ANNEXURE N12:
WATER BALANCE AND GEOHYDROLOGY STUDY BY SRK CONSULTING

Water Specialist Study for the Phase 2 ESIA for the Rössing Mine Expansion

Report Prepared for

Rio Tinto

Report No 393957/2

July 2010

Water Specialist Study for the Phase 2 ESIA for the Rössing Mine Expansion

Rio Tinto

SRK Project Number 393957/2

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List of acronyms

K denotes Hydraulic conductivity in m/day

mamsl denotes “metres above mean sea level”

RUL denotes “Rössing Uranium Limited”

ESIA denotes “Environmental and Social Impact Assessment”

PLS denotes “pregnant leach solution pond”

Mbgl denotes “metres below ground level”

TDX denotes

TDDS denotes

NTSC denotes

RDS Denotes “Return Dam Solution”

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1 Introduction

Rössing Uranium Mine is situated 60km north-east of Swakopmund in the Erongo region of Namibia. The mine is situated inland of the mist belt in a relatively arid area of the country with average annual rainfall between 35 and 40mm.

Aurecon has been commissioned by Rössing Uranium Limited (RUL) to compile an Environmental and Social Impact Assessment (ESIA) for the Rössing Expansion project which includes an extension to the existing SJ Pit and assessment of the impacts of using a heap leaching process. This ESIA is Phase 2 of the ESIA for the entire expansion project.

The scope of work addressed in this Phase 2 ESIA includes:

- Extension of the current SJ open pit;
- Increased waste rock disposal;
- Increased tailings disposal capacity;
- Establishment of an acid heap leach facility with disposal of ripios (spent ore);
- domestic waste disposal site;
- New sewage plant

The requirements of the project include a comprehensive water specialist study which should be used as input to the ESIA.

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SRK Consulting was requested to prepare the water management portion of the study. The water balance and catchment description of the site has been completed as per the design freeze announced by RUL on 04 November 2009. However, the geochemical and groundwater pollution flume modelling cannot be completed until the leach testing of waste rock and low-grade ore has been completed (the leach testing in the laboratory is underway and should be complete by mid to late – 2010 but the available results from the lab are included in this report). This report outlines the water aspects that can be described at this point in the study including the hydrological description of the site, hydrogeological description of the site, water balance for the site and impact assessment for the site.

2 Background and description of the project

The background to the project is described fully in the scoping report and is summarised as follows. Rössing Uranium Limited (RUL) has operated an open pit uranium mine in the Erongo Region of Namibia since 1976. Although of considerable extent, the Rössing ore body is of a low uranium grade and consequently large volumes of rock have to be mined to extract the uranium ore and to produce the processed uranium concentrate (yellow cake) that is the final product. As a result of an increase in uranium prices on the international market in recent years, RUL is able to consider the possible financial benefit from an expansion of its operations. The previous mine plan predicted an operational period ending in the year 2016. According to this plan, a sustainability assessment was undertaken and approved in 2005. RUL is now looking at a 2023 mine plan and consequently, the associated environmental and social issues are being reviewed. The maximum extent of the envisaged expansion would entail, in summary, an increase in size of the current mining pit known as SJ, the opening of new mining areas, with new disposal areas for waste rock, heap leach pad and ripios dump, a new high density tailings facility, and an increase in staff numbers and facilities.

The new infrastructure is indicated in SRK Drawing 393957/101 in Appendix 1 and is described below:

The open pits should be expanded in numerous phases as indicated in Figure 2-1 with the most critical extension being Phase 4 where the pit should expand across the Dome Gorge. Waste rock dumps should be used and extended where required.

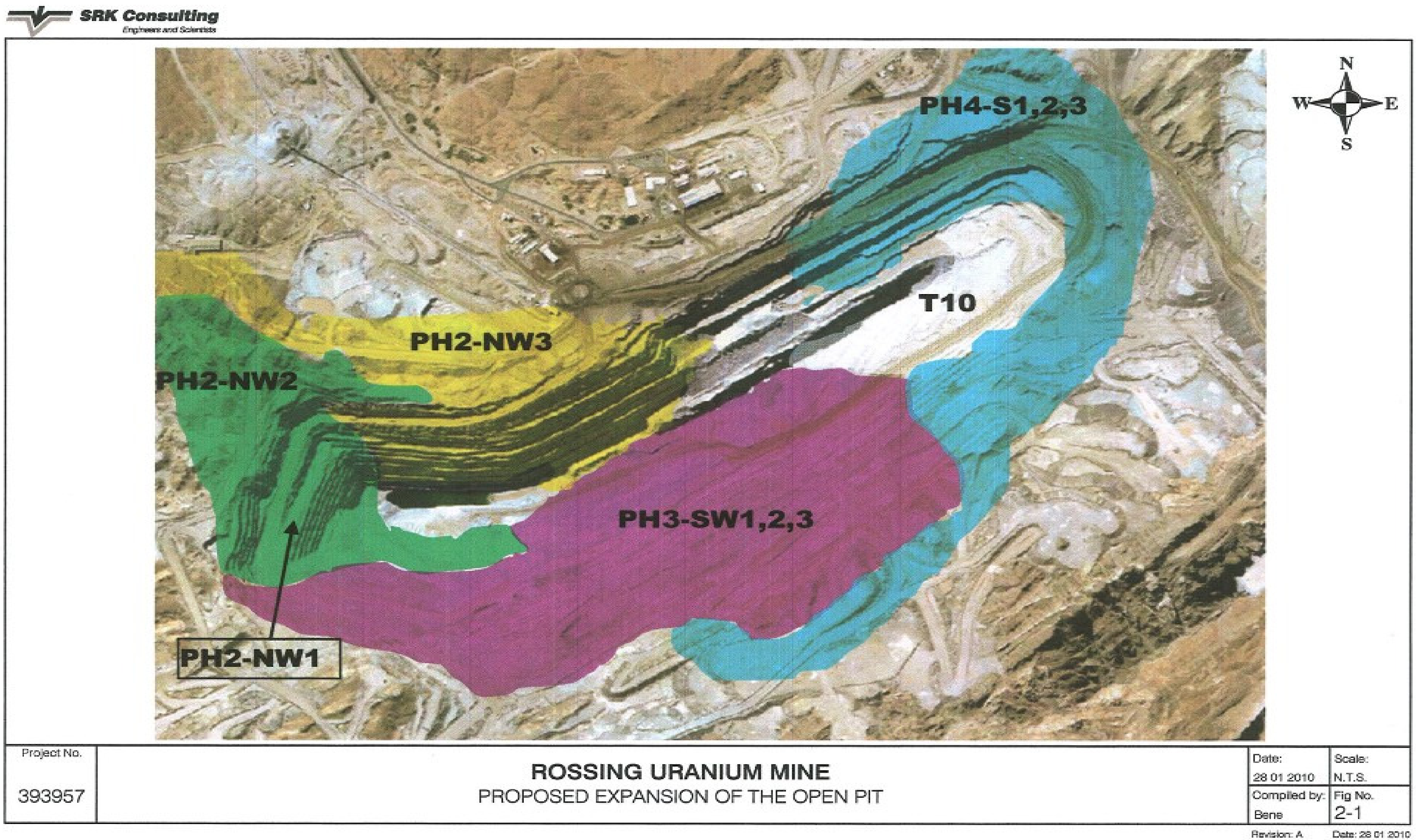


Figure 2-1 : Proposed expansion of the Open Pit

The ore from the open pit destined for heap leaching will be crushed at a new crusher situated adjacent to the existing crusher and the crushed ore will then be transferred via a conveyer to the new heap leach pad.

It is proposed to locate the **heap leach pad** on the northern end of the existing tailings facility and will consist of a lined base on which the crushed ore from the open pit is placed. The ore will be placed on the heap leach pad via a conveyor system and then irrigated with dilute sulfuric acid and hydrogen peroxide. The pregnant solution (the residual acid and peroxide with the extracted uranium) will be captured in channels that drain to a pregnant leach solution pond (PLS). The pregnant solution will then be treated in the CIX and SX plants.

The **CIX and SX plants** treat the pregnant solution further to abstract the minerals required. The position of the CIX and SX plant is situated to the north of the PLS pond.

The remaining material from the heap leach pad that has been leached should then be removed from the leach pad and disposed of to the **ripios dump** on the existing tailings facility. This means that the tailings facility will no longer be used for deposition of tailings and a new tailings facility will be constructed near the Dome Gorge on the Rössing Dome. In order to minimise the use of water it is envisaged that the method of tailings deposition will be a High Density slurry deposition on a **high density tailings facility**. The high density (HD) tailings deposition planned in Dome Gorge will reduce the return water requirements as the Tailings Solid:Liquid ratio will change from approximately 50:50 by mass to approximately 75:25 by mass after dewatering the slimes at source using high rate thickeners.

The method of operation proposed for a high density tailings facility for Rössing is based on an “advancing cone” method of deposition. The method is described by Metago Environmental Engineers (Brown, 2007):

- A discharge point is established at elevation either beginning from one of the existing crests or from a starter embankment.
- Discharge commences and continues until the deposited tailings, which forms a cone in front of the discharge pipe, builds up to the level of the pipe.
- At this stage deposition is moved to a second discharge point and the deposited tailings are allowed to drain and dry long enough to allow access to extend the pipe. Based on experience this period will be 3 to 5 days.
- Having extended the pipe by one pipe length (9m) out over the deposited cone, deposition is resumed and the process repeated until the cone has advanced over the full length planned. To accommodate variations in the topography over which the cone forms, to maximise storage, and to ensure that a contiguous mass is formed, the elevation of the discharge point is gradually varied. This enables raising or lowering of the spine of the advancing cone as it forms.
- When extending the pipe, it is supported on a low bund formed using a front end loader or excavator.

- Supernatant water is captured in low areas ahead of, or to the side of the advancing cone, depending on the topography around the advancing cone, using a mobile pump to allow flexibility. This would pump to a booster pump in the same manner as presently occurs with paddock operation except that the volume of water will be much lower.

As an advancing cone reaches an end point, a new (third) deposition point is formed and the second deposition point becomes the new advancing cone.

3 Objectives

The main objectives of the study as input to the ESIA will be to:

- Establish baselines for the surface water and ground water regimes;
- Determine the environmental significance of these in terms of risk and compliance;
- Assess the impacts associated with these on the biophysical environment and any relevant users, including the mining operations;
- Define mitigatory measures to mitigate unacceptable impacts.

4 Scope of Work

4.1 Project initiation and Scoping

A Specialist Integration site visit was undertaken from the 9^{th} -12^{th} of September 2008 and provided the opportunity for familiarisation with the site and operations and understanding of the extent and implications of the proposed Phase 2 Expansion.

4.2 Data review

SRK reviewed the following data:

- Relevant Namibian water and environmentally-related legislation and prevailing regulatory policies;
- Rio Tinto Corporate environmental policies/ benchmarks and practices;
- Aerial photographs covering the mine licence area and the area of influence;
- Site plans showing the areas in which new infrastructure will be located;
- Geological reports/models;
- Provision of representative samples of Waste Rock for geochemical test work;
- Climatic data;
- Hydrological reports and flow data;
- Storm water control plans;
- Latest mine water balance;
- Mine expansion plans;
- Relevant PFDs and P&IDs for the proposed expansion;
- Layout and mode of operation of the proposed heap leach facility;
- Rössing Standard Operating procedures;

- CSIR report on the Khan River (CSIR, 1997).
- Aquaterra Reports (March 2005 and updated in January 2010 and again in March 2010)

4.3 Characterisation of hydrological and hydrogeological regimes

The current status quo of the ground and surface water regimes are described based on available information collated from the data review. The output of the updated hydrogeological model completed by Aquaterra (Australian groundwater modelling consultants) was used to predict the impacts of the proposed mining operations on the groundwater and surface water conditions under various scenarios.

The groundwater model has been revised (March 2010) to include the heap leach pad and new HD Tailings facility, the expansion of the SJ pit and it now extends to the Khan River and as far as the Swakop River. This was undertaken to predict the impact of the developing cone of drawdown and to assess whether any seepage from the new facilities could impact on the Khan River and its potential receptors (i.e. vegetation requirements as well as down-gradient farming communities).

4.4 Water Balance Modelling

A water balance was prepared for the proposed and existing infrastructure. The following activities were undertaken:

- Collection of information for the mine including electronic layout plans of the site and waste dams and design reports/diagrams;
- Use the existing information to prepare a site water balance using a spreadsheet method;
- Presentation to the client.

The water balance can simulate:

- Where water can be used in the circuit;
- What changes in water use can be expected once the expansion activities included in the Phase 2 ESIA have been implemented.

4.5 Impact assessment

The surface and groundwater issues were identified and the probable impacts assessed. The Water Specialist team used the impact assessment methodology and tables used by the Aurecon Management team for this purpose.

4.6 Environmental management plan

Impacts rated medium or higher have a range of mitigation measures to reduce the impacts. These have been developed within a workshop at SRK to ensure that practicality and effectiveness at reasonable cost should be achieved.

5 Regulatory Framework

5.1 Namibian water and environmentally-related legislation

Table 5-1 identifies Namibian Articles, Policies and Acts that are particularly applicable to the water and environmental aspects of the Expansion Project.

Table 5-1 : Relevant Namibian Articles, Policies and Acts

Law/Ordinance	Applicability
Article 95 (1) of the Constitution of the Republic of Namibia (1990)	• Preservation of Namibia's ecosystems, essential ecological processes and biological diversity • Sustainable use of natural resources
Environmental Assessment Policy of 1995	• Prescribes Environmental Impact Assessments for any developments with potential negative impacts on the environment
Water Resources Management Act (24 of 2004)	• Effluent discharge permit required under sect 56 • Water related pollution and abstraction
Environmental Management Act 7 of 2007	• Establishes principles for EA • Ensures that the significant effects of activities are considered timeously and carefully • Allows for opportunities for participation by I&AP's throughout the assessment process
Hazardous Substances Ordinance 14 of 1974, and amendments	• Pollution prevention
Petroleum Products and Energy Amendment Act of 2000	• Disposal of used oil
Water Act (Act 56 of 1956)	• Ultimate control of water in Namibia as well as the accompanying regulations

Of those listed in Table 5-1, Article 95(1) of the Constitution, the Water Resources Management Act and the Environmental Management Act are the most relevant, although at this stage they do not have Regulations that provide specific guidance on water and effluent quality management or the approved environmental limits.

5.2 Rössing Standard operating Procedures

In the absence of specific Namibian regulations on water quality management and related aspects, RUL has developed a range of Rössing Standard Operating Procedures (SOPs) in support of its Policy for accepting "responsibility for the quality of surface and groundwater within the mining grant and for the prevention of mine-induced water quality deterioration in the Khan River downstream of the mine."

SOPs relevant to water management currently and applicable to the Expansion include:

- Water Strategy SOP No: POL/WRS/001
- Fresh water supply management SOP No: OWM/WSM/001
- Supervision of flow meters SOP No: OWM/WSM/001-002
- Water quality management SOP No: JE50/MSP/001
- Water quality monitoring SOP No: OWM/WQM/001
- Tailings facility monitoring SOP No: OTD/TDO/001
- Monitoring of sewage works SOP No: OWM/SPP/001
- Seepage control systems SOP No: OWM/SCP/002
- Water recycling SOP No: OWM/WSM/002

- Waste rock dumping SOP No: MIN/WRD/001
- Monitoring acid neutralisation SOP No: OWM/WQM/001
- Disposal of hydrocarbons SOP No: ENV/WMP/002-003
- Disposal of chemicals SOP No: ENV/WMP/005.

These SOPs are updated as required and authorised for use by the RUL Managing Director.

5.3 Groundwater quality guidelines

There is no surface water within the RUL mining grant (except during rainfall periods) but there are a number of salt springs dotted around the property which are discussed in more detail later in the report. There is no groundwater of a quality suitable for domestic use, or even comparable with recognised water quality guidelines for any category of use. In the absence of a pre-mining baseline for groundwater quality, RUL has established datasets for borehole water quality up-gradient of the mine and designated the range shown in Table 5-2 below as the baseline. This has enabled RUL to set Internal Standards for the parameters that are potentially affected by the mining operations.

Ambient Water Quality	Range	RUL Internal Standard
pH	7.0 ± 0.3	>6.5
Conductivity (mS/m)	2188 ± 366	
Total Dissolved Solids (mg/L)	18071 ± 3926	
Calcium (mg/L)	1488 ± 612	
Magnesium (mg/L)	257 ± 103	
Tot. Alkalinity (mg/L $CaCO_3$)	141 ± 27	
Chloride (mg/L)	8567 ± 2291	
Sulfate (mg/L)	2269 ± 523	2900
Fluoride (mg/L)	1.1 ± 0.4	
Nitrate (mg/L NO_3)	99 ± 24	150
Potassium (mg/L)	128 ± 12	
Sodium (mg/L)	4640 ± 1369	
Uranium (mg/L)	0.09 ± 0.02*	0.15*
U-234/U-238 activity ratio	>1.0	>1.0
Sulfate/Chloride Ratio	0.3 ± 0.1	0.4

* Excluding natural groundwater in uranium ore occurrences

5.4 Effluent discharge Permit

Rössing has to comply with the conditions of the Industrial and Domestic Effluent Discharge Permit number 385, issued/updated at 5-year intervals by the Department of Water Affairs (DWA). In view of the brackish nature of both the abstracted groundwater and various process streams, the Permit focuses strongly on conditions requiring recycling and reuse, as in the examples below.

- "The industrial effluent will be deposited in the tailings facility from where as much as possible of this effluent should be recycled."
- "The domestic effluent will be treated in the sewage effluent treatment facilities and the treated water should be recycled and used in the metallurgical process."
- "After removal of oil, waste water from the workshop and garage areas should be pumped to the Satec Hudamech sewage treatment plant."
- Tailings slurry should be disposed of in the tailings facility and the tailings solution should be recycled."
- "All seepage from any effluent disposal site observed on the surface or suspected underground, should be intercepted and recovered for re-use as far as reasonably practicable, in the mining and metallurgical process."
- "Water accumulated in the open pit due to the excavations, should be re-used in the mining processes."
- "The permit holder shall consider water savings and re-use measures for all water to the satisfaction of the Permanent Secretary."
- "An accurate water balance record showing total consumption, fresh water input, water recovery from specific seepage control boreholes, abstraction from production boreholes, loss of water in the mining processes, water savings effected and the re-use of water from the tailings facility, seepage dam, mine pond, open pit and treated sewage shall be submitted to the DWA."
- "RUL shall continue to investigate all possible ways of saving water, to conserve water and to optimize the re-use of water to the satisfaction of the DWA". In this context, all water in dewatering wells and cut-off trenches will be pumped back for eventual re-use in the mining activity."
- "All water and effluent meters shall be in a satisfactory operational state at all times. There shall be sufficient meters to allow for an accurate compilation of water balance records showing accurate water use and effluent production."
- "RUL will submit a monthly report to the DWA on the water balance at the uranium mine. The daily average water consumption and production of effluent for the month should be represented."
- "RUL will submit an annual report on or before 28 February each year to the DWA to review the prescribed monitoring programme, the agreed radiological monitoring programme, the status of water quality management, as well as the water conservation measures."

Rio Tinto Environmental Standards require operations to reduce their raw material consumption. Rio Tinto has set a water target for Rössing of 19% reduction in freshwater use per unit of product between 2003 and 2009. The actual water demand per tonne of ore milled has to be reported in six-monthly Rio Tinto HSE reports and indicates that the mine has reduced their water use on the mine. To achieve the target Rössing sets internal fresh water consumption limits for major users as well as water recovery and re-use targets.

The Water Quality Management SOP is attached in Appendix 2.

6 Characterisation of hydrological and hydrogeological regimes

6.1 Climate

Climatic data is required for both the hydrogeological and hydrological baseline description:

6.1.1 Rainfall

SRK received the updated rainfall data from RUL and this data was added to the previous data set to produce one set of records. Figure 6-1 below shows a comparison between the two sets of records.

