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REPORT

Compiled for
REPTILE URANIUM NAMIBIA (PTY) LTD
and its majority owned subsidiary
TUBAS MINING (PTY) LTD
and minority Joint Venture Owner
OPONONA INVESTMENTS (PTY) LTD

ENVIRONMENTAL IMPACT ASSESSMENT REPORT
and
DRAFT ENVIRONMENTAL MANAGEMENT PLAN
FOR THE TUBAS PROJECT

Report No TUBEIAREP/2011/01
5 October 2011
ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR THE TUBAS PROJECT

Compiled by: ........................................

JFC Friend
PrEng CEng

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EXECUTIVE SUMMARY

Reptile Uranium Namibia (Pty) Ltd intends to submit an application for a mining licence on EPL 3496 in the Namib-Naukluft Park to the competent Namibian authorities for the extraction of uranium from its Tubas project. However, before any mining licence can be granted, an environmental impact assessment (EIA) process must be undertaken by the relevant applicant and authorised by the Ministry of Environment and Tourism.

A scoping report in terms of Sections 19 and 26 of the draft environmental assessment (EA) regulations was completed in October 2010 for the Omahola project that consisted of the Shiyela Iron and INCA and Tubas uranium deposits. Subsequent work on these deposits and discussions with representatives of the Ministry of Environment and Tourism on 15 March 2011 resulted in the original Omahola project being subdivided into singular standalone projects, namely the Shiyela Iron, INCA uranium and Tubas uranium projects. This report represents the environmental impact assessment conducted for the Tubas project, originally part of the overall Omahola project, in accordance to the requirements stipulated in Section 27 of the draft EA regulations.

This proposed activity envisaged the design, construction and operation of a uranium processing facility in EPL 3496. Key findings from the EIA include, inter alia, the following:

- the Tubas deposit and processing plant are more viable as the mineralisation predominantly occurs in Aeolian, uncemented sand; with the ore predominantly free digging that allows for simple low cost (no blasting) mining techniques;
- creation of new job opportunities;
- the full operation of the proposed mine will have a significant economic impact on both regional and national levels, with recent estimates indicating that, when fully operational, direct and indirect taxes to the Namibian government will be in the order of N$ 27.2 million per year;
- although most of the direct employment effects will take place in the mining industry, the multiplier effect will result in job creation effects in areas such as transport, equipment manufacturing and personal services; and
- albeit that various negative impacts on the environment were identified through extensive specialist studies, none of them represented fatal flaws.

The above positive and negative implications of the proposed activity were assessed against various alternatives, inclusive of the no-go alternative, which is the option of not undertaking the proposed activity or any of its alternatives. With all the categorised alternatives, the location (site) alternative normally plays the biggest role in assessment of an activity and its related impacts. However, in the case of mining operations the location is seldom available for alternative selection as the proposed mineral for extraction is by its very nature exactly at a particular selected site. Alternative options were thus evaluated and assessed as part of the overall design of the proposed mining operation, inclusive of alternative extraction methods, relevant processing operations and scheduling and input alternatives.

In summary, the activity of mining will always result in some form of negative impact on the environment, whether impacts are mitigated or not. The ideal is to match the environment, social and economic issues to such an extent that the overall outcome of an activity will not result in a combined lesser value for the three issues. The economic benefit and potential social upliftment of the proposed Tubas project should outweigh the environmental impacts addressed in this report, through the implementation of mitigation measures, to result in an overall positive value for the combined environmental, social and economic issues identified.
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1. INTRODUCTION

Deep Yellow Limited (DYL), through its 100% owned subsidiary Reptile Uranium Namibia (Pty) Ltd (RUN), proposes to extract uranium for export from the Tubas deposit situated on exclusive prospecting licence (EPL) 3496 and intends to submit a mining licence application to the competent Namibian authorities. However, an environmental impact assessment (EIA) process must be undertaken by the relevant applicant and authorised by the Ministry of Environment and Tourism (MET, 2009) before any mining licence can be granted. In terms of Section 8 of the draft environmental assessment (EA) regulations (MET, 2009), RUN appointed Softchem as its environmental assessment practitioner (EAP) for this environmental impact assessment process.

A scoping report in terms of Sections 19 and 26 of the draft EA regulations was completed in October 2010 (Friend et al., 2010) for the Omahola project that consisted of the Shiyela Iron and INCA and Tubas uranium deposits. Subsequent work on these deposits and discussions with representatives of the Ministry of Environment and Tourism on 15 March 2011 resulted in the original Omahola project being subdivided into singular standalone projects, namely the Shiyela Iron, INCA uranium and Tubas uranium projects. This report represents the environmental impact assessment conducted for the Tubas project, originally part of the overall Omahola project.

In accordance to Section 26 of the draft EA regulations, the scoping report included terms of reference (plan of study) that set out the proposed approach to the relevant environmental impact assessment. For the Tubas project (as part of the Omahola project) the terms of reference included, inter alia, a description of tasks to be undertaken for the environmental impact assessment process, an indication of the stages for competent authority consultation, a description of the assessment methodology to be used and particulars of the public participation process to be followed. Finally, the terms of reference also proposed the relevant investigations to be completed for this EIA. The various aspects that were to be addressed to make an objective assessment of the proposed activity and any related alternatives, including the no-go option, were as follows (Friend et al., 2010):

- climate,
- geology,
- topography,
- soils,
- land use capabilities,
- hydrology,
- air quality,
- natural vegetation,
- animal life,
- archaeological, heritage and cultural aspects,
- sensitive landscapes and visual aspects,
- noise,
- social and economic environment, and
- occupational health and safety.
The above terms of reference were accepted by the Ministry of Environment and Tourism in their letter dated 30 March 2011 and is presented in Appendix A.

The EIA process followed for the Tubas project, based on the Namibian Environmental Assessment Policy of 1995 and the draft EA regulations of 2009, is illustrated in Figure 1.1 (Tarr and Figueira, 1999; SAIEA, 2003; MET, 2009; SAIEA, 2010). In terms of Section 27 of the draft EA regulations the components of this environmental impact assessment report are set out below, with references to the relevant sections within this report (MET, 2009):

- details and expertise of the EAP who prepared this report (Section 11);
- description of the proposed activity (Section 3);
- description of the property on which the activity is to be undertaken and the activity’s location on the property (Section 2);
- description of the environment that may be affected by the activity (Section 5, Appendices B to H, and Appendix O) and the manner in which the physical, biological, social, economic and cultural aspects of the environment may be affected by the proposed activity (Sections 5 and 8, Appendices B to H, and Appendix O);
- details of the public participation process (Section 9 and Appendices I to M);
- description of the need and desirability of the proposed activity (Section 4);
- identified potential alternatives, inclusive of associated advantages and disadvantages (Section 6);
- indication of the methodology used in determining significance of potential environmental impacts (Section 7);
- description and comparative assessment of alternatives (Section 6);
- summary of findings and recommendations of specialists (Sections 5 and 8);
- environmental issues identified during the EIA process, assessments of significance and mitigation measures (Section 8, Appendices B to H, and Appendix O);
- assessment of identified potentially significant impacts (Section 8);
- description of assumptions, uncertainties and gaps in knowledge (Section 13);
- reasoned opinion of whether activity should be authorised and any prescriptive conditions (Section 13);
- an environmental impact statement (Section 13);
- draft environmental management plan (Section 12 and Appendix N);
- irrevocable financial grantee (Section 13);
- copies of specialist’s reports (Appendices B to H, and Appendix O);
- any specific information required by the competent authority (Section 13); and
- in addition, health and safety issues (Section 10).
Figure 1.1 The environmental assessment process for projects in Namibia.
2. PROPERTY DESCRIPTION

2.1 Regional setting
RUN’s Tubas project is located in the west of central Namibia, Southern Africa; situated approximately 40 km east of the major deepwater seaport at Walvis Bay and east-southeast of the coastal town of Swakopmund. The location of the project in relation to the mentioned towns, as well as mining operations in the area, is shown in Figure 2.1. The regional setting in terms of climate, land cover and other regional characteristics is described in Section 5.

![Location of the Tubas deposit on EPL 3496.](image)

2.2 Proposed mining area
The proposed mining licence area is illustrated in Figure 2.2 and the coordinates of this area given in Table 2.1.

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<td>501000</td>
<td>7470000</td>
</tr>
<tr>
<td>7</td>
<td>501000</td>
<td>7465000</td>
</tr>
<tr>
<td>8</td>
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<td>7465000</td>
</tr>
<tr>
<td>9</td>
<td>497000</td>
<td>7463000</td>
</tr>
<tr>
<td>10</td>
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<td>7470000</td>
</tr>
<tr>
<td>12</td>
<td>484000</td>
<td>7470000</td>
</tr>
</tbody>
</table>
2.3 Land use
The proposed Tubas project is contained within the Namib Naukluft Park, which is used primarily for tourism. However, mineral exploration, drilling campaigns and mining operations have previously been undertaken either on or near the proposed project site intermittently during earlier ownerships (see Figures 2.3 and 2.4). According to SAIEA (2010), by the end of December 2009 four mining licences had been granted in the central Namib - two mines were operational, a third was undertaking trial mining, and the fourth was beginning construction.

![Figure 2.2 Location of the Tubas project area on EPL 3496.](image-url)
Figure 2.3 Previous magnetite mining on EPL 3496.

Figure 2.4 Active gypsum mining on EPL 3496.
3. DESCRIPTION OF THE PROPOSED ACTIVITY

The activities for the proposed Tubas project include, *inter alia*, construction of mining infrastructure, open cast mining, loading and hauling, processing of ore, tailings storage facility, the transport of U₃O₈ product, the disposal of waste rock, continuous rehabilitation and ultimately mine closure and final rehabilitation.

3.1 Resource Tubas deposit

The Tubas deposit is part of the greater Tubas palaeochannel prospect where a large amount of historical work was completed by Anglo American Prospecting Services (AAPS) during the late 1970s. Geomine Consulting Namibia (Geomine) was commissioned by RUN to conduct a review and audit of the AAPS data, resulting in Geomine declaring a JORC Code* compliant inferred resource for the overall Tubas Project of 77 Mt grading 228 ppm U₃O₈ at a cut-off grade of 100 ppm U₃O₈ in November 2007. (DYL, 2010)

* The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (the ‘JORC Code’ or ‘the Code’) sets out minimum standards, recommendations and guidelines for public reporting in Australasia of exploration results, mineral resources and ore reserves. The Joint Ore Reserves Committee (JORC) was established in 1971 and published several reports containing recommendations on the classification and public reporting of ore reserves prior to the release of the first edition of the JORC Code in 1989. Figure 3.1 sets out the framework for classifying tonnage and grade estimates to reflect different levels of geological confidence and different degrees of technical and economic evaluation. (AUSIMM, 2004)

![Figure 3.1 General relationship between exploration results, mineral resources and ore reserves.](image)

During 2007 RUN completed a reverse circulation (RC) drilling programme over part of the AAPS resource area centred on the main Tubas palaeochannel. The objective was to obtain information to supplement the Geomine resource estimate. Several holes from this programme intersected highly mineralised fine-grained red sand. Uranium mineralisation at Tubas comprises carnotite in Aeolian (wind-blown) red sand located immediately south of the Tubas palaeochannel system. The sand deposit as drilled is up to 18 m thick and contains visible organic carbon that would have acted as a reductant to precipitate the uranium. The sand is free-digging and occurs over wide areas although only one grid area of about 1 km by 1.4 km was drilled out for JORC Code resources. The low carbonate (calcrete) concentrations in the sand mean it will be amenable to either acid or alkaline uranium extraction.
A decision was made to excavate a N-S trench (Figure 3.2) centred on one of these holes, namely B2.800 7.500 (UTM 491805E 7467751N), which returned an average assay of 1,638 ppm U₃O₈ over 10 m from surface. Four other RC holes were drilled at 5 m spacings with two either side of this hole. The objective was to compare the results from the trench wall channel samples back to the holes’ chemical assays and radiometric logging equivalent uranium results. The trench was 20 m long at its planned terminal depth of 10 m, but in part was excavated to 11 m, ending in a hard undulating calcrete base. The walls of each cut and its floor were channel sampled on 1 m block patterns (Figure 3.3).

Some 4,300 one-metre channel samples were collected from the 12 m deep trench and chemically assayed. The results included exceptionally high U₃O₈ concentrations of up to 2.4%. It is notable that the average assay value for the complete trench section is 1,296 ppm U₃O₈ over 10 m from surface using no cut-off. Applying a 100 ppm cut-off this value becomes 1,430 ppm U₃O₈ over 9 m. Applying a 200 ppm cut-off this value becomes 1,590 ppm U₃O₈, representing the sand section only.

RUN undertook a close-spaced 718 holes for a total of 8,942 m air core drilling programme commencing on 20 m spaced N-S lines and 10 m centres, with the trench as the centre point. Grid spacing was later increased to 20 m by 20 m and towards the end of the programme to 40 m by 40 m, as depicted in Figure 3.4.
Figure 3.3  Final trench profile.

Figure 3.4  Gridded terrain model (GTM) values for holes drilled at TRS to date.
MSA Geoservices completed the Tubas modelling and based the JORC Code mineral resource estimate of 13,846,700 tonnes at 160 ppm eU₃O₈ for 2,217 tonnes (4.9 Mlbs) eU₃O₈ at 100 ppm U₃O₈ cut-off on data generated from RUN’s drilling and trenching campaigns completed in 2007 and 2008 only. Data from the AAPS phase was excluded from this study. (Venter and Hall, 2010)

Based on the very positive physical beneficiation test results and free-digging nature of the Tubas resource from surface, it is highly likely that much lower grades of contained uranium can economically be mined. For example, initial testing indicates 150 ppm U₃O₈ run-of-mine (ROM) material can be potentially upgraded to +500 ppm U₃O₈ for processing at the INCA processing plant.

3.2 Tubas process description

The proposed process flow diagram for the Tubas process plant is given in Figure 3.5, with a brief description of the proposed process given below.

Barren top soil, approximately 0 m to 2 m in thickness, will be pre-stripped and stockpiled in close proximity to the opencast pit on a barren and environmentally low risk area. This top soil will be used to cap the opencast pit once the barren Tubas material from the separation process is backfilled. At this stage two options are proposed for mining, namely either excavator and haul truck (Option 1), or cutter dredge and slurry pumping (Option 2).

For Option 1 the uranium bearing ore, with a cut-off grade of 50 mg/kg U₃O₈, will be mined in an opencast pit using excavators. Trucks will transport the run of mine (ROM) material to various stockpiles. Graders and bull dozers will assist with selective mining, general earthmoving and stockpiling, as well as haul road construction and maintenance. Typical ore to waste ratio will be approximately 1:1. Local underground highly saline water, required for dust suppression, will be extracted from the opencast pit and well points situated within the palaeochannel system. The water sources will be in close proximity to the opencast pit area. Non-mineralised material will stockpile in close proximity to the advancing opencast pit and be backfilled once sufficient pit area is available.

For Option 2 the uranium bearing ore, with a cut-off grade of 50 mg/kg U₃O₈, will be recovered from an advancing submerged opencast pit using a cutter dredge and slurry pump system on a floating pontoon (see Figure 3.6). An in-line radiometric discriminator will divert the non-mineralised slurry to the mined section of the opencast pit. ROM will be pumped to the beneficiation and separation plant. To maintain the water level within the opencast submerged pit, local saline underground water in the palaeochannel will be abstracted and recovered down-stream and up-stream of the advancing pit. The dimensions of the advancing submerged opencast pit will constantly change depending on the quantity of non-mineralised material, depth of mineralisation and uranium grade. In order to minimise evaporation and seepage loss, the surface area of the submerged pit will be kept as low as possible.

Barren de-watered material from the physical beneficiation processing plant will be either backfilled into, or temporarily stockpiled near the opencast pit. Once sufficient pit area is available, the temporarily stockpiled barren material will be backfilled into the pit. Thereafter, stockpiled top soil will cover the backfilled area so that it blends in with the surrounding environment. The Tubas process flow will be a comminution process to produce a uranium rich concentrate paste. The process will consist of wet crushing (or alternatively scrubbing and screening), washing, size separation and de-watering (vibrating de-watering screens and continuous de-watering centrifuges). The paste will have a particle size distribution of <20 µm, a moisture content of 40 % and a uranium content of approximately 1,000 to 3,000 mg/kg U₃O₈.
Figure 3.5  Proposed process flow sheet of Tubas beneficiation, separation and de-watering plant illustrating the wet crushing and scrubber alternatives.
Material from the open cast pit will be stored on a ROM pad in various stockpiles according to uranium grade and geology. ROM will be fed over a vibrating grizzly with 800 mm aperture. A hydraulic impact hammer will break the oversize that feeds back into the comminution circuit.

Two options will be available for the comminution process. In comminution Option 1 the vibrating grizzly undersize will be screened over an inclined static grizzly (100 mm aperture). The static grizzly undersize may be screened using a 2 mm wet vibrating screen. The static grizzly oversize will be wet-crushed in a primary impact crusher (approximately 1.0 kWh/t) to -100 mm. The crushed material will be combined with the 2 mm vibrating screen oversize. The -100 mm to +2 mm material will be wet-crushed by two centrifugal secondary crushers down to -2 mm particle size (approximately 2.5 kWh/t). Figure 3.7 illustrates the primary and secondary crushers for wet crushing application.

In comminution Option 2 the vibrating grizzly undersize will feed into a scrubber with a 10% ball charge at 40% moisture content (approximately 4.0 kWh/t). Figure 3.8 shows a typical scrubber layout. The scrubber product will be screened at 2 mm over a wet vibrating screen. Screen oversize will feed back into the scrubber circuit. The -2.0 mm material, produced by either comminution Option 1 or Option 2, will be diluted with water and pumped through a cyclone to remove -20 µm particles. The cyclone overflow will be combined with the overflow of cyclone phase 1 of the cyclone separation system, as illustrated in Figure 3.9.
Figure 3.8  A typical scrubber layout with feed box and product screen assembly at the exit.

Figure 3.9  Diagram illustrating the three-phase cyclone arrangement for classification of the -125 µm fraction. Phase II underflow produces the barren -125 µm to +20 µm fraction and the phase III overflow produces the -20 µm uranium concentrate fraction.
The cyclone underflow, consisting of -2.0 mm to +20 µm particle size, will be washed in a log washer (see Figure 3.10). The washed slurry leaving the log washer will be diluted with water and pumped to the teeter bed separator illustrated in Figure 3.11. Slurry entering the two-stage teeter bed separator (Figure 3.11 bottom image) will encounter an upward flow of water. Particles will be separated into three size ranges according to their relative size and, to a lesser extent, density. The teeter bed underflow products will be de-watered on de-watering screens and the fluid bed overflow consisting of -125 µm particles may be pumped through an ultrasonic wash vessel (currently under development) prior to separation in the three-phase cyclone separation system. (DYL, 2011)

The three-phase cyclone separation system will separate the solids into a -125 µm to +20 µm barren underflow and a -20 µm uranium concentrate overflow. The underflow will be de-watered on a vibrating de-watering screen. The cyclone overflow will be de-watered using a continuous de-watering centrifuge (see Figure 3.12). The final moisture content of the Tubas concentrate will be approximately 40 %. The de-watered centrifuge concentrate constitutes approximately 15 % to 20 % of ROM material. It will be loaded into highway tankers and transported to the INCA processing plant. Alternatively the Tubas concentrate can be re-pulped and pumped as slurry to the INCA processing plant located on the proposed INCA mining licence area.

All de-watered barren underflow streams from the teeter bed separator and cyclone separation will be combined and loaded onto haul trucks for use as backfill material in the opencast pit.

The plant will be semi-mobile. Most of the equipment will be housed in seagoing container structures, stacked on top and alongside one another (see Figure 3.13). All process plant and equipment used where slurry solution is present will be placed within waterproof bunded structures. Although modules are 250 tpa U₃O₈ product, it is proposed to start at 500 tpa U₃O₈ and increase to 1000 tpa U₃O₈, in the form of carnotite, over time.

![Figure 3.10 A log washer with twin screw assembly.](image-url)
Figure 3.11 Single-stage (top) and two-stage (bottom) teeter bed separator.

Figure 3.12 Cross section of a continuous de-watering centrifuge illustrating de-watering of slurry (brown arrow) and separation of clarified water (blue arrows) and settled solids (yellow arrows).
3.3 Water reticulation and requirements

Various qualities of water will be used for human consumption and ablutions, in the physical beneficiation plant, for dust suppression in the open pit and haul roads. RUN received licences to complete a well-field testing programme in the palaeochannel and is in the process of applying for abstraction permits, although the water is extremely saline and will require partial or full desalination to make it useable. Water will need to be put through a desalination plant or used as is for dust suppression. This water will be sourced from the extensive palaeochannel underground water system that is in close proximity to the physical beneficiation plant.

The chloride content of this raw water is significantly higher than sea water and will require reduction prior to use. This water source has been classified as unfit for human consumption and was classified as an unallocated water resource by the Ministry of Water Affairs and Forestry. However, palaeochannel and pit de-watering water can possibly be used in untreated or partially desalinated form as process water. Potable and product washing water will require complete desalination treatment in a reverse osmosis plant on site and pilot plant tests have indicated 70% recoveries and low pressures.

The raw water will be pumped from the surrounding well-fields in the palaeochannel to a raw water reservoir. Water from the raw water reservoir will feed both the process water tank and a reverse osmosis (RO) water treatment plant. The process water tank will feed the process water distribution network. The purified water from the RO plant will be used as gland seal, product cleaning and potable water. The concentrated waste brine stream of the RO plant will be re-used as dust suppression water and offered to the Roads Authority for use on the C28, C14 and other secondary roads in close proximity.
One sewage treatment plant will be installed to handle all sewage generated from the
gatehouse, offices and washdown from the plant workshops.

Application has been made to NamWater for a total of three million cubic metres of fresh
water a year and RUN is part of the desalination task force. Given the diminishing
volumes of water available from the Omdel and Kuiseb aquifer systems it is highly likely
that only desalinated water will be available from NamWater.

Water required for fire fighting duties will be extracted from the raw water reservoir. The
reservoir will be designed to meet the legal requirements in terms of fire water storage
volume. This implies that the suction for the fire fighting pumps will be lower than the
suction for all other raw water pumping systems by an amount that accommodates the
legal storage volume. Fire water will be supplied to the required areas using an electric
pump, augmented by a diesel driven fire water pump in the event of a power outage. A
dedicated diesel tank will be provided for the diesel driven fire water pump.

The amount of water for the system will meet any fire response requirements based on a
two hour residence for the maximum flow rate and will be fed via a pressurised ring main.
The fire detection systems will consist of the following:

- fire alarm sensors in all buildings, activated by smoke detection, as well as manual
  “break-glass” units as appropriate;
- local fire alarm annunciator panel per building or group of detectors;
- potential free-contactors to allow feedback to the programmable logic controller (PLC);
- manual call point per annunciator panel; and
- siren/strobe per annunciator panel.

Estimated water volumes are given in Table 3.1. Detailed water balances will be available
after engineering studies have been completed for the mining licence application.

