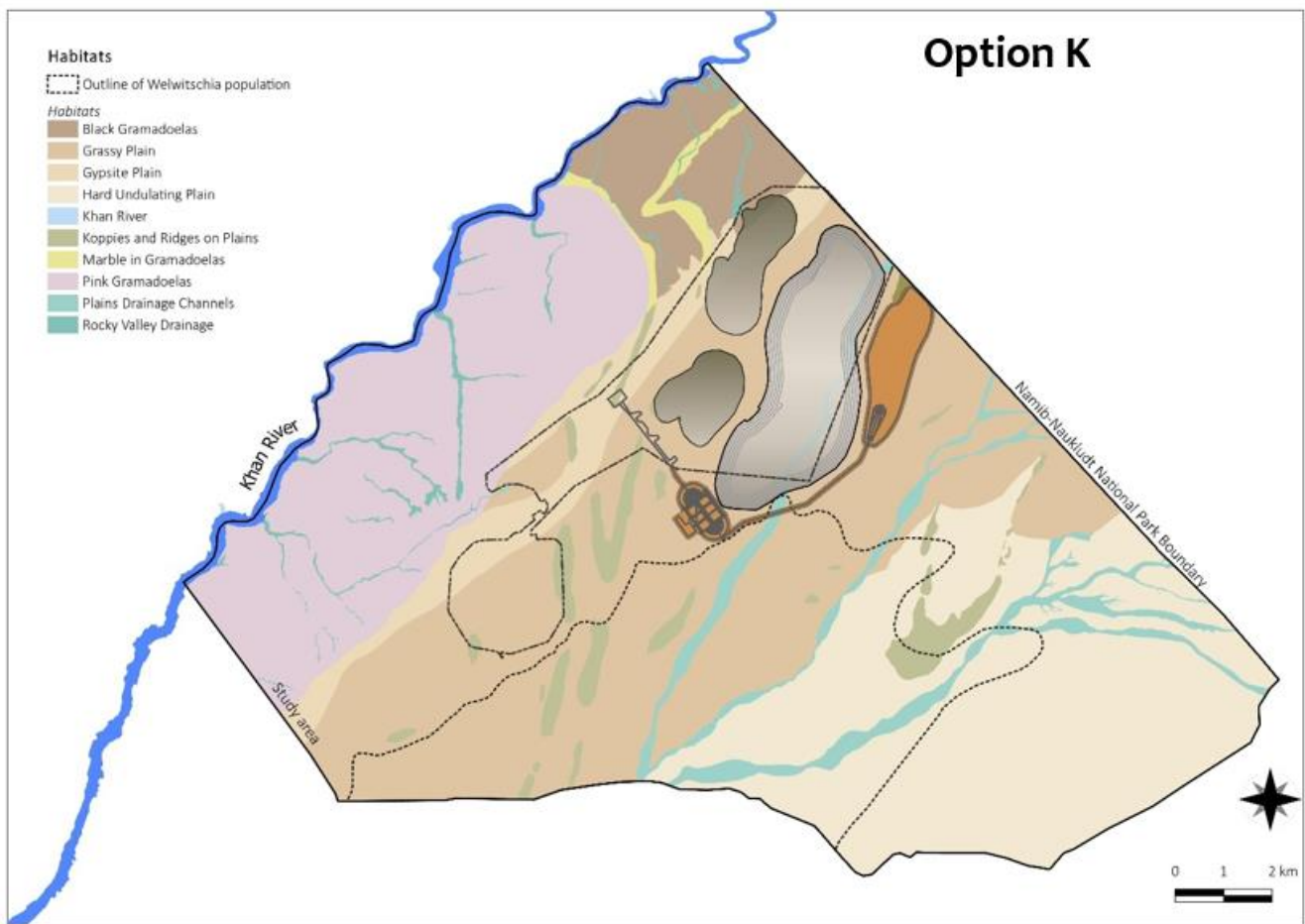


Figure 4-9: Option K Superimposed on the Habitats of the Study Area. (AWR, 2021)

The Husab Mine site sensitivities map produced in 2010 for the original EIA has been updated with information gathered over the past 10 years through monitoring and research. The sensitivities of the limestone ridge, and drainage channels has been increased (Figure 4-10). This is the updated sensitivities map on which the final layout of the heap leach Option K was determined.

4.6.3 Fauna

A relatively small number of desert-adapted mammal species occur within the project area and include large mammals such as the Hartmann’s Mountain zebra (*Equus zebra hartmannae*), Gemsbok (*Oryx gazella*) and Springbok (*Antidorcas marsupialis*). Monitoring of zebra, based on number and age of tracks, indicates a preference to the south-eastern area near the Husab Mountain, but zebra are also regularly found near the mine itself.

Small endemic mammals such as the dassie rat (*Petromus typicus*), pygmy rock mouse (*Petromyscus collinus*) and Setzer’s hairy-footed gerbil (*Gerbillurus setzeri*) also occur, and often play an ecological engineering role, creating habitat for plants (particularly grasses) and thus food for a range of large mammal herbivores.

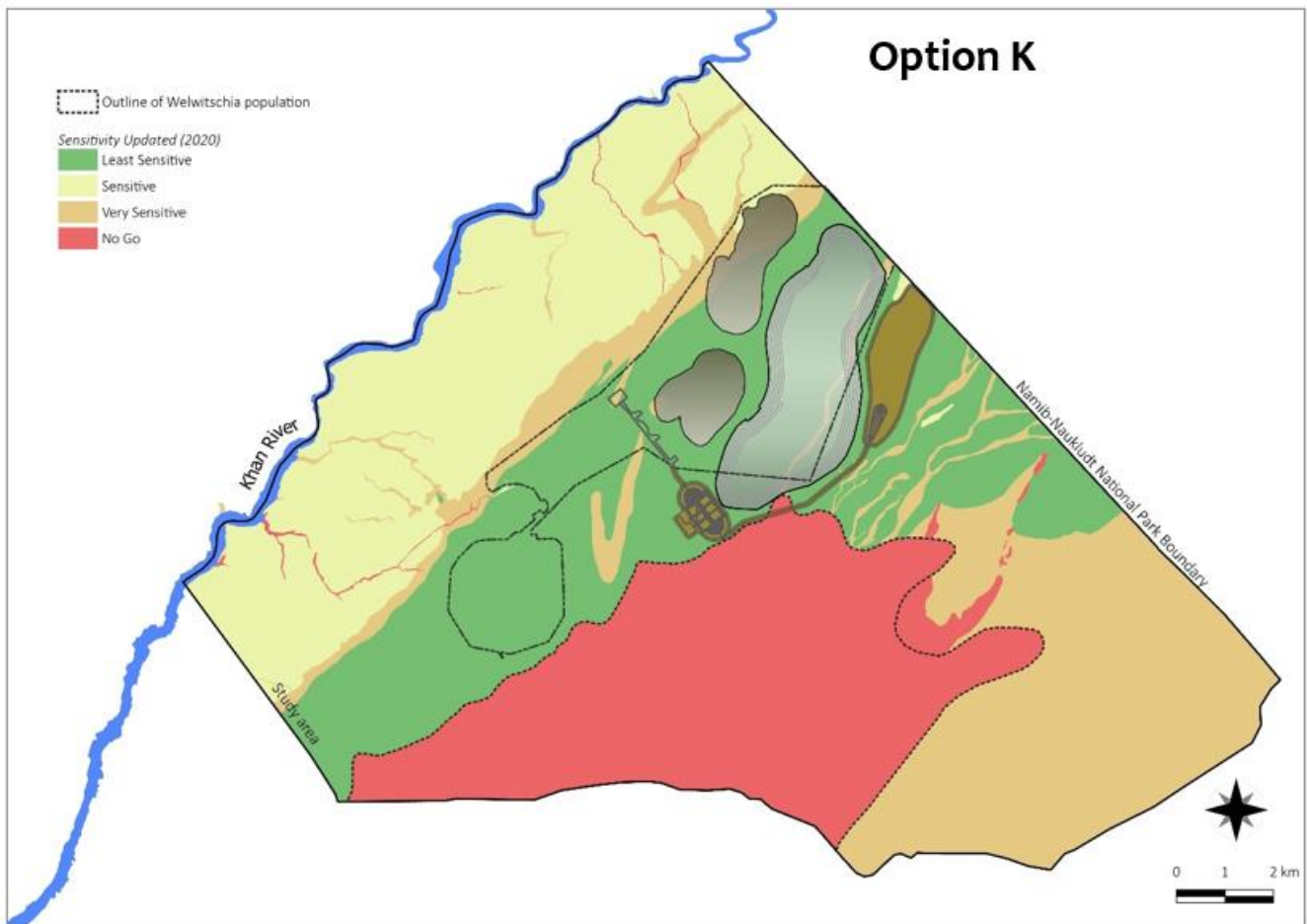


Figure 4-10: Option K Superimposed on the Updated Sensitivity Ratings of the Habitats of the Study Area (AWR 2021).

A recent study has shown how widespread the effect of gerbils is on the productivity of the gravel plains (Shaanika, 2020). The gravel plains, consisting of mostly unconsolidated loamy sandy gravel mix, support only sparsely distributed vegetation. Some of these are perennial shrubs such as the pencil bush (*Arthroa leubnitziae*) or dollar bush (*Zygophyllum stapffii*), but most of the biomass consists of ephemeral grasses such as *Stipagrostis* sp. Only in the numerous unremarkable vegetation patches do these grass species receive enough moisture to become perennial and only in those patches where gerbils dig their burrows does the total biomass become significant. These patches reach their highest density with the highest number of burrows per patch on the grassy plains habitat (Figure 4-11).

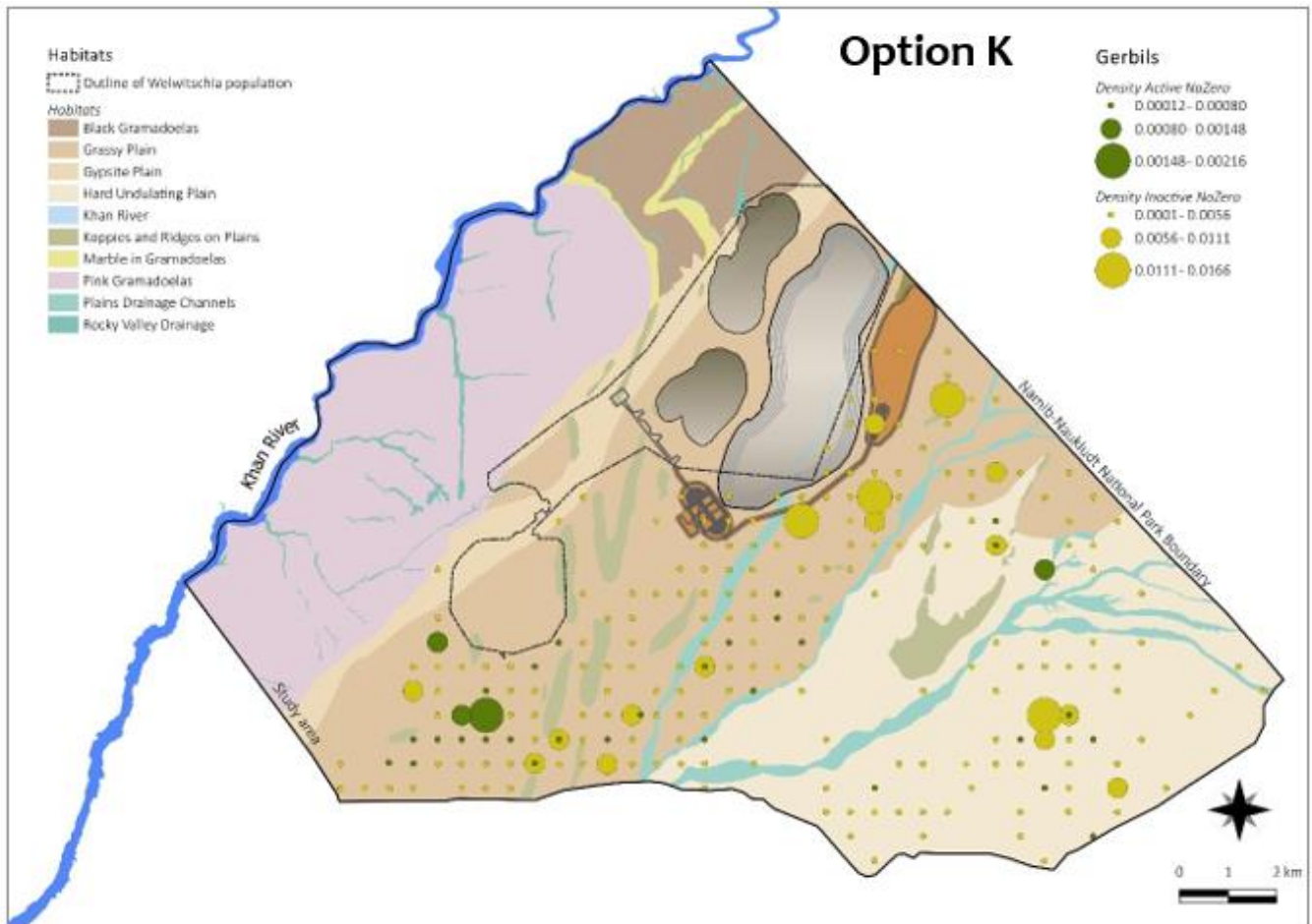


Figure 4-11: The Distribution Outside of the Mine Fence of Vegetation Patches with Gerbil Burrows Superimposed onto the Habitats of the Study Area, Relative to the Location of Option K.

4.6.4 Reviewing the Eco-Physiology and Eco-Hydrology of *Welwitschia*

The *Welwitschia mirabilis* field south of the mine hosts the largest population of this charismatic and iconic desert plant in the central Namib and includes many of the largest specimens known from Namibia, such as the big, or ‘Giant *Welwitschia*’ (Kers 1967). Figure 4-12 shows the relationship between the channel catchment size and the relative health of the *Welwitschia* population.

From research conducted by Wassenaar (2018) on the eco-physiology and eco-hydrology of *Welwitschia*, he drew the following conclusions:

- Studies conducted over the last few decades have greatly improved our knowledge about the ecophysiology of the species. More recent studies (Shuuya, 2016, Henschel et al., Krüger et al., 2017) have provided insight on spatiotemporal patterns of plant health and the *Welwitschia* plants’ principal sources of moisture.
- From this information it is possible to conclude that the species probably requires more water than the local rainfall and fog can provide. The *Welwitschia* habit of growing close to or in gullies and small drainage lines (Figure 4-8) can go some way to explaining its presence despite the hyper-aridity, but the higher numbers of stressed plants growing in the smaller catchment (Catchment A and B) suggests that it is unlikely to be able to maintain high rates of transpiration and growth without some additional factor that stabilises moisture levels.

- This may come in the form of a widely distributed but often disrupted sub-surface petrocalcic layer, which is known to retain moisture at plant-available potentials for longer than the surrounding substrate (Duniway et al., 2007).
- More importantly though, the spatial distribution of density and health strongly suggests that the drainage lines contribute a substantial amount of water to the *Welwitschia* field. This effect should be evaluated over the exceptionally long lifespan of a typical plant, and it probably plays out on several levels, one of which could be as a spatial filter for seedling survival.
- The surface flows in Catchment zone A, B and C (Figure 4-12), although its area is relatively small, is vital for plants growing in it, but it further contributes to the flows downstream of its confluence with the Husab channel. The construction of the Husab Mine has already decreased the amount of water flowing in these catchment zones. This implies that the potential impact of interference of flows in Catchment zones A, B, C and D should be viewed as cumulative and hence more significant (Figure 4-12).
- The lack of data or any systematic observations of surface flows in the Husab channel and other drainage lines on the Husab Plains means that statistical confidence in deductions about the relative importance of the drainages' surface water for the plants in the study population remains low. However, SLR (2018) calculated that the surface flows here occur more frequently than one would expect, given the local rainfall (i.e. that the upper catchment of the Husab channel is in a higher rainfall area than the Husab Mine (Section 4.4.2). Any long-term disruption of the potential for water to flow down this channel will ultimately significantly affect the plants that grow in its catchment in terms of their health status, chances of survival, their potential for growth and reproduction, and the chances for recruitment to the population. This will apply to plants along the length of the Husab channel to where it empties into the Swakop.
- It is not only the *Welwitschia* that will be impacted. Although Wassenaar has not specifically addressed other plant species associated with drainage lines, it can be accepted that they too will also be affected to varying extents. These will include *inter alia* the succulents *Zygophyllum stapffii* and (to a lesser extent) *Arthroa leubnitziae*, and the phreatophyte *Acacia erioloba*. In addition to the plant species themselves, all other invertebrate and vertebrate species that depend on the plants for food and shelter will be affected.
- All effort should thus be made to prevent the disruption of surface flows by the proposed project.

4.6.5 Welwitschia Health Versus Catchment Size

Taking the above mentioned into consideration, it is suggested that the *Welwitschia* plants are dependent (to some extent) on major flood events within the Husab channel (and others). This hypothesis is supported by the pattern of healthy *Welwitschia* plants, which are mostly found in channels with larger catchments. *Welwitschia* plants of poor health or dead individuals can be, to a higher percentage, found in drainage lines or plains with smaller or local catchments (Figure 4-12).

The *Welwitschia* health has been linked to catchment size (Figure 4-12, Table 4-3). The bigger catchments (Husab Catchment and eastern water divide) contributing to the *Welwitschias* south of the proposed project has a percentage of 78.2% and 82.7% of healthy *Welwitschias* respectively. Therefore, it appears that the bigger catchments will contribute more water to the *Welwitschia* plants downstream, and in return, have a direct impact on the health of the *Welwitschia* plants. The poorest health in *Welwitschia* plants was found in areas with locally small catchments or at the upper reaches of a new catchment.

Table 4-3: Welwitschia Health in Relation to Catchment Size (baseline data from 2012 WW survey).

Catchments	Catchment size (km ²)	Total Welwitschias	Percentage Health (%)			
			Good	Average	Poor	Dead
A	16	15 569	13.0	69.3	12.7	5.0
B	10	2 392	19.2	68.5	3.7	8.6
C	20	816	36.4	54.5	8.8	0.2
Husab channel D	345	2 193	78.2	17.5	1.6	2.7
E	251	4 086	82.7	11.4	1.3	4.6
F	46	2 586	29.6	60.5	0.5	9.3

Figure 4-12 shows the 6 different catchments areas established by earlier studies and adapted to indicate the size of a catchment relative to the plant health (AWR, 2021. Appendix I) of the Welwitschia populations. There is a clear indication that healthiest plants occur in the lower reaches of the larger channels, even though they are ephemeral.

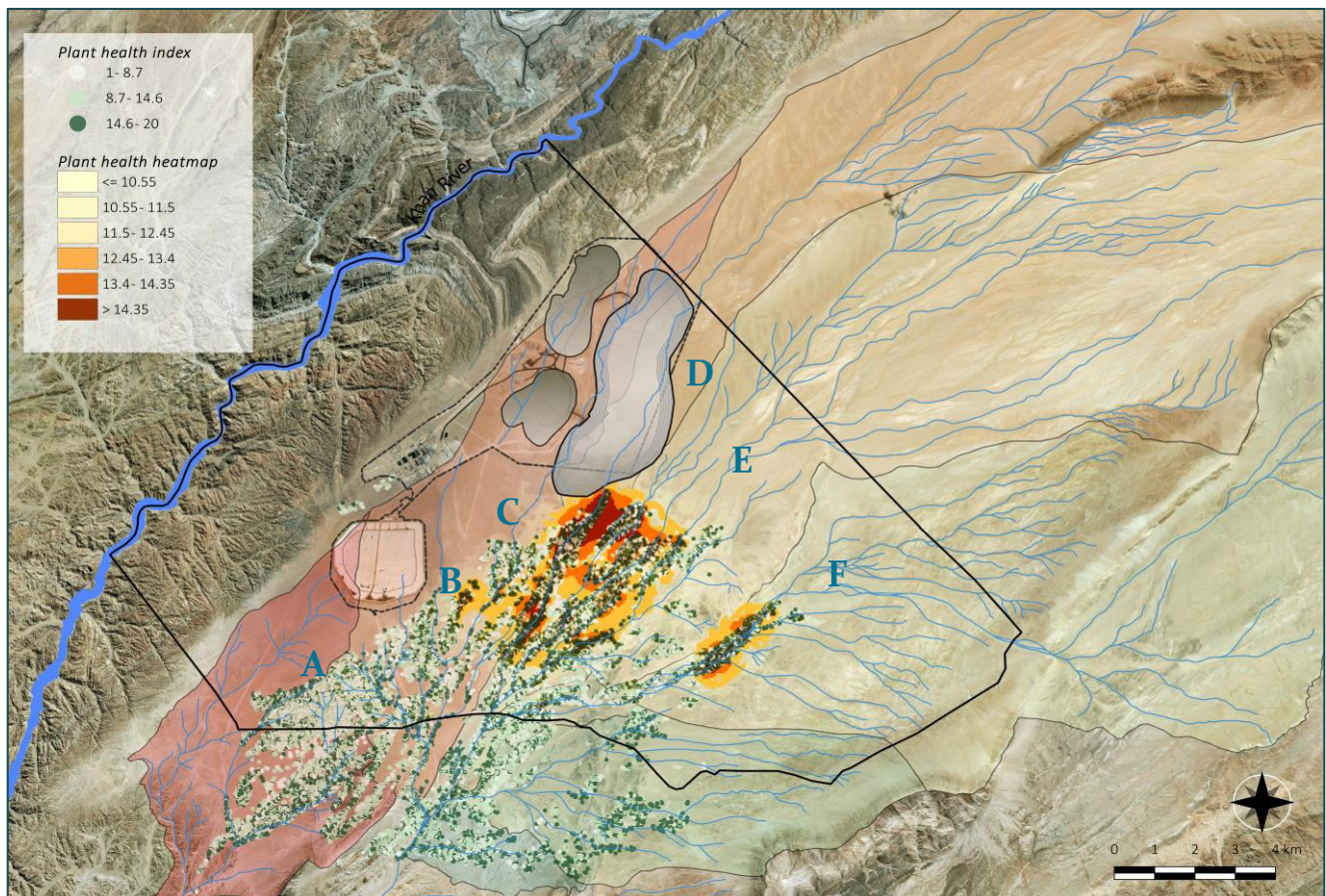


Figure 4-12: A Heat Map of Welwitschia Plant Health Relative to the Size of the Catchments (Adapted from Wassenaar, 2018).

- The healthiest plants are indicated by dark green dots, whilst the darker brown shading indicates the areas of the greatest number of healthy plants. Catchment D contains the Husab channel.

4.7 AIR QUALITY

The information presented in this Section has been sourced from the Air Quality Specialist Report (Appendix F) prepared by Airshed Planning Professionals (2021).

4.7.1 Air Quality Sensitive Receptors

Air quality sensitive receptors (AQSR) primarily refer to places where humans reside, as well as schools and hospitals. Ambient air quality guidelines and standards have been developed to protect human health. Ambient air quality, in contrast to occupational exposure, pertains to areas outside of an industrial site boundary, i.e. outside the Husab Mine fence. The area inside the mine fence is regulated under the Occupational Health and Safety Act.

The closest settlement to the mine is the town of Arandis (15 km, to the north-northwest) and the farms Palmenhorst and Hildenhof more than 13 km to the south-west. Tourist locations include the Big Welwitschia and the Welwitschia Flats campsite between 5 and 8 km to the south and southeast of the mine.

4.7.2 Existing Sources of Air Pollution in the Erongo Region

The identification of existing sources of emissions in the region and the characterisation of existing ambient pollutant concentrations is fundamental to the assessment of the potential for cumulative impacts and synergistic effects given the current mine and processing operations and their associated emissions.

The main sources of air pollution in the region include mining operations, public roads (paved, treated and unpaved), and natural exposed areas prone to wind erosion. In addition, there are also other pollution sources such as small boilers, incinerators, commercial activities, etc. Typical activities in the region and associated pollutants are summarized in Table 4-4.

Table 4-4: Typical activities in the region and associated pollutants

Air Pollution Sources	TSP*	PM10*	PM2.5*	SO ₂ *	NO _x *	CO*	VOCs*
Mining Operations	√	√	√	√	√	√	√
Paved and unpaved roads	√	√	√				
Vehicle tailpipe emissions	√	√	√	√	√	√	√
Wind-blown dust	√	√	√				
Miscellaneous (small boilers, incinerators, etc.)	√	√	√	√	√	√	√

*TSP: Total Suspended Particles, PM: Particulate Matter, SO₂: Sulphur Dioxide, NO_x: Nitrous Oxides, VOCs: Volatile Organic Compounds.

4.7.3 Existing Regional Mining Operations

Fugitive dust sources associated with mining activities include drilling and blasting operations, materials handling activities, crushers, vehicle-entrainment by haul vehicles and wind-blown dust from tailings impoundments and stockpiles. Mining operations represent potentially the most significant sources of fugitive dust emissions (PM_{2.5}, PM₁₀ and TSP) with small amounts of NO_x, CO, SO₂, methane, and carbon dioxide (CO₂) being released during blasting operations and from mine trucks. The sulphuric acid plant at Husab is another potential source of SO₂. Sources from other mining operations in the region, e.g. Rössing, are located too far away to have a significant influence on the air quality at the Husab Project site.

4.7.4 Vehicle Exhaust Emissions

There are several main roads within the Erongo Region. The B2 between Swakopmund and Usakos and between Swakopmund and Walvis Bay; and the road between Swakopmund and Henties Bay (C34) are the busiest roads in the area. Roads within the immediate vicinity of the Husab Mine include the partially paved C28 through the Namib Naukluft National Park (linking Swakopmund and Windhoek) and the D1991. The temporary access road towards the Husab Mine turns northwards of the C28 (Welwitschia Drive) and is now primarily used for maintenance of the permanent water pipeline and booster pump stations and environmental monitoring. Tourists use the de-proclaimed D1914 to visit the Big Welwitschia and welwitschia Field south of the Husab site and there are occasional travellers who access Wurstenquelle farm outside the NNNP to the east.

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere. Secondary pollutants are those formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions.

The significant primary pollutants emitted by vehicles include CO₂, CO, hydrocarbons (HCs), SO₂, NO_x, particulates and lead. Secondary pollutants include nitrogen dioxide (NO₂), photochemical oxidants (e.g. ozone), HCs, sulphuric acid, sulphates, nitric acid and nitrate aerosols. Toxic hydrocarbons emitted include benzene, 1,2-butadiene, aldehydes and polycyclic aromatic hydrocarbons (PAH). Benzene represents an aromatic HC present in petrol, with 85% to 90% of benzene emissions emanating from the exhaust and the remainder from evaporative losses.

4.7.5 Pollutants of Interest

The main pollutant of concern in the Erongo Region is particulate matter (PM). The impact of PM on human health is largely dependent on (i) particle characteristics, particularly particle size and chemical composition, and (ii) the duration, frequency and magnitude of exposure. The potential of particles to be inhaled and deposited in the lung is a function of the particles size, shape and density.

The Erongo Region has set air quality objectives for PM₁₀ and PM_{2.5} as well as dustfall levels. The radionuclide content of the inhalable dust fraction is a concern, especially in areas where people reside such as the towns along the coast and at Arandis.

The PM₁₀ and PM_{2.5} concentrations sampled provide useful information for the radiation assessment, and the collected dust can be analyzed for radionuclide content (See Section 4.8). Aside from ambient dust concentrations, the associated radionuclides posing a potential risk to human health and well-being is radon progeny. For this reason, radon is monitored in the region.

4.7.6 Measured Ambient Air Quality at The Husab Mine

Baseline monitoring commenced in August 2009 with eight (8) single dustfall units and increased to the current 33 single dustfall units. Gravimetric PM₁₀ monitoring (Minivol) commenced in July 2009 at Husab weather station, while the Grimm real time monitor was installed at Marble Ridge in May 2012.

The monitoring network was established as part of the air quality management planning for the operation of the mine, processing plant, and related infrastructure. The network design was based on atmospheric dispersion simulation results of pollutants associated with the operations at the mine. The location of the monitoring network relative to sensitive receptors and mine infrastructure is shown in Figure 4-13.

The identification of existing sources of emission and the characterisation of ambient pollutant concentrations is fundamental to the assessment of the potential for cumulative impacts in the region. Ambient monitoring data (particulates and gases) was obtained from the Husab Mine monitoring campaign for the period 2018 and 2019.