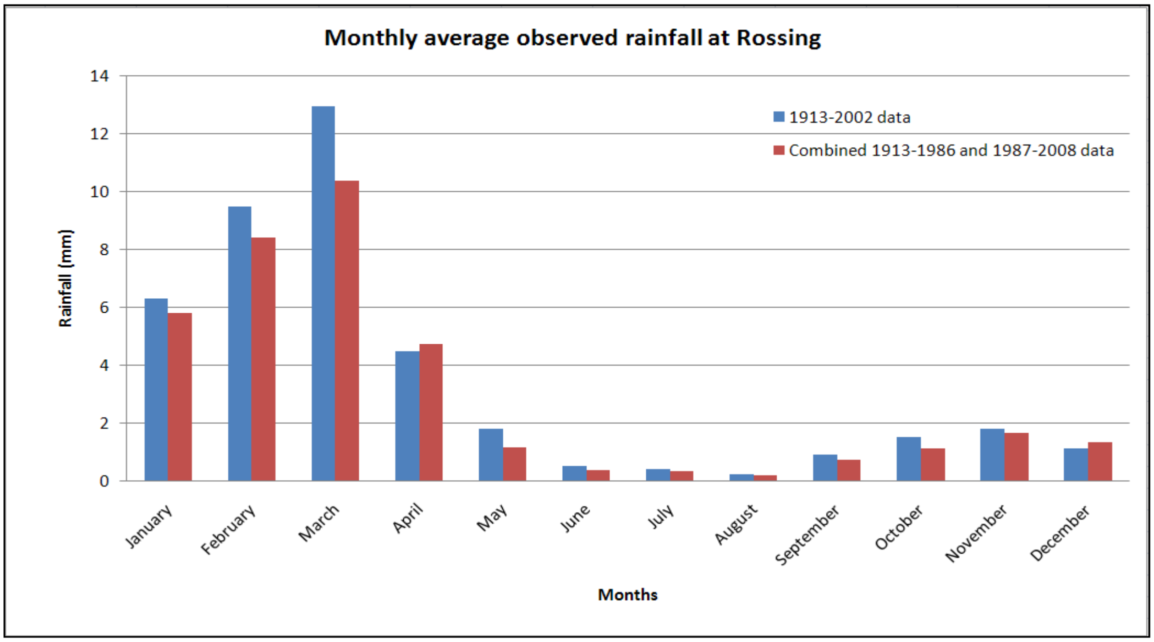


Figure 6-1 : Comparison between previous data set and current observed rainfall depths (Simm, 2009)

From the above Figure it is observed that during most months on average there is a lower rainfall than given by the previous record with an exception during the December and April months where there is slightly more rainfall.

The average annual rainfall data for the area is between 35-40mm/year. The data set is to be used by all other water related studies and represents 43 year rainfall record based on the previous 37 years plus additional 6 years of record.

Table 6-1 below gives tabulated values of the design rainfall depth as abstracted from the storm rainfall study.

Table 6-1: Adopted 24hr design rainfall depths (mm) for 2009

Return Period (years)	2	5	10	20	50	100	200	500	1000	2000	10000
Depth (mm)	11	21	28	37	50	61	73	92	109	128	183

6.1.2 Evaporation

Evaporation is one of the main causes of water loss at Rössing. The annual A-pan evaporation is around 2700 mm with an average daily rate of 7 mm as abstracted from the operating procedures OWM/WSM/003. Water savings can be achieved if evaporation from open water and wet sediments can be reduced. It is therefore important to monitor evaporation losses. The A-pan is located next to the weather station at Point Bill.

6.2 Topography

The Rössing Mine is at an elevation of approximately 540 mamsl and the terrain slopes towards the SE and the Khan River which is at an elevation of approximately 368 mamsl in the vicinity of the pit. The confluence of the Khan and Swakop Rivers is at an elevation of about 220 mamsl.

6.3 Description of hydrological catchments

The mine is situated within the catchment of four main tributaries of the Khan River. The layout of the main catchments is presented in the drawing in Appendix 1 and a condensed version is presented in Figure 6-2, namely:

- Pipeline/Dome Gorge
- Boulder Gorge
- Panner Gorge
- Pinnacle Gorge.

6.3.1 Pipeline/Dome Gorge

The Pipeline/Dome gorge flows in a south easterly direction draining runoff from the catchment upstream of the main water supply line situated to the east of the tailings facility. The heap leach pad will be situated in this area and any spills from the plant and pregnant solution pond/stormwater pond will discharge into this gorge and flow towards the road and through the existing culverts to the Pipeline Gorge (north of the plant). The water will then back up behind the HD tailings facility where it will seep into the shallow aquifers and intercepted by the existing groundwater trenches. Water that is not collected in the trenches will flow via the shallow groundwater channels to the north of the open pit side of the Dome Gorge. At a point upstream of the pit additional groundwater trenches have been installed to collect seepage. If the water bypasses these solution trenches then the seepage could bypass the open pit and discharge to the Dome Gorge. In this event, it is anticipated that the highly permeable amphibole schist (See Section 6.4) will intercept the seepage and drain it to the open pit.

Surface seepage rates collected from drains around the tailings dam is about 6 000m^3/day but this has historically fluctuated between 2000 and 7500 m^3/day.

6.3.2 Boulder Gorge

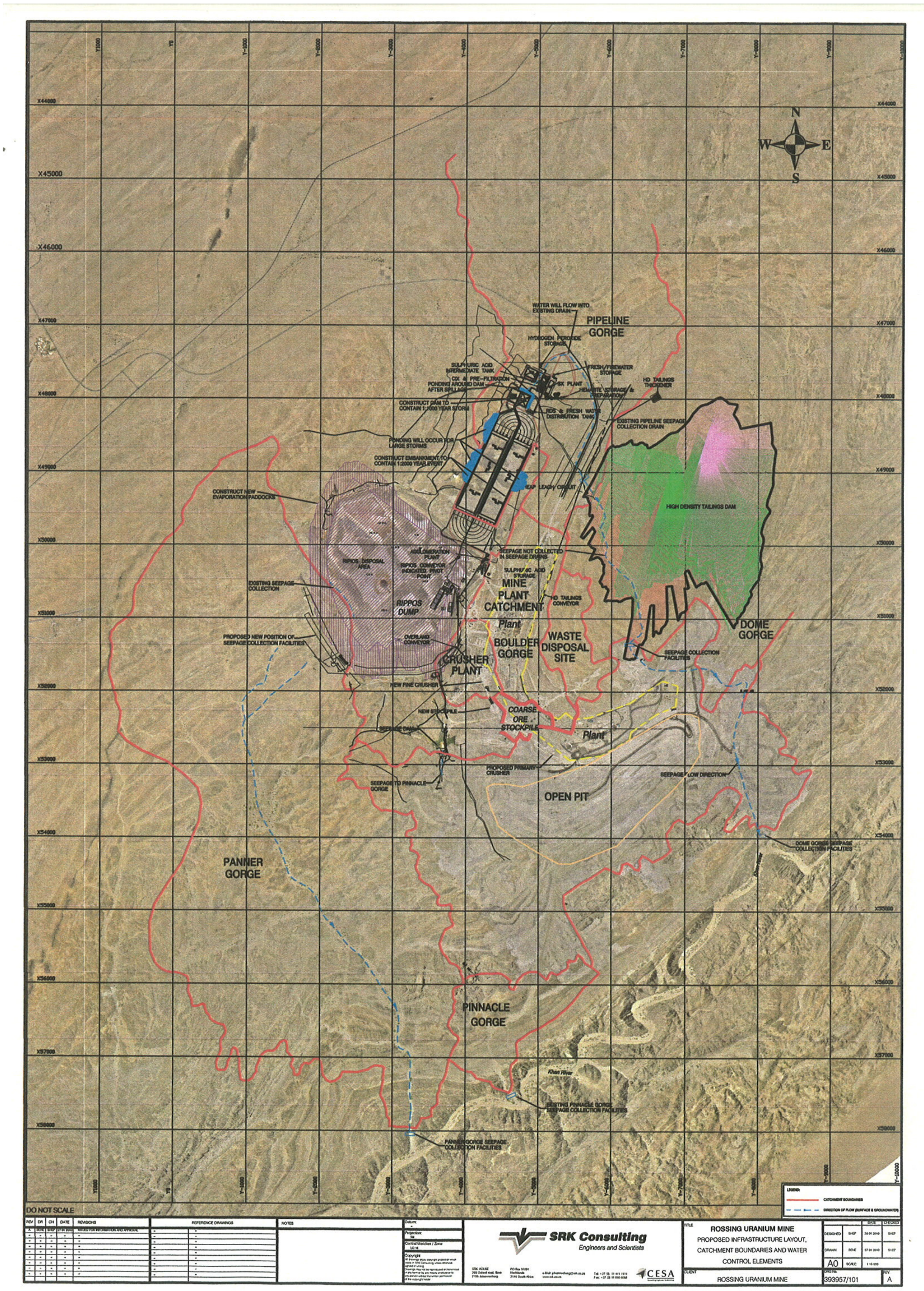
The **Boulder Gorge** contains the bulk of the mine plant area and includes the waste rock site catchment, crusher plant catchment and mine plant catchment. The watercourse drains to the east of the plant near the contractors' yard and is prevented from draining freely into the Khan River as the gorge is blocked by waste rock to the north of the open pit and seepage through the waste rock will be intercepted by the open pit.

6.3.3 Panner Gorge

The **Panner Gorge** is orientated in a southerly direction and drains to the west of the mine. The catchment does not have much influence on the mine at present but with the expansion, the ripios footprint will extend into the Panner Gorge. The existing seepage controls to the west of the existing tailings facility will be covered by ripios and additional drains will be required in the Panner Gorge catchment. There is an existing Panner Gorge seepage control collection trench at the confluence of the Panner Gorge with the Khan River.

6.3.4 Pinnacle Gorge

The **Pinnacle Gorge** has as its catchment the southern part of the tailings facility and the seepage collection dam. The flow is along the south western side of the open pit.



roj\393957_Rossing_Water_balance\8CAD\CONCEPTUAL\catchment drawing.dwg, bene

Figure 6-2 : Catchment boundaries

6.4 Hydrogeological description of the area

The summary of the Hydrogeological environment is referenced from the Aquaterra 2009 Modelling Report (Aquaterra, March 2010).

6.4.1 Regional Geology

The Rössing mine lies within the crystalline core of Damara Orogens Central Zone and is characterised by major northeast to southwest trending tecto-stratigraphical metasedimentary rocks of the Khan and Rössing Formations. The sequence is intensely folded resulting in the development of anticlinal structures (dome) and synclinal structures (basin). The Rössing orebody is interpreted as a migmatite zone (Ordovician in age) with uraniferous alaskite as small intrusive lenses to large replacement bodies which have been preferentially emplaced into the gneiss and biotite amphibolite schist units of the Khan Formation in the northern ore zone and into the lower marble and biotite cordierite gneiss of the Rössing Formation in the central ore zone.

Figure 6-3 shows the geology in the vicinity of Rössing and the lithologies are described in more detail in (Table 6-2).

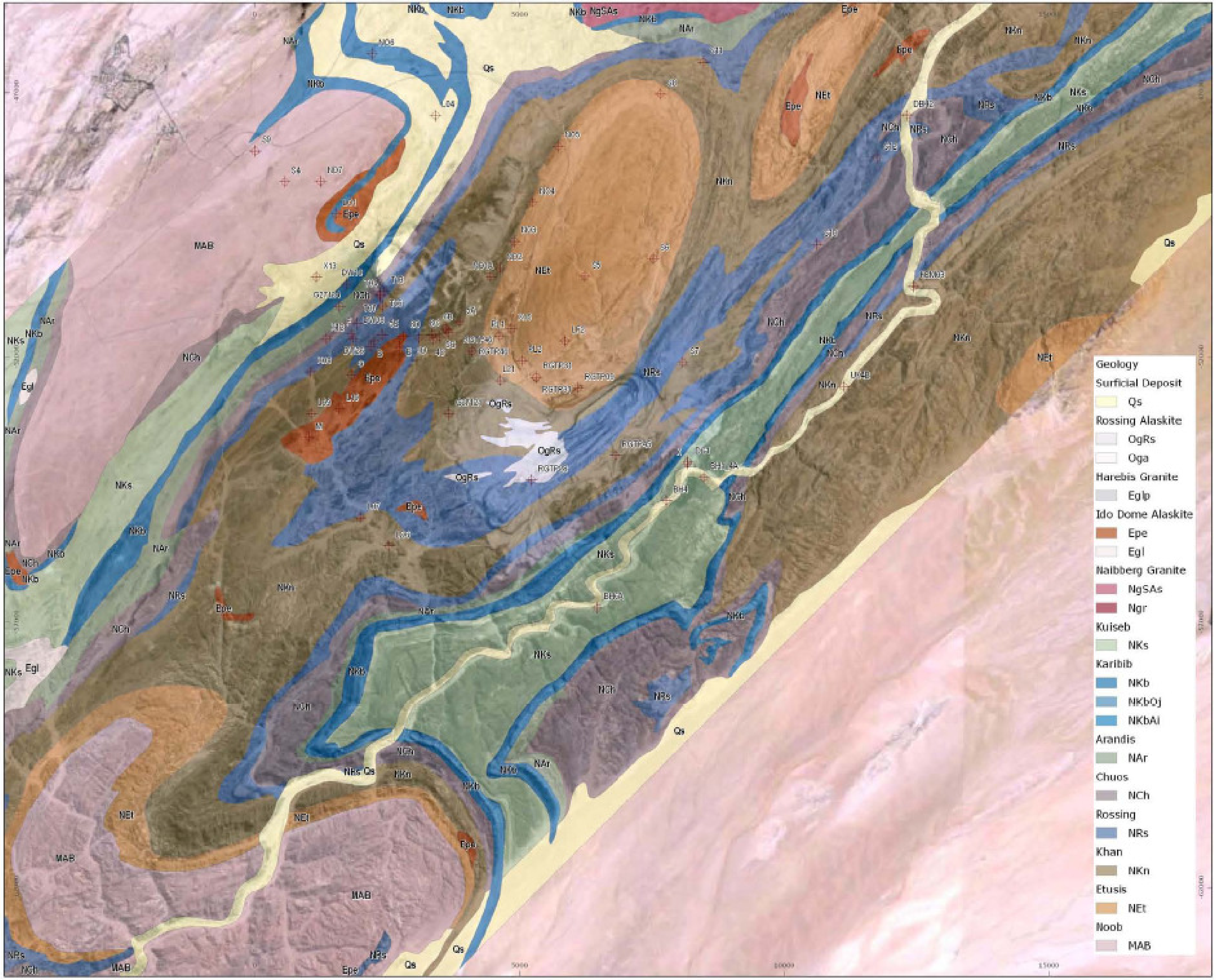


Figure 6-3 : Regional Geology showing location of Rössing Mine

Table 6-2: Regional Geology Lithological Description

SACS (unpublished)				LITHOLOGY
GROUP	SUBGROUP	FORMATION	Maximum thickness (metres)	
SWAKOP	KHOMAS	KUISEB	>3 000	Pelitic and semi-pelitic schist and gneiss, migmatite, calc-silicate rock, quartzite. Tinkas Member: pelitic and semi-pelitic schist, calc-silicate rock, marble, para-amphibolite.
		KARIBIB	1 000	Marble, calc-silicate rock, pelitic and semi-pelitic schist and gneiss, biotite-amphibole schist, quartz schist, migmatite.
		CHUOS	700	Diamictite, calc-silicate rock, pebbly schist, quartzite, ferruginous quartzite, migmatite.
	Discordance			Marble, pelitic schist and gneiss, biotite-hornblende schist, migmatite, calc-silicate rock, quartzite, metaconglomerate.
	UGAB	RÖSSING	200	
	Discordance			
NOSIB		KHAN	1 100	Migmatitic, banded and mottled quartzofeldspathic clinopyroxene-amphibole gneiss, hornblende-biotite schist, biotite schist and gneiss, migmatite, pyroxene-garnet-gneiss, amphibolite, quartzite, metaconglomerate.
		ETUSIS	3 000	Quartzite, metaconglomerate, pelitic and semi-pelitic schist and gneiss, migmatite, quartzofeldspathic clyopyroxene-amphibole gneiss, calc-silicate rock, metarhyolite.
Major unconformity				Gneissic granite, augen gneiss, quartzofeldspathic gneiss, pelitic schist and gneiss, migmatite, quartzite, marble, calc-silicate rock, amphibolite.
ABBABIS COMPLEX				

The Rössing Mine is situated along the northern limb of a complex synclinorium and the strata dip almost vertically towards the south. Vertical oblique-slip faults feature in the core of the mine synclinorium and are younger than the alaskites but older than Karoo dolerites which are also abundant in the region.

Several geological horizons are discussed in more detail below:

- The prominent dome feature on which the new high density tailings will be deposited is composed of metamorphic gneisses of the Etusis Formation;
- The SJ Fault is a 10m thick zone with higher permeability with a NE-SW orientation which passes through the SJ open pit;
- The Rössing Marbles (Hanging wall) are considered to be less competent and more weathered than the adjacent Khan Formation (Footwall) and there is a discordant amphibole schist (up to several metres thick) associated with this contact. The Karibib Marble of the overlying Swakop Group is less weathered and forms a distinctive ridge adjacent to the Khan River;
- Unconsolidated sediments form alluvial fill in the drainage network, particularly in the gorges.

6.4.2 Aquifer lithologies

The Rössing Marble comprises an impure serpentinic and graphitic marble overlain with gneiss, conglomerate and quartzite. Due to the potential carbonate dissolution and the consequent fracture enhancement, this unit is expected to have a higher hydraulic conductivity compared to the other consolidated rocks in the area and is considered a preferential path for groundwater flow.

A prominent amphibole schist structure, several meters thick, occurs on contact between the Rössing Marble and the Khan Formation and is also considered to be more permeable than the host rock. This unit has been explicitly incorporated into the new version of the groundwater model as it passes through Dome Gorge and the pits and as such could effectively act a as a cut off drain to seepage from the TSF in Dome Gorge , conveying it to the open pit.

All other rock types comprising metasediments such as schist, gneiss, migmatite, quartzite, calc-silicates have low permeability. The upper horizons have undergone various degrees of weathering and resulted in fracture enhancement, weathering and structural disintegration resulting in a greater permeability. The preferential flow along major faults due to the higher permeability than the surrounding rock has resulted in the formation of the gorges.

The Karibib Marble ridge adjacent to the Khan River has relatively low permeability and is considered a barrier to flow, except where this formation is transected by the major fault gorges (Dome Gorge, Pinnacle Gorge and Panner Gorge).

The alluvial fill in the drainage networks (particularly in the gorges) is characterised by high hydraulic conductivity and high specific yields.

6.4.3 Aquifer parameters

The alluvial aquifer in the Khan River has the highest hydraulic conductivity (K) of 40 m/day and the fill in the Gorges have been assigned a K of 10-20m/day. Other faults including the SJ Fault which runs through the open pit are assigned a K of 0.2-0.4m/day.

The Rössing Marble has the highest hydraulic conductivity of 0.15m/day compared with rest of the stratigraphy which is several orders of magnitude lower. Test pumping of the Khan banded gneisses has indicated a hydraulic conductivity of 0.004 to 0.09 m/day with an average of 0.04 m/day. These units can be considered as aquitards rather than aquifers (i.e. limiting to groundwater flow).

6.4.4 Groundwater flow

The general direction of the regional groundwater flow is from northeast to southwest towards the Khan River, conforming to the general drainage pattern. Groundwater levels are highly variable ranging from several metres below ground level due to mounding from the tailings facility to >150mbgl in the vicinity of the open pit which has a very steep drawdown cone due to the low hydraulic conductivity of the host rocks. Between the current tailings facility and the pit, a distance of less than 2km, the groundwater heads drop by over 300m.

Locally most of the flow from the tailings facility is captured in the open pit which acts a groundwater sink.

6.4.5 Groundwater abstraction

Groundwater abstraction takes place within and around the existing tailing facility and in the alluvium of the Khan River and its tributaries.

The groundwater abstraction schemes within the tailings storage facility are referred to as TDX, TDDS and NTSC wellfields and their function is to capture seepage from the tailings and make it available for recycling and reuse. Seepage to groundwater from the existing tailings facility is currently estimated at approximately 4800 m^3/day. Abstraction from the wellfields around the tailings dam is about 1500 m^3/day.

Rössing Mine abstracts brackish water from the Khan River for dust suppression and to supplement fresh water make-up for mine operations (OWM/KHN/001 (2008)). Five production boreholes in the Khan alluvial aquifer supply approximately 600m^3/day to the mine and the maximum permitted abstraction is 0.87Mm^3 per year as per the abstraction permit No 10200.

Other permit conditions require six-monthly vegetation surveys and monthly water level measurements in three boreholes. Rössing sets internal abstraction limits on a monthly basis. Due to public concern RUL has taken the decision to minimise the abstraction from the Khan River boreholes.

6.4.6 Recharge

Recharge from precipitation is sporadic but it is assumed that when the annual rainfall exceeds 20mm, 1% of incident rainfall (0.3mm/yr) recharges the basement rocks and 10% (or 3mm/yr) rainfall recharges the alluvium areas of the Gorges and the Kahn River. When annual rainfall does not exceed 20mm, it is assumed there is no rainfall recharge.