<table>
<thead>
<tr>
<th>Sources/use</th>
<th>m³/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well field water</td>
<td>366</td>
</tr>
<tr>
<td>NamWater make-up</td>
<td>to be confirmed</td>
</tr>
<tr>
<td>Potable water</td>
<td>1</td>
</tr>
<tr>
<td>Process water (processing 900 t/h)</td>
<td>305</td>
</tr>
<tr>
<td>Fire water</td>
<td>0.2</td>
</tr>
<tr>
<td>Gland seal water</td>
<td>5</td>
</tr>
<tr>
<td>Reverse osmosis brine</td>
<td>53</td>
</tr>
<tr>
<td>Evaporation</td>
<td>2</td>
</tr>
</tbody>
</table>

3.4 Barrens storage facility

The physical beneficiation and de-watering process does not lead to any chemical change
or dissolution of potentially harmful minerals of the Tubas ore. The barren de-watered
material, used to back-fill the opencast mining pit, will therefore not require a purpose-built
tailing storage facility. Tubas tailings paste produced by the INCA processing plant will
undergo neutralisation and stabilisation. The de-watered Tubas concentrate tailings paste
from the INCA processing plant will be neutralised and stabilised using calcite and lime to
render all dissolved harmful metal ions insoluble. The paste may be blended with the
Tubas barren and de-watered material for storage, along with the backfill from the
advancing Tubas opencast pit.
The storage of the Tubas tailings paste with the barren and de-watered Tubas material, containing some 10% to 15% calcium carbonate, will ensure the pH of the tailings remains near neutral to slightly alkali. All barren overburden and de-watered plant material will be used to back-fill the opencast pit, followed by top soil that will be stored in close proximity. The creation of separate waste dumps for barren or other material will therefore not required.

3.5 **Electricity supply**
The mining site is in the vicinity of the Kuiseb substation. Currently this substation must be upgraded to satisfy the increasing demand by the development of new uranium mines in the area, as well as the increasing demand from both the Swakopmund and Walvis Bay municipalities. All outgoing feeders from the substation are currently rated at 66 kV, but have to be upgraded to 132 kV. The substation is connected to Ruacana and Windhoek by 220 kV transmission lines. The electricity supplier, NamPower, has spare capacity that will be allotted to new mine developments on a first come, first served basis.

The Tubas beneficiation and separation plant requires approximately 3.6 MWh for the comminution circuit and approximately 4.8 MWh for the separation plant. The ultrasonic wash vessel may require 2.0 MWh, bringing the estimated energy demand of the Tubas plant to approximately 12.0 MWh. An official application to NamPower has been lodged and approval is pending on the granting of a mining licence.

It is envisaged that two 10 MVA 132/11 kV transformers will be installed. Plant reticulation to the motor control centres (MCC) will be 11 kV. Plant process reticulation will be 550 V and motors in excess of 350 kW, direct on line (DOL), will be supplied at 3,300 V. Small power and lighting will be at 400 V and emergency power will be produced by three 1,000 kVA diesel units. However this is modular and can be adapted to process requirements.

During the construction and commissioning of the NamPower transmission line the process plant will be supplied with electricity generated by temporary semi-mobile electricity generating plants running on diesel fuel.

3.6 **Access road**
The most acceptable access road to the mine site would be the existing approved park road (track) leading off the C28 road. This road is also currently used to conduct exploration activities (see Figure 3.14).

3.7 **Other site infrastructure/requirements**
Compressed air will be required at the process plant (plant air) and for instrument operation (instrumentation air). Two air compressors, one operating and one on stand-by will provide the compressed air requirements for the process plant. Each compressor will have an internal air drier and air filter. Two air receivers will be installed to supply the plant air reticulation and one instrument air receiver will supply the instrumentation air reticulation.

In the proposed site layout allowance has been made for the following buildings and facilities within the plant area:

- gate house,
- administration building,
- change house,
- laboratory,
- medical building,
- electrical substations and motor control centres,
All buildings will be “modular” type structures placed on an engineered terrace with a concrete floor slab, with adequate sanitary facilities and air conditioning as required. Steel structures will include the general workshop and stores building, pipe and cable racking and miscellaneous access platforms and walkways.
No need for onsite housing is foreseen for either the construction or production phase of the project. Housing would be located in either Walvis Bay or Swakopmund. However, during the plant start-up and commissioning phase an emergency dormitory will be available on site with a limited number of beds and ablution facilities.

General waste will be deemed to consist of domestic waste (comprising primarily of food wastes from the cafeteria and office waste) and industrial waste consisting of construction waste (concrete, wood, metal, and other scraps), empty non-hazardous reagent containers, tyres, and other waste products from the construction and operations stages. General provision will be made for disposal of all waste material at offsite licenced refuse/disposal sites as the site is located within a national park.

It is envisaged that the onsite communications and information management systems will consist of the following:

- telecommunication system,
- two-way radio system,
- security and closed circuit television (CCTV),
- access control,
- office local area network (LAN),
- supervisory control and data acquisition (SCADA), and
- central electronic control room.

The plant organigram at full production (1,000 tpa U₃O₈) was developed from first principles based on industry standards and experience of existing operations. It is foreseen that some non-core activities will be sub-contracted to external service providers. A total complement of 130 personnel is anticipated for the Tubas business operation at full capacity.

The mine site and processing plant will operate on a 24 hours per day, seven days a week basis. Transportation of the Tubas concentrate to the INCA processing plant will be based on the same schedule.

### 3.8 Transportation of the Tubas concentrate

The Tubas concentrate paste will either be hauled in covered tipper or closed tanker trucks, or slurry pumped to the processing plant situated at INCA. Transportation of uranium ore is common practice in countries such as Australia and has proven to be a low risk procedure. The ore will be in the form of a viscous paste. In the event of accidental spillage of any kind, the paste will not disperse widely. It can be contained easily by removing all spilled material and verifying with a Geiger counter that the affected area is contamination free.
4. NEED AND DESIRABILITY OF THE PROPOSED ACTIVITY

4.1 Demand for uranium

Uranium is used for peaceful purposes in the nuclear industry for the production of electricity. Nuclear power currently represents 13% of electricity generated worldwide, with the balance produced by coal 41%, hydro 16%, gas 21%, oil 6% and wind and other sources 3%. Sixteen countries depend on nuclear power for at least a quarter of their electricity, with France obtaining around three quarters of their power supply from nuclear energy. Countries like Belgium, Bulgaria, Czech Republic, Hungary, Slovakia, South Korea, Sweden, Switzerland, Slovenia and the Ukraine get one third or more of their electricity demands from nuclear power. (WNA, 2011a)

The countries with the largest nuclear power generating capacities are the United States (101,421 MW), France (63,130 W), Japan (44,642 MW), Russia (23,084 MW), Germany (20,339 MW), South Korea (18,785 MW), Ukraine (13,168 MW), Canada (12,044 MW), United Kingdom (10,745 MW) and China (11,271 MW) (WNA, 2011b). There is minimal growth in nuclear generation capacity in the major developed countries, with most anticipated growth emanating from countries in the East (WNA, 2011b), for example China (198 reactors either under construction, planned or proposed) and India (63 reactors under construction, planned and proposed). Today, the world produces as much electricity from nuclear energy as it did from all sources combined in 1960, see also Figure 4.1 (WNA, 2011a).

![Figure 4.1 Nuclear electricity production and share of total electricity production.](image)

There are at present 440 nuclear reactors in operation across the world (installed capacity of 376,791 MW), with a further 558 either presently under construction, planned or proposed (WNA, 2011b). The required uranium to supply these reactors is estimated at 68,971 t U₃O₈ per year (WNA, 2011b).
4.2 Supply of uranium

Uranium is ubiquitous on the earth and a constituent of most rocks and even of the sea. It is a metal approximately as common as tin or zinc, with some typical concentrations given in Table 4.1 (WNA, 2011c).

Table 4.1 Typical uranium concentrations.

<table>
<thead>
<tr>
<th>Location</th>
<th>Concentration (ppm U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high grade ore - 20% uranium</td>
<td>200,000</td>
</tr>
<tr>
<td>High grade ore – 2% uranium</td>
<td>20,000</td>
</tr>
<tr>
<td>Low grade ore – 0.1% uranium</td>
<td>1,000</td>
</tr>
<tr>
<td>Very low grade ore - 0.01% uranium</td>
<td>100</td>
</tr>
<tr>
<td>Granite</td>
<td>3 - 5</td>
</tr>
<tr>
<td>Sedimentary rock</td>
<td>2 - 3</td>
</tr>
<tr>
<td>Earth's continental crust (average)</td>
<td>2.8</td>
</tr>
<tr>
<td>Seawater</td>
<td>0.003</td>
</tr>
</tbody>
</table>

An ore body is, by definition, an occurrence of mineralisation from which a metal is economically recoverable. It is therefore relative to both costs of extraction and market prices. At present, neither the oceans nor any granites are ore bodies, but conceivably either could become so if prices were to rise sufficiently. Measured resources of uranium, the amount known to be economically recoverable from ore bodies, are thus also relative to costs and prices. They are also dependent on the intensity of past exploration effort. Changes in costs or prices, or further exploration, may alter measured resource figures markedly. At ten times the current price, seawater becomes a potential source of vast amounts of uranium. Thus any predictions of the future availability of any mineral, including uranium, which are based on current cost and price data and current geological knowledge, are likely to be extremely conservative. Table 4.2 gives some idea on the present understanding of uranium resources. (WNA, 2011c)

Table 4.2 Known recoverable resources of uranium (2009).

<table>
<thead>
<tr>
<th>Country</th>
<th>Uranium (tonne)</th>
<th>Percentage of world</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1,673,000</td>
<td>31</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>651,000</td>
<td>12</td>
</tr>
<tr>
<td>Canada</td>
<td>485,000</td>
<td>9</td>
</tr>
<tr>
<td>Russia</td>
<td>480,000</td>
<td>9</td>
</tr>
<tr>
<td>South Africa</td>
<td>295,000</td>
<td>5</td>
</tr>
<tr>
<td>Namibia</td>
<td>284,000</td>
<td>5</td>
</tr>
<tr>
<td>Brazil</td>
<td>279,000</td>
<td>5</td>
</tr>
<tr>
<td>Niger</td>
<td>272,000</td>
<td>5</td>
</tr>
<tr>
<td>United States</td>
<td>207,000</td>
<td>4</td>
</tr>
<tr>
<td>China</td>
<td>171,000</td>
<td>3</td>
</tr>
<tr>
<td>Jordan</td>
<td>112,000</td>
<td>2</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>111,000</td>
<td>2</td>
</tr>
<tr>
<td>Ukraine</td>
<td>105,000</td>
<td>2</td>
</tr>
<tr>
<td>India</td>
<td>80,000</td>
<td>1.5</td>
</tr>
<tr>
<td>Mongolia</td>
<td>49,000</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>150,000</td>
<td>3</td>
</tr>
<tr>
<td>World total</td>
<td>5,404,000</td>
<td>-</td>
</tr>
</tbody>
</table>
Albeit that present demands for uranium are augmented by nuclear weapons stockpiles (for example, from 2000 the dilution of 30 t of military high-enriched uranium has been displacing about 10,600 t of uranium oxide per year from mines, WNA, 2011c; and overall 500 t of Russian weapons high-enriched uranium will result in about 15,000 t of low-enriched uranium fuel for power reactors over 20 years, WNA, 2011d), the majority of these demands have to be met by mining. For 2010 the total world production from mining was 53,663 t uranium (63,285 t U₃O₈), with Kazakhstan having the largest share of uranium from mines at 33% (of world supply from mines), followed by Canada with 18% and Australia at 11% (WNA, 2011e). Consolidation in the uranium production industry since the early 1990s has resulted in ten mining companies accounting for 87% of the world’s uranium mine production, as shown in Table 4.3 (WNA, 2011e). The largest producing world uranium mines in 2010 are given in Table 4.4, with the world total uranium supply from mines contrasted against the world civil and estimated naval demand in Figure 4.2 (WNA, 2011e).

Table 4.3 The main uranium mining companies in 2010.

<table>
<thead>
<tr>
<th>Company</th>
<th>Uranium (tonne)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameco</td>
<td>8,758</td>
<td>16</td>
</tr>
<tr>
<td>Areva</td>
<td>8,319</td>
<td>16</td>
</tr>
<tr>
<td>KazAtomProm</td>
<td>8,116</td>
<td>15</td>
</tr>
<tr>
<td>Rio Tinto</td>
<td>6,293</td>
<td>12</td>
</tr>
<tr>
<td>ARMZ</td>
<td>4,311</td>
<td>8</td>
</tr>
<tr>
<td>Uranium One</td>
<td>2,855</td>
<td>5</td>
</tr>
<tr>
<td>Navoi</td>
<td>2,400</td>
<td>4</td>
</tr>
<tr>
<td>BHP Billton</td>
<td>2,330</td>
<td>4</td>
</tr>
<tr>
<td>Paladin</td>
<td>2,089</td>
<td>4</td>
</tr>
<tr>
<td>Sopamin</td>
<td>1,450</td>
<td>3</td>
</tr>
<tr>
<td>Anglo Gold</td>
<td>563</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>6,179</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>53,663</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 4.4 The largest producing Western world uranium mines in 2009.

<table>
<thead>
<tr>
<th>Mine</th>
<th>Country</th>
<th>Main owner</th>
<th>Type</th>
<th>Production (tonne U)</th>
<th>% of world</th>
</tr>
</thead>
<tbody>
<tr>
<td>McArthur River</td>
<td>Canada</td>
<td>Cameco</td>
<td>underground</td>
<td>7,654</td>
<td>14</td>
</tr>
<tr>
<td>Ranger</td>
<td>Australia</td>
<td>ERA (Rio Tinto 68%)</td>
<td>open pit</td>
<td>3,216</td>
<td>6</td>
</tr>
<tr>
<td>Rössing</td>
<td>Namibia</td>
<td>Rio Tinto (69%)</td>
<td>open pit</td>
<td>3,077</td>
<td>6</td>
</tr>
<tr>
<td>Kraznokamensk</td>
<td>Russia</td>
<td>ARMZ</td>
<td>underground</td>
<td>2,920</td>
<td>5</td>
</tr>
<tr>
<td>Arit</td>
<td>Niger</td>
<td>Somair/Areva</td>
<td>open pit</td>
<td>2,650</td>
<td>5</td>
</tr>
<tr>
<td>Tortkuduk</td>
<td>Kazakhstan</td>
<td>Katco JV/Areva</td>
<td>in-situ leaching</td>
<td>2,439</td>
<td>5</td>
</tr>
<tr>
<td>Olympic Dam</td>
<td>Australia</td>
<td>BHP Billiton</td>
<td>by-product/ground</td>
<td>2,330</td>
<td>4</td>
</tr>
<tr>
<td>Budenovskoye 2</td>
<td>Kazakhstan</td>
<td>Karatau JV/Kazatomprom</td>
<td>in-situ leaching</td>
<td>1,708</td>
<td>3</td>
</tr>
<tr>
<td>South Inkai</td>
<td>Kazakhstan</td>
<td>Beşşak Dala JV/Uranium One</td>
<td>in-situ leaching</td>
<td>1,701</td>
<td>3</td>
</tr>
<tr>
<td>Inkai</td>
<td>Kazakhstan</td>
<td>Inkai JV/Cameco</td>
<td>in-situ leaching</td>
<td>1,642</td>
<td>3</td>
</tr>
<tr>
<td><strong>Top ten total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>29,337</strong></td>
<td><strong>55</strong></td>
</tr>
</tbody>
</table>
4.3 Uranium oxide prices
Uranium oxide prices fluctuate like most commodities, dependent on supply and demand trends. As of 26 September 2011 the weekly spot price is $52.50/lb U₃O₈ (UXCC, 2011a). The price fluctuations for U₃O₈ between 1988 and September 2011 are illustrated in Figure 4.3 (UXCC, 2011b). Financial modelling for the proposed Tubas project indicates that the project is capable of producing satisfactory returns.

4.4 Relevance of economic viability
Uncertainties or substantial fluctuations in production levels, or the actual failure of resource projects, potentially create adverse social and environmental impacts. This is particularly so in the case of large scale projects involving major supporting physical and social infrastructure. Therefore the analysis of the broad economic viability of a project forms a relevant important component of an environmental impact assessment.
In the case of the proposed Tubas project, assessing economic viability involves consideration of the forecast demand for mined uranium, and its anticipated price relative to the proposed investment in its production. However, for this project fluctuations in the rate of production will have only a minor impact on the socio-economic structure of the region, compared with larger resource projects that involve the establishment of townships and the provisions of a wide range of support services. The proposed project places minimal demands on government services and the interaction with the local community will be relative modest and predominantly beneficial.

4.5 Economic and non-economic benefits and costs
Social and economic impacts of the proposed Tubas project forms part of the environmental impact assessment undertaken for the project. Naturally new job opportunities will be created at the proposed mine, coupled with economic benefits to the Namibian government and the Swakopmund/Walvis Bay regional community through direct and indirect taxes, and purchases and acquired services in the Swakopmund/Walvis Bay regional area.

Economic costs to the regional community will be minimal, particularly with regard to infrastructure, as dedicated power infrastructure will be developed as part of the proposed project in conjunction with the relevant authorities, water infrastructure for the project will be developed on site, and additional transportation infrastructure costs beyond the Namibian regional road system will be borne by Reptile Uranium Limited.

Significant non-economic benefits can be expected to emanate from increased employment opportunities in skilled and semi-skilled jobs, including the associated training and experience, in the Swakopmund/Walvis Bay regional community, including social upliftment programmes and through an employment multiplier of about two hundred per cent.
5. DESCRIPTION OF THE ENVIRONMENT

In this part of the report a description of the environment that may be affected by the activity is provided in accordance to Section 27(d) of the draft environmental assessment regulations (MET, 2009). Based on the terms of reference developed for this proposed activity in the scoping report (Friend et al., 2010), various specialist investigations were completed as part of the impact assessment process. Information and findings collated from these investigations are given in the proceeding sections, with the complete specialist reports provided in referenced appendices to this report in terms of Section 27(q) of the draft environmental assessment regulations (MET, 2009).

5.1 Climate

5.1.1 Rainfall
The average annual rainfall ranges from about 15 mm at the coast to about 35 mm further inland and can best be described as extremely variable, patchy and unreliable. A given location can go for years without any rain. However, the project area receives significant amounts of moisture from fog or dew, particularly near the coast. This fog is sufficient to support at least two species of lichens and many other plants in the project area. (Christian, 2006)

5.1.2 Temperature
The Namib Desert near the coast has a temperature range that is moderated by proximity to the sea. As distance increases from the coast the temperature range rapidly becomes more extreme. The hottest month is February, when maximum air temperatures can reach 40°C but the average maximum is 25°C - 30°C. The coldest month is August, when the average minimum temperatures are between 8°C and 12°C depending on distance from the coast. (Christian, 2006)

Monthly-diurnal-hourly-arithmetic-mean temperatures (measured at 10 m) are presented in Figure 5.1 (Khumalo and Liebenberg-Enslin, 2010). Monthly temperature trends are discussed in more detail in the specialist report in Appendix B.

![Figure 5.1](image_url)
5.1.3 Humidity
The average humidity for the region is illustrated in Figure 5.2 and shows a marked winter minima (Friend et al., 2005).

![Average humidity for the region.](image)

5.1.4 Wind
Near the coast strong southerly winds prevail, but westerly to south westerly winds are also frequent. With increasing distance from the coast the wind speed generally decreases and its direction becomes more variable. Warm easterly winds from the interior blow for typically between 7 and 14 days per year. These “berg winds” are hot dry winds caused by air descending from the interior. As the air descends it is compressed, causing a rapid increase in temperature. These winds can cause serious sandstorms, particularly in winter and spring. (Christian, 2006)

Seasonal wind roses for the region are shown in Figure 5.3 (Khumalo and Liebenberg-Enslin, 2010). Prevailing wind direction (predominantly from the north- and southwest) and other wind parameters are discussed in more detail in the specialist report in Appendix B.

5.2 Geology

5.2.1 Regional geology
Tubas consists of secondary uranium mineralisation (carnotite) in well-sorted aeolian sand that occurs immediately south of the Tubas palaeochannel. Generally uranium mineralisation occurs from 1 m to 2 m below surface to a depth of approximately 15 m and within all lithologies. The water table has been found to be variable and is estimated to be at approximately 10 m to 30 m depth. An idealised geological profile of the Tubas geology is illustrated in Figure 5.4 (Wagener, 1983).

5.2.2 Drilling information
A relatively small area was intensely grid drilled around a trial-mining trench to acquire bulk samples for physical beneficiation test work. The drill pattern on the Tubas project’s area is shown in Figure 5.5. Altogether 3,713 holes were drilled over a distance of 68,229 m.
5.2.3 Geophysics
Before any drilling commenced on the Tubas area a number of geophysical methods were carried out in order to identify radioactive targets and to delineate the Tubas palaeochannel. Upon identification of these potential targets, the drilling commenced by following higher radioactive areas that indicate the potential of carnotite within the Tubas channel. Geophysical data on the Tubas project area is illustrated in Figures 5.6 to 5.8 and proposed pits indicated on Figure 5.9.

5.3 Topography
The proposed project area (see Figure 5.10) consists of a wide variety of granitic rocks that occur in the mountainous areas to the east and low-lying gravel plains that are generally fairly flat, except where they have been incised by rivers (erosion cycles, leading to shifts in the horizontal and vertical alignments of watercourses, resulted in the formation of old river terraces that now stand at elevations of several metres higher than the present watercourses). (Christian, 2006)

5.4 Soils
The soils of the Namib Desert are formed by various processes, both mechanical and chemical. Near the coast fog, which contains salt and hydrogen sulphides, intensifies chemical processes and soil genesis (Smuts, 1988). Soil formation is a slow and weak process on the plains of the Namib. The soil usually forms a crust that provides a stabilising effect, but is also very sensitive to any form of disturbance (Seely and Pallet, 2008). However this terrain is also fairly easily restored (Burke, 2005).
Poorly sorted, gritty to pebbly, bedded, fluviatile sand and gravel which occupies erosion channels cut into the older sediments; generally poorly consolidated except for gypsum cemented zone. Clasts consist mainly of angular vein quartz with lesser amounts of other rock types listed below.

Loose aeolian sand, occasionally up to 1 m thick, and desert scree pavement consisting mainly of wind etched quartz fragments up to 2 cm across.

Gypsum duricrust capping, ranging from almost pure gypsum (partly altered to bassinite) to tough, gypsum impregnated, sand, grit and gravel.

Poorly consolidated sand bodies, brick red near the top but grading downwards through yellowish brown to pale grey; occasional grit and pebbly layers; sulphate content up to 20% near the top decreasing downwards to generally <5%, with roughly mirror imaged calcium carbonate content.

Grey to white calcritised gravel, grit and sand (valley calcrite); some zones of less well cemented to unconsolidated grey sand and grit; occasional red sand and minor clay beds. Clasts reach boulder dimensions and consist mainly of granite/gneiss, quartzite, vein quartz, calc-silicate rocks, dolerite, marble and feldspars.

Irregularly-surfaced basement succession consisting of granite, gneiss, marble and quartz-biotite schist; upper 2 to 3 m usually fractured and calcritised.

Figure 5.4 Idealised geological profile of Tubas resource.
Figure 5.5 Drill pattern for Tubas.

Figure 5.6 Drill holes over a radiometric image showing uranium high grade in white on the proposed Tubas mining licence area.
Figure 5.7 Drill holes over aerial electro-magnetic image with red as high on the proposed Tubas mining licence area.

Figure 5.8 Drill holes over interpretive image showing the ratio of uranium over thorium on the proposed Tubas mining licence area.
Figure 5.9 Tubas proposed pits in red over 2007 resource block model.