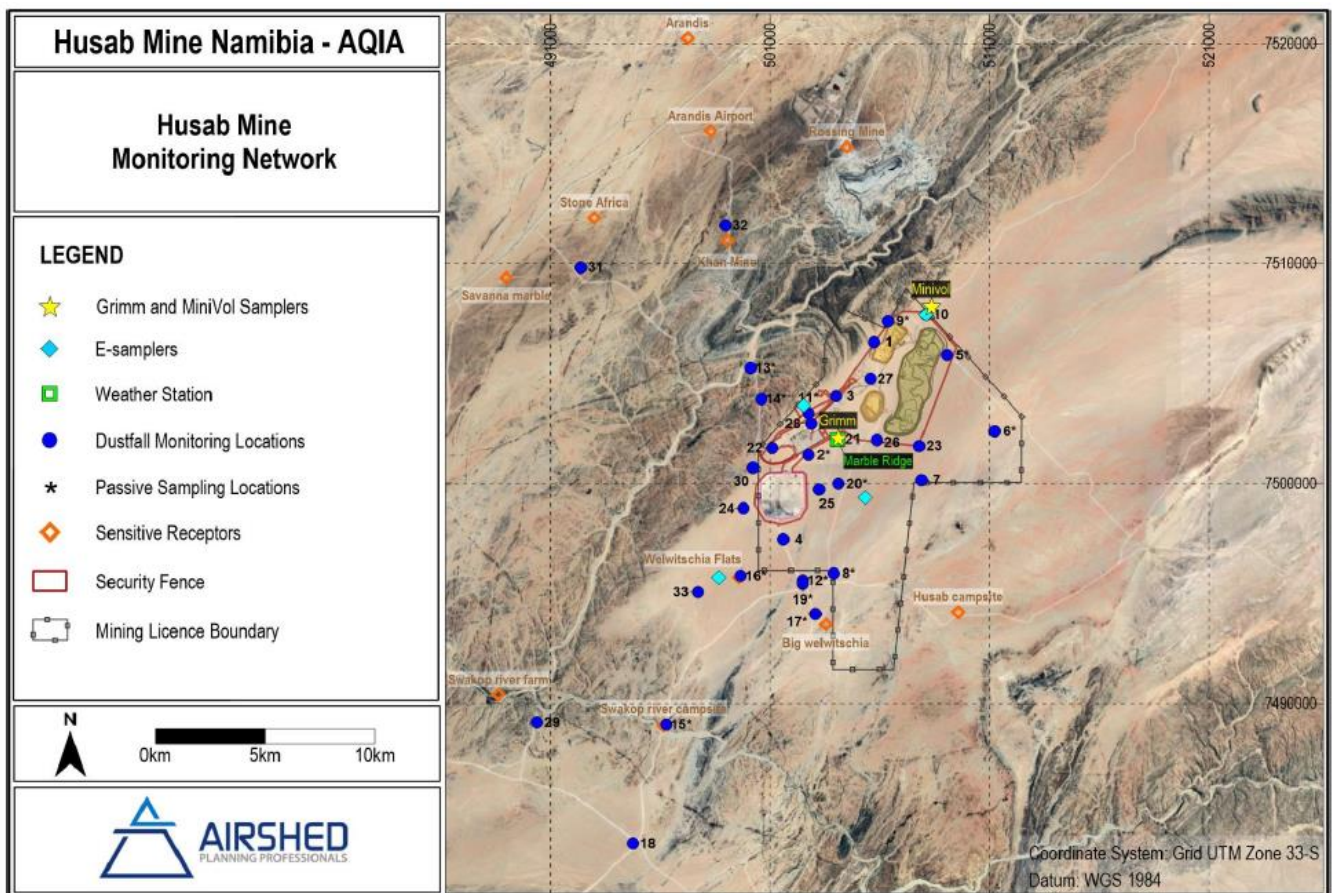


Figure 4-13: Husab Mine Monitoring Network (The E-Samplers were installed in 2020) (Airshed, 2021)

4.7.7 Measured PM₁₀ and PM_{2.5} Concentrations

PM₁₀ concentrations from the Minivol sampler, at the extreme northern end of Pit Zone 1, during the 2014 to 2016 monitoring campaign as well as PM₁₀ and PM_{2.5} concentrations from the Grimm sampler at Husab Mine, south of Pit Zone 2 and east of the processing plant, for the same period are presented in Appendix 7 of the Air Quality Report (Appendix F).

The Minivol samples are taken on a six-daily interval for a 24-hour period, whereas the Grimm sampler takes measurement continuously. As mining has progressed over the past few years, the pits have increased in size and more material is being moved; volumes will continue to increase until the optional mining and rates are reached. The 2018-2019 campaign will therefore record higher concentrations than those of 2014-2016. The poor rainfall in 2019 will also affect PM concentrations.

The adopted PM₁₀ air quality daily guideline (75 µg/m³) for the Husab Mine in 2018 was exceeded for 13 days out of 30 days for which gravimetric sampling results were available (equating to 43% exceedance) (Figure 4-14) and 6 days out of 33 days for which gravimetric sampling results were available (equating to 18% exceedance) in 2019 (Figure 4-15). The highest concentration sampled during 2018 and 2019 was 415 µg/m³ and 127 µg/m³, respectively. The annual average PM₁₀ concentration during 2018 and 2019 was 77 µg/m³ and 47 µg/m³ respectively, exceeding the annual guideline of 30 µg/m³.

Grimm sampler data was available from 2 Aug to 5 Oct 2019 and from 5 to 19 Dec 2019. For PM_{2.5}, the highest concentration recorded was 53.2 µg/m³ (09 Aug 2019) and the lowest concentration was 1.7 µg/m³ (08 Dec 2019). The highest concentration for PM₁₀ of 428 µg/m³ was recorded on 26 Sept while the lowest concentration

of 2.4 was recorded on 08 Dec 2019. The adopted AQO daily average limits were exceeded 3% of the time for PM_{2.5} (37.5 µg/m³) and 53% of the time for PM₁₀ (75 µg/m³). PM₁₀ and PM_{2.5} concentrations from the Grimm sampler are provided in Figure 4-16, in combination with the Minivol PM₁₀ concentrations.

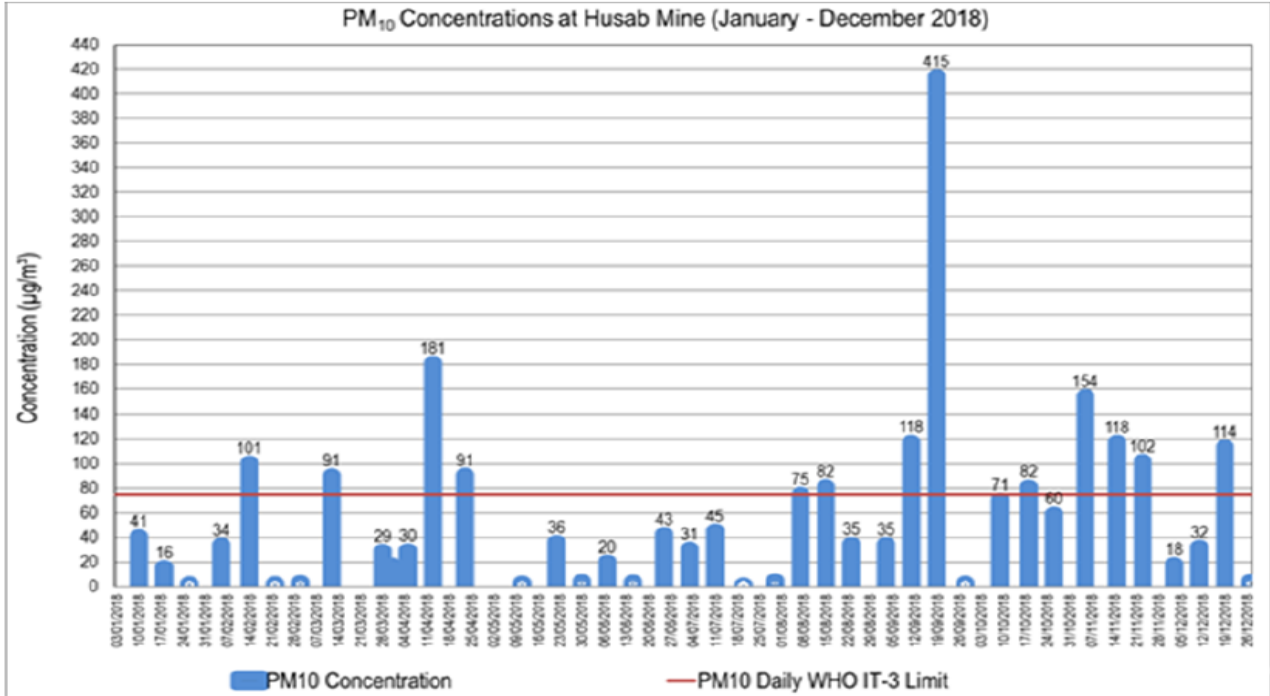


Figure 4-14: PM₁₀ Daily Concentrations from the Gravimetric Monitoring Station (January to December 2018)

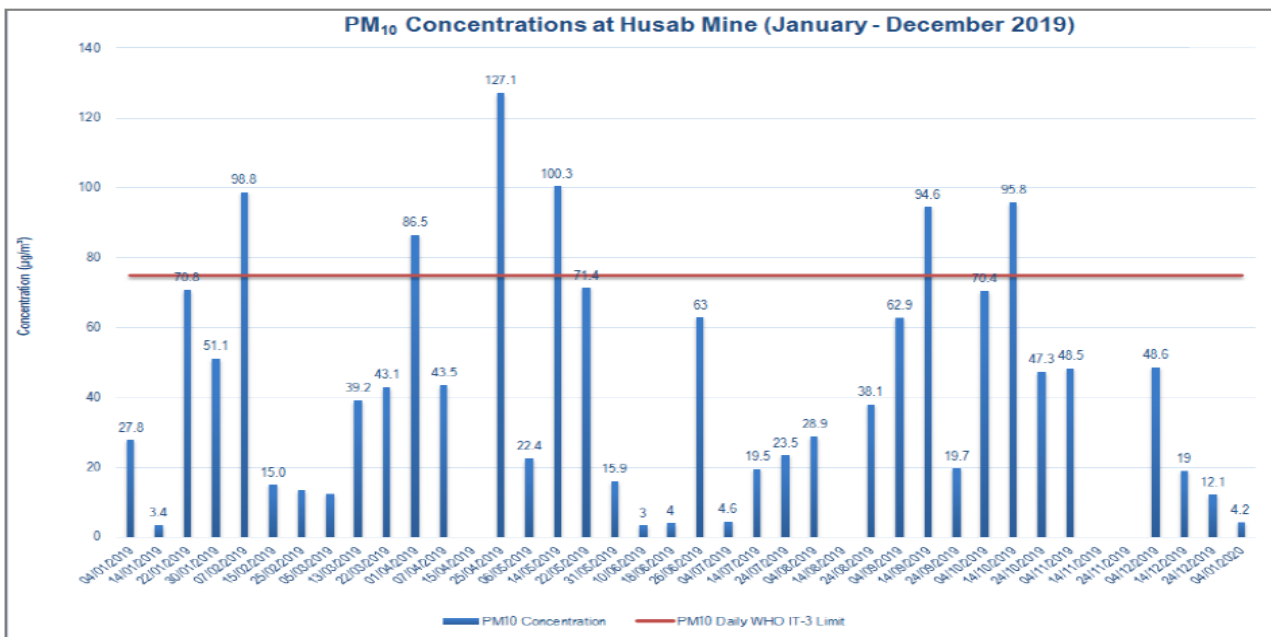


Figure 4-15: PM₁₀ Daily Concentrations from The Gravimetric Monitoring Station (Jan to Dec 2019)

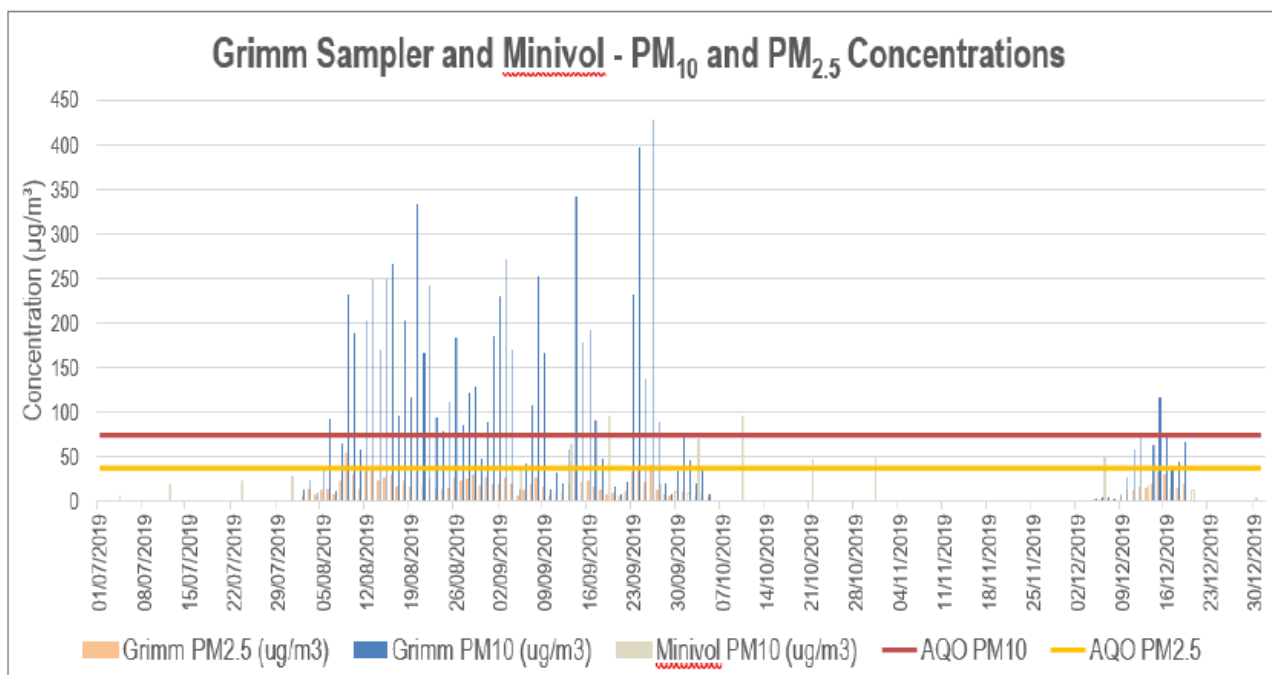


Figure 4-16: Daily PM10 and PM2.5 Data from Grimm Sampler and Minivol (2 Aug to 5 Oct 2019, and 5 to 19 Dec 2019)

4.7.8 Passive Sampling Results

NO_2 and SO_2 concentrations are sampled onto passive samplers and are reported as a concentration per volume ($\mu\text{g}/\text{m}^3$). Passive sampling was carried out for the period 8 July to 8 August 2019 (for NO_2 , SO_2 and VOCs) lasting four weeks. Passive sampling results for NO_2 , SO_2 and VOCs are presented in Table 4-5.

All pollutant concentrations were very low with NO_2 the only pollutant exceeding the annual AQO at eight sampling locations (EXT 02A, EXT 03A, EXT 09A, EXT 11, EXT20, EXT 21, EXT 22, and EXT 28), all which are located near the open pits and haul roads indicating the potential for on-site exceedances. SO_2 concentrations were low, and VOC results extremely low, and both maintained consistent concentrations below the detection limit across the sampling locations.

Table 4-5: Annual Average Extrapolated NO₂, SO₂ and Vocs Passive Sampling Results (Mg/M³) Based on the Sampling Campaign of 8 July to 8 August 2019 (Airshed, 2021)

Pollutant	Passive sampling results at various locations – 8 July to 8 August 2019									
	Limit	2A	3A	5	8	9A	10	11	12	13
NO ₂	40	68	52	23	8	41	33	55	13	19
SO ₂	50	32	53	2	15	1	15	4	4	1
VOC (Benzene)	5	0.7	0.7	1.4	0.7	0.7	0.7	0.7	0.7	0.7
VOC (Toluene)	20.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
VOC (Ethyl Benzene)	83.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
VOC (Xylene)	11.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Pollutant	Limit	14	15	16	17	19	20	21	22	28
NO ₂	40	38	17	22	8	12	43	45	41	54
SO ₂	50	2	28	13	3	1	8	3	2	3
VOC (Benzene)	5	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
VOC (Toluene)	20.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
VOC (Ethyl Benzene)	83.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
VOC (Xylene)	11.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Exceedance of standard/guideline indicated in **bold** (based on extrapolation of results)

4.7.9 Dustfall monitoring

The dustfall network at Husab is divided into two groups. Internal mine operations monitoring sites and the external third-party monitoring stations which are located on the mining license perimeter and beyond at the air quality sensitive receptors (Figure 4-13).

Dustfall deposition rates from the Husab Mine monitoring campaign for 2018 and 2019 are presented in Figure 4-17 and Figure 4-18 respectively. Dustfall rates are generally low for the sampling period and well within the acceptable dustfall rates of 600 mg/m²/day (adopted limit for residential areas) and 1 200 mg/m²/day (adopted limit for non-residential areas). The low dustfall rates show slight spatial and temporal variation across the site, with all the exceedance described below as being those of dustfall sites close to mining operations.

During the 2018 campaign (Figure 4-17), EXT 01 (April), EXT 27 (January, March, May, July and December) and EXT 28 (September, November and December) exceeded the 600 mg/m²/day limit but complied with the 1 200 mg/m²/day limit; while EXT 27 (February, April, August, September, October and November) exceeded the 1 200 mg/m²/day limit for non-residential areas).

EXT 28 is located near the secondary crusher and mill and the conveyor from the primary crusher, while EXT 27 is located next to the main haul road between Pit Zone 1 and the ore stockpile (see Figure 14). The relatively high rates at EXT 27 were likely a result of vehicle entrained dust from the busy haul road.

During the 2019 campaign (Figure 4-18), Ext 27 exceeded the 1 200 mg/m²/day limit for all the months except January, August and December 2019, with EXT 28 only exceeding the 1 200 mg/m²/day limit in March 2019. Dustfall rates, on average, decreased at all the locations when compared to 2018, except for Ext 27 and EXT28 which showed an increase.

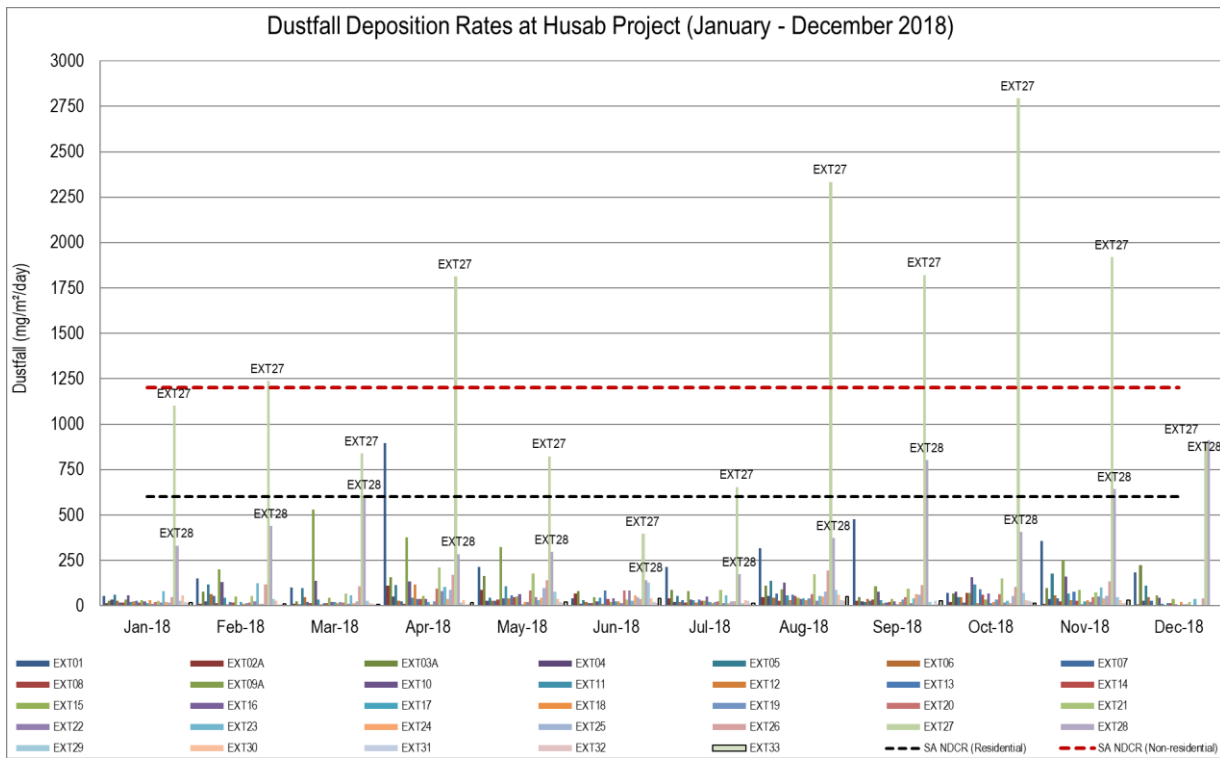


Figure 4-17: Monthly dustfall deposition rate per sampling location during 2018

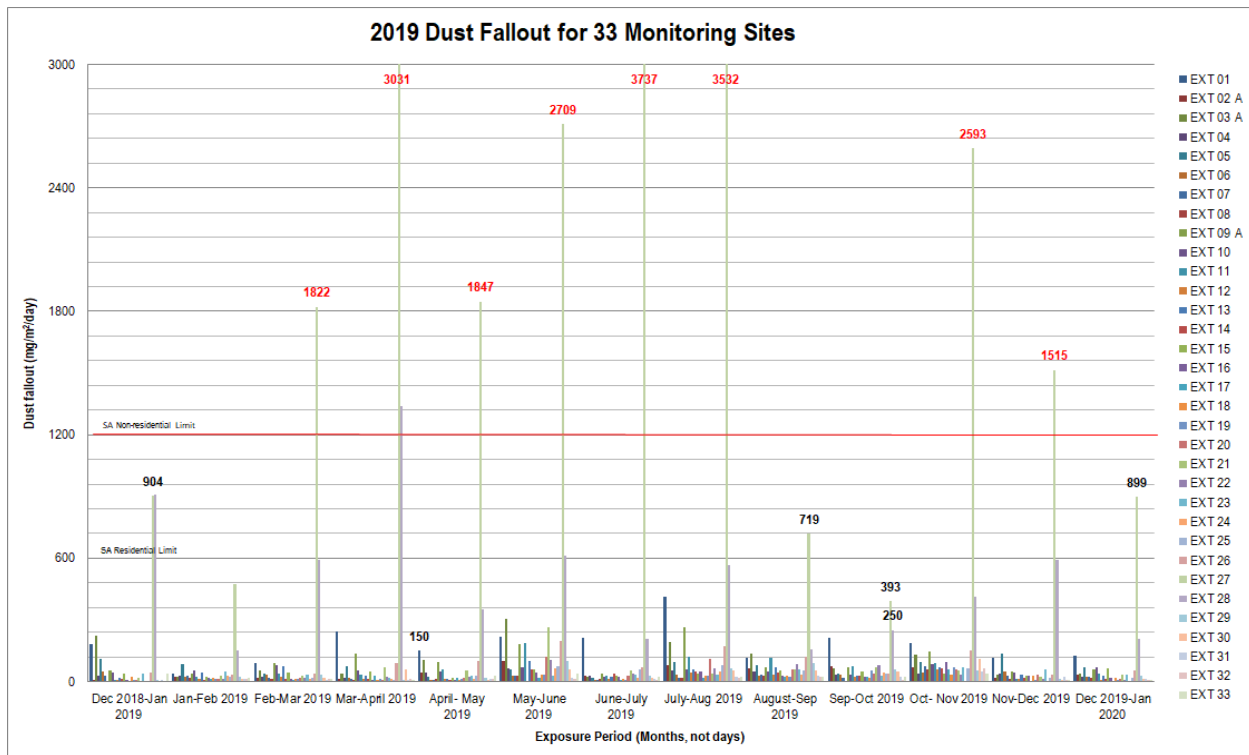


Figure 4-18: Monthly dustfall deposition rate per sampling location during 2019

4.8 RADIOLOGICAL BASELINE

A Radiological Impact Assessment for the Husab Mine Heap Leach Project was undertaken by radiation specialist, Dr Detlof von Oertzen (May 2021) (Appendix J). Natural sources of background radiation are explained and the radiological baseline for the Erongo region is provided in this section. The Radiation assessment is guided by the requirements of Namibia's Atomic Energy and Radiation Protection Act, Act No. 5 of 2005 [Act, 2005] and the Regulations under the Act, i.e. the Radiation Protection and Waste Disposal Regulations, No. 221 of 2011 [Regulations, 2011].

Humans have evolved in the permanent presence of ionising radiation from natural sources, including from radioactive terrestrial sources, cosmic radiation as well as radionuclides in the air, water and food. In addition to the various natural sources of ionising radiation, a variety of man-made sources have found their way into the environment and today form part of the perpetual sea of background radiation in the environment.

Natural background radiation (NBR) occurs because of the existence of various natural radiation sources that emit ionising radiation. Amongst others, natural sources of ionising radiation include soils, rocks, and groundwater. Radiation emitted from such sources is called terrestrial radiation. Elements such as uranium, thorium and potassium are naturally occurring radioactive elements.

Other natural radiation originates from atmospheric radioactive dust, which can be inhaled and/or ingested, as well as from radioactive gases such as radon and associated decay products. In addition, radiation from man-made sources, such as X-ray machines, X-ray fluorescence devices, sealed radioactive sources, radionuclides in equipment and medicines, cigarette smoke and other sources all contribute to the total exposure of a person and the environment to radiation.

Table 4-6: Natural background radiation contributors and their associated exposure doses summarises the main exposure contributions from the various natural sources contributing to the natural background radiation in the Erongo region (Von Oertzen, 2010).

Table 4-6: Natural background radiation contributors and their associated exposure doses

Source of Ionising Radiation	World Average Exposure Doses due to NBR [mSv.a ⁻¹]	NBR Exposure Doses in the Erongo Region [mSv.a ⁻¹]
Terrestrial	0.48	0.55
Cosmic	0.38	0.35
Radon	1.1	0.5
Atmospheric dust	0.006	0.04
Food	0.31	0.31
Total Annual Exposure Dose	2.3 mSv.a⁻¹	~ 1.7 mSv.a⁻¹

Certain mining operations, including those undertaken by Swakop Uranium at the Husab Mine, contribute to natural radiation to which humans are exposed. In most cases in which radioactive mineral ores are mined, these are crushed, milled, and concentrated, all of which adds to radiation exposures of persons at, or nearby, mining, milling, and processing activities. In addition, rock stockpiles, waste rock dumps, tailings and process facilities expose radioactive ore to the environment, which leads to an increase of atmospheric radon and thoron exhalations as well as the concentration of inhalable radioactive dust into the atmosphere. It may also contribute to the transport of radionuclides into groundwater by leaching from rocks, soil and radioactively contaminated surfaces exposed to the wind and rain.

Atmospheric Radon and its Progeny

Radon is a member of the uranium decay chain and is exhaled from minerals that contain enhanced levels of Radium-226. The mineral ores that are mined at Husab, the mining pits, on-site ore stockpiles, waste rock dumps and post-processing mineral waste all contain Radium-226 and therefore all exhale radon gas which is then readily mixed into the air that is inhaled by persons both on- and off-site.

Swakop Uranium monitors ambient radon concentrations at various on-site locations as part of its public exposure monitoring activities which are a regulatory requirement under Namibia’s Atomic Energy and Radiation Protection Act [Act, 2005] and the regulations under this Act [Regulations, 2012].

For the 2020 reporting period, atmospheric radon concentrations were monitored at the following receptor sites.

- Welwitschia campsite – to monitor exposure at nearest tourist campsite to the mine;
- Main Security Access – to monitor exposure at the mine’s perimeter;
- B2 Security Checkpoint – to monitor exposure at the turn-off from the B2 highway to the mine site; and
- Husab Contractors Camp – to monitor contractors residing onsite in the camp.

Monitoring was typically undertaken 2 or 3 times during the reporting period, each over a 4-day period, as per SU’s public radiation monitoring plan. The radon-related public exposure doses as summarised in Table 4-7 were reported, based on an extrapolated exposure period of 8,760 hours per year [SU, 2020].

Table 4-7: Average Annual Public Radon Exposure Doses at Select Receptor Locations*

Public receptor Location	Average Annual Public Radon Exposure Dose [μ Sv/a]
Welwitschia Campsite	520
Main Security Access	710
B2 Security Checkpoint	630
Husab Contractors Camp	810

**Note: these doses include the natural background contributions, based on a full year of occupancy.*

Sensitive Receptors

Receptors are the members of critical groups that are expected to receive the largest relevant exposure dose from radiation considering a specific pathway in a specific location. Critical groups (or representative persons) are those that are most at risk of being exposed to a specific exposure pathway and a number of these exist in close proximity to SU’s Husab Mine, including the permanent and temporary settlements around the Husab Mine site where public receptors may spend time. The sensitive or public receptors of potential radiological impacts from Husab’s mining operations include same receptors indicated in both the Air Quality (Figure 4-13) and the Visual (Figure 4-19) reports.

4.9 VISUAL

The information presented in this section has been sourced from the Visual Impact Assessment Report (Green Tree Environmental Consulting, 2021). The extent of the study is limited to the potential zone of influence, which in this case is a radius of 15 km around the project site, as beyond this the heap leach and infrastructure would recede into background views or be screened by topography and other infrastructure (Figure 4-19).