Base flow in the alluvial fill in the Kahn River upgradient of the mine is estimated at 500 m^3/day.

Recharge from the existing tailings storage facility is estimated at 32 mm/yr.

6.4.7 Water users

Due to the high salinity of ambient Rössing groundwater the only beneficial uses are for industrial and ecological purposes, e g dust suppression and maintaining the natural vegetation. The area around Rössing mine contains no freshwater resources and the only groundwater potentially suitable for agricultural use is found in the Khan River.

There are several salt springs which occur within the mine area which are used by fauna and the locations of these is shown below in minutes of degrees and indicated in Figure 6-4.

Site	Lat	Long
A	-22.5272	15.0531
B	-22.5269	15.0529
C	-22.6504	15.0632
D	-22.5294	14.9964

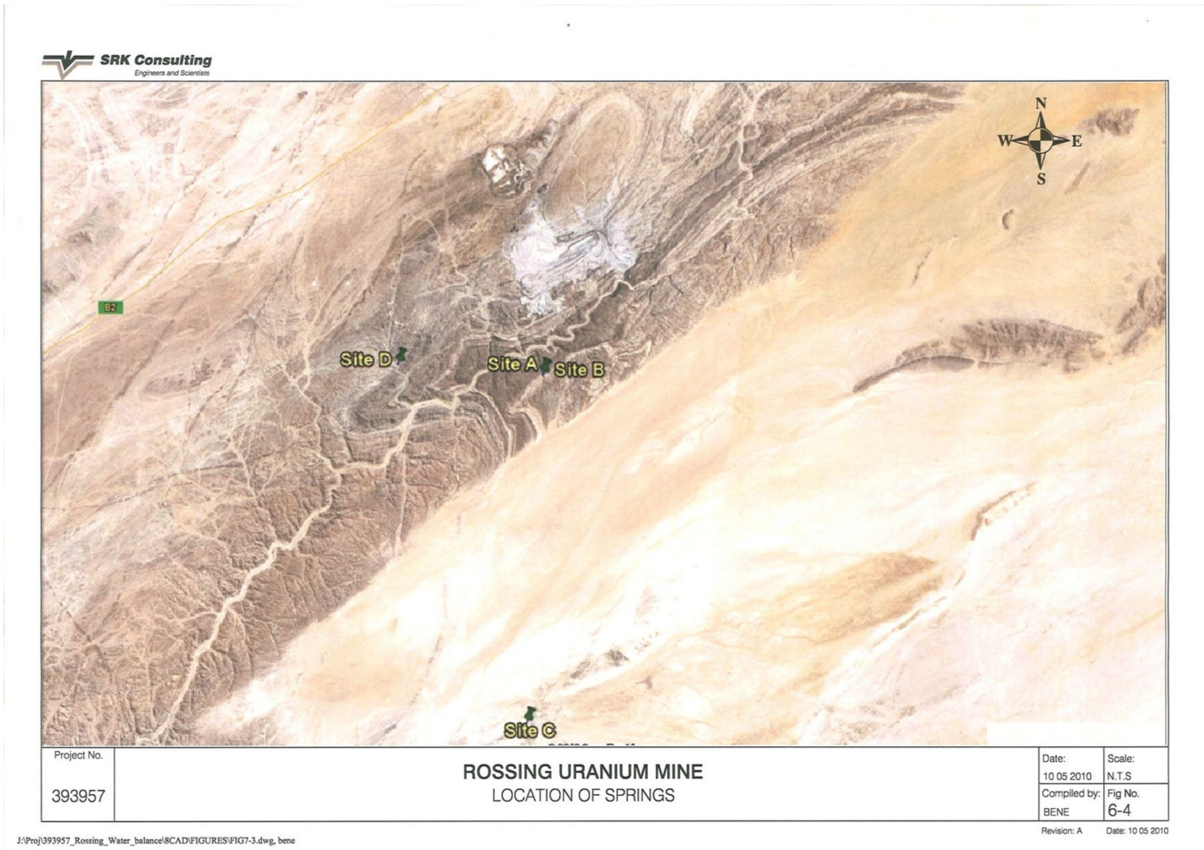


Figure 6-4 : Location of springs

6.5 Water quality

There are no significant sources of surface water or groundwater within the mining grant. Process water losses are minimised, spillages and seepages are largely recovered and recycled, and the piped NamWater supply from the Omdel Dam north of Swakopmund is drawn to make up the inevitable water losses. There are plans to reduce abstraction from the Khan River alluvium.

Fresh water is preferentially used for domestic purposes and for selected process applications that need domestic quality water such as reagent make-up, metallurgical processes, and gland service. High quality water is cascaded across various uses as far as possible, but most of it eventually ends up in the tailings circuit characterised by a pH of 2, dissolved salts of ±35,000 mg/l, sulfates of ±28,000 mg/l, chlorides of ±1,500 mg/l, nitrate (as NO_3) of ±50 mg/l, iron and manganese each of 4,000 to 5,000 mg/l. As the tailings slurry drains through the tailings facility the sulfate concentration is virtually halved through neutralisation of the residual sulfuric acid and precipitation of gypsum within the dam. The milling and extractive leach processes are adapted to using water of that extreme quality.

The water recycling systems at RUL have been extremely successful to the point of reducing make-up volume requirements to approximately 250 litres per tonne of ore milled. This make up rate will be further reduced towards 180 l/t with the implementation of the new heap leach process and the disposal of high density tailings (see water balance section).

The major water management focus at RUL is to contain the water in use within manageable circuits and to capture and retrieve spillages and seepages from cut-off trenches and well-points that intercept alluvial-channels, thus preventing any measureable discharge to the Khan River, in compliance with the effluent discharge permit.

The position of the mine-contaminated seepage plume from the tailings facility is continually tracked. There is an active program focussed on drawing the plume back towards its source by continual groundwater pumping. This means that the analytical focus is on preventing possible seepage to the Khan River.

Seepage from both the tailings facilities and the waste rock dumps situated around the pit will continue long after the mine has closed. The nature of these seepages needs to be investigated fully in terms of composition, flow paths, site discharge points, flow rates and longevity amongst other characteristics. Considerable work has been done on both the tailings and waste rock dump seepages with the objective of defining effective management measures that can be employed during both the operational and post-closure phases of the mine.

The status of the work carried out recently with regard to waste rock dump seepage is reported in the following section (Section 6.6).

The Khan River water is naturally brackish and unsuitable for most purposes other than livestock watering and sustaining hardy vegetation. Table 6-3 below shows typical selected analyses of Khan River water abstracted from RUL boreholes in the river bed, compared with the Namibian guidelines for stock watering. These boreholes have consistently provided water in full compliance with this guideline, and corroborate the contention that RUL operations have no measurable effect on its quality.

Table 6-3: Typical Khan River water quality compared with the Namibian Stock-watering Guidelines

Determinant	Stock Watering Standard (maximum concentration)	Khan River BH1.6A
Conductivity (mS/m)	3500	720
Sodium (mg/L)	2000	845
Calcium (mg/L)	1000	390
Magnesium (mg/L)	500	158
Chloride (mg/L)	3000	1850
Sulfate (mg/L)	700	668
Nitrate (as N mg/L)	400	2.1
Fluoride (mg/L)	6	1.1

Note: Obtained from the Rössing Water Management operating procedure.

6.6 Waste Rock Dump Seepage

6.6.1 Background

The Phase 2 Expansion Project will initially generate comparatively large volumes of waste rock as the Pit is enlarged to expose additional ore resources. The prevailing practice has been to deposit waste rock in dumps stepped back from the pit. These dumps are loosely classified as Low Grade (LG), High Calcite (HC) or Waste Dump (W) according to the characteristics of the waste rock being excavated, as summarised in **Error! Reference source not found.** below.

Table 6-4: Waste rock dumps around the Rössing Pit

Sample number	LOCATIONS	DESCRIPTION	EASTING (X)	NORTHING (Y)	ELEVATION (Z)
DATE: 5 Feb 2009	Samples taken from different dumps, "mining contaminated", but run of mine composites.				
LG2	LG2	Low Grade Dump	-5314.725	55195.693	510.066
LG4	LG4	Low Grade Dump	-6807.728	51554.953	548.332
LG5	LG5	Low Grade Dump	-3903.563	53801.2	536.269
LG7	LG7	Low Grade Dump	-7735.313	51927.553	577.313
HC7	HC7	High Calc Dump	-7773.034	52626.349	526.108
W2	W2	Waste Dump	-5095.656	55330.345	494.527
W3	W3	Waste Dump	-6458.157	54508.543	580.881
W4	W4	Waste Dump	-7686.456	51755.306	575.775
W5	W5	Waste Dump	-4084.051	54169.078	553.166
W7	W7	Waste Dump	-7441.606	53167.65	522.752

The layout of these dumps is shown in relation to the Pit, Plant and Khan River in Figure 6-5 below.

Composite Run-of- Mine waste rock samples as listed in Table 6-4 above have been taken by Rössing personnel and submitted to SRK Consulting in Johannesburg for specified geochemical testing.

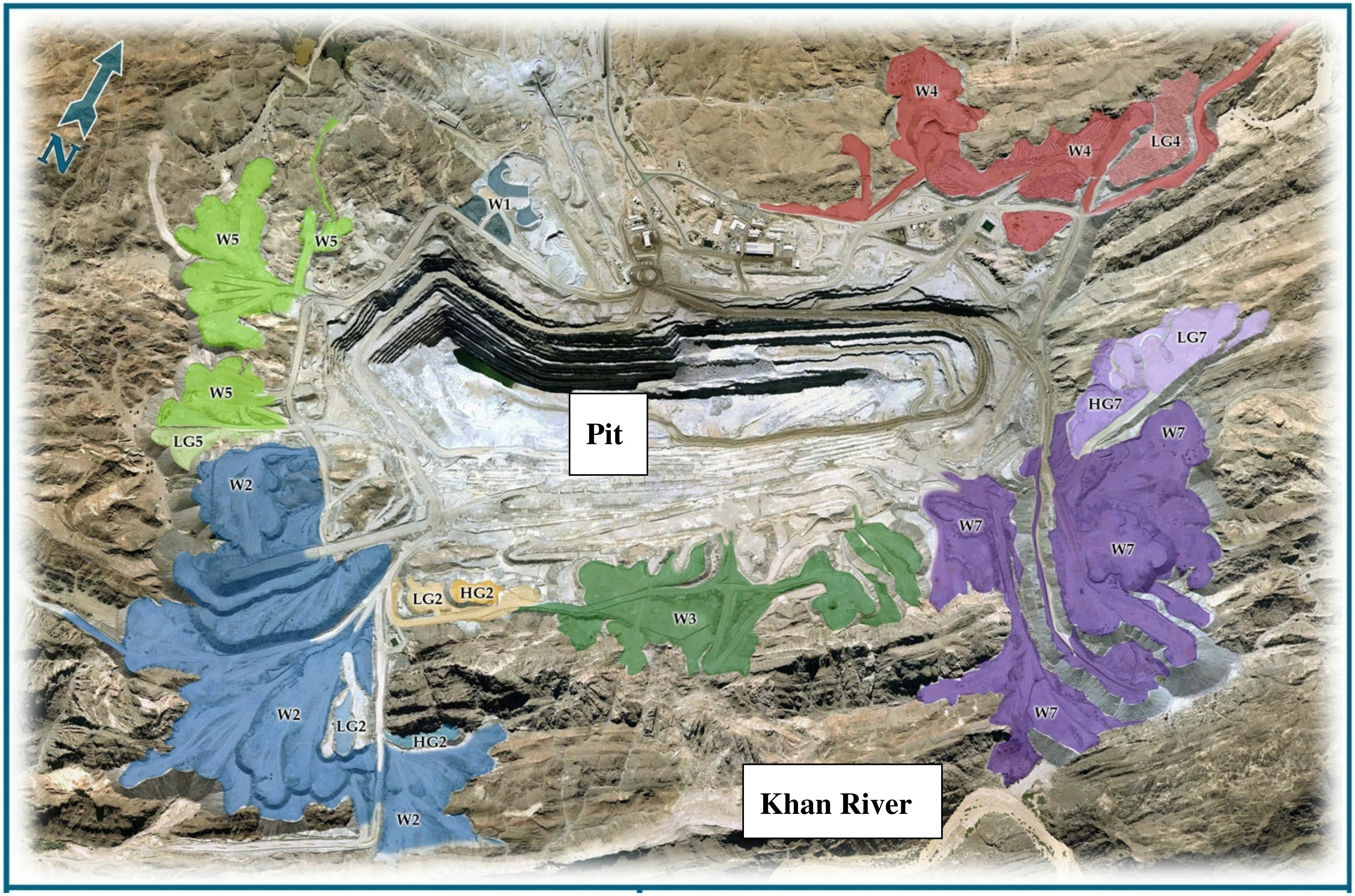


Figure 6-5: Layout of waste rock dumps at Rössing Uranium Mine

6.6.2 Objectives of the investigation

Much of the waste rock dumped can be classified as low-grade ore, and as such is likely to contain measurable concentrations of uranium (U), as well as various other potentially soluble components, amongst which are nitrate (NO_3) (derived from explosives used in the Pit) and sulfate (SO_4). The presence of these can be regarded as indicators of drainage from the waste rock dumps.

Rössing management is concerned that possibly-contaminated drainage may seep from the base of the various waste rock dumps and migrate towards the Khan River, a major tributary of the Swakop River which supplies downstream owners of small agricultural lots with irrigation water. Rössing management needs to understand the probability of this happening so that effective steps can be put in place to prevent the Khan River from receiving contaminated water, both during operation and after closure and rehabilitation of the mine site.

The investigation reported here, is to determine the acid generating potential of the waste rock sampled from ten waste rock dumps at Rössing, and the potential of the leachate from these dumps to convey contaminants, particularly uranium, sulfate and nitrate, to environmental and human receptors down-gradient of the dumps. Rössing has imposed effective environmental management measures in the form of boreholes and trenches in seepage paths to enable it to intercept potentially contaminated seepage during the operational phases of the mine, but this information is considered particularly important as it pertains to the mine after closure when passive management measures may be incorporated where feasible.

6.6.3 Previous work in support of the waste rock seepage assessment

ARD potential of rock and tailings

In June 2008, Environmental Geochemistry International (EGi) based in NSW Australia reported its results for estimating the ARD potential of 112 rock samples and 10 tailings samples from the Rössing Uranium Mine. EGi concluded that 12 rock samples (cordierite gneiss and pyritic quartzite) and two tailings samples were potentially acid forming based on total sulfur concentrations, assuming conservatively that all of the sulfur was in the oxidisable sulfide form. On the basis of this investigation it is possible that some of the waste rock may prove to be acid generating, and therefore have the potential to leach metals and elevated salt concentrations from the waste rock.

Groundwater modelling

AquaTerra has developed a groundwater model for the mine site and immediate surrounds, showing a general groundwater flow from northeast to southwest towards the Khan River. However the enlarged Pit will intercept much of the regional flow and act as a groundwater sink. Waste Rock Dumps situated to the north of the Pit will drain into the Pit, but those south of the Pit are expected to drain towards the Khan River.

Waste Rock Dump seepage model

As a further step in this investigation Rössing commissioned O'Kane Consultants Inc (OKC) based in Canada to complete a prediction of basal seepage from a generic waste rock dump to determine how much drainage should be expected from Rössing's waste rock dumps in response to the rainfall received in the area of the mine, which averages about 40 mm per annum, compared with evaporation of up to 2,700 mm per annum.

OKC reported the outcome of its prediction model in March 2010, and summarised the finding as "the volume of water that enters the top of the waste rock dump will eventually exit from its base", although surface evaporation was not considered. SRK has not investigated the significance of omitting evaporation from the model, but has accepted that the prediction is likely to be a conservative worst case.

6.7 Methodology used in assessing mobilisation of contamination from the waste rock

Extensive discussions were held with Rainer Schneeuweiss of RUL to agree the testing format likely to give the most useful projections. It was accepted that it would be unrealistic to try to simulate the patterns of drainage through a number of operational waste rock dumps that were continually growing in height through ongoing deposition. It was agreed that leach columns should be set up for the ten samples of waste rock received from Rössing for geochemical testwork. These would be irrigated on a weekly basis, and the drainage recovered and analysed for salts and metals (by ICP-MS quantitative scan), and particular note taken of sulfate, nitrate and uranium concentrations, considered to be markers for contamination from the mine. Irrigation of the columns would be stopped when the concentrations of SO_4, NO_3 and U in the column drainage stream were found to be stabilising.

6.7.1 Acid Base Accounting (ABA)

Before charging the leach columns, the acid generating potential for each of the ten waste rock samples was tested. The Modified Sobek procedure (EPA-600) was prescribed to ensure that only the carbonates and readily-weathered silicates would be included in the neutralising potential to avoid its over-estimation. Sulfur speciation allowed acid potential to be calculated on sulfide as well as on total sulfur: in oxidised material calculations based on total sulfur may provide unrealistically exaggerated values for acid generation.

Table 6-5 below summarises the results of the ABA testwork based on total sulfur and sulfide, and shows the acid-generating potential of the waste rock samples compared with their neutralising potentials.

Based on the sulfide (total sulfur) content, six (eight) of the ten samples tested showed relatively high acid generating potential, but six (six) of these contained large excesses of neutralising potential suggesting that the acid produced may be neutralised in situ, limiting the leaching of metals from the dumps represented by the samples, but probably producing a seepage with elevated salts, and particularly sulfate.

Figure 6-6 is plot of acid potential against neutralising potential on a log-log basis, and shows all samples other than W4 and W7 to be acid neutralising. W4 plots as potentially acid generating, while W7 plots within a band of uncertainty between acid generating and acid neutralising.

Table 6-5: Summary of the Acid-Base Accounting results for the waste rock samples received

Modified Sobek (EPA-600)	**LG 2**	**LG 4**	**LG 5**	**LG 7**	**HC 7**	**W 2**	**W 3**	**W 4**	**W 5**	**W 7**
Paste pH	9.2	8.2	9.3	8.5	8.6	9	9.3	8.6	8.5	8.6
Neutralization Potential (NP)	26	10	14	4.92	47	194	421	0.1	18	6.39
Balance based on total sulfur results										
Total Sulfur (%) (LECO)	0.01	0.182	0.03	1.2	0.139	0.746	0.695	0.212	0.135	0.212
Acid Potential (AP) (kg/t) - So	0.31	5.7	0.94	38	4.4	23.0	22.0	6.6	4.2	6.63
Nett Neutralization Potential (NNP)	26	4.74	13	-33	43	171	400	-6.63	14	-0.24
Neutralising Potential Ratio (NPR) (NP : AP)	74	1.8	15	0.13	11	8.3	19	0.91	4.3	0.96
Balance based on sulfide results										
Sulfide (S2-) Sulfur (%)	0.01	0.01	0.01	0.07	0.14	0.72	0.7	0.2	0.14	0.2
Acid Potential (AP) (kg/t) - S-2	0.31	0.31	0.31	2.2	4.4	22.5	21.9	6.25	4.38	6.25
Nett Neutralization Potential (NNP)	25.7	9.7	13.7	2.7	42.6	171.5	399.1	0.01	13.6	0.1
Neutralising Potential Ratio (NPR) (NP : AP)	82	31	44	1.2	10	7.6	18	0.002	3.1	0.02

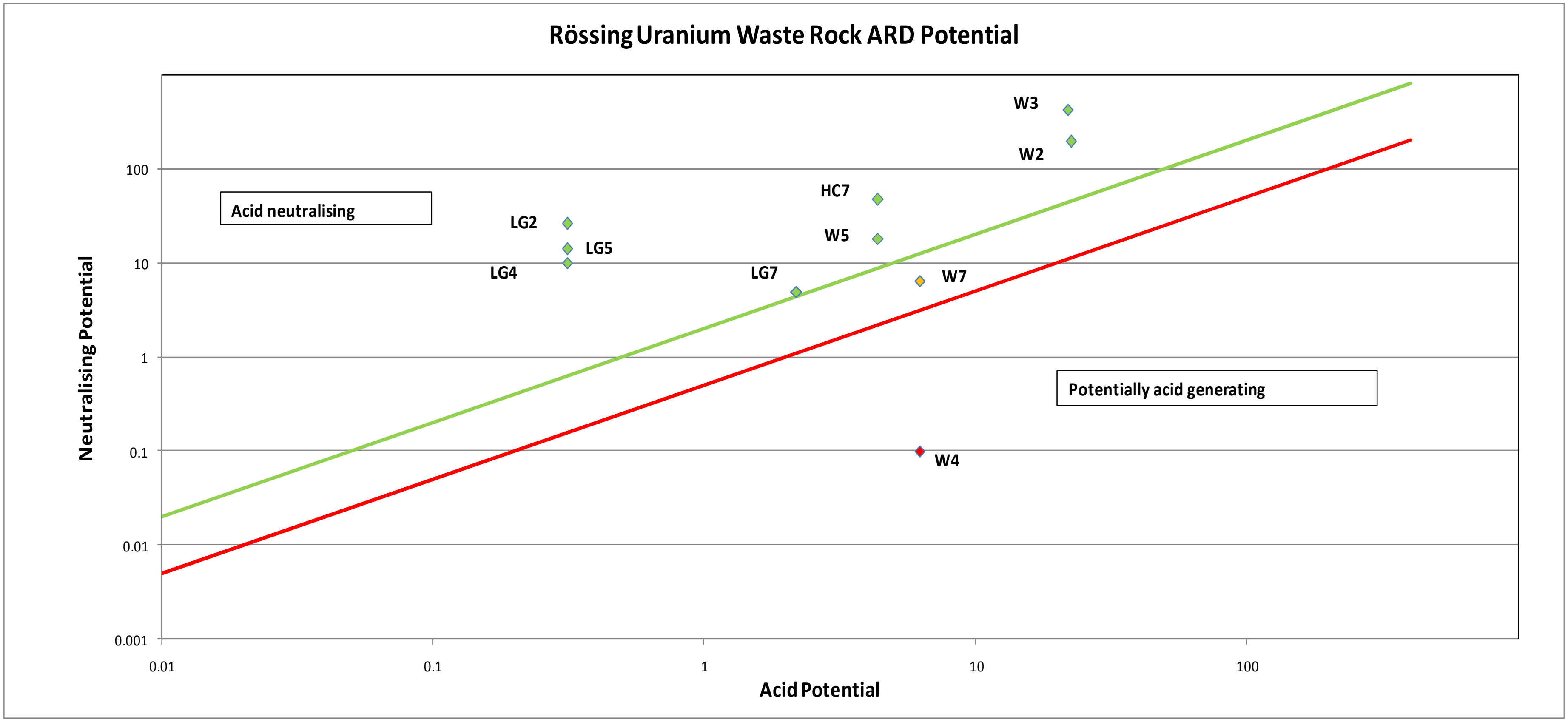


Figure 6-6: Plot of Acid Potential against Neutralising Potential for Rössing Uranium waste rock

6.8 Leach columns

Ten leach columns have been set up at WaterLab in Pretoria, each charged with 2000 g of a waste rock sample crushed to <3mm diameter. One litre (1000 ml) of deionised water is added to the column every seven days and allowed to drain over two days. The leach water captured each week is analysed by ICP-MS for a wide range of metals and metalloids including uranium, and separate analyses are conducted for nitrate and sulfate.