Figure 5.10 Topographical map of the Tubas project area.
The surface soils of most of the western and central parts of the project area can be classified as coastal gravel plains. Coastal gravel plains consist of thin soil crusts approximately 4 mm thick or more. They are generally either gypsum crusts (gypcrete) or calcium carbonate crusts (calcrete) that develop from deposits due to fog precipitation. (Walsdorff et al., 2009)

The coastal gravel plains of the Central Namib are very fragile systems and are extremely sensitive to destruction by development activities (NACOMA, 2009). The movement of vehicles over this type of terrain causes long-term damage, both to the soil type and to the ecology that it supports. Gravel plains are usually difficult to restore (Burke, 2005).

The gypsum plains occur only in the first 60 km strip from the coast. They have a very porous structure that is easily disturbed, reducing the value of the soil to the ecology that it supports (Seely and Pallet, 2008). The crust is usually very thin but can be up to 4 m thick close to the coast.

The calcrete plains are located further inland than the gypsum plains and may have a limited occurrence in the proposed mining licence area (Seely and Pallet 2008). This soil formation usually supports annual grasses that require at least 20 mm of rain to start germination.

Several smaller river washes cross the proposed mining licence area in the longitudinal direction that mostly contains washed sandy soils. The larger watercourses are usually comprised of coarse sand, sometimes mixed with some gravel in certain areas. In some places the sand is well packed and hard. Elsewhere only the surface is hard due to the formation of a crust, nominally 8 – 10 cm thick. These hard surfaces are often underlain by soft sand and powdery silt (Smuts, 1988).

In a few of the smaller tributaries of the Tumas drainage system, shallow pans are found. These are comprised of finer material, namely silt and clays mixed with carbonates and salts. These pans would become very soft after rain. The surfaces of such pans, in places where water has stood for some time, are devoid of vegetation (Smuts, 1988).

5.5 Land use capabilities
Major land uses in Namibia are illustrated in Figure 5.11 (Mendelsohn et al., 2002). Large parts of the Erongo Region are desert and retained by the state as protected areas under conservation management, including the Namib Naukluft Park (Mendelsohn et al., 2002). The arid nature of the landscape means that very little of the area has agricultural potential and is thus used primarily for tourism. However, mineral exploration, drilling campaigns and mining operations have previously been undertaken in the area, with illustrative examples of mining and other activities within the Namib Naukluft Park given in Figures 5.12 and 5.13.

5.6 Hydrology
The development of the Omahola project, comprising the Shiyela Iron and two uranium projects INCA and Tubas, initiated a groundwater monitoring campaign to provide baseline data for relevant studies and assessments, as well as long term monitoring data for environmental compliance (Stanton, 2010). The groundwater monitoring campaign, conducted by Namibian company Eco Aqua, is presented in more detail in the specialist report in Appendix C.

The locality map for the Tubas monitoring holes is shown in Figure 5.14. Seven boreholes were sunk on and around the Tubas project area. In order to assess the quality of groundwater in the region of the proposed Tubas project, it is necessary to distinguish between the various water classifications applicable to water within Namibia.
Figure 5.11 Major land uses in Namibia.

Figure 5.12 Example of a mining operation within the Namib Naukluft Park.
Water is classified into four groups according to certain parameters (determinants), namely (Stanton, 2010):

- Group A – water with an excellent quality,
- Group B – water with an acceptable quality,
- Group C – water with low health risk, and
- Group D – water with a high health risk, not suitable for human consumption.

The overall quality group into which a water is classified is determined by the parameter (determinant) that complies least with the guidelines for the quality of drinking water. The results from monitoring at Tubas is given in Appendix C, with the results from borehole TUBW6 given as typical example in Table 5.1; with reference to Group A and Group D Namibian water quality guidelines (Stanton, 2010). The groundwater is characterised by high salinities and is unsuitable for human consumption (Stanton, 2010).

### 5.7 Air quality

A baseline air quality characterisation and air quality impact study for the proposed INCA and Tubas uranium projects on EPL 3496, as part of the original Omahola project, was concluded by Airshed Planning Professionals, who also conducted similar studies for the strategic environmental assessment (SEA) for the Erongo region, and is presented in detail in Appendix B. The predicted baseline highest daily average PM$_{10}$ concentration for the Erongo region is shown in Figure 5.15, with annual average PM10 concentrations illustrated in Figure 5.16 (Khumalo and Liebenberg-Enslin, 2010)

Anthropogenic sources of emission in the vicinity of the proposed Omahola project site mostly include mining activities. Current operating mines in the Erongo Region include Rössing Uranium Mine, located approximately 40 km to the north northeast of the Omahola Project site, and Langer Heinrich Uranium Mine, situated about 44 km to the east. Valencia Uranium and Trekkopje mines are approved proposed uranium mines in the region and will also utilise opencast mining methods. (Khumalo and Liebenberg-Enslin, 2010)
**Figure 5.14** Locality map of monitoring holes for the Tubas project.

**Table 5.1** TUBW6 monitoring results.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>TUBW6</th>
<th>Group A</th>
<th>Group D</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (at 21°C)</td>
<td>7.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductivity (mS/m at 25°C)</td>
<td>3,888</td>
<td>150</td>
<td>400</td>
</tr>
<tr>
<td>Total dissolved solids</td>
<td>31,800</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>980</td>
<td>150</td>
<td>400</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>246</td>
<td>70</td>
<td>200</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>6,383</td>
<td>100</td>
<td>800</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>163</td>
<td>200</td>
<td>800</td>
</tr>
<tr>
<td>Total alkalinity (as CaCO₃)</td>
<td>67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bicarbonate (HCO₃⁻)</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbonate (CO₃²⁻)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride (Cl⁻)</td>
<td>10,250</td>
<td>250</td>
<td>1,200</td>
</tr>
<tr>
<td>Sulphate (SO₄²⁻)</td>
<td>1,824</td>
<td>200</td>
<td>1,200</td>
</tr>
<tr>
<td>Nitrate (NO₃⁻)</td>
<td>121</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>27.3</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Fluoride (F⁻)</td>
<td>2.5</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>167</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Sum of cations (meq/l)</td>
<td>350.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sum of anions (meq/l)</td>
<td>330.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arsenic (AS)</td>
<td>0.02</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Aluminium (Al)</td>
<td>&lt;0.009</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>&lt;0.001</td>
<td>0.05</td>
<td>2</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>0.56</td>
<td>0.05</td>
<td>2</td>
</tr>
<tr>
<td>Silicon (Si)</td>
<td>9.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uranium (U)</td>
<td>&lt;0.004</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>
Predicted background concentrations and measured dust deposition rates were obtained from the SEA study recently undertaken for the Erongo Region. Background concentrations predicted around the proposed Omahola project site are in the region of 180 µg/m³ (highest daily) and with an annual average of 40 µg/m³. (Khumalo and Liebenberg-Enslin, 2010)

**Figure 5.15** Predicted baseline highest daily average PM\textsubscript{10} concentration for the Erongo region.

### 5.8 Natural vegetation

A vegetation survey consisting of a systematic recording of all identifiable woody species, grasses, forbs and alien (exotic) plants within each of the stratified units on site was completed by Ekotrust and is presented in detail in Appendix D. The survey had the following objectives (Van Rooyen, 2010):

- to distinguish the different plant communities of the area
- to search the area for rare and/or threatened plant species, and
- to determine the impacts that the proposed mining venture will have on the vegetation and flora of the area.

A plant community is defined as a vegetation unit described by a specific plant species composition, having a uniform physiognomy and being restricted to a specific habitat (Van Rooyen, 2010). The plant communities (or associations) described do not exist as completely separated, clearly defined units in the area (Van Rooyen, 2010). Because of the relatively homogenous character of the habitat, these communities are in many instances related and form a continuum from one community to the next community within the larger ecosystem (Van Rooyen, 2010).
Figure 5.16 Predicted baseline annual average PM$_{10}$ concentration for the Erongo region.

The following plant communities were distinguished for the three Omahola project sites, namely (Van Rooyen, 2010):

1. *searsia marlothii-sarcostemma viminale* sparse shrubveld of granite inselbergs;
2. *aloe asperifolia-hoodia cf currorii* sparse shrubveld of rocky outcrops and schist ridges;
3. *zygophyllum stapfii-brownanthus* sp. sparse shrubveld of rocky ridges and "hardeveld" along drainage lines;
4. *acanthosicyos horridus-pechuel-loeschea leubnitziae* riverbeds and washes;
5. *arthraerua leubnitziae-zygophyllum stapfii* dwarf shrubland of the gravel plains and washes;
   5.1 *arthraerua leubnitziae-salsola tuberculata-gomphocarpus filiformis* dwarf shrubland of the gravel plains and sheetwashes;
   5.2 *arthraerua leubnitziae-salsola tuberculata-stipagrostis obtusa* sparse shrubveld of the gravel plains;
   5.3 *arthraerua leubnitziae-citrullus eciirhosus* sparse shrubland of gravel plains and sheetwashes;
6. *arthraerua leubnitziae-welwitschia mirabilis* sparse dwarf shrubland of the northern gravel plains and sheetwashes;
7. *zygophyllum stapfii-arthraerua leubnitziae* dwarf shrubland of the gravel plains;
8. *salsola tuberculata* shrubland of river terraces and undulating plains and footslopes;
9. *arthraerua leubnitziae* rocky ridges and dolerite dykes; and
10. barren gravel plains
Descriptions of these communities are provided in further detail by Van Rooyen (2010) in Appendix D. Using these communities a vegetation map for the Tubas project area is presented in Figure 5.17, with examples of relevant plant communities provided in Figures 5.18 to 5.25 (Van Rooyen, 2010).

Figure 5.17 Vegetation map of the Tubas project area.
Figure 5.18 Community 1: granite inselberg surrounded by sparsely vegetated plains.

Figure 5.19 Community 2: rocky outcrop with species such as *hoodia cf. currorii* and *aloe asperifolia*.
Figure 5.20 Community 3: bare rocky ridges with species such as *orthanthera albida* and *hexacyrtis dickiana* in the gullies.

Figure 5.21 Community 4: open to dense vegetation in the Tumas riverbed characterised by *gomphocarpus filiformis, salsola tuberculata* and scattered individuals of *acacia erioloba, tamarix usneoides, acanthosicyos horridus* and *capparis hereroensis*. 
Figure 5.22 Community 5.1 in wash in foreground with community 3 on terraces in the background.

Figure 5.23 Community 5.2: sparsely vegetated plains with *arthraerua leubnitziae* and *salsola tuberculata* the dominant species.
Figure 5.24 Community 8: stands of *salsola tuberculata* on river terraces.

Figure 5.25 Community 10: Barren plains with ‘foam or spongy’ soils covered with small quartz pebbles.
5.9 Animal life

5.9.1 Introduction
Two comprehensive studies on animal life within the project area were completed, namely a vertebrate fauna study (mammals, reptiles, amphibians and birds) by Environment and Wildlife Consulting Namibia (complete report in Appendix E; Cunningham, 2010) and an invertebrate fauna study by Biodata and Scarab (complete report in Appendix F; Irish and Scholtz, 2011). For the vertebrate study a field survey was conducted between 25 and 29 June 2010, which was preceded by a comprehensive literature desktop study that took place during June 2010. The baseline study for invertebrate fauna entailed a desktop literature review as well as an extensive field survey that spanned a period of three months. After the first significant summer rains in the project area, preservative pitfall traps were deployed in twelve vegetational habitats. Once-off manual invertebrate collection in each habitat was also undertaken as part of the field survey.

5.9.2 Mammals
Detailed descriptions of mammals occurring in the area are presented in Appendix E. Of the twelve species observed and/or confirmed from the area during the fieldwork the round-eared elephant shrew (*macroscelides proboscideus flavicaudatus*), bat-eared fox (*otocyon megalotis*) are viewed as the most important with conservation and legal status of endemic (vulnerable) and vulnerable/peripheral, respectively. Another important species is the brown hyena *parahyaena (hyaena) brunnea* that is classified as “insufficiently known” and probably “vulnerable” in Namibia, but occurs widespread throughout the coastal areas. (Cunningham, 2010)

Other important species expected to occur in the general area, although not confirmed during the fieldwork, are the Namibian wing-gland bat (*cistugo seabrai*), Namib long-eared bat (*laephotis namibensis*) and Littledale’s whistling rat (*protomys littledalei namibensis*). *protomys littledalei namibensis* is known from the better vegetated areas in the Swakop and Kuiseb River mouth areas and probably only occurs in the Tumas drainage lines under exceptionally wet periods. However, very little is known of this subspecies. (Cunningham, 2010)

5.9.3 Reptiles
Detailed descriptions of reptiles occurring in the area are presented in Appendix E. Of the 56 species of reptiles expected to occur in the general Swakopmund area, of which a high percentage are viewed as endemic (55.4%), only 14 species were observed and/or confirmed during the fieldwork conducted between 25 and 29 June 2010. All 14 species observed and/or confirmed from the area, are viewed as “secure”, including the nine endemic species. *Ptenopus carpi* (Carp’s barking gecko) is viewed as the most important species observed during the fieldwork, as their range is limited in Namibia (Kuiseb River to Rocky Point on barren gravel plains) and they are nowhere common (see Figure 5.26). Other reptile species of concern and expected to occur in the general area, are the endemic *afroedura africana* (African flat gecko), *pedioplanis husabensis* (Husab sand lizard), *leptotyphlops occidentalis* (Western thread snake) and *lycophidion namibianum* (Namibian wolf snake). Although the endemic *pedioplanis husabensis* potentially occurs in the area, none were observed. (Cunningham, 2010)

5.9.4 Amphibians
Amphibians are not viewed as important throughout the project area although the ephemeral Tumas drainage lines might occasionally serve as temporary habitat. *Poyntonophrynus (Bufo) hoeschi* and *phrynomantis annectens* are viewed as the most important but they are not exclusively associated with the proposed mining areas. (Cunningham, 2010)
5.9.5 **Birds**

Detailed descriptions of birds occurring in the area are presented in Appendix E. Although seven of the fourteen endemics to Namibia are expected to occur in the general area, very few birds were observed during the fieldwork conducted between 25 and 29 June 2010. Naturally more birds are expected to occur in the area during favourable environmental conditions (for example, rains and associated vegetative growth spurts); however, the extremely marginal environment limits the numbers and diversity. The most important species confirmed and/or expected to occur in the general area are *ammomanopsis grayi* (Gray’s lark), *namibornis herero* (Herero chat) and *eupodotis rueppellii* (Rüppell’s korhaan). *Ammomanopsis grayi* is viewed as the most important species from the area although not threatened and well represented in protected areas throughout coastal Namibia. No *namibornis herero* were observed during the fieldwork and they are known to favour the rocky areas towards the northeast, for example, Spitskoppe, etc. *Eupodotis rueppellii* occurs widespread throughout the western regions of Namibia. (Cunningham, 2010)

5.9.6 **Invertebrates**

The complete invertebrate study report is presented in Appendix F. A total of at least 319 distinct invertebrate species were recorded in the total project area (comprising the Shiyela Iron, INCA and Tubas projects) and 21,021 individual invertebrates were recovered from pitfall traps. During the fourth trapping period the diversity and abundance of recorded invertebrates increased significantly. The sensitivity of the different habitats was assessed by evaluating it according to the diversity and potential diversity of invertebrate trophic guilds, the habitat restoration potential and the uniqueness of the habitat. The Salsola river terraces and plains habitat were identified as the most sensitive habitat within the total project area, with the marble ridge habitat, northern gravel plains, lower Tumas drainages, western and southern gravel plains and granite hill categorised as “highly sensitive habitats”. (Irish and Scholtz, 2011)

5.10 **Archaeological, heritage and cultural aspects**

An archaeological survey of EPL 3496 was conducted during 2010 and the complete survey report presented in Appendix G (Kinahan, 2010). Archaeological assessment in Namibia follows the conventional three phase process of evaluation, assessment and mitigation, as shown in Figure 5.27.
The archaeological survey, focussed on the Tubas River valley and environs, has located thirty nine archaeological sites ranging in age from the late Pleistocene to recent (see Figure 5.28). Eighteen of these were recorded on the Tubas project area. Although the area is of generally low archaeological significance, the survey contributed to a better understanding of the local archaeology and identified some sites that require special protection. (Kinahan, 2010)

5.11 Sensitive landscapes and visual aspects
The Tubas project falls within the boundaries of the Namib Naukluft Park, which constitutes a sensitive landscape. The legal establishment of the present Namib Naukluft Park started at the beginning of the twentieth century when, in 1907 under German colonial rule, it was proclaimed as a game reserve. This area encompassed mainly the northern part of the current park that falls within the Erongo Region. (Friend et al., 2005)
The park is administered by the Ministry of Environment and Tourism (MET) in Namibia, maintaining all facilities associated with the park, for example, camp sites and roads. Visitors and non-MET residents of the Gobabeb Centre (located at the Kuiseb River) require permits for entry that outline their activities within the park. These permits normally allow visitors access to the park and to overnight at lookouts and camp sites. (Friend et al., 2005)

One of the major attractions to tourists visiting the Namib Naukluft Park is the scenic beauty of the park itself (Figure 5.29). This is based primarily on the lack of human activity and structures in the park, coupled to a sense of remoteness (Figure 5.30). Albeit that a large number of mining operations have started in certain parts of the park, coupled with increased tourism operations, the park remains virtually void of any human interaction.
Figure 5.29 Scenic beauty of the Namib Naukluft Park.

Figure 5.30 Sense of unique remoteness within the Namib Naukluft Park.
The sense of remoteness of the Namib Naukluft Park is directly related to the sense of place concept identified in Barnard et al. (2006). Sense of place is an environmental concern that can be impacted upon by development and should be considered accordingly. Impacts from the development of mines and industries can destroy the sense of place of an area and thus the spiritual, aesthetic and therapeutic qualities of an area will also be eliminated (Barnard et al., 2006).

Two essential requirements for an appreciation of sense of place are that it must be a person experiencing the sensation and it must be a place that is experienced. Sense of place therefore cannot exist in isolation, but requires an interaction between the affected individual and the place where it happens. The importance of the sense of place is thus determined not only by the place itself, but by the value that the individual gives it. (Barnard et al., 2003)

5.12 Noise
A baseline noise survey was completed for the proposed project area and the complete report presented in Appendix H (Cornelissen, 2010). A-weighted sound pressure levels were recorded over the period of an hour during different time periods and spread over a five day period. One of the measurements was also taken on a Sunday at the respective measurement points.

The median values of the measurements recorded during the five days for the proposed development varied between 31.6 dB(A) and 65.6 dB(A). Weekend time measurements varied between 32.7 dB(A) and 37.3 dB(A) for the various points. Both day and weekend measurements were substantially below the World Bank guideline values of 45 dB(A) and 55 dB(A), respectively. According to SANS 10103:2004 a change of 10 dB(A) is equivalent to an apparent doubling or halving of sound levels; putting into perspective the difference between the measured sound levels and the World Bank guideline. (Cornelissen, 2010)

5.13 Social environment

5.13.1 Introduction
The proposed Tubas project lies in the Erongo region, situated approximately 40 km to the east of Walvis Bay and east-southeast of Swakopmund. The area falls within the Namib Naukluft Park and no permanent settlements have been recorded. The socio-economic structure of the Erongo region, and Namibia as a whole, has important implications for proposed mining projects in terms of skills availability and labour pool. Mining and tourism are sectors in which prospects for growth are the best. The high unemployment and poverty levels in Namibia means that any new development is perceived as being economically beneficial to the area. (Friend et al., 2005)

5.13.2 Demographic characteristics
The population of the Erongo region is relatively small and densities are low. Most of the population is to be found in urban areas with 63% living in the towns of Walvis Bay, Swakopmund, Omaruru, Karibib, Arandis, Usakos, Uis and Henties Bay (IDC, 1995). Important for the study area is that the dependency ratio is low due to migration to the coastal cities (Walvis Bay and Swakopmund) for employment. Generally, the human development in the Erongo region is somewhat better than in the rest of the country (NPC, 2000a).

5.13.3 Population size and density of the Erongo region
The closest towns to the proposed Tubas project are Walvis Bay and Swakopmund. An overview of the population characteristics of both towns are given in Table 5.2 (CBS, 2002). The total population of the Erongo region is 107,629, which is approximately 6.7% of the total population of Namibia (CBS, 2002).
Walvis Bay is divided into urban and rural areas; however, most people live in the urban part. At 3.8 the average household size in Walvis Bay (urban) is slightly higher than that of Swakopmund, whereas the average household size in the Erongo region lies at 4.5 persons per household, a figure lower than the national average of 5.7 persons per household (NPC, 2000b).

<table>
<thead>
<tr>
<th>Town</th>
<th>No of households</th>
<th>Population</th>
<th>Average household size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Walvis Bay (urban)</td>
<td>10,719</td>
<td>22,053</td>
<td>18,796</td>
</tr>
<tr>
<td>Walvis Bay (rural)</td>
<td>189</td>
<td>363</td>
<td>260</td>
</tr>
<tr>
<td>Swakopmund</td>
<td>7,560</td>
<td>13,175</td>
<td>12,267</td>
</tr>
</tbody>
</table>

### 5.13.4 Migration
The primary route of migration in the Erongo Region is in-migration from the northern regions of the country by young male labourers seeking employment, primarily in Walvis Bay. However, a number of migrant labourers go to mining towns (for example, Arandis) and commercial farms within the Erongo Region (NPC, 2000b).

Out-migration occurs primarily from rural areas to socially more attractive areas, such as towns within the region and also to larger urban centres such as Windhoek. Only one-third of Erongo residents were born where they live, the rest have come to their place of residence from elsewhere (NPC, 2000b). Compared with all 13 regions of Namibia, no other region has such a high rate of people living in an area away from where they were born (NPC, 2000b).

### 5.13.5 Households and economic conditions
The main source of income (76% in 2000) in the Erongo region is wages (Mendelsohn et al., 2002 and NPC, 2000b). The number of households financed through pensions and cash remittances makes up 21% (NPC, 2000b) and the remaining 3% have no income at all. Approximately 40% of the households have one income, 20% have two incomes and below 5% of the households have three incomes (Mendelsohn et al., 2002). The statistics for the Erongo region reflects the general situation of Namibia. Looking at the Gini coefficient (a measure of inequality) the Erongo region has one of the highest levels of inequality within Namibia, reflecting the large differences in wealth between people within the region (Mendelsohn et al., 2002).

### 5.13.6 Human development
The World Bank (2001) classifies Namibia as one of the 48 developing nations in sub-Saharan Africa and groups the country within the Lower-middle-income Group ($756 - $2,995) based on its Gross National Income (GNI) per capita. However, the inadequacy of using income as the sole indicator of development was discussed by Friend (2003) by using an example from May et al. (2000); whereby South Africa was compared with Poland, Thailand, Venezuela, Botswana and Brazil. All of these countries have lower per capita income than South Africa, yet generally they perform better on indicators such as life expectancy, infant mortality and adult literacy (May et al., 2000).

The shortcomings of income as an indicator of development led the United Nations Development Programme (UNDP) to construct a composite index termed the Human Development Index (May et al., 2000). The index is a composite of three factors, namely (Harris and Codur, 1998 and May et al., 2000):
• longevity (as measured by life expectancy at birth),
• educational attainment (as measured by a combination of adult literacy and enrolment rates), and
• standard of living (as measured by real gross domestic product per capita).

Based on these factors the Human Development Index (HDI) indicates the relevant position of a country on an HDI scale between 0 and 1. Countries with an HDI below 0.5 are considered to have a low level of human development, those with an HDI between 0.5 and 0.8 a medium level, and those of 0.8 and above a high level of human development. (May et al., 2000)

The national HDI for Namibia in 2010 was 0.606 and the country was ranked 105 in the latest HDI rankings published (UNDP, 2010). The Erongo region has an HDI of 0.670 and is second only to the Karas region in the south, with a score of 0.730 (NPC, 2000a). The lowest HDI is recorded in the Caprivi region with 0.468 (NPC, 2000a).