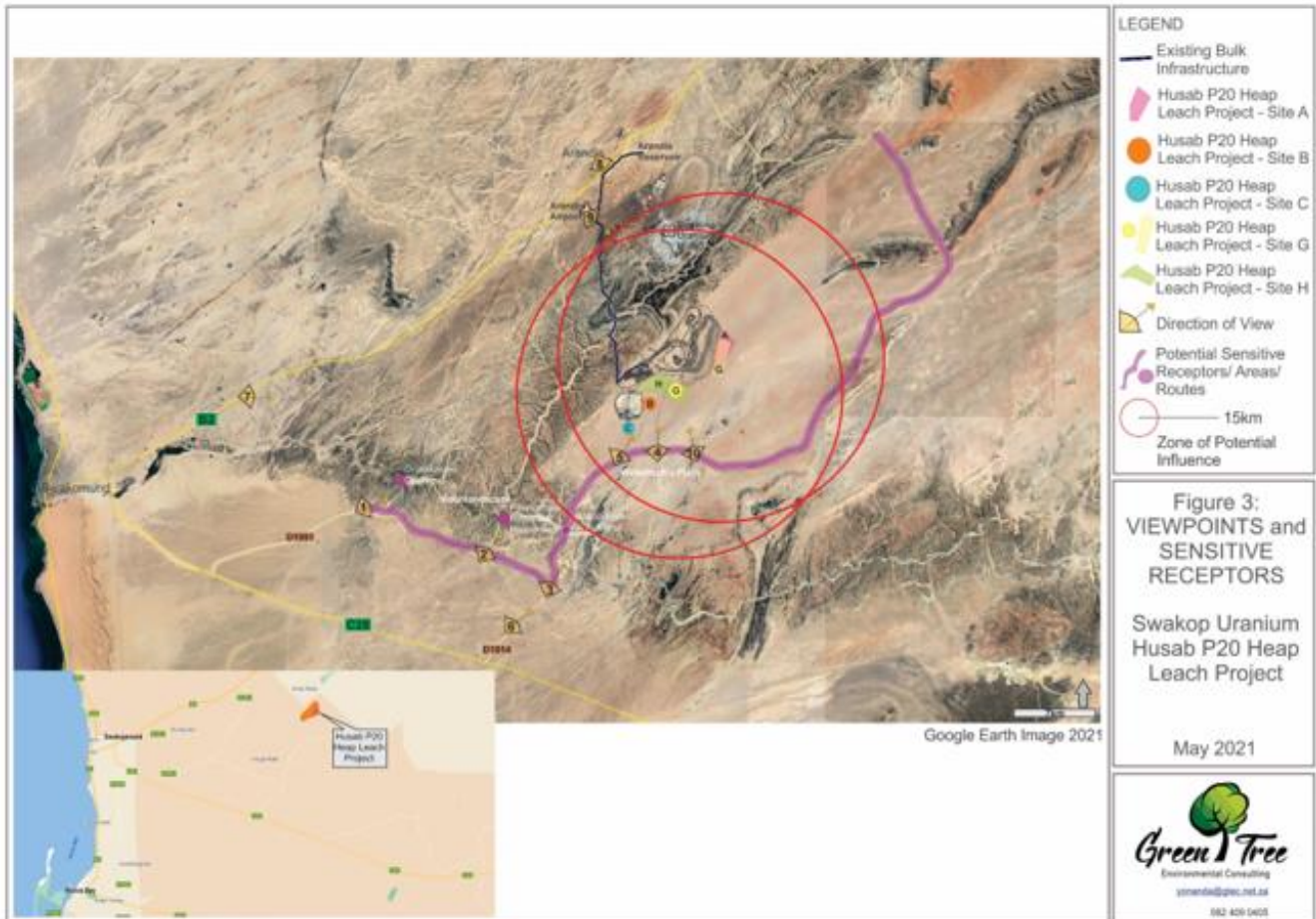


Figure 4-19: Visual Assessment Viewpoints and Sensitive Receptors.

4.9.1 Landscape Character

The Husab Mine is located in the northern part of the Namib Naukluft National Park and about 60 km inland from the coastal town of Swakopmund. The area is bounded by two major ephemeral watercourses, the Khan River north of the site, and the Swakop River located to the south. Between these two rivers the landscape has a slightly rolling topography that slopes toward the Swakop River. Both the Khan and Swakop River have been eroded into deep and mountainous valleys.

The project area falls within the Namib desert biome and vegetation cover is sparse, mainly perennial grasses, on the open gravel plains. A large section of the study area hosts the world-famous Welwitschia fields (see Section 4.6). The rocky limestone and granite outcrops have a higher diversity of plants and trees are mostly confined to the river valleys.

4.9.2 Land Use

The land use immediately outside of the Husab mine fence is a wildlife reserve and is part of the Namib Naukluft National Park. A campsite and the Big Welwitschia, a major tourist attraction, are located about 5 km south of the tailings storage facility, and a second campsite adjacent to the D1914 and the Swakop River. The Husab Mine footprint has been contained, to date, in the northern section of the Mining Licence area.

Within the potential zone of influence, and north of the Khan River other land uses include mining and quarrying with associated powerlines and access roads: the Rössing Uranium Mine, a limestone quarry, and the ruins of the old Khan Mine.

Arandis town is about 15 km north-northwest of Husab and small farm holdings are located near, and downstream of the confluence of the Swakop and Khan Rivers more than 12 km away.

Tourism is the main activity in the area to the south and southwest of the mine site. Tourist attractions in this area includes the Big Welwitschia, the Welwitschia Plain, the “Moonlandscape” and the camping sites. The D1991 and D1914 gravel roads used by tourists are highlighted in purple on Figure 4-19. Two panoramas of the existing Husab site are provided in Figure 4-20. View 10 below is taken from the Welwitschia Plain looking northwards toward the mine, and View 2 is from the tourist road D1991 viewpoint that overlooks the Moonlandscape north-eastwards toward the mine.



Figure 4-20: Top photograph is from View 10 on the Welwitschia Plain, about 7 km south of the mine. The bottom photograph is from View 2 looking north-eastwards across the Moon Landscape to the Husab Mine

4.9.3 Visual Resource Value / Scenic Quality

The scenic quality of the project area is primarily derived from the natural components of the Namib Naukluft National Park, vast open stretches of desert with mountains, ridges, valleys, and clusters of vegetation. This natural landscape has been compromised by the existing Husab Mine and associated activities and infrastructure, as well as the activities associated with the Rössing Uranium Mine.

Although the natural landscape has been compromised by the intrusion of mining related activities, it is still considered to be an area that exhibits a positive character which is valued.

4.9.4 Sense of Place

The sense of place is typically derived from the combination of all landscape types and their impact on the senses. The sense of place of the project area is described as natural/pastoral sense of place which is only compromised once the viewer/receptor is located close to the Husab Mine and associated activities and infrastructure.

4.9.5 Sensitive Receptors

The sensitivity of the visual receptors/ viewers is determined by looking at the susceptibility of the visual receptors to the change that the proposed project will bring to their views.

Sensitive receptors have been identified as follows:

- Resident staying on the farms – (Figure 4-19) Hildenhof, Plamenhorst and Goanikontes (High sensitivity, nearby farms);
- Tourists using the D1991 and D1914 gravel roads and visiting the various tourist attractions such as the Moonlandscape, Big Welwitschia, Welwitschia Plain and camping sites (High sensitivity, to the south of the Husab Mine); and
- Erongo residents or mine personnel who travel through the project area (Moderate sensitivity).

The visual study is provided in Appendix K.

4.10 ARCHAEOLOGY/HERITAGE

Several archaeological studies have been conducted for the Husab Mine and its associated Linear Infrastructure over the past 12 years, beginning with a study commissioned by the exploration drilling team in 2009. The area has thus been well studied and heritage sites of significance surveyed and documented, for example, the Welwitsch siding and Khan Mine valley. The Welwitsch siding and remnant of the rail embankment on the west of the site have been protected from disturbance by physical barriers. Known archaeological sites in the Husab Mine area are shown on the updated sensitivities plan (Figure 4-21).

Dr John Kinahan undertook an Archaeological Assessment desktop study for the proposed Heap Leach project to assess the possible impact of the proposed heap leach circuit on sites and/or materials protected under the National Heritage Act (27 of 2004) (Appendix L).

4.11 SOCIO-ECONOMICS

No specialist socio-economic study was undertaken for the EIA Amendment for proposed heap leach project and retention of the construction water pipeline.

Operation of the heap leach circuit is expected to require 246 permanent employees. The LOM will reduce by about 4 years with the concurrent processing of the low-grade ore with the existing processing plant.

4.12 UPDATED HUSAB MINE SITE SENSITIVITIES PLAN

Information from the specialist studies, past plans and monitoring reports have been collated onto an Updated Sensitivities plan which is shown in Figure 4-10 and Figure 4-21. This plan was provided to the Swakop Uranium technical team and alterations were subsequently made to the position of the HLF and the shape of the HLWF, Option K.

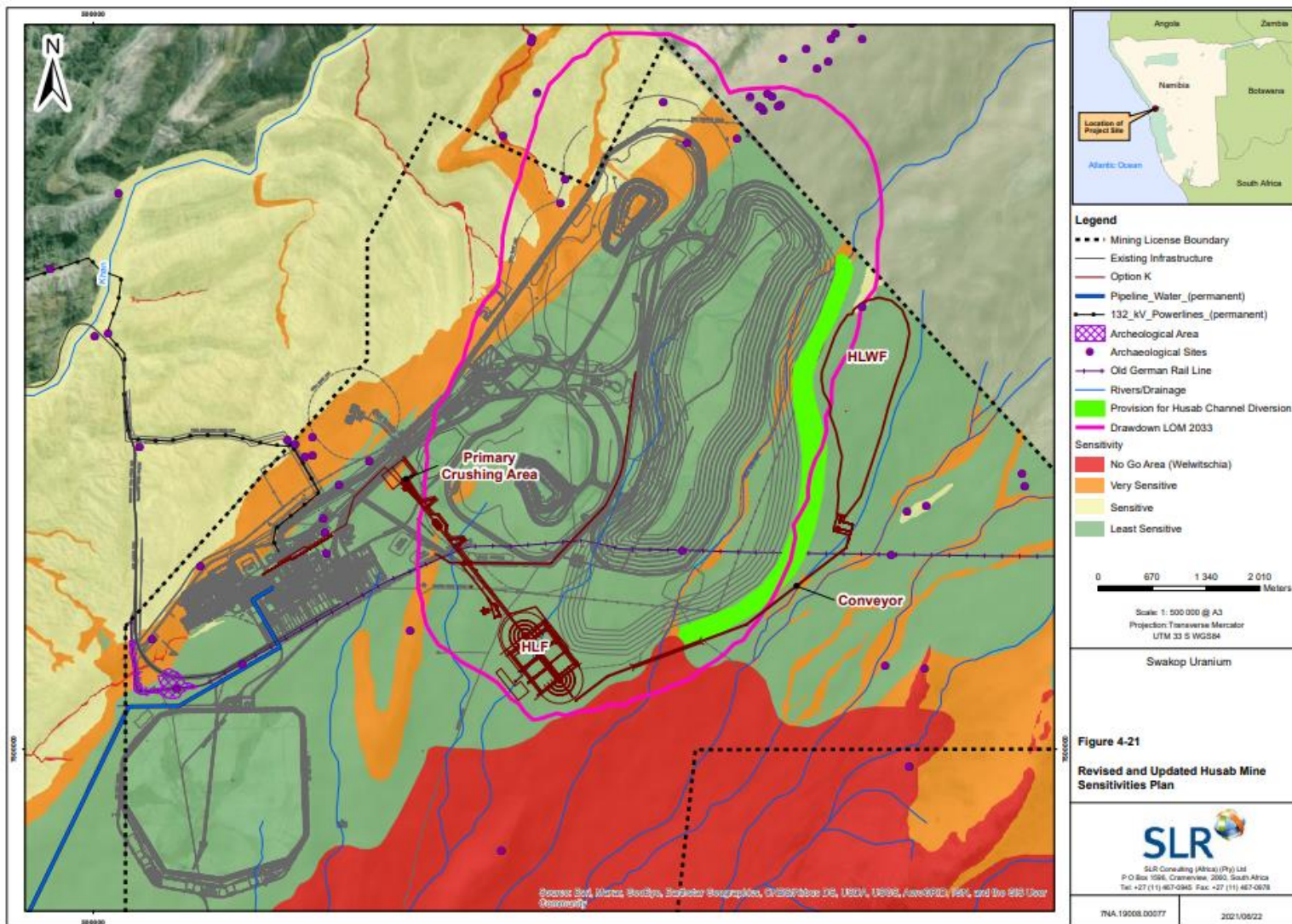


Figure 4-21: Revised and Updated Husab Mine Sensitivity Plan

5. PROJECT DESCRIPTION

This section provides a description of the construction temporary water pipeline and the construction and operation of the proposed heap leach facility and its related infrastructure.

5.1 SECTION ONE: RETENTION OF EXISTING CONSTRUCTION TEMPORARY WATER PIPELINE

Swakop Uranium wishes to retain the temporary water pipeline that was used during the Husab Mine construction phase until the permanent water supply was commissioned in 2016. The proposed heap leach process requires an additional 1,9Mm³ water per annum, and, although this amount can be supplied by the permanent water pipeline, Swakop Uranium wishes to retain the temporary line as a permanent contingency supply option.

Information in this section was obtained from the following sources:

- Environmental Impact Assessment Report for the Husab Mine Linear Infrastructure prepared for Swakop Uranium (Pty) Ltd (Metago, April 2011);
- Scoping Report (including impact assessment) for the Proposed Upgrade of the Track through the Khan Mine Gorge and across the Khan River for the Temporary Transport of Personnel to the Husab Project Site prepared for Swakop Uranium (Pty) Ltd (SLR, December 2012);
- Visual Impact Assessment for the Husab Heap Leach Project (Green Tree Environmental Consulting, May 2021);
- Biodiversity Impact Assessment Report for the Proposed Husab Mine Heap Leach Facility (African Wilderness Restoration, May 2021);
- Archaeological assessment of linear infrastructure for the Husab Project. John Kinahan; QRS 131. Commissioned by Metago, South Africa (2010); and
- Discussions with the Swakop Uranium Projects Technical Team and the Environmental Department.

5.1.1 Overview and pipeline description

The temporary overland water pipeline, required to supply water to the Husab mine during the construction phase, was approved as part of the Husab Mine's linear infrastructure EIA (Metago, 2011). The pipeline starts at NamWater's Central Namib reservoir (commonly referred to as the Rössing reservoir) and runs southwards through the Khan Mine valley, across the Khan River and then parallel to the tarred access road leading up to the Husab Mine (Figure 5-1). The pipe was purchased from the Trekoppie Mine that had also used it for a temporary water supply for 14 years until the desalination plant was commissioned.

The 25 cm diameter HPDE and steel piping lies adjacent to the gravel track that winds through Khan Mine valley and alongside the permanent access road. The pipeline is buried where secondary tracks join the main gravel road, and it has been buried next to a rock gabion in the Khan River bed to protect it from floods. The route has numerous bends, and the pipeline structure has been strengthened by hammering metal rods into the ground to stabilize the pipes. Safety signs were erected along the route warning people of the high-pressure pipeline (Figure 5-2).

Permission to lay the pipeline over various EPLs held along the route was obtained from Rössing Uranium Limited and the former holders of the Khan Mine, Ohlthaver and List. There are now several small Mining Licenses held by Khan Mine (Pty) Ltd along a section of the pipeline route. Khan Mine is alleged to start reprocessing of the tailings that remain in the vicinity of the old mine.

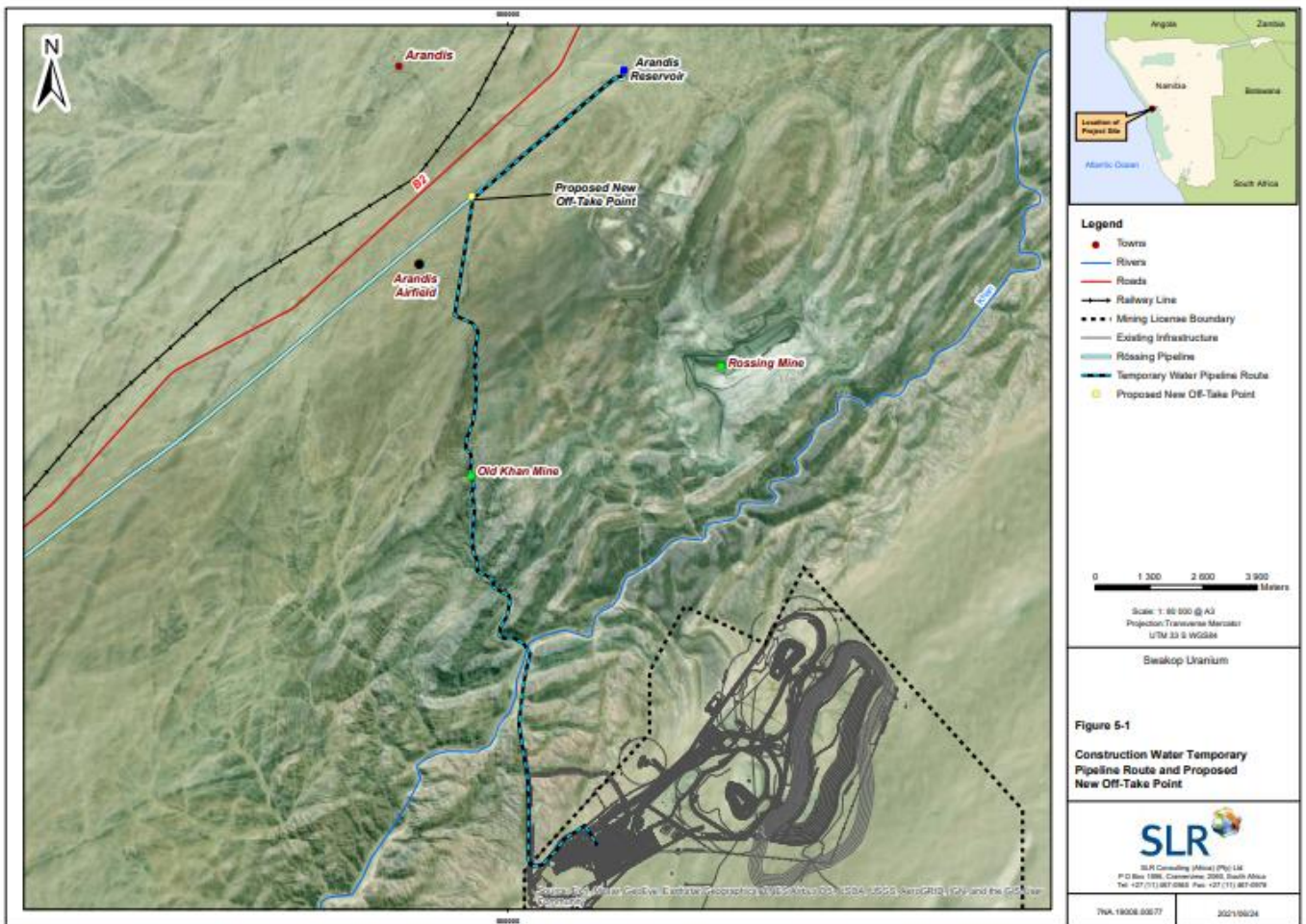


Figure 5-1: Construction water temporary pipeline route and proposed new off-take point.

The temporary water pipeline infrastructure was installed in 2013 was used until 2016. NamWater has borrowed 3,5 km of the pipe, and a section has been dismantled on the Husab site. Recent earthworks activity in the vicinity of the old Khan Mine has resulted in a section of the pipe being covered with rubble.

The pipeline was to have been removed following the commissioning of the permanent water supply line, as per the conditions in the Husab Mine EMP. Swakop Uranium now wishes for this pipeline to remain as a contingency supply for the 20-year LOM of the proposed heap leach facility.

5.1.2 Environmental Baseline and Potential Impact Summary

The environmental baseline for the Khan Mine valley, the Khan River crossing and the Paddeklip Valley up which the access road runs to the mine site were assessed during the Linear Infrastructure EIA in 2011 and the Khan Mine Road was reviewed again in December 2012 and April 2013 for the temporary transportation of personnel and construction materials for the Khan Bridge and 132 kV power line.

Potential impacts that were identified in 2011-2013 were premised on the fact that the pipeline and any movement of mine construction related traffic through the valley was to be temporary. The retention of the pipeline, and repair and maintenance activities still have the potential to impact on the heritage of the area, tourism, biodiversity, visual aspects and third-party safety.



Figure 5-2: Photographs of The Pipeline Along The Khan Mine Valley Route – 2014.

Biodiversity

The Khan River and its tributaries are important corridors for the movement of animals, particularly large ungulates such as zebra and kudu. Several protected *Faidherbia albida* and old *Vachellia erioloba* trees are found in the valleys. The pipeline lying directly on the surface of the ground restricts the movement of smaller mammals, reptiles, arachnids and insects. Water leaks, however, provide a source of water for animals and can lead to the local growth of vegetation (both invasive and native). The smell of water attracts some animals, and baboons have been observed trying to get water from the pipe (Pers. Comm. Env. Dept).

Heritage

Several archaeological and heritage sites are found along the pipeline route, mainly in the vicinity of the old Khan Mine and include remnant railway embankments, old mine houses, mine buildings and artifacts of past mining activity, including historic tailings residue. There are also two known cemetery sites downstream of the Khan Mine that are susceptible to erosion. There are also caves and springs along its route.

The physical pipeline can affect the direction of surface water flow during heavy rainfall events and could create localised erosion of sensitive features should the pipe burst.

The heavy rainfall event of June 2016 has highlighted how erosive flash floods in the narrow tributaries to the Khan River can be (Section 4.1.2 and 4.4). Should such an event occur over the Khan Mine valley, the resultant flood will impact the pipeline and potentially wash sections away. In reverse, the pipeline may prevent natural flow and cause altered flows to erode other sensitive features in the valley.

Tourism and visual

The Khan Mine valley and the historic Kahn Mine buildings have tourism potential, although Coastal Tourism Association of Namibia (CTAN) is not aware of any local tour companies currently visiting the site (CTAN, Focus meeting). It was considered in the early 2020's as a possible site for a mining heritage museum.

The pipeline runs parallel to most of the road and is clearly visible, thus impacting on the sense of place and the tourism experience.

Third party issues

Potential risks to third party users of the Khan Mine Road are the injuries that could be caused by the pressured pipe bursting if accidentally impacted or caused when inadvertent contact is made with the ends of the numerous metal rods holding the pipes steady.

The possible activities of the Khan Mine (Pty) Ltd related to reprocessing of the tailings could pose a risk to the pipeline in its current position in the mine area.

5.1.3 Pipeline upgrade and maintenance steps

Rössing Uranium and the new owner(s) of the Khan Mine (Pty) Ltd must be approached by Swakop Uranium to secure written permission to retain the pipeline over their EPL and Mining license respectively.

Should the Khan Mine wish for the pipeline to be moved to provide space for activities related to the reworking of the old tailings, Swakop Uranium must undertake a further scoping and route selection study for that section of the pipeline.

Additional water supply for the pipeline must be negotiated with both NamWater and Rössing. Sufficient capacity exists at the desalination plant for increased industrial activity in the region (Orano and NamWater Focus Meetings, Appendix D).

Rössing has recently refurbished their main water supply line and Swakop Uranium is now required to tie into this pipeline downstream of the Rössing reservoir at Point A (Figure 5-1) as shown on the satellite image below. An off-take point therefore must be constructed, and a very short section of pipe laid to join into the existing pipeline.

The 4,5 km pipeline running north-east of this off-take point must be removed and the corridor rehabilitated as per the requirements of the Husab Mine EMP.

The entire pipeline will have to be inspected for damaged pipe, loose couplings and worn seals and these must then be repaired prior to pressure testing.

The Husab Mine EMP commitments for the operation and maintenance of the pipeline must be followed.

5.1.4 Alternatives to the Pipeline

Alternative 1: Retention of the temporary construction water pipeline

The temporary water pipeline was constructed in 2013, used until 2016, and has remained in place for 7 years. Upgrades, maintenance and refurbishment of the line as a contingency supply for the Husab Mine proposed heap leach project is the option that is being addressed in this Scoping Report.

Alternative 2: The No-Go Option

If the proposed retention of this pipeline is not supported by the MEFT, the Swakop Uranium will have to remove the pipeline in its entirety and rehabilitate as per the current commitments in the Husab Mine EMP.

Swakop Uranium's permanent water pipeline capacity can provide the necessary water required for operation of the heap leach facility. However, Swakop Uranium will have to consider additional water storage capacity on site as a contingency supply.

5.2 SECTION TWO – PROPOSED HEAP LEACH PROJECT

Swakop Uranium (SU) is investigating the feasibility of utilising their low-grade run-of-mine (ROM) ore at the Husab Mine, in order to extract the available uranium through a heap leach process. The low-grade material cannot be treated as cost effectively (economically) through the current plant processes, the called the tank leach facility (TLF). Heap leaching provides the opportunity for expanded leaching capacity, without the need for additional milling and solid/liquid separation as is required for processing via the TLF. This section provides information of the heap leach process and its associated infrastructure.

Information for this section was obtained from the following sources:

- Discussions during an onsite meeting and site visit by SLR with the Swakop Uranium Technical Team on the 10th of February 2020.
- Pre-Feasibility Study Report for the Heap Leach Project, prepared by SGS Time Mining (Pty) Ltd (SGS) in 2017.
- Heap Leached Waste Facility Pre-Feasibility Design Report, prepared by Golder Associates for the SGS Time Mining Pre-Feasibility Study Report (2017).
- Husab Heap Leach Project, Process Description (2017). Report No. M7556-P610-001. Prepared by SGS Time Mining (Pty) Ltd.
- Further information provided by Swakop Uranium through e-mail correspondence, various telephonic discussions between SLR and the Swakop Uranium Technical Team.
- 2021. P20 Heap Leach Project Feasibility Study Report, prepared by SGS Time Mining (Pty) Ltd, M7556-0760-001REV A 18/3/2021.
- The Draft Internal Environmental Screening report, prepared by SLR in 2020.

5.2.1 Heap Leach Project Overview

SGS Time Mining (Pty) Ltd (SGS) was appointed in 2017 to do the pre-feasibility design of the proposed HLF, heap leach waste facility (HLWF) and associated infrastructure. Golder Associates were appointed by SGS in 2017 to do the civil engineering design of the HLWF and a desktop study of the geochemical analysis of the heap leached waste.

SGS Bateman (Pty) Ltd (SGS) was then appointed to complete a feasibility study (DFS) based on the results of scaled up tall column test work undertaken in-house by SU, which was to confirm the findings of the pre-feasibility study (PFS) test work done by SGS in 2017, and to further optimise the heap leach process.

The feasibility study HLF design is based on a dynamic heap leach circuit, with a dedicated residue waste storage facility, and associated civil, electrical, and surface water management infrastructure. The heap leach facility has been designed to contain all liquid effluent to mitigate potential environmental risks.

Low-grade material mining estimates, for Zone 1 and Zone 2 pits, indicates that approximately 180 Mt low-grade material between 100 and 400 ppm U₃O₈ is available for heap leaching. The HLF capacity was fixed at 7.5 Mtpa.

The DFS study indicated that the HLF could potentially reduce current and LOM processing costs, and that the proposed HLF facility design will be able to produce to produce approximately 52 million pounds (23 260 Mt) of U₃O₈ over a twenty-year life of mine (LOM) at an average recovery of 76% from the HLF, operating at 7,5Mtpa.

The DFS study made recommendations for additional work to cover the interface with the existing TLF to ensure sufficient back end (IX and SX and ADU), reagent (sulphuric acid) and utilities (water and power) capacity is available to support the HLF. In addition, the option for co-disposal of the heap leach waste within the existing tailings storage facility has not yet been explored.

Mini heap leach test work was also recommended by SGS to de-risk the current parameters for the heap leach design, e.g. heap slope stability and the ability of waste dump to support stacking equipment, amongst others. To this end, pilot heap leach testing is to be undertaken prior to the construction of the full HLF to resolve these issues.

The pilot heap leach facility involves construction of a scaled-down version of the plant, with the same process description, located within the footprint of the proposed heap leach facility. It is estimated that this pilot facility (including support facilities) will be scaled to between 5-15% of the main plant, but limited to 2 cells only, to investigate 2 different sets of conditions.

5.2.2 Facilities required for heap leach processing and heap leach waste disposal.

The proposed heap leach processing facilities are summarised below:

- Crushing, Screening and Agglomeration
 - primary crushing;
 - overland conveying;
 - secondary crushing, stockpiling; and
 - high pressure grind rolls crushing, screening and agglomeration.

These facilities will be located near the exiting crusher, low-grade ore stockpile and Pit Zone 2.
- Reagent Storage - constructed close to the HLF
 - flocculant make-up and storage;
 - hydrogen peroxide storage; and
 - sulphuric acid storage.
- Offices and control rooms
 - Control rooms at the screening and crushing points;
 - A plant complex, offices and parking;
 - Septic tank.
- Heap Leach, Solution Handling, Ponds and Reclamation (HLF)
 - racetrack stacking and reclamation system;
 - heap leach pad;
 - barren solution pond, intermediate leach solution (ILS) pond, pregnant leach solution (PLS) pond and wash water pond; and
 - the PLS pumping system from the PLS pond to tank leach facility PLS pond.
- Heap Leach Waste Storage Facility (HLWF)
 - conveyor from HLF;

- emergency stockpile area;
- electrical sub-station;
- clean and dirty water management and PCD,
- waste pad; and
- stacking system.
- Services and Utilities
 - process water;
 - potable water;
 - fire water; and
 - plant and instrument air.

- Tank Leach Facility (TLF) Interface

The proposed heap leach project will affect the following areas of the existing TLF plant infrastructure:

- ion exchange;
- solvent exchange;
- final product recovery;
- acid plant;
- water supply; and
- power supply.

The following heap leach process description was obtained from the SGSB 2021 report and SGS/SU Process Description document for the HLF and HLWF. The process flow is illustrated in Figure 5-3.

5.2.3 Heap Leach Process Description

Crushing, Screening and Agglomeration

During the SGSB study it was decided to establish a stand-alone primary crusher circuit, due to various interfacing issues and operational constraints with existing crushing facilities. Figure 5-4 provides a drawing of the heap leach circuit infrastructure.

The low-grade ore will be processed in two stages through a set of primary and secondary crushers. Once crushed and screened, the material will be stored in silos prior to final high pressure grind rolls (HPGR) crushing to < 8mm before being fed to the agglomeration drum. Process water (with pre-mixed flocculant) is pumped to the agglomerating drum from the existing process water reservoir to raise the moisture content and to reduce dust. In the agglomeration drum the leach reagents and sulphuric acid will be added.

The purpose of agglomeration is two-fold. It allows for contacting the ore with concentrated sulphuric acid to allow for the penetration of acid into the interstitial matrix of the ore by pugging, and thereby aids the leaching process of the ore when stacked and irrigated on the heap.