Leach columns would normally be irrigated at weekly intervals for 46 weeks or longer. At the time of reporting the columns had been leached for 10 weeks, and so the results need to be seen as work in progress.

6.8.1 Comparison of leach columns with the waste rock drainage model

The waste rock dumping program is expected to cater for 630 million tonnes of waste rock deposited in layers with step-backs at 5m intervals on a total footprint area of 610 hectares.

The seepage model assumes that annual rainfall infiltrating the dumps will be 15 mm/a, all of which will seep from the bottom of the WRD over a period of 3 years. The delayed seepage of the annual infiltration is due to water being held up in the dump by layers of fine (less permeable) tailings laid down at each step-back. The leach column accelerates the infiltration rate very markedly, as indicated in the comparative rates below.

Table 6-6: Comparison of irrigation rates of the leach column with the waste rock dumps

	Waste rock dump	Leach column
Material	Run-of Mine waste rock	< 3 mm diameter
Rainfall depth (mm/a)	15 mm	6600 mm
Water to solids ratio (by mass)	0.000145	26
Water to solids ratio (by volume)	0.00029	52
Equivalent years of rainfall	180,000 years	1 year

6.8.2 Column results

Tables and figures (6-7 to 6-10) are presented below to summarise the results of 10 weeks of column irrigation in showing the trends in pH, nitrate (mg/l N), sulfate (mg/l SO_4) and uranium (mg/l U).

Table 6-7: Weekly results for pH from each of the waste rock samples

Week	1	2	3	4	5	6	7	8	9	10
LG2	8.6	8.9	8.3	8.6	8.1	6.1	6.8	7.3	6.9	8.9
LG4	7.1	7.5	7.5	7.3	7.5	6.5	6.7	6.9	6.4	8.2
LG5	9.1	8.6	8.1	8.2	8.0	7.1	7.0	7.2	6.8	8.4
LG7	7.4	7.3	7.4	7.3	7.3	6.5	6.9	6.9	6.4	7.8
HC7	7.4	7.5	7.7	7.5	7.7	6.7	6.9	7.0	6.7	8.0
W2	7.9	7.9	7.9	7.9	8.1	7.0	6.9	7.2	7.1	8.0
W3	8.8	8.3	8.0	8.0	8.2	7.3	7.5	7.7	7.6	8.5
W4	7.8	7.5	7.5	7.3	7.5	6.8	7.2	7.1	7.1	7.9
W5	7.6	7.5	7.6	7.5	7.7	6.8	7.1	7.0	7.0	7.8
W7	7.9	7.7	7.5	7.5	7.4	6.8	7.0	6.9	6.8	7.7

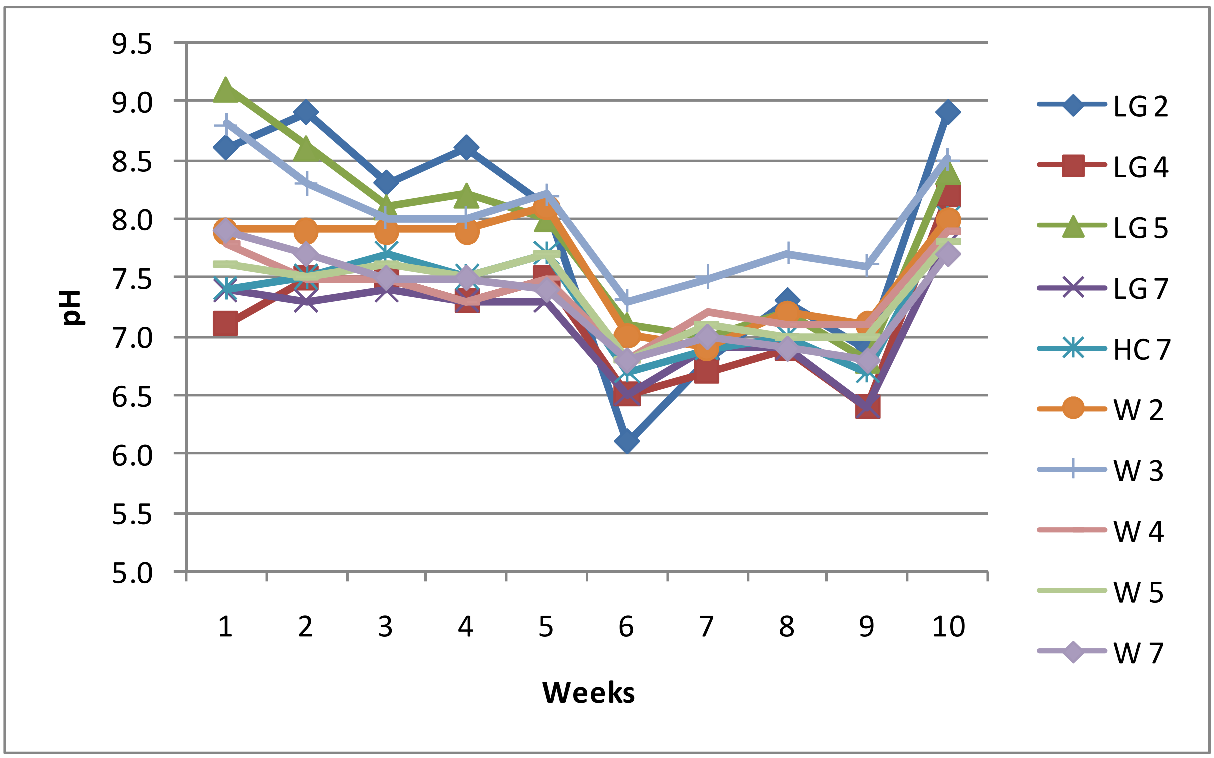


Figure 6-7: Weekly results for pH from each of the waste rock samples

Observation

The samples of primary interest are those highlighted in yellow as being the main drainage points towards the Khan River. In all cases the pH started slightly alkaline an dropped marginally week by week followed by a strong drop in week 6, after which it climbed gradually back to its starting value by week 10.

Table 6-8: Weekly results for Nitrate (as mg/l N) from each of the waste rock samples

Week	1	2	3	4	5	6	7	8	9	10
LG2	5.1	0.6	0.3	0.3	0.4	<0.2	0.2	<0.2	0.2	<0.2
LG4	6.2	2.5	0.6	0.3	0.2	0.2	0.2	<0.2	<0.2	<0.2
LG5	2.4	0.3	0.2	0.2	0.2	<0.2	0.3	<0.2	<0.2	<0.2
LG7	2.2	4.2	0.5	0.3	<0.2	0.3	0.2	<0.2	<0.2	<0.2
HC7	4.4	1.5	1	0.3	0.2	0.2	0.2	0.2	<0.2	<0.2
W2	1.8	0.5	0.2	0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2
W3	4	3.3	1.2	0.6	0.4	0.5	0.2	<0.2	<0.2	<0.2
W4	0.9	5.2	1.5	0.9	0.4	1.3	0.4	0.3	0.2	0.2
W5	12	0.2	0.2	0.2	0.2	0.2	<0.2	<0.2	<0.2	<0.2
W7	15	4.9	1.4	0.6	0.3	4.5	1.8	0.7	0.2	0.3

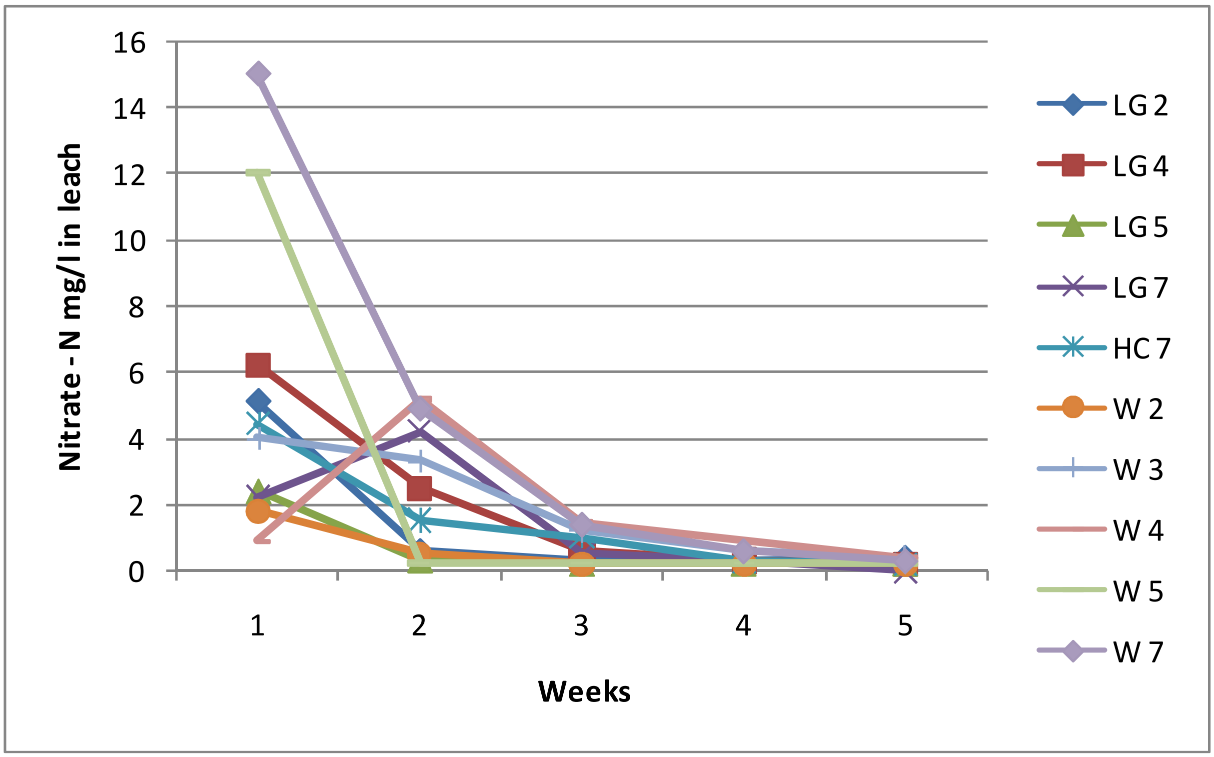


Figure 6-8: Weekly results for Nitrate from each of the waste rock samples

Observation

The inventory of highly soluble nitrate washed out rapidly to trace values by week 4. The week 6 result for W7 is seen as anomalous.

Table 6-9: Weekly results for Sulfate (as mg/l) from each of the waste rock samples

Week	1	2	3	4	5	6	7	8	9	10
LG2	86	46	13	5	5	6	5	5	5	5
LG4	739	468	431	309	336	419	423	318	254	243
LG5	94	39	12	5	5	5	5	5	5	5
LG7	811	510	464	394	385	526	503	442	359	362
HC7	303	287	143	123	130	49	152	108	49	79
W2	160	229	116	83	60	128	110	42	21	24
W3	70	170	63	39	37	66	42	27	11	16
W4	472	357	291	270	271	367	398	271	201	279
W5	565	366	308	228	238	264	342	193	164	164
W7	422	335	323	323	290	229	361	390	308	309

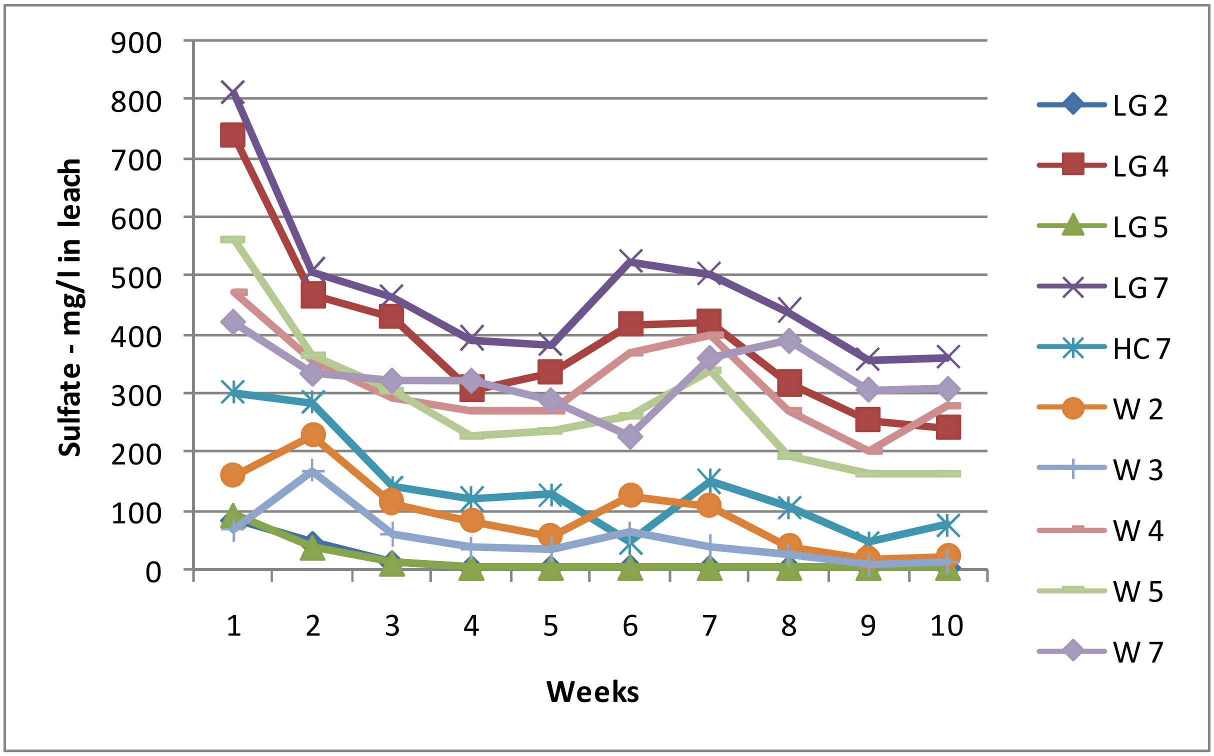


Figure 6-9: Weekly results for Sulfate from each of the waste rock samples

Observation

All samples showed somewhat variable weekly trends, although the overall trend in each case is to drop to significantly lower values by week 10. The explanation for these transient trends is not obvious.

Table 6-10: Weekly results for Uranium (as mg/l) from each of the waste rock samples

Week	1	2	3	4	5	6	7	8	9	10
LG2	0.024	0.151	0.217	0.426	0.289	0.540	0.616	0.594	0.356	0.307
LG4	0.138	0.301	0.376	0.336	0.326	0.464	0.530	0.623	0.535	0.337
LG5	0.033	0.089	0.062	0.116	0.081	0.155	0.134	0.130	0.053	0.067
LG7	0.039	0.126	0.046	0.070	0.037	0.058	0.057	0.051	0.049	0.036
HC7	0.068	0.159	0.130	0.115	0.110	0.146	0.160	0.165	0.160	0.123
W2	0.009	0.014	0.014	0.014	0.012	0.028	0.025	0.025	0.015	0.012
W3	0.001	0.011	0.002	0.000	0.000	0.005	0.005	0.001	0.000	0.000
W4	0.031	0.162	0.109	0.125	0.107	0.141	0.179	0.168	0.144	0.163
W5	0.011	0.025	0.034	0.036	0.024	0.032	0.034	0.051	0.045	0.036
W7	0.032	0.220	0.201	0.265	0.186	0.171	0.235	0.304	0.211	0.194

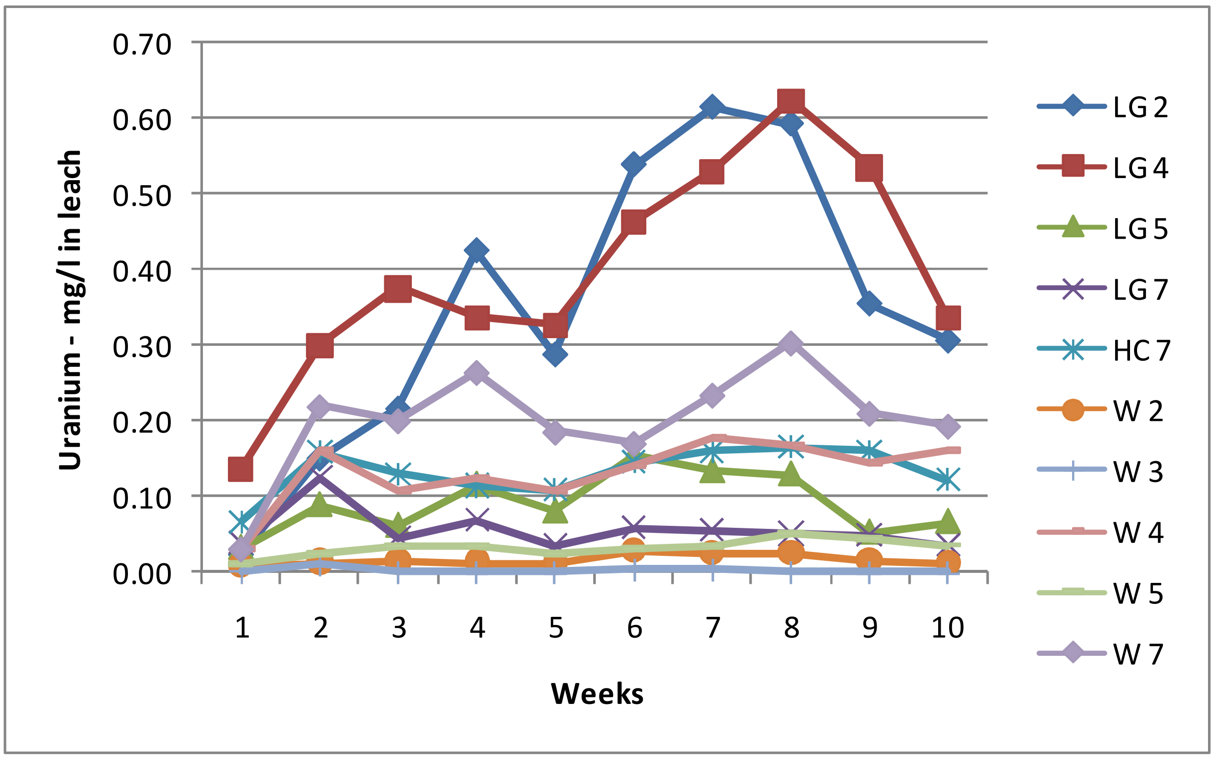


Figure 6-10: Weekly results for Uranium from each of the waste rock samples

Observation

W2 trebled its soluble uranium value at week 6, but by week 10 it declined to the starting value.