Another measure that can be used to assess the human development and poverty status of the Erongo region is that of the Human Poverty Index (HPI). This index measures the proportion of the population deprived of basic elements of life (NPC, 2000a). The following four attributes are contributing to the HPI (NPC, 2000a):

• longevity (in terms of life expectancy),
• knowledge (in terms of literacy),
• health indicators (percentage of underweight children and percentage of population without access to safe water and health services), and
• access to resources (the proportion of households with less than 20% of income available for non-food consumption and the percentage of poor households in the population).

In the Erongo region, an average of 15.3% of the population live in poverty compared to 23.4% of the total population of Namibia (NPC, 2000a).

In 1999 the UNDP examined the HDI and HPI for the Erongo region according to language groups (see Table 5.3; NPC, 2000a). In the region the German-speaking community has the highest HDI, followed by Afrikaans-speakers with the Nama/Damara-speaking community the lowest. The highest percentage living in poverty is recorded within the Oshiwambo-speaking community, followed by Otjiherero and Nama/Damara. German- and Afrikaans-speaking communities show the lowest percentage of people living in poverty.

**Table 5.3** Human development and poverty indices, based on language group, for the Erongo region.

<table>
<thead>
<tr>
<th>Language group</th>
<th>HDI</th>
<th>HPI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nama/Damara</td>
<td>0.578</td>
<td>23.7</td>
</tr>
<tr>
<td>Otjiherero</td>
<td>0.628</td>
<td>24.6</td>
</tr>
<tr>
<td>Oshiwambo</td>
<td>0.612</td>
<td>29.4</td>
</tr>
<tr>
<td>Afrikaans</td>
<td>0.810</td>
<td>9.3</td>
</tr>
<tr>
<td>German</td>
<td>0.917</td>
<td>9.2</td>
</tr>
</tbody>
</table>
5.13.7 Marginalised groups
Although the Erongo region is socially and economically better off than most other regions in Namibia, there is a wide variety of living situations and standards within region. Two groups were identified as being particularly marginalised, namely, the Topnaar Nama and residents of previous mining communities (NPC, 2000b).

There are two Topnaar Nama communities in Namibia, with one living along the Kuiseb river, a seasonal river forming the border between the northern stone desert and the southern sand dune sea; and the second in the Kunene region near Sessfontein (van den Eynden et al., 1992). The Topnaar is one of the oldest inhabitants of the Namib desert and earliest records date back to 1670. Oral tradition mentioned that the Topnaar Nama arrived from the North prior to occupying the Walvis Bay area. Traditionally the Topnaar Nama of the lower Kuiseb Valley lived by herding cattle, gardening and gathering the !nara (curcubit, acanthosicyos horridus). They were nomadic, restricted only by the availability of waterholes within the Kuiseb river and the !nara distribution (van den Eynden et al., 1992). In 1907 the Namib Naukluft Park was declared and restricted the movement of the Topnaar drastically (van den Eynden et al., 1992). At present, the Topnaar have a number of settlements along the Kuiseb river, some located within the Namib-Naukluft Park.

5.13.8 Health services
A total of 39 hospitals, 30 health centres and 251 clinics exist nationwide in Namibia, all being operated by the government (MHSS, 2000); with 15.4% of the hospitals, 3% of the health centres and 6.4% of the clinics located in the Erongo region (NPC, 2000b). The main hospitals are located at Walvis Bay, Swakopmund and Usakos (NPC, 2000b). According to Mendelsohn et al. (2002), the municipalities of Walvis Bay and Swakopmund both have sufficient health facilities. In the Erongo region 87% of the people live within 10 km of a public health facility.

5.13.9 Education
In the Erongo Region 91% of learners live within 5 km of schools (Mendelsohn et al., 2002). Tertiary education facilities have not been established in the region. The literacy rate (4 years or more of schooling) is 83% for females and 78% for males in the Erongo region, with illiteracy highest amongst the older generation.

5.14 Economic environment
5.14.1 Introduction
Between 1990 and 1995 Namibia experienced a real increase in gross domestic product (GDP) per capita of 1.6% per annum (economic indicators are not available on a regional level). However, between 1996 and 1998 the GDP growth was outstripped by population growth of 2% per annum (Hansohm and Mupotola-Sibongo, 1998). This decline represents Namibia’s (and the study area’s) vulnerability to external factors, including recurring drought, volatile international mineral markets and highly variable outputs from fisheries (Hansohm and Mupotola-Sibongo, 1998).

The Namibian economic policy during the period 1990 to 1995 encouraged foreign investment by targeting value-added natural resource manufacturing and tourism partnerships. Incentives included the promulgation of the Foreign Investment Act (1990) and the formation of export processing zones. These effectively reduced export production costs and provided tax-free profits and exemptions from indirect taxes and import duties (Agribo, 1998). These incentives facilitated present trade with Britain, Spain, and to a lesser extent, other EU members and Japan. The main activities of the economy of the Erongo region are:
• exploitation of mineral resources,
• offshore fishing,
• small stock and ostrich farming, and
• tourism.

Main economic activities in the Erongo region are concentrated in the two coastal towns of Walvis Bay and Swakopmund, as well as the mining sites of Rössing, Karibib and Navachab (NPC, 2000b). The smaller towns offer limited employment opportunities; while opportunities in agriculture, small-scale mining and tourism are scattered widely throughout the region.

5.14.2 Agriculture and fishing
Although agriculture has been the backbone of Namibian society for the past century, this sector only contributed 5.4% to the national GDP in 2008, which is a decrease from the 6.1% in 2000 (NPC, 2009). With the potential for agricultural production being limited due to natural factors, for example, semi to arid conditions, caused by erratic rainfall, and the sensitive ecology of the region; the potential for expansion of traditional farming methods is limited. However, the Regional Development Plan (NPC, 2000b) suggests that, inter alia, the possibility of cultivating desert plants with commercial potential, coastal fog harvesting for growing plants and algae, as well as the production of non-traditional, high value agricultural products should be investigated further.

With Namibia having one of the richest fishing grounds in the world, due to the cold Benguela stream of its west coast; the Namibian government subsequently sees commercial fishing as one of the main pillars of its economy (NPC, 2001). The fisheries sector contributed 3.3% to the national GDP in 2008 (NPC, 2009).

Walvis Bay is one of only two harbours in Namibia, the other being Lüderitz in the Karas region. Since independence the fish production industry has increased in both towns significantly. However, the development potential of the fishing industry in the Erongo region is very much determined by resource availability. Despite the attempt of good management practices, stock levels, and thus fishing quotas, vary (NPC, 2000b) and the fishing industry is largely seasonal, offering mainly contract employment.

5.14.3 Mining
Due to the scale of its influences across social, economic and environmental spheres, mining is a key activity within Namibia and the Erongo region. The mining contribution to GDP during 2008 was 15.8% (NPC, 2009). In Namibia up to 50% of its exports are mining-related, and mining earns the largest share of the country’s foreign exchange (Agribo, 1998; NPC, 2009). Although mining is central to the national economy, it accounts for only 4% of employment (Agribo, 1998).

The mining operations of economic significance within the Erongo region are Rössing Uranium, Navachab Gold, Langer Heinrich Uranium and the coastal salt works (NPC, 2000b). In the Erongo region, over 10% of the population are employed in the mining sector (MRCC, 1999).

5.14.4 Infrastructure
The national road network connects the Erongo region to the rest of the country via Okahandja, Windhoek and Otjiwarongo. The trunk roads between Windhoek, Okahandja, Swakopmund, Walvis Bay and Omaruru are tarred. Railway connections exist between Walvis Bay, Otjiwarongo and Windhoek. This railway network connects further to South Africa. A class A airport is located at Walvis Bay.
The harbour at Walvis Bay is one of the key economic features of the region (NPC, 2000b). The harbour has two bulk terminals, cold storage facilities and ship repair and marine engineering services. A border post exists at the harbour as well as at the Walvis Bay airport. Swakopmund and Walvis Bay are linked by a 220 kV power line from the national grid. (Friend et al., 2005)

5.14.5 Tourism
The potential of tourism in addressing alternative sustainable land-use options and livelihood creation is becoming increasingly important. Tourism has been advocated for its potential to drive both regional and national economic development (NPC, 2001). Furthermore, it has been conceptualised as an important vehicle for social transformation, promoting local ownership, local benefits, capacity building and skills development (Ashley and Garland, 1994). Importantly, tourism provides incentives for nature conservation and enhanced resource utilisation. (Friend et al., 2005)

As the sector is inextricably linked to Namibia’s resource base, sound environmental management is required. In terms of impact assessment, tourism introduces a range of activities, which are widely distributed, variable in extent and largely uncontrolled. Inherent in tourism is a drive to explore, and ultimately penetrate, remote wilderness areas. Therein lay both an opportunity and a threat to Namibia and the Erongo region. (Friend et al., 2005)

Tourism can act as a “drought-buffer”, as it is not adversely affected by the arid climate. The main tourist attractions of the Erongo region are the northern Namib-Naukluft Park, the Spitzkoppe area and the coastal town of Swakopmund. Economic analysis of the tourism sector challenges traditional economic models. The product is usually purchased from a distance, consists of a range of goods/services, and is reliant on non-priced environmental assets. Economic impacts are widespread and often unaccounted for. Adequate analysis is costly and time-consuming, requiring substantial data collection. The numerous economic impacts attributed to tourism include: income generation, employment opportunities, cross-sectorial linkages, foreign exchange earnings and government revenues. These benefits have the potential to be spatially widely dispersed. (Friend et al., 2005)

5.15 Environmental radiation
A radiological impact study for the proposed INCA and Tubas uranium projects on EPL 3496, as part of the original Omahola project, was conducted during 2010 and the complete impact study report presented in Appendix O (Von Oertzen, 2010).

5.15.1 Introduction
It has long been recognised that large doses of ionising radiation can damage human tissues. Over the years, as more was learned about radiation, scientists became increasingly concerned about the potentially damaging effects of exposure to large doses of radiation. The need to regulate exposure to radiation prompted the formation of a number of specialist bodies to consider what was needed to be done. In 1928, an independent non-governmental body of specialists in the field, the International X-ray and Radium Protection Committee, was established. It was later renamed the International Commission on Radiological Protection (ICRP). Its purpose is to establish basic principles for, and issue recommendations on, radiation protection. These principles and recommendations form the basis for national regulations governing the exposure of radiation workers and members of the public. They have also been incorporated by the International Atomic Energy Agency (IAEA) into its Basic Safety Standards for Radiation Protection published jointly with the World Health Organisation (WHO), International Labour Organisation (ILO) and the Nuclear Energy Agency (NEA). These standards are used worldwide to ensure safety and radiation protection of radiation workers and the general public. (Friend et al., 2005)
An intergovernmental body was formed in 1955 by the General Assembly of the United Nations as the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). UNSCEAR is directed to assemble, study and disseminate information on observed levels of ionising radiation and radioactivity (natural and man-made) in the environment, and on the effects of such radiation on man and the environment. (Friend et al., 2005)

Basic approaches to radiation protection are consistent all over the world. The ICRP recommends that any exposure above the natural background radiation should be kept as low as reasonably achievable, but below the individual dose limits. The individual dose limit for radiation workers averaged over 5 years is 100 mSv not exceeding 50 mSv in any one year, and for members of the general public it is 1 mSv per year. These dose limits have been established based on a prudent approach by assuming that there is no threshold dose below which there would be no effect. It means that any additional dose will cause a proportional increase in the chance of a health effect. This relationship has not yet been established in the low dose range where the dose limits have been set. Use of this relationship corresponds to a precautionary approach. (Friend et al., 2005)

There are many high natural background radiation areas around the world where the annual radiation dose received by members of the general public is even higher than the ICRP dose limit for radiation workers. The numbers of people exposed are too small to expect to detect any increases in health effects epidemiologically. Still the fact that there is no evidence so far of any increase does not mean the risk is being totally disregarded. The ICRP and the IAEA recommend the individual dose must be kept as low as reasonably achievable, and consideration must be given to the presence of other sources that may cause simultaneous radiation exposure to the same group of the public. Also, allowance for future sources or practices must be kept in mind so that the total dose received by an individual member of the public does not exceed the dose limit. (Friend et al., 2005)

5.15.2 Natural background radiation
Radiation exposures arise from both natural and anthropogenic (man-made) sources. Natural background radiation normally contributes the greatest exposure to individuals and forms the baseline to which man-made exposures are added. These include practices or events that have resulted in releases of radionuclides to the environment, atmospheric nuclear weapons testing, the operation of nuclear fuel cycle installations and accidents. Many individuals are exposed from time to time to medical radiation examinations or treatments. Certain individuals are also exposed to radiation in their work. (Friend et al., 2005)

The world average annual effective dose in areas of normal background is about 2.2 mSv (range 1 – 10 mSv), of which 40% is external exposure and 60% internal exposure (Holm, 2002). About half of this exposure comes from radon and its decay products. The dose from external irradiation is about 0.9 mSv/year, and comes approximately equally from cosmic radiation and terrestrial sources. Ingestion of natural radionuclides in foods and drinking water accounts for approximately 0.3 mSv/year. Variations about the mean values by factors of 5 - 10 are not unusual for many components of exposure. The greatest variation occurs for indoor radon concentrations, which span more than four orders of magnitude. (Friend et al., 2005)

Many areas throughout the world experience high levels of natural background radiation. Indeed, parts of the Erongo region in Namibia in which the Omahola project is located are known to have high levels of natural background radiation, especially of terrestrial origin. The contribution from cosmic radiation to the natural background radiation levels depends on the geographic location of the receptor. Typically in Namibia, exposure doses from cosmic radiation range between 0.3 mSv/year at the coast to approximately 0.7 mSv/year in the central highlands. The contribution of cosmic radiation to the natural background radiation in Namibia is shown in Figure 5.31. (Von Oertzen, 2010)
The contribution of terrestrial sources to the natural background radiation in the Erongo region is obtained from the assessment of airborne radiometric surveys. A preliminary figure for the dose rate from natural terrestrial gamma background radiation in the Erongo region ranges between close to zero up to 7.3 mSv/year, with a regional average of 0.7 mSv/year. The contribution of terrestrial radiation to the natural background radiation in Namibia is shown in Figure 5.32. (Von Oertzen, 2010)

The contribution of radioactive dust to the natural background radiation was recently measured as part of the strategic environmental assessment completed for the region and the Erongo regional average is some ten times the world average of 0.0058 mSv/year. The contribution of radioactive dust to the natural background radiation in the Erongo region of Namibia is shown in Figure 5.33. It is noted that the baseline contribution of dust is due to natural background sources of dust plus those produced by the existing uranium mines, most notably Rössing Uranium and Langer Heinrich Uranium. (Von Oertzen, 2010)

Radon (Rn\(^{222}\) and Rn\(^{220}\)) is a gas and is formed in soils through the radioactive decay of radium (Ra\(^{226}\) and Ra\(^{224}\)). Radon and its decay products are found in variable concentrations both indoors and outdoors, and are known to exist in many mining environments. The concentration of radon in the Erongo region was measured in a regional radon monitoring programme conducted as part of the recently completed strategic environmental assessment. The average regional radon inhalation dose measured over the 9 month period (August 2009 to April 2010) was 0.46 mSv/year. (Von Oertzen, 2010)
Figure 5.32 Contribution of cosmic radiation to natural background radiation in Namibia.

Figure 5.33 Contribution of radioactive dust to the natural background radiation in the Erongo region.
The various exposure contributions due to natural and man-made (anthropogenic) sources of ionising radiation in the Erongo region is compared with the world averages in Table 5.4 (Von Oertzen, 2010). These are the annual doses averaged over the world population and not necessarily the doses that any one individual would experience. Doses to individuals differ because of considerable variations in exposures depending on, inter alia, location and personal habits. (Friend et al., 2005)

Table 5.4 Exposure contributions in the Erongo region and world averages from natural and anthropogenic radiation sources.

<table>
<thead>
<tr>
<th>Source</th>
<th>Erongo region (mSv/year)</th>
<th>World average (mSv/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosmic radiation</td>
<td>0.35</td>
<td>0.38</td>
</tr>
<tr>
<td>Terrestrial radiation</td>
<td>0.55</td>
<td>0.48</td>
</tr>
<tr>
<td>Radioactive dust</td>
<td>0.04</td>
<td>0.0058</td>
</tr>
<tr>
<td>Radon</td>
<td>0.46¹</td>
<td>1.095</td>
</tr>
<tr>
<td>Ingestion</td>
<td>0.31²</td>
<td>0.31</td>
</tr>
<tr>
<td>Subtotal natural sources</td>
<td>1.71</td>
<td>2.27</td>
</tr>
<tr>
<td>Medical X-rays</td>
<td>0.02</td>
<td>0.37</td>
</tr>
<tr>
<td>Nuclear medicine</td>
<td>0.001³</td>
<td>0.03</td>
</tr>
<tr>
<td>Consumer products</td>
<td>0.01³</td>
<td>0.06</td>
</tr>
<tr>
<td>Nuclear weapons testing and production</td>
<td>0.0046⁴</td>
<td>0.0046</td>
</tr>
<tr>
<td>Nuclear fuel cycle</td>
<td>0.0002⁵</td>
<td>0.0002</td>
</tr>
<tr>
<td>Subtotal anthropogenic sources</td>
<td>0.03</td>
<td>0.46</td>
</tr>
<tr>
<td>Total</td>
<td>1.74</td>
<td>2.73</td>
</tr>
</tbody>
</table>

¹ regional average highly time and position dependent.
² assumed similar to world average.
³ assumed value.

5.15.3 Environmental radiation in the Omahola project area

The natural terrestrial gamma radiation in the Omahola project area is higher than the average values for the Erongo region. The radiometric map of the project area (see Figure 5.34) shows where enhanced levels of terrestrial radiation, corresponding to the uranium deposit, are indicated. As expected, when one moves out of the project area, the terrestrial gamma field returns to levels close the regional terrestrial background. (Von Oertzen, 2010)

The atmospheric concentration of airborne radon, and with it the concentration of short-lived radon progeny, is highly variable. Radon emanates from the crystal lattice of the uranium- and thorium-bearing ores in which the parents were embedded, and diffuses into the pore space of the substrate material from where it moves to the surface of the material and reaches the atmosphere. This flux of radon from the soil surface, rocks and tailings facilities is the so-called radon exhalation, and is strongly dependent on the prevailing seasonal and weather conditions and the time of day. In desert environments such as in the Namib, where low-level night-time atmospheric inversion layers occur, short-term atmospheric radon concentrations may increase dramatically as radon is trapped in gullies, pits and riverines. (Von Oertzen, 2010)
The airborne radon concentrations that were observed during the radon assessment range from 1.57 Bq.m$^{-3}$ to 62.5 Bq.m$^{-3}$, with an average activity concentration determined from measurements over the monitoring period of 20.58 Bq.m$^{-3}$. (Von Oertzen, 2010)
5.15.4 Radioactivity in water

The interpretation of radiological risk posed by radionuclides in water requires some understanding of the behaviour of these nuclides in water. In a closed system the progeny of Th and U are present in concentrations determined by the concentration of parent U and Th isotopes and the time since the system became closed to nuclide migration. (Friend et al., 2005)

In nature, closed systems rarely exist and predictions regarding nuclide concentrations in water bodies invariably include large uncertainties. These nuclides and their decay products are found in ground and spring waters in element specific concentrations, dependent on complex hydro-geologic processes and conditions (dissolution, transport and ion-exchange processes, as well as redox potentials and pH-conditions of the aqueous system). These hydro-geologic processes result in non-equilibrium conditions between parent nuclides and their progeny. However, characteristic behaviour in the natural environment can provide a basis for assumptions regarding probable behaviour. (Friend et al., 2005)

In the oxidised zone of the earth’s near-surface environment Th and U may both be mobilised, but in different ways (Ivanovich and Harmon, 1982). Thorium has an extremely low solubility in natural waters and there is a close correlation of Th concentration and detrital content of water. Thorium is almost entirely transported in particulate matter and is either bound in insoluble resistate minerals or is adsorbed on the surface of clay minerals. (Friend et al., 2005)

Even when thorium (for example, Th$^{230}$) is generated in solution by radioactive decay of U$^{234}$, it rapidly hydrolyses and adsorbs on to the nearest solid surface. By contrast, U may either move in a detrital, resistate phase, similar to Th, or in solution as a complex ion. Both elements appear in the 4$^{+}$ oxidation state in primary igneous rocks and minerals, but U, unlike Th, can be oxidised to 5$^{+}$ and 6$^{+}$ states in the near-surface environment. The 6$^{+}$ oxidation state forms soluble uranyl complex ions which play the most important role in U transport during weathering. (Friend et al., 2005)

Waters in the natural environment are variable in U content, depending mainly on factors such as contact time with U-bearing rock, U content of the contact rock, amount of evaporation and availability of complexing ions. Groundwaters are somewhat enriched in respect of U when compared to surface waters, especially in mineralised areas. (Friend et al., 2005)

An accurate assessment of the radiological quality of a water resource would require all natural occurring radioactive material (NORM) radionuclides to be considered, as shown in Table 5.5 (IAEA, 1996a). If groundwater should be considered for human consumption, detailed radioanalysis will be performed. Simple water treatment removes most of the radioactivity content. Water treatment processes cause a significant decrease in NORM when compared to the concentrations in the raw feed water. These processes include aeration, flocculation, sedimentation, pH-adaption and filtration. Another process that efficiently removes heavy metals and therefore also uranium, lead, polonium and radium, is flocculation. The nuclides are co-precipitated with other unwanted constituents and most of the radioactivity reports to the sludge. (Friend et al., 2005)

Assessment of radioactivity in water and the associated risk for humans can be interpreted in accordance with the guide in Table 5.6 (DWAF, 2002). This can be compared to the radionuclide analyses conducted on the project area's groundwater, and presented in Appendix C (Stanton, 2010). The radioactivity in all samples was low. U$^{235}$ and Ra$^{226}$ were the only measurable radionuclides present. (Stanton, 2010)
Table 5.5 Radiological dose coefficient for NORM radionuclides.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Nuclide</th>
<th>DCF* Sv/Bq</th>
<th>Activity Bq/l</th>
<th>Water consumption l/year</th>
<th>Dose element Sv/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 17 yrs</td>
<td>U-238</td>
<td>4.5E-08</td>
<td>1.0</td>
<td>730</td>
<td>3.3E-05</td>
</tr>
<tr>
<td></td>
<td>Th-234</td>
<td>3.4E-09</td>
<td>1.0</td>
<td>730</td>
<td>2.5E-06</td>
</tr>
<tr>
<td></td>
<td>Pa-234</td>
<td>5.1E-10</td>
<td>1.0</td>
<td>730</td>
<td>3.7E-07</td>
</tr>
<tr>
<td></td>
<td>U-234</td>
<td>4.9E-08</td>
<td>1.0</td>
<td>730</td>
<td>3.6E-05</td>
</tr>
<tr>
<td></td>
<td>Th-230</td>
<td>2.1E-07</td>
<td>1.0</td>
<td>730</td>
<td>1.5E-04</td>
</tr>
<tr>
<td></td>
<td>Ra-226</td>
<td>2.8E-07</td>
<td>1.0</td>
<td>730</td>
<td>2.0E-04</td>
</tr>
<tr>
<td></td>
<td>Pb-210</td>
<td>6.9E-07</td>
<td>1.0</td>
<td>730</td>
<td>5.0E-04</td>
</tr>
<tr>
<td></td>
<td>Bi-210</td>
<td>1.3E-09</td>
<td>1.0</td>
<td>730</td>
<td>9.5E-07</td>
</tr>
<tr>
<td></td>
<td>Po-210</td>
<td>1.2E-06</td>
<td>1.0</td>
<td>730</td>
<td>8.8E-04</td>
</tr>
<tr>
<td></td>
<td>Th-232</td>
<td>2.3E-07</td>
<td>1.0</td>
<td>730</td>
<td>1.7E-04</td>
</tr>
<tr>
<td></td>
<td>Ra-228</td>
<td>6.9E-07</td>
<td>1.0</td>
<td>730</td>
<td>5.0E-04</td>
</tr>
<tr>
<td></td>
<td>Ac-228</td>
<td>4.3E-10</td>
<td>1.0</td>
<td>730</td>
<td>3.1E-07</td>
</tr>
<tr>
<td></td>
<td>Th-228</td>
<td>7.2E-08</td>
<td>1.0</td>
<td>730</td>
<td>5.3E-05</td>
</tr>
<tr>
<td></td>
<td>Ra-224</td>
<td>6.5E-08</td>
<td>1.0</td>
<td>730</td>
<td>4.7E-05</td>
</tr>
<tr>
<td></td>
<td>U-235</td>
<td>4.7E-08</td>
<td>1.0</td>
<td>730</td>
<td>3.4E-05</td>
</tr>
<tr>
<td></td>
<td>Th-231</td>
<td>3.4E-10</td>
<td>1.0</td>
<td>730</td>
<td>2.5E-07</td>
</tr>
<tr>
<td></td>
<td>Pa-231</td>
<td>7.1E-07</td>
<td>1.0</td>
<td>730</td>
<td>5.2E-04</td>
</tr>
<tr>
<td></td>
<td>Ac-227</td>
<td>1.1E-06</td>
<td>1.0</td>
<td>730</td>
<td>8.0E-04</td>
</tr>
<tr>
<td></td>
<td>Th-227</td>
<td>8.8E-09</td>
<td>1.0</td>
<td>730</td>
<td>6.4E-06</td>
</tr>
<tr>
<td></td>
<td>Ra-223</td>
<td>0.0E+00</td>
<td>1.0</td>
<td>730</td>
<td>0.0E+00</td>
</tr>
</tbody>
</table>

* DCF = dose conversion factor.
### Table 5.6 Classification of a water resource in terms of radiological risk.