Secondly, it allows for the collection and binding of fines on the ore surface to improve the physical competence and regularize the shape of the ore being stacked onto the heap. This improves the structural characteristics of the heap and facilitates adequate percolation of irrigation solution during leaching. The agglomerated material is then conveyed overland to the racetrack configured dynamic heap leach pad (Figure 5-5).

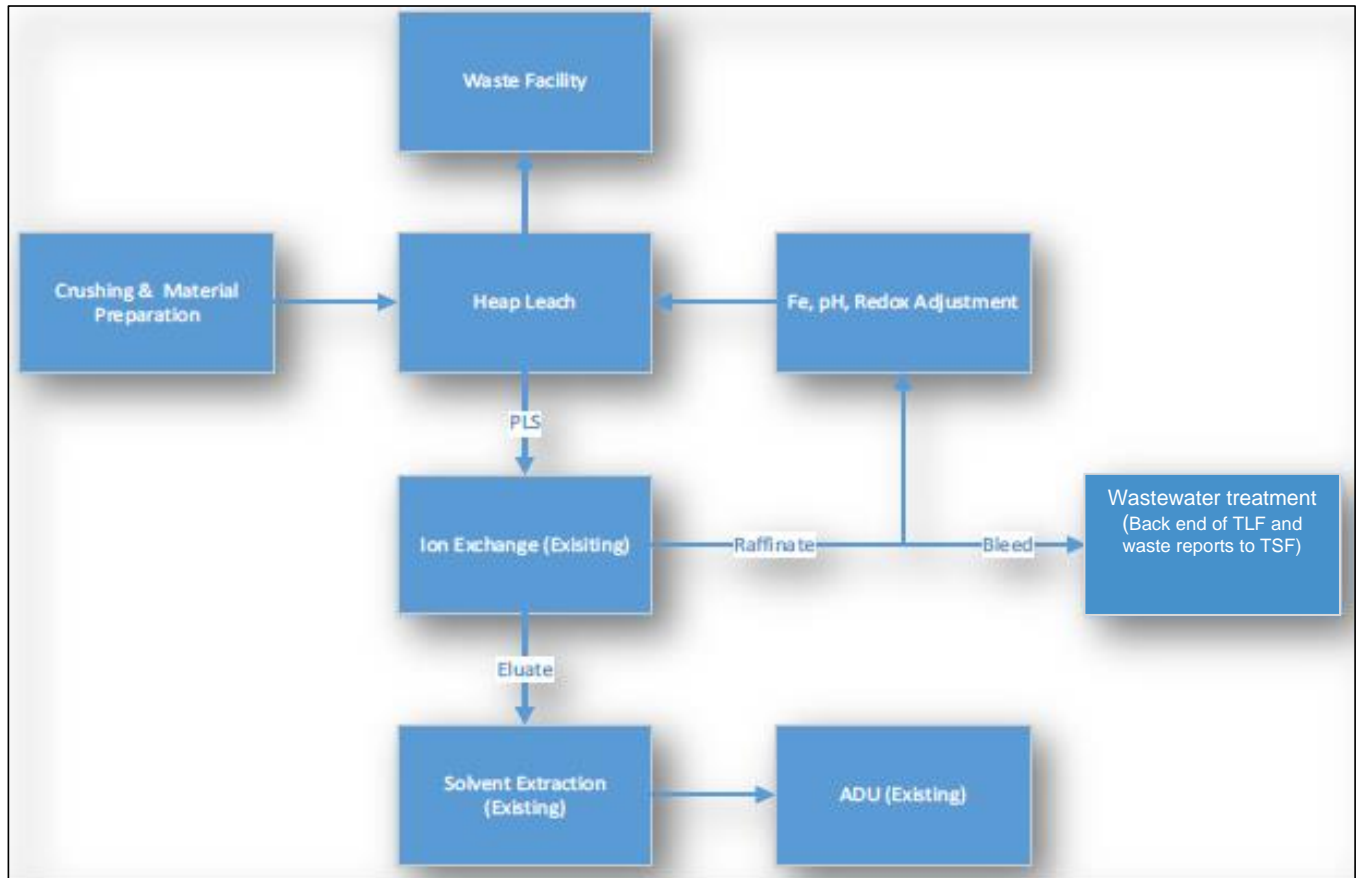


Figure 5-3: Heap Leach Facility Block Flow Diagram (SGSB, 2021).

Stacking the HLF

The heap leach operation is based on the use of a dedicated pad for the life-of-mine. The pad will be operated in a racetrack configuration (Figure 5-5), with cells arranged in an on/off fashion. The racetrack comprises of a central spine with a tipper and reclamation arm rotating around the central spine.

Stacking of a particular cell will commence from the top and proceed downward toward the toe according to a typical reverse pullback mode of operation. This process is repeated until the length of pad is fully stacked. At this point, the tripper is moved to the second pad where the process continues. The optimum heap height for the heaps has been determined to be 8-9 m with a 38° side slope, as reported in the Golder Associates study (2017).

Heap Leaching & Solution Management

The dynamic HL pad consists of six cells for the stacking, leaching, drain down, rinse, and reclamation operations, as well as a dormant cell to allow flexibility in the operation. Figure 5-5 provides a conceptual layout of the heap leach facility and associated solution ponds. (Refer to Table 5-1 for the HLF design parameters).

- Heap leaching pad and lining system that is composed of a double-layered liner as well as a seepage interception layer;
- Storm water pond and collection channels;
- Solution collection trench downhill of the HL pad and solution ponds;

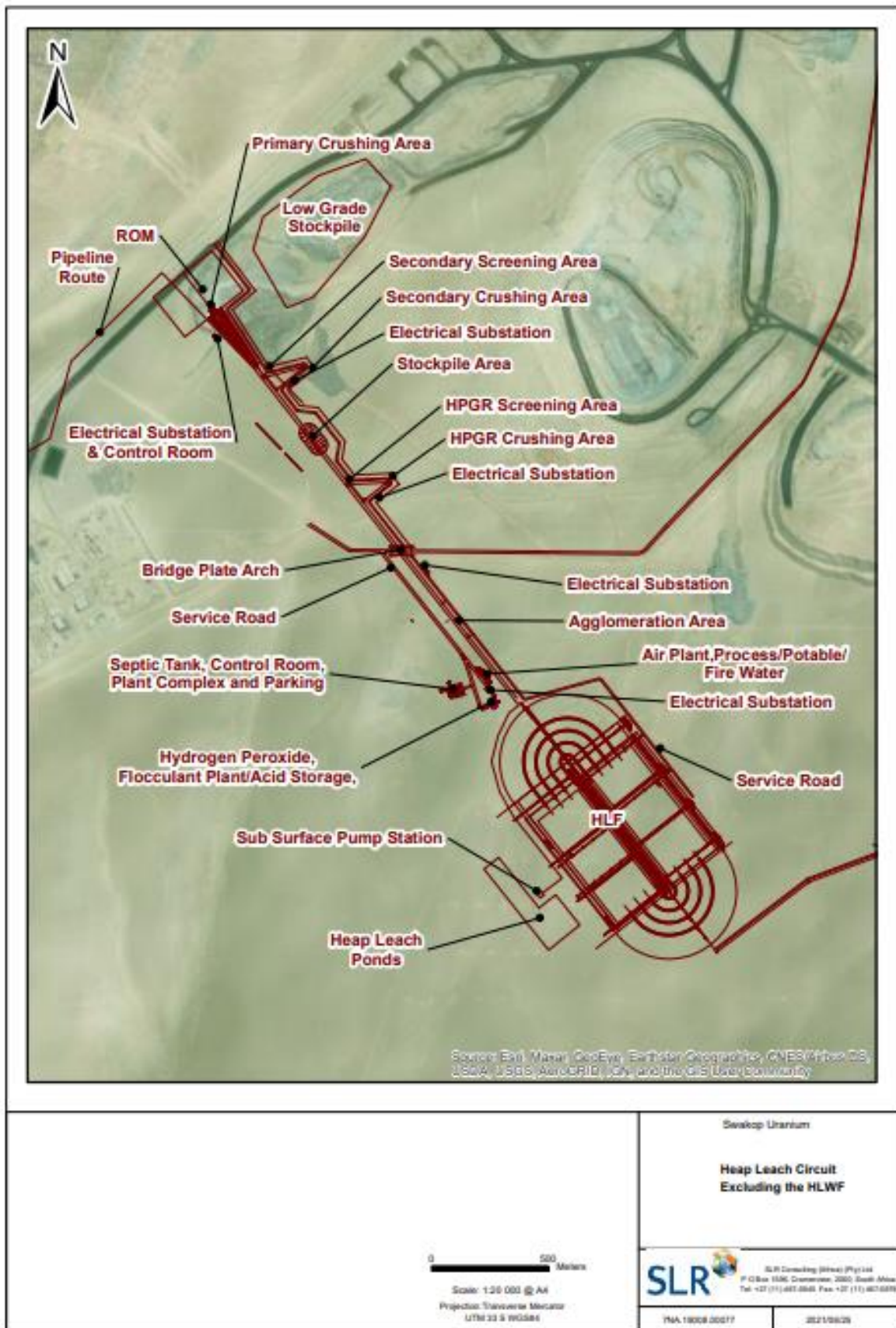


Figure 5-4: Drawing of the Heap Leach Circuit, excluding the HLF

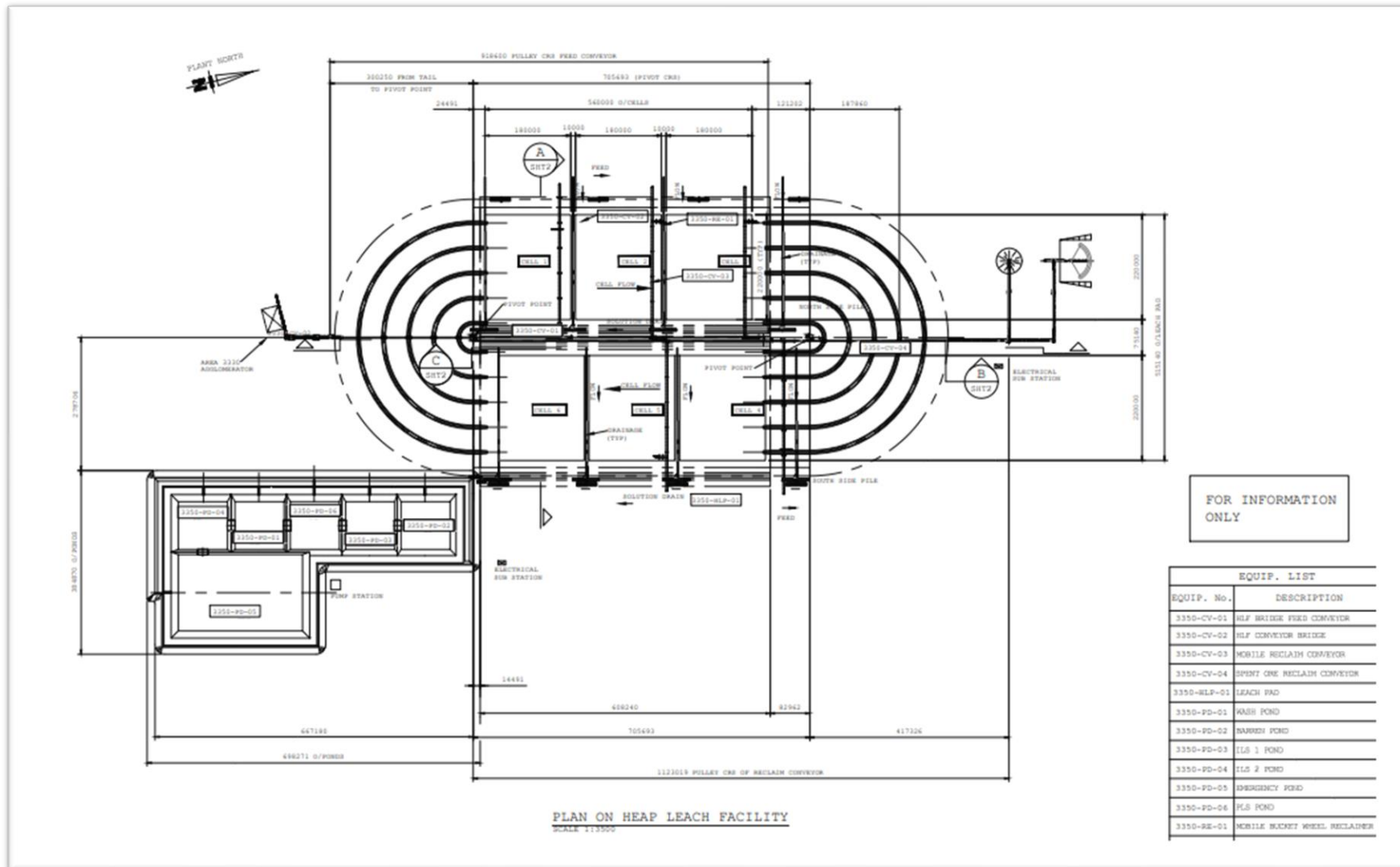


Figure 5-5: Diagram of the race-track heap leach facility and process solution ponds.

- Solution collection system consisting of a drainage layer and collection pipes that are to drain the leaching solution to the ponds;
- Reclamation loading system; and
- Closure and rehabilitation; allow for effective decommissioning and reclamation of HL facility components after leaching operations are complete.

As the stacking of a cell with the <8 mm agglomerated low-grade ore is completed and the section has been made ready for irrigation (by laying piping for drippers and sprinklers), the leaching and washing cycles are initiated. The sulphuric acid storage will accommodate 1 080 tonnes of acid per HL cycle, with the sulphuric acid delivered with 30-ton tankers over a three-day period during each HL cycle.

Solution is only applied to one cell at a time from each of the solution ponds: Barren solution and intermediate leach solutions (ILS 1 and ILS 2) are injected with sulphuric acid and hydrogen peroxide using inline mixers. Each reagent is added to achieve a certain inline concentration for the solution application to the heap. Barren, ILS 1 and ILS 2. solution will thus be maintained on a cell until the next cell is available for irrigation.

The irrigation sequence by solution is as follows:

- ILS 2: 20 days
- ILS 1: 20 days
- Barren: 10 days

Leach solution will be collected by a series of solution collection pipes within the drainage layer. The collection pipes will connect to intermediate header pipes for transport to the main outlet pipe. The main outlet pipe runs along the toe of the HLF to the solution ponds. All ponds will be installed with a level transmitter. Ponds will be supplied with double lining with interstitial porous layer. Any leaking liquid will thus travel along the inter-liner space to a leak detection well, where manual leak detection can be done.

Drainage from the heap needs to be managed to ensure the correct solutions reports from the heap to the correct pond (Table 5-2). The PLS pond will receive a certain volume of solution of the highest grade solution during leaching of the pad across all cells. The ILS 2 pond will then receive the next highest tenor solution available at a specific volume and so on down the concentration profile of the ponds.

The pregnant leach solution (PLS) is collected in the PLS pond and will to be pumped to the existing TLF PLS pond at the main processing plant. Barren solution from the TLF barren liquor pond is piped to the HLF barren pond as make-up solution. Wash water is used to rinse the cell at the end of the cycle, recovering reagents and uranium-bearing leach liquor.

In the event of a pond overflow, PLS overflows from its pond into the ILS pond; ILS overflows into the barren solution pond and barren solution overflows into the emergency storm water pond which was calculated for a the 1:50 year 24 hour storm event. The facility has been designed so that all liquid effluent is circulated in order to mitigate any environmental risks (SGS feasibility study report, 2021).

Once the leaching cycle is completed the washed and drained residue is reclaimed mechanically and placed onto a conveyor that transports it to the heap leach waste disposal facility.

HLF operational cycle

The heap leach pad operational cycle, from stacking, through leaching and reclamation will take 100 days resulting in ~6 cycles per year. Each cycle will include 17 days for stacking, 3 days for curing; surface piping and pipe laying, the leaching process will take 45 days whereafter 2 days for washing, 8 days for draining, 3 days for piping and network removal, and 17 days for reclamation.

Table 5-1: Heap Leach Design Parameters

Parameter	Units	Value
Heap Life	Years	20
Pad Dimensions		
Length	m	450
Width	m	580
Lift	m	8-9
Angle of repose	°	38
Cell Dimensions		
# of cells	-	6
Length	m	200
Width	m	180
Single cell area	m ²	36 000
HLF cells area	m ²	256 825
Solution Application		
Application rate	l/h/m ²	17
Barren flow (Max)	m ³ /h	604
ILS flow (Max)	m ³ /h	592
ILS drain rate (Max)	m ³ /h	606
Heap drain date	m ³ /h	1 900
PLS to extraction (Max)	m ³ /h	532
Wash water to heap (Max)	m ³ /h	588
Total acid consumption	kg/t	23,8

Table 5-2: HLF Pond Design Parameters

Description	Units	PLS Pond	ILS2 Pond	ILS1 Pond	Barren Pond	Wash water pond	Storm Pond
Area (top max depth)	m ²	3 060	3 060	3 060	3 060	3 060	4878
Area (bottom)	m ²	1 620	1 620	1 620	1 620	1 620	4048
Volume (max)	m ³	54 190	54 190	54 190	54 190	54 190	162 371
Volume (normal)	m ³	30 882	30 882	30 882	30 882	30 882	127 674

Post leach residue material (waste)

The post leach residue will be collected with a bucket wheel reclaimer onto a conveyor system which will transport it to a dedicated waste storage facility where it will be deposited by means of a grass-hopper stacker. The waste storage facility will be 70 m high, with benches every 15 m accommodating 375 000 tpa of leach residue (SGS Bateman, 2021). The HLWF footprint be approximately 170 ha.

According to the Golder Associates report (2017), the chemical composition of the waste material will pose a low health risk. The solids will have low leachability and comprise of silica (34-35%), aluminium (5.8-6.2%), iron total (2.2%), sodium (1.6-1.7%), and potassium (4.1-5.4%). These chemical elements, including in its current form (solids, low leachability), are not considered a human health risk.

An engineered environmental barrier is to be constructed in phases to match the dump progression and is designed according to the waste classification as specified in the Golder design report. The South African National Norms and Standards for Disposal of Waste to Landfill (GN R. 636 of 2013) was used for the selection of the waste facility barrier system. Geochemical characterisation and waste classification of the heap leached waste was classified as Type 3, which according to the Norms and Standards, requires at least a Class C barrier system which has been used in the conceptual design for the HLWF.

The Class C barrier system will comprise a 300 mm base layer constructed out of clayey material. This base layer will be overlain with 1.5 mm HDPE geomembrane and the geomembrane will be covered with a 100 mm thick silty sand or protection geotextile.

5.2.4 Clean / Dirty Water System for HLF and HLWF

The dirty water system will consist of canals located around the outside of the HLF and HLWF footprint and associated pollution control dams / dirty storm water dams (PCD & SWD). The canal will intercept the dirty water run-off from the HLF and HLWF and will discharge in the new PCD/SWD located at the lowest corner of both facilities (See also Section 6.4.3). The canals will also accommodate seepage from the seepage management system. The PCD/SWD will be lined with an HDPE geomembrane which will be regularly inspected and cleaned as necessary. Clean water will be diverted around the facility and back into existing drainage channels. Dirty water will be pumped from the pollution control dams back the main processing plant.

5.3 HEAP LEACH CONSTRUCTION (INCLUDING PILOT PLANT)

The construction activities for the proposed facilities are described from the various heap leach facility designs contained in the SGSB 2021 feasibility study report and from the Golder Associates 2017 HLWF description. General knowledge about the likely construction activity processes also informs the following.

5.3.1 Construction Phase – Pilot Plant and Full Heap Leach Processing Facilities

Site clearance

Protected plants that can be rescued and relocated will be identified and permits obtained for their removal prior to the start of construction. Other sensitive vegetation will be removed and relocated in advance of any mechanical equipment arriving on site.

Topsoil will be removed in advance of any earthworks required for the crushing and screening plant, the conveyor footprint and service roads, control rooms, office and parking areas, as well as the HLF and HLWF. This process will follow the standard operating procedures currently in existence. Topsoil will be stockpiled close to the areas where it will be needed for rehabilitation.

Earthworks

Site preparation will include the removal of unsuitable substrate by earth moving equipment and then cut and fill to obtain a flat working surface. Compaction of the surface will precede the start of any civil construction.

Depending on ground conditions rock may need blasting at the primary crusher located on a limestone outcrop.

Civil and Infrastructure works

Foundations for the crushing and screening sites, the heap leach facility and ponds will be prepared. Buildings will be constructed for the main HLF offices and the small control rooms required at certain points in the process.

Preparation of the heap leach pads, the ponds and the HLWF floors prior to installation of the liners will follow. The specifications for the various liners are as follows: -

- Temporary stockpiles – the crushed ore will be stockpiled prior to the final crushing stage on a prepared surface. The emergency stockpile at the WLHF will have the Class 3 liner.
- Heap Leach Facility - double liner and seepage/solution interception layer. The base layer will be a 600 mm compacted subgrade, followed by a geosynthetic clay liner. On top of this will be a 2 mm HDPWE geomembrane finished with an overliner drainage and protection layer with pipe network.
- Ponds – The base layer will be a 600 mm compacted subgrade followed by a 1,5 mm smooth HDPE geomembrane. On top of this is a HDPE Geonet (leak detection/recovery layer) and finished with a 2 mm smooth HDPE layer.
- Heap Leach Waste Facility - engineered environmental Class C barrier comprised of a 300 mm clayey base layer overlain with 1.5 mm HDPE geomembrane and then covered with a 100 mm thick silty sand or protection geotextile.

A power line, probably a wooden H frame, will supply power to the HLF and the HLWF.

All overland pipes will be installed above ground and in lined trenches over several kilometres between the HLF and existing process plant. This includes process, potable and fire water, the barren liquor and pregnant liquor solution. Return water pipelines will also be required to empty storm water pollution control ponds.

Operations

Covered in the process description in Section 5.2.3 above.

Closure

During the original feasibility study stages for the Husab Mine and processing plant, the project engineers were required to design for closure, preferably a walk away solution that did not require long term management. This objective must be included in the final designs for the heap leach circuit.

The heap leach facility and all its related infrastructure and equipment will be removed in its entirety. The remaining leach waste will be taken to the heap leach waste facility, and the liners will be removed.

The crushing and screening circuit and conveyors will all be dismantled, and salvageable elements will be decontaminated and sold. The remainder of the heap leach plant (i.e. non-salvageable, non-radioactive elements) including concrete, brickwork, liners, conveyor belts, some steelwork etc. will be dismantled or broken up and buried (with approval from the relevant authorities) in the open pit, WRD or primary crusher void.

Any radioactive material will be buried in the TSF. The HLF and pond footprints will be ripped and then contoured before topsoil is replaced and vegetation will be re-established, as recommended by the biodiversity and closure plans.

The HLWF is a permanent feature and must have the final slopes designed and contoured for stability and to promote run-off. The exposed surfaces must be covered with inert material (waste rock or riprap) sourced from existing waste dumps to prevent wind and water erosion. The final cover must limit water ingress to reduce the generation of leachate. Dirty water capture systems will have to remain and be managed until there is no longer any contaminated water of leachate emanating from the facility.

The Swakop Uranium Mine Closure Plan will have to be updated, taking the proposed new infrastructure and commitments from the Heap Leach EIA (amendment) process into consideration.

5.3.2 Timetable

The preliminary project schedule provided in the SGSB feasibility report is based on estimated lead times for major equipment. Securing of an environmental clearance certificate (ECC) is also a key component in the initiation of the proposed heap leach project.

Swakop Uranium intends to construct the pilot heap leach plant during 2021/2, and to have the full heap leach facility operational by 2023.

5.4 HEAP LEACH PROJECT ALTERNATIVES

5.4.1 Alternatives Relating to Ore Processing

Process low-grade ore through existing plant at end of LOM

Swakop Uranium currently mines uranium bearing ore from two open pits, Zone 1 and Zone 2 which is then processed at the existing plant with the tank leach process. Low grade ore is mined, like waste, as part of the mining process and is being stockpiled adjacent to Pit Zone 2, pending treatment toward the end of LOM through the existing plant.

If the heap leaching process is not adopted, this end of LOM treatment of the low-grade ore can still be done and is essentially the NO-GO option for the heap leach project.

Process low-grade ore via heap leach

An alternative for extraction of the uranium from the low-grade ore is to treat this concurrent with the main processing plant through a heap leach facility (HLF). The original HLF opportunity was based on spare primary crushing capacity and spare processing capacity at the back end of the existing tank leach process plant. (Subsequently the prefeasibility study determined that the low-grade ore would require its own crushing and screening circuitry).

However, the lower cost of processing material through a HLF was identified as an opportunity to treat low-grade material. A feasibility study for the heap leach processing option has been undertaken (SGS, 2021) which has determined that heap leaching appears to be economically feasible. This option is being carried forward as the preferred option for treatment of the low-grade ore.

5.4.2 Alternatives relating to heap leach process circuit design

The feasibility study adopted the racetrack heap leach stacking and reclaiming design, which is compact, but covers a large area (10 ha with ponds). During the site layout options discussion, the alternative of arranging the heap leach dumps in a longer narrower footprint was suggested to try and fit the heap leach processes in between existing infrastructure but this was discarded in favor of the race-track layout and its integrated stacker handling process.

The SGS prefeasibility study assessed optimal crushing size of the heap leach feed, the quantities of reagents and acid required to leach the uraninite, as well as heap leach pad design options and heap heights. The feasibility study refined these initial findings and has reduced the number of cells at the HLF from 10 to 6. The racetrack heap leach process design reviewed during the feasibility study is the option being taken forward.

5.4.3 Heap leach facility and related infrastructure footprint

The proposed HLF, HLWF and ponds combined will cover a footprint of 230 ha (Table 5-3). The racetrack HLF is almost as large as the existing crushing, milling and TLF and acid plant areas combined, and the HLWF is almost half the size (170 ha) of the existing tailings storage facility (400 ha) (refer to Figure 4-21).

Table 5-3: HLF Facility Surface Areas

Facility	Length (m)	Width (m)	Surface area (m ²)
Heap Leach Facility	1 300	600	780 000
Ponds	445	175	77 875
Heap Leach Waste Facility (Golder) (+10%)	1 300	1 300	1 185 900
The ROM	400	250	100 000
Secondary crush stockpile	147	80	11 760
Emergency stockpile area	Diameter is 53,5 m		2 248
Acid Storage Plant complete with Bund	20.5	20.5	420
Flocculant Make Up Plant complete with Bund	24	21	504
Hydrogen peroxide Storage Plant complete with Bund	12.5	10.5	131
Total area 2 158 838 m ²	TOTAL HECTARES		~216 ha

5.4.4 Site Layout Alternatives That Were Reviewed

This impact assessment process spent several weeks trying to determine the optimal layout the heap leach facility, the heap leach waste facility, and the associated crushing, screening, conveyors, control rooms and temporary stockpile areas.

Although the Swakop Uranium mining license area is large, there are several constraints to the positioning of infrastructure from topographical, ecological, financial, technical and logistical perspective. These constraints are discussed further below.

Site layout constraints A: - mining licence boundary, ore deposits, existing infrastructure, power and water

The Swakop Uranium mining licence boundary encloses the area in which several potential uranium deposits have been identified. The Rössing Formation that hosts the orebody mined at Rössing and at Husab was traced beneath the sand cover southwards and across the Swakop River. Several zones of mineralisation have been identified which run south-westwards from the Zones 1 and Zone 2. Note that Zone 3 is located south of Zone 2.

The positioning of mine and plant infrastructure, especially the plant and waste rock dump, during the Husab Project feasibility and optimization studies (2010-2013) was strongly influenced by the location of the mineralised zone and the outline of the Welwitschia field that was being mapped at the time. In addition, the topography, and revised access route to the site, resulted in the plant and offices being placed along the watershed between the Khan and Swakop Rivers. (The very first access route suggested for the newly discovered deposits was via a road and rail line through the Namib Naukluft National Park.)

Existing plant, crushing circuit, haul roads, powerlines, permanent water pipelines, magazine and emulsions depot cannot summarily be moved to accommodate new infrastructure. This is related to either additional costs, or loss of productivity when water or power supply is interrupted, licensing (explosives magazine), or mine planning for Pit Zones 1 and 2.

Site layout constraints B: - Welwitschia field, ecologically sensitive areas, surface drainage, water catchments, topography and archaeology, ground water

The original biodiversity studies identified and mapped several ecologically sensitive areas on the mining license area in 2010, primarily the rocky outcrops which are either limestone or granite, the watershed between the Khan and Swakop Rivers, and the renowned Welwitschia Field. This original ecological sensitivity base plan together with topography of the area, also influenced where the mine and plant infrastructure were placed: only small areas of sensitive vegetation were sacrificed when finalising the mine site layout.

Extensive archaeological surveys have been undertaken on the mining license area, and along infrastructure routes to the site. An important heritage site, the Welwitsch siding, is situated to the west of the plant and north of the tailings storage facility and has been protected from development (marked in purple hatch on Figure 4-21). Prior to the start of construction other areas close to the mine and plant site were demarcated as No-Go areas to limit accidental damage to vegetation, and to protect the Welwitsch rail siding. These No-Go areas are still featured as a hatched area on the mine plan and consequently affected the early site HLF and HLWF layout options discussed in Table 5-4 below).

Environmental monitoring programmes have been in place at the Husab Mine since 2011 and, over time, the environmental department and biodiversity specialist have reviewed the sensitivity rating of the area and have updated the sensitivities plan (AWR, 2021, Figure 4-21). In addition, the importance of the various catchments (large and small) that feed the Welwitschia field have been recognised (See Section 4.4.1) and is an important consideration for future development at the Husab Mine, particularly when assessing cumulative impacts.