W3 has insignificantly low uranium values throughout the 10 week leach period.

W7 peaked at ten times its starting value at week 8 before starting to decline.

6.8.3 Depletion of AP, NP and Uranium from the leach columns

Table 6-11 below provides a summary of the inventory depletion over ten weeks of column leaching for acid potential, neutralising potential and uranium in each of the WRDs W2, W3 and W7, which are considered to drain towards the Khan River.

Table 6-11: Depletion of AP, NP and U percentages over 10 weeks of column leaching

WRD	AP remaining (%)	NP remaining (%)	Uranium remaining (%)
W2	98.6	99.8	99.0
W3	99.1	99.9	Below detection
W7	81.3	79.8	93.7

6.9 Comment

Table 6-11 above indicates that despite the high irrigation rates of the columns the inventories of AP, NP and uranium have shown very little depletion. W2 and W3 have neutralising potentials of 170 and 400 times their respective acid potentials and would be expected to remain neutral with little leaching of metals or elevation of salts in their seepage streams. W7 has lower AP and NP but at almost equivalent levels, so that some variability in WRD seepage may be expected depending on the spatial distribution of the sulfide and carbonate species. W7 is the most geochemically active of the three dumps under discussion (at this stage), and is situated close to the Khan River which will require protection from its seepage.

Constituents other than uranium are shown in the weekly leach tests to be uniformly close to their detection limits, and appear to present little risk to the WRD seepage water quality.

At this stage the column leach tests on the waste rock samples have run for only 10 weeks, and a question remains as to whether all the in situ surface-bound chemical components have been flushed from the columns or whether any level of weathering of rock has commenced. This can only be reliably answered in time through interpretation of column results over longer periods. The indication is that there is unlikely to be major depletion of uranium from the WRD within the next 20-30 years when the mine will expect to be decommissioned, and the uranium residuals in the seepage water from the waste rock dumps will need to be prevented from entering the Khan River system.

At this stage the solubilisation mechanism for the uranium in the WRD is unknown. It is understood that the most common source of the Rössing uranium is the ore uraninite composed primarily of the water-insoluble uranium oxide. Acid generation within the waste rock, particularly at micro-sites within the dumps, could be responsible for dissolving uranium from its ores, but this is conjecture at this stage. The columns indicate that uranium in concentrations of concern is being liberated from the test material and the remaining inventory of uranium in the columns indicates that this will continue for a considerable time. To resolve uncertainties the column tests should be continued until the geochemical mechanisms involved can be clarified.

At this stage it would be prudent to assume that the concentrations of soluble uranium currently experienced in the drainage channels near the Khan river, typically ranging between 0.1 and 0.3 mg/l should be expected at closure, and will need to be prevented from entering the Khan River. The use of passive chemical barriers has been mooted, and this option (and others) should now be investigated further for their feasibility.

7 Water Balance

This section describes the available water resources and water requirements for the mine.

The water balance was compiled for the average monthly conditions assuming no rainfall in order to ensure the water requirements are not reduced due to rainfall. During rainfall events the only change to the water balance will be a reduction in water requirements for a few days as the water is sourced from the stormwater dams (less than 10 days). A site water balance was developed to evaluate the water requirements and where water can be sourced to sustain the plant operation.

This section describes the available water resources and water requirements for the mine.

A simplified water balance was compiled for the Rössing mine for the existing situation with the present infrastructure. The existing simplified water balance was prepared by using existing values from the mines existing water balance. These values may vary from month to month but gives a good indication of where water is sourced and where the water is used in the mine.

A second water balance was prepared for the situation assuming that Phase 2 of the Rössing expansion has been constructed. This was undertaken by overlaying the new infrastructure for Phase 2 onto the existing water balance. This was undertaken to identify how much additional water will be required to sustain the mine and identify where different types of water can be used on the mine. The phase 2 water balance was then simplified as per the existing water balance so that the water usage could be compared.

7.1 Assumptions

The assumptions used in the existing water balance are as follows:

- All freshwater is sourced from Namwater which is the bulk water supplier for Namibia;
- All volumes are measured in m³/day and the ore moisture volume is based on 2.5% of moisture contained in the ore;
- Acid is 97% pure with 3% water content;
- Khan provides brackish water used for dust suppression in the open pit; this will be minimised in the future;
- Groundwater refers to the water released from the ore during blasting and is collected at the lowest point in the pit, in the open pit sump and also used for dust suppression;
- Entrainment- water locked up within the tailings material is not extractable;
- Tails dam RDS evaporation – evaporation from the open pool of water in paddy;
- Seepage evaporation- evaporation from open seepage trenches around the tailings dam;
- Uranium plant evaporation- evaporation lost to the atmosphere while in the plant circuit;
- Dust suppression-dust suppression in the open pit;
- Primary crushers evaporation-sum of evaporations from coarse ore stockpile, ammonium nitrate stores and primary crushers;
- Seepage loss- seepage losses estimated to be lost as obtained from the groundwater model;

- Treated sewage losses - Treated sewage is used as dust suppression;

The following assumptions were made for the future water balance:

- The water from Khan river is removed from the water balance (presently the use is less than 1Ml/d);
- The water requirement for the existing mine elements remains as it presently except for the existing tailings dam which will be replaced with a High Density Tailings Facility;
- The new High Density Tailings Facility on the dome is a High Density thickened tailings facility;
- Information regarding the tailings water characteristics was obtained from Metago Engineers in a spreadsheet entitled " Estimated Water Use, Water Make up and Deposited tailings Water Characteristics" and the data includes:
  - The volume of water pumped to the High Density Thickened Tailings facility is 19153 m^3/d;
  - Entrainment at 4625 m^3/d;
  - Tailings Dam RDS Evaporation at 1123 m^3/d;
- Groundwater inflow into the pit (including the return water from dust suppression) that can be used as make up water is 151 m^3/d (0.151 Ml/d). It is assumed that the existing inflows into the pit do not increase substantially from the existing inflow into the pit. If this water is not pumped out of the pit the water will evaporate and the pit will remain dry. The groundwater model excludes water inflow into the pit but for the water balance some return flow from the pit is presently experienced;
- Sulfuric Acid at 684 m^3/d was obtained from the "Annual Steady State Water Balance (Nominal Case)" PFD obtained from the process engineers;
- Hydrogen Peroxide at 22 m^3/d was obtained from the "Annual Steady State Water Balance (Nominal Case)" PFD obtained from the process engineers;
- Evaporation losses from the plant and potable water requirements for the plant were abstracted from the "Annual Steady State Water Balance (Nominal Case)" PFD obtained from the process engineers
- The existing seepage capturing systems remain in place except for the Panner gorge seepage collection facilities which will be moved to cater for the Ripios footprint area which extends over the existing seepage collection facilities;
- The storage facilities on site will be more interlinked and thus evaporation from the facilities will change depending on the operational requirements. When excess water is available then the stormwater dams will be full and when excess water is minimal the dams may be empty. At this stage of the water balance it is assumed that good management of water is occurring
- The additional sewage water that is expected from the expansion will be reused in the system.

7.2 Simplified water balance for existing mine

The mine water balance components and the flows are illustrated in Figure 7-1 Clean water circuits are shown in blue and the dirty water circuits in red (sewage) and grey lines are for consumption and evaporation. All the flow rates are steady state values and given in m^3/day.

The following should be noted:

- Rössing Mine has a water balance that is updated on a monthly basis and the plant places tremendous importance in optimal use of water within the mine circuit in terms of quality (ie where best can water with a specific quality be used). This allows for the minimisation of Namwater use on the mine.
- The main source of water is raw water makeup from Namwater which is about 9250m^3/d and is about 82% of the water inflow into the plant;
- The second major source of water is presently the Khan River wellfield system which is about 8% of the water supply to the plant. Rössing Mine are in the process of reducing the amounts of water abstracted from the Khan River;
- The Namwater is only used once all circulating water on the mine is reused. The Namwater use per tonne is usually less than 250l/t;
- The additional water sources are the water that flows into the pit and water that is contained within the ore amounts to about 10% of the inflow of water into the circuit;
- The major water losses from the existing water circuit largely relate to water losses in the tailings circuit and include:
  - Entrainment of water in the tailings dam which is about 17% of the water losses at the mine;
  - Tailings Dam and RDS evaporation which accounts for about 56% of the water losses from the mine;
  - Seepage losses from the tailings dam which accounts for 1.8% of the water losses from the mine;
  - Seepage and evaporation losses from the seepage collection trenches and seepage dams which accounts for about 5.7% of the water losses from the mine;
  - The tailings facility therefore losses about 81% of the total water losses from the mine.
- Evaporative water losses from the uranium plant and crusher plant account for about 9% of the water losses from the mine;
- Water used for dust suppression at the pit and mine area accounts for about 10% of the water losses from the mine

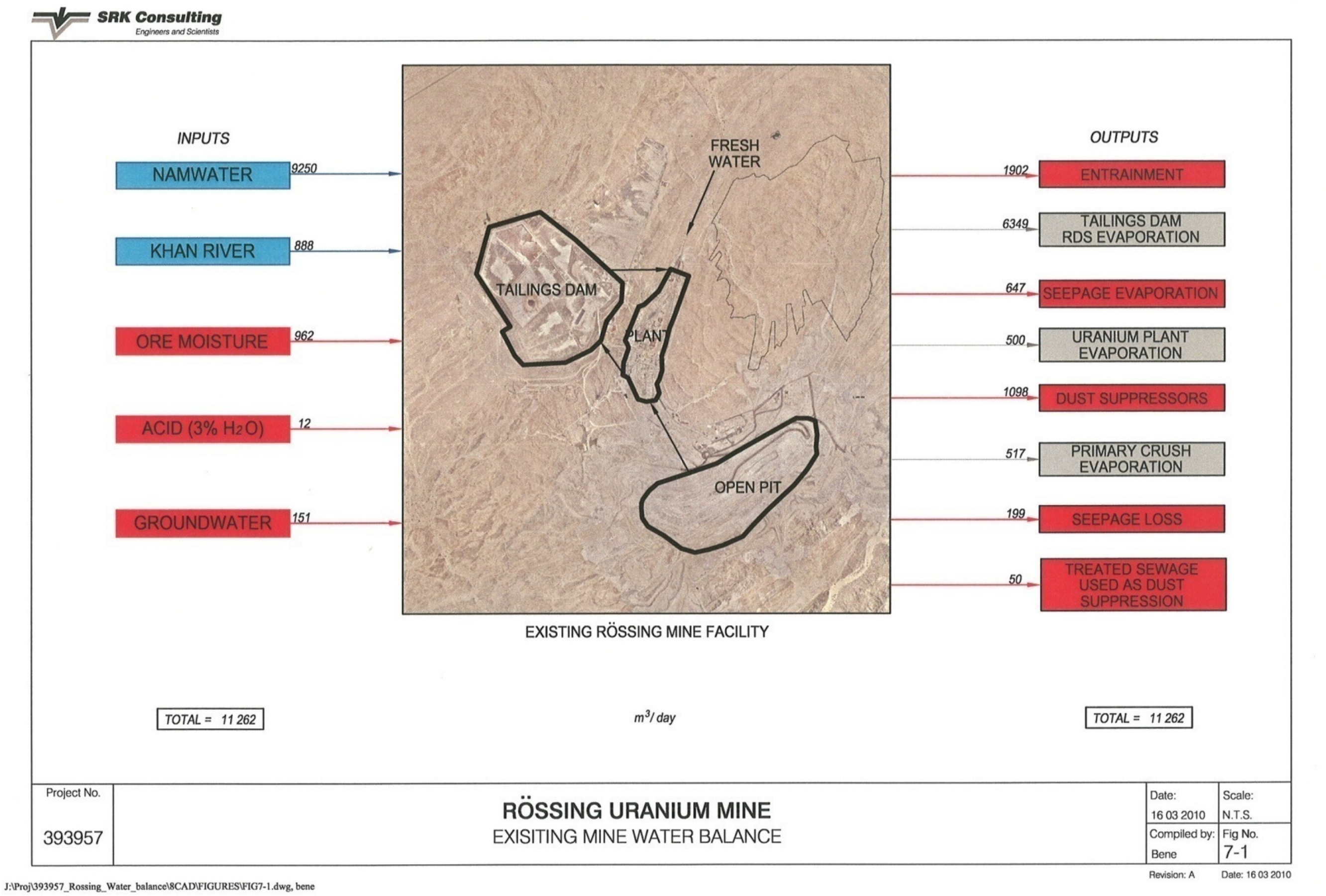


Figure 7-1: Existing Mine Water Balance

7.3 Simplified Water Balance for existing and future mine

The existing and future mine water balance components and the flows are illustrated in Figure 7-2.

The following should be noted:

- The main source of water is raw water makeup from Namwater which is about 14942m^3/d and is about 87.5% of the water inflow into the plant. The increase in percentage increase from the existing water balance (82%) is due to the reduction in Khan river borehole use;
- There will be an increase in Namwater use of about 5700 m^3/d which is about a 60% increase in water use from the existing to the future mining scenario. The expected future tonnage at the mine plant is double the existing tonnage and the reason that the water use does not double is due to the changing of the existing tailings facility to a High Density Facility which substantially reduces the evaporation;
- The Namwater use per tonne will be about 180l/t which is substantially lower than the existing Namwater use per tonne of 250l/t;
- The additional water sources are the water that flows into the pit and water that is contained within the ore amounts to about 6.8% of the inflow of water into the circuit;
- The major water losses from the future water circuit largely relate to water losses in the tailings circuit although the actual volumes are substantially reduced. The losses include:
  - Entrainment of water in the tailings dam which is about 27% of the water losses at the mine. This is significantly higher than the 17% of the existing system. This increase in the loss is because the entrainment water is dependent on the material which will not significantly change from the future to the existing situation. The reduction in evaporation means that the entrainment proportion increases;
  - Tailings Dam and RDS evaporation reduces from 56% of the water losses on the mine to about 6.5% of the losses in the mine. This substantial decrease is because there is less water that is pumped to the tailings dam thus resulting in less water that can be evaporated;
  - Seepage losses from the tailings dam which accounts for 7.9% of the water losses from the mine. This is significantly higher than the 1.8% of the existing system. This increase in the loss as a portion of total water loss is because the evaporation losses at the tailings dam are significantly lower. The reduction in evaporation means that the seepage proportion increases ;
  - The tailings facility therefore losses about 41% of the total water losses from the mine.
- Water is lost in the Ripios dump via evaporation and seepage and this is about 21% of the water lost at the mine and from the heap leap pad 16%;
- Evaporative water losses from the uranium plant and crusher plant account for about 11% of the water losses from the mine;
- Water used for dust suppression at the pit and mine area accounts for about 8% of the water losses from the mine

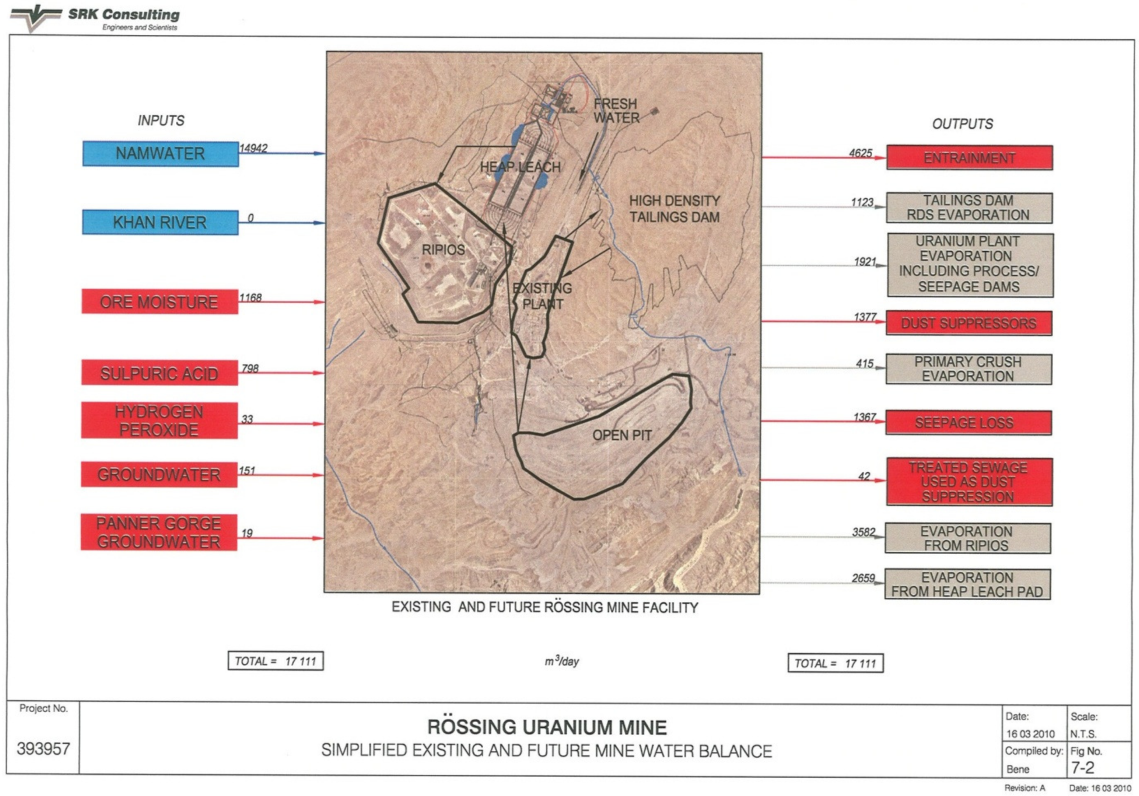


Figure 7-2: Simplified Existing and future Mine water Balance

7.4 Water balance summary

The integration of the existing and future water balance will:

- Increase the total water use at the mine by about 5700 m^3/d but it must be noted that during the initial stages of the implementation of the new High Density Tailings Facility there will be a period when the tailings facility area will be "wetted up". This means that the plant will receive less water that originally expected from the seepage collection facilities and thus additional water will be needed from Namwater;
- It is likely that during the initial start up of the plant the tailings will not be a thickened as per the design requirements and additional water will be required from Namwater. The water use will double from the present use and therefore at worst 20 000 m^3/d of water may be required during the start up phase.
- The reduction in Khan River borehole use will reduce the amount of water available at the crushers for dust suppression. This dust suppression will need to be sourced from elsewhere and polluted water that cannot be used in the plant will be the first source of water but additional reticulation to bring water to the dust suppression dam may need to be investigated;
- The Heap leach pad is a closed circuit and any of the RDS that is available in the heap leach circuit is the preferred make up water. Only when no RDS is available will Namwater be used;
- Water losses from the tailings dam are presently 9100 m^3/d which will drop to about 7300 m^3/d once the high density tailings facility is constructed;

8 Impact Assessment

The five specific components of Rössing's Expansion project are the subject of the present impact assessment of these aspects on the water environment and are described in more detail below:

- Extension of the current SJ open pit;
- Increased waste rock disposal;
- Dome Gorge tailings storage facility;
- Establishment of an acid heap leach facility with disposal of ripios;
- Domestic waste disposal and sewage works.

8.1 Issues relating to Expansion Infrastructure as part of the Phase 2 ESIA

A groundwater flow model has been developed and re-calibrated by Aquaterra in Australia to evaluate the impacts to groundwater resources from the Expansion infrastructure that are addressed in this Phase 2 ESIA. The issues with regard to runoff and water management are also included.

8.1.1 Extension of SJ open pit

The extension to the pit will occur in phases and is mostly a lateral expansion without increasing the current depth. The S4 extension to the northeast appears to intercept the Dome Gorge which could reduce base flow to the Dome tributary. This would also have the effect of intercepting seepage from the Dome Gorge Tailings.

The current ground water levels have been used to re-calibrate the model and shows that the cone of drawdown associated with the pit is very steep particularly on the north-eastern face due to the low permeability of the host rock (Figure 8-1)However, the cone of drawdown appears to extend to the Khan River at the end of the calibration period and it is assumed that there may be a lowering of the water table in the Khan River (located a distance of nearly 3km from the pit) due to the SJ expansion.