<table>
<thead>
<tr>
<th>Class/colour</th>
<th>Dose range mSv/a</th>
<th>Health effects and typical exposure scenarios</th>
<th>Intervention decision time frames</th>
</tr>
</thead>
</table>
| Class 0 Blue (ideal water quality) | 0.01 – 0.10 | - There are no observable health effects.  
- This is the range of exposure from ideal quality water sources.  
- Most treated water falls in this water quality range.  
- Additional doses that result from human activities that fall within this range are difficult or impossible to determine and/or to distinguish from variations in background doses with sufficient confidence. | Intervention not applicable for this class of water. |
| Class 1 Green (good water quality) | > 0.10 – 1 | - There are no observable health effects.  
- It is the range of exposure from some natural and untreated water sources (e.g. ground water / wells) as well as water sources that could be influenced by mining and mineral processing activities.  
- A dose between 0.2 to 0.8 mSv/a is typical worldwide range of ingestion radiation dose resulting from water as well as food.  
- A dose equal to 1 mSv/a corresponds to the regulatory public dose limit for human activities involving radioactive material. | No intervention is required although ALARA principles apply. |
| Class 2 Yellow (marginal water quality) | > 1 – 10 | - A small increase in fatal cancer risk associated with this dose range.  
- Probably only a small number of natural water sources of this quality exist, resulting from exceptional geological conditions.  
- Abnormal operating conditions at some nuclear certified mineral and mining processes may result in a dose in this range when a person drinks the untreated water. Intervention will most likely be required to improve the quality of water that is released into the public domain.  
- The total natural background radiation from all exposure pathways, not only water, falls in this range. | Intervention considerations within less than 2 years. |
| Class 3 Red (poor water quality) | > 10 – 100 | - Health effects are statistically detectable in very large population groups.  
- This range represents excessive exposure.  
- It is highly unlikely to find water of this poor quality in the natural environment. | Intervention is required in less than 1 year. |
| Class 4 Purple (unacceptable water quality) | > 100 | - Health effects may be clinically detectable and a significant increase in the fatal cancer risk (greater than one in a thousand).  
- A dose greater than 100 mSv can only occur during a major accident at a nuclear facility. These facilities have to demonstrate that such an accident cannot happen with a frequency of more than once in a million years. The probability of a fatal car accident on some roads is also higher than one in a thousand. | Immediate intervention is required. |
6. ALTERNATIVES

6.1 Ecologically sustainable development
The goal of ecologically sustainable development (ESD) is to achieve development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (EPA, 1995a). The objectives of ESD are to (EPA, 1995a):

- enhance the individual and community wellbeing and welfare by following a path of economic development that safeguards the welfare of future generations;
- provide for equity within and between generations; and
- protect biological diversity and maintain essential ecological processes and life support systems.

The challenge for governments and the mining industry is to develop further the mining industry and efficiently manage the renewable and non-renewable resources on which it depends, in accordance with the principles of ESD. Governments are committed to achieving this by pursuing a number of strategic approaches and initiatives to ensure that sound environmental practices are used and promoted throughout all key sectors of the mining industry. (EPA, 1995a)

The precautionary principle is a major principle of ESD that underlines Reptile Uranium Namibia's environment protection approach to efficient management of the renewable and non-renewable resources on which it depends. The principle states that (EPA, 1995a):

*where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.*

In the application of the precautionary principle, public and private decisions should be guided by (EPA, 1995a):

- careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and
- an assessment of the risk-weighted consequences of various options.

The specific designs, approaches and locations used for the proposed development in Section 3, are largely dependent on the physical, biological and social environments impacting on, and being impacted upon, the proposed development. However, ESD principles guided the approaches used to design the Tubas project's processing facilities, the manner in which mining will proceed and strategies for rehabilitation. These principles are as follows (EPA, 1995a):

- adoption of external and internal code of practice, guidelines, standards and principles for exploration, environmental management, rehabilitation and community relations activities;
- comprehensive study, planning, evaluation and development of project proposals;
- extensive consultation with government, landowners and community groups;
- objective and comprehensive environmental impact and risk assessment of projects;
- comprehensive environmental management systems;
- research and development programmes;
• industry environmental review, education and knowledge-sharing networks;
• integration of long-term economic, environmental, social and equity goals in policies, actions and activities;
• ensuring that environmental assets are appropriately valued;
• involving communities in decisions and actions on issues that affect them;
• developing environmentally sound international competitiveness and an economy that can enhance environment protection; and
• recognising the global dimension of the environment and impacts on it.

6.2 Assessment of alternatives
In terms of Section 26(1)(b) of the draft environmental assessment regulations it is a requirement to provide a description of any feasible and reasonable alternatives that have been identified. Alternatives are different means of meeting the general purpose and need of a proposal (DEAT, 2006) and can be categorised into the following (DEAT, 1998):
• demand alternatives (for example, using energy more efficiently rather than building more generating capacity),
• activity alternatives (for example, providing public transport rather than increasing road capacity),
• location alternatives (for example, either for the entire proposal or for components of the proposal, like the location of a processing plant for a mine),
• process alternatives (for example, the re-use of process water in an industrial plant, waste minimising or energy efficient technology, different mining methods),
• scheduling alternatives (for example, staggering the travelling to and from a plant during off peak times), and
• input alternatives (for example, use of alternative raw materials or energy sources).

The no-go alternative is the option of not undertaking the proposed activity or any of its alternatives. The no-go alternative also provides the baseline against which the impacts of other alternatives should be compared. It should be noted that the no-go alternative may sometimes not be a “real” or “implementable” alternative (for example, where the capacity of a sewage pipeline has to be increased to cope with current demand). It should, however, remain the default option and must always be included to provide the baseline for assessment of the impacts of other alternatives and also to illustrate the implications of not authorising the activity. (DEAT, 2006)

With all the categorised alternatives, the location (site) alternative normally plays the biggest role in assessment of an activity and its related impacts. However, in the case of mining operations the location is seldom available for alternative selection as the proposed mineral for extraction is by its very nature exactly at a particular selected site. It is thus imperative that alternatives in some of the other categories be investigated for mining operations, inclusive of alternative extraction methods and relevant processing operations. Scheduling and input alternatives can also be assessed for future benefits to the environment. These alternative options were evaluated and assessed as part of the overall design of the proposed mining operation, findings of specialist investigations (Sections 5 and 8) considered and the final proposed mining and process design presented in Section 3.
6.3 Consequences of not proceeding

The Tubas deposit and processing plant are more viable as the mineralisation predominantly occurs in Aeolian, un-cemented red (and other colour) sand, close to the surface. The ore is predominantly free digging that allows for simple low cost (no blasting) mining techniques. The physical beneficiation plant (no chemicals) will produce a concentrate that will be delivered to the INCA processing plant. The INCA processing plant will supply loaded resin to Rössing, another uranium extraction plant, or even one to be built by RUN sometime in the future. Rössing will process the loaded resin, and return the stripped resin back to INCA. The Tubas beneficiation plant would therefore augment Rössing’s production. The advantage to Namibia would be additional income in the form of increased uranium production, royalties and taxes.

The construction phase of the proposed Tubas project will create up to 150 jobs in Namibia. During the actual operational phase, approximately 130 employment opportunities will exist at the mine. Although many of these newly created job opportunities will occur in the mining industry, additional job creation effects will take place in various other sectors as well; for example, personnel services, transport and equipment manufacturing. There will be no employment benefit if the mine does not proceed.

The proposed Tubas development will generate new income opportunities for the Namibian government and to the Swakopmund/Walvis Bay regional communities. These income derived sources will include:

- royalties,
- indirect government taxes,
- licence fees and charges,
- pay as you earn (PAYE) taxes, and
- company taxes paid to government.

The proposed development will also contribute to the Swakopmund/Walvis Bay and regional communities through sourcing of materials, services and labour. Recent estimates indicate that, when fully operational, direct and indirect taxes to the Namibian government will be in the order of N$27.2 million per year. This income will be foregone if the mine does not proceed. In addition, about N$100 million will be spent on diesel fuel, N$146 million for mining contractor, N$3.6 million for concentrate transportation and N$74 million on electricity. Purchases and acquired services in the Swakopmund/Walvis Bay regional area, associated with full operation, are estimated to be approximately N$20 million per year, and in the rest of Namibia, approaching N$10 million per year. During the construction phase of approximately 6 months, an estimated N$340 million to N$540 million will be spent on the project, of which at least 30% will be locally sourced. These purchases will not be made if the mine does not proceed.

Benefits for not proceeding with the project can be summarised as the following primary benefits:

- the resource will remain in place for possible future development,
- there will be no further visual impact of development,
- there will be no disruption to local communities arising from construction and operation, and
- there will be no alteration to local biodiversity arising from construction and operation.
The objective of the assessment of impacts is to identify and assess all the significant impacts that may arise from the undertaking of an activity and the findings used to inform the competent authority’s decision as to whether the activity should be either authorised, authorised subject to conditions that will mitigate the impacts to within acceptable levels, or should be refused (DEAT, 2006). In this sense impacts are defined by DEAT (2006) as the changes in an environmental parameter that result from undertaking an activity. These changes are the difference between effects on an environmental parameter where the activity is undertaken compared to that where the activity is not undertaken, and occur over a specific period and within a defined area (DEAT, 2006).

**7.1 Impact types**

Different types of impacts may occur from the undertaking of an activity, which may be positive or negative, and can be categorised as being either direct (primary), indirect (secondary) or cumulative impacts. Direct impacts are impacts that are caused directly by the activity and generally occur at the same time and at the place of the activity (for example, dust generated by blasting operations on the site of the activity). These impacts are usually associated with the construction, operation or maintenance of an activity and are generally obvious and quantifiable. However, indirect impacts are induced changes that may occur as a result of the activity (for example, the use of water from a natural source at the activity will reduce the capacity for supply to other users). These types of impacts include all the potential impacts that either do not manifest immediately when the activity is undertaken, or which occur at a different place as a result of the activity. (Jain *et al.*, 1993; Fuggle and Rabie, 1994; DEAT, 2006)

Cumulative impacts are impacts that result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities (for example, removal of vegetation may cause soil erosion, leading to excessive sediments in a receiving stream, leading to reduced sunlight penetrating the water and thus reducing dissolved oxygen in the water and adversely affecting aquatic life and water quality). Cumulative impacts can occur from the collective impacts of individual minor actions over a period of time and can include both direct and indirect impacts. (Jain *et al.*, 1993; DEAT, 2006)

**7.2 Identification of impacts**

The identification of the potential impacts of an activity on the environment should include impacts that may occur during the start/construction, operation and decommissioning/rehabilitation phases of an activity (DEAT, 2006). The process of identification and assessment of impacts includes, *inter alia*, the (Jain *et al.*, 1993; DEAT, 2006):

- determination of current environmental conditions in sufficient detail so that there is a baseline against which impacts can be identified and measured;
- determination of future changes to the environment that will occur if the proposed activity does not take place;
- understanding of the activity in sufficient detail to understand its consequences; and
- identification of significant impacts that are likely to occur if the activity is undertaken.

**7.3 Impact mitigation**

Once impacts have been identified and predicted for a particular activity, appropriate mitigation measures need to be established (DEAT, 2006). Mitigation measures are the modification of certain activities in such a way as to reduce the impacts on the environment (Jain *et al.*, 1993). The objectives of mitigation are to (DEAT, 2006):
• find more environmentally sound ways of doing things;
• enhance the environmental benefits of a proposed activity;
• avoid, minimise or remedy negative impacts; and
• ensure that residual negative impacts are within acceptable levels.

When mitigation is considered for (certain) impacts, it should be organised in a hierarchy of actions, namely (DEAT, 2006):
• avoid negative impacts as far as possible through the use of preventative measures,
• minimise or reduce negative impacts to “as low as practicable” levels, and
• remedy or compensate for negative residual impacts that are unavoidable and cannot be reduced further.

7.4 Impact assessment methodology
The concepts for environmental impact assessments in this report will relate to risk assessment (the process whereby certain impacts to the environment are identified), risk valuation (by using a stipulated assessment criteria whereby impacts are given a rating or weighting and obtaining an overall rating or significance of an impact) and risk management (relating directly to applicable mitigation measures to be implemented to manage a risk of an impact in the "best" interest of a society; Shogren, 1990). Such an assessment is also a requirement in terms of Sections 26(1)(g) and 26(1)(i)(iii) of the environmental assessment (EA) regulations (MET, 2009). The guideline criteria set out in Section 27(k) of the EA regulations, in conjunction with assessment criteria from DEAT (1998), Friend et al. (2005), DEAT (2006) and Friend and Van Rooyen (2009); will be followed in this report and are presented in the following sections.

7.4.1 Nature or status of the impact
An appraisal of the type of effect the activity would have on the affected environment; rated as either positive (beneficial impact on the environment), neutral (no impact on the environment), or negative (adverse impact on and at a cost to the environment).

7.4.2 Extent or scale of the impact
Indicates whether the impact will be either site specific (impacting within the boundaries of the site), local (within an area of 5 km of the site), regional (Namib-Naukluft Park area), on a national scale (Namibia) or across international borders (Southern Africa).

7.4.3 Duration of the impact
Indicates whether the lifetime of the impact will be either short term (0 - 5 years), medium term (5 - 15 years), long term (where the impact will cease after the operational life of the activity, either because of natural process or human intervention), or permanent (where mitigation either by natural process or human intervention will not occur in such a way or in such a time span that the impact can be considered transient).

7.4.4 Intensity or magnitude of the impact
Establishes whether the impact is destructive or benign and is indicated as either low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected), medium (where the affected environment is altered but natural, cultural and social functions and processes continue, albeit in a modified way), high (natural, cultural or social functions or processes are altered to the extent that it will temporarily cease); or very high (natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
7.4.5 Probability of the impact
Describes the likelihood of the impact actually occurring and is indicated as either improbable (the possibility of the impact to materialise is very low, either because of design, historic experience or implementation of adequate corrective actions), probable (there is a distinct possibility that the impact will occur), highly probable (it is most likely that the impact will occur), or definite (the impact will occur regardless of any prevention or corrective actions).

7.4.6 Determination of significance
After assessment of an impact in accordance to the preceding five criteria, the significance of an impact can be determined through a synthesis of the aspects produced in terms of their nature, extent, duration, intensity and probability. In Table 7.1 various ratings are accorded to these criteria. These ratings are now used to calculate a significance (S) rating and are formulated by adding the sum of ratings given to the extent (E), duration (D) and intensity (I) and then multiplying the sum with the probability (P) of an impact as follows:

\[ \text{Significance (S)} = (E + D + I) \times P \]

The resultant ratings are now described as follows (see also Table 7.1):

- S < 25 implies a low impact (meaning this impact would not have a direct influence on the decision to develop in the area),
- S = (25 - 50) implies a medium impact (where the relevant impact could influence the decision to develop in the area unless it is effectively mitigated), and
- S > 50 implies a high impact (this impact must have an influence on the decision process to develop in the area).

### Table 7.1 Ratings used for determining impact significance.

<table>
<thead>
<tr>
<th>Nature of impact (N)</th>
<th>Extent of impact (E)</th>
<th>Duration of impact (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>site specific</td>
<td>short term</td>
</tr>
<tr>
<td>positive</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>neutral</td>
<td>0</td>
<td>medium term</td>
</tr>
<tr>
<td>negative</td>
<td>-</td>
<td>long term</td>
</tr>
<tr>
<td></td>
<td>regional</td>
<td>permanent</td>
</tr>
<tr>
<td></td>
<td>national</td>
<td></td>
</tr>
<tr>
<td></td>
<td>international</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intensity of impact (I)</th>
<th>Probability of impact (P)</th>
<th>Significance of impact (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>improbable</td>
<td>low &lt; 25</td>
</tr>
<tr>
<td>medium</td>
<td>probable</td>
<td>medium 25 - 50</td>
</tr>
<tr>
<td>high</td>
<td>highly probable</td>
<td>high &gt; 50</td>
</tr>
<tr>
<td>very high</td>
<td>definite</td>
<td></td>
</tr>
</tbody>
</table>

7.4.7 Additional evaluation criteria
Apart from the assessment criteria presented in the preceding sections; impacts will also be evaluated and assessed based on cumulative impacts, relevant reversibility, potential for irreplaceable loss of resources and level of confidence.

Cumulative impacts (see Table 7.2) can arise from one or more activities and can be defined as being either an additive impact, that is where it adds to the impact caused by other similar impacts; or an interactive impact, that is where a cumulative impact is caused by different impacts that combine to form a new impact.
Interactive impacts may cause either countervailing (the nett adverse cumulative impact is less than the sum of the individual impacts), or synergistic (the nett adverse cumulative impact is greater than the sum of the individual impacts).  (DEAT, 2006)

The reversibility of an impact simply indicates to what degree its influence on the relevant environment can be negated and is presented in Table 7.2. The potential for irreplaceable loss of resources, based on a relevant impact, indicates the degree to which the impact may cause such loss and is presented in Table 7.2.

The level of confidence indicates the level of certainty that specialists have in the accuracy of their predictions with regard to a relevant assessment and its related determined significance. This will be based on any factors that could bring into doubt the accuracy of their relevant predictions, (for example, an investigation undertaken during a non-ideal season, key research data being unavailable) and thus compromise the level of confidence in the assessment of an impact. The levels of confidence used in this report are presented in Table 7.2 and for levels with either a medium or low level applicable, an additional explanation will be provided as to what the relevant impacting factors were.

<table>
<thead>
<tr>
<th>Cumulative impacts</th>
<th>Reversibility of impacts</th>
<th>Potential for resource loss</th>
<th>Level of confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>none expected</td>
<td>complete</td>
<td>will not take place</td>
<td>definite</td>
</tr>
<tr>
<td>additive</td>
<td>intermediate</td>
<td>there is a possibility of</td>
<td>high</td>
</tr>
<tr>
<td>interactive countervailing</td>
<td>not possible</td>
<td>this will definitely happen</td>
<td>medium</td>
</tr>
<tr>
<td>interactive synergistic</td>
<td>int cou</td>
<td></td>
<td>low</td>
</tr>
</tbody>
</table>

**7.4.8 Impact assessment presentation**

All relevant impacts on the environment are rated and evaluated as set out in the preceding sections and presented via impact tables. It should be noted that impacts are evaluated after mitigation measures, where relevant and indicated as such in the impact tables, have been taken into account. The project impacts are further subdivided into the following three phases*, from which impacting activities can be identified (DEAT, 1998):

- construction phase [CP] – all activities on and off site, including the transport of material,
- operational phase [OP] – all activities, including operation and maintenance of structures, and
- decommissioning/rehabilitation (closure) phase [DP] – any activity related to the physical dismantling of the structures and/or restoring of process/mining land to some degree of its former state.

* note that while planning and design is recognised as a project phase, it is for this project and generally for most projects, of no negative impact significance.
8. ENVIRONMENTAL IMPACTS AND MITIGATION

8.1 Geology

By the very nature of the activity, mining will impact detrimentally on the physical composition of the environment. The removal of mineralised material for feed to the uranium processing plant will change the geological formation at the mining site permanently. Using a conventional open pit operation, large open pits will be created and pre-stripping of the initial open pit will also require the construction of waste stockpiles. During operation of the proposed mine, barren material from the uranium processing plant will also be stockpiled on the waste stockpiles.

The removal of mineralised rock and changing of the geological composition at the site cannot be mitigated. However, as mining progresses to different sections of the mine, it should be feasible to facilitate backfilling of the waste burden into some of the mined out areas. Rehabilitation of the mined out areas and the stockpile facility will be progressive throughout the life of the mine. Any remaining waste rock stockpiles will be shaped and contoured to blend into the surrounding environment. The environmental impact assessment table for geology is presented below.

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Geology</th>
<th>Phase</th>
<th>CP/OP/DP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Mining excavation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitigation: Implementation of a properly engineered rehabilitation strategy, inclusive of backfilling.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td></td>
<td>negative</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>42</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>yes</td>
<td>Cumulative impacts</td>
<td>no</td>
<td>Reversibility</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8.2 Land use capabilities

Albeit that the proposed mining activity is situated within a national park, the overall area is not pristine as previous mineral exploration, drilling campaigns and mining operations have been undertaken either on or near the proposed project site intermittently during earlier ownerships. However, environmental rehabilitation offers the opportunity to sustain land development and use, and reduces the burden on the taxpayer to fund rehabilitation of abandoned mines (MME, 2002). Rehabilitation based on the polluter pays principle should ensure protection of the environment, both during and after mining operations (MME, 2002). The primary objectives for decommissioning and rehabilitation at the Tubas project will thus be:

- the removal of process facilities and the closure of open pit areas,
- the rehabilitation of stockpile facilities,
- the removal or other disposition of supporting infrastructure such as fences, water supply pipeline (if required for project) and power supply line (if not required for future tourist or other land use in the vicinity),
- the rehabilitation of the landscape to a similar condition as the surrounding areas (note, not to present condition, which reflects adverse impacts due to previous mining and exploration activities), and
- the return of the land for use by tourism or an equivalent use.