The planned expansion of the WRD footprint will cover several kilometres of the main feeder channel to the Welwitschia Field, the Husab drainage channel. The WRD expansion EIA Amendment (SLR, 2018) was approved, with the commitment in the EMP, and on the environmental clearance certificate, that an engineered diversion channel must be constructed to maintain flow of water to the Welwitschia field. This channel is still to be built, but its position affects possible layout options for the HLF and HLWF.

Given that the HLF and HLWF contain hazardous material, they should ideally be located within the long-term drawdown area created by the pits (Figure 4-21), so that potential long-term seepage from the facilities is directed toward the open pit.

Site layout constraints C: - technical, financial, and logistical

The original premise for the concurrent treatment of the low-grade ore was apparent capacity at both the front and tail end of the existing LTF. During the prefeasibility and feasibility studies it was determined that a separate crushing and screening facility would be required to handle the additional crushing and screening of 7.5 million tonnes per annum of low-grade ore destined for the HLF.

Conveyor distances, power supply, service roads, water supply, sewage facilities, and the distances over which pumping of the PLS to the TLF are all financial and technical considerations. The closer the HLF and HLWF are to existing facilities, the less technical and expensive are the logistics of getting utilities and reagents to the site, and the PLS back to the plant.

The radiation and environmental mitigation measures required to reduce impacts and protect health also affect the technical and financial aspects of the proposed project, e.g. dust suppression, conveyor roof and sides, liners.

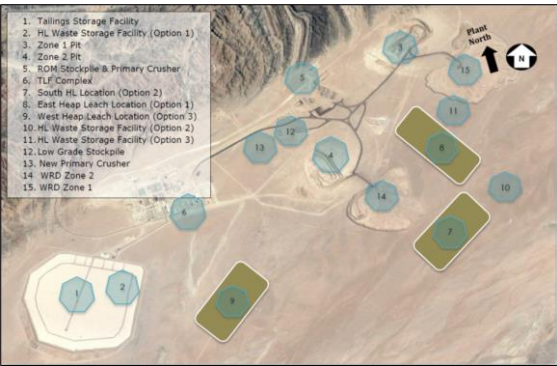
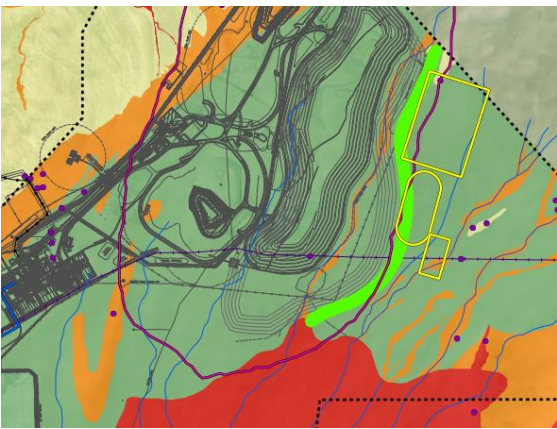
The option of co-disposal of the heap leach waste within the tailings storage facility requires further studies to determine the logistical and operational costs. The TSF LOM capacity already accounts for the tailings that would be produced from the processing of the low-grade ore through the TLF.

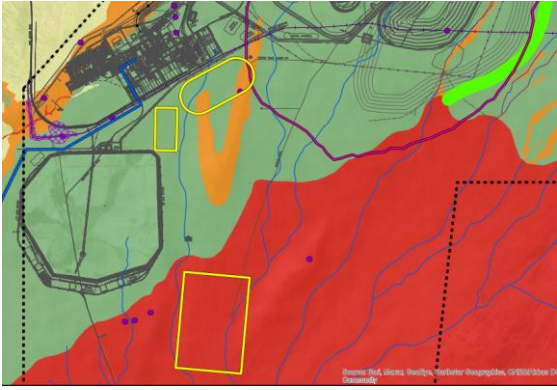
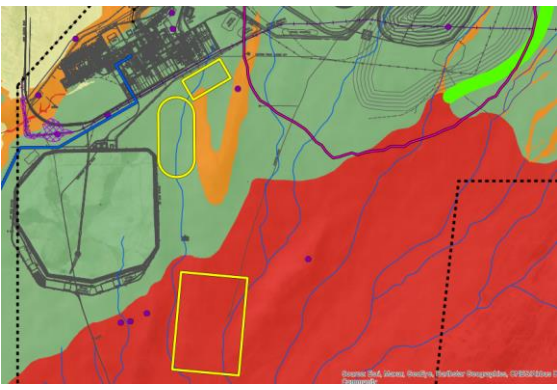
The different site layout constraints provide above must be all be considered when determining the optimum placement of the proposed heap leach facility and its associated infrastructure.

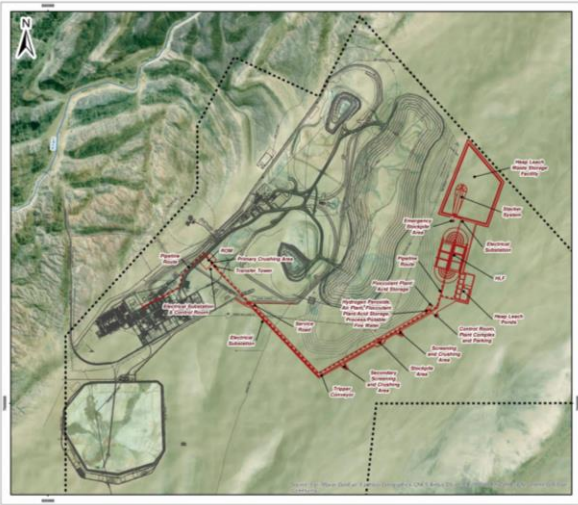
5.4.5 HLF and HLWF layout and associated infrastructure options

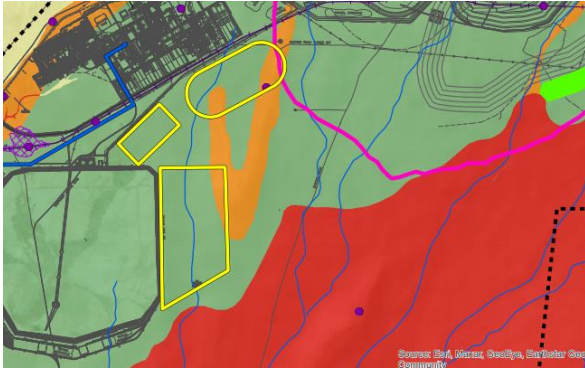
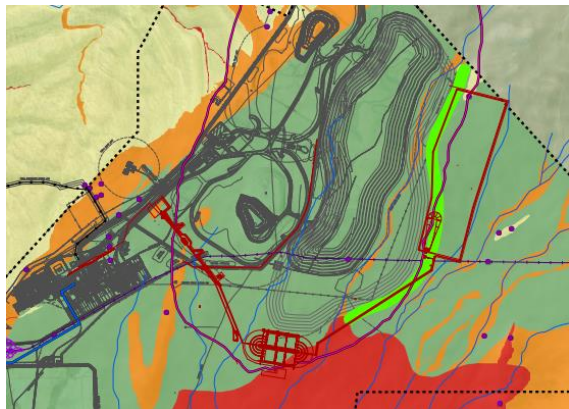
The options for the placement of the HLF, ponds and HLWF are constrained by several different factors as described above. Finding an optimal position for these facilities has been a challenging exercise for the project team. The options that have been considered, and discarded, are described briefly in Table 5-4 below. The plans are illustrative with the various site options shown in yellow on the updated sensitivities plan. Disposal options for the waste material after leaching have also been considered.

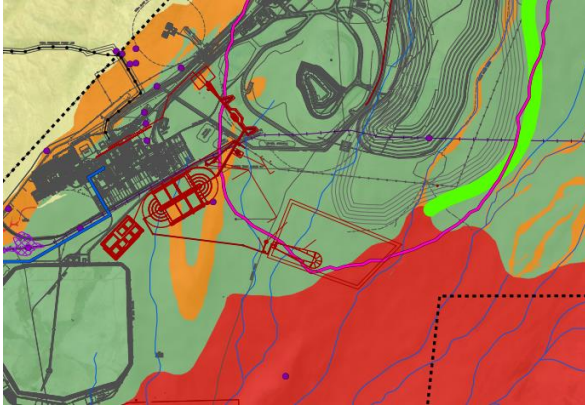
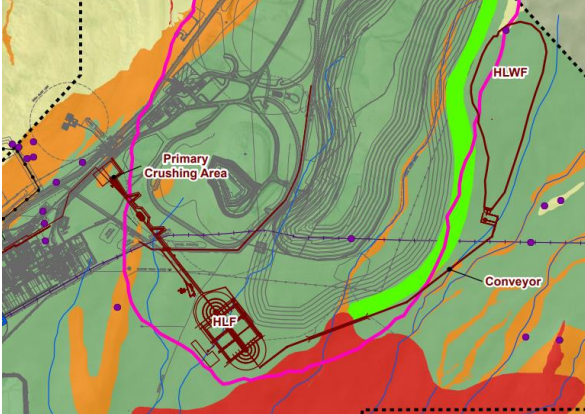
Table 5-4: Heap Leach Project Layout Alternatives That Were Considered

Option	Proposed site layout	Description and comment on the option suitability
<p>Pre-feasibility study</p>		<p>At the start of the pre-feasibility study in 2017, three possible leach pad site location options, relative to the existing TLF plant were identified by SGS, South Heap Leach Location (Option 1), South-East HL Location (Option 2) and West Heap Leach Location (Option 3). Three possible HLWF locations were identified namely ‘HL Waste Storage Facility’ (Option 1), ‘HL Waste Storage Facility’ (Option 2), and ‘HL Waste Storage Facility’ (Option 3). These are shown in the figure alongside as items 2, 10, and 11 respectively.</p> <p>Two possible sites for the new primary crusher were also identified i.e. Item 13 and near the selected heap pad location.</p> <p>This was prefeasibility: Old Google images, and no site sensitivity map used.</p>
<p>Option 1 East Heap Location</p>		<p>Option 1 includes the HLF on the eastern side of the mining site, to the south-east of the current WRD.</p> <p>Low-grade ore crushed in the existing circuit was to be conveyed to the secondary crushing and screening circuit placed to the south of the extended WRD. The heap leach pad, ponds and heap leach waste facility were located adjacent to the WRD (taking cognisance of the proposed Amendment WRD design and Husab Drainage line to be diverted – as per the 2018 EIA amendment).</p> <p>Low-grade ore could not be crushed at existing crusher, and therefore a separate crushing facility for low-grade ore was proposed.</p>

Option	Proposed site layout	Description and comment on the option suitability
<p>Option 2A: Heap Leach Location adjacent to the TSF</p>		<p>This option was placed on the Mine Plan that has hatched No-Go areas as mentioned in Section 5.4.4 above. The updated sensitivities plan has subsequently been added.</p> <p>Option 2A entails a HLF east of the TSF. For this option the HL pad is located between the marble ridge and the processing plant. The ponds were located between the HL pad and the TSF and the HLWF was located south-east of the TSF in the Welwitschia Field, an area identified as “No-Go” from a biodiversity perspective.</p> <p>The HLF straddles the northern end of the sensitive marble ridge.</p> <p>The position of the HLWF in the red zone resulted in this site option being discarded.</p>
<p>Option 2B: Heap Leach Location adjacent to the TSF</p>		<p>This option was placed on the Mine Plan that has hatched No-Go areas as mentioned in Section 5.4.4 above. The updated sensitivities plan has subsequently been added.</p> <p>Option 2B is very similar to option 2 A, however for this option the HLF pad is adjacent to the TSF (east), and the ponds lie between the marble ridge and the processing plant. The HLWF is located in a position similar to Option 2A, i.e. south-east of the TSF in the Welwitschia Field, an area identified as “No-Go” from a biodiversity perspective.</p> <p>HLF is in a drainage channel of the WW field & adjacent to the sensitive marble ridge.</p> <p>The position of the HLWF in the red zone resulted in this site option being discarded.</p>
<p>Option 3: Co-disposal of waste in adjacent to current TSF</p>		<p>Option 3 entails the co-disposal of post leach residue (i.e. waste residues from HLF) with tailings from the processing plant into the TSF. The location of the HL pad and the ponds would correlate with either one of options 2A or 2B for this option.</p> <p>For this option it was thought that the current TSF footprint could be extended towards the south and south-west to allow additional capacity in the TSF to co-dispose the waste residues from HLF with the tailings. (No Figure for this option is available as this is only conceptual).</p> <p>Although the TSF has been designed to take the tailings of the low-grade ore processed through the TLF over the LOM, the drier and coarser HL residue may not be suitable for co-disposal. A detailed engineering study would be required to assess this option.</p>

Option	Proposed site layout	Description and comment on the option suitability
<p>Option 4: Co-disposal of the waste onto the existing WRD</p>		<p>Option 4 entails the co-disposal of post HLF residue with the waste rock on the existing WRD. The proximity of the HLF pad and ponds as shown in Option 1 was thought to be suitable for WRD co-disposal.</p> <p>For this option it was assumed that a section of the current WRD would be designed to cater for the co disposal of the waste residues from HLF. (No Figure for this option is available as this is only conceptual).</p> <p>SU is of the opinion that a co-disposal facility within the WRD could potentially compromise the operational safety of haul trucks and other equipment, as well as the WRD stability.</p> <p>Co-disposal by dumping between waste rock loads was discarded because of potential safety issues with soft zones in the dump potentially affecting haul trucks.</p> <p>This option was discarded.</p>
<p>Option A or Base Case</p>		<p>“Base Case” Option A is very similar to the Option 1 site layout.</p> <p>The HLF and HLWF are located to the east of the extended WRD. However, no provision has been made for the engineered Husab channel diversion that is a requirement for the expansion of the WRD.</p> <p>Conveyors, crushers and stockpile areas potentially block the required river diversion.</p> <p>This option was modified because the HLWF size was incorrect and insufficient space was left for the proposed Husab channel diversion.</p> <p>NOTE: Option A/Base Case was used in the feasibility study and for the <u>quantitative</u> air quality assessment.</p>

Option	Proposed site layout	Description and comment on the option suitability
<p>Option F</p>		<p>In Option F the HLF and ponds are south of the existing TLF and adjacent to the tailings pipeline. The HLF straddles the northern end of the marble ridge, but the HLWF was moved out of the Welwitschia Field and is sandwiched between the current TSF and the western limb of the marble ridge.</p> <p>This option was discarded because of the sensitivity of the marble ridge.</p>
<p>Option G</p>		<p>For Option G, based on the OLD sensitivities plan, the HLF and ponds were situated to the south of the proposed extended WRD footprint, and the HLWF to the east of the WRD, with provision made for the Husab drainage diversion channel.</p> <p>The Option G site location was presented to the environmental specialists of as one of two site layout options (with Option H) to assess for the EIA Amendment. Unfortunately, the OLD site sensitivities plan used for this proposed layout, and the HLF was partially situated in the Welwitschia Field and in the Husab channel.</p> <p>Option G was assessed by the specialists in their reports. Subsequently, the UPDATED Ecological Sensitivities plan was supplied to the team. This resulted in the final layout Option J where the HLF has been moved out of the Welwitschia Field.</p>
<p>Option J</p>	<p>No plan available</p>	<p>Place HLWF adjacent to the WRD over the Husab channel/diversion and move channel diversion further to the east. PROS - the HLWF would be within the drawdown cone for the pits and can be closed with WRD at end LOM. CONS - the natural Husab channel is permeable and long-term seepage could flow along it. A diversion to east requires major earthworks to create a gradient. Also, the diversion cannot start outside mining license boundary. Option discarded.</p>

Option	Proposed site layout	Description and comment on the option suitability
<p>Option H</p>		<p>For Option H, based on the OLD sensitivities plan, the HLF and ponds were situated south of the existing plant, adjacent to the tailings pipeline and return water lines. The HLF straddles the marble outcrop.</p> <p>The Option G site location was presented to the environmental specialists of as one of two site layout options (with Option G) to assess for the EIA Amendment.</p> <p>Unfortunately, the OLD site sensitivities plan used for this proposed layout, and the HLWF was partially situated in the Welwitschia Field and Husab channel.</p> <p>This option was assessed by the specialists in their reports. Subsequently, the UPDATED Ecological Sensitivities plan was supplied to the team. The sensitivity of the marble ridge is considered sensitive.</p> <p>The HLWF can be shifted out of the No-Go area, but it is a permanent feature and thus cannot be located over the potential ore deposit Zone 3, south-east of Pit Zone 2.</p> <p>Option H was discarded in favour of Option K.</p>
<p>Option K</p>		<p>Option K is a modified version of Option G. The HLF has been moved out of the Welwitschia Field and Husab channel and reorientated to allow for a single corridor for conveyors, roads, and pipelines etc. The project team is cognisant of the fact that the HLF encroaches on the mineralised Zone 3.</p> <p>The environmental specialists undertook their assessments on Options G and H. The biodiversity study provided the updated sensitives plan and, as a result, Options G and H were unacceptable accepted because either the HLF or the HLWF were partially situated in the No-Go zone.</p> <p>The air quality, biodiversity, radiation and surface and ground water specialists were asked to review the revised Option J and to provide a professional opinion on the impacts of the new site.</p> <p>Option K is the site layout being presented to the authorities for authorisation.</p>

6. ENVIRONMENTAL IMPACT ASSESSMENT

6.1 IMPACT ASSESSMENT METHODOLOGY

The method used for the assessment of environmental issues is set out in Table 6-1. This assessment methodology enables the assessment of environmental issues including cumulative impacts, the severity of impacts (including the nature of impacts and the degree to which impacts may cause irreplaceable loss of resources), the extent of the impacts, the duration and reversibility of impacts, the probability of the impact occurring, and the degree to which the impacts can be mitigated.

Table 6-1: Impact Assessment Methodology

Note: Part A provides the definition for determining impact consequence (combining intensity, spatial scale and duration) and impact significance (the overall rating of the impact). Impact consequence and significance are determined from Part B and C. The interpretation of the impact significance is given in Part D.

PART A: DEFINITION AND CRITERIA*					
Definition of SIGNIFICANCE		Significance = consequence x probability			
Definition of CONSEQUENCE		Consequence is a function of severity, spatial extent and duration			
Criteria for ranking of the SEVERITY of environmental impacts	H	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action.			
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints.			
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.			
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.			
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.			
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.			
Criteria for ranking the DURATION of impacts	L	Quickly reversible. Less than the project life. Short term			
	M	Reversible over time. Life of the project. Medium term			
	H	Permanent. Beyond closure. Long term.			
Criteria for ranking the SPATIAL SCALE of impacts	L	Localised - Within the site boundary.			
	M	Fairly widespread – Beyond the site boundary. Local			
	H	Widespread – Far beyond site boundary. Regional/ national			
PART B: DETERMINING CONSEQUENCE					
SEVERITY = L					
DURATION	Long term	H	Medium	Medium	Medium
	Medium term	M	Low	Low	Medium
	Short term	L	Low	Low	Medium
SEVERITY = M					

DURATION	Long term	H	Medium	High	High
	Medium term	M	Medium	Medium	High
	Short term	L	Low	Medium	Medium
SEVERITY = H					
DURATION	Long term	H	High	High	High
	Medium term	M	Medium	Medium	High
	Short term	L	Medium	Medium	High
			L	M	H
			Localised Within site boundary Site	Fairly widespread Beyond site boundary Local	Widespread Far beyond site boundary Regional/ national
SPATIAL SCALE					
PART C: DETERMINING SIGNIFICANCE					
PROBABILITY (of exposure to impacts)	Definite/ Continuous	H	Medium	Medium	High
	Possible/ frequent	M	Medium	Medium	High
	Unlikely/ seldom	L	Low	Low	Medium
			L	M	H
CONSEQUENCE					
PART D: INTERPRETATION OF SIGNIFICANCE					
Significance	Decision guideline				
High	It would influence the decision regardless of any possible mitigation.				
Medium	It should have an influence on the decision unless it is mitigated.				
Low	It will not have an influence on the decision.				

*H = high, M= medium and L= low and + denotes a positive impact.

This methodology was utilised by all specialists in order for the impact ratings to be comparable for consolidation within this Scoping Report (Including Impact Assessment). The methodology is qualitative but takes consideration of scientific data from each of the specialist investigations, as relevant.

6.2 IDENTIFICATION AND DESCRIPTION OF POTENTIAL IMPACTS

The construction, decommissioning and closure activities associated with the proposed heap leach facilities are similar in nature to that assessed and approved in the original Husab Mine EIAs. General construction activities have not been reassessed, except where the potential changes in environmental aspects and impacts associated with construction of the heap leach facility are significant. Impacts related to the operation of heap leach facility, and closure of the HLWF are discussed further in this report, as is retention of the construction water pipeline.

6.3 SECTION ONE: RETENTION OF THE CONSTRUCTION WATER PIPELINE

Swakop Uranium wishes to retain the installed 25 cm diameter temporary water supply line that was installed for water supply for the construction of the Husab Mine (Figure 5-1) and plant as a back-up water provision to the mine in times of high-water demand. This section provides an overview of the previously assessed impacts associated with the linear infrastructure (2011 EIA for Husab Mine's linear infrastructure (roads, pipelines, power lines etc.) (Metago, 2011). In addition, potential impacts were discussed with Husab Mine environmental department and commentary supplied in the Biodiversity Assessment.

The previous impact assessment included the potential disturbance due to the establishment of linear infrastructure in a relatively non-disturbed area. Note that retention of the temporary construction water pipeline is mainly administrative, as approval for the pipeline was given by the MEFT in June 2011.

6.3.1 Biodiversity

The Kahn River and its tributaries are important corridors for the movement of wild animals. The refurbishment and then maintenance of the pipeline may impact on fauna, when disturbed by these activities, or through accidents. The biodiversity specialist indicated that the **impact rating is low** for the retention of the pipeline. Mitigation measures include:-

- Adhere to the speed limit, no driving off track, and no driving in the area after sundown and before sunrise.
- Certain instances of injury to animals may be considered emergency situations. These will be managed in accordance with the Swakop Uranium emergency response procedure.
- No one may disturb, kill or collect any plant or animal. No wood may be collected.
- Protected species (i.e. *Vachellia erioloba*, *Faidherbia albida*, *Parkinsonia africana*, *Tamarisk usneoides*) will be avoided.
- All water leaks must be repaired within 48 hours of being detected.

6.3.2 Visual impacts and tourism

The visual character of an area is determined by considering landscape character, scenic quality, sensitivity of the visual resource, sense of place and visual receptors. The Khan Mine valley and the historic Kahn Mine buildings have tourism potential that should be preserved.

The pipeline has a **high visual impact** in the area as it is placed on surface alongside the gravel road (Figure 5-2) and is clearly visible. There is no mitigation measure other than burying the pipeline, but that would require a separate approval process.

6.3.3 Archaeological resources/heritage

There are several archaeological/heritage structures along the pipeline route that may be impacted by the refurbishment and long-term maintenance of the pipeline. Mitigation measures from the LEIA EMP are provided but potential impacts to archaeological/heritage site are rated as **medium**.

- The Khan Mine railway embankment which runs from the Khan Mine to Arandis must not be disturbed in any way.
- The old Khan Mine tailings material must not be moved or removed.
- All other archaeological sites along the track; grave sites, rubbish dumps, wells, camelthorn trees will not be disturbed in any way by the refurbishment and maintenance activities along the pipeline route.
- Erosion control measures are to be provided in areas where there is a risk of storm water damage to heritage sites caused by pipe bursts or deflection of the natural flow of storm water.
- No contractors or Swakop Uranium staff may make use of the buildings in the Khan Mine heritage site. The Khan Mine and other heritage sites along the route are strictly out of bound, i.e. as a No-Go Area;
- Driving off road is not permitted.

6.3.4 Surface rights and use of the Khan Mine valley road

Swakop Uranium does not have legal jurisdiction over the area through which the Khan Mine gorge track is located. The area falls inside a conservancy and land issues are managed by the state. Rössing Uranium holds EPL rights, and the Khan Mine (Pty) Ltd has a Mining Licence over sections of the route along which the pipeline runs. The road is also used by the Police, and by local tourists.

- Rössing Uranium and the new owner(s) of the Khan Mine (Pty) Ltd must be approached by Swakop Uranium to secure written permission to retain the pipeline over their EPL and Mining license respectively.
- If the Kahn Mine does reopen, their health and safety rules must be followed.
- The pipeline poses potential risks to third party users of the Khan Mine road should the pressured pipe burst, is accidentally impacted, or when inadvertent contact is made with metal rods holding the pipes steady.
- The existing pipes are close on 20 years old.
- All waste from refurbishing will managed as per Swakop Uranium waste management procedure.

6.4 SECTION TWO: HEAP LEACH FACILITY IMPACT ASSESSMENT

The specialists provided SLR with an impact assessment of the proposed heap leach facilities for site layouts Option G and Option H at the end of May 2021. These site layouts were developed on the original 2010 ecological sensitivity layout plans and, as a result, the HLF in Option G and HLWF in Option H were inadvertently partially placed in the No-Go zone, over Welwitschias and the Husab channel. The **updated ecological sensitivities** plan was provided to the Swakop Uranium technical team who, following discussion, agreed on Option K which is relatively like Option G.

Concurrently, several in-depth discussions were held between the air quality and biodiversity specialists, Swakop Uranium's environmental department and the SLR team regarding the potential impacts of the transportation and deposition of potentially acidic dust on vegetation under high velocity wind conditions, and the preferred placement of the HLF and HLWF.

Option K is the layout that is presented in this Scoping Report. The air quality, radiation and biodiversity specialists were requested to **provide comment** on the new position. The ground water and surface water reports **required remodeling**. All the updated reports are attached as appendices.

6.4.1 Soils

Information from the original EIA and EIA Amendment for the WRD were used for this section.

The footprint of the proposed heap leach circuit and its infrastructure will impact at least 216 ha of mostly undisturbed soils, only the primary crusher is in an area that has already been impacted by the ROM conveyor and the low-grade ore stockpile.

Soils are a significant component of most ecosystems. As an ecological driver, soil is the medium in which most vegetation grows and a range of vertebrates and invertebrates exist. In the context of mining and related infrastructure, soil is even more significant if one considers that mining is a temporary land use after which rehabilitation using stockpiled soil is the key to re-establishing post closure land capability that will support post closure land uses.

During the construction and operation of the heap leach waste facility there are several activities that have the potential to disturb soils through removal, compaction and/or erosion or through pollution by hazardous liquids or dustfall (also contaminated dust).

Physical soil disturbance can result in a loss of soil functionality as an ecological driver. In the case of erosion, the soils will be lost to the area of disturbance, and in the case of compaction the soils functionality will firstly be compromised through a lack of rooting ability and aeration, and secondly the compacted soils are likely to erode because with less inherent functionality there will be little chance for the establishment of vegetation and other matter that naturally protects the soils from erosion.

Various soil horizons (e.g. calcrete) and surface crusts have been identified by the soils, groundwater and biodiversity specialists. These features are probably important aspects of ecosystem functionality in the protection of soils from erosion and/or the retention of moisture in parts of the soil horizon. Soils can be conserved and reused but it is not yet clear whether the calcrete and crust layers can be effectively re-established with the same or similar material.

Pollution of soils by various means can result in a loss of soil functionality because it can create a toxic environment for vegetation, vertebrates and invertebrates that rely on the soil. It could also negatively impact on the chemistry of the soils such that current growth conditions are impaired.

The impact assessment rating for the loss of soil resource through disturbance and pollution is presented in Table 6-2 below.

Table 6-2: Soils Impact Assessment

IMPACT	SUMMARY MITIGATION		Severity	Spatial Scale	Duration	Consequence	Probability of Occurrence	Significance
Loss of soils resource through physical disturbance	Keep footprint to minimum. Strip and stockpile soil, replace on closure.	Unmitigated	M	L	H	M	H	High
		Mitigated	M	L	M	M	M	Medium
Loss of soil ecological functioning from pollution	Pollution prevention procedures	Unmitigated	M	M	H	H	H	High
	Effective storm water management system	Mitigated	M	L	M	M	M	Medium

Recommended mitigation measures

- Limit the disturbance of soils to what is absolutely necessary both in terms of site clearing and construction of the facilities. Clearly delineate No-Go areas.
- Where soils are to be disturbed the soil must be stripped, stored, maintained and replaced in accordance with the specifications of the soil management plan. Note: Experience has shown that very few mines ever have enough topsoil for rehabilitation.
- Pilot studies will be undertaken during the operation phase to determine the best method of re-creating the subsurface impermeable layer and crust layers and restoring their role as ecological drivers.
- Pollution prevention through basic infrastructure design, especially storm water management systems.
- Crushed ore and heap leach waste to be kept moist on conveyors; dust mitigation measures at all screening and tipping points.
- Emergency response procedures to enable fast reaction to contain and remediate pollution incidents.
- As part of closure planning, the designs of the HLWF must take into account the requirements for long term pollution prevention and confirmatory monitoring.

Two other concerns that were raised during this impact assessment process by the specialist are a) the possibility of acidic dust from the heap leach process contaminating surface soils, and/or causing damage to plant leaves, and b) the formation of a thin layer of fine dust, wetted by fog, that creates an impermeable barrier to rainfall infiltrating the soil. There is a paucity of information on these possible impacts, and detailed studies are thus recommended during the pilot plant trials.

6.4.2 Groundwater

Information for this section has been sourced from past ground water models, the Waste Rock Dump Expansion EIA Amendment and the 2021 SLR Groundwater Model Report and Impact Assessment Report (Appendix G).

Site layout Option G and Option H were modelled and assessed during May 2021 and the impact assessment indicated a preference for Option H over Option G, primarily because seepage below the HLF south of the plant would only penetrate about 20 below surface.