The bottom of the pit elevation is below the Khan River elevation, so this could induce flow from the Khan aquifer, but the Karibib Marble is an impermeable layer that should minimise this effect as it is a barrier to groundwater flow.

Inflows into the open pit are estimated to increase to 1450 m^3/day in 2013 once the Dome gorge TSF is commissioned. On closure of the Dome Gorge TSF the tailings recharge source dissipates and the inflows will drop to about a quarter of the current rate after 500 years (i.e. 345 m^3/day).

Twenty years after closure (Figure 8-2) there is still a cone of drawdown towards the pit which continues to act as a sump but due to the high evaporation rate which is much greater than the pit inflows, no pit lake is anticipated to form and the pit will remain dry.

The water table in the Khan River also rebounds but this could be due to cessation of pumping from the Khan alluvial aquifer.

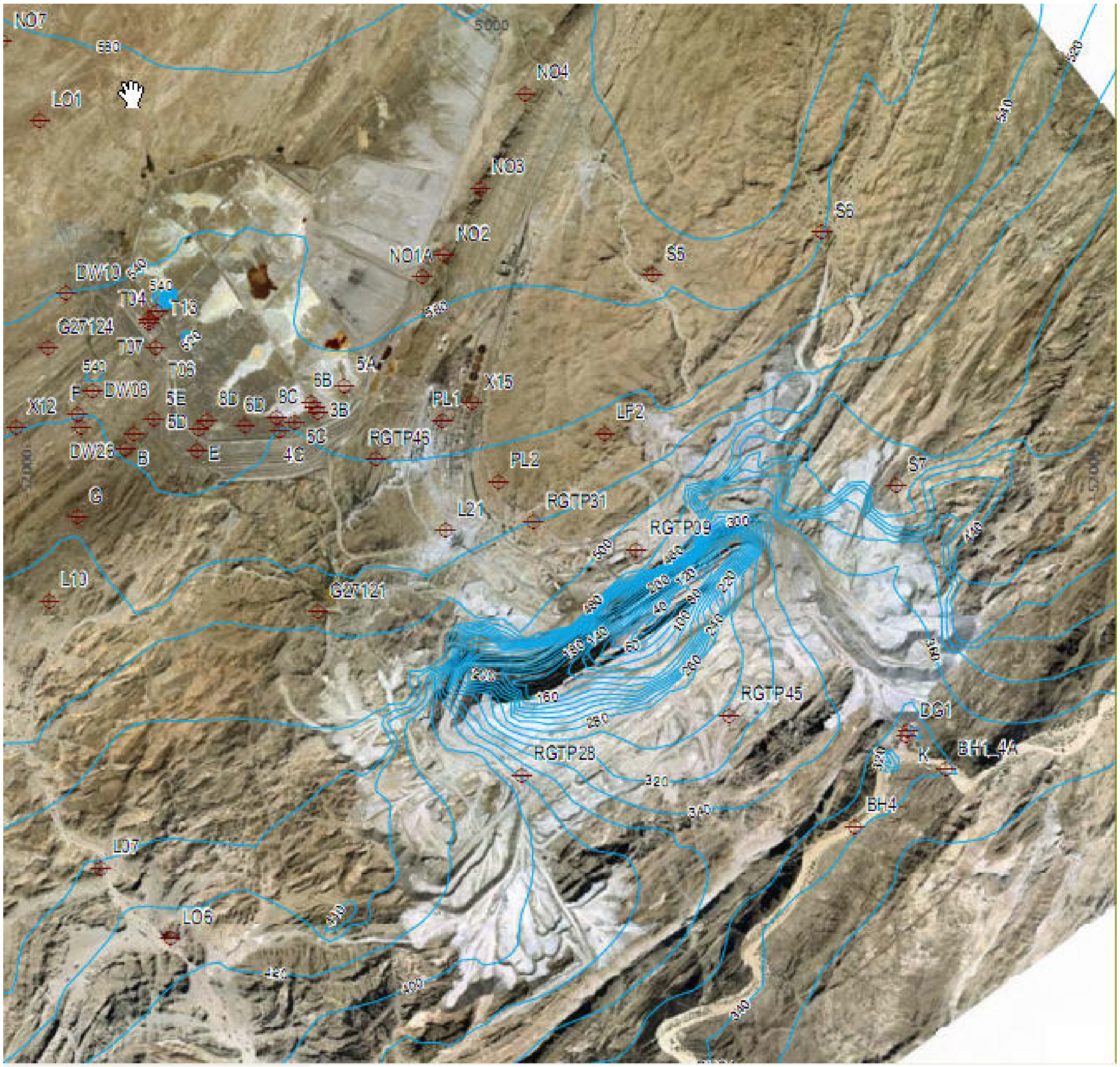


Figure 8-1: Modelled water levels in fractured rock aquifer at end of mining (Aquaterra 2009)

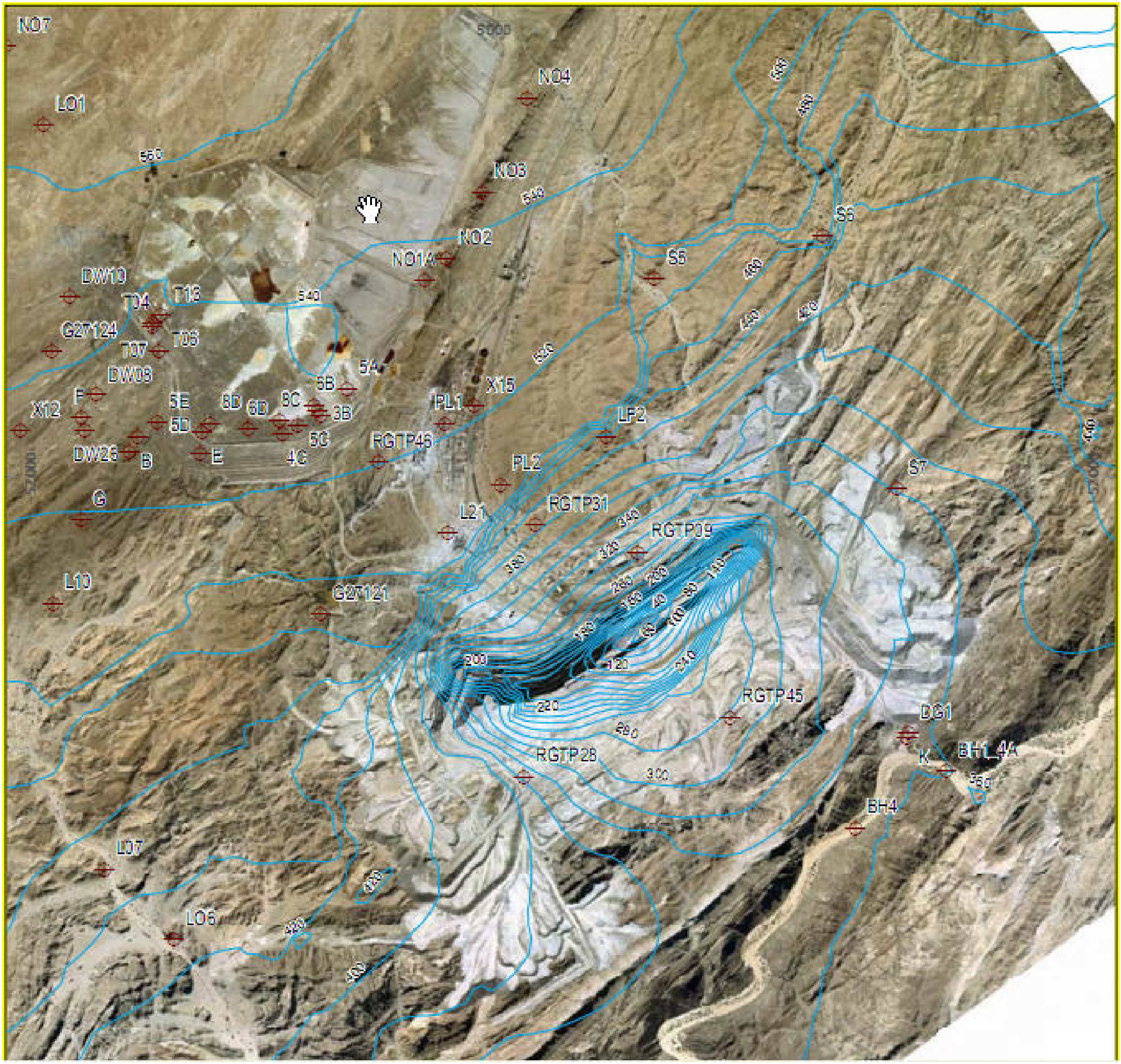


Figure 8-2: Modelled water levels 20 years after closure (Aquaterra 2009)

The following issues in the pit are expected:

- Road damage due to erosion could occur for rainfall events greater than about 20mm
- Vehicles will not be able to ascend the haul road for rainfall events greater than 10mm
- The ponding at the base of the pit may prevent ore being reached. The runoff into the pit for a 1:10 year event will be about 22,000 m^3 and for a 1:100 year event is 52,000 m^3. The volume of the inflow may exceed the pit collection facility and could affect the production and potentially be a safety risk.

8.1.2 Increased waste rock disposal

The waste rock types for the expanded SJ Pit are currently being subjected to geochemical analysis to determine their propensity to generate acid, mobilise metals and release salts that could migrate to the Khan River over time. Column leach tests have now been run for 10 weeks and the early indications are that soluble uranium will be present in the seepage water from the waste rock dumps at closure of the mine.

To test the predicted impact against water quality data collected so far the recent figures for nitrate and sulfate in the Khan River were compared to the calculated effect of leachates for the expansion components associated with the Phase 1 ESIA. The actual long-term impact of the waste rock dumps on the entire Khan River along the mine frontage is much smaller than the predicted figures suggest. The most likely explanation for the relatively low observed impact of leachates is that heavy rain on the mine is usually accompanied by runoff in the Khan River resulting in dilution of the solutes.

It is expected that the waste rock dumps will continue to contribute small loads of nitrate, sulfate and uranium to the Khan River aquifer during the operational phase. Column leaching indicates that nitrates are fairly quickly washed out of the dumps, but sulfates and uranium releases will persist beyond closure. Column testing together with store and release modelling of the waste rock dumps indicates that whatever rainfall infiltrates the dumps will emerge in time as basal seepage, carrying variable sulfate concentrations and levels of uranium that remain of concern. Clearly the contaminating effect will diminish with time but the column tests have not run long enough to predict this period. However, rainfall entering the dups has been estimated at about 15 mm per year, so that leaching time frames are likely to be far longer than the remaining operating period of the mine. It is expected that the extended waste rock dumps will continue to leach small loads of potential contaminants into the Khan River. Investigative work is currently planned to test the feasibility of using chemically reactive barriers to intercept and immobilise small loads of contaminants up-gradient of the Khan River.

8.1.3 Dome Gorge Tailings storage facility

The Dome Gorge tailings storage facility is located on the Dome structure of the Etusis Unit which has been drilled recently for sterilisation drilling. It has been assigned a relatively low hydraulic conductivity of 0.07m/day (RUL) in the Aquaterra model. The main impacts on the groundwater that could be associated with storage of high density tailings on the Dome Gorge tailings facility is groundwater mounding and increased recharge under the tailings storage facility as shown in (Figure 8-3) The mounding will increase the piezometric head under the Dome Gorge TSF by about 40m and will encourage transport of solutes away from the tailings storage facility. By 20 years after closure, recharge stops and the mound dissipates.

The cone of depression resulting from the open pit situated south of the Dome is expected to intercept most solutes entering the groundwater from the tailings storage facility. However, the transport modelling has not yet been completed to confirm this. In the interim, particle tracking was undertaken by Aquaterra and shows that much of the flow from the Dome Gorge TSF will be captured by the alluvium in the gorge and by faults which will drain into the open pit.

However there is a minor component of flow that is predicted to escape the pit capture to the south east but this seepage will not reach the Khan River during the tailings storage facility deposition or even within 500 years of the facility closure (Figure 8-4). The Rössing Marble which occurs to the south of the Dome Gorge tailings facility is believed to function as a preferential flow path for seepage as indicated in Figure 8-5. In addition, the Rössing Granite is believed to act as a barrier to groundwater flow preventing flow in a southerly direction.

Note particle tracking does not take into account any potential hydrochemical changes that are likely to affect the fate and transport of contaminants but is the worst case scenario expected from transport modelling and should not be seen as the furthest extent of unacceptably high solute concentrations which is why the transport model is required.

Additional boreholes are required in this area to measure the actual groundwater flow paths south of the Dome tailings storage facility.

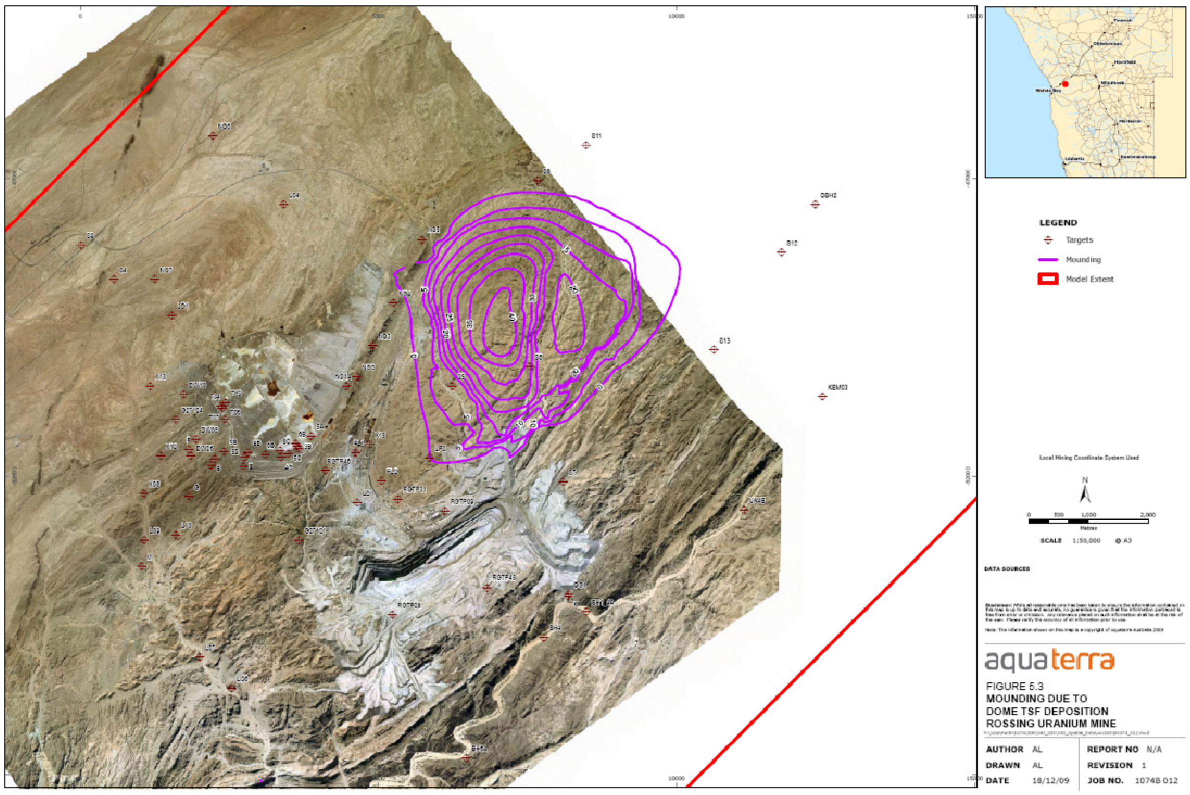


Figure 8-3: Mounding due to Dome TSF Deposition (Aquaterra 2009)

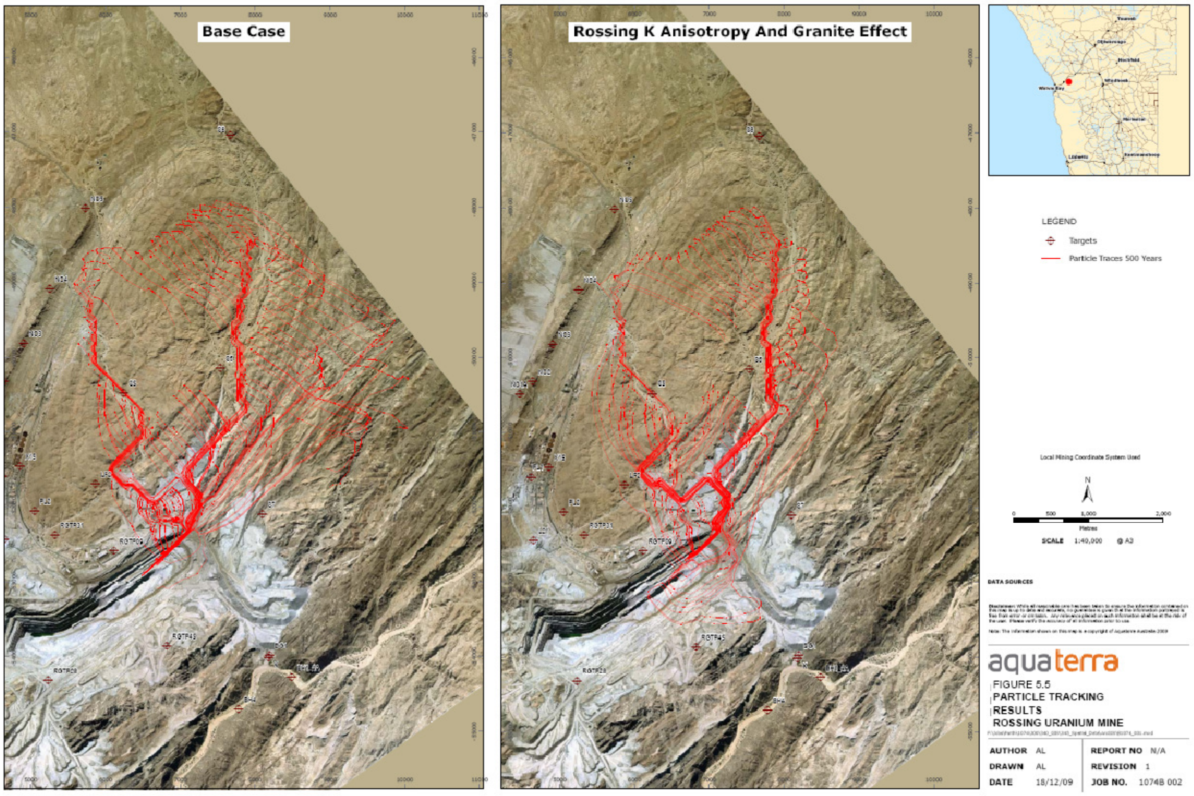


Figure 8-4 : Particle tracking results for the Dome TSF (Aquaterra 2009)

The following issues from the tailings facilities are expected:

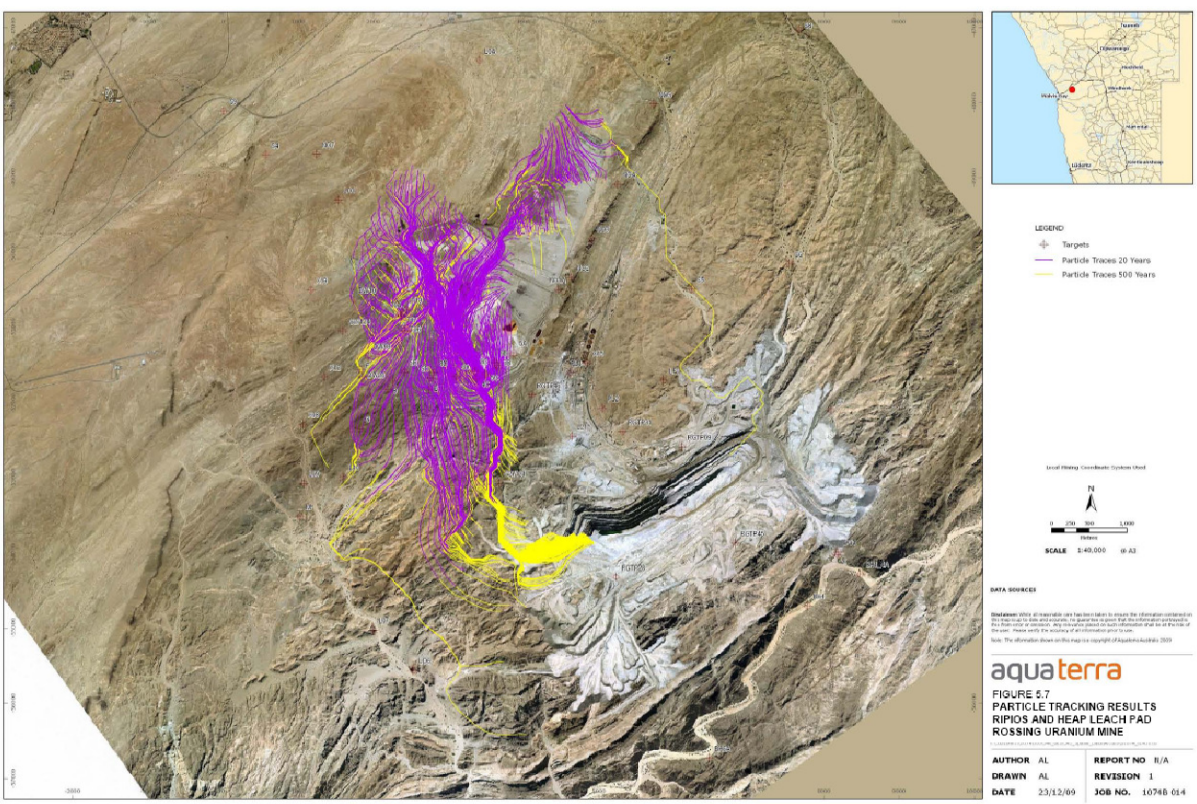
- Runoff from the tailings dam will flow along the gorges where the tailings have been placed. If the runoff exceeds 2m/s we can expect erosion of the tailings side slopes and tailings to be included in the water. This water/tailings will back up behind the waste rock dump to the north of the pit;
- Groundwater seepage and supernatant water (there should not be much water) flowing over the tailings will enter the seepage collection facilities but if the normal collection capacities are exceeded then the water will create a groundwater mound which will drive the solute transport. The water is redirected into the pit via fractures
- The runoff and seepage water from the tailings is likely to transport contaminants such as sulfates, uranium, iron, manganese and nitrate
- The Rössing Marble is very important as an influence on seepage movement. It outcrops south of the Dome Gorge tailings facility and functions as a preferential flowpath for seepage as shown by the particle tracking.
- Although some seepage (estimated at 10m^3/day) could occur in the NE to SW direction, the model predicts that the particles would not reach the Khan River within 500 years after closure.
- In the unlikely event that it does reach the Khan River, the dilution ratios would be 1:23 and 1:53 at the end of deposition and after 500 years respectively.