The final land use objective should take into account the land capability of the rehabilitated area, and the level of management that will be required to maintain this land use (EPA, 1995b). The environmental impact assessment table for land use capabilities is presented below.
8.3 Hydrology

By the very nature of the proposed Tubas project’s location within the Namib Naukluft Park, where water remains a scarce resource, it is of the utmost importance that there are no adverse impacts on groundwater resources in the environment. The high salinity groundwater in the project area (see Section 5.6), making the water unusable for human consumption, will be treated to potable water quality for use in the project and thus negate any adverse impacts on the environment. However, should water be obtained from sources other than the groundwater available on site, such water use will have a negative impact on the water resources of the region. The environmental impact assessment table for hydrology is presented below.

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Hydrology</th>
<th>Phase</th>
<th>CP/OP/DP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitigation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence level</td>
<td>Mitigation required</td>
<td>Evaluation of impacts</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>yes</td>
<td>negative</td>
<td>Nature</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>yes</td>
<td>Cumulative impacts</td>
<td>no</td>
</tr>
</tbody>
</table>

8.4 Air quality

Exceedances of the relevant evaluation criteria for average highest daily PM$_{10}$ concentrations were predicted at the proposed project site boundary as a result of unmitigated mining operations (without taking background concentrations into consideration). However, the application of suitable mitigation measures to the main contributing sources of PM$_{10}$ and total suspended particle (TSP) emissions would result in the reduction of impacts at the proposed project site boundary. With the consideration of background concentrations, exceedances of the relevant evaluation criteria for PM$_{10}$ were predicted for all the modelled scenarios. It should be noted that this is primarily due to windblown dust from natural background sources. (Khumalo and Liebenberg-Enslin, 2010)

Dispersion models for the highest daily average predicted PM$_{10}$ and average daily predicted PM$_{10}$ groundlevel concentrations (in $\mu g/m^3$) for all sources due to mitigated emissions are illustrated in Figures 8.1 and 8.2 respectively (Khumalo and Liebenberg-Enslin, 2010). Detailed mitigation measures are described in Appendix B (Khumalo and Liebenberg-Enslin, 2010). Environmental impact assessment tables for air quality impacts during construction, operational and closure phases are provided below (Khumalo and Liebenberg-Enslin, 2010).
Figure 8.1 Highest daily average predicted PM$_{10}$ groundlevel concentrations (in µg/m$^3$) for all sources due to mitigated emissions.

Figure 8.2 Average daily predicted PM$_{10}$ groundlevel concentrations (in µg/m$^3$) for all sources due to mitigated emissions.
Environmental aspect: Air quality

### Phase CP
**Description:** The construction phase will comprise land clearing, site development operations and erecting the associated infrastructure. Each of these activities will have a potential for dust generation.

**Mitigation:** General mitigation measures for dust include wet suppression and wind speed reduction.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>yes</td>
<td>Nature: negative; Extent: 3; Duration: 1; Intensity: 2; Probability: 6; Significance: 36</td>
</tr>
</tbody>
</table>

**Potential for irreplaceable loss of resources:** n/a – not applicable to air quality.

---

### Phase OP
**Description:** The proposed operational phase will include dust generating activities such as excavation, drilling, blasting, materials handling activities, wind erosion of stockpiles, hauling of ore and waste on unpaved roads and crushing and screening.

**Mitigation:** General mitigation measures for dust include wet suppression on unpaved roads, materials handling activities and crushing and screening.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>medium</td>
<td>yes</td>
<td>Nature: negative; Extent: 3; Duration: 3; Intensity: 2; Probability: 6; Significance: 48</td>
</tr>
</tbody>
</table>

**Potential for irreplaceable loss of resources:** n/a – not applicable to air quality.

---

### Phase DP
**Description:** The decommissioning/rehabilitation (closure) phase will comprise demolition and rehabilitation activities. Each of these activities has a potential for dust generation.

**Mitigation:** General mitigation measures for dust include wet suppression.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>yes</td>
<td>Nature: positive; Extent: 3; Duration: 1; Intensity: 2; Probability: 6; Significance: 36</td>
</tr>
</tbody>
</table>

**Potential for irreplaceable loss of resources:** n/a – not applicable to air quality.

---

### 8.5 Natural vegetation

The vegetation types on site were subjectively evaluated in terms of sensitivity and illustrated on a sensitivity map for the Tubas project's area in Figure 8.3. The following categories of sensitivity were used based on a number of parameters that is, low, low-medium, medium, medium-high and high. Low and low-medium sensitivity means the sensitivity is not significant enough and should not have an influence on the decision about the project. However, any protected trees and other scheduled rare species may not be removed/destroyed without a permit. (Van Rooyen, 2010)

Medium means a sensitivity rating that is real and sufficiently important to require management, for example, management or protection of the rare/threatened flora, protection of the specific habitat on the property and/or rehabilitation. Medium-high means a sensitivity rating where the habitat could be excluded from any development. High means a sensitivity rating that should influence the decision whether or not to proceed with the project. (Van Rooyen, 2010)
Environmental impact assessment tables for impacts on indigenous vegetation during construction, operational and closure phases are provided below. Further impact assessment tables are provided for impacts of vegetation removal through mining on faunal species; mining on ephemeral drainage lines; vehicles, off-road driving and other forms of trampling and compaction on vegetation; alien invasive vegetation; loss of topsoil; and dust levels on vegetation in Appendix D. Detailed rehabilitation measures are also presented in Appendix D. (Van Rooyen, 2010)

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Natural vegetation</th>
<th>Phase</th>
<th>CP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Indigenous vegetation/plant communities.</td>
<td>Mitigation: The prominent rocky ridges, rocky outcrops, inselbergs and main watercourses should not form part of any mining activities and should be regarded as no-go areas. Besides the no-go option, the next option is to identify particularly valuable plant species and to try to avoid areas in which they occur, for example, Welwitschia mirabilis and significant lichen fields. Protected plant species may not be removed or damaged without permits issued by the relevant authorities. Other aspects are provided in Appendix D.</td>
<td>Confidence level</td>
<td>Mitigation required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nature</td>
<td>Extent</td>
</tr>
<tr>
<td>medium</td>
<td>yes</td>
<td>negative</td>
<td>1</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>yes</td>
<td>Cumulative impacts</td>
<td>yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Natural vegetation</th>
<th>Phase</th>
<th>OP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Indigenous vegetation/plant communities.</td>
<td>Mitigation: The prominent rocky ridges, rocky outcrops, inselbergs and main watercourses should not form part of any mining activities and should be regarded as no-go areas. Besides the no-go option, the next option is to identify particularly valuable plant species and to try to avoid areas in which they occur, for example, Welwitschia mirabilis and significant lichen fields. Protected plant species may not be removed or damaged without permits issued by the relevant authorities. Other aspects are provided in Appendix D.</td>
<td>Confidence level</td>
<td>Mitigation required</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nature</td>
<td>Extent</td>
</tr>
<tr>
<td>high</td>
<td>yes</td>
<td>negative</td>
<td>1</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>yes</td>
<td>Cumulative impacts</td>
<td>yes</td>
</tr>
</tbody>
</table>
**Environmental aspect:** Natural vegetation  
**Phase:** DP

**Description:** Indigenous vegetation/plant communities.

**Mitigation:** The prominent rocky ridges, rocky outcrops, inselbergs and main watercourses should not form part of any mining activities and should be regarded as no-go areas. Rehabilitation should be initiated from the start of the mining operations. It should include aspects such as landscaping to recreate the original habitat, dressing with topsoil, re-seeding and transplanting if possible. Other aspects are provided in Appendix D.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nature</td>
</tr>
<tr>
<td>medium</td>
<td>yes</td>
<td>positive</td>
</tr>
<tr>
<td><strong>Potential for irreplaceable loss of resources</strong></td>
<td>no</td>
<td>Cumulative impacts</td>
</tr>
</tbody>
</table>

* Shading indicates inversion due to positive nature.

8.6 Animal life

All developments either change or are destructive to the local fauna to some or other degree. Assessing potential impacts is occasionally obvious, but more often difficult to predict accurately. Such predictions may change depending on the scope of the development, that is, the development, once initiated, may have a different effect on the fauna as originally predicted. Thus continuing monitoring of such impacts during the development phase(s) is imperative. Faunal loss with the proposed mining development would be localised. Environmental impact assessment tables for the construction, operational and closure phases are provided below, indicating the potential/envisaged impacts expected regarding faunal loss (vertebrate), which is obviously closely linked to habitat destruction. (Cunningham, 2010)

**Environmental aspect:** Animal life  
**Phase:** CP

**Description:** Certain habitats are viewed as sensitive with unique species.

**Mitigation:** Sensitive habitats (that is, drainage lines, rocky outcrops/ridges and inselbergs) should be avoided. Off road driving should be prohibited throughout the area. Illegal collection of veld foods, poaching and killing of fauna viewed as dangerous, for example, snakes and carnivores, should be prohibited. Destruction of habitat, for example, larger trees, should be avoided.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nature</td>
</tr>
<tr>
<td>high</td>
<td>yes</td>
<td>negative</td>
</tr>
<tr>
<td><strong>Potential for irreplaceable loss of resources</strong></td>
<td>yes</td>
<td>Cumulative impacts</td>
</tr>
</tbody>
</table>

**Environmental aspect:** Animal life  
**Phase:** OP

**Description:** Certain habitats are viewed as sensitive with unique species.

**Mitigation:** Sensitive habitats (that is, drainage lines, rocky outcrops/ridges and inselbergs) should be avoided. Off road driving should be prohibited throughout the area. Illegal collection of veld foods, poaching and killing of fauna viewed as dangerous, for example, snakes and carnivores, should be prohibited. Destruction of habitat, for example, larger trees, should be avoided.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nature</td>
</tr>
<tr>
<td>high</td>
<td>yes</td>
<td>negative</td>
</tr>
<tr>
<td><strong>Potential for irreplaceable loss of resources</strong></td>
<td>no</td>
<td>Cumulative impacts</td>
</tr>
</tbody>
</table>
Environmental impact assessment report

Environmental aspect: Animal life

Description: Certain habitats are viewed as sensitive with unique species.

Mitigation: Recreate habitats that are favourable to unique species should these have been damaged and/or destroyed during the construction and operational phases, that is, replant vegetation to recreate the original habitat to lure species (colonisers).

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nature</td>
</tr>
<tr>
<td>high</td>
<td>yes</td>
<td>positive</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>no</td>
<td>Cumulative impacts</td>
</tr>
</tbody>
</table>

* shading indicates inversion due to positive nature.

Environmental impact assessment tables for impacts on invertebrate habitats by footprint of the project area during construction and operational phases are provided below. Further impact assessment tables are provided for impacts on invertebrate habitats due to water extraction, due to disruption of surface water flow, due to discharge to groundwater, due to dust and on invertebrate populations due to habitat fragmentation in Appendix F. Detailed mitigation measures are also presented in Appendix F (Irish and Scholtz, 2011).

Environmental aspect: Invertebrates

Description: Disruption and destruction of invertebrate habitats by the footprint of the project. (Further detail provided in Appendix F.)

Mitigation: Avoid no-go and highly sensitive habitats as far as possible. Design footprints of all facilities to be as small as possible and to restrict unnecessary collateral damage around the periphery. Other aspects are provided in Appendix F.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nature</td>
</tr>
<tr>
<td>high</td>
<td>yes</td>
<td>negative</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>yes</td>
<td>Cumulative impacts</td>
</tr>
</tbody>
</table>

Environmental aspect: Invertebrates

Description: Disruption and destruction of invertebrate habitats by the footprint of the project. (Further detail provided in Appendix F.)

Mitigation: Avoid no-go and highly sensitive habitats as far as possible. Design footprints of all facilities to be as small as possible and to restrict unnecessary collateral damage around the periphery. Other aspects are provided in Appendix F.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nature</td>
</tr>
<tr>
<td>high</td>
<td>yes</td>
<td>negative</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>yes</td>
<td>Cumulative impacts</td>
</tr>
</tbody>
</table>

8.7 Archaeological, heritage and cultural impacts

For the impact assessment methodology used in assessing impacts relating to archaeological aspects, the construction phase of the project is taken to include the ongoing exploration programme. Confidence levels for the assessment are high because the assessment is focused on specific exploration targets. The results indicate that mitigation will be required to offset negative impacts, although these will have a local or site specific extent. The duration and intensity of these impacts will be high, due to the fact that archaeological sites are sensitive and damage to the archaeological record cannot be reversed.
The significance of the impacts is considered to be relatively low, although it will lead to an irreplaceable loss. For present purposes, the operation and decommissioning (closure) phases of the project are treated as having the same impacts (unaltered) as the construction phase. This view is based on impacts on archaeological sites tend to continue on mining properties during the operational phase, so this is taken as a precautionary principle. Also, decommissioning phases normally include landscape scale rehabilitation, which has a very high potential for negative archaeological impact in the Namib. (Kinahan, 2010)

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Archaeological, heritage and cultural</th>
<th>Phase</th>
<th>CP/OP/DP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Recognised archaeological and related sites.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mitigation:** A number of archaeological sites are directly vulnerable to encroachment or damage as a result of their close proximity to access routes and work areas. More detail provided in Appendix G.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>Nature: negative; Extent: 2*; Duration: 4*; Intensity: 3*; Probability: 4*; Significance: 25*</td>
</tr>
<tr>
<td></td>
<td>Potential for irreplaceable loss of resources</td>
<td>yes*; Cumulative impacts; yes; Reversibility: no*</td>
</tr>
</tbody>
</table>

* colours and value (significance) adjusted by specialist and presented as such.

### 8.8 Sensitive landscapes and visual impacts

The degree to which an activity adversely affects the visual quality of a landscape depends upon the amount of visual contrast that is created between the activity and the existing landscape character. The amount of contrast and the degree of visual dominance of a proposed activity in the landscape can be measured by predicting the magnitude of change in each of the basic visual elements (scale, colour, line, form, texture, space) in the landscape. Together with the overall landscape alteration, the visual changes introduced by separate components of the proposed activity (land and water surfaces, vegetation and structures) can be measured in terms of the basic elements. (Smardon, 1979)

Assessing the amount of contrast for a proposed activity in this manner will indicate the severity of its visual impact (Smardon, 1979). The severity of visual impact of an activity depends upon (Smardon, 1979):

- visual contrast - the difference in appearance between two (or more) elements and/or an element and its background (Smardon et al., 1988);
- visual dominance – that visual object(s) that exerts the greatest influence on the visual character of the landscape (Smardon et al., 1988); and
- relative importance of its elements – severe impacts may occur where important elements are altered or where a new important element is added (Smardon, 1979).

In the case of the Tubas project access to the proposed mining area will be from the C28 road to the north, via an existing approved park track. This track is not one accessible to the general public. This fact and the location of the proposed Tubas mining area being approximately ten kilometres south of the C28 road, will result in the actual proposed siting of the plant and office building infrastructure being such that it will not be clearly visible from outside of the mining area. However, during night time fugitive light could be noticeable to those travelling the C28 road. The environmental impact assessment table for sensitive landscapes and visual impacts is presented below.
**Environmental aspect**: Sensitive landscapes and visual impacts  
**Phase**: CP/OP

**Description**: Impact on sensitive landscapes and visual impacts during construction and operational activities of the proposed activity.

**Mitigation**: Development should take place behind the ridge north of the C14 road and additional screening implemented, if need be, to ensure no direct line of sight of mining activity from the C14 road.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nature</td>
</tr>
<tr>
<td>high</td>
<td>possibly</td>
<td>negative</td>
</tr>
</tbody>
</table>

**Potential for irreplaceable loss of resources**

<table>
<thead>
<tr>
<th></th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td>Cumulative impacts</td>
<td>no</td>
<td>Reversibility</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**8.9 Noise**

During construction the predominant source of noise will be from, *inter alia*, trucks, diesel powered plant, drilling and grinding. Blasting will also take place during construction. The impacts from noise will be limited, predominantly due to the absence of any receptors within the vicinity of the site. There will be a slight effect on the fauna that will likely move out of the immediate vicinity. General vehicle and people activity will probably have a greater effect in this regard than noise alone. Consequently, the severity is considered moderate with low significance. (Cornelissen, 2010)

During operation the predominant continuous noise source will be from haul trucks and components of the process plant such as crushers and mills. Blasting will also have a substantial noise effect, particularly when shallow, before containment by the pit, but will be of a short duration and therefore more limited impact. Vibrations from blasting may also affect nearby receptors but there should be very little chance of structural damage being caused. As with construction, the impacts from noise will be limited, predominantly due to the absence of any receptors within the vicinity of the site. Once again, there will be a slight effect on the fauna that will likely move out of the immediate vicinity. General activity will probably have a greater effect in this regard than noise alone. The severity is considered moderate with medium significance. (Cornelissen, 2010)

Decommissioning noise sources will be similar to construction with heavy diesel equipment, grinders, pneumatic hammers and trucks generating most of the noise. As for construction and operation, general activity will have a greater effect than noise on fauna movement and the absence of receptors will reduce the severity of the impact. Consequently, the severity is considered medium to low with moderate significance. Environmental impact assessment tables for the construction, operational and closure phases are provided below, indicating the potential/envisaged impacts expected from noise. (Cornelissen, 2010)

**Environmental aspect**: Noise impacts  
**Phase**: CP

**Description**: Adverse noise levels due to construction activities.

**Mitigation**: Make use of noise abatement technologies where feasible. Select equipment with low sound power level rating and ensure it is well maintained. Limit loud activities to daylight hours as far as possible. Implement a noise monitoring programme coupled to a grievance procedure.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nature</td>
</tr>
<tr>
<td>high</td>
<td>yes</td>
<td>negative</td>
</tr>
</tbody>
</table>

**Potential for irreplaceable loss of resources**

<table>
<thead>
<tr>
<th></th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td>Cumulative impacts</td>
<td>no</td>
<td>Reversibility</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Environmental aspect | Noise impacts - blasting | Phase | OP
--- | --- | --- | ---
Description: Adverse noise levels due to operational activities - blasting.
Mitigation: Restrict blasting to daylight hours.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>Nature</td>
<td>Extent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>negative</td>
<td>2</td>
</tr>
</tbody>
</table>

Potential for irreplaceable loss of resources: no Cumulative impacts; no Reversibility; yes

Environmental aspect | Noise impacts - trucks | Phase | OP
--- | --- | --- | ---
Description: Adverse noise levels due to operational activities - trucks.
Mitigation: Select vehicles with low sound power level rating, adequate exhaust silencers and ensure they are well maintained.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>Nature</td>
<td>Extent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>negative</td>
<td>2</td>
</tr>
</tbody>
</table>

Potential for irreplaceable loss of resources: no Cumulative impacts; no Reversibility; yes

Environmental aspect | Noise impacts – process plant | Phase | OP
--- | --- | --- | ---
Description: Adverse noise levels due to operational activities – process plant.
Mitigation: Make use of noise abatement technologies where feasible. Select equipment with low sound power level rating and ensure it is well maintained. Ensure rollers used for conveyor systems are machined for optimum roundness. Limit loud activities to daylight hours as far as possible. Continue noise monitoring programme coupled to a grievance procedure.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>Nature</td>
<td>Extent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>negative</td>
<td>2</td>
</tr>
</tbody>
</table>

Potential for irreplaceable loss of resources: no Cumulative impacts; no Reversibility; yes

Environmental aspect | Noise impacts | Phase | DP
--- | --- | --- | ---
Description: Adverse noise levels due to decommissioning activities.
Mitigation: Make use of noise abatement technologies where feasible. Select equipment with low sound power level rating and ensure it is well maintained. Limit loud activities to daylight hours as far as possible. Continue noise monitoring programme coupled to a grievance procedure.

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>Nature</td>
<td>Extent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>negative</td>
<td>2</td>
</tr>
</tbody>
</table>

Potential for irreplaceable loss of resources: no Cumulative impacts; no Reversibility; yes

8.10 Social and economic environment
The impact of the proposed mining operation will be positive by creating approximately 130 new job opportunities in the region. The majority of these jobs will be filled by people recruited from the Swakopmund/Walvis Bay and surrounding area. During the construction phase it is estimated that the total workforce will be up to 150 people. With an average of 15.3% of the population in the Erongo region living in poverty, the advent of new job opportunities in the region will result in the social upliftment of many households.
Naturally the advent of new job opportunities will also result in the migration of many people from other regions. This could negatively impact on the present opportunities available for local residents in the region.

Apart from providing new job opportunities in the region, RUN also intends participating in various social upliftment programmes. These will include distribution of information on environmental issues at the proposed visitor's centre and assisting in educational programmes within the region. Regular meetings with interested and affected parties with regard the proposed mining operation and associated (environmental) impacts will also be conducted on a quarterly basis prior to operation of the proposed mine, thereafter on at least an annual basis. The full operation of the proposed mine will have a significant economic impact on both regional and national levels. Recent estimates indicate that, when fully operational, direct and indirect taxes to the Namibian government will be in the order of N$ 27.2 million per year. Although most of the direct employment effects will take place in the mining industry, the multiplier effect will result in job creation effects in areas such as transport, equipment manufacturing and personal services.

During the operational life of the mine, especially during the construction phase, the economic impact on the region and at national level will be positive. However, when the mine closes, the resultant loss in employment opportunities will have a negative effect on the region and the country as a whole. To address this impact it is proposed to notify relevant stakeholders three years in advance of mine closure. This should assist in negating the mainly negative economic impact during the decommissioning phase and eventual closure of the mine. The environmental impact assessment table for social and economic impacts is presented below.

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Social and economic impacts</th>
<th>Phase</th>
<th>CP/OP/DP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Increased employment opportunities and increased government revenues and local business community multiplier spinoffs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitigation: None.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Evaluation of impacts**

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td>positive</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>28*</td>
</tr>
</tbody>
</table>

* shading indicates inversion due to positive nature.

8.11 Radiation exposures and control

8.11.1 Fundamental concepts

Natural ionising radiation and naturally occurring radioactive substances are permanent features of any environment. Therefore radiological health risks associated with natural radiation exposures can only be minimised and cannot be eliminated entirely. The acceptance by society of risks associated with nuclear radiation exposures is conditional on the benefits to be gained from activities that have radiation hazards associated with them. Nevertheless, these risks must be minimised by the application of radiation safety standards, with different standards applied to radiation workers and to members of the public. (Friend et al., 2005)

In modern uranium mines personal radiation exposures are low and thus there is no likelihood of non-stochastic effects of radiation on human beings (non-stochastic or deterministic effects are certain to occur if a relevant dose exceeds a threshold limit). (Friend et al., 2005)
Occupational radiation exposures of uranium mine workers have to be kept below the annual radiation dose limit of 20 mSv. Therefore, radiation protection practices in mining and mineral processing of radioactive ores normally focus on the stochastic effects of ionising radiation. Stochastic effects may ensue if an irradiated cell is modified rather than killed in an organ tissue. Modified cells may, after a prolonged delay, develop into cancer. The body's repair and defence mechanisms make this a very improbable outcome at small doses; nevertheless, there is no evidence of a threshold dose below which cancer cannot result. The probability of occurrence of cancer is higher for higher doses, but the severity of any cancer that may result from irradiation is independent of the dose. If the cell damaged by radiation exposure is a germ cell, whose function is to transmit genetic information to progeny, it is conceivable that hereditary effects of various types may develop in the descendants of the exposed individual. The likelihood of stochastic effects is presumed to be proportional to the dose received, also without a dose threshold. In addition to the aforementioned health effects, other health effects may occur in infants due to exposure of the embryo or foetus to radiation. These effects include a greater likelihood of leukaemia. (Friend et al., 2005)

From Friend et al. (2005) the probability of developing a fatal cancer as a result of radiation exposures of workers and the whole population is about $4 \times 10^{-2}$ per Sievert and $5 \times 10^{-2}$ per Sievert of whole body dose respectively. For example, if workers receive the annual whole body dose of 1 mSv it would correspond to a fatality risk of $4 \times 10^{-5}$ per annum. That is, if a group of approximately 25,000 workers receives and annual whole body effective dose of 1 mSv, then one person from this group may develop a fatal cancer. This can be compared to risk acceptance by the public, which is generally as follows (IAEA, 1996a):

- $1 \times 10^{-4}$ – people are willing to spend public money to control a hazard,
- $1 \times 10^{-5}$ – people still recognise the hazard and accept inconvenience to avoid it, and
- $1 \times 10^{-6}$ – not of great concern to the average person.