Option K was then agreed upon because the heap leach facilities were moved out of the No-go area. The groundwater dispersion model was modelling was redone and this section provides the results of that modelling and assessment.

Groundwater contaminants (see also Section 4.3.3)

The potential impact on groundwater would be due to the change in water quality because of possible seepage of pregnant liquor solution from beneath the HLP, or seepage of leachate from beneath the HLWF. Uranium is a likely contaminant in all seepage. Section 4.3.3 discussed the geochemical characterisation of regular waste rock, and that of the sub-economic material being stored near Pit Zone 2.

Golder Associates (2017) classified the heap leach waste as Type 3 which requires a Class C liner. The liner specifications for the HLWF are an engineered environmental Class C barrier comprised of a 300 mm clayey base layer overlain with 1.5 mm HDPE geomembrane, and then covered with a 100 mm thick silty sand or protection geotextile.

Modelling results

According to the model report (SLR, 2021), the transient non-reactive transport simulations indicate potential leachates from the HLFs leach pad and HLWF, in the worst-case scenario (high rainfall ingress, coupled with acid rock drainage and little neutralisation potential), will be stored in the sediments underlying the facility and will not migrate horizontally to any significant extent (Figure 6-1). Additionally, vertical migration of contaminated seepage will be limited to 60 m below the HLF and 80 m below the HLWF, and no significant migration of the contaminant plume was predicted.

Drawdown cone zone of influence

The extent of the water level drawdown cause by Pit zones 1 and Pits Zone 2 was modelled for the end of LOM by SLR in 2016. Figure 4-21 shows the extent of the 1-10 m contour for the LOM drawdown. Ideally, any potentially seepage generating mine infrastructure should be placed within the drawdown cone as an additional protection measure against ground water pollution because of seepage.

For Option K the HLP is within the drawdown cone. This facility will however be removed in its entirety once heap leaching is completed. A portion of the HLWF is within the end of LOM drawdown cone. Ground water flow in the area is toward the north-west toward the WRD and will continue into the drawdown cone.

Rating of Impacts

The potential impacts on ground water are rated according to the worst-case scenario, which is heavy rains, waste that has high acid rock potential and low neutralising potential. The liners for the HLF and HLWF must be in place as per the specifications, without the liners the radiation assessment would consider the facilities to be fatally flawed.

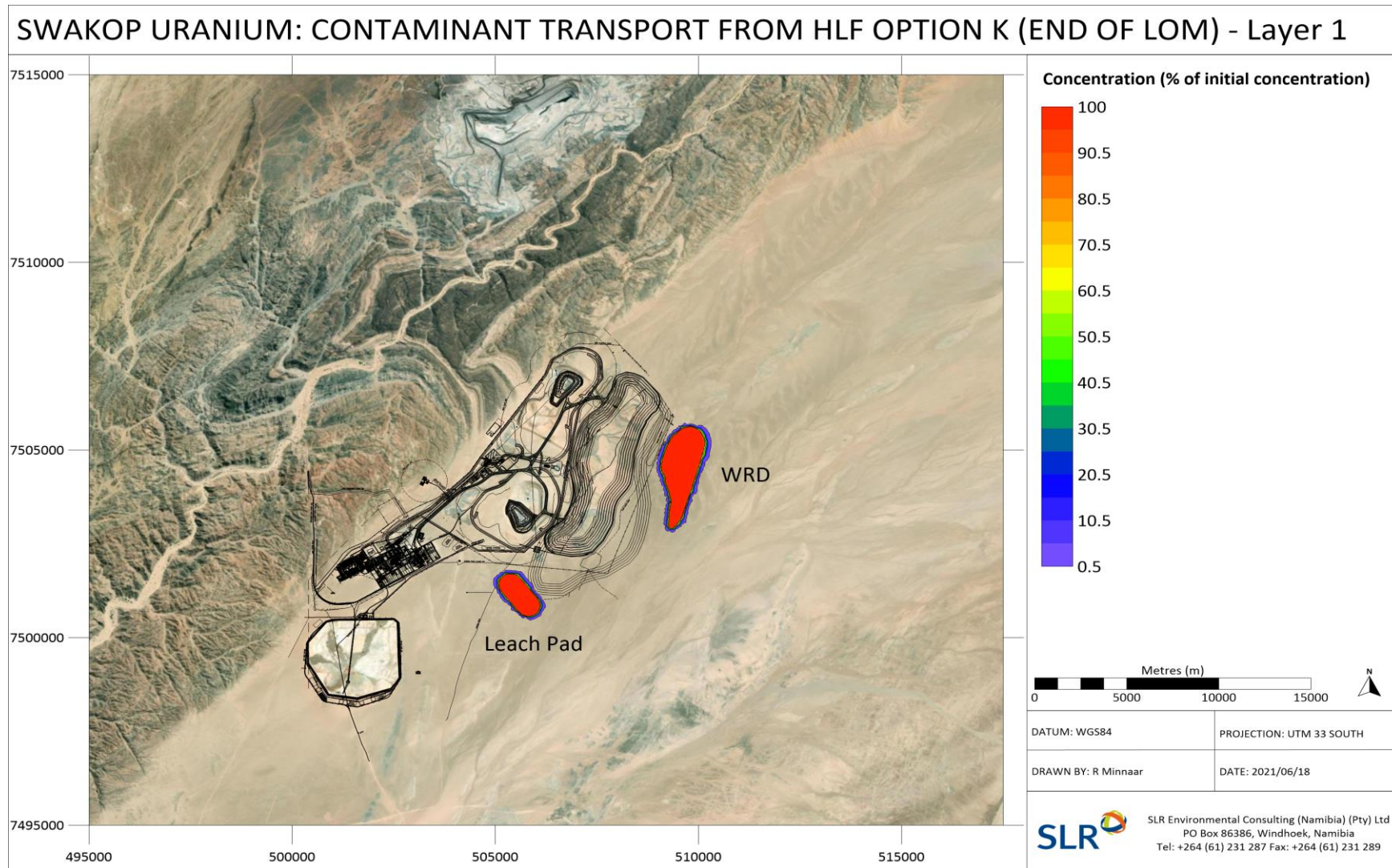


Figure 6-1: Simulated Spreading of Potential Plume Emanating from the HLF After LOM for Option K Model Layer 1

Table 6-3: Groundwater Impact Assessment

IMPACT	SUMMARY MITIGATION		Severity	Spatial Scale	Duration	Consequence	Probability of Occurrence	Significance
Deep groundwater contamination due to seepage and recharge by contaminated leachate from the HLF, potential AMD and run-off from HLWF	The HLF and HLWF are correctly lined, liner stays intact, and the correct storm water control measures are in place.	Worst case	M	L	H	M	H	Medium
		Mitigated	L	L	H	M	L	Low
Shallow groundwater contamination due to seepage and recharge by contaminated leachate from the HLF and potential and run-off from HLWF	The HLF and HLWF are correctly lined, liner stays intact, and the correct storm water control measures are in place.	Worst case	H	M	H	H	H	High
		Mitigated	M	M	H	M	L	Low

Recommended mitigation measures

- Both the HLF and HLWF is to be constructed with a Class C liner as a primary mitigation measure, and thus potential for seepage into groundwater is likely to be very low. The liner must conform to the standards specified.
- The HLF is within the LOM drawdown cone for the mine and will be removed entirely at the end of LOM. No further groundwater impacts should occur thereafter.
- Proper stormwater management is required to prevent runoff reaching the shallow Husab channel, and subsequently the shallow perched alluvial aquifer, feeding downstream Welwitschias.
- The HLF and HLWF require additional design mitigation measures to ensure that storm water does not spill into the environment with 1:50 rainfall events. To this end the surface water report (SLR 2021) provides a design for storm water collection and storage, but the HLWF must also be designed with footwalls that prevent underflow emanating from the heap following storms.
- All piping to and from the HLF and the existing plant must be in a lined channel. Dirty storm water pumped from the SWDs must also be contained, special mitigation measures are required for the section from the HLWF across the Husab channel/diversion.
- On closure, the HLWF must be closed with an engineered capping that reduces rainfall ingress to limit long term potential seepage and which prevents wind erosion of the waste.
- Provision must be made in the HLWF design for the proposed channel diversion to be constructed around the proposed expansion of the current WRD.
- The HLWF infrastructure should be located 100 m from the Husab channel and the other channel to the east to further limit the impact of potentially contaminated run-off from reaching the channels.

- It should still be established if any pathway from the source to the receptor exists through a source-pathway-receptor assessment is required to assess whether numerical modelling of downstream risk is required.
- Two additional pairs of shallow and deep ground water monitoring boreholes must be drilled between the Husab canal diversion and the HLWF (red dots in Figure 4-5). (Boreholes are already planned in the vicinity of the HLF for the extended WRD).

Appendix G provides the full Groundwater Assessment Reports.

6.4.3 Surface Water

Potential impacts on surface water can result primarily as a result of dirty/contaminated stormwater water running off the surface of the mine site and infrastructure facilities and into the environment and water courses causing pollution. Siltation of water channels could also occur because of erosion by storm water runoff of disturbed surfaces, or waste rock and heap leach slopes. The construction of infrastructure within catchments, or across, or within a stream channel also impacts on the total catchment yield, or impedes or stream flow, or disturbs the natural course of the water flow, respectively.

Storm water management plan (SWMP)

The design of an integrated storm water management plan for a mine is important, more so if the commodity being mined is potentially hazardous to human health and/or the environment. The planned heap leach process for the Husab mine is to extract uranium from low-grade ore utilizing sulphuric acid. Both the product and by-products of the heap leach processing are hazardous, and measures must be implemented in terms of Namibian legislation pertaining to mining, radiation and environmental protection (Section 3.1).

The Surface Water report in Appendix H provides concept design specifications for dirty water management systems for the HLF and HLWF. The SWMP was developed based on the “South African Regulations on Use of Water for Mining and Related Activities aimed at the Protection of Water Resources” (GN. 704 of 1999) and incorporates mitigation measures to reduce impacts on existing surface water resources with respect to water quality and quantity. In developing the concept SWMP the following mitigation measures to address these identified concerns the following design criteria was used:

- Capacity: dirty water systems will be designed, constructed, maintained, and operated so that they are not likely to spill into a clean water system or the environment more frequently than once in 50 years.
- Conveyance: all water systems will be designed, constructed, maintained, and operated so that they convey a 1:50 year flood event.
- Freeboard: as a minimum, any dirty storm water dams will be designed, constructed, maintained, and operated to have 0.8m freeboard above full supply level.
- Collect and re-use: dirty water will be collected and re-used as far as practical.
- Diversion: flow of any surface water or floodwater into operational areas will be minimised.

Open channels with a trapezoidal cross-sectional area are designed to flow into a storm water dam sized for each facility, the HLF and HLWF. The dams are to be equipped with pumps so that storm water run-off can be pumped to existing the plant for use, or disposal on the TSF, when large storm events occur.

The SWMP report has reiterated the need for collection channels or toe paddocks around the perimeter of the WRD to collect dirty runoff, as per the requirements of the approval of the WRD expansion. It is anticipated that these perimeter channels/ toe paddocks may be designed to feed into the HLP collection channels. The lining of these will needs to be considered based on the water quality assessment of the WRD runoff.

Impact on catchment yield

This impact is assessed qualitatively. Figure 4-6 and Figure 4-12 in Section 4 provide a picture of the catchments that occur on the Husab Mine site and which feed the Welwitschia field south of the mine. Three of the smaller catchments have already been reduced significantly by the placement of the mine, processing plant, tailings storage facility and the waste rock dump. The proposed expansions of the WRD requires the Husab channel to be diverted to ensure that surface water flow along this important feeder to the Welwitschias is not impeded. The placement of the HLF and the HLWF in Option K has taken drainage lines into consideration and the structures have been placed out of the major channels.

The relatively small reduction in catchment yield that occurs because of the HLF and HLWF is as a result of the capture of dirty stormwater on these facilities, and the loss of that volume of water to the natural system.

Prevention of pollution

Other than the development and implementation of a SWMP, pollution of surface water courses could occur through poor hazardous materials handling and storage. Swakop Uranium's Standard Operating Procedures for Hydrocarbon and hazardous material management must be followed.

Impact Assessment

The proposed heap leach mining project designs include various mitigation by design measures embedded in the SWMP model development. Theoretically, without these measures, the impacts on the environment would be much higher, although the mine would not be allowed to proceed without compliance with Namibia's Radiation and Environmental Regulations.

The impacts of the proposed activities and the infrastructure are identified and assessed based on the impact's magnitude, as well as the receptor's sensitivity, culminating in an impact significance for the most important impacts are provided in Table 6-4 below.

Table 6-4: Surface Water Impact Assessment

IMPACT	SUMMARY MITIGATION		Severity	Spatial Scale	Duration	Consequence	Probability of Occurrence	Significance
Baseline surface water quality affected by sediment and silt	Correct stormwater management systems for construction, operations	Unmitigated	H	M	H	M	M	High
		Mitigated	L	M	L	L	L	Low
Baseline surface water quality affected dirty water runoff	Correctly designed and implemented stormwater management system for operations	Unmitigated	H	H	H	H	H	High
		Mitigated	L	L	L	L	L	Low
Reduced catchment runoff	Catchment already reduced, but HLWF and HLP removes clean water from system	Unmitigated	L	M	L	L	L	Low
		Mitigated	L	M	L	L	L	Low

Mitigation Recommendations

The concept SWMP presented in this report was developed based on applicable legislation and guidelines and incorporates mitigation measures to reduce impacts on existing surface water resources with respect to water quality and quantity. A summary of the proposed mitigation measures follows:

- Separation of clean and dirty water by the proposed stormwater infrastructure
 - Collection and containment of dirty runoff from proposed mining activities, within infrastructure sized to accommodate the 1 in 50-year, 24-hour duration storm event.

Dirty water conveyance infrastructure at the plant is sized for flows during a 50-year 24-hour event using the SCS method. GN 704 requires that dirty water containment facilities are designed, constructed, maintained and operated so that they are not likely to spill into a clean water environment more frequently than once in 50 years. The dirty water containment facilities in this case do not spill, due to the presence of uranium and therefore the chance to cause radiation. A critical component in sizing the containment pond is the rate at which water is pumped from the pond for re-use/disposal at the main plant. GN 704 also requires that as a minimum, the 1:50 year design volume and a 0.8 m freeboard allowance should always be available.

In addition to the measures that are implicit in the SWMP, the following management measures, including some developed for ground water mitigation, are planned for implementation:

- The HLF and HLWF require additional design mitigation measures to ensure that storm water does not spill into the environment with 1:50 rainfall events. To this end the surface water report (SLR 2021) provides a design for storm water collection and storage, but the HLWF must also be designed with footwalls that prevent underflow emanating from the heap following storms.
- However, due to the presence of uranium, and therefore the chance to cause radiation contamination, it is recommended that the SWD dams be sized for a higher design flood, or that additional buffer storage is provided that is greater than the 1:50 year 24-hour rainfall event. A precautionary principle has thus been applied by the surface water specialist and the capacities of SWD for the HLF and HLWF are therefore increased to 15 000 m³ and 30 000 m³ respectively.
- On closure, the HLWF must be closed with an engineered capping that reduces rainfall ingress to limit long term potential seepage and which prevents wind erosion of the waste.
- Provision must be made in the HLWF design for the proposed channel diversion to be constructed around the proposed expansion of the current WRD.
- The HLWF infrastructure should be located 100 m from the Husab channel and the other channel to the east to further limit the impact of potentially contaminated run-off from reaching the channels.
- Infrastructure design: the design of all onsite access roads, plant areas, stockpiles, heap leach areas etc. will consider stormwater management and erosion control during both the construction and operational phases.
- Good housekeeping practices will be implemented and maintained by clean-up of accidental spillages, as well as ensuring all dislodged material like run-of-mine stockpile is kept within the confined storage footprints. In addition, clean-up material and materials safety data sheets for chemical and hazardous substances will be kept on site for immediate clean-up of accidental spillages of pollutants.
- Regularly scheduled inspection and maintenance of water management facilities, to include inspection of drainage structures and liners for any in channel erosion or cracks; de-silting of silt traps/sumps and PCDs; and any pumps and pipelines should be maintained according to manufacturer's specifications.
- Vehicles or plant equipment servicing will be undertaken within suitably equipped facilities, either within workshops, or within bunded areas, from which any stormwater is conveyed to a pollution control dam, preferably after passing through an oil and silt interceptor.

- Pollutant Storage – any substances which may potentially pollute surface water will be stored within a suitably sized bunded area and where practicable covered by a roof to prevent contact with rainfall and/or runoff, and
- The mine plans will install runoff gauging stations in the Husab riverbed upstream and downstream of the diversion.

All measures implemented for the mitigation of impacts, will be regularly reviewed as best practice and as compliance with various licences issued on site by authorities.

See Appendix H for the Surface Water Report.

6.4.4 Biodiversity

The identified potential biodiversity impact factors involved in the proposed HL project are discussed in this subsection. The information below is taken directly from the Biodiversity Specialist Report (Wassenaar; 2021).

Dust as a plant stressor

Dust consists of particulate matter that is small enough to be raised and carried by wind. Many industries, and especially mining, are associated with particulate emissions ranging from carbon soot to mineral dust (Farmer, 1993). Dust is mostly viewed from the perspective of its effects on human health (Radiation Section 4.8 and 6.4.7), but it has been shown to affect plants' physiological processes – and thus presumably also their 'health' – through a number of pathways (Grantz et al., 2003).

Dust and photosynthesis

The effect of dust on plants photosynthetic ability differs: -

- according to the particles' size distribution and shape and their chemical characteristics (Farmer, 1993; Grantz et al., 2003);
- whether dust clogs stomata, causes physical damage, or decreases the amount of photosynthetically active radiation (PAR) reaching the photosynthesis apparatus (Van Heerden et al., 2007);
- if dust increases leaf temperature because of a net absorption of infrared radiation (Grantz et al., 2003),
- or could be a combination of some or all of the above.

Clogging of stomata results in a decrease in the amount of CO₂ that can be assimilated during photosynthesis. This aspect, together with the blocking of PAR, is the best studied mechanism. During mining, dust is mostly produced and subsequently dispersed after an event that disturbs the soil surface, like blasting, moving soil with front-end loaders or trucks driving on loose material (Petavratzi et al., 2005).

It is therefore not always a continuous phenomenon, being associated with events that occur at certain times of day. In this regard, the timing of dust dispersion matters for plants: if it is deposited when the stomata are closed (at night for C3 and C4 plants, in the day for CAM plants), it interferes less with the photosynthesis process than if it is deposited when the stomata are open (Hirano et al., 1995).

Size is the second factor that modulates the clogging effect – smaller particles tend to be more effective at blocking the stomatal opening than larger particles do (Hirano et al., 1995). The size of a typical stoma on a *Welwitschia* plant is 10 µm, about the same as the largest dust particles that fall in the PM10 class. Hence, if the dust source contains a relatively large fraction of PM10 class particles, this effect of clogging is likely to be greater. Clogging further depends on the distribution of stomata on leaves.

For example, *Welwitschia* leaves have equal numbers of stomata on the upper and lower surfaces (Krüger et al., 2017). Dust deposition on these leaves will thus affect principally the stomata on the upper leaf surface, leaving the lower stomata open to allow gas exchange, but presumably at least partially affecting water use efficiency and gas exchange. The stomatal distribution of other desert plants of the area has not yet been studied in detail.

The decreased amount of PAR reaching the cells and photosynthesis apparatus results in a decreased amount of electron transport along the photochemical pathway, thus decreasing the amount of carbon that can be assimilated (Sharifi et al., 1997; Van Heerden et al., 2007). Physical damage can be caused through abrasion as a result of high windspeeds during east wind conditions (Figure 6-2); this is quite common in the Namib and especially *Welwitschia* leaves can be damaged in this way (AWR 2021).



Figure 6-2: A) The photograph on the left is an example of a *Welwitschia* leaf that has been abraded by dust carried by the strong east winds. B) The photograph on the right shows the deposition of dust on the lee of *Welwitschia* plants resulting from strong east wind conditions.

Dust shape

Naturally occurring desert dust is probably rounded due to constant abrasion, whereas dust created by blasting and crushing is more angular, and the sharper/rough edges can cause physical damage to the plant leaves (and stems) (Van Heerden et al., 2007). The various effects described above have all been documented to lesser or greater degree, but there is still confusion about the extent of damage that will result in either decreased productivity, or decreased reproduction or in plant death.

Monitoring at the Husab Mine has only shown an indication of a relationship between dust load and plant health where some mortalities of plants close to the pits where dust loads are truly excessive ($> \sim 500\text{mg}/\text{m}^2/\text{day}$). The physiological effects and secondary losses of plant material through abscission of leaves can be reversible if the stressor is removed (Van Heerden et al., 2007; Bao et al., 2016), with some indication that growth rates can be affected depending on the type of dust (Bao et al., 2016). However, continued stress caused by abrasion on desert plants by sharper particles will affect plant health and perhaps hamper the plants growth or survival.

Fine dust layers on soil

An additional pathway for an impact to occur to plants is the caking of the surface of the soil by fine particles that forms a physical crust when receiving low moisture additions (such as would happen in a fog or light rainfall event). This pathway has received scant attention in the literature. Observations made at Skorpion Zinc mine at

the start of mining in 2000 showed that a fine dust layer, wetted by fog, reduced the movement of the usually mobile desert sand and seedbank (Pers. Comm., M Louw).

Heavy rainfall and hoof action of grazing animals can break such a crust quickly, but it is possible that it might have enough effect to decrease the amount of water infiltration from local rainfall. Additionally, the pH of the dust may further affect soil nutrient availability (Grantz et al., 2003).

Dust acidity

There is surprisingly little known about the role of dust pH in damaging plant tissues. Some research has shown that alkaline or acidic particulate matter can cause cell death through focal plasmolysis (Farmer, 1993; Grantz et al., 2003). Most documented general toxic effects of dust particles on vegetation are linked to their acidity, trace metal content, nutrient content, surfactant properties, or salinity (Grantz et al., 2003), but the levels at which significant plant damage occurs are still a bit of a mystery, particularly for pH. The implication of this uncertainty is that the potential for impacts as a result of highly alkaline (caustic) or acidic (corrosive) dust should be assessed with the precautionary principle until more is known about potential impacts.

Figure 6-2 shows how dust accumulated in the lee of plants as a result of the sand moving easterly winds. The issue of potentially acidic dust from the HLF and HLWF should be tested by the pilot plant.

Water stress

This subject was described in great detail in the biodiversity assessment for the proposed expansion of the waste rock dump (Wassenaar, 2018). The discussion in an appendix to the 2021 Biodiversity report (Appendix I).

Several lines of evidence suggest that variable, irregular surface flows in the ephemeral drainage lines on the gravel plains are most likely critical for the survival of at least the Welwitschia plants and most likely for all the other local perennial shrub species. All of these, and especially the Welwitschia plants, occur near such drainage lines at the bottom end of long ephemeral catchments. The details of the surface and sub-surface hydrology could be interesting, but the report by Wassenaar (2018) suggests that the persistence of these plant species depend on these drainages simply being kept patent. Any interference with surface flows is thus likely to lead to downstream impacts on plant vitality and ultimately on population health.

Biodiversity impact assessment - Flora

The biodiversity assessment of Option G and Option H indicated a slight preference for Option G. Both Options are discussed in the report (Appendix I) but only impacts related to Option K are provided here (Figure 6-3).

- Interference with water supply to the Welwitschias (Option K)

The viability of the population of Welwitschia plants to the south of the mine critically depends on uninterrupted surface flows in the numerous catchments that feed into the main drainage of the plain south of the mine (Wassenaar, 2018). Although the HLWF for Option K misses the drainage lines as well as the proposed bypass channel for the expanded main WRD (Figure 6-3, arrows 2 and 3), it is still at this stage a concept outline. There is therefore a chance that the final drawings will not entirely avoid these critical drainages. Should this occur, the water that could have been transported downstream to the Welwitschias after a large upstream rain event, will be prevented from doing so, thus raising the risks to the plants.

Additionally, at the point where the conveyor belt crosses the Husab Channel (Figure 6-3, arrow 4), the siting of support structures for the belt could interfere with water flow.

- Destruction or damage to Welwitschia plants underneath or in the vicinity of the conveyor belt (Option K).

Individual plants may be damaged or destroyed during the construction of the conveyor belt, its support structures and any service roads along the infrastructure. The loss of any single plant represents a loss of reproductive potential and therefore an increased risk to the population. However, the total number of plants at risk is a very small percentage of the total population, hence the significance of this impact is already not large.

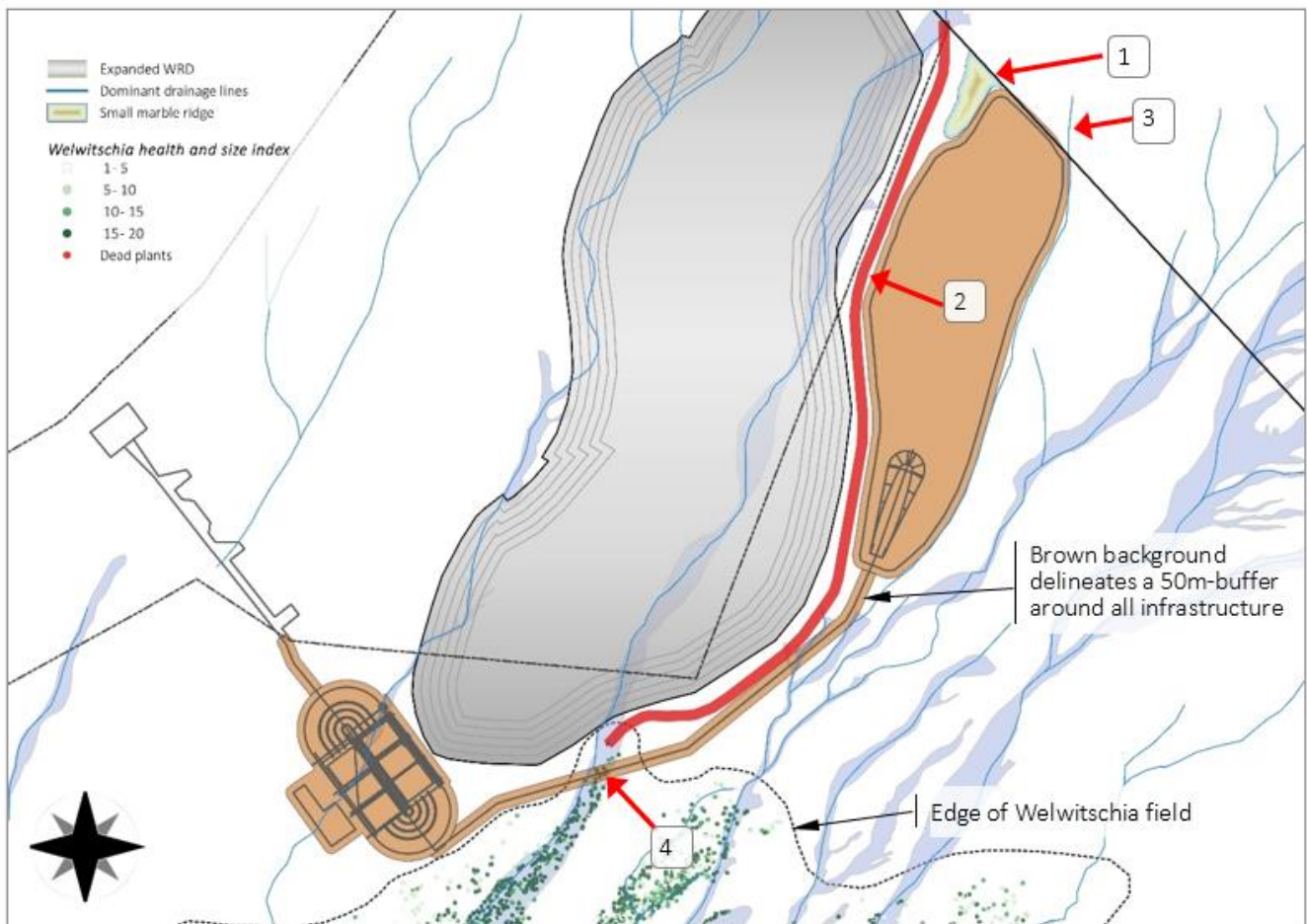


Figure 6-3: Layout and location of Option K (HLWF has idealised shape and is off the sensitive koppie)

- Note that the shape and location of the HLWF in this layout is approximate, as it was digitised by eye from a supplied image. Key issues to avoid in final design of the HLWF are indicated with red arrows:
- Arrow 1 points to the location of a small marble ridge, considered to be sensitive to disturbance on biodiversity grounds – this should be avoided.
- Arrow 2 points to the approximate position of the proposed bypass channel for the expanded WRD.
- Arrow 3 points to the location of a minor drainage line that should be avoided.
- Arrow 4 indicates the point where the conveyor belt will cross the main Husab Channel as well as some Welwitschia plants. Construction here requires a specific Standard Operating Procedure to ensure avoidance of plants and avoidance of obstruction of water flow. Additionally, at the point where the conveyor belt crosses the Husab Channel (Figure 6-3, arrow 4), the siting of support structures for the belt could interfere with water flow.
- Dust deposition on the plants growing on the marble ridges downwind of the HLF and on the Welwitschia plants downwind of the HLWF and HLF.

This impact is relevant to all biodiversity but for Option K it relates to two sites of special biodiversity interest, namely the protected plant species on the main marble ridge and the Welwitschia plants in the large population to the SW of the project. A large source of dust emissions potentially emanates from the HLF itself when the ore is deposited and then reclaimed, and this facility is located only about 1 km from the high-

diversity areas of the main marble ridge and from the edge of the Welwitschia field in a south-westerly direction.