8.1.4 Heap Leach Pad and Ripios

In the current design freeze, the heap leach facility is developed over the north-eastern sector of the current tailings storage facility and the ripios is disposed of over the top of the remainder of the current facility. Drainage from the deposition of the existing tailings facility was simulated at a rate of 32 mm/yr. The seepage out of the ripios is simulated over a 10 year period at a rate of 0.6mm/year and the seepage from the lined heap leach pad is simulated at the rate of 10^{-8}m/sec and that only 50% of the pad area is actively leaking (this is a conservative estimate used by Aquaterra in their numerical model . This is unlikely as the plastic liner of the heap leach pad should have a seepage rate of less than 10^{-10}m/sec) and thus the current modelling scenario is a worst case scenario..

The main groundwater impact from the development of the ripios and heap leach pad is continued groundwater mounding that will increase the piezometric head under the heap leach pad by between 5-10 metres.(Aquaterra 2010)

Particle tracking modelling for a period of 20 years after closure are shown in (Figure 8-5) and suggest that the flow originating from these two facilities will be significant only along the enhanced permeability zones associated with Pinnacle Gorge. Twenty years after closure (2043) the seepage will have moved 3000m and still be north of the open pit. By 500 years (to be confirmed by Aquaterra), the seepage would have entered the pit (due to the sump effect) although there is some very limited seepage which passes to the west of the pit but still has not reached the Khan River.



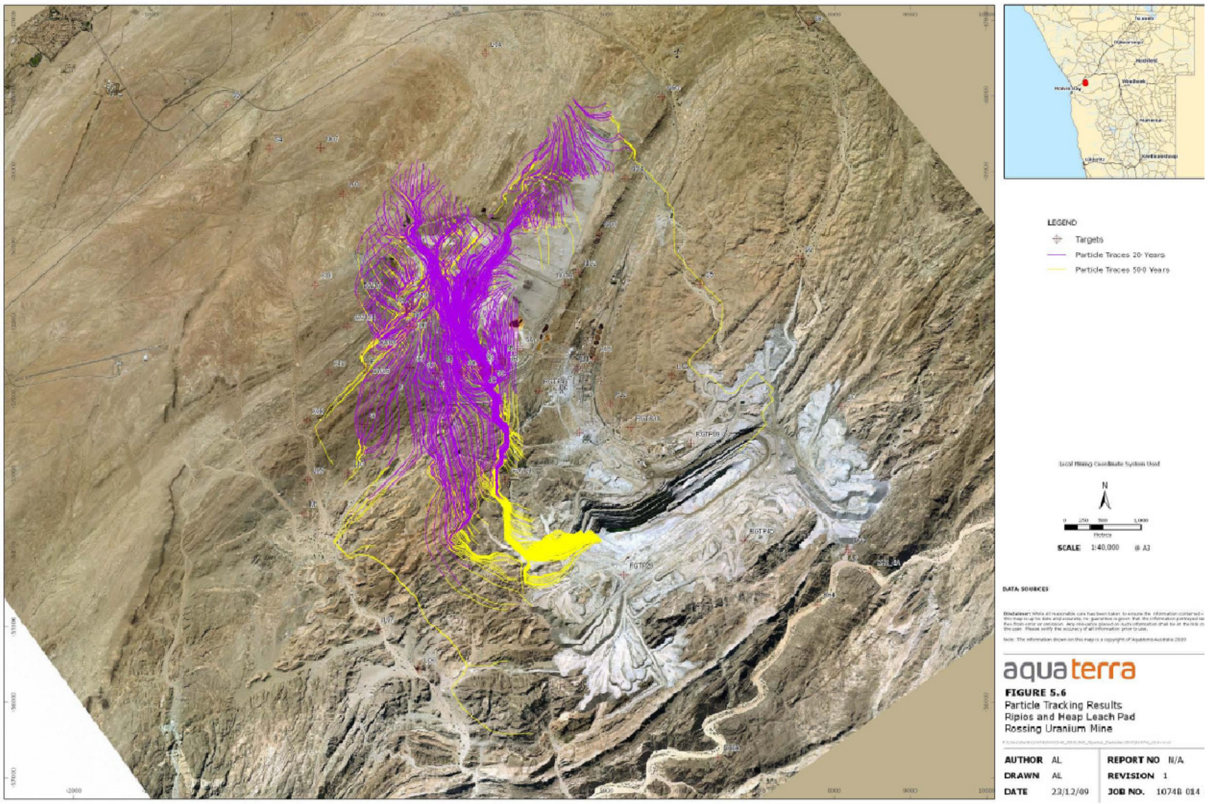


Figure 8-5 : Particle tracking results for Ripios and Heap Leach Pad (Aquaterra 2009)

The following issues from the heap leach pad and ripios facilities (in terms of seepage from the facilities) are expected:

- Groundwater seepage from the ripios may be slightly acidic (pH 4-5) but no more than the existing tailings;
- The ripios is placed on top of the existing tailings facility and this will result in a higher head to drive the groundwater plume. This may result in additional water that needs to be captured in the seepage facilities and could impact the stability of the outside face ;
- The ripios is going to be more permeable than the underlying tailings. The water entrained in the ripios is likely to drain through the ripios rather than the tailings possibly causing stability issues;
- Runoff from the side slopes of the ripios will contain sediment and this may be dispersed during rainfall events;
- The Ripios will cover the existing tailings facility wellfield named TDX, TDDS and NTSC resulting in a delayed recovery of the water for reuse;
- Ponding of water will occur upstream of the heap leach embankments as the heap leach pad is situated in a depression. This water may flow onto the pad (for rainfall events in excess of 128mm). This water could end up in the stormwater dam. For smaller rainfall events the water will both evaporate and seep into the underlying tailings after the rainfall event;

- Spillage from the stormwater dam below the PLS will occur for rainfall events greater than 100mm. If this occurs then the contaminated solution will flow to the north of the plant into an existing canal. This water will eventually back up behind the HD tailings and the water could be collected in the seepage control trenches. If the water is not collected in these collection facilities then the water will seep into the alluvial aquifers and will be intercepted in the open pit
- Solute transport modelling is recommended to assess seepage attenuation along the flow path in more detail. At this stage it is predicted that the limited volume of seepage that could possibly escape the pit's capture and eventually enter the Khan River would have an insignificant impact on the water quality.

8.1.5 Sewage Plant

No issues are expected from the sewage plant if designed, operated and maintained correctly.

8.1.6 Issues of Make-up Water Availability

This report does not deal with the security of the NamWater Supply to sustain the expansion, but this is a critical issue that the mine needs to address on a sustained basis.

The fresh water supply to Rössing Mine is sourced from the largely artificially recharged Omdel dam on the Omaruru River. On-going yield assessments have indicated that the safe yield has been exceeded, and the increasing demand from the new mining groups active in the supply area is likely to be unsustainable in the medium term unless new water sources are developed. NamWater has recently (2009) completed an EIA on the prospect of establishing a sea water desalination plant north of Swakopmund to augment the supply. Recent reports however, indicate that the funding mechanism has not yet been finalised and progress appears to be slow, with no certainty as to when RUL would be allowed to increase its daily supply from NamWater. Rössing Mine has a water supply agreement where NamWater needs to supply Rössing with 4 million m^3/year

8.2 Methodology

For each impact, the EXTENT (spatial scale), MAGNITUDE (size or degree scale) and DURATION (time scale) will be described. These criteria are used to ascertain the SIGNIFICANCE of the impact, firstly in the case of no mitigation and then with the most effective mitigation measure(s) in place. The mitigation described in the SEIA Report will represent the full range of plausible and pragmatic measures but does not necessarily imply that they should or will all be implemented. The decision as to which combination of alternatives and mitigation measures to apply for will lie with RU as the proponent, and their acceptance and approval ultimately with MET:DEA and MME. The SEIA Report will explicitly describe RU's commitments in this regard. The tables on the following pages show the scales used to assess these variables and define each of the rating categories.

Table 8-1: Assessment criteria for the evaluation of impacts

CRITERIA	CATEGORY	DESCRIPTION
Extent or spatial influence of impact	**National**	Within Namibia
	Regional	Within the Erongo Region
	Local	Mine Licence Area and Mine Accessory Works Area
*** Magnitude of impact (at the indicated spatial scale)**	**High**	Social and/or natural functions and/ or processes are *severely* altered
	Medium	Social and/or natural functions and/ or processes are *notably* altered
	Low	Social and/or natural functions and/ or processes are *slightly* altered
	Very Low	Social and/or natural functions and/ or processes are *negligibly* altered
	Zero	Social and/or natural functions and/ or processes remain *unaltered*
Duration of impact	**Short term** (construction period)	Up to 3 years
	Medium Term	Between 3 and 10 years
	Long Term	More than 10 years after construction

* Note: where applicable, the magnitude of the impact has to be related to the relevant standard (threshold value specified and source referred).

The SIGNIFICANCE of an impact is derived by taking into account the temporal and spatial scales and magnitude. The means of arriving at the different significance ratings is explained in the following table, developed by Ninham Shand in 1995 as a means of minimising subjectivity in such evaluations, i.e. to allow for standardisation in the determination of significance.

Table 8-2: Definition of significance ratings

SIGNIFICANCE RATINGS	LEVEL OF CRITERIA REQUIRED
High	• High magnitude with a regional extent and long term duration • High magnitude with either a regional extent and medium term duration or a local extent and long term duration • Medium magnitude with a regional extent and long term duration
Medium	• High magnitude with a local extent and medium term duration • High magnitude with a regional extent and construction period or a site specific extent and long term duration • High magnitude with either a local extent and construction period duration or a site specific extent and medium term duration • Medium magnitude with any combination of extent and duration except site specific and construction period or regional and long term • Low magnitude with a regional extent and long term duration
Low	• High magnitude with a site specific extent and construction period duration • Medium magnitude with a site specific extent and construction period duration • Low magnitude with any combination of extent and duration except site specific and construction period or regional and long term • Very low magnitude with a regional extent and long term duration
Very low	• Low magnitude with a site specific extent and construction period duration • Very low magnitude with any combination of extent and duration except regional and long term
Neutral	• Zero magnitude with any combination of extent and duration

Once the significance of an impact has been determined, the PROBABILITY of this impact occurring as well as the CONFIDENCE in the assessment of the impact would be determined using the rating systems outlined in the following two tables. It is important to note that the significance of an impact should always be considered in concert with the probability of that impact occurring.

Table 8-3: Definition of probability ratings

PROBABILITY RATINGS	CRITERIA
Definite	Estimated greater than 95% chance of the impact occurring.
Probable	Estimated 5 to 95% chance of the impact occurring.
Unlikely	Estimated less than 5% chance of the impact occurring.

Table 8-4: Definition of confidence ratings

CONFIDENCE RATINGS	CRITERIA
Certain	Wealth of information on and sound understanding of the environmental factors potentially influencing the impact.
Sure	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact.
Unsure	Limited useful information on and understanding of the environmental factors potentially influencing this impact.

Lastly, the REVERSIBILITY of the impact is estimated using the rating system outlined in the following table.

Table 8-5: Definition of reversibility ratings

REVERSIBILITY RATINGS	CRITERIA
Irreversible	The activity will lead to an impact that is permanent.
Reversible	The impact is reversible, within a period of 10 years.

8.3 Rating of Impacts and Mitigation Measures

The most important impacts are rated in terms of the provided impact rating procedure for Pre and Post mitigation measures. The mitigation measures are presented below each table and indicated in the general layout plan 393957/101 in Appendix 1.

8.3.1 Rating of the impact of floodwaters damaging heap leach infrastructure

Spillage from the stormwater dam below the PLS will occur for rainfall events greater than 100mm. If this occurs then the contaminated solution will flow to the north of the plant and may damage the infrastructure which may cause additional pollutants to be transported from site to the environment.

The impact of the expansion assuming no mitigation measures are in place is as follows

Assessment Criteria	Pit	Heap Leach Pad and Plant	Ripios	HD Tailings Dam	Waste Rock Dump
Spatial	N/Al	Local	N/Al	N/Al	N/Al
Magnitude	N/A	Medium	N/A	N/A	N/A
Duration	N/A	Short Term	N/A	N/A	N/A
Significance	N/A	Low	N/A	N/A	N/A

The mitigation measures required to minimise the potential flooding damage will require the plants and storage tanks to be placed on a platform situated above the 1:2000 year flood high water level. No post mitigation rating has been done as the significance is low.

8.3.2 Rating of the Impact of pollution on downstream water resources

The impact of the expansion assuming no new mitigation measures are in place is as follows

Assessment Criteria	Pit	Heap Leach Pad and Plant	Ripios	HDTailings Dams	Waste Rock Dump
Spatial	Local	Local	Regional	Regional	Regional
Magnitude	Low	High	Low	Medium	Medium
Duration	Long term	Long term	Long term	Long term	Long term
Significance	Low	Medium	Medium	High	High

Measures for water management around the heap leach pad includes

1 Already in place

- The PLS pond has been designed for 100mm of rainfall in 24 hours (this relates to about a 1:1000 year event);
- The internal drains are designed for 100mm of rainfall in 24 hours (this relates to about a 1:1000 year event);
- The base of the pad is impermeable with almost zero seepage expected

2 To be implemented in future

- The embankment walls should be constructed to an elevation such that the 1:2000 year flood high water will be lower than the embankment. This is to reduce the amount of rainwater entering the heap leach pad.

The water management around the ripios dump should include the following measuress:

- Toe paddocks to be constructed at the base of the dumps to contain the sediment-laden runoff;
- The paddocks to be extended as the ripios dump grows. Maintenance of the paddocks to collect the silt should be undertaken to ensure sufficient freeboard is maintained. The paddock should be constructed 25m from the edge of the ripios dump and the wall should be 1000mm (Simm, 2009). The reason for the paddock is to manage the silt load from the ripios dump. The wall should extend around the edge of the ripios dump outline. It is envisaged that the paddock wall should only be constructed as the ripios dump extends and not all constructed at the beginning of the project;
- The dewatering wells to the west of the dump will be covered with the extension of the dump and these trenches and seepage control facilities should be reconstructed to the west of the final Ripios dump position. The measures may include seepage trenches or dewatering boreholes depending on a more detailed study

The waste rock management measures should include the following bearing in the mind that the seepage from the base of the dump is likely to continue indefinitely.

- Leach column testing should continue for approximately a year or to a point where realistic predictions can be made concerning the quality of seepage from the bases of the dumps;
- Lysimeter systems should be constructed at the base of specified waste rock dumps to provide direct evidence of flow rates and seepage composition (based on detailed chemical analysis);
- A program of performance trials on candidate passive chemical barriers should be started to determine their effectiveness and reliability in capturing and immobilizing uranium and other contaminants in seepage flows to the Khan River.

The application of erosion and sediment control measures such as evaporation paddocks where the runoff from the waste rock should directly impact the Khan river;

- The final pit geometry should allow for the runoff from the top of the dump to flow towards the pit;

The following water management measures are envisaged at the heap leach plant:

- Workshops and reagent tanks to be contained in a bunded area sized for 110% of the potential spillage;
- Appropriately spaced monitoring boreholes should be installed around the plant to check that seepage is not leaving the site in an uncontrolled way.

Water that flows into the pit that can be collected will continue to be used for dust suppression

The following water management measures are envisaged at the high density tailings dam

- Upstream cut-off drains
- Seepage control facilities to be constructed below the tailings facility in the low gorges.

- A transport model being developed by Aquaterra will be used to assist in formulating appropriate management measures;
- Additional boreholes are required to monitor the effectiveness of the management measures;

Additional protection facilities:

- The feasibility of using reactive barriers in the tributaries to the Khan should be investigated and implemented where applicable. These reactive barriers should reduce the solute transported in the groundwater before it enters the Khan as baseflow;
- Existing boreholes in the Khan River to investigate the effectiveness of the reactive barrier.

The impact of the expansion assuming mitigation measures are in place is as follows

Assessment Criteria	Pit	Heap Leach Pad and Plant	Ripios	HDy Tailings Dam	Waste Rock Dump
Spatial	Local	Local	Local	Local	Local
Magnitude	Low	Low	Low	Low	Low
Duration	Long term	Long term	Long term	Long term	Long term
Significance	Low	Low	Low	Low	Low

8.3.3 Impact of the expansion on the surrounding Khan River catchment

It is possible that the expanded pit should intercept water that would previously contribute to the baseflow of the Khan River. It is also possible that the cone of drawdown of the deepened and expanded pit should reach the Khan River lowering the baseflow in the alluvial aquifer. This may impact the water resource. The impact of the expansion assuming no mitigation measures are in place is as follows

Assessment Criteria	Pit	Heap Leach Pad and Plant	Ripios	HDDensity Tailings Dams	Waste Rock Dump
Spatial	Local	N/A	N/A	N/A	N/A
Magnitude	Medium	N/A	N/A	N/A	N/A
Duration	Long Term	N/A	N/A	N/A	N/A
Significance	Medium	N/A	N/A	N/A	N/A

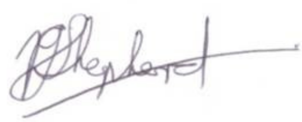
Rössing mine has historically used up to a 1000 m^3/day from the Khan River and has elected to reduce this substantially.

Assessment Criteria	Pit	Heap Leach Pad and Plant	Ripios	HD Tailings Dam	Waste Rock Dump
Spatial	Local	N/A	N/A	N/A	N/A
Magnitude	Low	N/A	N/A	N/A	N/A
Duration	Long Term	N/A	N/A	N/A	N/A
Significance	Low	N/A	N/A	N/A	N/A

The open pit acts a sump to the groundwater flows and a steep cone of drawdown is associated with it. In addition, capture of flow via the SJ fault into the pit should decrease the base flows in the Dome Gorge and Pinnacle gorge which could reduce the base flow to the Khan River from these tributaries. However, modelling has shown that the cone of drawdown could possibly extend as far as the Khan River within the fractured rock aquifer.