Table 8.1 provides a comparison between radiological risk and the fatality risk of people involved in a range of activities (UNEP, 1985 and NRPB, 1986). Dependent on the relevant occupational health and safety enforcement, these risks may vary from country to country. As an example from Table 8.1, a risk of 1 in 11,000 in the metal industry means that, on average, one fatality may occur per year in a group of 11,000 metal workers (Kvasnicka, 2001). It is anticipated that the average fatality risk factor due to radiation exposures for the Tubas workforce will be lower than that of commercial airline crew. (Friend et al., 2005)

8.11.2 Radiological protection standards

Reptile Uranium Namibia (Pty) Ltd is committed to comply with all national regulatory requirements for radiological protection and to apply as low as reasonably achievable (ALARA) principles in radiation protection and radioactive waste management.

The draft regulations of the Namibian National Radiation Protection Authority are largely based on the recommendations of the International Atomic Energy Association, as defined in the Basic Safety Standards (IAEA, 1996a). Accordingly, the Tubas project will have to comply with the national regulatory requirements for radiological protection, which are underpinned by the following elements: justification of practices, dose limitation and optimisation of protection. These principal elements of the radiological protection standards are summarised below. (Friend et al., 2005; Von Oertzen, 2010)
Table 8.1 Average annual risks of death from accidents in various industries and daily activities.

<table>
<thead>
<tr>
<th>Industry/activity</th>
<th>Risk of death per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking 10 cigarettes per day</td>
<td>1 in 200</td>
</tr>
<tr>
<td>Fishing</td>
<td>1 in 800</td>
</tr>
<tr>
<td>Natural causes (40 year old person)</td>
<td>1 in 850</td>
</tr>
<tr>
<td>Driving car</td>
<td>1 in 5,000</td>
</tr>
<tr>
<td>Police</td>
<td>1 in 5,000</td>
</tr>
<tr>
<td>Coal mining</td>
<td>1 in 6,000</td>
</tr>
<tr>
<td>Commercial aircraft crew receiving the cosmic radiation dose of 4 mSv/a</td>
<td>1 in 6,300</td>
</tr>
<tr>
<td>Construction industry</td>
<td>1 in 6,800</td>
</tr>
<tr>
<td>Metal manufacturing</td>
<td>1 in 11,000</td>
</tr>
<tr>
<td>Radiation workers exposed to 2 mSv/a</td>
<td>1 in 12,500</td>
</tr>
<tr>
<td>A person flying frequently</td>
<td>1 in 25,000</td>
</tr>
<tr>
<td>Radiation workers exposed to 1 mSv/a</td>
<td>1 in 25,000</td>
</tr>
<tr>
<td>Accidents in the home</td>
<td>1 in 26,000</td>
</tr>
<tr>
<td>Timber and furniture industry</td>
<td>1 in 34,500</td>
</tr>
<tr>
<td>Accident at work (all employment)</td>
<td>1 in 43,500</td>
</tr>
<tr>
<td>Textile industry</td>
<td>1 in 50,000</td>
</tr>
<tr>
<td>Employees exposed to 0.5 mSv/a</td>
<td>1 in 50,000</td>
</tr>
</tbody>
</table>

Justification of practices
No practice or source within a practice should be authorised unless the practice produces sufficient benefit to the exposed individuals or to society to offset the radiation harm that it might cause; that is: unless the practice is justified, taking into account social, economic and other relevant factors (Friend et al., 2005). Further explanations are provided in Appendix O (Von Oertzen, 2010).

Dose limitation
The normal exposure of individuals shall be restricted so that neither the total effective dose, nor the total equivalent dose to relevant organs or tissues, caused by the possible combination of exposures from authorised practices, exceeds any relevant dose limit. (Friend et al., 2005) The following dose limits shall be applied at Tubas (Friend et al., 2005; Von Oertzen, 2010):

Worker exposure
The occupational exposure of any worker shall be so controlled that the following limits are not exceeded (ICRP, 1990):

- an effective dose of 20 mSv per year averaged over five consecutive years,
- an effective dose of 50 mSv in any single year,
- an equivalent dose to the lens of the eye of 150 mSv in a year, and
- an equivalent dose to the extremities (hands and feet) or the skin of 500 mSv in a year.
Application of ALARA principles by Reptile Uranium Namibia (Pty) Ltd will result in the maximum as well as average annual occupational exposures being well below the above statutory dose limits.

Public exposure
The estimated average doses to the relevant critical groups of members of the public that are attributable to practices shall not exceed the following limits (ICRP, 1990):

- an effective dose of 1 mSv in a year,
- in special circumstances, an effective dose of up to 5 mSv in a single year provided that the average dose over five consecutive years does not exceed 1 mSv per year,
- an equivalent dose to the lens of the eye of 15 mSv in a year, and
- an equivalent dose to the skin of 50 mSv in a year.

Optimisation of protection
In relation to exposures from any particular source within a practice, except for therapeutic medical exposures, protection and safety shall be optimised in order that the magnitude of individual doses, the number of people exposed and the likelihood of incurring exposures all be kept as low as reasonably achievable, economic and social factors being taken into account. (Friend et al., 2005; Von Oertzen, 2010)

The transport of radioactive sources (uranium product) shall be subject to the requirements of the IAEA Regulations for the Safe Transport of Radioactive Material and any applicable international convention (IAEA, 1996b). Any machinery, equipment and tools that were used in the controlled area would be monitored for surface contamination. (Friend et al., 2005)

8.11.3 Occupational ionising radiation

Sources of radiation exposure
There are three main pathways for delivery of radiation doses to the human body that must be considered, and that may require active control, in mining and processing of uranium. They are (Friend et al., 2005; Von Oertzen, 2010):

- direct irradiation by gamma radiation from radioactive materials (for example, uranium ore, tailings and uranium product);
- inhalation of radon daughters (radon progeny), and of airborne long-lived alpha (LL-α) emitting radionuclides; and
- ingestion of radioactive material.

Gamma irradiation
Radioactivity in material is concentrated throughout uranium extraction processes at various stages during the process. The main sources of gamma radiation are expected to be the following (Friend et al., 2005; Von Oertzen, 2010):

- uranium ore body and truck loads of uranium ore;
- radioactive contaminant deposit build-up in pipes and associated equipment;
- the uranium oxide product;
- sealed radiation sources used for process control, for example, density and flow meters; and
- uranium-bearing materials contained in ore stockpiles, waste rock dumps, pulps and sludge, and tailings facilities.
The radiation protection monitoring programme (RPMP) that will be developed for the proposed mining operation will include external dose rate surveys by hand held gamma survey meters and personal gamma radiation dose monitoring of radiation workers working in the controlled area by personal thermo luminescent dosimeters (TLDs).

Inhalation of radon progeny
Radon (Rn\(^{222}\)) is generated by the radioactive decay of radium (Ra-226). Therefore, the main sources of radon emanation are uranium ore and uranium tailings that contain radium. However, in open cut uranium mines the radon and radon daughter exposures of workers are usually low due to fast atmospheric dispersion of radon. The RPMP will include quarterly radon activity concentration monitoring in ground level air by passive nuclear track etch detectors in selected areas of the project. Any maintenance operations that would involve a confine space entry where radium bearing material is present will follow a special work procedure that will include radon daughter monitoring. (Friend et al., 2005; Von Oertzen, 2010)

Inhalation of LL-\(\alpha\) (long-lived alpha emitting) dust
Mining operations, transport of ore, ore crushing, dry tailings and material spills can be potential sources of airborne dust. The success of dust abatement programmes and general housekeeping will be major factors in determining the dose to workers through this exposure pathway. Occupational health and radiation protection programmes will include specific actions to minimise dust exposure as far as possible. Design of the mine will include consideration of dust potential aspects, as well as travel routes and water spraying of the pit roads. (Friend et al., 2005)

At the proposed Tubas project a radiation management plan (RMP) will be implemented that will include the following measures, inter alia, to minimise personal exposures of workers to long lived airborne dust (Friend et al., 2005):

- prompt wet clean-up of all spills capable of generating radioactive dust;
- provision and maintenance of dust control for uranium oxide packaging;
- survey, decontamination and wetting (as appropriate) before and during equipment maintenance; and
- use of suitable personnel protection for tasks involving potential radiation exposure.

Ingestion of radioactive material
The radiation management plan will include principles of minimisation of ingestion of radioactive material. These principles will ensure that cleanliness and personal hygiene standards at all offices, rest and ablution areas are of a high standard. Work areas will be radiologically classified as non-controlled, supervised or controlled. Workers will not be allowed to eat and smoke in controlled areas and designated rooms will be dedicated for eating in supervised areas. Surface contamination of accessible surfaces in the controlled and supervised areas will be periodically checked. Any person who worked in the controlled area will have the surface contamination of their boots, clothing and hands checked by surface contamination monitors before leaving controlled areas.

Before starting a shift, workers will leave their personal clothing in a clean part of the change room, change into their work clothing in a dirty part of the change room and enter the controlled area. At the end of a shift workers will leave their work clothing in the dirty part of the change room, shower, change into their personal clothing and leave the change room. The change room will be at the boundary of the controlled and the supervised areas. Surface contamination monitors will be provided at the entry into the clean part of the change room. The surface alpha contamination of accessible surfaces in the change room will be periodically measured as per the radiation protection monitoring programme.
Estimates of worker dose

Radiation exposures of workers will be estimated based on the radiation monitoring to be outlined in detail in the radiation protection monitoring programme, which will be part of the radiation management plan. Gamma doses of plant operators at Tubas are expected to be similar to the doses received by hydrometallurgical plant operators at other uranium operations that process uranium of a similar ore grade. For example, at one of the largest uranium producing operations in the world, Australia’s Olympic Dam, plant operator doses have been reported to be approximately 1 mSv/year (Hondros, 1995) with doses reported for uranium oxide operators in the order of 5 mSv/a. (Friend et al., 2005)

The resultant dose to a worker from the three main pathways can be expressed as follows (Friend et al., 2005):

\[ E_T = H_p(d) + h_{\alpha I} + h_{Rn} \]

where:
- \( E_T \) = resultant annual effective dose,
- \( H_p(d) \) = personal whole body dose equivalent from external gamma radiation,
- \( h_{\alpha I} \) = committed effective dose for the inhaled long-lived alpha activity,
- \( h_{Rn} \) = committed effective dose from inhaled radon daughters, and

and all in units of mSv/year.

Personal external gamma radiation exposures of radiation workers (workers who would work in the controlled area) will be measured on a quarterly basis by TLDs, in accordance with the proposed radiation protection monitoring programme. The committed effective dose, \( h_{\alpha I} \) (in mSv/year), will be estimated from (Friend et al., 2005; Von Oertzen, 2010):

\[ h_{\alpha I} = AC_{\alpha} \times DCF \times ET \times V_{\text{rate}} \]

where \( AC_{\alpha} \) is the average long lived alpha activity concentration (in Bq/m\(^3\)) measured in air by personal/area samplers, taking into account the inhaled dust activity to the committed effective dose conversion factor (DCF in mSv/Bq), the exposure time (ET in hours per year) and \( V_{\text{rate}} \) the hourly breathing rate for workers, which is assumed to be 1.2 m\(^3\)/h as per the recommendations by the ICRP for adult workers (ICRP, 1995).

The exposure dose from inhaled radon and radon daughters, \( h_{Rn} \) (in mSv/year), will be estimated from the following equation (Von Oertzen, 2010):

\[ h_{Rn} = AC_{Rn} \times CF_{Rn} \times ET \]

where:
- \( AC_{Rn} \) = average radon activity concentration (Bq/m\(^3\)),
- \( CF_{Rn} \) = conversion factor (mSv/Bq.h.m\(^{-3}\)), and
- ET = exposure time (h/year).

The annual dose assessment will be detailed in the proposed radiation management plan and periodically revised, depending on the analysis of operational monitoring data.

8.11.4 Environmental ionising radiation

The human exposure pathways that are typically investigated when determining the impact of a practice, such as a uranium mine, are shown in Figure 8.4 (Friend et al., 2005). At the Tubas project the focus will be on atmospheric releases as the impact zone of any liquid releases is expected to be limited to the mine site (Von Oertzen, 2010).

A detailed radiological assessment will be commissioned prior to the commencement of mining operations to determine a representative radiological baseline. Such a baseline survey will also include the ongoing sampling and analysis of groundwater in the project area, so as to establish a quantitative basis on which changes in the radionuclide content of groundwater resources can be determined. (Von Oertzen, 2010)
The baseline survey will also establish a quantitative basis on which incremental exposure doses can be determined, that is, exposure doses that can be attributed to the operations of the project. The survey will also be used to establish suitable indicators for environmental rehabilitation and long-term radiological safety monitoring of the project area. (Von Oertzen, 2010)

Based on the mitigation and control measures proposed in the previous sections, and the high natural background radiation (resulting in a neutral nature of overall impact), the environmental impact assessment table for radiation is presented below.

<table>
<thead>
<tr>
<th>Environmental aspect</th>
<th>Radiation</th>
<th>Phase</th>
<th>CP/OP/DP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Radiation levels due to mining activities.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitigation: Implementation of various radiological programmes as set out in Section 8.10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Confidence level</th>
<th>Mitigation required</th>
<th>Evaluation of impacts</th>
<th>Nature</th>
<th>Extent</th>
<th>Duration</th>
<th>Intensity</th>
<th>Probability</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>high</td>
<td>yes</td>
<td></td>
<td>neutral</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>42</td>
</tr>
<tr>
<td>Potential for irreplaceable loss of resources</td>
<td>yes</td>
<td>Cumulative impacts</td>
<td>yes</td>
<td>Reversibility</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9. PUBLIC PARTICIPATION PROCESS

In terms of Section 26(1)(h) of the draft EA regulations (MET, 2009) it is a requirement to provide details of the public participation process conducted in accordance with Section 32 of the draft EA regulations. Although the term stakeholder engagement is gaining acceptance worldwide as a replacement for the term public participation (DEAT, 2002), this is still the terminology used within the draft EA regulations and will be utilised throughout the report where relevant. Clarification of the term public versus stakeholder is provided in Figure 9.1 (DEAT, 2002).

![Figure 9.1 Clarification of the term "public" versus "stakeholder".](image)

Public participation forms an integral part of any present day environmental assessment process. The objectives of public participation can be summarised as follows (Lakhani, 2000):

- informing stakeholders;
- presentation of views, concerns and values;
- maximising benefits and minimising risks;
- influencing project design;
- obtaining local knowledge;
- increasing public confidence;
- better transparency and accountability in decision-making; and
- less conflict (decision-making through consensus).

In order to address these objectives, information exchange meetings were held with the Ministries of Mines and Energy (MME) and Environment and Tourism (MET) on 30 November 2009 and on 23 March 2010. During these meetings representatives of Reptile Uranium Namibia and Softchem gave presentations of the proposed activity, and obtained feedback and suggestions from representatives of the MME and MET present at these meetings. Notification letters, minutes (30 November 2009 meeting) and meeting summary (23 March 2010) of these meetings are presented in Appendix I.

In addition to the above, the various other actions required for public participation, in terms of Section 32 of the draft EA regulations, are set out in the following sections.

9.1 Notification of potentially interested and affected parties

The requirements for the notification of potentially interested and affected parties of this application are set out in detail in Section 32(2)(b) of the draft EA regulations (MET, 2009). These requirements have been addressed and include, *inter alia*;

- forwarding letters to the owners and occupiers of land adjacent to the site (see Appendix J for copies of these letters);
• forwarding letters to government authorities (see Appendix J for copies of these letters);
• fixing of a notice board at a place conspicuous to the public (DEA, 2010); and
• placing of advertisements in at least one local newspaper (DEA, 2010).

9.2 Proof of notice boards and advertisements
Proof of the placement of a notice board (DEA, 2010) is given in Figures 9.2 and 9.3. The advertisements placed in the Republikein newspaper on 10 September 2010, the Namibian newspaper on 13 September 2010, and The Southern Times newspaper on 17 - 23 September 2010 are shown in Figures 9.4, 9.5 and 9.6 respectively.

9.3 Register of interested and affected parties
An interested and affected parties register has been opened, as required in terms of Section 33(1) of the draft EA regulations (MET, 2009), and the present edition is presented in Appendix K.

9.4 Public participation meetings
Public participation meetings were held in Windhoek on 3 November 2010 and in Swakopmund on 5 November 2010. Proof of the placement of advertisements for these meetings in the Republikein newspaper on 12 October 2010, the Namibian newspaper on 13 October 2010, and The Southern Times newspaper on 15 - 21 October 2010 are shown in Figures 9.7, 9.8 and 9.9 respectively. Attendance lists to these meetings are presented in Appendix K.

9.5 Summary of issues raised by interested and affected parties
Written comments on the project were received from interested and affected parties (stakeholders), with the written comments received presented in Appendix L, and a consolidation of stakeholder's feedback and project team responses given in Appendix M.

Figure 9.2 Placement of notice board at entrance to EPL3496.
Omahola Project

Notice is hereby given that Reptile Uranium Namibia (RUN) intends to submit applications for mining licences on EPL 3496 in the Namib-Naukluft Park to the competent Namibian authorities for the extraction of uranium, iron and associated minerals.

In order to register as an interested and/or affected party (IAP); comment on the proposed activity; and/or to obtain more information on the project, please contact Ms Guddie Kriel on 064-415200, or via email to either guddie@reptile.com.na or francois@softchem.co.za.

More information on the project is available at: www.deepyellow.com.au and www.softchem.co.za.

Figure 9.3 Wording on notice board placed at entrance to EPL3496.

Figure 9.4 Advertisement published in the Republikein newspaper on 10 September 2010.
Figure 9.5 Advertisement published in the Namibian newspaper on 13 September 2010.

Figure 9.6 Advertisement published in The Southern Times newspaper on 17 - 23 September 2010.
Figure 9.7  Advertisement published in the Republikein newspaper on 12 October 2010.

Figure 9.8  Advertisement published in the Namibian newspaper on 13 October 2010.
Figure 9.6  Advertisement published in The Southern Times newspaper on 15 - 21 October 2010.
10. HEALTH AND SAFETY

10.1 Regulatory framework
Regulatory safety requirements for the project is presently set out in the tenth draft Mine Health and Safety regulations, regulations made under Section 138A of the Minerals (Prospecting and Mining) Act (No 33 of 1992): health and safety of persons employed or otherwise present in or at mines. These regulations shall apply to any mineral licence area in Namibia.

10.2 Input of health and safety controls at design stage
RUN intends that, to the maximum practical extend possible; hazards will either be designed-out or minimised at the design stage, rather than controlled by procedures during operation. In the design of the processing plant, review by the environmental and safety personnel/consultants will be a key requirement before design finalisation.

Design criteria adopted for safety and radiation control will place special emphasis on spillage control by either bunding or cut-off/flow isolation and prevention of dispersion of dry materials containing radionuclides. In terms of normal industrial safety, review of the design will include ease of access, maintenance, operation, operator ergonomics, safety zoning and other potential industrial hazards.

10.3 Hazards
Hazards that will be present at the Tubas mining site and require control will include:
- injuries from slips/trips/falls;
- manual handling injuries (including back injuries);
- entanglement in rotating machinery;
- falls from height (or into holes);
- injuries in use of hand and power tools;
- injuries from uncontrolled release of high-pressure fluids;
- machinery impacts and vehicle accidents;
- electrocution;
- fire, explosion, or burn injuries;
- solvent vapour intoxication;
- accidental inhalation of U-product; and
- skin damage by chemicals (either immediate or delayed).

A major safety concern at Tubas, associated with all remote sites, is the risk of vehicle accidents on gravel roads, with long travel distances to nearby facilities, and the likely presence of animals. RUN personnel will be instructed to allow adequate time for any trip, always to carry water, and to stop and rest periodically. Driving at night is to be undertaken only with extreme caution, and RUN will limit the necessity for travel at night. All travel off-site, as part of operations, will require formal approval and a log will be kept.

There is no workplace hazard that cannot be adequately controlled by either:
- physical design (including shields, guarding, or interlocks);
- operating procedures (for example, registers, logbooks and work permits);
- personal protective gear (for example, hardhats, gloves, goggles and respiratory equipment); or
• thorough and ongoing safety training and meetings.

RUN will strive to ensure, by employee training and by safety reviews, that all work will take place only after due consideration has been given to the proper control of all work-related hazards. The company will develop a culture of safety within the workforce and then work to maintain that culture through a structured and dynamic programme.

10.4 Safety management system

10.4.1 Purpose
At RUN formal systems and documentation will be put in place as part of the safety management system (SMS) to ensure:

• a safe work environment;
• safe systems of work;
• safe plant and equipment; and
• the availability of such information, instruction, and training as required to be able to work safely.

10.4.2 Training
There will be a safety induction for all employees, whether directly employed or employed via contractors; with tests, reviews and ongoing safety education and discussion meetings, held on a regular basis, and formally minuted. Mandatory safety inductions will also be implemented for all visitors to the proposed mining site.

10.4.3 Ongoing safety reviews/audits
A basic methodology for promoting a safe workplace and operation is to require regular safety reviews or audits. These reviews/audits will be scheduled on a yearly basis, typically on an employee's return from annual leave.

10.4.4 Formalisation of procedures
Safety management procedures will include formal inspections, review of identified hazards and selection of control requirements, review of any accidents and near-misses, regular formal safety reviews and planning meetings. Active involvement of personnel (in the establishment, enforcement and review of these procedures) will ensure buy-in with the company's safety management system.

10.4.5 Management of chemicals
All hazardous chemicals to be used on site will have material safety datasheets (MSDSs) collated and readily available. Chemicals will not be chosen for use until after health and safety reviews, consideration of alternatives, and identification of methods of hazard control. Chemical hazards training will be an integral part of safety training and induction. Procedures will be developed for use and handling of all dangerous chemicals. There will be proper personal protective equipment supplied and workers required to wear suitable protective clothing whenever the handling of certain chemicals necessitates such actions.

10.5 Radiation management

10.5.1 Introduction
The radiation management plan (RMP) to be developed for the mining operation will consider relevant nationally and internationally accepted principles of radiation protection (ICRP, 1997). The principles of justification for all operational practices, optimisation of radiation protection and dose limitation will form the basis of these programmes. The radiation management plan will, inter alia, outline requirements for the following:
• worker radiation protection (through the radiation protection monitoring programme, RPMP),
• environmental monitoring (detail will be addressed in the environmental radiation protection monitoring programme, ERPMP),
• radioactive waste management (radioactive waste management programme, RWMP),
• physical security of radioactive items,
• quality management,
• transportation of radioactive material,
• occurrence reporting and corrective actions,
• mine rehabilitation and close-out (mine rehabilitation and close-out programme, MRCP), and
• internal and external auditing.

Programmes and requirements for worker radiation protection will include:
• classification of the facility’s areas, demarcation and warning signs,
• monitoring of workers and the workplace,
• contamination control,
• monitoring of equipment released from uranium mining and processing areas to be refurbished or scrapped,
• personnel radiation exposure and risk records,
• training of personnel working in radiation supervised and controlled areas, and
• provision of radiation monitoring instrumentation.