The overall risk that dust will affect plant (or other organisms) health is a function of 1) the total dust load of the various particulate sizes per day and per year, 2) the distribution of wind directions and velocities at different times of the year, 3) the likely fallout pattern (plus the location of the dust sources relative to the biodiversity features of interest), 4) the chemical nature and physical shape (including angularity) of the dust.

- ***Likely sources and loads of dust emissions:*** With heavy dust loads¹, plants can be physiologically compromised or die. Several mechanisms are involved in dust impacts, including clogging of stomata, interference with photosynthetically active radiation, and increases in leaf temperatures. All these mechanisms can result in compromised photosynthesis and water conservation.

Total dust emissions are expected to be relatively low, especially with mitigation, at least as a fractional contribution by the HL project to the overall dust emissions, but the area close to the HLF will experience dust loads exceeding national safety standards. Observations of the situation of plants growing in close vicinity to the pits, it is likely that the plants immediately adjacent to the HLF will experience dust loads high enough to cause permanent damage and death.

The sources of dust for Option K may be slightly lower than Option G as the HLF is now tucked away in the lee of the WRD which may afford some protection from the easterly winds. The HLF is located slightly further away from the Welwitschia field, with the bulk the HLWF mass even further away. Despite the altered locations the HLF is still close to the welwitschia plants which increases the chances that dust will reach some of the closer plants.

- ***Distribution of wind directions and velocities:*** In the context of producing an impact on biodiversity, the north-easterly and easterly winds are the most relevant because these are most likely to disperse wind-eroded dust from the HLWF and the HLF itself towards the Welwitschia population and onto the marble ridge.

Although the expected dust loads may thus be low on average, there is a chance that dust can be transported towards the biodiversity features during a significant part of the year when wind speeds from the north-east are in excess of the minimum threshold for lifting and transporting dust particles for at least 15% of the time between June and August (Liebenberg-Enslin, 2021). This risk is currently unknown, but the dispersion model's fallout pattern suggests that risk is present (Figure 6-4)

- ***The likely fallout pattern:*** Liebenberg-Enslin (2021) simulated the dispersion of dust from the base case option (Table 5-4). In this scenario, the main infrastructure is located to the SE of the main WRD, with the HLWF between the HLF and the park boundary (Table 5-4). She considered the primary source of dust to be the crusher, which is located in the plant area near the pit (and thus for all practical purposes not important in terms of biodiversity impacts), followed by the HLF with almost no contribution from the HLWF. The dispersion model, clearly following this scenario (Figures 17 to 31 in Air Quality Assessment, Appendix F) predicts for almost all unmitigated scenarios and for many of the mitigated scenarios, that especially PM10 fallout will reach a significant number of plants in the Welwitschia field.

The likelihood that dust from the HLWF will reach the plants for more than 30 days in the year to be at least moderately high (for HLWF) and high (for HLF), even though the total amounts might be relatively small, especially for the fraction larger than PM10.

¹ There is not good data to define what is meant by "heavy" dust loads. Plants inside the unmitigated dispersion zone of the current dust dispersion model for Husab Mine typically receive more than 150 and up to 1,700 mg/m²/day (Wassenaar, 2018), with the plants near the pits receiving the highest loads. These plants are all physiologically compromised, and those that received the highest loads have died. However, the relationship between plant health and dust load remains poorly clarified, and particularly the potential multiplier effect of high or low pH of dust.

- **The issue of acid dust:** The pH of the waste material in the HLWF, and thus also the pH of any dust emitted from there, will be between 4.5 and 5.2, enough to be considered a skin corrosive and eye irritant (Golder Associates, 2017). A pH lower than neutral is likely to have corrosive effects on plant tissues, which will be multiplied over time and with fog precipitation, thus exacerbating any existing damage as a result of natural dust scour. There is however surprisingly little information available on this aspect (see Section 0 above), with the result that it is difficult to gauge the risk to the plants.

Table 6-5 below provides the impact rating for Option K for unmitigated and mitigated scenarios.

Table 6-5: Biodiversity Impact Assessment

IMPACT	SUMMARY MITIGATION		Severity	Spatial Scale	Duration	Consequence	Probability of Occurrence	Significance
Interference with water supply to the Welwitschia field	Keep infrastructure 50m from channels, construct bridge for conveyor over Husab channel.	Unmitigated	M	M	H	H	M	High
		Mitigated	L	L	L	L	L	Low
Destruction of or damage to Welwitschia plants underneath or in the vicinity of the conveyor belt (Option K).	No structure within 30 m of a WW plant, service road carefully placed	Unmitigated	M	L	H	M	M	Medium
		Mitigated	L	L	L	L	L	Low
Dust deposition	Dust suppression as per air quality report, pH of material on conveyor as neutral as possible	Unmitigated	H	M	H	M	M	High
		Mitigated	L	L	M	L	L	Medium
Destruction of the gravel plain vegetation patches and the ecological engineering effect of gerbils	Only mitigation is to place HLWF elsewhere. Cumulative impact.	Unmitigated	L	L	M	L	L	Low
		Mitigated	L	L	M	L	L	Low

Biodiversity impact assessment - Fauna

Destruction of the gravel plain vegetation patches and the ecological engineering effect of gerbils that excavate their burrows here, have consequent knock-on effects on plant productivity and large herbivore presence. A Master's level study conducted on the role of gerbils as ecological engineers has conclusively shown that these small mammals are critical for the maintenance of vegetation productivity on the gravel plains. The enhanced productivity of the naturally occurring vegetation patches is quite likely the reason why zebras are resident in this hyper-arid zone.

A study conducted for Swakop Uranium's biodiversity monitoring programme has shown that the zebras do indeed utilise the area in question. The destruction of these vegetation patches and the removal of the gerbils will thus lead to an unknown reduction in the number of zebras that can be supported in this area, as well as to a reduction in the time that they can spend here.

None of the significant impacts are likely to cause an extinction of a species. Although there is not enough data to make confident statements about current probability of extinction for all the species involved, it is also unlikely that the loss of plants on the marble ridge or even some *Welwitschia* plants will significantly increase the chances of local extinction of any particular species.

However, the impacts are to protected species, raising the significance of the impact. Moreover, the impacts could significantly affect the local populations and could, in the long-term, cause an additional risk to the occurrence of a specific species in this area.

Mitigation Recommendations

- Ensure that design specifications for the HLWF includes explicit instructions to keep all infrastructure edges at least 50 m, (preferably 100 m), away from the closest edge of recognisable drainage channels as well as from the bypass channel (see Figure 6-3). Keep HLWF off the sensitive koppie in the north.
- Locate the HLWF as far away from the *Welwitschia* field as possible and shape the HLWF to reduce the potential the movement of dust by wind erosion.
- Locate the HLF as far from the marble ridge and *Welwitschia* field as possible to minimise the impact of dust.
- Construct a bridge to support the conveyor belt where it crosses the Husab Channel (Figure 6-3, arrow 4). No support structures should be built inside the channel itself.
- Ensure that design specifications for the conveyor belt clearly specifies that no structure may be erected closer than 30 m from any individual *Welwitschia* plant.
- Similarly, the design specifications for any service roads should make it clear that the edge of the road should not come closer than 30 m from the nearest individual *Welwitschia* plants.
- Draft a Standard Operating Procedure for locating, marking and avoiding individual plants during construction of the conveyor belt and any service road.
- Apply all dust reduction mitigations proposed by Liebenberg-Enslin (2021). Ensure that the leached material remains moist until the point where it is loaded onto the conveyor belt for transport to the HLWF. Ensure that material being transported on the conveyor belt remains moist enough to decrease the production of dust to almost zero.
- With the significant uncertainty around the effect of acidic dust on plant leaves (*Welwitschia* and other species), additional dust buckets should be placed in several locations around the main dust sources to monitor both dust loads and pH of dust. Simultaneously, the health of plants near the dust buckets should be estimated using different indicators and correlated with dust levels and pH, while comparing with control plants that are outside the zone of potential risk. Should there be any indication of damage to the relative health of these plants, further systematically controlled investigation may be necessary to determine the probable cause, and mitigations should be reviewed and improved.
- Ensure that the pH of material being transported to the HLWF is as close to neutral as is possible (pH 6 to 7).
- All efforts must be made to prevent physical harm to fauna in the footprint of the HL circuit infrastructure during vegetation and topsoil removal.

Option K was the preferred option of the three that were formally assessed by the biodiversity specialist. There are however a few caveats and conditions to this evaluation.

- The potential corrosive nature of the dust is entirely unknown. It may turn out to have a minor effect at the pH levels of the waste material (4.5-5.2), or it may not. Also, the corrosive effect is unlikely to be significant unless the dust is wetted by fog (rain would probably just wash the dust off). Hence, the overlap of fog days with strong wind days will be a major determinant of the severity of the effect. Fog peaks in the summer, so high dust loads in the winter, as occurs with NE and E winds, will theoretically mean a significantly lower risk. However, none of this is yet known. The uncertainty increases the risk assessment enough to strongly recommend an intensive monitoring of dust loads and their potential effects on the plants around the HLF.
- In addition, the cumulative impacts on the ecological engineering function adds an unmitigatable effect that would represent a residual impact for the whole Husab project. As such it would be a candidate for calculating biodiversity offsets², but magnitude is still unknown. This should be quantified before an offset is determined.

6.4.5 Air Quality

Airshed undertook a quantitative assessment on the Base Case layout option, and qualitatively assessed Option G and Option H. Airshed was asked to provide opinion on the preferred Option K and this is included in the Air Quality report provided in Appendix F.

Assessment of Impacts

Four locations were considered for the HLF – the Base Case (the air quality study preferred option), and Option G, Option H and Option K, as shown in Table 5-4.

The Base Case location was **quantitatively** assessed, both as stand alone, and cumulatively with the existing mine and plant; the dispersion models diagrams provided reflect this (Figure 6-4). Options G, H and K were **qualitatively** assessed based on the results from the Base Case (Table 5-4). This approach assumes the low-grade ore throughput to be the same for all options, including the HL pad and waste storage facility areas and heights. The main pollutant of concern from the heap leach process circuit is particulate matter that primarily results from the crushing and screening operations, followed by materials handling.

Wind erosion is an intermittent source of emission likely to occur for only 15% of the time (when the wind exceeds 5.4 m/s), and only when the HL material is dry (during stacking and reclaiming). It could, however, result in significant short-term impacts when incidences of high wind speeds occur.

The air quality dispersion model assumed the mitigation measures and control efficiencies for the mitigated scenario as shown in Table 6-6: Assumed Mitigation Measures and Associated Control Efficiencies Table 6-6.

During the leaching process at the HLF, very low concentrations of sulphuric acid mist are expected due to very low saturation concentrations in the air and the likelihood that the spray droplets would deposit close to the application unless it is very fine and there is a strong wind present. Also, as indicated by the Golder report (Golder Associates, 2017), the chemical composition of the waste material will pose a low health risk.

Dispersion simulation results from the Base Case location indicate that both PM_{2.5} ground level concentrations (Figure 6-4) and dustfall rates resulting from the heap leach project only are restricted to the area around the HLF and HLWF, with low GLCs off-site and at the air quality sensitive receptors even without mitigation. With mitigation in place, these impacts are lower and impact smaller areas on-site.

² The current policy environment in Namibia does not allow a feasible route to biodiversity offsets, but there are encouraging signs that this will change in the near future.

Table 6-6: Assumed Mitigation Measures and Associated Control Efficiencies

Source	Mitigation	Control Efficiency (%)
Materials Handling	Dust suppression at Primary and Secondary Crushers using a chute	75% for telescopic chute with water sprays
	Dust suppression through water sprays at HPGR and agglomeration area	50% for water sprays
	no information on stacking and leaching - assumed no mitigation	0%
Crushing & Screening	hooding with fabric filters	83%
Conveyor	roof and one side covered	50%
Service Road	Watering (minimum application rate of 2 litres/m ² /hour)	50%
Wind Erosion	No mitigation assumed	0%

Over an annual average, the HL Project contributes between 1% and 6% to the cumulative PM_{2.5} GLCs at the AQSRs, and between 0% and 12% to the dustfall rates. It must be noted that these cumulative PM_{2.5} concentrations and dustfall rates are very low and well below the AQOs. Simulated PM₁₀ GLCs, on the other hand, resulted in high short-term impacts on-site and contributing up to 41% of the 24-hour AQO concentration (75 µg/m³) at the nearest AQSRs when unmitigated. With mitigation in place, the impacts reduce, covering smaller areas around the crushers and screens, materials transfer points, HL pad and waste storage facility.

Cumulatively, the total HL Project contributes between 6% and 28% to the PM₁₀ GLCs at the AQSRs. With mitigation in place at all the sources, the cumulative PM₁₀ annual average GLCs are well below the AQO, and even the short-term GLCs (24-hour average) are likely to remain within the set limit.

For the simulated average daily Dustfall modelled for the Base Case and assessed cumulatively (both mine and the proposed heap leach), the impacts remain within the Husab fence line for both unmitigated and mitigated scenarios, except for the south-westerly low dustfall plume from the TSF.

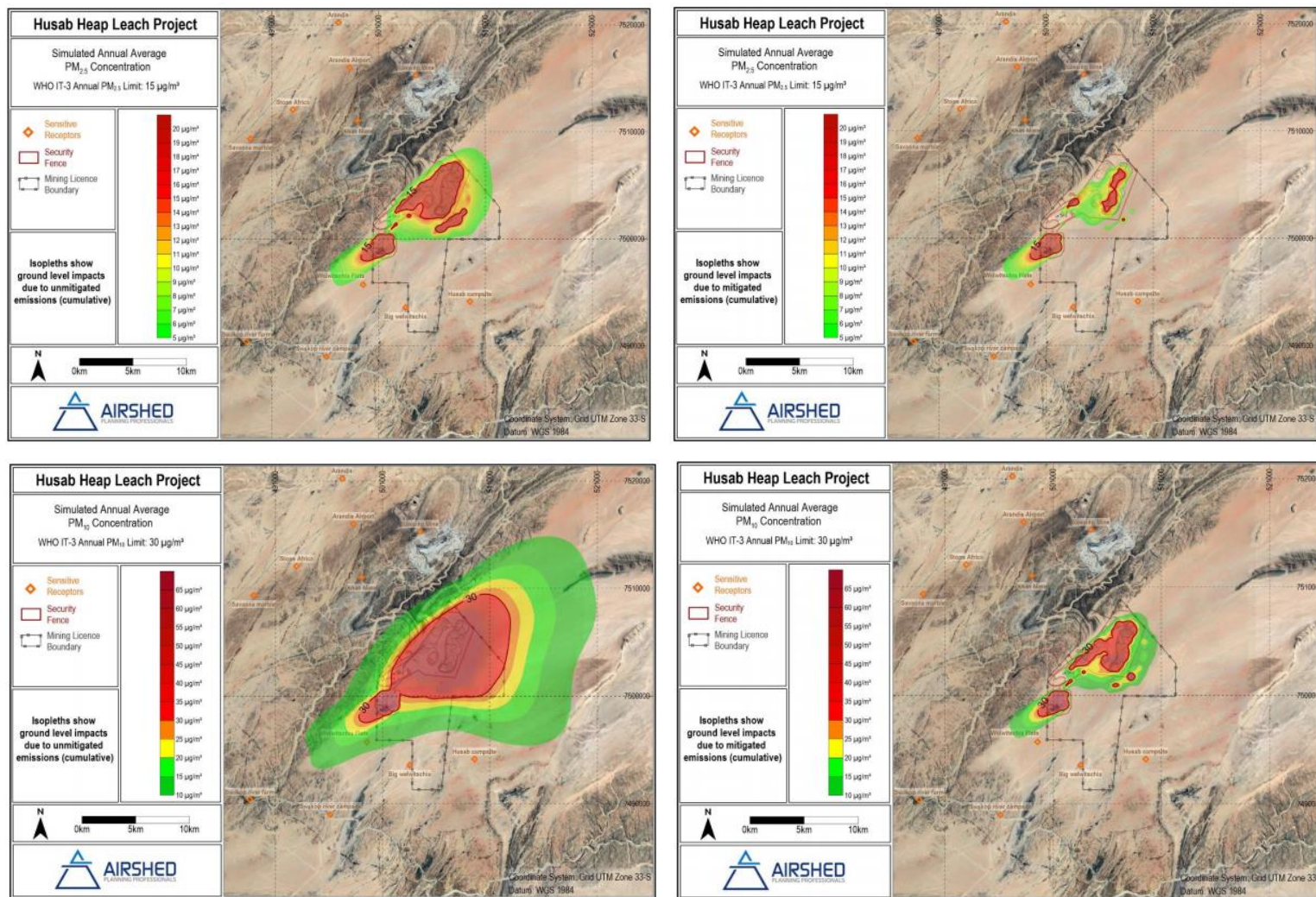


Figure 6-4: Area of exceedance of the annual AQO for PM2.5 (TOP) and PM10 (BOTTOM) due to unmitigated (LEFT) and unmitigated (RIGHT) cumulative emissions from the Heap Leach Base Case and Husab Mining and Processing Operations

In the screening of the potential impacts from the alternative location options of the HLF, Option G, Option H and Option K, the following aspects are accounted for:

- the main pollutant of concern is PM10 and the simulated impacts from the Base Case is used as reference;
- the main sources of emissions are crushing and screening, and materials handling operations and the locations of these sources are considered; and
- the prevailing wind field is from southwest to west with less frequent, but strong winds from the northeast.

Table 6-7: Significance rating of the Husab Heap Leach Base Case option (Air Quality)

			Severity	Spatial Scale	Duration	Consequence	Probability of Occurrence	Significance
PM2.5 GLCs	Incremental – HLF Project only	Unmitigated	L	L	M	L	M	Medium
		Mitigated	L	L	M	L	L	Low
	Cumulative – HLF + Husab Mine	Unmitigated	M	M	M	M	M	Medium
		Mitigated	L	M	M	L	M	Medium
PM10 GLCs	Incremental – HLF Project only	Unmitigated	M	M	M	M	M	Medium
		Mitigated	L	L	M	L	M	Medium
	Cumulative – HLF + Husab Mine	Unmitigated	M	M	M	M	M	Medium
		Mitigated	L	M	M	L	M	Medium
Dustfall rates	Incremental – HLF Project only	Unmitigated	L	L	M	L	M	Low
		Mitigated	L	L	M	L	M	Low
	Cumulative – HLF + Husab Mine	Unmitigated	L	L	M	L	M	Low
		Mitigated	L	L	M	L	M	Low

Option G: located to the south-west of the WRD has a greater probability for exceedances of PM10 short-term GLCs outside the mining license boundary and likely to contribute more to the GLCs at the nearest AQSRs, specifically the Big Welwitschia, the Welwitschia flats and the Husab Campsite.

Option H: adjacent to the TSF would increase the potential for cumulative impacts due to its close proximity to the TSF which is the main source of off-site PM10 24-hour exceedances due to wind erosion. Also, the potential for impacts at the AQSRs to the southwest of the mine is greater.

Option K: the location of the HLF adjacent to the WRD would decrease the potential for cumulative impacts, since the WRD would likely act as a windbreak against the strong north-easterly winds, and likely to cause any wind entrained material from the westerly winds to be blown into the WRD. The WRD is also likely to shield the HLWF from westerly winds. Likewise, windblown dust from the HLWF due to south-easterly winds would be blown into the WRD.

The only concern for Option K would be dust emanating from the conveyor between the HLP and the HLWF. If the material is wet, it has a lower potential for wind erosion. With the conveyor covered on the either side and with a roof, the potential for windblown dust would reduce significantly. The location of the crushers towards the plant area increases the cumulative impacts, but again, with the recommended mitigation measures in place should result in a minor cumulative contribution to air quality impacts.

From an air quality perspective, the preferred location would have been the Base Case option, followed by Option K.

Mitigation Recommendations

The following mitigation measures should be implemented throughout the life of the Heap Leach circuit:

- Good engineering practices during design of the HL process and related infrastructure to ensure minimal emissions to air during construction, operations and at closure.
- The National Pollutant Inventory (NPI) provides the following mitigation measures and control efficiencies for crushing operations –
 - 65% for hooding with cyclones;
 - 75% for hooding with scrubbers;
 - 8% for hooding with fabric filters; and
 - 100% enclosed or underground.
- For materials handling, specifically during stacking and reclaiming, 25% control efficiency CE can be achieved with variable height stacker and 75% CE using telescopic chute with water sprays.
- It is understood that a Pilot Plant is considered to precede the HLF operations. This would provide an ideal opportunity to monitor the impacts from the operations by installing dustfall units downwind of the HL pad, the HL waste stockpile, the crushers, and conveyors, and to conduct acid mist sampling during the leaching process.
- It is further recommended that the effect of the WRD on localised (micro-climate) wind speeds and direction be determined through specialised modelling to assess the effectiveness of the WRD to act as a wind shield for the preferred HLF location (and also on the erosive effects that changing wind patterns may have on other emission sources).
- Husab Mine operates an extensive ambient air quality monitoring network, and data from this network should be used to track the impact from the proposed Heap Leach project as well as ensure increased concentrations and dustfall rates do not exceed the relevant air quality objectives.
- In addition, the acid mist sampling campaigns currently being conducted 3 times annually around the sulphuric acid treatment plant, should be expanded to cover at least four (4) locations around the HLF and HL ponds to ensure the acid mist concentrations are as low as expected. Should the monitoring data indicate high concentrations (and dustfall rates), the source(s) of emissions must be identified, and additional mitigation measures applied.

See Appendix F for the full air quality report.

6.4.6 Visual

The visual impact assessment was undertaken for Option G and Option H (Appendix K). No additional assessment was undertaken for Option K as the most significant feature that would contribute to the visual impact is the HLWF and its position at Option G is similar to that of Option K. The impact assessment for Option G is therefore also applicable to the preferred Option K.

Impact Assessment

The visual impact of the proposed project has been determined using visibility, visual absorption capacity, landscape integrity, visual exposure and viewer sensitivity criteria. When the *severity/magnitude* of the impact is qualified with spatial, duration and probability criteria the significance of the impact can be predicted.

The visual impact of the project will mostly be because of the visibility of the HLF and the HLWF with its associated stacker system. The rest of the infrastructure associated with the project will mostly be on ground level or will not exceed 3 m and will have a minimal visual impact. This will, however, contribute to the cumulative impact of the overall project. The crushing and screening will take place between the existing process plant and the mined area and will therefore be absorbed into the current activities but will contribute to the cumulative impacts.

The visual impact will mostly be associated with the construction and operational phase of the project. The mine is already visible from the B2 road, the D1914/Welwitschia Drive, and the Moonlandscape road/lookout points both during the day and night. The heap leach circuit will add to the complexity, and the HLWF will remain visible in perpetuity.

Table 6-8 provides the ratings for the visual impact assessment. Figure 6-5 provides a before and after view of the heap leach waste facility as viewed from 7 km south of the site. For Option K the facility is still 70 m high, but has been elongated.



Figure 6-5. A panorama looking northwards toward the Husab Mine from the Welwitschia Flats ~7 km south. (View 10 on Figure 4-19) The after photograph shows the HLWF as it would appear in Option G.

Table 6-8: Visual impact assessment

IMPACT	SUMMARY MITIGATION		Severity	Spatial Scale	Duration	Consequence	Probability of Occurrence	Significance
Increased dust Visual quality altered	Mitigation includes dust suppression.	Unmitigated	M	M	L	M	H	Medium
		Mitigated	L	M	L	L	M	Medium
Visual quality altered - increase in project component height and additional lighting	Mitigation measures are possible but unlikely to hide/screen the proposed activities completely	Unmitigated	M	M	M	M	H	Medium
		Mitigated	L	M	M	M	M	Medium
Decommissioning & rehabilitation.	Improved visual quality once structures removed and HLWF rehabilitated	Unmitigated	M	M	L	M	H	Medium
		Mitigated	L	M	L	L	M	Medium

The visual impact of the HLF and related infrastructure is not significant relative to the other bio-physical impacts that may occur. At closure, the only heap leach infrastructure that will remain is the HLWF, a 70m high and almost 3 km long landform.

Mitigation Recommendations

Mitigation measures for this project are limited since the usual mitigation measures such as vegetation berms or screens are not feasible in a desert environment. The following key management and mitigation measures (as per the approved EMP) remain key for the WRD amendment:

- Land disturbance will be limited to what is absolutely necessary;
- All dust emission sources will be managed with dust suppressants to limit visual intrusion by dust;
- Minimise the number of lights used, as long as safety is not compromised. Install light fixtures that provide precisely directed illumination to reduce light “spillage” beyond the immediate surrounds of the site.
- Structures that are to remain following decommissioning must be shaped to integrate into the surrounding landscape. A professional landscape architect could be commissioned to assist with closure planning, especially for the final HLWF;
- In line with the SEA (SAIEA, 2010) recommendations, Swakop Uranium will investigate the possible alternative equivalent tourist sites (outside of the visual impact zone) for the Welwitschia related attractions. If such alternatives are identified, Swakop Uranium will contribute to the establishment of these alternative attraction sites and associated access routes as a form of visual impact offset.

6.4.7 Radiation

Qualitative Assessment of Radiological Impacts of Heap Leaching

Potential radiological impacts are location-dependant and are the result of specific operational practices which lead to the release of radionuclides into the environment. Relevant heap leach operational practices include, amongst others: -

- primary and secondary mineral ore crushers;
- conveying crushed ore;
- agglomeration;
- stacking of the HLF; and
- removal of leached mineral waste and its conveyance and disposal on the heap leach waste.

The list below provides a qualitative summary of the potential radiologically relevant impacts associated with the HL options considered in this study:

- Generation of radiologically relevant dust due to mining, blasting, conveying and stockpiling of HL feed material as is of relevance for the atmospheric and aquatic exposure pathways.
- Crushing, screening and the associated conveyance of feed material generates radiologically relevant dust as is of relevance for the atmospheric and aquatic exposure pathways.
- Conveying and stacking of agglomerated feed material onto the HSF potentially contaminates the conveyor system as well as the area in which conveying takes place as is of relevance for the atmospheric and aquatic exposure pathways.
- Leaching is used to produce pregnant liquid that is radiologically relevant, while the seepage of pregnant liquid as is of relevance for the aquatic pathway.
- Run-off/spillage of rinse water used at the HLF and pregnant liquid may lead to radioactive contamination of the soil as is of relevance for the atmospheric and aquatic pathways.
- Post-leaching handling of pregnant liquid may potentially lead to contamination as is of relevance for the atmospheric and aquatic pathways. Handling of pregnant liquid may lead to direct external exposure to gamma radiation.
- The production of concentrated uranium from pregnant liquid from the HLF is potentially associated with a multitude of new and incremental radiologically relevant impacts. This is because the operation of the HSF increases the overall production of uranium concentrate at the Husab Mine, which necessitates additional handling and processing of uranium concentrate which potentially implies additional relevant impacts on direct external exposures to gamma radiation as well as the atmospheric and aquatic pathways.
- Removal and handling of radioactive waste and residues from the HLF, and the conveyance of such materials to the waste disposal facility may potentially contaminate the soil as is of relevance to the atmospheric and aquatic pathways.
- Disposal of waste and radioactive residues originating at the HLF may potentially contaminate soil as is of relevance to the atmospheric and aquatic pathways.
- Due to the climatic conditions in the hyper-arid Namib, mineral waste eventually dries out completely. Unless covered by an inert substance, such as for example a layer of uncontaminated soil, waste rock, clay or liner, the exposure of dry mineral waste residues to the forces of the wind and water as is of relevance for the atmospheric pathway and aquatic pathways.

- During/following high-rainfall episodes, run-off and/or spillage from the mineral waste disposal facility may potentially lead to environmental releases in the form of radioactive contaminants seeping into the soil as is of relevance to the atmospheric and aquatic pathways.

Quantitative assessment of radiological impacts

The radiation report utilised the air quality model produced by Airshed for the Husab heap leach project. Of importance to the radiological study is the dispersion of PM_{2.5} as inhalable and respirable dust. In addition, the ground water model produce by SLR for this report was also used to assess potential aquatic dispersion of radio nuclides in ground water.

Atmospheric dust

A radiological impact assessment focusing on members of the public (as opposed to occupational impacts) must consider the contributions of radioactive particulates with an aerodynamic diameter below 2.5 µm (PM_{2.5}). Figure 6-4 in Section 6.4.5 above, shows the dispersion models for PM_{2.5} for the Base Case site layout, for the mitigated and unmitigated scenarios. The radiological study computed the annual average public inhalation exposure doses (µSv/a) for each of the public receptors for the unmitigated and mitigated scenarios, for the heap leach project, and the cumulative effects of the Husab Mine with the heap leach project.

Direct external exposure pathway

The direct external exposure pathway due to radiation sources originating at uranium mines is important on the mining site (and therefore relevant for occupational exposure dose management) and in situations where members of the public are living on or very closer to areas that contain mineral waste and associated residues that are contaminated with radionuclides [Von Oertzen, 2018]. The direct external exposure pathway is not considered relevant for any of the public receptors identified in Section 4.7, as these receptor locations are physically separated from the actual mining site and therefore any of the various on-site sources of direct external gamma radiation.

Aquatic exposure pathway

Members of the public could, potentially, be exposed to radiation as a result of the ingestion of contaminated water, consuming food that is grown on soil irrigated with contaminated water or consuming products from livestock that has been drinking contaminated water or eating contaminated plants. Monitoring of boreholes at the select receptor sites do show evidence of radionuclides in the borehole water, but this is not attributable to the Husab Mine, as most borehole water in the Swakop River and the Khan River are characterised by considerable radionuclide concentrations, which are the result of in-river transfers that have been taking place for millennia (Von Oertzen, 2021).