J A C Cowan, Pr Sci Nat

D Duthe, Pr Sci Nat



P J Shepherd, Pr Sci Nat

SRK Consulting

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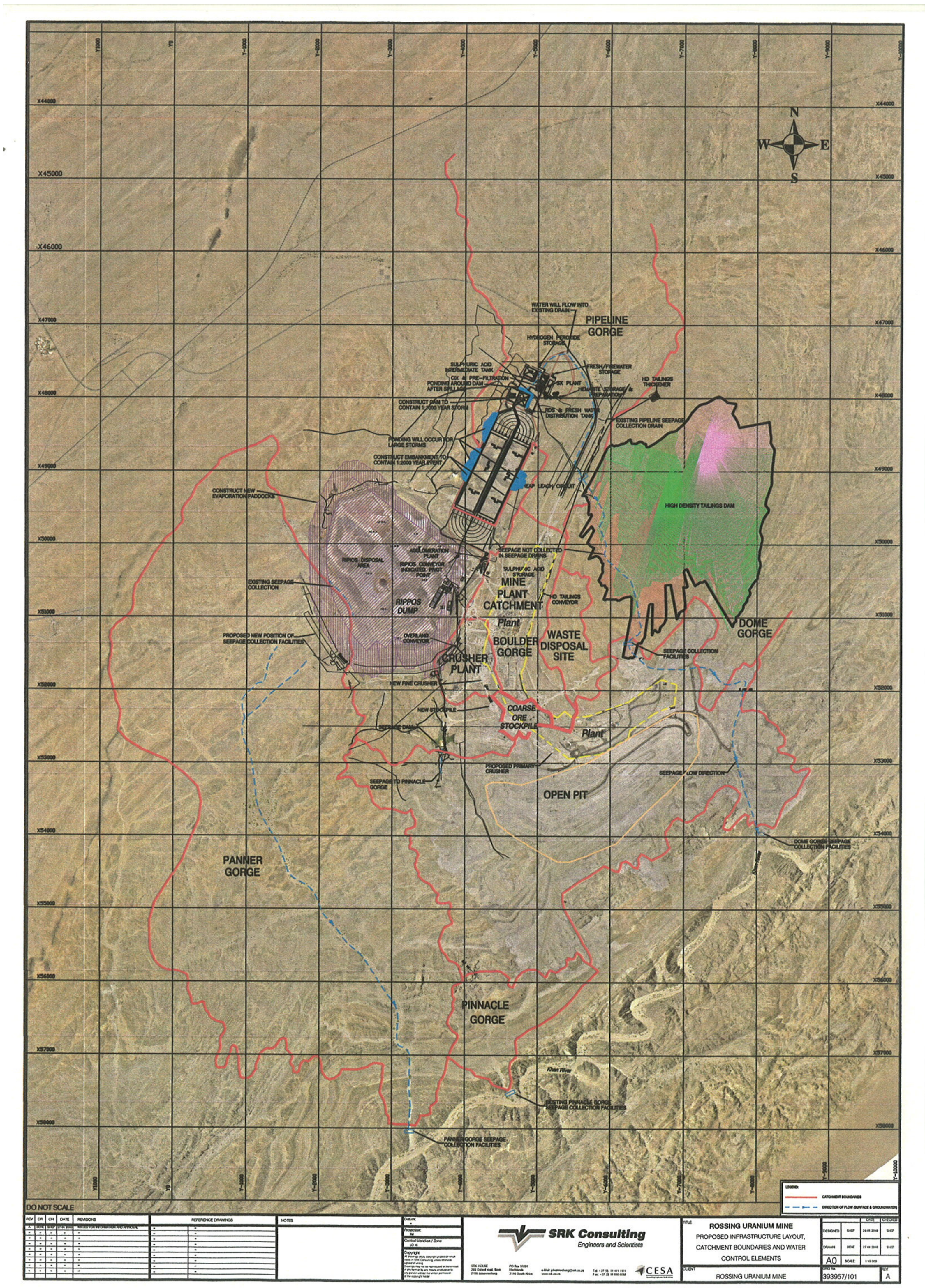
Kathryn Rozlapa Jon Hall, Rössing groundwater model updated calibration , prepared by Aquaterra Consulting Pty Ltd, March 2005

Appendices

Appendix 1: Drawing 393957/101



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Appendix 2: Rössing Standard Operating Procedures

Rössing

RÖSSING STANDARD OPERATING PROCEDURES		Reference: JE50/MSP/001	Revision No: 7
		Page: 1 of 8	Date: May 2008
Compiled / Revised:	Reviewed:	Approved:	Authorised:
A Mutota	A Mutota	B Morwe	M Leech
Subject: Water Quality Management			

CONTENTS

related procedureS:

ORIGINAL DOCUMENT

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1 POLICY

Rössing Uranium Ltd accepts responsibility for the quality of surface and groundwater within the mining grant and for the prevention of mine-induced water quality deterioration in the Khan River downstream of the mine. The goal is to maintain an acceptable quality for normal use of the water resources, i. e. for industrial, agricultural or environmental purposes. (***NB***: There are no freshwater resources in the area.)

2 OBJECTIVES

Groundwater, as a limited natural resource of economic and ecological value, should be used in a sustainable manner and preserved in a state as close to natural as possible. As groundwater contamination can be a very slow process with long-term impact a precautionary approach to prevent pollution is more effective and economic than later rehabilitation. The objective of water quality management is to maintain a suitable groundwater quality for the highest beneficial use to which the groundwater resources or occurrences can presently or potentially be put.

3 STRATEGIES

Rössing has reviewed international water quality management practices and selected the policy of differentiated protection of groundwater resources. This means that groundwater quality is preserved only as needed to protect present and future uses. This policy is based on a realistic evaluation of groundwater resources in the mining area. Due to the high salinity of ambient Rössing groundwater the only beneficial uses are for industrial and ecological purposes, e g dust suppression and maintaining the natural vegetation. The area around Rössing mine contains no freshwater resources and the only groundwater potentially suitable for agricultural use is found in the Khan River.

The groundwater quality management strategy is based on the concept of aquifer classification. Aquifers are classified according to importance of use, threat of contamination or water quality vulnerability. The system evaluates the usefulness of aquifers relative to their water quality and is utilised to set internal water quality standards.

Water resources at Rössing are classified as follows:

Aquifer	Potential Use
Khan River	Agricultural, industrial and ecological
Primary and secondary aquifers in the mining grant	Industrial and ecological

4 Water Quality Standards

4.1 Khan River

Khan River groundwater could potentially be used for stock watering and irrigation of crops, even though there are no users downstream of the mine. The paucity of water users is due to a lack of land suitable for farming. The closest current users are situated in the Swakop River just downstream of the Khan River confluence. Rössing mine uses Khan groundwater for industrial purposes like dust suppression or plant washing.

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The table on the next page shows the concentration of significant parameters measured in January 2006 in borehole 1.6A immediately downstream of the mine compared to the Namibian standard for stock watering.

Determinant	Stock Watering Standard (maximum concentration)	Khan River BH1.6A
Conductivity (mS/m)	3500	720
Sodium (mg/L)	2000	845
Calcium (mg/L)	1000	390
Magnesium (mg/L)	500	158
Chloride (mg/L)	3000	1850
Sulfate (mg/L)	1000	668
Nitrate (mg/L)	400	2.1
Fluoride (mg/L)	6	1.1

The aim of the water quality management programme is to prevent any deterioration of the Khan River water quality to levels that would make it unfit for stock watering. In the event that certain water quality parameters should exceed the standard, the procedure for reporting and follow-up of environmental non-conformances (EMS/OPS/011) will be applied.

4.2 Mining Grant

In the absence of pre-mine baseline samples from the mining grant the ambient water quality has been established from boreholes upstream of the tailings dam. Results are shown in the table below.

Ambient Water Quality	Range	RUL Internal Standard
pH	7.0 ± 0.3	6.5
Conductivity (mS/m)	2188 ± 366	
Total Dissolved Solids (mg/L)	18071 ± 3926	
Calcium (mg/L)	1488 ± 612	
Magnesium (mg/L)	257 ± 103	
Tot. Alkalinity (mg/L $CaCO_3$)	141 ± 27	
Chloride (mg/L)	8567 ± 2291	
Sulfate (mg/L)	2269 ± 523	2900
Fluoride (mg/L)	1.1 ± 0.4	
Nitrate (mg/L NO_3)	99 ± 24	150
Potassium (mg/L)	128 ± 12	
Sodium (mg/L)	4640 ± 1369	
Uranium (mg/L)	0.09 ± 0.02*	0.15*
U-234/U-238 activity ratio	>1.0	>1.0

Sulfate/Chloride Ratio	0.3 ± 0.1	0.4

* Excluding natural groundwater in uranium ore occurrences.

High uranium concentrations occur in natural groundwater that is in contact with uranium ore. High uranium levels alone are therefore not an indication of groundwater contamination. To distinguish

between natural and seepage-derived uranium Rössing uses the isotope activity ratio of U-234 to U-238. Studies in the Witwatersrand and elsewhere have shown that activity ratios of 1.0 or lower are found in processed uranium, while U-234 predominates in groundwater containing natural uranium (ratio >1.0). The internal criterion for uranium is therefore a U-234/U-238 activity ratio >1.0.

As there are no applicable standards for industrial water use in Namibia an internal standard has been set. The objective of water quality management in the mining area is to prevent as far as possible any spreading of the seepage plume around the tailings dam beyond the area that it occupied in 1999. Seepage is mainly characterized by increased sulfate and nitrate concentrations and U-234/U-238 ratios ≤1.0. Based on the ambient water quality site-specific standards for seepage indicators were determined (see table above). If these are exceeded in areas beyond the 1999 seepage plume the non-conformance has to be reported, reasons investigated and remedial action identified according to procedure EMS/OPS/011. Wherever possible, the ambient water quality will be maintained or restored by active or passive measures. Remedial action is required within the seepage plume if the water quality deteriorates to such an extent that the ecology is affected.

5 COMPLIANCE CRITERIA

Rössing will strive to comply with the internal standards set out in paragraph 4 and ensure that ecosystem health is maintained. This commitment is in line with the company's Health, Safety and Environment Policy and the Rio Tinto environmental standard on Water Use and Quality Control.

External control of Rössing's water quality management programme is administered by the Department of Water Affairs (DWA) in form of an industrial and domestic effluent discharge exemption permit (current number 385). The objectives of the permit as stated by the DWA are to regulate the disposal of effluents produced by the mine and to prevent the spread of groundwater pollution from effluent or waste disposal sites into the mining grant or the Khan River. A copy of the permit is attached in Appendix 1.

In addition to this procedure there are other standard operating procedures related to water quality management and compliance with DWA permit conditions. These are listed in the table below with reference to paragraph numbers in the permit.

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Para.	Subject	Procedure number	Responsible Section
1.1, 2.6.3	Seepage control systems	OWM/SCP/002	Water Management
2.2.7, 2.2.8, 2.5.14	Water recycling	OWM/WSM/002	Water Management
2.3.2, 2.5.14	Fresh water supply management	OWM/WSM/001	Water Management
2.4.2	Waste rock	MIN/WRD/001	Mine Planning
2.4.4	Disposal of	ENV/WMP/002-003	OH & E Management
2.4.4	Disposal of	ENV/WMP/005	OH & E Management
2.5.4, 2.5.5, 2.5.11	Water quality monitoring	OWM/WQM/001	Water Management
2.5.9, 2.5.12	Monitoring of sewage plants	OWM/SPP/001	Water Management
2.5.15	Supervision of flow meters	OWM/WSM/001-002, SCP002	Water Management
2.6.2	Monitor acid neutralisation	OWM/WQM/001	Water Management

6 RESPONSIBILITIES

In terms of the DWA permit the General Manager Operations assumes responsibility for compliance with the permit conditions. From the General Manager Operations responsibility devolves upon second and third level managers. Currently, the Tailings & Water section in the Processing department is responsible for the implementation of the water quality monitoring programme and compilation of internal and external reports. At Rössing mine tailings and water aspects (including water quality) are inseparable and require joint management. The responsibility for water quality management and monitoring has been assigned to the Water Management Monitoring unit, while the Water Management Maintenance unit operates the seepage control systems.

The principal tools for water quality management are water quality monitoring and operation of seepage control systems, which are described in separate procedures (refer to OWM/WQM/001 and OWM/SCP/002). The programme is supported by efforts to reduce seepage from the tailings dam by improving tailings disposal methods and optimizing direct water recovery (OTD/TDO/001). Continuous improvement opportunities for tailings and water issues are identified during annual review visits of the mine’s tailings dam and water management consultants. Approved actions are entered in the EMS database with detailed implementation programmes.

7 ASPECTS

The water quality management programme addresses all environmental aspects related to surface and groundwater chemistry in the mining grant and the Khan River. The area monitored extends beyond the mining grant to compare the water composition encountered on site to the ambient water quality in the wider environment. In addition to the monitoring of seepage from the tailings dam, special monitoring programmes are in place for sewage plant effluent and leachates from the landfill site (see OWM/SPP/001 and OWM/WQM/001). Waste management procedures are in place to prevent water pollution, amongst others (e. g. ENV/WMP/002, ENV/WMP/005, ENV/WMP/006).

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8 MANAGEMENT AND RESOURCES

8.1 Programmes

The table below shows improvement opportunities identified during reviews in the last 3 years. The actions are either in progress or planned for implementation in the near future. Detailed environmental management programmes (EMP) can be found in the consultants' reports and the EMS database.

Objective	Action	Responsibility
Reduce the volume of water discharged to the tailings dam	Reduce system changes and flushing, investigate thickened tailings discharge	Supt Projects, Technical Support Tailings Dam, Foreman Tailings Dam
Recover seepage stored inside the tailings dam and reduce outflow	Install production boreholes on the tailings dam	Hydrogeologist
Improve and extend seepage control systems	Monitor system performance, install new production boreholes or trenches where required	Water Specialist, Hydrogeologist
Prevent impact of mine closure on water quality	Prepare a well-researched closure plan with provision for continued seepage control	Supt Sustainable Development
Prevent impact of mine closure on water quality	Model groundwater flow from the tailings dam into the environment	Water Specialist and consultant

Progress with actions is described in internal monthly reports or in the EMS database (refer to the database for reporting frequency and project completion dates).

8.2 Data Evaluation and Reporting

The need for remedial actions, which do not arise from the planning and review process, is identified by evaluation of monitoring results. Water quality data are collected and processed by Water Control Officers according to procedure OWM/WQM/001. The Water Specialist uses the database to draw conclusions on the observed variations in water quality and make recommendations in reports to the Superintendent Tailings & Water, if appropriate.

Tailings & Water reports to the Department of Water Affairs on an ad hoc, monthly or annual basis any incidents, analysis results or other data requested. The table below shows the required information as specified in permit 385 (Appendix 1). The Superintendent Tailings & Water (Supt T&W) is responsible to ensure that reports to the DWA are compiled and submitted to the General Manager Operations.

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Para-graph	Communication / Data	Source	Frequency	Last update to DWA
2.1.1	Application for new permit	Water Specialist	Every 5 years	Nov 2004
2.3.3	Any change in process techniques with a bearing on the quality of wastes, effluents or water economy or change in supervision	Responsible Manager via Water Specialist	Immediately	Feb 2006
2.4.2	Three-year waste rock dumping plan	Mine Planning	Annual update	Feb 2006
2.5.2	Names and numbering (Plan 1002A, water balance)	Water Specialist	Annual update	Feb 2006
2.5.6	New seepage areas	Water Specialist	Immediately	None in 2007
2.5.7	Logs of new boreholes drilled for seepage control	Hydrogeologist	Within 3 months	Jul 2005
2.5.10, 2.5.17	Chemical analyses of water samples as prescribed	**Hydrogeologist**	Annually	Feb 2007
2.5.11	Programme for radionuclide analyses	**Water Specialist**	Annually	Feb 2007
2.5.11	Results of radionuclide analyses	**Water Specialist**	Annually	Feb 2007
2.5.12, 2.5.17	Results of monthly sewage quality analyses	**Hydrogeologist**	Annually	Feb 2007
2.5.13, 2.5.18	Water balance as prescribed	**Hydrogeologist**	Monthly	Monthly
2.5.19	Annual report on all water-related aspects	**Water Specialist**	By 28 Feb	Feb 2007

2.1.1: The application for a new permit should reach the DWA at least six months before expiry of the existing permit. The application letter to the Permanent Secretary for Water Affairs is accompanied by DWA questionnaire WA2 and plans or drawings specified in the questionnaire. The letter may contain any changes to the permit proposed by RUL and updates to the Rössing technical report.

2.3.3: The Manager responsible for process changes must communicate these to the Supt TD&WM who will ensure that the DWA is informed. Water savings measures and changes in supervision of permit-related matters originate within the Tailings Dam & Water Management section and are reported by the Supt T&W.

2.4.2: The Hydrogeologist obtains the updated waste rock dumping plan from Mine Planning and sends it to the DWA with the Annual Report.

2.5.2: The Chief Surveyor updates the water control plan, which the Hydrogeologist sends to the DWA with the Annual Report.

2.5.6: The requirement to report new seepage areas originates from the time before seepage control measures were constructed. In the unlikely event that new seepage areas are found in future these will be reported to the DWA immediately.

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2.5.7: It is one of the Hydrogeologist's duties to compile geological logs of new any boreholes drilled and ensure that copies are sent to the DWA within the specified time.

2.5.10, 12, 17: The Senior Water Control Officer assembles the results of water quality analyses, including sewage effluent, in tables, which are incorporated in the Annual Report to the DWA.

2.5.11: The radionuclide sampling programme for the coming year and results of the current year form part of the Annual Report. They are also discussed in meetings with DWA officials from time to time.

2.5.13, 18: Water balance data are processed by the Hydrogeologist and sent in a letter to the DWA before the 7th of each month.

2.5.19: The Annual Report on water-related aspects is prepared by the Water Specialist with input from others in Tailings Dam & Water Management or other relevant sections. Besides DWA-specific information it also reports all aspects required by the Rio Tinto Water Use and Quality Control standard, item 3.2.

8.3 Incidents and Non-conformance

Environmental incidents with a potential for water pollution are reported and investigated according to procedure EMS/OPS/010. Examples of such incidents are spillage of chemicals, acid or process solutions into a riverbed containing groundwater, disposal of old oil into the environment or an overflow of tailings beyond the confines of the tailings dam.

According to permit 385 Rössing must monitor the mining area and Khan River for new seepage areas and inform the DWA if such areas are discovered. New seepage areas are therefore classified as environmental incidents and investigated accordingly. In addition a notification is sent to the DWA.

Any non-conformance with permit conditions or water quality standards is handled according to procedure EMS/OPS/011. The adherence to permit conditions relating to the disposal of tailings and process solutions as well as water conservation and recycling is the responsibility of the Plant Operations department. Conformance with conditions on supervision of effluent disposal, water quality monitoring and management, seepage control and reporting to the DWA is monitored by Water Management.

Exceedance of the internal water quality standards as determined in paragraph 4 of this procedure in the area outside the 1999 seepage plume is regarded as a significant non-conformance according to the definition in EMS/OPS/011. In this case procedure 5.2 in EMS/OPS/011 has to be followed. The Senior Water Control Officer will identify non-conformances upon receipt of new water analysis results and report them to the Water Specialist, Hydrogeologist and EMS Co-ordinator. The EMS Co-ordinator will arrange a formal review with the team to investigate the reasons for the exceedance, evaluate the severity and identify remedial measures. If an EMP is required the responsible person appointed by the review team enters it in the EMS database and follows up in the usual way. The results of the non-conformance review are summarised in the internal month end report.

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9 AUDITING

As mentioned in paragraph 6, progress with improvement opportunities is reviewed with consultants on an annual basis. A report on the findings and new actions is compiled and distributed to the responsible persons.

The water quality management programme is audited by internal and/or external auditors according to EMS audit procedures (EMS/AUD/001 and 002). The comprehensive audit includes all aspects pertaining to the scope and performance of the programme with special emphasis on improvement opportunities and compliance with permit conditions. A report on audit findings is distributed to involved parties. Significant findings are discussed and agreed remedial action programmes included in the EMS database.

10 CHANGES FROM PREVIOUS VERSION

Rev. 1: Job titles and responsibilities were changed according to the new structure of the Organisational Services department and the Water Management unit. Rev. 2: Job titles and responsibilities were changed according to the new structure of the Plant Operations department. Rev. 3: Included more details on reporting procedures (8.2). Rev. 4: Reviewed and updated according to latest status, only minor changes made. Rev.5: Updates names on front page and new position names in text. Replaced average 1998-99 analysis data of borehole 1.6A with latest data for January 2006. Added U-234/U-238 activity ratio >1.0 as internal limit for uranium. Minor editing and date changes. Rev. 6: Minor editing, updated names and job titles. Rev. 7: Minor editing, updated front page.

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