The quality management programme will address the following issues:
• responsibilities,
• radiation protection policy,
• review of processes and procedures,
• organisation,
• document control,
• process and plant design and design changes,
• inspection and testing (including radiation monitor calibrations),
• audits and surveillance, and
• records and reports.

Formal reports on the performance of radiological control and radiation impacts will be prepared annually. These reports will be submitted to regulatory authorities and will also be accessible to interested and affected parties. During the first two years of operation reporting will be more frequent.

10.5.2 Elements of radiation protection for workers

The annual effective dose limit at Tubas for persons designated as occupational exposed will be 20 mSv. In addition, the annual equivalent dose limit for individual organs and tissues of such persons will be 500 mSv, except for the lens of the eye, for which the limit will be 150 mSv.
The basis for the protection of the occupational exposure of women who are not pregnant will be the same as for men. However, when a female worker is pregnant, her exposure will be controlled so that the standard of protection to the conceptus is the same as for a member of the public. As the RMP would include the ALARA principles, the annual personal occupational radiation exposures will be well below the statutory annual dose limits. (The annual effective dose limit for visitors to nuclear authorised sites, as well as persons not designated as occupationally exposed to radiation, is 1 mSv.)

In order to optimise radiation protection and monitoring within the project area, workplaces will be designated into three types, namely controlled, supervised and non-controlled.

**Controlled area**

An area in which normal working conditions, including the possible occurrence of minor mishaps, require that a worker follows well established procedures and practices aimed specifically at controlling radiation exposures and handling radioactive material.

Controlled areas must be appropriately delineated and access is restricted to those who are adequately trained, as required for occupationally exposed persons (OEPs). Other persons, for example visitors, may be allowed access provided that a worker who has received adequate training or instruction on radiation hazards accompanies them.

The effective dose for workers in a controlled area can potentially exceed 5 mSv/year and contamination of surface areas may exceed 4.0 Bq/cm² beta activity and 0.4 Bq/cm² alpha activity.

**Supervised area**

These are areas in which the working conditions are kept under review, but special procedures are not normally required. A programme of surveillance is implemented to detect any deterioration in the protection arrangements. The effective dose for workers in a supervised area can potentially exceed 1 mSv/year, but is less than 5 mSv/year. Contamination of surface areas exceeds 0.4 Bq/cm² beta activity and 0.04 Bq/cm² alpha activity by a factor not greater than ten.

**Non-controlled areas**

These are areas where no radiation hazards exist and the potential dose attributable to plant operations is less than 1 mSv/year. Non-controlled areas immediately adjacent to supervised and controlled areas will be screened quarterly for contamination when leaving these areas. This is to ensure that radioactive material is not spread to non-controlled areas.

**General**

Notices will be displayed at security access control points that will inform workers and visitors of the presence of low-level radioactive material and the associated precautionary measures such as designated areas for eating, drinking and smoking. Access and egress control will be exercised in accordance to the designation of an area. Vehicles will be washed before entering the supervised area from the controlled area; and all vehicles, tools and equipment will have their surface contamination measured before they leave the site. Decontamination will be affected when required.

Monitoring of the work areas and workers will aim at determining an appropriate level of radiation protection. This information is used to confirm the classification of workplaces and also to identify exposure fluctuations in working areas. The results of routine monitoring are also used to re-assess the demarcation of designated areas.
Personal air sampling will be performed during maintenance activities on dry and dusty process circuits and the duration of maintenance will be logged. The required personal protection equipment (PPE) shall always be worn during these maintenance operations.

Housekeeping shall be of primary importance. Radioactive ore and concentrate present as dust deposited on external surfaces of plant equipment and on floors will be removed routinely as part of a housekeeping programme. Spilled material will be removed immediately following a spillage incident.

Occupational hygiene requirements in respect of PPE for work in the supervised and controlled areas normally overlap with PPE required for radiation protection. Respiratory protection will be provided in areas where dry material will be handled and dusty conditions exist. Specific operations with radioactive material that generate a high dust load will be assessed for its dose contribution to workers. The results will be used to determine whether the quality respiratory protection is adequate.

The following practices will be prohibited in supervised and controlled plant process areas:

- eating, drinking and smoking, and
- people with open wounds entering these areas.

Rest house facilities where people could eat, drink and smoke will be provided. Facilities will be available for workers to wash, along with a sign requesting them to wash their hands and face before eating. Provision will be made for clean clothing to replace contaminated clothing. Personnel who occasionally work in controlled areas with high dust loads will be required to shower at the end of each working shift before leaving for home.

10.5.3 Radiation protection of members of the public and the environment

The environmental radiation protection monitoring programme (ERPMP) will be established with the aim to provide data for assessing the incremental radiation impact to the local environment, if any, generated by proposed operations at Tubas. In view of this, an ongoing programme is being planned that will build on baseline studies. The ERPMP will outline the monitoring of the external gamma dose rate at 1 m above ground, the environmental dust activity concentration in ground level air, the radon activity concentration in air, soil sampling and water sampling. The sampling will cover the pre-operational stage, the operational stage and post-operational stage of the project. The ERPMP will also provide information for the assessment of annual incremental radiation exposures to members of the public (the critical group of the public).

A conservative approach will be followed by Tubas by postulating the permanent presence of a hypothetical member of the public at the nearest point to the mine site visited by tourists touring in the Naukluft Park. The annual effective dose for members of the public arising from operations at Tubas operations will be constrained at a value less than 1 mSv/a. One of the main aims of the radiation management plan and the ERPMP, by following ALARA principles, is to ensure that the annual exposure for the critical group of the public is well below 1 mSv. This will be achieved by addressing the following requirements:

- environmental monitoring of the external gamma radiation, airborne dust and radon; and sampling of soil and water (this will include where and how frequently the monitoring/sampling is to be carried out and what monitoring/sampling methodology is to be used);
- assessment of the incremental annual radiation exposure to a hypothetical critical group of the public member;
• keep appropriate records of the results of the monitoring programme;
• report a summary of the monitoring results to the regulatory authority at required intervals;
• report promptly any significant increase in environmental radiation fields or contamination that could be attributed to the radiation or radioactive discharges emitted by sources under Tubas responsibility;
• establish and maintain a capability to carry out emergency monitoring, in case of unexpected increases in radiation fields or radioactive contamination due to accidental or other unusual events affecting radioactive material;
• verify the adequacy of the assumptions made for the prior assessment of radiological consequences of releases to the environment; and
• periodically review the ERPMP.

10.5.4 Radioactive waste management programme

Basic principles for radioactive waste management, as defined by the International Atomic Energy Agency (IAEA, 2002) and applicable to Tubas, will be detailed in the radioactive waste management programme (RWMP) and based on the principles set out below.

Radioactive waste will be managed in such a way that:

• an acceptable level of protection for human health and the environment will be secured,
• predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today,
• not to impose undue burdens on future generations, and
• the generation of radioactive waste will be kept to the minimum practicable.

Designs for waste management and final waste disposal will therefore be based on the principle of protecting the public from incidental radiation exposure by limiting external radiation dose rates and avoiding future human intrusion.

Operational waste management will be based on a systematic waste survey that will be performed early during the operations phase and the necessary information to segregate all waste as non-process waste and process waste will be collected.

Non-process waste is considered unlikely to become radioactively contaminated up to the point of segregation. This waste is disposed of in accordance with conventional requirements for hazardous and non-hazardous waste. There are no radiological restrictions on the handling or disposal of non-process waste.

Process waste is waste for which the potential exists that it may have become radioactively contaminated. A systematic review of areas and plant processes will be performed to identify sources, storage areas and transit routes of waste. The flow diagram in Figure 10.1 (Friend et al., 2005) illustrates the steps that are required for systematic management of radioactive waste.

There are areas where waste is not generated but non-radioactive waste is stored, or non-radioactive waste generated, and can become radioactively contaminated; for example:

• radioactivity can be imported through wind action,
• spillage from nearby bunded radioactive storage areas, and
• transporting contained radioactive material through a “clean” area and accidental spills.
A systematic review of all areas will identify clean areas where a potential exists for contamination.

Of the different waste streams produced by mining and milling operations, tailings represent the greatest challenge, particularly in terms of long term management, because of the large volumes produced and their content of very long lived radionuclides and heavy metals. Since tailings will continue to present a potential hazard to human health after closure, additional analyses and measures may be needed to provide for the protection of future generations. Such measures will not be left until closure but will be considered and implemented throughout the design, construction and operation. The protection of the public, from the start of proposed operations to post-closure, will be considered in its entirety from the beginning of the design of the facilities.

Engineering controls of radioactive tailings may fail because of natural processes (such as erosion) or events that result in the release of increased amounts of radionuclides to the environment. These events and processes are of a probabilistic nature and, for properly designed waste management systems, will have a probability of occurrence in any given year of far less than unity. Due consideration will be given to the probability of the event occurring and to its likely impact on the integrity of the disposal system.
To conform to the principles for managing radioactive waste, access to and dispersion in the environment of the hazardous constituents of the tailings will have to be restricted for long periods into the future. The key issues, which will be considered in the design of a tailings management facility, include the:

- stability of the pit and surface impoundment in relation to natural processes such as earthquakes, floods and erosion;
- hydrological, hydro-geological and geochemical characteristics of the site;
- chemical and physical characteristics of the tailings in relation to the potential for the generation and transport of contaminants; and
- appropriate use of neutralisation agents, radium precipitating additives, artificial or natural liners, radon barriers and evaporation circuits, with the reliability, longevity and durability of such agents factored in.

Good mining practice will be followed to the extent practicable and consistently with the requirements for radiological protection, such that the design of the waste management facilities:

- maximises the use of natural material for containment,
- maximises the placement of waste material in mining pits,
- minimises the impact on the surrounding environment during operations and after closure,
- minimises the need to retrieve or relocate waste at closure, and
- minimises the need for surveillance and maintenance during operations and for institutional controls after closure.

The principle that undue burdens should not be placed on future generations leads to the conclusion that a passive approach to design for closure is preferable to a design that needs significant and ongoing maintenance. Such a passive approach is generally best achieved by disposal in mined out pits. This option will significantly reduce the need for surface disposal of tailings. Disposal of waste below ground level is typically less susceptible to surface erosion of material to the environment and to intrusion, and generally necessitates less maintenance than surface tailings impoundments. At the proposed Tubas mine a combination of a surface impoundment and a return of tailings to the mining pits will exist.

Waste management for discrete and homogeneous waste will be operated in accordance with a documented waste management programme. This programme will describe in detail all aspects of the management of the waste and include provision for:

- detailed and documented procedures for operation, maintenance, monitoring, quality assurance and safety;
- training of personnel in the implementation of the procedures;
- adequate surveillance and maintenance of all the structures, systems and components of the waste management facility that are important to safety;
- a system of controlled and supervised areas and clearance procedures for materials removed from the site;
- timely submissions to the regulatory body of inspection reports, monitoring results and reports on unusual occurrences; and
- the development of contingency plans for failures of the waste management facilities that may result in a significant reduction in the protection of human health or the environment.
Measures will be taken during operations to limit the rates of release to the environment of contaminants in liquid and airborne effluents. Measures will be used to ensure that solid waste remains under proper control so that the misuse of tailings is avoided. Releases of radon or radioactive dusts into the atmosphere and of radium and other radionuclides into surface water and groundwater by surface runoff or leaching from solid waste will be minimised.

Once any part of the waste management facilities is no longer needed, it will be closed to the extent practicable during operations (for example, closure of a waste rock pile).

A radioactive waste safety assessment will be maintained that will cover the operational, closure and post-closure phases of the facility. The scope and extent of the assessment will be commensurate with the site specific issues that will be addressed and will be sufficient to be able to identify and evaluate all relevant risk components over the relevant periods of the facilities' lifetimes. The assessment will be an iterative one, analyses being refined and models and input information updated as the process proceeds from development of the concept through design, construction, operation and closure.

Finally, a surveillance programme for the surface tailing impoundment and other waste management areas will contain, inter alia, the following elements:

- waste management areas conditions;
- site drawings and photographs;
- site inspection;
- environmental monitoring;
- site inspection documentation;

- description of the vicinity of the waste management area,
- description of the waste management site,
- access to, and security of, the waste management site,
- design of the waste management area, and
- description of adjacent areas.

- waste management site: baseline map,
- waste management site: as-built drawings,
- site baseline photographs, and
- maps and photographs from site inspection.

- inspection frequency,
- preparation for inspection,
- inspection team,
- routine site inspection,
- on-site areas, and
- off-site areas.

- atmospheric,
- water, and
- biological.

- site inspection checklist,
- site inspection maps,
- site inspection photograph, and
- site inspection report.

 signs and fences;
 security;
 record keeping and reports;
 emergency notification and response;
 quality assurance;
 health and safety during inspections; and
 reportable incidents.

All of the issues identified above will be addressed by the radiation waste management programme that will be discussed with the national regulatory authority before being submitted for approval.
11. DETAILS OF THE ENVIRONMENTAL ASSESSMENT PRACTITIONER

In terms of Section 26(1)(a) of the draft EA regulations (MET, 2009) it is a requirement to provide details of the environmental assessment practitioner (EAP) who prepared the report and the expertise of the EAP to carry out scoping procedures. This is provided in the following sections under general information, experience and related publications.

11.1 General information

Name: John Francois Curling Friend
Education: BEng (Chem) Pretoria 1986
MSc (Eng) Cape Town 1991
Dip MktM IMM 1995
Affiliations: FSAIChe (Fellow, South African Institution of Chemical Engineers)
FIChE (Fellow, United Kingdom Institution of Chemical Engineers)
FWISA (Fellow, Water Institute of South Africa)
FIWM(SA) (Fellow, Institute of Waste Management of Southern Africa)
Registrations: PrEng (Professional Engineer, Engineering Council of South Africa)
CEng (Chartered Engineer, United Kingdom Engineering Council)

11.2 Experience

1991 - Present
Softchem, founder member. Waste management (Eloptro), water management (Sasol Mining and Eskom), water treatment dedicated software (Anglo American Research Laboratories and Veolia Eau in France), functional specifications and operating manuals for water treatment plants (Saldanha Steel as subcontractor to DB Thermal), technical and environmental auditing (Eskom), environmental impact assessments (including public participation meetings) and evaluations (ABI/Coca-Cola, Necsa, Paladin Resources/Langer Heinrich Uranium and Gautrans), environmental management programme report (Eurocoal), environmental consulting and ISO 14001 environmental system implementation (Eskom, Midvaal Water Company and Vametco Alloys).

2005 - Present
SI Analytics (Pty) Ltd., Director Operations and Projects. Supplying air monitoring equipment to industry and government.

1997 - Present
Waterops (Pty) Ltd., Director: Operations and Marketing. Water treatment plant operations and troubleshooting, through Thermax representation supply of various chemicals and ion exchange resins.

1998 - 2007
University of Pretoria, Department of Chemical Engineering, Senior Lecturer. Responsible for the Environmental Engineering Group lecturing environmental engineering and postgraduate courses in environmental management, air quality management, waste management, air pollution control and water management.

1992 - 1998

1990 - 1992
Eskom Chemical Engineering Division, Design Engineer. Water management studies at numerous power stations and external to Eskom, eg Soda Ash Botswana. Effluent treatment plant design.
1988 - 1990
Koeberg Nuclear Power Station, Engineer in Training. Water treatment plant operation and troubleshooting, sodium hypochlorite production, sewage treatment and water chlorination plants, ion exchange resins.

1985 - 1986

11.3 Related publications*


* additional publications available from the website www.softchem.co.za.
12. **DRAFT ENVIRONMENTAL MANAGEMENT PLAN**

In terms of Section 27(o) of the draft EA regulations (MET, 2009) it is a requirement to complete a draft environmental management plan containing the aspects contemplated in Section 28 of the draft EA regulations. This is best utilised and formerly developed by the implementation of an environmental management system.

### 12.1 Environmental management system

RUN will strive to align its environmental management system (EMS) in accordance with the ISO 14001:2004 standard (even if not accredited under the standard). ISO 14001 is the world's most recognised EMS framework, enabling organisations to demonstrate sound environmental management by minimising harmful effects on the environment and achieving continual improvement through a formal environmental management system, which is subject to external audit verification.

### 12.2 Development of the environmental management system

In order to address all relevant environmental impacts and to assist in the development of a practical environmental management plan, RUN will implement the following four level documented environmental management system:

- **Level 1** - this level of documentation will consist of the company's environmental policy and the environmental management system manual (roadmap to the complete EMS);
- **Level 2** - environmental specific and company related documentation;
- **Level 3** - environmental and related registers and activity specific work instructions; and
- **Level 4** - records (for example, analyses and month end reports) and related documentation (for example, feedback reports to authorities, management reviews and audit reports).

The following four EMS procedures will be developed, approved, authorised and implemented at the proposed mining site (ISO 14001, 2004):

- *Environmental policy and management review procedure*;
- *Environmental management system planning procedure* (addressing environmental aspects; legal and other requirements; and objectives, targets and programmes);
- *Environmental management system implementation and operation procedure* (addressing resources, roles, responsibility and authority; competency, training and awareness; communication; documentation; control of documents; operational control; and emergency preparedness and response); and
- *Environmental management system checking procedure* (addressing monitoring and measurement; evaluation of compliance; nonconformity, corrective and preventive action; control of records; and internal audit).

The following Level 3 documents are, *inter alia*, envisaged for the proposed mining site, for ISO 14001 alignment:

- environmental aspects and impacts register,
- environmental legal register,
- environmental objectives, targets and programme,
- environmental training register,
- environmental complaints register, and
- EMS audit schedule.
The company will strive to have the proposed environmental management system, with related documentation and practical requirements, implemented during/prior to the construction phase of the proposed project.

12.3 Development of the draft environmental management plan

The environmental impacts identified in Section 8, proposed measures for mitigation of these impacts, monitoring actions and methods required for implementation of these mitigated measures, responsibilities and resources required for implementation form the basis of compiling a suitable draft environmental management plan in terms of the requirements stipulated by Section 28 of the draft EA regulations. The required draft environmental management plan is set out in Appendix N.
13. SPECIFIC INFORMATION REQUIRED BY COMPETENT AUTHORITY

13.1 Assumptions and uncertainties
In terms of Section 27(l) of the draft EA regulations (MET, 2009) it is required to give a description of any assumptions, uncertainties and gaps in knowledge encountered in the completion of this environmental impact assessment report. These were all addressed in individual specialist reports presented in the attached Appendices B to H, Appendix O, and where relevant, in Sections 3, 5 and 8 of this EIA report.

13.2 Reasoned opinion
It is the reasoned opinion of the EAP that compiled this report, based on the findings contained in this report, that the proposed activity be authorised. As further requested in Section 27(l) of the draft EA regulations for stipulating any conditions that should be made in respect of such an authorisation, no further conditions are prescribed apart from the recommended mitigation measures stated in Section 8 of this report and relevant specialist reports in Appendices B to H, and Appendix O.

13.3 Irrevocable financial grantee (guarantee)
In terms of Section 27(p) of the draft EA regulations an applicant must provide an independently managed and irrevocable financial grantee as security for rehabilitation, decommissioning or reclamation measures with respect to a proposed activity (MET, 2009). Such financial grantee must be in accordance either to Section 30(1) of the draft EA regulations for a new application, or to Section 30(2) if already in existence before commencement of the draft EA regulations. As the draft EA regulations have not yet been implemented, Section 30(2) will be relevant for this application and in order to address the relevant requirements of Section 30(2), the applicant (RUN) has drafted the following:

Reptile Uranium Namibia (Proprietary) (Limited) (RUN) is aware of its moral and legal responsibilities regarding the environment and rehabilitation guarantees. When granted a mining licence (ML) or licences, RUN will, in terms of the specified conditions, establish an environmental trust fund for the purpose of funding environmental rehabilitation and aftercare. This trust fund will be known as the Reptile Uranium Environmental Trust Fund (the Trust).

Under current Namibian legislation no particular legal framework (or benchmark) exists to determine environmental rehabilitation obligations and/or the type of resources the ML holder must make provision for, to meet such potential future environmental obligations. Clearly it is no longer prudent to make provision for future environmental rehabilitation in the RUN financial statements only.

The purpose of the Trust will be to meet RUN’s environmental and associated financial obligations as a ML holder. The proposed structure of the Trust is detailed as follows:

- RUN and its Australian and Namibian listed parent company, Deep Yellow Limited (DYL), respectively as founder and co-founder, will establish the Trust.
- The sole beneficiary of the Trust will be RUN with the objective to ensure that RUN is in a position to meet its legal environmental obligations in Namibia.
- The agreement between the Trust and RUN will make provision for the Trust to call on RUN to provide funds for environmental rehabilitation and aftercare.
- DYL will support RUN’s obligations with an appropriate parent company guarantee.
- DYL’s obligations will be secured by respective floating charges registered under Australian legislation.
- The securities or assets held by the Trust will be adjusted from time to time and independently determined in accordance with the required environmental rehabilitation and aftercare costs.
13.4 Other matters
Copies of specialist reports, completed in terms of this environmental impact assessment, are attached in Appendices B to H, and Appendix O, as required by Section 27(q) of the draft EA regulations.

At this stage no other specific information is required by the relevant authority, as requested by Section 27(r) of the draft EA regulations.

13.5 Environmental impact statement
This proposed activity envisaged the design, construction and operation of a uranium processing facility in EPL 3496. Key findings from the EIA include, \textit{inter alia}, the following:

- the Tubas deposit and processing plant are more viable as the mineralisation predominantly occurs in Aeolian, uncremented sand; with the ore predominantly free digging that allows for simple low cost (no blasting) mining techniques;
- creation of new job opportunities;
- the full operation of the proposed mine will have a significant economic impact on both regional and national levels, with recent estimates indicating that, when fully operational, direct and indirect taxes to the Namibian government will be in the order of N$ 27.2 million per year;
- although most of the direct employment effects will take place in the mining industry, the multiplier effect will result in job creation effects in areas such as transport, equipment manufacturing and personal services; and
- albeit that various negative impacts on the environment were identified through extensive specialist studies, none of them represented fatal flaws.

A further requirement of an environmental impact assessment statement in terms of Section 27(n) of the draft EA regulations is to include a comparative assessment of the positive and negative implications of the proposed activity and identified alternatives. The above positive and negative implications of the proposed activity were assessed against various alternatives, inclusive of the no-go alternative, which is the option of not undertaking the proposed activity or any of its alternatives. With all the categorised alternatives, the location (site) alternative normally plays the biggest role in assessment of an activity and its related impacts. However, in the case of mining operations the location is seldom available for alternative selection as the proposed mineral for extraction is by its very nature exactly at a particular selected site. Alternative options were thus evaluated and assessed as part of the overall design of the proposed mining operation, inclusive of alternative extraction methods, relevant processing operations and scheduling and input alternatives. With the major alternative category being that of site (location) alternatives addressed, any other alternative categories (demand, activity, process, scheduling and input) can be suitably managed through mitigation measures to negate major negative implications.

In summary, the activity of mining will always result in some form of negative impact on the environment, whether impacts are mitigated or not. The ideal is to match the environment, social and economic issues to such an extent that the overall outcome of an activity will not result in a combined lesser value for the three issues. The economic benefit and potential social upliftment of the proposed Tubas project should outweigh the environmental impacts addressed in this report, through the implementation of mitigation measures, to result in an overall positive value for the combined environmental, social and economic issues identified.
14. REFERENCES


ICRP (INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION) (1990) Recommendations of the ICRP on radiological protection. *International Commission on Radiological Protection publication*, ICRP publication No 60, Vienna.