Impact Assessment

Each of the sensitive receptors around the Husab Mine was assessed in terms of the potential for exposure due the amount of time adults or infants are likely to be residential, tourist or working at the site, and their relative exposure to the different pathways described above. Note that all emissions scenarios considered in this section are for total emissions due to current operations at the Husab plus those attributable to the proposed HL project at the Mine: i.e. cumulative.

The radiological impact assessment indicates that, for the receptors identified as members of the critical groups and based on eleven distinct exposure scenarios, all public radiation exposure doses from current operations at the Husab Mine, plus those that can be attributable to the proposed heap leach operations are trivial as they result in total exposure doses that are less than 10 µSv/a for both adult and infant receptors.

Impacts at the Husab Mine

An increase of the Husab Mine's total production capacity implies that the risk of adverse environmental impacts increases. The HLF contributes some 10% (unmitigated), 5% (mitigated) to existing total particulate emissions from the Husab Mine [Airshed, 2021]. Similarly, the HLF adds to the PM10 emissions contribution by 4% (unmitigated) or 3% (mitigated). PM2.5 increases by 2% in the unmitigated scenario and drops to 1% all mitigation measures are applied.

The following list summarises the principal radiological impacts of the proposed heap leaching options and associated processing infrastructure: -

- Generation of additional radiologically relevant dust as well as radon which may have adverse impacts on sensitive air quality receptors in the area;
- Potential contamination, seepage and other unintended emissions of radiologically relevant minerals and gases into the environment;
- Generation of additional radiologically relevant mineral waste;
- Disposal of radiologically relevant mineral and non-mineral waste;
- Impacts associated with the possibility that the long-term management of the waste disposal facility is suboptimal and would then result in unintended emissions of radiologically relevant minerals and gases into the environment;
- Impacts associated with the management of mining activities that are extended by way of the addition of a heap leach facility and leads to unintended emissions of radiologically relevant minerals and gases into the environment; and
- The potential impacts associated with the ultimate failure of the waste disposal facility following the decommissioning of the heap leaching facility and associated infrastructure, noting that adverse impacts can potentially occur decades after the closure of a facility.

All the heap leach layouts have similar impacts and Table 6-9 and Table 6-10 present the result of the significance rating associated with the radiological impacts. Note that these figures were taken directly from the Radiological Report, which is available as Appendix J.

Table 6-9: Significance rating of radiological impacts applicable to the proposed heap leach process, for atmospheric pathway.

Radiological Impact	Overall Significance Rating Associated with the Radiological Impacts			
	Atmospheric (dust)		Atmospheric (radon)	
	Mitigated Scenario	Unmitigated Scenario	Mitigated Scenario	Unmitigated Scenario
A. Radiologically relevant dust is released into the atmosphere	medium	medium	not applicable	not applicable
B. Radon is released into the atmosphere	not applicable	not applicable	medium	medium
C. Radiologically relevant material is released into the environment as a result of seepage	medium	medium	medium	medium
D. Radiologically relevant material is released into the environment as a result of inadequate stormwater controls and management systems	medium	medium	medium	medium
E. Radiologically relevant mineral waste material is released into the environment	medium	medium	medium	medium
F. The design of the waste disposal system does not cater for extreme weather events and causes radionuclide emissions into the environment	medium	medium	medium	medium
G. Provisions on closure of the HLF do not adequately ensure the long-term containment of mineral waste, resulting in the eventual release of radiologically relevant material into the environment	medium	medium	medium	medium

Table 6-10: Summary of the radiological impacts applicable to the proposed heap leach process, relevant to aquatic and direct external pathways

Radiological Impact	Consequence Rating Associated with the Radiological Impacts			
	Aquatic Pathway		Direct External Pathway	
	Mitigated Scenario	Unmitigated Scenario	Mitigated Scenario	Unmitigated Scenario
A. Radiologically relevant dust is released into the atmosphere	medium	medium	medium	medium
B. Radon is released into the atmosphere	not applicable	not applicable	not applicable	not applicable
C. Radiologically relevant material is released into the environment as a result of seepage	medium	medium	medium	medium
D. Radiologically relevant material is released into the environment as a result of inadequate stormwater controls and management systems	medium	medium	medium	medium
E. Radiologically relevant mineral waste material is released into the environment	medium	medium	medium	medium
F. The design of the waste disposal system does not cater for extreme weather events and causes radionuclide emissions into the environment	medium	medium	medium	medium
G. Provisions on closure of the HLF do not adequately ensure the long-term containment of mineral waste, resulting in the eventual release of radiologically relevant material into the environment	medium	medium	medium	medium

Table 6-11: Results of the Probability, Consequence and Overall Significance Ratings

Radiological Impacts	Unmitigated	Mitigated
Probability summation for atmospheric dust, atmospheric radon, aquatic and direct external pathways	HIGH	MEDIUM
Consequence summation for atmospheric dust, atmospheric radon, aquatic and direct external pathways	MEDIUM	LOW
Significance summation for atmospheric dust, atmospheric radon, aquatic and direct external pathways	MEDIUM	MEDIUM

The radiation study recommends that **only mitigated heap leaching options are considered for implementation**, provided that environmental impacts are minimised by way of applying best practice mitigation measures as applied in modern open pit mining and processing environments in hyper-arid climates as is the case in the western Namib desert.

The heap leaching options considered in this study can be considered for implementation, provided that best practice mitigation measures are applied, as are described in the mitigation section below.

In view of the principle of optimisation as applies to radiological practices in Namibia, **all unmitigated heap leaching options should be excluded and should not to be implemented (i.e. considered a fatal flaw)** as their radiological impacts are not as low as reasonably achievable, taking economic and social factors into account.

Mitigation measures for radiation

The following measures form part of the essential mitigation approaches focusing on reducing dust emissions from mining and milling operations, as are applicable in hyper arid climates, such as Namibia’s Namib desert: The mitigation measures proposed by the air Quality assessment applies:-

- active dust suppression measures (e.g. water sprays) at both the primary and secondary crushers as well as in all screening operations;
- active dust suppression in all transport, stacking and agglomeration areas;
- passive dust control measures (e.g. by way of hooding, roofing and covering) of crushers, screens, conveyors and grasshopper stackers; and
- active as well as passive dust controls on all on-site service roads (e.g. dusticide and/or water sprays).

Liner design and SWMP

The following recommendations, which are to be read with others included in the EIA for this project, are formulated from a radiological perspective aimed at minimising radiation-related environmental impacts as a result of mining, processing and heap leaching operations at Husab:

- The process to dispose of the mineral waste from heap leaching is to satisfy the Namibian regulatory requirements for the disposal of radioactive waste, as per the Atomic Energy and Radiation Protection Act, Act No. 5 of 2005 and Regulations;
- The operations of the HLF are to be included in the Husab Mine’s Radiation Management Plan, which is to be submitted to the Namibian National Radiation Protection Authority **for approval prior** to the commencement of HL operations;

- Monitoring of total suspended particle concentrations in the atmosphere, total inhalable and respirable atmospheric dust concentrations and their associated radionuclide concentrations are to be further strengthened as part of SU's ongoing implementation of the Husab Mine's Radiation Management Plan;
- The public and occupational exposure dose monitoring programs undertaken as part of the implementation of SU's Radiation Management Plan are to strengthen the monitoring of actual atmospheric and aquatic emissions into the environment;
- All environmental releases originating from the Husab Mine's operations are to be regularly quantified and are to form an active part of the risk register that informs the application of mitigation practices at the Mine;
- Public and occupational dose assessments are to be based on empirical data for radionuclide concentrations and particle characteristics of dust from mining, blasting and mineral transport, waste disposal and tailings storage facilities, and use local weather data as part of the ongoing modelling of dispersion of dust in the atmosphere and seepage of effluents into the groundwater.

6.4.8 Archaeology

Figure 4-19 shows the known archaeological sites at the Husab Mine that have been documented and assessed in terms of their significance and vulnerability by Dr Kinahan. Option K will potentially affect one site (QRS105/86) at the far north of the HLWF, and conveyor infrastructure will cross the old narrow gauge rail line embankment in two places.

Impact Assessment

The archaeological assessment identified 8 sites that may have been proximal to the original heap leach layouts (Appendix L). Of these, 5 sites are within the existing crushing and plant area and already impacted, and the other 3 are further east of the HLWF of Option K and are unlikely to be disturbed. All these sites have already documented.

Site QRS106/85 was not identified in the report, it is however the site of an old seed digging with a manuport located on a schist outcrop and correspondence with Dr Kinahan has confirmed that it too is of no significance, given the large number of seed diggings in the area.

On the basis of the archaeological desk assessment, it is concluded that construction of the proposed heap leach facility at the Husab Mine will have a Low to Moderate archaeological impact. Given that detailed documentation has already been carried out on the (8 plus one other) sites that were identified, it is not considered necessary to carry out further mitigation on these sites.

The most likely impact of the proposed heap leach facility at Husab Mine on sites and materials protected under the National Heritage Act (27 of 2004) would be damage through inadvertent disturbance and possible destruction in the course of construction activities. The consequences of such impacts must be considered as permanent. However, all of the sites that lie in close proximity to the proposed surface works have been documented and investigated in sufficient detail that an adequate record exists in the event that the sites are destroyed.

Recommendations

- If feasible, adjust the position of the HLWF away from site QRS 106/85.
- Keep all infrastructure that crosses the rail embankment in a narrow corridor to limit damage to the feature. Avoid placing the conveyor plinths on the rail embankment.
- All construction and operation activities must be conducted within the demarcated footprint for the heap leach facility and its related infrastructure to avoid damage to known archaeological sites.

- The Husab Mine has adopted the Chance Finds Procedure recommended by Dr Kinahan and it is a Swakop Uranium Procedure developed as part of the ISO 14001 standard. The Chance Finds Procedure is used when buried archaeological remains are discovered, which are not visible to surface survey, so that they may be handled in accordance with the provisions of Part V Section 46 of the National Heritage Act (27 of 2004).
- Should archaeological remains be exposed during the soils removal and earthworks phase of construction, all activities must stop immediately, and the environmental department must be advised.

6.5 PROJECT IMPACT ASSESSMENT

6.5.1 Consolidation of Impact Ratings

The Table 6-12 below provides the consolidated Impact Assessment for those impacts that may have a significant effect on the receiving environment.

Table 6-12: Project Impact Assessment Table

Environmental Aspect	Unmitigated	Mitigated	High level mitigations and recommendations
Loss of soils resource through physical disturbance	High	Medium	Plan construction activities to limit the size of the footprint to be disturbed. Remove and stockpile topsoil, including the HLWF, as per the site clearance procedures.
Loss of soil ecological functioning from pollution	High	Medium	Ensure pollution prevention procedures, including the stormwater management system, are applied, and reduce contaminated dust emissions as per the air quality requirements. Utilise stockpiled topsoil for rehabilitation at closure.
Baseline surface water quality affected by sediment and silt	High	Low	The management of water through the stormwater management plan will significantly reduce the risks of environmental and surface water pollution.
Baseline surface water quality affected by dirty water runoff	High	Low	
Reduced catchment runoff	Low	Low	
Deep groundwater contamination	Medium	Low	The HFL post leach residue waste was classified as Type 3 waste requiring a Class C barrier system to reduce the seepage of leachate into underlying aquifers at both infrastructures. The liner is the primary mitigation measure to the prevention of seepage flow into the underlying sediments.
Shallow groundwater contamination	High	Low	All piping to and from the HLF and the existing plant must be in a lined channel. Further, HLF and all associated infrastructure will be removed at mine closure. The HLWF remains permanently. The surface of the HLWF and must be covered with an engineered design that limits water ingress and controls surface water runoff.
Interference to water supply to the Welwitschias	High	Low	

Environmental Aspect	Unmitigated	Mitigated	High level mitigations and recommendations
Destruction of or damage to Welwitschia plants	Medium	Low	The Husab channel has to be diverted around the extended waste rock dump footprint. The HLF and HLWF have been moved out of the No-Go Zone (WW and Husab channel) with Option K.
Dust deposition on vegetation (& soil)	High	Medium	No development is allowed within 30 m of a Welwitschia plant and no infrastructure is to be placed in the Husab channel or its diversion. All dust suppression measures must be implemented.
Destruction of the gravel plain vegetation patches and the ecological engineering effect of gerbils	Low	Low	All stormwater measures must be implemented. The HLF and HLWF must have a Class C liner. All piping containing hazardous material to be contained in an impermeable system. The pilot plant and potential impacts must be identified and monitored, and mitigation measures found for any impacts identified. The potential effects of acidic dust on vegetation must be investigated. All efforts must be made to prevent physical harm to fauna in the footprint of the HL circuit infrastructure footprint during vegetation and topsoil removal.
PM2.5 GLCs Cumulative HL and mine	Medium	Medium	Reduction in the dispersion of the inhalable fraction of dust is an important mitigation for potential impacts on human health (radiation). Mitigation measures that reduce the potential for acidic dustfall on vegetation or onto the soil or in stream channels must be applied.
PM10 GLCs Cumulative HL and mine	Medium	Medium	
Dustfall rates Cumulative HL and mine	Low	Low	
Radiological impacts Probability summation for atmospheric dust, atmospheric radon, aquatic and direct external pathways	High	Medium	The reduction in potential radiation impacts is dependent upon the implementation of all the recommended air quality mitigation measures. In addition, the design of the Class 3 liner, and storm water management systems is also relevant.

Environmental Aspect	Unmitigated	Mitigated	High level mitigations and recommendations
Consequence summation for atmospheric dust, atmospheric radon, aquatic and direct external pathways	Medium	Low	Based on the principle of optimisation as applied to radiological practices in Namibia, all unmitigated heap leaching options are associated with radiological impacts that are not as low as reasonably achievable, taking economic and social factors into account. Therefore, only mitigated heap leaching options must be considered for implementation, and these are to employ best practice mitigation measures as relevant and applicable in modern open pit mining environments in hyper-arid climates
Significance summation for atmospheric dust, atmospheric radon, aquatic and direct external pathways	Medium	Medium	
Archaeological impacts	Medium	Low	One site and two sections of the narrow-gauge rail embankment are potentially affected. From an Archaeological impact point of view the mitigation of these features has already been undertaken during past site investigations, and documentation of heritage sites. No further mitigation is required, other than the application of the Chance Find Protocol as presented within the Archaeological Report.
Visual impacts	Medium	Medium	From a visual impact perspective all the heap leach infrastructure will add to the visual complexity of the Husab site. The HLWF is the one large feature that remains after closure. Dust suppression will lessen visual impacts.

6.5.2 Cumulative Impacts

The original Husab project EIA was approved on the basis that the mine footprint and therefore its impacts would be kept as small as possible. The following text is taken directly from the Biodiversity Assessment Report.

“The Husab Mine is located in a national park, where the protection of biodiversity and the enjoyment of nature are the primary land uses. Its presence inside the park sits uncomfortably with the main land uses, but its impacts on biodiversity features as such were fairly well contained. The heap leach project, coming soon after an expansion of the main WRD, which followed on the addition of a large tailings storage facility (that was not part of the original EIA), represents what has now become a pattern of footprint creep. Each of the individual additional developments do not on their own cause enough significant harm to organisms or ecological processes to become a fatal flaw, but the cumulative impact has certainly grown significantly.”

All the changes to the mine and its processing and waste disposal options are creating a cumulative impact on the area, and specifically, on the catchments and drainage systems that feed the Welwitschia Field. The cumulative increase in the dust load also has created cumulative adverse effects for human health, and on biodiversity functioning.

These cumulative impacts have been discussed in each of the specialist sections, and the air quality and radiation assessments have been undertaken for the combined mine, processing plant and proposed heap leach facility.

Welwitschia health and relative catchment size

The surface water and biodiversity baselines describe how incremental development in the catchments can affect the Welwitschia downstream. The biodiversity specialist elaborates on this in an addendum to his report which is attached as Appendix I. Figure 6-6 illustrates how 3 of the smaller catchments have already been significantly reduced. The proposed diversion of the main feeder to the field, the Husab channel has to be diverted around the expanded waste rock dump. The HLWF, a permanent structure, will now remain between the Husab channel diversion and the next major catchment to the east (“D” is in the approximate position of the HLWF).

Dust as a plant stressor

Not only is the water supply to the Welwitschia being compromised, but the cumulative dust load, and in particular, the potentially acidic dust that the heap leaching process could generate, is of concern.

A monitoring programme for the detection of potential impacts of dust on vegetation health is being undertaken at Husab by the Gobabeb Research Team. The experimental design of the monitoring programme was based on the initial dispersion model defined by Airshed Professionals in their impact assessment report (Airshed, 2013), and the subsequent location and re-location of dust buckets.

Dust buckets are located on both the inside and outside of the modelled dust dispersion contours. The plant health monitoring only uses the air dispersion model for total suspended particles (TSP). Dust buckets are also located at different distances from the mine with the hypothesis that the dust load collected in the buckets will be inversely related to distance that they are away from the mine. In the same way, it is postulated that plants further away from the dust source will receive less dust on average and over time.

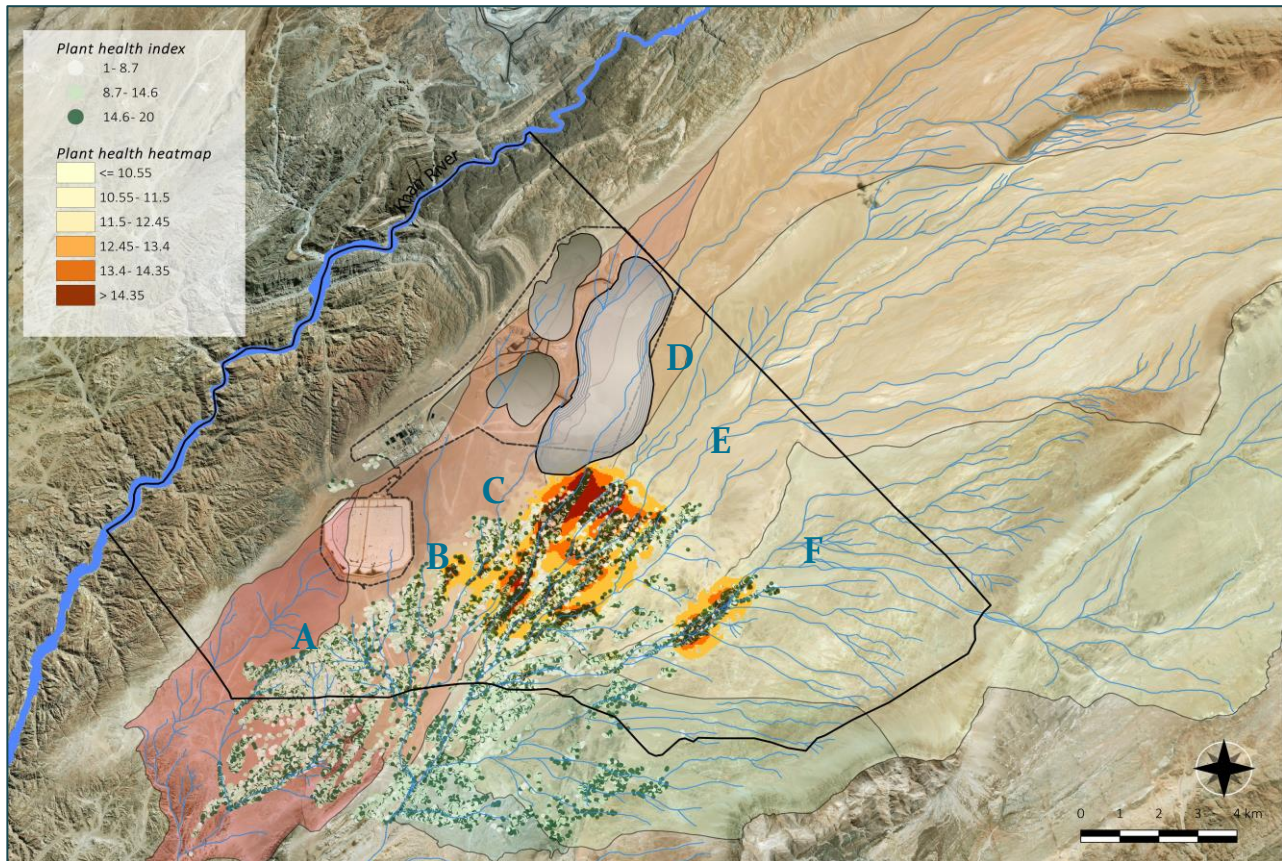


Figure 6-6: A Heat Map of Welwitschia Plant Health Relative to the Size of the Catchments (Adapted from Wassenaar, 2018).

- The healthiest plants are indicated by dark green dots, whilst the darker brown shading indicates the areas of the greatest number of healthy plants. Catchment D contains the Husab channel.

Plant health monitoring occurs twice per year (April-May and Oct-Nov). Between zero and five plants of three shrub species are selected in a 200 m circle around each dust bucket. A three-point scoring system is used to estimate the dust load on the plant leaves, and a number of plant dimensional variables (height, width, etc), the leaf cover, photosynthesis efficiency and (till recently) and water potential are measured and recorded. The research team then relate these variables to distance and dust load to determine if the predicted dust fallout patterns under unmitigated and mitigated scenarios are related to plant health (growth, photosynthesis and water potential).

A positive relationship between the log of the dust load and the leaf dust score has been determined, indicating that the assumption of a distance-related decline in dust level holds. The increased dust load closer to the mine has apparently not been heavy enough to result in any depression of growth or photosynthesis although plants in close proximity to the primary crusher and haul roads have succumbed.

Water potential was not expected to be affected, because there is no direct mechanism by which this can happen due to dust, and Airshed (2021) also did not find any evidence of such an effect. It has been concluded that current dust loads are not enough to result in negative physiological effects on plants, either because the mitigation efforts are successful or because the plants are adapted to dust at these levels of deposition.

Microscopic effects of dust such as abrasion by angular particles, and acidic impacts have not yet been investigated.

Gerbils - ecological engineers

Another aspect of biodiversity that is being impacted is the ecological functioning of the gerbil populations in the Mining License area. Before construction of the mine and plant began, a rapid survey of the gerbil burrows was undertaken in 2012. More recently, a detailed study on the burrows distribution and frequency was undertaken by a masters student. Figure 6-7 below provides a synopsis of the research.

The colour gradient from light blue to orange here represent a “heatmap” of z-scores of the number of burrows per patch. The dataset on which it is based was combined from two surveys, the first conducted in 2012 and the second in 2020 (see Shaanika, 2020). Because these two surveys used different survey methods, the data was standardized by calculating a z-score (value minus mean divided by standard deviation). The inclusion of the 2012 data (before mining), shows the relative loss of numbers of burrows that has already occurred when the mine was constructed. The orange rectangle indicates the general area where the highest numbers of burrows seem to be concentrated. This area includes the mine and the proposed heap leach infrastructure.

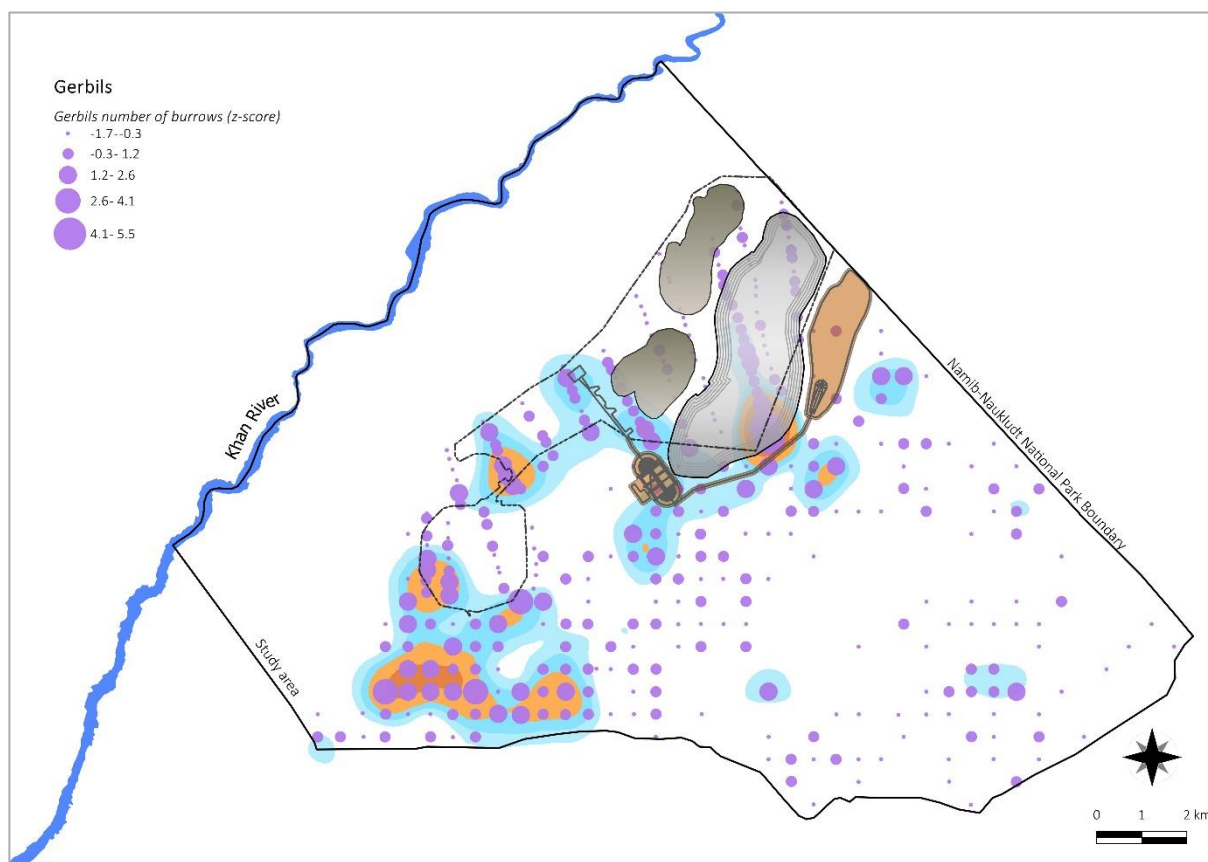


Figure 6-7. The distribution of the number of burrows per patch, overlain on a heatmap showing the spatial tendency for higher z-scores of the number of burrows per patch. Superimposed on that is the location and layout of Option K

7. EMP AMENDMENT

The EMP has been amended to include mitigation and management actions relating to the construction, operation and decommissioning of the Heap Leach Project. The Amended EMP is available for review as **Appendix M** of this report.

8. IMPACT STATEMENT AND CONCLUSION

The impact assessment has included input from previous investigations on site, comment from key stakeholders, as well as specialist assessments of key aspects that may be vulnerable to impact. From these inputs, it has been determined that the critical decision-making criteria as to whether this project is authorised is related to the conservation of local biodiversity, and to the prevention of pollution of ground and surface water, and to the containment of impacts related to the generation of inhalable dust fractions and exposure to radiation.

The specialist investigations have indicated medium and low impacts with mitigation. These mitigation measures have been included in the Amended EMP. The following overarching conditions are applicable to the impact assessment for the proposed heap leach facility and related infrastructure:-

- All the specialist assessments have assumed that the Husab channel will be diverted around the extended footprint of the waste rock dump and that the impact of this is already accounted for, except that it contributes to the cumulative impact on the Welwitschia field.
- The soils, radiation, visual and biodiversity assessments all require that the mitigation measures provided by the air quality assessment are fully implemented. Dust must be contained.
- The soils, ground and surface water, radiation and biodiversity impact assessments also depend on the implementation of an effective and managed storm water management system. The HLWF must be designed for closure.
- The soils, ground water, surface water, radiation and biodiversity impact assessments all depend on the correct design and implementation of the Class C liner for the HLF and HLWF. Without the liner the impacts to surface and ground water, and to any downstream receptors, would be significantly higher.
- The radiological assessment concludes that, in view of the principle of optimisation as applies to radiological practices in Namibia, all unmitigated heap leaching options should be excluded from further considerations and therefore should not be implemented as their radiological impacts are not as low as reasonably achievable, taking economic and social factors into account. Based on considerations presented above, **this study recommends that only mitigated heap leaching options are considered for implementation**, provided that environmental impacts are minimised by way of applying best practice mitigation measures as applied in modern open pit mining and processing environments in hyper-arid climates as is the case in the western Namib desert.

The EAP undertaking this EIA Amendment of the Husab Mine EIA for the proposed construction and development of the Heap Leaching Project at the Husab Mine recommends that the proposed project can proceed, provided that all air quality mitigation measures and all the specified liners are installed and maintained, and that dirty storm water is correctly managed in order to prevent groundwater pollution, to keep Welwitschia feeder drainage channels open and clean, and to limit radiation and dust emission that can affect the health of humans and biodiversity.

9. REFERENCES

- Airshed Planning Professional. 2020. Husab P20 Heap Leach Project, Namibia: Air Quality Screening Assessment
- AWR. 2020. Biodiversity Impact Scoping for the Proposed Husab Mine Heap Leach Facility.
- Golder (2017): SGS-TIME MINING Heap Leached Waste Facility Pre-feasibility Design for Swakop Uranium Husab P20 Project.- Report No. 1545107-316841-2 REV0.
- J&J Kinahan. 2013. Specialist archaeological contribution to the proposed amendments to the Husab Mine plan and infrastructure
- METAGO (2010): Environmental impact Assessment Report for the Proposed Husab Mine- Project No. M009-03, Report No. 2.
- SGS (2017): Husab P20 Heap Leach Project, Pre-Feasibility Study report. Report No. TS518-0000-T-REP-001 REV0.
- SLR. 2018. Scoping Report for the proposed changes to the Husab Mine and Linear Infrastructure.
- SLR. 2020. Swakop Uranium Heap Leach Screening EIA – Water Specialist input.
- VO Consulting. 2020. Radiological Screening Assessment for the Husab Mine Heap Leach Project.

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